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CONTENTS.

PART I.—JANUARY, 1894.

PART II.—MAY, 1894.

PART III.—AUGUST, 1894.

PART IV.—FEBRUARY, 1896.

PART V.—JUNE, 1896.

PART VI.—JULY, 1896.

PART VII.—OCTOBER, 1896.

PART VIII.—FEBRUARY, 1897.

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THE LINNEAN SOCIETY OF LONDON.

REPORT ON ENTOMOSTRACA FROM THE GULF OF GUINEA.

BY

THOMAS SCOTT, F.L.S.,
NATURALIST TO THE FISHERY BOARD FOR SCOTLAND.

NATURÆ DISCERE MORES

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January 1894.

TRANSACTIONS

OF

THE LINNEAN SOCIETY.

I. *Report on Entomostraca from the Gulf of Guinea, collected by John Rattray, B.Sc.* *By* THOMAS SCOTT, *F.L.S., Naturalist to the Fishery Board for Scotland.*

Read 2nd February, 1893.

(Plates I.–XV.)

THE following Report contains a Catalogue, more or less descriptive, of all the Entomostraca obtained in the tow-net gatherings collected by Mr. John Rattray, in the Gulf of Guinea, while engaged as naturalist on board the Telegraph Steamer 'Buccaneer.'

It is not necessary that I should enter into any explanation of the causes of the delay in the publication of the Report on the Entomostraca further than to state that the collections were handed over to me early in 1891, and since then all the leisure that could be spared has been devoted to their examination and to the preparation of the following Catalogue.

In the preparation of the Report the author has to acknowledge the valuable aid he has received from Professor G. S. Brady, F.R.S. He is also under great obligations to the Senatus of the University of Edinburgh for the privilege of consulting the numerous works on Natural History in the University Library, and to Mr. Webster, the Librarian, who has always been ready to help in hunting up any literature wanted.

My thanks are also due to Dr. T. Wemyss Fulton, of the Fishery Board for Scotland, for the active interest he has taken in the preparation of the Report; among other things he obtained for me the privilege of consulting the valuable Natural History Works in the Library of the Royal Society of Edinburgh.

The Government Grant Committee of the Royal Society of London allocated to me the sum of £20 in 1891, and again in 1892, for the purposes of this investigation; and this enabled me to retain the services of my son, Mr. Andrew Scott, for the preparation of the drawings that accompany and illustrate the Report, which, by their acknowledged accuracy as well as their beauty, add greatly to its value. My son also prepared the greater number of the dissections represented by the drawings, which were necessary for the satisfactory diagnosis of the various species recorded.

The Entomostraca described in the following Catalogue include species belonging to the orders Copepoda, Cladocera, and Ostracoda. The first is represented by one hundred and forty-eight species, the second by two species, and the third by twenty-four species.

The great tendency to, and multiplicity of, variation observed, especially in certain groups, has caused considerable difficulty in deciding the value that should be placed on the amount of variation met with. Though care has been taken to avoid as far as possible attaching a higher value to these variations than they deserved, it has been necessary in not a few instances to give them specific and even generic rank, in order to dispose of them in anything like a satisfactory manner.

A considerable number of more or less immature forms occurred in nearly all the tow-nettings, and were the cause of much trouble during the examination of the material; the liability of mistaking an immature specimen of one species for a member of another, and a different one, is considerable, and has to be kept constantly in view during the examination of such small organisms.

Since writing this Report I have, through the kindness of Dr. T. Wemyss Fulton, of the Fishery Board for Scotland, been favoured with a perusal of Dr. Giesbrecht's excellent work on the Mediterranean Copepoda, which has enabled me to make some alterations that will bring it more into conformity with recent views on the nomenclature of that important group of the Crustacea; while the Introductory Remarks by Mr. Rattray, which follow, will add to its completeness.

INTRODUCTORY REMARKS. By JOHN RATTRAY, B.Sc., F.R.S.E.

For the opportunity of taking part in this expedition, of the results of which a report on the Entomostraca is now presented, I have exclusively to thank Dr. John Murray, of H.M.S. 'Challenger' Commission. J. Y. Buchanan, Esq., formerly chemist on board H.M.S. 'Challenger,' accompanied the expedition, and all my work was carried on under his immediate supervision on board the S.S. 'Buccaneer' (Captain Thomson, R.N.R.), then in the service of the India Rubber, Gutta Percha, and Telegraph Works Co., Ld., of Silvertown, Essex, and at that time engaged in sounding-operations preliminary to the laying down of a telegraph-cable on the West Coast of Tropical Africa.

Sailing from Liverpool in the S.S. 'Nubia' in the beginning of December 1885, the 'Buccaneer' was joined by Mr. Buchanan and myself at Sierra Leone on December 23, and sailed at once northwards, touching on Dec. 24 at Bullama and Bassao, between the Isles de Los and Dakar, near Cape Verd, arriving at Dakar on the evening of the same day to complete preliminary arrangements for the sounding expedition, which started thence on December 29.

So far as relates to the Biological collections, the equipment provided consisted of a supply of botanical paper with botanical press for the preservation of such larger plant specimens as might be procured on any short expeditions that might be possible on shore. Such chances were found only at rare intervals: thus gatherings were made on the outward voyage at Madeira, in the vicinity of Funchal (Dec. 10), at Teneriffe, in and around Santa Cruz (Dec. 12 and March 28, 1886), at Sierra Leone (Dec. 21), at Conakoy, Isles de Los (March 17, 1886), at Dakar (Dec. 26–29), at Accra, North Coast of Gulf of Guinea (Jan. 16), at São Thomé, Gulf of Guinea (Jan. 25 and 31 and Feb. 1, 1886), at Principé Island, Gulf of Guinea (Jan. 27), and at St. Paul de Loanda, E. coast of Gulf of Guinea (Feb. 10–17). On Dec. 13 some algæ and shells were procured at Las Palmas, Gran Canaria, a landing for a few hours only being possible. During the brief calls at Bullama and Bassao on Dec. 24, the time was entirely occupied in the collecting of marine specimens either floating on the very muddy waters of these parts or occurring on the beach; the visits paid to Libreville, Gaboon River, on January 28, and to Bananah Creek, Congo River, on February 7, were so brief that no landing could be effected. So far as relates to Phanerogams, the best gatherings were made in and about Santa Cruz and at São Thomé; a considerable number of Thalamifloræ were found at both; Papaveraceæ and Coniferæ especially at Santa Cruz; Malvaceæ especially at São Thomé. At the latter Leguminous, Rosaceous, Crassulaceous, Myrtaceous, Onagraceous, Samydaceous, and Cucurbitaceous Calycifloræ were well represented; at the former were gathered some Ficoideæ and Umbelliferæ not obtained at the latter. At St. Paul de Loanda, Leguminous and Myrtaceous Calycifloræ only were found, *e. g.* especially *Indigofera*, *Dialium*, *Cæsalpinia*, *Crotalaria*, *Tamarindus*, and *Psidium*. Of Epigynous Monopetaloid Compositæ more were obtained at Santa Cruz than at São Thomé; but, on the other hand, more hypogynous specimens at the latter than at the former, the Jasminaceæ, Apocynaceæ, and Convolvulaceæ predominating. Again, Apetalæ, Nyctaginaceæ, Amarantaceæ, Urticaceæ, Euphorbiaceæ, and Monocotyledones—especially Connaceæ, Cyperaceæ, and Gramineæ—were found most abundantly at São Thomé. Most Filices were obtained from Principé Island, including particularly species of *Nephrolepis*, *Nephrodium*, *Polypodium*, and many young forms. At Dakar and at St. Paul de Loanda the coast-flora was poor, owing to the vast stretches of sand; at the former were observed species of *Argemone*, *Urena*, *Vigna*, *Cassia*, *Albizzia*, *Sesbania*, *Jussiæa*, *Heliotropium*, *Clerodendron*, *Hyptis*, *Scirpus*, *Chloris*, *Pennisetum*, *Penicillaria*, *Andropogon*, *Cenchrus*, not obtained at the latter, which, on the other hand, yielded species of *Sesuvium*, *Sida*, *Tribulus*, *Monetia*, *Indigofera*, *Psidium*, *Pluchea*, *Dichoma*, *Ipomœa*, *Boerhaavia*, *Bougainvillea*, *Centema*, *Pupalia*, *Phyllanthus*, *Euphorbia*. *Panicum*, *Sporobolus*, *Eragrostis*, *Aristida*, &c., not found at Dakar.

Much difficulty was experienced in protecting specimens against the hot moist atmosphere of the tropics, and recourse was ultimately had to having them deposited near the furnaces of the steamer. This at length proved effective, but was accompained by the accumulation of much dust, which might, however, have been largely avoided by wrapping in fine muslin, had that been available.

Among Algæ specially noteworthy were the exuberant growths of Corallinæ near Las Palmas, attached to a soft sandstone on a narrow isthmus joining the volcanic sections of the island, and of *Padina* (Adanson) on the beach, about 3 miles from Dakar, at the far side of the bay surrounding Goree Island.

For the preservation of zoological specimens the following means were at hand:—methylated spirit, alsolute alcohol, glycerine, benzole, ether, chloroform, acetic acid, ammonia, hydrochloric acid, sulphuric acid, nitric acid, corrosive sublimate, caustic potash, osmic acid, chromic acid, picric acid, iodine, picrocarmine, hæmatoxylin, Canada balsam; with accessories such as slides, cover-glasses, watch-glasses, porcelain dishes, spirit-lamp, camel-hair brushes, needles, spatulas, two nets of varying degrees of fineness, a tank-box, shrimp-trawls, mud-bags, and specimen bottles. Some 200 bottles of 4-oz. capacity, in addition to several boxfuls of others of larger sizes. At the end of the work all the available bottles were filled, and as many others as could be obtained empty from the supplies of the ship.

Many micro-preparations were made of the products of the soundings, of which 411 were taken during the cruise, and of the contents of the tow-nets at various points. Larger specimens, such as species of Pisces, were procured from native fishermen at St. Paul de Loanda, and for these the tank-box proved very useful. Larger Crustacea, of which a few were found on shore, were preserved in spirit at once. Numerous shells of Mollusca were obtained dry; but one of the most important departments of the work was the preservation of the more delicate Arthropoda (Copepoda, Amphipoda, Schizopoda, &c.), Ascidia, ova, fish-larvæ, *Sagitta*, &c., found in the tow-net gatherings. For these the methods adopted were essentially those practised at the zoological stations of Naples * and elsewhere. For delicate objects, Prof. E. R. Lankester had recommended, in a letter to Dr. John Murray, two plans: (α) corrosive sublimate followed by dilute then stronger alcohol, and (β) $\frac{1}{10}$ per cent. osmic acid, or this mixed with very dilute chromic acid or acetic acid, giving a short exposure of 1 to 2 minutes according to size: this to be followed by alcohols of increasing strength. The latter method was recommended for *Clione* and other Pteropoda; it was adopted but rarely, owing to the difficulty of prosecuting many different methods in a limited amount of space (the laboratory at command being quite small, but very compact) the combined chrom-osmic or aceto-osmic plans were not tried at all: the former method was freely used. For the Radiolaria the osmic acid process also proved of use, it had been recommended by Hartwig and by Haeckel; but a glycerine medium to follow it was not employed because of the unsuitability of its refractive index to that of the Radiolarian skeleton.

For preserving the products of the tow-net pure alcohol was never adopted *ab initio*, but acidulated alcohol was tried, following the directions of Paul Mayer and Whitman, viz. 70 or 80 per cent. alcohol with a small addition of pure hydrochloric acid and a trace of picric acid. The specimens were subsequently washed with strong spirit to remove the acid, and preserved in spirit. Again, the picrosulphuric acid method following

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* Mayer, Mittheil. zool. Stat. Neap. ii. (1881) p. 1; Journ. Roy. Micr. Soc. n. s. ii. (1882) p. 866.

Kleinenberg's * formula, as adopted by Mayer †, that is, without the addition of creosote, was often used, because of its reported high degree of penetrability for chitinized structures. The fixing agent was simply added to the sea-water, and this was subsequently succeeded by increasing strengths of spirit. Mayer's ‡ picro-hydrochloric acid method was only employed a few times.

Corrosive sublimate was extensively used, and was found to be of special service on account of the rapidity of its action. Lang's § methods were simplified and accelerated by adding a little of the solid salt to the sea-water; the hot solution of the salt was never adopted, though it has been recommended for *Sagitta*, Copepoda, *Saphirina*, and other Arthropod larvæ. In a few cases, following Carnoy ‖, a trace of acetic acid was added to the corrosive solution. The mercuric salt was removed by subsequent washing—the mode of filtration was found of advantage from its speed and cleanliness—and successive treatment with progressive strengths of spirit. The animals were in all cases, where preservation was required, killed as rapidly as possible after capture, with a view to the obtaining of good results for structural purposes.

Tow-net collections were made throughout the whole course of the voyage; the total number of these was, however, somewhat less than the total number of soundings, because (1) soundings were sometimes taken with much speed in shallow depths, and the delay of the steamer was therefore brief; (2) tow-net gatherings could not continuously be obtained by night and by day, save only at intervals. During work only one net was really lost through the snapping of gear belonging to the net itself, a few others, usually in deep water, were lost on account of the breaking of the cable upon which they were attached.

The majority of the gatherings were made in the upper strata of the water, or say down to 25 fathoms; but deep-sea nets were repeatedly used. The deepest were wrought at 360 and 460 fathoms on January 22, in lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E.

Prof. Chrystal's double-hooped net was used at a depth of 260 fms., but the collection obtained was small. On Feb. 5, in lat. 4° 26′ 7″ S., long. 10° 1′ 8″ E., two nets were set adrift at 235, 185, and 85 fathoms attached to balloon buoys in a S. ½ W. current of 0·54 knots; and, again, similarly on Feb. 22, in lat. 5° 59′ 4″ S., long. 3° 49′ 4″ E., a series of nets were exposed at 30, 40, 70, 100, 130, 160, 190, and 200 fms.,—the temperatures at these respective depths being 61°·3 F., 59°·3 F., 57°·5 F., 55° F., 52°·5 F., 49° F., and 46°·7 F.; but in heaving up, after an exposure of 7 hours, the cable snapped, and all but the uppermost were lost. Three more deep-sea nets were lost by the breaking of a steel rope attached to an anchor-dredge in lat. 5° 54′ S., long. 11° 48′ W., when, out of 1780 fms. of rope, 1675 fms. were lost together with the anchor-dredge, weighing 5 cwt. 2 qrs. 14 lbs. These accidents were specially to be regretted by reason of the opportunities

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* Foster and Balfour, Embryol.

† Journ. Roy. Micr. Soc. n. s. ii. (1882) p. 867.

‡ Mittheil. zool. Stat. Neap. 1881, p. 5.

§ Zool. Anzeig. 1878, p. 79.

‖ La Biol. Cellulaire, p. 95.

they presented for ascertaining something of life at these depths. In lat. 0° 7′ 8″ S., long. 14° 28′ 6″ W., nets were employed at intervals down to 100 fms. on March 10; and again on March 11, down to 75 fms., in lat. 0° 0′ 7″ N., long. 13° 4′ W.

The time of exposure of tow-nets varied with circumstances and opportunities from 20 minutes to 7 hours (the latter when sent adrift from the ship). Inshore nets taken at Conakoy, Isles de Los, Bullama, Bassao, Dakar, Accra, off Little Bassam, in the vicinity of the submarine gully known as the "bottomless pit," Porto Novo, Libreville (Gaboon River), Bananah Creek (Congo River), and St. Paul de Loanda were always at or near the surface. Of special interest is the series procured during soundings in the vicinity of the Congo cañon, where gyrations of the water, accompanied by the production of coarse bubbles of foam, were very evident on the surface of the sea.

For Ascidia, Prof. Herdman had recommended three plans, all of which were employed, viz.: (1) picric acid and alcohol; (2) osmic acid and alcohol; and (3) picric acid alone, without alcohol, for *Salpæ* and *Doliolum*. Some were also preserved in glycerine, without either picric acid or spirit to prevent opacity. For living specimens of sclerodermic corals, of which only a few were obtained, the corrosive sublimate treatment was employed. No Hydrozoa were preserved, according to Pagenstecher's * method, by the use of sodium chloride and alum succeeded by stronger and stronger alcohols. For the Peridinidæ, of which several were obtained, Géza Entz's † recommendation of glycerine was not followed, though tried, chiefly on account of refractive considerations. Porifera have been treated by Keller ‡ with osmic and chromic acids, the former of the strength of $\frac{1}{20}$ to $\frac{1}{10}$ per cent., the latter very dilute; but of these, the only representatives obtained were found on the shore at Ascension Island, and were immediately placed in spirit.

Subjoined is a list of the positions of the 48 stations of the expedition, where the best available means were adopted for obtaining collections, with the surface temperature observed at each:—

Station I. Dec. 29, 1885, lat. 13° 48′ N., long. 19° 18′ W. (75° F.).
„ II. Jan. 1, 1886, lat. 7° 54′ N., long. 17° 25′ W. (82°·2 F.).
„ III. „ 2, „ lat. 7° 1′ N., long. 15° 54′ W. (82°·9 F.).
„ IV. „ 3, „ lat. 7° 33′ N., long. 15° 18′ W. (83° F.).
„ V. „ 4, „ lat. 7° 20′ N., long. 13° 26′ W. (83°·2 F.).
„ VI. „ „ „ lat. 7° 8′ N., long. 13° 27′ W. (83°·4 F.).
„ VII. „ 5, „ lat. 5° 48′ N., long. 14° 20′ W. (85°·5 F.).
„ VIII. „ 9, „ lat. 3° 57′ 2″ N., long. 7° 42′ 8″ W. (82°·8 F.). Here a S.E. current down to 150 fms.

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* Zeitschr. wiss. Zool. xvii. (1867) p. 379.

† Zool. Anzeig. 1881, p. 575.

‡ Zeitschr. wiss. Zool. xxx. p. 568.

Station	IX.	Jan. 10,	1886,	lat. 3° 0′ 8″ N., long. 7° 43′ W. (83° F.). Station in and near outer edge of Guinea current. Water ultramarine.
,,	X.	,, 13,	,,	lat. 3° 58′ N., long. 3° 42′ W. (83°·7 F.).
,,	XI.	,, 19,	,,	lat. 5° 15′ 4″ N., long. 3° 10′ E. (83°·2 F.).
,,	XII.	,, 20,	,,	lat. 4° 12′ 7″ N., long. 3° 57′ 5″ E. (82°·7 F.). A strong N.N.W. current 2 to 3 fms. deep, and under it a strong current in opposite direction.
,,	XIII.	,, ,,	,,	lat. 3° 55′ 3″ N., long. 4° 7′ 3″ E. (83°·2 F.).
,,	XIV.	,, 21,	,,	lat. 2° 20′ 2″ N., long. 5° 7′ 8″ E. (82°·2 F.).
,,	XV.	,, 22,	,,	lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E. (82°·9 F.). Current N. 37° W.= 0·72 knots.
,,	XVI.	,, 23,	,,	lat. 0° 38′ 6″ N., long. 6° 25′ 8″ E. (82°·9 F.).
,,	XVII.	,, 29,	,,	lat. 0° 21′ 1″ N., long. 7° 33′ E. (83° F.).
,,	XVIII.	Feb. 3,	,,	lat. 1° 22′ 2″ S., long. 7° 45′ E. (81°·4 F.).
,,	XIX.	,, ,,	,,	lat. 1° 6′ 2″ S., long. 8° 10′ 4″ E. (83° F.).
,,	XX.	,, ,,	,,	lat. 1° 1′ 2″ S., long. 8° 19′ 7″ E. (82°·8 F.).
,,	XXI.	,, 4,	,,	lat. 2° 39′ S., long. 8° 58′ E. (81°·7 F.). A floating island near this.
,,	XXII.	,, ,,	,,	lat. 2° 47′ S., long. 8° 46′ E. (82°·7 F.).
,,	XXIII.	,, 5,	,,	lat. 4° 26′ 7″ S., long. 10° 1′ 8″ E. (82°·1 F.). Current S. ½ W.=0·54 knots.
,,	XXIV.	,, 6,	,,	lat. 5° 54′ S., long. 11° 33′ E. (82° F.).
,,	XXV.	,, ,,	,,	lat. 5° 55′ 8″ S., long. 11° 50′ 3″ E. (84°·2 F.). Current W. by S. true.
,,	XXVI.	,, 9,	,,	lat. 8° 8′ 2″ S., long. 12° 29′ 4″ E. (79°·8 F.). (At Loanda.)
,,	XXVII.	,, 19,	,,	lat. 5° 9′ S., long. 10° 43′ E. (82°·3 F.).
,,	XXVIII.	,, 20,	,,	lat. 5° 51′ 7″ S., long. 8° 36′ 5″ E. (83°·3 F.).
,,	XXIX.	,, 21,	,,	lat. 5° 47′ 7″ S., long. 6° 49′ 5″ E. (82°·2 F.).
,,	XXX.	,, ,,	,,	lat. 5° 50′ 9″ S., long. 5° 1′ 4″ E. (81°·7 F.).
,,	XXXI.	,, 22,	,,	lat. 5° 59′ 4″ S., long. 3° 49′ 4″ E. (83° F.).
,,	XXXII.	,, 23,	,,	lat. 6° 2′ 2″ S., long. 1° 50′ 7″ E. (81°·8 F.).
,,	XXXIII.	,, ,,	,,	lat. 5° 58′ 1″ S., long. 0° 1′ 5″ E. (81° F.).
,,	XXXIV.	,, 24,	,,	lat. 5° 58′ 5″ S., long. 1° 24′ 1″ W. (81° F.).
,,	XXXV.	,, 25,	,,	lat. 5° 59′ 5″ S., long. 3° 24′ 5″ W. (80° F.).
,,	XXXVI.	,, ,,	,,	lat. 6° 0′ 7″ S., long. 5° 5′ 4″ W. (81° F.).
,,	XXXVII.	,, 26,	,,	lat. 6° 3′ 4″ S., long. 6° 27′ 2″ W. (85°·5 F.).
	XXXVIII.	,, ,,	,,	lat. 3° 58′ 6″ S., long. 8° 11′ W. (79°·8 F.).
,,	XXXIX.	,, 27,	,,	lat. 5° 56′ 3″ S., long. 9° 32′ 6″ W. (80°·6 F.).
,,	XL.	,, 28,	,,	lat. 5° 54′ S., long. 11° 48′ W (81° F.).
,,	XLI.	Mar. 5,	,,	lat. 6° 0′ 3″ S., long. 13° 24′ 9″ W. (81° F.).
,,	XLII.	,, 6,	,,	lat. 3° 59′ S., long. 13° 28′ W.
,,	XLIII.	,, 7,	,,	lat. 2° 42′ 2″ S., long. 14° 43′ 4″ W. (81°·5 F.).
,,	XLIV.	,, 9,	,,	lat. 0° 1′ 6″ S., long. 15° 56′ 5″ W. (81° F.).
,,	XLV.	,, 10,	,,	lat. 0° 7′ 8″ S., long. 14° 28′ 6″ W. (81°·6 F.).
,,	XLVI.	,, 11,	,,	lat. 0° 0′ 7″ N., long. 18° 4′ W. (80°·8 F.).
,,	XLVII.	,, 12,	,,	lat. 1° 17′ 6″ N., long. 13° 54′ 4″ W. (82°·3 F.).
,,	XLVIII.	,, 13,	,,	lat. 3° 3′ 4″ N., long. 15° 0′ 9″ W. (83°·1 F.).

PART I.

COPEPODA.

The material from which the Copepoda noticed in this Report were obtained was collected chiefly by means of tow-nets worked at the surface and at various depths (under surface) from 2 to 460 fathoms, and a few were shore gatherings.

The material was contained in 149 bottles, which represented about as many separate gatherings.

Lists of species obtained in some of the more important gatherings are appended to these introductory remarks (*vide* p. 13).

Comparatively few of the species were generally distributed throughout the area examined, or were of frequent or common occurrence in the tow-nettings.

The following were among the most common and most widely distributed species in the collection:—*Eucalanus attenuatus*, *Rhincalanus cornutus*, *Undina vulgaris*, *Euchæta marina*, *Temora stylifera*, *Corycæus varius*, *Corycæus speciosus*, and *Oncæa obtusa*. On the other hand, a considerable number of species, though obtained in gatherings from localities all over the area examined, were uncommon or rare in the collections in which they occurred—*Eucalanus setiger* and *Pleuromma abdominale* may be given as examples. Other species, though observed in comparatively few gatherings, were yet moderately common in those in which they did occur—*Hemicalanus longicornis* is a striking example of this. This species was observed in comparatively few gatherings, but in one of these no fewer than 80 fairly perfect specimens were obtained; in contrast to this, it may be stated that scarcely half a dozen specimens of *Hemicalani* were observed in the whole of the 'Challenger' collections. Several species, as *Acartia spinicaudata*, *Oithona minuta*, *Amymone Andrewi*, *Ilyopsyllus affinis*, and some other Harpactids, were obtained in gatherings from inshore and brackish-water localities, as, for example, from a shore collection at Accra and at São Thomé Island, and in surface-gatherings from Bananah Creek at the mouth of the River Congo, and from Loanda Harbour. A few fish-parasites, including the pretty *Hessella*, were also observed, and are described in this Report.

Many of the species occurred more frequently in the surface tow-nettings collected during the night than in those collected during the day, while in the under-surface tow-nettings they were of more frequent occurrence in those collected during the day than in those collected during the night. This will be observed by referring to the classified list of species.

The following Table exhibits some points of interest respecting the general distribution of species in surface and under-surface, and in day and night, collections:—

TABLE I.—Description of the Tow-net Gatherings.

	Number of tow-net gatherings.	Average number of species in each of the gatherings.	Maximum number of species in any one of the gatherings.	Minimum number of species in any one of the gatherings.	Number of gatherings collected during the day.	Maximum depth at which material was collected.	Minimum depth at which material was collected.	Number of gatherings collected during the night.	Maximum depth at which material was collected.	Minimum depth at which material was collected.	Average number of species in each of the day tow-net gatherings.	Maximum number of species in any one of the day tow-net gatherings.	Minimum number of species in any one of the day tow-net gatherings.	Average number of species in each of the night tow-net gatherings.	Maximum number of species in any one of the night tow-net gatherings.	Minimum number of species in any one of the night tow-net gatherings.
Surface	84	14·57	32	1	46	—	—	38	—	—	11	32	1	18·7	28	3
Under-surface..	65	23·3	42	6	48	fms. 460	fms. $2\frac{1}{2}$	17	fms. 50	fms. 2	23·4 +	42	6	21·8 –	38	9
Total number..	149	18·3			94	—	—	55	—	—	17·54+			19·67+		

It will be observed from this Table that the difference between the average number of species in each of the day and night surface tow-net gatherings is rather considerable; while as regards the average number of species in each of the day and night under-surface tow-net gatherings there is comparatively little difference, and the difference shown is the reverse of that observed in the surface tow-net gatherings. Further, the average number of species in the surface-gatherings is much greater in those collected during the night, but in the under-surface gatherings the average is rather greater in those collected during the day; while in the combined surface and under-surface tow-nettings the average is, again, in favour of the night collections.

The area in which the tow-net gatherings were made may be described approximately as extending from lat. 7° 54′ N., long. 17° 25 W., eastward to Accra on the Gold Coast, thence southwards across the Bights of Benin and Biafra to São Thomé Island; from São Thomé Island eastwards towards the mouth of the Gaboon River; then southwards to the mouth of the Congo and to Bananah Creek, and thence to Loanda Harbour. No gatherings from mid-ocean are included in the collection: the greatest distance from land where tow-nettings were collected was not much, if at all, over 400 miles; but the greater number of them were collected much nearer land than that, and this probably explains why the 'Buccaneer' Copepoda—which exceed in number of species those obtained from the 'Challenger' collections, extending over an immensely wider area—differ so much in the entire absence of some species, and in the comparatively greater abundance of others, when compared with the 'Challenger' Copepoda, and also accounts for the presence of many curious and interesting species not represented in that collection.

Summary of the 'Buccaneer' Tow-net Collections, with the number of Species observed in each separate gathering.

The surface tow-nettings are kept together, the under-surface are arranged according to the depth at which the tow-nets were let down, and the whole of the tow-net gatherings are arranged as near as possible in the order in which they were collected. In the Table the figures 1, 2, 3, &c. *above* the line represent the number of the gathering as near as possible in the order in which it was collected. "D" indicates that the collection was made between 6 A.M. (inclusive) and 6 P.M., "N" that the collection was made between 6 P.M. (inclusive) and 6 A.M., "SD" or "SN" that the collection was made inshore during the day or night. The figures *under* the line show the number of species observed in each separate gathering. Thus:—"Surface, $\frac{3\text{ N}}{16}$," indicates that No. 3 tow-netting was a surface gathering collected between 6 P.M. and 6 A.M., and that sixteen species of Copepoda were observed in it. "Surface, $\frac{73\text{ SD}}{5}$," indicates that No. 73 was an inshore gathering collected between 6 A.M. and 6 P.M., in which five species of Copepoda were observed. "100 fms., $\frac{8\text{ D}}{26}$," indicates that No. 8 was a gathering from 100 fathoms collected during the day, and yielded twenty-six species of Copepoda; and so on as in the Table.

TABLE II.—Summary of Tow-net Collections.

Surface Tow-net Gatherings.

$\frac{3\text{ N}}{16}$,	$\frac{9\text{ N}}{16}$,	$\frac{12\text{ D}}{7}$,	$\frac{13\text{ D}}{16}$,	$\frac{14\text{ N}}{23}$,	$\frac{16\text{ D}}{16}$,	$\frac{22\text{ D}}{17}$,	$\frac{27\text{ SD}}{16}$,	$\frac{28\text{ SD}}{7}$,
$\frac{31\text{ D}}{14}$,	$\frac{32\text{ D}}{15}$,	$\frac{34\text{ D}}{5}$,	$\frac{36\text{ N}}{7}$,	$\frac{37\text{ N}}{7}$,	$\frac{39\text{ SD}}{4}$,	$\frac{40\text{ D}}{15}$,	$\frac{48\text{ N}}{24}$,	$\frac{49\text{ D}}{13}$,
$\frac{73\text{ SD}}{5}$,	$\frac{74\text{ D}}{11}$,	$\frac{75\text{ N}}{4}$,	$\frac{76\text{ N}}{23}$,	$\frac{77\text{ SD}}{0}$,	$\frac{78\text{ D}}{5}$,	$\frac{79\text{ D}}{4}$,	$\frac{80\text{ N}}{4}$,	$\frac{81\text{ N}}{19}$,
$\frac{82\text{ N}}{25}$,	$\frac{83\text{ N}}{20}$,	$\frac{84\text{ N}}{24}$,	$\frac{85\text{ N}}{26}$,	$\frac{86\text{ D}}{28}$,	$\frac{87\text{ D}}{9}$,	$\frac{91\text{ SD}}{3}$,	$\frac{92\text{ D}}{12}$,	$\frac{93\text{ D}}{14}$,
$\frac{94\text{ N}}{19}$,	$\frac{95\text{ N}}{28}$,	$\frac{96\text{ N}}{25}$,	$\frac{97\text{ N}}{26}$,	$\frac{98\text{ N}}{22}$,	$\frac{99\text{ D}}{8}$,	$\frac{102\text{ D}}{7}$,	$\frac{103\text{ N}}{17}$,	$\frac{104\text{ N}}{16}$,
$\frac{105\text{ N}}{23}$,	$\frac{106\text{ N}}{22}$,	$\frac{107\text{ D}}{17}$,	$\frac{108\text{ D}}{10}$,	$\frac{110\text{ N}}{5}$,	$\frac{111\text{ N}}{19}$,	$\frac{112\text{ N}}{21}$,	$\frac{120\text{ N}}{21}$,	$\frac{121\text{ N}}{15}$,
$\frac{122\text{ N}}{15}$,	$\frac{123\text{ D}}{14}$,	$\frac{124\text{ D}}{7}$,	$\frac{125\text{ D}}{17}$,	$\frac{126\text{ D}}{11}$,	$\frac{127\text{ D}}{1}$,	$\frac{128\text{ D}}{11}$,	$\frac{129\text{ D}}{16}$,	$\frac{130\text{ D}}{25}$,
$\frac{131\text{ D}}{18}$,	$\frac{132\text{ D}}{19}$,	$\frac{133\text{ N}}{21}$,	$\frac{134\text{ N}}{23}$,	$\frac{135\text{ N}}{22}$,	$\frac{136\text{ N}}{3}$,	$\frac{137\text{ D}}{27}$,	$\frac{138\text{ D}}{15}$,	$\frac{139\text{ D}}{4}$,
$\frac{140\text{ D}}{12}$,	$\frac{141\text{ D}}{8}$,	$\frac{142\text{ D}}{7}$,	$\frac{143\text{ D}}{3}$,	$\frac{144\text{ D}}{6}$,	$\frac{145\text{ D}}{6}$,	$\frac{146\text{ N}}{14}$,	$\frac{147\text{ N}}{12}$,	$\frac{148\text{ D}}{14}$,
$\frac{149\text{ D}}{20}$.								

Two fathoms Tow-net Gathering.

$\frac{19\text{ N}}{12}$

Two and half fathoms Tow-net Gathering.

$\frac{88\text{ D}}{23}$.

Three fathoms Tow-net Gatherings.

$\frac{24\text{ D}}{21}$, $\frac{33\text{ N}}{11}$, $\frac{35\text{ D}}{6}$, $\frac{38\text{ N}}{9}$.

Five fathoms Tow-net Gathering.

$\frac{89\text{ D}}{17}$.

Ten fathoms Tow-net Gatherings.

$\frac{41\text{ D}}{21}$, $\frac{42\text{ D}}{15}$, $\frac{45\text{ N}}{21}$, $\frac{50\text{ D}}{22}$, $\frac{51\text{ N}}{25}$, $\frac{54\text{ N}}{20}$, $\frac{55\text{ N}}{21}$, $\frac{64\text{ D}}{27}$, $\frac{65\text{ D}}{21}$, $\frac{67\text{ D}}{23}$,
$\frac{69\text{ D}}{19}$, $\frac{72\text{ D}}{36}$, $\frac{100\text{ D}}{19}$, $\frac{114\text{ D}}{32}$.

Fifteen fathoms Tow-net Gatherings.

$\frac{15\text{ N}}{15}$, $\frac{18\text{ D}}{11}$, $\frac{71\text{ N}}{39}$.

Twenty fathoms Tow-net Gatherings.

$\frac{47\text{ N}}{24}$, $\frac{52\text{ N}}{30}$, $\frac{53\text{ N}}{29}$, $\frac{56\text{ D}}{26}$, $\frac{66\text{ D}}{27}$, $\frac{68\text{ D}}{39}$, $\frac{70\text{ D}}{23}$, $\frac{90\text{ D}}{24}$, $\frac{101\text{ D}}{18}$, $\frac{109\text{ D}}{22}$,
$\frac{115\text{ D}}{28}$.

Twenty-five fathoms Tow-net Gatherings.

$\frac{1\text{ N}}{25}$, $\frac{5\text{ N}}{10}$, $\frac{6\text{ D}}{21}$, $\frac{10\text{ N}}{16}$, $\frac{17\text{ D}}{15}$, $\frac{20\text{ N}}{16}$, $\frac{23\text{ D}}{29}$, $\frac{25\text{ D}}{30}$, $\frac{29\text{ D}}{37}$.

Thirty fathoms Tow-net Gatherings.

$\frac{43\text{ D}}{27}$, $\frac{46\text{ N}}{36}$, $\frac{57\text{ D}}{45}$, $\frac{113\text{ D}}{35}$.

Thirty-five fathoms Tow-net Gathering.

$\frac{58\text{ D}}{33}$.

Fifty fathoms Tow-net Gatherings.

$\frac{2\text{ N}}{26}$, $\frac{4\text{ N}}{34}$, $\frac{7\text{ D}}{11}$, $\frac{11\text{ N}}{13}$, $\frac{21\text{ D}}{35}$, $\frac{26\text{ D}}{30}$, $\frac{30\text{ D}}{31}$, $\frac{44\text{ D}}{28}$.

Sixty fathoms Tow-net Gathering.

$\frac{59\text{ D}}{15}$.

Eighty-five fathoms Tow-net Gathering.

$$\frac{116\text{ D}}{14}.$$

One hundred fathoms Tow-net Gathering.

$$\frac{8\text{ D}}{27}.$$

One hundred and thirty-five fathoms Tow-net Gathering.

$$\frac{117\text{ D}}{24}.$$

One hundred and sixty fathoms Tow-net Gathering.

$$\frac{60\text{ D}}{20}.$$

One hundred and eighty-five fathoms Tow-net Gathering.

$$\frac{118\text{ D}}{31}.$$

Two hundred and thirty-five fathoms Tow-net Gathering.

$$\frac{119\text{ D}}{33}.$$

Two hundred and sixty fathoms Tow-net Gathering.

$$\frac{61\text{ D}}{26}.$$

Three hundred and sixty fathoms Tow-net Gathering.

$$\frac{62\text{ D}}{47}.$$

Four hundred and sixty fathoms Tow-net Gathering.

$$\frac{63\text{ D}}{28}.$$

The following separate Lists, representing about 16·6 per cent. of the entire number of the 'Buccaneer' tow-nettings, are given for the purpose of showing, among other details, the comparative differences in the general grouping of species in gatherings collected at the surface from others collected at various depths.

The richest hauls—that is, those containing the greatest number of species—were under-surface gatherings, and were, with few exceptions, from no very extreme depths. Several good catches were also obtained by working the tow-net at the surface during the night (see Table II.). The gathering that yielded the greatest number of species was No. 62 from 360 fathoms, collected during the middle of the day, on January 22nd, in lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E.; forty-seven species were obtained in this gathering. The collection that appeared to contain the greatest number of individuals was No. 113, from 30 fathoms, collected during the middle of the day, on February 5th, at Station 23.

List I.—Tow-net Gathering No. 3, surface, collected at Station 2, January 1st, 1886, between 6 and 8.15 p.m. The specific gravity of the water calculated at 60° F. was 1·0224, surface temperature of water 82°·2 F.

Euchæta marina (*Prestandrea*).
Temora stylifera (*Dana*).
Candace pachydactyla, *Dana*.
Labidocera detruncata, var. intermedia.
Pontellina plumata, *Dana*.
Oithona Challengeri, *Brady*.
Microsetella atlantica, *Brady & Robertson*.
Miracia efferata, *Dana*.
Clytemnestra rostrata (*Brady*).
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— pellucidus, *Dana*.
—— venustus, *Dana*.
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana*.
Saphirina ovalis, *Dana*.

List II.—This List gives the number of species obtained in Tow-net Gathering No. 4, from 50 fathoms, collected at Station 2 (lat. 7° 54′ N., long. 17° 25′ W.), January 1st, between 7.20 and 8.20 p.m.

Calanus valgus, *Brady*.
—— gracilis, *Dana*.
—— comptus, *Dana*.
Eucalanus attenuatus, *Dana*.
Hemicalanus longicornis, *Claus*.
—— plumosus, *Claus*.
Heterocalanus serricaudatus, n. sp.
Pleuromma abdominale (*Lubbock*).
Undina vulgaris, *Dana*.
Scolecithrix Danæ, *Lubbock*.
—— Bradyi, *Giesbrecht*.
—— securifrons, n. sp.
—— ctenopus, *Giesbrecht*.
—— tenuipes, n. sp.
Euchæta marina (*Prestandrea*).
—— hebes, *Giesbrecht*.
—— australis, *Brady*.
Euchæta barbata, *Brady*.
Ætidius armatus, *Brady*.
Clausocalanus arcuicornis (*Dana*).
Phyllopus bidentatus, *Brady*.
Candace pectinata, *Brady*.
—— pachydactyla, *Dana*.
—— intermedia, n. sp.
Acartia laxa, *Dana*.
Oithona Challengeri, *Brady*.
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
Oncæa obtusa (*Dana*).
—— gracilis (*Dana*).
Saphirina metallina, *Dana*.
*Saphirinella stylifera (*Lubbock*).

List III.—Tow-net Gathering No. 8, 100 fathoms, collected at Station 3, January 2nd, between 9 a.m. and 5.30 p.m. Specific gravity of the water at 100 fathoms 1·02608, temperature 56°·4 F.

Calanus propinquus, *Brady*.
Eucalanus attenuatus, *Dana*.
Rhincalanus cornutus, *Dana*.
Hemicalanus longicornis, *Claus*.
Augaptilis longicaudatus (*Claus*).
Calocalanus pavo (*Dana*).
Heterochæta spinifrons, *Claus*.
Leuckartia flavicornis, *Claus*.
Scolecithrix Danæ (*Lubbock*).
—— minor, *Brady*.
Euchæta marina (*Prestandrea*).
Ætidius armatus, *Brady*.
Temora stylifera (*Dana*).
Acartia laxa, *Dana*.
Phaënna spinifera, *Claus*.
Oithona Challengeri, *Brady*.

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* *Saphirinella* is now known to be the male form of *Copilia*, of which there are several species.

Miracia efferata, *Dana*.
Machairopus (?) idyoides, *Brady*.
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
Oncæa obtusa (*Dana*).
Oncæa gracilis (*Dana*).
Copilia mirabilis, *Dana*.
Lubbockia squillimana, *Claus*.
Saphirina metallina, *Dana*.
Saphirinella stylifera (*Lubbock*).

List IV.—Tow-net Gathering No. 14, surface, lat. 5° 58′ N., long. 14° 20′ W., January 5th. Collected in the evening after darkness set in.

Calanus valgus, *Brady*.
—— propinquus, *Brady*.
Eucalanus attenuatus, *Dana*.
Rhincalanus cornutus, *Dana*.
Leuckartia flavicornis, *Claus*.
Undina vulgaris, *Dana*.
Euchirella messinensis (*Claus*).
Scolecithrix Danæ (*Lubbock*).
Euchæta marina (*Prestandrea*).
Candace pachydactyla, *Dana*.
Pontellopsis villosa, *Brady*.
Pontellina plumata, *Dana*.
Labidocera detruncata, var. intermedia, n. var.
Oithona setigera, *Dana*.
Miracia efferata, *Dana*.
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— pellucidus, *Dana*.
Oncæa obtusa, *Dana*.
Copilia mirabilis, *Dana*.
Saphirina ovalis, *Dana*.
Saphirinella stylifera (*Lubbock*).

List V.—Tow-net Gathering No. 21, 50 fathoms, Station 9 (lat. 3° 0′ 8″ N., long. 7° 43′ W.), January 10th. Collected at noon. Temperature (corrected) of water at 50 fathoms 59°·59 F., sp. gr. 1·02632.

Eucalanus setiger, *Brady*.
—— attenuatus, *Dana*.
—— spinifer, n. sp.
Rhincalanus cornutus, *Dana*.
Hemicalanus longicornis, *Claus*.
Augaptilis longicaudatus (*Claus*).
Leuckartia flavicornis, *Claus*.
Scolecithrix Danæ (*Lubbock*).
—— Bradyi, *Giesbrecht*.
—— ctenopus, *Giesbrecht*.
—— tenuipes, n. sp.
Euchæta marina (*Prestandrea*).
—— Hessei, *Brady*, var. similis, n. var.
Candace pachydactyla, *Dana*.
—— intermedia, n. sp.
Acartia laxa, *Dana*.
Clausocalanus arcuicornis (*Dana*).
Temora stylifera (*Dana*).
Phaënna spinifera, *Claus*.
Pontellina plumata (*Dana*).
Oithona Challengeri, *Brady*.
Euterpe gracilis, var. armata, n. var.
Miracia efferata, *Dana*.
Clytemnestra rostrata (*Brady*).
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— pellucidus, *Dana*.
—— limbatus, *Brady*.
Oncæa obtusa, *Dana*.
—— gracilis, n. sp.
—— mediterranea (*Claus*).
Copilia mirabilis, *Dana*.
Saphirina metallina, *Dana*.
Saphirinella stylifera (*Lubbock*).

List VI.—Tow-net Gathering No. 29, 25 fathoms, lat. 3° 58′ N., long. 3° 42′ W., January 13th. Collected between 8 a.m. and 1 p.m. Temperature at 25 fathoms 67°·7 F., sp. gr. 1·02606.

Calanus valgus, *Brady*.
—— gracilis, *Dana*.
Paracalanus parvus (*Claus*).
Eucalanus setiger, *Brady*.
—— attenuatus, *Dana*.
—— spinifer, n. sp.
Rhincalanus cornutus, *Dana*.
Hemicalanus mucronatus, *Claus*.
Calocalanus pavo (*Dana*).
Heterochæta spinifrons, *Claus*.
Leuckartia flavicornis, *Claus*.
Undina vulgaris, *Dana*.
Scolecithrix Danæ (*Lubbock*).
—— ctenopus, *Giesbrecht*.
Euchæta marina (*Prestandrea*).
—— hebes, *Giesbrecht*.
Ætidius armatus, *Brady*.
Clausocalanus furcatus (*Brady*).
Centropages violaceus, *Claus*.
Mecynocera Clausi, *I. C. Thompson*.
Candace pachydactyla, *Dana*.
Acartia laxa, *Dana*.
Pontellina plumata (*Dana*).
Miracia efferata, *Dana*.
Clytemnestra rostrata (*Brady*).
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— pellucidus, *Dana*.
—— venustus, *Dana*.
Oncæa obtusa, *Dana*.
Copilia mirabilis, *Dana*.
Saphirina opaca, *Lubbock*.
—— splendens, *Dana*.
—— metallina, *Dana*.
Saphirinella stylifera (*Lubbock*).
Clausocalanus arcuicornis (*Dana*).

List VII.—Tow-net Gathering No. 46, 30 fathoms, lat. 3° 22′ 5″ N., long. 4° 11′ 8″ E., January 20th. Collected about 7 p.m.

Calanus valgus, *Brady*.
—— propinquus, *Brady*.
—— gracilis, *Dana*.
Eucalanus setiger, *Brady*.
—— attenuatus, *Dana*.
Rhincalanus cornutus, *Dana*.
Hemicalanus longicornis, *Claus*.
—— mucronatus, *Claus*.
Pleuromma abdominale (*Lubbock*).
Leuckartia flavicornis, *Claus*.
Undina vulgaris, *Dana*.
Euchirella messinensis (*Claus*).
Scolecithrix Danæ (*Lubbock*).
Euchæta marina (*Prestandrea*).
Ætidius armatus, *Brady*.
Temora stylifera (*Dana*).
Centropages furcatus (*Dana*).
Mecynocera Clausi, *I. C. Thompson*.
Candace pectinata, *Brady*.
Acartia laxa, *Dana*.
Oithona Challengeri, *Brady*.
—— setigera, *Dana*.
Microsetella atlantica, *Brady & Robertson*.
Clytemnestra rostrata (*Brady*).
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— limbatus, *Brady*.
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana*.
Lubbockia squillimana, *Claus*.
Saphirina ovalis, *Dana*.
—— opalina, *Dana*.
—— opaca, *Lubbock*.
—— metallina, *Dana*.
Saphirinella stylifera (*Lubbock*).

List VIII.—Tow-net Gathering No. 55, 10 fathoms, lat. 1° 55′ 5″ N., long 5° 55′ 5″ E., January 22nd. Collected during the middle of the day. Temperature (corrected) of the water 81°·98 F., surface sp. gr. 1·02358.

Paracalanus parvus (*Claus*).
Eucalanus attenuatus, *Dana*.
Euchæta marina (*Prestandrea*).
Clausocalanus furcatus (*Brady*).
Temora stylifera (*Dana*).
Centropages furcatus (*Dana*).
—— violaceus, *Claus*.
Candace pectinata, *Brady*.
Pontellina plumata (*Dana*).
Oithona Challengeri, *Brady*.
Miracia efferata, *Dana*.
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— pellucidus, *Dana*.
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana*.
Saphirina ovalis, *Dana*.
—— inæqualis, *Dana*.
—— opaca, *Lubbock*.
Saphirinella stylifera (*Lubbock*).

List IX.—Tow-net Gathering No. 57, 30 fathoms. Locality, date, and time of collection the same as List VIII. Temperature of the water 63°·98 F.

Calanus valgus, *Brady*.
—— propinquus, *Brady*.
—— gracilis, *Dana*.
Paracalanus parvus (*Claus*).
Eucalanus attenuatus, *Dana*.
Rhincalanus cornutus, *Dana*.
Hemicalanus longicornis, *Claus*.
Calocalanus pavo (*Dana*).
—— plumulosus (*Claus*).
Heterochæta spinifrons, *Claus*.
Leuckartia flavicornis, *Claus*.
Undina vulgaris, *Dana*.
Scolecithrix Danæ (*Lubbock*).
—— minor, *Brady*.
—— Bradyi, *Giesbrecht*.
—— ctenopus, *Giesbrecht*.
Euchæta marina (*Prestandrea*).
Ætidius armatus, *Brady*.
Clausocalanus furcatus (*Brady*).
—— arcuicornis (*Dana*).
Temora stylifera (*Dana*).
—— longicornis (*Müller*).
Mecynocera Clausi, *I. C. Thompson*.
Centropages furcatus (*Dana*).
Candace pachydactyla, *Dana*.
—— intermedea, n. sp.
—— truncata, *Dana*.
Acartia laxa, *Dana*.
Pontellina plumata, *Dana*.
Oithona Challengeri, *Brady*.
Microsetella atlantica, *Brady & Robertson*.
Miracia efferata, *Dana*.
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— pellucidus, *Dana*.
—— limbatus, *Brady*.
—— venustus, *Dana*.
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana*.
Lubbockia squillimana, *Claus*.
Saphirina ovalis, *Dana*.
—— metallina, *Dana*.
Saphirinella stylifera (*Lubbock*).

List X.—Tow-net Gathering No. 59, 60 fathoms. Locality, date, and time of collection the same as List VIII. Temperature of water 60°·25 F., sp. gr. 1·02629.

Eucalanus setiger, *Brady*.
Rhincalanus cornutus, *Dana*.
Pleuromma abdominale (*Lubbock*).
Heterochæta spinifrons, *Claus*.
Leuckartia flavicornis, *Claus*.
Euchæta hebes, *Giesbrecht*.

Candace pachydactyla, *Dana.*
Ætidius armatus, *Brady.*
Phaënna spinifer, *Claus.*
Oithona Challengeri, *Brady.*
Corycæus varius, *Dana.*
Corycæus speciosus, *Dana.*
Copilia mirabilis, *Dana.*
Saphirina metallina, *Dana.*
Saphirinella stylifera (*Lubbock*).

List XI.—Tow-net Gathering No. 60, 160 fathoms. Locality, date, and time of collection the same as List VIII. Temperature about 50° F.

Paracalanus parvus (*Claus*).
Undina vulgaris, *Dana.*
Euchæta marina (*Prestandrea*).
Temora stylifera (*Dana*).
Centropages violaceus, *Claus.*
Pontellina plumata, *Dana.*
Labidocera detruncata, var. intermedia.
Miracia efferata, *Dana.*
Setella gracilis, *Dana.*
Corycæus varius, *Dana.*
Corycæus speciosus, *Dana.*
—— pellucidus, *Dana.*
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana.*
Saphirina ovalis, *Dana.*
—— inæqualis, *Dana.*
—— opaca, *Lubbock.*
—— splendens, *Dana.*
Saphirinella stylifera (*Lubbock*).

List XII.—Tow-net Gathering No. 61, 260 fathoms. Locality, date, and time of collection the same as List VIII. Temperature of water about 46° F.

Calanus valgus, *Brady.*
—— gracilis, *Dana.*
Eucalanus attenuatus, *Dana.*
Rhincalanus cornutus, *Dana.*
Hemicalanus longicornis, *Claus.*
Pleuromma abdominalis (*Lubbock*).
Heterochæta spinifrons, *Claus.*
Leuckartia flavicornis, *Claus.*
Scolecithrix Danæ (*Lubbock*).
—— Bradyi, *Giesbrecht.*
Ætidius armatus, *Brady.*
Euchæta marina (*Prestandrea*).
Candace pectinata, *Brady.*
Candace pachydactyla, *Dana.*
Pontellina plumata, *Dana.*
Oithona Challengeri, *Brady.*
Miracia efferata, *Dana.*
Corycæus varius, *Dana.*
—— speciosus, *Dana.*
—— pellucidus, *Dana.*
—— limbatus, *Brady.*
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana.*
Saphirina serrata, *Brady.*
Saphirinella stylifera (*Lubbock*).
Saphirella abyssicola, nov. gen. et sp.

List XIII.—Tow-net Gathering No. 62, 360 fathoms. Locality, date, and time of collection the same as List VIII. Temperature of water about 43° F.

Calanus propinquus, *Brady.*
Paracalanus parvus (*Claus*).
Eucalanus attenuatus, *Dana.*
Rhincalanus cornutus, *Dana.*
Hemicalanus longicornis, *Claus.*
—— longicaudatus, *Claus.*
—— plumosus, *Claus.*
Augaptilis hecticus, *Giesbrecht.*
Calocalanus pavo (*Dana*).
Pleuromma abdominale (*Lubbock*).
—— princeps, n. sp.
Leuckartia flavicornis, *Claus.*
Undina vulgaris, *Dana.*
Scolecithrix Danæ (*Lubbock*).
—— longicornis, n. sp.
—— Bradyi, *Giesbrecht.*

Scolecithrix tenuipes, n. sp.
Amallophora dubia, nov. gen. et sp.
Euchæta marina (*Prestandrea*).
—— barbata, *Brady*.
Ætidius armatus, *Brady*.
—— armiger, *Giesbrecht*.
Clausocalanus arcuicornis (*Dana*).
Phyllopus bidentatus, *Brady*.
Temora stylifera (*Dana*).
Candace truncata, *Dana*.
Acartia laxa, *Dana*.
Mormonilla phasma, *Giesbrecht*.
Phaënna spinifera, *Claus*.
Pontellina plumata, *Dana*.
Oithona Challengeri, *Brady*.
—— setiger, *Dana*.
Miracia efferata, *Dana*.
Setella gracilis, *Dana*.
Ægisthus longirostris, n. sp.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— pellucidus, *Dana*.
—— limbatus, *Brady*.
—— obtusus, *Dana*.
Oncæa obtusa (*Dana*).
—— gracilis (*Dana*).
Copilia mirabilis, *Dana*.
Lubbockia squillimana, *Claus*.
Saphirina inæqualis, *Dana*.
—— metallina, *Dana*.
Saphirinella stylifera (*Lubbock*).

List XIV.—Tow-net Gathering No. 63, 460 fathoms. Locality, date, and time of collection the same as List VIII.

Calanus propinquus, *Brady*.
—— gracilis, *Dana*.
Paracalanus parvus (*Claus*).
Eucalanus attenuatus, *Dana*.
Rhincalanus cornutus, *Dana*.
Hemicalanus longicornis, *Claus*.
Pleuromma abdominale (*Lubbock*).
Heterochæta spinifrons, *Claus*.
Leuckartia flavicornis, *Claus*.
Undina vulgaris, *Dana*.
Euchirella messinensis (*Claus*).
Amallophora dubia, nov. gen. et sp.
—— magna, n. sp.
Euchæta marina (*Prestandrea*).
Euchæta Hessei, var. similis, n. var.
Ætidius armiger, *Giesbrecht*.
Temora longicornis (*Müller*).
Candace varicans, *Giesbrecht*.
Oithona Challengeri, *Brady*.
Microsetella atlantica, *Brady & Robertson*.
Longipedia minor, *T. & A. Scott*.
Clytemnestra rostrata, *Brady*.
Setella gracilis. *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— venustus, *Dana*.
Oncæa obtusa (*Dana*).
(?) Saphirina nigromaculata, *Claus*.

List XV.—Tow-net Gathering No. 68, 20 fathoms. Off São Thomé Island (lat. 3° 34′ N., long. 6° 30′ 4″ E.). Collected after midday, January 23rd.

Calanus valgus, *Brady*.
—— propinquus, *Brady*.
—— gracilis, *Dana*.
Eucalanus attenuatus, *Dana*.
Rhincalanus cornutus, *Dana*.
Hemicalanus longicornis, *Claus*.
—— mucronatus, *Claus*.
Augaptilis hecticus, *Giesbrecht*.
—— Rattrayi, n. sp.
Pleuromma abdominale (*Lubbock*).
Heterochæta spinifrons, *Claus*.
Leuckartia flavicornis, *Claus*.
Undina vulgaris, *Dana*.
Scolecithrix Danæ (*Lubbock*).
—— Bradyi, *Giesbrecht*.
—— ctenopus, *Giesbrecht*.
Euchæta marina (*Prestandrea*).
—— ?, sp.
Ætidius armatus.
Clausocalanus arcuicornis (*Dana*).
Temora stylifera (*Dana*).
Mecynocera Clausi, *I. C. Thompson*.

Candace pectinata, *Brady.*
—— pachydactyla, *Dana.*
—— truncata, *Dana.*
Pontellina plumata, *Dana.*
Stenhelia accraensis.
Setella gracilis, *Dana.*
Corycæus varius, *Dana.*
—— speciosus, *Dana.*
—— pellucidus, *Dana.*
Corycæus limbatus, *Brady.*
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana.*
Lubbockia squillimana, *Claus.*
Saphirina ovalis, *Dana.*
—— opaca, *Lubbock.*
—— metallina, *Dana.*
Saphirinella stylifera (*Lubbock*).

List XVI.—Tow-net Gathering No. 71, 15 fathoms, lat. 0° 28′ 7″ N., long. 6° 35′ 2″ E. Collected about 6 p.m., January 23rd.

Calanus valgus, *Brady.*
—— propinquus, *Dana.*
—— gracilis, *Dana.*
Paracalanus parvus (*Claus*).
Eucalanus attenuatus, *Dana.*
Rhincalanus cornutus, *Dana.*
Hemicalanus longicornis, *Claus.*
Heterochæta spinifrons, *Claus.*
Undina vulgaris, *Dana.*
Scolecithrix Danæ (*Lubbock*).
—— Bradyi, *Giesbrecht.*
Euchæta marina (*Prestandrea*).
—— hebes, *Giesbrecht.*
Clausocalanus furcatus (*Brady*).
Temora stylifera (*Dana*).
—— longicornis, *Müller.*
Centropages violaceus (*Claus*).
Candace pachydactyla, *Dana.*
—— intermedia, n. sp.
Acartia laxa, *Dana.*
Pontellina plumata, *Dana.*
Oithona Challengeri, *Brady.*
Microsetella atlantica, *Brady & Robertson.*
Miracia efferata, *Dana.*
Clytemnestra rostrata (*Brady*).
Setella gracilis, *Dana.*
Corycæus varius, *Dana.*
—— speciosus, *Dana.*
—— pellucidus, *Dana.*
—— limbatus, *Brady.*
—— venustus, *Dana.*
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana.*
Lubbockia squillimana, *Claus.*
Saphirina inæqualis, *Dana.*
—— opalina, *Dana.*
—— opaca, *Lubbock.*
—— splendens, *Dana.*
Saphirinella stylifera (*Lubbock*).

List XVII.—Tow-net Gathering No. 82, surface, lat. 0° 22′ 8″ N., long. 8° 33′ 2″ E. Collected about midnight, January 28th. Sp. gr. of the water 1·02237.

Calanus valgus, *Brady.*
Paracalanus parvus (*Claus*).
Eucalanus attenuatus, *Dana.*
Rhincalanus cornutus, *Dana.*
Leuckartia flavicornis, *Claus.*
Undina vulgaris, *Dana.*
Euchæta marina (*Prestandrea*).
Temora stylifera (*Dana*).
—— longicornis, *Müller.*
Centropages furcatus (*Dana*).
Candace pectinata, *Brady.*
—— intermedia, n. sp.
Pontellina plumata, *Dana.*
Oithona Challengeri, *Brady.*
Microsetella atlantica, *Brady & Robertson.*
Euterpe gracilis, var. armata, n. var.
Clytemnestra rostrata (*Brady*).
Setella gracilis, *Dana.*
Corycæus varius, *Dana.*
—— speciosus, *Dana.*
—— pellucidus, *Dana.*
—— obtusus, *Dana.*
Oncæa obtusa (*Dana*).
Saphirina ovalis, *Dana.*
—— inæqualis, *Dana.*

List XVIII.—Tow-net Gathering No. 91, shore (low tide), São Thomé Island. Collected during the day, January 31st

Laophonte pygmæa, n. sp.
—— longipes, n. sp.
Machairopus idyoides, *Brady*.

List XIX.—Tow-net Gathering No. 92, surface, lat. 0° 7′ 6″ N., long. 6° 59′ 2″ E. Collected February 2nd, shortly after midday.

Calanus valgus, *Brady*.
Temora stylifera (*Dana*).
Pontellina plumata, *Dana*.
Oithona Challengeri, *Brady*.
Microsetella atlantica, *B. & R.*
Miracia efferata, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— pellucidus, *Dana*.
—— venustus, *Dana*.
—— obtusus, *Dana*.
Oncæa obtusa (*Dana*).

List XX.—Tow-net Gathering No. 97, surface, lat. 0° 45′ 8″ S., long. 7° 37′ 4″ E. Collected February 3rd, shortly after midnight.

Calanus valgus, *Brady*.
Rhincalanus cornutus, *Dana*.
Leuckartia flavicornis, *Claus*.
Undina vulgaris, *Dana*.
Scolecithrix Bradyi, *Giesbrecht*.
Euchæta hebes, *Giesbrecht*.
Temora stylifera (*Dana*).
—— longicornis (*Müller*).
Candace intermedia, n. sp.
Labidocera acutifrons (*Dana*).
Pontellina plumata, *Dana*.
Oithona Challengeri, *Brady*.
Euterpe gracilis, var. armata, n. var.
Microsetella atlantica, *Brady & Robertson*.
Miracia efferata, *Dana*.
Clytæmnestra rostrata (*Brady*).
Setella gracilis, *Dana*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— pellucidus, *Dana*.
—— limbatus, *Brady*.
—— venustus, *Dana*.
Oncæa obtusa (*Dana*).
Lubbockia squillimana, *Claus*.
Saphirina inæqualis, *Dana*.
—— serrata, *Brady*.

List XXI.—Tow-net Gathering No. 113, 30 fathoms, Station 23 (lat. 4° 26′ 7″ S., long. 10° 1′ 8″ E.). Collected between 11 A.M. and 3 P.M., February 5th. Temperature 82°·1 F., sp. gr. at noon 1·02347. This gathering contained a greater number of individual specimens, though not of species, than any other in the collection.

Calanus propinquus, *Brady*.
—— gracilis, *Dana*.
—— tonsus, *Brady*.
Eucalanus setiger, *Brady*.
—— attenuatus, *Dana*.
Rhincalanus cornutus, *Dana*.
Hemicalanus longicornis, *Claus*.
—— mucronatus, *Claus*.
Heterochæta spinifrons, *Claus*.
Undina vulgaris, *Dana*.
Euchirella messinensis (*Claus*).
Scolecithrix Danæ (*Lubbock*).
Euchæta marina (*Prestandrea*).
—— barbata, *Brady*.
Candace pectinata, *Brady*.
—— pachydactyla, *Dana*.
—— intermedia, n. sp.
—— truncata, *Dana*.
Acartia laxa, *Dana*.
Phaënna spinifera, *Claus*.

Labidocera acutifrons (*Dana*).
Pontella securifera, *Brady*.
Oithona Challengeri, *Brady*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
Oncæa obtusa (*Dana*).
—— gracilis (*Dana*).
Copilia mirabilis, *Dana*.
Copilia quadrata, *Dana*.
—— Rattrayi, n. sp.
Lubbockia squillimana, *Claus*.
Saphirina inæqualis, *Dana*.
—— serrata, *Brady*.
—— splendens, *Dana*.
—— metallina, *Dana*.
Saphirinella stylifera (*Lubbock*).

List XXII.—Tow-net Gathering No. 119, 235 fathoms, Station 23. Date and hour of collection the same as last. At 200 fathoms the temperature was 55° F., sp. gr. 1·02648.

Calanus valgus, *Brady*.
—— propinquus, *Brady*.
—— gracilis, *Dana*.
Eucalanus attenuatus, *Dana*.
—— spinifer, n. sp.
Rhincalanus cornutus, *Dana*.
Hemicalanus longicornis (*Claus*).
—— plumosus, *Claus*.
Pleuromma abdominale (*Lubbock*).
Heterochæta spinifrons, *Claus*.
Leuckartia flavicornis, *Claus*.
Scolecithrix minor, *Brady*.
Euchæta marina (*Prestandrea*).
Ætidius armatus, *Brady*.
Mecynocera Clausi, *I. C. Thompson*.
Acartia laxa, *Dana*.
Mormonilla phasma, *Giesbrecht*.
Euterpe gracilis, var. armata, n. var.
Microsetella atlantica, *Brady & Robertson*.
Miracia efferata, *Dana*.
Clytemnestra rostrata (*Brady*).
Setella gracilis, *Dana*.
Ægisthus longirostris, n. sp.
Oncæa obtusa (*Dana*).
—— gracilis (*Dana*).
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
Copilia mirabilis, *Dana*.
Lubbockia squillimana, *Claus*.
Saphirina splendens, *Dana*.
—— metallina, *Dana*.
Saphirinella stylifera (*Lubbock*).
Artotrogus abyssicolus, n. sp.

List XXIII.—Tow-net Gathering No. 133, surface, lat. 6° 29′ 4″ S., long. 11° 24′ 8″ E. Collected at 7.30 P.M., February 8th. Sp. gr. at 8 P.M. 1·02398.

Paracalanus parvus (*Claus*).
Pleuromma abdominale (*Lubbock*).
Leuckartia flavicornis, *Claus*.
Undina vulgaris, *Dana*.
Scolecithrix Danæ (*Lubbock*).
Temora dubia (*Lubbock*).
—— longicornis (*Müller*).
Centropages brachiatus, *Dana*.
—— furcatus, *Dana*.
Candace pachydactyla, *Dana*.
—— intermedia, n. sp.
Pontellopsis villosa, *Brady*.
Pontella securifer, *Brady*.
—— inermis, *Brady*.
Oithona setigera, *Dana*.
Microsetella atlantica, *Brady & Robertson*.
Corycæus varius, *Dana*.
—— speciosus, *Dana*.
—— obtusus, *Dana*.
Oncæa obtusa (*Dana*).
Lubbockia squillimana, *Claus*.

List XXIV.—Tow-net Gathering No. 137, surface, lat. 7° 38′ S., long. 12° 3′ 3″ E. Collected at 5 A.M., February 9th. Sp. gr. at 4 A.M. 1·02623.

Calanus valgus, *Brady*.
—— propinquus, *Brady*.
Paracalanus parvus (*Claus*).
Eucalanus attenuatus, *Dana*.
Rhincalanus cornutus, *Dana*.
Undina vulgaris, *Dana*.
Scolecithrix Danæ (*Lubbock*).
Euchæta marina (*Prestandrea*).
Temora dubia (*Lubbock*).
—— longicornis (*Müller*).
Candace pectinata, *Brady*.
Acartia laxa, *Dana*.
Pontellopsis villosa, *Brady*.
Labidocera acutifrons (*Dana*).
Pontella securifer, *Brady*.
—— inermis, *Brady*.
Oithona plumifera, *Dana*.
Corycæus speciosus, *Dana*.
—— pellucidus, *Dana*.
—— limbatus, *Brady*.
Oncæa obtusa (*Dana*).
Copilia mirabilis, *Dana*.
Lubbockia squillimana, *Claus*.
Saphirina inæqualis, *Dana*.
—— opalina, *Dana*.
—— splendens, *Dana*.
Saphirinella stylifera (*Lubbock*).

List XXV.—Tow-net Gatherings Nos. 141, 142, 143, 144, and 145, surface, Loanda Harbour. Collected during the afternoon, February 13th and 15th. Surface-temperature at noon on the 13th was 78°·2 F.; at noon on the 15th the surface-temperature of the seaward part of the Harbour, where all the tow-net gatherings, except No. 141, were collected, was 79°·2 F. Few species were observed in any of the Loanda Harbour gatherings.

Eucalanus attenuatus, *Dana*.
Temora longicornis (*Müller*).
Centropages brachiatus, *Dana*.
—— furcatus, *Dana*.
Acartia plumosa, n. sp.
Paracartia dubia, n. g. et sp.
—— spinicaudata, n. g. et sp.
Oithona setigera, *Dana*.
—— minuta, n. sp.
Longipedia minor, *T. & A. Scott*.
Euterpe gracilis, var. armata, n. var.
Corycæus obtusus (*Dana*).
Hersiliodes Livingstoni, n. sp.
Lichomolgus propinquus, n. sp.

COPEPODA.

INDEX TO GENERA AND SPECIES.

Section I. *GNATHOSTOMA*, Thorell.

Family CALANIDÆ.

Genus CALANUS, Leach.

1819. *Calanus*, Leach, Dict. Nat. Sci. vol. xiv. Art. Entomostraca.

CALANUS VALGUS, Brady.

1883. *Calanus valgus*, Brady, 'Challenger' Copepoda, p. 33, pl. iii. figs. 1–7.

Habitat. Station 2 (lat. 7° 54′ N., long. 17° 25′ W.), in 5 and 25 fathoms, tow-nettings, January 1st (night collection). Lat. 3° 58′ N., long. 3° 42′ W., in 25 and 50 fathoms, tow-nettings, January 13th (day collections). Bananah Creek, Mouth of the Congo, surface tow-netting (day collection). Lat. 7° 51′ 6″·8, long. 11° 14′ 7″ E., surface tow-netting (night collection), &c.

This species was obtained in 55 tow-nettings, 24 of which were surface nettings and 31 under-surface nettings: 5 of the surface and 22 of the under-surface nettings were day collections, while 19 surface and 11 under-surface nettings were night collections, as shown in the annexed formula:—

$$\text{Tow-nettings } 55\begin{cases} 24 \text{ surface} & \begin{cases} 5 \text{ day collections.} \\ 19 \text{ night ditto.} \end{cases} \\ 31 \text{ under-surface} & \begin{cases} 22 \text{ day ditto.} \\ 11 \text{ night ditto.} \end{cases} \end{cases}$$

The under-surface tow-nettings ranged from 5 to 260 fathoms. *Calanus valgus* was taken in the open sea, where the specific gravity of the water was 1·02620, and the temperature 82·2 F., and at Bananah Creek, where the sp. gr. of the water was 1·00870 and the temperature 82° F. It was also captured at a depth of 260 fathoms (as recorded above), where the temperature of the water was about 46° F. This species is thus apparently able to exist under very varied conditions, as regards the density and temperature of the water. It also appeared to be generally distributed throughout the area examined, but was more plentiful near, and south of, the Equator. The flexed position of the right fifth foot of the male, referred to by Dr. Brady in his Report on the 'Challenger' Copepoda, was also observed in many of 'Buccaneer' specimens.

CALANUS PROPINQUUS, Brady.

1883. *Calanus propinquus*, Brady, op. cit. p. 34, pl. ii. figs. 1–7, pl. xiv. figs. 10, 11.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms, day collection, January 22nd. Station 23, surface and 235 fathoms, day collections, February 5th.

This species, though only satisfactorily identified in tow-nettings from the localities described, may have occurred in others. Usually I was unable to identify this *Calanus* with certainty, except by carefully dissecting the specimens; hence the probability of its being of more frequent occurrence in the collection than the few localities given for it would seem to indicate.

CALANUS TONSUS, Brady.

1883. *Calanus tonsus*, Brady, op. cit. p. 34, pl. iv. figs. 8, 9.

Habitat. In a tow-netting from Station 23, a surface gathering.

The large and tumid first abdominal segment seems to be a fairly good character of this species.

CALANUS GRACILIS, Dana.

1852. *Calanus gracilis*, Dana, Crust. U.S. Expl. Exped. p. 1078, pl. lxxiv. fig. 10.
1883. *Calanus gracilis*, Brady, op. cit. p. 35, pl. v. figs. 1–6, and pl. xlvi. fig. 1.

Habitat. Station 2, 5 fathoms, night tow-netting, January 1st. Station 3, 25 fathoms, January 2nd (day collection). Lat. 3° 22′ 5″ N., long. 4° 11′ 8″ E., 30 fathoms, January 20th (night collection). Station 21, surface, February 3rd (day collection). Station 23, surface and 235 fathoms (the first a day, the other a night collection).

Calanus gracilis was obtained in 19 tow-nettings—4 of these were surface gatherings and 15 were under-surface gatherings. 2 of the surface and 12 of the under-surface tow-nettings were day collections, while 2 of the surface and 4 of the under-surface were night collections, as in the formula :—

$$\text{Tow-nettings 19}\begin{cases}\text{4 surface} & \begin{cases}\text{2 day collections.}\\ \text{2 night ditto.}\end{cases}\\ \text{15 under-surface} & \begin{cases}\text{12 day ditto.}\\ \text{4 night ditto.}\end{cases}\end{cases}$$

The under-surface tow-nettings ranged from 5 to 460 fathoms. Though frequent in a few of the gatherings in which it occurred, *Calanus gracilis* was not a common species, but was, nevertheless, widely though sparingly distributed throughout the greater part of the area examined. The specimens obtained were mostly females, and were readily distinguished from the other species of *Calanus* by the long anterior antennæ and the peculiar terminal spine of the first swimming-feet.

? CALANUS COMPTUS, Dana. (Pl. V. figs. 46–50; Pl. VI. figs. 1–5.)

1853. *Calanus comptus,* Dana, Crust. U.S. Expl. Exped. p. 1050, pl. lxxii. fig. 2 *a.*

Male. Length, exclusive of tail-setæ, 3·3 mm. Body composed of six segments, the first as long as the entire length of the other five. Anterior antennæ scarcely longer than the cephalothorax, 23-jointed, and very sparingly setiferous; the proportional lengths of the joints are nearly as in the formula:—

$$\frac{36 . 6 . 6 . 7 . 8 . 8 . 7 . 8 . 11 . 12 . 13 . 17 . 18 . 20 . 20 . 21 . 22 . 22 . 18 . 19 . 18 . 19 . 16}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21 \quad 22 \quad 23}.$$

Posterior antennæ and mouth-organs nearly as in *Calanus finmarchicus.* The first four pairs of swimming-feet closely resemble those of *Cal. gracilis,* Dana, the peculiar terminal spine of the outer branches of the first pair in both species being almost identical. The fifth pair also resemble those of that species, as figured in the 'Challenger' Copepoda, except that the small secondary branch is 3-jointed. Abdomen short, 5-jointed, the second segment rather longer than any of the others. Caudal stylets short.

Habitat. Lat. 6° 34′ N., long. 12° 39′ W., surface collection. One or two specimens only were obtained.

This *Calanus* so closely resembles *Calanus gracilis* in many respects that I am inclined to consider it as simply a variety of that species.

Genus PARACALANUS, Boeck (1864).

PARACALANUS PARVUS (Claus). (Pl. I. figs. 9–14.)

1863. *Calanus parvus,* Claus, Die freilebenden Copepoden, p. 173, t. xxvi. figs. 10–14, t. xxvii. figs. 1–4.
1864. *Paracalanus parvus,* Boeck, Oversigt Norges Copepoder, p. 232.

Length 1·12 mm. Cephalothorax elongate-ovate, rounded in front and behind. Anterior antennæ reaching to the end of the caudal stylets, 24-jointed; the proportional lengths of the joints are as follow (antennæ the same in both sexes):—

$$\frac{35 . 25 . 12 . 12 . 10 . 10 . 12 . 13 . 10 . 10 . 10 . 13 . 12 . 13 . 15 . 15 . 15 . 15 . 15 . 15 . 13 . 14 . 15 . 27}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21 \quad 22 \quad 23 \quad 24}.$$

Posterior antennæ and mouth-organs as in *Calanus.* The inner branch of the first pair of swimming-feet 2-jointed, about as long as the first two joints of the outer branch; the basal joint of the peduncle bears a stout plumose seta near the inner distal angle. The basal joints of both branches of the fourth pair are small, the second and third joints of the inner branch and the second joint of the outer branch are furnished on the side with an armature of spines as in the figure (fig. 11), and the outer margin of the last joint of the outer branch is distinctly dentate from the base to the first marginal spine. All the first four pairs of swimming-feet have the inner margins of both branches furnished with long plumose hairs. The fifth feet in the male are 1-branched—the right short, 3-jointed, and terminating in two short spines of unequal length; the left 5-jointed, apparently hinged between the first and second joints; length of the joints subequal, the last terminating in two small spines. Fifth pair of feet in the female 1-branched, 2-jointed, the last joint much narrower than the first and terminating in one long and one short spiniform setæ.

Habitat. Lat. 6° 34′ N., long. 12° 39′ W., surface, January 6th (day collection). Off Accra, 3 fathoms, January 15th (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10, 20, 30, 360, and 460 fathoms, January 22nd (day collection). Station 18, surface tow-netting, February 3rd (day collection). Station 24 (off the mouth of the Congo River), surface tow-netting, February 6th (day collection). Lat. 5° 9′ 8″ S., long. 11° 10′ 4″ E., surface tow-netting, February 19th (day collection), &c.

Paracalanus parvus occurred in 49 tow-nettings, 29 of which were surface and 20 under-surface gatherings. The under-surface tow-nettings ranged from 2½ to 460 fathoms. 11 of the surface and 16 of the under-surface tow-nettings were day collections, while 18 surface and 4 under-surface were night collections, as in the formula:—

$$\text{Tow-nettings } 49\begin{cases}29 \text{ surface} & \begin{cases}11 \text{ day collections.}\\ 18 \text{ night ditto.}\end{cases}\\ 20 \text{ under-surface} & \begin{cases}16 \text{ day ditto.}\\ 4 \text{ night ditto.}\end{cases}\end{cases}$$

This species was comparatively frequent in all the gatherings in which it was observed.

PARACALANUS PYGMÆUS (Claus). (Pl. I. figs. 1–8.)

1863. *Calanus pygmæus*, Claus, Die freilebenden Copepoden, p. 74.

Female. Length ·7 mm. (1–36th of an inch). Body robust, composed of four segments, the first being fully twice the entire length of the outer three; rostrum short, stout, prominent. Anterior antennæ reaching beyond the cephalothorax, 24-jointed, sparingly setiferous; setæ mostly small, except towards the extremity, where there are several moderately long hairs; the proportional lengths of the joints are as shown in the formula:—

$$\frac{30}{1}.\frac{6}{2}.\frac{5}{3}.\frac{5}{4}.\frac{5}{5}.\frac{5}{6}.\frac{5}{7}.\frac{5}{8}.\frac{6}{9}.\frac{7}{10}.\frac{8}{11}.\frac{8}{12}.\frac{8}{13}.\frac{8}{14}.\frac{8}{15}.\frac{7}{16}.\frac{8}{17}.\frac{11}{18}.\frac{8}{19}.\frac{12}{20}.\frac{11}{21}.\frac{12}{22}.\frac{10}{23}.\frac{15}{24}.$$

Posterior antennæ small, provided with moderately long setæ; the primary branch composed of two nearly equal joints; secondary branch fully half the length of the other; 7-jointed, the third, fourth, and fifth joints very short, the others longer and subequal. Mouth-organs as in *Paracalanus parvus.* The swimming-feet are also similar to those of that species, but differ in their armature, especially in having the second as well as the last joints of the outer branches of the second, third, and fourth pairs serrate on the outer margin, in the terminal spines being proportionally smaller, and in both branches of the fourth pair being more slender. The fifth pair resemble those of *Paracalanus parvus*, but are proportionally stouter and have much shorter terminal spines. Abdomen small, composed of four segments, the second and third segments very short. Caudal stylets nearly as long as the last abdominal segment, breadth about half the length; apical setæ four. No males were observed.

Habitat. Lat. 3° 57′ 2″ N., long. 7° 42′ 8″ W., 2 fathoms, January 9th (night collection). Libreville, Gaboon River, surface, January 28th (day collection). Bananah Creek, Congo River, surface, February 7th (day collection).

Comparatively few specimens of *Paracalanus pygmæus* were obtained.

Genus EUCALANUS, Dana.

Eucalanus and *Calanus* (in part), Dana, Crust. U.S. Expl. Exped. (1852).

EUCALANUS ATTENUATUS, Dana.

1852. *Calanus attenuatus*, Dana, loc. cit. p. 1080, pl. lxxv. fig. 2.
1856. *Calanus mirabilis*, Lubbock, Trans. Entom. Soc. vol. iv. pl. v. figs. 1–6.
1883. *Eucalanus attenuatus*, Brady, op. cit. p. 38, pl. ii. figs. 8–10, pl. vi. figs. 1–8.

Habitat. Station 2, 5, 25, and 50 fathoms tow-nettings, January 1st (night collections). Station 9, 25 and 50 fathoms tow-nettings, January 10th (day collections). Station 14, 10 fathoms tow-netting, January 21st (night collection). Lagoon Island, São Thomé, surface tow-netting, January 28th (night collection). Station 23, surface, 10, 20, 85, 135, 185, and 235 fathoms tow-nettings, February 5th (day collections). Bananah Creek, Congo River, surface tow-netting, February 7th (day collection). Loanda Harbour (seaward), surface, February 15th (day collection).

This was one of the more common and generally distributed species in the 'Buccaneer' collections. It occurred in 89 tow-nettings, 41 of these being surface and 48 under-surface gatherings. The under-surface tow-nettings ranged in depth from 2 to 460 fathoms. 18 of the surface and 35 of the under-surface gatherings were collected during the day, while 23 of the surface and 13 of the under-surface were collected during the night, as in the formula:—

$$\text{Tow-nettings } 89\begin{cases}41 \text{ surface} & \begin{cases}18 \text{ day collections.}\\ 23 \text{ night ditto.}\end{cases}\\ 48 \text{ under-surface} & \begin{cases}35 \text{ day ditto.}\\ 13 \text{ night ditto.}\end{cases}\end{cases}$$

Eucalanus attenuatus was taken at the surface in the open sea, the specific gravity of the water being 1·02543 and temperature 85°·5 F., and at 360 fathoms with the temperature of the water at about 43° F. It was taken off the mouth of the Congo River, where the specific gravity of the water was 1·01984 and the temperature 82° F. (the colour of the water here,—lat. 5° 54′ 3″ S., long. 11° 33′ E.,—was "brownish olive-green to amber-brown"), and at Bananah Creek, where the specific gravity was only 1·00870. It will be observed from these records that this *Eucalanus* is able to live in water of very varied character, as regards density and temperature. A species capable of existing under such a diversity of conditions might be expected to have a wide distribution, and such is the case with this *Eucalanus*. Dana has recorded it from the Pacific and China Seas. In the 'Challenger' Report it is recorded from the Malayan and Australasian Seas. Sir John Lubbock has recorded it from the Bay of Biscay * and Mr. I. C. Thompson from Madeira and the Canary Islands †. Prof. Claus records a *Calanella* from the Mediteranean, which Dr. Brady thinks is "in all probability identical with the present species."

EUCALANUS SPINIFER, n. sp. (Pl. I. figs. 15–23.)

Length 5·5 mm. Forehead triangular; rostrum as in *Eucalanus attenuatus*; postero-lateral angles produced and spiniform; anterior antennæ 22-jointed, reaching to the extremity of the caudal stylets, the proportional lengths of the joints are nearly as follows:—

40	11	11	12	12	13	20	18	20	25	29	27	29	29	29	26	29	27	24	23	13	10
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

The secondary branch of the posterior antennæ small, 7-jointed, the two basal and the terminal joints longer than the others, both branches furnished with numerous plumose hairs. The secondary branch of the mandible-palp 3-jointed, stouter and nearer the distal end of the large basal part than that of *E. attenuatus*; both branches furnished with a number of long hairs, those of the secondary branch being setiferous from the middle to near the extremity (fig. 17). Anterior and posterior foot-jaws as in *E. attenuatus*. The inner branches of first pair of swimming-feet 2-jointed, joints subequal; the following three pairs as in *Eucalanus attenuatus*. Fifth pair of feet in the male 1-branched, each branch 4-jointed, the last joint terminating in a long somewhat curved spine; on the inner margin and near the base of the spine springs a stout plumose hair, the length of which exceeds that of the terminal spine. Abdomen very short and 3-jointed, the basal joint as long as the other two together. Caudal stylets nearly as long as the last two abdominal segments, each stylet furnished with five plumose hairs, the inner one being about half the length of the other four, which are about equal.

Habitat. Station 9, 50 fathoms tow-netting, January 10th (day collection). Lat. 5° 10′ N., long. 3° 56′ 2″ W., inshore surface tow-netting, January 12th (night collection). Lat. 3° 58′ N., long. 3° 42′ W., 25 fathoms tow-netting, January 13th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35 fathoms tow-netting, January 22nd (day collection). Lat. 4° 26′ 7″ S., long. 10° 1′ 8″ E., 238 fathoms tow-netting, February 5th (day collection).

The tow-nettings from the localities described were the only gatherings in which this *Eucalanus* was observed, but, though its distribution was limited, a considerable number of specimens were obtained. Its chief and most apparent distinctive characters are the spiniform lateral angles of the last thoracic segment and the form of the male fifth feet. *Eucalanus spinifer* is also a larger and more robust species than *Eucalanus attenuatus*, which it closely resembles.

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* Trans. Entom. Soc. vol. iv. pt. 2, p. 10.

† Trans. Linn. Soc.

EUCALANUS SETIGER, Brady.

1883. *Eucalanus setiger,* Brady, op. cit. p. 39, pl. iii. figs. 8–15.

Habitat. Station 2, 50 fathoms, January 1st (night collection). Station 9, 50 fathoms, January 10th (day collection). Off Accra, surface and 3 fathoms tow-nettings, January 16th (day collection). Lat. 0° 45′ 8″ S., long. 7° 37′ 4″ E., surface tow-netting, February 2nd (night collection). Bananah Creek, Congo River, surface tow-netting, February 7th (day collection), &c.

Eucalanus setiger was observed in 32 tow-nettings, 15 of which were surface and 17 under-surface gatherings. The under-surface tow-nettings were from various depths, ranging from 3 to 60 fathoms. Of the surface gatherings 10 of them were day, and 5 (including 1 close inshore) were night collections. Of the under-surface gatherings, 11 were day and 6 were night collections, as in the formula:—

$$\text{Tow-nettings 32}\left\{\begin{array}{l}\text{15 surface}\left\{\begin{array}{l}\text{10 day collections.}\\ \text{5 night ditto.}\end{array}\right.\\ \text{17 under-surface}\left\{\begin{array}{l}\text{11 day ditto.}\\ \text{6 night ditto.}\end{array}\right.\end{array}\right.$$

By comparing this with other formulæ it will be observed that *Eucalanus setiger* occurred in a proportionally greater number of day surface tow-nettings than do the majority of the species recorded in this Report, the occurrence of which is frequent enough to admit of comparison. This difference may only be due to accidental causes; nevertheless it seems of sufficient interest to be worth noting, as possibly indicating less susceptibility to the influence of daylight or sunlight than those species which occur more frequently in night than in day surface collections.

Eucalanus setiger, like *Eucalanus attenuatus*, seems able to exist under very varied conditions as regards the density and temperature of the water: it was obtained in the open sea at Station 2 (50 fathoms), the density of the water being about 1·02620 and temperature (corrected) 56°·85 F.; at Station 23 (surface), density 1·02347 and temperature 82°·1 F.; and at Bananah Creek, where the density of the water was only 1·00870. This may readily be distinguished from the other *Eucalani* of this Report by its smaller size and by lateral setæ on the last two thoracic segments.

Genus RHINCALANUS, Dana (1852).

RHINCALANUS CORNUTUS, Dana.

1852. *Rhincalanus cornutus,* Dana, loc. cit. p. 1083, pl. lxxvii. figs. 2 *a–d*.
1883. *Rhincalanus cornutus,* Brady, op. cit. p. 41, pl. vii. figs. 1–10.

Habitat. Station 3, 100 fathoms tow-netting, January 2nd (day collection). Station 9, 25 and 50 fathoms tow-nettings, January 10th (day collection). Station 14, 10 and 20 fathoms, January 21st (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 55″ E., 30, 60, 260, 360, and 460 fathoms tow-nettings, January 22nd (day collections). Station 23, surface, and 10, 20, 85, 135, 185, and 235 fathoms tow-nettings, February 5th (day collections), &c.

This species was observed in 70 tow-nettings, 29 of these were surface and 41 under-surface gatherings. The under-surface comprised tow-nettings from various depths from 3 to 460 fathoms. 9 of the surface and 30 of the under-surface tow-nettings were collected during the day, while 20 surface and 11 under-surface were collected during the night, as shown by the formula:—

$$\text{Tow-nettings } 70 \begin{cases} 29 \text{ surface} & \begin{cases} 9 \text{ day collections.} \\ 20 \text{ night ditto.} \end{cases} \\ 41 \text{ under-surface} & \begin{cases} 30 \text{ day ditto.} \\ 11 \text{ night ditto.} \end{cases} \end{cases}$$

The superficial and bathymetrical distribution of *Rhincalanus cornutus* was co-extensive with the area examined, except that, unlike either *Eucalanus attenuatus* or *setiger*, it was not obtained in any gathering from Bananah Creek or Loanda Harbour, where the specific gravity approximates so closely to that of fresh water. I have not observed a single specimen among the large number that have passed through my hands that could be ascribed to *Rhincalanus gigas*, Brady.

Rhincalanus aculeatus, n. sp. (Pl. II. figs. 11–24.)

Length about 3·25 mm. (exclusive of tail-setæ, which were fully 1 mm. in length). Body ovate, attenuate towards the head. Forehead produced forward into a strongly spiniform rostrum. The postero-lateral angles of the last thoracic segment are produced backward into spine-like processes. The anterior antennæ long and slender, reaching to beyond the caudal stylets, 21-jointed; the proportional lengths of the joints are nearly as follows:—

$$\frac{170}{1}.\frac{42}{2}.\frac{17}{3}.\frac{18}{4}.\frac{14}{5}.\frac{14}{6}.\frac{10}{7}.\frac{9}{8}.\frac{9}{9}.\frac{12}{10}.\frac{13}{11}.\frac{45}{12}.\frac{54}{13}.\frac{59}{14}.\frac{72}{15}.\frac{85}{16}.\frac{82}{17}.\frac{82}{18}.\frac{80}{19}.\frac{80}{20}.\frac{30}{21}.$$

The anterior antennæ are sparingly setiferous. The secondary branch of the posterior antennæ about two-thirds the length of the primary branch, 6-jointed, the first joint fully half as long as the second, the third, fourth, and fifth small, the last as long as all the preceding three together; the end of the primary branch is furnished with four long plumose setæ and a small plain one; two plumose setæ spring from the end of the last joint of the secondary branch and one from each of the preceding four joints. Mandible stout, the distal end with four teeth, three of which are close together and one separated from the others by a deep and moderately wide sinus. I failed to observe a mandible-palp. The maxilla-palp furnished with three very long setæ, which are plumose from the middle. The anterior foot-jaws resemble those of *Hemicalanus* more closely than those of *Rhincalanus*. The posterior foot-jaw as in *Rhincalanus cornutus*, but differing in being furnished with three ciliated heart-like processes, two of which are on the under margin and near the end of the first segment and one on the upper margin of the second segment. Both branches of the first four pairs of swimming-feet 3-jointed, the second of the two basal joints of the first feet is produced on the inside so as to form a stout process to which the inner branch is attached. A stout curved spine springs from the end of the posterior margin of the second joint of the outer branch of the second pair of swimming-feet, which is fully half as long as the next joint. The end of the last joint of the outer branch of the first pair is furnished with a stout plumose spinous seta, while the outer branches of the next three pairs have each a terminal falciform spine ciliated on the inner margin and finely serrate on the outer margin. Fifth pair of feet 2-branched, inner branch 1-jointed, rudimentary, and bearing at its apex a long plumose seta; the outer branch 2-jointed; an extremely long slender seta springs from the outer edge near the proximal end of the second basal joint on both sides. The terminal joints of both of the outer branches bear several small spines on the outer margin and one on the inner margin. Abdomen short, 4-jointed; second and third joints smaller than the first, subequal. Caudal stylets fully as long as the last abdominal segment, and furnished with densely plumose dark-coloured setæ.

Habitat. Lat. 6° 38′ N., long. 12° 37′ W., 25 fathoms tow-netting, January 6th (day collection). One specimen only of this curious form was obtained.

Rhincalanus aculeatus differs somewhat from the generic characters of *Rhincalanus* as described by Prof. Brady in the number of joints of the anterior antennæ, the comparatively long terminal joint of the secondary branch of the posterior antennæ, and in the form of the mandible and maxilla, but agrees with the other characters; I have therefore included it in that genus.

Genus HEMICALANUS, Claus, 1863.

Hemicalanus, Claus, Die freilebenden Copepoden, 1863 (not *Hemicalanus* of Dana);
Brady, 'Challenger' Copepoda, 1883.

HEMICALANUS LONGICORNIS, Claus.

1863. *Hemicalanus longicornis*, Claus, loc. cit. p. 179, pl. xxix. fig. 1.
1883. *Hemicalanus longicornis*, Brady, op. cit. p. 44, pl. ix. figs. 1–5.

Habitat. Station 2, 25 and 50 fathoms, January 1st (night collection). Station 3, 100 fathoms (day collection). Station 9, 50 fathoms (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 30, 260, 360, and 460 fathoms (day collections). Station 23, surface, and 10, 20, 85, 135, 185, and 235 fathoms, January 5th (day collections).

Hemicalanus longicornis was obtained in 26 tow-nettings, but only one of these was from the surface, all the others were under-surface gatherings and ranged in depth from 5 to 460 fathoms. 21 of these tow-nettings (including the surface gathering) were day collections, while 5 were night collections, as shown in the formula:—

$$\text{Tow-nettings 26}\left\{\begin{array}{ll}\text{1 surface} & \text{1 day collection.}\\ \text{25 under-surface} & \left\{\begin{array}{l}\text{20 day collections.}\\ \text{5 night ditto.}\end{array}\right.\end{array}\right.$$

This *Hemicalanus* was of frequent occurrence in some of the tow-nettings. It was very common in a gathering from 35 fathoms, collected on the 22nd January in lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E.; in this gathering eighty-five perfect specimens, besides a number of others more or less damaged, were obtained.

HEMICALANUS PLUMOSUS, Claus. (Pl. II. fig. 6; Pl. VI. fig. 6.)

1863. *Hemicalanus plumosus*, Claus, Die freilebenden Copepoden, p. 178, pl. xxviii. fig. 12, pl. xxix. figs. 4–7.

Habitat. Station 2, 50 fathoms (night collection). Lat. 6° 38′ N., long. 12° 37′ W., 25 fathoms (day collection). Lat. 3° 55′ 3″ N., long. 4° 7′ 3″ E., 30 fathoms (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms (day collection). Station 23, 85 fathoms and 235 fathoms (day collections).

This appears to be a scarce species in the ‘Buccaneer collections; only a few specimens have been obtained. Claus (*loc. cit.*) gives a very full description and some very good figures of this *Hemicalanus*. *Hemicalanus plumosus* comes very near *Hemicalanus orientalis*, Brady, described in the ‘Report on the ‘Challenger’ Copepoda.’

HEMICALANUS MUCRONATUS, Claus.

1863. *Hemicalanus mucronatus*, Claus, loc. cit. p. 179, pl. xxix. fig. 2.

Length (exclusive of the tail-setæ) of the specimen figured 3·8 mm. (the length varies in different specimens). Body somewhat cylindrical. Head pyramidal, the apex mucronate—in some specimens spiniform, the postero-lateral angles of last thoracic segment rounded. Anterior antennæ, reaching to beyond the caudal stylets, 25-jointed. The proportional lengths of the joints are represented very nearly by the annexed formula:—

$$\frac{40 . 10 . 15 . 17 . 18 . 18 . 18 . 18 . 21 . 20 . 22 . 23 . 30 . 34 . 34 . 35 . 37 . 37 . 33 . 28 . 30 . 29 . 28 . 27 . 18}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21 \quad 22 \quad 23 \quad 24 \quad 25}.$$

Posterior antennæ similar to those of *H. plumosus*. The mouth-organs are also similar to those of that species, except that the anterior foot-jaws are weaker, the spines on the second and third joints of the same foot-jaws are shorter and more slender, and the terminal setæ of both anterior and posterior foot-jaws are not spiniferous or ciliated as in *Hemicalanus plumosus*. The swimming-feet are similar to those of *Hemicalanus plumosus*. Abdomen 4-jointed, first segment much larger than the others. Caudal stylets short, divergent, the terminal setæ densely plumose.

Habitat. (1) Station 2, 50 fathoms tow-netting, January 1st (night collection). (2) Lat. 3° 58′ N., long. 3° 42′ W., 25 fathoms tow-netting, January 13th (day collection). (3) Lat. 3° 22′ 5″ N., long. 4° 11′ 8″ E., 30 fathoms tow-netting, January 20th (night collection). (4) Station 14, 10 fathoms tow-netting, January 21st (night collection). (5) Lat. 6° 38′ N., long. 12° 37′ W., 25 fathoms tow-netting (day collection). (6) Lat. 1° 55′ 5″ E., 35 fathoms tow-netting, January 22nd (day collection). (7) Off São Thomé Island (lat. 0° 34′ N., long. 6° 30′ 4″ E.), 20 fathoms tow-netting, January 23rd (day collection). (8) Station 23, surface tow-netting, February 5th (day collection).

Several specimens of *H. mucronatus* were obtained; the size of the specimens varied to some extent, and the forehead was more spiniform in some specimens than in others. This species comes very near *Hemicalanus aculeatus*, Brady, in general form and in the structure of the appendages, but is much smaller than Brady's specimen. The length of the specimen described and figured in this Report, which was one of the largest of the 'Buccaneer' specimens, was, as already stated, 3·8 mm.; but *Hemicalanus aculeatus*, Brady, measured 5·75 mm. in length—that is, fully half as long again as the 'Buccaneer' specimen.

It is interesting to note that while six species of *Hemicalanus* (including four of Claus's Mediterranean species) have been obtained in the 'Buccaneer' collection, only three (including one of Claus's Mediterranean species) were observed in the collections of the 'Challenger' expedition, and further, that while *Hemicalani* were of frequent occurrence in the 'Buccaneer' tow-nettings, 85 perfect specimens, besides a number of others more or less damaged, were captured in a single tow-net gathering. The three species recorded in the 'Challenger' Report were represented in the collection "only by about half a dozen specimens in all." Such a remarkable difference in the distribution of the *Hemicalani* seems to indicate that their distribution is local, and that, with perhaps one or two exceptions, they prefer to frequent what is comparatively inshore water to mid-ocean. *Hemicalanus longicornis* appears to be more cosmopolitan than the other species and to have a more or less general distribution throughout tropical and subtropical seas. Yet, though this *Hemicalanus* has undoubtedly an extensive distribution, it is noteworthy that none of Dana's species can be satisfactorily ascribed to it. This might have been accounted for had it been a critical species, but the extremely long anterior antennæ of *Hemicalanus longicornis* at once distinguish it from all other *Calanidæ*.

Genus AUGAPTILIS, Giesbrecht (1889).

Hemicalanus, Claus (in part).

AUGAPTILIS LONGICAUDATUS (Claus). (Pl. I. figs. 24–26; Pl. II. fig. 5.)

1863. *Hemicalanus longicaudatus,* Claus, loc. cit. p. 179, pl. xxix. fig. 3.

1892. *Augaptilis longicornis,* Giesbrecht, Fauna und Flora des Golfes von Neapel (Copepoden), p. 414, pl. 27. fig. 31; pl. 28. figs. 2, 8, 19, 23, 31, 35, 38; pl. 39. figs. 37, 48.

Habitat. Station 3, 100 fathoms tow-netting, January 2nd (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms tow-netting (day collection).

This *Augaptilis* occurred only in the tow-nettings from the two localities described; it differs from other species of *Hemicalanus* in the great length of the secondary branch of the posterior antennæ, in the comparatively long caudal stylets, and particularly by the anterior and posterior foot-jaws being furnished with moderately long setæ, which possess each a double row of short filaments with round, flat, button-like tops. These filaments (or sense-organs?) somewhat resemble "drawing-tacks," *i. e.* small nails with round flat heads, used for fixing drawing-paper upon a drawing-board. There is a double row of these filaments on each seta, the filaments of each double row being usually opposite each other; there are about 147 of these filaments in the length of a millimetre. They impart to the setæ that are furnished with them a very marked and striking appearance. Prof. Claus considers them as forming an important and distinctive specific character, and refers to them in his description of the species in the following terms:—"Die Hakenborsten der oberen und untern Maxillarfüsse tragen zwei Reihen sehr zierlich geknöpfter Seitenspitzen." This form of filament appears to be peculiar to *Augaptilis longicaudatus*. Another species (*Augaptilis Rattrayi*) described in this Report possesses similar filaments, but the button-tops, instead of being round, are broadly crescent-shaped. Not more than about half a dozen specimens of *Augaptilis longicaudatus* were obtained in the 'Buccaneer' collections.

Augaptilis hecticus, Giesbrecht. (Pl. I. figs. 37–39, Pl. II. figs. 1–4, 38–42.)

1892. *Augaptilis hecticus,* Giesbrecht, op. cit. p. 414, pl. 27. fig. 30; pl. 28. figs. 5, 9, 16, 30, 33, 37; pl. 29. fig. 18; pl. 39. fig. 45.

1892. *Hemicalanus longisetosus,* Scott (MS. name).

Length, exclusive of tail-setæ, 2·46 mm.; cephalothorax elongate, slender, cylindrical, subtriangular in front, rounded behind; anterior antennæ, reaching beyond the extremity of the abdomen, 25-jointed; the right antenna of the male 18-jointed. The proportional lengths of the joints are nearly as follows:—

Male. 20 . 12 . 10 . 13 . 13 . 13 . 12 . 56 . 20 . 22 . 18 . 17 . 19 . 22 . 35 . 29 . 18 . 18.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25.
Female. 20 . 8 . 8 . 8 . 8 . 8 . 8 . 8 . 10 . 10 . 11 . 13 . 15 . 15 . 14 . 13 . 14 . 15 . 12 . 10 . 10 . 10 . 11 . 15 . 18.

In the male antennæ the eighth joint is rather longer than the united lengths of the preceding four joints, and there is a distinct hinge between the fourteenth and fifteenth joints; the fifteenth bears at the proximal end a slender hair-like appendage which extends forward beyond the extremity of the joint. A densely plumose seta springs from the lower terminal angle of the sixteenth joint, and from the upper angle a rather long non-plumose spinous seta; a second densely plumose seta, similar to that on the sixteenth, springs from the upper terminal angle of the seventeenth joint. The second and third last joints of the female anterior antennæ and the left male antenna are likewise furnished with one or two (?) plumose setæ similar to those of the male eighth antenna; the antennæ of both sexes are otherwise sparingly setiferous. The secondary branch of the posterior antennæ is fully half the length of the primary branch, 6(?)-jointed, both branches with long plumose hairs; mandible styliform, the extremity somewhat furcate, but one of the teeth nearly obsolete; other mouth-organs as in *Hemicalanus longicornis*. Five pairs of swimming-feet in both sexes, all of them 2-branched, with both branches 3-jointed; the terminal spine of the outer branch of the fourth pair has a row of minute tubercules along its exterior margin; the inner margin is ciliated. The middle joint of the outer branch of the right (?) fifth foot of the male bears a stout, slightly curved process on the upper part of the inner margin; the last joint bears a short terminal spine, immediately behind which, on the inner margin, is a moderately long plumose hair; the last joint of the outer branch of the left foot bears a long curved terminal spine, finely serrate on its inner edge; both the inner margins are furnished with several long plumose hairs which extend beyond the terminal spine of the outer branch of the left foot. Abdomen in the male 5-jointed, in the female 4-jointed; the length of the segments in both are subequal. Caudal stylets in the male about as long as the last two abdominal segments, and in the female about the length of the last segment of the abdomen. Each stylet is furnished with one extremely long seta, which is longer than the cephalothorax and abdomen together; each seta bears a dense mass of fine hairs, near, but not quite at, its extremity; the extreme end appears to be free from hairs; there are also three short and densely plumose setæ on the exterior margin of the stylets, one near the middle and two near the extremity of each stylet.

Habitat. (1) Lat. 3° 58′ N., long. 3° 42′ W., 25 fathoms tow-netting January, 13th (day collection). (2) Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms tow-netting, January 22nd (day collection, temperature of the water about 43° F.). (3) Off São Thomé Island (lat. 0° 34′ N., long. 6° 30′ 4″ E.), 24 fathoms tow-netting, January 23rd (day collection).

Only two or three specimens of this interesting form were obtained. The extremely long tail-setæ, with the remarkable accumulation of fine hairs near their extremity, distinguish this *Augaptilis* at once from the other species described in this Report.

AUGAPTILIS RATTRAYI, n. sp. (Pl. II. figs. 25–37.)

Length, exclusive of tail-setæ, 1·9 mm. Cephalothorax robust, seen from above broadly ovate, measuring in breadth 2·6 mm., rounded in front, the postero-lateral angles of the last thoracic segment also rounded. Thoracic segments five, the first as long as all the other four together. Every part of the integument—cephalothorax, abdomen, and appendages—is covered more or less with minute spinous hairs. Anterior antennæ short, not much longer than the first thoracic segment, 24-jointed. The proportional lengths of the joints are nearly as follows:—

60 .	25 .	20 .	20 .	20 .	20 .	22 .	35 .	35 .	32 .	43 .	50 .	53 .	49 .	52 .	54 .	60 .	56 .	47 .	49 .	40 .	42 .	45 .	36
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24.

The antennæ are sparingly setiferous, the setæ on the second, eighteenth, and twentieth joints being the longest. The posterior antennæ have the basal part stout, the primary and secondary branches short, the secondary branch being shorter and more slender than the other and 7-jointed; the last joint is rather longer than all the preceding four together, and furnished at the extremity with three long setæ, which are plumose from the middle. The end of the primary branch is also furnished with a number of hairs similar to those of the secondary branch. The mandibles are slender and terminate in two moderately long teeth, between which is another minute and rudimentary one; the mandible-palp is stout, 2-branched, one of the branches 2-, the other 4-jointed; both branches bear several plumose hairs. The "rod-like process" of the maxillæ terminates in three very long plumose hairs. Two hairs, bearing each a double row of peculiar short filaments having flat broadly crescent-shaped tops, which extend from near the distal end to about the middle of the hairs, spring from the extremity of a stout lateral appendage of the maxillæ. Anterior foot-jaws stout, 5-jointed, the first two with several stout spinous hairs on the anterior margin, the last three with a number of long setæ having a double row of short filaments, with flat, broadly crescent-shaped tops, each double row not extending below the middle of the seta. The posterior foot-jaw 6-jointed, the first two joints moderately stout and long, sparingly setiferous on the upper margin; the second joint has also a long non-plumose hair attached to its upper distal angle; the next three joints are short and stout, and bear four long filamentiferous setæ similar to those of the anterior foot-jaws. The end joint is small and rudimentary, and terminates in one short and two long non-plumose hairs. The swimming-feet are as in *Hemicalanus longicornis*; the five pairs are 2-branched and each branch 3-jointed, all of them being more or less thickly beset with short spinous hairs. The basal joint of the outer branches of the first pair bears on its posterior distal angle an elongate spine, which extends to the extremity of the last joint. The exterior distal angles of the first and second joints of the outer branches of the third and fourth pairs bear one very stout spine, having a short spinous process on each side of it at its base. Abdomen short, 3-jointed, the first joint much longer than the other two together. Caudal stylets short, somewhat divergent, each with six plumose hairs, four terminal, which are moderately long and subequal; a smaller one on the lower outer margin, and one very slender hair near the base of the second terminal seta, counting from the inside.

Habitat. (1) Station 3, 100 fathoms tow-netting, January 2nd (day collection), specific gravity of the water 1·02608, temperature 56°·4 F. (2) Lat. 6° 38′ N., long. 12° 37′ W., 25 fathoms tow-netting, January 6th (day collection), sp. g. of the water (surface) 1·02400, temperature (surface) 83°·5 F. (3) Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35 fathoms tow-netting, January 22nd (day collection), temperature at 30 fathoms 63°·98 F. (4) Off São Thomé Island, lat. 0° 34′ N., long. 6° 20′ 4″ E., 20 fathoms tow-netting, January 23rd (day collection).

Only one adult specimen and a few others more or less immature were obtained; the adult specimen is from locality (3), and is the one from which the drawings were made.

The peculiar short flat-topped filaments (sense-organs?) with which several of the hairs of the maxillæ and foot-jaws are furnished resemble those observed and described in *Augaptilis longicaudatus*, which Prof. Claus speaks of as "sehr zierlich geknöpfte Seitenspitzen," but instead of the tops being circular like a button, as in that species, they are broadly crescent-shaped; the "button-tops" are also larger than those of *Augaptilis longicaudatus*. In *Augaptilis Rattrayi* there are about forty button-topped filaments in the length of a millimetre, but in *Augaptilis longicaudatus* the number of filaments in a millimetre is about one hundred and forty-seven. The filaments in each double row are usually opposite each other, as shown in the enlarged drawings. They give a peculiar and striking appearance to the setæ that are provided with them.

Genus CALOCALANUS, Giesbrecht (1891).

Elenco dei Copepodi pelagici,—R. Corvetta 'Vettor Pisani.' (Atti della Reale Accademia dei Lincei, serie iv. Rendiconti, vol. v. pt. 1.)

CALOCALANUS PAVO (Dana). (Pl. VI. figs. 9, 10.)

1852. *Calanus pavo,* Dana, loc. cit. p. 1061, pl. 72.
1892. *Calocalanus pavo,* Giesbrecht, op. cit. p. 185, pls. 1, 4, 9, 36.

Length about 7 mm. Cephalothorax rounded in front and behind. Anterior antennæ fully a half longer than the cephalothorax and abdomen together, 24-jointed, the first joint large and bearing two plumose and a few plain setæ, the last joint long and slender, furnished at its extremity with four plain setæ of moderate length. The second and third last joints possess longer setæ than any of the other joints; all the joints from the eleventh to the twentieth inclusive bear each a number of small hairs on the upper margin besides the longer setæ with which all the joints are more or less furnished. The proportional lengths of the joints are very nearly as in the annexed formula:—

$$\frac{45 . 10 . 10 . 10 . 10 . 10 . 10 . 10 . 11 . 11 . 15 . 15 . 17 . 18 . 22 . 24 . 27 . 28 . 29 . 30 . 25 . 24 . 20 . 87}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21 \quad 22 \quad 23 \quad 24}$$

Secondary branch of the posterior antennæ as long as the primary branch, 8-jointed; the third and last much larger than the other joints; both branches setiferous. Mandibles stout, the apex furnished with several more or less rudimentary teeth; the mandible-palp well developed; secondary branch 5(?)-jointed, shorter than the primary, the basal part furnished with three setæ on its inner margin. Maxillæ large, somewhat similar to those of *Eucalanus*, but the basal part dilated. Foot-jaws as in *Eucalanus*, but the terminal setæ of first foot-jaws plain. The first four pairs of swimming-feet 2-branched, outer branches 3-jointed, the inner branch of first pair 2-, of the others 3-jointed. The outer branches of second, third, and fourth pairs only with sabre-like terminal spines; the second joint of the outer and the second and third joints of the inner branches armed with transverse rows of spines. Fifth pair of feet in the male (?) 1-branched, branches 3-jointed, the terminal joint longer than the other two together, compressed, the extremities rounded and furnished with several long setæ and two or three transverse rows of small hairs as in the figure. Abdomen very short, 3(?)-jointed. Caudal stylets extremely divergent, bearing four long spreading setæ, two of which are divided to near the base.

Habitat. Station 2, surface and 25 fathoms tow-nettings, January 1st (night collections). Station 3, 25 fathoms, January 2nd (day collection). Station 9, 50 fathoms, January 10th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 and 460 fathoms tow-netting, January 22nd (day collection). Station 23, 20 fathoms, February 5th (day collection).

This species was comparatively frequent all over the area examined. It is readily distinguished from other *Calanidæ* described in this Report by the remarkably divergent caudal stylets, which are at almost right angles to the abdomen. The anterior antennæ and tail-setæ appear to be, in this species, more than usually fragile; not a single perfect specimen was obtained in the whole collection. The tail-setæ were commonly altogether wanting or the stumps of them only remained, and the anterior antennæ were, with very few exceptions, all more or less damaged. It was only after very carefully searching the tow-nettings that a few specimens were discovered that had the joints of the antennæ complete; the figure, therefore, represents the anterior antennæ perfect as regards the number of joints. No specimens with perfect caudal setæ were obtained.

CALOCALANUS PLUMULOSUS (Claus). (Pl. I. figs. 35, 36; Pl. VI. figs. 7, 8.)

1863. *Calanus plumulosus*, Claus, Die freilebenden Copepoden, p. 174, taf. xxvi. figs. 15, 16.

1892. *Calocalanus plumulosus*, Giesbrecht, op. cit. p. 185, pls. 3, 9, 36.

Length (female) 1·3 mm. Body elongate, first segment nearly equal to twice the entire length of the other three; postero-lateral angles of thorax rounded. Anterior antennæ, reaching somewhat beyond the extremity of the abdomen, 24-jointed; the large basal joint bears one long plumose seta near the proximal end, the last joint is slender and equal to the combined length of the preceding two. The proportional lengths of the joints are nearly as shown in the formula:—

$$\frac{50 . 10 . 10 . 10 . 10 . 10 . 10 . 10 . 11 . 13 . 16 . 16 . 18 . 18 . 18 . 19 . 18 . 21 . 21 . 21 . 21 . 20 . 15 . 36}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9\quad 10\quad 11\quad 12\quad 13\quad 14\quad 15\quad 16\quad 17\quad 18\quad 19\quad 20\quad 21\quad 22\quad 23\quad 24}.$$

Posterior antennæ, mouth-appendages, and swimming-feet as in *Calocalanus pavo*. The last joint of each foot of the fifth pair is equal to half the length of the foot, and the third joint is nearly one and a half times the length of the preceding one; the broadly rounded extremity of the last joint bears a small spine near the outer angle, a much larger spine near the middle, and a moderately long seta near the inner angle; there are also two small setæ near the distal end of the inner margin; both margins of the joints are also more or less fringed with cilia (Pl. I. fig. 35). Abdomen short, first segment rather tumid, the second much shorter than either the first or third, breadth of the second and third increasing towards the distal end; the first and second have each a fringe of small serræ concentric with, and a little anterior to, the distal margin. Stylets about equal to the length of the second abdominal segment, slightly divergent, and furnished with four terminal plumose setæ, and one very small seta near the extremity of the inner margin.

Calocalanus plumulosus was obtained in a tow-net gathering from 30 fathoms, lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., collected January 22nd. Only a few specimens were observed.

This species differs very markedly, not only in its greater size but also in general appearance, from *Calocalanus pavo*; moreover, the anterior antennæ are proportionally much shorter than in that species. The proportional lengths of the joints of the anterior antennæ and fifth feet also differ considerably in the two species. Another character of the spirit specimens is the abruptly flexed abdomen, which is bent at a right angle in all those obtained. The position of the caudal stylets in *Calocalanus plumulosus* is almost normal, while those of *Calocalanus pavo* are extremely divergent. The long plumose seta on the basal joint of the anterior antennæ appears also to be a character of *Calocalanus plumulosus* *.

Genus HETEROCALANUS, nov. gen. (Provisional name.)

Anterior antennæ 22-jointed; right antennæ of the male resembling that of the

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* "Dieser" (the long basal joint of the anterior antennæ) "trägt eine kräftige, zweiseitig befiederte, gelb pigmentirte Borste." Claus, *loc. cit.*

Pontellidæ. Second branch of the posterior antennæ longer than the primary branch, 4-jointed. Mandibles stout, broad, furnished with papilliform teeth and elongate tooth-like processes on the exterior angle; mandible palp 2-branched, secondary branch 3-jointed. Anterior foot-jaws like those of *Rhincalanus cornutus.* Posterior foot-jaws strong, 6-jointed, the two basal joints large. The first four pairs of swimming-feet have both branches 3-jointed. Fifth pair in both sexes 1-branched, those of the male dissimilar and adapted for grasping; those of the female the same on both sides, 3-jointed, the last joint produced into a large curved spiniform process. Ovisac large.

HETEROCALANUS SERRICAUDATUS, n. sp. (Pl. II. figs. 43–48; Pl. III. figs. 1–7.)

Length 1·15 mm. Body elongate, narrowly rounded in front, the postero-lateral angles of last thoracic segment rounded and bearing several small spines. Anterior antennæ longer than the body; those of the female slender, 22-jointed, sparingly setiferous. The proportional lengths of the joints are nearly as follows:—

$$\frac{11 \,.\, 11 \,.\, 5 \,.\, 7 \,.\, 6 \,.\, 10 \,.\, 5 \,.\, 6 \,.\, 10 \,.\, 12 \,.\, 14 \,.\, 16 \,.\, 18 \,.\, 18 \,.\, 18 \,.\, 16 \,.\, 14 \,.\, 14 \,.\, 13 \,.\, 14 \,.\, 12 \,.\, 3}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21 \quad 22}.$$

The right anterior antenna of the male also 22-jointed, distinctly hinged between the 18th and 19th joints, the upper margin of the 18th joint serrate; the 11th and 12th joints are small, the 14th, 15th, and 16th dilated. The general form of the male right antenna somewhat resembles that of the *Pontellidæ.* Posterior antennæ have the secondary branches longer than the primary, 4-jointed, the third joint very small, imparting to the branch the appearance of being much constricted in the middle; both branches furnished with numerous non-plumose hairs. Mandible stout, broad, bearing several small papillose teeth, and on the exterior angle three elongate tooth-like processes and a short plumose seta. The basal part of the mandible palp is comparatively large, and produced laterally to form the base of the secondary branch, which is 3-jointed. Both branches are furnished with a number of non-plumose hairs (Pl. III. fig. 4). Anterior foot-jaws like those of *Rhincalanus cornutus,* short, obscurely 3(or 4 ?)-jointed. Posterior foot-jaws strong, 6-jointed, the two basal joints large, the other four small, subequal; each of the fourth, fifth, and sixth joints bear interiorly a stout, elongate, blunt-pointed spine, that of the fifth being much larger than those of the other two joints; the terminal joint is also furnished with six long plumose hairs. The first four pairs of swimming-feet are 2-branched, both branches 3-jointed. The joints of the inner branch of the first pair subequal; the outer branch is without dagger-like spines at the distal angles of the joints. The first joint of the inner branch and the middle joint of the outer branch of the second, third, and fourth pairs are smaller than the other joints, and the exterior distal angles of all the joints of the outer branches bear stout dagger-like spines, which are finely serrate on both edges; the last joint has an additional and similar spine arising from an excavation on the lower half of the outer margin. The terminal spines of the outer branches are finely serrate on the outer edge, except near the base, which is plain; the extremity of the terminal spines is slightly curved outwards. The terminal spines of the outer branches of the first pair are more slender than those of the others; all the four pairs are furnished with numerous stout plumose setæ on the inner margins of both branches as well as round the extremity of the inner branches. The fifth pair in the male is 1-branched. The second joint of the right foot bears interiorly a small dilated process having a number of small spines; the extremity of the last joint truncate; an elongate curved appendage with a tumid base springs from the inner angle, and a stout setiferous spine from the outer angle of the extremity of the last joint. The second joint of the left foot has a long slender appendage, very faintly serrate on the inner edge. The outer angle of the third joint and the extremity of the fourth terminate in a long spinous process, and the inner edge of the base of the last joint is ciliated. The fifth pair in the female is 1-branched, the right and left are similar, and 3(or 4?)-jointed; the first and second joints stout, the third short, but produced inwards into a large curved spiniform process, finely but distinctly serrate on both margins; the last (?) joint nearly obsolete, terminating in one long plain spine and a second short one, serrate on the inner edge. Abdomen (exclusive of caudal stylets) nearly half as long as the cephalothorax, 5-jointed in the male, 4-jointed in the female; the second, third, and fourth segments in the male, and the first, second, and third in the female, fringed posteriorly with a prominent row of saw-like teeth. Caudal stylets as long as the last abdominal segment, narrow, somewhat divergent, bearing each four moderately long, terminal, plumose setæ, and a fifth which springs from a notch on the outer margin; all the setæ are articulated below the proximal half; there is also a small hair between the two inner setæ. Ova forming one large circular complanate cluster, containing about sixteen large ova arranged in a single layer, eleven or twelve round the circumference, the others central.

Habitat. Lat. 5° 10′ N., long. 3° 56′ 2″ W., surface, close inshore, January 12th (night collection). Off Accra, three fathoms, January 16th (night collection). Off Appi, surface tow-netting, January 18th (day collection). Libreville, Gaboon River, in two surface tow-nettings, January 28th (day collection). Bananah Creek, Congo River, surface tow-netting, February 8th (night collection).

Heterocalanus serricaudatus appears to be more confined to inshore waters than many of the species recorded in this Report, though it seems nevertheless capable of existing under varied conditions as regards the density of the water, having been obtained in water varying in specific gravity from 1·02511 to 1·00870.

Genus Pleuromma, Claus.

Pleuromma, Claus, Die freilebenden Copepoden (1863).
? *Metridia*, Boeck, Oversigt af Norges Marine Copepoda, 1864.
? *Metridia*, Brady, Monograph, British Copepoda, vol. i. 1878.

Pleuromma abdominale, Claus.

1863. *Pleuromma abdominale*, Claus, loc. cit. p. 195, pl. v. figs. 1–6, 13, 14; pl. vi. figs. 1–10.
1883. *Pleuromma abdominale*, Brady, 'Challenger,' Copepoda, p. 46, pl. xi. figs. 1–13.

Habitat. Station 2, 25 fathoms tow-netting, January 1st (night collection). Lat. 3° 55′ 3″ N., long. 4° 7′ 13″ E., 50 fathoms tow-netting, January 20th (day collection). Off São Thomé Island (lat. 0° 34′ N., long. 6° 31′ 6″ E.), 20 fathoms tow-netting, January 23rd (day collection). Station 23, 235 fathoms tow-netting, February 5th (day collection).

Pleuromma abdominale was obtained in 25 tow-nettings, eight of which were surface gatherings, and seventeen under-surface, ranging in depth from 3 to 460 fathoms; one of the surface and seven of the under-surface gatherings were day collections, the others were collected during the night, as shown in the formula :—

$$\text{Tow-nettings 25}\begin{cases}\text{8 surface} & \begin{cases}\text{1 day collection.}\\ \text{7 night collections.}\end{cases}\\ \text{17 under-surface} & \begin{cases}\text{7 day ditto.}\\ \text{10 night ditto.}\end{cases}\end{cases}$$

In the adult males the abdomen was usually more or less distorted, as figured by Prof. Brady in his Report on the 'Challenger' Copepoda.

The form agreeing with *Pleuromma gracile*, Claus, was obtained in a few of the tow-nettings, and the difference between it and *Pleuromma abdominale* is so marked and constant in the 'Buccaneer' specimens that I have considered it preferable to record them separately.

PLEUROMMA GRACILE, Claus. (Pl. VI. figs. 11–14.)

1863. *Pleuromma gracile,* Claus, loc. cit. p. 197, pl. v. figs. 7–11.

1883. ? *Pleuromma abdominale,* Brady (in part), op. cit. p. 46, pl. xii. figs. 1–16; pl. xxxi. figs. 13, 14.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 250 and 360 fathoms tow-nettings, January 22nd (day collections). Lagoon, São Thomé Island, surface.

A form agreeing with the description and figures of *Pleuromma gracile* in 'Die freilebenden Copepoden' occurred in the gatherings described; it seems to be distinct from *Pleuromma abdominale.*

PLEUROMMA PRINCEPS, n. sp. (Pl. III. figs. 8–20.)

Length (exclusive of tail-setæ) 12 mm. Cephalothorax elongate, robust. Forehead acute; postero-lateral angles of the last thoracic segment produced, shortly spiniform. Left anterior antenna of male 25-jointed; the right antenna is 22-jointed, hinged at the eighteenth joint, the proportional lengths of the joints as in the annexed formula :—

Left. 50 . 20 . 20 . 15 . 20 . 20 . 20 . 15 . 20 . 25 . 30 . 30 . 40 . 45 . 50 . 50 . 50 . 50 . 55 . 38 . 35 . 37 . 40 · 30 . 10.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25.
Right. 70 . 20 . 20 . 20 . 20 . 25 . 16 . 15 . 12 . 12 . 25 . 24 . 30 . 45 . 40 . 50 . 60 . 13 . 70 . 80 . 30 . 7 .

The nineteenth joint is furnished at the distal end with a tooth-like process which extends over the base of the next joint. There are also, near the middle of the same joint, one long and one very short spine, which extend in a forward direction along the margin of the segment; both antennæ are sparingly setiferous. Posterior antennæ as in *Pleuromma abdominale*; setæ on both branches plumose. The mouth-organs also as in *P. abdominale*, but the anterior foot-jaw bears two elongate spines which spring from a prominent basal part near its extremity. The distal processes of the maxillæ appear to be less produced than in *Pleuromma abdominale*. The first pair of swimming-feet are smaller than the following three pairs; the posterior outer aspect of the basal joint of the inner branch is beset with numerous fine cilia, and the outer margin of the middle joint is fringed with fine hairs. The exterior margin of the second, and the upper half of the third, segment of the outer branch are also fringed with fine hairs, while the lower half of the third segment is finely serrate. The outer branch of the second pair of swimming-feet on both sides has the first segment "deeply excavated at the base;" the excavation is bounded interiorly by two strong, upward-directed, curved spines. There is no "thumb-like prominence" on the basal segment of the third pair of feet, as in *Pleuromma abdominale*. The fourth pair of feet closely resemble the preceding pair. The last segment of the outer branch of the first pair terminates in a long stout seta, plumose on the inner margin. The outer branch of the second, third, and fourth pairs terminates in a moderately short, stout, sabre-like spine, the inner margin fringed with cilia, the outer margin very faintly toothed. The fifth pair of feet strongly prehensile; one branch (the right?) terminates in a clumsy claw-like segment. A small spine springs from near the proximal end of the penultimate segment. The last segment of the other branch is furnished, on the inner side and near the base, with a moderately long, stout process, and two peculiar, stalked appendages. There is also at the base of the last segment a thin plate having a saw-like edge, and partly surrounded with delicate cilia; both branches of the fifth feet are about the same length. Abdomen 4-jointed; joints subequal. Caudal stylets twice the length of the last abdominal segment, and each furnished with six setæ, four of them on the rounded extremity of the stylet, one on the outer margin, and a very small slender seta on the inner margin. All the setæ are densely plumose.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms tow-netting, January 22nd (day collection).

Only one specimen—a male—of this fine species was obtained.

Genus HETEROCHÆTA, Claus.

Heterochæta, Claus, Die freilebenden Copepoden (1863).

HETEROCHÆTA SPINIFRONS, Claus.

1863. *Heterochæta spinifrons*, Claus, loc. cit. p. 182, pl. xxxii. figs. 8, 9, 14, 16.

1883. *Heterochæta spinifrons*, Brady, Report 'Chall.' Copep. p. 49, pl. xiii. figs. 1–13.

Habitat. Station 2, 25 fathoms tow-netting, January 1st (night collection). Lat. 3° 58′ N., long. 3° 42′ W., 50 fathoms tow-netting, January 13th (night collection). Station 14, 10 fathoms, January 21st (night collection). Off São Thomé Island (lat. 0° 34′ N., long. 6° 30′ 4″ E.), 20 fathoms, January 23rd (day collection). Station 23, 235 fathoms, February 5th (day collection).

Heterochæta spinifrons occurred in 20 tow-nettings; only one of these was a surface gathering collected during the day, the other nineteen were under-surface and ranged in depth from 5 to 460 fathoms; fifteen of these were day collections, and four night collections, as shown in the formula :—

$$\text{Tow-nettings 20}\begin{cases}\text{1 surface} & \text{1 day collection.}\\ \text{19 under-surface} & \begin{cases}\text{15 day collections.}\\ \text{4 night ditto.}\end{cases}\end{cases}$$

This, though generally distributed, was a somewhat rare species in the 'Buccaneer' collection. The dilated outer branches of the fourth pair of swimming-feet, with their short terminal spines, and the extremely long and slender seta of the right caudal stylet, allow of its being readily distinguished from most other species.

Genus Leuckartia, Claus.

Leuckartia, Claus, Die freilebenden Copepoden (1863).

Leuckartia flavicornis, Claus.

1863. *Leuckartia flavicornis*, Claus, loc. cit. p. 183, pl. xxxii. figs. 1–7.
1883. *Leuckartia flavicornis*, Brady, op. cit. p. 50, pl. xv. figs. 1–9, 16.

Habitat. Station 2, 25 fathoms, January 1st (night collection). Off Accra, surface tow-netting, January 16th (night collection). Lagoon, São Thomé Island, surface tow-netting, January 27th (night collection). Station 23, 10, 20, 85, 135, 185, and 235 fathoms tow-nettings, February 5th (day collection). Bananah Creek, Congo River, surface tow-netting, February 7th (day collection).

This *Leuckartia* was observed in 67 tow-nettings; 30 of these were surface gatherings, and 37 under-surface. The under-surface tow-nettings were from various depths, from 10 to 460 fathoms. Seven of the surface and 27 of the under-surface tow-nettings were day collections, the others were night collections, as exhibited by the annexed formula :—

$$\text{Tow-nettings 67}\begin{cases}\text{30 surface} & \begin{cases}\text{7 day collections.}\\ \text{23 night ditto.}\end{cases}\\ \text{37 under surface} & \begin{cases}\text{27 day ditto.}\\ \text{10 night ditto.}\end{cases}\end{cases}$$

This species appears to have been widely distributed throughout the area examined during the 'Buccaneer's' expedition, but comparatively few specimens were observed in the tow-nettings in which it occurred, except in those from deep water.

Genus Undina, Dana.

Undina, Dana, Proc. Amer. Acad. Sci. (1849).

Undina vulgaris, Dana.

1852. *Undina vulgaris*, Dana, Crust. of U.S. Expl. Exped. p. 1092, pl. lxxvii. fig. 8, *a–d*.

1856. *Undina longipes*, Lubbock, Trans. Entom. Soc. p. 17, pl. vi. figs. 1–5.
1883. *Undina vulgaris*, Brady, Report 'Chall.' Copep. p. 53, pl. xv. figs. 11–15 ; pl. xviii. fig. 6.

Habitat. Station 2, surface tow-nettings, January 1st (night collection). Lat. 3° 58′ N., long. 3° 10′ W., surface tow-netting, January 13th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 20, 35, and 460 fathoms tow-nettings, January 22nd (day collections). Lagoon, São Thomé Island, surface tow-netting, January 27th (night collection). Station 21, surface tow-netting, February 4th (day collection). Bananah Creek, Congo River, surface tow-netting, February 7th (day collection).

Undina vulgaris was observed in 89 tow-nettings; 51 of these were surface gatherings and 38 under-surface, the depth of which ranged from 2 to 460 fathoms; 20 of the surface and 26 of the under-surface gatherings were collected during the day, while 31 of the surface and 12 of the under-surface gatherings were collected during the night, as shown by the annexed formula :—

$$\text{Tow-nettings } 89 \begin{cases} 51 \text{ surface} \begin{cases} 20 \text{ day collections.} \\ 31 \text{ night ditto.} \end{cases} \\ 38 \text{ under-surface} \begin{cases} 26 \text{ day ditto.} \\ 12 \text{ night ditto.} \end{cases} \end{cases}$$

This *Undina* was comparatively common in the 'Buccaneer' collections, both sexes being equally frequent. It was also one of the more common of the 'Challenger' Copepoda. Another species (*Undina Darwini*, Lubbock), which appears to have been almost as common as *Undina vulgaris* in the 'Challenger' collections, was entirely absent from the 'Buccaneer' tow-nettings, not a trace of it being observed, though carefully sought for.

Genus Euchirella, Giesbrecht (1891).

Elenco dei Copepodi pelagici,—R. Corvetta 'Vettor Pisani.' (Atti della Reale Accademia dei Lincei, serie iv. Rendiconti, vol. v. pt. 1, p. 336.)

? Euchirella messinensis (Claus). (Pl. VI. figs. 15 & 16.)

? *Undina messinensis*, Claus, Die freilebenden Copepoden, p. 187, pl. 31.

Length, exclusive of tail-setæ, 5 mm. Body elongate, robust. Forehead subtruncate; postero-lateral angles of the last thoracic segment rounded and furnished with a number of hairs. Anterior antennæ reaching to near the extremity of the abdomen; the left 24-, the right 23-jointed, the proportional lengths of the joints nearly as in the annexed formula :—

Right antenna. 10 . 13 . 7 . 6 . 7 . 7 . 7 . 11 . 8 . 8 . 8 . 14 . 19 . 19 . 19 . 20 . 18 . 20 . 18 . 13 . 13 . 12 . 14.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24.
Left antenna. 10 . 13 . 7 . 6 . 6 . 7 . 6 . 8 . 6 . 7 . 7 . 8 . 14 . 15 . 20 . 19 . 20 . 18 . 20 . 17 . 14 . 13 . 11 . 14.

The 3rd, 7th, 8th, 13th, 17th, and 20th joints are each furnished with a long plain seta. The terminal joint bears three (or four ?) long setæ, two of them plumose; there is also a plumose seta on the penultimate joint, and two stout short plumose hairs spring from near the end of the basal joint. The posterior antennæ have the secondary branch large and stout, 6-jointed, the first and last joints long, the intermediate very short. The small intermediate joints bear each one seta, and the extremity of the last joint three long plumose setæ; the primary branch is extremely short, being almost rudimentary. Mandible stout, with numerous terminal papillose teeth; the exterior angle bears a strong laterally-produced spine, which is serrate on the upper margin. The mandible palp is of moderate size, 2-branched, each branch with several long terminal plumose hairs. The maxillæ are large, and bear at the extremity and on the interior margin a number of stout setiferous spines; the external branch of the maxilla-palp very short and broad; terminal branch stout, somewhat digitiform; both branches with numerous plumose hairs. Foot-jaws as in *Euchæta Hessei*, except that near the extremity of the anterior foot-jaw are two setiferous spines much stouter than the others, and also two plain spinous setæ on the lower extreme angle of the ultimate joint. The first four pairs of swimming-feet are similar to those of *Euchæta*; the first pair resemble those of *Euchæta Hessei*, except that the inner branch has a lobe-like process near the base, and the outer branch a long slender terminal spine, finely serrate on the outer margin; the outer branches of the second, third, and fourth pairs armed with a stout terminal spine, having about twenty strong saw-like teeth on its outer margin. The basal joint of the fourth pair bears a large bifurcate spiniform appendage; the setæ on both branches of all the four pairs are densely plumose. Abdomen short, composed of four segments, the first large, being nearly as long as all the other three together. Caudal stylets short, divaricate, each with one short spine on the outer distal angle, and four moderately long terminal plumose hairs; another slender hair springs from near the inner distal angle of each stylet, and is about half the length of the others.

Habitat. Station 2, 50 fathoms, January 1st (night tow-netting). Lat. 5° 58′ N., long. 14° 20′ W., surface gathering, January 5th (night tow-netting). Lat. 3° 22′ 5″ N., long. 4° 11′ 8″ E., 20 and 30 fathoms tow-nettings, January 20th (night collections). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms tow-netting, January 22nd (day collection). Lat. 1° 29′ N., long. 7° 33′ 8″ E., surface tow-netting, January 27th (night collection). Station 23, 30 fathoms, February 5th (day collection).

Only a few specimens of this species were obtained; they were all females, and were readily distinguished by the large forked spiniform appendage on the basal joints of the fourth pair of swimming-feet. As has been pointed out by Prof. Brady, *Undina messinensis*, Claus, differs from *Undina*, Dana, by the absence of the first pair of foot-jaws in the male (as described by Dr. Claus), and by the inner branches of the first and second swimming-feet being only 1-jointed (Claus, however describes the inner branch of the second pair as 2-jointed, but in the 'Buccaneer' specimens it was certainly only 1-jointed). In *Undina*, Dana, on the other hand, the inner branches of all the swimming-feet are 3-jointed. *Undina messinensis* has the fifth pair of feet in the male similar to those of *Euchæta pulchra*, Lubbock (to which it has been doubtfully referred), but differs from that and all other *Euchætæ* known to me by the very rudimentary form of the primary branch of the posterior antennæ.

Genus Scolecithrix, Brady.

Scolecithrix, Brady, Report 'Challenger' Copepoda (1883).

Scolecithrix securifrons, n. sp. (Pl. IV. figs. 40–56; Pl. V. fig. 1.)

Length, exclusive of tail-setæ, about 4 mm. Cephalothorax robust, the anterior segment fully two-thirds the length of the body. Forehead with a prominent median keel, which is continued downwards to the slightly furcate rostrum. Anterior antennæ longer than the body, 23-jointed in the female, 19-jointed in the male. The annexed formula shows very nearly the proportional lengths of the joints:—

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23.
Male.	10	11	5	6	6	7	6	41	22	13	13	14	13	10	9	13	13	12	3				
Female.	13	12	6	6	7	7	7	21	9	11	14	15	15	15	14	14	14	13	13	13	14	12	3.

The long eighth joint has one or two pseudo-divisions, indicating the possible coalescence of two, if not three, smaller joints. The secondary branch of the posterior antennæ is half as long again as the primary one, 5-jointed, the third and fourth joints small, the last joint with three terminal setæ; several setæ spring from the vicinity of the two small joints; the primary branch is furnished with a number of terminal setæ, which, with the others, are all more or less plumose. Mandible-palp with two small branches set wide apart, and each with numerous plumose hairs. Maxillæ and other mouth-organs as in *Scolecithrix Danæ*. First pair of swimming-feet small, inner branch 1-jointed, with a lobe-like appendage, terminal spine of the outer branch small. All the joints of the second and third pairs are armed with transverse curved rows of short stout spinules, and the terminal sabre-like spines of the outer branches have their exterior margin strongly and coarsely toothed. The fourth pair wants the transverse rows of spinules, but is otherwise similar to the second and third pairs. The fifth pair in the female is very small, 1-branched, 2-jointed, and with a moderately long slender, curved, terminal spine, the distal half serrate on the outer margin; a small blunt process springs from the inner distal angle of the terminal joint, close to the base of the elongate spine; this spine was apparently hinged to the extremity of the last joint, for in one or two specimens it was turned upward at a right angle to the joint, and in such a manner as to allow of its being applied to the base of the first abdominal segment. The fifth feet in the male are strongly developed; the left foot is 1-branched, 3-jointed, with a curved finger-like process at the extremity; the right has a slender 1-jointed inner branch, curved outwards so as to be opposed to the 2-jointed clawed terminal part of the outer branch; the basal part to which the two branches are attached is much dilated. Abdomen in the female short, first segment larger and much wider posteriorly than the next; the posterior margin of the abdominal segments in both sexes fringed with hairs. Caudal stylets short, divergent, each with four long terminal plumose setæ nearly equal in length, and a small hair near the base of the inner seta.

Habitat. Station 2, 50 fathoms tow-netting, January 1st (night collection). Lat. 7°33′ N., long. 15° 18′ W., 25 fathoms tow-netting, January 2nd (night collection). Lat. 1° 55′ 5″ N., long. 55° 55′ 5″ E., 360 fathoms tow-netting, January 22nd (day collection). Lat. 0° 25′ 1″ N., long. 6° 35′ 2″ E., 10 fathoms tow-netting, January 23rd (night collection). Station 23, 185 fathoms tow-netting, February 5th (day collection).

Not more than one, or at most two, specimens of this *Scolecithrix* were obtained in each of the tow-nettings from the localities here recorded. The prominent keeled forehead, which gives this species such a marked character, enables it to be readily distinguished.

SCOLECITHRIX CTENOPUS, Giesbrecht. (Pl. V. figs. 2–9.)

1892. *Scolecithrix ctenopus*, Giesbrecht, Fauna und Flora des Golfes von Neapel (Copepoden), p. 285, pls. 13, 37.

Male. Length, exclusive of tail-setæ, 1·83 mm. The cephalothorax elongate, rounded in front and behind. Anterior antennæ slender, reaching to the extremity of the abdomen, the left 21-, the right 20-jointed. The proportional lengths of the joints of the left antenna are nearly as follows :—

$$\frac{16 \,.\, 16 \,.\, 3 \,.\, 3 \,.\, 3 \,.\, 4 \,.\, 4 \,.\, 16 \,.\, 5 \,.\, 5 \,.\, 6 \,.\, 6 \,.\, 6 \,.\, 5 \,.\, 6 \,.\, 5 \,.\, 6 \,.\, 6 \,.\, 6 \,.\, 6 \,.\, 3}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21}.$$

The sixteenth joint of the right antenna consists of two coalescent joints, but otherwise the right and left antennæ are similar ; posterior antennæ and mouth-organs as in *Scolecithrix Danæ*. The inner branch of the third pair of swimming-feet small, the terminal spine of the outer branch somewhat distorted, its outer margin being furnished with irregular but stout and prominent teeth. The fifth pair of feet has one very short 3-jointed, and one very long, slender, 4-jointed branch, which extends beyond the extremity of the abdomen ; the last segment of the elongate branch is curved, furnished on one side with a dense fringe of hairs, and terminates in two unequal spines ; the small 3-jointed branch is about as long as the first segment of the long branch, the basal joint being longer than the other two together. Abdomen 4-jointed ; joints subequal, fully one-fifth the length of the cephalothorax. Caudal stylets short, not divergent, bearing at the extremity four moderately long plumose hairs, the inner being shorter, and the next one considerably longer than the others ; the arrangement of the tail-setæ in this species resembles *Undina* more than *Scolecithrix*.

Habitat. Station 2, 50 fathoms tow-netting, January 1st (night collection). Station 9, 50 fathoms tow-netting, January 10th (day collection). Lat. 3° 58′ N., long. 3° 42′ W., 25 fathoms tow-netting, January 13th (day collection). Lat. 3° 55′ 3″ N., long. 4° 7′ 3″ E., 20 fathoms tow-netting, January 20th (day collection). Lat. 0° 21′ 1″ N., long. 7° 33′ E., 20 fathoms tow-netting, January 29th (day collection).

Scotecithrix ctenopus was comparatively a rare species in the 'Buccaneer' collection, having been observed in only a few of the tow-nettings. The most marked characteristic of this *Scolecithrix* is the extremely long branch of the fifth foot, having the last segment curved, and with the margin densely setiferous.

SCOLECITHRIX TENUIPES*, n. sp. (Pl. V. figs. 10–19.)

Male. Length, exclusive of tail-setæ, 1·4 mm. Anterior antennæ reaching to beyond

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* From the long slender fifth foot.

the extremity of the abdomen, the left 21-, the right 20-jointed. The following are the proportional lengths of the joints, nearly, of the left antenna :—

$$\frac{5 \,.\, 4 \,.\, 3 \,.\, 3 \,.\, 3 \,.\, 3 \,.\, 3 \,.\, 13 \,.\, 4 \,.\, 4 \,.\, 5 \,.\, 5 \,.\, 5 \,.\, 6 \,.\, 5 \,.\, 5 \,.\, 5 \,.\, 6 \,.\, 5 \,.\, 5 \,.\, 3}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21}.$$

The sixteenth joint of the right antenna consists of two coalescent joints, but otherwise both right and left antennæ are similar. The posterior antennæ, mouth-organs, and first pair of swimming-feet are somewhat similar to those of *Scolecithrix Danæ*. The outer branch of the third pair has a distorted terminal spine, as in *Scolecithrix ctenopus*. The segments of all the first four pairs of swimming-feet are armed with curved, transverse rows of short, stout spinules. The fifth pair of feet consists of one very long, slender branch, and an extremely short, almost obsolete, 3-jointed one. The elongate branch has the basal joint somewhat stout and short, the second long, fully twice the length of the third ; the fourth long and slender, longer than the second ; the last joint is extremely small, with a spiniform extremity. Abdomen, caudal stylets, and tail-setæ as in *Scolecithrix ctenopus*, which appears to be closely allied to the species now described. The fifth pair of feet are, however, decidedly different from those of *Scolecithrix ctenopus*, being much more slender and without the fringe of hairs. The terminal worm-like sense-organs of the anterior foot-jaws are stouter than those of *Scolecithrix ctenopus*, though that species is the larger of the two.

Habitat. Station 2, 50 fathoms tow-netting, January 1st (night collection). Station 9, 50 fathoms tow-netting, January 10th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 30 and 360 fathoms tow-nettings, January 22nd (day collection).

Scolecithrix tenuipes was not obtained from any surface gathering, and was of rare occurrence in the few tow-nettings in which it was observed.

SCOLECITHRIX DANÆ (Lubbock).

1856. *Undina Danæ*, Lubbock, Trans. Entom. Soc. vol. iv. p. 15, pl. ix. figs. 6–9.
1883. *Scolecithrix Danæ*, Brady, Report 'Chall.' Copep. p. 57, pl. xvii. figs. 1–12.

Habitat. Station 2, surface tow-netting, January 1st (night collection). Station 9, 25 fathoms tow-netting, January 10th (day collection). Station 11, 10 fathoms tow-netting, January 19th (day collection). Stations 21 and 22, surface tow-nettings, February 4th (day collection). Lat. 5° 55′ 1″ S., long. 11° 30′ 7″ E., surface tow-netting, February 18th (night collection).

Scolecithrix Danæ was observed in 57 tow-nettings, 20 of which were surface gatherings, and the others under-surface ; 10 of the surface and 24 of the under-surface were day collections, while 10 of the surface and 13 of the under-surface gatherings were collected during the night, as shown by the formula :—

$$\text{Tow-nettings } 57 \begin{cases} 20 \text{ surface} & \begin{cases} 10 \text{ day collections.} \\ 10 \text{ night ditto.} \end{cases} \\ 37 \text{ under-surface} & \begin{cases} 24 \text{ day ditto.} \\ 13 \text{ night ditto.} \end{cases} \end{cases}$$

The under-surface tow-nettings ranged from 5 to 260 fathoms. This species was more or less common in nearly all the tow-nettings in which it was observed.

SCOLECITHRIX MINOR, Brady.

1883. *Scolecithrix minor,* Brady, op. cit. p. 58, pl. xvi. figs. 15–16; pl. xviii. figs. 1–5.

Habitat. Station 3, surface tow-netting, January 2nd (day collection). Lat. 3° 55′ 3″ N., long. 4° 11′ 8″ E., 50 fathoms tow-netting, January 20th (day collection). Station 14, 10 fathoms, January 21st (night collection). Lat. 0° 21′ 1″ N., long 7° 33′ E., 20 fathoms, January 29th (day collection). Station 23, 235 fathoms, February 5th (day tow-netting). Station 24 (off the mouth of the Congo, colour of the water brownish-olive green to amber-brown), surface, February 6th (day collection).

This *Scolecithrix* was a somewhat rare species in the 'Buccaneer' tow-nettings; males especially were very scarce, and were observed only in a 30-fathoms tow-netting from lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E. The ultimate joint of the longer branch of the male fifth foot and the appendage of the same branch were not so long as shown in the figure in the 'Challenger' Report, but otherwise the 'Buccaneer' specimens agreed with the description and drawings of *Scolecithrix minor* (loc. cit.). I have examined many specimens, mature and immature, of *Scolecithrix Danæ*, and have certainly not found the fifth pair of feet in any of them to agree in structure with those of *Scolecithrix minor*; hence I feel satisfied that the two are quite distinct from each other.

SCOLECITHRIX LONGICORNIS, n. sp. (Pl. V. figs. 20–28.)

Female. Length, not including tail-setæ, 1·54 mm. The first body-segment is more than twice the entire length of the other three; the forehead is rounded. Anterior antennæ slender, reaching to the extremity of the abdomen, 23-jointed, and furnished with a number of very small setæ (with the exception of the last joints, which bear longer setæ) (fig. 21); the proportional lengths of the joints nearly as in the formula:—

$$\frac{6\,.\,4\,.\,3\,.\,3\,.\,3\,.\,3\,.\,3\,.\,7\,.\,2\,.\,3\,.\,4\,.\,4\,.\,5\,.\,6\,.\,5\,.\,6\,.\,6\,.\,6\,.\,6\,.\,6\,.\,6\,.\,5\,.\,4}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9\quad 10\quad 11\quad 12\quad 13\quad 14\quad 15\quad 16\quad 17\quad 18\quad 19\quad 20\quad 21\quad 22\quad 23}.$$

The anterior foot-jaws terminate in four lobes with several plumose setæ at their extremity, while one lobe forms the base of a fascicle of slender sensory filaments; a single filament also springs from the end of the lowest of the four setiferous lobes. Posterior foot-jaws small, the first two joints long, the third very short, the fourth equal to the entire length of the last three. Other mouth-organs similar to *Scolecithrix Danæ*. The first four pairs of swimming-feet similar to those of *Scolecithrix securifrons*. Fifth pair small, 3-jointed, the middle joint rather longer than either of the other two, and bearing several small spiniform setæ at its exterior distal angle; the extremity of the last joint is produced forward into a triangular sharp-pointed process, while an elongate spine, serrate on the outer margin, springs from the inner distal angle (fig. 27). Abdomen short, stout, composed of four segments, the first segment large, the other three very short. Caudal stylets short, the length and breadth equal; each stylet bears four long plumose terminal setæ, and one small seta on the inner distal angle.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms (day collection). Station 23, 135 fathoms, February 5th (day collection).

This *Scolecithrix* was obtained in only two tow-nettings from comparatively deep water.

SCOLECITHRIX BRADYI, Giesbrecht. (Pl. V. figs. 29–39.)

1892. *Scolecithrix Bradyi*, Giesbrecht, op. cit. p. 283, pls. 4, 13, 37.

Length about 1·8 mm. In form like that of *Scolecithrix Danæ*. Anterior antennæ in the male as long as the cephalothorax, 19-jointed; in the female 23-jointed and about one-fourth longer than those of the male. The proportional lengths of the joints are nearly as in the annexed formula:—

Male. 4 . 4 . 2 . 2 . 2 . 2 . 2 . 12 . 3 . 4 . 5 . 5 . 5 . 5 . 4 . 4 . 5 . 6 . 7.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23.
Female. 5 . 5 . 3 . 3 . 3 . 3 . 3 . 7½ . 3 . 4 . 5 . 5 . 5 . 6 . 6 . 6 . 6 . 5 . 5 . 5 . 6 . 5 . 3.

The basal joints bear a number of setæ, but the others are very sparingly setiferous; posterior antennæ and mouth-organs as in *Scolecithrix Danæ*, but the larger branch of the mandible-palp bears a number of very long slender setæ. The first four pairs of swimming-feet are similar to those of *Scolecithrix securifrons*; the terminal spines of the outer branches are finely but somewhat unequally serrate on the outer margin and ciliated on the inner. Fifth pair wanting in the female, 1-branched in the male; basal joints dilated; the third joint of the (?) right foot elongate, with a short digit-like process on the inner margin near the distal end, the last joint divided to near the base into two subequal segments, the inner of which is curved upward so as to form a hook-like appendage. The (?) left foot 5-jointed and longer than the other; the second joint is the longest, being nearly as long as all the following three together, and bearing at its inner distal angle an appendage which is fully as long as the third joint. Abdomen and caudal stylets in both sexes as in *Scolecithrix Danæ*.

Scolecithrix Bradyi resembles *Scolecithrix Danæ* very nearly in its general form, but is much smaller; it differs in possessing extremely long hairs on the larger branch of the mandible-palp, and especially in the form of the fifth pair of feet.

Habitat. Station 2, 25 fathoms tow-netting, January 1st (night collection). Station 9, 50 fathoms tow-netting, January 10th (day collection). Off São Thomé Island (lat. 0° 34′ N., long. 6° 30′ 4″ E.), 20 fathoms tow-netting, January 23rd (day collection). Station 23, 135 fathoms tow-netting, February 5th (day collection).

Scolecithrix affinis was obtained in thirteen of the tow-nettings, one only of which was a surface (night) gathering, the other twelve being under-surface, the depth of which ranged from 5 to 360 fathoms, and of which three were collected during the day and nine during the night, as in the formula:—

Tow-nettings 13 { 1 surface { 0 day collection.
1 night ditto.
12 under-surface { 3 day collections.
9 night ditto.

SCOLECITHRIX LATIPES, n. sp. (Pl. III. figs. 21–23; Pl. V. figs. 40–43.)

Female. Length 3·2 mm. (1-8th of an inch). Body stout. Abdomen short, 4-jointed Forehead with a median keel extending round the front to the bifid rostrum. Anterior antennæ rather longer than the thorax, 23-jointed, sparingly setiferous (fig. 58). The proportional lengths of the joints are as shown in the formula:—

$$\frac{35 \,.\, 5 \,.\, 5 \,.\, 5 \,.\, 5 \,.\, 5 \,.\, 11 \,.\, 5 \,.\, 5 \,.\, 6 \,.\, 8 \,.\, 8 \,.\, 8 \,.\, 8 \,.\, 9 \,.\, 9 \,.\, 6 \,.\, 8 \,.\, 8 \,.\, 6 \,.\, 9 \,.\, 10 \,.\, 7}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21 \quad 22 \quad 23}.$$

The posterior antennæ, mouth-organs, and swimming-feet are somewhat as in *Scolecithrix Danæ*, but the anterior foot-jaws are strongly gibbous on the underside (Pl. V. fig. 42). The fifth pair of feet are simple, considerably dilated, especially towards the end, and are each furnished with three spines on the broadly-rounded apex; the inner spine, which is longer than the others, is finely serrate on the outer margin, the others are plain (Pl. III. fig. 22). Caudal stylets short, slightly divergent, and furnished with four long, plumose, terminal setæ.

This form, of which only one or two specimens (females) were obtained, occurred in a gathering from 85 fathoms, collected February 5th at Station 23 (lat. 4° 26′ 7″ S., long. 10° 1′ 8″ E.).

Scolecithrix tatipes was readily distinguished from the other species of *Scolecithrix* by the peculiar form of the fifth pair of feet, which are broad and leaf-like.

SCOLECITHRIX MAJOR, n. sp. (Pl. III. figs. 24–26; Pl. V. figs. 44, 45.)

Female. Length 3 mm. (1-8th of an inch). Body elongate. The anterior foot-jaws are stout and the marginal lobes are furnished with long, spiniform, plumose, terminal setæ; all the sensory filaments are large with the exception of two, which are smaller and provided with elongate acutely-pointed heads. The terminal spines of the swimming-feet, especially those of the third and fourth pairs, are coarsely toothed on the outer margin; there are sixteen or seventeen large teeth along the margin. Fifth pair small, simple, 2-jointed; the last joint is about three times the length of the other, and armed with one moderately long terminal and one small subterminal spine, while a long spiniform seta springs from near the middle of the inner margin. Abdomen long, composed of four segments, the first three nearly equal, the last much shorter. Caudal stylets short, about as long as the last abdominal segment; apical setæ four, plumose.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms (day collection, January 22nd).

The form of the animal, the armature of the anterior foot-jaws, and the coarsely-toothed terminal spines of the swimming-feet are characters which distinguish this from other species of *Scolecithrix*. A considerable portion of the anterior antennæ was wanting in the only specimen obtained.

SCOLECITHRIX TUMIDA, n. sp.* (Pl. III. figs. 33–38.)

? *Scolecithrix abyssalis*, Giesbrecht, op. cit. p. 284, pl. 13. figs. 15, 40, pl. 37. fig. 7.

Female. Length 2·4 mm. Body somewhat robust; forehead obtuse, with a small

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* This is probably the *Scolecithrix abyssalis* of Giesbrecht; but, as there appear to be some differences between his

rostrum; postero-lateral angles of last thoracic segment rounded. Anterior antennæ long, reaching to near the extremity of the abdomen, 21-jointed and sparingly setiferous. The annexed formula shows the proportional lengths of the joints :—

12	3	3	3	3	3	8	3	3	4	6	6	7	7	8	7	7	7	6	8	11
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Anterior foot-jaws stout; four of the marginal lobes are each armed with a long setiferous spine and two setæ; a number of slender sensory filaments spring from the end of the anterior foot-jaws as in other species of *Scolecithrix*. The terminal spines of the swimming-feet are finely toothed on the outer margin; the arrangement of the marginal teeth of the terminal spines of the third and fourth pairs differs from those of the second, as shown in figure 36. The fifth pair are small, somewhat dilated, and 1-jointed, armed with one terminal spine, a stout and prominent spine on the inner margin, and a small tooth on the outer margin (fig. 37). Abdomen short, stout, the last segment small. Caudal stylets short, the breadth about equal to the length, and furnished with one subterminal and three apical setæ.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms (January 22nd, day collection). Station 23, 85, and 235 fathoms (February 5th, day collection).

Scolecithrix tumida is a rare species in the 'Buccaneer' collections; its robust form, the spinous armature of the anterior foot-jaws, and the dilated fifth pair of feet are characters that readily distinguish it from other species of *Scolecithrix*.

SCOLECITHRIX DUBIA, Giesbrecht. (Pl. III. figs. 27–32.)

1892. *Scolecithrix dubia,* Giesbrecht, op. cit. p. 284, pl. 13. fig. 29 *a*.

1892. *Scolecithrix simulans,* Scott (MS. name).

? *Male.* Length 1·6 mm. Body robust; abdomen of moderate length, 3-jointed, the middle segment rather shorter than the first or last. Anterior antennæ reaching to about the end of the second abdominal segment, sparingly setiferous, composed of twenty joints, the eighth equal to the entire length of the preceding four, the last two elongate, slender. The formula shows the proportional lengths of the different joints :—

5	5	3	3	3	3	3	12	3	5	6	7	7	7	7	5	5	4	8	9
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

The articulation between the sixteenth and seventeenth joints of the right antenna is imperfect and somewhat indistinct. The posterior antennæ, mouth-appendages, and first four pairs of swimming-feet nearly as in *Scolecithrix Danæ*, except that the marginal lobes, especially the one nearest the apex, of the anterior foot-jaws bear elongate curved spines with ciliate inner margins; the apex, as in *Scolecithrix Danæ,* bears a number of hair-like filaments (fig. 29). The terminal spines of the swimming-feet are finely serrate on the outer and ciliate on the inner margins. The fifth pair are unequal; the (?) left consists of three joints; the basal part of the elongate middle joint is considerably swollen and bears a (?) spiniform appendage on its inner aspect; the inner angle at the distal end

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description and figures and the description and figures given in this Report, I leave the 'Buccaneer' species as originally described.

forms a produced lobe-like process; the last joint small, curved inward, and bearing a minute bent terminal spine. The (?) right foot is longer than the other and 5-jointed; the first joint is about twice the length of the first joint of the (?) left foot, but the first and second joints of the (?) right are together scarcely equal to the length of the same joints of the other foot; an elongate appendage—? as long as the third joint—springs from the end of the second joint; the third and fourth joints, which are subequal in length, are more slender than the preceding joint, and are together nearly equal in length to the first; the fifth, which is scarcely so long as the fourth and appears to be connected with it by a hinged articulation, is ciliate on the inner edge.

Habitat. Lat. 4° 26′ 7″ S., long. 10° 1′ 8″ E., in a tow-net gathering from 235 fathoms collected between 11 A.M. and 3.30 P.M. February 5th.

This *Scolecithrix* somewhat resembles *Amallophora* in the form of the feet of the fifth pair, but differs in the number and proportional length of the joints. It also differs from any other *Scolecithrix* described in this Report in the proportional length of the joints of the anterior antennæ, the form of the anterior foot-jaws, and the fifth pair of feet.

Subgenus AMALLOPHORA *.

(Subgenus of *Scolecithrix*, Brady.)

Anterior antennæ 20- to 23-jointed. Mouth-organs and swimming-feet nearly as in *Scolecithrix*, except that the anterior foot-jaws are furnished with one or more appendages, each consisting of a bundle of filaments resembling a sheaf of corn in miniature. Fifth pair of feet in the male dissimilar, 1- or 2-branched, prehensile; in the female simple, 1-branched.

AMALLOPHORA TYPICA, n. sp. (Pl. III. figs. 39–46; Pl. VI. figs. 1–4.)

Length 2·7 mm. (about 1-9th of an inch). Body elongate, moderately stout; forehead rounded. Anterior antennæ rather longer than the body, 20-jointed, and sparingly setiferous. The formula shows approximately the proportional lengths of the joints:—

$$\frac{15}{1}.\frac{18}{2}.\frac{10}{3}.\frac{10}{4}.\frac{10}{5}.\frac{10}{6}.\frac{10}{7}.\frac{17}{8}.\frac{64}{9}.\frac{21}{10}.\frac{25}{11}.\frac{26}{12}.\frac{26}{13}.\frac{22}{14}.\frac{14}{15}.\frac{15}{16}.\frac{14}{17}.\frac{16}{18}.\frac{14}{19}.\frac{10}{20}.$$

The first seven joints bear short club-shaped appendages. Primary branch of the posterior antennæ short, secondary branch moderately long, the intermediate three very short (fig. 41). Mandible small, with a large 2-branched palp, one of the branches 2-, the other 4-jointed (fig. 42). Anterior foot-jaws stout, short, 4-jointed, first joint long, the second provided with an appendage bearing a large rounded cluster of curled filaments, and somewhat resembling a sheaf of corn in miniature; third and fourth joints small and armed with a large spiniform and several small plumose setæ (fig. 44). Posterior foot-jaws slender and elongate, 6-jointed, the first, second, and fourth joints long, the others very short and bearing a few setæ. The first four pairs of swimming-feet as in *Scolecithrix*; the terminal spines are strongly serrate on the outer edge, those of the third

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* Ἄμαλλα, a bundle or sheaf, and φέρειν, to carry.

pair considerably narrowed at the base. The fifth pair is simple, consisting of one short 3-jointed branch, which terminates in a small spine, and one very long and slender branch, composed of four nearly equal parts, and bearing a ciliate digitiform process and a number of short setæ at the apex. Abdomen short, the first segment rather narrower than the next; the last is very small. The caudal stylets are also very short and somewhat divergent (Pl. IV. fig. 4).

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., in a tow-net gathering from 35 fathoms, collected January 22nd. Only one specimen of this curious form was obtained.

AMALLOPHORA MAGNA, n. sp. (Pl. IV. figs. 5–9.)

Female. Length about 4·5 mm. (2-11ths of an inch). Body robust, attenuated towards the front, the first segment equal to the entire length of the other body-segments and abdomen; head produced into a distinct though small median keel, which passes round over the forehead (fig. 31). The postero-lateral angles of the last thoracic segment are produced ventrally into a small tooth. Anterior foot-jaws small; four of the marginal lobes are furnished with long terminal plumose setæ, while the other forms the base of a long setose spine; several small sensory filaments, some of which have rounded heads, spring from the extremity of the foot-jaw, as shown in fig. 6. The other mouth-organs and swimming-feet are similar to those in *Scolecithrix Danæ*, except that the large terminal spines of the swimming-feet are strongly toothed on the outer margin. The fifth pair are very small, simple, 2-jointed; the second joint is nearly twice the length of the other and provided with one terminal and two submarginal setæ; the terminal and one of the submarginal setæ are long and slender, the other is very short (fig. 9). Abdomen short.

Habitat. Off São Thomé Island, 20 fathoms, January 23rd (day collection).

One specimen only of this curious form was obtained; it wanted a considerable portion of the anterior antennæ and part of the abdomen, but, though thus mutilated, the peculiar structure of the anterior foot-jaws and the large, strongly-toothed, terminal spines of the swimming-feet, together with the large size of the animal, readily distinguish this from allied species. No males were observed.

AMALLOPHORA DUBIA, n. sp. (Pl. IV. figs. 10–18.)

Male. Length 2·5 mm. (1-10th of an inch). In this species the first cephalothoracic segment is nearly equal to the entire length of the other three body-segments and the abdomen. Anterior antennæ about as long as the cephalothorax; the right antenna is 18-, the left 23-jointed; in the right antenna, which is indistinctly geniculate at the proximal half (fig. 11), the seventh joint is composed of five and the fifteenth of two coalesced joints; the first thirteen joints of the left antenna and the corresponding joints of the right have a row of elongate setæ along the upper margin, each of which is furnished with a membrane-like unilateral expansion or fringe as shown in the figure, but the remaining portion of the antennæ is only sparingly setiferous. The annexed formula shows the proportional lengths of the right and left antennæ:—

Right antenna.	12	4	4	4	4	4	18	5	5	7	12	12	11	10	12	5	8	9.					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18.					
Left antenna.	12	4	4	4	4	4	4	4	4	4	4	5	5	7	13	13	13	12	6	6	5	10	10.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23.

The mouth-organs are as in *Scolecilhrix*, except that the anterior foot-jaws are each provided with two peculiar appendages, consisting of a moderately stout filament bearing an oblong conical head, which appears to be composed of dense fibre-like tissue (fig. 13). The posterior foot-jaws are furnished at the extremity with a few hair-like papilliferous filaments (fig. 14). The swimming-feet are as in *Scolecithrix*, but the first four pairs differ in the form and amount of their armature (figs. 15, 16). The fifth pair has the second joint of the left foot elongate; the basal part of the joint is greatly dilated, and is furnished interiorly with a spiniform appendage which terminates in a small apical seta; the third and fourth joints are small and slender; both branches of the right foot are 2-jointed and furnished with small digitiform terminal processes (fig. 17). The abdomen is composed of four segments, the first being rather shorter than the others. Caudal stylets short, each bearing four moderately long, plumose, terminal hairs (fig. 18).

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5′ E. In two gatherings, one from 360 fathoms and one from 460 fathoms. Collected during the middle of the day, January 22nd.

Variety *similis.* (Pl. IV. figs. 19–23.)

This is a form which occurred along with the other in the gathering from 460 fathoms, and which, though closely resembling it, yet differs in a few points. It resembles *Amallophora dubia*, especially in the form of the fifth pair of feet, but differs considerably in the proportional length of the joints of the anterior antennæ and of the segments of the abdomen, as will be observed by comparing the figures of the variety with those of the species.

AMALLOPHORA ROBUSTA, n. sp. (Pl. IV. figs. 24–29.)

Female. Length 3 mm. (1-8th of an inch). The body is robust, with a rounded forehead and a small rostrum. The anterior foot-jaws are provided with a number of terminal filaments, the majority of which are comparatively short and possess ovate conical heads, while three of them are stout and moderately long and resemble those in *Scolecithrix* (fig. 25). Posterior foot-jaws as in *Scolecithrix*, except that the first joint in each is furnished with a short and stout filament having an ovate pointed head like the smaller filaments of the anterior foot-jaws. The swimming-feet are similar to those of *Amallophora magna*, but the terminal spines are long, and finely serrate on the outer edge, and plain on the inner edge. The fifth feet are small, simple, and 2-jointed; a large setose spine springs from the inner margin, and a small spiniform seta from the outer margin, of the last joint; while a plain spine, smaller than that on the inner margin, springs from the inner part of the rounded apex, as shown in the figure (fig. 28). Abdomen comparatively small, 4-jointed, the segments subequal. Caudal stylets about half the length of the last abdominal segment, and furnished with four apical plumose setæ.

Habitat. Station 23 (Lat. 4° 26′ 7″ S., long. 10° 1′ 8″ E.), in a gathering from 85 fathoms. Collected about midday, February 5th.

One or two specimens only of this species were obtained. The armature of the anterior and posterior foot-jaws, the long and finely serrate terminal spines of the swimming-feet, and the form and armature of the fifth pair are characters by which this may be distinguished from other allied species.

Genus EUCHÆTA, Philippi.

Euchæta, Philippi, Archiv f. Naturgesch. 1843; Dana, Proc. Amer. Acad. Sci. 1849; Claus, Die freilebenden Copepoden, 1863; Brady, Report Chall. Copep. 1883.

EUCHÆTA MARINA (Prestandrea, 1833).

1843. *Euchæta Prestandreæ*, Philippi, Archiv. f. Naturgesch. Taf. iv. fig. 5.

1863. *Euchæta Prestandreæ*, Claus, Die freilebenden Copepoden, p. 183, pl. v. fig. 12 *a*, pl. ix. figs. 6, 7, 9, 12, pl. xxx. figs. 8–17.

1883. *Euchæta Prestandreæ*, Brady, Report Chall. Copep. p. 60, pl. xviii. figs. 7–15, and pl. xix.

1892. *Euchæta marina*, Giesbrecht, Fauna und Flora des Golfes von Neapel (Copepoden), p. 262, pls. 1, 15, 16, 37.

Habitat. Stations 2, 3, 9, 11, 14, 21, 24, and others; also Lagoon, São Thomé Island, surface tow-nettings.

Euchæta marina was one of the commoner species observed in the collection. It occurred in 106 tow-nettings, 47 of which were surface-gatherings and 59 under-surface, ranging from 2 to 460 fathoms. 16 of the surface and 41 of the under-surface tow-nettings were collected during the day, and 31 of the surface and 18 of the under-surface during the night, as represented in the formula:—

$$\text{Tow-nettings } 106\begin{cases}47 \text{ surface} & \begin{cases}16 \text{ day collections.}\\ 31 \text{ night ditto.}\end{cases}\\ 59 \text{ under-surface} & \begin{cases}41 \text{ day ditto.}\\ 18 \text{ night ditto.}\end{cases}\end{cases}$$

A greater number of *Euchæta marina* carried ova than any other species of Calanidæ in the 'Buccaneer' collection. The clusters of ova somewhat resembled miniature bunches of grapes.

EUCHÆTA PULCHRA (Lubbock).

1856. *Undina pulchra*, Lubbock, Trans. Entom. Soc. iv. p. 14, pl. iv. figs. 5–8, pl. vii. fig. 6.

1883. *Euchæta pulchra*, Brady, Report Chall. Copep. p. 63, pl. xiv. figs. 6–9, pl. xx. figs. 14–19.

Habitat. Lat. 7° 33′ N., long. 15° 18′ W., 25 fathoms tow-netting, January 2nd (night collection). Lat. 2° 34′ 9″ N., long. 5° 22′ 2″ E., 20 fathoms, January 21st (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35 fathoms, January 22nd (day collection). Lat. 0° 25′ 1″ N., long. 6° 36′ 6″ E., 10 fathoms, January 24th (night collection). These are the only tow-nettings in which this *Euchæta* was observed, and a few specimens only were obtained.

Euchæta australis, Brady. (Pl. VI. fig. 23.)

1883. *Euchæta australis,* Brady, Report Chall. Copep. p. 65, pl. xxi. figs. 5–11.

A single specimen of this species (a male) was obtained in a tow-net gathering from 50 fathoms at Station 2 (lat. 7° 54′ N., long. 17° 25′ W.). Collected between 7.20 and 8.20 p.m., January 1st. I have nothing to add to the description of this apparently rare species contained in the Report on the Copepoda of the 'Challenger' Expedition. The species, after being dissected, was easily recognized by the description and figures of it in that Report.

Euchæta gigas, Brady.

1883. *Euchæta gigas,* Brady, loc. cit. p. 65, pl. xxii. figs. 1–5.

This *Euchæta* was obtained in a tow-net gathering from a depth of 35 fathoms in lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E. Collected during the day, January 22nd. Two or at most three specimens (females) were obtained.

Euchæta barbata, Brady. (Pl. VI. fig. 17.)

1883. *Euchæta barbata,* Brady, loc. cit. p. 66, pl. xxii. figs. 6–12.

This *Euchæta* was obtained in three different tow-net gatherings, in one from 50 fathoms at Station 2, January 1st, in one from 360 fathoms in lat. 1° 55″ 5′ N., long. 5° 55′ 5″ E., January 22nd, and in one from 30 fathoms, at Station 23, February 4th.

This remarkable species is readily distinguished from other *Euchætæ* by the tufts of setæ on the last abdominal segment, by the first abdominal segment being greatly dilated ventrally, and by the tufts of setæ on the posterior angles of the last thoracic segment. Very few specimens (females) were obtained.

Euchæta (?) Hessei, Brady, var. similis, nov. var. (Pl. VI. figs. 24 & 25.)

1883. *Euchæta Hessei,* Brady, loc. cit. p. 63, pl. xx. figs. 1–13, pl. xxiii. figs. 11–14.

Male. Length 2·2 mm. (1-12th of an inch). Body elongate, rounded in front; the postero-lateral angles of the last thoracic segment are produced in aculeate spines, as shown in fig. 1. Anterior antennæ as long as the thorax, 21-jointed, geniculate at the twelfth joint; the eighth and twelfth joints are composed of two or three coalesced joints and are indistinctly articulated; the basal joints are furnished with leaf-like appendages, and a club-shaped filament springs from the end of the last joint. The annexed formula shows the proportional lengths of the joints:—

$$\frac{10\,.\,3\,.\,3\,.\,3\,.\,3\,.\,3\,.\,3\,.\,8\,.\,3\,.\,3\,.\,4\,.\,4\,.\,5\,.\,6\,.\,6\,.\,6\,.\,9\,.\,14\,.\,8\,.\,8\,.\,8}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9\quad 10\quad 11\quad 12\quad 13\quad 14\quad 15\quad 16\quad 17\quad 18\quad 19\quad 20\quad 21}.$$

Posterior antennæ and mouth-organs similar to those of *Euchæta marina,* but the anterior foot-jaws, though small, are somewhat stout, as shown in fig. 4. Swimming-feet also as in that species, except that the terminal spines of the swimming-feet are more coarsely serrate—especially those of the third and fourth pairs, the serrations of which number about eighteen; the secondary spines of the second pair are longer than in the other swimming-feet. The fifth pair (fig. 25) closely resemble those of *Euchæta Hessei* as figured in the 'Challenger' Copepoda. Abdomen composed of four nearly equal segments. Caudal stylets very short, furnished with four long plumose hairs.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms (day collection, January 22nd).

This comes very near *Euchæta Hessei*,* and is possibly a form of that species. It differs in the following points:—It wants the prominent rostrum of *Euchæta Hessei*; the posterior margin of the last thoracic segment bears on each side a small but distinct aculeate spine; it possesses small but stout anterior foot-jaws; the inner edge of the terminal spines of the swimming-feet is densely ciliate. The right foot of the fifth pair has no secondary appendage and terminates in a spiniform process; the left foot has a very short inner appendage, and the last joint, which is elongate, is geniculate near the middle. No females were observed.

EUCHÆTA HEBES, Giesbrecht. (Pl. VI. figs. 18 & 19.)

1892. *Euchæta hebes*, Giesbrecht, op. cit. p. 263, pls. 15, 16, 37.

Male. Length 2·7 mm. (1-9th of an inch). Body elongate, rostrum small. Anterior antennæ not longer than the thorax, 22-jointed; the second joint bears a number of small club-shaped appendages; the upper margin of the eighth joint is produced near the distal end into a small digitiform setiferous lobe; the proportional lengths of the joints is shown in the annexed formula:—

$$\frac{6\,.\,5\,.\,3\,.\,3\,.\,3\,.\,4\,.\,4\,.\,9\,.\,4\,.\,4\,.\,6\,.\,6\,.\,6\,.\,7\,.\,7\,.\,8\,.\,9\,.\,8\,.\,8\,.\,9\,.\,8\,.\,11}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9\quad 10\quad 11\quad 12\quad 13\quad 14\quad 15\quad 16\quad 17\quad 18\quad 19\quad 20\quad 21\quad 22}.$$

Posterior antennæ robust, the primary branch considerably shorter than the secondary. Mouth-organs as in *Euchæta marina*, except that the posterior foot-jaws are comparatively short and stout. Swimming-feet nearly as in *Euchæta marina*; the fifth pair are unequal in length; the left is 2-branched, the outer branch 3-jointed, the last joint being long and slender, with a bluntly rounded extremity, the inner branch is 1-jointed and as long as the first two joints of the outer branch; the right foot, which has a small rudimentary inner branch, is shorter than the other and terminates in three processes; one of these processes is stout, curved, and spiniform; the second is oblong-ovate, somewhat truncate at the apex, and bears a dense fringe of cilia on the distal end of the inner margin; the third is a strong, somewhat hook-like appendage, serrate on the inner edge. The whole forms a complicate apparatus with which the left foot probably interlocks. Abdomen elongate, of four nearly equal segments, the posterior margins of which are serrate. Caudal stylets very short, nearly obsolete, and furnished with four plumose setæ—the third from the outside being considerably longer than the others.

Habitat. Station 2, 50 fathoms (night collection, January 1st). Station 9, 50 fathoms (day collection, January 10th).

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* This reference is to the description and drawings of *Euchæta Hessei* in the 'Challenger' Copepoda, as no *Euchæta* agreeing with these was obtained in the 'Buccaneer' collections.

This species is closely allied to *Euchæta marina*, but differs in several important points and especially in the character of the fifth feet; it also wants the prominent bifid rostrum of that species. No females were observed.

EUCHÆTA HEBES, var. VALIDA. (Pl. VI. figs. 20–22.)

A form, which may be only a variety of *Euchæta hebes*, occurred along with that species in a tow-net gathering from 50 fathoms at Station 2 (lat. 7° 54′ N., long. 17° 25′ W.). But while resembling *Euchæta hebes* in general form and in the form of the fifth feet, it differs in some of its structural details as well as by its much greater size. The following is a description of some of its more obvious differences:—

Length (male) 5·7 mm., of which the body forms two-thirds and the abdomen one-third. Anterior antennæ reaching somewhat beyond the last thoracic segment, 22-jointed, sparingly setiferous; the eighth joint, which is longer than the preceding two together, and the seventeenth, eighteenth, and last are subequal, and are the longest joints of the antennæ. The proportional lengths of the joints are nearly as shown in the formula:—

$$\frac{12 . 12 . 5 . 6 . 7 . 8 . 9 . 19 . 6 . 8 . 11 . 10 . 13 . 14 . 15 . 16 . 19 . 19 . 16 . 16 . 15 . 19}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21 \quad 22}.$$

Between each of the large marginal teeth of the proximal half of the terminal spines of the second, third, and fourth swimming-feet there is a very small tooth; it can only be satisfactorily distinguished by using a moderately high magnification (fig. 21). The second joint of the (?) right foot of the fifth pair is moderately short and considerably swollen, and bears interiorly at its distal end an appendage, the length of which is rather greater than the elongate third joint; the fourth joint is very slender and as long as the third, and terminates in a blunt-pointed extremity. The (?) left foot is 4-jointed, the first joint is short, the second and third elongate; the last, which is comparatively short, ends in a complex trifid apparatus, somewhat similar to that of *Euchæta hebes* (fig. 22). Abdomen slender, the last segment about two-thirds the length of the preceding. Stylets short, their breadth scarcely equal to the length; the long seta—the third seta from the outside—of each is at least equal in length to the abdomen.

Genus CANDACE, Dana.

Candacia, Dana, Amer. Journ. Sci. 1846.
Ifionyx, Kröyer, Nat. Tidsskr. 1849.
Candace, Dana, U. S. Expl. Exped. 1852.

CANDACE PACHYDACTYLA, Dana.

1852. *Candace pachydactyla*, Dana, U. S. Expl. Exped. p. 1113, pl. lxxviii. figs. 2 *a–b*.
1883. *Candace pachydactyla*, Brady, Report Chall. Exped. p. 68, pl. xxxi. figs. 2–9.

Habitat. Station 2, 5 fathoms tow-netting, January 1st (night collection). Lat. 4° 21′ 8″ N., long. 1° 57′ W., surface tow-netting, January 14th (day collection). Station 24, 10 fathoms, January 21st (night collection). Lagoon, São Thomé Island, surface, January 27th (day collection). Station 23, surface, 10, 20, 85, and 185 fathoms tow-nettings, February 5th (day collection). Lat. 8° 36′ 8″ S., long. 12° 57′ E., surface, February 9th (day collection).

This *Candace* was obtained from 57 tow-nettings, 24 of which were surface and 33 under-surface gatherings; 37 of the tow-nettings (16 surface and 21 under-surface) were collected during the day, and 20 (8 surface and 12 under-surface) were collected during the night, as shown in the formula:—

Tow-nettings 57	24 surface	16 day collection.
		8 night ditto.
	33 under-surface	21 day ditto.
		12 night ditto.

The under-surface tow-nettings ranged in depth from 2 to 260 fathoms. *Candace pachydactyla*, as noted above, occurred in twice as many day surface as in night surface-gatherings; its distribution in this respect is thus more or less the reverse of that of most of the species described in this Report.

Candace pectinata, Brady.

1878. *Candace pectinata*, Brady, Monog. Brit. Copep. i. p. 49, pl. viii. figs. 14, 15; pl. x. figs. 1–12.
1883. *Candace pectinata*, Brady, Report Chall. Copep. p. 67, pl. xxx. figs. 1–13.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35 fathoms, January 22nd (day collection). Station 23, surface tow-netting, February 5th (day collection).

This *Candace* was of rare occurrence in the 'Buccaneer' collections.

Candace intermedia, n. sp. (Pl. IV. figs. 30–37.)

? *Candace curta*, Dana (1852), Crust. U. S. Expl. Expedition.

Length, exclusive of tail-setæ, 2·46 mm. In form somewhat like *Candace pectinata*, Brady, but the posterior margin of the first thoracic segment is produced in the median dorsal line so as to form a distinct hump, which is usually of a chocolate-brown colour, while the surrounding integument is white or nearly so (fig. 56). The last thoracic segment (figs. 62, 63) is furnished on each side with four small hairs, the posterior one being the longest. The 16th, 17th, and 18th joints of the right male antennæ are toothed in a manner somewhat similar to that of *Candace pectinata*, but the teeth on the 18th joint (the joint on the distal side of the hinge) do not form a distinct beard-like fringe as in that species. The proportional lengths of the joints, especially of the right male antenna, differ from those of *C. pectinata* and are very nearly as in the annexed formula:—

Male antennæ.	10	10	3	5	6	3	3	3	3	3	4	6	6	7	8	6	10	10	10	6	5	6	8.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23.
Female antennæ.	10	10	3	4	5	3	3	3	3	3	5	5	5	7	7	9	8	9	7	5	4	5	6.

The 17th joint in the male is usually dark-coloured. The mouth-organs and swimming-feet, except the fifth pair, resemble those of *Candace pectinata*. The fifth feet in the female are somewhat like those of *Candace pachydactyla*, but the terminal spines only are dark-coloured; the fifth feet in the male are intermediate in form (fig. 35) between *Candace pectinata* and *Candace pachydactyla.* The abdomen in the female has the first segment stout and rounded—not "produced at each side into a triangular prominence," as in *Candace pectinata.* The first segment in the male, however, is produced on the right side similar to that species. The posterior margin of all the abdominal segments is finely and distinctly serrate. Between the second and third setæ of the caudal stylets (counting from the outside) there is a short stout spine, which was quite conspicuous in some of the specimens.

This species is intermediate between *Candace pectinata* and *Candace pachydactyla,* but is readily distinguished from both by the characteristic dark-coloured dorsal hump described above.

Habitat. Station 2, 5 fathoms, January 1st (night collection). Station 9, 50 fathoms (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35 fathoms, January 22nd (day collection). Station 23, surface and 10 fathoms, February 5th (day collection). Lat. 7° 54′ 6″ S., long. 12° 14′ 7″ E., surface, February 9th (day collection). This species occurred in 16 tow-nettings, 9 of which were surface and 7 under-surface gatherings; the under-surface tow-nettings were from 5 to 50 fathoms. The proportion of day to night gatherings in which it was observed is shown in the annexed formula:—

$$\text{Tow-nettings } 16\left\{\begin{array}{l}9 \text{ surface } \left\{\begin{array}{l}2 \text{ day collections.}\\ 7 \text{ night ditto.}\end{array}\right.\\ 7 \text{ under-surface } \left\{\begin{array}{l}4 \text{ day ditto.}\\ 3 \text{ night ditto.}\end{array}\right.\end{array}\right.$$

Candace intermedia, though restricted in its distribution, was nevertheless of frequent occurrence in some of the gatherings in which it was observed.

CANDACE VARICANS, Giesbrecht. (Pl. IV. figs. 38, 39; Pl. VII. figs. 7–10.)

1892. *Candace varicans,* Giesbrecht, Fauna und Flora des Golfes von Neapel (Copepoden), p. 439, pl. 22. figs. 22, 23.

Candace tenuiremus, Scott (MS. name).

Length, exclusive of tail-setæ, 2·3 mm. Anterior antennæ long and slender, reaching to the extremity of the abdomen, 24-jointed in the female, the right antenna in the male 23-jointed; the proportional lengths of the joints as in the annexed formula:—

Male right antenna. 10 . 10 . 5 . 4 . 6 . 7 . 3 . 4 . 3 . 3 . 4 . 4 . 8 . 7 . 8 . 8 . 6 . 13 . 11 . 13 . 7 . 6 . 8.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24.
Female antenna ...12 . 10 . 4 . 4 . 6 . 8 . 4 . 3 . 4 . 4 . 4 . 7 . 7 . 8 . 9 . 10 . 11 . 12 . 13 . 12 . 7 . 6 . 7 . 10.

The 18th joint of the right male antenna (the joint on the proximal side of the hinge) is distinctly pectinate; the 17th joint, which is about half the length of the 18th, is finely toothed, and the 19th has a fringe of small fine setæ on the upper margin; several of the basal joints bear strong marginal spines, and the 20th joint is as long as the following two joints together. The female antennæ resemble those of *Candace truncata.* The mouth-organs and first four pairs of swimming-feet resemble those of other species of *Candace.* The 5th pair in the female 3-jointed, the last joint long, with three long, stout, terminal setose spines, and a small spine on the exterior margin below the middle of the segment; the 2nd joint has a stout seta on the exterior distal angle. The 5th pair in the male are somewhat similar to those of *Candace pectinata* and *Candace pachydactyla*; the left foot is 4-jointed, the penultimate being longer than the others, and furnished with a fringe of hairs on the lower exterior margin and a small spine near the interior distal angle; the outer margin of the last joint has a fringe of hairs on the upper half and four spines (2 short, 1 long, and 1 intermediate) near the margin of the lower half. There is a small tuft of hairs and a spine on the inner aspect of the same foot; the right foot terminates in a stout prehensile hand like *Candace pectinata.* The posterior thoracic segment has the lateral angles produced into stout prominent spines, which in the male reach to near the end of the first abdominal segment. The abdomen in the male 5-, in the female 3-jointed; the first segment of the female abdomen is about as long as the other two together, stout and rounded, but not produced into angular processes as in *Candace pectinata.* It resembles *Candace truncata* in this respect, but the middle segment is much shorter than in that species. The abdomen of the female in the 'Buccaneer' specimens is dark-coloured—almost black, but only the stylets of the male abdomen are dark-coloured. The tail-setæ are also dark-coloured and densely plumose. This species is intermediate between *Candace pachydactyla* and *Candace truncata*; its chief distinctive characters seem to be the form of the anterior male antenna and of the male and female fifth feet.

Habitat. Lat. 1° 55′ 5″ S., long. 5° 55′ 5″ E. It was obtained in two tow-nettings from this locality, one from 35 fathoms and one from 460 fathoms. The peculiar arrangement of the colour, together with its decided character, make the species, especially the females, quite conspicuous among their *confrères.*

CANDACE TRUNCATA, Dana.

1852. *Candace truncata,* Dana, Crust. U. S. Explor. Exped. p. 1118, pl. lxxviii. figs. 8 *a–d.*

1863. ? *Candace bispinosa,* Claus, Die freilebenden Copep. p. 191, pl. xxvii. figs. 9–16; pl. xxxiii. fig. 5.

1883. *Candace truncata,* Brady, Report 'Challenger' Copep. p. 69, pl. xxviii. figs. 12–15; pl. xxix. figs. 1–14.

Habitat. Station 2, 25 fathoms tow-netting, January 1st (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 20 and 30 fathoms tow-netting, January 22nd (day collections). Off São Thomé Island, lat. 0° 38′ 6″ N., long. 6° 25′ 8″ E., 20 fathoms tow-netting, January 23rd (day collection). Station 23, surface tow-netting, February 5th (day collection).

Candace truncata was a somewhat rare species in the 'Buccaneer' collection, the tow-nettings described above being the only ones in which it was observed. It nevertheless appears to have a wide distribution.

Genus Mormonilla, Giesbrecht (1891).

Corynuropis, Scott (MS. 1892).

Resembles *Corynura*, Brady, in general appearance but differs in the following details :—

1st. The body becomes gradually narrower posteriorly, so that the thorax and abdomen are not clearly defined the one from the other.

2nd. The secondary branch of the posterior antennæ is multiarticulate.

3rd. The maxillæ are provided with a well-developed bilobed palp.

4th. The anterior foot-jaws are large and resemble those of *Hemicalanus longicornis*, Claus.

5th. The posterior foot-jaws, which are furnished with a number of marginal setæ, are 2-jointed, the apical joint being comparatively short (fig. 17). They resemble neither *Acartia* nor *Corynura*.

6th. The outer branches of the first four pairs of swimming-feet are 2-, and the inner branches 1-jointed, except the first and second pairs, which appear to have the inner branches very indistinctly 2-jointed.

7th. In the female the fifth pair of feet is absent or obsolete. Male unknown.

These differences, especially the 3rd, 5th, and 7th, are too important to allow of the 'Buccaneer' specimens being ascribed to *Corynura*, even though the general resemblance is very striking.

Mormonilla phasma, Giesbrecht. (Pl. VII. figs. 11–21.)

1892. *Mormonilla phasma*, Giesbrecht, Fauna und Flora des Golfes von Neapel (Copepoden), p. 536, pl. 43. figs. 28–32, 34–41.

1892. *Corynuropis tenuicaudatus*, Scott (MS. name).

Female. Length 1·7 mm. Body elongate-pyriform, composed of five segments, the first equal to the combined length of the other body-segments and abdomen; forehead narrowly rounded. Anterior antennæ slender, 5-jointed, and bearing a number of long plain setæ, especially at the extremity, where there are six or seven of considerable length; the second and fourth joints are subequal and fully twice the length of the third joint, as shown by the annexed formula :—

$$\text{Anterior antennæ. } \frac{14\ .\ 20\ .\ 9\ .\ 23\ .\ 14}{1\quad 2\quad 3\quad 4\quad 5}.$$

The basal joint of the posterior antennæ short; the primary branch moderately stout, 2-jointed; the end joint about three-fourths the length of the first; the integument of both partly covered with fine cilia. Secondary branch rather longer than the first joint of the primary branch, 8-jointed; all the joints small except the first, which is nearly equal to the entire length of the next three; the last joint of the principal branch and all the joints of the secondary one are furnished with very long plumose setæ (fig. 13). Mandibles with a broad dentate biting part; the principal branch of the palp is furnished with long aculeate setæ, and the small secondary branch with plumose setæ (fig. 14).

The maxillæ are well developed and provided with a stout bilobed palp—one lobe bearing long plumose, the other aculeate setæ (fig. 15). Anterior foot-jaws large, 5-jointed, the first joint about twice the length of the remaining portion, the three apical joints very short; the third and fourth joints bear each one, and the last three, moderately long aculeate setæ; the anterior foot-jaws are also provided with four marginal setiferous lobes—three on the first joint and one on the proximal end of the second. Posterior foot-jaws smaller, 2-jointed, and bearing several stout marginal and terminal setæ; the last joint is comparatively short (fig. 17). The last joint of the outer branches of the first four pairs of swimming-feet are each provided with a long slender terminal spine, very finely serrate on the outer and ciliate on the inner edge, and also with several long plumose setæ; the inner branches, which are shorter than the outer, bear two long terminal setæ, and a subterminal one. In the first pair, which differ from the others, the exterior margin of the outer branch is armed with three stout spines and a subterminal spiniform seta, while the interior margin of the inner branch bears three processes resembling somewhat the dilated bases of rudimentary hairs. The inner margin of the second basal joint is also armed with several short spines (fig. 18). Abdomen slender, 3-jointed, the middle segment scarcely half the length of either the first or third. Caudal stylets very slender, once and a half the length of the abdomen, bearing each four long terminal setæ, and a small subterminal seta exteriorly, while a moderately long seta springs from the outer margin and near the base of each stylet, as shown in figure 21.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms, tow-net gathering. Collected during the day, January 22nd. Temperature of the water about 43° F. Lat. 4° 24′ 7″ S., long. 10° 1′ 8″ E., in tow-net gatherings from 235 fathoms and 185 fathoms. Collected between 11 A.M. and 3.30 P.M., February 5th. Temperature of the water at 200 fathoms 55° F. A considerable number of specimens were obtained in the first of the three gatherings. No males were observed.

This species has a close general resemblance to *Corynura gracilis*, Brady, and I was at first inclined to ascribe it to that genus, but a further study of the structure of the animal showed that there were differences between it and *Corynura* so important as to make its position in that genus untenable (see remarks to description of genus, p. 64).

Genus ACARTIA, Dana.

Acartia, Dana, Amer. Journ. Sci. 1846; Brady, Report ‘Chall.’ Copep. 1883.

Dias, Lilljeborg, Crust. ex. ord. trib. 1853; Claus, Die freilebend. Copep. 1863; Boeck, Oversigt Norg. Copep. 1864; Brady, Monogr. Brit. Copep. 1878.

ACARTIA LAXA, Dana.

1852. *Acartia laxa*, Dana, Crust. U.S. Expl. Exped. p. 1123, pl. lxxix. figs. 5 *a–c*.
1883. *Acartia laxa*, Brady, Report ‘Chall.’ Copep. p. 73, pl. xxxii. figs. 1–11.

Habitat. Station 2, 25 fathoms, tow-netting, January 1st (night collection). Station 9, 50 fathoms, January 10th (day collection). Off São Thomé Island (lat. 0° 38′ 6″ N., long. 6° 25′ 8″ E.), 20 fathoms, January 23rd (day collection). Station 22, 20 fathoms, February 4th (day collection). Lat. 5° 55′ 1″ S., long. 11° 30′ 7″ E., surface, February 18th (night collection), &c.

Acartia laxa was observed in 38 tow-nettings, 11 of which were surface and 27 under-surface gatherings. The under-surface tow-nettings ranged in depth from 5 to 235 fathoms. Four of the surface and 19 of the under-surface gatherings were collected during the day, while 7 surface and 8 under-surface gatherings were collected during the night, as shown in the formula :—

$$\text{Tow-nettings } 38 \begin{cases} \text{11 surface} & \begin{cases} \text{4 day collections.} \\ \text{7 night ditto.} \end{cases} \\ \text{27 under-surface} & \begin{cases} \text{19 day ditto.} \\ \text{8 night ditto.} \end{cases} \end{cases}$$

Acartia laxa was of frequent occurrence in nearly all of the tow-nettings in which it was observed.

ACARTIA DENTICORNIS, Brady.

1883. *Acartia denticornis*, Brady, op. cit. p. 73, pl. xxxi. fig. 1, pl. xxxii. figs. 12–17.

Habitat. Lagoon, São Thomé Island, surface tow-netting, January 27th (night collection). Libreville, Gaboon River, surface, January 28th (day collection). Lat. 4° 40′ S., long. 10° 25′ 2″ E., surface, February 5th (night collection). Bananah Creek, Congo River, surface, February 7th (day collection). Loanda Harbour, surface, February 13th (day collection).

The distribution of *Acartia denticornis* within the area dealt with in this Report appears to have been more restricted than *Acartia laxa*; it was also more confined to inshore and surface gatherings than was that species. It is interesting to note that this apparent preference of *A. denticornis* for localities more or less inshore is borne out to some extent by the 'Challenger' records, where the following statement occurs (*loc. cit.* p. 74) :—"Abundant in Hilo Harbour, Sandwich Islands (August 1875); one or two specimens noted in a gathering from the Philippine Islands and (?) in the Atlantic, north of Tristan d'Acunha."

Acartia denticornis was obtained in 14 of the 'Buccaneer' tow-nettings—all of them surface gatherings. Eight of the tow-nettings were day and 6 were night collections. The specific gravity of the water in which it occurred varied from 1·0255 to 1·0087.

ACARTIA PLUMOSA, n. sp. (Pl. VII. figs. 22–32.)

Length 1·2 mm. Body elongate-ovate, somewhat rounded in front; the rounded postero-lateral angles of the last thoracic segment bear a number of small spines. Anterior antennæ about as long as the cephalothorax, those of the female 20-jointed and furnished with numerous plumose setæ; the annexed formula shows the proportional lengths of the joints :—

$$\frac{18\,.\,11\,.\,10\,.\,9\,.\,12\,.\,8\,.\,8\,.\,5\,.\,13\,.\,11\,.\,15\,.\,15\,.\,15\,.\,12\,.\,14\,.\,15\,.\,10\,.\,18\,.\,10\,.\,8}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9\quad 10\quad 11\quad 12\quad 13\quad 14\quad 15\quad 16\quad 17\quad 18\quad 19\quad 20}.$$

The male right antenna is 17-jointed; the 11th, 12th, and 13th appear to be each composed of two coalesced joints, indistinctly hinged between the 12th and 13th joints, both of which are ciliate on the upper margin. On the proximal side of the hinge there is one and on the distal side three short stout spines, as shown in fig. 8. Posterior antennæ and mouth-organs as in *Paracartia spinicaudata*. The length of the joints of the inner branches of the first pair of swimming-feet is about equal, while the first joint of the outer branch is much stouter and once and a half the length of the next. The inner branch of the fourth pair is slender, the first joint of which reaches nearly to the middle of the second joint of the outer branch; the last joint of the outer branch is much smaller than either of the other two joints; the terminal spines are long and slender (fig. 27). The fifth pair in the female are each furnished with two long setæ, one of which is submarginal and plumose and one apical; the basal part of the plain apical seta is considerably dilated and gibbous (figs. 29, 30). The right fifth foot in the male is much longer than the other, and the penultimate joint, which is shorter than either the preceding or following joints, is produced interiorly into an elongate protuberance; the last joint of the left foot is armed with a large spine on its inner aspect; each foot terminates in a short stout spine, and the first joint of both is furnished with a long plum se seta on the outer margin (fig. 30). In the abdomen of the female the first segment is about once and a half the length of the next and fully twice the length of the last segment; the first and second segments are sparingly dentate on the posterior margin (fig. 31). Caudal stylets longer than the last, and nearly as long as the penultimate, abdominal segment; caudal setæ as in *Acartia Clausi*. The first segment in the male abdomen is considerably narrower than those that follow. The caudal stylets are about three-fourths the length of those of the female and not longer than the last abdominal segment, and furnished with setæ as in the female (fig. 32).

Habitat. Bananah Creek, Congo River, in a surface gathering collected at noon, February 7th; the specific gravity of the water when the gathering was made was 1·00870; and in Loanda Harbour, in two surface gatherings collected in the seaward part of the Harbour during the afternoon of the 15th February. The surface temperature of the water was about 79° F.

Acartia plumosa somewhat resembles *Acartia discaudata* (Giesb.), especially in the male right anterior antennæ and fifth pair of feet, which are quite prominent in adult specimens.

ACARTIA CLAUSI, Giesbrecht. (Pl. VII. figs. 33–40.)

1889. *Acartia Clausi*, Giesbrecht, Rendiconti R. Accad. d. Lincei, vol. v. fasc. 11.
1892. *Acartia gaboonensis*, Scott (MS. name).

Length fully 1 mm. Viewed dorsally the body is oblong-ovate, the forehead is broadly triangular, almost truncate, with the lateral angles somewhat produced; the last thoracic segment has the postero-lateral angles rounded. Anterior antennæ nearly as long as the thorax, those of the female, which are 21-jointed, are sparingly setiferous, except towards the extremity, where the last five joints bear moderately long plumose setæ; a plumose seta also springs from the 8th and 12th joints, counting from the end. The proportional lengths of the joints are nearly as shown in the formula:—

$$\frac{34 . 8 . 10 . 6 . 11 . 16 . 14 . 15 . 15 . 13 . 11 . 16 . 18 . 18 . 15 . 15 . 17 . 9 . 16 . 10 . 6}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21}.$$

The jointing of the proximal half of the antennæ was somewhat indistinct and required a high power of the microscope and careful focussing to make out the articulations. The right anterior antenna of the male is 15-jointed, and hinged between the 11th and 12th joints; both of these joints are fringed with small teeth on the upper margin, while a moderately stout spine springs from the proximal end of the 12th joint (fig. 35); the male antennæ are shorter than those of the female, and are provided with a greater number of plumose setæ. The posterior antennæ and mouth-organs resemble those of *Paracartia spinicaudata*. The first four pairs of swimming-feet also resemble those of that species. The fifth pair in the female have the apex subtriangular and are each furnished interiorly with an elongate stout spine, serrate on the inner margin of the distal half and exteriorly with a long plumose seta (fig. 31). In the male the fifth pair are comparatively short and stout, as in *Acartia denticornis*, Brady; the proximal joint of each is furnished on the exterior margin with a long plumose seta (fig. 38). Abdomen in the female short, stout, and composed of three segments; the first is longer than both the other two together, the second is about equal in length to the third; the posterior margin of the first and second joints is fringed with small teeth. The caudal stylets are somewhat longer than the last abdominal segment, and are each provided with six plumose setæ arranged as follows:—one, strongly curved, near the middle of the exterior margin; one subterminal; three terminal, the middle one being much longer than any of the others; and one (small) on the lower half and near the inner margin of the stylet. The abdomen in the male is composed of five segments; the first is rather narrower than the next, and the penultimate one is very short. The stylets are shorter than those of the female, but the number and arrangement of the plumose setæ are similar (fig. 34).

Habitat. Libreville, Gaboon River, in a surface gathering collected at midday, January 28th. The surface temperature of the water was 83°·4 F., and the specific gravity 1·02301.

This *Acartia* resembles *Acartia denticornis*, Brady, in several of its characters, but differs in some important points, especially in the armature and proportional length of the joints of the male right anterior antenna and in the form of the male and female fifth feet and abdomen.

Subgenus PARACARTIA, n. subgen.

Near *Acartia*, Dana, but differing very markedly in the form of the fifth pair of feet, which in the female are each armed with a stout curved spine; in the male the fifth pair are large and unsymmetrical, that of the left side being about half the length of the right; the male right antenna has also the joints of the proximal half somewhat tumid, as in *Pontella*.

Paracartia spinicaudata, n. sp. (Pl. VIII. figs. 1–11.)

Female. Length 1·25 mm. Cephalothorax elongate, rather tumid, rounded in front, the postero-lateral angles of the last thoracic segment acute. Anterior antenna as long as the cephalothorax, 20-jointed, and bearing a number of long plumose setæ distributed as follows—one on each of the 2nd, 3rd, 4th, 8th, 9th, 10th, 13th, 15th, 16th, and 18th joints, two (one smaller than the other) on the 19th, and five on the last joint. The 7th joint is about as long as all the preceding three together; the 12th and last joints are shorter than the others. The proportional lengths of the joints are nearly as in the annexed formula :—

$$\frac{30 . 16 . 9 . 13 . 11 . 9 . 30 . 15 . 10 . 15 . 15 . 12 . 6 . 14 . 12 . 16 . 13 . 15 . 14 . 7}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20}.$$

Posterior antennæ, mouth-organs, and first four pairs of swimming-feet as in *Acartia laxa*, except that the last joint of the outer branch of the first swimming-feet has the lower exterior surface setose. Fifth pair of feet small, 1-branched, the basal part short and tumid and furnished with a stout curved spine, the distal half of which is strongly toothed on both margins; exteriorly and close to the spine and about a third of its length is a small plain seta; the right and left branches are alike. Abdomen short, 3-jointed; the first segment is somewhat triangular in form and has the distal end fully twice the breadth of the next segment; it is also longer than both the second and last segments together. Caudal stylets short and broad, rather longer than the last abdominal segment, each stylet armed with a prominent and strong terminal spine and two setæ, one on each side of the spine; there are also two setæ on the exterior margin of the stylets, and a third, with a distinct basal part, a little above the inner of the two terminal setæ. The terminal spines, which are about double the length of the stylets, and all the setæ, except the one last described, are plumose.

Habitat. Bananah Creek, Congo River, in one surface tow-netting collected at noon and in another collected at 4.30 p.m. February 7th, 1886. Several specimens, all females, were obtained in these two tow-nettings.

The more obvious characters which serve to distinguish this species are the fifth feet and the peculiar form of the abdomen.

Paracartia dubia, n. sp. (Pl. VII. figs. 41, 42; Pl. VIII. figs. 12–15.)

Male. Length about 1·2 mm. Body elongate, broadly subtriangular in front, and rounded posteriorly, composed of five segments; head indistinctly separated from the thorax. Anterior antennæ about as long as the body, that of the left side provided with a number of moderately long setæ, 20-jointed, the proportional lengths of the joints being nearly as shown in the formula :—

$$\frac{16 . 14 . 6 . 5 . 5 . 8 . 10 . 10 . 12 . 11 . 9 . 20 . 20 . 15 . 12 . 16 . 11 . 18 . 10 . 8}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20}.$$

The proximal half of the right antenna, which bears several long plumose hairs, has the lower portion somewhat dilated; there is a hinged articulation between the fifth and sixth joints, counting from the end. The sixth joint, which is nearly as long as the remaining portion of the antenna, has a rounded excavation on the upper edge and near the proximal end; the lower side of the excavation is produced into a stout tooth-like lobe; the fifth joint, still counting from the end of the antenna, is about half the length of the preceding, and bears a styloid process on its upper margin and a long plumose seta at the upper distal angle; the ultimate and penultimate joints are also furnished with a number of long plumose setæ (Pl. VII. fig. 42). The posterior antennæ and mouth-organs as in *Paracartia spinicaudata.* The first four pairs of swimming-feet similar to those of *Acartia.* The fifth pair is largely developed, that of the right side large, 4-jointed, the first and second joints stout, the other two slender, elongate; the fourth joint appears as if it were articulated to the *side* of the third. There is a stout digitiform process on the inner side of the upper half of the second joint, and near the middle of the third joint the outer margin is produced into a bluntly triangular lobe; the last joint bears an apical appendage, the basal part of which is tumid, the extremity slender and setiform. The right foot has an inner rudimentary second branch composed of one joint about equal in length to the first joint of the outer branch. The left foot, which is stout, scarcely reaches to the middle of the second joint of the principal branch of the right foot, and appears to be 3-jointed; the second joint is furnished with a membraneous, curved (?) sexual process, as shown in figure 9. Abdomen composed of five segments, the first short, of greater width than the next, the outline of the sides rounded (Pl. VIII. fig. 15); the second and third joints are long, while the combined length of the fourth and fifth is scarcely equal to the third. The stylets are somewhat longer than the last abdominal segment, and have the third apical seta, counting from the outside, considerably longer than any of the others.

Habitat. Loanda Harbour, in material collected with surface tow-net, on the afternoon of February 15th. Several specimens, males only, were obtained.

As females only of *Paracartia spinicaudata*, and males only of *P. dubia*, were obtained in the tow-net gathering from Loanda Harbour, it is just possible that they may both belong to the same species, but the difference between the two is so considerable and so marked that it seems better, for the present at least, to describe them under separate names.

A species described and figured by I. C. Thompson in the 'Proceedings of the Liverpool Biological Society,' vol. ii. p. 141 (1888), as *Acartia verrucosa*, resembles somewhat the *Paracartia spinicaudata* of this Report; but the difference in the form of the fifth feet and in other important details is great enough to render them at least specifically distinct.

Genus ÆTIDIUS, Brady.

Ætidius, Brady, Report on the Copepoda of the 'Challenger' Expedition, 1883.

ÆTIDIUS ARMATUS, Brady.

1883. *Ætidius armatus*, Brady, Report 'Chall.' Copep. p. 76, pl. x. figs. 5–16.

Habitat. Station 2, 5 fathoms tow-netting, January 1st (night collection). Lat. 3° 58′

N., long. 3° 42′ W., 50 fathoms, January 13th (day collection). Lat. 3° 55′ 3″ N., long. 4° 7′ 3″ E., 30 fathoms, January 20th (day collection). Off São Thomé Island (lat. 0° 34″ N., long. 6° 31′ 6″ E.), 20 fathoms, January 23rd (day collection). Station 3, 135 fathoms, February 5th (day collection).

Ætidius armatus occurred in 19 tow-nettings, all of which were under-surface collections and ranged in depth from 5 to 160 fathoms; 2 of the tow-nettings were collected during the night, the other 17 were day collections. With one exception, all the tow-nettings were from 20 fathoms or more, and eleven of them from 50 fathoms and over. The difference between the bathymetrical distribution of this species and of *Acartia denticornis* is very marked, the *Acartia* having been observed only in surface gatherings. The distribution of *Ætidius* was nearly coextensive with the area examined, and in some of the tow-nettings it was of comparatively frequent occurrence. The strong curved rostrum, and the spinous and strongly produced lateral angles of the last thoracic segment, are so conspicuous as to make the species readily distinguished from other Copepoda. It was obtained at five of the 'Challenger' stations, one of which (Station 348, lat. 3° 10′ N., long. 14° 51′ W.) was in the vicinity of the area traversed by the 'Buccaneer.'

ÆTIDIUS ARMIGER (Giesbrecht). (Pl. VIII. figs. 16–27.)

1892. *Gaëtanus armiger*, Giesbrecht, Fauna und Flora des Golfes von Neapel (Copepoden), p. 224, pl. xiv. figs. 19, 20, 22, 26, 28, pl. xxxvi. figs. 2, 6.

Female. Length, exclusive of tail-setæ, 2·6 mm. (about 1-10th of an inch). The male is rather smaller than the female. Body robust, composed of four segments, the first segment more than twice the entire length of the other three, rounded anteriorly and furnished with a prominent sharp-pointed rostrum. The postero-lateral angles of the last thoracic segment are produced backward into spiniform processes as long as the first abdominal segment. Anterior antennæ reaching to the extremity of the abdomen, alike in both sexes, and composed of 24 joints, which are sparingly setiferous; the proportional lengths of the joints nearly as in the formula :—

$$\frac{9\,.\,6\,.\,3\,.\,3\,.\,3\,.\,3\,.\,4\,.\,6\,.\,3\,.\,3\,.\,4\,.\,6\,.\,5\,.\,6\,.\,7\,.\,7\,.\,7\,.\,9\,.\,8\,.\,7\,.\,8\,.\,8\,.\,7\,.\,3}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9\quad 10\quad 11\quad 12\quad 13\quad 14\quad 15\quad 16\quad 17\quad 18\quad 19\quad 20\quad 21\quad 22\quad 23\quad 24}.$$

The basal joint of the posterior antennæ wants the three setæ shown in Brady's figure of *Ætidius armatus*; the first joint of the secondary branch is small, the second larger, the third, fourth, and fifth small and bearing each a long plumose seta; the sixth joint is fully one third the length of the whole branch, and furnished with one plain and three long plumose terminal setæ. Mandibles and maxillæ as in *Æ. armatus*; one of the two small intermediate digits of the maxilla-palp terminates in a spiniform plumose seta. Foot-jaws also similar to those of *Ætidius armatus*, except that the two outer marginal lobes of the anterior foot-jaw terminate each in a stout elongate spine, ciliate on the inner edge; and the inner distal angle of the basal joint of the second foot-jaw forms a blunt, rounded process, the end of which is ciliate and bears a few setæ (fig. 22). The first four pairs of swimming-feet resemble those of *Ætidius armatus*, except that the second joint of the inner branch of the second pair is shorter than the other. Fifth pair in the male small, each composed of a basal joint and two 1-jointed branches; the outer branch is comparatively large and bears two small unequal teeth at the extremity; the inner branch is small and rudimentary, with a rounded end. Abdomen in both sexes composed of five (?) segments, the last segment very small, the other segments in the male abdomen subequal; in that of the female the first segment is large and tumid, the second smaller, while the third and fourth are about equal and smaller than the second. Caudal stylets short and broad, and furnished with four long and two very small terminal plumose setæ.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 and 460 fathoms, January 22nd (day collection). Station 23, 135 fathoms, February 5th (day collection). *Ætidius armiger*, of which only two or three specimens have been obtained, is quite distinct from *Æ. armatus*, being readily distinguished by the difference in the form of the male fifth feet, and by the peculiar spiny armature of the forehead and last thoracic segment.

Genus CLAUSOCALANUS, Giesbrecht, 1888.

Drepanopus, Brady (in part).

CLAUSOCALANUS FURCATUS (Brady).

1883. *Drepanopus furcatus*, Brady, Report of the 'Challenger' Copepoda, p. 77, pl. iv. figs. 1 & 2; pl. xxiv. figs. 12–15.

1892. *Clausocalanus furcatus*, Giesbrecht, Fauna und Flora des Golfes von Neapel (Copepoden), p. 194, pl. xxxvi. figs. 32, 33, 35.

Habitat. Station 2, 25 fathoms (night collection), January 1st. Lat. 3° 58′ N., long. 3° 42′ W., 25 fathoms (day collection), January 13th. Off São Thomé Island (lat. 0° 34′ N., long. 6° 30′ 4″ E.), 10 fathoms, January 23rd (day collection). Station 23, 10 fathoms, February 5th (day collection). Lat. 6° 39′ 5″ S., long. 11° 24′ 7″ E., surface, February 8th (night collection), &c.

This species occurred in 20 tow-nettings, 3 of which were surface and 17 under-surface gatherings. The under-surface gatherings were from various depths ranging from 2½ to 50 fathoms. The 3 surface tow-nettings were night collections; 11 of the under-surface were day and 6 were night collections, as shown by the formula:—

$$\text{Tow-nettings } 20 \begin{cases} 3 \text{ surface} & \begin{cases} \text{no day collections.} \\ 3 \text{ night ditto.} \end{cases} \\ 17 \text{ under-surface} & \begin{cases} 11 \text{ day ditto.} \\ 6 \text{ night ditto.} \end{cases} \end{cases}$$

CLAUSOCALANUS LATIPES, n. sp. (Provisional name.) (Pl. VIII. figs. 28–37.)

Female. Anterior antennæ long and slender, provided with a very few short setæ and composed of 23 joints, the proportional lengths of the joints being nearly as shown in the formula :—

$$\frac{3}{1}\cdot\frac{5}{2}\cdot\frac{2}{3}\cdot\frac{2}{4}\cdot\frac{2}{5}\cdot\frac{2}{6}\cdot\frac{2}{7}\cdot\frac{4}{8}\cdot\frac{2}{9}\cdot\frac{2}{10}\cdot\frac{3}{11}\cdot\frac{3}{12}\cdot\frac{4}{13}\cdot\frac{4}{14}\cdot\frac{4}{15}\cdot\frac{4}{16}\cdot\frac{4}{17}\cdot\frac{4}{18}\cdot\frac{4}{19}\cdot\frac{4}{20}\cdot\frac{4}{21}\cdot\frac{5}{22}\cdot\frac{6}{23}$$

The posterior antennæ nearly as in *Drepanopus pectinatus*. Mandibles well developed, strongly dentiferous on the biting-edge, and furnished with a large two-branched palp one branch being 2-, the other 4-jointed (fig. 29). Anterior foot-jaws 4-jointed, the last two very small; marginal lobes six, five of them large, each with two (or three) plumose terminal setæ; the other small, forming the base of a single plain seta; three plain setæ spring from the last joint of this foot-jaw. The posterior foot-jaws are 7-jointed; the first and second joints are large, subequal, and longer than the entire length of the next three; the third to the last joints are small and furnished with a few plumose hairs (fig. 31). First pair of swimming-feet similar to those of *Drepanopus pectinatus*, but there are longer spines on the outer distal angles of the first two joints of the outer branch, and the inner distal angle of the second basal joint terminates in a short spine instead of a plumose hair. The three following pairs are also similar to *Drepanopus pectinatus*, except that the distal margin of the second basal joint is strongly denticulated in the second pair, and in the third pair is furnished with a few large spiniform teeth; the terminal spines of the outer branches are long and broad, and finely serrate on the outer margin. The fifth pair are robust, simple, and composed of two 2-jointed branches of unequal length; in the short branch the last joint is much smaller than the other and terminates in three conical tooth-like prolongations; in the other branch, which is at least twice the length of the short one, the last joint is rather longer than the first, and bears a small spine near the middle of the outer margin and three spiniform teeth at the extremity (fig. 35). The abdomen is composed of four segments, the first longer than the others, the next two subequal, the last small. Caudal stylets about as long as the last abdominal segment and bearing four plumose terminal hairs.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35 fathoms.

One specimen only of this species has been obtained; it appears to be a female. While agreeing with *Drepanopus* in its more important details of structure, *Clausocalanus latipes* differs from both the species described in the Report on the 'Challenger' Copepoda, especially in the number and proportional length of the joints of the anterior antennæ and in the form of the fifth feet. It agrees in some respects with *Clausocalanus furcatus*, Brady, but in that species, the inner branches of the second pair of swimming-feet are 1-jointed, the fifth pair and the anterior antennæ also differ considerably, so that for the present it seems better to consider the species as distinct.

CLAUSOCALANUS ARCUICORNIS (Dana). (Pl. VIII. figs. 38–47.)

1849. *Calanus arcuicornis*, Dana, Amer. Journ. Sc. vol. viii.

1892. *Clausocalanus arcuicornis*, Giesbrecht, op. cit. p. 193, pls. 1, 2, 10, 36.

Length, not including tail-setæ, 1·3 mm. Body elongate, composed of five segments, the first nearly twice the entire length of the other four. Forehead rounded, produced into a small, sharp-pointed rostrum. Anterior antennæ slender, as long as the cephalothorax, 20-jointed, and sparingly setiferous, the proportional lengths of the joints as in the formula:—

$$\begin{array}{cccccccccccccccccccc} 34\,. & 4\,. & 4\,. & 4\,. & 4\,. & 3\,. & 3\,. & 4\,. & 4\,. & 4\,. & 4\,. & 10\,. & 16\,. & 10\,. & 12\,. & 12\,. & 18\,. & 15\,. & 18\,. & 22 \\ \hline 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 & 19 & 20 \end{array}$$

The first joint is stout and long, and the second considerably broader than those immediately following. The primary branch of the posterior antennæ is short and 2-jointed; the secondary branch is fully twice the length of the other, and composed of six joints; the second joint is long and about equal to the entire length of the next four; the third, fourth, and fifth joints are very small (fig. 39). Mandible-palp small, one branch is 4-, the other 2-jointed (fig. 40). Maxillæ nearly as in *Drepanopus pectinatus*. Anterior foot-jaw very small, with four (or five) marginal setiferous lobes. Posterior foot-jaw small, 7-jointed, and bearing a few spinous setæ; the first and second joints are elongate, the third short, the fourth about twice the length of the third, the fifth about equal to the third and as long as the next two together (fig. 41). The first four pairs of swimming-feet resemble those of *Drepanopus pectinatus*, except that the first two joints of the outer branch of the first pair have no spines on the exterior distal angles. The fifth pair are simple and consist of one very short 2-jointed branch, and one which is long and 4-jointed; the last joint of the short branch is very small and terminates in three small spines; the extremity of the long branch terminates on one side in a digitiform lobe, which is opposed by a finger-like process, articulated to the basal part of the lobe; both are fringed with fine cilia (fig. 45). Abdomen 5-jointed, the last segment very small. Caudal stylets short, length about equal to the breadth, each furnished with four plumose terminal setæ.

Habitat. Station 2, 50 fathoms, January 1st (night collection). Station 9, 50 fathoms, January 10th (day collection). Lat. 3° 58′ N., long. 3° 42′ W., 25 and 50 fathoms, January 13th (day collection). Off Accra, 3 fathoms, January 16th (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms, January 22nd (day collection). Off São Thomé Island, 20 fathoms, January 23rd (day collection).

Males only of this species were obtained.

Genus PHYLLOPUS, Brady.

Phyllopus, Brady, Report on the Copep. of the Chall. Exp. 1883.

PHYLLOPUS BIDENTATUS, Brady. (Pl. VI. figs. 26–28.)

1883. *Phyllopus bidentatus*, Brady, Report Chall. Copep. p. 78, pl. v. figs. 7–14.

Habitat. Station 2, 5 fathoms, January 1st (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms, January 22nd (day collection). Temperature of water at 360 fathoms about 43° F.

Three specimens only of this curious form were obtained, and they were all more or less damaged; two of them were carefully dissected, from these dissections figures have been prepared of a few of the more important details, not represented in the 'Challenger' Report. I have also been enabled to add the following description:—Secondary branch of the anterior antennæ nearly twice the length of the primary branch, 8-jointed, the last nearly as long as the preceding six joints, and furnished with four terminal hairs. Both branches of the first four pairs of swimming-feet 3-jointed, the middle joint of the outer branch of the first pair shortest, bearing a comparatively long, slightly curved, setiferous spine on the exterior distal angle; the last joint has two shorter and more slender spines on its outer margin, and a long slender terminal spine, both branches furnished with numerous, long, plumose setæ. In the second, third, and fourth pairs the inner are much shorter than the outer branches; the three joints of the outer branches are each armed with a stout dagger-like spine at the outer distal angles; the last joint has two similar additional spines inserted in excavations of the outer margin, and a broad falciform terminal spine, finely serrate on the outer margin; both branches are well furnished with plumose setæ. The fifth pair in the female resemble the figured example in the 'Challenger' Report, but their form seems to vary somewhat in different specimens, both as regards the serration of the last joint, and also the comparative length and breadth of the joints. Abdomen in the female 4-jointed, first joint much larger than the others and dilated. Caudal stylets short, not divergent, each with five long, plumose terminal setæ, the second from the inside longer than the others.

The mouth is a short tube; the front part projects outward and backward so as to form an oblique opening. The edge of the upper part of the tube has a dense fringe of hairs, which can be readily observed if the specimen be in a favourable position. Judging from a careful examination of the 'Buccaneer' specimens, I am inclined to think that the figures in the 'Challenger' Report represent a female instead of a male.

Genus Temora, Baird.

Temora, Baird, Brit. Entomostraca, 1850.
Diaptomus, Lubbock, Trans. Entom. Soc. 1856.

Temora stylifera (Dana).

1849. *Calanus stylifer*, Dana, Amer. Journ. Sci. vol. viii.
1856. *Diaptomus dubius*, Lubbock, Trans. Entom. Soc. vol. iv. n. s. p. 21, pl. ii. figs. 1–7.
1883. *Temora dubia*, Brady, Report Chall. Copep. p. 79, pl. xxv. figs. 1–17.

Habitat. Station 2, surface and 25 fathoms, January 1st (night collections). Station 9, 25 fathoms, January 10th (day collection). Station 11, 10 fathoms, January 19th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms, January 22nd (day collection). Lagoon, São Thomé Island, surface, January 27th (one day and one night collection). Libreville, Gaboon River, surface, January 28th (day collection). Station 23, 10, 20, 135, and 185 fathoms, February 5th (day collections). Bananah

Creek, Congo River, surface, February 7th (two day collections). Lat. 5° 55′ 1″ S., long. 11° 30′ 7″ E., February 18th (night collection).

Temora stylifera was observed in 105 tow-nettings, 61 of them surface and 44 under-surface gatherings: of the surface gatherings 25 were collected during the day and 36 during the night; of the under-surface gatherings, which ranged in depth from 2 to 360 fathoms, 37 were collected during the day and 7 during the night, as shown by the annexed formula:—

$$\text{Tow-nettings } 105 \begin{cases} 61 \text{ surface} & \begin{cases} 25 \text{ day collections.} \\ 36 \text{ night ditto.} \end{cases} \\ 44 \text{ under-surface} & \begin{cases} 37 \text{ day ditto.} \\ 7 \text{ night ditto.} \end{cases} \end{cases}$$

This was one of the more common and generally distributed species in the 'Buccaneer' collection; it also appears to be one of the most common of the extra-European Copepoda.

TEMORA LONGICORNIS (Müller). (Pl. VII. fig. 47.)

1785?. *Cyclops longicornis,* Müller, Entom. p. 115, t. xix. figs. 7–9.
1850. *Temora finmarchica,* Baird, Brit. Entom. p. 228, pl. xxviii. figs. 1 *a–g*.
1849?. *Calanus turbinatus,* Dana, Amer. Journ. Sc. vol. viii.
1857. *Diaptomus longicaudatus,* Lubbock, Ann. & Mag. Nat. Hist. ser. 2, vol. xx. pl. x. figs. 11, 12; pl. xi. figs. 12, 13.
1878. *Temora longicornis,* Brady, Monogr. Brit. Copep. vol. i. p. 54, pl. iii. figs. 10–19.

Habitat. Lat. 7° 33′ N., long. 15° 18′ W., surface, midnight, January 2nd. Station 9, 50 fathoms, January 10th (day collection). Off Accra, 3 fathoms, January 15th (night collection). Same locality, January 16th, surface, night collection, and 3 fathoms, day collection. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35 and 460 fathoms, January 22nd (day collections). Libreville, Gaboon River, surface, January 28th (day collection). Bananah Creek, Congo River, surface, February 6th (day collection). Loanda Harbour, surface, February 13th (day collection), and again on the 15th in the seaward part of the Harbour, also surface (day collection). Lat. 5° 40′ 8″ S., long. 11° 33′ 4″ E., surface, February 19th, &c. (day collection).

This *Temora* was observed in 57 tow-nettings, 40 of which were surface and 17 under-surface gatherings; 16 of the surface gatherings and 12 of the under-surface were day collections, while 24 surface and 5 under-surface were night collections, as shown by the formula:—

$$\text{Tow-nettings } 57 \begin{cases} 40 \text{ surface} & \begin{cases} 16 \text{ day collections.} \\ 24 \text{ night ditto.} \end{cases} \\ 17 \text{ under-surface} & \begin{cases} 12 \text{ day ditto.} \\ 5 \text{ night ditto.} \end{cases} \end{cases}$$

The under-surface tow-nettings were from depths ranging from 3 to 50 fathoms, and one from 135 and another from 460 fathoms.

Temora longicornis was not only generally distributed throughout the area examined, but was a moderately common species in some of the tow-nettings in which it occurred. This species is readily distinguished from either *Temora stylifera* (Dana) or *Temora armata*, Claus, by having the last thoracic segment in both sexes rounded at the postero-lateral angles. The first pair of swimming-feet have the inner branches more or less distinctly 2-jointed. The male fifth pair (fig. 47) differ somewhat from the same pair of feet in British specimens, but otherwise the 'Buccaneer' specimens agree with those of the British seas.

Genus CENTROPAGES, Kröyer.

Centropages, Kröyer, Nat. Tidskr. 1849; Boeck, Oversigt Norges Copep. 1864; Brady, Monogr. Brit. Copep. 1878.

Catopia, Dana, Proc. Amer. Acad. Sci. 1849.

Calanopia, id. (in part) Crust. U.S. Expl. Exped. 1852.

Ichthyophorba, Lilljeborg, De Crust. ex. ord. trib. 1853; Claus, Die freilebenden Copepoden, 1863.

CENTROPAGES BRACHIATUS (Dana).

1852. *Calanopia brachiata*, Dana, Crust. U.S. Expl. Exped. p. 1133, pl. lxxix. figs. 7 *a, b*.

1883. *Centropages brachiatus*, Brady, Report Chall. Copep. p. 82, pl. xxvi. figs. 1–7.

Habitat. Lat. 7° 33′ N., long. 15° 18′ W., surface, January 2nd (midnight collection). Lat. 5° 10′ N., long. 3° 56′ 2″ W., surface (close inshore), January 12th (night collection). Station 21, surface, February 4th (day collection). Station 23, 20 fathoms, February 5th (day collection). Bananah Creek, Congo River, surface, February 7th (two day collections). Loanda Harbour, surface, February 13th (day collection).

Centropages brachiatus was observed in 37 tow-nettings, comprising 28 surface and 9 under-surface gatherings. The under-surface tow-nettings included two at 3 fathoms, two at 10 fathoms, one at 20 fathoms, two at 25 fathoms, and two at 50 fathoms. 14 of the surface and 6 of the under-surface gatherings were day collections, while 14 surface and 3 under-surface were night collections, as shown by the formula:—

$$\text{Tow-nettings } 37\begin{cases}28 \text{ surface} & \begin{cases}14 \text{ day collections.}\\ 14 \text{ night ditto.}\end{cases}\\ 9 \text{ under-surface} & \begin{cases}6 \text{ day ditto.}\\ 3 \text{ night ditto.}\end{cases}\end{cases}$$

This, though occurring in a considerable number of tow-nettings, was by no means a common species. The size of the 'Buccaneer' specimens agreed with those of the 'Challenger' collections, viz. 8–100ths of an inch=about 2 mm. (not 4·4 mm. as stated in the 'Challenger' Report).

CENTROPAGES FURCATUS (Dana).

1852. *Catopia furcata*, Dana, Crust. U.S. Expl. Exped. p. 1173, pl. lxxix. figs. 1 *a–d*.

1883. *Centropages furcatus*, Brady, Report Chall. Copep. p. 83, pl. xxviii. figs. 1–11.

Habitat. Lat. 7° 33′ N., long. 15° 18′ W., surface, January 2nd (midnight collection). Lat. 5° 10′ N., long. 3° 56′ 2″ W., surface (close inshore), January 12th (night collection).

Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10 and 30 fathoms, January 22nd (day collections). Libreville, Gaboon River, surface, January 28th (two day collections). Lat. 5° 56′ 5″ S., long. 11° 17′ 2″ E., surface, February 8th (night collection). Loanda Harbour (seaward), surface, February 15th, &c. (day collection).

This *Centropages* was observed in 49 tow-nettings, 33 of which were surface and 16 under-surface gatherings; 11 of the surface and 11 of the under-surface tow-nettings were day collections, and 22 surface and 5 under-surface were night collections, as shown by the annexed formula:—

$$\text{Tow-nettings 49}\left\{\begin{array}{l}\text{33 surface}\left\{\begin{array}{l}\text{11 day collections.}\\ \text{22 night ditto.}\end{array}\right.\\ \text{16 under-surface}\left\{\begin{array}{l}\text{11 day ditto.}\\ \text{5 night ditto.}\end{array}\right.\end{array}\right.$$

The under-surface tow-nettings were from depths ranging from 3 to 50 fathoms. This species can be readily distinguished, even in the immature stages, by the characteristic armature of the last thoracic segment.

CENTROPAGES VIOLACEUS (Claus).

1863. *Ichthyophorba violacea*, Claus, Die freilebenden Copep. p. 199, pl. xxxi. figs. 13, 14.

1883. *Centropages violaceus*, Brady, Report Chall. Copep. p. 83, pl. xxvii. figs. 1–14.

Habitat. Station 2, 50 fathoms, January 1st (night collection). Station 9, 25 fathoms, January 10th (day collection). Off São Thomé Island (lat. 0° 32′ 7″ N., long. 6° 31′ 6″ E.), 10 fathoms, January 23rd (day collection). Lat. 1° 47′ 7″ S., long. 8° 21′ 3″ E., surface, February 4th, &c. (night collection).

Centropages violaceus was obtained in 11 tow-nettings, one of which was a surface (night) gathering, and the other 10 under-surface gatherings; 6 of the under-surface gatherings were day, and 4 were night collections, as shown by the formula:—

$$\text{Tow-nettings 11}\left\{\begin{array}{l}\text{1 surface}\left\{\begin{array}{l}\text{0 day collection.}\\ \text{1 night ditto.}\end{array}\right.\\ \text{10 under-surface}\left\{\begin{array}{l}\text{6 day collections.}\\ \text{4 night ditto.}\end{array}\right.\end{array}\right.$$

Four of the under-surface gatherings were from 10 fathoms, two from 15 fathoms, one from 20 fathoms, two from 25 fathoms, and one from 50 fathoms.

This *Centropages* was much rarer in the 'Buccaneer' collections than the other two species recorded in the 'Challenger' collection. On the other hand, it was the more common of the three species of *Centropages* observed by Dr. Brady. *Centropages violaceus* differs from the other two species in having the postero-lateral angles of the last thoracic segment rounded off instead of being produced into spinous processes. No indication of colour could be detected in the 'Buccaneer' specimens. This was probably due to their long immersion in spirit, which had extracted the colour characteristic of the species.

Genus Temoropia, n. gen. (Provisional name.)

Anterior antennæ ? 22- or ? 23-jointed; the right antenna of the male 19-jointed, hinged between the 15th and 16th joints. Posterior antennæ and mouth-organs as in *Calanus*. Inner branch of the first pair of swimming-feet 2-jointed, of the second, third, and fourth pairs 3-jointed. Fifth pair in the female simple, alike on both sides, and each composed of a single 3-jointed branch; in the male the fifth pair, which are prehensile, and each composed of a single branch, are large and conspicuous. The female abdomen consists of four and the male of five segments; the first segment in the female is considerably dilated.

Temoropia mayumbaensis, n. sp. (Pl. VIII. figs. 18, 19; Pl. IX. figs. 1–12.)

Length ·93 mm. Body elongate-ovate, composed of five segments; the first segment, which is about as long as the combined length of the next three, is indistinctly articulated at the upper half. Forehead broadly triangular. Anterior antennæ of the female ? 22- or ? 23-jointed.[*] The right anterior antenna of the male scarcely reaches to the end of the thorax, is sparingly setiferous, and 19-jointed, constricted between the 11th and 12th, and hinged between the 15th and 16th joints; the proportional lengths of the joints as in the formula :—

Male:	30	10	8	8	9	6	7	8	9	9	14	27	11	12	27	28	17	15	22
Right anterior antenna.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Posterior antennæ and mouth-organs as in *Calanus*. The inner branches of the first pair of swimming-feet are 2-jointed; the inner branches of the second, third, and fourth pairs 3-jointed; the first joint is short, while the last is equal to the combined length of the preceding two joints. Fifth pair of feet in the female simple, each composed of a single 3-jointed branch, one branch being rather longer than the other; the first joint in both is somewhat dilated; the inner distal angle of the second joint is furnished with a spiniform seta nearly as long as the last joint; the last joint has a conical and pointed extremity with a small tooth-like process on the inner margin. The fifth pair in the male is large and conspicuous; the right foot is composed of two moderately large joints, which decrease in breadth towards the extremity, and terminates in a long slender curved spine. The left foot, which consists of three broad joints, has an excavation at the apex in which the terminal spine of the foot probably interlocks, while a long curved spine springs from the end of the first joint (Pl. IX. fig. 9). The abdomen in the female consists of four, in the male of five, segments; the first segment in the female is considerably swollen, and is produced ventrally and posteriorly into a large rounded process (Pl. IX. fig. 10). Caudal stylets short, each furnished with three stout plumose terminal setæ, and a small seta on the inner margin.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35 and 360 fathoms (day collections). Station 23 (lat. 1° 26′ 7″ S., long. 10° 1′ 8″ E.), 235 fathoms (day collection).

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[*] The basal portions only of the anterior antennæ of all the females, and of the left antenna of all the males, remain intact; they were broken off, mostly, at the end of the eighth joint; but, judging from the number of joints in the male right antenna, the female antennæ probably consist of twenty-two or twenty-three joints.

About twenty specimens of this species were obtained in tow-nettings from the localities described; the specimens were all more or less imperfect, especially the anterior antennæ and swimming-feet.

The specific name has reference to Mayumba, a place on the coast near Station 23, one of the two localities where the species was obtained.

Genus MECYNOCERA, I. C. Thompson (1888).

1888. *Mecynocera,* I. C. Thompson, Journ. Linn. Soc. (Zoology) vol. xx. p. 146.

MECYNOCERA CLAUSII, I. C. Thompson. (Pl. I. figs. 27–34; Pl. II. 7–10.)

1888. *Mecynocera clausii,* I. C. Thompson, Journ. Linn. Soc. (Zoology) vol. xx. p. 146, pl. xi. figs. 1–4.

Length fully 1 mm. Female somewhat longer than the male. Body elongate, slender. Cephalothorax composed of six segments; viewed dorsally the first is almost cylindrical; forehead somewhat angularly rounded; the postero-lateral angles of the last segment are rounded. Anterior antennæ fully twice the length of the animal, slender, 24-jointed; the 16th to the 20th joints are considerably longer than any of the others; several of the middle joints of both antennæ in male and female are provided with longitudinal rows of small spiniform teeth; two, or even three, rows were observed on some of the joints, on others only one row; the antennæ are sparingly setiferous (Pl. I. fig. 31). The annexed formula shows the proportional lengths of the joints:—

$$\frac{7}{1}\cdot\frac{14}{2}\cdot\frac{7}{3}\cdot\frac{7}{4}\cdot\frac{7}{5}\cdot\frac{7}{6}\cdot\frac{7}{7}\cdot\frac{12}{8}\cdot\frac{12}{9}\cdot\frac{10}{10}\cdot\frac{12}{11}\cdot\frac{13}{12}\cdot\frac{14}{13}\cdot\frac{17}{14}\cdot\frac{18}{15}\cdot\frac{22}{16}\cdot\frac{24}{17}\cdot\frac{29}{18}\cdot\frac{26}{19}\cdot\frac{24}{20}\cdot\frac{18}{21}\cdot\frac{12}{22}\cdot\frac{8}{23}\cdot\frac{14}{24}.$$

The basal joint of the posterior antennæ stout, primary branch 2-jointed (exclusive of the basal joint), the first being nearly a third longer than the other; secondary branch 7-jointed; the second joint is longer than the first, and nearly equal to the entire length of the next four; the third to the last joints very short (Pl. I. fig. 30). Mandible-palp well developed, 2-branched, basal part stout, distally narrowed and produced to form the base of the 1-jointed branch; the second branch, which occupies a submarginal position, is 4-jointed (Pl. II. fig. 7). Foot-jaws and swimming-feet nearly as in *Rhincalanus,* except that the inner branches of the first swimming-feet are 1-jointed, the inner branches of the second, third, and fourth pairs are 3-jointed; the exterior distal angles of the joints of the outer branches are armed with short stout spines which are curved inwardly; the last joint of the outer branches of the fourth pair has a similar spine on the exterior margin (Pl. I. fig. 33); the outer branches of all the first four pairs possess long delicate terminal spines. The fifth pair are 1-branched, alike on both sides and in both sexes; basal portion 2-jointed, not much stouter than the terminal portion, which is 3-jointed. There is, so far as could be observed, no terminal spine. Caudal stylets somewhat divergent, and about two thirds the length of the last abdominal segment; caudal setæ four, long, plumose.

Habitat. Station 2, 25 fathoms, collected January 1st. Lat. 6° 34′ N., long. 12° 39′ W., surface, collected January 6th. Lat. 4° 31′ 6″ N., long. 6° 4′ 4″ W., 50 fathoms, collected

January 11th. Off São Thomé Island (lat. 0° 34′ N., long. 6° 30′ 4″ E.), 20 fathoms, collected January 23rd. Lat. 4° 26′ 7″ S., long. 10° 1′ 8″ E., 235 fathoms, collected February 5th, &c.

Mecynocera Clausii was observed in 16 of the tow-net collections, 1 only being a surface gathering; the deepest under-surface gathering in which it was observed was 235 fathoms.

$$\text{Tow-nettings } 16\left\{\begin{array}{l}1 \text{ surface} \left\{\begin{array}{l}1 \text{ day collection.}\\ 0 \text{ night ditto.}\end{array}\right.\\ 15 \text{ under-surface} \left\{\begin{array}{l}12 \text{ day collections.}\\ 3 \text{ night ditto.}\end{array}\right.\end{array}\right.$$

The 'Buccaneer' specimens of this species differed from *Mecynocera Clausii*, I. C. Thompson, as described and figured in the 'Transactions' of the Linnean Society, vol. xx. p. 150, pl. xi. figs. 1–4. *Mecynocera Clausii* is there described as wanting a fifth pair of feet, whereas the 'Buccaneer' specimens possess a fifth pair large enough to be easily observed without requiring to dissect the animal to see them.

Genus PHAËNNA, Claus.

Phaënna, Claus. Die freilebenden Copepoden, 1863.

PHAËNNA SPINIFERA, Claus. (Pl. VI. fig. 35; Pl. VII. figs. 1, 2.)

1863. *Phaënna spinifera,* Claus, Die freilebenden Copepoden, p. 189, pl. xxxi. figs. 1–7.

Length 2·25 mm. Body globose (breadth about 1·1 mm.), composed of five segments, the first rather longer than the next two together. Anterior antennæ as long as the cephalothorax, 24-jointed. The proportional lengths of the joints are very nearly as shown in the formula:—

$$\frac{10\,.\,4\,.\,3\,.\,4\,.\,4\,.\,4\,.\,4\,.\,5\,.\,4\,.\,4\,.\,4\,.\,6\,.\,7\,.\,9\,.\,9\,.\,9\,.\,10\,.\,10\,.\,8\,.\,9\,.\,7\,.\,8\,.\,9\,.\,4}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9\quad 10\quad 11\quad 12\quad 13\quad 14\quad 15\quad 16\quad 17\quad 18\quad 19\quad 20\quad 21\quad 22\quad 23\quad 24}.$$

Sparingly setiferous; the basal joint in the female bears on its upper margin a single plumose seta*. The ends of the third, last, and of the basal joints bear each a plumose hair on the underside. In the male the basal joint wants the plumose seta. The posterior antennæ have the primary branch much shorter than the secondary; the secondary branch 5-jointed; the first and last joints are large, the three intermediate ones very small, both branches furnished with long plumose hairs. Mandibles elongate, bearing numerous small teeth at the distal ends; mandible-palp stout, 2-branched, both branches furnished with plumose hairs, the basal part with three short hairs on its inner aspect. Maxillæ large, foliaceous. Anterior foot-jaws short, truncate; joints crowded, not clearly defined, setiferous, the apical part bearing one long, faintly serrate, spiniform, curved appendage; and a number of peculiar, cylindrical processes (sense-

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* "Das basale Glied trägt im weiblichen Geschlechte eine befiederte Borste," Claus, *loc. cit.* p. 189.

organs ?), densely ciliated at the extremity; posterior foot-jaw in the female slender, 6-jointed, the last two joints very small. Three long setæ, plumose along the upper edge, spring from the terminal joints; the basal joints are sparingly setiferous; the posterior foot-jaw is stouter in the male, and the terminal joints bear a much larger number of setæ. First pair of swimming-feet 2-branched, the outer 3-jointed, the inner 2-jointed; both branches with numerous stout plumose setæ, the terminal spine of the outer branch slender, and faintly serrate on the outer margin. The inner branch of the second pair 2-jointed, of the third and fourth pairs 3-jointed and armed on the side with fascicles of short, stout, and sharp-pointed spines; the outer branches foliaceous and bearing several strong spines on the exterior margin, one at the base of the first and second joints, and three on the last joint; the terminal spines of the outer branches of the second, third, and fourth pairs broad, falciform, the outer margin faintly serrate. The fifth pair wanting in the female, in the male simple, 1-branched, 5(?)-jointed, the left branch longer and stouter than the right, with the last joint small and fringed with hairs; the right branch terminates in a slender spine. Abdomen in the male 5-, in the female 4-jointed, the last joint the smallest. Caudal stylets short, divergent, and furnished with several plumose setæ, the second seta from the inside being much longer than the others.

Habitat. Station 9, 25 and 50 fathoms, January 10th (day collections). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 35, 60, and 360 fathoms, January 22nd (day collections). Station 23, surface, 20 and 85 fathoms, February 5th (day collections). These were the only gatherings in which *Phaënna spinifera* was obtained.

The ciliated processes of the anterior foot-jaws resemble somewhat the worm-like sense-organs of the same appendages in *Scolecithrix*, but instead of being produced so as to form lengthened hair- or "worm-"like processes, as in that genus, they are cylindrical and truncate, and furnished with a terminal fascicle of delicate cilia.

Subfamily PONTELLINÆ, Dana.

Genus LABIDOCERA, Lubbock, 1853.

Pontella, Dana (in part), Amer. Journ. Sci. 1846; Claus, Die freilebenden Copep. 1863; Brady, Monogr. Brit. Copep. 1878; id. Report Chall. Copep. 1883.
Labidocera, Lubbock, Ann. & Mag. Nat. Hist. ser. 2, vol. xi. (1853).

LABIDOCERA DETRUNCATA (Dana), var. INTERMEDIA. (Pl. VI. figs. 36–38; Pl. VII. figs. 3, 4.)

Length 3 mm. Cephalothorax elongate-ovate, the postero-lateral angles of the last thoracic segment produced, acute. Anterior antennæ in the female 23-jointed, the upper margin of the first eight or nine joints furnished with moderately short, plumose setæ, and the lower margin with a fringe of delicate hairs extending to the 12th joint. Right anterior antennæ of the male 17-jointed, hinged between the 13th and 14th joints, the upper margins of these joints minutely denticulate (a $\frac{1}{4}$-inch objective is required to see the denticulation distinctly). The 12th joint is not denticulate. Mandible strongly toothed; the distal end is covered exteriorly with numerous short spinous setæ arranged in oblique rows; the two inner teeth of the mandible are large and wide apart. The posterior foot-jaws are somewhat similar to those of *Labidocera acuta*, Dana. The third segment of the right fifth foot of the male has the base produced into a long stout spine, and at the distal end is furnished with a long curved and slender appendage, bearing two short claw-like processes at its extremity. The left foot is 3-jointed; the second joint is shorter than the first, the third is about equal in length to the second and somewhat triangular in shape; the apex terminates in three teeth, the middle one being the longest. The fifth pair in the female are intermediate between *Labidocera detruncata* and *Labidocera acutifrons*, Dana. Abdomen in the male 4-jointed, in the female 3-jointed; the middle segment in the female large and tumid, the last segment of the male abdomen smaller than the other three, which are subequal in length.

The form here described differs from *Labidocera detruncata*, as described and figured in the 'Challenger' Report, in the following particulars:—the right anterior male antenna differs in the proportional length of the joints and in the absence of the prominent denticulations on the 12th, 13th, and 14th joints, but especially on the 12th, and also in the postero-lateral angles of the last thoracic segment being acutely and strongly produced so as to resemble, in this respect, *Labidocera acutifrons*. The fifth pair of feet in the male of the variety here described resemble Dana's figure very closely, much more so than that of the specimen figured in the Report on the 'Challenger' Copepoda.

Habitat. Lat. 5 58′ N., long. 14 20′ W., surface, January 6th (one day and one night collection). Off São Thomé Island (lat. 0 32′ 7″ N., long. 6 31′ 6″ E.), 10 fathoms, January 23rd (day collection). Lagoon, São Thomé Island, surface, January 27th and 28th (one day and one night collection). Lat. 1 30′ 3″ S., long. 8 8′ 6″ E., surface, February 3rd (night collection). Lat. 4 55′ 9″ S., long. 10 47′ 3″ E., surface, February 5th (night collection). Lat. 5 56′ 5″ S., long. 11 17′ 2″ E., surface, February 8th (night collection). Lat. 6 39′ 5″ S., long. 11 24′ 7″ E., surface, February 8th (night collection).

This was comparatively a rare species in the 'Buccaneer' collection. The above is a full list of the localities where it was obtained.

Labidocera Darwinii (Lubbock). (Pl. VI. figs. 39–42; Pl. VII. figs. 5, 6.)

1853. *Labidocera Darwinii*, Lubbock, Ann. & Mag. Nat. Hist. ser. 2, vol. ii. p. 29, pl. i. figs. 1–11.
1892?. *Labidocera Lubbockii*, Giesbrecht, Pelag. Copep. Golfes von Neapel, p. 459, pls. 23, 25, 41.

Length, male 2·2 mm., female 2·4 mm. The forehead is broadly rounded, and does not possess any angular median projection. The last thoracic segment has the lateral angles considerably produced, and in the male more so on the right side than the left, but the same on both sides in the female. Anterior antennæ 24-jointed; the two basal joints are moderately stout and large, several of the succeeding joints are very short, while from the 16th to the end all the joints, but especially the 18th and 19th, are elongate and slender. The approximate proportional lengths of the joints are shown in the formula:—

$$\frac{7 . 10 . 1 . 1 . 1 . 1 . 2 . 2 . 3 . 3 . 3 . 4 . 5 . 5 . 6 . 9 . 9 . 10 . 11 . 8 . 7 . 7 . 6 . 6}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20 \quad 21 \quad 22 \quad 23 \quad 24}.$$

The middle joints of the right male antenna are slightly swollen; the 3rd joint has a number of indistinct articulations; the 9th and 10th joints, between which is a distinctly hinged articulation, are furnished with marginal appendages that are toothed along the upper edge; the free portion of the appendage of the 9th joint extends backward the whole length of the preceding joint, while that of the 10th joint projects only a little forward beyond the joint to which it belongs; the 7th joint is about twice the length of the preceding one, and equal to the next; the 9th is a little shorter than the 8th, and about half the length of the 10th; the 11th is about two thirds the length of the 10th, and equal to the next two together. The marginal teeth on the appendage of the 9th joint spring from the distal end of a quadrangular base; the basal parts of the teeth are closely applied to each other, end to end, as shown in the enlarged drawing; the marginal teeth on the appendage of the 10th joint are somewhat conical in shape, and are slightly curved forward. The apical portion of the posterior foot-jaw is 4-jointed (Pl. VI. fig. 39). The first joint of the right fifth foot of the male (fig. 41) has a broad triangular outline, and part of the outer angle is, as it were, cut off to form an attachment for the next joint; the last joint is considerably swollen, so that the inner margin forms an elevated arch; a stout curved and spoon-like claw is articulated to the exterior portion of the joint, and the claw is opposed by a produced basal process so as to form a prehensile organ closely resembling the beak of a bird, and giving to the whole joint somewhat the appearance of an enlarged "bird's-head process" observed in species of Polyzoa. The last joint of the left foot has a bifid apex and a small blunt-pointed tooth on its outer margin; part of its inner surface is covered with fine cilia, while the inner angle of the second joint is produced in the form of a ringed (? sexual) process. Fifth pair in the female simple, the basal joints stout, with a small seta on the proximal half; outer branches elongate, attenuated towards the pointed apex, and furnished exteriorly with a comparatively large subapical spine, and with a minute spine on the interior edge. The inner branches are small, curved, stoutly spiniform, and not half the length of the outer branch. The abdomen in the male is composed of four, in the female of two segments, as shown in Pl. VI. fig. 42 and Pl. VII. fig. 5. In the female the caudal stylets are unequal in length; the fourth caudal seta, counting from the outside, in both male and female, but especially the former, is considerably longer than the others (fig. 42). In all the female specimens obtained an apparently structureless membrane of an irregular outline covered the greater portion of the abdomen, and extended beyond the stylets to about halfway over the caudal setæ, as shown in fig. 42.

Habitat. Libreville, Gaboon River, in surface tow-net material collected after midday, January 28th.

Though the *Labidocera* now described differs in one or two points from Sir John Lubbock's *Labidocera Darwinii*, especially in the number of joints of the apical portion of the posterior foot-jaws, yet its agreement with that species is closer than with *Labidocera acutifrons*, Dana; the 'Buccaneer' specimens have therefore been ascribed provisionally to Lubbock's species.

LABIDOCERA ACUTIFRONS (Dana).

1852. *Pontella acutifrons*, Dana, Crust. U.S. Expl. Exped. p. 1149, pl. lxxx. figs. 11 *a–h*.
1883. *Pontella acutifrons*, Brady, Report Chall. Copep. p. 91, pl. xxxv. figs. 1–13.

Habitat. Lat. 5° 10′ N., long. 3° 56′ 2″ W., surface (close inshore), January 12th (night collection). Near Appi (Porto Novo), surface, January 18th (day collection). Libreville, Gaboon River, surface, January 28th (two day collections). Bananah Creek, Congo River, surface, February 7th (day collection). Lat. 7° 54′ 6″ S., long. 12° 14′ 7″ E., surface, February 9th (night collection).

This *Labidocera* was obtained in 24 tow-nettings, 20 of which were surface and 4 under-surface gatherings; one of the under-surface gatherings was from 2½ fathoms (day collection), one from 3 fathoms (night collection), one from 10 fathoms (day collection), and one from 50 fathoms (day collection). 10 of the surface-gatherings were day, and 10 were night collections, as in the formula:—

$$\text{Tow-nettings } 24\begin{cases}20 \text{ surface} & \begin{cases}10 \text{ day collections.}\\ 10 \text{ night ditto.}\end{cases}\\ 4 \text{ under-surface} & \begin{cases}3 \text{ day ditto.}\\ 1 \text{ night collection.}\end{cases}\end{cases}$$

Labidocera acutifrons was comparatively a rare species, though generally distributed throughout the area examined.

LABIDOCERA ACUTA (Dana).

1859. *Pontella acuta*, Dana, Crust. U.S. Expl. Exped. p. 1150, pl. lxxx. figs. 12 *a–c*.
1883. *Pontella acuta*, Brady, Report Chall. Copep. p. 89, pl. xxxvi. figs. 1–12.

Habitat. Libreville, at the mouth of the Gaboon River. Only one or two specimens of what appeared to be this species were obtained.

Genus PONTELLA, Dana, 1846.

Pontia, Milne-Edwards, Hist. Nat. des Crust. (1828).

Pontella, Dana (in part), Amer. Journ. Sc. (2) vol. i. (1846); Brady (in part), Report 'Challenger' Copepoda, 1883; Giesbrecht, Fauna und Flora des Golfes von Neapel (Pelagische Copepoden), 1892.

PONTELLA INERMIS, Brady.

1883. *Pontella inermis*, Brady, Report Chall. Copep. p. 95, pl. xlv. figs. 10–15.

Habitat. Lat. 5° 10′ N., long. 3° 56′ 2″ W., surface (close inshore), January 12th (night collection). Station 24 (off the mouth of the Congo), surface, February 6th (two day collections). Also in surface gatherings collected on the 8th February at the following localities:—Lat. 5° 56′ 5″ S., long. 11° 17′ 2″ E.; lat. 5° 54′ 4″ S., long. 10° 50′ 7″ E.; lat. 6° 3′ 3″ S., long. 11° 7′ 5″ E.; lat. 6° 29′ 4″ S., long. 11° 24′ 8″ E.; lat. 6° 39′ 5″ S., long. 11° 24′ 7″ E.; and on the 9th February at lat. 7° 38′ S., long. 12° 3′ 3″ E.

Pontella inermis was observed only in tow-nettings from the localities described above. They were all surface gatherings, and comprised four day and five night collections.

PONTELLA SECURIFER, Brady.

1883. *Pontella securifer*, Brady, Report Chall. Copep. p. 96, pl. xlv. figs. 1–9.

Habitat. Lat. 3° 57′ 2″ N., long. 7° 42′ 8″ W., 2 fathoms, January 9th (night collections). Lat. 0° 22′ 4″ N., long. 7° 59′ 8″ E., surface, January 29th (day collection). Station 23, surface, day collection, February 5th. Lat. 5° 56′ 5″ S., long. 11° 17′ 2″ E., surface, February 8th (night collection), also on the same date at lat. 6° 3′ 3″ S., long. 11° 7′ 5″ E., surface (day collection); lat. 6° 23′ 3″ S., long. 11° 3′ 8″ E., surface (day collection); lat. 6° 29′ 4″ S., long. 11° 24′ 8″ E., surface (night collection). On the 9th February at lat. 7° 38′ S., long. 12° 3′ 3″ E., surface (night collection); lat. 8° 36′ 8″ S., long. 12° 57′ E., surface (day collection); and on February 18th at lat. 5° 53′ S., long. 11° 31′ 1″ E.

All the tow-nettings in which *Pontella securifer* was obtained were surface gatherings, and comprised five day and four night collections. This species is readily distinguished from the other *Pontellæ* by the remarkable "hatchet-shaped" appendage of the right male antennæ. A few specimens only of this interesting species were obtained.

PONTELLA (?) MEDITERRANEA (Claus), var. GABOONENSIS, nov. var. (Pl. V. figs. 43–48.)

1863. *Pontellina mediterranea*, Claus, Die freilebenden Copepoden, p. 211, t. ii. figs. 8–10, t. iii. fig. 8, t. xxxvi. figs. 11, 12.

Male. Length 2·5 mm. Rostrum with prominent frontal eye as in *Pontella securifer*, Brady. The posterior thoracic angles scarcely produced. Anterior antennæ not reaching to the end of the thorax; that of the left side 24-jointed; the first and second joints are moderately stout, the third to the eleventh are short, while the 17th, 18th, 19th, and 22nd are longer than any of the others with the exception of the basal joints, as shown by the annexed formula:—

Left anterior antenna.	22 .	14 .	4 .	4 .	4 .	4 .	4 .	4 .	5 .	5 .	4 .	8 .	8 .	8 .	10 .	14 .	15 .	18 .	19 .	14 .	13 .	15 .	10 .	13
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24.

Several of the small proximal joints are furnished with moderately long plumose setæ on the upper edge, and a fringe of fine hairs or cilia on the lower margin (fig. 44). The sixth, seventh, and eighth joints of the right antenna are abruptly and considerably dilated; the first of the three, which is also the shortest, bears a stout elongate spine on its upper edge (fig. 45). The tenth and eleventh joints, which are long, and connected together by a hinged articulation, are finely toothed along the upper margin; the denticulations of the tenth joint appear to be bifid, as shown by the figure; the penultimate joint is as long as the preceding and fully twice the length of the terminal joint. The joints of the apical portion of the posterior foot-jaws gradually decrease in length towards the extremity; the first joint is about twice the length of the third, the second is as long as the third and fourth together, the terminal joint is very small (fig. 46). Inner branches of the first pair of swimming-feet 3-jointed, and not longer than the first two joints of the outer branch. Inner branches of the second, third, and fourth pairs 2-jointed. The basal angle of the short, tumid, terminal joint of the right fifth foot is produced into a moderately long digitiform process, which appears to interlock with the spoon-like apical part of the stout angularly curved terminal claw. The last joint of the left foot is furnished with three stout apical spines, one of which is short, while the longer one of the other two is about equal in length to the terminal joint (fig. 48). Abdomen composed of four (? five) segments, the first and third segments are considerably longer than the others. Caudal stylets longer than the third abdominal segment; the fourth seta of each stylet (counting from the outside) is about twice the length of the others.

Habitat. Libreville, at the mouth of the Gaboon River, in two surface gatherings—one being collected near the highest point reached.

Figure 47 shows the fifth feet of an immature female from the same locality. Only three female specimens were obtained, which were all immature.

The *Pontella* here described seems to be nearly identical with *Pontellina mediterranea*, Claus, except that Claus's specimens were larger—4 mm. There is also a difference in the number of joints that precede the three swollen ones of the right male antenna: Claus describes the three swollen joints as "vom dreizehnten bis funfzehnten Gliede," but in the 'Buccaneer' specimens it is the sixth to the eighth joints that are swollen. Moreover, there is some difference in the armature of the prehensile part of the right fifth foot; in the 'Buccaneer' specimens the "eight large and numerous small boat-like knobs" described by Claus are wanting. But as these differences are comparatively unimportant, and may be due to local causes, there appears to be no sufficient reason to consider the 'Buccaneer' specimens distinct from *Pontella mediterranea*, Claus, except as a local variety.

Genus PONTELLOPSIS, Brady.

(*Pontellopsis*, Brady, 'Challenger' Copepoda, p. 85, 1883.)
? *Monops*, Lubbock, 1853.

PONTELLOPSIS VILLOSA, Brady. (Pl. VI. figs. 29–34.)

Pontellopsis villosa, Brady, op. cit. p. 86, pl. xxxiv. figs. 10–13, pl. xxxv. figs. 14–20.

Male. Length 1·85 mm. Right anterior antenna somewhat like that of *Pontella plumosa*, Dana, but differing in the armature and in the number and proportional length of the joints (fig. 34). The left anterior antenna, the posterior antennæ, mouth-organs, and swimming-feet are similar to those of the female (see also pl. xxxv. figs. 14–20, of the 'Challenger' Copepoda). The annexed formula shows the proportional lengths of the joints of the left anterior antenna, which is 18-jointed :—

$$\frac{5\,.\,7\,.\,6\,.\,7\,.\,4\,.\,4\,.\,4\,.\,4\,.\,3\,.\,6\,.\,7\,.\,8\,.\,9\,.\,6\,.\,6\,.\,7\,.\,7\,.\,7}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9\quad 10\quad 11\quad 12\quad 13\quad 14\quad 15\quad 16\quad 17\quad 18}\cdot$$

The fifth pair of feet are nearly like those of *Pontella plumosa*; the most obvious difference between them is in the size and proportional length of the joints. Abdomen stout, short, and composed of five segments; the first is rather longer than the combined length of the next two; the second, third, fourth, and fifth segments are nearly equal in length. Caudal stylets about equal in length to the three preceding abdominal segments.

Pontellopsis villosa was obtained in 21 tow-nettings from various parts of the area traversed by the 'Buccaneer,' between lat. 5° 58′ N., long. 1° 4′ 10″ W., and lat. 5° 9′ 8″ S., long. 11° 10′ 4″ E., all of which, except one from 10 fathoms, were surface-gatherings. The number of day and night collections are as follows :—

$$\text{Tow-nettings } 21\begin{cases}20\text{ surface} & \begin{cases}9\text{ day collections.}\\ 11\text{ night ditto.}\end{cases}\\ 1\text{ under-surface (10 fathoms)} & \begin{cases}1\text{ day collection.}\\ 0\text{ ,, ditto.}\end{cases}\end{cases}$$

The genus and species were described by Dr. Brady from female specimens, of which only three were obtained. In the 'Buccaneer' collections a considerable number of specimens were observed, but comparatively few of them were females, and none of them reached the dimensions of those described in the 'Challenger' Copepoda; the females also wanted the peculiar lateral abdominal appendage possessed by the 'Challenger' specimens; otherwise, however, the 'Buccaneer' specimens (females) agree in every respect with those described and figured in the 'Challenger' Report. The last three thoracic segments of all the 'Buccaneer' specimens possess a brownish coloured mark of an irregular outline on each side of the median dorsal line, as shown in figure 29. The abdomen in the females is also commonly distorted, and the first segment is furnished with two small protuberances; the form and size of the caudal stylets are also more or less unequal.

Dr. Giesbrecht* considers *Monops*, Lubbock, to be synonymous with *Pontellopsis*, Brady, and as *Monops* is prior to the other he substitutes it for *Pontellopsis*.

Genus PONTELLINA, Dana, 1852.

Pontella, Brady (in part.), Report on the 'Challenger' Copepoda, 1883.

Pontellina, Giesbrecht, Fauna und Flora des Golfes von Neapel (Pelagische Copepoden), 1892.

PONTELLINA PLUMATA, Dana.

1852. *Pontellina plumata*, Dana, Crust. U.S. Expl. Exped. p. 1135, pl. lxxix. figs. 10 *a–d*.

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* 'Fauna und Flora des Golfes von Neapel (Pelagische Copepoden),' p. 486.

1852. *Pontella turgida*, ♂, Dana, loc. cit. p. 1136, pl. lxxix. figs. 11 *a*, *b*, figs. 12 *a*, *b*.
1883. *Pontella plumata*, Brady, Report Chall. Copep. p. 92, pl. xxxvii. figs. 1–11.

Habitat. Station 3, 25 fathoms, January 2nd (day collection). Station 9, 25 fathoms, January 10th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10, 20, 30, 260, and 360 fathoms, January 22nd (day collections). Station 23, 10 and 185 fathoms, February 5th (day collection). Lat. 8° 36′ 8″ S., long. 12° 57′ E., surface, February 13th (day collection), &c.

Pontellina plumata occurred in 67 tow-nettings, 39 of which were surface and 28 under-surface gatherings. The under-surface gatherings ranged from $2\frac{1}{2}$ to 360 fathoms; 16 of the surface and 21 of the under-surface were day collections, while 23 surface and 7 under-surface were night collections, as shown by the annexed formula :—

$$\text{Tow-nettings } 67\begin{cases}39 \text{ surface} & \begin{cases}16 \text{ day collections.}\\ 23 \text{ night ditto.}\end{cases}\\ 28 \text{ under-surface} & \begin{cases}21 \text{ day ditto.}\\ 7 \text{ night ditto.}\end{cases}\end{cases}$$

This species was abundant in the 'Buccaneer' collection, both sexes being frequent. Its distribution was co-extensive with the area examined.

Family CYCLOPIDÆ.

Genus OITHONA, Baird.

Oithona, Baird, Zoologist, 1843.

OITHONA CHALLENGERII, Brady.

1883. *Oithona Challengerii*, Brady, Report Chall. Copep. p. 97, pl. xl. figs. 1–10.

Habitat. Station 2, 5 fathoms, January 1st (night collection). Station 9, 50 fathoms, January 10th (day collection). Station 18, surface, February 3rd (day collection). Station 23, surface, February 5th (day collection). Lat. 5° 53′ S., long. 11° 31′ 1″ E., surface, February 18th (night collection), &c.

O. Challengerii seemed to be distributed all over the area examined; in some tow-nettings it was rather rare, but in others frequent. Considerable care was necessary in diagnosing the species, owing to the close resemblance between it and others of the same genus, and to their being so long immersed in spirit, which rendered it very difficult to make out the number of joints in the antennæ.

OITHONA PLUMIFERA, Dana.

1852. *Oithona plumifera*, Dana, Crust. U.S. Expl. Exped. p. 1100, pl. 76.

Habitat. Lat. 4° 31′ 6″ N., long. 6° 4′ 4″ W., 25 fathoms, January 11th (day collection). Lat. 3° 58′ N., long. 3° 42′ W., 50 fathoms, January 13th (day collection). Lat. 2° 22′ 2″ S., long. 7° 45′ E., 20 fathoms, February 3rd (day collection). Station 21, surface, February

4th (day collection). Station 22, 20 fathoms, February 4th (day collection). Station 24, surface, February 6th (day collection). Lat. 7° 38′ S., long. 12° 3′ 3″ E., surface, February 9th (night collection).

This *Oithona* has long densely plumose setæ of a persistent purplish colour, which are sufficiently conspicuous to enable the species to be readily distinguished. *Oithona plumifera*, though frequent in the tow-nettings in which it was observed, appeared to be somewhat rare generally, as the seven collections noticed above were the only ones in which it was obtained.

OITHONA MINUTA, n. sp. (Pl. IX. figs. 14–25.)

Length, female ·64 mm., male ·5 mm. Body moderately stout, ovate. Anterior antennæ not reaching to the end of the thorax: in the female composed of nine distinct joints; the basal joint, which forms about a third part of the whole length of the antenna, is indistinctly divided into seven unequal portions by very faint lines that do not appear to be true joints. If these indistinct articulations be included the female antennæ will consist of fifteen joints, the proportional lengths of which are nearly as shown in the formula:—

$$\frac{(32 \,.\, 4 \,.\, 4 \,.\, 13 \,.\, 4 \,.\, 4 \,.\, 4) \,.\, 14 \,.\, 24 \,.\, 34 \,.\, 10 \,.\, 16 \,.\, 6 \,.\, 12 \,.\, 11}{(1 \,.\, 2 \,.\, 3 \,.\, 4 \,.\, 5 \,.\, 6 \,.\, 7) \,.\, 8 \,.\, 9 \,.\, 10 \,.\, 11 \,.\, 12 \,.\, 13 \,.\, 14 \,.\, 15}.$$

The figures in parentheses refer to the indistinct pseudo-articulations observed in the elongate basal joint. Male antennæ 11-jointed, hinged between the ninth and tenth joints (fig. 16). Posterior antennæ nearly as in *Oithona spinirostris*, Claus (fig. 17) The principal branch of the mandible-palp is armed with two stout, curved, claw-like apical appendages bearing minute marginal spines; the accessory branch is 4-jointed and furnished with several long plumose setæ (fig. 19). The biting part has on one side a short, stout, submarginal tooth, and on the other side a spiniform seta at the apical angle fully twice the length of the apical teeth (fig. 18). Anterior and posterior foot-jaws nearly as in *Oithona Challengerii* or *Oithona spinirostris*, as are also the swimming-feet. The feet of the fifth pair in the female are bisetose, with moderately long plumose setæ; those of the male very minute, with two very small setæ. Abdomen of the female 4-, of the male 5-jointed; stylets as long as the last abdominal segment; the last abdominal segment and stylets in the male are a third shorter than in the female, the tail-setæ in the male are also much shorter than in the female (figs. 24, 25).

This minute but distinct *Oithona* was obtained in a tow-net gathering collected at Bananah Creek, Congo River, February 7th; the sp. gr. of the water was only 1·00870. In two tow-net gatherings from the seaward portion of Loanda Harbour, February 15th, surface-temperature of the water at noon 79·2 F.: the Loanda Harbour tow-net gatherings were collected during the afternoon. *Oithona minuta* was moderately common in these last two gatherings, and many of the females carried ovisacs.

OITHONA SETIGERA, Dana.

1852. *Oithona setigera,* Dana, Crust. U.S. Expl. Exped. p. 1101, pl. 76.

Habitat. In tow-net gatherings from 50 fathoms, lat. 3° 58′ N., long. 3° 42′ W. (temperature 61°·45 F., sp. gr. 1·02531), collected between 8 A.M. and 1 P.M., January 13th; and from 360 fathoms, lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E. (temperature about 43° F.), collected January 22nd. *Oithona setigera* was also obtained in a few other gatherings, but was much less frequent than *Oithona Challengerii.*

Subfamily LONGIPEDIINÆ, Boeck.

Genus LONGIPEDIA, Claus (1863).

LONGIPEDIA MINOR, T. & A. Scott. (Pl. XII. figs. 10–13.)

1882. *Longipedia coronata,* Giesbrecht, Die freileb. Copepoden der Kieler Föhrde, p. 99, pls. i., iv., xii.
1893. *Longipedia coronata,* var. *minor,* T. & A. Scot, Ann. Scott. Nat. Hist. vol. ii. pt. 2, p. 93.
1893. *Longipedia coronata,* var. *minor,* T. Scott, xi. Ann. Rept. Fishery Board for Scotland, pt. iii. p. 200, pl. ii. figs. 14–20.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms, tow-net gathering, collected January 22nd. Loanda Harbour, in three surface tow-net collections, February 15th. Four or five specimens in all were obtained; they differed considerably from *Longipedia coronata* as described by Drs. Claus and Brady.

Genus MICROSETELLA, Brady & Robertson (1873).

Microsetella, Brady & Robertson, Ann. & Mag. Nat. Hist. ser. 4, vol. xii. p. 130 (1873).
Ectinosoma, Brady (in part), Mon. Brit. Copepoda, vol. ii. p. 13; id. Report on the 'Challenger' Copepoda, p. 100 (1883).

MICROSETELLA ATLANTICA, Brady & Robertson.

1873. *Microsetella atlantica,* Brady & Robertson, Ann. & Mag. Nat. Hist. ser. 4, vol. xii. p. 130, pl. ix. figs. 11–16.
1880. *Ectinosoma atlanticum,* Brady, Mon. Brit. Copep. viii. p. 13, pl. xxxviii. figs. 11–19.
1883. *Ectinosoma atlanticum,* id. Report Chall. Copep. p. 100, pl. iv. figs. 10–14.

Habitat. Lat. 7° 33′ N., long. 15° 18′ W., surface, January 2nd (night collection). Lat. 3° 58′ N., long. 3° 42′ W., 50 fathoms, January 13th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms, January 22nd (day collection). Lat. 6° 47′ 5″ S., long. 11° 30′ 6″ E., surface, February 8th (night collection), &c.

Microsetella atlantica was observed in 40 tow-nettings, 19 of which were surface and 21 under-surface gatherings; 4 of the surface and 15 of the under-surface gatherings were day collections, while 15 of the surface and 6 under-surface were night collections, as shown by the annexed formula:—

$$\text{Tow-nettings } 40 \begin{cases} 19 \text{ surface} & \begin{cases} 4 \text{ day collections.} \\ 15 \text{ night ditto.} \end{cases} \\ 21 \text{ under-surface} & \begin{cases} 15 \text{ day ditto} \\ 6 \text{ night ditto.} \end{cases} \end{cases}$$

The under-surface tow-nettings included eighteen gatherings from $2\frac{1}{2}$ to 50 fathoms, and one at 185, 235, and 460 fathoms. This species appeared to be distributed all over the area examined, and was comparatively frequent in some of the gatherings; females with ovisacs were not uncommon.

Canthocamptus roseus, Dana, probably belongs to this species. Dana's description (so far as it goes) and figure agree with *Microsetella atlantica*, but the description is too meagre to admit of a satisfactory comparison. There is a difference between the two as regards size and colour, but such differences are not of much value unless allied with structural differences.

Genus ECTINOSOMA, Boeck.

Ectinosoma, Boeck, Oversigt Norges Copepoder, 1864.
Ectinosoma, Brady (in part), Mon. Brit. Copep. vol. ii. p. 10.

ECTINOSOMA CHRYSTALII, n. sp. (Pl. IX. figs. 26–35.)

Length 1 mm. Body robust; anterior antennæ short, stout, furnished with numerous long setæ; 6-jointed, the third joint is somewhat longer than either the preceding or following; the last is smaller than the others and about two-thirds the length of the penultimate joint, truncate at the apex, and furnished with three long apical setæ. The long middle joint of the posterior foot-jaw is setose on the upper edge, and a long plumose seta that extends beyond the apex of the foot-jaw springs from the upper distal angle of the first joint; last joint short, provided with three setæ (fig. 34). The second basal joints of the first pair of swimming-feet are furnished interiorly with a setose spine that extends nearly to the middle of the second joint of the inner branches; the outer branches, which are comparatively short, reach only to the end of the second joint of the inner branches, and the spines on the exterior edge are elongate and sharp-pointed, otherwise the first pair closely resemble those of *Ectinosoma spinipes*. The second basal joint of the fourth pair is somewhat produced and armed exteriorly with an elongate setose spine; the branches of the fourth pair are nearly of equal length, and armed similar to the first pair, except that the exterior marginal spines of the outer branches are not elongate nor setose. Fifth pair nearly as in *Ectinosoma melaniceps*, Boeck. Caudal stylets about equal in length to the last abdominal segment; the inner of the two principal caudal setæ considerably longer than the other.

Habitat. Station 3 (lat. 7° 1′ 1″ N., long. 15° 54′ W.), 25 fathoms, collected between 9 A.M. and 5.30 P.M., January 2nd.

Several specimens, all females, were obtained in this gathering. The species is named after Professor Chrystal, who designed a tow-net used in collecting some of the material from which the Copepoda described in this Report were obtained.

Genus BRADYA, Boeck, 1872.

Bradya, Boeck, Nye Slægter og Arter af Saltvands-Copepoder, 1872.

BRADYA BREVICORNIS, sp. n. (Pl. IX. figs. 36–43.)

Length 88 mm. Somewhat similar in form to *Bradya typica*, Boeck. Anterior antennæ short, stout, upper edge fringed with long setæ, 7-jointed, the second joint shorter than, and having the upper distal angle produced so as to extend considerably over, the next joint; the fourth joint is much shorter than either the preceding or following joints; the last joint is very small and bears two long terminal setæ. In the 2-jointed secondary branches of the posterior antennæ the distal joint is about twice the length of the proximal one (fig. 38). The anterior foot-jaws are short and stout. The small terminal joint of the posterior foot-jaws bears two long, stout, blunt-pointed spines, ciliate on both edges, and a long, slender seta; a long, plain seta springs from the end of the first joint (fig. 40). The first four pairs of swimming-feet are nearly as in *Bradya typica*; the fifth pair are longer than broad, the apex of the second joint is obliquely truncate and furnished with two setæ, while the inner distal angle terminates in a stout conical spine. Caudal stylets about once and a half the length of the last abdominal segment. The inner of the two principal tail-setæ is about twice the length of the other; a small spiniform seta springs from the outer margin and near the distal end of each stylet.

Habitat. In a surface tow-net gathering from a lagoon, São Thomé Island, collected January 21st.

Subfamily TACHIDIINÆ, Boeck.

Genus EUTERPE, Claus.

Euterpe, Claus, Die freilebenden Copepoden, 1863; Brady, Monog. Brit. Copep. 1880.

EUTERPE GRACILIS, Claus, var. ARMATA, n. var. (Pl. XII. figs. 14–23.)

Length ·9 mm. Body as in *Euterpe gracilis*, but with the rostrum more pyramidal, slightly curved. Anterior antennæ 7-jointed, shorter than the first body-segment. The proportional lengths of the joints as in the formula:—

$$\frac{5\,.\,10\,.\,8\,.\,9\,.\,6\,.\,5\,.\,9}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7}.$$

The fourth joint bears one and the last joint two slender sensory hairs at their distal end. The last three joints also bear a number of long plain setæ. Posterior antennæ 4-jointed, the first two short, the third and fourth longer, subequal; a small 1-jointed secondary branch springs from near the end of the second joint. The mouth-organs and swimming-feet are similar to those of *Euterpe gracilis*, but with the following differences:— The second joint of the inner branches of the first pair of swimming-feet bears a moderately long and stout setiferous terminal spine, which is curved outwards; near the middle of the same joint is a curved transverse row of setæ extending from the outer margin to fully halfway across the joint. The extremity of the outer branches of the second pair is furnished with a long spine, finely serrate on the outer edge, a shorter setiferous spine, a long slender plumose seta, and several small setose spines; the inner branches also bear a row of small spines at their extremities in addition to the plumose hairs. The inner branches of the third and fourth pairs are each armed with a long, stout, strongly setiferous, and straight terminal spine, in addition to several smaller spines and a slender plumose seta. The extremity of the outer branches bears a long curved spine, serrate on the outer edge, two smaller dagger-like spines, and a plumose hair; these smaller spines and the spines at the outer distal angles of the first and second joints are strongly serrate on both margins. A row of spinous setæ extends obliquely across the lower middle portion of the last joint of the inner branches of the fourth pair as well as round the extremity of the joint. The fifth pair as in *Euterpe gracilis*, but with only one short and three long dagger-like terminal spines. A moderately long seta springs from the external margin and near the base of each branch, and a row of small spines extends obliquely from the marginal seta to fully halfway across the segment; moreover, the extremity and inner margin of each branch are fringed with short spinous setæ. Ovisac single, large, containing numerous ova.

Habitat. Station 9, 50 fathoms, January 10th (day collection). Off Accra, surface, 1 day and 1 night collection; 3 fathoms, 1 day and 1 night collection, January 16th. Lagoon, São Thomé Island, surface, January 27th (night collection). Station 23, 235 fathoms, February 5th (day collection). Loanda Harbour, surface, February 15th (day collection).

This species was obtained in 29 tow-nettings, 16 of which were surface and 13 under-surface gatherings; 4 of the surface gatherings were collected during the day and 12 during the night, while 10 of the under-surface were collected during the day and 3 during the night, as shown by the annexed formula:—

$$\text{Tow-nettings } 29\begin{cases}16 \text{ surface} & \begin{cases}4 \text{ day collections.}\\ 12 \text{ night ditto.}\end{cases}\\ 13 \text{ under-surface} & \begin{cases}10 \text{ day ditto.}\\ 3 \text{ night ditto.}\end{cases}\end{cases}$$

The under-surface gatherings were from depths ranging from $2\frac{1}{2}$ to 235 fathoms.

The form here described, though agreeing generally with *Euterpe gracilis*, differs in several important points, as, for instance, in the proportional length of the joints of the anterior antennæ, in the inner branches of the third and fourth pairs of swimming-feet being furnished with prominent, strongly setiferous, terminal spines, and in the fifth pair possessing four instead of five terminal spines. These differences, which are sufficiently characteristic to allow of the variety being readily distinguished, may ultimately be considered of specific value; meanwhile, however, I prefer to consider the 'Buccaneer' specimens as constituting a variety of *Euterpe gracilis*.

Subfamily AMYMONINÆ, Boeck.

Genus AMYMONE, Claus.

Amymone, Die freilebenden Copepoden, 1863; Brady, Monog. Brit. Copep. 1880.

AMYMONE ANDREWI, n. sp. (Pl. XI. figs. 44–47; Pl. X. fig. 1.)

Length ·55 mm. Cephalothorax somewhat similar in form to *Amymone sphærica*, Claus, except that the last thoracic segment is more produced and does not bear any spine-like processes. Anterior antennæ not longer than the first thoracic segment, 8-jointed, the proportional lengths as follows :—

$$\frac{24 \,.\, 24 \,.\, 18 \,.\, 13 \,.\, 6 \,.\, 5 \,.\, 3 \,.\, 8}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8}.$$

The fourth joint bears a long sensory hair at its distal end, and two similar but rather small hairs spring from the extremity of the last joint. Posterior antennæ slender, 3-jointed, the second and third joints subequal, the last terminating in one long and one short, stout, claw-like seta ; the first joint bears at its distal end a small 1-jointed secondary branch possessing four apical setæ. The terminal joint of the first foot-jaws is slender, and furnished with several long plumose hairs and at the extremity with three stout spiniform setæ. A stout setiferous process springs from the end of the second last joint and reaches to the end of the spiniform setæ just described. Second foot-jaws 2-jointed, long, and powerful. The hands possess strong curved terminal claws, bearing below the middle portion one long and one short spinous seta. The basal part of the hands is produced outward into a stout, curved, spiniform process ; the hollow formed by this spiniform process bears a peculiar dilated appendage, furnished with several small spine-like tubercles on its outer surface. The inner margin of the hand is doubly and finely serrate. The integument is closely beset with minute tubercles, much more prominent and distinct than those of *A. sphærica*.

Habitat. Lagoon, São Thomé Island, surface, January 27th (night collection). Specific gravity of the water 1·0237 to 1·0255. One specimen only of this curious species was obtained : I was able to prepare the foregoing description without dissecting it.

The posterior foot-jaws in this species form powerful grasping-organs. The produced base of the hand acting as a sort of thumb and the terminal claw as a finger, with the dilated appendage in the hollow at the base of the hand acting as an interlocking arrangement, form together an elaborate and efficient instrument for grasping purposes, such as I have not observed in any other described species. This curious and interesting genus is represented in various and widely distant localities. It has been observed in various parts of the North Sea, as at Heligoland, Christiania, and several places on the English and Scotch coasts ; at Messina, Naples, and other localities on the Mediterranean coast (*Claus*) ; in the Gulf of Mexico (*Herrick*) ; and on the West Coast of Africa, as now recorded.

The species is named after my son Andrew Scott, who has assisted me so well with the preparation of this Report, and who discovered the only specimen of this genus obtained in the ' Buccaneer ' tow-nettings.

Subfamily STENHELIINÆ, Brady (1880).

Genus STENHELIA, Boeck (1864).

Stenhelia, Boeck, Oversigt Norges Copepoder, 1864.

STENHELIA ACCRAENSIS, n. sp. (Pl. X. figs. 2–12.)

Length ·85 mm. Body moderately robust ; first cephalothoracic segment considerably longer than the entire length of the other four; rostrum prominent. Anterior antennæ short and stout, 9-jointed; the upper distal angle of the fourth joint is produced forward over the next, while the terminal joint is about as long as the total length of the preceding four; the relative lengths of the joints are nearly as shown in the formula:—

$$\frac{10 \,.\, 8 \,.\, 5 \,.\, 3 \,.\, 2 \,.\, 3 \,.\, 2 \,.\, 2 \,.\, 9}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9}.$$

Mandibles and maxillæ nearly as in *Stenhelia hispida*. Foot-jaws nearly as in *Stenhelia ima*. The swimming-feet are also nearly as in the last-named species, except that the proportional lengths of the joints are somewhat different; the first joint of the inner branches of the first pair is not longer than the outer branches and not much longer than the combined length of the second and third joints. The inner branches of the fourth pair are somewhat longer than the outer branches. The fifth pair closely resemble those of *Stenhelia ima* (fig. 11). Caudal stylets somewhat widely apart, about equal in length to the last abdominal segment, and furnished with four apical setæ (fig. 12).

Habitat. Accra, in a shore gathering, collected January 16th.

Subfamily CANTHOCAMPTINÆ, Brady (1880).

Monograph of the British Copepoda, vol. ii. p. 47.

Genus LAOPHONTE, Philippi (1840).

Laophonte, Philippi, Archiv für Naturgeschichte, 1840.
Cleta, Claus, Die freilebenden Copepoden, 1863.
Asellopsis, B. & R., Ann. & Mag. Nat. Hist. vol. xii. 1873.

LAOPHONTE SERRATA (Claus). (Pl. XII. figs. 24–28.)

1863. *Cleta serrata*, Claus, loc. cit. p. 123, t. xv. figs. 13–20.
1880. *Laophonte serrata*, Brady, op. cit. vol. ii. p. 71, pl. lxxii. figs. 1–14.

Habitat. Accra, in a shore gathering, collected January 16th. This, though apparently widely distributed, is nevertheless a rare species. It has been obtained in a few British localities, but always sparingly.

The strong conical tooth-like process on the second joint of the anterior antennæ and the serrated margin of the third joint (fig. 25) are well-marked characters of the species.

LAOPHONTE LONGIPES, n. sp. (Pl. X. figs. 13–23.)

Length ·6 mm. Body elongate; anterior antennæ 7-jointed; the first three joints are together about equal to twice the entire length of the other four, and the last is about equal to the combined length of the two preceding joints. The relative lengths of the joints are nearly as follows:—

$$\frac{6 \,.\, 7 \,.\, 7 \,.\, 2 \,.\, 2 \,.\, 2 \,.\, 4}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7}.$$

The upper distal portion of the fourth joint is produced and forms the base of a sensory filament and one or two setæ. The secondary branch of the posterior antennæ is very short and provided with four setæ—three terminal and one subterminal. Mouth-organs nearly as in *Laophonte similis*, Claus. The outer branches of the first pair of swimming-feet 2-jointed, not reaching to the middle of the inner branches; the first joint is about two-thirds the length of the second. The inner branches of the fourth pair, which reach nearly to the end of the second joint of the outer branches, have the first joint fully half as long as the second, but the first and second joints of the outer branches are about equal in length. Fifth pair nearly as in *Laophonte curticauda*. Caudal stylets somewhat divergent; length about three times the breadth; principal tail-setæ elongate, two-thirds the length of the animal.

Habitat. In a shore gathering from São Thomé Island, collected January 25th at low water; and in a tow-net gathering from 20 fathoms off São Thomé, collected January 23rd.

LAOPHONTE PYGMÆA, n. sp. (Pl. X. figs. 21–30.)

Length ·46 mm. (1-54th of an inch). Body elongate, slender. Anterior antennæ 7-jointed, nearly as in *Laophonte brevicornis*; the annexed formula shows the proportional lengths of the joints:—

$$\frac{6\,.\,7\,.\,7\,.\,2\,.\,2\,.\,3\,.\,4}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7}.$$

The posterior antennæ and mouth-organs are also nearly as in *Laophonte brevicornis*, except that the posterior foot-jaws have the second joint finely ciliate on the inner edge and furnished with a small seta near the middle of the exterior edge. Inner branches of first swimming-feet small, 2-jointed; inner branches of fourth pair very short, scarcely longer than the first joint of the outer branches, 2-jointed; the first joint is very small, and the apex of the second is provided with one stout terminal and two subterminal setæ. The outer branches are armed with a stout apical spine (fig. 28). Feet of the fifth pair nearly as in *Laophonte curticauda*, Boeck; outer margin and surface of basal joints ciliate. Caudal stylets somewhat divergent; their breadth is nearly equal to half the length, and each is provided with two stout apical setæ, the inner one being nearly double the length of the other.

Habitat. Shore, São Thomé Island, in the same gathering as the last.

LAOPHONTE BREVICORNIS, n. sp. (Pl. X figs. 31–37.)

Length ·58 mm. Body slender. Anterior antennæ 6-jointed, the fourth and fifth joints very short; the upper portion of the fourth is produced so as to extend to near the extremity of the following joint and form the base of a moderately stout sensory filament. The relative lengths of the joints are nearly as shown in the annexed formula:—

$$\frac{10\,.\,7\,.\,7\,.\,2\,.\,2\,.\,8}{1\quad 2\quad 3\quad 4\quad 5\quad 6}.$$

Second joint of posterior foot-jaws with a row of very fine cilia on the upper margin;

both the two joints and the terminal claws appear to be otherwise destitute of spines or setæ. Outer branches of first pair of swimming-feet 2-jointed, fully half the length of the first joint of the inner branches, the joints subequal; the length of the first joint of the inner branch is equal to nearly four times its breadth; the terminal claw is stout, and fully two-thirds the length of the first joint and nearly twice and a half the length of the second (fig. 34). The inner branches of the fourth pair, which are scarcely equal in length to the first joint of the outer branches, are composed of two nearly equal joints —the first being the smaller of the two and possessing a moderately long seta on its inner edge; the last joint is furnished with two coarsely plumose terminal setæ and a similar seta on the inner and outer margin; the joints of the 3-jointed outer branches are subequal in length, but the middle one is the shortest of the three (fig. 35). The second joint of the fifth pair, which is considerably smaller than the basal joint, is broader at the distal than the proximal end, and furnished with six setæ round the exteriorly oblique apex; the basal joint is somewhat truncate at the apex and provided with three plain apical setæ and two coarsely plumose setæ on the lower portion of the inner margin (fig. 36). Caudal stylets about equal in length to the last abdominal segment and comparatively wide apart. Each stylet is furnished with one long and stout and a few small setæ; the length of the principal seta is equal to about once and a half the combined length of the stylet and last abdominal segment, and has the extremity curved outwards (fig. 34).

Habitat. In a shore gathering at Accra, collected January 16th.

Genus Cletodes, Brady (1872).

Cletodes, Brady, Nat. Hist. Trans. Northumb. & Durham, 1872.
Lilljeborgia, Claus, Die Copepoden-Fauna von Nizza, 1866.
Orthopsyllus, Brady & Robertson, Ann. & Mag. Nat. Hist. vol. xii. 1873.

Cletodes linearis (Claus). (Pl. XII. figs. 29–32.)

1866. *Lilljeborgia linearis,* Claus, Die Copepoden-Fauna von Nizza, p. 22, t. ii. figs. 1–8.
1873. *Orthopsyllus linearis,* B. & R., Ann. & Mag. Nat. Hist. vol. xii. p. 138.
1880. *Cletodes linearis,* Brady, Brit. Copep. vol. ii. p. 95, pl. lxxx. figs. 1–14.

Habitat. Accra, in a shore gathering, collected January 16th. Loanda Harbour, in a surface tow-net gathering, collected February 13th.

This species, though numerically scarce, appears to have an extensive distribution. In 'British Copepoda' Professor Brady records it from Scilly Islands, also from Newry and Roundstone, Ireland, and Claus has recorded it from Nice.

Subfamily Harpacticinæ, Boeck (in part).

Oversigt Norges Copepoder, 1864.

Genus Dactylopus, Claus (1863).

Dactylopus, Claus, Die freilebenden Copepoden, 1863.
Dactylopus, Brady, British Copepoda, 1880.

Dactylopus latipes, n. sp. (Pl. X. figs. 38–43.)

Length 1·25 mm. (1-20th of an inch). Body moderately robust. First segment of the cephalothorax once and a half the entire length of the other four segments; rostrum slightly curved, stout, of moderate length. Anterior antennæ short, stout, 9-jointed; first joint large, the fourth provided with a long sensory filament; the proportional lengths of the joints nearly as in the formula:—

$$\frac{15\ .\ 8\ .\ 7\ .\ 6\ .\ 3\ .\ 4\ .\ 2\ .\ 1\ .\ 8}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8\quad 9}.$$

Second foot-jaws short and stout; a plumose seta springs from near the inner distal angle of the first joint; the inner margin of the second joint is ciliate, and a small seta springs from the side and near the middle of the same joint (fig. 40); the terminal claw is provided with a slender seta near the base. First pair of swimming-feet nearly as in *Dactylopus tisboides,* Claus. The fifth pair consists of large foliaceous plates partly overlapping each other and forming, apparently, a kind of ovigerous pouch for the protection of the ova (fig. 42; see also fig. 38). Abdominal segments fringed with small teeth; their general surface is also more or less hispid. Caudal stylets about equal in length to the last abdominal segment and rather longer than broad. The inner of the two principal tail-setæ is equal to the entire length of the abdomen and stylets.

Habitat. Accra, in a shore gathering with *Dactylopus propinquus, Laophonte serrata, Stenhelia,* &c., collected January 16th.

Dactylopus propinquus, n. sp. (Pl. X. figs. 44–52; Pl. XI. figs. 1–3.)

Female. Length ·5 mm. (1-50th of an inch). Body moderately stout. Anterior antennæ short and stout, 6-jointed; the upper portion is produced and forms the base of a long sensory filament. The annexed formula shows the proportional lengths of the joints:—

$$\frac{8\ .\ 5\ .\ 8\ .\ 2\ .\ 4\ .\ 6}{1\quad 2\quad 3\quad 4\quad 5\quad 6}.$$

Posterior antennæ nearly as in *Dactylopus tisboides,* Claus (Pl. X. fig. 47). The first joint of the posterior foot-jaws bears two small spinous setæ on the inner margin and another at the inner distal angle; a row of small spinous setæ extends diagonally from near the outer edge at the proximal end to the upper edge near the distal end of the second joint; the terminal claw is stout and provided with a small seta on its inner aspect. The outer branches of the first swimming-feet consist of three nearly equal joints—the middle one being somewhat shorter than the first or third, the last two joints of the inner branches very short and armed with one stout terminal claw and a long seta; the exterior margin of both the last two joints bears several small spiniform teeth (fig. 49). The inner branches of the second, third, and fourth pairs are somewhat shorter than these of *Dactylopus Stromii* (Baird), but otherwise they resemble very closely the same swimming-feet of that species. The second joint in the fifth pair, which does not extend much beyond the apex of the basal joint, is subquadrangular in outline and furnished with five long setæ on its outer nearly straight margin, and another on the inner lateral margin; the broadly triangular portion of the basal joint bears one apical and two subapical stout plain setæ, and two slender setæ spring from the anterior margin (fig. 50). Caudal stylets very short, fringed with long slender serræ; the longer of the two principal terminal setæ is fully twice the length of the abdomen. Ovisacs two.

Habitat. Accra, in a shore gathering collected January 16th. Off São Thomé Island, in a tow-net gathering from 20 fathoms, collected January 23rd, and in a tow-net gathering from a lagoon by the shore of São Thomé Island, collected January 23rd.

A form, which is probably the male of the *Dactylopus* now described, occurs in the same gatherings with it. The only important difference is in the anterior antennæ, which are somewhat longer and 8-jointed; they are hinged between the fifth and sixth joints. But though the anterior antennæ of the male usually consist of the same number of joints as in the female, and frequently of a fewer number, it occasionally happens that they are composed of more joints—as, for instance, in *Ilyopsyllus coriaceus* (Brady and Robertson *) and *Ilyopsyllus affinis*, described in this Report, in both of which the male antennæ consist of a greater number of joints than those of the female.

The first swimming-feet of the male of *Dactylopus propinquus* are similar to those of the female already described; the second pair resemble those of the male of *Dactylopus Stromii* (Baird). The first abdominal segment is provided with a pair of trispinose appendages as shown in Pl. XI. fig. 3 (see also Pl. X. fig. 14).

Genus Thalestris, Claus.

Thalestris, Claus, Die freilebenden Copepoden, p. 128 (1863).

Thalestris forficula, Claus. (Pl. XII. figs. 33–41.)

1863. *Thalestris forficula,* Claus, Die freilebenden Copepoden, p. 131, pl. xvii. figs. 7–11.

Habitat. In a shore gathering from Accra, collected January 16th.

The length (·5 mm.) of the 'Buccaneer' specimen is less than that stated by Claus, which is ·8 mm. The anterior antennæ are 8-jointed; the relative lengths of the joints being nearly as shown by the annexed formula:—

$$\frac{9\,.\,8\,.\,6\,.\,5\,.\,4\,.\,4\,.\,3\,.\,4}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7\quad 8}.$$

The secondary branch of posterior antennæ 2-jointed. First pair of swimming-feet elongate, the inner branches considerably longer than the outer; terminal claws short and stout. Inner branches of the second, third, and fourth pairs shorter than the outer branches: in the fourth pair the inner branches reach only to about the end of the second joint of the outer branches, while the outer branches are long and slender, with a long slender terminal spine, ciliate on the outer edge (fig. 39). Second joint of the fifth pair

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* Brit. Copep. vol. ii. pl. lxxxii. fig. 4.

elongate, larger than the basal joint and furnished with six plain setæ—two apical, two subapical, and two on the lower half of the outer margin (fig. 40). Caudal stylets very short; the basal part of the principal caudal setæ is distinctly gibbous, as shown in fig. 41. Claus also, *op. cit.*, describes and figures this character of the tail-setæ. He obtained *Thalestris forficula* at Messina.

Genus ILYOPSYLLUS, Brady & Robertson.

Ilyopsyllus, Brady & Robertson, Ann. & Mag. Nat. Hist. s. 4, vol. xii. p. 132 (1873).

ILYOPSYLLUS AFFINIS, n. sp. (Pl. XI. figs. 4–17.)

Length ·5 mm. Body tumid, similar in form to *Ilyopsyllus coriaceus*, B. & R.; rostrum broadly triangular, furcate at the apex.

Anterior antennæ 5-jointed in the female, 8-jointed in the male; the produced upper distal portion of the dilated basal joint is more or less hispid and furnished with several spiniform setæ; a curved fold fringed with long stout serræ occurs near the distal end of the base, and extends from the upper margin downwards about two-thirds the breadth of the joint. In the female the three apical joints are of nearly equal length. The proportional lengths of the joints are nearly as shown in the formula:—

$$\text{Female: } 20 \,.\, 10 \,.\, 8 \,.\, 7 \,.\, 8$$

$$\text{Male: } \frac{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8}{8 \,.\, 20 \,.\, 5 \,.\, 9 \,.\, 7 \,.\, 10 \,.\, 6 \,.\, 5}.$$

The third and fourth joints in the male are each provided with a long "olfactory" appendage, as are also the female antennæ, and these olfactory filaments appear to have a small joint near the proximal end, as shown by the figs. 4 and 5; posterior antennæ and mandibles nearly as in *Ilyopsyllus coriaceus*. Fig. 10 represents what appear to be the maxillæ and oral aperture. Figs. 11 and 12 represent what appear to be the anterior and posterior foot-jaws as observed in the dissections of the animal. The first four pairs of swimming-feet resemble those of *Ilyopsyllus coriaceus*, except that the middle joint of the outer branches of the first pair is somewhat longer than either the first or third joints. Fifth pair small, simple, obliquely truncate at the apex, with the lateral angles somewhat produced and bearing each a small spiniform seta, and a similar seta springs from the distal half of the outer margin; a transverse curved row of small spines extends nearly across the basal part of each foot (fig. 15). Abdominal segments fringed with stout cilia. Caudal stylets short, breadth about equal to the length, each furnished with two very short setæ and a long one, which is slightly spathulate at the base.

Habitat. In a shore lagoon at São Thomé Island, among species of Conferva.

Genus Harpacticus, Milne-Edwards (1838).

Harpacticus chelifer, ? var. (Pl. XII. figs. 42–46.)

1776. *Cyclops chelifer,* Müller, Zool. Dan. Prodr. 2413 ; Entomostraca, p. 114, t. xix. figs. 1–3.
1850. *Arpacticus,* Baird, Brit. Entom. p. 212, t. xxix. figs. 2, 3, 3 *a–g.*
1863. *Harpacticus,* Claus, Die freilebenden Copepoden, p. 135, t. xix. figs. 12–19.
1880. *Harpacticus,* Brady, Brit. Copep. vol. ii. p. 146, pl. lxv. figs. 1–15, pl. lxiv. figs. 10, 11.

A form of *Harpacticus* closely resembling *Harpacticus chelifer* was obtained in a shore gathering collected at Accra, January 16th, and in a tow-net gathering from 185 fathoms at Station 23, collected February 5th.

The chief point of difference seems to be the absence of the curved spines or "claws" on the inner distal margin of the last joint of the posterior foot-jaws; the inner margin of these foot-jaws is also not concave as in *H. chelifer*, but in all other respects the 'Buccaneer' specimens closely resemble that species.

Genus Miracia, Dana.

Miracia, Dana, Proceed. Amer. Acad. Sci. 1849.

Miracia efferata, Dana.

Habitat. Station 2, 50 fathoms, January 1st (night collection). Station 9, surface, 25 and 50 fathoms, January 10th (day collections). Station 14, 10 fathoms, January 21st (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10 to 360 fathoms, January 22nd (day collections). Lat. 6° 3′ 3″ S., long. 11° 7′ 5″ E., surface, February 8th (day collection).

This *Miracia* was observed in 49 tow-nettings, 18 of which were surface and 31 under-surface gatherings. The under-surface gatherings were from 3 to 360 fathoms, 8 of the surface and 21 of the under-surface tow-nettings were day collections, while 10 surface and 10 under-surface were night collections, as shown by the formula:—

$$\text{Tow-nettings } 49 \begin{cases} 18 \text{ surface} & \begin{cases} 8 \text{ day collections.} \\ 10 \text{ night ditto.} \end{cases} \\ 31 \text{ under-surface} & \begin{cases} 21 \text{ day ditto.} \\ 10 \text{ night ditto.} \end{cases} \end{cases}$$

It was of frequent occurrence in several of the gatherings, and many of the specimens carried ovisacs.

Miracia minor, n. sp. (Pl. XI. figs. 18–30.)

Length ·93 mm. General form as of *Miracia efferata*, but not half the size. Anterior antennæ 8-jointed, slender in the female; the proportional lengths of the joints are as follows:—

$$\frac{18\ .\ 15\ .\ 13\ .\ 19\ .\ 14\ .\ 20\ .\ 11\ .\ 15}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8}.$$

The joints bear from one to four setæ each, except the last, which has one on the upper and four on the lower side; it has also three terminal setæ. The seta which springs from the upper distal angle of the third joint is longer than those on the other joints except the last, and a long sensory filament springs from the upper distal angle of the fourth joint. In the male antennæ the first three joints are short, the third being shorter than either of the other two; the fourth is dilated and longer than the preceding three together; the fifth is short; the sixth long and slender; the seventh is very small; the eighth a little longer than the seventh and furnished with four terminal setæ; the male antennæ hinged between the fifth and sixth joints. The following are the proportional lengths of the joints :—

$$\begin{array}{cccccccc} 10\,. & 9\,. & 4\,. & 24\,. & 9\,. & 11\,. & 2\,. & 5 \\ 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \end{array}.$$

Posterior antennæ 4-jointed—the last joint as long as the preceding two together, and ciliated along one of its margins. A small 1-jointed secondary appendage, furnished with two stout terminal setæ and a few marginal cilia, springs from the end of the second joint. Mouth-organs as in *Miracia efferata*, except that the posterior foot-jaws are 3-jointed and nearly alike in both sexes, but that of the male has a longer terminal claw; in neither, however, is the terminal claw so short as in *Miracia efferata*. The first pair of swimming-feet has the inner branches scarcely so long as the outer ones; the second joint of the outer branches is furnished with a moderately long plumose hair on the inner distal angle; the inner margin is fringed with short stout setæ, as are also the ends of the first and second joints. The second pair in the female resembles the third and fourth pairs, but are rather smaller. The inner branches of the second pair in the male are 2-jointed; the last joint bears one short terminal spine, and one on the lower half of the outer margin; on the inner margin are two long plumose hairs. The third and fourth pairs are similar in both sexes; the inner branches being shorter than the outer; all the joints of both branches are fringed with hairs on the external margin; the inner distal angle of the last joint bears a long, slender, non-plumose hair (or spine). The fifth feet small, foliaceous, 2-jointed; the proximal joint in the male is armed with two spinous setæ; the distal bears one long setiferous spine and two short spines, also a small hair on the inner aspect, as shown in the figure. In the female the proximal joint is armed with one long setiferous spine and four small spinous setæ (one of which is very minute); the distal joint is somewhat cylindrical in form, and is furnished with several setiferous spines at the extremity. Abdomen in the male 5-, in the female 4-jointed—the first two joints being coalescent in the female. The posterior margin of the last three segments, in both sexes, fringed with small spinous setæ. Caudal stylets rather longer than the last abdominal segment, each furnished with one moderately long setiferous and two shorter spines, besides several spinous setæ on the outer aspect near the middle of the stylet. At the extremity are one long and stout and one short setiferous spine and a number of spinous setæ; the long terminal setiferous spine is fully half as long again as the stylet.

Habitat. Station 23, 235 fathoms, February 5th (day collection).

Several specimens, a few carrying ovisacs, were obtained in this gathering, which was the only one in which *Miracia minor* was observed. It differs from both Dana's species, especially in the number and proportional lengths of the joints of the anterior antennæ.

Genus Machairopus, Brady.

Machairopus, Brady, Report on the 'Challenger' Copepoda, 1883.

Machairopus idyoides, Brady.

1883. *Machairopus idyoides,* Brady, Report 'Challenger' Copep. p. 104, pl. xli. figs. 1–12.

Habitat. The shore of São Thomé Island, January 31st (day collection).

This collection, which contained a very small quantity of weed and sand, yielded a number of *Harpacticidæ*, including two specimens of the *Machairopus.* The 'Challenger' specimens ("two or three only were found") were from Betsy Cove, Kerguelen Island.

The full and carefully figured details which accompany the description of this species make its identification comparatively easy and certain.

Genus Ægisthus, Giesbrecht, 1891.

Ægisthus, Giesbrecht, Fauna und Flora des Golfes von Neapel (Pelagische Copepoden), p. 573 (1892).
Thaumatopsyllus *, Scott, MS. name, 1892.

Body slender, elongate, and with a more or less sharp-pointed rostrum. Anterior antennæ slender, in the female about equal in length to the first body-segment, 6-jointed; in the male the anterior antennæ are longer, and consist of a greater number of joints. Posterior antennæ somewhat similar to those of *Miracia,* 3-jointed, and with a small 1-jointed secondary branch. Mandibles well developed, the broad biting apex irregularly toothed; mandible-palp (?) absent or very rudimentary. Posterior foot-jaws 5-jointed, the three apical joints very small; a long, stout, curved spine springs from the inner distal angle of the second joint; in the male the posterior foot-jaws are smaller than those of the female. Both branches of the first four pairs of swimming-feet 3-jointed and of nearly equal length; in the first pair in the female the articulation between the second and third joints is imperfect and indistinct. Fifth pair simple, 1-branched, 1- (or indistinctly 2-) jointed in the female; distinctly 2-jointed in the male. The tail-setæ of the species for which the genus is instituted are extremely long, and may or may not form a generic character. (*Note.*—This description was written before I saw Giesbrecht's work.)

Ægisthus longirostris, n. sp. (Pl. XI. figs. 31–44.)

Body elongate, slender, gradually tapering towards the posterior end; forehead produced into a long pointed rostrum. Caudal stylets short, each terminating in an

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* θαυματὸς, wonderful; ψύλλος, a flea.

extremely long, slender, jointed, setiferous spine, bearing a plumose seta at its extremity (fig. 31). Length, exclusive of caudal spines, 2·4 mm.; length to the extremity of the caudal spines 12·5 mm. ($\frac{1}{2}$ an inch). Anterior antennæ (female) slender, about equal in length to the first cephalothoracic segment, 6-jointed, sparingly setiferous, penultimate joint very short. The upper distal end of the first joint is produced to form a broadly conical tooth provided with an apical seta. A long "olfactory" appendage springs from the end of the third joint. The relative lengths of the joints are nearly as follows:—

$$\frac{10 \,.\, 12 \,.\, 13 \,.\, 8 \,.\, 1 \,.\, 3}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6}.$$

Anterior antennæ of the male very long and slender, fully twice the length of those of the female, 7-jointed, penultimate joint extremely long; the olfactory appendage that springs from the distal half of the fourth joint and the principal apical seta are also very long. The annexed formula shows the relative lengths of the joints:—

$$\frac{12 \,.\, 13 \,.\, 5 \,.\, 15 \,.\, 6 \,.\, 38 \,.\, 12}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7}.$$

Both the male and female antennæ are geniculate between the first and second joints (fig. 34). Second and third joints of the posterior antennæ elongate: secondary branch very short, with two apical setæ. Mandibles broad, with the truncate distal end irregularly toothed and bearing a pectinate stout seta at the outer angle (fig. 36); no trace of a palp was observed. The maxillæ have a well-developed biting part and a small secondary appendage bearing three apical setæ. Anterior foot-jaws small; first joint armed with two stout spines, setose on both edges, and a small spine and a seta; the very small terminal point bears three apical setæ. The last three joints of the second foot-jaws are very small and furnished with several long setæ; the inner distal portion of the elongate second joint is produced and forms the base of a long, stout, curved spine; there is a small setiferous process on the inner margin of the proximal end (fig. 39). The posterior foot-jaws in the male are somewhat similar to those of the female, but smaller and less setiferous (fig. 40). The middle joint of the second, third, and fourth pairs of swimming-feet shorter than the first or third; the marginal spines of the outer branches stout, dagger-shaped, and serrate on both margins; terminal spines elongate, falcate, serrate on the outer edge, the inner edge ciliate. Fifth pair of feet simple, each foot armed with three long dagger-shaped spines on the outer margin and two at the apex: both edges of these spines are serrate except near the base; there are two plumose setæ near the middle of the inner margin, and a plain seta near the base of the outer margin of each foot, as shown in fig. 43.

Habitat. In a tow-net gathering from 360 fathoms. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., collected January 22nd; and in tow-net gatherings from 185 fathoms and 235 fathoms, Station 23, collected February 5th.

Several specimens of this remarkable species were obtained. They do not agree with *Ægisthus aculeatus*, Giesbrecht,—*e. g.* the fifth pair of thoracic feet, &c.

Genus CLYTEMNESTRA, Dana.

Clytemnestra, Dana, Proc. Amer. Acad. Sci. 1849.
Goniopsyllus, Brady, Report 'Challenger,' Copepoda, 1883.
Goniopelte, Claus, Arb. Zool. Inst. Wien, 1889.
Saphir, L. Car. 1890.

Head and first thoracic segment coalescent. Forehead usually subrostrate. The joints of the cephalothorax much constricted in front, dilated behind so as to form prominent lateral triangular processes. Anterior antennæ 6- to 8-jointed, geniculate in the male. Posterior antennæ 3(or 4 ?)-jointed; secondary branch wanting, or very small and rudimentary. Mandible slender, apex obscurely digitiform; the palp absent or very rudimentary. Maxillæ also rudimentary. Anterior foot-jaw small, clawed at the apex. Posterior foot-jaw elongate, 2- or 3-jointed; terminal claw, in the male, long and powerful, in the female small. First pair of swimming-feet 2-branched, inner branch 3-jointed, the outer with one to three joints. The second, third, and fourth pairs nearly alike, 2-branched, both branches 3-jointed. Feet of fifth pair 1-branched, the branches similar and 1-jointed, and the same in both sexes.

CLYTEMNESTRA ROSTRATA (Brady). (Pl. XII. figs. 47–57; Pl. XIII. figs. 1–3.)

1883. *Goniopsyllus rostratus,* Brady, Report on the 'Challenger' Copepoda, p. 107, pl. xlii. figs. 9–16.
1849. *Clytemnestra* (?) *scutellata,* Dana, Proc. Amer. Acad. Science.
1860. *Clytemnestra* (?) *tenuis,* Lubbock, Trans. Linn. Soc. vol. xxiii. p. 180, pl. xxix. figs. 6, 7.
1889. (?) *Goniopelte gracilis,* Claus, Arb. Zool. Inst. Wien, t. ix.

Length about 1·25 mm. The body is usually more or less curved inwards. The forehead is subtruncate, with middle part produced forward so as to form a prominent rostrum. Postero-lateral angles of the first four thoracic segments extended backward into angular processes; the last thoracic segment smaller than either the preceding one or the first abdominal segment, its postero-lateral angles not produced. Abdomen 5-jointed in the male, 4-jointed in the female; the first abdominal segment in the female composed of two coalescent segments, with usually a pellucid spot in the median dorsal line (Pl. XII. fig. 48). Body, seen dorsally, elongate, narrow, and tapering gradually from the head backwards. Caudal stylets short, about as long as the last abdominal segment, each furnished with a few short marginal hairs, and in the male with two long plumose terminal setæ. The plumose setæ are wanting in the female and are replaced by two or three plain and very small hairs. Anterior antennæ in both male and female 7-jointed, the proportional lengths of the segments being nearly as follows:—

Male.	12 .	19 .	6 .	22 .	3 .	18 .	25
	1	2	3	4	5	6	7 .
Female.	12 .	20 .	16 .	15 .	15 .	17 .	22

The anterior antennæ of both male and female are sparingly setiferous. There is a hair-like filament on the upper margin and near the middle of the third joint in both sexes, while the upper distal angle of the fourth segment and the extremity of the last bear each two similar filaments or "sensory hairs," one of which on both segments is longer and stouter than the other. In the male the third (?) and last joints are hinged, and the fifth bears a spiniform appendage. The posterior antennæ are of moderate length and 3-jointed (Claus says 4-jointed, and the basal joint of some of the 'Buccaneer' specimens has a faint line, requiring the $\frac{1}{4}$-inch objective to see it, crossing the basal segment near the middle, which may be a pseudo-joint; but there are certainly only *three distinct joints* in all of the 'Buccaneer' specimens examined), having at the distal end of the first segment a 1-jointed rudimentary branch bearing two long terminal plumose setæ. The lower margin and the distal half of the surface of the last segment of the primary branch is setose; the upper edge of the same segment bears one, and at the extremity five setæ. Mandibles small, basal part somewhat dilated, the upper part slender, with the extremity furcate or obscurely digitiform; the mandible-palp absent or very rudimentary (no palp was observed in any of the 'Buccaneer' specimens, though they were dissected with the greatest possible care). Maxillæ rudimentary, bearing two terminal spiniform setæ, and one seta near the middle of the basal part. Anterior foot-jaws small; the end joint with three terminal spiniform setæ, the middle one being the longest. There is at the end of the basal segment a proportionally large marginal process bearing three terminal spiniform hairs, which imparts to the anterior foot-jaws the appearance as if they were 2-branched; a long, slender, marginal hair springs from the proximal half of the basal joint. Posterior foot-jaws in the male large, composed of two long segments and a long, curved, terminal claw, nearly as long as the second joint, and forming a powerful prehensile organ; the upper margin of the second joint is finely serrate. The posterior foot-jaw in the female, which is also 2-jointed (Pl. XII. fig. 56), is shorter and more slender than that of the male, the terminal claw being also short and feeble, the length of the whole appendage being little, if at all, longer than the first joint of the male appendage (Prof. Brady describes, *loc. cit.*, the posterior foot-jaws as possessing a rudimentary third joint, but no such joint was observed in the 'Buccaneer' specimens). First pair of swimming-feet 2-branched, inner branches 3-jointed, the last joint being the shortest; outer branches 1-jointed, rather longer than the first joint of the inner branches. All the joints are furnished with long plumose hairs; a single plumose hair springs from the outer margin of the second basal joint. Second, third, and fourth pairs nearly alike, also 2-branched, both branches 3-jointed, joints subequal; the outer branches rather shorter than the inner ones, all well furnished with long plumose setæ. Fifth pair of feet 1-branched, 2-jointed, slender, the second joint twice the length of the first, bearing a long, slender, setiferous, terminal spine, and a similar one on the inner margin near the extremity of the joint; four short spinous hairs spring at irregular intervals along the outer margin; there is also a slender hair on the outer margin and near the distal end of the first joint. The preceding description of the five pairs of feet applies to both sexes. Ova not apparently enclosed in a sac, but forming a single cluster somewhat similar to that of *Euchæta marina*.

Habitat. Station 2, surface, January 1st (night tow-netting). Station 9, 50 fathoms, January 10th (day tow-netting). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms, January 22nd (day tow-netting). Station 23, 10, 185, 235 fathoms, February 5th, &c. (day tow-nettings, and a surface night tow-netting).

This interesting species was obtained in 31 tow-nettings, 16 of these being surface and 15 under-surface collections. One of the surface and 9 of the under-surface tow-nettings were day collections, while 15 surface and 6 under-surface were night collections, as shown in the formula:—

$$\text{Tow-nettings } 31\begin{cases}16 \text{ surface} & \begin{cases}1 \text{ day collection.}\\ 15 \text{ night collections.}\end{cases}\\ 15 \text{ under-surface} & \begin{cases}9 \text{ day ditto.}\\ 6 \text{ night ditto.}\end{cases}\end{cases}$$

The under-surface tow-nettings ranged from 3 to 460 fathoms.

Clytemnestra rostrata was of more or less frequent occurrence in nearly all the tow-nettings in which it was observed. Specimens carrying ova were not uncommon in some of the collections.

The form here described, including its real and supposed varieties, has been the subject of a good deal of misunderstanding and controversy, due in great part to the meagreness and insufficiency of Dana's description and figures. Nevertheless, after having carefully dissected and examined a large number of specimens, I have no doubt whatever that the species under consideration belongs to Dana's *Clytemnestra*, and I hesitate to ascribe it to his *Clytemnestra scutellata* only because of the difference in number of the joints of the inner branches of the first pair of swimming-feet, which in *C. scutellata*, as described by Dana, are 3-jointed, but which in the 'Buccaneer' specimens are 1-jointed; and also because of the very marked difference in the form of the dorsal aspect between the 'Buccaneer' specimens and Dana's figure of *Clytemnestra scutellata*. Dana's figure represents the thoracic as decidedly broader than the abdominal part of the body, whereas the form of the 'Buccaneer' specimens is elongate-narrow, with the breadth *gradually diminishing* from the head to the last abdominal segment, and in this respect they agree with *Goniopsyllus rostratus*, Brady, and *Goniopelte gracilis*, Claus. Further, the 'Buccaneer' specimens differ from *Goniopsyllus rostratus*, as figured and described by Prof. Brady in the 'Challenger' Report, in two important points: first, the posterior antennæ of the 'Buccaneer' specimens possess a rudimentary but yet distinct secondary branch bearing two plumose hairs, while in *Goniopsyllus rostratus* the secondary branch is wanting, being represented by a single plumose hair attached to the end of the basal joint of the primary branch; second, the inner branches of the first pair of swimming-feet in *Goniopsyllus rostratus* are described as 3-jointed, whereas in the 'Buccaneer' specimens they are only 1-jointed, and are so in both the male and female. On the other hand, the species described and figured by Prof. Claus as *Goniopelte gracilis* agrees, so far as I can make out, in every essential particular with the 'Buccaneer' specimens, so that the 'Buccaneer' specimens appear to belong to *Goniopelte gracilis*, Claus, rather than to *Goniopsyllus rostratus*, Brady.

In an interesting paper by Prof. Claus in the 'Zoologischer Anzeiger,' No. 378

(Nov. 30, 1891), he discusses somewhat fully the classification of the species now under consideration, as well as that of its allied forms, and also the various opinions expressed by different writers bearing on the same question. In this paper Prof. Claus shows, more or less conclusively, that *Sapphir rostratus*, L. Car., is synonymous with *Goniopsyllus rostratus*, Brady, and also that *Clytemnestra Hendorffi*, Poppe, is equivalent to *Goniopelte gracilis*, Claus. In a concluding note, referring to the likelihood that *Goniopelte* may be synonymous with *Goniopsyllus*, he says: "But if it is desirable,—which I could not advise, taking into account the different points,—that the two forms *Goniopelte* and *Goniopsyllus* should be made only different species of the same genus, *Clytemnestra*, for reasons given in my work on Copepods, would not be valid as a generic name. It must in that case be *Goniopsyllus*, Brady." With all deference, however, to what Prof. Claus has stated, I prefer meantime to restore Dana's generic name, *Clytemnestra*; for, though his description be imperfect, there need be no uncertainty as to his figures.

(*Note.*—The preceding remarks on *Clytemnestra* were written at the close of 1891, and long before I saw Giesbrecht's Monograph of the Neapolitan Copepoda.)

Genus SETELLA, Dana.

Setella, Dana, Crust. U.S. Expl. Exped. 1852.

SETELLA GRACILIS, Dana.

1852. *Setella gracilis*, Dana, Crust. U.S. Expl. Exped. p. 1198, pl. lxxxv. figs. 3 *a, g*.
1883. *Setella gracilis*, Brady, Report Chall. Copep. p. 108, pl. l. figs. 1–10.

Habitat.—Station 2, 5 fathoms, January 1st (night collection). Station 9, 50 fathoms, January 10th (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms, January 22nd (day collection). Station 18, surface, February 3rd (day collection). Lat. 6° 47′ 5″ S., long. 11° 30′ 6″ E., surface, February 8th (day collection), &c.

Setella gracilis was obtained in 85 tow-nettings, 34 of which were surface and 51 under-surface gatherings. The under-surface gatherings were from various depths, from 2½ to 460 fathoms. 11 of the surface and 34 of the under-surface tow-nettings were collected during the day, and 23 of the surface and 17 under-surface were night collections, as shown by the formula:—

$$\text{Tow-nettings 85}\begin{cases}\text{34 surface} & \begin{cases}\text{11 day collections.}\\ \text{23 night ditto.}\end{cases}\\ \text{51 under-surface} & \begin{cases}\text{34 day ditto.}\\ \text{17 night ditto.}\end{cases}\end{cases}$$

A considerable proportion of the specimens carried ovisacs. The size of the specimens varied sufficiently to lead me to think that there were more than one species of *Setella* in the collection; but careful dissection showed little, if any, structural difference among the specimens, and any structural difference observed was easily accounted for by difference in maturity or sex.

Section II. *PŒCILOSTOMA*, Thorell.

Family CORYCÆIDÆ, Dana.

Genus Corycæus, Dana.

Corycæus, Dana, Proc. Acad. Nat. Sci. Philadelphia, 1845.
Corycæus, Brady, Report on the Copepoda of the 'Challenger' Expedition, 1883.

Corycæus varius, Dana.

1852. *Corycæus varius*, Dana, Crust. U.S. Expl. Exped. p. 1211, pl. lxxxv. figs. 4 *a–i*.
1856. *Corycæus styliferus*, Lubbock, Trans. Entom. Soc. iv. N. S. pl. v. figs. 7, 8.
1863. *Corycæus furcifer*, Claus, Die freilebenden Copep. p. 157, pl. xxiv. figs. 7–12.
1883. *Corycæus varius*, Brady, Report Chall. Copepoda, p. 111, pl. lii. figs. 1–14.

Habitat. Station 2, 25 fathoms, January 1st (night collection). Station 9, 50 fathoms, January 10th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 460 fathoms, January 22nd (day collection). Station 18, surface, February 3rd (day collection). Bananah Creek, Congo River, surface, February 7th (day collection), &c.

This *Corycæus* was observed in 110 tow-nettings, comprising 48 surface and 62 under-surface gatherings. The under-surface gatherings ranged in depth from 2 to 460 fathoms. 23 of the surface and 44 of the under-surface tow-nettings were day collections, while 25 surface and 18 under-surface were night collections, as shown by the annexed formula:—

$$\text{Tow-nettings } 110\begin{cases}48 \text{ surface} & \begin{cases}23 \text{ day collections.}\\ 25 \text{ night ditto.}\end{cases}\\ 62 \text{ under-surface} & \begin{cases}44 \text{ day ditto.}\\ 18 \text{ night ditto.}\end{cases}\end{cases}$$

This was the most common species of *Corycæus* in the collection, both as regards its general distribution throughout the area examined and its frequency in the tow-nettings in which it occurred.

Corycæus pellucidus, Dana.

1852. *Corycæus pellucidus*, Dana, Crust. U.S. Expl. Exped. p. 1224, pl. lxxxvi. fig. 6.
1863. *Corycæus rostratus*, Claus, Die freilebenden Copepoden, p. 157, pl. xxviii. fig. 5.
1883. *Corycæus pellucidus*, Brady, Report Chall. Copep. p. 112, pl. lii. figs. 15–19.

Habitat. Station 2, 50 fathoms, January 1st (night collection). Station 9, surface, 25 and 50 fathoms, January 10th (day collections). Lagoon, São Thomé Island, surface, January 27th (one day and one night collection). Station 18, surface, February 3rd (day collection). Lat. 7° 38′ S., long. 12° 3′ 3″ E., surface, February 9th (night collection), &c.

This *Corycæus*, which was a moderately common species in the collection, occurred in 81 of the tow-nettings, which comprised 42 surface and 39 under-surface gatherings. The under-surface tow-nettings ranged in depth from 2 to 360 fathoms. 15 of the surface and 30 under-surface tow-nettings were day collections, while 27 surface and 9 under-surface were night collections, as shown in the formula :—

$$\text{Tow-nettings 81}\begin{cases}\text{42 surface} & \begin{cases}\text{15 day collections.}\\ \text{27 night ditto.}\end{cases}\\ \text{39 under-surface} & \begin{cases}\text{30 day ditto.}\\ \text{9 night ditto.}\end{cases}\end{cases}$$

The distribution of *Corycæus pellucidus* was co-extensive with the area examined. The long spine-like and strongly setiferous hairs of the posterior foot-jaws form an easily recognized character of this species.

CORYCÆUS LIMBATUS, Brady.

1883. *Corycæus limbatus*, Brady, Report Chall. Copep. p. 114, pl. xlix. figs. 18–22.

Habitat. Station 2, night collection. January 1st. Station 9, 50 fathoms, January 10th (day collection). Station 11, 10 fathoms, January 19th (day collection). Lagoon, São Thomé Island, surface, January 27th (night collection). Lat. 7° 38′ S., long. 12° 3′ 3″ E., surface, February 9th (night collection), &c.

Corycæus limbatus was obtained in 25 tow-nettings, 10 of which were surface and 15 under-surface gatherings. The depth of the under-surface tow-nettings ranged from 2½ to 50 fathoms, exclusive of two, one of which was from 260 fathoms and one from 360 fathoms. 4 of the surface and 10 of the under-surface tow-nettings—including the two specially referred to—were day collections, while 6 of the surface and 5 of the under-surface were night collections, as shown by the formula :—

$$\text{Tow-nettings 25}\begin{cases}\text{10 surface} & \begin{cases}\text{4 day collections.}\\ \text{6 night ditto.}\end{cases}\\ \text{15 under-surface} & \begin{cases}\text{10 day ditto.}\\ \text{5 night ditto.}\end{cases}\end{cases}$$

This *Corycæus*, though generally distributed over the area examined, was nevertheless a comparatively rare species, only a few specimens at most being observed in any one of the tow-nettings in which it occurred.

CORYCÆUS VENUSTUS, Dana.

1852. *Corycæus venustus*, Dana, Crust. U. S. Expl. Exped. p. 1222, pl. lxxxvi. figs. 4 *a–d*.

1883. *Corycæus venustus*, Brady, Report Chall. Copep. p. 115, pl. liv. figs. 8–10.

Habitat. Station 2, surface, January 1st (night collection). Station 9, surface and 25 fathoms, January 10th (day collections). Lat. 1 55′ 5″ N., long. 5° 55′ 5″ E., 30 and 460 fathoms, January 22nd (day collections). Lat. 6 23′ 3″ S., long. 11 3′ 8″ E., surface, February 8th (day collection).

This species—one of the rarer of the *Corycæidæ* in the collection—was obtained in 24 tow-nettings, 13 of which were surface and 11 under-surface gatherings. The surface tow-nettings comprised 7 day and 6 night collections, and the under-surface 7 day and 4 night collections, as shown in the formula:—

$$\text{Tow-nettings } 24\left\{\begin{array}{ll}\text{13 surface} & \left\{\begin{array}{l}\text{7 day collections.}\\ \text{6 night ditto.}\end{array}\right.\\ \text{11 under-surface} & \left\{\begin{array}{l}\text{7 day ditto.}\\ \text{4 night ditto.}\end{array}\right.\end{array}\right.$$

The under-surface tow-nettings included four at 10 fathoms, one at 15 fathoms, one at 20 fathoms, two at 25 fathoms, one at 30 fathoms, one at 50 fathoms, and one at 460 fathoms.

CORYCÆUS SPECIOSUS, Dana.

1852. *Corycæus speciosus,* Dana, Crust. U.S. Expl. Exped. p. 1222, pl. lxxxvi. figs. 4 *a–d*.
1883. *Corycæus speciosus,* Brady, Report Chall. Copep. p. 115, pl. liv. figs. 8–10.

Habitat. Station 2, 5, 25, and 50 fathoms, January 1st (night collection). Station 9, surface, 25 and 50 fathoms, January 10th (day collections). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10, 20, 30, 60, 260, 360, and 460 fathoms, January 22nd (day collections: the nets were fixed at intervals on a deep-sea line and exposed simultaneously from 11 A.M. to 2.23 P.M.). Station 23, surface, 10, 20, 135, 185, and 235 fathoms, February 5th (day collections: nets fixed on deep-sea line and exposed simultaneously from 11 A.M. to 3.30 P.M.). Lat. 7° 54′ 6″ S., long. 12° 14′ 7″ E., surface, February 9th (day collection), &c.

This fine and well-marked species was observed in 86 tow-nettings, 32 of which were surface and 54 under-surface collections. The depth of the under-surface tow-nettings ranged from 2 to 460 fathoms. 17 of the surface and 39 of the under-surface tow-nettings were day collections, while 15 surface and 15 under-surface were night collections, as shown in the annexed formula:—

$$\text{Tow-nettings } 86\left\{\begin{array}{ll}\text{32 surface} & \left\{\begin{array}{l}\text{17 day collections.}\\ \text{15 night ditto.}\end{array}\right.\\ \text{54 under-surface} & \left\{\begin{array}{l}\text{39 day ditto.}\\ \text{15 night ditto.}\end{array}\right.\end{array}\right.$$

Corycæus speciosus was one of the more common species of the *Corycæidæ* observed in the collection, but it was not obtained in any gathering from localities where the water was of a decidedly brackish character, as at Bananah Creek. The remarkably divergent caudal stylets made this an easily recognized species; several specimens were obtained with ovisacs.

CORYCÆUS OBTUSUS, Dana.

1852. *Corycæus obtusus,*Dana, Crust. U.S. Expl. Exped. p. 1211, pl. lxxxv. fig. 6.
1857. ? *Corycæus anglicus,* Lubbock, Ann. & Mag. Nat. Hist. vol. xx. pl. xi. figs. 14–17.
1883. *Corycæus obtusus,* Brady, Report Chall. Copep. p. 116, pl. xlvi. figs. 7–9.

Habitat. Station 2, 50 fathoms, January 1st (night collection). Off Accra, 3 fathoms, January 16th (day collection). Lagoon, São Thomé Island, surface, January 27th (night collection). Loanda Harbour, surface, February 13th (day collection).

Corycæus obtusus was observed in 39 tow-nettings, 23 of which were surface and 16 under-surface gatherings; 7 of the surface and 10 of the under-surface tow-nettings were collected during the day, while 16 of the surface and 6 of the under-surface were night collections, as shown in the annexed formula:—

$$\text{Tow-nettings 39} \begin{cases} \text{23 surface} \begin{cases} \text{7 day collections.} \\ \text{16 night ditto.} \end{cases} \\ \text{16 under-surface} \begin{cases} \text{10 day ditto.} \\ \text{6 night ditto.} \end{cases} \end{cases}$$

The under-surface tow-nettings ranged from $2\frac{1}{2}$ to 50 fathoms, and one at 185 fathoms. The hook-like process at the base and on the under surface of the first abdominal segment seems to be peculiar to this species and forms one of its distinctive characters.

Genus Copilia, Dana.

Copilia, Dana, Proc. Amer. Acad. Sci. 1849; Brady, Report on the Copepoda of the 'Challenger' Expedition, 1883.

Copilia mirabilis, Dana.

1852. *Copilia mirabilis*, Dana, Crust. U.S. Expl. Exped. p. 1232, pl. lxxx. figs. 14 *a–g*.
1856. *Saphirina stylifera*, Lubbock, Trans. Entom. Soc. vol. iv. p. 28, pl. iv. figs. 9, 10 ♂.
1863. ? *Copilia denticulata*, Claus, Die freilebenden Copepoden, p. 161, pl. xxv. figs. 14–20.
1883. *Copilia mirabilis*, Brady, Report Chall. Copepoda, p. 117, pl. liii. figs. 1–11.

Habitat. Station 2, surface and 50 fathoms, January 1st (night collection). Station 9, surface and 25 and 50 fathoms, January 10th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10, 20, 30, 60, and 360 fathoms, January 22nd (day collection). Station 23, surface, February 5th (day collection).

Copilia mirabilis was observed in 70 tow-nettings, 24 of which were surface and 46 under-surface gatherings. The under-surface gatherings ranged in depth from 2 to 360 fathoms. 12 of the surface and 33 of the under-surface tow-nettings were day collections, while 12 surface and 13 under-surface were night collections, as shown by the annexed formula:—

$$\text{Tow-nettings 70} \begin{cases} \text{24 surface} \begin{cases} \text{12 day collections.} \\ \text{12 night ditto.} \end{cases} \\ \text{46 under-surface} \begin{cases} \text{33 day ditto.} \\ \text{13 night ditto.} \end{cases} \end{cases}$$

This species was of frequent occurrence in several of the tow-nettings.

Copilia quadrata, Dana.

1849. *Copilia quadrata*, Dana, Proc. Amer. Acad. Boston, vol. ii.
1866. *Saphirinella pellucida*, Claus, Die Copepoden-Fauna von Nizza.
1892. *Copilia quadrata*, Giesbrecht, Fauna und Flora des Golfes von Neapel (Pelagische Copepoden), p. 658, pl. 2. fig. 3, pl. 50. figs. 1, 10, 13, 16, 22, 28, 33, 36, 41.

Habitat. Station 23 (lat. 4° 26′ 7″ S., long. 10 1′ 8″ E.), 30 fathoms, in a tow-net gathering collected between 11 A.M. and 3 P.M. A few specimens (male and female) were observed; they were readily distinguished by being larger and much broader in proportion to the length than the others.

? COPILIA DENTICULATA, Claus.

1863. *Copilia denticulata,* Claus, Die freilebenden Copepoden, p. 161, pl. xxv. figs. 14–20.

One or two specimens (♀) of a *Copilia* apparently belonging to this species occurred in a few of the tow-net gatherings along with *Copilia mirabilis.*

COPILIA FULTONI, n. sp. (Pl. XI. figs. 45–50; Pl. XII. figs. 1–3.)

Length, including caudal stylets, 5·3 mm. ($\frac{10}{47}$ of an inch), the length of the caudal stylets is about 1·6 mm. The first cephalothoracic segment is equal to about four-tenths of the entire length of the animal, including the stylets. Anterior antennæ as in *Copilia mirabilis,* Dana, 6-jointed, the proportional lengths of the joints as in the formula:—

$$\frac{40\,.\,35\,.\,17\,.\,35\,.\,17\,.\,16}{1\quad 2\quad 3\quad 4\quad 5\quad 6}.$$

Posterior antennæ and mandibles also nearly as in *Copilia mirabilis,* except that the third joint of the posterior antennæ is scarcely two-thirds the length of the preceding joint, and the marginal spine of the second joint is much smaller than that on the interodistal angle of the first joint (Pl. XI. figs. 47–48). The maxillæ consist each of a single broadly spatulate joint bearing three apical spines (Pl. XI. fig. 49). Anterior foot-jaws stout, 1-jointed, and provided with two terminal spines and two lateral spiniform setæ (Pl. XI. fig. 50). Posterior foot-jaws 2-jointed and armed with a stout, nearly straight claw (Pl. XII. fig. 1). Swimming-feet as in *Copilia mirabilis.* Fifth pair rudimentary, each consisting of one small joint provided with a terminal spine and two small setæ. The abdomen is 4-jointed and is about equal to the combined length of the last three thoracic segments; the postero-distal angles of the first abdominal segment each bear two small spiniform setæ, and the last joint is about equal to the combined length of the two preceding joints. The second last thoracic segment only is produced into a median dorsal spine.

Habitat. Station 23, in a tow-net gathering from 30 fathoms, collected February 5th. Only three specimens were obtained.

The comparatively short posterior abdominal segment distinguishes this species at a glance from *Copilia mirabilis,* Dana. It differs from *Copilia Brucii,* I. C. Thompson, by the evenly rounded outline of the first body-segment, in the proportional length of the joints of the posterior antennæ, in the second last thoracic segment being produced into a median dorsal spine, and in the presence of a fifth pair of feet, besides one or two other points shown by the drawings.

In the Report on the 'Challenger' Copepoda the abdomen of *Copilia* is, in the definition of the genus, stated to consist of five segments, and in the drawings of *Copilia mirabilis* the fourth pair of swimming-feet are represented as attached to what is described as the last thoracic segment; if this be correct, then, should a fifth pair of feet be present, they would necessarily be attached to the same segment as the fourth pair, which would be very unusual, the fifth pair only being usually attached to the last segment of the thorax. In the species now described, if the abdomen be held to consist of five segments, the appendages of the first segment are not a fifth pair of feet, and the fourth pair are attached to what, in that case, is the last thoracic segment, and a separate segment, for the support of a fifth pair of feet, is entirely absent. In these circumstances I prefer to consider the abdomen as consisting of four segments and that the fourth pair of swimming-feet are appendages of the second last segment of the thorax, and further that the rudimentary appendages of the next, or last, thoracic segment are a fifth pair of feet, because such an arrangement of the parts is more in harmony with those of closely allied genera.

Genus LUBBOCKIA, Claus.

Lubbockia, Claus, Die freilebenden Copepoden, 1863; Brady, Report on the Copepoda of the 'Challenger' Expedition, 1883.

LUBBOCKIA SQUILLIMANA, Claus.

1863. *Lubbockia squillimana,* Claus, Die freilebenden Copepoden, p. 164, pl. xxv. figs. 1–5.
1883. *Lubbockia squillimana,* Brady, Report Chall. Copep. p. 118, pl. liii. figs. 12–16, pl. liv. figs. 1–7.

Habitat. Station 3, 100 fathoms, January 2nd (day collection). Station 9, 25 fathoms, January 10th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms, January 22nd (day collection). Station 23, surface and at 10 fathoms, February 5th (day collection). Lat. 8° 36′ 8″ S., long. 12° 5′ 7″ E., surface, February 9th (day collection), &c.

Lubbockia squillimana was observed in 39 tow-nettings, 13 of which were surface gatherings and 26 under-surface. The under-surface gatherings were from various depths from 10 to 360 fathoms; 3 of the surface and 18 of the under-surface tow-nettings were day collections, while 10 surface and 8 under-surface were night collections, as in the formula:—

$$\text{Tow-nettings } 39\begin{cases}13\text{ surface} & \begin{cases}3\text{ day collections.}\\ 10\text{ night ditto.}\end{cases}\\ 26\text{ under-surface} & \begin{cases}18\text{ day ditto.}\\ 8\text{ night ditto.}\end{cases}\end{cases}$$

Though generally distributed throughout the area represented in this Report, and though observed in a considerable number of gatherings, *Lubbockia* was of less frequent occurrence in the tow-nettings in which it was obtained than some other species with a more restricted distribution. Specimens of both sexes were collected, but females were much more common than males; several females carrying ovisacs were taken.

Genus Oncæa, Philippi.

Oncæa, Philippi, Wiegmann's Archiv, 1843.
Antaria, Dana, Proc. Amer. Acad. Sci. 1849.

Oncæa obtusa (Dana).

1843. *Oncæa venusta*?, Philippi, Wiegmann's Archiv, pl. 111. fig. 3.
1852. *Antaria obtusa*, Dana, Crust. U.S. Expl. Exped. p. 1230, pl. lxxxvi. figs. 13 *a–c*.
1883. *Oncæa obtusa*, Brady, Report Chall. Copep. p. 120, pl. li. figs. 1–11.

Habitat. Station 2, surface, 5, 25, and 50 fathoms, January 1st (night collections). Station 9, surface, 25 and 50 fathoms, January 10th (day collections). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10, 20, 30, 260, 360, and 460 fathoms, January 22nd (day collections). Bananah Creek, Congo River, surface, February 7th (day collection). Loanda Harbour, surface, February 13th (day collection).

Oncæa obtusa was observed in 119 tow-nettings, 60 of which were surface and 59 under-surface gatherings. The under-surface tow-nettings ranged in depth from 2 to 460 fathoms. 26 of the surface and 41 of the under-surface gatherings were day collections; 34 of the surface and 18 of the under-surface gatherings were night collections, as shown by the formula:—

$$\text{Tow-nettings } 119 \left\{ \begin{array}{l} 60 \text{ surface} \left\{ \begin{array}{l} 26 \text{ day collections.} \\ 34 \text{ night ditto.} \end{array} \right. \\ 59 \text{ under-surface} \left\{ \begin{array}{l} 41 \text{ day ditto.} \\ 18 \text{ night ditto.} \end{array} \right. \end{array} \right.$$

This was one of the most common and most generally distributed species in the 'Buccaneer' collection; many of the specimens carried ovisacs, and though the collection had been for several years in spirit a considerable proportion of the *Oncææ* retained much of the vivid coloration so characteristic of the species.

Oncæa gracilis (Dana). (Pl. XIII. figs. 4–12.)

1853. *Antaria gracilis*, Dana, Crust. U.S. Expl. Exped. p. 1229, pl. lxxxvi. fig. 11 *a*.

Length 1·1 mm. Cephalothorax narrow, ovate. Abdomen elongate, slender; the breadth of the first abdominal segment is somewhat less than two-thirds its length, and one-third the length of the abdomen, exclusive of the stylets; the second segment is scarcely half the length of the first, and equal to the combined length of the next two; the third segment is nearly twice the length of the last, while the caudal stylets are somewhat longer than the last abdominal segment (fig. 12). The anterior antennæ are similar to those of *Oncæa obtusa*, but are more slender; the relative lengths of the joints are nearly as in the formula:—

$$\frac{4 \,.\, 4 \,.\, 13 \,.\, 2 \,.\, 1 \,.\, 3}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6}.$$

The last joint of the posterior antennæ about as long as the preceding one, but more slender and furnished with four long, stout, apical setæ, and another seta near the base. Mouth-appendages nearly as in *Oncæa obtusa*, except that the last joint of the posterior foot-jaw is elongate and armed with a long, powerful, nearly straight terminal claw, which is finely serrate on the inner edge (fig. 10). First swimming-feet also similar to that species, but more slender, and provided with much longer terminal spines,—the terminal spine of the outer branch is equal to about three times the length of the joint from which it springs. The terminal spines of the three pairs (both branches) are also long. The inner branch of the fourth pair is much shorter than the outer branch, and its three joints are nearly equal in length; the terminal spine is long and setiform. Fifth pair of feet as in *Oncæa obtusa*.

Habitat. Station 2, 50 fathoms, collected January 1st, between 7.20 and 8.20 P.M. Station 9, 50 fathoms, collected January 10th, during the day. Off Appi* (near Porto Novo), surface, collected January 18th (day). Lat. 3° 55′ 3″ N., long. 4° 7′ 3″ E., 30 fathoms, collected January 20th. Lat. 2° 34′ 9″ N., long. 5° 22′ 2″ E., 20 fathoms, collected January 21st. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms, collected January 22nd. Station 23, in two gatherings at 30 and 85 fathoms, collected February 5th. All the gatherings except the first one were collected during the day.

Though I have included this species under *Oncæa*, it nevertheless differs very markedly from the very common *Oncæa obtusa*, Dana. The last joint of the posterior antennæ is elongate and slender; the inner branch of the fourth pair of swimming-feet is considerably shorter than the outer branch, and consists of three nearly equal joints; the abdomen is long and slender, and the last three segments are much longer, comparatively, than in *Oncæa obtusa*. These differences, taken together, should perhaps be considered of more than merely specific value, but I prefer meantime to refer the species above described to *Oncæa*.

Note.—The species described above agrees in several points with *Conæa rapax*, Giesbrecht (Mon. Pelag. Copep. of the Gulf of Naples), and should perhaps be ascribed to that genus.

ONCÆA MEDITERRANEA (Claus). (Pl. XIII. figs. 13–17.)

1863. *Antaria mediterranea,* Claus, Die freilebenden Copepoden, p. 159, pl. xxx. figs. 1–7.

Length ·85 mm. (1-30th of an inch). Somewhat like *Oncæa obtusa* in general form, but with a proportionally shorter abdomen. Abdomen, including caudal stylets, equal to about two-fifths the length of the cephalothorax; length of first abdominal segment equal to about twice the breadth, and to fully twice the entire length, of the remaining segments; and, together with the caudal stylets, the length of the last abdominal segment is rather greater than that of the two preceding segments added together. Caudal stylets about twice as long as broad, and nearly equal in length to the last two abdominal segments. Anterior antennæ slender; the proportional lengths of the joints are nearly as shown in the formula:—

$$\frac{2\,.\,3\,.\,8\,.\,2\,.\,1\,.\,2}{1\quad 2\quad 3\quad 4\quad 5\quad 6}.$$

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[*] *Note by Mr. Rattray.*—"Appi is a flourishing village, with three French factories. It is the nearest port to the inland town of Porto Novo, and communicates with it by a lagoon. The surf at Appi is very heavy, and it is impossible to land except in a native boat built for that purpose. The boats are manned by about sixteen negroes and propelled by paddles. The beach is steep and sandy."

Last joint of the posterior antennæ fully three-fourths the length of the preceding joint. Mouth-organs similar to those of *Oncœa obtusa*, except that the last joint of the posterior foot-jaw is broadly ovate; the fringe of hairs on the inner margin extends backwards from the apex nearly three-fourths the length of the joint, and is bounded at the proximal end by a small spine (fig. 16). The swimming-feet are similar to those of *Oncœa obtusa*, but the joints, especially of the outer branches of the first pair, are proportionally longer, and the length of the terminal spines of both branches of all the swimming-feet is much greater than those of that species: in the first pair the terminal spine of the outer branches is equal to the combined length of the second and last joints; in the fourth pair the terminal spines of both branches are equal to the entire length of the branches they spring from; the terminal spines of the inner branches are also serrate on both branches. The fifth pair, like those of *Oncœa obtusa*, are very small and rudimentary. One or two females only of this species were obtained.

Habitat. Station 9, 50 fathoms, collected January 10th. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 360 fathoms, collected January 22nd.

This species, though closely resembling *Oncœa obtusa*, appears to be quite distinct from it; the following are some points in which it differs from that species:—the last joint of the secondary branch of the posterior antennæ is considerably longer; the joints of the outer branches of the first swimming-feet are proportionally longer; the abdomen is shorter, being only equal to about two-fifths of the length of the cephalothorax; and the terminal spines of the swimming-feet, and especially of the fourth pair, are of much greater length than those of *Oncœa obtusa*. *Oncœa mediterranea* (Claus) seems to agree much closer with this species than with *Oncœa obtusa* (Dana), and I have therefore ascribed it to the species described by Dr. Claus.

Genus Hersiliodes, Canu, 1888.

Hersiliodes Livingstoni, n. sp. (Pl. XIII. figs. 31–38.)

Length, exclusive of tail-setæ, 1·63 mm. Viewed dorsally the body is broadly ovate, and much constricted near the posterior end; it is composed of six segments, the first being nearly equal to the entire length of the other five; the fifth segment is short, and considerably narrower than that which precedes or follows it; the breadth of the last segment is greatest posteriorly. Forehead rounded. Anterior antennæ stout, 7-jointed, and bearing numerous setæ; the proportional lengths of the joints are nearly as shown in the formula:—

$$\frac{15 \,.\, 25 \,.\, 12 \,.\, 18 \,.\, 14 \,.\, 11 \,.\, 11}{1 \quad\; 2 \quad\; 3 \quad\; 4 \quad\; 5 \quad\; 6 \quad\; 7}.$$

Posterior antennæ stout, 4-jointed, the first joint being nearly equal to the combined length of the other three; the third joint bears two stout curved spines at the exterior distal angle, while the truncate extremity of the last joint is armed with four elongate curved spines and a few setæ (fig. 33). The mouth is in the form of a small conical tube, the margin of which is fringed with cilia. The mandible is armed exteriorly with a stout, somewhat curved tooth, having a double row of serratures along its inner margin, and interiorly with three setiferous spines. Maxillæ simple, terminating in two very short and rounded spiniferous lobes (fig. 34). The anterior foot-jaws are furnished with a short, stout, and slightly curved terminal claw, which is provided with several setiferous spines at the base, while two stout setiferous spines spring from the end of the first joint and close to the basal part of the claw. The posterior foot-jaws are large; they are furnished with several spiniform plumose setæ on the inner margin, and terminate in stout, elongate, and strongly curved claws, from the base of which springs a strong and curved claw-like spine (fig. 35). Both branches of the first four pairs of swimming-feet 3-jointed; joints short and broad. The exterior margin of the outer branches of the first pair is furnished with four spines,—one on each of the first and second, and two on the last joint. Round the end and inner margin of the last joint there are six long plumose setæ, while one long seta, also plumose, springs from the inner distal angle of the second joint. The first and second joints of the inner branches have no spine on the outer margin; the outer distal angle of the second joint forms a tooth-like process; the last joint is furnished with a stout spine on the lower half of the exterior margin,—the margin being hollowed out to receive the base of the spine; there are also five plumose setæ round the end and inner edge of the last joint. The extremities of both branches of the second, third, and fourth pairs are armed with one long and one short spine; the long spine of the outer branches is ciliate along the inner edge (fig. 37). The foot of the fifth pair consists of a broad foliaceous joint, rounded at the extremity, and furnished with one long terminal and three small submarginal setæ (fig. 38). Abdomen composed of four segments; the first is considerably dilated, the first, third, and fourth are about equal in length, but the second is rather longer. Caudal stylets half as long again as the last abdominal segment, somewhat divergent, and furnished with two long and three short terminal setæ; there is also a small submarginal spine about one-third the length of the stylet from the extremity (fig. 31).

Habitat. Loanda Harbour; surface tow-net gathering, collected February 15.

Genus Pachysoma, Claus.

Pachysoma, Claus, Die freilebenden Copepoden, 1863.

Pachysoma punctatum, Claus. (Pl. XIII. figs. 18–24.)

1863. *Pachysoma punctatum,* Claus, op. cit. p. 163, pl. xxv. figs. 6–11.

Length 2·5 mm. Body rotund; forehead produced into a small triangular pointed rostrum. Anterior antennæ very short, stout, 7-jointed, the third and fourth joints shorter than the others; the proportional lengths of the joints are as follows:—

$$\frac{30 \;.\; 25 \;.\; 9 \;.\; 12 \;.\; 22 \;.\; 20 \;.\; 15}{1 \quad\; 2 \quad\; 3 \quad\; 4 \quad\; 5 \quad\; 6 \quad\; 7}.$$

Posterior antennæ nearly as in *Lichomolgus,* 4-jointed, the third joint short, the others of moderate length and subequal (fig. 20). Mandibles small, stylet-shaped, ciliate along one edge; the maxillæ consist of small 1-jointed appendages bearing two long apical setæ. Anterior foot-jaws rudimentary, 1-jointed, with a moderately stout terminal claw and a small seta (fig. 23). Basal joint of posterior foot-jaws greatly dilated; second joint stout, bearing two marginal spiniform setæ and armed with a strong curved terminal claw, which is provided with a small seta near the base and on the inner aspect. Swimming-feet nearly as in *Lichomolgus*, both branches 3-jointed; the setæ on their inner margins are stout and densely plumose; the inner branches are considerably longer than the outer (fig. 24). Fifth pair rudimentary and provided with one small marginal and two apical plumose setæ. Abdomen short, composed of four segments; first segment large, the next three much shorter and narrower; in the male the postero-lateral angles of the first abdominal segment carry two plumose setæ. Caudal stylets about equal in length to the first abdominal segment; apical setæ three, and one on the outer edge about one-third the length of the stylet from the proximal end. The structure of the integument is shown in fig. 18.

Habitat. Station 9, in a tow-netting from 25 fathoms. Lat. 2° 34′ 9″ N., long. 5° 22′ 2″ E., 20 fathoms. Station 14, in two tow-net gatherings from 10 and 20 fathoms. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 20 fathoms, and lat. 0° 21′ 1″ N., long. 7° 0′ 33″ E., 20 fathoms.

Though observed in these six separate tow-net gatherings, very few specimens were obtained.

Genus LICHOMOLGUS, Thorell.

Lichomolgus, Thorell, Om Krustaceer i Ascidier, p. 74 (1859).

LICHOMOLGUS CONGOENSIS, n. sp. (Pl. XIII. figs. 39–48.)

Length fully 1 mm. Cephalothorax moderately robust. Anterior antennæ fully half the length of the first cephalothoracic segment, 7-jointed, nearly as in *Lichomolgus fucicolus*; the relative lengths of the joints are shown in the formula:—

$$\frac{12\ .\ 26\ .\ 8\ .\ 17\ .\ 18\ .\ 15\ .\ 10}{1\quad\ 2\quad\ 3\quad\ 4\quad\ 5\quad\ 6\quad\ 7}.$$

Posterior antennæ 4-jointed; first, second, and fourth joints elongate, subequal; third joint very short and bearing two stout setæ on the upper distal angle; the last joint is armed with two slender curved terminal spines and two setæ; there is also a small seta on the inner margin near the apex (fig. 41). The mandible consists of a comparatively broad and apparently abruptly bent process, the truncate apex of which is furnished with a comb-like fringe of short setæ; a stout stylet-like appendage, finely crenate on the upper edge, springs from the outer distal angle, and is closely applied to the anterior edge of the appendage, and extends some distance beyond its fringed apex (fig. 42). The maxillæ are simple 1-jointed appendages, bearing a few apical setæ (fig. 43). Foot-jaws nearly as in *Lichomolgus fucicolus*, except that the posterior foot-jaw is armed with a long curved spine on the inner margin of the proximal half of the second joint (fig. 45). The four pairs of swimming-feet are also nearly as in *Lichomolgus fucicolus*, except that there are stout dagger-shaped spines on the exterior margin and apex of the outer branches; the apex of the inner branches is also provided with similar spines; the inner branch of the fourth pair is 2-jointed (fig. 46). Fifth pair subquadrangular, rather longer than broad, and furnished with two stout terminal spines. Abdomen scarcely equal to half the length of the cephalothorax. Caudal stylets about as long as broad, and three-fourths the length of the last abdominal segment. The fourth tail-seta, counting from the outside, is stouter and rather longer than the others.

Habitat. Bananah Creek, Congo River, in a surface tow-net gathering, collected February 6th. Only two specimens (females) were obtained.

Genus Pseudanthessius, Claus.

Pseudanthessius, Claus, Arb. Zool. Inst. Wien, 1889.

Pseudanthessius propinquus, n. sp. (Pl. XIII. figs. 49-56; Pl. XIV. figs. 1, 4.)

Length 1·3 mm. (1-18th of an inch). Anterior antennæ 7-jointed; the formula shows the proportional lengths of the joints:—

$$\begin{array}{ccccccc} 12 . & 21 . & 6 . & 12 . & 12 . & 11 . & 8 \\ \hline 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{array}.$$

The short penultimate joint of the posterior antennæ bears a long slender spine on its upper distal angle; the last joint is provided with a stout curved apical spine and five setæ. Mandibles somewhat as in *Lichomolgus congoensis,* but the stylet-like appendage is longer and strongly dentate on the upper edge, the basal tooth being much larger than the others (Pl. XIII. fig. 52). Maxillæ armed with three stout terminal spines, two of which are serrate on both edges, and a small marginal seta (Pl. XIII. fig. 53). Anterior foot-jaws stout, 1-jointed, and provided with four strong terminal spines, the two larger of which are furnished with several tooth-like processes. Posterior foot-jaws in the female short, 3-jointed; the second joint carries two short, stout, marginal spines, and the last joint, which is small, carries one terminal and four lateral setæ (Pl. XIII. fig. 54). In the male the posterior foot-jaws are more slender; the first and second joints are fully twice as long as broad, and the inner margin is fringed with cilia; the last joint is very short and forms the base of a stout, elongate, curved claw, which is furnished with two small setæ near the base. The fourth pair of swimming-feet are nearly as in *Pseudanthessius Thorelli* (Brady), but the margins of the 1-jointed inner branches are not ciliate; a moderately long plumose seta springs from the proximal half of the inner edge (? and probably also from the outer edge opposite to the other) (Pl. XIV. fig. 3). The first three pairs of swimming-feet are nearly as in *Lichomolgus fucicolus.* The fifth pair consist each of a moderately stout joint, furnished with two apical spines. Abdomen, inclusive of stylets, nearly equal to three-fourths the length of the cephalothorax: in the male the first segment is as long as the next two together; in the female the first segment is rather more than half the length of the abdomen, the remaining three segments are as in the male. Caudal stylets once and a half the length of the last abdominal segment, and furnished with one seta near the middle of the outer margin and four apical setæ.

Habitat. Loanda Harbour, in a surface tow-net gathering, collected February 15th. Very few specimens were obtained.

Genus Saphirina, Thompson.

Saphirina, Thompson, Zoological Researches, 1829

Saphirina ovalis, Dana.

1852. *Saphirina ovalis,* Dana.
1883. *Saphirina ovalis,* Brady, Report Chall. Copep. p. 123, pl. xlvii. figs. 1–12.

Habitat. Station 2, January 1st (night collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10 and 30 fathoms, January 22nd (day collections). Station 21, surface, February 4th (day collection). Station 24, surface, February 6th (day collection), &c.

This Saphirine was obtained in 27 tow-nettings, 10 of which were surface and 17 under-surface gatherings. The under-surface tow-nettings ranged from 2 to 50 fathoms, with the exception of one which was from 185 fathoms. 2 of the surface and 13 of the under-surface were day collections, while 8 surface and 4 under-surface were night collections, as shown in the formula:—

$$\text{Tow-nettings } 27 \begin{cases} 10 \text{ surface.} & \begin{cases} 2 \text{ day collections.} \\ 8 \text{ night ditto.} \end{cases} \\ 17 \text{ under-surface} & \begin{cases} 13 \text{ day ditto.} \\ 4 \text{ night ditto.} \end{cases} \end{cases}$$

Only one or at most very few specimens were observed in any one of the tow-nettings. The females of *Saphirina ovalis* were usually readily distinguished from other Saphirines by the numerous, circular, opaque white spots scattered somewhat symmetrically over the entire dorsal surface, and which imparted a rather elegant appearance to the specimens. (It will be understood that the ornamentation described is that of specimens which have been several years in spirit.)

Note.—This appears to be the species described by Giesbrecht as *Saphirina stellata* and = *S. ovalis* of Dr. Brady's 'Challenger' Copepoda, but not *S. ovalis*, Dana.

Saphirina inæqualis, Dana. (Not *S. nigromaculata*, Claus.)

1852. *Saphirina inæqualis,* Dana, Crust. U.S. Expl. Exped. p. 1244, pl. lxxxvii. fig. 7.
1860. *Saphirina elegans* (♀), Lubbock, Trans. Linn. Soc. vol. xxiii. p. 12, pl. xxix. figs. 18, 19.
1883. *Saphirina inæqualis,* Brady, Report Chall. Copep. p. 124, pl. xlviii. figs. 1–5.

Habitat. Station 9, 25 fathoms, January 10th (day collection). Station 11, 10 fathoms, January 19th (day collection). Station 14, 20 fathoms, January 21st (night collection). Station 18, surface, February 3rd (day collection). Station 24, surface, February 6th (day collection). Lat. 5° 40′ 8″ S., long. 11° 33′ 4″ E., surface, February 19th (day collection), &c.

Saphirina inæqualis was observed in 41 tow-nettings, 22 of which were surface and 19 under-surface gatherings; 8 of the surface and 14 of the under-surface gatherings were day collections, while 14 of the surface and 5 of the under-surface were night collections. The under-surface tow-nettings ranged from $2\frac{1}{2}$ to 25 fathoms, with the exception of one which was from 360 fathoms.

$$\text{Tow-nettings 41}\left\{\begin{array}{ll}\text{22 surface} & \left\{\begin{array}{l}\text{8 day collections.}\\ \text{14 night ditto.}\end{array}\right.\\ \text{19 under-surface} & \left\{\begin{array}{l}\text{14 day ditto.}\\ \text{5 night ditto.}\end{array}\right.\end{array}\right.$$

This was the most common of the Saphirines in the 'Buccaneer' collections.

SAPHIRINA SERRATA, Brady.

1883. *Saphirina serrata*, Brady, Report Chall. Copep. p. 125, pl. xlix. figs. 1, 2.

Habitat. Station 9, 25 fathoms, January 11th (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 260 fathoms, January 22nd (day collection). Station 23, surface and 10 fathoms, February 5th (day collections). Lat. 5° 40′ 8″ S., long. 11° 33′ 4″ E., surface, February 19th (day collection), &c.

This species occurred in 20 tow-nettings, 10 of which were surface and 10 under-surface gatherings. The surface comprised 5 day and 5 night collections; the under-surface 8 day and 2 night collections, as shown in the formula :—

$$\text{Tow-nettings 20}\left\{\begin{array}{ll}\text{10 surface} & \left\{\begin{array}{l}\text{5 day collections.}\\ \text{5 night ditto.}\end{array}\right.\\ \text{10 under-surface} & \left\{\begin{array}{l}\text{8 day ditto.}\\ \text{2 night ditto.}\end{array}\right.\end{array}\right.$$

The under-surface tow-nettings included one at 3 fathoms, three at 10 fathoms, one at 15 fathoms, two at 20 fathoms, one at 25 fathoms, one at 50 fathoms, and one at 260 fathoms. The distinct, though finely serrate, margins of the abdominal segments (except the first) in the female constitute one of the most prominent characters of the species. *S. serrata* was one of the less common of the Saphirines in the collection.

SAPHIRINA OPALINA, Dana.

1852. *Saphirina opalina*, Dana, Crust. U.S. Expl. Exp. p. 1254, pl. lxxxviii. fig. 4.
1860. *Saphirina Thomsoni*, Lubbock, Trans. Linn. Soc. vol. xxiii. p. 186, pl. xxix. figs. 22, 23.
1883. *Saphirina opalina*, Brady, Report Chall. Copep. p. 126, pl. xlix. figs. 3–6.

Habitat. Station 9, 25 fathoms, January 10th (day collection). Off São Thomé Island (lat. 0° 34′ N., long. 6° 30′ 4″ E.), 10 fathoms, January 23rd (day collection). Station 23, 20 fathoms, February 5th (day collection). Lat. 7° 38′ S., long. 12° 3′ 3″ E., surface, February 9th (night collection), &c.

This Saphirine was obtained in 5 surface and 8 under-surface tow-nettings. The 8 under-surface gatherings comprised two at 10 fathoms, one at 15 fathoms, two at 20 fathoms, and two at 25 fathoms. The annexed formula shows the number of day and night collections :—

$$\text{Tow-nettings 13}\left\{\begin{array}{ll}\text{5 surface} & \left\{\begin{array}{l}\text{1 day collection.}\\ \text{4 night collections.}\end{array}\right.\\ \text{8 under-surface} & \left\{\begin{array}{l}\text{5 day ditto.}\\ \text{3 night ditto.}\end{array}\right.\end{array}\right.$$

This species was readily distinguished from other Saphirines by the peculiar form of the very short caudal stylets.

SAPHIRINA OPACA, Lubbock.

1856. *Saphirina opaca,* Lubbock, Trans. Ent. Soc. vol. iv. p. 27, pl. v. figs. 9–11.
1883. *Saphirina opaca,* Brady, Report Chall. Copep. p. 127, pl. xlix. figs. 14–17.

Habitat. Lat. 3° 58′ N., long. 3° 42′ W., 25 fathoms, January 13th (day collection). Off São Thomé Island (lat. 0° 46′ 6″ N., long. 6° 22′ E.), 10 fathoms, January 23rd (day collection). Off the Gaboon River (lat. 0° 22′ 8″ N., long. 8° 16′ 7″ E.), surface, January 28th (two night collections). Station 23, 10 fathoms, February 5th (day collection).

This comparatively large species was obtained in 18 tow-nettings, 7 of which were surface and 11 under-surface gatherings. The under-surface tow-nettings included one at 2½ fathoms, six at 10 fathoms, one at 15 fathoms, one at 20 fathoms, one at 25 fathoms, and one at 30 fathoms. 1 surface and 9 under-surface gatherings were collected during the day, while 6 surface and 2 under-surface were night collections, as shown by the annexed formula:—

$$\text{Tow-nettings 18}\begin{cases}\text{7 surface} & \begin{cases}\text{1 day collection.}\\ \text{6 night collections.}\end{cases}\\ \text{11 under-surface} & \begin{cases}\text{9 day ditto.}\\ \text{2 night ditto.}\end{cases}\end{cases}$$

The large size, elongate form, and the produced inner angle of the caudal stylets serve to distinguish this from most of the other Saphirines in the collection. A few specimens carried ovisacs.

SAPHIRINA SPLENDENS, Dana.

1852. *Saphirina splendens,* Dana, Crust. U.S. Expl. Exped. p. 1216, pl. lxxxvii. fig. 9.
1883. *Saphirina splendens,* Brady, Report Chall. Copep. p. 127, pl. xlix. figs. 11–13.

Habitat. Station 3, 25 fathoms, January 2nd (day collection). Lat. 4° 31′ 6″ N., long. 6° 4′ 44″ W., 50 fathoms, January 11th (day collection). Off the Gaboon River (lat. 0° 22′ 8″ N., long. 8° 25′ E.), surface, January 29th (night collection). Station 23, surface and 10 fathoms, February 5th (day collection). Lat. 7° 38′ S., long. 12° 3′ 3″ E., surface, February 9th (night collection), &c.

Saphirina splendens occurred in 16 tow-nettings—6 surface and 10 under-surface. The surface tow-nettings comprised 3 day and 3 night collections, the under-surface 9 day collections and 1 night collection. The under-surface tow-nettings included one at 2½ fathoms, four at 10 fathoms, one at 15 fathoms, two at 25 fathoms, and two at 50 fathoms. The annexed formula shows the number of day and night collections:—

$$\text{Tow-nettings 16}\begin{cases}\text{6 surface} & \begin{cases}\text{3 day collections.}\\ \text{3 night ditto.}\end{cases}\\ \text{10 under-surface} & \begin{cases}\text{9 day ditto.}\\ \text{1 night collection.}\end{cases}\end{cases}$$

SAPHIRINA METALLINA, Dana. (Pl. XII. fig. 4.)

1852. *Saphirina metallina,* Dana, Crust. U.S. Expl. Exped. p. 1242, pl. lxxxvii. fig. 5.
1860. *Saphirina cylindrica,* Lubbock, Trans. Linn. Soc. vol. xxiii. p. 184, pl. xxix. figs 13–15.
1883. *Saphirina metallina,* Brady, Report Chall. Copep. p. 128, pl. l. figs. 11–17.

Habitat. Station 2, 5, 25, and 50 fathoms, January 1st (night collections). Station 3, 100 fathoms, January 2nd (day collection). Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 30, 60, and 360 fathoms, January 22nd (day collections). Station 23, surface, one day and one night collection; also in one at 20, 85, 135, and 235 fathoms, February 5th, &c. (day collections).

Saphirina metallina occurred in 29 tow-nettings; only 4 of these were surface, the other 25 being under-surface and ranging in depth from 5 to 360 fathoms. The surface gatherings comprised 1 day and 3 night collections, and the under-surface 19 day and 6 night collections, as shown by the annexed formula:—

$$\text{Tow-nettings } 29 \begin{cases} \text{4 surface} & \begin{cases} \text{1 day collection.} \\ \text{3 night collections.} \end{cases} \\ \text{25 under-surface} & \begin{cases} \text{19 day ditto.} \\ \text{6 night ditto.} \end{cases} \end{cases}$$

The form of the caudal stylets in this species makes it readily distinguished from all other Saphirines. A peculiar appendage of the caudal stylets is, by deep staining, brought prominently into view. The outline of the appendage may be perceived without staining by observing the diffraction of light around its edges, but it is only by allowing the specimen to be well soaked in the stain (Kleinenberg's hæmatoxylin does very well to stain with) that the appendage can be seen to advantage. It is then observed to possess a narrow oval outline with an acute apex; a thickened part extends from base to apex like the midrib of a leaf. The whole appendage has thus the appearance of a seta possessing delicate wing-like expansions. Such a leaf-like appendage (*cercophyllum*) has not been noticed in any other species of *Saphirina* in the 'Buccaneer' collections. These *cercophylla* probably enable the animal to move with greater rapidity through the water, and thus to be more successful in the struggle for existence. By possessing greater celerity in its movements it would be able to escape more readily from its enemies and be more certain of success in attacking its prey. Whether the *cercophylla* are used as an additional motive-power or not is at present conjectural, but the study of the animal in the living state should tend to throw some light on the use of these curious organs.

SAPHIRINA SINUICAUDA, Brady.

1883. *Saphirina sinuicauda,* Brady, Report Chall. Copep. p. 129, pl. xlix. figs. 7–10.

Habitat. Lat. 23° 4′ 9″ N., long. 5° 22′ 2″ E., 20 fathoms, January 21st (night collection). Station 24, surface, February 6th (day collection).

This was one of the rarest of the Saphirines observed in the 'Buccaneer' collections, and is distinguished from the other species by the form of the inner branch of the second swimming-foot and of the caudal lamellæ. Only two or three specimens in all were obtained.

Genus SAPHIRINELLA, Claus.

Saphirinella, Claus, Die freilebenden Copepoden, 1863.

SAPHIRINELLA STYLIFERA (Lubbock).

1856. *Saphirina stylifera*, Lubbock, Trans. Ent. Soc. vol. iv. p. 28, pl. iv. figs. 9, 10.
1866. *Saphirinella stylifera*, Claus, Die Copepoden-Fauna von Nizza, p. 17, pl. i. figs. 13, 14.

Habitat. Station 2, 5, 25, and 50 fathoms, January 1st (night collections). Station 3, 25, 50, and 100 fathoms day tow-nettings, and 50 fathoms night tow-netting, January 2nd. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., 10, 20, 30, 60, 260, and 360 fathoms, January 22nd (day collections). Station 23, surface, 20, 85, 185, and 235 fathoms, February 5th (day collections).

Saphirinella stylifera was obtained in 58 tow-nettings, 37 of which were day and 21 were night collections. 47 of the collections were under-surface, the others were surface gatherings, as shown by the annexed formula:—

$$\text{Tow-nettings } 58\begin{cases}11\text{ surface} & \begin{cases}4\text{ day collections.}\\ 7\text{ night ditto.}\end{cases}\\ 47\text{ under-surface} & \begin{cases}33\text{ day ditto.}\\ 14\text{ night ditto.}\end{cases}\end{cases}$$

The under-surface tow-nettings included gatherings from 5 to 360 fathoms, in nearly all of which *Saphirinella* was more or less frequent.

Many specimens of *Saphirinella* were obtained, but they all appeared to belong to the one species *Saphirinella stylifera* (Lubbock). Very few specimens were observed in the 'Challenger' collections, which is the more remarkable considering the number of gatherings and the extensive area represented.

NOTE.—*Saphirinella*: It has been shown by Dr. Giesbrecht that *Saphirinella* is only the male form of *Copilia*, and that *Saphirinella stylifera*, Lubbock, is the male of *Copilia mirabilis*, Dana.

SAPHIRELLA, nov. gen. (Provisional name.)

Anterior antennæ nearly as in *Saphirina*, 5-jointed. Posterior antennæ 3-jointed. Mandibles stout, each bearing a strong terminal conical tooth, serrate on both margins, and a stout plumose terminal spine. Maxillæ broadly subquadrangular and furnished with a few terminal setæ. Posterior foot-jaws stout, 3-jointed, and armed with a moderately strong terminal claw. The swimming-feet are 2-branched, each branch consists of a single broadly foliaceous joint; fifth pair rudimentary or obsolete.

SAPHIRELLA ABYSSICOLA, n. sp. (Pl. XIII. figs. 57, 58; Pl. XIV. figs. 5–10.)

Length 1·2 mm. Cephalothorax robust; the first segment, which is about as long as broad, is fully two-fifths the length of the whole animal; the triangular postero-distal angles of the second segment are extended backwards to near the end of the fourth segment. Anterior antennæ nearly as in *Saphirina*, short, stout, 5-jointed, the third and fourth joints shorter than the others; the proportional lengths of the joints are shown by the annexed formula:—

$$\frac{12 \,.\, 19 \,.\, 10 \,.\, 8 \,.\, 12}{1 \quad 2 \quad 3 \quad 4 \quad 5}.$$

The posterior antennæ consist of three nearly equal joints, and are furnished with one or two marginal and a number of apical setæ, two of the apical setæ and one subapical being strongly curved, long, and spiniform (Pl. XIII. fig. 58). Mandibles stout, armed with a strong terminal conical tooth; serrate on both edges, and a stout plumose spine; there are also two stout subapical plumose setæ (Pl. XIV. fig. 6). Maxillæ broadly subquadrangular, bearing one submarginal and a few terminal setæ (Pl. XIV. fig. 7). The basal joint of the anterior foot-jaws is considerably dilated, and is provided with two stout plumose spines on the inner distal angle; the last joint is small, about once and a half longer than broad, and bears four spines on its truncate apex (Pl. XIV. fig. 8). Posterior foot-jaw stout, 3-jointed, the last joint very small and furnished with a moderately strong and nearly straight claw and a long, spiniform, plain seta; the first joint bears three setæ on its inner distal angle, and there are two setæ near the middle of the second joint (Pl. XIV. fig. 9). Swimming-feet stout, 2-branched; each branch consists of a single broadly foliaceous joint; the outer branch of the first pair carries four stout dagger-shaped marginal and subterminal spines, serrate on both edges, and three terminal plumose setæ; the inner branch carries three similar spines, two plain apical setæ, and a seta near the base of the inner margin. The second pair of feet are like the first, but the three dagger-shaped spines on the inner branch are replaced by plumose setæ. Only two pairs of feet were observed; the others were wanting. The last segment of the abdomen is about twice and a half longer than broad. Caudal stylets very short, each bearing a long, slender, sabre-like spine and a few very small setæ.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., in a tow-net gathering from 260 fathoms, collected January 22nd.

Section III. *SIPHONOSTOMA*, Thorell.

Family ARTOTROGIDÆ.

CYCLOPICERA, Brady (1872).

? CYCLOPICERA LATA, Brady. (Pl. XIII. figs. 25–30.)

1868. *Ascomyzon echinicola*, Norman, Brit. Assoc. Report, p. 300.
1872. *Cyclopicera lata*, Brady, Nat. Hist. Trans. Northumb. and Durham, vol. iv. p. 433, pl. xviii. figs. 3–8.
1880. *Cyclopicera lata*, Brady, Mon. Brit. Copep. vol. iii. p. 56, pl. lxxxix. fig. 12; pl. xc. figs. 11–14

Length ·7 mm. Body subrotund; first body-segment shorter than broad and about equal to half the entire length of the animal, exclusive of caudal stylets; forehead broadly rounded. Anterior antennæ slender, shorter than the first body-segment, 20-jointed; the second to the ninth joints and also the eighteenth and twentieth, which are all of nearly equal length, are shorter than the others, as shown in the annexed formula:—

$$\frac{10 . 4 . 3 . 3 . 3 . 2 . 2 . 3 . 4 . 4 . 7 . 7 . 7 . 6 . 7 . 8 . 10 . 4 . 6 . 3}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15 \quad 16 \quad 17 \quad 18 \quad 19 \quad 20}.$$

An olfactory filament springs from the end of the seventeenth joint. Posterior antennæ and mouth-organs nearly as in *Artotrogus Boeckii*, except that the mandibular stylets are considerably longer and their terminal setæ shorter; the terminal claw of the posterior foot-jaws is also longer in the 'Buccaneer' specimens. The five pairs of swimming-feet also resemble those of *Artotrogus Boeckii*. In the fourth pair (fig. 26) a long, stout, plumose seta springs from the extero-distal angle of the first basal joint, and the outer distal angle of the second joint of the inner branch is bidentate. The abdomen consists of three segments, and the caudal stylets, which are about three times as long as broad, are equal in length to the last abdominal segment.

Habitat. Accra, in a shore gathering, collected January 16th. One or two specimens only were obtained.

ARTOTROGUS, Boeck (1859).

Artotrogus (pars) and *Asterocheres*, Boeck, Tvende nye parasitiske Krebsdyr, 1859.
Ascomyzon, Thorell, Om Krustaceer i Ascidier, 1859.

? ARTOTROGUS ABYSSICOLUS, n. sp. (Pl. XII. figs. 5–9; Pl. XIV. figs. 11–18.)

Female. Length 1·1 mm. Cephalothorax robust; the first segment, which is considerably dilated and equal to about four-ninths the length of the entire animal, is anteriorly three-lobed; the two side-lobes are rounded, but the middle one is broadly triangular; the last thoracic segment is very small and scarcely so broad as the first segment of the abdomen. The abdomen is elongate and slender, and nearly of equal breadth throughout; first segment about equal to the length of the next two together, the remaining segments become gradually shorter. Caudal stylets about half the length of the last abdominal segment, and furnished with five moderately long setæ. Anterior antennæ short, 8-jointed, the last joint longer than any of the others; a long sensory filament springs from the end of the sixth joint; the relative lengths of the joints are shown in the formula:—

$$\frac{27 . 12 . 6 . 12 . 8 . 18 . 10 . 34}{1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8}.$$

Posterior antennæ 4-jointed, the second and third joints subequal and longer than the first or fourth; the last joint bears three spines—two terminal, one of which is moderately long and one short, and a marginal spine; a small 1-jointed secondary branch springs from near the end of the second joint. The mandible consists of an elongate basal joint furnished with two long, slender, terminal setæ. The first joint of the anterior foot-jaws is stout and without spines or setæ; the apical portion of the foot-jaw is long and slender, the proximal half being about four times longer than broad and finely ciliate on the inner aspect, while the distal half forms a strongly curved claw; no articulation was observed between the claw and the broadened basal part. Posterior foot-jaw 4-jointed, second joint large, third and fourth much narrower and shorter; the second, third, and fourth are each provided with a small spine on the inner aspect; terminal claw equal to fully twice the length of the last joint, stout and slightly curved. Swimming-feet nearly as in *Artotrogus* (Pl. XIV. figs. 17, 18). No fifth pair were observed. Siphon as in *Artotrogus*.

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., in a tow-net gathering from 360 fathoms, collected January 22nd. Station 23, in a tow-net gathering from 235 fathoms, collected February 5th.

Several specimens of what may be the male (? immature) of this species occurred in the same gatherings; they differed in the following points:—Body elongate ovate; abdomen long and very slender, and apparently 6-jointed, the first segment being distinctly constricted in the middle (Pl. XII. fig. 9). The anterior antennæ consist of four moderately stout, short joints, and an extremely long, slender, apical part without articulations (Pl. XII. fig. 6). The approximate proportional lengths of the basal joints and long apical part are as follows:—

$$\frac{25\,.\,8\,.\,8\,.\,4\,.\,270.}{1\quad 2\quad 3\quad 4\quad 5}$$

The posterior foot-jaws are more slender (Pl. XII. fig. 8). All the other appendages closely agree with the foregoing description.

Caligus, Müller.

Caligus (?) Thymni, Dana. (Pl. XIV. fig. 21.)

1853. *Caligus Thymni*, Dana, Crust. U.S. Expl. Exped. p. 1353, pl. xciv. fig. 3 *a*.

Habitat. Station 9, in a tow-net gathering from 25 fathoms, collected about midday, January 10th. One specimen only.

This specimen, which is doubtfully referred to *Caligus Thymni*, Dana, differs from that species chiefly in the form and comparative length of the posterior part of the abdomen. In the 'Buccaneer' specimen this part is somewhat narrower and longer proportionally than Dana's figure represents *Caligus Thymni* to be.

Caligus Murrayanus, n. sp. Provisional name. (Pl. XIV. fig. 19.)

Length 3 mm. Frontal plate produced and much narrower anteriorly. Fourth pair of feet elongate and rather slender. The first abdominal (genital) segment in the female, which becomes wider posteriorly, is about one-and-a-half times longer than it is broad at the middle, and equal to about half the length of the cephalothorax. The posterior part of the abdomen, exclusive of caudal stylets, is about half as long as the genital segment, and the breadth less than half the length. A small sucker-like appendage springs from each side of the median ventral line and at the posterior end of the genital segment. Caudal stylets very short.

Habitat. Loanda Harbour, in a surface tow-net gathering, during the afternoon of February 15th. One specimen only obtained.

The outline of the frontal plate, in this species, somewhat resembles an equilateral triangle, from the apical part of which a portion equal to about two fifths of the height has been cut off, while the sucker-disks are situated near the middle of what remains of each side. The species is named in compliment to Dr. Murray of the 'Challenger' Expedition, who has done so much to foster and encourage the study of marine zoology.

Caligus bengoensis, n. sp. Provisional name. (Pl. XIV. fig. 20.)

Length about 2·4 mm. Frontal plate about one fifth of the length of the cephalothorax, narrower anteriorly. Sucker-disks forming almost a complete circle. The length of the genital segment of the abdomen is about equal to one-and-one-third times its breadth; the following segment is shorter than broad, and in length equal to about half the breadth of the genital segment; the last abdominal segment is longer than the preceding one, and about as broad as long. Caudal stylets half as long as the last abdominal segment. The fourth pair of feet are moderately stout.

Habitat. Loanda Harbour, in a surface tow-net gathering, but not the same as that in which *Caligus Murrayanus* was obtained.

Caligus dubius, n. sp. Provisional name. (Pl. XIV. fig. 22.)

Female. Length 3·6 mm. Forehead broadly rounded, sucker-disks comparatively shallow. Cephalothorax equal to about four sevenths of the entire length of the animal. The genital segment, which becomes wider towards the distal end, is about as long as the remaining portion of the abdomen, including caudal stylets; its breadth at the distal end is equal to about three fourths the length, and the postero-lateral angles are rounded. The remaining portion of the abdomen, the length of which is about equal to the posterior end of the genital segment, is three times longer than broad; no articulations were observed in this part of the abdomen. The length of the caudal stylets is equal to twice the breadth, and each is furnished with three moderately short plumose setæ.

Habitat. Loanda Harbour, in two surface tow-net gatherings, collected, one on the 13th and one on the 15th of February; also in a surface tow-net gathering collected off Appi, January 18th.

Nogagus, Leach.

Nogagus validus, Dana. (Pl. XIV. fig. 23.)

1853. *Nogagus validus*, Dana, Crust. Expl. Exped. p. 1363, pl. xciv. fig. 9 *a–h*.

Habitat. Lat. 1° 55′ 5″ N., long 5° 55′ 5″ E., in a tow-net gathering from 30 fathoms, collected January 22nd. One specimen only was obtained.

HESSELLA, Brady.

HESSELLA CYLINDRICA, Brady.

1883. *Hessella cylindrica*, Brady, 'Challenger' Copepoda, p. 136, pl. lv. figs. 9–13.

1860. ? *Baculus elongatus*, Lubbock, Trans. Linn. Soc. vol. xxiii. p. 190, pl. xxix. fig. 10.

Habitat. Station 3, in a tow-net gathering from 25 fathoms, collected January 2nd. Only one specimen of this interesting species was obtained.

This appears to be the *Baculus elongatus*, Lubbock, described by Sir John Lubbock in his paper "On some Oceanic Entomostraca collected by Captain Toynbee," and published in vol. xxiii. of the Transactions of the Linnean Society. If my conjecture is right, Sir John Lubbock's name must take precedence of that of Dr. Brady.

INCERTÆ SEDIS.

PONTOPSYLLUS ELONGATUS, n. g. et sp. (Pl. XIV. figs. 24–30.)

Length 2·23 mm. (1-11th of an inch). Body cylindrical; first segment four sevenths of the whole length of the animal and equal to twice the combined length of the remaining three segments, which are subequal. Abdomen very short, composed of four segments; the two intermediate segments, which are of about equal length, are shorter than the first or fourth. Caudal stylets rudimentary and furnished with a moderately stout curved plumose terminal seta and three small marginal ones; the integument of the last abdominal segment is covered with minute cilia, and the terminal seta of each of the caudal stylets is curved inwards (fig. 24). Anterior antennæ short, 5-jointed, bearing a few scattered hairs; the anterior distal angle of the basal joint is provided with a long plain seta that reaches beyond the apex of the antenna. The proportional lengths of the joints are as follows:—

$$\begin{array}{ccccccccc} 27 & . & 18 & . & 15 & . & 15 & . & 18 \\ 1 & & 2 & & 3 & & 4 & & 5 \end{array}$$

The posterior antennæ are 2-jointed and very short and stout; a strong curved claw, articulated to the exterior half of the truncate apex and opposed by a stout pointed tooth, forms a powerful grasping-organ (fig. 26). Mandible and maxillæ rudimentary; the first consists of a simple, somewhat stylet-shaped appendage, the other of two strong hooked spines attached to a stout 1-jointed basal part (figs. 27 *a*, *b*). Posterior foot-jaws large; the dilated basal joint carries an elongate, slender, apical appendage, the distal end of which is clothed with fine cilia, and, becoming gradually attenuated, terminates in a small spiral coil of about one-and-a-half turns, as shown in figure. The four pairs of swimming-feet are all similar and consist of two short 2-jointed branches; the exterior distal angles of the joints of the outer branches are furnished with stout dagger-shaped spines, finely serrate on both edges; the broad terminal spines, which are more than twice the length of the branches from which they spring, are plain on the inner and serrate on the outer margin; the inner branches have no terminal spine; both branches are provided with several long plumose setæ (fig. 29).

Habitat. Lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E., in a gathering from 360 fathoms, collected January 22nd. One specimen only was obtained.

A form that may be an immature stage of the foregoing was obtained in a surface tow-net gathering from Loanda Harbour, collected February 15th, and is represented by fig. 58. The anterior antennæ are 2-jointed; the posterior foot-jaws are large and well-developed; the siphon is elongate, with a flattened sucker-like disk at the extremity (fig. 30)

This form is closely analogous to the immature stage of *Caligus*, formerly described as a distinct genus under the name of *Chalimus*.

PART II.

CLADOCERA AND OSTRACODA.

INDEX OF GENERA AND SPECIES.

CLADOCERA.

Cladocera were exceedingly rare in regard to the number of species observed, only two species having been obtained in the whole of the 'Buccaneer' collections. They represented, however, two widely prevailing groups—the *Calyptomera* and *Gynomera*; the first is confined almost exclusively to fresh and brackish water, while species belonging to the other are to be found in fresh water and also in the open sea.

The following are the two species referred to:—

CALYPTOMERA.

Family PENILIDÆ, Dana.

Genus Penilia, Dana (1853).

Penilia orientalis, Dana.

1853. *Penilia orientalis*, Dana, Crust. U.S. Expl. Exped. p. 1270, pl. lxxxix. fig. 3 *a–e*.

Habitat. Loanda Harbour, in three surface tow-net gatherings, collected February 15th. A number of specimens were observed.

GYMNOMERA.

Family POLYPHEMIDÆ, Baird.

Genus Evadne, Lovén.

Evadne Nordmanni, Lovén.

This species was obtained in a number of the tow-net gatherings.

OSTRACODA.

Comparatively few Ostracoda were obtained in the 'Buccaneer' collections. The Ostracoda, with the exception of *Halocypris* and a few others, live among the weed, or on the sand and mud at the bottom of the water, and can be captured only by the dredge or other implement suited for collecting bottom material; dead shells of Ostracods, however, may be frequently obtained by carefully examining the sand or other débris on the shore. As, therefore, the 'Buccaneer' collections consisted chiefly of tow-net gatherings, pelagic species, as *Halocypris*, were the only forms observed in all but a very few of the gatherings.

Several species of *Cythere*, as well as one or two of other genera belonging both to the Cypridæ and Cytheridæ, were obtained in a surface gathering from a lagoon at São Thomé Island, in another from Loanda Harbour, and in a third collected off the mouth of the River Congo.

One of the most interesting captures was an Ostracod closely allied to *Cypria exsculpta* (Fischer), which in this Report is named provisionally *Cypria atlantica*; it was obtained in the gathering collected off the mouth of the River Congo, referred to above, at about 40 miles from land. It is well known to students of the Entomostraca that several species of the Cypridæ, as, for example, *Cypria ophthalmica* (Jurine), *Cypris prasina*, Fischer, *Candona candida* (Müller), &c., though usually or frequently obtained in fresh water, are nevertheless occasionally obtained also in water more or less brackish, but have not been known to occur in the open sea, except as dead shells; it is therefore interesting to find a species closely resembling a freshwater *Cypria* living in the sea so many miles from land.

It is possible that the fresh water poured into the sea by the River Congo may extend to a distance of 40 miles or more from land before it becomes thoroughly mingled with the water of the Atlantic, and may thus form a suitable *habitat* for a species which possibly would not be able to live in pure sea-water. Whether this be the correct explanation of the occurrence of a *Cypria* so far out at sea, or not, it is a subject of some interest as bearing on the distribution of species.

It may be stated in connexion with this that several surface tow-net gatherings were collected off the mouth of the Congo, and within a few miles of each other, but the *Cypria* was observed only in the one mentioned under the description of the species.

Though the Ostracoda described in this Report be comparatively few in number, they nevertheless include representatives of three out of the four principal Groups, viz. :—the Podocopa, the Myodocopa, and the Platycopa. The following are the descriptions of species obtained belonging to these three Groups :—

I. *PODOCOPA.*

Family CYPRIDÆ.

Cypria, Zenker (1854).

(?) Cypria atlantica, n. sp. (Pl. XIV. figs. 31–33; Pl. XV. figs. 16, 20, 21, 25.)

Shell compressed; seen from the side, the dorsal margin is considerably arched, highest and somewhat angular in front of the middle; the dorsal margin slopes gently backwards from the highest part in a nearly straight line till it joins the broadly curved posterior margin; the front slope has a greater declivity and is very slightly curved, and merges in the boldly rounded anterior margin; ventral margin nearly straight. Greatest height equal to two-thirds of the length. Outline seen from above ovate; sides evenly rounded, widest behind the middle; greatest width equal to about seven sixteenths of the length; extremities acutely angular, but more so in front than behind; the sides also converge more gradually towards the anterior extremity than they do posteriorly. Surface of shell ornamented with impressed reticulate lines, having the interspaces covered with minute dots that appear to have a linear arrangement when viewed in certain positions. Length of shell ·61 mm. (1-41st of an inch). Antennules 7-jointed, basal joint large, the others small; the formula shows the relative lengths of the joints :—

$$\frac{32\ .\ 10\ .\ 11\ .\ 8\ .\ 7\ .\ 6\ .\ 9}{1\ .\ 2\ .\ 3\ .\ 4\ .\ 5\ .\ 6\ .\ 7}.$$

The last two or three joints are provided with several long plain setæ; there are also a few scattered setæ on the other joints. Antennæ 4-jointed; the proportional lengths of the joints are as follows :—

$$\frac{10\ .\ 14\ .\ 10\ .\ 4}{1\ .\ 2\ .\ 3\ .\ 4}.$$

Five long and nearly equal setæ spring from the end of the second joint; the terminal claws reach only to about the middle of the setæ. Post-abdomen moderately stout, armed at the apex with two strong, curved, and nearly equal claws, and a small seta; a small seta also springs from near the middle of the lower margin of the post-abdomen.

Habitat. Lat. 5° 53′ 0″ S., long. 11 31′ 1″ E., in a surface tow-net gathering collected 11.30 P.M., February 18th. (Off the mouth of the River Congo, about 40 miles from land.)

A considerable number of specimens were obtained. The occurrence in the open sea of a species so closely related to a freshwater *Cypria* is of interest as forming another link connecting the truly freshwater with the truly marine Ostracoda.

Figure 33, Pl. XIV., is that of an immature specimen.

PHLYCTENOPHORA, Brady (1880).

PHLYCTENOPHORA AFRICANA, n. sp. (Pl. XIV. figs. 34, 35; Pl. XV. figs. 17–19.)

Shell elongate ovate; seen from the side the dorsal margin forms a depressed arch, rather highest in front of the middle; ventral margin sinuated in front, gently convex behind; anterior extremity somewhat attenuate and evenly rounded; posterior margin slightly produced and angular below the middle; greatest height equal to five twelfths of the length. The outline seen from above is compressed ovate, widest in the middle; greatest width a little more than a third of the length; sides tapering similarly and evenly to both extremities, which are subacute. Length 1 mm. (1-25th of an inch). Antennules 7-jointed; relative lengths of the joints nearly as in the formula :—

$$\frac{22\ .\ 5\ .\ 5\ .\ 5\ .\ 6\ .\ 4\ .\ 4}{1\quad 2\quad 3\quad 4\quad 5\quad 6\quad 7}.$$

The last joint bears a moderately stout and long apical spine; the other joints are more or less setiferous; setæ plain. Antennæ 6-jointed, sparingly setiferous; the first three joints large, the last three small, as shown by the relative lengths of the joints given in the formula :—

$$\frac{17\ .\ 16\ .\ 17\ .\ 4\ .\ 7\ .\ 3}{1\quad 2\quad 3\quad 4\quad 5\quad 6}.$$

A fascicle of about six short setæ springs from the side and near the distal end of the third joint, while the penultimate joint carries one spine, and the last joint two moderately long claw-like spines. Post-abdomen short, stout, and armed with two strong terminal claws, setiferous on the lower distal half, and a few small setæ.

Habitat. Loanda Harbour, in a surface tow-net gathering, collected February 13th. Several specimens were obtained.

PONTOCYPRIS, G. O. Sars (1865).

PONTOCYPRIS TRIGONELLA, G. O. Sars. (Pl. XIV. figs. 36, 37.)

1865. *Pontocypris trigonella,* G. O. Sars, Oversigt af Norges Marine Ostrac. p. 16.

1889. *Pontocypris trigonella,* Brady and Norman, Mon. M. & F.-w. Ostrac. of the N. Atlantic and N.W. Europe, p. 109, pl. xxii. figs. 18–25, pl. xxiii. fig. 6.

Habitat. São Thomé Island, in a surface tow-net gathering from a shore-lagoon, collected January 27th. One specimen only was obtained.

(?) **PONTOCYPRIS SUBRENIFORMIS**, n. sp. Provisional name. (Pl. XIV. figs. 38, 39.)

Outline of the shell seen from the side subreniform; dorsal margin considerably arched; extremities similarly and somewhat obliquely rounded; ventral margin slightly concave; greatest height at the middle scarcely equal to four ninths of the length. Seen from above oblong ovate, widest at the middle, tapering at the sides from the middle to each end in nearly straight lines; extremities obtusely pointed. Greatest width equal to rather more than one third the length. Length ·58 mm.

Habitat. In the same gathering with the last.

Family BAIRDIIDÆ.

BAIRDIA, M'Coy (1844).

BAIRDIA INORNATA, n. sp. (Pl. XIV. figs. 40, 41.)

Viewed laterally the dorsal margin of the shell is boldly arcuate; highest a little behind the middle; at the highest the dorsal margin is obtusely angular, and from thence it slopes rapidly downwards on both sides, but more so behind than in front, till it merges in the evenly rounded extremities; ventral margin gently sinuated; greatest height equal to two-thirds of the length. The outline of the shell seen from above is compressed ovate; greatest width slightly behind the middle and equal to about five twelfths of the length; the sides curve regularly towards both ends; extremities subacute; surface of valves smooth. Length ·7 mm.

Habitat. Lat. 5° 53′ 0″ S., long. 11° 31′ 1″ E.; in a surface tow-net gathering collected at 11.30 P.M., February 18th. One specimen only obtained: it was in the same gathering with *Cypria atlantica,* already described, and which was taken off the mouth of the River Congo, at about 40 miles from land.

Family CYTHERIDÆ.

CYTHERE, Müller (1785).

CYTHERE MULTICAVA, n. sp. (Pl. XIV. figs. 42, 43; Pl. XV. figs. 13, 15.)

Shell elongate, rather tumid; seen from the side, dorsal margin highest and bluntly angular in front of the middle; thence it slopes gently backwards in a nearly straight line to the rounded, obscurely crenate, posterior end; anterior margin oblique, inferiorly rounded and crenulate, flattened above, and sloping posteriorly upward to the hinge-prominence. Height rather less than half the length. As seen from above oblong, sides nearly parallel, slightly gibbous in front; width about two fifths of the length; posterior extremity broadly rounded at the sides, centrally produced and truncate; anteriorly the valves taper gently to the obtusely pointed extremity. Shell ornamented with numerous small circular depressions arranged in irregular lines. Length ·77 mm.

Antennules 6-jointed, first and second joints long, the others small; their relative lengths are as follows:—

$$\frac{25}{1} . \frac{27}{2} . \frac{10}{3} . \frac{6}{4} . \frac{8}{5} . \frac{10}{6}.$$

A stout spine springs from the exterior distal angle of the third, fourth, and fifth, and from the apex of the last joint.

First and third joints of the antennæ elongate, subequal, about three times as long as the second joint; last joint very small, and furnished with two apical spines. A long, hair-like appendage carried by the second joint is connected by a duct with a (?) poison-gland situated at the base of the antennæ.

Habitat. Loanda Harbour, in a gathering collected February 13th. A few specimens only were obtained.

CYTHERE SCULPTILIS, n. sp. (Pl. XIV. figs. 44, 45.)

Shell: viewed laterally, the outline of the shell is broad and obliquely rounded in front, narrow behind; greatest height in front of the middle equal to fully half the length; dorsal margin forming a sinuous declivity towards the posterior end; posterior extremity subtruncate, somewhat produced below and bluntly dentate; lower part of anterior margin crenate or bluntly toothed, ventral margin shallow concave. Seen from above, subquadrangular; anterior end truncate; sides subparallel, sinuated; greatest width scarcely equal to half or three sevenths of the length, constricted behind the middle, gently rounded and converging posteriorly. Towards the posterior end the edges of the valves become flattened and are produced backwards, and terminate in obliquely truncate ends as in the figures. Length ·54 mm.

Habitat. With the last in a surface tow-net gathering from a lagoon, São Thomé Island. One specimen only obtained.

CYTHERE RADULA, Brady.

Cythere radula, Brady, Report on the 'Challenger' Copepoda, p. 102, pl. xix. fig. 4 *a*, *b*.

Habitat. Lagoon, São Thomé Island, in the same gathering with the last. A single valve evidently belonging to *Cythere radula* was obtained, but was broken while being examined.

CYTHERE RIMOSA, n. sp. (Pl. XIV. figs. 46, 47.)

Shell tumid; seen from the side the dorsal margin is highest behind the middle, thence it slopes gently in a nearly straight line to the anterior end, but merges behind into the boldly and somewhat obliquely rounded posterior margin; front margin subtruncate, the lower part of the shell slightly produced; greatest height equal to fully half the length. The outline seen from above subovate, sides nearly parallel, but somewhat wider in front of the middle; thence they converge in a gently rounded curve to the posterior end, which is slightly emarginate; greatest width scarcely equal to half the length. Posterior extremity subtriangular, with the apex truncate. Surface of the valve curiously sculptured, with flattened ridges arranged in irregular and more or less oblique lines extending across the shell. Length ·6 mm.

Habitat. Lagoon, São Thomé Island, in a surface tow-net gathering, collected January 27th, also the same gathering with *Cypria atlantica* collected off the mouth of the river Congo, at about 40 miles from land, February 18th.

CYTHERE THALASSICA, n. sp. (Pl. XIV. figs. 48, 49.)

Outline of shell, seen from the side, narrow, elliptical, highest at the middle; greatest height scarcely equal to half the length; dorsal margin gently and evenly arched, ventral margin nearly straight; both extremities similarly and boldly rounded. Seen from above, ovate, rather widest at the middle, width and height about equal; anteriorly the sides, which are slightly rounded, converge gently towards the obtusely pointed extremity; posterior end broadly and moderately convex. Surfaces of valves smooth. Length ·85 mm.

Habitat. In a lagoon, São Thomé Island, in a surface tow-net gathering, collected January 27th. One or two specimens only obtained.

CYTHERE VENUSTA, n. sp. (Pl. XIV. figs. 50, 51.)

Shell, seen from the side, broadly elliptical; greatest height behind the middle, scarcely equal to half the length. The dorsal margin is slightly arcuate, middle portion forming a nearly straight line, but gently curved in front to where it joins the boldly and evenly rounded anterior extremity; posterior margin moderately and regularly convex; ventral margin slightly concave. Seen from above the shell is broadly ovate, widest behind the middle; greatest width equal to five twelfths of the length; sides evenly rounded, converging gently towards the anterior extremity, but more convex posteriorly; extremities bluntly angular; valves somewhat unequal, the right being rather smaller than the left. Surface of the valves ornamented with flattened and gently curved longitudinal ribs placed side by side, extending from the posterior extremity, but becoming obsolete towards the anterior end, where they run out into shallow circular depressions; the front margin is marked with a number of impressed, short, radiating lines. Length ·8 mm. (1-31st of an inch).

Habitat. Loanda Harbour, in a surface tow-net gathering, collected February 13th. One specimen only obtained.

This species closely resembles *Cythere costellata*, Roemer, an ostracod obtained fossil in the Tertiary deposits of England and also in France.

XESTOLEBERIS, G. O. Sars (1865).

XESTOLEBERIS (?) MARGARITEA (Brady).

1865. *Cytheridea margaritea*, Brady, Trans. Zool. Soc. vol. v. p. 370, pl. lviii. fig. 6, *a*, *b*.

1880. *Xestoleberis margaritea*, Brady, Report on the 'Challenger' Copepoda, p. 127, pl. xxx. fig. 2, *a*, *b*.

Habitat. Lagoon, São Thomé Island, in a surface tow-net gathering, collected January 27th; several species were obtained. The *Xestoleberis* now recorded, when viewed laterally, differs from *X. margaritea* described and figured in the 'Challenger' Report in being rather more pointed at the anterior end, but otherwise it seems to agree with that species; it also agrees with the figures of the same species in the 'Monograph of the Marine and Fresh-water Ostracoda of the North Atlantic and North-western Europe,' by Brady and Norman, p. 246.

CYTHERURA, G. O. Sars.

CYTHERURA SIMULANS, n. sp. (Pl. XIV. figs. 52, 53.)

Shell, viewed laterally, subovate; greatest height behind the middle equal to about four ninths of the length; dorsal margin moderately and evenly arched; ventral margin slightly concave; beak subcentral, obtuse, more prominent than in *Cytherura similis*, G. O. Sars, which the species now described somewhat resembles; anterior extremity evenly rounded and slightly oblique; the outline seen from above is subovate, widest behind the middle; width equal to the height; sides flattened centrally, converging and gently curved; anterior subtruncate behind, with the middle part shortly produced to a blunt pointed apex; anterior extremity subacuminate. Length ·46 mm.

Habitat. Loanda Harbour, in a surface tow-net gathering, collected February 13th. One specimen only obtained.

CYTHEROPTERON, G. O. Sars (1865).

CYTHEROPTERON TRILOBITIS, Brady. (Pl. XIV. figs. 54, 55.)

1880. *Cytheropteron trilobitis*, Brady, On Ostracoda collected by H. B. Brady in South Sea Islands, Trans. R. S. E. vol. xxxv. pt. ii. p. 511, pl. iii. figs. 22, 23.

Habitat. In a lagoon, São Thomé Island, in a tow-net gathering, collected January 27. Only a few valves of this species were obtained; it differs very little from the 'Challenger' specimen.

II. *MYODOCOPA.*

Family CYPRIDINIDÆ, Baird.

Genus ASTEROPE, Philippi.

ASTEROPE SQUAMIGER, n. sp. (Pl. XIV. figs. 56, 57; Pl. XV. figs. 14, 22, 23, 26.)

Female. Shell, seen from the side, subrotundate, highest at the middle, convex and evenly rounded in front; dorsal margin nearly straight; extremities evenly rounded; the posterior curve slightly oblique, notch well defined, beak subacute, height equal to four fifths of the length. Length 1·15 mm. Seen from above ovate, tumid, widest at the middle; width equal to three fifths of the length; sides moderately and regularly convex; posterior extremity obtusely rounded; valves slightly produced in the middle; anterior extremity emarginate. Surface of shell ornamented with small squamiferous markings. Antennules 6-jointed and of moderate length, the second to the fifth joints subequal, the last very small and furnished with several slender apical setæ and a slightly hooked claw. Secondary branches of antennæ 3-jointed, ; first and third joints short, the last bearing a short seta at its apex. First maxillæ nearly as in *Asterope teres*, Jones; post-abdomen armed with about six spines, the first large and serrate on the posterior edge, the next three shorter and plumose and apparently articulated near the base, the others very small.

Habitat. (?) Lagoon, São Thomé Island, in a surface tow-net gathering, collected during night, January 27th. Two specimens only.

SARSIELLA, Norman, 1868.

SARSIELLA MURRAYANA, n. sp. (Pl. XIV. fig. 58; Pl. XV. figs. 24, 28, 29, 31.)

Male. Shell laterally compressed in front, tumid behind, seen from the side subrotund; height equal to three fourths of the length; dorsal margin slightly convex; front margin boldly rounded and continuous with the anterior end; posterior extremity produced in front into a blunt-pointed, triangular, beak-like process; dorsal angle at the junction of the posterior and dorsal margin rounded; there is a small, tumid, triangular, tooth-like process a little behind the dorsal angle (fig. 40). Surface of the shell covered with small puncture-like markings.

Antennules 4-jointed; first joint elongate, second and third subequal and shorter than the first; last joint fully three fourths the length of the preceding and furnished with several apical setæ of moderate length; second joint of natatory branch rather longer than the next two joints together; third to the last joints small, subequal. Post-abdomen armed with a long, powerful, terminal claw and four spines of varying length on the posterior distal margin. Oviferous foot nearly as in *Asterope Mariæ* (Baird). Length ·93 mm.

Habitat. Lagoon, São Thomé Island, in a surface tow-net gathering collected during night, January 27th. Two specimens only obtained.

Family CONCHŒCIDÆ.

Subfamily HALOCYPRINÆ, Dana.

Genus HALOCYPRIS, Dana (1853).

HALOCYPRIS BREVIROSTRIS, Dana.

1853. *Halocypris brevirostris*, Dana, Crust. U.S. Expl. Exped. p. 1303, pl. xci. fig. 9, *a–c*.

Habitat. From the following, among other localities :—

January 5th,	lat. 5° 58′ 0″ N.,	long. 14° 10′ 0″ W.,	surface gatherings.
,, 10th,	,, 3° 0′ 8″ N.,	,, 7° 43′ 0″ W.,	50 fathoms (Station 9).
,, 20th,	,, 3° 22′ 5″ N.,	,, 4° 11′ 8″ E.,	30 fathoms.
,, 21st,	,, 2° 34′ 9″ N.,	,, 5° 22′ 2″ E.,	20 fathoms.
,, 22nd,	,, 1° 55′ 5″ N.,	,, 5° 55′ 5″ E.,	20 and 30 fathoms.
February 5th,	,, 4° 26′ 7″ S.,	,, 10° 1′ 8″ E.,	20 and 30 fathoms (Station 23).

The first of these gatherings was collected in the evening after dark, the others during the day. The specimens observed in any of the gatherings were comparatively few in number.

HALOCYPRIS ELONGATA, n. sp. (Pl. XV. figs. 1, 2, 27, 30.)

Shell, seen from the side, elongate, anterior extremity rounded below the notch and continuous with the ventral margin; ventral and dorsal margins nearly straight, dorsal produced posteriorly so as to be considerably longer than the ventral; posterior margin oblique, nearly straight, forming an acute angle at its junction with the dorsal edge; the ventral angle obtusely rounded; shell highest posteriorly, greatest height fully one third of the length. Length 3·2 mm. Seen from above, elongate ovate, widest at the middle, width equal to rather less than one third of the length; from the middle the shell tapers and becomes much compressed towards the posterior extremity, which is somewhat obtuse; anteriorly the width decreases more gradually to the base of the rostrum, whence the valves rapidly converge to the sharp pointed extremity of the beak; surface of the valves smooth. The setæ of the anterior antennæ of the female are four short and one long; the second joint is somewhat shorter than that which precedes or follows; the last joint is very short. The distal part of the tentacle seems to be continuous with the basal portion instead of sagittiform as in *Halocypris atlantica*, Lubbock. Natatory branch of the posterior antennæ slender; secondary branch small; first joint somewhat dilated and furnished with two small spines; apical joint small, bearing five setæ—two very small, two elongate and reaching to near the extremity of the apical setæ of the primary branch, and one about half as long.

Habitat. From several localities, among which are the following :—

January 10th,	lat. 3° 0′ 8″ N.,	long. 7° 43′ 0″ W.,	50 fathoms (Station 9).
,, 20th,	,, 3° 55′ 3″ N.,	,, 4° 7′ 3″ E.,	30 fathoms.
,, 22nd,	,, 1° 55′ 5″ N.,	,, 5° 55′ 5″ E.,	20, 30, and 35 fathoms.
February 5th,	,, 4° 26′ 7″ S.,	,, 10° 1′ 8″ E.,	20 and 30 fathoms (Station 23).

This species was not observed in any surface tow-net gathering.

Halocypris torosa, n. sp. (Pl. XV. figs. 3, 4, 32, 35, 37.)

Shell tumid; surface of valves finely reticulated. Seen from the side the dorsal margin is nearly straight, slightly sinuate; a sulcus begins near the middle of the dorsal margin and passes obliquely backward across each valve; the tumidity extends downward, anterior to the sulcus, and overhangs the nearly straight ventral margin. A second, though very shallow, groove is observed in some of the more robust specimens, between the subcentral sulcus and the posterior extremity. Posterior margin truncate, dorsal angle slightly produced; at the anterior end the ventral margin rises obliquely in a nearly straight line and merges in the small rounded angle below the notch. The beak is a hood-like process with broad overhanging sides. Shell highest at the posterior end; height equal to nearly half the length; length 3·75 mm. Seen from above oblong-ovate, widest behind the middle; greatest width equal to two fifths the length. Sides sinuous, posterior extremity rounded, anterior end bluntly angular. Anterior antennæ with four apical setæ and a curved hair-like filament; one of the apical setæ is very long and is provided with a fringe of small teeth on a portion of the proximal half, similar to *Halocypris imbricata*; a small plumose seta springs from near the middle of the penultimate joint. The blunt-pointed arrow-like head of the tentacle reaches slightly beyond the extremity of the antennæ. Secondary branch of the posterior antennæ furnished with a stout plumose seta on the enlarged basal joint; the small terminal joint bears an extremely long ringed seta, another about one third as long, and five very small setæ, as well as a strongly-hooked claw. The first foot consists of four moderately long subequal joints, which are sparingly setiferous, and a very small terminal joint furnished with three long plumose setæ.

Habitat. The following are some localities where this species was obtained:—

January	5th,	lat.	5° 58′ 0″ N.,	long.	14° 20′ 0″ W.,	collected near surface.
,,	20th,	,,	3° 55′ 3″ N.,	,,	4° 7′ 3″ E.,	20 and 30 fathoms.
,,	21st,	,,	2° 20′ 2″ N.,	,,	5° 7′ 8″ E.,	20 fathoms (Station 14).
,,	22nd,	,,	1° 55′ 5″ N.,	,,	5° 55′ 5″ E.,	35 and 460 fathoms.
,,	23rd,	,,	0° 25′ 1″ N.,	,,	6° 36′ 6″ E.,	10 fathoms.

This species appears to be intermediate between *H. atlantica*, Lubbock, and *H. imbricata*, Brady.

Halocypris aculeata, n. sp. (Pl. XV. figs. 5, 6, 33, 34, 38.)

Shell seen from the side highest at the middle, height nearly equal to half the length; dorsal margin straight, right valve terminating posteriorly in a short backward-directed spine-like process, similar to that at the anterior extremity of the left valve; ventral margin convex, evenly rounded, and forming a continuous curve from the postero-dorsal spine round to the shallow notch under the beak in front. Seen from above elongate-ovate, widest at the middle, evenly rounded, and tapering to the posterior extremity; tapering and somewhat sinuate anteriorly. Valves smooth. Length 1 mm.

Antennules in the female provided with numerous apical setæ of moderate length (fig. 54). The last joint of the male antennule is abruptly curved and furnished with a dense subapical fascicle of short hairs, besides several terminal setæ, one of which is of considerable length and much longer than the others; tentacle very slender and scarcely reaching to the extremity of the antennule.

Secondary branch of the male antennæ nearly two thirds the length of the natatory branch and furnished with two apical setæ—one extremely long and one about two fifths the length of the other. The antennal hook, which is slightly dentate on the inner margin at the distal end, carries one short seta and two elongate ones on the exterior edge, immediately behind the geniculation (fig. 55).

Habitat. Lat. 0° 19′ 2″ S., long. 7° 19′ 0″ E. This is the nearest observed position to where the material containing specimens of this species was collected. It was a surface gathering, collected at 8.45 P.M.; the position recorded was taken about 40 minutes earlier on February 2nd.

The drawings of the side and dorsal views are from two specimens which differed somewhat in size. The length of the spines at the extremities of the dorsal margin varies in different specimens.

HALOCYPRIS PUNICA, n. sp. (Pl. XV. figs. 7, 8, 39, 40.)

Shell (*male*) robust, subcentrally gibbous. Outline as seen from the side:—Dorsal margin sinuated; ventral margin slightly convex, immediately posterior to the subcentral gibbosity, then bending up posteriorly in a flattened curve to a little below the horizontal middle line of the shell; thence the posterior extremity recedes upward in a gentle slope to the dorsal margin, with which it forms a bluntly-rounded obtuse angle; the anterior margin is boldly convex below the notch, then evenly and gently rounded inferiorly, where it merges into the ventral margin. Greatest height fully equal to half the length. Beak prominent, stout. Seen from above, broadly and rather irregularly ovate; greatest breadth, in front of the middle, equal to about half the length; posterior extremity bluntly rounded; anterior end subacute. Antennules furnished with nine apical setæ, the two inner ones abruptly twice geniculated at the base; two of the outer rather longer than the others, and bearing a double row of small spiniform teeth near the middle; tentacle slender and extending considerably beyond the apex of the antennules. Secondary branch of the antennæ short and stout, basal part dilated. The upper margin with two processes—one narrow and tooth-like, the other larger and bearing two small spines; apical joint furnished with two terminal elongate setæ, three small submarginal filaments, and a small hook; the hook has the inner margin at the distal end slightly crenate or toothed. Several of the plumose setæ of the natatory branch are thickened or spatulate at the extremity. Length ·77 mm.

Habitat. Station 9 (lat. 3° 0′ 8″ N., long. 7° 13′ 0″ W.), 50 fathoms, in a tow-net gathering, collected January 10th. A few specimens only were obtained.

III. *PLATYCOPA.*

Family CYTHERELLIDÆ, G. O. Sars.

Genus Cytherella, Jones (1849).

Cytherella africana, n. sp. (Pl. XV. figs. 9, 10, 36, 41, 42.)

As seen from the side, the valves of the shell are broadly elliptical; dorsal margin flatly and somewhat unevenly rounded; ventral margin slightly concave, extremities boldly convex. Shell rather highest behind the middle; height fully half the length. Seen from above, the greatest breadth is near the posterior end, which is subtruncate; the sides are slightly curved and converge gently towards the anterior extremity, which is somewhat emarginate. Surface of valves smooth. Length ·86 mm. (1-29th of an inch),

Anterior antennæ 7-jointed, setiferous, the last joint with three spines fully twice the length of the joint; the secondary branch of the posterior antennæ scarcely equal in length to the first joint of the larger branch; post-abdominal laminæ armed on the exterior margin and apex with several strong divaricate spines; inner margin with three or four smaller spines, having one of the edges setose (fig. 42).

Habitat. Loanda Harbour, in a surface tow-net gathering, collected February 13th. 1886. The form of the shell of this species closely resembles *Cytherella scotica*, Brady. It differs in being scarcely so truncate behind; seen from above, the sides of the shell are more distinctly curved in outline, and the dorsal margin, seen from the side, is slightly convex instead of concave.

(?) Cytherella pumila. (Pl. XV. figs. 11, 12.)

Shell outline, seen from the side, broadly elliptical; dorsal margin flatly convex and obscurely angulated; greatest height equal to five ninths of the length; ventral margin gently and evenly rounded; extremities also moderately convex, but the anterior end is rather narrower than the other and somewhat oblique. Seen from above, ovate; greatest breadth behind the middle and equal to four ninths of the length; sides evenly rounded; extremities subacute. Length ·57 mm.

Habitat. Loanda Harbour, in a surface tow-net gathering collected February 13th. A single perfect specimen only was obtained and two valves.

DESCRIPTION OF THE PLATES.

Plate I.

Paracalanus pygmæus (Claus).

Fig. 1. Female, lateral view. × 53.
2. Anterior antenna. × 84.
3. Posterior antenna. × 165.
4. Posterior foot-jaw. × 170.

Fig. 5. Foot of second pair. × 125.
6. Foot of fourth pair. × 125.
7. Foot of fifth pair. × 250.
8. Abdomen and caudal stylets. × 125.

Paracalanus parvus (Claus).

ig. 9. Female, dorsal view. × 40.
10. Foot of first pair. × 95.
11. Foot of fourth pair. × 95.
Fig. 12. Foot of fifth pair, female. × 190.
13. Foot of fifth pair, male. × 125.
14. Abdomen and caudal stylets. × 63.

Eucalanus spinifer, n. sp.

Fig. 15. Female, dorsal view. × 10.
16. Posterior antenna. × 18.
17. Mandible. × 13.
18. Maxilla. × 13.
19. Anterior foot-jaw. × 23.
Fig. 20. Posterior foot-jaw. × 13.
21. Foot of first pair. × 35.
22. Foot of third pair. × 35.
23. Foot of fifth pair. × 86.

Augaptilis longicaudatus (Claus).

Fig. 24. Female, dorsal view. × 12.
25. Posterior antenna. × 28.
Fig. 26. Anterior foot-jaw (*a*, one of the seta more highly magnified). × 35.

Mecynocera Clausi, I. C. Thompson.

Fig. 27. Male, dorsal view. × 32.
28. Female, lateral view. × 32.
29. Anterior antenna. × 35.
30. Posterior antenna. × 125.
Fig. 31. Posterior foot-jaw. × 84.
32. Foot of first pair. × 100.
33. Foot of fourth pair. × 100.
34. Foot of fifth pair. × 125.

Calocalanus plumulosus (Claus).

Fig. 35. Foot of fifth pair. × 125.
Fig. 36. Abdomen and caudal stylets. × 63.

Augaptilis hecticus, Giesbrecht.

Fig. 37. Anterior antenna, male. × 23.
38. Posterior antenna. × 18.
Fig. 39. Foot of fifth pair, female. × 86.

PLATE II.

Augaptilis hecticus, Giesbrecht.

Fig. 1. Posterior foot-jaw. × 70.
2. Foot of second pair of swimming-feet. × 43.
Fig. 3. Terminal spine of outer branch of fourth pair. × 345.
4. Fifth pair of thoracic feet, male. × 170.

Augaptilis longicaudatus (Claus).

Fig. 5. Abdomen and caudal stylets. × 23.

Hemicalanus plumosus, Claus.

Fig. 6. Posterior foot-jaw. × 32.

Mecynocera Clausi, I. C. Thompson.

Fig. 7. Mandible. × 125.
8. Anterior foot-jaw. × 165.
Fig. 9. Abdomen and caudal stylets, female. 63 ×.
10. Abdomen and caudal stylets, male. × 63.

Rhincalanus aculeatus, n. sp.

Fig. 11. Female, dorsal view. × 12·5.
12. Female, lateral view. × 12·5.
13. Anterior antenna. × 12·5.
14. Posterior antenna. × 20.
15. Mandible. × 76.
16. Maxilla. × 17.
17. Anterior foot-jaw. × 40.
Fig. 18. Posterior foot-jaw. × 32.
19. Foot of first pair. × 38.
20. Foot of second pair. × 30.
21. Foot of fourth pair. × 30.
22. Foot of fifth pair. × 38.
23. (?) Immature female. × 10.
24. Foot of fifth pair of same. × 17.

Augaptilis Rattrayi, n. sp.

Fig. 25. Female, dorsal view. × 9.
26. Anterior antenna. × 22.
27. Posterior antenna. × 18.
28. Mandible. × 18.
29. Maxilla. × 18.
30. Anterior foot-jaw. × 28.
31. Posterior foot-jaw. × 28.
32. Foot of first pair. × 28.
Fig. 33. Foot of third pair. × 20.
34. Foot of fifth pair. × 28.
35. Rostrum. × 32.
36. Portion of seta of the posterior foot-jaw (*aa,* "buttons" more highly magnified). × 380.
37. Portion of test highly magnified.

Augaptilis hecticus, Giesbrecht.

Fig. 38. Male, dorsal view. × 20.
39. Anterior antenna, female. × 13.
40. Mandible. × 115.
Fig. 41. Anterior foot-jaw. × 70.
42. Abdomen and caudal stylets, female. × 20.

Heterocalanus serricaudata, n. sp.

Fig. 43. Female, dorsal view. × 32.
44. Female, lateral view (*a,* ovisac more highly magnified). × 32.
45. Posterior foot-jaw. × 190.
Fig. 46. Foot of fifth pair, female. × 135.
47. Abdomen and caudal stylets, female. × 76.
48. Abdomen and caudal stylets, male. × 76.

PLATE III.

Heterocalanus serricaudatus, n. sp.

Fig. 1. Antenior antenna, female. × 100.
2. Right anterior antenna, male. × 76.
3. Posterior antenna. × 70.
4. Mandible (*a,* mandible palp). × 190.
Fig. 5. Anterior foot-jaw. × 250.
6. One of the swimming-feet. × 128.
7. Fifth pair of thoracic feet, male. × 150.

Pleuromma princeps, n. sp.

Fig. 8. Male, dorsal view. × 4.
9. Male, lateral view. × 4.
10. Right anterior antenna (*a*, nineteenth joint more highly magnified). × 8.
11. Left anterior antenna. × 4.
12. Posterior antenna. × 9.
13. Mandible and palp. × 10·5.
Fig. 14. Maxilla. × 10.
15. Anterior foot-jaw. × 13·5.
16. Posterior foot-jaw. × 12.
17. Foot of first pair. × 13·5.
18. Foot of second pair. × 13·5.
19. Foot of fourth pair. × 13·5.
20. Foot of fifth pair. × 16.

Scolecithrix latipes, n. sp. ♀.

Fig. 21. Terminal spine of outer branch of fourth swimming-foot. × 95.
Fig. 22. Foot of fifth pair. × 76.
23. Abdomen and caudal stylets. × 20.

Scolecithrix major, n. sp. ♀.

Fig. 24. Anterior foot-jaw. × 76.
25. Terminal spine of outer branch of third swimming-foot. × 127.
26. Foot of fifth pair. × 127.

Scolecithrix dubia, Giesbrecht. ♂.

Fig. 27. Male, lateral view. × 27.
28. Left anterior antenna. × 35.
29. Anterior foot-jaw. × 18.
Fig. 30. Terminal spine of outer branch of fourth swimming foot. × 127.
31. Fifth pair of thoracic feet. × 84.
32. Abdomen and caudal stylets. × 80.

Scolecithrix tumida, n. sp.

Fig. 33. Female, lateral view. × 18.
34. Anterior antenna. × 22.
35. Anterior foot-jaw. × 95.
Fig. 36. Terminal spine of outer branch of fourth swimming-foot. × 127.
37. Fifth pair of thoracic feet. × 127.
38. Abdomen and caudal stylets. × 27.

Amallophora typica, n. sp.

Fig. 39. Male, lateral view. × 20.
40. Anterior antenna. × 27.
41. Posterior antenna. × 23.
42. Mandible. × 47.
Fig. 43. Maxilla. × 47.
44. Anterior foot-jaw. × 115.
45. Posterior foot-jaw. × 35.
46. Foot of second pair. × 35.

PLATE IV.

Amallophora typica, n. sp.

Fig. 1. Foot of third pair. × 35.
2. Foot of fourth pair. × 35.
Fig. 3. Foot of fifth pair. × 57.
4. Abdomen and caudal stylets. × 18.

Amallophora magna, n. sp.

Fig. 5. Female, lateral view. × 10.
6. Anterior foot-jaw. × 127.
7. Posterior foot-jaw. × 20.
Fig. 8. Terminal spine of outer branch of fourth swimming-foot, highly magnified.
9. Foot of fifth pair. × 125.

Amallophora dubia, n. sp.

Fig. 10. Male, lateral view. × 13.
11. Right anterior antenna. × 20.
12. Left anterior antenna. × 20.
13. Anterior foot-jaw. × 95.
14. Posterior foot-jaw. × 63.
Fig. 15. Foot of first pair. × 63.
16. Foot of fourth pair. × 48.
17. Fifth pair of thoracic feet. × 40.
18. Abdomen and caudal stylets. × 27.

Amallophora dubia, var. *similis*.

Fig. 19. Male, lateral view. × 18.
20. Anterior antenna. × 27.
21. Terminal spine of outer branch of fourth swimming-foot. × 127.
22. Fifth pair of thoracic feet. × 63.
23. Abdomen and caudal stylets. × 27.

Amallophora robusta, n. sp.

Fig. 24. Female, lateral view. × 13.
25. Anterior foot-jaw. × 53.
26. Posterior foot-jaw. × 53.
Fig. 27. Terminal spine of outer branch of fourth swimming-foot. × 127.
28. Fifth pair of thoracic feet. × 95.
29. Abdomen and caudal stylets. × 27.

Candace intermedia, n. sp.

Fig. 30. Male, lateral view. × 22.
31. Anterior antenna, female. × 37.
32. Anterior antenna, male. × 37.
33. Anterior foot-jaw. × 20.
34. Fifth pair of thoracic feet, female. × 127.
Fig. 35. Fifth pair of thoracic feet, male. × 67.
36. Abdomen and caudal stylets, female. × 27.
37. Abdomen and caudal stylets, male. × 27.

Candace varicans, Giesbrecht.

Fig. 38. Abdomen and caudal stylets, female. × 20.
39. Abdomen and caudal stylets, male. × 20.

Scolecithrix securifrons, n. sp.

Fig. 40. Male, lateral view. × 9.
41. Anterior antenna, female. × 13.
42. Anterior antenna, male. × 13.
43. Posterior antenna. × 27.
44. Mandible. × 27.
45. Maxilla. × 27.
46. Anterior foot-jaw. × 63.
47. Posterior foot-jaw, female. × 40.
48. Posterior foot-jaw, male. × 40.
49. Foot of first pair. × 35.
Fig. 50. Foot of second pair. × 27.
51. Foot of fourth pair. × 20.
52. Fifth pair of thoracic feet, female. × 40.
53. Fifth pair of thoracic feet, male. × 20.
54. Abdomen and caudal stylets, female, dorsal view. × 16.
55. Abdomen and caudal stylets, male, dorsal view. × 13.
56. Abdomen, female, lateral view. × 12.

PLATE V.

Scolecithrix securifrons, n. sp.

Fig. 1. Rostrum. × 27.

Scolecithrix ctenopus, Giesbrecht. ♂.

Fig. 2. Male, lateral view. × 22.
3. Right anterior antenna. × 23.
4. Left anterior antenna. × 23.
5. Anterior foot-jaw. × 150.
Fig. 6. Posterior foot-jaw. × 127.
7. Foot of third pair. × 46.
8. Foot of fifth pair. × 12.
9. Abdomen and caudal stylets. × 34.

Scolecithrix tenuipes, n. sp. ♂.

Fig. 10. Male, lateral view. × 20.
11. Right anterior antenna. × 28.
12. Left anterior antenna. × 28.
13. Anterior foot-jaw. × 115.
14. Posterior foot-jaw. × 115.
Fig. 15. Foot of second pair. × 73.
16. Foot of third pair. × 73.
17. Foot of fourth pair. × 57.
18. Fifth pair. × 57.
19. Abdomen and caudal stylets. × 35.

Scolecithrix longicornis, n. sp. ♀.

Fig. 20. Female, lateral view. × 27.
21. Anterior antenna. × 36.
22. Anterior foot-jaw. × 127.
23. Posterior foot-jaw. × 85.
24. Foot of first pair. × 64.
Fig. 25. Foot of second pair. × 76.
26. Foot of third pair. × 64.
27. Foot of fifth pair. × 250.
28. Abdomen and caudal stylets. × 53.

Scolecithrix Bradyi, Giesbrecht.

Fig. 29. Male, lateral view. × 18.
30. Anterior antenna, female. × 48.
31. Anterior antenna, male. × 53.
32. Posterior antenna. × 95.
33. Mandible. × 63.
34. Anterior foot-jaw. × 170.
35. Posterior foot-jaw. × 95.
Fig. 36. Terminal spine of outer branch of one of the swimming-feet. × 170.
37. Fifth pair of thoracic feet, male. × 53
38. Abdomen and caudal stylets, female. × 40.
39. Abdomen and caudal stylets, male. × 32.

Scolecithrix latipes, n. sp. ♀.

Fig. 40. Female, lateral view. × 12.
41. Anterior antenna. × 18
Fig. 42. Anterior foot-jaw. × 25.
43. Rostrum. × 27.

Scolecithrix major, n. sp.

Fig. 44. Female, lateral view. × 18.
Fig. 45. Abdomen and caudal stylets. × 20.

Calanus comptus, Dana. ♂.

Fig. 46. Male, lateral view. × 13.
47. Anterior antenna. × 13.
48. Posterior antenna. × 23.
Fig. 49. Mandible. × 35.
50. Maxilla. × 35.

PLATE VI

Calanus comptus, Dana. ♂.

Fig. 1. Posterior foot-jaw. × 56.
2. Foot of first pair. × 35.
3. Terminal spine of outer branch of first swimming-foot, greatly magnified.
4. Foot of fourth pair. × 23.
5. Foot of fifth pair. × 23.

Hemicalanus plumosus, Claus.

Fig. 6. Anterior foot-jaw. × 27.

Calocalanus plumulosus (Claus).

Fig. 7. Female, lateral view. × 35.
Fig. 8. Anterior antenna. × 53.

Calocanus pavo (Dana).

Fig. 9. Female, dorsal view. × 53.
Fig. 10. Fifth pair of thoracic feet. × 115.

Pleuromma gracile, Claus.

Fig. 11. Male, dorsal view. × 17·5.
12. Right anterior antenna of the same. × 23.
13. Left anterior antenna of the same. × 35.
14. 14th joint of left anterior antenna. × 415.

Euchirella messinensis (Claus).

Fig. 15. Male, dorsal view. × 7·6.
Fig. 16. Posterior antenna. × 20.

Euchæta barbata, Brady.

Fig. 17. Male, dorsal view. × 6·5.

Euchæta hebes, Giesbrecht.

Fig. 18. Male, lateral view. × 13.
Fig. 19. Fifth pair of thoracic feet. × 26.

Euchæta hebes, var. *valida*.

Fig. 20. Male, lateral view. × 5·8.
21. Terminal spine of outer branch of fourth swimming-feet. × 63.
22. Fifth pair of thoracic feet. × 13.

Euchæta australis, Brady.

Fig. 23. Female, dorsal view. × 9.

Euchæta (?) *Hessei*, var. *similis*.

Fig. 24. Male, lateral view. × 18.
Fig. 25. Fifth pair of thoracic feet. × 53.

Phyllopus bidentatus, Brady.

Fig. 26. Male, dorsal view. × 10.
27. Mouth as seen from the side (*a*, outline, seen from above), highly magnified.
28. Fifth pair of thoracic feet. × 43.

Pontellopsis villosa, Brady.

Fig. 29. Male, dorsal view. × 13.
30. Anterior antenna, male. × 20.
31. Posterior antenna. × 26.
Fig. 32. Fifth pair of thoracic feet, female. × 63.
33. Fifth pair of thoracic feet, male. × 53.
34. Abdomen and caudal stylets. × 35.

Phaënna spinifera, Claus.

Fig. 35. Male, lateral view. × 13.

Labidocera detruncata, var. *intermedia*.

Fig. 36. Posterior foot-jaw. × 41.
37. Fifth pair of thoracic feet, female. × 76.
Fig. 38. Fifth pair of thoracic feet, male, × 34.

Labidocera Darwinii (Lubbock).

Fig. 39. Posterior foot-jaw. × 50.
40. Fifth pair of thoracic feet, female. × 63.
Fig. 41. Fifth pair of thoracic feet, male. × 50.
42. Abdomen and caudal stylets, female. × 38.

Pontella mediterranea, Claus.

Fig. 43. Female, dorsal view. × 13.
44. Anterior antenna, female (and rostrum). × 27.
45. Hinged joints of right anterior antenna, male. × 63.
Fig. 46. Posterior foot-jaw. × 48.
47. Fifth pair of thoracic feet, female (? immature). × 100.
48. Fifth pair of thoracic feet, mael. × 63.

Plate VII.

Phaënna spinifera, Claus.

Fig. 1. Anterior foot-jaw. × 95.
Fig. 2. Fifth pair of thoracic feet. × 50.

Labidocera detruncata, var. *intermedia*.

Fig. 3. Female, lateral view. × 13.
Fig. 4. Anterior antenna, male. × 20.

Labidocera Darwinii (Lubbock).

Fig. 5. Male, dorsal view. × 18.
Fig. 6. Hinged joints of right anterior antenna, male. × 50.

Candace varicans, Giesbrecht.

Fig. 7. Anterior antenna, female. × 24.
8. Right anterior antenna, male. × 24.
Fig. 9. Fifth pair of thoracic feet, female. × 95.
10. Fifth pair of thoracic feet, male. × 95.

Mormonilla phasma, Giesbrecht.

Fig. 11. Female, lateral view. × 27.
12. Anterior antenna. × 32.
13. Posterior antenna. × 63.
14. Mandible. × 50.
15. Maxilla. × 50.
16. Anterior foot-jaw. × 76.
Fig. 17. Posterior foot-jaw. × 95.
18. Foot of first pair. × 95.
19. Foot of second pair. × 95.
20. Foot of fourth pair. × 76.
21. Abdomen and caudal stylets. × 53.

Acartia plumosa, n. sp.

Fig. 22. Female, dorsal view. × 32.
23. Anterior antenna, female. × 63.
24. Right anterior antenna, male. × 63.
25. Hinged joints of male right anterior antenna. × 253.
26. Foot of first pair. × 95.
27. Foot of fourth pair. × 76.
28. Fifth pair of thoracic feet, female (front view). × 153.
Fig. 29. Foot of fifth pair, female (side view). × 153.
30. Fifth pair of thoracic feet, male. × 153.
31. Abdomen and caudal stylets, female. × 50.
32. Abdomen and caudal stylets, male. × 50.

Acartia Clausi, Giesbrecht.

Fig. 33. Male, dorsal view. × 32.
34. Anterior antenna, female. × 63.
35. Right anterior antenna, male (*a*, hinged joints more magnified). × 63.
36. Foot of fourth pair. × 95.
37. Fifth pair of thoracic feet, female. × 125.
Fig. 38. Fifth pair of thoracic feet, male. × 153.
39. Abdomen and caudal stylets, female. × 50.
40. Abdomen and caudal stylets, male. × 50.

Paracartia dubia, n. sp.

Fig. 41. Left anterior antenna of male. × 63.
Fig. 42. Fifth pair of thoracic feet, male. × 127.

PLATE VIII.

Paracartia spinicaudata, n. sp. ♀.

Fig. 1. Female, dorsal view. × 40.
2. Anterior antenna. × 63.
3. Posterior antenna. × 127.
4. Mandible and palp. × 127.
5. Maxilla. × 127.
6. Anterior foot-jaw. × 127.
Fig. 7. Posterior foot-jaw. × 127.
8. Foot of first pair. × 127.
9. Foot of fourth pair. × 95.
10. Fifth pair of thoracic feet. × 127.
11. Abdomen and caudal stylets. × 95.

Paracartia dubia, n. sp. ♂.

Fig. 12. Male, dorsal view. × 27.
13. Right anterior antenna. × 63.
Fig. 14. Foot of fourth pair. × 95.
15. Abdomen and caudal stylets. × 63.

Ætidius armiger, Giesbrecht.

Fig. 16. Female, dorsal view. × 20.
17. Male, lateral view. × 21.
18. Anterior antenna. × 21.
19. Posterior antenna. × 23.
20. Mandible and palp. × 38.
21. Anterior foot-jaw. × 47.
Fig. 22. Posterior foot-jaw. × 39.
23. Foot of first pair. × 57.
24. Foot of second pair. × 57.
25. Foot of fourth pair. × 42.
26. Fifth pair of thoracic feet. × 85.
27. Abdomen and caudal stylets. × 39.

Clausocalanus latipes, n. sp. ♂.

Fig. 28. Right anterior antenna. × 59.
29. Mandible and palp. × 115.
30. Anterior foot-jaw. × 115.
31. Posterior foot-jaw. × 115.
32. Foot of first pair. × 86.
Fig. 33. Foot of second pair. × 86.
34. Foot of third pair. × 86.
35. Foot of fourth pair. × 86.
36. Fifth pair of thoracic feet. × 230.
37. Abdomen and caudal stylets. × 57.

Clausocalanus arcuicornis, Dana, ♂.

Fig. 38. Male, lateral view. × 23.
39. Anterior antenna. × 35.
40. Posterior antenna. × 23.
41. Mandible palp. × 85.
42. Maxilla. × 113.
Fig. 43. Anterior foot-jaw. × 276.
44. Posterior foot-jaw. × 172.
45. Foot of first pair. × 115.
46. Fifth pair of thoracic feet. × 115.
47. Abdomen and caudal stylets. × 57.

Temoropia mayumbaensis, n. sp.

Fig. 48. Right anterior antenna of male. × 88.
Fig. 49. Mandible and palp. × 63.

PLATE IX.

Temoropia mayumbaensis, n. sp.

Fig. 1. Male, dorsal view. × 53.
2. Posterior antenna. × 83.
3. Maxilla. × 95.
4. Anterior foot-jaw. × 190.
5. Posterior foot-jaw. × 63.
6. Foot of first pair. × 152.
7. Inner branch of second thoracic feet. × 95.
Fig. 8. Fifth pair of thoracic feet, female. × 95.
9. Fifth pair of thoracic feet, male. × 95.
10. Abdomen and caudal stylets, female, dorsal view. × 63.
11. Abdomen of female, lateral view. × 63.
12. Abdomen and caudal stylets, male. × 63.

Temora longicornis (Müller).

Fig. 13. Fifth pair of thoracic feet, male. × 95.

Oithona minuta, n. sp.

Fig. 14. Female, dorsal view. × 72.
15. Anterior antenna, female. × 169.
16. Anterior antenna, male. × 230.
17. Posterior antenna. × 230.
18. Mandible. × 270.
19. Mandible palp. × 230.
20. Anterior foot-jaw. × 230.
Fig. 21. Posterior foot-jaw. × 345.
22. Foot of first pair. × 230.
23. Foot of fourth pair. × 230.
24. Abdomen and caudal stylets, female (*a*, fifth pair of feet). × 127.
25. Abdomen and caudal stylets, male. × 200.

Ectinosoma Chrystali, n. sp.

Fig. 26. Female, lateral view. × 42.
27. Anterior antenna, female. × 230.
28. Posterior antenna. × 127.
29. Mandible and palp. × 35.
30. Anterior foot-jaw. × 253.
31. Posterior foot-jaw. × 253.
Fig. 32. Foot of first pair of swimming-feet. × 138.
33. Foot of fourth pair of swimming-feet. × 127.
34. Foot of fifth pair. × 190.
35. Last abdominal segments and caudal stylets. × 95.

Bradya brevicornis, n. sp.

Fig. 36. Female, lateral view. × 53.
37. Anterior antenna. × 460.
38. Posterior antenna. × 170.
39. Anterior foot-jaw. × 460.
40. Posterior foot-jaw. × 345.
Fig. 41. Foot of first pair. × 190.
42. Foot of fifth pair. × 190.
43. Last abdominal segments and caudal stylets. × 95.

Amymone Andrewi, n. sp.

Fig. 44. Female, lateral view. × 63.
45. Anterior antenna. × 190.
Fig. 46. Posterior antenna. × 190.
47. Anterior foot-jaw. × 380.

PLATE X.

Amymone Andrewi, n. sp.

Fig. 1. Posterior foot-jaw. × 253.

Stenhelia accraensis, n. sp.

Fig. 2. Female, lateral view. × 53.
3. Anterior antenna. × 253.
4. Posterior antenna. × 190.
5. Mandible and palp. × 380.
6. Maxilla. × 190.
7. Anterior foot-jaw. × 253.
Fig. 8. Posterior foot-jaw. × 253.
9. Foot of first pair. × 152.
10. Foot of fourth pair. × 152.
11. Foot of fifth pair. × 126.
12. Last abdominal segments and caudal stylets. × 63.

Laophonte longipes, n. sp.

Fig. 13. Female, lateral view. × 53.
14. Anterior antenna. × 253.
15. Posterior antenna. × 380.
16. Mandible and palp. × 380.
17. Maxilla. × 500.
18 Anterior foot-jaw. × 253.
Fig. 19. Posterior foot-jaw. × 190.
20. Foot of first pair. × 190.
21. Foot of fourth pair. × 190.
22. Foot of fifth pair. × 190.
23. Last abdominal segments and caudal stylets. × 95.

Laophonte pygmæa, n. sp.

Fig. 24. Female, lateral view. × 53.
25. Anterior antenna. × 253.
26. Posterior foot-jaw. × 253.
27 Foot of first pair. × 253.
Fig. 28. Foot of fourth pair. × 253.
29. Foot of fifth pair. × 253.
30. Last abdominal segments and caudal stylets. × 127.

Laophonte brevicornis, n. sp.

Fig. 31. Female, lateral view. × 53.
32. Anterior antenna. × 253.
33. Posterior foot-jaw. × 253.
34. Foot of first pair. × 253.
Fig. 35. Foot of fourth pair. × 253.
36. Foot of fifth pair. × 253.
37. Last abdominal segments and caudal stylets. × 126.

Dactylopus latipes, n. sp.

Fig. 38. Female lateral view. × 33.
39. Anterior antenna. × 190.
40. Posterior foot-jaw. × 253.
41. Foot of first pair. × 190.
Fig. 42. Foot of fifth pair. × 127.
43. Last abdominal segments and caudal stylets. × 63.

Dactylopus propinquus, n. sp.

Fig. 44. Female, lateral view. × 53.
45. Anterior antenna, female. × 190.
46. Anterior antenna, male. × 253.
47. Posterior antenna. × 253.
48. Posterior foot-jaw. × 253.
Fig 49. Foot of first pair. × 190.
50. Foot of fifth pair, female. × 190.
51. Foot of fifth pair, male. × 190.
52. One of the appendages of first abdominal segment, male. × 190.

PLATE XI.

Dactylopus propinquus, n. sp.

Fig. 1. Foot of second pair of swimming-feet, male. × 190.
2. Foot of third pair of swimming-feet, male. × 190.
3. Last abdominal segments and caudal stylets. × 95.

Ilyopsyllus affinis, n. sp.

Fig. 4. Female, dorsal view. × 60.
5. Female, lateral view. × 60.
6. Anterior antenna, female. × 250.
7. Anterior antenna, male. × 250.
8. Posterior antenna. × 330.
9. Mandible and palp. × 380.
10. Maxilla and (?) oral aperture. × 500.
Fig. 11. Anterior foot-jaw. × 500.
12. Posterior foot-jaw. × 330.
13. Foot of first pair. × 190.
14. Foot of third pair. × 152.
15. Foot of fifth pair, female. × 500.
16. Abdomen and caudal stylets. × 95.
17. Rostrum. × 300.

Miracia minor, n. sp.

Fig. 18. Female, lateral view. × 53.
19. Anterior antenna, female. × 152.
20. Anterior antenna, male. × 190.
21. Posterior antenna. × 190.
22. Posterior foot-jaw, female. × 253.
23. Posterior foot jaw, male. × 253.
24. Foot of first pair. × 108.
Fig. 25. Foot of second pair, female. × 108.
26. Foot of second pair, male. × 108.
27. Foot of third pair. × 108.
28. Fifth pair of thoracic feet, female. × 95.
29. Foot of fifth pair, male. × 190.
30. Abdomen and caudal stylets. × 76.

Ægisthus longirostris, n. sp.

Fig. 31. Female, dorsal view. × 20.
32. Female, side view. × 18.
33. Anterior antenna, female. × 53.
34. Anterior antenna, male. × 32.
35. Posterior antenna. × 63.
36. Mandible. × 190.
37. Maxilla. × 140.
Fig. 38. Anterior foot-jaw. × 190.
39. Posterior foot-jaw, female. × 95.
40. Posterior foot-jaw, male. × 95.
41. Foot of first pair. × 40.
42. Foot of fourth pair. × 40.
43. Fifth pair of thoracic feet. × 53.
44. Extremity of one of the stylets. × 190.

Copilia Fultoni, n. sp.

Fig. 45. Adult dorsal view. × 10·7.
46. Anterior antenna. × 63.
47. Posterior antenna. × 40.
Fig. 48. Mandible. × 257.
49. Maxilla. × 190.
50. Anterior foot-jaw. × 253.

Plate XII.

Copilia Fultoni, n. sp.

Fig. 1. Posterior foot-jaw. × 20.
2. Foot of fourth pair of swimming-feet. × 63.
3. Abdomen and caudal stylets (*a*, fifth foot). × 26.

Saphirina metallina, Dana.

Fig. 4. One of the caudal stylets with leaf-like appendages (*cercophylla*). × 125.

(?) *Artotrogus abyssicolus*, n. sp. (?) ♂.

Fig. 5. Adult, dorsal view. × 27.
6. Anterior antenna. × 63.
7. Posterior antenna. × 253.
Fig. 8. Posterior foot-jaw. × 253.
9. Abdomen and caudal stylets. × 84.

Longipedia minor, T. & A. Scott.

Fig. 10. Male, lateral view. × 53.
11. Foot of second pair. × 84.
12. Fifth pair of thoracic feet and appendages of first abdominal segment. × 190.
13. Last abdominal segments and caudal stylets. × 153.

Euterpe gracilis, Claus, var. *armata*, n. var.

Fig. 14. Female, lateral view. × 53.
15. Anterior antenna. × 190.
16. Anterior antenna. × 190.
17. Mandible. × 190.
18. Maxilla. × 190.
Fig. 19. Anterior foot-jaw. × 190.
20. Posterior foot-jaw. × 253.
21. Foot of first pair. × 190.
22. Foot of fourth pair. × 190.
23. Fifth pair of thoracic feet. × 190.

Laophonte serrata, Claus.

Fig. 24. Female, lateral view. × 53.
25. Anterior antenna. × 190.
26. Foot of first pair. × 153.
Fig. 27. Foot of fifth pair. × 127.
28. Last abdominal segments and caudal stylets. × 95.

Cletodes linearis, Claus.

Fig. 29. Female, lateral view. × 53.
30. Anterior antenna, female. × 190.
31. Foot of fifth pair, female. × 153.
Fig. 32. Fifth pair of thoracic feet (*a*), and appendages (*b*) of first abdominal segment. × 153.

Thalestris forficula, Claus.

Fig. 33. Female, lateral view. × 53.
34. Anterior antenna. × 190.
35. Posterior antenna. × 190.
36. Anterior foot-jaw. × 253.
37. Posterior foot-jaw. × 253.
Fig. 38. Foot of first pair. × 153.
39. Foot of fourth pair. × 153.
40. Foot of fifth pair. × 153.
41. Last abdominal segments and caudal stylets. × 127.

Harpacticus chelifer, Müller, var.

Fig. 42. Male, lateral view. × 20.
43. Posterior foot-jaw. × 76.
44. Foot of first pair. × 50.
Fig. 45. Foot of second pair. × 50.
46. Foot of fifth pair. × 127.

Clytemnestra rostrata (Brady).

Fig. 47. Female, lateral view. × 32.
48. Female, dorsal view. × 32.
49. Male, dorsal view. × 32.
50. Anterior antenna, female. × 95.
51. Anterior antenna, male. × 95.
52. Posterior antenna. × 127.
Fig. 53. Mandible and palpi. × 253.
54. Maxilla. × 380.
55. Anterior foot-jaw. × 253.
56. Posterior foot-jaw, female. × 127.
57. Posterior foot-jaw, male. × 95.

Plate XIII.

Clytemnestra rostrata (Brady).

Fig. 1. Foot of first pair of swimming-feet. × 95.
2. Foot of second pair of swimming-feet. × 95.
3. Foot of fifth pair of swimming-feet. × 127.

Oncæa gracilis (Dana).

Fig. 4. Female, dorsal view. × 53.
5. Anterior antenna. × 53.
6. Posterior antenna. × 84.
7. Mandible. × 153.
8. Maxilla. × 153.
Fig. 9. Anterior foot-jaw. × 127
10. Posterior foot-jaw. × 95
11. Foot of fourth pair. × 95.
12. Abdomen and caudal stylets (*a*, fifth feet). × 50.

Oncæa mediterranea (Claus).

Fig. 13. Female, dorsal view. × 53.
14. Anterior antenna. × 63.
15. Posterior antenna. × 100.
Fig. 16. Posterior foot-jaw. × 95.
17. Foot of fourth pair. × 127.

Pachysoma punctata, Claus.

Fig. 18. Adult, dorsal view. × 18.
19. Anterior antenna. × 48.
20. Posterior antenna. × 63.
21. (?) Mandible. × 190.
Fig. 22. (?) Maxilla. × 153.
23. (?) Anterior foot-jaw. × 253.
24. Foot of fourth pair. × 50.

Cyclopicera lata, Brady.

Fig. 25. Male, dorsal view. × 53.
26. Anterior antenna. × 100.
27. Mandible. × 190.
Fig. 28. Maxilla. × 153.
29. Foot of fourth pair. × 100.
30. Foot of fifth pair. × 190.

Hersiliodes Livingstoni, n. sp.

Fig. 31. Female, dorsal view. × 27.
32. Anterior antenna. × 127.
33. Posterior antenna. × 95.
34. *m.*, Mandible; *mx.*, Maxilla; Mouth. × 127.
Fig. 35. Anterior foot-jaw. Posterior foot-jaw. × 127.
36. Foot of first pair. × 76.
37. Foot of fourth pair. × 76.
38. Foot of fifth pair. × 48.

Lichomolgus congoensis, n. sp.

Fig. 39. Female, dorsal view. × 35.
40. Anterior antenna. × 127.
41. Posterior antenna. × 127.
42. Mandible. × 253.
43. Maxilla. × 253.
Fig. 44. Anterior foot-jaw. × 253.
45. Posterior foot-jaw. × 190.
46. Foot of fourth pair. × 135.
47. Foot of fifth pair. × 190.
48. Abdomen and caudal stylets. × 84.

Pseudanthessius propinquus, n. sp.

Fig. 49. Male, dorsal view. × 35.
50. Anterior antenna. × 170.
51. Posterior antenna. × 135.
52. Mandible. × 190.
53. Maxilla. × 253.
Fig. 54. Posterior foot-jaw, female. × 84.
55. Foot of first pair. × 135.
56. Abdomen and caudal stylets, female. × 40.

Saphirella abyssicola, n. sp.

Fig. 57. (?) Adult, dorsal view. × 25.
Fig. 58. Posterior antenna. × 125.

PLATE XIV.

Pseudanthessius propinquus, n. sp.

Fig. 1. Anterior foot-jaw. × 190.
2. Posterior foot-jaw, male. × 53.
3. Foot of fourth pair of swimming-feet. × 135.
4. Foot of fifth pair. × 127.

Saphirella abyssicola, n. sp.

Fig. 5. Anterior antenna. × 125.
6. Mandible. × 190.
7. Maxilla. × 152.
Fig. 8. Anterior foot-jaw. × 190.
9. Posterior foot-jaw. × 170.
10. Foot of first pair of swimming-feet. × 95.

Artrotrogus abyssicolus, n. sp.

Fig. 11. Female, dorsal view. × 35.
12. Anterior antenna. × 127.
13. Posterior antenna. × 135.
14. Mandible. × 253.
15. Anterior foot-jaw. × 152.
Fig. 16. Posterior foot-jaw. × 152.
17. Foot of first pair of swimming-feet. × 100.
18. Foot of fourth pair of swimming-feet. × 95.

Caligus Murrayanus, n. sp.

Fig. 19. Adult, ventral view. × 17.

Caligus bengoensis, n. sp.

Fig. 20. Adult, ventral view. × 19.

(?) *Caligus Thymni*, Dana.

Fig. 21. Adult, ventral view. × 8.

Caligus dubius, n. sp.

Fig. 22. Adult, ventral view. × 12·5.

Nogagus validus, Dana.

Fig. 23. Adult, ventral view. × 7·5.

Pontopsyllus elongatus, n. g. et sp.

Fig. 24. Adult, dorsal view. × 20.
25. Anterior antenna. × 135.
26. Posterior antenna. × 84.
27. Mandible (*m.*) and maxilla (*mx.*). × 190.
28. One of the foot-jaws. × 125.
Fig. 29. Foot of fourth pair of swimming-feet. × 95.
30. (?) Immature form; (*s.*) sucking-disk. × 60.

Cypria atlantica, n. sp.

Fig. 31. Shell seen from the side. × 40.
32. Shell seen from above. × 40.
Fig. 33. Shell seen from the side (young). × 46.

Phlyctenophora africana, n. sp.

Fig. 34. Shell seen from the side. × 27.
Fig. 35. Shell seen from above. × 27.

Pontocypris trigonella, G. O. Sars.

Fig. 36. Shell seen from the side. × 27.
Fig. 37. Shell seen from above. × 27.

Pontocypris subreniformis, n. sp.

Fig. 38. Shell seen from the side. × 44.
Fig. 39. Shell seen from above. × 44.

Bairdia inornata, n. sp.

Fig. 40. Shell seen from the side. ×37. | Fig. 41. Shell seen from above. ×37.

Cythere multicava, n. sp.

Fig. 42. Shell seen from the side. ×32. | Fig. 43. Shell seen from above. ×32.

Cythere sculptilis, n. sp.

Fig. 44. Shell seen from the side. ×48. | Fig. 45. Shell seen from above. ×48.

Cythere rimosa, n. sp.

Fig. 46. Shell seen from the side. ×40. | Fig. 47. Shell seen from above. ×40.

Cythere thalassica, n. sp.

Fig. 48. Shell seen from the side. ×30. | Fig. 49. Shell seen from above. ×30.

Cythere venusta, n. sp.

Fig. 50. Shell seen from the side. ×28·5. | Fig. 51. Shell seen from above. ×28·5.

Cytherura simulans, n. sp.

Fig. 52. Shell seen from the side. ×54. | Fig. 53. Shell seen from above. ×54.

Cytheropteron trilobites, Brady.

Fig. 54. Shell seen from the side. ×40·5. | Fig. 55. Shell seen from above. ×40·5.

Asterope squamiger, n. sp.

Fig. 56. Shell seen from the side. ×22. | Fig. 57. Shell seen from above. ×22.

Sarsiella Murrayana, n. sp.

Fig. 58. Shell seen from the side. × 27.

PLATE XV.

Fig. 1. *Halocypris elongata*, n. sp. Shell seen from the side. × 8·5.
2. ,, ,, n. sp. Shell seen from above. × 8·5.
3. ,, *torosa*, n. sp. Shell seen from the side. × 7.
4. ,, ,, n. sp. Shell seen from above. × 7.
5. ,, *aculeata*, n. sp. Shell seen from the side. × 30.
6. ,, ,, n. sp. Shell seen from above. × 30.
7. ,, *punica*, n. sp. Shell seen from the side. × 32.
8. ,, ,, n. sp. Shell seen from above. × 32.
9. *Cytherella africana*, n. sp. Shell seen from the side. × 28·5.
10. ,, ,, n. sp. Shell seen from above. × 28·5.
11. ,, *pumila*, n. sp. Shell seen from the side. × 40.
12. ,, ,, n. sp. Shell seen from above. × 40.
13. *Cythere multicava*, n. sp. Antennule. × 95.
14. *Asterope squamiger*, n. sp. Antennule. × 54.
15. *Cythere multicava*, n. sp. Antenna. × 95.

Fig. 16. *Cypria atlantica.* Shell structure highly magnified.
17. *Phlyctenophora africana,* n. sp. One of the antennules. × 95.
18. ,, ,, n. sp. One of the antennæ. × 127.
19. ,, ,, n. sp. The post-abdomen. × 95.
20. *Cypria atlantica,* n. sp. One of the antennæ. × 127.
21. ,, ,, n. sp. One of the antennules. × 95.
22. *Asterope squamiger,* n. sp. One of the antennæ. × 54.
23. ,, ,, n. sp. The post-abdomen. × 27.
24. *Sarsiella Murrayana,* n. sp. One of the antennules. × 54.
25. *Cypria atlantica,* n. sp. The post-abdomen. × 127.
26. *Asterope squamiger,* n. sp. One of the first maxillæ. × 54.
27. *Halocypris elongata,* n. sp. One of the antennæ.
28. *Sarsiella Murrayana,* n. sp. Ovigerous foot. × 190.
29. ,, ,, n. sp. One of the antennæ. × 80.
30. *Halocypris elongata,* n. sp. One of the antennules.
31. *Sarsiella Murrayana,* n.sp. The post-abdomen. × 127.
32. *Halocypris torosa,* n. sp. One of the antennules. × 13.
33. ,, *aculeata,* n. sp. One of the antennules (female). × 54.
34. ,, ,, n. sp. One of the antennæ. × 27.
35. ,, *torosa,* n. sp. First foot. × 13.
36. *Cytherella africana,* n. sp. One of the anterior antennæ. × 95.
37. *Halocypris torosa,* n. sp. One of the antennæ. × 13.
38. ,, *aculeata,* n. sp. One of the antennules (male). × 40.
39. ,, *punica,* n. sp. One of the antennules. × 54.
40. ,, ,, n. sp. One of the antennæ. × 54.
41. *Cytherella africana,* n. sp. One of the posterior antennæ. × 95.
42. ,, ,, n. sp. The post-abdomen. × 95.


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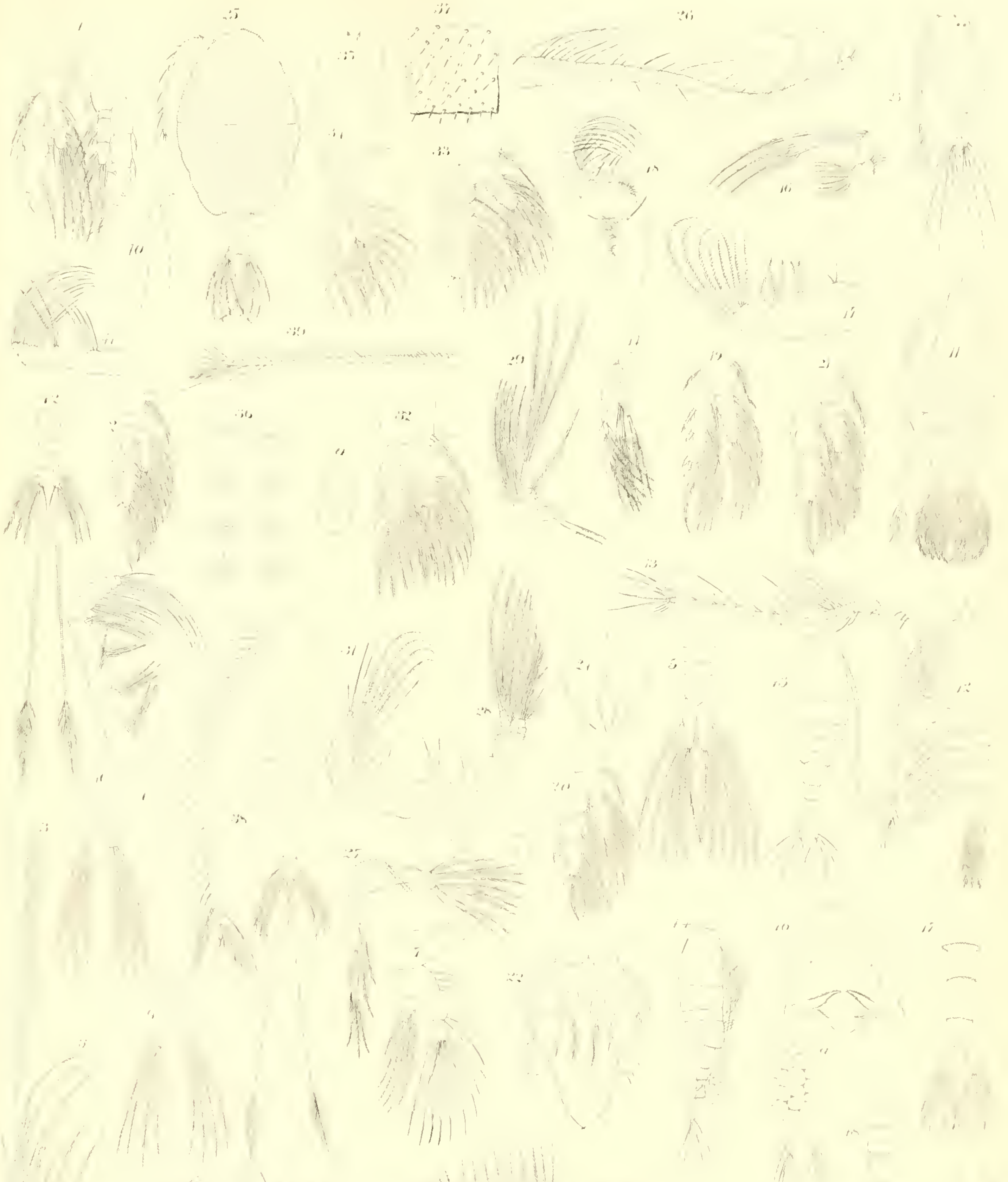
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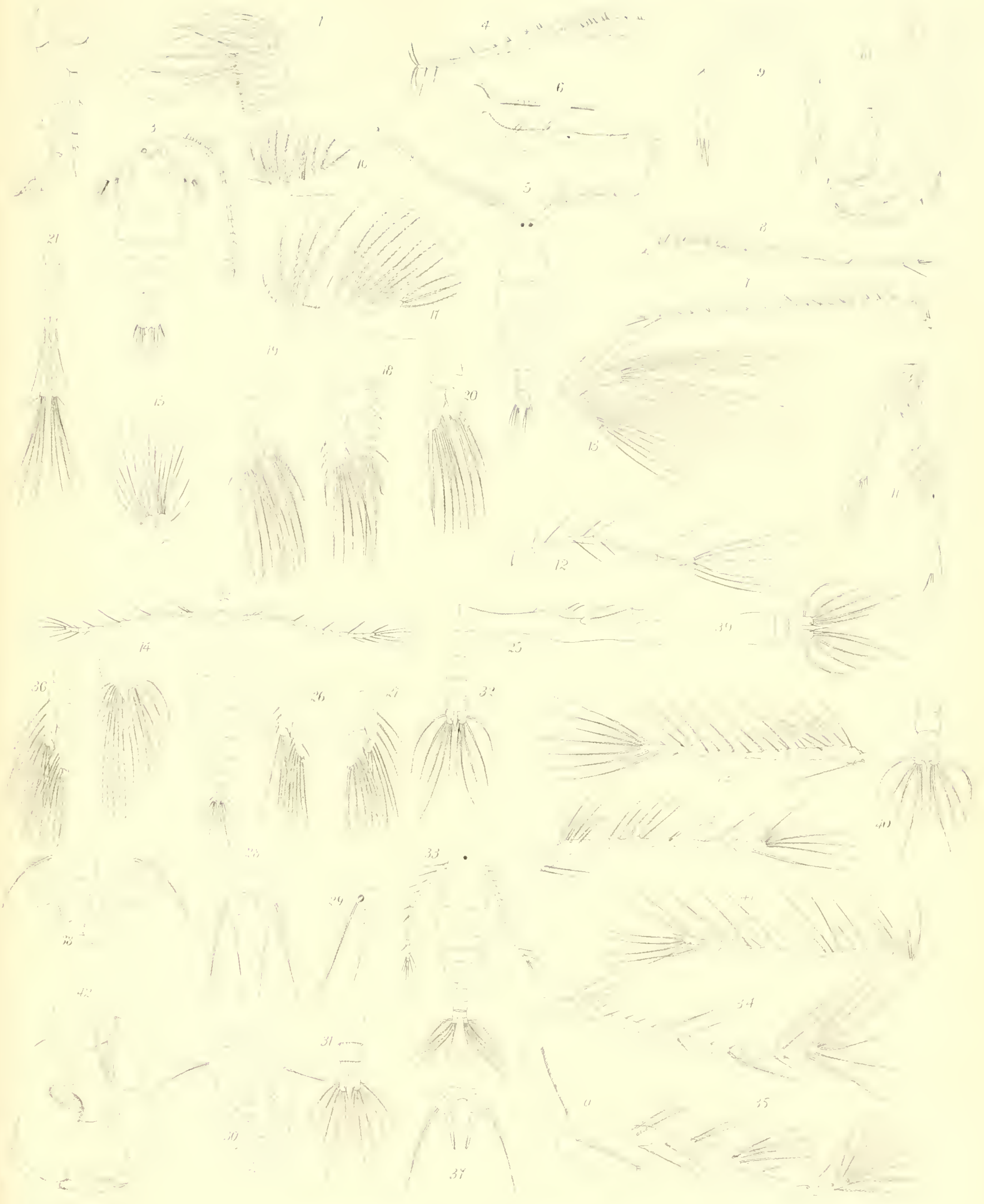

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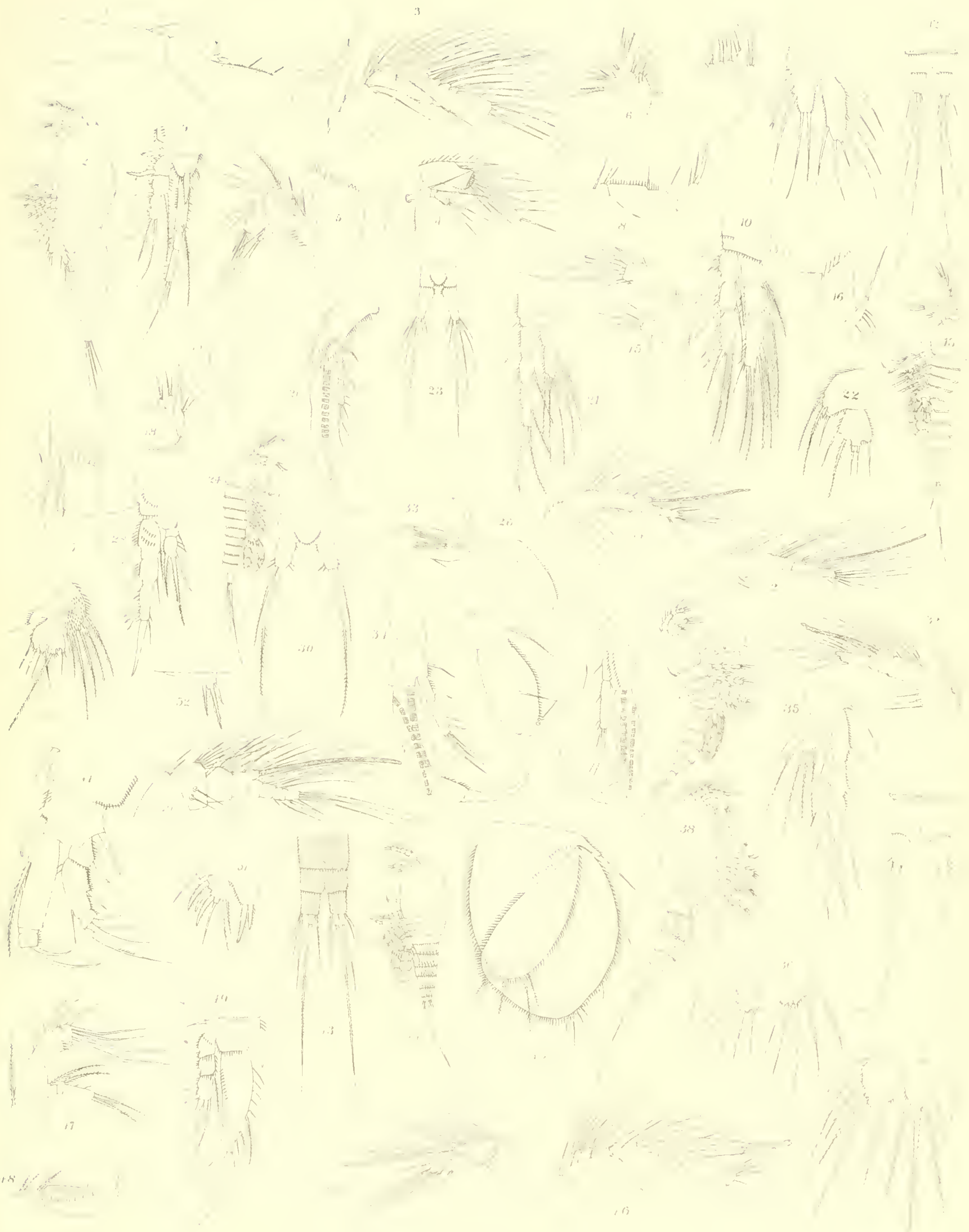

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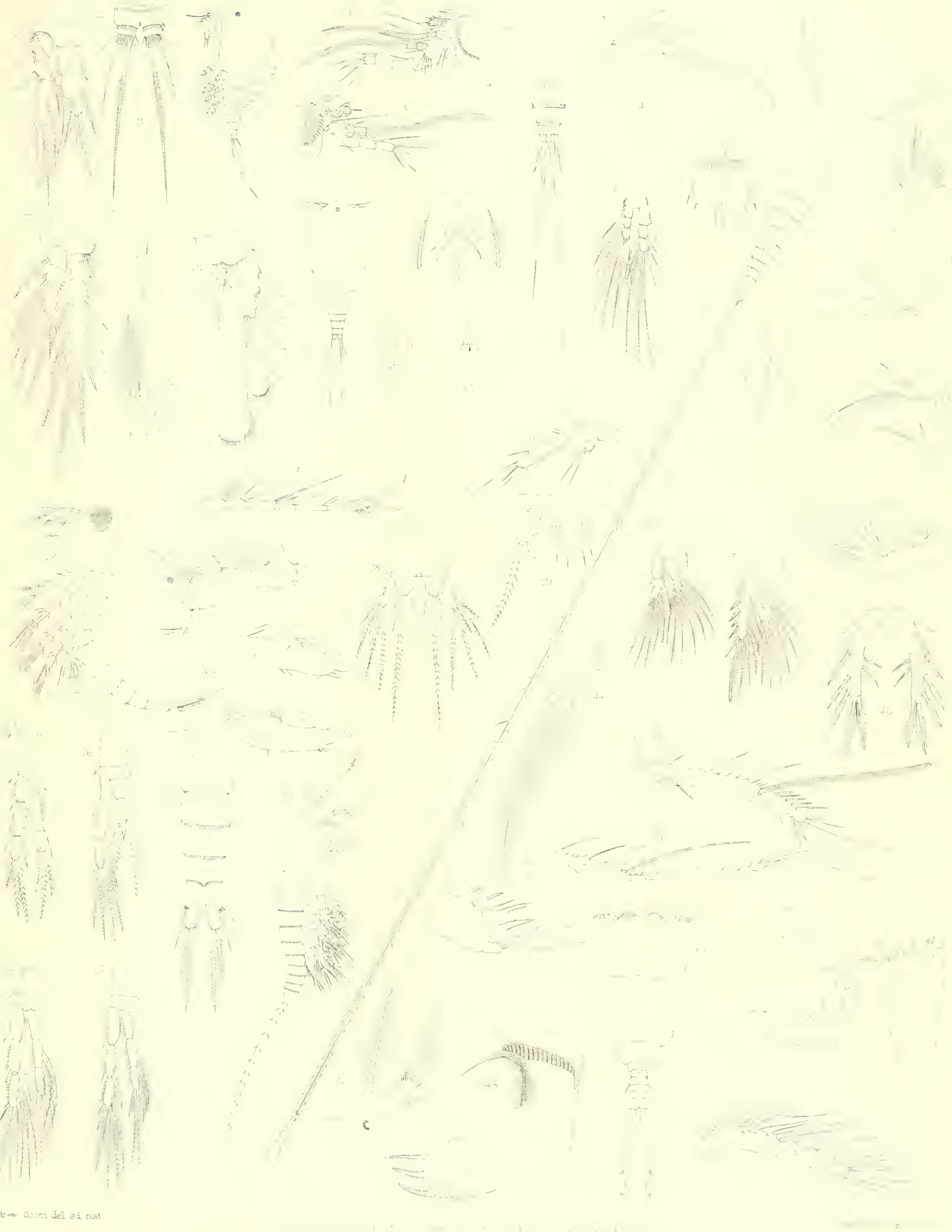

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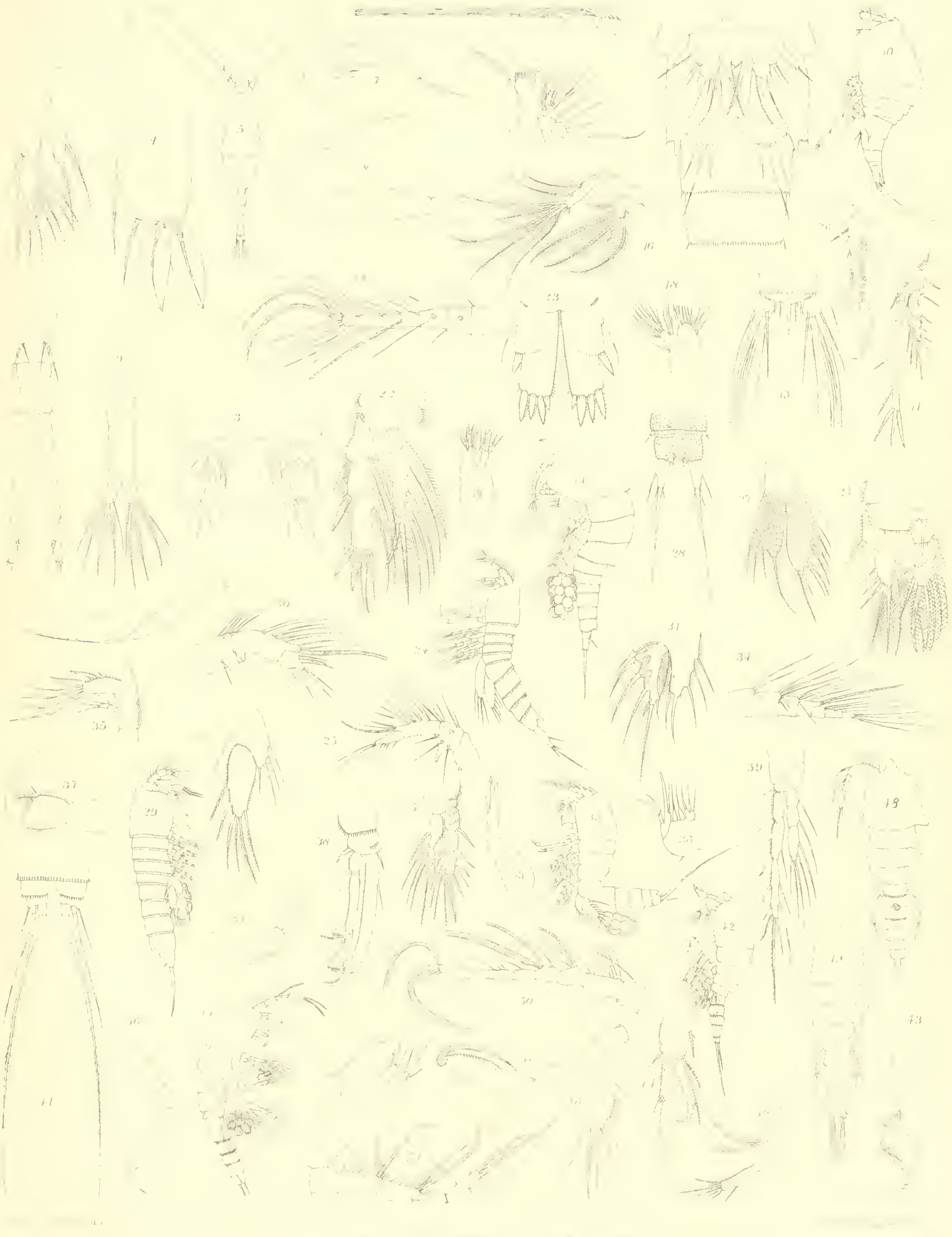

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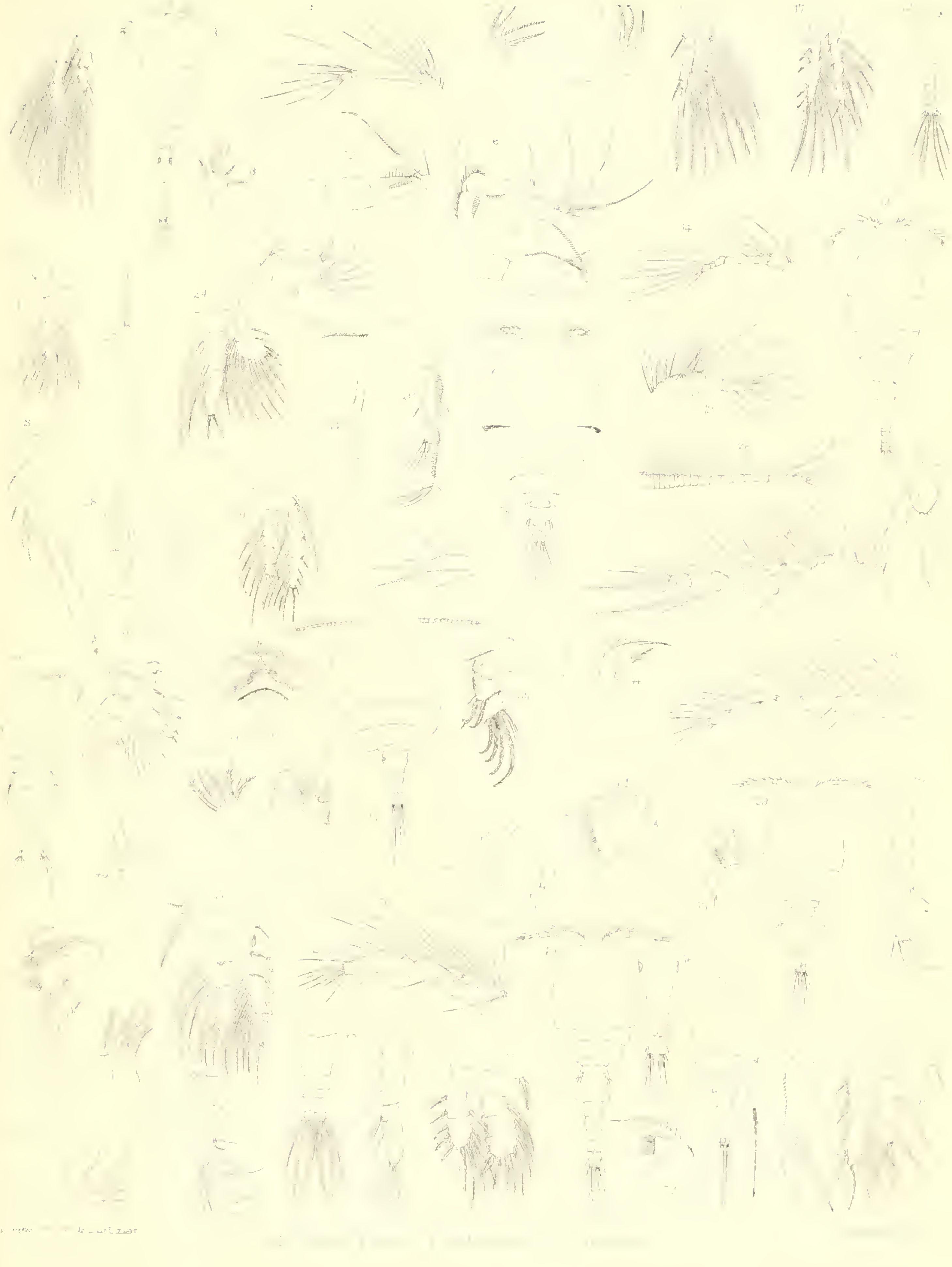

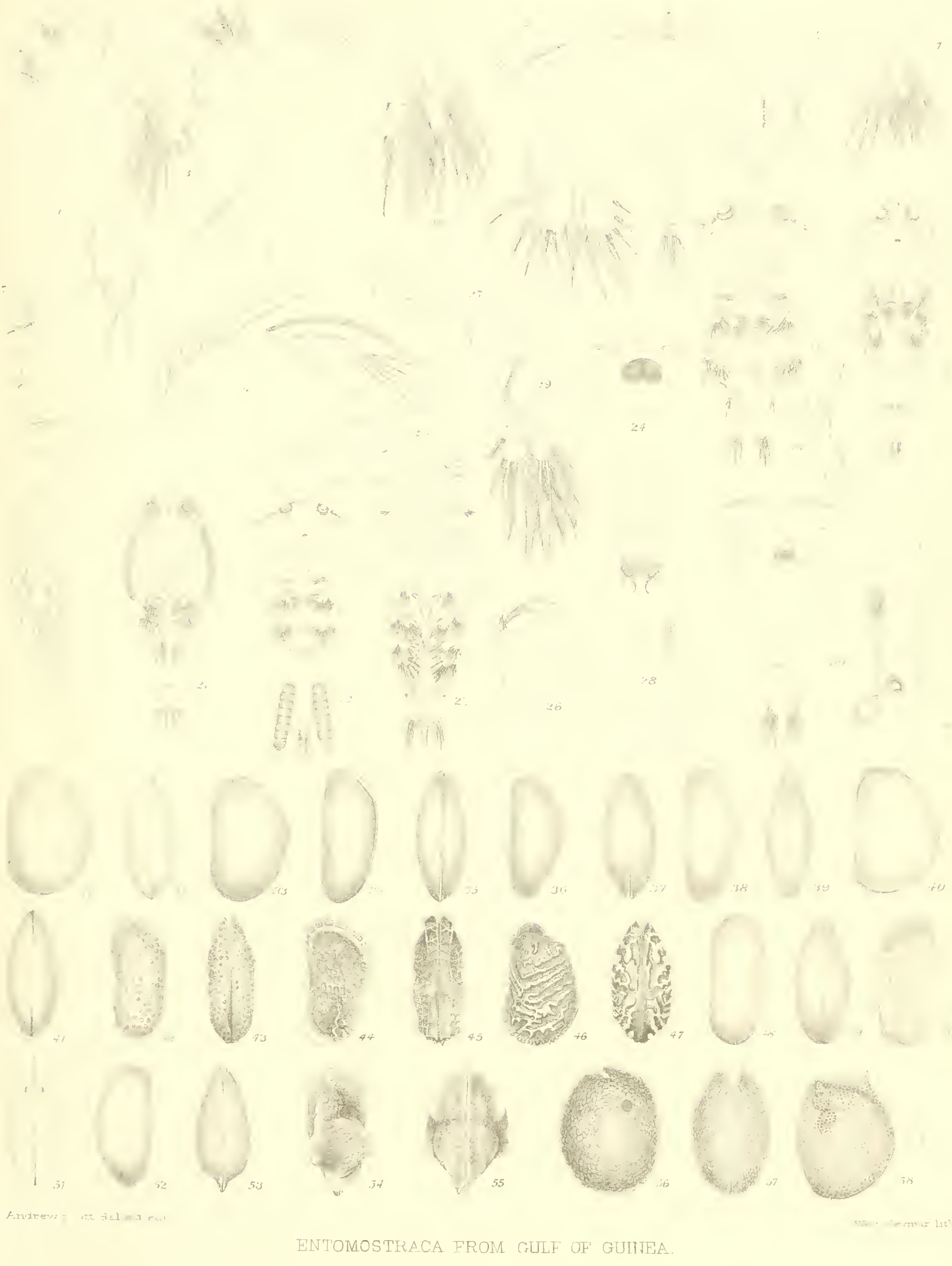

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THE TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON.

THE SUBTERRANEAN CRUSTACEA OF NEW ZEALAND: WITH SOME GENERAL REMARKS ON THE FAUNA OF CAVES AND WELLS.

BY

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II. *The Subterranean Crustacea of New Zealand: with some general Remarks on the Fauna of Caves and Wells.* *By* CHARLES CHILTON, *M.A., D.Sc., F.L.S., Rector, District High School, Port Chalmers, New Zealand.*

Read 20th April, 1893.

(Plates XVI.–XXIII.)

CONTENTS.

I. INTRODUCTION.

IN the following paper an attempt is made to give a fuller account than has yet been published of the Blind Crustacea found in the underground waters of the Canterbury Plains in the South Island of New Zealand. The existence of similar Crustacea in the caves and wells and in the deep waters of lakes in Europe and North America has long been known, and has attracted much attention, both because of the inherent interest of the subject, and because of the bearing that the facts have on some general questions of Biology connected with the Theory of Descent, particularly on the effects of use and disuse, and on the influence of the environment on the animals.

The existence of these animals in New Zealand was first recorded by me [22] about eleven years ago, but the original descriptions, though fairly accurate so far as they go, were very short and meagre, and the figures were rough and crude, and many points were left on which fuller and more complete information was much to be desired. Moreover, during the time that has elapsed since they were first discovered, much additional information has been gathered as to their occurrence and distribution, and no connected account of these has as yet been published. During the same time, too, some important works on the Blind Subterranean Crustacea of other parts of the world have appeared, particularly Packard's work on the Cave Fauna of North America [83], and Wrześniowski's very important memoir on "Three Subterranean Amphipoda" [124].

If we consider the peculiarities of the New-Zealand fauna and flora, and remember that New Zealand forms by itself a distinct zoological province, which has long been more or less perfectly isolated from other provinces, we should naturally expect that the Subterranean Crustacea of New Zealand would present us with some new interesting facts, and that they would differ largely from the similar Crustacea found elsewhere. This proves to be the case. The Subterranean Crustacean fauna is peculiarly rich, and much more varied than that of either Europe or North America; so far as at present known, it consists of six distinct species, three Amphipods and three Isopods, belonging to five different genera. Of these genera *Crangonyx* is already known from the subterranean waters of Europe and North America, but none of the others have been recorded from underground habitats elsewhere, though one, *Gammarus*, is more or less allied to the blind *Niphargus* of Europe, the species of which were indeed originally assigned to *Gammarus*, and are still so assigned by some writers. Two genera are new: one, *Cruregens*, belongs to a family, the *Anthuridæ*, no members of which were previously known to inhabit underground waters, and the other, *Phreatoicus*, which now contains three species (two from the subterranean waters of New Zealand, and one freshwater one from the top of the Mt. Kosciusko plateau in Australia), is so peculiar that it forms the type of a new and very remarkable family of the Isopoda.

In the following pages I give a full detailed description of the external anatomy of each of these six species, in addition to the brief specific diagnoses and, usually, a discussion on the characters of the genus. I have given what is known of their occurrence and distribution, of their habits, and of the peculiarities which they present in common with or in addition to other Subterranean Crustacea; their probable origin is discussed at some length. I have given also a short historical introduction showing the growth of our knowledge on the subject of Cave and Well Sessile-eyed Crustacea; and have concluded with some remarks on the bearing of the facts presented by them on the general questions of Biology.

For their kindness in providing me with material, I have to record my best thanks to Mr. R. M. Laing, of the Christchurch Boys' High School, Mr. E. Wilkinson, of the School of Agriculture, Lincoln, Messrs. J. B. Mayne and W. W. Smith of Ashburton, Mr. D. L. Inwood and Miss Young of Winchester. Mr. W. P. Hay of Irvington, Indiana, U.S.A., has kindly supplied me with specimens of some North-American Subterranean Crustacea. Mr. Smith, of Ashburton, has been particularly zealous and unwearying in his efforts to obtain specimens for me, and I am much indebted to him for additional knowledge on their distribution and on the general question of the underground waters of the plains. My friend and fellow-worker, Mr. G. M. Thomson, Science Master of the Dunedin High Schools, has assisted me in many ways by his advice and criticism, and by his kindness in supplying me with works from his library that I could not otherwise have obtained. To many writers I am indebted for copies of their various papers, particularly to Professor A. S. Packard and to Dr. R. Moniez, who have sent me copies of important works by them on the subterranean fauna of their respective countries; while, in common with all other workers on the Amphipoda, I am greatly indebted to the Rev. T. R. R. Stebbing for the very full and valuable Bibliographical Introduction to his Report on the 'Challenger' Amphipoda. Situated as I am at the Antipodes, far from the chief biological libraries of Europe and America, to which one would have liked to have recourse, I can perhaps appreciate the full value of this introduction better than those who are more favourably circumstanced in this respect.

II. Historical Sketch.

The following historical sketch of the growth of our knowledge of the Sessile-eyed Crustacea inhabiting caves and wells is in many respects very imperfect, for I am unable to consult many of the original papers and works quoted; it contains, however, I trust, references to most of the more important works on the subject. In its compilation I have derived much assistance from Alois Humbert's paper on *Niphargus puteanus*, var. *Forelii* [62], Professor Packard's paper on the "Cave Fauna of North America" [83], from Wrześniowski's work on "Three Subterranean Amphipoda" [121], and from the bibliographical introduction to Stebbing's "Report on the 'Challenger' Amphipoda" [108]. I have endeavoured to include the Subterranean Isopoda as well as the Amphipoda, but the parts bearing on them are, I fear, much more incomplete than those on the Amphipoda, as there is no general bibliography on the Isopoda at all comparable to that which Stebbing has compiled with so much care and labour for the Amphipoda.

Franz von Paula Schrank, in his account of *Gammarus pulex* [98, p. 535] says, "*Habitat in aquis, rivis, fontibus; albissimus dum natat.*" From the words "*in fontibus; albissimus dum natat*" Stebbing [108, p. 31] thinks it is fair to infer that Schrank had seen one of the well-shrimps. If this be so it would appear that we have in this work of Schrank (1781) the first mention of Subterranean Crustacea.

W. E. Leach [72]. The first undoubted reference to "well-shrimps" appears to have been made by Leach. In the article "Crustaceology" in the 'Edinburgh Encyclopædia,' published probably in 1813–1814, after *Gammarus pulex* a species is mentioned [72, p. 403] which is not numbered but "which Mr. Leach considers to be different from *pulex*." It came from a well in London. "It differs principally from *Gammarus pulex* in having the upper process of the tail much longer. The colour, when alive, was cinereous, but so translucent that the eyes could not be distinguished. It stands in Mr. Leach's cabinet under the specific name *subterraneus*." It is evident from this brief description that the animal in question is not a true *Gammarus*, but is a subterranean species, probably a *Niphargus*. Stebbing [108, p. 84] thinks it is probably identical with *Niphargus aquilex*, Schiödte, and it is assigned to this species also by Spence Bate and Westwood [4, p. 316]. Wrześniowski [124, p. 602] thinks that the description given is scarcely sufficient to enable us to decide whether the animal belongs to *Niphargus aquilex*, Schiödte, or *Crangonyx compactus*, Spence Bate; but in the latter species the terminal uropoda are not very long, and, as Leach specially mentions that they are long in his specimen, it appears more likely that it is a *Niphargus*.

I. C. Zenker. From a remark made by Zenker in connection with *Gammarus pulex*, Leydig infers [73, p. 245], and according to Wrześniowski [124, p. 602] with good reason, that Zenker had met with *Niphargus puteanus* in Thuringia.

Paul Gervais, in 1835, in a paper [46] describing the freshwater Gammarids of Paris, after giving the two species *Gammarus pulex*, Fabr., and *G. Roeselii* (= *G. fluviatilis*, Roesel), says: "There is also found in the environs of Paris, but only in the water from wells, a third kind of shrimp, remarkable for its small size, which does not in fact exceed 3 or 4 mm." He considers this simply a "variété de séjour," and draws attention to its slender appearance—"est constamment étiolée"—and to the fact that its eyes are without pigment and not apparent. He names it *Gammarus pulex minutus* [46, p. 127]. This name he afterwards altered to *Gammarus lacteus*, but without giving any further description of any value [47, p. 488].

C. L. Koch [69]. About the same time Koch described a species under the name *Gammarus puteanus* from wells at Ratisbon ("Regensburg"), giving the following diagnosis: "G. diaphano-albus, lateribus subochraceis, testis caudæ inermibus; articulo penultimo pedum 4 anteriorum quadrato." He does not describe it as blind, but says "Die Augen sind gelb" [69, *h.* 5, *n.* 2]. Wrześniowski gives the species under the provisional name *Niphargus ratisbonensis*? [124, p. 673]. Later on Koch describes a variety found "in den Brunnen der Stadt Zweibrücken," differing from the specimens from Ratisbon in colour and in the shape of the hands of the gnathopoda [69, *h.* 36, *n.* 22]. Koch's work was issued in parts, and it appears to be very difficult to determine the exact date at which each part appeared. See Stebbing [108, p. 158].

H. Milne-Edwards, in 1840, describes *Gammarus pungens* [77, iii. p. 47], from "les eaux thermales du Mont Cassini en Italie," as having "le petit appendice terminal des dernières fausses pates tout-à-fait rudimentaire, et le grand appendice très-poilu et à peine épineux." Spence Bate [5, p. 217, & 4, p. 314] and Stebbing [108, p. 253] consider this a *Niphargus*. At the same time Milne-Edwards also describes another species, *Gammarus Ermannii* [77, iii. p. 49], from warm springs of Kamtschatka; Spence Bate, who saw the specimen preserved in the Museum of the Jardin des Plantes, afterwards placed this species under the genus *Crangonyx* [5, p. 179].

Theodor G. Tellkampf, in 1844, in describing some new species of Arthropoda from the Mammoth Cave of Kentucky, gives, under the head of "*Crustacea, Malacostraca,*" the species *Triura cavernicola* [109, pp. 321, 322, pl. 18]. Schiödte and afterwards Boeck suggested that the species belonged to the Amphipoda, and Dana (Choristopoda, p. 306), in a note says:—"Genus *Triura*, Tellkampf, Rhoeæ forsan affinis." Stebbing [108, p. 208], after giving a portion of Tellkampf's description, gives also a copy of his figure, and says that it will suffice to show that the animal cannot belong to the Amphipoda. A. S. Packard, junr., had, moreover, already shown in 1871 that the animal is not a Crustacean at all, but belongs to the Thysanurous Neuroptera, and that it is probably the same as *Machilis variabilis*, Say: Tellkampf's erroneous reference of the animal to the Crustacea having been caused by his mistaking the labial and maxillary palpi for feet, and regarding the nine pairs of abdominal spines as feet [82, p. 14].

J. C. Schiödte, in 1847, briefly communicated to the Académie des Sciences de Copenhague the results of his researches on the fauna of the caves of Carniola and Istria, and gives a short diagnosis of *Gammarus stygius* [93, p. 81]. In a later work, published 1849–51, he minutely described the species, figured it, and formed for it the new genus *Niphargus* [94, pp. 26–28]. According to Humbert [62, p. 283] he did not notice the great resemblances between his species and *Gammarus puteanus*, Koch.

In the same paper, Schiödte also describes with great fulness, and figures, *Pherusa alba*, Koch, an isopod belonging to the Oniscidæ. As the name *Pherusa* was preoccupied, he renames the species *Titanethes albus*, placing it in "Ordo *Isopoda*—Familia *Onisci*—Tribus *Oniscini*." Owing to Koch's use of the name *Pherusa*, earlier employed among the Amphipoda, it appears that Schiödte's *Titanethes* has itself been spoken of as an Amphipod. With regard to this species, Spence Bate [4, ii. p. 440] gives the reference "'Herrich Schäffer, Contin. of Panzer,' fasc. 180, pl. 24," and this, together with the above quoted from Stebbing [108, p. 24], is all the information I can gather on this species.

Robert Caspary [19], in 1849, gave a full account with figures of *Gammarus puteanus*, Koch, from specimens found at Elberfeld. He was not able to discover eyes, although he examined more than 30 specimens. The small size of his specimens (4–6 mm.) and the absence of eggs from the brood-pouches of the females show, says Wrześniowski [124, p. 603], that he had to deal with very young specimens. He considers the mouth-parts, but, according to Wrześniowski [124, p. 603], gives an incorrect figure of the palp of the first maxillæ.

In his list [15] giving the synonymy of *Asellus sieboldii*, de Rougemont (= *A. cavaticus*, Schiödte), Bovallius gives a reference to this paper by Caspary, as follows :—"1849. . . . . Fuhlrott. (Caspary), in Verhandl. des naturh. Vereins der preuss. Rheinlande und Westfalens, Jahrg. 6, fig. ;" thus without mentioning any name as used by Caspary. I am unable to consult Caspary's paper, and therefore cannot say what information, if any, he gives on *Asellus cavaticus*. According to Packard [83, p. 146], Caspary gives a "figure, without name, of *Asellus cavaticus*, Leydig." The next entry in Bovallius's list of synonyms is under the date 1871 [15, p. 11].

A. Hosius [61], in 1850, sets forth very fully the characters which separate the three species, *Gammarus pulex* from running waters, *Gammarus fluviatilis* (= *G. Röselii*, Gervais) from still or weakly flowing waters, and *Gammarus puteanus* from wells. He compares the three species as regards the maxillæ, and gives two drawings of the maxillæ of *G. puteanus*, taken from Caspary, and retaining the erroneous figuring of the palp. The incorrectness was also pointed out by Spence Bate and Westwood [4, i. p. 311].

A. Costa [32], in 1851, gives, among others in his list of Amphipoda, *Gammarus longicaudatus* from the drinking-water of Naples, and *G. montanus* from the Lago del Maltese. Afterwards he admitted that the two were the same, and the first as "*Gammarus longicaudata*," A. Costa, appears alone in his Catalogue [see Stebbing, 108, p. 249]. Wrześniowski gives the species under *Niphargus* [124, p. 696–7]. Spence Bate and Westwood, without comment, give it as a synonym of *Niphargus aquilex*, Schiödte [4, i. p. 316].

J. O. Westwood [120], in April 1853, communicated to the Linnean Society the discovery of a well-shrimp in a well near Maidenhead, England. This was at the time referred to *Niphargus stygius*, Schiödte, but was afterwards separated under the name *Niphargus aquilex* by Schiödte [95, pp. 349–351]. Bate and Westwood point out that Schiödte has been misled into describing it with "dorso carinato" by examining dried specimens, but they retain his name *Niphargus aquilex* on other grounds [4, i. p. 317].

In an anonymous paper on some Crustacea [57], quoted by Stebbing thus :—"Anonymous (? Halliday)," Latin diagnoses of the genus *Niphargus* and the two species *N. stygius* and *N. aquilex* are given. The full account of the former is given in English as applying equally well to the latter, except for the differences mentioned in the diagnoses. As these amounted to little more than applying a smooth back to *N. stygius*, and by mistake a keeled one to *N. aquilex*, Spence Bate was, he says, misled by this to assume the identity of the two species.

Adam White [121] in his 'Popular History of British Crustacea,' in 1857, omits the *Gammarus subterraneus*, Leach, which he had previously suggested might be "*Gammarus pulex*, var. jun. ?." He changes *Niphargus stygius*, Westwood, into *Niphargus aquilex*, Schiödte, and asks whether this may not be the *Gammarus subterraneus* of Leach [see 108, p. 305].

A. DE LA VALETTE ST. GEORGE [112], in 1857, published a very minute account of the external and internal anatomy of the well-shrimps found at Cologne and Munich. He calls the species examined by him *Gammarus puteanus*, but they are referred by Bate and Westwood to *Niphargus aquilex*, Schiödte [4, i. p. 315]. His work is illustrated by fine figures, and among other points he draws attention to the sense-organs found on the antennæ, remarking, however, that the calceoli increase in size towards the end of the antennæ, which, as Stebbing points out [108, p. 301], is certainly not the case in all Amphipoda.

C. CHYZER, in 1858 [28, p. 4], announces Tóth's finding *Gammarus puteanus* and *G. fossarum*, Koch, "im Orczy-Garten zu Pest."

C. SPENCE BATE [6] in 1859, in a paper on the genus *Niphargus*, Schiödte, establishes two new species, *N. fontanus* and *N. Kochianus*, and also describes a new genus, *Crangonyx*, with the species *C. subterraneus*. Some discussion on the genus *Crangonyx* will be found further on (pp. 215–226).

R. M. BRUZELIUS [17], in 1859, established the new genus *Eriopis*, with the species *E. elongata*, "habitat in locis profundis maris Bohusiæ." The genus *Eriopis* is evidently very close to *Niphargus*, Schiödte, with which it was identified by Boeck. Stebbing also accepts this view; Wrześniowski, however, retains it as a separate genus, but alters the name to *Eriopsis*, as *Eriopis* was preoccupied [124, p. 634].

A. R. HOGAN [59 and 60], in 1859, published a paper on the habits, food-supply, and habitat of the species described by Spence Bate, viz., *Niphargus Kochianus*, *N. fontanus*, and *Crangonyx subterraneus*. In his notice of this paper Stebbing mentions that specimens of *Niphargus aquilex*, from a well near Tunbridge Wells, lived in his (Stebbing's) room from January 1886 till March 3rd, 1886, when they all died at about the same time, perhaps from the coldness of the night. Although they were very active in walking about the bottom of their jar, Stebbing never saw them attempt to swim. Another set of about a dozen were placed in a small jar on June 15th, 1886. Two were females with eggs; these died within a couple of days, surrounded by some rapidly developed parasitic growth; the others lived on for a considerable time, the last not dying until November 24th, 1886 [108, p. 316]. Wrześniowski [124, p. 604] refers to these observations on the habits of *Niphargus aquilex* in captivity as though they had been made by Hogan—a mistake natural enough, considering the way in which they are incorporated with the notice of Hogan's paper. Hogan published another paper on the same subject in 1861 [60].

JOHANNES LACHMANN [71], in 1859, describes parasites found in the intestine of the well-shrimp (*Gammarus puteanus*), the name being, however, misspelt "*Grammarus*" throughout the paper. The parasites are said to belong to the puzzling group of the Gregarines. (Quoted from Stebbing [108, p. 317].)

JOSEPH SCHÖBL [92] in 1860 published an elaborate monograph, illustrated by 10 plates, on "Typhloniscus—eine neue blinde Gattung der Crustacea Isopoda," in which he describes the new species *Typhloniscus Steinii*. This species, which belongs to the Oniscidæ, is not an inhabitant of wells or caves, but lives, like *Platyarthrus*, in ants' nests. It, however, resembles cave-species in the want of eyes, colour of the body, &c., and has been often mentioned as a blind Isopod along with *Titanethes albus*. This species was afterwards referred to *Platyarthrus Hoffmannseggii* by Budde-Lund [18, p. 199].

VICTOR SILL [100], in 1861, repeats Koch's description of *Gammarus puteanus*, but without adding anything new.

SPENCE BATE, in the 'Catalogue of the Amphipoda in the British Museum,' published in 1862 [5], gives the following subterranean species, all of which have been already referred to :—*Niphargus stygius*, Schiödte, with which he combines *N. aquilex*, Schiödte (though on further examination this was retained as a separate species); *N. fontanus*, Spence Bate; *N. Kochianus*, Spence Bate; *N. puteanus*, Koch; *Crangonyx subterraneus*, Spence Bate; and *C. Ermannii*=*Gammarus Ermannii*, Milne-Edwards. He leaves *Gammarus pungens*, Milne-Edwards, under the genus *Gammarus*, but adds as a footnote, "This species appears closely to resemble a *Niphargus*" [5, p. 217].

Bate and **Westwood** [4]. The parts of the 'History of the British Sessile-eyed Crustacea,' by these authors, which contained the account of the subterranean forms, appeared in 1862 [Stebbing, 108, p. 340], though the titlepage of volume i. bears the date 1863. A fuller account of the species already mentioned is given, there is a short account of some of the previous works on the subject and of the habits of some of the species, and *Niphargus aquilex*, Schiödte, is reinstated as a separate species distinct from *N. stygius*, Schiödte. Under *N. fontanus*, the authors say :—"Professor Westwood thinks that this species may be identical with the *N. stygius* of Schiödte, since both agree in the more robust form of the animal and the shape of the hands; there are, however, other important differences; as, for instance, the form of the second and third segments of the tail, which, together with the diversity of habitat, will probably prove to be of specific value" [4, i. p. 322]. Again, under *N. Kochianus* they say :—"We are inclined to think this species identical with the specimens captured at Bonn, described and figured by Caspary and Hosius, referred to in the synonyms under *N. aquilex*, but want of specimens from that locality prevents our determining this point" [4. i. p. 325].

In speaking of the three species *N. aquilex*, *N. fontanus*, and *N. Kochianus*, Alois Humbert very shrewdly remarks :—"A n'en juger que par les descriptions et par les figures intercalées dans le texte, ces trois espèces semblent être bien tranchées et faciles à distinguer, mais dans la pratique la détermination n'est pas facile" [62, p. 287].

De Rougemont has, indeed, united *N. fontanus* and *N. Kochianus*, as well as *Crangonyx subterraneus* with *Gammarus puteanus*, Koch; but, as will be seen from the remarks below, his identifications can hardly all be accepted. Stebbing says, in connection with this point that "the matter, perhaps, is not yet ripe for final determination" [108, p. 312].

It is strange that so little has been written on the Subterranean Crustacea of England: thus I know of no special work on them since the publication of the 'History of the British Sessile-eyed Crustacea;' this is the more peculiar when we remember that many points in connection with them were left uncertain (*Crangonyx subterraneus*, for instance, being described from a single specimen), and that they are widely distributed in England and Ireland, and probably abundant.

Camil Heller [58], in his list of the freshwater Amphipoda of South Europe, says that they all belong to the genus *Gammarus*, Fabric., of which he makes *Crangonyx* and *Niphargus* subgenera. He omits Costa's *G. longicaudatus*, and unites *Gammarus puteanus*, Caspary, *Niphargus stygius*, Schöidte, and *N. aquilex*, Schiödte, but, according to Wrześniowski, without giving good reasons for so doing [124, p. 604].

Among the freshwater Crustacea mentioned by Heller is *Crangonyx recurvus*, Grube, which had been found by Grube in 1861 in the Vrana lake in the Island of Cherso, on the Illyrian coast, and described under the name *Gammarus recurvus*, and was afterwards redescribed by him and placed under *Crangonyx*. I regret that I have been unable to get a description of this species, as it would have been interesting to see what relation it bears to the various Subterranean Crustacea of Europe.

Pratz [88], in 1867, described under the name *Gammarus Caspary* a new species from a well at Munich, and mentions several remarkable differences between the male and female. In view of the "caractères contradictoires" presented by this species, and the "polymorphisme" of the *Gammari* found in the same town by de Rougemont, Moniez thinks [78, p. 18] that it is very desirable that the *Gammari* of the wells at Munich should be re-studied.

W. Czerniavski [33], in 1868, described a new species of *Niphargus*, from the Black Sea, under the name *N. ponticus*. This species differs from the usual species of *Niphargus* in the presence of well-developed eyes, in the colour, the gnathopoda, &c.; and from the small size (2·1 millim.), and the small number of joints in the flagella of the antennæ, it is probable that the single specimen obtained was, as Wrześniowski points out [124, p. 605], a young specimen, and further information regarding the species is desirable.

F. Plateau [86], in his researches on the freshwater Amphipoda of Belgium, makes special mention of the well-shrimps which he had taken at Ghent, and which had also been collected by Professor Bellynck at Namur. He calls his specimens *Gammarus puteanus*, Koch, and states that they have triangular, pigmentless eyes. Plateau appears to have been acquainted only with Koch's work on *Niphargus*, and ignores the works of later writers.

Gustav Joseph [65], in 1868, recorded the finding of a new species of *Niphargus, N. orcinus*, in the brooks of the hill-grottoes of Carniola, "which probably from these reaches the lake of Zirlenitz [Zirknitz], where it can be freely gathered. It comes to the surface after sunset in calm weather."—See Stebbing [108, p. 384]. The full description of this species was not given till 1882.

F. A. Forel [38], in 1869, indicated for the first time the existence of blind Gammarids from the deep waters of the Lake of Geneva. Afterwards, in 1873, similar animals were found in the Lake of Neuchâtel.

Boeck [14], in his work published in 1870, gives the genus *Niphargus*, Schiödte, for the single marine species *Eriopis elongatus*, Bruzelius.

Paul Godet [48, p. 153], in 1871, described three specimens of a *Gammarus* found in a well at Neuchâtel, pointing out the characters by which they differ from *Gammarus fluviatilis*, and comparing them with *G. puteanus*, Koch, and *G. puteanus*, La Valette. Stebbing says that, judging by the figure, it cannot be far removed from *Niphargus aquilex*, Schiödte [108, p. 1630].

A notice of Godet's observations on these well-shrimps had been previously communicated to the Société des Sciences naturelles de Neuchâtel, by P. Coulon, in 1867. See Wrześniowski [124, p. 605].

S. I. Smith [102], in 1871, among other Crustacea dredged from Lake Superior, in North America, describes *Crangonyx gracilis*, Smith, n. s., and says that it much resembles *C. recurvatus* [*recurvus*], Grube, "in the form of the antennulæ, antennæ, gnathopoda, &c., while it differs much in the ultimate pleopoda and in the form of the telson." It is important to note the occurrence of this species, though not blind, in connection with the question of the distribution and origin of the subterranean forms.

A. S. Packard, Jun. [81], 1871, in describing the Crustaceans and Insects of the Mammoth Cave, describes an Isopod as a new genus and species under the name *Cæcidotea stygia*. This species was described from imperfect specimens, and its structure and affinities were consequently completely misunderstood. In point of fact it has nothing whatever to do with *Idotea*, but comes very close to *Asellus*, with which it is indeed united by Forbes [41, p. 11]. It will be further noticed in the account of Packard's larger work on the 'Cave Fauna of North America' [83].

E. D. Cope [30, pp. 6 and 14], in 1872, found in a cave adjoining the Wyandotte Cave an Isopod which he refers to the genus *Cæcidotea*, previously established by Packard, but describes it as a new species, *C. microcephala*. He gives a description and figure of the species, but owing to imperfect specimens his account is even more unsuccessful than Packard's: thus he describes and figures the uropoda as "egg-pouches full of eggs." This is the species which had been referred to by Cope in a previous paper as an "unknown Crustacean with external egg-pouches" [29]. Packard has since united it with his *Cæcidotea stygia* [83, p. 29].

In the same paper [30, pp. 8 and 17] Cope also describes a blind Amphipod under the name *Stygobromus vitreus*, nov. gen. et sp. He says that his genus is nearer to the true *Gammarus* than to *Niphargus*, Schiödte; but his description is very unsatisfactory, and gives no assistance in the attempt to ascertain the true position of the animal. S. I. Smith afterwards referred this species to *Crangonyx* under the name *C. vitreus*, Cope, and it appears under this name in Packard's larger work [83, p. 34].

Although described in Cope's paper "On the Wyandotte Cave and its Fauna," this species is not from that cave, but from the Mammoth Cave, and had been referred to as a "Gammaroid Crustacean" in an earlier paper by Cope [29].

F. Leydig [74, p. 269] had, in 1871, recorded the existence of *Asellus cavaticus* in the Falkenstein Cave. This species is usually referred to as *Asellus cavaticus*, Schiödte, and consequently was, I presume, first mentioned under that name by Schiödte; but, unfortunately, the works at my disposal do not enable me to say where Schiödte mentions it, or what information, if any, he gives about it. Bovallius, in his "Notes on the Family Asellidæ," in his list of synonyms of the species, gives no reference to any paper on the subject by Schiödte, and says, "As Schiödte never has given a diagnosis of *A. cavaticus*, and none of the following authors, using that name, did describe the animal, the name *A. cavaticus* must be rejected, and substituted by *A. Sieboldii*, Ph. de Rougemont" [15, p. 11].

A. Frič [42, p. 246, fig. 95], in 1872, recorded the existence of *Gammarus puteanus* in wells at Prague, Bohemia; but, according to Wrzesniowski [124, p. 605], his observations on the subject are of little value, the third uropods, for example, being represented as seven-jointed!

R. Wiedersheim [122] found in 1873, in a small lake in the Falkenstein Cave, about 600 ft. from the mouth, an eyeless Gammarid which he does not describe, but believes to be the same as *Gammarus puteanus* from wells at Tübingen.

Apparently also in the same paper he gives an account of the habits of *Asellus cavaticus*. See Packard [83, p. 149].

S. Fries [43], in 1874, also studied the fauna of the same cave, but found only one example of a blind Gammarid. He thinks this to be the descendant of the eyed *Gammarus pulex* living in the neighbourhood outside the cave, and strengthens his opinion by observations on *Gammarus fossarum* kept during the winter in the dark, which lost pigment and whose eyes paled; but, as Humbert points out, Fries does not appear to have been acquainted with the genus *Niphargus* and the characters by which it is distinguished from the true *Gammarus*. See Humbert [62, p. 289]. Fries also appears to have referred in his paper to *Asellus cavaticus*, Schiödte.

F. A. Forel, in a series of works on the deep-water fauna of the Lake of Geneva, repeatedly mentions an interesting crustacean under the name *Gammarus cæcus*. This, I presume, is the species afterwards fully described by Humbert under the name *Niphargus puteanus*, var. *Forelii* [62].

Eugène Simon [101], in 1875, enumerates and shortly describes several species of Crustacea living in caves, among them "*Niphargus subterraneus* (Leach)=*puteanus* (C. Koch), *aquilex*, and *stygius*, (Schiödte), Carniola, also in wells." (Dr. von Martens, 'Zoological Record' for 1875.)

Ph. de Rougemont [89], in 1875, published an exhaustive paper on *Gammarus puteanus*, Koch. He had found five different forms in a well at Munich and a sixth form at Neuchâtel, the last having been previously described by Godet. He fully describes the various sense-organs, recognizes the olfactory cylinders on the flagellum of the upper antennæ as organs of smell, and explains the fact that they are longer in the blind *Gammarus puteanus* and *Asellus* from wells than in *Gammarus pulex* and *Asellus aquaticus* as a natural compensation made to the former for their want of sight.

De Rougemont was astonished to find five different forms so nearly allied living together in a single well, and at not finding any small forms similar to the larger kinds; consequently he came to the conclusion that all these five kinds as well as the large one from Neuchâtel are simply different stages in the life-history of the one species, and he states that he has seen individuals pass at the moulting of the exoskeleton from the first form (*Crangonyx subterraneus*) to the second (*Niphargus Kochianus*), and that he has seen the transformation also from the fourth form into the fifth. He concludes therefore that the genera *Crangonyx* and *Niphargus* ought not to be separated, since they represent different states of the same species, and further he proposes to suppress the genus *Niphargus,* as he considers it only a modification of *Gammarus pulex.* To the single species *Gammarus puteanus,* Koch, he therefore refers all the following forms :—I. Form : *Gammarus minutus,* Gervais ; *Crangonyx subterraneus,* Spence Bate. II. Form : *Niphargus Kochianus,* Spence Bate. III. Form : *Gammarus puteanus,* Caspary : *Gammarus puteanus,* Hosius ; *Niphargus fontanus,* Spence Bate. IV. Form : *Gammarus puteanus,* Koch. V. Form : *Niphargus stygius,* Schiödte ; *Gammarus puteanus,* Koch, La Valette St. George, and Plateau. VI. Form : a colossal specimen, 33 millim. long, from Neuchâtel.

These conclusions arrived at by de Rougemont have been very fully criticized by Aloïs Humbert [62, pp. 294–296], Wrześniowski [124, pp. 687–694], and others, who have shown that, in addition to the inherent improbability of some of de Rougemont's assertions, there are so many inaccuracies, inconsistencies, and contradictions in his own work and such neglect to notice points of special importance, as, for example, the difference between the undivided telson of *Crangonyx* and the deeply-cleft telson of *Niphargus,* that de Rougemont's views cannot be seriously accepted. It is therefore unnecessary to discuss the subject further, and I need only say that I feel quite convinced of the justice and truth of the remarks made on the matter by Humbert and Wrześniowski. It is of course quite possible that some of the various subterranean species described under *Niphargus* (*Gammarus*) are not entitled to full specific rank, but should rather be looked upon as local varieties, which, indeed, we might naturally expect to arise owing to isolation ; but certainly we cannot admit that all the forms mentioned by de Rougemont are modifications *due to age,* and if *Crangonyx subterraneus,* Spence Bate, can change at a single moult into *Niphargus Kochianus,* Spence Bate, it will be useless to attempt to classify Amphipoda into genera and species at all. The existence of five different forms in the single well at Munich, if this really was the case, is not so strange or so unprecedented as de Rougemont seems to have thought it, for the space in which they live is of course not merely the well itself, but the subterranean waters connected therewith, which may be very extended ; and Spence Bate had previously recorded the three species *Niphargus fontanus, N. Kochianus,* and *Crangonyx subterraneus* from the same well at Ringwood, England, while Wrześniowski has since recorded the two species *Niphargus tatrensis* and *Boruta tenebrarum* living together in one well ; and I have taken from a single well at Eyreton the three Amphipods *Calliopius subterraneus, Gammarus fragilis,* and *Crangonyx compactus,* as well as the two Isopods *Cruregens fontanus* and *Phreatoicus typicus.*

A year later, in 1876, de Rougemont published a French translation of his paper on *Gammarus puteanus* under the title "Étude de la Faune des eaux privées de la lumière," and this contained in addition a description of the Isopod *Asellus Sieboldii,* which Bovallius identified with the *A. cavaticus,* Schiödte, of earlier writers, though he retains de Rougemont's name, as he was the first to describe the species [15, p. 11].

S. I. Smith, 1874, in a work on the Crustacea of the fresh waters of the United States [103], describes both sexes of *Crangonyx gracilis,* Smith, an eyed species that has been already mentioned. He also mentions *Crangonyx vitreus,* Packard, giving under protest *Stygobromus vitreus,* Cope, as a synonym ; Packard, however, in his last work keeps the two separate [83, p. 34].

Smith also describes *Crangonyx tenuis,* n. s., "a slender, elongated species with very low epimera, resembling more in form the species of *Niphargus* than the typical species of *Crangonyx.*"

In 1875, S. I. Smith [104], in a paper on the Crustaceans of the Caves of Kentucky and Indiana, states that *Crangonyx* (*Stygobromus*) *vitreus,* Cope, is very different from *Crangonyx vitreus,* Packard, of which he had previously, as above stated, given it as a synonym under protest. The latter species is, he says, closely allied to *C. gracilis,* Smith, from Michigan, Lake Superior, &c., differing principally in the structure of the eyes. In his account of this paper, Stebbing adds, "Since Packard's species in any case must yield its specific name, one is led by Professor Smith's account to regard it as a synonym of *Crangonyx gracilis*" [108, p. 451]. Packard afterwards refers to the species as *C. Packardii,* Smith ; but I am unable to find when this name was assigned to it.

S. A. Forbes [41], in 1876, describes an Amphipod found in a well at Normal, Illinois, under the name *Crangonyx mucronatus*. This species is, he says, perhaps entitled to rank as the type of a new genus, but for want of material for a more general study of its relations it is left with its nearest allies in the genus *Crangonyx*. The differences between the sexes are given, the most remarkable being in connection with the telson, which is very largely developed in the male. (See below, pp. 218–219.)

Aloïs Humbert [62] published his description of *Niphargus puteanus*, var. *Forelii*, in 1876. Besides a very careful and minute description of this variety, and of another named *onesiensis*, this work contains much important information on the general subject of blind subterranean Crustacea. After some introductory remarks he gives an historical sketch of previous works on the subject, in the course of which he fully criticizes de Rougemont's views as already stated, and pointed out that his own observations do not at all correspond with those of de Rougemont: thus among the specimens handed to him by Professor Forel were some very small, only 2 millim. long, which should therefore correspond with de Rougemont's first form, and belong to *Crangonyx subterraneus*, Spence Bate; but these, Humbert says, already had the characters well marked, the two gnathopods already having the form of the adult and the telson being deeply cleft. Humbert then considers the characters of the genus *Niphargus*, and gives a new definition of it. He discusses the place in the genus of his own varieties, and compares them with the species previously described by other authors. He distinguishes two varieties, *Niphargus puteanus* var. *Forelii*, from the deep waters of the Lake of Geneva, and *N. puteanus* var. *onesiensis*, from a well at Onex near Geneva, and gives at length the minute differences between the two. In considering the origin of the *Niphargus* found in the Lake of Geneva, he gives good reasons for believing that it is not merely a modification of *Gammarus pulex*, and concludes that it is probably descended from an ancient genus now extinct; he is inclined to think the *Niphargi* of the lakes come from those in the subterranean waters. This point was afterwards fully considered by Professor Forel, who finally came to the same conclusion as Humbert, though he had previously thought otherwise [40, pp. 170–183].

In the detailed description of *Niphargus puteanus*, var. *Forelii*, that follows, Humbert pays special attention to the various organs of sense. On the head and on the first segments of the pereion, on the dorsal portion, are found "capsules sensitives," and on the upper antennæ "cylindres olfactifs," "bâtonnets hyalins," "soies auditives," and also "capsules sensitives" like those on the head, &c. The females are said to be distinguished from the males by their smaller size, the brood-plates, and the shorter length of the terminal uropoda.

P. Godet [49], in 1878, was induced by Humbert's criticism of de Rougemont's work to rectify his measurements of the large specimen from Neuchâtel, as his measurements previously given had not corresponded with those given by de Rougemont. In connection herewith de Rougemont stated that he still held to his opinions previously published.

J. D. Catta [20], in 1878, described a new species of Amphipod, *Gammarus rhipidiophorus*, found only in a well at La Ciotat (Bouches-du-Rhône, France), a hundred yards or so from the Mediterranean; the water in the well becomes brackish in summer. He considers that the genus *Niphargus* should be given up, as the various differences between them are more or less bridged over by different species. In connection with this question, however, Wrześniowski points out [124, p. 607] that Catta says nothing about the mouth-parts, in which are found some of the most prominent marks of distinction; and Stebbing also says:—"The discovery of transition-forms between two genera will always cause some difficulty, but as such forms have probably existed in innumerable cases where they have not been discovered, it is a question how far the discovery of them should be allowed to interfere with well-established distinctions either of genera or species. When *Niphargus aquilex* and *Gammarus pulex* are side by side, it is rather the difference of the *facies* than the likeness which attracts attention" [108, p. 475]. It may here be added, the differences originally laid down between *Niphargus* and *Crangonyx* have to some extent been bridged over in the same way by species subsequently described, but that still the differences between *Gammarus, Niphargus,* and *Crangonyx* are much greater than those between many other genera of the Amphipoda. The main interest in the discussion is its bearing on the question—Have all the species classed under, say, *Niphargus,* arisen from the parent genus, whatever it may be, by one common origin, or have some of them arisen independently in different localities in which they have been isolated ?

Franz Leydig [73], 1878, in his remarks on the anatomy &c. of Amphipoda and Isopoda makes a good many references to the subterranean forms. With regard to the plumose bristles called "capsules sensitives" by Humbert, he says that they may be sensitive, but they are not capsules, they are modified pores. "In view of the very varying statements of authors on the eye of *Gammarus puteanus,* he made investigations from which he determines that the optic ganglion is present, but not the eye, though pigment-spots mimicking the eye have led some observers to believe that an eye existed in fact" (quoted from Stebbing [108, p. 481]). In connection with this point I may add that I have occasionally observed similar pigment-spots in the New-Zealand species, in none of which can I find any external trace of eyes except in *Crangonyx compactus,* which has two or three imperfect lenses ; some of the cave-inhabiting species of *Crangonyx* from North America also have imperfect external eyes. It seems probable that there may be great differences in the amount of degeneration of the eyes in different species, and perhaps also in individuals of the same species from different localities.

In remarking on the distribution of and distinctions between *Gammarus pulex,* de Geer, *Gammarus fluviatilis,* Rösel, and *Gammarus* (*Niphargus*) *puteanus,* Koch, Leydig adopts the view of de Rougemont, that *Gammarus pulex minutus,* Gervais, is identical with Koch's *G. puteanus,* which may, of course, be correct enough, while de Rougemont's other observations are unreliable.

F. A. Forel [39], in 1878, in an account of the fauna of the Swiss Lakes, mentions *Gammarus puteanus,* var. *Forelii,* Humbert, as being found in "die *tiefe* Region" in the Lake of Geneva.

Gustav Joseph [66], in 1879, discovered *Niphargus puteanus* at Venice, and states that their introduction into these carefully-covered wells is best explained by the transport of water from the mainland to replenish these wells in the dry season.

S. Fries [43], in 1879, discusses the occurrence of Well Shrimps in the slightly brackish wells of Heligoland, &c., and advocates the view that they must have existed in these localities before the islands were separated from the mainland. He examined specimens from these wells of Heligoland, from the Falkenstein Caves, from the springs running out of the caverns, from the Hilgerhäusen Caves, and from the depths of the Lake of Geneva, and finds no greater differences than would justify the naming of varieties. He therefore follows de Rougemont in uniting them all under the name *Gammarus puteanus.* From this it appears probable that at any rate some of the described species of *Niphargus* are to be looked upon merely as local varieties of one and the same species ; but this in no way justifies de Rougemont's inclusion of *Crangonyx subterraneus,* Spence Bate, with the others, and does not support his statement as to the elaborate series of metamorphoses passed through by the specimens examined by him.

In the same paper Fries also discusses the blind Isopod, *Asellus cavaticus,* Schiödte. He had uniformly found this in company with *Gammarus puteanus,* which, according to de Rougemont, is its mortal foe. He agrees with de Rougemont that *Asellus cavaticus* is related to *A. aquaticus,* very much as *Gammarus puteanus* is to *G. pulex.* Judging, however, from the scanty descriptions of *Asellus cavaticus* that I have been able to consult, the connection between the first two appears much closer than that between the last two.

Fries's remarks lead de Rougemont to repeat that he is still of the same opinion [90].

Professor Giebel [50], in 1879, mentions the finding of *Niphargus puteanus* in Halle-a.-S.

Oscar Grimm [51], in 1880, described a new species of *Niphargus*—*N. caspius*—found in the Caspian

Sea at a depth of 35 to 90 fathoms. The species may, he says, be identical with *N. ponticus*, Czerniavski, but he is not able rightly to determine this species, as Czerniavski's description appears to be very defective. He points out that "*N. caspius* differs in many respects from the other species of *Niphargus*, and, indeed, from *N. puteanus*, as in its shorter antennæ, the differently formed hand of the last pair of limbs, &c.: so that our species may perhaps be regarded as the representative of a new genus between *Niphargus* and *Gammarus*." He also remarks that *N. caspius* is very probably the "extinct Gammarid" from which the other species of *Niphargus* have arisen.

Professor Asper [1], in 1880, met in some of the Swiss Lakes a Gammarid which strikingly reminded him of the common *Gammarus pulex*. "The lake-form, however, was smaller and of a glassy transparency. Specimens from depths of 110 and of 60 metres possessed beautiful organs of vision, with clearly observed crystal-cones. At Wädensweil, at a depth of 40 metres, along with seeing forms, were found blind specimens agreeing in the smallest detail with '*Niphargus Forelii*' from the Lake of Geneva. Specimens from Oberrieden Dr. Aspen regards as intermediate forms between *Gammarus pulex* and the '*Forelii*' variety of *Niphargus*." (See Stebbing [108, p. 508].) Forel, however, though admitting that these are modified so far as the colour and the eyes are concerned, states that they are not "des *Niphargus* avec des yeux, des *Niphargus* incomplètement modifiés," that the hands of the gnathopods and the third uropods are not modified, so that "ils ont le type *Gammarus* et non le type *Niphargus*" [40, p. 180].

C. Parona [85], in 1880, discovered blind "Shrimps" in the cave of Monte Fenere, Val Sesia, Piedmont. He considers his form to come very close to *Niphargus puteanus*, var. *Forelii*, Humbert. He gives a general history of the species, strongly supporting de Rougemont's views. One female specimen with short terminal uropoda specially attracted his attention as showing relation to *Crangonyx*. Moniez has, however, shown that the specimen in question was mutilated, having lost the third uropods, as frequently happens with *Niphargus* [78, p. 43]. In this paper Parona also describes a new species of *Titanethes*, viz. *T. feneriensis*.

Max Weber, in 1879, published a paper "Ueber *Asellus cavaticus*, Schiödte" [116].

H. Blanc [11], in 1880, described a new species of the same genus, *Asellus Forelii*, from the deep waters of the Lake of Geneva, pointing out the differences between it and *A. cavaticus*, Schiödte, to which it appears to be closely related.

Both of these species appear to have been referred to by Max Weber [117] in a paper published in 1881, but I am unable to say what information he gives on the subject.

Max Weber [118], (apparently in 1880), "examined histologically and chemically, and described, the so-called liver of terrestrial, freshwater, subterraneous, littoral, and truly marine species of different orders" of Crustacea. The blind and subterranean forms examined were *Typhloniscus Steinii*, *Asellus cavaticus*, and *Gammarus puteanus*. (See Stebbing [108, p. 525].)

According to Ludwig [75], 1881, *Gammarus puteanus* has been found "in einen Brunnen zu Greiz."

Packard and Cope [31], in 1881, investigated the fauna of the Nickajack Cave in Tennessee. They describe a new species of the genus *Cæcidotea*, viz. *C. nickajackensis*, Packard, in which the body is longer, narrower, and slenderer than in *C. stygia*, Packard, from the Mammoth and Wyandotte Caves. The authors add:—"This species forms, in the antennæ and slightly purplish colour and the proportions of the leg-joints, perhaps a nearer approach to the genus *Asellus* than that of the Mammoth and Wyandotte Caves; on the other hand, *C. stygia* approaches *Asellus* more in its shorter, broader body, with its shorter, broader abdomen. It seems quite evident that the two species must have descended from different species of *Asellus*. Thus far we know of but one species of *Asellus*, *A. communis* of Say, from the Middle and Northern States; whether there is an additional species in the Gulf States, from which the present species may have been derived, remains to be seen.

"The genus *Cecidotæa* differs from *Asellus* in the larger and much longer head, the longer claw of the first pair of feet, the much longer telson, and in the rami of the caudal appendages being of nearly equal size, while in *Asellus* one is minute; it is also eyeless. The *Asellus Forelii* of the Swiss Lakes belongs to *Cecidotæa*" [31, p. 880]. The statement that one of the rami of the caudal appendages of *Asellus* is minute is, of course, erroneous, and must have been based on some misunderstanding or erroneous observation. This statement is repeated on p. 19 (evidently copied from above) in Packard's larger paper, but is omitted in the fuller account on p. 29, where the differences between *Cæcidotea* and *Asellus* are given in considerably different terms, and it is stated the *Asellus Forelii*, Blanc, does not belong to *Cæcidotea* [83, p. 30]. Forbes united *Cæcidotea* with *Asellus*, as a detailed comparison of *C. stygia* "with undoubted *Asellus*, especially with the admirable plates of *A. aquaticus* in the 'Crustacés d'eau douce de Norvège,' has failed to reveal any structural peculiarities which could positively serve as the characters of a distinct genus" [41, p. 11]. In 1886, however, Packard still retained the genus *Cæcidotea* on "taxonomic grounds" [83, p. 30].

In the paper now under consideration, Packard and Cope write the name of the genus throughout as *Cecidotæa*, though in establishing the genus Packard had originally spelt it *Cæcidotea*; in his larger work again he spells it *Cæcidotæa*. Bovallius writes it *Cæcidothea* [15, p. 13]. Whether these varied spellings are intentional or accidental it would no doubt be better to adhere to the original spelling, as suggested by Stebbing [108, p. xx].

In the same paper [31, p. 880] a new species, *Crangonyx antennatus*, Packard, is described and figured. This species is said to be very different from *C. vitreus*, Cope, and from *C. Packardii*, Smith, but to present various resemblances to *C. gracilis*, Smith, from Lake Superior.

Chas. Chilton [22], in 1881, recorded the occurrence of subterranean Crustacea at Eyreton, North Canterbury, New Zealand. He briefly described and figured three Amphipods, *Calliopius subterraneus*, *Gammarus fragilis*, and *Crangonyx compactus*, and one Isopod, *Cruregens fontanus*, all the species being new. The genus *Cruregens* is also new, though apparently somewhat nearly allied to *Paranthura*. A short notice of this paper by Aloïs Humbert, appeared in the Arch. Sci. Nat. viii. (Sept. 1882) p. 265. A year later Chilton [23] gave a few additional facts on the occurrence and distribution of these species and also described another Isopod, *Phreatoicus typicus*, nov. gen. et sp., obtained from the same well at Eyreton. These Crustacea have since been obtained at various localities in the Canterbury Plains, and are fully discussed in the paper below, in which an additional species, *Phreatoicus assimilis*, sp. nov., is described from Winchester. Another species of the same genus, *Phreatoicus australis*, was obtained in 1889 in freshwater streams near the top of Mt. Kosciusko in Australia, and has been fully described by Chilton [26]. It of course possesses eyes, while the subterranean species are blind.

O. P. Hay [56], in 1882, described a new species of *Crangonyx*, *C. lucifugus*, from a well in Abingdon, Knox county, Illinois. It appears to resemble *C. tenuis*, Smith, but in the third uropod the two rami are both absent, and the peduncle itself is much reduced. He also describes *Crangonyx bifurcus*, sp. nov., found in a rivulet at Macon, Mississippi. He says: "The three species, *C. gracilis*, *C. bifurcus*, and *C. lucifugus*, present an interesting gradation in the form of the posterior caudal stylets." Attention has been directed to this point further on (see p. 218).

Professor Vejdovsky [113], in his work on the fauna of the wells of Prague, mentions *Niphargus puteanus*, but does not closely describe it. The species seems to be widely spread at Prague. Vejdovsky shares de Rougement's opinion as to the identity of the various species of Well-Shrimps.

Gustav Joseph [67], in 1882, gives very minutely his observations on the cave-fauna of Carniola, and describes a species, *Niphargus orcinus*, previously named by him. He mentions the following species as found in Carniola:—*Niphargus stygius*, Schiödte; *N. puteanus*, de la Valette St. George; *N. puteanus*, var. *Forelii*, A. Humbert; and *N. orcinus*, sp. nov.

Two species of *Titanethes* and one of *Typhloniscus* also appear to have been described by Joseph in this paper. They are *Titanethes fracticornis*, Joseph, *T. brevicornis*, Joseph, from Carniola, and *Typhloniscus stygius*, Joseph, from Italy. They are mentioned by Packard in his list of the cave-animals of Europe [83, p. 86].

F. A. Forel [40, p. 134] could not find *Niphargus* in the Savoy lakes, in Lake Bourget, and Lake Annecy, but *Niphargus puteanus*, Koch, was found in a well at Annecy.

O. E. Imhof [64] also was unable to find *Niphargus* in these lakes, though in Lake Bourget *Asellus Forelii*, Blanc, was found.

According to Eugène Daday [34] *Niphargus stygius* is found in Transylvania, at Kis-Nyires and Ugra.

Ed. van Beneden [10] also records the occurrence of *Niphargus puteanus* at Liége.

F. A. Forel [40], in 1885, published his very exhaustive and comprehensive work on "La Faune profonde des Lacs suisses," in which many references are made to the blind *Niphargus* and *Asellus*. In the fauna of the deep water he mentions *Gammarus pulex*, Deg. (which appears to descend to considerable depths, although the author says that the forms he has seen differ little from those of the littoral region), *Niphargus puteanus*, var. *Forelii*, Humbert, and *Asellus Forelii*, Blanc. He is inclined to raise Humbert's variety of *Niphargus* to the rank of a species, and mentions that it is nearer to the *Niphargus* of wells than to the *Gammarus pulex* of the littoral region of the lake. He afterwards calls it *Niphargus Forelii*. *Asellus Forelii*, Blanc, is abundant at various depths; two specimens found at depths of 200 mètres and 300 mètres had rudiments of eyes; all the others, even the young from the pouch of the female, showed no trace of eyes. The species is intermediate between *Asellus aquaticus* and *A. cavaticus*, Schiödte, but is nearer the latter. The author records *Niphargus Forelii* from the following lakes:—Geneva, Neuchâtel, Lucerne, Walenstadt, Zurich, Como; and *Asellus Forelii* from Bourget, Annecy, Geneva, Lucerne.

After an elaborate argument the author comes to the conclusion that the two species *Niphargus Forelii* and *Asellus Forelii* are not derived from the fauna of the littoral region, but from the underground waters of the surrounding country, which must therefore have more or less free communication with the deep waters of the lakes.

G. Budde-Lund [18] in his 'Crustacea Isopoda Terrestria,' published in 1885, identifies *Typhloniscus Steinii*, Schöbl, and *Itea crassicornis*, Koch, with *Platyarthrus Hoffmannseggii*, Brandt, a species found in ants' nests throughout Europe; he also gives another species, *P. Schöblii*, from Algeria [18, p. 201]. In the appendix [18, p. 306] he gives *Typhloniscus stygius*, Joseph, under the name *Platyarthrus stygius*, but does not say where it is found, or whether in ants' nests or in caverns. Packard, in his list of European cave-animals, gives it as from Italy [83, p. 86]. Under the genus *Titanethes* Budde-Lund gives a short description of *Titanethes albus* (= *Pherusa alba*, Koch), and merely mentions *T. alpicola*, Heller, *T. graniger*, Frivaldsky, *T. feneriensis*, Parona, *T. fracticornis*, Joseph, and *T. brevicornis*, Joseph [18, p. 254].

G. du Plessis-Gouret [87] deals with the same subject as that handled by Forel. He found *Niphargus Forelii* opposite Ouchy in the Lake of Geneva, where Forel had not found it, and states that it occurs also in the Lake of Lucerne. He says, without hesitation, that the lake *Niphargus* is descended from the underground *Niphargus*.

G. Asper [2], in 1885, refers to his former work on this subject, but does not mention the forms supposed to be intermediate between *Gammarus pulex* and *Niphargus Forelii*. He is of opinion that the *Niphargus* gets into the lakes from wells.

R. Schneider [96], 1855, described from the mines at Clausthal a variety of *Gammarus pulex*, under the name *G. pulex* var. *subterraneus*, which differs from the normal specimens of the species in its loss of colour, the partial degeneration of the eyes, the possession of two joints only in the secondary flagellum of the upper antennæ as in *Niphargus puteanus*, &c. Schneider appears to consider it to some extent intermediate between *Gammarus pulex* and *Niphargus puteanus*. In connection with it Stebbing says: "The special interest of the form lies in its occurrence in the waters of mines of which the age can be more or less definitely ascertained" [108, p. 573]. It is discussed by Moniez, who has found a somewhat similar form at Emmerin [78, p. 39].

Karl Bovallius [15], in 1886, in his 'Notes on the Family Asellidæ,' mentions and gives brief descriptions of *Asellus Forelii*, Blanc, *A. Sieboldii*, de Rougemont (=*A. cavaticus*, Schiödte), and *Cæcidotæa stygia*, Packard. He omits *Cæcidotæa nickajackensis*, Packard, the account of which he had evidently not seen. In the introduction [15, p. 3] he says:—"*Cæcidotæa* seems to be closely connected with *Asellus Forelii* and *A. cavaticus*, but without any knowledge of the form of its pleopoda it is impossible to say whether it ought to be united with *Asellus* or not."

R. Schneider [97], in 1887, described a new variety *freibergensis*, Schn., of *Asellus aquaticus*, found in the water of the mines of Freiburg. It bears to *A. aquaticus* much the same relation as *Gammarus pulex* var. *subterraneus*, Schn., does to the normal *G. pulex*. It is smaller, quite colourless, the eyes persistent, but presenting the same example of degradation as in *G. pulex* var. *subterraneus*.

A. E. Jurinac [68] found in the caves of Croatia a species which he first named *Eriopis croatica* and afterwards *Niphargus croaticus*. According to Moniez, it is characterized by the antennæ, which are longer than the body, and contain 73 joints, the last six segments of the pleon are furnished with a thick row of forked spines, the hand is almost square in the female and oval in the male [78, p. 49].

A. S. Packard's [83] paper on "The Cave Fauna of North America" was read in November 1886, but I am unable to find out exactly when it was published. It contains a very full and comprehensive account of the various caves, with the fauna of each, and a discussion on some of the points of general importance presented thereby. The cave Isopoda given are *Cæcidotæa stygia*, Packard, and *C. nickajackensis*, Packard. A fuller account than had previously been published is given of the genus *Cæcidotæa*, which is retained as distinct from *Asellus* "on taxonomic grounds" *, and, as it is pointed out, it presents constant differences from the blind Isopods of European caves and wells and from the depths of the Swiss lakes, which, though exposed to similar conditions, have developed in a different direction. The two species *C. stygia* and *C. nickajackensis* are described in some detail and compared with the surface species *Asellus communis*, and the author says: "It seems quite evident that the two species have descended from different species of *Asellus*. Whether there is an additional species in the Southern States from which the present species [*C. nickajackensis*] may have been derived remains to be seen" [83, p. 33]. Two species, *A. intermedius* and *A. brevicauda*, described by Forbes from Southern Illinois, are mentioned, but it is stated that neither has been found in central or northern Illinois, "although the most varied situations were carefully searched" [83, p. 33]. The Amphipoda given are *Crangonyx vitreus*, Smith (=*Stygobromus vitreus*, Cope), *C. Packardii*, Smith (=*C. vitreus*, Packard), *C. antennatus*, Packard, *C. mucronatus*, Forbes, and *C. lucifugus*, Hay. Of the three last mentioned, the original descriptions given by their authors are simply reproduced, the other two are described and figured by Professor S. I. Smith. Of the first species, *C. vitreus*, he says:—"I know of no species with which this is closely enough allied to make its affinities of any value on the question of

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* Since this was written I have, through the kindness of Mr. W. P. Hay, received specimens of *Cæcidotæa stygia* from wells in Irvington, Indiana, and they differ so much in the proportions of the body and in other points from *Asellus communis*, of which Mr. Hay has also sent me specimens, that I fully agree with Packard that *Cæcidotæa* should rank as a distinct genus separate from *Asellus*.

the origin of the cave-fauna" [83, p. 35]. This species does not possess even rudimentary eyes, but in *C. Packardii* an imperfect eye is present. The latter species is very close to *C. gracilis*, Smith, and the "differences are all such as very naturally lead to the supposition that this subterranean form has been derived from the *C. gracilis* at no very remote period" [83, p. 36].

The brain of the eyeless *Cæcidotæa* is described and compared with that of *Asellus*, from which it appears "that the eyeless *Cæcidotæa* differs from *Asellus*, as regards its brain and organs of sight, in the complete loss of the optic ganglion, the optic nerve, and the almost and sometimes quite total loss of the pigment-cells and lenses" [83, p. 109]. *Cæcidotæa* does not appear to be always totally eyeless. In specimens from a well at Normal, Illinois, the eye was represented by a black speck, varying in distinctness; no trace of eyes could, however, be detected in most of the Mammoth Cave specimens. The brains of eyed and eyeless species of *Crangonyx* were also examined and compared, and the result thus stated: "we see very slight differences between the brains of the eyed and the eyeless *Crangonyx*. The optic ganglia have about the same proportions as do the other lobes and the arrangement of the ganglion-cells. Perhaps striking differences should not be expected, as the eyes of the eyed species of *Crangonyx* are small compared with those of *Gammarus*."

Numerous references to these cave Crustacea are made in the course of the author's remarks on the general question of the peculiarities of the cave-fauna.

Thos. R. R. Stebbing [108] in his "Report on the 'Challenger' Amphipoda," published in 1888, notices in his biographical introduction previous writings on the blind Amphipoda found in caves, wells, and the deep waters of lakes, with occasional remarks and criticisms of his own, most of which have been already incorporated above.

R. Moniez [78], in 1889, gave a full account of the fauna of the "Département du Nord," and particularly of the town of Lille, and besides giving the Crustacea found in this locality he mentions also those recorded from other places by previous observers. He describes under the name *Gammarus fluviatilis*, var. *d'Emmerin*, a single specimen from the reservoirs of Emmerin, which seems to differ from the *Gammari* found at the surface in much the same way as the *G. pulex*, var. *subterraneus*, described by Schneider does; but as the last segments of the pleon bear groups of strong spines, it approaches more nearly to *G. fluviatilis*. Moniez says that it forms in some manner a connecting-link between the surface type and the variety described by Schneider. The number of joints in the flagella of the antennæ are rather numerous, the secondary appendage of the upper antenna containing *five* joints, a point to which Moniez attaches some importance. The importance of this is, however, somewhat lessened when we remember that the single specimen examined was of large size, viz. 22 millim. in length, for the numbers of joints in the flagella of the antennæ, and also in the secondary appendage, appear to increase with the size of the animal; thus I have a large specimen of *Gammarus fragilis*, 14 millim. long, which has the secondary appendage composed of *nine* joints, whilst in another only 7 millim. long there are only *six* joints, and I have seen specimens with even fewer joints than this. Of course, in species where the normal number of joints is very small, the variation will not be so great, but the same reasoning will apply to a modified degree.

Moniez does not accept the genus *Niphargus*, and under the name *Gammarus puteanus*, Koch, he describes two forms; the first, "*G. puteanus* à main triangulaire," corresponds to *Niphargus aquilex*, Spence Bate, and to *N. puteanus*, var. *onesiensis*, Humbert, and this is the species which should, he considers, be looked upon as the true type of *Niphargus puteanus*. The other form, "*Gammarus puteanus* à main ovale," differs in the form of the hand of the gnathopods, and particularly in the last uropoda, which are short and bear only one branch consisting of a single joint, thus resembling *Crangonyx*, though the telson is double and not simple as in that genus. This form Moniez constantly found associated with *Niphargus puteanus* (à main triangulaire), but in much fewer numbers; and as he cannot identify it with any of the previously described species and is not inclined to see a new species in it, he suggests that it may be a second form of the male of *Niphargus puteanus*.

Wrześniowski, however, makes this form a separate species under the provisional name *Niphargus Moniezi*, considering it a connecting-form between *Niphargus* and *Crangonyx* [124, p. 672].

Moniez did not find *Asellus cavaticus* along with *Niphargus puteanus* at Lille, although these two species are frequently found associated. He accounts for this by suggesting that owing to the habits of the animal it is not so likely to be drawn up the pumps as the Amphipods are. He gives, however, brief notices of the various Isopods found by other authors in wells, caves, &c., as he has already done a few pages previously for the Amphipods found in similar situations.

August Wrześniowski [123], in 1888, published an elaborate paper in the Polish language under the title "De tribus Crustaceis Amphipodis subterraneis." In 1890 there appeared a translation, apparently with some additions and alterations, in German [124]. This exceedingly careful and conscientious work will be quite indispensable to all future students of the subterranean Crustacea, and it will therefore be sufficient to indicate here briefly the contents of the paper. Some of the more general questions raised are considered elsewhere.

The paper commences with a full historical sketch of the subject, which I have freely made use of in drawing up the present account. Wrześniowski, however, deals only with the Amphipoda. Then follows a discussion on the genera *Gammarus, Niphargus, Eriopis, Crangonyx, Goplana,* and *Boruta,* the genus *Eriopis,* Bruzelius, being retained under the altered form *Eriopsis,* and a new genus *Boruta* being established apparently nearly related to *Goplana,* Wrześniowski, but differing in some details of the mouth-parts. The three new Amphipods described are *Niphargus tatrensis,* sp. nov., *Niphargus puteanus,* var. *Vejdovskyi,* var. nov., and *Boruta tenebrarum,* nov. gen. et sp. These species are described at great length and compared with previously described species, the mouth-parts in particular receiving special attention and being figured with great care. There is a discussion on the multiplicity of species of *Niphargus,* with an elaborate criticism of the views of de Rougemont, an account of the geographical distribution of the subterranean Gammarids and of their probable origin, a bibliographical list of works relating to the subject, and tables of measurements of the different species.

I regret exceedingly that my imperfect knowledge of German has prevented me from making as full use of this paper as I should like to have done.

III. The History, Distribution, and Occurrence of the New Zealand Subterranean Crustacea.

The occurrence of blind Crustacea in the underground waters of Canterbury, New Zealand, was first recorded by me in a paper read before the Philosophical Institute of Canterbury, on the 3rd November, 1881 [22]. This paper contained descriptions illustrated with figures of four new species,—one Isopod, *Cruregens fontanus*, and three Amphipods, *Crangonyx compactus*, *Calliope subterranea*, and *Gammarus fragilis*,—and was subsequently published in the 'Transactions of the New Zealand Institute.'

In 1882, in a second paper read before the same Institute on the 5th October [23], I made a few additions and corrections to the first paper, giving a few facts as to the occurrence of the different species, and also described another Isopod, *Phreatoicus typicus*, a new species and genus for which I have since made a separate family, the Phreatoicidæ [26, p. 151].

The five species mentioned above had all been obtained from a well at East Eyreton, about 13 or 14 miles from Christchurch, and most of them were subsequently obtained from other wells in the immediate neighbourhood. Nothing further of importance regarding these Crustacea was ascertained until towards the end of 1883, when Mr. D. L. Inwood, of Winchester, near Temuka, South Canterbury, wrote to me stating that he had taken similar blind Crustacea from a pump at Winchester. He afterwards very kindly forwarded me some specimens, which proved to belong to *Gammarus fragilis*, *Calliope subterranea*, *Cruregens fontanus*, and to a species of *Phreatoicus*. A short note recording the occurrence of these species at Winchester was published in the 'New Zealand Journal of Science' for March, 1884 [24], in which also the generic name *Calliope* was altered to *Calliopius*, as the former name was preoccupied, and it was pointed out that the specimens referred to *Phreatoicus typicus* differed to some extent from the Eyreton specimens, though whether they were entitled to rank as a new variety or not was at the time left an open question; in the present paper they have been placed under the new species *Phreatoicus assimilis*.

In 1889, Mr. G. M. Thomson [110, p. 262], recorded the existence of *Calliopius subterraneus* in wells at Ashburton from specimens forwarded to him by Mr. W. W. Smith. I have since received numerous specimens of this species from various wells in that locality, both from Mr. Smith, and also from Mr. J. B. Mayne, Head Master of the Ashburton Public School.

In 1891, Mr. R. M. Laing, of the Christchurch Boys' High School, sent me several specimens of *Gammarus fragilis* from wells at Leeston, about 27 miles from Christchurch in a southerly direction. He has since sent me specimens of *Crangonyx compactus* and *Cruregens fontanus* also from the same well.

In the year 1892 Mr. E. Wilkinson, of the School of Agriculture, Lincoln, sent me a large number of specimens of *Calliopius subterraneus* from wells at that place, about 12 miles from Christchurch.

These are all the localities from which I have seen specimens of these Crustacea up to the present time, though from various correspondents I learn that they have been seen in other localities on the Canterbury Plains. Mr. Smith wrote me (Aug. 1892) that he had heard of them from as far north as Leithfield, and also from Alford Forest, only a few miles from the base of the ranges, in a well 46 feet deep.

About the end of 1889 I received from the Trustees of the Australian Museum, Sydney, a small collection of terrestrial and freshwater Crustacea, collected for the Museum by Mr. R. Helms, while on an expedition to the Mt. Kosciusko plateau. Among these I at once saw that there was one belonging to the genus *Phreatoicus*, which had been established for the blind form from the wells at Eyreton. The occurrence of a species of this genus inhabiting the surface-waters on the top of the Mt. Kosciusko plateau, at a height of nearly 6000 feet above sea-level, was first published in the small 'Handbook of Christchurch,' prepared for the Meeting of the Australian Association for the Advancement of Science, at Christchurch, in January 1891 [63, p. 19]. The species was afterwards fully described in the 'Records of the Australian Museum' under the name *Phreatoicus australis* [26]. In the present paper I have compared it with the two subterranean species *P. typicus* and *P. assimilis*.

Subterranean Crustacea have now been actually obtained from the following localities in the Canterbury Plains:—

1. *East Eyreton*, about 15 miles north of Christchurch, altitude about 120 feet above sea-level *.

2. *Lincoln*, about 12 miles south of Christchurch, altitude about 28 feet above sea-level.

3. *Leeston*, about 27 miles south of Christchurch, altitude about 60 feet above sea-level.

4. *Ashburton*, about 50 miles south-west of Christchurch, altitude about 323 feet above sea-level.

5. *Winchester*, about 85 miles south-west of Christchurch, altitude about 136 feet above sea-level.

I have also heard of Crustacea being seen from wells at several other localities in addition to those given above; but leaving these out of consideration, the localities given, from all of which I have actual specimens, are sufficient to show that these Crustacea are widely distributed in Canterbury, so far as distance north and south is concerned; the distribution from east to west, so far as at present known, appears to be much more restricted, and it is perhaps worthy of notice that all the places mentioned are within short distances of the sea, none of them being more than 10 or 12 miles from it.

No doubt further research will demonstrate the occurrence of these Crustacea at many other places; at the same time it is to be remarked that they do not occur in the artesian waters of Christchurch. The area in which artesian wells can be sunk with success is a narrow belt parallel to the sea, extending from Flaxton, north of the Waimakariri, to Lake Ellesmere, the inland boundary being the contour of about 50 feet above the sea. The depth below the surface of the first water-bearing stratum varies from about 55 feet at Riccarton to 136 at New Brighton, on the sea-coast, and there is a second water-bearing stratum at about double the depth of the first in each locality. Crustacea appear to be absent from both of these water-bearing strata; I have frequently sought for them in vain in water from wells to the first stratum, and others have been equally unsuccessful; moreover, as the water of these wells is used throughout the whole district for drinking-purposes without previous filtering, the animals would certainly have been noticed had they been present. With regard to the wells reaching to the second stratum, Mr. R. M. Laing tells me that he endeavoured to collect Crustacea from a well of this kind at the Christchurch Boys' High School, Bath, by fixing a muslin bag over the mouth of the pipe for some hours, but that no trace of any Crustacea was obtained. Of course, this evidence, though very satisfactory so far as it goes, is by no means conclusive, and it would be well to repeat the experiment in other wells and at different times, in order to confirm or disprove the results of the single trial already made.

In the above-mentioned 'Handbook of Christchurch' [63, p. 33] it is pointed out that although it is commonly thought that the main source of the water-supply of the artesian wells is the leakage of the bed of the Waimakariri, the few careful observations that have

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* This height has been obtained from the Survey Department through the kindness of Mr. C. W. Adams, Chief Surveyor, Dunedin. The other heights are taken from the figures given in the time-tables published by the New Zealand Railway Commissioners.

been made do not confirm this hypothesis at all, as floods in the river never affect the height of the water in the wells, while heavy rain makes them rise, and a continuance of dry weather makes them fall. The absence of subterranean Crustacea appears to confirm the opinion that the water of the artesian wells is not derived from the leakage of the Waimakariri, for the water in which they are found at Eyreton is almost certainly derived, partly at any rate, from the Waimakariri, and if they exist there we might reasonably expect to find them distributed all over the water affected by leakage from that river.

All the subterranean Crustacea hitherto collected from the underground waters of the Canterbury Plains have been obtained by means of the ordinary suction-pumps with which the wells are usually fitted. In the same way similar Crustacea have been obtained in England by Spence Bate and others, in France by Moniez, in various parts of Europe by numerous observers, and in North America by Hay, Forbes, and others. In Europe and North America these Crustacea have also been procured from underground streams in caves and from the deep waters of lakes, but none have as yet been obtained in this way in New Zealand. These situations have not yet been properly searched, and it is quite possible that the blind Crustacea may yet be obtained by exploring the caves in different parts of the colony, and by dredging in the deep alpine lakes of Otago.

The pumps referred to are mostly ordinary suction-pumps, and consequently do not go down to a depth of much more than 30 feet. In some cases, however, owing to a continuance of dry weather for several years, the pipes have had to be driven deeper, and fitted with a cylinder-pump, and Crustacea have still been occasionally taken from them; but it would be obviously rather more difficult to bring up Crustacea from greater depths in this way than from less depths by an ordinary suction-pump, even although they were equally numerous in the waters underground in the two cases. In some cases there is an actual well, the soil having been excavated to a depth of 25 feet or so, and a hole thus formed in which the water can accumulate; in the majority of cases, however, the suction-pipe has been simply driven into the ground like that of an ordinary artesian well. The Crustacea are obtained quite as freely from wells of the one description as of the other. I have myself noticed that the Crustacea are often brought up most abundantly when pumping is first commenced, and that jerking the handle of the pump somewhat violently is often more successful than pumping at the ordinary rate. Mr. J. B. Mayne has noticed the same thing in connection with pumps at Ashburton, and Mr. E. Wilkinson, of Lincoln, states that the Crustacea come up most abundantly after the pump has been left for a time, especially in the early morning. Of course, these facts can be easily accounted for if we consider the character of the small animals with which we have to deal, for a sudden upward flow of the water would be more likely to carry them with it than a more gradual flow, and they would be more likely to be found in the neighbourhood of the pipe, or indeed in the pipe itself, when the waters had been for some time undisturbed by pumping.

In order to collect them I have generally taken a small hand-bowl, pumped it full by a few vigorous or jerking motions of the handle, then examined it to see if any Crustacea have been brought up, catching any that there may be with a dipping-tube, and pumping the bowl full again after the lapse of a few minutes; and where the Crustacea have been fairly numerous I have found this intermittent method of pumping more successful than continuous pumping. In other wells where the Crustacea were found only sparingly, Mr. Smith of Ashburton found it better to collect them by tying a muslin net over the spout of the pump; and in order to prevent the animals being injured he floats the net in a bucketful of water, the bucket being raised so that the level of the water in it is higher than the spout of the pump.

Mr. Smith reports from Ashburton that all the subterranean animals appear to have been brought up by the pumps most abundantly some eighteen months or two years ago, when, owing to the continued drought, the water in the wells was sinking; but that since the wells were sunk deeper, and up to the present time when the water is now rising again in most wells, the animals have been much rarer. Thus in one of his letters he says:—"I generally enquire wherever I go if any animals come up in the water, the answer being that there were plenty twelve months ago but none lately." In another he says that one gentleman informs him "that they frequently saw minute 'pale shells with white slugs in them' before the pump went dry eighteen months ago; since sinking the pump 15 feet more, they have not detected any animals in the water." In another letter, dated 29th June, 1892, Mr. Smith says Mr. Dolman, a practical well-sinker of the district, informed him "that he had not seen a single animal in well-water for some months. There is, however, not much well-sinking going on, as the water is almost up to its usual height."

My own experience tends to strengthen the conclusion that the animals are brought up most abundantly while the level of the water is sinking, for I found them very abundant at Eyreton from 1881 up to about 1886, during the whole of which time the water was sinking, and the wells had to be deepened several times. I have had few opportunities of collecting at Eyreton since, but I am told that very few animals have been seen during the last two or three years. In 1891 Mr. R. M. Laing sent me quite a number of subterranean Crustacea from one of the wells at Leeston, and he states in a later letter that the well has since become dry.

From the one well at EYRETON in which I first noticed the Crustacea I have collected the following five species:—*Gammarus fragilis*, *Crangonyx compactus*, *Calliopius subterraneus*, *Cruregens fontanus*, and *Phreatoicus typicus*. Of these *Calliopius subterraneus*, the female, has always been much more abundant than any of the others; for two or three years from 1881 I seldom had to pump for more than 10 or 15 minutes without obtaining some specimens of this species. After the well was deepened it was less abundant, and did not preponderate over the others so much as before. The male of this species is very rare; I have seen only about half a dozen specimens altogether. Whether this species is really so much more abundant than the others in the underground waters is, perhaps, a little doubtful, as from its smaller size it would naturally be drawn up the pipe more easily than the larger forms. Of the other species, *Gammarus fragilis* and *Crangonyx compactus* have been about equally abundant on the whole, but sometimes one form has preponderated and sometimes the other; *Cruregens fontanus*, though somewhat numerous, has not been so commonly obtained as the others; this may perhaps be accounted for by its habit of creeping instead of swimming like the Amphipods. Moniez notes the same thing with regard to *Asellus cavaticus*, Schiödte, which is frequently found along with *Gammarus puteanus*, but has not been met with from the district of Lille nor from Prague, although the latter species is found at both places; he accounts for this by stating that, owing to the habits of the animal, it would rarely be brought up by the pumps [78, p. 51].

The occurrence of *Phreatoicus typicus* has been somewhat peculiar. Although the Crustacea coming up the pump were pretty carefully watched and collected from January 1881, no specimen of *Phreatoicus* was observed until the beginning of September 1882, while in a month from that date some six or seven other specimens, all females, were obtained. I have not taken it again since then; but in the year 1892 a single specimen, also a female, was taken at Ashburton by Mr. Smith. This species is represented at Winchester by a closely allied species, described in this paper as *Phreatoicus assimilis*, and of this I have three specimens only, two males and one female.

From LEESTON the following species are so far known—*Gammarus fragilis*, *Crangonyx compactus*, and *Cruregens fontanus*; from LINCOLN, *Calliopius subterraneus*; from ASHBURTON, *Calliopius subterraneus*, *Gammarus fragilis*, *Cruregens fontanus*, and *Phreatoicus typicus*; from WINCHESTER, *Calliopius subterraneus*, *Gammarus fragilis*, *Cruregens fontanus*, and the representative species *Phreatoicus assimitis*.

IV. DETAILED DESCRIPTIONS OF THE NEW ZEALAND SUBTERRANEAN CRUSTACEA.

ISOPODA.

Family PHREATOICIDÆ.

Genus PHREATOICUS, Chilton.

(Transactions New Zealand Institute, vol. xv. p. 89.)

The following are the characters that I originally assigned to this genus in 1882, when I had only one species, *Phreatoicus typicus*, before me. They apply, with the slight limitations given below, to the three species of the genus now known, and may therefore still stand in the form in which they were originally put:—

"Body long, subcylindrical, laterally compressed. Upper antenna short, lower long, with flagellum. Mandible with an appendage. First pair of legs subchelate, others simple; first *four* pairs articulated to body at the anterior ends of their segments and directed forward; last *three* articulated at posterior ends of their segments and directed backward. Abdomen long, of six distinct segments, last joined to telson. Sixth pair of pleopoda biramous, styliform. Telson large, subconical."

On this description I may make the following remarks:—

1. The lateral compression of the body is not great and is seen chiefly in the pleon, where the pleura of the segments are produced downward.

2. With regard to the legs, the first pair is subchelate in both sexes, but is larger in the male than in the female, and the fourth pair in the male is slightly modified so as to

be almost subchelate; in the female the fourth pair is simple like the preceding. The statement that the first four are attached to the body at the anterior ends of their segments and the last three at the posterior ends, although true enough of the typical species, required some modification in the case of *P. australis*, for the last three pairs in this species are attached to the centres of their segments, the epimera occupying almost all the inferior margins, and this is also true in a modified degree of the other species. The point that I wished to bring out would be better expressed by saying that the legs are divided into an anterior series of four and a posterior series of three, and this would apply equally well to the three species.

3. "Abdomen long" should perhaps read "pleon long" in order to be consistent with the term "pleopoda" used afterwards. The term "uropoda" is again a very convenient one to use in place of "sixth pair of pleopoda."

4. The peculiarities of the pleopoda, as shown in the descriptions given below, are, no doubt, quite worthy of being mentioned among the characters of the genus, but they cannot be observed without dissection, and so long as the genus can be sufficiently distinguished by other points more easily observed, there is no necessity to introduce them. Perhaps some of them, such as the possession of an "epipodite," will prove to be characters of the family and not merely of the genus.

PHREATOICUS ASSIMILIS, sp. nov. (Plates XVI. & XVII.)

Phreatoicus typicus, Chilton, New Zealand Journal of Science, ii. p. 89 (March 1884).

Phreatoicus typicus (pars), Thomson and Chilton, Transactions New Zealand Institute, vol. xviii. p. 151.

Specific diagnosis. Body somewhat stout. Pleura of the second, third, fourth, and fifth segments of the pleon very largely developed, much deeper than their respective segments; the inferior margins somewhat sparsely fringed with small spinules. The projection at the extremity of the telson not much produced, broader than long; upper angle of its extremity sharp and tipped with a few setæ; lower angle rounded. Lower antennæ about half as long as the body; peduncle with the fifth joint only about half as long again as the fourth; flagellum much longer than the peduncle. Legs stoutish, with the joints somewhat expanded, all the pairs well supplied with setæ. Lower lip with each half ovate, with the extremity well rounded. Inner lobe of the first maxilla rather narrow and with only four plumose setæ at its extremity.

Colour. Translucent.

Length. About half an inch (10 to 12 mm.).

Habitat. Winchester, South Canterbury, in wells (*D. L. Inwood*).

Detailed Description.

The following detailed description is mainly taken from a male specimen that was dissected for the purpose. A few points regarding the surface of the body &c. have been taken from a female specimen that was mounted dry on a slide.

Body (Pl. XVI. fig. 1). The female specimen has the body 10·5 mm. long, and the peræon about 1·5 mm. deep. The body is of uniform breadth throughout its whole length. In the peræon the depth is about equal to the breadth, the ventral surface being more or less flat, so that here the body is semi-cylindrical; in the pleon the segments (except the first and sixth) have the pleura much produced below into smooth, flat, thin plates protecting the pleopoda on either side.

The surface of the body is smooth throughout, with a few setæ scattered here and there either singly or in small tufts, chiefly on the dorsal surface.

Head (Pl. XVI. fig. 1). The dorsal surface is convex, curving downward in front, making the outline of the head in lateral view roughly subtriangular. The anterior margin, as seen from above, is concave behind the bases of the antennæ. A depressed line on the side of the head toward the posterior end runs down more or less parallel with the posterior margin and runs out into the inferior margin; it does not extend over the dorsal surface of the head. Behind the base of the lower antennæ there is a slight cleft in the front margin, and behind this a slight depression on the surface which extends backward a little distance and then turns downward. The inferior margin of the head is nearly straight. In the dried specimen there is no trace of the eyes, the exoskeleton being apparently continuous over the place where the eyes would be situated if they were present.

Peræon (Pl. XVI. fig. 1). The first segment is only half as long as the second; it widens a little inferiorly and has the antero-inferior angle somewhat produced, so that the front margin slopes forward and brings the lower part of the segment very close up to the head. The inferior margin is slightly convex and not hollowed for the reception of the epimeron, which appears to be ankylosed to the segment, the suture being indistinct. The second, third, and fourth segments are all similar and subequal, and of the same length at the inferior margin as on the dorsal surface. The inferior margin is nearly straight, but slightly concave anteriorly for the reception of the shallow epimeron; the anterior angle produced into a rounded knob, tipped with a few setæ; the posterior angle rounded, with a few setæ in the third and fourth segments. The fifth segment is somewhat shorter than the fourth; the anterior angle of the inferior margin is rounded and bears a few setæ, while the rest of the inferior margin is deeply emarginate to receive the triangular epimeron; the sixth and seventh segments are similar to the fifth, but each is shorter than the preceding one.

Pleon (Pl. XVI. fig. 1). The first segment is shorter than the last segment of the peræon, but of nearly the same depth; the inferior margin is rounded off at both angles and bears about 6 to 8 minute spinules scattered along the margin. The second, third, and fourth segments are subequal and somewhat longer than the first; they have their pleura produced inferiorly into large, thin plates, considerably deeper than the respective segments. The pleuron of each segment has the anterior angle of the inferior margin rounded; posteriorly the pleuron is slightly produced so as to overlap that of the succeeding segment; that of the second segment is also produced anteriorly as far as the anterior margin of the first segment, fitting in below its small pleuron; the posterior angles are slightly produced and usually bear a few minute spinules. The fifth segment is nearly as long as the three preceding; its pleuron has the posterior angle well rounded, the posterior margin and part of the inferior margin being sparingly supplied with spinules.

The sixth segment is completely coalesced with the telson, forming a somewhat conical tail-piece, which ends posteriorly in a small projection broader than long, its upper angle at the extremity sharp and tipped with a few small setæ, the lower angle being rounded and free from setæ. Below this projection the inferior margin on each side is slightly irregular, more or less dentate, and is fringed with spinules. The posterior margin in front of the articulation of the uropoda is convex and bears four stout spiniform setæ.

The *upper antennæ* (Pl. XVI. fig. 2) consist of about 9 or 10 joints, of which the three at the base may be considered the peduncle, although there is little or nothing to distinguish them from the succeeding joints. The first and second joints are subequal and somewhat larger than the third; all three bear several small setæ at the distal end; the first three joints of the flagellum are subequal and a little shorter than the last joint of the peduncle; the remaining joints are longer and thicker, being usually considerably swollen, especially towards the distal end, the swelling being chiefly due to a thickening of the chitinous integument; the penultimate joint is usually the thickest, the terminal one being small. The joints of the flagellum bear a few minute spinules distally, and the last four joints have in addition one or two small "olfactory cylinders."

The number of the joints in the antennæ and their relative sizes are subject to considerable variation. The one drawn (Pl. XVI. fig. 2) has the terminal joints less swollen than usual; the penultimate joint is slightly constricted at the middle and bears two groups of "olfactory cylinders;" hence it probably represents two joints, and in that case this antenna would contain altogether ten joints. The other antenna of the same specimen was more normal; it also contained ten joints, and those toward the end were more swollen, the antepenultimate being the largest.

he *lower antennæ* (Pl. XVI. fig. 3) are about half as long as the body. The peduncle is somewhat longer than the upper antennæ. The first two joints are short and subequal; the third is about as long as the first and second together, curving slightly upward, the upper margin being concave and the lower convex, while there are two small groups of setæ on the lower margin and one on the upper margin at the extremity; the fourth joint is half as long again as the third, having a few spinules along each margin and a tuft at the extremity in the middle; the fifth joint is considerably longer than the fourth, bearing three or four small tufts of setæ along each margin and tufts of longer setæ at the extremity. The flagellum contains about 30 joints, each bearing at the extremity a circlet of setæ about half as long as the joint from which they spring; some are placed singly, others in small tufts. At the base of the flagellum each joint is as broad as long, but they gradually become longer and narrower until at the end each joint is about four times as long as broad.

The *upper lip* (Pl. XVI. fig. 4) is rather large and strong, being thick and chitinous. It is broader than long, rounded distally, the middle of the distal margin very slightly produced; the extremity is covered very densely with fine short setæ, directed chiefly towards the centre and forming a thick fur.

The *mandibles* (Pl. XVI. figs. 5, 6) are very similar in general structure to those of *Phreatoicus australis* [26, pp. 156, 157, pl. xxiii. figs. 5 and 5 *a*]. In a lateral view of the head the large basal joint is seen extending along the anterior portion of the lower margin of the head, which, however, is nearly straight and is not hollowed out for the reception of the mandible as described by Sars [91, p. 94] in *Asellus aquaticus*. Below the base of the lower antennæ arises the 3-jointed palp, which extends forward beneath the antennæ, its third joint being usually bent sharply inward, nearly at right angles to the second. From this point the basal joint extends downward and curves forward and inward to form the cutting-edge. The molar tubercle arises from the concave inner surface of the basal joint and extends inwards to meet its fellow on the other side, at a point above and somewhat posterior to the cutting-edge; it is large and strong, but not so stout as in *Phreatoicus australis*. A view of the outer convex surface of the mandible with the palp attached is shown in fig. 5; in this the molar tubercle is of course completely hidden from view; it will be seen that there are a few setæ at the base of the palp on the side toward the base of the mandible, a small row of fine hairs on the other side of the palp, and another on the inferior edge of the basal portion of the mandible. The figure that I originally gave of the mandible of *Phreatoicus typicus* [23, pl. iv. fig. 5] is almost the reverse of the one now referred to, and shows it from the inner side as it rests on its rounded outer surface—its most natural position when dissected out; the molar tubercle then projects directly upward and only its extremity is shown.

As usual, the two mandibles differ slightly in the cutting-edge. In the right mandible there is only the one cutting-edge formed by the extremity of the basal joint itself; this appears usually to consist of three teeth only. In the left mandible (fig. 6) the corresponding part is formed of four teeth, two long ones of equal length and the other two shorter; in addition to this there is the secondary cutting-edge, composed of three teeth on a process which arises inside and extends parallel to the outer cutting-edge almost as far as its extremity. At the base of this and between it and the molar tubercle is another projection nearly as broad as long, having its extremity rounded and bordered by a double row of stout setæ; the outermost of these are short, stout, and denticulated; the inner ones, nearer the molar tubercle, become gradually longer, more slender, and plumose instead of denticulate. This process is the same in both mandibles.

The mandibular palp (see fig. 5) is the same in both mandibles; the first joint is short, only half as long as the second, and bears several long setæ at its extremity; the second joint is oblong and bears three tufts of setæ on its lower margin toward the end and another tuft at the extremity; the third joint is fully as long as the second, and is usually bent upward and inward at right angles to it. Its anterior margin is slightly concave toward the distal end, and bears two regular rows of slightly curved, coarsely plumose setæ; those at the basal end of the row are very short, but the others gradually lengthen distally till the terminal one is about as long as the portion of the joint bearing the row.

The *lower lip* (fig. 7) consists of two lobes narrowed at the base, ovate in shape, with the extremity rounded; the inner margins are fringed with long setæ projecting radially inward, those toward the extremity being the longest. On the outer margins about the middle is a thick tuft of finer setæ, and nearer the base another group of shorter setæ forming a sort of fur, which extends on to the surface of the lip. The two lobes are quite divided almost to the base, where they appear to be connected with a soft membrane;

each has fine setæ arranged on the surface near the base of the inner margin. The outer margins appear thick and chitinous, but the rest of the lip is thin and delicate.

The *first maxilla* (fig. 8) consists of two lobes, which appear somewhat indistinctly articulated to a basal portion, which may perhaps represent the combined basos and ischium, the two lobes representing the internal and external *laciniæ* arising from the basos and ischium respectively. See Boas [13, pp. 495–8] and Parker [84, p. 22].

There is a tuft of fine setæ on the outer margin of the base near the articulation of the outer lobe, and another on the inner margin at the base of the inner lobe. The outer lobe is long, its articulation with the base very oblique; the distal portion curves slightly inward, having the margins parallel and both fringed with numerous fine setæ; the end, which is oblique, is crowned with numerous short spiniform setæ, the innermost of which are more or less denticulate. The inner lobe is narrow at the base, but expands somewhat toward the distal end; it has both margins and a portion of the outer (posterior) surface covered with rather long but very fine setæ. At the rounded extremity there are four long setæ, rather distant from each other; they appear segmented, and are densely plumose and somewhat denticulated toward the extremity; at the base of each of the two innermost is a single simple seta.

Bands of muscles can be seen attached to the bases of each of the lobes, but no muscles extend into the lobes themselves, a fact which, without further evidence, would be almost sufficient to show that the two lobes cannot represent the exopodite and endopodite of the typical crustacean limb, as some authors have held.

The *second maxilla* (fig. 9) is of the usual shape, and consists of a broad, somewhat rectangular basal portion, having two lobes articulated to its distal end, and being produced distally on the inner side so as to form a third lobe, which, however, is not divided off from the basal portion. The outer margin of the base is straight, and is fringed almost throughout with numerous fine, stiff setæ; the inner margin is slightly concave, and is fringed with two rows of setæ. The outer (posterior) row consists of about 15 setæ, not very closely packed, and denticulate at the ends; at the distal end of this row succeeds a number of finer stiff setæ, forming at first a kind of continuation of the row and then spreading out so as to cover the surface of the end of the inner lobe. The inner (anterior) row consists of a much greater number of setæ, apparently simple, with thickened bases, the setæ being so closely packed that the bases almost adjoin; towards the proximal end of the row the thickened base of each seta is rather long, but in the others it gradually decreases till in the setæ at the distal end of the row the base is quite short. This row of setæ is situated along the edge of the inner margin; but at the distal end, when it has reached about halfway along the inner lobe, it leaves the margin and is continued for a short distance along the inner (anterior) surface of the lobe; beyond the end of the row is a single simple seta.

The inner lobe curves slightly inward; its extremity is truncate, with the corners rounded off, and it bears about 12 long setæ, the outermost being the longest and simply plumose, while the inner ones are shorter and in addition to the plumes bear denticulations toward the ends, the denticulations increasing in distinctness and strength as they proceed inward.

The two articulated lobes are similar and subequal; they are oblong, with the extremities rounded. Each bears at the end and along the distal portion of the inner margin a large number of long pectinated setæ, which curve somewhat inward. On the outermost setæ, which are the longest, the pectinations which project at right angles to the setæ are very fine, but they become much coarser on the inner shorter setæ.

Various portions of the second maxilla bear very fine but rather long straight setæ, like those on the first maxilla. Those on the outer surface have already been described. On the inner surface there is a large tuft on the basal portion toward the inner edge, and two other tufts near the base of the outer articulated lobe; the inner margin of the inner articulated lobe is also fringed with fine setæ.

The *maxillipedes* (figs. 10, 11) are large and appear more perfectly developed than in most other genera of the Isopoda. In general structure they closely resemble those of *Phreatoicus australis* as well as those of *P. typicus*, but my original description and figure [23, pl. iv. fig. 9] of the maxillipedes of the latter species are imperfect and based on a partial misconception of the appendage.

The first joint, the *coxa*, is irregular in outline, appearing more or less circular when seen from the anterior side; from it arises the large *basos* and, on the outer side, the *epipodite*. This is a large flat plate reaching beyond the end of the ischium, irregularly elliptical in outline, slightly emarginate at the distal end, the margins being entire; along the inner edge, where it impinges against the basos, the margin itself and the neighbouring portion of the outer surface are covered with very fine setæ. The *basos*, when seen from the outside, is quadrangular, about twice as long as broad, the outer margin fringed with fine delicate setæ like those on the neighbouring portion of the epipodite; besides the portion of the basos thus seen, another portion almost at right angles to it projects inward, and this is produced distally beyond the basos proper into a large concave plate, reaching beyond the inner extremity of the meros and having its convex surface turned inward toward the median line. The inner margin of this plate up to the end of the basos proper is thickly fringed with fine delicate setæ; beyond this the whole margin of the distal portion of the concave plate is thickly fringed with large plumose setæ, those at the extremity being shorter than the others and more or less pectinate instead of plumose. Many other setæ, similar to these at the extremity, are scattered over the distal end of the convex side of the plate. These setæ probably form straining apparatus of some kind.

Near the base of the plate, a little beyond the extremity of the basos proper, are two long "coupling-spines," slightly hooked at the extremity, very similar to those of *Asellus aquaticus*, as described and figured by Sars [91, pl. ix. fig. 5″].

The *ischium* is short, transverse, with one or two setæ at the extremity on the inner edge. The *meros* is subtriangular, produced at the outer side about halfway along the carpus, and is somewhat hollowed distally to receive the carpus; there are a few rather stout setæ on the outer margin at the extremity, and the inner margin is convex and fringed with rather long setæ. The *carpus* is somewhat sunk in the meros, slightly narrowed at the base, the outer margin slightly sinuous and with a small tuft of setæ at the extremity, the inner margin convex and densely fringed with long setæ.

The *propodos* is oblong; outer margin slightly convex, with one or two setæ at the extremity only; inner margin slightly convex and densely fringed with setæ, except at the base. The *dactylos* is similar to the propodos, but much shorter and narrower; it bears setæ arranged as in the propodos, two or three of those at the extremity being very long and robust.

First appendage of peræon (Pl. XVII. figs. 1, 2, 3). *In the male* these form large well-developed subchelate gnathopoda, very similar in general appearance to those found in many Amphipoda. In the female they are similar, but much smaller. Unfortunately, the only female specimen that I have of this species has been mounted dry on a slide, and I am, therefore, unable to give a full detailed description of its gnathopods, but so far as I can see they are very like those of *Phreatoicus typicus* as described later on [see p. 199, Pl. XVIII. figs. 7, 8], except that they are stouter and rather better supplied with setæ. The following description therefore applies to the male only.

The *coxa* (epimeron) is small, attached to the anterior portion of its segment, and is more or less ankylosed to it; it is free from setæ, and is emarginate below to receive the basos. The *basos* is longer than the ischium; it is constricted at the base and has three small tufts of setæ on the posterior margin. The *ischium* is similar to and nearly as long as the basos; it has two or three tufts of setæ on the posterior margin and two stout setæ at the middle of the anterior margin, where it is slightly convex. The *meros* has a small tuft of setæ at the extremity of the posterior margin, which is straight: this joint is expanded distally, produced anteriorly and inward, and is hollowed out at the end to receive the rounded end of the large propodos; the inner margin of the cup-shaped socket thus formed is very densely fringed with long straight setæ projecting radially inward (Pl. XVII. fig. 3). The *carpus* is small, sub-oblong, the posterior margin with a tuft of setæ towards the extremity and one or two separate setæ placed more proximally, the anterior margin completely covered by the propodos and meros. The *propodos* is very large, forming much the largest portion of the whole limb; it is produced backwards beyond the carpus into a rounded lobe which rests back on to the meros; the whole joint is oval in outline, the anterior margin very convex and without setæ, with the exception of a small tuft at the extremity; the posterior margin slightly sinuous, fringed with short setæ; the palm oblique and well defined, armed with a rounded lobe near the base of the dactylos, followed by four very short triangular spines placed on slightly rounded lobes: these spines decrease in size as they recede from the dactylos; between the base of the dactylos and the rounded lobe is a row of 7 to 8 setæ, and from the lobe toward the end of the palm is a row of simple setæ, each with a distinctly enlarged base, and near this row a few scattered setæ on the surface of the propodos. The *dactylos* is strong, as long as the palm, both margins fringed with a few minute spinules, the extremity forming a distinct nail, with a small secondary nail on the inner margin at its base.

The second appendage of the peræon (Pl. XVII. fig. 4).—The *coxa* is similar to that of the first appendage, but is slightly larger and is distinctly marked off from its segment. The *basos* is narrow at the base, but widens out at the middle, where the breadth is nearly half the length, and it narrows slightly again toward the distal end; the anterior margin is fringed throughout its whole length with short, stout setæ; the posterior margin bears one or two similar setæ about the middle and a tuft of finer setæ at the extremity. The *ischium* is about three-fourths as long as the basos: it is narrow at the base but considerably expanded distally; the anterior margin is convex, slightly irregular, and bears five spiniform setæ, followed by a series of three or four finer setæ towards the extremity; the posterior margin is nearly straight, bearing five or six small tufts of one or two setæ each, and a larger tuft of longer setæ at the extremity. The *meros* is about three-fourths as long as the ischium, subtriangular, and produced at the antero-distal angle; the anterior margin is strongly convex, bearing five spiniform setæ, with a row of six or seven along the distal end; the posterior margin straight and fringed with numerous setæ. The *carpus* is somewhat smaller than the meros, similar in shape, but not produced at the antero-distal angle; the anterior margin convex, with setæ toward the extremity only; posterior margin straight and fringed externally with spiniform setæ. The *propodos* is oblong, slightly longer than the carpus and a little narrowed distally; the anterior margin is slightly convex and bears a few fine setæ, chiefly toward the extremity; the posterior margin straight, bordered with five spiniform setæ and a number of finer hairs: at its extremity the propodos is produced alongside the base of the dactylos into a small triangular projection (Pl. XVII. fig. 5) similar to that described by Sars [91, p. 100] in *Asellus aquaticus*. The *dactylos* is slender: the end forms a distinct nail with three or four setæ on the surface of the dactylos at its base: on the inner margin is a small secondary nail at the base of the large one, with a seta arising in the angle between the two.

The third appendage of the peræon is almost exactly the same as the second in all respects, and fig. 4, drawn from the second, will equally well delineate the third.

The fourth appendage of the peræon (figs. 6, 7) is like the second and third in the female, but it is slightly modified *in the male* to form a grasping-organ, instead of being merely adapted for walking. The whole leg is somewhat shorter than the preceding; the *basos* is the same; the *ischium* also the same, except that it is shorter than in the preceding legs; the *meros* and *carpus* are much shorter, but otherwise similar, and with the same general arrangement of setæ; the *propodos* has the anterior margin very convex, the posterior margin being developed into a slightly concave palm, distinctly defined by a small group of three or four very stout spiniform setæ, and occupying nearly three-fourths of the whole margin; the *dactylos* is rather short, and is considerably curved.

The first four pairs of appendages to the peræon form an anterior series, differing very considerably in structure from the last three pairs, forming the posterior series. In the anterior series the dactylos is directed backward, while in the posterior pair it is directed forward, as in the majority of the Amphipoda.

The fifth, sixth, and seventh appendages of the peræon (figs. 8, 9) are similar to each other, but differ in size, the sixth being larger than the fifth, and the seventh as much larger than the sixth. I shall describe the sixth pair only, and it must be understood that this pair represents the mean between the fifth and seventh pairs, not in size only, but also in the number and size of the setæ found on the various joints.

The *coxa* is subtriangular in outline, and fits into a triangular emargination in the segment, the lower margin of the coxa being straight or somewhat concave. In the fifth segment the coxa occupies only the posterior half of the lower margin of the segment, but in the sixth and seventh segments, which are considerably shorter, the coxa occupies nearly the whole of the lower margin. The *basos* is oblong, about twice as long as broad, its slightly convex anterior margin supplied with eight or nine short but rather stout setæ and a tuft of finer hairs at the extremity; the posterior margin produced somewhat backward, as in the Amphipoda, irregularly serrate, and armed, except towards the extremity, with about a dozen strong spiniform setæ. The *ischium* is as long as the basos, its anterior margin straight, obscurely serrate, and with five small tufts of setæ marking the serrations, and a transverse row along the distal margin; the posterior margin is convex, with five serrations, each of the first four bearing a strong spiniform seta, and the last a row of about four or five. The *meros* is rather more than half as long as the ischium, the anterior margin straight and bearing three groups of stout setæ, the distal one being the largest; the posterior margin bears two or three spiniform setæ, and a row of three or four along the distal margin at the posterior angle, which is somewhat produced. The *carpus* is as long as the *propodos*, but broader: both are oblong, slightly expanding distally, with groups of stout setæ along both margins, but more especially along the anterior margin, and a row along the end at each angle. The *dactylos* is about as long as the setæ at the end of the propodos, similar to the dactylos of the second pair of legs, but more slender.

The *pleopoda* of *Phreatoicus* are large and well developed, and present such peculiarities that they are well worthy of careful examination and description. The five pairs all appear to be branchial in function, and though the first pair differ in shape from the others, they appear to be the same in minute structure, probably fulfil the same function, and do not act as an "imperfect operculum" to the others as I originally stated [23, p. 91]. All the pleopoda hang vertically from the ventral surface of their segments, and are protected laterally by the greatly developed pleura.

The *first pair of pleopoda* (Pl. XVII. fig. 10) have the basal joint or *protopodite* subrectangular, with one seta at the extremity on the outer margin, and several similarly placed on the inner margin. From the protopodite arise two rami, both long and narrow; the inner one, *endopodite*, is narrow-elliptical, about five times as long as broad, with the margins quite entire and without setæ, and the extremity subacute; the outer ramus, *exopodite*, is oblong, longer than the endopodite, the inner margin nearly straight, outer margin irregularly curved at each end; the whole of the inner margin and the extremity fringed with rather long setæ; on the outer margin the setæ are long at the end, but they become smaller toward the base and disappear altogether before the base is quite reached. All the setæ on the inner margin are simple, those at the extremity and on the neighbouring portion of the outer margin are plumose; the others on the outer margin become gradually less plumose as they approach the base, until at about the middle of the joint they are quite simple.

The *second pair of pleopoda* (fig. 11) differ in the two sexes, being specially modified in the male so as to serve as an accessory copulatory organ. It will be convenient to describe that of the male first. The *protopodite* has the same general shape as in the first pair, and bears a few setæ at its extremity on the inner margin; the *endopodite* is similar to that of the first pair, but bears on the inner side a long, narrow, curved appendage, the "penial filament," which does not reach so far as the end of the endopodite; it appears to be semi-cylindrical, being concave on the outer side, and bears four or five short setæ at its extremity. The portion of the endopodite between its base and the base of the "penial filament" is about one-fourth the length of the whole endopodite; it is slightly enlarged, and bears toward the inner margin a powerful muscle attached to the base of the "penial filament."

It will be seen from fig. 11 that the "penial filament" of *Phreatoicus assimilis*, as drawn, is much shorter than in *P. australis* [26, pl. xxvi. fig. 2]; it is, however, quite probable that, like other secondary sexual characters, it may vary very greatly in development at different seasons. The *exopodite* is large, and consists of two joints; on the outer side it is produced backward at the base into a rounded lobe which lies alongside of the protopodite; the outer margin of the first joint is fringed rather sparingly with short simple setæ, its inner margin is straight and more thickly fringed with similar setæ; the second joint is triangular, articulated to the first joint by a very narrow base; the inner margin is straight, and, like that of the first joint, is fringed with simple setæ, but these are much longer than on the first joint; the extremity, which is oblique, is bordered on the outer margin by about 10 long delicately plumose setæ.

The endopodite does not hang by the side of the exopodite, but overlaps it, and the exopodite is curved so as to receive it; a raised ridge runs from the outer extremity of the protopodite toward the outer margin of the first joint of the exopodite, meeting it at about the middle, and thus bordering the depression within which the exopodite lies. The endopodite usually overlaps the exopodite to a greater extent than is shown in fig. 11, where it was purposely somewhat separated from the exopodite to allow the form of the latter to be more clearly seen. The more natural position of the two is shown in fig. 12, which represents the third pair of pleopoda.

I have had no opportunity of examining the pleopoda of a female specimen of *Phreatoicus assimilis*, but from the analogy of *P. australis* and *P. typicus* I have no doubt that the second pleopoda would resemble that of the male, as above described, except that there would be no penial filament.

The third pair of pleopoda (fig. 12) are similar to the second, but the *endopodite* is rather smaller in proportion to the *exopodite*, and does not reach beyond the base of the second joint of the latter. From the outer margin of the protopodite arises a sub-triangular lobe projecting nearly at right angles to the protopodite, and apparently representing the *epipodite*; its margins bear long simple setæ, widely separated from each other, and its integument, though apparently thicker than that of the rest of the pleopod, is more or less membranaceous, so that this epipodite is perhaps also branchial in function.

The significance of the occurrence of an epipodite in the pleopoda of *Phreatoicus* is considered later on (see p. 244).

The fourth and fifth pairs of pleopoda contain precisely the same parts as the third pair, but each is much shorter and broader than the preceding.

The *uropoda* (fig. 13) are long, the peduncle as long as the inner ramus, and reaching considerably beyond the end of the telson. Its lower margin is straight and bears three tufts of setæ on the proximal portion and another tuft at the extremity; the upper surface is flat or slightly concave, the outer margin with a few small setæ scattered along the whole length; the inner margin with few setæ, except towards the end, where it is somewhat raised and bears two stout spiniform setæ on the projection. The outer ramus is considerably shorter than the inner, but of the same shape; each is lanceolate, a little constricted at the base, and bears numerous tufts of one or two stout setæ and many fine hairs; the extremities narrow somewhat abruptly and are free from setæ.

Male reproductive organs. I came across the male reproductive organs in the specimen from which I was dissecting out the appendages. They seem to have the same general shape as in *Asellus aquaticus* [91, pl. x. fig. 7], but there appears to be a great number of the oval *cul-de-sacs*, apparently five or six. The vas deferens was quite crammed with spermatozoa, which resemble those of *Asellus*.

I have been unable to find an external male organ in either of the two specimens I possess.

PHREATOICUS TYPICUS, Chilton. (Pl. XVIII. figs. 1–12.)

Phreatoicus typicus, Chilton, New Zealand Journal of Science, vol. i. p. 279 (Nov. 1882); id. Transactions New Zealand Institute, vol. xv. p. 89, plate iv.; Thomson & Chilton, Transactions New Zealand Institute, vol. xviii. p. 151; T. R. R. Stebbing, Report on the 'Challenger' Amphipoda, pp. 543, 587; R. Moniez, "Faune des eaux souterraines du département du Nord &c.," extrait de la Revue Biologique du Nord de la France, tome i. (1888–1889), p. 53.

Specific diagnosis. Body somewhat slender. Pleura of the second, third, fourth, and fifth segments of the pleon moderately produced, not deeper than their respective segments; their inferior margins well supplied with setæ, especially in the fifth segment. Extremity of the telson forming a narrow projection much longer than broad, narrowing distally, the truncate extremity tipped with rather long setæ. Lower antennæ about three-fourths as long as the body; flagellum much longer than the peduncle, which is slender and has the fifth joint twice as long as the fourth. Legs slender; joints scarcely expanded, the first four pairs not very abundantly supplied with setæ. Lower lip with each half subtriangular, with the inner distal angle somewhat acute. Inner lobe of the first maxilla broad, expanded distally, and bearing about nine long plumose setæ.

Colour. Translucent.

Length. Rather more than half an inch (15 mm.).

Habitat. Eyreton (*Chilton*) and Ashburton (*W. W. Smith*), in wells.

Detailed Description.

Unfortunately I have no male specimen of this species, all the few specimens I have seen, about ten altogether, being females. The following detailed description applies therefore to the female only, though doubtless it will apply equally well to the male, except as regards the first and fourth appendages of the peræon and the second pleopoda, which are specially modified in the male.

I described this species pretty fully in my original paper [23], and in the present paper I have given a full detailed description of the new species *P. assimilis*, and I shall therefore give only such further details of *P. typicus* as are necessary to exhibit clearly the differences between the two species.

Body (Pl. XVIII. fig. 1). It will be seen, from a comparison of Pl. XVI. fig. 1 and Pl. XVIII. fig. 1, that the body is much more slender than in *P. assimilis*; thus in one specimen that I have mounted dry on a slide, and from which fig. 1, Pl. XVIII. is taken, the body is fully 15 mm. long, yet the depth is only 1·5 mm., the same as the depth of a specimen of *P. assimilis* that was only 10·5 mm. long.

The surface of the whole body is smooth, and though there are a few fine setæ scattered over it, chiefly in the pleon, they are not so numerous nor so distinctly arranged in small tufts as in *P. assimilis*.

Peræon (Pl. XVIII. fig. 1). The first segment is very short, not half so long as the succeeding; it widens inferiorly, and has the inferior angle somewhat produced and brought close up to the head, so that the first pair of appendages of the peræon seem almost to arise from the head. The next three segments are subequal and rather longer than deep; they are quite rectangular in outline, the inferior margin being almost straight and scarcely hollowed, except slightly in the first segment for the reception of the coxa of the appendage, which is small and placed well to the anterior end of each segment. The next three segments are similar, but each is shorter than the preceding segment; the inferior margin of each is emarginated towards the posterior end for the triangular coxa.

Pleon (figs. 1, 11). In the pleon this species resembles *P. assimilis* as above described, but the pleural portions are not so largely developed, being somewhat shallower than their respective segments, and their inferior margins are more abundantly supplied with setæ. In each segment there is a slight ridge where the pleural portion leaves the body-ring proper, but the integument is quite continuous, and there is no suture or line of division of any kind.

The projection at the end of the telson (fig. 12) is narrow, longer than broad, projects slightly upwards, and has the truncate extremity tipped with a few setæ; there is a stout seta below at its base; the inferior margin of the telson on each side from this projection to the articulation of the uropoda is irregular and fringed with very fine setæ.

The *upper antenna* (fig. 2) extends a little beyond the extremity of the third joint of the peduncle of the lower antennæ; it usually contains eight joints, but is not distinctly divided into peduncle and flagellum. The first three joints are similar, but each smaller than the preceding, oblong, about twice as long as broad, with a few setæ at the distal end; the fourth joint is like the third, but shorter; the fifth shorter still, but somewhat expanded distally; the sixth and seventh are subequal to each other and to the first joint and are considerably swollen; the eighth joint is usually small, but swollen; the last three bear at the extremity one or two small "olfactory cylinders" of the usual shape in addition to a few simple setæ.

The *lower antennæ* (fig. 2) are about three-fourths as long as the body, the flagellum being much longer than the peduncle. The first two joints are subequal, short, as broad as long, without setæ; the third is as long as the first and second together, its upper margin slightly convex, lower margin straight, one or two small setæ on the lower margin at the distal end; the fourth is about half as long again as the third, but slightly narrower, sides straight and parallel, one or two small setæ on the margins, and tufts of longer setæ above and below at the extremity; the fifth joint is similar to the fourth but about twice as long, each margin bears about four small setæ and there are tufts of longer setæ at the end; the first joint of the flagellum is about twice as long as the second, which is about as broad as long; the remaining joints (about 35 altogether) gradually become longer and narrower till at the end each is about six times as long as broad, each bears one or two small setæ at the distal end, but toward the extremity of the flagellum these become very small.

The *upper lip* does not differ in any important respect from that of *P. assimilis.*

The *mandibles* (fig. 3) also appear to resemble those of *P. assimilis*, but the left mandible has only three teeth on the terminal cutting-edge, with three also on the secondary cutting-edge. In the specimen from which I have taken the drawing (fig. 3), these teeth are much sharper and more acute than those shown in the figure of *P. assimilis* (Pl. XVI. fig. 6), but this is probably due to the fact that they belong to a younger specimen. In the figure they are flattened out so as to be seen full in front, while those of *P. assimilis* are seen in profile.

The *lower lip* (Pl. XVIII. fig. 4) differs considerably in shape from that of *P. assimilis.* Each lobe is triangular, inner margin straight, outer margin very convex, especially toward the base, the extremity being more or less acute, not rounded, and there is a small projection on the inner margin at some little distance from the extremity. The extremity is densely covered with long setæ; the inner margins and the distal portions of the outer margins are fringed with fine setæ.

The *first maxilla* (fig. 5) bears a general resemblance to that of *P. assimilis*, but the inner lobe is much broader, especially toward the extremity, which is rounded and bears about 9 or 10 long plumose setæ, about twice as many as in *P. assimilis.* The two simple setæ also present at the extremity are situated near the base of the third and fourth setæ respectively from the outer margin of the lobe. In *P. assimilis* they are situated at the base of the two inner setæ.

The *second maxillæ* (fig. 6) differ from those of *P. assimilis* in the following points:—The inner margin of the basal portion is more convex, and bears a very distinct row of long plumose setæ, which have thickened bases; those at the distal end have the base quite short, but toward the proximal end of the row the bases become gradually longer. At the lower end of the row on the surface of the base is another somewhat imperfect row of simple setæ. The inner (fixed) lobe is longer than in *P. assimilis* and has the end more rounded, and the long plumose setæ, instead of being confined to the extremity, extend for some distance along the inner margin toward the base.

The *maxillipedes* are practically identical with those of *P. assimilis*, but the "grappling setæ" are slightly different, being long curved setæ slightly hooked at the end; they thus resemble those of *P. australis*, but are more slender. In the specimen dissected there are two on one side and three on the other. *P. assimilis* has two on each side, and they are straight, with hooks at the end.

The *first pair of legs* of the female (Pl. XVIII. figs. 7, 8) are much more slender than in *P. assimilis*. The *coxa* is small, shallow, partly cleft below and ankylosed to the body-segment. The *basos* is narrow oblong, about three times as long as broad, and is almost free from setæ except a small tuft at the extremity on the posterior margin. The *ischium* is nearly as broad as the basos; posterior margin straight, with three or four minute spinules; anterior margin slightly produced in the centre and bearing a stout seta at this point. The *meros* is subtriangular, and has the posterior margin straight, with a few setæ at the extremity; the anterior margin is convex and produced distally into a rounded lobe extending about halfway along the carpus, the edge of this lobe next the carpus being fringed with stout setæ. The *carpus* is suboblong, its junction with the meros being oblique; on the posterior margin there is a small seta near the base and a small tuft of larger setæ toward the extremity. The *propodos* is subtriangular, expanding distally, longer than the meros; the anterior margin convex, especially toward the base, and bearing one or two minute setæ and a small tuft at the base of the dactylos; the posterior margin is straight, produced at the extremity to define the palm, the postero-distal angle being thickly covered with setæ. The palm is oblique, concave, and bears five or six very acute setæ with expanded bases, those nearest the base of the dactylos being the best marked, the others gradually becoming more slender until they are indistinguishable from the ordinary stout setæ at the postero-distal angle; in addition to these the palms bear a few simple setæ. The *dactylos* is somewhat stout, longer than the palm, both margins bearing a few spinules, the extremity being separated off as a distinct tooth.

The peculiar setæ on the palm are of the same kind as those described in the male of *Phreatoicus australis* [26, pl. xxiv. fig. 5 *a*], but they are not so stout and well marked. The female of that species has the first pair of legs very like those described above, but shorter and stouter and more spiniform, and the palm more oblique and not concave.

The *second pair of legs* (fig. 9) is rather longer than the first pair; the *coxa*, *basos*, and *ischium* are similar to the corresponding joints of the first pair; the *meros* is subtriangular, about three-fourths as long as the ischium, posterior margin straight and fringed with a few setæ, the anterior margin slightly convex, and with the antero-distal angle slightly produced, a few setæ on the margin and at the extremity; the *carpus* is oblong, not so long as the meros, posterior margin straight and with a few setæ, anterior margin nearly straight, and with setæ at the extremity only; *propodos* similar to the carpus but usually a little longer, the extremity produced into a small triangular lobe at the side of the dactylos; *dactylos* nearly half as long as the propodos, extremity forming a distinct nail, with a small tooth at its base.

The *third* and *fourth pairs of legs* are similar to the second and of the same size.

The *fifth*, *sixth*, and *seventh pairs of legs* (see fig. 10) are similar to each other, but each is larger than the preceding. The *coxa* is deeper than in the first four pair of legs and is triangular, fitting into a triangular emargination in the inferior margin of the segment; in the fifth segment this is at the posterior end, but in the sixth and seventh it approaches nearer the centre, though still in the posterior half of the margin. The *basos* is only slightly expanded, being oblong, about three times as long as broad, both margins somewhat scantily supplied with setæ. The *ischium* is very long, being considerably longer than the basos, narrow oblong; front margin straight, with five or six setæ; posterior margin a little convex, with a few spiniform setæ. The *meros* not half so long as the ischium; postero-distal angle a little produced; both margins with spiniform setæ, those at the extremity being very strong. The *carpus* and *propodos* similar, the carpus usually longer than the propodos; both oblong, and both margins supplied with spiniform setæ arranged in tufts, those on the anterior margin being larger than those on the posterior. The *dactylos* as in the preceding legs, but longer and more slender.

The above description applies to the fifth, sixth, and seventh pairs of legs, but it is to be remembered that the spines as described above are larger and more numerous in the sixth than in the fifth, and in the seventh than in the sixth.

The *pleopoda* appear to be similar to those of *P. assimilis*, but are rather more slender; the fifth pleopoda are very short and small.

The *uropoda* (fig. 12) differ from those of *P. assimilis* only in being longer and more slender, and in having the setæ on the inferior margin of the peduncle smaller and not arranged in distinct tufts, but evenly distributed along the whole margin.

In one of the females examined, brood-plates were beginning to appear at the bases of the appendages of the peræon; one of these is shown in the drawing of the second pair of legs (fig. 9).

Comparison of the three known Species of Phreatoicus.

When I first received the specimens of the *Phreatoicus* from Winchester along with the other species which were known from Eyreton (i. e. *Calliopius subterraneus*, *Gammarus fragilis*, and *Cruregens fontanus*), I naturally thought that they would belong to the Eyreton species *Phreatoicus typicus*; and though at the time I noticed that there were a few variations, I thought that these might prove to be due to differences of age or sex. I was therefore somewhat surprised to find on a close examination that this was not the case, but that the differences were quite sufficient to warrant the creation of another species, viz. *P. assimilis*. Besides being found at Eyreton *Phreatoicus typicus* is also known from Ashburton, only about 30 miles from Winchester, where *Phreatoicus assimilis* is found; and the existence of two subterranean species of the same genus being so near each other is a fact of considerable importance, and it would be interesting to know whether the species have differentiated since adopting a subterranean life, or whether they have descended from two different surface species. It is therefore desirable that the differences between them should be clearly set forth, and that they should be compared not only with each other but also with the species *Phreatoicus australis* [26], found on the top of the Mt. Kosciusko plateau in Australia, and at a height of nearly 6000 feet above the sea.

It is quite possible that on an examination of a greater number of specimens from various localities the differences between *P. typicus* and *P. assimilis* may partially or wholly break down; but, so far as my observations at present go, the Ashburton specimen of *P. typicus* is practically identical with those from Eyreton and differs from *P. assimilis* in the following points:—

(1) The body and the appendages are much more slender than in *P. assimilis*. This character is of course only a relative one and therefore difficult to estimate with accuracy, but in my specimens the differences, especially in the legs and the lower antennæ, are very marked.

(2) The pleura of the second to fifth pleon-segments, inclusive, are not so greatly developed and have all the inferior margins regularly supplied with moderately stout setæ. In *P. assimilis* the pleura are considerably deeper than their respective segments and have the inferior margins only sparsely fringed with spinules.

(3) The shape of the projection at the end of the telson is quite different in the two species.

(4) The shape of the lobes of the lower lip also differs to some extent.

(5) The inner lobe of the first maxilla is broader distally and bears fully twice as many long plumose setæ as in *P. assimilis*.

(6) There are slight differences in the second maxillæ; thus the long plumose setæ on the innermost lobe extend some distance along the inner margin, while in *P. assimilis* they are pretty well confined to the extremity; the rows of setæ along the inner margin of the basal portion also differ in character.

(7) The grappling-setæ of the maxillipedes also differ slightly.

The differences in the mouth-parts are somewhat peculiar, and were quite unsuspected when I had from other reasons already perceived that there were two species. The differences in the inner lobe of the first maxillæ are very noticeable.

Of the two, *P. assimilis* approaches more nearly to *P. australis* than *P. typicus* does, and I am inclined to think that, leaving out of account the special characters which are due to their subterranean life, *P. assimilis* is more closely related to *P. australis* than it is to *P. typicus*. The two former agree with each other and differ from *P. typicus* in the following points:—

(1) The stouter body and appendages.

(2) The shape of the lobes of the lower lip.

(3) The inner lobe of the first maxilla bears only 4 or 5 plumose setæ.

(4) The pleura of the pleon-segments are almost equally well developed in both.

On the other hand, *P. australis* has the projection at the end of the telson rather more like that of *P. typicus*, and in the second maxillæ and the maxillipedes it is also quite as close to *P. typicus* as to *P. assimilis*, if not closer; but in the last two points the differences of all three species are very trivial.

Phreatoicus australis differs from both the subterranean species in the following points, in addition to those which are evidently due to the different modes of life:—

(1) The body and especially the legs and pleura of the pleon are more abundantly supplied with setæ.

(2) The telson proper is much shorter and rounder.

(3) The inferior margin of the sixth segment of the pleon bears about 15 setæ instead of only 4 in front of the articulation of the uropoda.

(4) The first pair of legs in both sexes differ slightly in the shape of the propodos and in the armature of the palm.

(5) There are also slight differences in the maxillipedes.

(6) The body is much stouter than in either of the subterranean species.

Without a much fuller knowledge of the habits of each species than we possess, it is difficult to see the reason for the differences between them; and until we are able to do this, to some extent, it will be almost impossible to assign its true importance to each difference and thus to discover the true relationships of the species. The abundant setæ on *P. australis* are perhaps protective; and, if so, we can see why they should be less abundant in the subterranean forms, though even in these species they are pretty numerous, especially on the last three pairs of legs. The slender body and appendages of *P. typicus* may also be an adaptation to a subterranean mode of life, and, if so, it would appear that *P. typicus* has been longer underground than *P. assimilis*; but in the present state of our knowledge all speculations of this kind must be received with the greatest caution. The questions suggested may perhaps be some day solved by the discovery of species of *Phreatoicus* still living above ground in the mountain-streams of the Southern Alps, places where very little search of the kind required has hitherto been made.

It is worthy of notice that the species of *Phreatoicus* do not show the increase in the number of sensory setæ, &c., in compensation for the loss of eyes that has been observed in some other subterranean species. (See p. 262.)

Special points in the Structure of Phreatoicus.

In many respects *Phreatoicus* appears to be a very generalized type of the Isopoda, possessing all the segments of the body and their appendages in a more perfect form than any other Isopod I know. Thus in the body all the segments both of the peræon and the pleon are well developed and separate, except of course that the telson is joined to the sixth segment of the pleon as in nearly all Isopoda. The antennæ, though well developed, do not present any peculiarity, and the lower antenna does not possess the rudimentary exopodite found in some genera of the Asellidæ, such as *Janira*, *Ianthe*, *Stenetrium* [9, p. 9]. The mouth-parts are all particularly well developed, no parts usual in the Isopoda being absent or coalesced; the maxillipedes especially have all the joints perfect and separate. The legs of the peræon all have the coxæ more or less separate from the segment, showing, I think, clearly that they are really the first joints of the legs, and not outgrowths of the body-ring ("epimera"). This view was first advanced by Spence Bate in 1855 [7], and has, I believe, since been pretty generally adopted, though, as Stebbing says, "It is a disputed question whether we have at the base of the leg an outgrowth of the body-ring carrying the more or less obsolescent first joint of the leg soldered to it, or whether the side-plate is itself a protective expansion of the first joint" [108, p. 1730]. In quoting Spence Bate's arguments to show that the so-called "epimera" are really the coxæ of the legs, Stebbing [108, p. 289] appears rather to favour the first view. Against this I may call attention to the fact that, in *Phreatoicus*, in the segments of the pleon the pleural portion of the body-ring has grown out to form a protection to the pleopoda, the coxal portion of which is present, but is in no way attached to this outgrowth of the body-ring, and the outgrowth is quite continuous with the body-ring, not being marked off by any suture or line of division. The same thing is of course true of the pleon of most Amphipoda. Thus these true outgrowths of the body-ring appear clearly marked off from the "epimera," which are either quite separate from the body-ring, or have a suture clearly showing the line of division, a fact that can be easily accounted for if the "epimera" are formed solely from the coxæ of the legs.

In the pleopoda of *Phreatoicus* we find several peculiarities which will probably be useful in helping us to trace out the homologies of the pleopoda of other Isopods. All the pleopoda have the basal portion, the "protopodite," present and of moderate size, and in the third, fourth, and fifth pleopoda this bears a fair-sized "epipodite." The existence of this epipodite is a point of considerable interest. I am not aware of any other case where the epipodite is present in any of the pleopoda of Isopods. In the 'Journal of the Royal Microscopical Society' for October 1891 (p. 593), in an abstract of a paper by Dr. J. Nusbaum [80] on "The Morphology of Isopodan Feet," it is stated that, according to the author, the epipodite of the thoracic legs has fused with the ventral wall of the body-segments. If this should be so in the peræon it certainly does not appear to be the case with the posterior pleopoda of *Phreatoicus*. There is no trace of the epipodite in the first and second pairs of pleopoda, nor can I suggest any reason for its absence.

Both the exopodite and the endopodite are present in all the pleopoda, both being large flat plates, apparently branchial in function. In all the pleopoda, except the first pair, the exopodite consists of two joints. This character is also possessed by some of the pleopoda of *Ianthe* [16], *Munna* [27, p. 11], and some allied genera, but the more general rule among the Isopoda is that the exopodite consists of one joint only. In the second pleopoda of the male, although there is a "penial filament," the whole pleopod has been very little modified, and it is quite easy to recognize the various parts, and to see that the penial filament is only a specialized portion of the endopodite. In *Ianthe* [16], *Munna* [27, p. 10], *Ichnosoma*, and *Acanthomunna* [9, p. 46] much further modification of the pleopod has taken place, and it is not so easy to see the homologies of the various parts. Thus both Bovallius and Beddard consider the large triangular portion which forms the main part of the pleopod to be the protopodite, and Beddard considers the penial filament to be the endopodite, and the exopodite to be represented by a small membranous portion at its base. Whether this is really so, or whether this view will require modification, is a question that must be left for future determination; but this interpretation of the various parts does not appear to harmonize well with what we find in *Phreatoicus*.

Affinities of Phreatoicus.

Phreatoicus presents so many peculiarities that it is difficult to determine its exact systematic position, and its affinities must therefore be discussed at some length. The following account is partly reproduced from my paper on *Phreatoicus australis* [26], but it has been revised and to some extent made more complete.

When I originally described the genus *Phreatoicus* in 1882 [23], I placed it in the Isopoda, and pointed out various separate resemblances to the Idoteidæ, the Anthuridæ, and the Tanaidæ, and also drew attention to the several resemblances to the Amphipoda; but after doing this I left the exact position of the genus among the other Isopoda an open question for the time. When preparing the "Critical List of the Crustacea Malacostraca of New Zealand" [111, p. 151] Mr. Thomson, judging from the general appearance (he had not had an opportunity of examining specimens), was inclined to place it under the Amphipoda, and, as I did not agree with this opinion, it was arranged that the genus should be placed between the Amphipoda and the Isopoda under a separate heading with the following note:—"The systematic position of this singular Crustacean is doubtful. In general appearance I was inclined to place it among the Amphipoda, but from the fact of the first five pairs of *pleopoda* acting as branchial organs, and from the absence of any such organs attached to the *pereion*, Mr. Chilton places it among the Isopoda.—G. M. T." [111, p. 151].

Unfortunately, however, the separate heading was omitted by some error, probably on the part of the printer, and the genus therefore appears under the last family of the Amphipoda, viz. the Platyscelidæ, as though it belonged to that family. It is no wonder, therefore, that the Rev. T. R. R. Stebbing, in his notice of the "Critical List," says, in speaking of *Phreatoicus*, "I do not know what are the special reasons for classing it among the Platyscelidæ." He also says, "The list [*i. e.* our 'Critical List'] continues with 'Suborder II. ISOPODA. Tribe I. Anisopoda. Fam. I. Tanaidæ;' and probably the affinities of *Phreatoicus* will eventually prove to be rather with the Tanaidæ than with the Hyperina" [108, p. 587]. In another reference to the species *Phreatoicus typicus*, Mr. Stebbing calls it "a singular well-shrimp of a new genus and species, which appears to be an Isopod with some remarkable Amphipodan affinities" [108, p. 543].

At first sight *Phreatoicus* certainly does look very like an Amphipod, but on examination this is found to be due to superficial resemblances only, and not to any real affinity to that group. These resemblances appear to be as follows:—

(1) The body, especially in the pleon, is more or less laterally compressed.

(2) The pleura of the segments of the pleon are produced downwards, so as to protect the pleopoda on either side, just as in the Amphipoda.

(3) The legs of the peræon consist of an anterior series of *four* and a posterior series of *three*.

(4) The general appearance of the legs and of the uropoda is not unlike that common among the Amphipoda.

(5) The pleon is formed of six separate segments, and is better developed than in most Isopoda.

I think these are all the points in which *Phreatoicus* specially resembles the Amphipoda, and an examination of them shows that none is of any particular importance in its bearing on the systematic position of the genus. I will take the points one by one under their appropriate numbers as given above.

(1) Most of the Isopoda are, it is true, more or less dorso-ventrally compressed, and I do not know of any one in which there is any lateral compression as in *Phreatoicus*; but here the lateral compression is not great, and is chiefly confined to the pleon, where the downward prolongation of the pleura is no doubt a special adaptation for the protection of the pleopoda, and may very well have arisen quite independently of the similar adaptation in the Amphipoda. The peræon of *Phreatoicus* is subcylindrical, and thus resembles *Anthura* and *Paranthura*, and other genera of the Anthuridæ [106], and some species of *Idotea*, such as *Idotea elongata* [24, p. 198], in which there is no dorso-ventral compression. On the other hand, lateral compression is by no means universal among the Amphipoda; there are many genera where the body is more or less cylindrical, as in *Caprella* &c., *Corophium*, *Haplocheira*, and many others, while there are also some, such as *Icilius*, *Iphigenia*, and *Cyamus*, in which the body is much flattened, as in most Isopoda.

(2) This point has practically already been disposed of in the consideration of (1), and I need only add that *Phreatoicus* has the pleura of the first *five* segments of the pleon produced downwards, while in the Amphipoda it is only in the first *three* segments that the pleura are so produced.

(3) The division of the appendages of the peræon into an anterior series of four and a posterior series of three has been used by Dana in separating the Anisopoda from the typical Isopoda, and it is by no means a special Amphipodan character. It is, moreover, probably of little importance from a systematic point of view, seeing that it is found in such widely different genera as *Phreatoicus*, *Stenetrium*, *Munnopsis*, *Tanais*, and *Arcturus*, and its adoption as the chief bond of connection between a number of forms results, as Professor Haswell has pointed out, in "an extremely artificial arrangement" [55, p. 10].

(4) The appendages of the peræon appear at first sight undoubtedly Amphipodan, but here, again, a closer examination shows that the resemblance is merely superficial, for in all the legs we find that the *ischium* is fairly long, often as long or even longer than the preceding joint, the *basos*, while in almost all the Amphipoda the ischium is quite short, often transverse. In the possession of moderately long ischia, *Phreatoicus* agrees with most other Isopoda. I am not aware that anyone but myself has drawn attention to this difference between the Isopoda and the Amphipoda; but it appears to be one of very general application, though, of course, there are some exceptions to it as to every other rule in Natural Science. Thus, in the Apseudidæ and the Tanaidæ [106], the ischium is usually short, while in a few cases in the Amphipoda it is long, as in the second gnathopoda of the Lysianassidæ, and also in the second gnathopoda of *Seba* [108, p. 783], and perhaps in a few others. But in all these cases that I know of in the Amphipoda the long ischium is found in one pair of legs only, and I know of no Amphipod that has the ischium in each pair of legs long as in the Isopoda; so that, while the possession of short

ischia would not necessarily prove that the animal is not an Isopod (unless, indeed, we remove the Apseudidæ and the Tanaidæ to the Amphipoda, and this, notwithstanding Gerstaecker's opinion, does not seem to be desirable), the fact that it possesses long ischia in all the appendages of the peræon is a pretty clear indication that it is not an Amphipod.

It may also be pointed out that although the first appendage of the peræon of *Phreatoicus* is subchelate, as in the Amphipoda, the second appendage resembles the third in being quite simple, while in the Amphipoda the second appendage is usually subchelate like the first, or, if not actually subchelate, it shows a greater tendency to resemble the first leg than the third.

(5) In the possession of a long pleon of six separate segments, *Phreatoicus* certainly resembles the Amphipoda, and differs from most Isopods, but the same character is also possessed by the Apseudidæ and the Tanaidæ, and by the genus *Hyssura* [106, p. 128] in the Anthuridæ; and in many other Isopods, such as *Limnoria* and many of the Cymothoidæ, Oniscidæ, &c., the pleon, though not long, is composed of more or less separate segments.

The reasons given above will, I think, be quite sufficient to prove that there are no good grounds for classing *Phreatoicus* with the Amphipoda; for positive evidence that it is an Isopod it will be sufficient to take the following :—

(1) The first five pairs of pleopoda are branchial, and there are no branchial plates attached to the appendages of the peræon. The pleopoda themselves are quite different in form from those of the Amphipoda.

(2) The whole of the mouth-parts are distinctly Isopodan in character, and quite different from those of the Amphipoda.

(3) As shown above, the legs are really Isopodan, though at first sight they may appear to be Amphipodan.

(4) The telson is joined to the sixth segment of the pleon, as is usually the case with the Isopoda, but not with the Amphipoda. It is quite true, as Stebbing [108, p. 549] has pointed out, that this is also the case with certain Amphipoda, the *Hyperina* for example; but this is exceptional, and since *Phreatoicus* is certainly not one of the *Hyperina*, it does not affect the present argument. The large size and the form of the telson itself also clearly mark it off from the Amphipoda.

It will be noticed that, in considering the differences between the Isopoda and Amphipoda, I have confined myself to external characters. Other important differences in the internal anatomy have been pointed out by Blanc [12], but the material at my disposal did not permit of my testing *Phreatoicus* by these points, even if I had possessed the necessary skill to do so.

We have now to compare *Phreatoicus* with the other Isopoda to see what place it should take among them. It will be sufficient if we compare it with the Tanaidæ, Anthuridæ, Idoteidæ, and the Asellidæ.

It agrees with the Tanaidæ in the cylindrical form of the body, in the direction of the legs, and in the possession of a pleon formed of six separate segments. All these characters are, however, separately shared by other groups, and the differences in other respects are very considerable, and we may safely conclude that *Phreatoicus* has no very close affinity with the Tanaidæ.

The Apseudidæ, which rank close to the Tanaidæ, do not seem to present any greater affinity to *Phreatoicus*.

The resemblance of the Anthuridæ is, however, somewhat greater. There is a fairly good general resemblance in the shape of the body and in the legs, and though the pleon is usually short in the Anthuridæ, it is often composed of separate segments, and these may be of fair length, as in the genus *Hyssura*, Norman and Stebbing [106, p. 128]. The mouth-parts are very different, being specially modified in the Anthuridæ for the purpose of suction, and this, combined with differences in the pleopoda, uropoda, &c., is sufficient to make a pretty wide difference between the two.

With the Idoteidæ, *Phreatoicus* agrees in the shape of the body, in the antennæ, and to some extent in the mouth-parts. In the Idoteidæ these are more modified than in *Phreatoicus*, though formed on the same plan, and the mandible has no palp. It is probable, however, that the presence or absence of a mandibular palp is not a point of great systematic importance, for in the Amphipoda we have genera, in other respects closely similar, differing in this point; thus the old genus *Montagua*, Spence Bate, has been divided into *Stenothoë*, in which the mandible has no palp, and *Metopa*, in which the palp is present [108, p. 293]. A much more important difference is found in the structure of the pleon and the uropoda. In the Idoteidæ the segments of the pleon, except the last, are usually very short and more or less coalesced and the uropoda form flat plates covering up the pleopoda. There are, however, sufficient signs that the pleon of Idoteidæ has been derived from a pleon formed of separate segments, and that the uropoda, though now very different, are simply a modified form of the typical uropoda consisting of a peduncle and two rami; and it is quite probable that the special modifications of the Idoteidæ in these respects are of comparative recent date, and that their ancestors presented a much closer resemblance to *Phreatoicus* than the present Idoteidæ do.

The Arcturidæ, again, might be compared with *Phreatoicus* in much the same way, but they present a further resemblance in the legs, which, though very different in form, are very distinctly divided into an anterior series of four and a posterior series of three.

When we come to compare *Phreatoicus* with the Asellidæ we at once see a very great difference in the form of the body, but on closer examination the resemblances are seen to be much more numerous and much closer than might at first sight be expected. The head, antennæ, mouth-parts, and the legs are all in pretty close agreement; the resemblance in the mouth-parts is indeed somewhat striking, and although the legs of the last three pairs are more Amphipodan and flattened, there is a general resemblance in the relative lengths of the different joints to those of *Asellus*. In describing *Phreatoicus australis* I took Sars's description of *Asellus aquaticus* [91, pp. 96–100] as my guide, and was able to follow it pretty closely. The uropoda, again, are not very unlike those of *Asellus*, and the pleopoda of *Phreatoicus* appear to present more resemblances to those of the Asellidæ than to those of any other Isopods that I know. Besides differing very greatly in the shape of the body, *Phreatoicus* differs greatly from the Asellidæ, as from the Idoteidæ, in the structure of the pleon. In the Asellidæ this is short, usually composed of a single flattened piece, and the pleopoda lie horizontally under it, and are protected by a more or less perfect operculum formed of the first pair. In *Phreatoicus* the segments of the pleon are all separate, and the pleopoda hang vertically down, and are not protected below; indeed the shape of the pleon renders protection of the pleopoda below unnecessary.

These differences are pretty considerable and quite enough to show that *Phreatoicus* cannot be placed under the Asellidæ, but they are of such a nature that they do not prevent us from considering that the affinities of *Phreatoicus* are with the Asellidæ. For it is quite clear that the latter must have arisen from ancestors possessing a pleon formed of six separate segments, and that these have gradually coalesced to form a single plate; just as we see the same process going on at the present time in the Idoteidæ, where some species have the pleon formed of four or five segments, others of only two or three, and others, again, like *Idotea elongata*, Miers, with the pleon formed of a single piece [241, p. 198]. The horizontal position of the pleopoda and the development of an operculum from the first pair would naturally follow from the flattening of the body in the Asellidæ, which would otherwise leave the pleopoda much exposed below. Thus *Phreatoicus* appears to differ from the Asellidæ chiefly in having preserved the fully-developed pleon which must have been possessed by the ancestors of the Asellide, while in the latter this has been specially modified in accordance with the general flattening of the body, which would render a long-jointed pleon unsuitable and a source of danger to the animal, especially by the exposure to which it would subject the pleopoda. The flattening of the body in the Asellidæ would naturally follow as the result of their adopting a creeping mode of life; *Phreatoicus* walks erect or swims much in the same way as the Amphipoda.

There is one genus, *Limnoria*, formerly classed with the Asellidæ, which differs from them and resembles *Phreatoicus* in having the pleon composed of six separate segments with the pleopoda unprotected. *Limnoria*, however, resembles the normal Asellidæ in the flat depressed body, and the segments of the pleon, though separate, are short, and it may perhaps be looked upon as an approach toward the ancestral form of the Asellidæ, though its structure has been modified to some extent to suit its mode of life; thus the antennæ are very short, and the legs are short and perhaps little used for walking, and the mouth-parts are somewhat modified. Unfortunately, I do not know sufficient of the pleopoda of *Limnoria* to compare them with those of *Asellus* and *Phreatoicus*, but from the other resemblances we may with good reason look upon *Limnoria* as an intermediate link, to some extent connecting *Phreatoicus* with the Asellidæ. The very great difference in appearance between the two latter is due to the fact that the body of the Asellidæ is flat, depressed, and the animals are therefore represented as seen from above, while, owing to its body being somewhat laterally compressed, *Phreatoicus* is usually seen in side view. This difference in the form of the body is, however, probably not of much importance from a systematic point of view, for we have great differences in this respect in species of *Idotea* and in some of the Cymothoidæ, and, on the whole, I think we must place *Phreatoicus* somewhere near to the Asellidæ, but forming a separate family, the Phreatoicidæ, which bears to the Asellidæ somewhat the same relation that the Caprellidæ do to the Cyamidæ in the Amphipoda. *Limnoria* may perhaps be placed, as is done by many authors, in a separate family, the Limnoriidæ, possessing some of the ancestral characters of the Asellidæ, and thus approaching nearer to the Phreatoicidæ. Gerstaecker puts *Limnoria* under the Sphæronidæ, but forming a separate section, the *Limnorina* [45, p. 220].

From what has been already said it will be seen that *Phreatoicus* occupies a fairly central position among the Isopoda, retaining to a greater extent than any others the typical characters of the Isopoda.

The following are the characters which I have provisionally advanced for the new family Phreatoicidæ. These are simply given for the sake of comparison, and will no doubt require revision when other forms allied to *Phreatoicus* are discovered :—

Family PHREATOICIDÆ.

"Body subcylindrical, more or less laterally compressed. Mandibles with a well-developed appendage. Legs distinctly divided into an anterior series of four and a posterior series of three. Pleopoda broad and foliaceous and branchial in function, but not protected by an operculum. Pleon* large, of six distinct segments. Uropoda styliform." [26, p. 151.]

Family ANTHURIDÆ.

Genus Cruregens, Chilton.

(Transactions New Zealand Institute, vol. xiv. p. 175.)

The following characters were assigned to this genus when I originally described it :— "Body subcylindrical. Head small. First six thoracic segments subequal, the seventh *small and without appendages.* Antennæ subequal, neither having a flagellum. First pair of thoracic legs large and subchelate, the second and third subchelate but smaller; the three posterior pairs simple. First pair of abdominal appendages forming an operculum enclosing the branchial plates, last pair biramous. Telson squamiform."

It is scarcely necessary to explain that the above description was drawn up by a tyro in the study of the Crustacea, and that though modelled on the descriptions given by others of allied genera, it contains much that is unnecessary and little that is essential.

The genus appears to fall under Norman and Stebbing's [106] "Section B," though the mouth-parts are even more modified than in the species assigned to this section by these authors. The following generic diagnosis may be given for the sake of comparison

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* I have substituted "pleon" for "abdomen," which I had inadvertently put in my original diagnosis.

with Norman and Stebbing's descriptions; but even this must be considered merely provisional, as only the one species is known, and nothing is known of the distinctive characters of the two sexes:—

Eyes wanting. Segments of the pleon separate (in both sexes?). Both pairs of antennæ without distinct flagella (in adults?). Mandibles without palp. Maxillipedes not divided into separate joints. Last segment of the peræon small and without appendages (in adults?).

All the specimens that I have seen, many scores in number, agree in having the seventh segment of the peræon small and without appendages; but as I have never seen a specimen that I could be certain was sexually mature, I am doubtful whether this character would hold in the adult also or not. My specimens have been obtained from several wells in different localities, and were collected at different times during a period of about ten years, and it seems scarcely likely that all the specimens should be immature, and that during the whole time not a single mature specimen should be obtained, unless, indeed, the adult differs from the immature form in habits in such a way as to prevent it being liable to be drawn up by the pump. I have one specimen that has the integument of the under surface of the peræon much expanded, somewhat in the same way as shown by Stebbing in his figure of the "gravid female" of *Paranthura nigro-punctata* [106, pl. xxvi. fig. ii. D, ♀]; but in my specimen I can discover no trace of eggs or young, and it appears to be the integument itself that is distended, and not a pouch formed by brood-plates attached to the bases of the legs in the usual way; so that I am uncertain whether this specimen is really an adult female or is abnormal in some way, owing perhaps to half-completed ecdysis or some similar cause.

All this uncertainty makes comparison of *Cruregens* with other genera of the Anthuridæ a very difficult task, but it appears to approach to *Paranthura* more nearly than to any other. It resembles this genus generally in the antennæ (leaving out of consideration the special brush-like antenna of the adult male in *Paranthura*), in the peræon and its appendages, and in the pleon and the pleopoda, though the uropoda are much more slender in *Cruregens*. It differs, however, in the mouth-parts, for the mandibles have no palp and the maxillipedes have lost all trace of separate joints. If the absence of the seventh pair of legs is a character that holds in adults, this would form another difference between the two genera.

It is to be noted that the seventh pair of legs appears to be developed at a later period of the life-history in the Anthuridæ than in other Isopoda, for specimens without them, but apparently mature in other respects, are not infrequently met with. Besides *Cruregens* we have the following examples:—*Hyssura producta* is founded on a single specimen about a quarter of an inch long, of which Stebbing and Norman say "the last segment of the peræon in the type specimen has no legs, nor can we see any sign of scars where they would have been attached, and the specimen was otherwise quite perfect" [106, p. 128]; *Paranthura neglecta*, Beddard, is said to have the seventh segment of the peræon absent, the specimen is 6 millim. long, and from the absence of the last pair of legs Beddard considers it to be immature, though he does not mention any other point of immaturity about it [9, p. 114]; I have also a small specimen of an Anthurid from Port

Jackson, probably *Paranthura australis*, Haswell, which has only six pairs of legs, the seventh segment of the peræon being small and without appendages, as in *Cruregens*; my specimen is, however, only 3·5 millim. long, and is evidently immature.

Cruregens fontanus, Chilton. (Pl. XIX. figs. 1–22.)

Cruregens fontanus, Chilton, New Zealand Journal of Science, vol. i. p. 44 (January 1882); id. Transactions New Zealand Institute, vol. xiv. p. 175, pl. x. figs. 1–12; id. ibid. vol. xv. p. 88; Humbert, Archives des Sciences physiques et naturelles, t. viii. p. 256 (September 1882); Chilton, New Zealand Journal of Science, ii. p. 89 (March 1884); Thomson & Chilton, Transactions New Zealand Institute, vol. xviii. p. 152; Moniez, "Faune des Eaux souterraines du Département du Nord &c.," extrait de la Revue Biologique du Nord de la France, tome i. (1888–89) p. 53.

Specific diagnosis. No trace of eyes. Antennæ subequal, upper slightly shorter than the lower, and with four joints; lower with the third joint only half as long as the fourth. First pair of legs with powerful subchelate hand; propodos triangular, broadest at base palm straight, armed with two rows of setæ. Uropoda slender, inner branch narrow, almost rod-like, not enclosing the end of the pleon. Telson linguiform, extremity tipped with three or four short setæ.

Colour translucent, slightly yellowish, owing to the liver-tubes showing through the transparent integument.

Length of largest specimens about 12 mm.

Habitat. Eyreton, North Canterbury (*Chilton*); Leeston (*R. M. Laing*); Winchester, South Canterbury (*D. L. Inwood*) (in wells).

Detailed Description.

The following detailed description is derived from the comparison and examination of a considerable number of specimens. I can detect no differences between the specimens from the various localities mentioned above.

Body (fig. 1). The body is cylindrical throughout; the head is slightly flattened vertically and is smaller than the first segment of the peræon. The first segment of the peræon is rather shorter than the second and is rather loosely articulated to it, the body being narrowed at this point, thus allowing free movement between the two; the second segment is in the same way loosely articulated to the third, though not quite to the same extent; the third, fourth, fifth, and sixth segments subequal, about as long as the second, oblong in outline as seen in dorsal view, about half as long again as broad, and firmly articulated together, the body not being narrowed at the articulations; the seventh segment is small, only about one-third as long as the sixth, and bears no appendages.

Pleon (fig. 20). The pleon to the end of the telson is rather longer than the sixth and seventh segments of the peræon. The first segment is longer than the succeeding, the second, third, and fourth are subequal, the fifth longer than the first; each of these five segments quite separate and bearing a seta on each side; the sixth segment is longer than the fifth, widest in the centre, where its posterior margin is deeply cleft, and in a dorsal view it does not extend quite to the sides of the pleon. It is apparently clearly divided off from the telson, although this seems to be very exceptional in the Isopoda.

The surface of the whole body is smooth and bears a few short separate setæ scattered over it, especially on the dorsal surface.

The *upper antennæ* (figs. 2, 3) are rather shorter than the lower; peduncle of three joints: first joint the largest, with an "auditory seta" on its outer margin and one or two simple setæ at the extremity; second joint about two-thirds the length of the first and narrower, with two "auditory setæ" and one or two simple setæ at the extremity; third joint longer than the second, nearly as long as the first, extremity bearing simple setæ and one auditory seta. The remaining portion of the antenna appears to represent the flagellum; it consists of one very short, indistinct joint, followed by one as long as the second joint of the peduncle; this joint bears at its extremity a few simple setæ and about four or five "olfactory cylinders"; it is followed by two or three very minute joints, of which the first bears an "olfactory cylinder" and the last ends in a small pencil of three very long simple setæ.

The *lower antennæ* (figs. 2, 4, 5) have the first joint very small, nearly rectangular, broader than long; this joint can be seen only when the antenna is viewed from below, as in fig. 5; it is quite concealed in a view from above by the base of the upper antennæ. The second joint is large and broad, considerably longer than the first joint of the upper antennæ, which rests on the top of it in an oblique groove; it bears a minute seta at the extremity on the inner side. The third joint is short, narrow at the base, more or less geniculate with the first, and bears one or two minute setæ at the extremity on the inner side. The fourth joint is twice as long as the third; it bears several long setæ at the extremity and one or two small ones on the inner margin. The fifth joint is rather longer than the fourth, but slightly narrower; at the extremity it bears several simple setæ, some of them very long, and three "auditory setæ." The remaining part of the antenna may by analogy be considered as the flagellum; it consists of one joint about as long as the second joint of the peduncle, and at its extremity a minute joint ending in a pencil of long setæ.

Mouth-parts. The mouth of *Cruregens fontanus*, like that of other Anthuridæ, is adapted for suction. It is situated near the anterior end of the head, and the various parts project forwards and can usually be seen in a dorsal view between the bases of the antennæ. To form the sucking-apparatus the various parts are much modified, and have coalesced to such an extent that I have found considerable difficulty in determining the homologies of all the parts. My difficulty has been increased by the want of the necessary works of reference. Spence Bate and Westwood give very little information on the subject in their 'British Sessile-eyed Crustacea' [4]. Norman and Stebbing [106], in their account of the "Isopoda of the 'Lightning,' 'Porcupine,' and 'Valorous' Expeditions," supply figures of the mouth-parts of some of the Anthuridæ, but, unfortunately, they give no description beyond the brief accounts comprised in the generic diagnoses. I regret that I have not been able to consult

Schiödte's paper on the mouth-parts of *Cyathura carinata* referred to by Norman and Stebbing *. I have consulted Dohrn's paper on *Paranthura costana* [36] with much benefit. *Cruregens*, however, differs from all other Anthuridæ that I know in having the mandibles entirely without palps, and the mouth-parts seem more specialized than in other species.

The projecting tube formed by the mouth-parts is closed above by the *upper lip* (fig. 6), which projects downward and forward from below the bases of the lower antennæ. It consists of a triangular plate with doubly-curving sides and an acute extremity, which is chitinous throughout and seems very hard and strong. The sides of the tubes are enclosed by the greatly modified *mandibles* (fig. 7) and by the distal portions of the much simplified *maxillipedes*, which also form the covering for the tube below. The mandibles, which show no sign whatever of a palp, appear more or less completely ankylosed to the wall of the head and almost incapable of independent movement. Fig. 8 is a view of them from below and partly from the side, to show how they are attached to the ends of the maxillipedes and form the covering on the sides between them and the upper lip. The mandibles are subtriangular, running out to a sharp point distally; the distal portion bears on the inside a thin chitinous plate with rounded margin, which is very thin and sharp, and perhaps acts as a lancet or cutting-organ of some kind.

Within the tube of the mouth, enclosed as above described, we should expect to find a lower lip and two pairs of maxillæ. Fig. 12 represents what I suppose to be the *lower lip*; it consists of an oblong plate narrowed at the base, with the distal extremity truncate, the corners being rounded off and the extremity fringed with a few fine setæ directed forward. The margins appear to be curled in or thickened, and the centre is strengthened by a thickening which extends distally from the narrow base and gradually thins out. The *first maxillæ* (figs. 9, 10) are easily recognized and are of the form usual in this section of the Anthuridæ; they are very long, extending back at the base nearly to the posterior end of the head; each consists of a long, slightly curving, and gradually tapering shaft, which bears at the extremity on the outside a fine saw-like edge made up of a number of sharp teeth; on the opposite side is a thin flange curving out from the maxilla and having a very sharp razor-like edge. The maxilla is acutely pointed at the extremity: at the base it is jointed on to a short chitinous piece, which is again jointed on to a curving transverse bar; to the distal end of the first piece is attached the tendon of a strong muscle, by the contraction of which the maxilla is protruded, while it is drawn back again by muscles attached to the base of the maxilla itself; possibly also the maxilla can be somewhat rotated on its base so as to bring the two saw-like edges together. In any case they evidently form most efficient lancet-like organs. It appears probable from Dohrn's figure [36, pl. ix. fig. 8] that at the base of the first maxilla of *Paranthura costana* there is an apparatus similar to that here described, but his figure is not very clear and shows the transverse bar as though continuous with the maxilla itself.

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* "Krebsdyrenes Sugemund," Naturhistorisk Tidsskrift 3 R. 10 B. (1875), p. 211, tab. iv.

I have not been able to make out the *second maxillæ* quite satisfactorily, for they seem to be closely connected at the base with the part I have considered the lower lip, and it is difficult to separate the two without injuring them; the first maxillæ are not connected with these, simply working between them and being articulated to the head much posteriorly. Usually the lower lip and second maxilla come away together and then present the appearance shown in fig. 11; this evidently corresponds to Dohrn's "fig. 9," which he calls the "Verwachsenes zweites Maxillenpaar (?)"; but in the species he describes the central portion (lower lip ?) is deeply cleft, while it is not so in *Cruregens*. In this figure 11 the base of the second maxilla can be seen as a strongly curving bar proceeding from a central portion that lies just along the base of the lower lip, and is perhaps joined to it; on each side this bar afterwards curves inward and ends in an expanded distal portion bearing numerous fine setæ. The whole of this end is soft and delicate; it is difficult to make out its exact form, but it appears to widen out vertically, and probably helps to close in the sides of the suctorial tube formed by the mouth (see fig. 13).

The *maxillipedes* (fig. 14) have the basal portion completely ankylosed to the underside of the head; about the middle there is a small and chitinous plate similar to that figured by Dohrn in *Paranthura costana* and by Norman and Stebbing in *Anthelura elongata* [106, pl. xxv. fig. 1, C, L]. In the latter species the corresponding plate is slightly pointed at the extremity, and is situated nearer the posterior end of the head, at the base of the maxillipedes. Hence it appears probable that this plate represents the large chitinous plate found in *Phreatoicus*, the Idoteidæ, Asellidæ, &c., and is therefore the epipodite. In *Cruregens*, however, this plate is situated much further from the posterior margin of the head, and the remainder of the maxillipede has been so modified that all trace of its separate joints has been lost. Anteriorly from this the two maxillipedes are contiguous for a short distance, but then rapidly separate, a seta being placed in the middle of the inner concave margin. The extremity narrows nearly to a point, and has at the end a very small terminal joint bearing a number of rather long setæ, one or two others being situated on the outer edge at a little distance from the extremity.

The *first pair of legs* (figs. 15, 16) forms powerful subchelate claws, which can be extended considerably beyond the head and even beyond the ends of the antennæ. The coxa is indistinguishable and appears completely ankylosed to the body-segment. The basos is narrow at the base and rapidly widens out to its greatest breadth at the middle, where the breadth is rather more than one-third of the length; it narrows again slightly towards the distal end; the posterior margin is regularly arched, the anterior sinuous; near the base there are two rather long "auditory setæ." The ischium is equal in length to the basos and is similar in form; the posterior margin is convex and bears four small spinules; the anterior side is hollowed out into a longitudinal groove to receive the rest of the limb when bent back upon it. The meros is short, transverse; at its junction with the ischium it is narrow, but it rapidly widens out, forming anteriorly an oval lobe, which bears at the end a few small setæ; the posterior margin is straight, lies in the same line as that of the ischium, and bears two setæ at the extremity. The carpus is small, subrectangular, and is surrounded by the propodos, except on the posterior side, where it is produced at the extremity into a small rounded lobe bearing a few long setæ and covered with a thick fur of very short setæ. The propodos is very large, about as long as the three preceding joints together; it is subtriangular, widest towards the base, where it is more than half as broad as long; the anterior margin is very convex and bears no setæ except a small one at the base of the dactylos; the posterior margin is straight and is produced along the end of the carpus into a small rounded lobe; all the rest forms a rather broad palm, fringed throughout its whole length on the outside with a row of serrated setæ of fair length, one or two of these being considerably longer than the others, and two or three long ones being situated at the extremity. The dactylos is as long as the propodos, is considerably curved, and tapers gradually to the acute extremity; the inner margin bears about 15 minute spinules at regular distances; the tip is brown in colour, but is otherwise not clearly marked off into a distinct unguis.

When the limb is seen from the inner side (fig. III. *p*) only a triangular portion of the carpus is seen, the rest being overlapped by the propodos. The inner margin of the palm appears slightly convex and is fringed with a thick row of setæ, which appear simple and are much more numerous than those in the row on the outer margin. At the base this row leaves the margin of the propodos, and curves along the side, thus marking the place where the tip of the dactylos overlaps the propodos.

The *second pair of legs* (figs. 17, 18) is slender and subchelate. The basos is longer than the ischium, narrow at the base, widening distally, greatest breadth rather more than one-fifth the length; two "auditory setæ" near the base as in the first pair of legs, both margins with a few small spinules. The ischium is similar in shape to the basos, widest at the middle, where the breadth is about one-fourth the length, narrowing toward both ends, a few spinules on each margin. The meros is triangular, very narrow at the base; posterior margin straight, with two or three long setæ at the extremity; antero-distal angle produced and tipped with two setæ. The carpus is small, with three setæ at the extremity of the posterior margin; the junction with the propodos oblique. The propodos is narrow ovate, as long as the ischium, length about two and a half times the greatest breadth; anterior margin convex, with a few small setæ, and at the base of the dactylos a small group of two longer ones and an "auditory seta"; the palm occupying about two-thirds the posterior margin, not clearly defined, slightly convex, armed with about eight stout setæ, each bearing a subapical hair and being serrate on the opposite side; besides these there are also a few simple setæ. The dactylos is slightly curved, fitting closely on to the palm; inner margin with a few minute spinules, and towards the end one or two small setæ marking off the terminal unguis.

The *third pair of legs* is similar to the second in size and form.

The *fourth pair of legs* (fig. 19) is about as long as the third, but they are simple and not subchelate. The basos and ischium are similar to those of the second and third pairs, but the basos is a little more widened in the centre and bears three "auditory setæ." The meros is rather more than half as long as the ischium, triangular, narrow at the base; anterior margin straight, with a seta about the middle and two longer ones at the extremity; posterior margin slightly convex, somewhat produced distally, and bearing at the end three or four setæ. The carpus is rather longer than the meros, oblong; the anterior margin with three spiniform setæ and two or three simple setæ at the end; the posterior margin straight, with a few simple setæ, and in the middle a long "auditory seta." The propodos is similar to the carpus, but considerably longer; the anterior margin armed with four or five spiniform setæ and a few simple ones, the posterior margin having at the extremity a group of two or three simple setæ and one "auditory seta." The dactylos is similar to that of the third pair of legs. The spiniform setæ on the anterior margins of the carpus and propodos are similar to those on the palms of the second and third pairs of legs, but are smaller and not quite so well marked.

The *fifth* and *sixth pairs of legs* are similar to the fourth, but may sometimes be a little longer.

The *seventh pair of legs* is entirely absent in all the specimens that I have examined.

The *first pleopoda* (fig. 21) form an operculum completely closing in the branchial plates below. The protopodite appears to consist of two joints, a very short coxa, and a rectangular basos, which is broader than long, and bears on the inner margin three stout setæ, dentate at the extremity; these appear to act like the "coupling-spines" to which Stebbing has drawn special attention in the Amphipoda. The exopodite which forms the operculum is an oval plate bulging downward; it is about twice as long as broad, its inner margin nearly straight, outer margin very convex, bearing on the distal half about six very delicate plumose setæ, with three or four shorter ones at the extremity. The endopodite is narrow styliform, slightly enlarged at the base, somewhat sinuous, sides parallel, extremity rounded and tipped with three or four plumose setæ.

The *second, third, fourth,* and *fifth pleopoda* (fig. 22) are all alike and of the usual form. Each consists of a short transverse protopodite, an oval endopodite well rounded at the end and with the margins free from setæ, and a longer and rather narrower expodite, which is slightly constricted on the outer margin toward the extremity; the margin is rather irregular, and bears a few finely plumose setæ on the inner side and at the end, with sometimes one on the outer side. The number of these setæ appears to vary somewhat in the different pleopoda, but I have not noticed any other differences between them.

I have not hitherto met with any special modification of the pleopoda of the male like that occurring in the Asellidæ, &c., and do not know whether such a peculiarity has been recorded in the Anthuridæ.

The *uropoda* (fig. 23) are articulated to the end of the sixth segment of the pleon. The basal portion or peduncle is large, flat, and nearly rectangular, and reaches nearly to the end of the telson; it is about two and a half times as long as broad; the outer margin is straight and bears a few setæ on the distal half; the inner portion extends as a flat plate to the median line of the body, the right or the left uropods often having their inner margins in contact below the telson; the inner distal angle bears a single small seta. The endopodite is articulated to the posterior margin of the peduncle on its outer half; it is oblong, more than three times as long as broad, extremity rounded, the end and the two margins being fringed with long setæ, which are thickest and longest at the extremity;

these setæ appear to be simple, but among them are two small groups, each containing two "auditory setæ." The expodite is articulated to the dorsal and outer surface of the peduncle near its anterior end: it is slender, and consists of a thin rod or narrow plate, a little deeper than broad, and shows no tendency to enclose the hinder end of the pleon as in *Anthura*, &c.; it reaches slightly beyond the extremity of the peduncle, and has its upper and lower margins and the extremity fringed with setæ, those at the end being the longest.

The *telson* (see fig. 20) is slightly longer than all the preceding part of the pleon; it is squamiform, rather more than half as broad as long, the distal portion ovate, the extremity tipped with five or six small setæ.

The telson is distinctly separated from the sixth segment of the pleon, a very unusual feature in the Isopoda, which generally have the sixth segment of the pleon and the telson confluent; this character is, in fact, so constant that it is given by Blanc [12] as one of the points of difference between the Isopoda and the Amphipoda. Most authors have drawn the telson of *Anthura* and other species as separate from the sixth segment of the pleon, but I am not aware that anyone has drawn special attention to this unusual character.

It will be seen that I have described the uropoda as consisting of a peduncle and two branches, each consisting of a single joint, whilst most authors have described the inner branch as *two*-jointed, considering the part I have taken as the flagellum to be the first joint of the endopodite. If the endopodite were really two-jointed it would be an exception from all other Isopods. It may consist of several joints in the Tanaidæ and the Apseudidæ, which differ in several well-marked features from the Isopods, but in all others, so far as my knowledge goes, the endopodite never consists of more than a single joint. The interpretation of the uropod that I have given is certainly correct for *Cruregens*, for in this genus the exopodite can be plainly seen to be articulated to the dorsal side of the peduncle, and the peduncle is quite continuous past the base of the exopodite to its junction with the sixth segment of the pleon; this can be seen both above and still more easily below. In most other species of the Anthuridæ the exopodite is broad and its articulation extends right across the peduncle, thus concealing its true nature. Gerstaecker [45, pl. xiv. fig. 26] certainly figures the uropod of *Paranthura costana*, Sp. Bate, with a short separate peduncle bearing two branches, one of which is *two*-jointed; but his figure is not very clear, and I think he has probably been misled in the way suggested above. Dohrn [36], dealing with the same species, interprets the uropod in the same way that I have done, and as I had formed my own conclusion before consulting Dohrn's paper, I was particularly pleased to find my opinion confirmed by him. This portion of his paper appears to have been overlooked by systematic writers on the Anthuridæ. The great enlargement and elongation of the peduncle in *Cruregens*, *Anthuria*, &c., are only exaggerations of what we find in most of the Oniscidæ, where the two rami are widely separated; and in *Hyssura*, Norman and Stebbing [106, pp. 128, 129, pl. xxv. fig. v.), we have evidently an intermediate form where the peduncle is quite short and the two rami therefore much more closely approximated at their bases. Even in this genus, however, Stebbing and Norman speak of the endopodite as *two*-

jointed, though according to their figure their "first joint" of the endopodite is quite continuous with the true peduncle and evidently a part of it.

Gerstaecker considers the branch I have described as the *exopodite* to be the *endopodite* or inner branch; and in this he may perhaps be right, though without an appeal to embryology there seems to me little to help us to decide which is the exopodite and which the endopodite, and I have therefore followed the majority of authors. In *Hyssura* as figured by Stebbing the shorter branch certainly appears to be the *endopodite*; but this may be apparent only, and due to the fact that in the figure the animal is "viewed dorso-laterally" [106, pl. xxv. fig. v. *Pl.*].

AMPHIPODA.

Genus Crangonyx, Spence Bate.

(British Sessile-eyed Crustacea, vol. i. p. 326.)

The following is the definition given by Spence Bate when establishing this genus:— "Superior antennæ having a secondary appendage. First pair of gnathopoda rather larger than the second. Posterior pair of pleopoda unibranched, not longer than the preceding pair. Telson single, entire."

In his subsequent explanation he gives the additional information that the eyes are imperfectly developed, that the superior antennæ are not much longer than the inferior, but rather more robust, and that the first two pairs of legs are small, rather unequal in size, and subchelate.

Numerous species belonging to this genus have been described by Packard, O. P. Hay, S. I. Smith, Grube, &c., but, so far as I am aware, no one has revised the characters of the genus, although it is evident that this must be done before it can be made to suit all the species that have been assigned to it. The genus *Stygobromus*, Cope [30], is considered by S. I. Smith [104] to be equivalent to *Crangonyx*; but Cope's description is very imperfect, and does not in any way add to our knowledge of the genus. Wrześniowski points out that no description of the mouth-parts of *Crangonyx* is known to him [124, p. 635]. I am able to give below some account of the mouth-parts of *Crangonyx compactus*; and from this it will be seen that in the mouth-parts the genus approaches very closely to *Niphargus*, which it resembles also in many other points, such as in the antennæ, the gnathopoda, and the uropoda. Although Spence Bate described the terminal pair of uropoda as *uni*branched, the inner ramus is really present in *C. gracilis* and *C. compactus*, and probably in others, though it is rudimentary as in *Niphargus*. It appears, however, that there is a great amount of variation in the development of the terminal uropoda in different species; this has been pointed out by O. P. Hay, who shows the transition in three species as follows:—

C. gracilis has the outer ramus of the third uropoda twice as long as the peduncle, the inner ramus present, but rudimentary.

C. bifurcus has the outer ramus of the third uropoda two-thirds the length of the peduncle, while it is doubtful whether there is anything to represent the inner ramus.

C. lucifugus has both rami absent and the peduncle itself reduced [56, pp. 143–146].

This variability of the third uropoda is only what we might have expected from the affinity of the genus to *Niphargus*, where the third uropoda are also very variable, differing in length in the two sexes, and often being greatly elongated. Although *Crangonyx* evidently comes very close to *Niphargus*, it appears to be a good genus, and to differ constantly from *Niphargus* in the more robust body and in the telson, which is always entire and never cleft as in *Niphargus*. This difference in the telson is very striking, and is somewhat remarkable, as it appears to give us some insight to the direction that the development of the telson has taken in this group; for if we are to look upon *Gammarus* as representing one of the older types among the Amphipoda, as suggested by Stebbing [108, p. xvi], from which *Niphargus* and *Crangonyx* have successively developed, then it is evident that the development must have been from the double telson of *Gammarus* to the deeply-cleft telson of *Niphargus*, and then to the single entire telson of *Crangonyx*. Considerations such as these naturally give rise to the questions:—What is the use of the telson? and why is it double in some species, deeply cleft in others, and entire in others again? But in propounding such questions we only draw attention to our ignorance, and a much more complete knowledge of the habits of these animals must be gained before we can hope to give any solution. In *Crangonyx mucronatus*, Forbes, which Packard leaves in the genus *Crangonyx*, though the species is, he says, perhaps entitled to rank as the type of a new genus, there appears to be a great difference between the male and the female in the development of the telson. Forbes thus describes the two:—

"The telson of the male is a smooth cylindrical appendage, usually about as long as the first three abdominal segments, and as large as the last joint of the pedicel of the lower antenna. It presents a very slight double curve, is obliquely rounded at the end, and tipped by a cluster of short hairs. In some cases this appendage is half as long as the body. . . . . . In the female this (the telson) is very similar to the telson of *C. gracilis*, Smith. It is flattened and slightly emarginate, a little longer than broad, extending to the tips of the second pair of anal legs, and bears two terminal clusters of spines of four or five each." Quoted from Packard [83, pp. 37, 38].

I am not aware of any other species of *Niphargus* or *Crangonyx* in which there is a difference between the sexes in the telson, and a cylindrical telson half as long as the animal is so remarkable that I was at first almost inclined to suspect some mistake; but specimens lately received from Mr. W. P. Hay, of Irvington, Indiana, agree in all respects with Mr. Forbes's description; but, as he points out, there can be little doubt that the species should form the type of a separate genus distinct from *Crangonyx*.

The species that I have to describe, *Crangonyx compactus*, is remarkable in that the three pairs of pleopoda have each only *one* branch instead of *two*, as in almost all Amphipoda, the inner branch being apparently the one that is absent. These examples are sufficient to show how imperfect our knowledge of the Amphipoda still is, and what startling variations may be found when least expected.

It would be interesting to know whether the other species of *Crangonyx* agree with

C. compactus in the possession of *single*-branched pleopoda, or whether they have normal pleopoda with two branches *. Unfortunately, the pleopoda are usually neglected in the brief descriptions given of new species, and are seldom referred to even in more elaborate descriptions; this is, of course, due to the fact that the pleopoda are less subject to variation than most organs of the Amphipoda. To such a degree is this the case that Fritz Müller speaks of them as being "reproduced in wearisome uniformity throughout the entire order" [79, p. 15, footnote]. Stebbing [108, p. 350] has, however, pointed out that this statement is somewhat overdrawn, and has perhaps had the disadvantageous tendency of discouraging the examination of these organs.

Wrześniowski [124, p. 634] remarks that there is much variation in the degree of development of the eyes in the different species of *Crangonyx*, some being described as without eyes, others having more or less perfectly developed eyes. I had originally stated that I could find no eyes in *Crangonyx compactus*; I find, however, that they are represented by two or three small lenses, which, however, do not appear to be furnished with any pigment, and are probably useless so far as sight is concerned.

As I have examined only the one species belonging to the genus, and as the descriptions of other species to which I have access do not give much information on the details of their structure, I have not attempted to revise the characters of the genus, but must leave that for some one with a wider knowledge of the subject. It will be sufficient for the present to repeat that the genus appears to differ from *Niphargus* in the more robust body, in the last pair of uropoda, and in the single uncleft telson.

CRANGONYX COMPACTUS, Chilton. (Pl. XX. figs. 1–30.)

Crangonyx compactus, Chilton, New Zealand Journal of Science, vol. i. (March 1882) p. 44; id. Transactions New Zealand Institute, vol. xiv. p. 177, plate x. figs. 13 to 19; Thomson & Chilton, Transactions New Zealand Institute, vol. xviii. p. 147; Moniez, "Faune des Eaux souterraines du Département du Nord &c.," extrait de la Revue Biologique du Nord de la France, tome i. (1888–1889) p. 50; Wrześniowski, 'O trzech kiełzach podziemnych,' De tribus Crustaceis Amphipodis subterraneis, pp. 16, 41, 90; Wrześniowski, "Ueber drei unterirdische Gammariden," Zeitschrift für wissenschaftliche Zoologie, L. 4, pp. 611, 634, 698.

Specific diagnosis. Eyes small, without pigment, consisting of two or three imperfect lenses only. Upper antennæ about one-third the length of the body; first joint of peduncle much larger than the second; flagellum longer than the peduncle; secondary appendage small and slender, consisting of one long and one short joint. Peduncle of lower antennæ longer than peduncle of upper; flagellum shorter than the last joint of peduncle, consisting of four joints. Gnathopoda subequal, propodos of each only slightly broader than the carpus; palm about one-half the length of the inferior edge, defined by a stout spine on each side. Peræopoda subequal, the last three pairs having the basi narrow, not expanded as usual. Inferior edge of the three anterior segments of the pleon furnished with five or six small setæ. The three pairs of pleopoda *one*-branched. The uropoda short and broad, the third pair with the outer branch about

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* In both *C. gracilis*, Smith, and *C. mucronatus*, Forbes, specimens of which have recently been sent to me by Mr. W. P. Hay, the pleopoda have the normal *two* branches.

three times as long as the peduncle, the inner branch rudimentary. Telson about half as long as the terminal uropoda, narrowing slightly towards the extremity, which bears two stout setæ.

Colour. White, semi-transparent.

Length. About 8 mm.

Habitat. Eyreton (*Chilton*) and Leeston (*R. M. Laing*); Canterbury (in wells).

Remarks. Moniez says [78, p. 50] that this species differs little from *Crangonyx subterraneus*, Spence Bate. Bate's description of that species is, however, not sufficiently detailed to allow of a comparison of any value between the two.

Detailed Description.

Body (Pl. XX. fig. 1.). The body is rather stout and deep, especially in the pleon. The side-plates (*coxæ*) are about half as deep as their respective segments, and are all nearly equal in size. The head is as long as the first segment of the peræon; segments of peræon subequal, the posterior ones a little longer than those preceding them. First three segments of the pleon subequal, a little longer than the last segment of the peræon, about twice as deep as long; inferior margin of each segment slightly convex and furnished with four or five setæ, arranged chiefly towards the anterior end; last three segments of the pleon very short.

Eyes rudimentary, represented by two or three imperfect lenses without pigment.

Upper antennæ (figs. 2 & 3) considerably longer than the lower, about one-third the length of the body; peduncle slightly shorter than the flagellum; first joint nearly as long as the second and third together, upper margin straight and furnished with a few minute spinules, lower surface grooved, bearing on the inner margin three stout setæ, the third being at the distal end, the outer margin without setæ, winged, produced downwards at the base, where it is slightly convex; the second joint half as long again as the third, a few fine setæ on both upper and lower margins, those at the extremity being longest and most numerous; third joint similar to the second except in size. Secondary appendage small, reaching to about the end of the second joint of the main flagellum, consisting of two joints, the first as long as the first joint of the flagellum but very slender, bearing ordinary setæ; the second small, bearing ordinary setæ and a minute olfactory cylinder at the extremity. Flagellum consisting of about thirteen joints, those at the base nearly as broad as long, the others becoming more and more slender, each joint from the second onwards bearing on the lower side of the distal extremity two olfactory cylinders nearly as long as the succeeding joint, and two small tufts of ordinary setæ, one above, the other below.

Lower antennæ (fig. 4) having the first two joints very short, the gland-cone arising from the second joint being very long and reaching nearly to the end of the lower margin of the third joint; third joint subquadrangular, with two stout setæ in the middle of the upper margin and one long simple seta at the extremity of the lower margin; fourth joint only half as broad as the third, upper margin bearing a stout seta near the base, followed by two or three slender setæ, lower margin with three oblique rows of setæ, each containing four or five, the lateral surface of the joint also bearing two or three small tufts of setæ; the fifth joint is as long as the fourth, but rather more slender, armed with setæ in a similar way to the fourth, but with more numerous tufts; the flagellum shorter than the fifth joint, consisting of five joints, of which the first is the longest; the articulations between the joints are oblique, and each bears at the extremity a row of four or five small setæ, and there is another row of four or five rather longer setæ on the lower margin towards the extremity.

The *upper lip* (fig. 5) is rather delicate, broader than long, the extremity very slightly emarginate and somewhat sparingly supplied with the usual incurving setæ.

The *mandibles* (figs. 6, 7, 8, 9) closely resemble in general shape those of *Niphargus*, as described by Humbert and other authors. The palp is rather large in proportion to the mandible itself; it has the first joint small, the margins without setæ; the second joint rather broad, especially in the middle, where it is strongly curved, the convex margin bearing about six or seven long setæ, which project almost at right angles to the joint; the third joint about as long as the second, outer margin nearly straight and without setæ, inner margin bearing on the distal half a double row of long setæ, which increase in length towards the distal end. The palp is the same in both mandibles.

The outer cutting-edge is practically the same in both mandibles, and consists of five teeth, the two largest of which are somewhat widely separated, the other three teeth are smaller and subequal. In the right mandible (fig. 6) the secondary cutting-edge is very similar to that of *Niphargus puteanus*, figured by Humbert, and resembles in shape an open hand with the fingers close together; the part corresponding to the thumb is denticulated throughout, while that corresponding to the fingers has the distal extremity oblique and finely serrate. At the base of this secondary cutting-edge are two stout spiniform setæ denticulated similarly to the thumb, and following these is a stout plumose seta (see fig. 7).

The secondary cutting-edge of the right mandible usually has the form just described, but it is evidently subject to some variation, for in one specimen, which otherwise appeared quite normal, it had the form represented in fig. 8, which, it will be seen, is very different from the usual form. Whether this was the result of accident or not I cannot say, but it shows how careful one ought to be before laying much stress on the form of these minute mouth-parts unless they are found to be constant by the examination of a large number of specimens.

In the left mandible (fig. 9) the secondary cutting-edge resembles the outer cutting-edge, and consists like it of five separate teeth; at its base are stout denticulated setæ similar to those in the left mandible. It will be seen that this figure is inverted.

The molar tubercle, which appears to be the same in both mandibles, is small and presents no remarkable feature.

The lower lip (fig. 10) is very delicate, broad; extremity of each outer lobe very broadly rounded and covered with fine setæ; inner lobes small and very delicate; the lateral backward processes are short and rather obtuse.

The *first maxilla* (figs. 11, 12, 13) is very similar to that of *Niphargus puteanus*. The palp has the first joint short, its extremity oblique; the second joint slightly narrowing towards the extremity, which bears three stout setæ at the end and one more slender placed a slight distance from the end; the three stout setæ are finely serrate at the ends (fig. 13). The middle lobe of the maxilla is broad, nearly as broad as long, the extremity slightly oblique, bearing seven stout spiniform setæ, of which the innermost one is the largest and is a little separated from the others; it is serrate on the inner margin towards the extremity, on the surface of the lobe at its base are several fine hairs; the seta next to it is only about half as long and bears one strong tooth on the inner margin, the remaining setæ bear one or more denticulations or serrations, as shown in fig. 12. The inner lobe is small and delicate; its extremity is rounded and bears one or two finely plumose setæ.

A few very fine hairs are scattered over the surface of the whole maxilla. The extremity of the palp appears to be the same both in the right and left mandibles, and does not take different forms as in some species of *Gammarus*.

The *second maxilla* (figs. 14 & 15) is very similar to that of *Niphargus*. Its outer lobe is slightly longer and broader than the inner, and bears at the extremity a great number of slightly curved setæ; the inner lobe bears about six large setæ, the innermost one of which is much the largest, and is situated a little distance from the extremity on the inner margin, the basal portion of it is sparingly plumose, and its extremity is plumose or almost dentate on one side. Some of the remaining setæ are similar to this one, but others appear to want the plumes at the end (fig. 15).

A few fine hairs are sparingly scattered over the whole surface of the maxilla.

The *maxillipedes* (figs. 16, 17, 18) do not present any remarkable feature. The lobe attached to the basos ("inner lobe") is rectangular, the extremity truncate and bearing about four stout setæ much curved inwards; there are two fine setæ on the inner margin and a few fine hairs on the surface towards the outer margin (fig. 17); the lobe attached to the ischium reaches nearly as far as the extremity of the outer margin of the next joint, the meros, its inner margin is nearly straight and bears about ten to twelve setæ, of which two near the extremity are pretty stout, the others being rather slender; besides these spiniform setæ there are a few finer setæ or hairs along the inner margin (fig. 18).

When seen from below, the basos bears no setæ on its outer margin, but there are three at the extremity near the inner angle; there are three or four setæ on the inner margin of the ischium and one at the extremity of the inner margin of the meros; the last-mentioned two joints have no setæ on their outer margins. The carpus has the outer margin much curved, with a single seta at the extremity, its inner margin is curved and thickly fringed with long setæ; on the upper surface of this joint there is a distinct row of six setæ running parallel to the inner margin near the extremity. The propodos has the outer margin very convex, and produced on the upper surface into a small lobe at the base of the dactylos; on the upper surface (fig. 17) towards the end of the joint is a dense mass of long setæ, arranged chiefly in three longitudinal rows; the inner margin has the basal portion free from setæ, but the distal half thickly fringed with long setæ; on the under surface of the propodos there are two or three long setæ at the base of the dactylos. The dactylos is as long as the propodos, and is very acutely pointed; on the outer margin near the base it bears a single seta; its extremity is marked off into a distinct unguis, at the base of which is a small seta on the inner margin.

First gnathopod (fig. 20). The coxa (side-plate) is almost rectangular, sloping a little forward, its anterior edge bearing five or six short setæ. The basos is narrow at the base, but rapidly widens until it is quite half as broad as long; its anterior edge is nearly straight and bears a tuft of five long setæ near the base and a single seta at the extremity; the posterior margin is very convex and bears four or five setæ, the longest being at the extremity. The ischium is short, broader than long, and bears five or six setæ at the extremity of the posterior margin. The meros is rounded distally, and has the whole extremity thickly fringed with long, rather stout setæ. The carpus is triangular, extremity nearly straight, with a row of long setæ running parallel to it along the posterior half of the inner surface; the short posterior margin densely covered with setæ, apparently arranged in three or four transverse rows. The propodos is ovate, about as long as the three preceding joints together, scarcely wider than the carpus; anterior margin convex, with four or five setæ separately situated along the inner surface near it and a small tuft at the base of the dactylos; posterior margin with numerous setæ partially arranged in five or six tufts; palm oblique, occupying rather more than half the posterior margin, defined by two stout spines and fringed with numerous short setæ, a few longer setæ being situated on the surface of the propodos near the palm. The dactylos is slightly curved, fitting closely on to the palm; the terminal unguis distinct and marked off by a small tooth on the inner margin at its base; on the outer margin the dactylos bears a plumose seta at a little distance from the base.

The *second gnathopod* (fig. 21) is about as large as the first and closely resembles it in form. The coxa is similar but somewhat larger, the basos slightly longer in proportion to its breadth. The carpus much longer than in the first gnathopod, with more numerous tufts of setæ on its posterior margin and a shorter row along the extremity. The propodos is like that of the first gnathopod, but the palm does not occupy so much of the posterior margin, and there is a larger number of tufts of setæ between the end of the palm and the base of the posterior margin.

In both gnathopoda the outer surface bears fewer setæ than the inner.

The *first peræopod* (fig. 22) has the coxa like that of the second gnathopod. The basos is longer, and widens considerably about the middle, where the breadth is rather more than one-third the length; it is much constricted on both sides near the base, and after widening narrows again slightly at the extremity; the anterior margin bears a few small setæ, and the posterior margin bears six stout setæ, each situated in a slight serration. The ischium is similar to that of the second gnathopod. The meros is slightly longer than the carpus, and is a little produced at the antero-distal angle; the anterior margin slightly convex, and bearing one spiniform seta at the centre and another at the extremity; posterior margin straight, with a few long setæ, the longest two being at the extremity. The carpus is oblong, narrowed at the base; anterior margin with one or two minute spinules; posterior margin straight, with five stout setæ. The propodos is shorter and narrower than the carpus but of similar shape; posterior margin with a row of six or seven short setæ, the last being the longest;

anterior margin with a small tuft at the base of the dactylos and a single seta situated more proximally. The dactylos is short.

The *second peræopod* is exactly similar to the first in size and form.

The *third*, *fourth*, and *fifth peræopoda* are all similar to each other, but each is slightly larger than the preceding; they are all somewhat remarkable in having the basos rather narrow and not expanded posteriorly into a semicircular plate as in most Amphipoda. Fig. 23 represents the fourth peræopod, and it will be convenient to take this one for description, as it represents a mean between the fifth and seventh. The coxa is almost semicircular, upper margin straight, the lower convex margin thickly fringed with short spines, which are most numerous posteriorly. The basos is narrowed a little at the base; it is oblong, the breadth being slightly more than one-third the length; anterior margin with two setæ, one at the extremity and one above it; posterior margin straight, with two or three stout setæ about the middle and one or two longer ones at the extremity. The ischium is very similar to that of the preceding peræopoda; the meros oblong, about three times as long as broad, both margins bearing stout setæ, especially at the extremity; the carpus slightly longer than the meros, but a little narrower, the setæ on it more numerous and larger than in the meros; the propodos as long as the carpus, but narrower, apparently twisted so that the dactylos projects backwards, both margins having stout setæ or spines, those on the posterior margin being most numerous; the dactylos is short, not much longer than the setæ at the end of the propodos.

The *pleopoda* (figs. 24, 25, 26) are small and are very remarkable, in that each bears only one branch, which appears to be the outer one, there being no trace whatever of the second branch. I do not know of any other species of the Amphipoda where this is the case: in the *Cerapinæ* the inner branches may be rudimentary and even entirely absent in the case of the third pleopod; but it is easy to see that this is due to the habit of the animal living in a tube, which has to some extent modified all its pleopoda and the tail-part. In the present species the portions of the pleopoda that are present appear quite perfect, and I know of nothing in the habits of the animal to explain why these pleopoda should have only one branch while those of *Gammarus fragilis* and *Calliopius subterraneus* have the normal two branches.

The *first pleopod* (fig. 24) is the longest; the basal portion is oblong, slender, without setæ, except the two "coupling spines" at the extremity of the inner margin; these seem not unlike those of *Niphargus*, each bearing two or three tubercles on the one side and being slightly hooked at the end. The single branch is nearly twice as long as the peduncle and consists of eleven joints, each bearing the two long plumose setæ in the usual way. I cannot find any trace of the "cleft spines" mentioned by Stebbing [108, p. xiv &c.], Sars [91, p. 53], Humbert [62, p. 351], &c., on the inner margin of the first joint of this branch, and it is therefore probable that it represents the outer branch, the inner one being absent.

Stebbing [108, p. xiv] has drawn special attention to these "cleft-spines" and also to the "coupling-spines," and, with regard to the latter, points out that they have been described and figured by Sars in his account of *Gammarus neglectus* [91, p. 53], and indicated by S. I. Smith in his figure of *Cerapus tubularis*, but not, he thinks, alluded to by any other writers. It is but just to Humbert to mention that he had drawn and described the "coupling-spines" ("deux petits crochets") of *Niphargus puteanus*, var. *Forelii*, in 1876 [62, p. 350].

The *second pleopod* (fig. 25) has the peduncle considerably longer and broader than in the first, the basal part of it being pretty distinctly marked off as a separate joint, probably representing the coxa. The outer margin bears four small spines on the distal half, the inner margin having only the coupling-spines at the extremity. The branch is only as long as the peduncle and contains only six joints, of which the first is much the largest.

The *third pleopod* (fig. 26) is similar to the second, but smaller and more reduced; the peduncle is similar, but narrowed at the base; the branch is not so long as the peduncle, and consists of three joints only, the first being much larger than the other two together.

The *uropoda* are all short and rather stout. The *first uropod* (fig. 27) has the peduncle much longer than the rami, stout, broad above, the upper surface being somewhat concave, its outer margin bearing seven small spines; the outer ramus is slightly smaller than the inner, both falciform, curving upwards, the lower surface of each regularly curved and with setæ, the upper surface with three or four small spines near the base and one near the apex.

The *second uropod* (fig. 28) is similar to the first, but shorter and bearing fewer setæ.

The *third uropod* (fig. 29) has the peduncle short, with two spines on the lower margin at the extremity; the inner ramus very small, rudimentary, with a small spine at the end; outer ramus about three times as long as the peduncle, gradually tapering, the upper margin with eight setæ arranged in four pairs in a longitudinal row, the extremity separated from the other portion and forming a small second joint.

The *telson* (fig. 30) reaches about halfway to the end of the last uropod. It is more or less oblong, narrowing slightly towards the end, which bears a stout spine in a slight emargination at each corner; the sides are slightly convex and the extremity between the two spines is either straight or slightly concave. There is no sign whatever of any cleft or division.

Genus GAMMARUS, Fabricius, 1775.

(See Stebbing's Report on the 'Challenger' Amphipoda, p. 1005.)

Full information on this very old genus will be found in Stebbing's Report as quoted above. In it he quotes the following generic diagnosis as having been given by Boeck in 1876:—

"*Mandibles* with the third joint of the palpi elongate, narrow.

"*First maxillæ* with the inner plate broad, long, furnished on the inner margin with very many plumose setæ.

"The body not carinate. The three hinder segments of the pleon furnished in the middle with fascicles of spines. The anterior side-plates of moderate size.

"*Upper antennæ* longer than the *lower*; the peduncle moderately elongate.

"*Lower antennæ* with a short flagellum.

"*First* and *second gnathopods* with the hand small; the *second* larger than the *first.*

"The *third uropods* with long rami, furnished on the margin with spines and plumose setæ, extending beyond the rami of the two preceding pairs; the inner ramus more or less shorter than the outer.

"*Telson* long, cleft to the base."

This definition answers very well to include *Gammarus fragilis*, which is the only species of the genus that I have had an opportunity of closely examining.

GAMMARUS FRAGILIS, Chilton. (Pl. XXI. figs. 1–25.)

Gammarus fragilis, Chilton, New Zealand Journal of Science, vol. i. (January 1882) p. 14; id. Transactions New Zealand Institute, vol. xiv. p. 179, plate ix. figs. 11 to 18; id. New Zealand Journal of Science, vol. ii. (March 1884) p. 89; Thomson & Chilton, Transactions New Zealand Institute, vol. xviii. p. 146; Moniez, "Faune des Eaux souterraines du Département du Nord &c.," extrait de la Revue Biologique du Nord de la France, tome i. (1888–89) p. 50; Wrzesniowski, "O trzech kielzach podziemnych," De tribus Crustaceis Amphipodis subterraneis, pp. 16, 90; id. "Ueber drei unterirdische Gammariden," Zeitschrift für wissenschaftliche Zoologie, L. 4, pp. 611, 698.

Specific diagnosis. Eyes wanting. Body rather slender. Superior antennæ somewhat longer than the body; flagellum much longer than peduncle, secondary containing from five to nine joints. Peduncle of lower antennæ longer than peduncle of upper; flagellum longer than peduncle. Gnathopoda subequal, moderately large, each with the propodos ovate; palm very oblique. First and second peræopoda rather short, slender; last three pairs of peræopoda very long, the last (fifth) about as long as the body. Terminal uropoda with the rami subequal, about twice as long as the peduncle, cylindrical, not flattened or expanded.

Colour. White, semi-transparent.

Length of largest specimen 15 mm.

Habitat. Eyreton, North Canterbury (*Chilton*), Leeston (*R. M. Laing*), Winchester, South Canterbury (*D. L. Inwood*): in wells.

Remarks. It will be seen from the following detailed description that this species is a true *Gammarus*, and that in all generic characters it agrees very closely with *Gammarus neglectus* as described by Sars. I have not attempted to compare *G. fragilis* with the numerous other species of the genus already described. It appears to be well characterized by the very long peræopoda, the want of eyes, and the long cylindrical rami of the terminal uropoda.

Detailed Description.

The *body* (Pl. XXI. fig. 1) is smooth, rather slender; the appendages are also very long and somewhat slender. The coxæ (side-plates) of the first four segments of the peræon are rather deep, though not so deep as their respective segments. The segments of the peræon are all of about the same length and as long as the head; the first three segments of the pleon are rather longer, their inferior margins bear two or three stout setæ towards the anterior end; the fourth segment of the pleon has a strong spine on the inferior margin at the base of the uropod, and each of the last three segments bears four or five long spine-like setæ on the dorsal surface.

The *upper antennæ* (fig. 2) appear to vary somewhat in length as compared with the body, but they are always very long, usually about as long as the body. The first joint of the peduncle is stout, rather more than twice as long as broad; the upper margin is straight, with a tuft of fine setæ at the extremity; lower margin slightly curved and bearing two short transverse rows of spiniform setæ, the second row being situated at the extremity. Second joint about as long as the first, but only about half the width; upper margin with three or four fine setæ; lower margin with three or four tufts each containing a spiniform seta and one or more fine hairs, at the extremity there are tufts above and below and in the centre. Third joint about one-third as long as the second, a few setæ above and below at the extremity. Secondary appendage slender, usually containing six or seven joints, though there may be as many as nine, each joint with minute setæ at the extremity; flagellum more than twice as long as the peduncle, consisting of a great number of joints, the setæ on which are very short and fine, each joint bears a single small olfactory cylinder.

The *lower antennæ* (fig. 3) are more than half as long as the upper. The first joint of the peduncle is very short and bears a single seta at the extremity of the lower margin; second joint very short, the gland-cone (the so-called "olfactory denticle") not reaching quite to the end of the succeeding joint; the third joint more than twice as long as the second, upper margin curved, lower margin with a tuft of strong spiniform setæ at the extremity; fourth joint very long, upper surface bearing five tufts of two stout setæ each, the lower surface with numerous small tufts of stout setæ and fine hairs irregularly arranged; the fifth joint slightly longer than the fourth and narrower, upper surface with about five small tufts, lower surface with five larger tufts of longer setæ; flagellum usually about as long as the peduncle, though the relative lengths vary somewhat; it usually contains about twenty joints, each bearing a few fine setæ at the extremity.

The *upper lip* (fig. 4) is strongly chitinous and of the usual shape, being more or less semicircular, very broad; the apex bears a thick fur of minute setæ, mostly converging inwards.

The *mandibles* (figs. 5, 6, 7, 8) appear to present a pretty close resemblance to those of *Gammarus neglectus* as described and figured by Sars. The palp, which is the same in both mandibles, is large and strong. The first joint is the shortest; it widens slightly distally and bears four or five setæ at the extremity. The second joint is about twice as long as the first; it is rather broad, and bears on the inner margin about a dozen long setæ, those towards the end being the longest. The third joint is somewhat shorter than the second, and bears on the surface of the side four small tufts each containing two setæ; the outer margin is slightly curved and is free from setæ; the inner margin has along its whole length, except a little at the base, a thick fringe of stiff setæ about half as long as the joint is wide; at the extremity are three long setæ nearly as long as the joint itself.

The armature of the right mandible differs from that of the left, as is the case in this and many other genera of the Amphipoda. In the left mandible (fig. 6) the outer cutting-edge consists of five strong teeth and the inner or secondary cutting-edge is similar in general form but contains only four teeth, one of which is considerably longer than the other three; both outer and inner cutting-edges are curved so as to be concave on the inner side. In the right mandible (figs. 7, 8) the outer edge is not unlike that of the left, but contains only four teeth, and the inner cutting-edge is very different. When seen in profile, as in figure 8, it appears slender, dividing into two branches or forks, the upper one apparently tubercled, and the lower one bearing two or three denticulations at its base; in this view it seems not very unlike that of *Gammarus neglectus* as figured by Sars [91, pl. iv. fig. 4]. When this inner cutting-edge is seen *en face* (fig. 7), however, it is found to be much more like that of *Crangonyx compactus* than would at first have been suspected; the upper portion proves to be broad and triangular in shape, with the edge dentate, and it is these denticulations which make the piece appear tubercled when seen in profile; the lower piece is narrow and bears one or two teeth on the surface at its base as already described.

Next to the secondary cutting-edge in each mandible follow four or five strong denticulate or stiffly plumose setæ. The molar tubercle does not appear to present any remarkable feature.

The *lower lip* (fig. 9) is of the usual form, deeply cleft, each lobe bearing on its rounded extremity a number of very fine irregular setæ, and on its inner margin a thick fringe of rather stouter setæ.

The *first maxilla* (figs. 10, 11, 12) has the inner lobe very delicate and fringed with nine or ten * delicate plumose setæ, each of which shows a transverse division at some distance from the base; the surface of this plate is also covered with fine delicate scattered setæ. The middle lobe ends in about ten strong setæ, curving inwards; most of them have two sharp teeth on the inner edge, but the two innermost bear more numerous teeth. The palp has the first joint short, rectangular, and the second large, flat, and curved inwards. On the left side (fig. 11) the palp ends in about seven stout setæ or spines, closely approximated together; a single small simple seta is situated on the surface at a slight distance from the extremity. In the maxilla on the left side (fig. 12) the palp has the same general shape, but the setæ at the end are much more slender and not so crowded, and there appear to be only six of them. The difference between the extremities of the two palps is really rather greater than would appear to be the case from figs. 11, 12, for the right maxilla is here considerably compressed in order to show the spines more distinctly.

The *second maxilla* (fig. 13) has the form usual in *Gammarus*. The inner lobe

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* The number of setæ on the inner lobes of the first and second maxilla varies very greatly in different specimens. The numbers given in the text probably represent the average. I have another drawing showing 13 on the inner lobe of the first maxilla and 21 on that of the second maxilla.

bears a very oblique row of about twelve * finely plumose setæ similar to those on the inner lobe of the first maxilla; the inner margin of this lobe is fringed with many simple setæ and the surface of the lobe bears a few very fine simple setæ scattered over it. The outer lobe bears many long curved setæ at the extremity as usual; many, if not all, of these are finely serrate on the inner side.

The *maxillipedes* (figs. 14, 15) are somewhat slender. When viewed from below (fig. 14) the first joint (*coxa*) is seen to bear three setæ on the outer margin. The next joint, the basos, is obliquely articulated with the coxa and bears near its base a short transverse row of short setæ, and at its extremity towards the inner margin a dense row of stout setæ. The meros is rather longer than broad and bears a single seta on its inner margin at the extremity. The carpus is about as long as the three preceding joints together, and more than twice as long as broad; its outer margin is regularly curved and bears no setæ; the inner margin is nearly straight and is thickly fringed with setæ, which are chiefly arranged in irregular, short, transverse rows containing about two or three setæ each. The propodos is rather more than half as long as the carpus; on its outer margin at the extremity it bears two or three very long setæ and its inner margin is thickly fringed with long setæ irregularly arranged in tufts. The dactylos is very nearly as long as the propodos; it is strongly curved and very acute; the outer margin bears a fairly long seta near the base, and the inner margin bears three small setæ, the third situated at the base of the terminal unguis, which is distinctly marked off from the rest of the dactylos.

When seen from above (fig. 15) the carpus bears at the extremity an oblique row of four or five long setæ and another similar row on the surface at some distance from the extremity; the propodos has a longitudinal row of about twelve long setæ along the centre of the upper surface (just like that which Humbert draws in *Niphargus puteanus*, var. *Forelii* [62, pl. vi. fig. 9]), and a small tuft of two setæ near the outer margin. The inner lobe of the maxillipede—that is, the one attached to the basos—is rectangular, and bears at the end three stout spines and five or six longer stiffly-plumose setæ; the inner margin also bears three or four similar plumose setæ. The outer lobe attached to the ischium bears on the inner margin about twelve stout spines, which, at the extremity, gradually merge into long denticulate setæ; a few simple setæ are found along the inner margin, more particularly on the basal portion.

The *gnathopoda* are about equal in size and almost identical in structure and in the arrangement of the setæ on them, but the setæ on the inner surface of each are more numerous than, and very different from, those on the outer surface and require separate description.

The *first gnathopod* (fig. 16) has the coxa (side-plate) nearly square, the lower surface bearing a few fine setæ. The basos is long, the front margin with a few irregular setæ, the posterior margin with a tuft at the extremity. Ischium very short, with a tuft of setæ on the posterior margin at the extremity, and this is extended into a short row along the inner surface of the joint. Meros narrow when seen from the outside, being partially overlapped by the carpus; on the inner side it appears nearly rectangular, the

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* See note on previous page.

end truncate and fringed with a dense double row of long setæ, which also form a dense tuft on the posterior side. The carpus is triangular, widening distally, the short posterior margin being densely covered with long setæ arranged in five or six transverse rows; there are no setæ on the outer surface, but on the inner surface there is a transverse row of long setæ along the end and another shorter row at a slight distance from the end; there are also two small tufts at the antero-distal angle and another situated more proximally. The propodos is large, fully as long as the basos, ovate, about twice as long as broad, and not much broader than the carpus; the outer surface bears few setæ, then a few very small ones along the anterior margin, a small tuft at the base of the dactylos, and a few along the palm; on the inner surface near the anterior margin are five transverse rows each containing from five to seven long setæ: the palm is slightly convex and occupies almost all the lower margin; it is defined by two large spines, a third large spine is situated on the inner surface a little nearer the base of the propodos, and near it are two or three small transverse rows of setæ; between the end of the palm and the base of the propodos are two other transverse rows on the posterior margin; the palm is armed with a double row of short stout spines, and near the edge of the palm on the inner surface are about six small tufts of setæ. The dactylos is long and curved, fitting closely on to the palm; the inner surface bears about six small tufts of setæ; the inner margin is minutely serrate, the serrations lying close to one another, and it bears about fifteen minute spinules placed at regular distances from one another along the inner edge; the extremity is acute.

The *second gnathopod* (fig. 17) differs from the first in having the extremities of the ischium and meros less densely fringed with setæ; on the inner surface of the carpus the transverse row situated a little from the end is very short, containing only about six setæ, and there is another small tuft near it; in the propodos on the posterior margin are six transverse rows, instead of two, between the base and the end of the palm, and the tufts of setæ near the palm are much smaller, containing only two or three setæ each.

The description of the gnathopoda, as given above, applies to the adult female. I am unable at present to say whether the male differs in any particulars or not.

The *first peræopod* (fig. 18) is slender, of the same length as the second, and very much shorter than the third. The coxa (side-plate) is rounded below and bears a few small setæ irregularly placed along the margin. The basos is long, oblong in shape; the anterior margin with three or four rather long setæ near the base, and three short spines towards the extremity; the posterior margin is similarly supplied with setæ, but the long setæ are further from the base. The ischium is short, rectangular, with a single seta on the posterior margin at the extremity. The meros is slightly more than half as long as the basos, and is somewhat produced at the antero-distal angle; the anterior margin is slightly convex, and bears three short spines, the last being at the extremity; the posterior margin is straight, and bears three tufts, each containing two slender setæ. The carpus is shorter than the meros, and bears on the posterior margin two spines and a few slender setæ. The propodos is a little longer than the carpus, and bears on the posterior margin short spines arranged in four groups; the anterior margin bears a few fine hairs and a small tuft of setæ at the base of the dactylos. The dactylos is rather short, and bears a single seta on the inner margin, imperfectly marking off the terminal unguis.

The *second peræopod* is similar in all respects to the first.

The *third, fourth,* and *fifth peræopoda* (see fig. 19) are all very long, and each is longer than the preceding; the fifth is about as long as the whole body. The lengths of the peræopoda, as compared with the body, appear to vary, as is the case also with the antennæ, and to increase with the age and size of the animal. The coxæ of these peræopoda are not easy to make out very distinctly; that of the fifth is small, almost semicircular, regularly curved below, and bearing four setæ on the posterior portion; those of the third and fourth peræopoda appear similar, but flatter inferiorly, and with fewer setæ; that of the third fits in front into an emargination on the posterior side of the coxa of the second peræopod.

It will be sufficient to describe the *fourth peræopod* (figs. 19, 20) as a mean between the third and fifth. The basos is not much expanded, and narrows distally; both margins bear small spines arranged in slight serrations; the ischium bears one or two spines at the extremity of the anterior margin; the meros, carpus, and propodos are all similar, but each is longer and narrower, and bears more numerous setæ than the preceding. In all both margins bear numerous tufts of long spines arranged in slight serrations; the dactylos is fairly long, of the same width throughout until near the end, where it narrows suddenly; at this point on the inner margin are usually three setæ, though in large specimens there may be as many as six. In the tuft of setæ at the base of the dactylos are stout spines, fine setæ, and one or two plumose setæ similar to the "auditory setæ" found on the antennæ and elsewhere, but much curved or bent at the middle. Similar setæ are found in most of the tufts on the posterior margin of the propodos.

The *pleopoda* are of the usual shape, and the three pairs are almost identical. Fig. 21 represents the *third* pair; in it the peduncle appears to consist of a short coxa and a long basos about three times as long as broad. The outer margin is somewhat convex, inner margin straight and bearing four fairly long setæ, the longest being at the extremity near the two "coupling-spines." The latter seem to closely resemble those of *Gammarus neglectus,* as described and figured by Sars [91, p. 53], except that there are two only instead of three, as in that species; each bears three or four teeth on each side.

The outer ramus, which is somewhat shorter than the inner, is hollowed out on its inner side for the reception of the base of the inner ramus, and its margin, which is thinned out, bears four or five of the ordinary plumose hairs. The first joint of the inner ramus bears on its inner margin three "cleft-spines," like those described by Stebbing.

The *first* and *second pleopoda* appear slightly larger than the third, and have the spines on the inner margin of the peduncle smaller and fewer, otherwise they precisely resemble the third pleopoda.

The *first uropoda* (fig. 22) extend as far backwards as the extremity of the second uropoda; there is a strong spine on the body-segment just at their base. The peduncle is considerably longer than the rami; its lower margin straight or slightly curved, upper surface broad, concave; both inner and outer margins supplied with about six small spines, a large spine nearly half as long as the inner ramus being situated at the extremity of the inner margin. The outer ramus is slightly longer than the inner; upper margin with three small spines, a large one and two small ones at the extremity; inner ramus similar, but with two large spines at the extremity.

The *second uropoda* (fig. 23) are small, not reaching to the end of the peduncle of the third uropoda. Peduncle stout, about as long as the rami, concave above, both inner and outer upper margins with two or three spines; outer ramus slightly shorter than the inner, upper margin with three small spines, a large one and two small ones at the extremity; inner ramus with its upper margin supplied with about twelve small spines arranged closely in a row, two large ones and two or three short ones at the extremity.

The *third uropoda* (fig. 24) are very long, nearly as long as the whole pleon. The peduncle is rectangular, about three times as long as broad, two setæ on the side near the lower margin; upper surface slightly concave; both inner and outer margins with spines, two or three at the extremity of the outer margin and one large one at the extremity of the inner margin. The two rami of equal length, nearly twice as long as the peduncle, each cylindrical, scarcely tapering towards the end; outer surface of each with five groups, each containing three spines; inner surface with five similar groups of stout spines, and in addition a number of long plumose hairs; extremity of each with about six or seven spines of various lengths.

In fig. 24 the last uropoda are represented as usually seen, the outer row of setæ being shown on the outer ramus and the inner row with the plumose hairs being seen on the inner ramus, which is somewhat twisted round. The spines or setæ on these uropoda are shorter in proportion to the appendage in large specimens, and this is the case also with the spines on the legs and in other parts of the body.

The telson (fig. 25) is short, reaching only slightly beyond the base of the peduncle of the last uropod. It is cleft right to the base, each half being more or less rectangular; the outer margin curved, extremity straight or slightly rounded, bearing on the inner half four long spines about half as long as the telson, and towards the outer side two or three similar spines situated a slight distance from the extremity.

The above description applies to fully developed females. I am not able to say whether the males differ from the females in the last pair of uropoda, as in *Niphargus*, but the numerous specimens that I have seen and closely examined all agree with the description given above.

Genus Calliopius, Leach.

(Bate & Westwood, Brit. Sessile-eyed Crust. i. p. 259.)

Of this genus Bate and Westwood give only the following as the generic character:—"Like *Pherusa*, except that at least the second pair of gnathopoda have the propodos largely developed" [4, p. 259]; and of *Pherusa* they merely say, "Like *Atylus*, but telson not divided. Gnathopoda small" [4, p. 252].

According to Stebbing the genus *Amphithopsis*, Boeck, is most probably a synonym of *Pherusa*, and of this genus he gives the following account in his notice of Boeck's work. The genus is, he states, instituted for those species which have "an elongate, compressed body with moderate epimera and long antennæ; the inner plate of the first maxillæ furnished with four or five long, thick, plumose setæ; the inner plate of the second maxillæ with many simple setæ at the extremity, but several on the inner side very strong and plumose; the maxillipeds large, with palps of moderate length; the two first pairs of feet with hands of nearly the same size, small; the third and fourth pairs of legs with the fifth joint very long, longer than the third joint; the telson simple; the last uropods with the branches long, often unequal; the marsupial plates much larger than the branchiæ, closely margined with hairs" [108, p. 324].

It appears to me that all the genera mentioned, together with several other allied genera, require careful revision and systematic redescription; and in the meantime I prefer to leave my species *Calliopius subterraneus* under *Calliopius*, where I first placed it, although, if we consider only the female, it should no doubt be put in the same genus as *Pherusa cærulea*, G. M. Thomson. It is evident, too, that due attention must be paid to the sexual differences, for in *Calliopius subterraneus* the female is a *Pherusa*, while the male, which differs chiefly in the possession of larger gnathopoda, would be better placed under *Calliopius*.

CALLIOPIUS SUBTERRANEUS, Chilton. (♂, Pl. XXII. figs. 1–15, Pl. XXIII. figs. 1–9; ♀, Pl. XXIII. figs. 10–18.)

Calliope subterranea, Chilton, New Zealand Journal of Science, vol. i. (January 1882) p. 14; id. Transactions New Zealand Institute, vol. xiv. p. 177, plate ix. figs. 1–10; id. New Zealand Journal of Science, vol. ii. (March 1884) p. 89.

Calliopius subterraneus, Thomson & Chilton, Transactions New Zealand Institute, vol. xviii. p. 148; Thomson, Transactions New Zealand Institute, vol. xxi. p. 262.

Calliope subterranea, Moniez, "Faune des Eaux souterraines du Département du Nord &c.," extrait de la Revue Biologique du Nord de la France, tome i. (1888–89) p. 50; Wrześniowski, "O trzech kiełzach podziemnych," De tribus Crustaceis Amphipodis subterraneis, pp. 16, 90; id. "Ueber drei unterirdische Gammariden," Zeitschrift für wissenschaftliche Zoologie, L. 4, pp. 611, 698.

Specific description.—Male. Cephalon not produced into an appreciable rostrum. Eyes wanting. Upper antennæ about two-thirds the length of the body; first joint of peduncle stout, second and third each much shorter than the preceding; secondary flagellum represented by a minute joint shorter than first joint of main flagellum. Lower antennæ stout, much shorter than the upper; flagellum about as long as the peduncle. Calceoli are present on the second and third joints of the peduncle, and on the flagellum of the upper antenna, and on the flagellum of the lower antenna. First gnathopod very large and strong; carpus very short; propodos much longer than basos; palm occupying nearly the whole of the posterior margin. Second gnathopod also large, but more slender than the first; carpus triangular, more than half as long as propodos; palm of propodos convex, occupying about half the posterior margin. Last three pairs of peræopoda long and slender, each much longer than the preceding. Second uropods with the outer branch only about half as long as the inner. Telson rather short, subrectangular; posterior angles rounded and each furnished with a single fine seta; hinder margin slightly concave.

Female. Differs from the male in the following points: the size is smaller, only about two-thirds as large; the antennæ are more slender and less strongly supplied with setæ, and apparently do not bear calceoli; the gnathopoda are much smaller and more slender, the first having the carpus triangular, as long as the propodos, which is elliptical, and has the palm only slightly oblique; the second gnathopod is very long and slender, carpus and propodos similar, narrow oblong, carpus much longer than propodos, palm of latter quite transverse.

Length. Largest male 12 mm.; largest female about 6 mm.

Colour. White, semitransparent.

Habitat. Eyreton (*Chilton*), Lincoln (*E. Wilkinson*), Ashburton (*W. W. Smith and J. B. Mayne*), Winchester (*D. L. Inwood*): in wells.

Remarks. The female of this species bears a very close general resemblance to *Pherusa cærulea*, G. M. Thomson [107, p. 206]. I had judged this to be the case from the comparison of Stebbing's figures of the latter with my specimens, and an examination of specimens of *Pherusa cærulea*, kindly supplied by Mr. Thomson, shows that the resemblance is even closer than I had imagined. *Pherusa cærulea* is stouter in body, has the side-plates deeper, and of course differs also in the possession of eyes and in its very distinct dark blue colour, but in the form of the antennæ, the mouth-parts, and the gnathopods there is little difference of any importance. The upper antenna has a rudimentary secondary flagellum (not mentioned in Stebbing's description), as in *Calliopius subterraneus*, but it is somewhat longer, being longer than the first joint of the main flagellum; in the specimen I have dissected there are small calceoli on both antennæ, just as in the specimens of *Calliopius subterraneus* that I have described below as "immature males." The gnathopods have the same general shape, but are not so long and slender, and, especially in the second, do not bear so many tufts of setæ as in the female of *Calliopius subterraneus*; the peræopoda are shorter, the uropoda are similar and in like manner armed with spines, but the second has the branches less unequal in length, and the telson is rounder. The specimen of *Pherusa cærulea* that I have examined is probably a young male, but none of the few specimens in my hands have the gnathopoda so largely developed as in *Calliopius subterraneus.* On the whole it appears that the two species are very closely related, and either *Calliopius subterraneus* has been derived from *Pherusa cærulea*, or, what is more likely, both have been derived from a closely allied species once widely spread in New Zealand.

Calliopius fluviatilis, G. M. Thomson, is very common in freshwater streams in New Zealand, but is not so closely allied to the subterranean species as is *Pherusa cærulea.* It differs considerably in the gnathopoda, and in the last pair of peræopoda, which have the last joint simple, ending in a small pencil of long hairs, as in species of the Œdiceroidæ, and it seems scarcely necessary to compare it in detail with *Calliopius subterraneus.*

Detailed Description.

In this species the male differs in a very marked manner from the female, being of considerably larger size, differing also in the antennæ and particularly in the gnathopoda. The males are very much rarer than the females; I have seen only about half a dozen males altogether, while I must have seen hundreds of specimens of the female. It will be convenient to describe the male first, and afterwards to point out more in detail the characters in which the female differs from the male.

The *body* (Pl. XXII. fig. 1) is smooth, fairly stout. The head is longer than the first segment of the peræon; the segments of the peræon subequal; first three segments of the pleon considerably longer than the last segment of the peræon. The side-plates of the first four segments of the peræon are nearly as deep as their respective segments. The inferior margins of the first three segments of the pleon are regularly rounded and have no setæ.

Eyes. There is no external sign of the eyes.

The *upper antennæ* (fig. 2) are more than two-thirds as long as the body. The peduncle has the first joint stout, about half as broad as long, with a few minute setæ scattered over it, the lower surface with a row of about seven or eight short setæ, and at the extremity three or four long auditory setæ. The second joint is about two-thirds as long as the first, but not much more than half the width; the lower surface bears a few minute spinules and some longer setæ at the extremity; on the inner surface, towards the upper side, is a row of three or four "calceoli," at the base of each of which are two or three simple setæ. Third joint about half as long as the second, similarly furnished with calceoli and setæ. There is a minute secondary appendage on the inner surface, consisting of a single small joint tipped with two setæ. The flagellum is more than twice as long as the peduncle, and consists of a great number of joints, of which about the first third bear calceoli arranged in two rows, the first being situated on the inner surface towards the upper margin, the other also on the inner surface but lower down, and being on joints of the flagellum alternating with those that bear the first-mentioned row of calceoli, the part of each joint that bears a calceolus is somewhat produced into a small rounded prominence, which bears three or four simple setæ as well as the calceolus. Towards the extremity of the flagellum the joints become much more elongated and cease to bear calceoli. Olfactory cylinders are found on the joints which do not bear calceoli, as well as on some, if not all, of those which do bear calceoli.

The *lower antennæ* (fig. 4) are about half as long as the upper, both the peduncle and the flagellum being rather stout. The "gland-cone" attached to the second joint is rather large and prominent. and bears two separate setæ at some little distance from the apex. The short third joint is grooved below, and bears at the extremity of its lower margin two simple setæ; its articulation with the fourth joint is very oblique. The fourth joint is rather broad, nearly half as broad as long; its upper margin bears three setæ in slight serrations; there is a tuft of four setæ in the middle of the lower margin and another larger tuft at the extremity. The fifth joint is slightly longer than the fourth; on the upper surface it bears four or five small tufts of setæ, and on the lower margin four larger tufts; along the extremity is a row of about seven auditory setæ. The flagellum is rather longer than the peduncle, and is stout, especially toward the base, where each joint is much broader than long. It bears two rows of calceoli, arranged in the same way as in the upper antenna; the calceoli decrease in size towards the end of the flagellum, and cease entirely at about the seventh joint from the end. In addition to the calceoli each joint bears a few simple setæ at the extremity.

The general appearance of the calceoli is shown in fig. 3. These organs have been fully investigated by Blanc, as I learn from the abstract given by Stebbing. The general arrangement of the calceoli in the present species appears to resemble closely that in *Eusiroides cæsaris* as described and figured by Stebbing [108, p. 970]. When seen in profile, the outline of the calceolus is very different from that shown in fig. 3, and is more like that shown by Stebbing in his figure of the calceoli of *Tryphosa antennipotens* [108, pl. vi. fig. *a. s.* with enlargement]. In that species, too, the calceoli on both antennæ are arranged in the same way as in the present species—"in both pairs so placed that, while the calceoli of alternate joints are seen full face, those of the other alternate joints will be seen in profile" [108, p. 618].

The *upper lip* (fig. 5) is rather large, oval in outline, widening distally; the end is regularly rounded at the corners and nearly straight in the centre, and bears many short converging setæ.

Mandibles (figs. 6, 7, 8). The *left mandible* is shown in fig. 6, and differs considerably from the right in the details of the cutting-edges. The palp, which is the same in both mandibles, is large and rather broad. Its first joint is very short, not much longer than broad; it bears no setæ. The second joint is the largest, being rather more than three times as long as the first; it expands slightly towards the distal end, and bears at the extremity on the inner margin, which is there convex, a row of six or seven fairly long setæ. The third joint is about three-fourths as long as the second; it is broadest near the base, narrows considerably toward the end, and is much curved, so that the extremity is almost at right angles to the plane in which the base of the joint lies (the double curving is not well shown in the figure). Along its concave margin it is thickly fringed with a dense row of short setæ; three longer ones are situated at the extremity. The surface on the concave side appears striated, the appearance being probably due to rows of very minute setæ.

The molar tubercle is strong; it has the extremity oblique, and covered, as usual, with rows of short spines. The sides of the tubercle bear numerous fine setæ, and in connection with it is a long filament or seta, as described by Humbert in *Niphargus puteanus*, by Sars in *Gammarus neglectus*, and by other authors.

The outer cutting-edge of the left mandible (fig. 7) consists of about six sharp teeth of varying shape, as shown in the figure; the inner or secondary is edge somewhat similar, but contains only four main teeth. Both edges are very concave on the inside, and were a good deal compressed in the slide from which fig. 7 was drawn; between the inner edge and the molar tubercle are five or six stout bristles.

The right mandible differs principally from the left in the two cutting-edges. The outer edge is similar to that of the left, but appears to consist of five main teeth only, and usually presents the appearance shown in fig. 8. The inner edge is very different from that of the left; it has a stout rounded base, and bifurcates towards the end; each division tapers to a point, bears one or two teeth, and is more or less tubercled, as shown in the figure.

Lower lip. Fig. 9 represents a portion of the lower lip of the large male from which this description is taken, the appendage having been torn in dissecting it out; the whole of the lip is better shown in Pl. XXIII. fig. 10, which is taken from a female specimen. The two outer lobes are comparatively long and narrow towards the extremity; their outer margins are fringed with very delicate setæ, and the inner margins bear numerous short setæ curving inward. The division between the two lobes does not appear to reach quite to the base of the lip. The inner lobes were not observed in the female; a part which probably belongs to them is shown in the drawing taken from the male (Pl. XXII. fig. 9). The lateral backward processes are moderately long and narrow.

The *first maxilla* (Pl. XXII. fig. 10, 11, 12, 13) in the male specimen dissected had the inner plate very small and delicate, oval, and with five plumose setæ on the inner margin. The middle lobe is broad, rectangular, squarely truncate at the end, and bears about twelve strongly denticulated spines, as shown in fig. 11; the form and position of these spines will be more easily understood from the figure than from a verbal description. The palp has the first joint short, not much longer than broad, the end somewhat oblique; the second joint is long and curved, rather broad, and terminates in the right (?) maxilla (fig. 12) in about seven stout, short setæ or spines. The two outermost are the longest and narrowest and are bristled; the others, which are short and stout, form very sharp teeth; near the base of the second tooth from the outside arises a single simple seta. In the other maxilla (fig. 13) the end of the palp is very different; it bears five setæ, very much longer and narrower than those on the right (?); the single simple seta arises from the base of the second outermost one as on the right (?).

The *second maxilla* is shown in fig. 14, and does not appear to present any remarkable feature. On the surface of the inner lobe is an oblique row containing seven plumose setæ. The surface of this lobe towards the base is covered with very fine delicate setæ, and similar setæ are found on the outer margins of both lobes towards their extremities. The end of the outer lobe bears about seven or eight long setæ, curved slightly inward; the end of the inner lobe bears similar setæ, which are, however, much shorter, and some of them plumose. The setæ extend some distance along the inner margin, but gradually become smaller as they recede from the extremity.

The *maxillipedes*, as seen from below, are shown in fig. 15. The *basos* bears at its extremity, towards the inner side, a group of nine or ten long setæ; the plate attached to it—the inner plate—extends only as far as the end of the inner margin of the meros; it bears at the end two stout sharp teeth and a third more slender, and numerous stiffly plumose bristles; its inner margin bears five or six plumose hairs. The *ischium* bears at the extremity a group of setæ as in the basos; the plate attached to it—the outer plate—reaches as far as the extremity of the outer edge of the meros; its inner edge is straight and bears about ten moderately stout spines, which gradually merge at the end into long, stiffly plumose, curved setæ; in addition to these spines the inner margin bears numerous slender setæ; the convex outer margin of the plate is also supplied with many very fine setæ like those found on some parts of the maxillæ. The *meros* bears about six setæ on the outer margin towards the extremity and numerous setæ on its inner margin. The *carpus* is similarly supplied with setæ. The *propodos* is about two-thirds as long as the carpus; it bears three or four setæ on the outer margin, and numerous long ones on the inner margin and on the surface near to it; on the upper surface of the propodos (fig. 16) is a longitudinal row of about twelve setæ, extending right along the centre, with a few others more or less irregularly placed; the outer extremity of the propodos at the base of the dactylos is produced into a small rounded lobe. The *dactylos* is long and slender, being about two-thirds the length of the propodos; both margins bear five or six setæ; it narrows somewhat abruptly at the extremity, and bears a stout spine or nail. The normal form of the dactylos is shown in fig. 16; that shown in fig. 15 is evidently deformed, and was found on the right side of the same maxillipede.

The foregoing descriptions of the mouth-parts have been taken from a large-sized male specimen. The mouth-parts of the female differ in several respects and are described below, where some remarks on the probable changes that take place in the mouth-parts during the development of the male will also be found.

The *first gnathopod* (Pl. XXIII. fig. 1) is very large and strong, much larger than the second. The coxa (side-plate) is nearly as deep as its segments and is rhomboidal in outline, projecting strongly forward; it bears a very minute seta at the anterior end of the lower margin, and one or two at the hinder end. The basos is long, somewhat curved at the base; the anterior surface is grooved to receive the propodos when the limb is bent back at rest. The ischium is short and of the usual form. The meros is short, not much longer than the ischium; the anterior surface is rounded and bears a number of setæ more or less regularly arranged in three transverse rows. The carpus is very short, subtriangular, produced below on the outer side into a small rounded lobe, densely tipped with setæ; when seen from the inside (fig. 2) the carpus appears quite rectangular. The propodos is very large, much longer than the basos; the upper margin is regularly curved and without setæ, except one or two very small ones at the base of the dactylos; the basal part of the lower margin forms a rounded lobe densely covered with numerous setæ arranged in five transverse rows; the palm occupies the whole length of the lower margin with the exception of this lobe; it appears rather broad, the outer edge bearing ten small tufts of rather long setæ, each tuft containing from two to four setæ. When seen from the inside (fig. 2) the end of the palm, against which the dactylos impinges, appears to be slightly concave; the end is defined by three long spines; round the edge of the hollow on the inside is a row of about seven shorter spines, and near them are some simple setæ more or less regularly arranged in tufts. The inner edge of the palm is rather convex, and, except towards the proximal end of the palm, it extends beyond the inner edge; it is minutely serrate and fringed with a few small setæ, and near it is a longitudinal series of about twelve short oblique rows of long setæ, each containing from five to ten setæ. The dactylos is large and strong, slightly curved, and with a few very minute setæ on the concave margin, but these do not project beyond the margin of the dactylos; the extremity is not distinctly marked off into a terminal unguis.

The *second gnathopod* (Pl. XXIII. figs. 3, 4) is slightly longer than the first, but is much more slender. The coxa is rectangular, deeper than broad, the lower angles rounded, and with six minute setæ on the lower margin; arising from the coxa there appear to be *two*[*] gill-plates, one rather larger than the other. The basos is long, nearly straight, the posterior margin bearing seven or eight long setæ on the proximal half, and a shorter one at the extremity. The ischium is rather long, one-third as long as the basos; its posterior margin bears three or four small setæ. The meros is about as long as the ischium; its distal extremity bears a fringe of about eight or nine long setæ. The carpus is nearly as long as the ischium and meros together; it is subtriangular, very narrow at the base, and rather loosely articulated to the meros, so that the distal part of the limb can readily turn upon this as a pivot, and hence often appears reversed, as shown in the figure of the whole animal (Pl. XXII. fig. 1). The anterior margin of the carpus is nearly straight, with a single minute seta at the extremity; the posterior margin is strongly curved, and thickly fringed with long setæ arranged in about twelve transverse rows, a small tuft of two or three being situated on the outer surface near the extremity. On the inner surface (Pl. XXIII. fig. 4) the carpus bears towards the extremity a transverse row of four or five setæ and three or four separate setæ placed more proximally along the middle of the joint. The propodos is longer than the carpus and meros combined; the anterior margin is straight, giving the limb a somewhat awkward appearance; towards the end it bears three or four minute setæ and two or three at the base of the dactylos; the posterior margin is strongly convex, the palm occupying more than one-half the whole length; it is defined by a stout spine and fringed on the outer surface with minute spinules, arranged singly, and a row of six separate long setæ running parallel to the palm; the basal part of the margin below the palm is thickly fringed with long setæ, arranged in about eleven transverse rows as in the carpus. When the propodos is viewed from the inside, the dactylos is seen to extend a little beyond the defining-spine and to fit into a slight depression bordered by four spines, one of which is much longer than the others; running parallel to the palm is a longitudinal series of from twelve to fifteen oblique rows of long setæ, each containing from two to four. The dactylos is similar to that of the first gnathopod, but is not so large and powerful.

The *first peræopod* (fig. 5) has the coxa (side-plate) and basos entirely similar to those of the second gnathopod, and, like it, appears to bear a double gill-plate. The ischium is short and of the usual form. The meros is oblong, rather more than half the length of the basos; its posterior margin straight, with five or six separate setæ, the anterior margin slightly convex and with the distal angle a little produced; it bears a seta near the middle and another at the extremity. The carpus is more than half the length of

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[*] Though there are certainly two plates attached to the coxa, both in the second gnathopod and in the first and second peræopoda, in the male specimen dissected, I have not found them in female specimens, and am not sure that the second plate is a gill-plate. It differs in appearance from the true gill-plate, and might be considered a brood-plate, but it bears no setæ on the margin, and I am practically certain that the specimen is a male.

the meros and is similarly furnished with setæ, but those on the posterior margin are rather stouter than in the meros. The propodos is longer than the carpus and rather more slender; its anterior margin bears six fine setæ and the posterior margin six groups, each containing one stout seta and usually one or two small ones. The dactylos is of average length, very acute, with the terminal unguis imperfectly defined; on the outer margin, near the base, it bears a single seta, sparingly plumose at the end.

The *second peræopod* is similar in all respects to the first.

The *third, fourth,* and *fifth peræopoda* are all similar to each other, but each is larger than the preceding; each appears to have only one gill-plate. Fig. 6 represents the *third peræopod* and may be taken as a sample. The coxa is normally deep, distinctly bilobed, the posterior lobe being rather the larger. The basos is considerably expanded, oval in shape, about two-thirds as broad as long; its anterior margin bears nine or ten stout setæ; the posterior margin minutely serrate and having a small seta in each serration. The ischium as usual. The meros is rather broad, the postero-distal angle somewhat produced, both margins with groups of long stout setæ. The carpus is longer than the meros, but much narrower; the propodos somewhat longer than the carpus; both bear groups of long stout setæ on both margins, those on the anterior margin being larger than those on the posterior margin. The dactylos is like that of the first peræopod, but bears three small setæ on the outer margin in addition to the plumose one near the base.

The *first pleopod* is of the usual form; the peduncle is rather short and has both margins free from setæ; there are two coupling-spines, each bearing three or four teeth; the first joint of the inner ramus bears two cleft spines; the inner ramus is slightly longer than the outer.

The *second* and *third pleopoda* are similar to the first.

The *first uropod* (fig. 7) has the peduncle long and slender, much longer than the rami; its upper surface is flat or slightly concave; both the upper margins supplied with spines. In the large male there were only three or four spines on each margin, but in females the spines are usually much more numerous (compare Pl. XXIII. figs. 7, 16). The two rami are similar, with spines on both margins and longer spines at the ends; the outer ramus is a little shorter than the inner.

The *second uropod* (fig. 8) is shorter than the first and has the outer ramus not much more than half as long as the inner. It is supplied with setæ in a similar manner to the first uropod.

The *third uropod* (fig. 9) reaches further back than the others, the peduncle reaching as far as the ends of the first and second uropods; it bears spine-like setæ on both the upper margins. The rami are longer than the peduncle, somewhat broad, narrowing gradually to the ends, which are acute and bear no setæ; both margins of each bear three or four tufts of small spines. In the male specimen drawn the outer ramus is somewhat shorter than the inner, but in females the two rami are of about the same length and the whole uropod is rather longer and more slender (compare figs. 9, 11, Pl. XXIII.).

The *telson* (see fig. 17) is short, not reaching to the end of the peduncle of the third uropod; it is nearly rectangular, rather broader than long; the angles at the extremity rounded, and each bearing a fine hair; the hinder margin slightly concave. Fig. 17 is taken from a female; in one male specimen examined the hinder margin was slightly more concave.

Sexual differences. The female differs from the male as above described in many characteristic features, and especially in the gnathopoda, so that if they had not been taken together it is rather unlikely that the two forms would both have been assigned to the same species. With the facts before me, however, I have no doubt that we have to deal with the two sexes of the one species. The one form I consider the male from its largely developed gnathopoda, from the absence of brood-plates &c., although I have not actually found fully-developed spermatozoa in it. The other form is undoubtedly a female, for I have frequently taken it bearing eggs; it is found associated with the male both at Eyreton and Ashburton; it is much smaller, the largest specimens being not more than two-thirds the size of the largest male, and it is very much more numerous. Although I have not yet obtained a complete series of transitional forms, still from the facts given below I feel convinced that in this species, as in many other Amphipoda, the young male at first resembles the female in the form of the gnathopoda &c., and that the peculiar characteristics of the male are not acquired until the animal has attained to sexual maturity.

In the female the *antennæ* are more slender than in the male; in accordance with the smaller size of the animal, the setæ on them are less prominent, especially in the lower antennæ, and the calceoli are wanting. I have found calceoli in some specimens which in other characters closely resembled females, but, as I have already said, these are more probably immature males. As the calceoli in these specimens are of very small size, extremely delicate and transparent, and hence easily overlooked, I thought at first that they were perhaps present also in the females, though I had failed to see them; however, I have since looked for them very carefully in several mature females and can find no trace of them.

In the *upper lip*, the *mandibles*, and the *lower lip* the female does not appear to differ from the male.

In the *first maxilla* the inner lobe is larger and bears fully twice as many plumose setæ as in the male specimen drawn in fig. 10, Pl. XXII. It is quite possible that the number of plumose setæ on the inner plate of this maxilla bears some relation to the size of the animal irrespective of its sex; but all the female specimens examined have about twice the number found in the male, and I have not had sufficient male specimens of different sizes to be able to decide how many of these setæ are usually present, or whether the one figured is exceptional or not.

In full-grown females the setæ on the middle lobe and at the end of the palp closely resemble those of the male as drawn, the two palps being different as in the male.

In the *second maxilla* in the female the oblique row of plumose setæ contains about twice as many setæ as in the male figured in fig. VI. *n*, and the remarks made in connection with the first maxilla apply to the second maxilla also.

In the *maxillipedes* (fig. 11, Pl. XXIII.) we find a very considerable difference between the two sexes (compare fig. 15, Pl. XXII., and fig. 11, Pl. XXIII.). In the female the two lobes are considerably larger than in the male, the inner lobe reaching nearly to the end of the *outer* margin of the meros, and the outer lobe nearly to the end of the carpus; the lobes are also broader, but the armature of each is practically the same in both sexes. The meros, carpus, and propodos bear fewer setæ in the female, especially on the outer margins, and I cannot find the central row of setæ along the upper surface of the propodos which was certainly present in the male specimen figured. Notwithstanding these differences, there is a very close agreement in other respects, the resemblance being greater than would be imagined from a comparison of fig. 15, Pl. XXII., and fig. 11, Pl. XXIII.; and I wish to repeat that I am not yet certain how far the differences observed are due to sex and how far to size alone.

It is, however, in the gnathopoda that we find the greatest difference between the sexes; and it is, perhaps, worthy of note that each gnathopod is quite different in the two sexes, while in most cases in the Amphipoda one pair, at least, is the same, or nearly the same, in both male and female.

The *first gnathopod* of the female (figs. 12, 13, Pl. XXIII.) has the basos rather stout, widening distally, its posterior margin bearing a few setæ. The *ischium* and *meros* short, subequal, each with a few setæ at the extremity on the posterior margin. The *carpus* triangular, a few setæ on the anterior margin; the posterior margin irregularly serrate and with small tufts or transverse rows of setæ, an oblique row of four or five setæ being situated on the surface of the joint near the postero-distal corner. The *propodos* is about as long as the carpus and not broader than the latter at its distal end, subelliptical in outline; the anterior margin with three or four setæ and a small tuft at the base of the dactylos; the posterior margin with four short transverse rows, an oblique row of seven or eight widely separated setæ extending along the surface of the joint near the posterior margin; the palm is a little oblique, defined by two stout setæ, its edge somewhat crenate and fringed with a few small setæ. The *dactylos* moderately stout, curved, with a few setæ on its inner margin.

The *second gnathopod* (figs. 14, 15) is similar in general structure to the first, but is much longer and more slender. The *basos*, *ischium*, and *meros* are all similar to those of the first gnathopod, but more slender; the *carpus* is very long, much longer than the propodos, narrow oblong, its posterior margin with about eight or nine tufts of setæ in slight serrations; the *propodos* is also oblong in outline, of the same width as the carpus, both margins with tufts of setæ, those on the posterior margin the longer, a very distinct transverse row being situated at the base of the dactylos; the palm is transverse, defined by a small projection and a stout seta; the *dactylos* very short.

In the *peræopoda*, *pleopoda*, and *uropoda* the female does not differ from the male except in the few small points already mentioned, and it is quite probable that these are as much due to size as to difference of sex. I have, however, usually found the telson a little more deeply emarginate on the hinder margin in the male than in the female, but the difference is very slight.

I have several times found small specimens otherwise like the ordinary female form but bearing calceoli on both antennæ, the calceoli being much smaller and much less numerous than in the adult male, as above described, but similarly arranged. The gnathopods of these forms, which I consider immature males, are usually quite like those of the ordinary female form; but I have rough drawings of one (made in 1883) in which the propodos of the first gnathopod is more ovate, the palm oblique, occupying fully half the posterior margin, and the tufts of setæ much reduced in number and containing shorter setæ or spines; the second gnathopod has the carpus as usual, but the propodos is shorter and differs in shape, being somewhat expanded distally, the posterior margin bears only three tufts of setæ instead of about eight as usual, and the palm is rather oblique. It will be seen that in so far as this specimen differs from the female it approaches towards the male; I have, however, not succeeded in finding any other forms intermediate between this and the fully-developed male. This particular specimen presented a peculiarity in the third pair of uropoda, having the two rami very unequal, one being as long as the peduncle and the other twice as long; I have never seen any other specimen with this peculiarity in such a marked degree, though specimens are occasionally seen in which the two rami are a little unequal.

In the first maxilla these "immature males" differ very considerably from the adult form; the ends of the palps of the right and left maxillæ are quite symmetrical, and the armature of the end of the outer lobe consists chiefly of broad comb-like setæ like those shown in fig. 18, Pl. XXIII., being thus about as different as can be from the adult form as shown in fig. 11, Pl. XXII. In the former figure, only some of the setæ are shown, those on one side; the other curved denticulated setæ which are found on the other side and particularly towards the inner margin have been omitted in order to show clearly those that are represented. I have found the first maxilla to be similar to this in other small forms in which I could find no calceoli whatever, which were probably either still younger males or young females, and I suppose that this form of the first maxilla is to be found only in immature individuals. Adult females have the first maxilla practically the same as that of the large male represented in figs. 18, 19, 20, 21, Pl. XXIII., so far as the two palps and the armature of the middle lobe are concerned. I have not as yet found intermediate forms between the adult and the small specimens.

Summary of the more important points in Part IV.

It will be convenient here to summarize briefly the more important points that have been brought out in the examination of the six species now described, as some of them might otherwise be overlooked in the mass of technical description.

(1) The genus *Phreatoicus* is shown to be a very peculiar one, requiring for its reception the creation of a new family, the Phreatoicidæ, which approaches in some respects to Asellidæ, differing, however, very much in the laterally-compressed body and the long six-jointed pleon.

(2) The pleopoda of *Phreatoicus* are well-developed and in some respects different from those of most other Isopoda. In the first pair there is a one-jointed endopodite and a one-jointed exopodite; in all the other pairs the exopodite is two-jointed, while in the third, fourth, and fifth pairs there is also a separate appendage arising from the protopodite and probably representing the epipodite. In the male the second pair of

pleopoda are specially modified, the penial filament being formed from a portion of the endopodite, a fact that will perhaps be useful to throw light on the more modified second pleopoda in the males of various Asellidæ, &c.

(3) A consideration of the coxæ of *Phreatoicus* leads to a short discussion in support of Spence Bate's contention that the "epimera" or "side-plates" are in reality the coxæ of the appendages of the peræon.

(4) In discussing the systematic position of *Phreatoicus* reference is made to the external characters by which the Amphipoda are separated from the Isopoda, and an additional difference is shown to exist in the *ischia* of the appendages of the peræon, as these are of moderate length in all Isopoda except the Apseudidæ and Tanaidæ, while they are almost always very short in the Amphipoda.

(5) The genus *Cruregens*, belonging to the Anthuridæ, is described and compared with some allied genera. It has only six pairs of legs, and thus appears to permanently retain this larval character of the Isopoda, owing probably to an arrest of development.

(6) The mouth-parts of *Cruregens*, which are very difficult to determine, are fully described, and it is shown that the mandibles are small and without any trace of a palp—a character very exceptional in the Anthuridæ.

(7) The terminal uropoda of *Cruregens* are shown to consist of an oblong peduncle, a long narrow exopodite arising from near the anterior end of the peduncle, and a one-jointed endopodite arising from its posterior end. Other authors, with the exception of Dohrn, have apparently wrongly described the uropoda of the Anthuridæ as having a two-jointed endopodite, the distal portion of the peduncle having been mistaken for a part of the endopodite.

(8) The telson of *Cruregens* and of some other Anthurids is distinctly separated from the last segment of the pleon, though this is exceptional among the Isopoda.

(9) The genus *Crangonyx* is discussed at some length, and the mouth-parts of *Crangonyx compactus* are described. The mouth-parts of *Crangonyx* do not appear to have been previously described.

(10) The pleopoda of *Crangonyx compactus* have each only *one* ramus instead of *two*, as is almost universally the case in other Amphipoda. It appears to be the inner branch that is wanting. Nothing appears to be known of the pleopoda of most of the other species of *Crangonyx*.

(11) The species *Gammarus fragilis* appears to correspond well with the characters usually assigned to the genus, but it is interesting to note that the present species has very long antennæ, peræopoda, and terminal uropoda, thus showing some approach to the characters of *Niphargus*.

(12) In *Calliopius subterraneus* there is very great dissimilarity between the two sexes, chiefly in the gnathopoda, *both* of these in the male differing considerably from those of the female, while in other species one pair is usually almost or quite alike in the two sexes. There are also differences in some of the mouth-parts, viz. in characters which are often made use of for generic differentiation.

Some remarks are made on the calceoli found in the males of this species; they are also found in some specimens which otherwise resemble the females, but these are looked upon as immature males which have not yet acquired the peculiar gnathopoda of the fully-developed male.

V. The General Fauna of the Subterranean Waters of Canterbury.

In addition to the Crustacea described in the present paper there are doubtless many other forms to be found in the underground waters of the Canterbury Plains. In his paper on the fauna of the subterranean waters of the North of France, Dr. R. Moniez [78] gives a very long list, including Protozoa, Cœlenterata, Turbellaria, Nematoda, Annelida, Rotifera, Gasteropoda, and various Crustacea, in addition to the Amphipoda and Isopoda, viz. Copepoda, Ostracoda, and Cladocera. In the various caves of North America, as described by Packard [83], and likewise in those of Europe, described by Joseph [67] and other writers, the fauna is a very extended one, and naturally includes many air-breathing forms that would be unable to exist in subterranean waters.

I have made no extended search for other forms from the wells of Canterbury, but in collecting the Crustacea I have occasionally met with others, and it will perhaps be well to mention briefly here what is known on the subject, in the hope that greater attention will be directed to the matter in the future.

Attached to the Amphipoda (*Crangonyx compactus, Gammarus fragilis, Calliopius subterraneus*) I have, on several occasions, noticed a small stalked Infusorian, probably a *Vorticella*, or something allied thereto. Various worms have been brought up by the pump—one, an Oligochæte, is, Professor Haswell tells me, *Phreoryctes Smithii*, Beddard; another is a very remarkable Turbellarian, which is at present being investigated by Professor W. A. Haswell, of Sydney.

Mr. W. W. Smith, who has examined the water brought up by pumps in the Ashburton district with great care and perseverance, has succeeded in detecting several forms that have not yet been observed from the Eyreton wells. Among these are some small Gasteropoda, a small Centipede, and a peculiar worm, *Phreodrilus subterraneus*, Beddard [8]. The shells have been observed from several wells, but only very few specimens have as yet been obtained; these were submitted to Mr. Suter of Christchurch, who states that they appear to be *Potamopyrgus antipodum*, Gray, var. *spelæa*, Frauenfeld. *P. antipodum* is a freshwater species which is very widely distributed in New Zealand, and has probably received various names for its different varieties: the type of *P. spelæa* was found in the Collingwood Caves near Nelson. There seems no doubt that the shells found at Ashburton really belong to the true subterranean fauna, as Mr. Suter states that they were without pigment and of a dirty white colour, and the animals were still alive when got from the pump by Mr. Smith, who watched their movements for some hours before sending them off to Mr. Suter.

The aquatic worm obtained by Mr. Smith was forwarded to Mr. F. E. Beddard, who has described it as "*Phreodrilus subterraneus*, nov. gen. et n. sp.," making it the type of a new family of the Aquatic Oligochæta, viz. the Phreodrilidæ [8]. The genus is, he considers, a very remarkable one, and, in addition to various peculiarities in the internal anatomy, the character of the setæ is alone sufficient for the creation of a new family. He regards the Phreodrilidæ as a very low form of Oligochæta, greatly specialized in certain directions. He adds :—"I should explain that in using the term 'low' I do not mean that this genus is in any way near the ancestral form of the Oligochæta. The simplicity of structure in this and other aquatic genera is rather to be looked upon as evidence of degeneration." He places the Phreodrilidæ nearer the Naidomorpha than to any other group of the Oligochæta, though admitting that the position of the genital organs suggests an affinity with the Enchytræidæ. There are also a few points in which *Phreodrilus* recalls the higher among the Oligochæta, and Mr. Beddard comes to the conclusion that "it should be placed some way off the line leading from the more highly-developed Lumbriculidæ to the lower Naidomorpha, but that its precise relationships require further study, and cannot be determined with any probability of success at the present time" [8, p. 292].

I have given the above account of *Phreodrilus* pretty fully because it appears in many respects to be parallel to the case of *Phreatoicus*, for which I have had to establish a new family. The two cases confirm each other, and show how exceedingly interesting the subterranean fauna really is. No doubt other discoveries quite as interesting as these will yet repay careful and systematic search, for as yet the ground has been prospected merely, not thoroughly worked.

Besides animals which, like the above-mentioned, undoubtedly belong to the true subterranean fauna, it appears that surface animals from the neighbourhood of the wells may sometimes be obtained through the pump, apparently from the well. Thus I have several times taken *Cyclops novæ-zealandiæ*, G. M. Thomson, from wells at Eyreton. The specimens were exactly like those found in surface pools in the neighbourhood and had the eye perfect, and had no doubt got into the well by accident—an accident that with this small creature might very easily happen. On one occasion Mr. Smith, after pumping for three quarters of an hour from a well at the Elgin Schoolhouse near Ashburton, 50 feet deep, and fitted with a cylinder-pump, obtained a spider and a small Gasteropod shell, and the seeds of some plants. The spider, which has perfect eyes, is, Mr. Goyen informs me, a species of *Theridion* frequently found in dark situations, such as crevices of rocks, &c. The seeds were submitted to Mr. D. Petrie, who writes that one belongs to *Chenopodium*, which is abundant everywhere in the district. The shell, determined by Mr. Suter, is *Amphipeplea ampulla*, Hutton, a species found everywhere in creeks, rivers, pools, &c.; the animal had evidently been dead for some time, as the body was decayed; the shell was of the normal horny colour, and, like the spider and the seeds, it must apparently have got into the pump by some accident, and forms no part of the true subterranean fauna. Mr. Suter points out that the shell of this specimen showed no approach to the dead-white colour of the *Potamopyrgus*, which is no doubt truly subterranean.

At the same time and from the same pump Mr. Smith obtained one or two specimens of *Calliopius subterraneus*.

VI. The Canterbury Plains and their Underground Waters.

All the localities from which subterranean Crustacea have been as yet collected in New Zealand are situated on the Canterbury Plains, and in order to clear the way for the discussion of the probable origin of these forms it will be convenient to state first a few facts about the formation of the plains and as to their underground waters. Much of what follows is taken from the late Sir Julius von Haast's 'Geology of the Provinces of Canterbury and Westland, New Zealand' [53]. In speaking of the plains formed on the eastern side of the Southern Alps he says :—

"The most prominent amongst these are the Canterbury Plains, which, by their position, nature, and general characteristics, form a prominent feature of this island, and are already the centre of a rich, industrious, and large population. They begin at the dolerite plateau of Timaru, and stretch without interruption to Double Corner, in a general direction from south-west to north-east, with a length of about 112 miles. Their breadth from a few miles at both extremities, north and south, augments as we advance towards their centre, having their greatest lateral extension near Banks Peninsula, where, in a direction from east to west, they stretch a distance of nearly 50 miles to the base of the mountains. The Pacific Ocean is their boundary on the eastern side, where a long shore stretches in a line nearly from south-west to north-east—from Timaru to Double Corner—being only interrupted by the volcanic system of Banks Peninsula, which rises so conspicuously in the middle of that low shore, and to the existence of which so great a portion of the loose strata composing these plains owes its preservation from the destructive agencies of the waves and currents. The western boundary is formed by the outrunning spurs of the Southern Alps, having, as I have pointed out previously, by their disintegration, offered the material for the present configuration and other physical features of the plains. In their great bulk they consist of the accumulation of post-pliocene torrents. Having had their glacier-sources much nearer to Banks Peninsula than in present times, the latter were able to throw the boulders, shingle, sand, and ooze, carried along with them, not only in greater masses, but also on steeper slopes than the present rivers crossing them can do, for reasons given in the geological portion. These post-pliocene deposits of large rivers have covered with an almost uniform gradient the palæozoic, volcanic, or tertiary rocks composing here the sea-bottom" [53, p. 231].

The Canterbury Plains slope towards the sea at the rate of about 40 feet to the mile for the first fifteen or twenty miles from the mountains, and at an average of 24 feet to the mile for the remainder of the distance to the sea. This may be illustrated by the following figures taken from Sir Julius von Haast's 'Geology' [53, p. 403], showing the fall of two of the rivers in the basins of which subterranean Crustacea have been found :—

Name of River.		Difference between two Stations.	Length of Plains.	Fall of Plains per mile.
		feet.	miles.	feet.
Ashburton	From Two Brothers to sea .... mean	1500	$35\frac{1}{2}$	$42\frac{1}{4}$
	From Two Brothers, 1500 feet, to Railway crossing, 305 feet	1195	25	48
	From Railway crossing, 305 feet, to sea (50 feet above sea-level)	255	$10\frac{1}{2}$	29
Waimakariri ..	From upper gorge to sea .... mean	1580	44	36
	From junction of Kowhai, 1410 feet, to lagoon at gorge hill, 1182 feet	228	5	$41\frac{1}{2}$
	From lagoon, 1182 feet, to the so-called 18th-mile peg, 355 feet......................	827	$18\frac{3}{4}$	44
	From 18th-mile peg, 355 feet, to last raised beach near North Road, 33 feet	322	$13\frac{1}{4}$	$24\frac{1}{4}$
	From last raised beach, 33 feet, to sea........	33	4	8

Some of the other rivers show rather more gradual falls than those quoted in the table above; thus the River Selwyn from its entrance into the plains to its mouth at Lake Ellesmere has a total fall of 790 feet in a distance of 29 miles, or an average of $27\frac{1}{4}$ feet per mile.

With regard to the origin of the plains Sir Julius von Haast says:—"All the levels, surveys, engineering works, together with well-sinking, have amply confirmed my views that the Canterbury Plains are of fluviatile origin, that, with the exception of some morainic accumulation in the upper portion and the drift sands round Banks Peninsula, and the partial lacustrine deposits filling the former extension of Lake Ellesmere, the whole of the plains were formed by huge rivers issuing from the frontal end of gigantic glaciers" [53, p. 396]. Consequently the Canterbury Plains consist of river shingle and sand, cemented more or less by a ferruginous matrix; this has been proved by the sinking of wells in many directions on the Plains, some of them to considerable depths. In a well between the Ashburton and Rakaia, "where a supply of water was reached at a depth of 220 feet, the shingle at the bottom became much cleaner and incoherent, resembling the small shingle in the Rakaia river-bed" [53, p. 473].

All over the plains water is found at a greater or less depth below the surface, the depth varying according to the locality, the dryness of the season, the condition of neighbouring rivers, &c. In a great many places this water is found within about 30 feet of the surface, and can hence be brought up by suction-pumps; in some cases, however, as in the one quoted above, water is not found until a depth of 200 feet or more is reached. These underground waters can percolate through the river-shingle of which the plains are composed with considerable freedom; thus whenever a hole is dug to the water-bearing stratum, it is quickly filled by the water running in from the shingle all around: the various wells at Eyreton, again, are quickly affected by the state of the river Eyre, which is from one to three or more miles distant from them; thus if the water in these wells has sunk owing to drought when the river continues dry, it quickly rises again when the river is in flood. Evidently a considerable quantity of the water of the Eyre and of other rivers flowing across the Canterbury Plains must leak away through the loose sand and shingle in their beds, and go to supply the subterranean waters. The Canterbury rivers are so rapid and so frequently in flood that they are continually washing away parts of their beds, and thus opening up a way for the water to escape through the loose shingle thus exposed, and there is no opportunity given for such openings to be permanently closed by the finer sediment brought down by the rivers. It frequently happens that in the bed of the river Eyre, some five or ten miles above East Eyreton, towards the source of the river, there is a considerable quantity of water, while the whole of this, except of course that lost by evaporation, sinks into the ground before Eyreton is reached, so that there the river-bed is quite dry.

The subterranean waters, instead of being evenly spread over a whole district, often no doubt form more or less distinct streams, and probably different streams arising from different sources may be found one below another; thus Mr. Smith says that in the sections of the Canterbury Plains exposed at the mouths of the Rangitata and Ashburton rivers, subterranean streams may be seen to flow out at various heights in considerable volume and force. These different streams are no doubt separated by harder and more impervious strata, and they will have different sources; some of them will, perhaps, obtain their supply of water from the leakage that takes place at the foot of the hills owing to the break of the continuity of the strata of the plain.

In his Presidential Address to Section E at the Christchurch Meeting of the Australasian Association, Mr. G. S. Griffiths [52] has given a number of facts about the subterranean waters of a part of Australia which it will be interesting to compare with what we know of those of Canterbury. Speaking of the artesian wells which are being sunk on the back blocks from the centre of Queensland down towards the mouth of the Murray, he says:—"The chief sources of these water-supplies must be looked for in the great eastern cordillera, which sheds the surface streams that also cross Riverina. Along its crests the rainfall is of course greatest, being from 20 in. to 40 in. per annum in the Queensland portion; and it is near to the long ribbon-shaped region of heaviest rainfall—that is, along the sides of the watershed—that the superficial deposits, being largely composed of gravel and rock *débris*, are most pervious. Further, the continuity of the strata of the plains is broken at the hill-foot, where they die out against the outcropping rocks of the main range, and this line of break affords to the water flowing down the hills a ready passage beneath the sediments of the plains.

"Under these circumstances a large proportion of the rain caught on the ranges leaks under the subsoil directly it falls, and it flows to the sea slowly indeed, but with its volume undiminished either by the evaporation which lowers the surface waters of the Riverina 6 ft. per annum, or by the demands of vegetation, which are much greater upon river-water than the public has any idea of.

"As these subterranean waters travel away from their sources they must thin out.... But it appears to me that in every district of any size there must be deeper channels in that ancient land-surface which is now the bed-rock or reef of the miner.....

"These underground watercourses, or, as the miner would describe them, these wet leads, will run out into the plains for greater distances than a hundred miles. Indeed, when we remember that the streams are undiminished by evaporation or the demands of vegetation, and that they have been the recipients of all the leakage of the hills throughout all the ages that have passed since the sea retired, it appears to me that the deeper leads must be saturated with water right through from the mountain-foot to the Australian Bight. For, however slow the circulation of the system may be, as the water has never ceased to run in at the upper ends of the region, and as it does not rise to the surface as springs, it must run out at the lower end into the sea, escaping in the form of submarine springs. As a matter of fact, along the south coast of Australia, between Warrnambool and the Murray mouth, the sea literally bubbles up with fresh water which has leaked up through the sea-sands" [52, pp. 235, 236].

Doubtless a large portion of the deeper underground waters of the Canterbury Plains escapes into the sea in the same way by submarine springs, for in many cases they are known to be much below the sea-level. Thus the water-bearing stratum that supplies the ordinary artesians of Christchurch is, at the coast at New Brighton, 136 feet below the surface, and there is another stratum below at about twice that depth [63, p. 33]. Other portions of these underground waters in Canterbury rise to the surface, before reaching the sea, as springs, like those which form the source of the river Avon near Christchurch.

Facts like those quoted above from Mr. Griffith's address, and the widespread distribution of the subterranean genus *Niphargus* in Europe, and of the closely-allied genus *Crangonyx* in North America and elsewhere, remind us of what might otherwise be overlooked, viz. the universality and great extent of underground waters. An instructive example is given by Wallace in his 'Malay Archipelago':—

"The little island of Kilwaru is a mere sandbank, just large enough to contain a small village, and situated between the islands of Ceram-laut and Kissa—straits about a third of a mile wide separating it from each of them. It is surrounded by coral-reefs, and offers good anchorage in both monsoons. Though not more than fifty yards across, and not elevated more than three or four feet above the highest tides, it has wells of excellent drinking-water—a singular phenomenon, which would seem to imply deep-seated subterranean channels connecting it with other islands" [114, pp. 375–6].

Many similar facts have been brought to light in connection with the boring of artesian wells, and some of these will be found collected in Lyell's 'Principles of Geology' [76, vol. i. p. 385 &c.], where it is shown not only that the underground waters extend to great depths, often far below the level of the ocean, but that various distinct sheets of water may be met with, one below another, five distinct sheets having been intersected in a well at St. Ouen, in France [76, vol. i. p. 389]. Lyell also gives some examples showing that there are often open passages by which the subterranean waters circulate. Thus, in a well at Tours, from a depth of 364 feet, there were brought up a freshwater shell, some land species, some seeds of plants and other vegetable matter, all of which, it was supposed, had flowed from some valleys of Auvergne or Vivarais, distant about 150 miles, since the preceding autumn. After giving other examples of a similar kind, Lyell says, "we see evidence of the water not having been simply filtered through porous rock, but having flowed through continuous underground channels. Such examples suggest the idea that the leaky beds of rivers are often the feeders of springs" [76, vol. i. p. 391].

Professor Forel, in considering the origin of the blind *Niphargus Forelii* and *Asellus Forelii*, comes to the conclusion that they have originated, not in the lakes themselves, but in the underground waters, and he gives various interesting facts showing the communication that must exist between these waters and the deep waters of the lakes [40, pp. 182–183 &c.]. The same thing is found in North America, for some of the blind cave-species, *Cæcidotæa stygia* for example, are obtained from wells in various districts, showing that they exist widely spread in the underground waters, and not merely in the caves themselves. It is possible that some of the species, perhaps *Cæcidotæa stygia*, may have originated in the underground waters, and not actually in the caves, thus forming an exact parallel to the case of *Asellus Forelii* in the Swiss lakes.

It will not be necessary to bring forward any additional facts to show that there must be abundant opportunities by which specimens of the freshwater fauna of any country might be carried into the underground waters which almost everywhere exist, and thus have a chance of giving rise to subterranean species.

In the case of the Canterbury Plains, the subterranean waters have almost everywhere sunk several feet further from the surface of the land during recent years, owing to a succession of exceptionally dry seasons. Thus at Eyreton the level of the water has sunk on an average about 10 or 12 feet; Miss Young tells me that it has sunk also at Winchester, and that the well there, from which subterranean Crustacea have been obtained, has had to be deepened, and it will be seen from the following interesting account, prepared by Mr. W. W. Smith, that the lowering of the water has been very marked at Ashburton:—

"Previous to the years 1890 and 1891 no lowering or discoloration of the subterranean water was observed on the plains, at least there are no records of such existing. The water in the pipe-wells and in the outflowing streams at the base of the terraces of the Ashburton river, and also in the surface springs on the plains, remained constant at all seasons and perfectly pure. As the drought increased, the water in the pipe-wells lowered, and left them all, with one exception, dry. Near one house a large surface spring rose in a small gully, and discharged a heavy flow of cool pure water. It began to diminish in volume in October 1890, and by the December following it had ceased to flow. The terrace springs, situated 25 feet lower, held out several months longer, and they in turn gradually became dry. Half a mile below Ashburton a large strong-flowing spring exists right in the river-bed; it is distant about a quarter of a mile from the nearest terrace, and situated 12 feet below it. It flows out of a partially conglomerated bed of small stones and clay, and unquestionably belongs to a lower stratum or stream of water than those supplying the pipe-wells in the town. The water in this spring is never affected in volume or colour by the flooding of the river, but retains its purity at all seasons. The nearest terrace is 12 feet above it, and is composed chiefly of clay. It is only a few feet above the stratum of water which supplies the wells in the town. Before the drought several springs arose at the base of the terrace, none of which, nor any of the surface-springs, have at present recommenced to flow.

"I may mention that Mr. W. F. Dolman, a practical well-sinker in business here, informed me that there is no question about the water flowing between the various strata or irregular beds of shingle and sand composing the plains, at least in the Ashburton district. Some of the beds are intensely hard and extremely difficult to pierce with the steel-pointed pipes. After the lowering of the water, Mr. Dolman ascertained when driving the pipes to unusual depths that the pipe frequently entered 'dry-beds,' and he had either to draw up or lower the pipe to tap the water. The deepest well he has driven is 65 feet, and it has continued to give a good flow ever since it was driven. Mr. Dolman states that there is no limit, so far as he knows, to the depth the water is found in the plains, although it flows in thinner or shallower streams the lower he sinks. Referring to the discoloration of some streams, he informed me that he has found small round particles of clay in the water, and he attributes its discoloration to these floating particles. When sinking open wells, Mr. Dolman has occasionally observed the direction and rate at which the subterranean water flows. He estimates its motion at from one-quarter to one-half a mile an hour. One important fact he has several times ascertained, when driving the pipes through the lower and harder beds, is the rising of the water in the pipe to various heights from the newly-tapped stream. He has known it to rise from 2 feet to 14 feet, and afterwards to remain permanent. There is considerable difference in the work of sinking the various wells—some are put down in a few hours, the pipes driving freely, and others require as many days, and this sometimes with a heavier 'monkey' at work. These facts can be better studied by an examination of the high sections of the plains at the mouths of the Rangitata and the Ashburton Rivers.

"The exceptional well I have mentioned, which did not become dry, is driven 27 feet, and is in a low-lying part of the town. Nearly all the pipe-wells originally driven were sunk to various depths, ranging from 15 feet to 22 feet. These, without any exception, became dry."

VII. Origin of the Subterranean Crustacea.

In considering the source from which the subterranean Crustacea have been derived, it will be well to state first what little is known of the freshwater forms of the Amphipoda and Isopoda found in New Zealand and Australia.

In New Zealand only one freshwater Isopod is known, *Idotea lacustris*, G. M. Thomson [21, p. 263], and this one has no connection whatever with the subterranean fauna. In Australia, however, a species of *Phreatoicus* is known, *P. australis* [26], as yet found only on the top of Mt. Kosciusko, about 6000 feet above the sea. In the Amphipoda we have two freshwater species recorded from New Zealand. One, *Calliopius fluviatilis*, is very common in almost all running streams of the South Island; but is also found in various places in Otago Harbour, in water that is quite salt. This species is very abundant in the surface-streams of the Canterbury Plains, in the localities where the subterranean forms also abound; but, as I have already pointed out, although it approaches *Calliopius subterraneus*, it is dissimilar in several respects, and it does not seem at all likely that *C. subterraneus* is directly descended from it. The other species is *Pherusa cærulea*, G. M. Thomson [107, p. 206], found by Mr. Thomson on the top of the Old Man Range, 3000 feet, in Otago, and as yet known from this locality only. I have compared this species in some detail with *Calliopius subterraneus* (see above, p. 235), and have shown that in many points the resemblance is very great, and that most probably *Pherusa cærulea* and *Calliopius subterraneus* are both descended from a species formerly widely spread in New Zealand.

This is all that is as yet known of the freshwater Amphipoda and Isopoda; but it must be remembered that our knowledge of the subject is very imperfect, and that careful search of other streams, especially in the mountainous parts, will probably reveal other forms. As an example, I may mention that until lately *Idotea lacustris* was known only from the Tomahawk Lagoon near Dunedin, a lagoon situated very close to the sea; I have, however, since collected a variety of the same species in great abundance in the streams, up to a height of about 1000 feet, around Mt. Mihiwaka, between Port Chalmers and Blueskin, as well as in streams some five or six miles distant, and on the other side of the Waitati valley [21, p. 263]. In the same situations I have also taken another Amphipod, at present undescribed; this, however, appears to belong to the genus *Hyalella*, and throws no light on the origin of any of the subterranean forms.

No freshwater Amphipoda have been described from Australia, but in January 1892 Mr. Thomson collected two species on Mt. Wellington, near Hobart, Tasmania, and examples of both species have since been kindly supplied to me by Mr. Alex. Morton, of the Tasmanian Museum. They are being examined by Mr. Thomson and have not yet been fully worked out. One is a rather large species, and seems to belong to *Niphargus* in its general structure and in the uropoda, though the terminal uropoda are not very long. The other species, which is smaller, and comes from the top of Mt. Wellington, about 4000 feet high, also seems to approach very closely to *Niphargus*, though very different from the preceding species in general appearance; it closely resembles that species in the antennæ, the mouth-parts, and the gnathopoda, which are subequal, and have the propodos subquadrate, as in most species of *Niphargus*; the telson also is deeply cleft, not double, and bears stout spines on the hinder margin of each lobe, as in *Niphargus*; the body, however, is not slender, but rather compact, and the third uropods, though consisting of a very small inner branch and a longer two-jointed outer branch, are not elongated, and the second joint of the outer branch is very small, so that in these respects the animal resembles *Crangonyx* rather than *Niphargus*. It is, however, very different from *Crangonyx compactus* in the gnathopoda, the side-plates, the base of the peræopoda and the pleopoda, and of course also in the telson. However, the species presents a nearer approach to both *Niphargus* and *Crangonyx* than any form at present found in the surface-streams of Europe, and it is interesting, because it shows the wide distribution of forms similar to those from which *Niphargus* and *Crangonyx* must have been derived*.

The question of the origin of the subterranean Crustacea has from the first given rise to much discussion and to the most diverse opinions. Unfortunately, too, the question has been obscured by some of the conclusions being based on insufficient facts, and by some of the facts themselves being at first incorrectly stated, as, for example, the affinities of *Cæcidotæa*.

The explanation that most readily offers itself is that the subterranean Crustacea are

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* This species Mr. Thomson has named *Niphargus montanus*, sp. nov.: the one previously mentioned he calls *Niphargus Mortoni*, sp. nov., though he tells me he does not feel satisfied about placing it in the genus *Niphargus*.

direct descendants from those now living in fresh waters on the surface of the earth. This view has been strongly upheld by some—by Fries, among others—and appeared to receive some support from the fact that specimens of *Gammarus fossarum*, kept in darkness during the winter, lost to some extent the pigment of the eyes, thus showing some approach to the blind *Niphargi*. I shall refer to this again later on.

Others, again, confining their attention more particularly to the special affinities of one or two genera of the subterranean Crustacea, have pointed out that, in place of being allied to freshwater forms, they more closely resemble marine forms, some of which are inhabitants of deep water. Thus Spence Bate states that *Niphargus* resembles the marine *Eriopis* much more than the freshwater *Gammarus* [4, p. 314], and that *Crangonyx* appears to have its nearest ally in the marine *Gammarella* [4, p. 326]. This resemblance of the subterranean forms to members of the marine fauna appeared at first to receive some confirmation from the unfortunate name *Cæcidotæa* [81] given to the blind Isopods from the North-American caves, and from the mistaken ideas as to its affinities; and, misled by this and by the very imperfect knowledge of the freshwater Crustacea of New Zealand, I have also stated that the subterranean Crustacea of New Zealand appeared to have been derived from a marine source [23, p. 88]. No doubt the subterranean Crustacea, as well as the freshwater forms, have originally sprung from forms inhabiting the sea, but from the fuller array of facts now before us there can be no doubt that they have not been derived directly from these, but from a freshwater fauna. *Niphargus* and *Crangonyx* may, perhaps, show affinities to marine forms, and there certainly does not appear to be any closely-allied form now inhabiting the surface fresh waters of Europe; but in North America various species of *Crangonyx* are found in surface-streams, &c., and the fact that a closely-allied form is found in the fresh waters of Tasmania seems to show that the genus has probably been at one time widely spread in the freshwaters of the globe. *Cæcidotæa* is really a very close ally of the freshwater *Asellus*, species of which are found in the streams of both Europe and North America, with representative subterranean forms in both places. Professor S. I. Smith, in view of the fact that the Crustaceans have several times been referred to as indicating the partially marine origin of the cave-fauna of the Western States of North America, has considered their affinities in detail, and points out that, looking at the Crustaceans alone, there is "no reason for supposing that the fauna of the caves of Kentucky and Indiana has been derived from any other source than the recent fauna of the surface of the neighbouring region" [104]. The fuller knowledge that we now possess forces us to a somewhat similar conclusion with regard to the subterranean fauna of New Zealand, though here our knowledge is not so complete. The New-Zealand forms at present known are six in number—*Gammarus fragilis*, *Crangonyx compactus*, *Calliopius subterraneus*, *Cruregens fontanus*, *Phreatoicus typicus*, and *Phreatoicus assimilis*; and if we consider in turn the freshwater allies of these, we find the following facts:—No freshwater species of *Gammarus* is known from New Zealand or Australia as yet, but the genus is one very widely distributed and has freshwater species in other parts of the world; *Crangonyx*, as has been already pointed out, appears to be exclusively confined to fresh water, species are known either from surface-streams or from caves and wells in England (*C. subterraneus*), Italy (*C. pungens*), North America (*C. gracilis*, *C. vitreus*, &c.), Kamtschatka (*C. Ermanni*), New Zealand (*C. compactus*), and a form more or less closely allied still inhabits the fresh waters of Tasmania; *Calliopius subterraneus* appears to have its nearest ally in *Pherusa cærulea*, found in a stream on the top of mountains 3000 feet high in Otago, New Zealand, while another species (*Calliopius fluviatilis*), which perhaps belongs to the same genus, is very abundant in the freshwater streams of the South Island of New Zealand; no freshwater form at all approaching *Cruregens* is as yet known; besides the two subterranean species, the only other known species of *Phreatoicus* is found on the top of the Mt. Kosciusko Plateau in Australia, living in pools and streams.

It will thus be seen that there is no difficulty in supposing that the subterranean fauna of New Zealand has been derived directly from a freshwater fauna, and when we consider the affinities of the general fauna of the North-American caves as given by Packard [83], or of the various European caves, there can no longer be any doubt that the cave- and well-fauna has been derived from the surface-fauna of the neighbourhood.

While this conclusion thus appears to be well founded, it by no means follows that the subterranean fauna is necessarily derived from the freshwater fauna *at present* inhabiting the surface-streams and lakes; indeed there are several facts which seem to show that some species at any rate are derived from a more ancient surface-fauna. Thus, while the subterranean species *Asellus cavaticus* may perhaps be the direct descendant of the surface-species *A. aquaticus*, there is no doubt that *Niphargus* is not a mere modified form of any of the surface-inhabiting *Gammari* at present found in Europe. Wrześniowski has clearly pointed out that experiments like those made by Fries and observations on pale forms of *Gammarus* found in mines, &c., like the one described by Schneider, do not bear on the question, for the specimens approach *Niphargus* only in the pale body and in the partial loss of the eyes while still retaining the general build and characteristic mouth-parts, &c., of *Gammarus*. As to the actual origin of *Gammarus* and *Niphargus* we are, he says, quite in the dark; but he is of opinion that neither is derived from the other, but both from a common ancestor. Humbert had previously come to much the same conclusion and is of opinion that *Niphargus* is an ancient genus derived from a form now extinct.

The Crayfish inhabiting the caves of North America also appear to be more ancient than those at present found in the surface-water of the neighbourhood. Speaking of *Cambarus pellucidus*, Professor Faxon says it "is a very aberrant species, with no very closely related form outside the cave. The simple form of the male appendages, and the combination of characters belonging to different groups, seen in *C. pellucidus*, indicate, to my mind, that it is a very ancient form, which has been preserved in the seclusion of the cave, whilst its nearest kin succumbed in the sharper struggle incident to life outside, or were replaced by modified descendants evolved to meet the changeable conditions which obtain without the caverns" [37, p. 42].

This view is, he says, confirmed by the fact that the same form, *C. pellucidus*, is found in caves on both sides of that ancient river, the Ohio, and by the discovery by Gustav Joseph of a species of *Cambarus* in the caves of Carniola in Southern Austria. As the present Crayfish of Europe belong to a different genus, *Astacus*, Professor Faxon looks upon the existence of a *Cambarus* in the Carniolan caves (if the species really belongs to that genus) as evidence of the former existence of the genus *Cambarus* in the rivers of Europe [37, p. 42]. In connection with the latter point it is as well to mention that Packard has stated that Joseph's species, *Cambarus stygius*, is based only on a single dry specimen from one cave and remains of the forceps of another specimen from another cave, and that "it seems premature to draw conclusions from such limited facts" [83, p. 119, footnote].

Passing on to the New-Zealand forms we find that although six species are known from the underground waters of the Canterbury Plains, only one, *Calliopius fluviatilis*, G. M. Thomson, is found in the surface-waters of the neighbourhood, and that this species, though allied to some extent to *Calliopius subterraneus*, is dissimilar in several points, and certainly not so close to it as is *Pherusa cærulea* *. It would therefore seem that the subterranean forms are more ancient than the present surface-fauna of the Canterbury Plains; and this is confirmed by the fact that their nearest allies are found in remote situations. Thus *Pherusa cærulea*, the nearest ally of *Calliopius subterraneus*, is known only from one situation on the top of a mountain between 200 and 300 miles distant; no allies of *Gammarus fragilis* nor of *Cruregens fontanus* are known from the fresh waters of the southern hemisphere; *Crangonyx compactus* has its nearest allies in Europe and North America; while *Phreatoicus*, which is proved to be an ancient form by the possession of characters common to several families, appears to have been preserved only in the subterranean waters of New Zealand and on the top of Mt. Koscinsko in Australia.

Although it is thus probably true that some species of the subterranean fauna are ancient forms that have long since taken up their abode in the underground waters, we should naturally expect to find others, especially in the fauna of caves, that have much more lately adopted a cave life and are the direct descendants of surface-species still inhabiting the neighbourhood. Such specimens we undoubtedly do find, and they appear also to show several stages or transitions from surface-forms accidentally carried into the caves up to true cave-inhabiting forms. Thus in the caves of America among others the surface-forms *Cambarus Bartonii* [83, p. 40] and *Asellus communis* [83, p. 33] have been found, the specimens of these being more or less bleached and much paler in colour than the ordinary surface-forms; again, the cave Myriopod *Pseudotremia cavernarum* is, Packard says, only a modified form of the widely diffused *Lysiopetalum lactarium*, Say, and various other examples of the same kind are also to be found in Packard's work.

In the same way Schneider has described a subterranean variety of *Gammarus pulex*, found in mines at Clausthal, which differs from the normal forms of that genus in its pale colour, the partial degeneration of the eye, and the lengthening of the anterior antennæ [96]. Moniez also has found in the reservoir at Emmerin in the north of France a single specimen of a *Gammarus* which has been modified in much the same way as the

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* I have already pointed out, p. 234, that *Calliopius subterraneus* should perhaps be transferred to *Pherusa*, but that for the present I have left it in the genus in which it was originally placed, as the limits of these two and other allied genera appear to me to need fresh and careful definition.

variety described by Schneider, forming to some extent a link between this variety and the surface-type, though approaching again towards *Gammarus fluviatilis*, while Schneider's variety seems to come from *Gammarus pulex* [78, p. 40]. These examples are sufficient to make it clear that the subterranean fauna of any country is not always to be looked upon as a whole, but that the different species have in many cases adopted the subterranean life at different times, and that under favourable circumstances the subterranean forms may even at the present time be reinforced by immigrants from the surface. It is, however, obvious that transitional forms of the kind spoken of above will be much more common in caves than in underground waters, for the means of entrance will usually be greater, and immigrants from the surface will have to struggle with the forms that have already become adapted to a subterranean life, and will hence find it difficult to establish themselves unless they should happen to be carried into regions not already peopled. This is probably the reason why the subterranean Amphipod fauna of Europe is so fixed in character and uniform as it is, and why the subterranean species sometimes belong to such ancient forms.

In the case of the New-Zealand forms it is rather rash to speculate, but, considering the similarity of conditions all over the Canterbury Plains and the fact that all the known species, with the exception of *Phreatoicus assimilis*, are found together in the same stratum of water at Eyreton, it seems probable that all the forms adopted the subterranean life at about the same time, and that they are not now being reinforced by fresh immigrants from the surface. This is not for want of opportunities (for I have shown above, on p. 249 *et seq.*, that there are doubtless many ways by which the surface-forms can gain access to the underground waters), but because the surface-fauna from which the subterranean forms were derived no longer exists in its entirety. If it still exists at all it will doubtless be found preserved in mountainous situations in the same way as *Pherusa cærulea* and *Phreatoicus australis*.

The deep-water fauna of the sea and especially of freshwater lakes presents many resemblances to the subterranean fauna. The deep-water fauna of the Swiss Lakes, as described by Professor Forel [40], is particularly interesting in this connection, as it contains two species at least which also belong to the subterranean fauna, viz. *Niphargus Forelii* (= *N. puteanus*, Koch, var. *Forelii*, Humbert) and *Asellus Forelii*, Blanc. In considering the origin of this deep-water fauna Professor Forel comes to the conclusion that the greater part of it is derived from the littoral fauna of the lakes themselves, the animals having descended to greater or less depths, and having become more or less modified accordingly, and he also points out that every year new immigrants come to renew the deep-water fauna, just as we saw probably happens with the cave-fauna. With regard to the two species mentioned above, however, the case is different, and after a very long and full discussion of the whole problem [40, pp. 170–183] he decides that these come, not from the littoral fauna, but from the subterranean fauna that is so widespread throughout Europe. This confirms the conclusion of Humbert, Wrześniowski, and others, that *Niphargus* is not the direct descendant of *Gammarus pulex* of the surface. The latter species is found in the littoral fauna of the lakes and sometimes extends to deep water; but though it may be somewhat modified as regards colour, eyes, &c.,

it still preserves the distinguishing marks of *Gammarus* and shows no approach in structure to *Niphargus*. Professor Forel points out that there must be means of communication—not necessarily permanent—between the subterranean waters and the deep waters of the lakes and also between the subterranean waters of different localities, thus fully confirming what I had already written above on p. 258 before I had read Professor Forel's remarks on the subject.

VIII. THE SPECIAL CHARACTERISTICS OF THE SUBTERRANEAN FAUNA.

The special conditions of cave- and well-life and the peculiarities of the subterranean fauna have been discussed more or less elaborately by many authors, and a complete dissertation on the subject would require a volume to itself. All that can be done here is to mention a few points upon which information is supplied by the six subterranean Crustacea described in this paper. The subject has been fully discussed by Schiödte, Joseph, and Packard; and Forel has considered the conditions of life in the deep waters of the Swiss Lakes, the fauna of which presents many analogies to that of the underground waters.

Colour.

The effect of the absence of light on the colour of all animals living in caves and in underground waters seems to be very uniform, all such permanent residents being bleached and colourless. Speaking of the inhabitants of caves, Packard says:—"As regards change of colour, we do not recall an exception to the general law, that all cave-animals are either colourless or nearly white, or, as in the case of Arachnida and insects, much paler than their out-of-door relatives" [83, p. 117].

The same statement might be made concerning the inhabitants of underground waters, different authors speaking of them as "colourless," "snow-white," "translucent," &c. The Crustacea are usually more or less translucent, vitreous, and pellucid, though by no means so much so as pelagic members of the same group. The six species dealt with in this paper may be described as white or colourless, more or less translucent. I have sometimes noticed a slight pink or rosy tint on the body of *Calliopius subterraneus*, which is most apparent in female specimens bearing eggs, and then appears to arise chiefly from the yolk of the eggs themselves; the "liver"-tubes of *Cruregens fontanus*, which can easily be seen through the transparent integument, are of a very pale yellow colour, and the tip of the dactylos of the first pair of appendages of the peræon (gnathopoda) is of a very distinct but light brown.

The subterranean worm *Phreodrilus subterraneus*, Beddard, is stated by Mr. Smith (quoted by Beddard [8, p. 273]) to be "fleshy red" during life. This is chiefly due to the red colour of the fluid in the various vessels of the vascular system, the integument and the greater part of the body being colourless; this was plainly seen in a very fine specimen that Mr. Smith kindly sent alive to me in September 1892.

Professor S. I. Smith has pointed out that the deep-sea Crustacea present a marked contrast to cave Crustacea in colour. In a general account of the Crustacea of the

'Albatross' dredgings in 1883 [105] he points out that the colour of these deep-sea forms is very striking. A few are nearly colourless, but the majority are some shade of red or orange. A few species (100 to 300 fathoms) are conspicuously marked with scarlet or vermilion, but such markings were not noticed in any species from below 1000 fathoms. Below this, orange-red of varying intensity is apparently the most common colour. He also shows that some of the species ranging down to 2000 fathoms possess eyes, some of them as well developed as in corresponding shallow-water forms. Summing up these facts he says:—

"However strong may be the arguments of the physicists against the possibility of light penetrating the depths from which these animals come, the colour and the structure of their eyes, as compared with blind cave-dwelling species, show conclusively that the darkness beneath 2000 fathoms of water is very different from that of ordinary caverns. While it may be possible that this modification of the darkness of the ocean abysses is due to phosphorescence of the animals themselves, it does not seem probable that it is wholly due to this cause" [105, p. 56].

I wished to test this conclusion by studying the colour of animals found in the deep waters of lakes, such as those of Switzerland, but, unfortunately, the facts that I find ready to hand are not very conclusive either way. In considering the modifications undergone by the deep-water species, Forel says under the head "Pigmentation":—"La couleur est généralement plus claire dans les espèces littorales" [40, p. 167]. He also states that Du Plessis has noticed a rosy colour in some Turbellarians from the deep waters, which is not found in those of the littoral region. There does not, however, appear to be a prevailing red or orange tint at all comparable to that which has been noticed by Smith in deep-water marine Crustacea, or special attention would have been drawn to it by Forel; but, again, the species of Crustacea found in the deep waters of the Swiss Lakes are very few in number compared with those in the deep waters of the sea, and there are none of the larger forms like those examined by Smith, so that there is scarcely a sufficient basis for a comparison of any value. Forel describes *Niphargus Forelii* as "blanchâtre avec des teintes rosées," and *Asellus Forelii* as "d'un blanc grisâtre, sale" [40, pp. 112, 113].

On the whole, however, the colour of the animals in the deep waters of the Swiss Lakes appears to resemble that of the animals in caves and underground waters rather than that of the inhabitants of the deep waters of the ocean; and this would incline us to imagine that the difference in colour between the two last-mentioned is due to some differences of chemical composition rather than to the presence or absence of light.

Loss of Eyes.

In all animals inhabiting caves and underground waters the eyes appear to undergo more or less degeneration. Schneider has described the commencement of such degeneration in *Gammarus pulex*, var. *subterraneus* [96], and in *Asellus aquaticus*, var. *freibergensis* [97], and Moniez in *Gammarus fluviatilis*, var. *d'Emmerin* [78, p. 39]. Packard, who has considered the subject very fully in connection with the inhabitants of the North-American caves, in which all stages of degeneration are met with, thus sums up the effects of the loss of sight on the eyes and optic lobes:—

"1. Total atrophy of optic lobes and optic nerves, with or without the persistence in part of the pigment or retina and the crystalline lens (*Cæcidotæa*, *Crangonyx*, *Chthonius*, *Adelops*, *Pseudotremia*).

"2. Persistence of the optic lobes and optic nerves, but total atrophy of the rods and cones, retina (pigment), and facets (*Oronectes*).

"3. Total atrophy of the optic lobes, optic nerves, and all the optic elements, including rods and cones, retina (pigment), and facets (*Anophthalmus*, *Scoterpes*, and ? *Anthrobia*)" [83, p. 118].

He also points out that we never find any rudiments of the optic lobes and optic nerves; if they are wanting at all they are totally abolished; while, "on the other hand, we have series, as in *Cæcidotæa* or *Chthonius*, where there is but a single, or two or three, or several crystalline lenses, partially enveloped in pigment" [83, p. 118]. He lays stress on these facts as opposed to what he calls the "invariably slow action involved in pure Darwinism."

Many conflicting statements have been made by different authors as to the presence or absence of the eyes of the European species *Niphargus puteanus*, and in consequence it was fully investigated by Leydig, who found "that the optic ganglion is present, but not the eye, though pigment-spots mimicking the eye have led some observers to believe that an eye existed in fact" [quoted from Stebbing, 108, p. 481].

While this may no doubt be quite true of the specimens observed by Leydig, it appears from Packard's results that the external eye may be represented in varying degrees of completeness in different specimens of the same species; and that being so, there is no ground for refusing to believe that it may be altogether absent in some, though present (more or less imperfectly) in others. Forel, too, has pointed out that the blindness of *Asellus Forelii*, Blanc, is not without exception; two specimens taken near Morges and Ouchy, at depths of 200 m. and 300 m., presented rudiments of eyes, whilst all other specimens taken up to that time—even young taken from the brood-pouch of the female—were absolutely devoid of eyes [40, p. 114]. We can hardly suppose that Forel was deceived by mimicking pigment-spots in these two specimens only.

In the New Zealand subterranean Crustacea I have not been able to find any external trace of eyes except in the one species *Crangonyx compactus*, in which the eye is represented by two or three imperfect lenses apparently quite without pigment. In all the other species all trace of external eyes appears to be wanting. I regret that as yet I have had no opportunity of making sections to study the condition of the optic lobes and nerves.

Compensation for Loss of Eyesight.

Several authors have pointed out that in many species inhabiting the dark regions of caves or underground waters the loss of eyesight has been more or less compensated for by increased powers in the other senses—especially those of touch and smell. Many of the species are more slender and possess longer antennæ, legs, and other appendages than their surface-dwelling allies. In some cases the increased length of the antennæ, &c., would no doubt give greater tactile power; but it also appears probable that, in the case of species living in underground waters, the greater slenderness of the body has been acquired in order to adapt the animal for its life in the restricted spaces between the stones and shingle in which it has to live. This explanation is strongly suggested by a comparison of the two subterranean species of *Phreatoicus* with the surface-species *P. australis.*

The whole subject of the compensation for the loss of eyesight has been fully discussed by Packard [83, pp. 123–130], who has supplemented the anatomical descriptions with an account of what is known of the habits of some of the species. To this account I must refer the reader, and I shall only add here the few facts bearing on the same question that I have observed in the New-Zealand species.

In the two species of *Phreatoicus, P. typicus* and *P. assimilis,* the body is more slender and the antennæ and legs longer, especially in *P. typicus,* than in the surface-species *P. australis,* but I have not observed any marked increase in the number or size of the olfactory rods, nor have I observed any other sensory setæ like those found in some of the other species.

In *Cruregens fontanus* the antennæ are well supplied with olfactory rods, which appear to be more numerous and of greater length than in allied eyed species; besides these, other sensory setæ, like the "soies auditives" described by Sars, are found in considerable abundance on the antennæ, the various joints of the legs, and the uropoda. Similar setæ are found in the same places in eyed species of *Anthura, Paranthura,* &c., and Sars has figured them also in *Asellus aquaticus,* but they are rather more numerous and are longer in *Cruregens* than in the other species.

In *Crangonyx compactus* I have not noticed any increase in the number of sensory setæ beyond what we usually find in similar Amphipods; in this species, too, the body is compact and not elongated as in some other species, and the legs are only of the usual length.

In *Gammarus fragilis* the body is slender, and the antennæ, peræopoda, and terminal uropoda are much elongated. On the peræopoda, the last three pairs of which are of great length, setæ somewhat like the "soies auditives" occur in most of the tufts of setæ found on the various joints, but with this exception there does not appear to be any increase of sensory setæ beyond what we usually find in species of *Gammarus.*

In *Calliopius subterraneus* the body is rather more slender and the various limbs rather more elongated than in the closely allied species *Pherusa cærulea.* Numerous "soies auditives" are found at various places on the antennæ, which, in the male, are also abundantly supplied with "calceoli," which are no doubt also sensory in function. These, however, are also found in *Pherusa cærulea* and in *Calliopius fluviatilis,* and in some species described by Stebbing, such as *Eusiroides Cæsaris,* &c., the calceoli are quite as numerous as in *Calliopius subterraneus.*

On the whole the New-Zealand subterranean Crustacea give only a modified support to the conclusion that subterranean species are more abundantly supplied with sense-organs (other than eyes) than allied surface-animals. Probably the former have been more carefully examined than the majority of surface or marine species, and a fuller examination of the latter will perhaps show that many of them are as well supplied with sensory setæ as the subterranean species.

The Food of Subterranean Animals.

The source of the food-supply for the animals living in caves and underground waters is a question of much interest and of considerable difficulty. Almost all writers on the subject speak of the food-supply being very scanty, and yet the animals, though of course few in numbers compared with those living on the surface of the earth, are yet numerous, and when captured do not look particularly ill-fed. According to Packard [83, p. 24] the blind fish of the caves of North America probably live on the blind crayfish and the *Crangonyx*, and perhaps the *Cæcidotæa*, and the crayfish also lives on *Cæcidotæa*; so that, confining our attention to the Crustacea, the question is narrowed down to the food of *Crangonyx* and *Cæcidotæa*, viz. animals similar to those found in underground waters of the Canterbury Plains. As Packard points out:—"It goes without saying that there are no truly vegetable-eating animals living permanently in the caves; no plant-life exists (except in rare cases a very few fungi, and most of these probably carried in by man) in the caves on account of the total darkness" [83, p. 25].

Crangonyx and *Cæcidotæa* are hence probably mainly carnivorous, but what they find to eat is a great puzzle. Packard suggests that they may devour their own young; but what the young find to live on he considers still more difficult to conjecture, as rotifers, infusoria, and copepods are so very scarce. Cope, writing of the fauna of the Wyandotte Cave [30, p. 13], states:—"As to the small Crustaceans, little food is necessary to support their small economy, but even that little might be thought to be wanting, as we observe the clearness and limpidity of the water in which they dwell. Nevertheless, the fact that some cave-waters communicate with outside streams is a sufficient indication of the presence of vegetable life and vegetable débris in variable quantities at different times. Minute freshwater algæ no doubt occur there, the spores being brought in by external communication, while remains of larger forms, as confervæ &c., would occur plentifully after floods."

Still the supply imported in this way must be very scanty, and as an illustration of the general poverty of the food-supply in the caves Packard mentions that in the Wyandotte Cave the common Myriopod was found gathered around the hardened drops of tallow which strew the pathways of the cave *.

Concerning the food of the *Niphargus* found in the well at Ringwood, Hogan, quoted by Stebbing [108, p. 316], remarks:—"Some water drawn from the pump at Ringwood has been proved by microscopical examination to contain numerous animalcules; and this will probably turn out to be the case with all the waters in which *Niphargi* are found."

The facts bearing on this subject that I have observed in connection with the New-

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* "The Cave-Beetles of Kentucky," American Naturalist, x. (1876) p. 285.

Zealand subterranean forms do not, I am afraid, help much toward a solution. The water in which they are found is very clear and pure, with very little sediment, and in almost all cases is used for drinking without being filtered. Some years ago Mr. George Gray, of the School of Agriculture, Lincoln, was kind enough to analyse some of the water from the Eyreton pump for me, and he found that the amount of organic matter in it was considerably below that allowed for a healthy drinking-water. Mr. Mayne, speaking of the Ashburton water, informs me that "it stands the permanganate of potash test." There appear to be very few Infusoria or Rotifera in it; certainly it could not be said to contain "numerous animalcules," as stated by Hogan of the water at Ringwood.

The intestinal canal of the various species is frequently full of a dark blackish or brownish material, but though I have frequently examined this I have not found anything in it that I could recognize except grains of sand and earth.

I have frequently kept specimens of some of the species in small freshwater aquaria, and in this have seen them apparently eating small filamentous algæ. In April, 1890, I put three specimens of *Cruregens fontanus* into a small bottle containing water taken from the Brighton Creek, near the sea; the water in this creek is often brackish, and has *Ruppia maritima* &c. growing in it, but at the time when I filled my bottle the water was quite fresh to the taste. In the bottle I had a small piece of *Ruppia maritima* growing, also various filamentous algæ, and no doubt plenty of Infusoria &c. In this the three specimens of *Cruregens* lived till the beginning of June, when one was lost sight of, a second one died at the beginning of August, and the third about the end of that month, having thus lived for about five months. During this time I frequently saw them seize pieces of the algæ with their gnathopoda, but I could never make quite certain whether they ate them or not.

The mouth of *Cruregens*, like that of the other Anthuridæ, appears to be suctorial, but I can form no idea as to what the underground *Cruregens* sucks, unless it merely sucks up a great quantity of water, retaining any organic materials that it may contain; the maxillæ form lancet-organs, but I have never seen the animals using them for piercing the stems of the *Ruppia maritima* or for any similar purpose. So far as I am aware, we are equally ignorant of the use that the marine Anthuridæ make of their suctorial apparatus: from the structure of their mouths we should almost expect them to suck nutritive fluids from the bodies of other animals; but I have never heard of them doing this, and if they did we might reasonably expect some species at least to have permanently adopted a parasitic manner of life; the only parasitic species, however, known to me is *Eisothistos vermiformis*, Haswell [54, p. 1], which lives in the tubes of Serpulæ (*Vermilia*). Haswell says nothing about the structure of its mouth, and it is uncertain whether it actually derives its nourishment from the *Vermilia* or not. The other species are usually taken creeping freely on the surface of various sea-weeds, but whether they live upon these sea-weeds or not does not appear to be known.

Summing up, we are forced to admit that very little is as yet known as to the source of the food-supply of the subterranean Crustacea, and further observations on this point are very desirable. It must also be remembered that these animals may live for a long l

time with very little food; thus Dr. John Stoan states that a blind fish (*Amblyopsis spelæus*) lived for twenty months "without having taken any visible food" (see Packard [83, p. 127]).

Arrested Development.

The fauna of caves and underground regions presents us with several examples of what appears to be an arrest of development.

Packard has drawn attention to one example. Writing of the cave-dwelling Myriopod *Pseudotremia cavernarum*, and comparing it with the widely diffused *Lysiopetalum lactarium*, Say, he remarks :—"It differs in having only about half as many segments as in its out-of-door parent form (this diminution in the number of segments being due to arrest of development) . . ." [83, p. 120].

In our New-Zealand forms we have a good example of the same thing in *Cruregens fontanus*, which has the seventh segment of the peræon small and without appendages, as is the case in the young forms of many Isopods. It seems tolerably clear that we have here simply a case of arrested growth, and not a reversion to a true ancestral form, for while in the process of development of the embryo of the Isopoda the seventh pair of the appendages of the peræon are the last to be developed, I am not aware of any reason for supposing that the ancestors of the Isopoda ever possessed only six pairs of appendages to the peræon.

In remarking on this example, Aloïs Humbert quotes other cases observed by Heller. He states (Archives des Sciences naturelles, viii. [Sept. 1882] p. 267) :—

"Nous rappellerons à ce sujet que le Dr. Camil Heller a décrit un genre cavernicole de Gloméride (*Trachysphæra*), se distinguant des *Glomeris* en ce qu'il ne possède que 11 segments au lieu de 12, et 15 paires de pattes au lieu de 17 ; le même auteur a fait connaître un autre Myriapode (*Brachydesmus*) provenant, comme le précédent, des grottes de la Carniole et ne différant des *Polydesmus* que parce qu'il n'a que 19 segments au lieu de 20, nombre normal chez les Polydesmides adultes. Si les *Trachysphæra Schmidtii* et *Brachydesmus subterraneus* ont été établis d'après des individus réellement adultes, ce que nous avons certaines raisons de croire, il y aurait chez ces deux Myriapodes un arrêt de développement tout-à-fait semblable à celui que M. Chilton vient d'observer aux antipodes chez son Crustacé souterrain."

M. Humbert attributes this arrest of development in cave-animals to the influence of darkness, the lack of sufficient food, and the other necessary conditions of their environment.

I have given above merely the examples of arrested development that are known to me; probably a full examination of the literature of the subject would show that many others have been recorded.

Habits.

In their habits in confinement the subterranean Crustacea seem to differ but little from their surface allies. Observations on their habits have been made by Hogan [59 and 60], Stebbing [108], Packard [83, pp. 123–130, &c.], and others. According to Hogan, quoted by Spence Bate [1, i. p. 321], *Niphargus fontanus* "soon dies if exposed to the light." This is certainly not my experience with the New-Zealand forms: I have kept all the species, except *Phreatoicus*, for longer or shorter periods in glass bottles, in which they could get no shelter, exposed to the full light of day; and if the water was properly aerated, they appeared to live without inconvenience. As stated above, species of *Cruregens fontanus* have thus lived for five months. In the same bottle I afterwards kept a specimen of *Gammarus fragilis*, which appeared quite at home, but then unfortunately died during an unsuccessful attempt to moult its exoskeleton. It had no shelter from the ordinary light of day, and made no attempt to hide itself; if placed so that the strong light of a lamp was focussed on to it by the convex surface of the bottle it, however, moved away. I did not notice anything peculiar in its habits; it usually crawled around at the bottom of the jar or along the stems of the plants in the bottle, but at times swam freely like ordinary Amphipods.

There is very little more to record concerning the habits of the *Cruregens*. The animals usually crawled about on the bottom or along the stems and leaves of the *Ruppia maritima*; they could not, however, crawl up the vertical sides of the bottle, the glass being too smooth for them; they ran backward and forward with equal rapidity, and did not seem particular which way they went; they did not swim, but if they dropped off the plant wriggled helplessly till they reached the bottom. I did not notice anything that would indicate any power of vision, but, on the other hand, often saw them running against objects in a way which seemed to indicate that they were totally blind; occasionally I have seen two approach very near each other, apparently without being aware of it, and then suddenly jump apart when one touched the other.

IX. THE BEARINGS OF THE PHENOMENA OF SUBTERRANEAN LIFE ON THE THEORY OF DESCENT.

It has been early recognized that the phenomena of cave and subterranean life have an important bearing on the Theory of Descent. Here the conditions of life are so peculiar, so abnormal, the fauna so scanty, and its environment so simple and so restricted that we may naturally expect to find the problems that are to be solved presented to us in their simplest forms. Thus we have no vegetable life of any kind except a few fungi, only a comparatively small number of animals of various groups, and these surrounded by continual night and exposed to a temperature probably pretty uniform from year to year; in many cases we can tell, with at any rate a fair approach to accuracy, from what surface-species the underground species has descended; and knowing also, within certain limits, the age of the latter, we can estimate the changes undergone and consequently the rate at which these have been made in this particular instance.

The importance of *Isolation* in securing permanence of type in the case of cave-dwelling animals has been dwelt upon by Packard [83, pp. 140–141]. Similar remarks would apply with perhaps even greater force to the subterranean fauna, such as that of the underground waters of the Canterbury Plains, for it is probably even more completely isolated from the surface-fauna than is that of caves.

It is, however, with regard to the effects of the disuse of organs that the cave and subterranean fauna has been studied with the greatest interest, and here we closely approach the controversy between the Neo-Darwinians and the Neo-Lamarckians. While it would be utter presumption on the part of the writer to enter upon a discussion of this question, it will be interesting to review a few of the opinions expressed by various writers on the subject in so far as it is exemplified by the phenomena of subterranean life.

Darwin, in his 'Origin of Species' [35, pp. 110–112], after pointing out that in the case of the mole and similar burrowing animals natural selection will probably aid the effects of disuse in producing blindness, refers to the blind inhabitants of caves, and remarks:—"As it is difficult to imagine that eyes, though useless, could be in any way injurious to animals living in darkness, their total loss may be attributed to disuse" [35, p. 110].

Further on, after quoting Schiödte's observations as to animals, some of which are adapted to the twilight and others to the perfect darkness of caves, he observes:—"By the time that an animal had reached, after numberless generations, the deepest recesses, disuse will on this view have more or less perfectly obliterated its eyes, and natural selection will often have effected other changes, such as in increase in the length of the antennæ or palpi, as a compensation for blindness" [35, p. 111].

That animals living in darkness do as a general rule gradually lose their eyes is now a very familiar fact, and it no doubt appears at first sight simplest to explain this as an example of the effects of disuse; but there are numerous instances known of animals living in darkness that yet possess more or less perfect eyes, and unless these can be accounted for in some way they would appear to prove that the effect of darkness, *per se*, does not necessarily produce degeneration of the eyes. Semper, in his 'Animal Life' [99, pp. 76–87], after giving a number of examples of the loss of eyesight apparently through disuse, adds that "it would nevertheless be wholly false to assume that lack of light must necessarily lead to total or partial blindness" [99, p. 84]; he then proceeds to give examples of animals living in darkness with more or less perfect eyes, and on the contrary, of animals blind or half-blind, which yet "live in well-illuminated situations, where the moderate intensity of the light would allow them the full use of eyes." The examples given by Semper have been considered in detail by Packard [83, pp. 130–132], who points out that some, at any rate, of the first group are "twilight animals," living near the entrance of the caves as well as in the total darkness of the innermost recesses, and that those animals which live in total darkness may perhaps cross with those living near the entrance, and the eyes thus remain unimpaired. Other cases, in which our knowledge is not so complete, may, he considers, perhaps be explained in the same way; and with regard to the second group, *i. e.* blind or half-blind animals living in well-lighted situations, many may spend the greater part of their lives burrowing in the mud or in dark places where eyes would be of little or no service to them; in this way he explains the blind *Cymothoa* mentioned by Semper [99, p. 83] which he found in the full light of day.

Whilst some cases may perhaps be accounted for in this way, it does not seem to me that all, even of those mentioned by Semper, can be thus explained. Thus Packard appears to make no reference to the *Pinnotheres* mentioned by Semper [99, p. 80], the zoæa of which has well-developed eyes of the typical character, while the full-grown animals which live in the "water-lungs" of Holothurians "gradually become blind or half-blind; the brow grows forward over the eyes, and finally covers them so completely that, in the oldest individuals, not the slightest trace of them, or of the pigment, is to be seen through the thick skin; while at the same time the eyes seem to undergo a more or less extensive retrogressive metamorphosis" [99, p. 81].

Cases like this certainly seem to indicate, as Semper observes, "that the influence of darkness is proved to be direct in each individual, and not hereditary." Here we see that the eyes are preserved in the free swimming zoæa, where they are of service to the animal, but are gradually lost in the adult, where they are no longer required; and while this shows the powerful effects of disuse in the individual, it does not show that these effects are inherited without the intervention of Natural Selection, as appears to be assumed by Packard and others, who account for the blindness of cave animals by the *direct* effect of the darkness and the consequent disuse of the organs. If the characters thus acquired through disuse were necessarily inherited, we should expect to find the eyes of the zoæa of the *Pinnotheres* more or less imperfect.

Packard, who discusses the bearing of cave life on the Theory of Descent at considerable length, is thoroughly Neo-Lamarckian in his views, and sees little or no room for the operation of Natural Selection. Thus, on p. 121, he remarks :—

"Given great changes in the physical surroundings, inducing loss of eyes through disuse, the abolition in some cases of the optic ganglia and optic nerves, the elongation of the appendages, isolation from out-of-door allies, and the transmission by heredity owing to close in-and-in breeding within the narrow fixed limits of the cave, are not these collectively *veræ causæ*? Do they not fully account for the original variations and their fixation? In short, can we not clearly understand the mode of origin of cave species and genera? What room is there in a case like this, or in that of parasitic animals, for the operation of natural selection? The latter principle only plays, it has seemed to us, a very subordinate and final part in the set of causes inducing the origin of these forms" [83, p. 121].

If these modifications, however, were the direct inherited effect of the environment, *i. e.* darkness &c., should we not expect to find them similar in all animals subjected to the same conditions? The modifications might be greater in some instances than in others, in accordance with the varying lengths of time that the animals had lived under these conditions, but we should certainly expect that the development in all cases would be proceeding uniformly and in the same direction. Now it seems to me that we do not find this process demonstrated even in the facts adduced by Packard himself, but that there is a certain apparent capriciousness which is inconsistent with the constant and uniformly acting causes that he sets forth. Thus, in the case of the eyes, instead of the degeneration proceeding on similar lines in all individuals, we may have—:

(1) Total atrophy of optic lobes and optic nerves, with or without the persistence in part of the pigment or retina and the crystalline lens;

(2) Persistence of the optic lobes and optic nerves, but total atrophy of the rods and cones, retina (pigment), and facets; or

(3) Total atrophy of the optic lobes, optic nerves, and all the optic elements. [See 83, p. 118.]

If we consider the other modifications of the body, legs, antennæ, &c., which Packard also accounts for as "evidently the result of loss of sight" [83, p. 120], we still find the same capriciousness, and even in a more marked degree. Thus, taking our New Zealand forms, we find that *Cruregens fontanus* and *Calliopius subterraneus* have developed additional sensory setæ beyond what are usually to be found in their surface relatives, while apparently *Gammarus fragilis* and *Crangonyx compactus*, and certainly the two species of *Phrealoicus*, have not. Again, in the species of *Phreatoicus*, in *Gammarus fragilis*, and to a less degree in *Calliopius subterraneus* and *Cruregens fontanus*, the body, antennæ, and appendages are slender and elongated, while there is no sign of a similar modification in *Crangonyx compactus*, which has the body normally stout, the antennæ and legs of only moderate length, and the uropoda even somewhat short and stumpy.

Many similar examples could doubtless be adduced from a review of the underground fauna of other countries. Thus *Borula tenebrarum* [124, pp. 677–687] does not appear to have the body particularly slender or the appendages elongated, while the species of *Niphargus* usually do possess these peculiarities; in *Niphargus* the outer branch of the third uropoda is greatly elongated, in *Gammarus fragilis* the peduncle and both branches of the third uropoda are similarly elongated, while again in *Crangonyx mucronatus*, Forbes, the elongation takes place, not in the third uropoda at all, but in the telson!

These examples, showing a development apparently capricious and varying in its direction in animals all subjected to the same or similar environment, appear to point rather to the action of Natural Selection seizing here upon one variation useful to the animal and there upon another, and fixing and maintaining these variations just as we find it doing in the more complicated phenomena of surface life. Packard refers to the cave Crustaceans as living "in a sphere where there is little, if any, occasion for struggling for existence between these organisms" [83, p. 110].

But surely here, as elsewhere, the animals tend to increase in a geometrical ratio, and, since all cannot live, must necessarily struggle among themselves for food, which is, as Packard points out, very scanty. The *Cæcidotea* and *Crangonyx* of the North-American caves are, Packard states, eaten by the blind crayfish, and must therefore "struggle," in the sense in which the word is used by Darwin, with their destroyer, and in this struggle they appear to have developed those additional olfactory setæ, &c., mentioned by Packard, which enable them more readily to escape their enemy. If they had no occasion for struggling for existence, why should these additional sense-organs be developed at all?

Packard does not appear to have considered the action of Natural Selection on the individuals of the same species, an action which results in the perfecting and maintaining in a state of perfection any organ that is of importance to the animal. It is, however, this action of Natural Selection which is of the most importance when we consider the case of the blind inhabitants of caves, &c., as has been clearly pointed out by Wallace [115, p. 413, &c.], Weismann [119, p. 90, &c.], &c. My former teacher, Professor Hutton, put it very clearly and impressively in his lectures when he said that Natural Selection consists not so much in the "*Survival of the Fittest*" as in the "*Non-survival of the Unfittest*"; and, as he proceeded to demonstrate, the difference between the two points of view is a real one, and not a mere question of words. Thus, in the case of any animal living in the full light, a certain degree of perfection of eyesight will be required by the animal in order to enable it to escape its enemies, obtain food, &c., and all individuals falling below this standard will perish; so that by the action of Natural Selection the eyesight of the animal will be kept in perfect adaptation to its environment. Now in the case of animals that have taken to living in dark caverns, &c., the eyesight, being no longer of use to the animal, will no longer be maintained in its state of perfection by Natural Selection (although of course Natural Selection will still act on other organs that are of use in the darkness); consequently all degrees of eyesight will stand an equal chance of preservation, and by the intercrossing of individuals of varying degrees of perfection there will result a degeneration of the eyesight—a "regression towards mediocrity," as Galton has called it. The explanation of the gradual loss of the eyes in cave animals is the one adopted by Wallace, in his 'Darwinism' [115, p. 416], who also adds that besides becoming useless, the eyes might also become injurious on account of their delicacy of organization and liability to accidents and disease; so that in addition to the "regression towards mediocrity," owing to the withdrawal of the action of Natural Selection in maintaining perfection, Natural Selection would also actively reduce and finally abort them. It is important to observe that this "regression towards mediocrity" is a general law of heredity, and produces its effect quite irrespective of any use or disuse of the organ in question [Wallace, 115, p. 414]. A similar explanation has been given by Weismann [119, pp. 90 and 292], who has introduced the term "*Panmixia*" for the suspension of the preserving influence of Natural Selection, and the consequent intercrossing of animals of all standards of perfection.

Of course, if we accept his dogma of the non-heredity of acquired characters, that at once excludes the effects of disuse as an explanation of the blindness of cave animals; but even without going to this length the principle of *panmixia*, combined with the other active effect of Natural Selection adduced by Wallace, will be sufficient to account for much of the degeneration of eyesight, and to these must be added another equally important consideration advanced by Lankester [70, p. 818–819]. After pointing out that the eyesight of different individuals varies, owing to congenital fortuitous variations, he remarks:—

"Suppose that a number of some species of Arthropod or Fish be swept into a cavern or be carried from less to greater depths in the sea, those individuals with perfect eyes would follow the glimmer of light, and eventually escape to the outer air or the shallower depths, leaving behind those with imperfect eyes to breed in the dark place. A natural selection would thus be effected."

This explanation is no doubt a true statement of fact, for caverns and underground waters have in all probability been gradually peopled by animals from the surrounding neighbourhood, and as they advanced further and further into the darkness a selection of this kind would go on in each generation, and, as Poulton has observed, "such a sifting process would certainly greatly quicken the rate of degeneration due to *panmixia* alone" [119, p. 292, footnote]. The same explanation is quoted with approval by W. P. Ball, who considers, however, that *panmixia* "would probably be the most important factor in causing blindness" [3, pp. 17, 72].

To the various causes mentioned above we must add the effects of disuse *in the individual*, which are undoubtedly very considerable in amount, and in cave animals breeding in the darkness would commence in all cases from birth.

I may add here one or two notes on the age of the blind fauna of caves and wells, and on the rate at which development has consequently taken place in these animals. Although, as I have pointed out elsewhere (pp. 253–258), there is reason to believe that some, at any rate, of the blind species are older than the surface fauna at present inhabiting the same neighbourhood, there seems little reason to doubt that the whole underground fauna is of comparatively recent origin. Packard [82, p. 25], after considering the facts on the question adduced by Cope, came to the conclusion that "the subterranean fauna of this country does not date back of the Quaternary Period." In his later paper he repeats this opinion, and, after considering the different classes of caves more fully, adds:—

"It seems, then, fair to assume that the final completion of the caverns, when they became ready for occupancy by their present fauna, may not date back more than, to put it into concrete figures, from 7000 to 10,000 years, the time generally held by geologists to be sufficient for the cutting of the present river gorge of the Niagara and the Falls of St. Anthony. We may, then, put the age of our cave fauna as not much over from 5000 to 10,000 years before the dawn of history, which itself extends back some 5000 to 6000 years" [83, p. 23].

He concludes, therefore, that the greatest part of the cave fauna of North America was directly derived from the present fauna, and that consequently the changes undergone have been brought about in at most a few thousands of years.

The fauna of the European caves described by Schiödte, &c., also seems to date from the "close of the Tertiary, or more probably the beginning of the Quaternary Period" (Packard [82, p. 25]).

In New Zealand, too, the subterranean fauna must be very recent, geologically speaking. All the places where subterranean forms are found are marked on Professor Haast's geological map of Canterbury and Westland [53] as either "post-pliocene alluvium" or "recent alluvium," most of them being in the latter. *Phreatoicus*, by its generalized character and by its occurrence in Australia as well as in New Zealand, is shown to be an ancient form, probably once widely spread in fresh waters, but of course it does not follow that its subterranean species are more ancient than the other subterranean forms. If thorough search were made it is quite possible that some species of the genus would still be found inhabiting freshwater streams among the Southern Alps.

In speaking of the variety *freibergensis*, Schneider, of *Asellus aquaticus*, Moniez says:—

"Différents auteurs (Schneider, Chilton, etc.) attachent beaucoup d'importance à la date à laquelle ont été forés les puits dont ils ont étudié les eaux, admettant volontiers, mais bien gratuitement, à notre avis, que c'est à cette époque que les animaux y sont arrivés et ont commencé à se modifier. Nous avons déjà fait entendre, à propos du *Cyclops pulchellus* (p. 34), que cette façon naïve de procéder à l'étude de la variation des espèces ne peut se soutenir, car elle ne tient pas compte d'un facteur important dans la question, celle des *eaux souterraines*, dans lesquelles les animaux observés pouvaient vivre avant le forage, et par lesquelles, grâce aux infiltrations, de nouveaux individus à l'état d'œufs, ou même à l'état parfait, peuvent arriver à tout instant, comme nous l'avons fait remarquer plus haut (pp. 37, 38)" [78, p. 52, footnote].

It is true that in my first paper on the Subterranean Crustacea of New Zealand I did mention the age of the well from which they were obtained, because I wished to give all the facts that might have a bearing on the question, and though the age of the well has, of course, nothing to do with the development of the Subterranean Crustacea, it may have had some effect on numbers occurring at that particular place; but there is nothing in my paper that can be interpreted to mean that I imagined that the Crustacea—all true subterranean forms—had begun to modify only after the well was bored; and in my second paper [23, p. 87, &c.] I made it quite clear that the Crustacea are inhabitants of the underground waters and not merely of the wells.

The cases brought forward by Schneider, i. e. *Gammarus pulex*, var. *subterraneus*, and *Asellus aquaticus*, var. *freibergensis*, seem to me to be quite different. Here, as in the case of *Gammarus fluviatilis*, var. *d'Emmerin*, mentioned by Moniez himself, we have subterranean varieties which differ from the parent species still found on the surface only in a few small points, such as colour, slight degeneration of the eyes, &c., and though I do not know what age is to be assigned to the mines in which Schneider found his examples, I see no reason for doubting that these slight differences have been acquired in a very few generations. Other similar examples are given by Packard; one is that of some examples of an isopod found in subterranean regions, which, although of the normal form and size of *Asellus communis* (the surface species), were bleached as white as *Cæcidotea stygia*, and of this variety, which he calls *pallida*, Packard remarks:—"It is interesting to note the occurrence of this bleached variety, which may have become thus modified after but a few generations, perhaps but one or two" [83, p. 32].

Other examples given appear to confirm this view, and all go to show that slight modifications, such as in the cases mentioned above, may be produced within very short periods.

X. CONCLUSION.

In the foregoing pages I have endeavoured to give as full and accurate an account of the Subterranean Crustacea of New Zealand as the material and the time at my disposal would allow. But although the work has gradually grown under my hands until the present memoir has far exceeded the limits I originally anticipated, its increase in size has, I fear, only multiplied its imperfections, and given rise to more questions than have been solved. It has, indeed, shown that no single animal can be profitably studied by itself, but that in attempting to explain one we must study all, and that the one can be thoroughly known only when all are known.

In concluding his work on the fauna of the Swiss Lakes, Forel has pointed out that the phenomena connected therewith, which at first appeared strange, anomalous, and altogether unaccountable, were gradually interpreted with increasing knowledge until they harmonized with what we learn of the workings of nature in other places less far removed from man's curious gaze. The same statement applies to the consideration of subterranean life, and we can exclaim with Forel—"La nature est grande et belle, parce qu'elle est harmonieuse en tout et partout."

But one fact that has been impressed upon me more than any other by the very existence of subterranean life is the keenness of the struggle for existence that goes on in the world of animals and plants. I am not aware that he ever did so, but from the tendency of animals to increase in a geometrical ratio, and the consequent struggle for life, Darwin might have deduced the conclusion that every spot on earth capable of supporting life at all would be occupied by its appropriate denizen; and certainly such a conclusion would have been amply verified by the facts now known. Even if we take a single group like the Crustacea, and of these only the small and apparently helpless Amphipoda and Isopoda, we find that they have spread until scarcely any place can be named from which they are absent. They are found on land and in the sea; in running streams and in stagnant ponds; in hot springs and in frozen pools; high on mountain-tops and deep in mines; on the seashore and far out in the ocean; burrowing in mud and boring into wood and stone; on the surface of the sea and in its lowest depths; in the waters on the earth and in the dark recesses of caverns and of the waters under the earth, where no storm ruffles the everlasting stillness, no light illumines the thick darkness, and no sound breaks the eternal silence.

XI. Bibliography.

List of Works referred to.

[The originals of many of the works quoted below have been inaccessible to the writer, the contents being, however, known to him through abstracts and notices in other works. The chief source from which such information has been gained is given in each case, but in many cases the contents of a paper have been known through abstracts in several other works.

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Quoted from Wrześniowski [124, p. 707].

EXPLANATION OF THE PLATES.

Plate XVI.

Phreatoicus assimilis.

Fig. 1. Side view of the whole animal, a female. × 12.
2. Upper antenna.
3. Lower antenna.
4. Upper lip. × 58.
5. Outer convex surface of mandible with palp attached.
6. Left mandible.
7. Lower lip. × 58.
8. First maxilla. × 58.
9. Second maxilla. × 58.
10 & 11. Maxillipedes.

Plate XVII.

Phreatoicus assimilis.

Fig. 1–3. First appendage of the peræon.
4. Second ditto.
5. Propodos produced along the base of dactylos.
6. Fourth appendage of the peræon.
7. The same, distal extremity enlarged.
8–9. Fifth and sixth appendages of the peræon.
10. First pleopod. × 19.
11. Second pleopod, of male. × 19.
12. Third pleopod. × 19.
13. Side view of end of pleon, showing the telson and uropoda. × 19.

Plate XVIII.

Phreatoicus typicus.

Fig. 1. Side view of the whole animal, a female. × 6.
2. The antennæ, side view, showing the upper antenna and the peduncle of the lower antenna. × 35.
3. Extremity of the left mandible, much compressed. × 180.
4. Lower lip. × 58.
5. First maxilla. × 58.
6. Second maxilla. × 58.
7. Leg of the first pair, of female. × 19.
8. Extremity of the same. × 45.
9. Leg of the second pair. × 19.
10. Leg of the sixth pair. × 19.
11. Lower margins of the first five segments of pleon. × 19.
12. Side view of end of the pleon, showing the telson and uropoda. × 19.

PLATE XIX.

Cruregens fontanus.

Fig. 1. Side view of the whole animal. × 12.
2. Antennæ, from above. × 45.
3. End of upper antenna. × 180.
4. Portion of lower antenna. × 180.
5. Basal portion of lower antenna, from below. × 45.
6. Upper lip. × 120.
7. Mandibles. × 120.
8. Mandibles and end of maxillipedes, seen from below and partly from the side. × 120.
9. First maxilla. × 56.
10. Portion of same. × 120.
11. Second maxilla and lower lip. × 120.
12. Lower lip. × 120.
13. Second maxilla. × 120.
14. Maxillipedes, distal portion, from below. × 120.
15. Leg of first pair, outside view. × 30.
16. Portion of the same, inside view. × 30.
17. Leg of second pair. × 30.
18. Palm of same. × 83.
19. Leg of fourth pair. × 30.
20. Pleon, with telson and uropoda, from above. × 30.
21. First pleopod, from below. × 30.
22. One of the posterior pleopoda. × 45.
23. Uropoda, from above. × 30.

PLATE XX.

Crangonyx compactus.

Fig. 1. Side view of the whole animal. × 12.
2. Upper antenna. × 45.
3. Portion of flagellum of same. × 120.
4. Lower antenna. × 45.
5. Upper lip. × 120.
6. Right mandible. × 70.
7. Extremity of same. × 240.
8. Extremity of right mandible of another specimen. × 240.
9. Extremity of left mandible (figure inverted). × 240.
10. Lower lip. × 120.
11. First maxilla. × 120.
12. Extremity of middle lobe of same. × 350.
13. Extremity of palp of same. × 240.
14. Second maxilla. × 120.
15. Extremity of inner lobe of same. × 350
16. Maxillipedes, from below. × 70.
17. Extremity of same, from above. × 120.
18. Inner lobe of same. × 120.

Fig. 19. Outer lobe of same. × 120.
20. First gnathopod. × 30.
21. Second gnathopod. × 30.
22. First peræopod. × 30.
23. Fourth peræopod. × 30.
24. First pleopod. × 30, with "coupling-spines" more enlarged.
25. Second pleopod. × 30.
26. Third pleopod. × 30.
27. First uropod. × 30.
28. Second uropod. × 30.
29. Third uropod. × 30.
30. Telson. × 30.

PLATE XXI.

Gammarus fragilis.

Fig. 1. Side view of whole animal. × 12.
2. Upper antenna. × 30.
3. Lower antenna. × 30.
4. Upper lip. × 70.
5. Left mandible, showing palp and cutting-edges only. × 70.
6. Extremity of same. × 120.
7. Extremity of right mandible, from above, compressed. × 70.
8. The same seen in profile from below. × 70.
9. Lower lip. × 70.
10. First maxilla of right side. × 70.
11. Extremity of palp of same. × 120.
12. Extremity of palp of first maxilla of left side. × 120.
13. Second maxilla. × 70.
14. Maxillipedes, from below. × 45.
15. The same, from above. × 45.
16. First gnathopod, inner side, from a large specimen. × 30.
17. Second gnathopod, outer side, from smaller specimen. × 30.
18. First peræopod. × 30.
19. Fourth peræopod, basal joints and extremity. × 30.
20. Extremity of same. × 70, with "auditory seta" more magnified.
21. Third pleopod. × 30, with "coupling-spines" more magnified.
22. First uropod. × 30.
23. Second uropod. × 30.
24. Third uropod. × 30.
25. Telson. × 30.

PLATE XXII.

Calliopius subterraneus, ♂.

Fig. 1. Side view of male. × 12.
2. Peduncle of upper antenna. × 30.
3. Calceolus from the same, highly magnified.
4. Lower antenna. × 30.

Fig. 5. Upper lip. × 58.
6. Left mandible. × 58.
7. Extremity of same. × 120.
8. Extremity of right mandible. × 120.
9. Portion of lower lip. × 58.
10. First maxilla. × 45.
11. Extremity of middle lobe of same. × 180.
12. Extremity of palp of same, right (?) side. × 180.
13. Extremity of palp of first maxilla of other (? left) side. × 180.
(These two drawings, 12 and 13, were accidentally made one from above and one from below, hence they both face in the same direction.)
14. Second maxilla. × 120.
15. Maxillipede, from below. × 45.
16. Extremity of the same, from above. × 45.

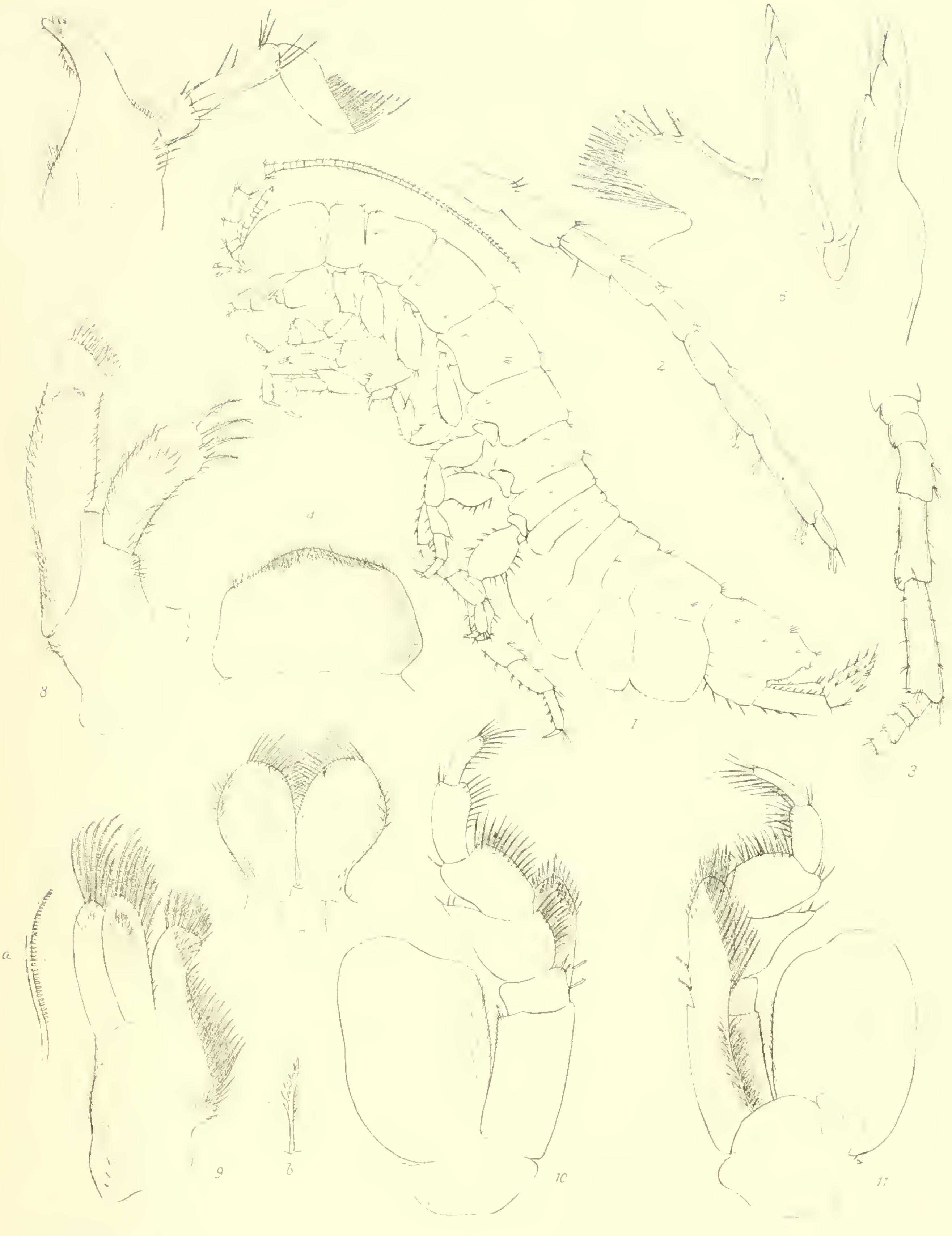
Plate XXIII.

Calliopius subterraneus, ♂.

Fig. 1. First gnathopod, outer side. × 19.
2. Extremity of the same, inner side. × 19.
3. Second gnathopod, outer side. × 19.
4. Extremity of the same, inner side. × 19.
5. First peræopod. × 19.
6. Third peræopod. × 19.
7. First uropod. × 19.
8. Second uropod. × 19.
9. Third uropod. × 19.

Calliopius subterraneus, ♀.

10. Lower lip. × 120.
11. Maxillipede, from above. × 120.
12. First gnathopod. × 45.
13. Extremity of the same. × 120.
14. Second gnathopod. × 19.
15. Extremity of same. × 120.
16. Side view of posterior end of pleon, showing the uropoda and telson. × 45.
17. Third uropod and telson, from above. × 45.
18. Extremity of middle lobe of first maxilla of a small specimen (an immature male?), showing some of the setæ only. × 145.



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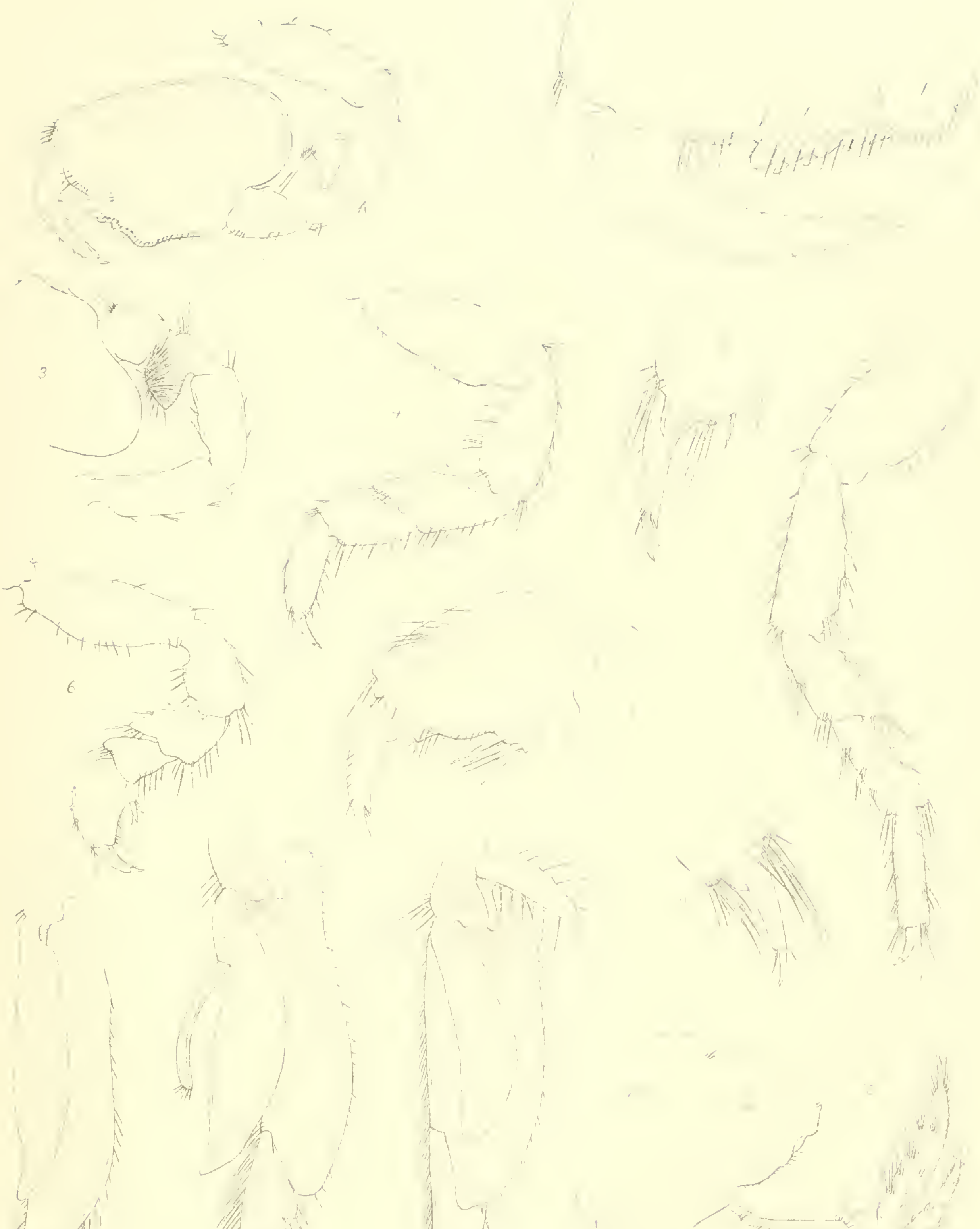
Berjean & Highley sc.

West, Newman imp.

PHREATOICUS ASSIMILIS *Chilton, sp. n.*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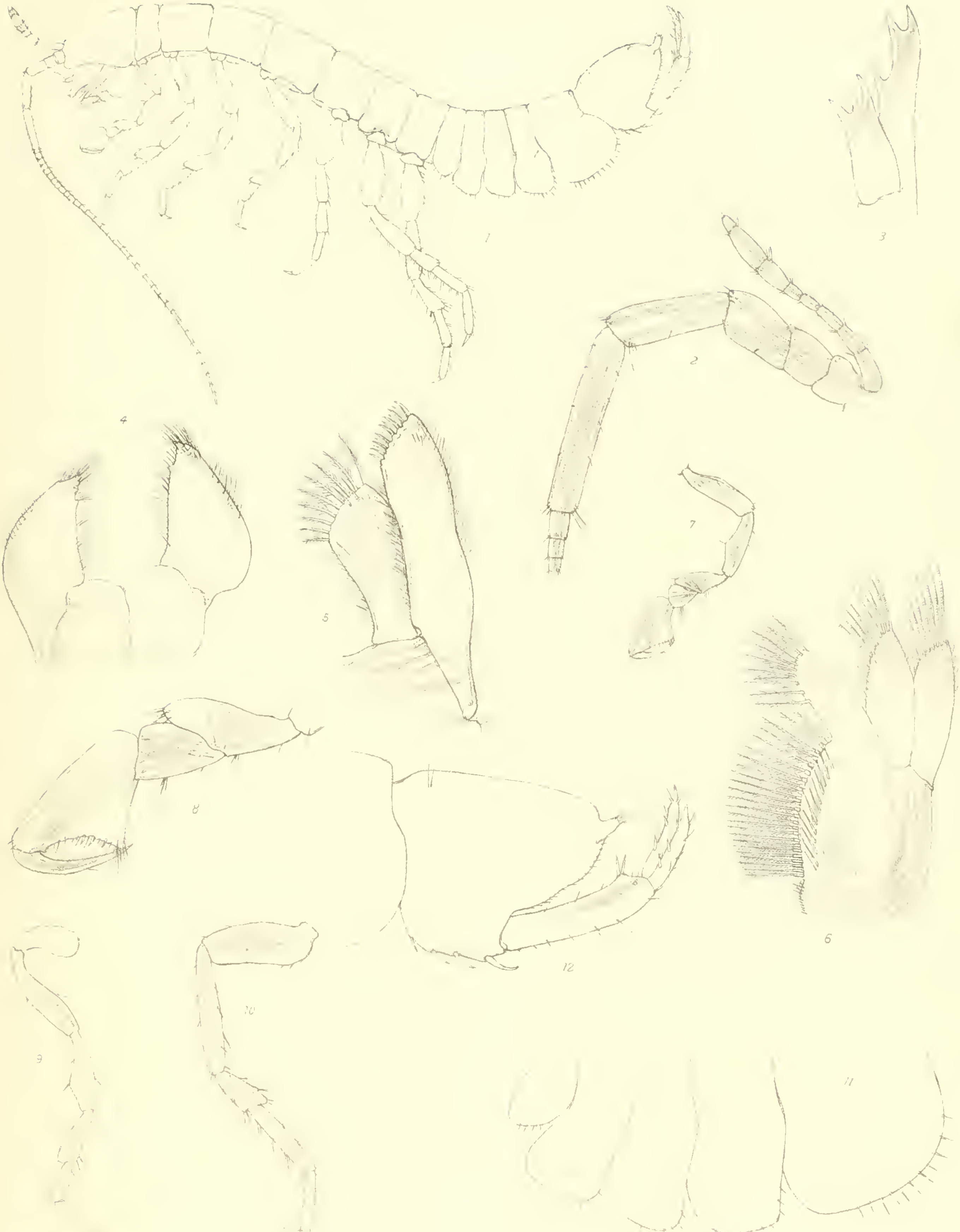
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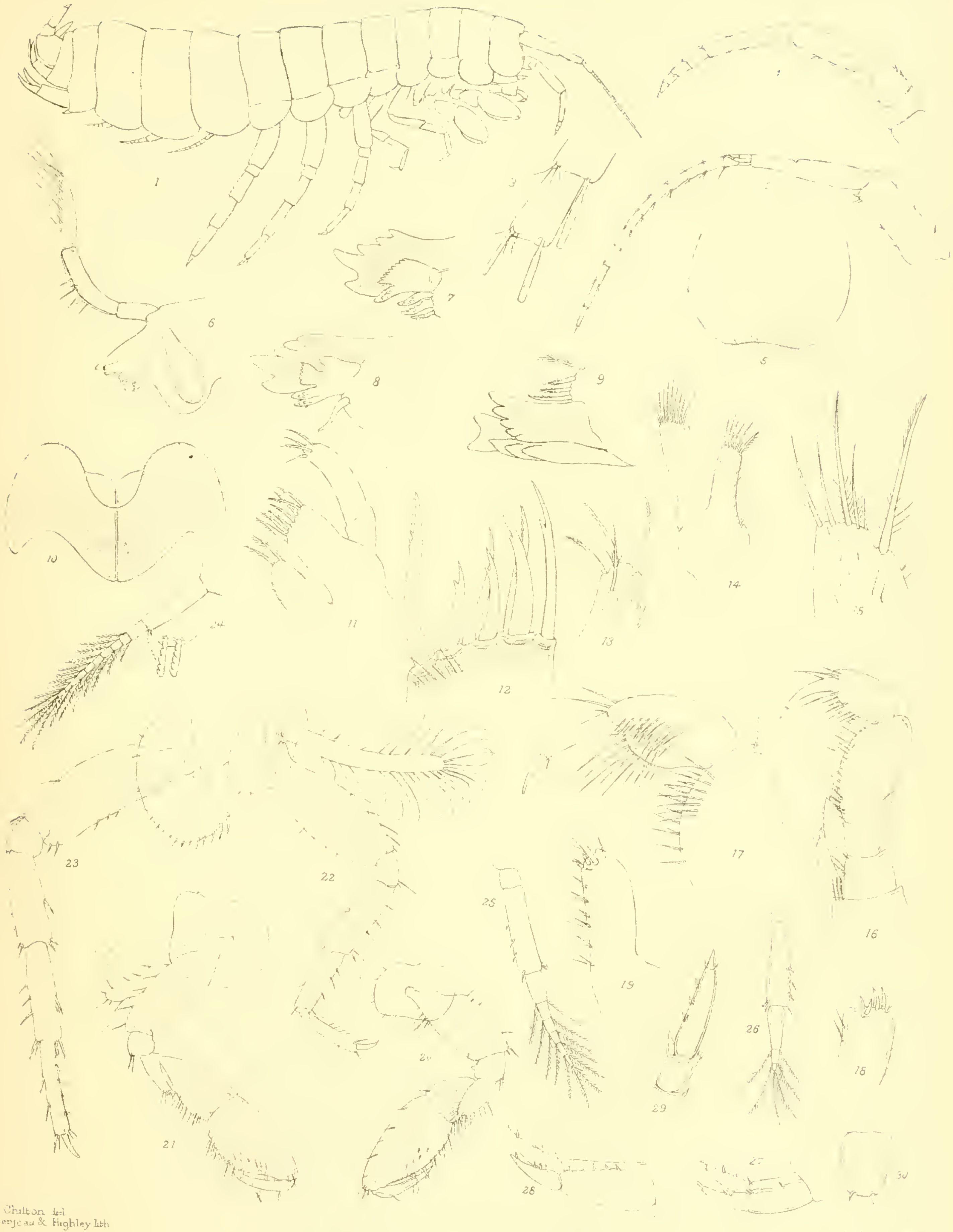
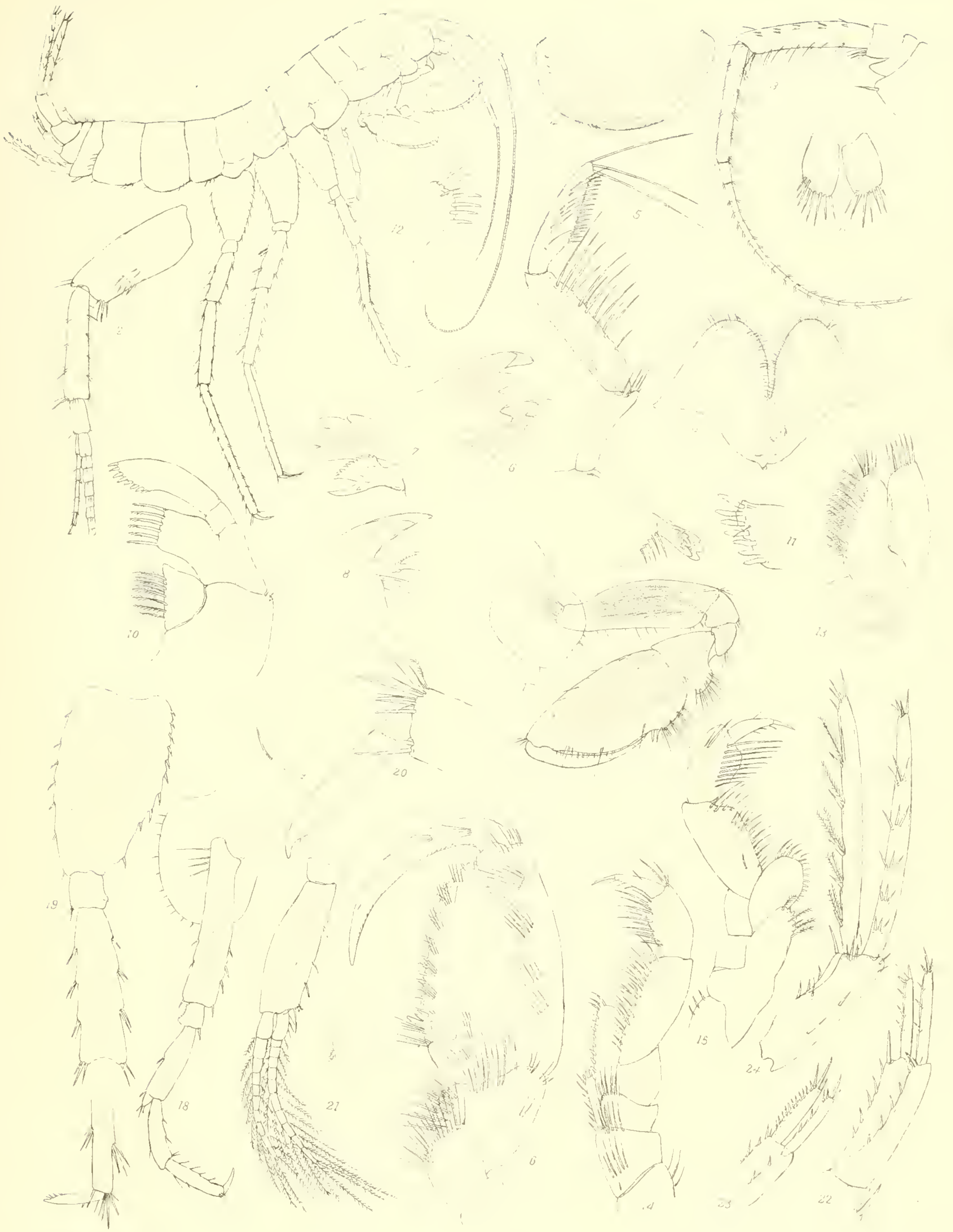


C. Chilton del.
Berjeau & Highley lith.

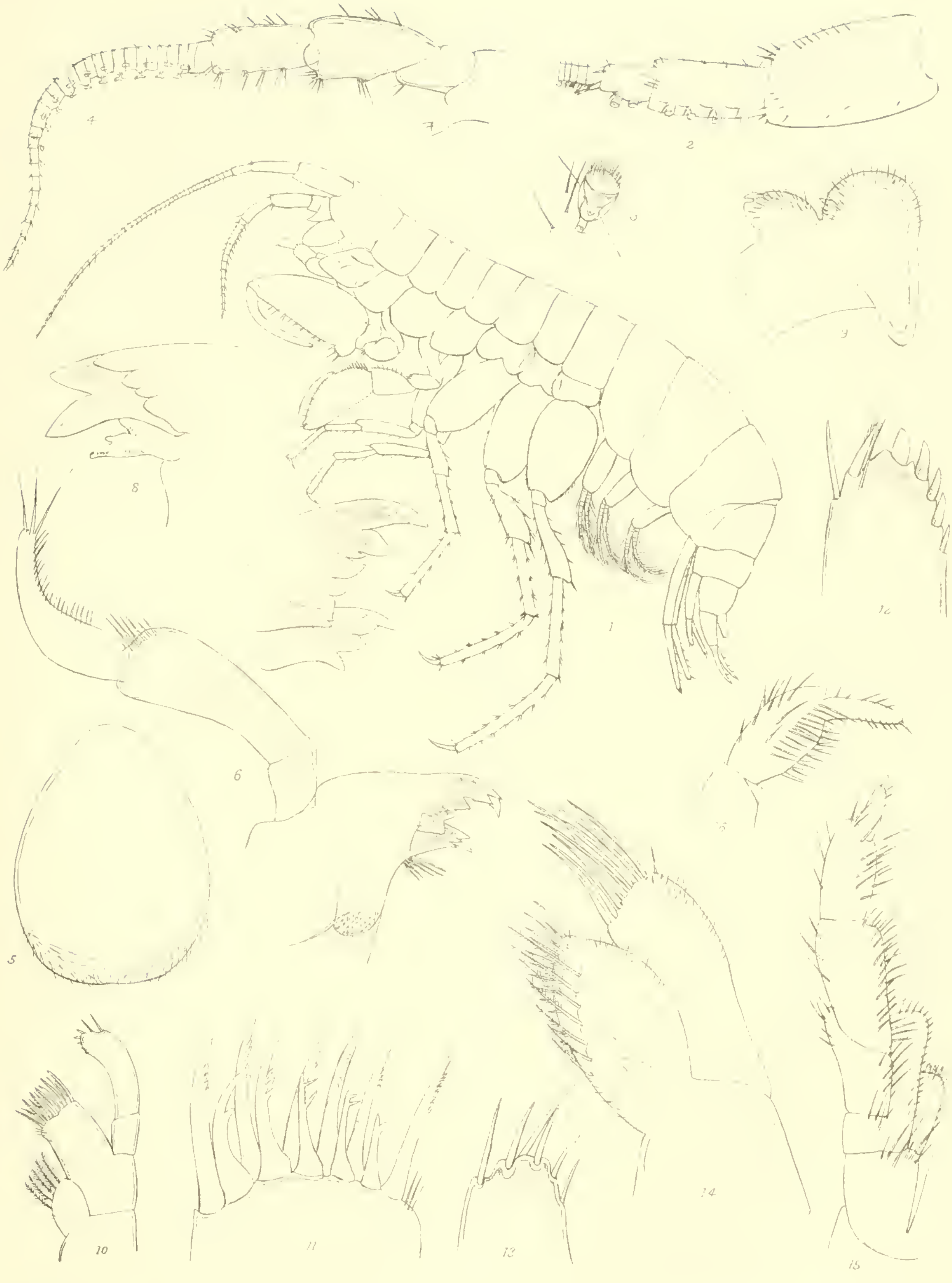
Hanhart imp.

CRANGONYX COMPACTUS, Chilton.



Chilton del.
Berjeau & Highley lith.

GAMMARUS [illegible]



C. Chilton del.
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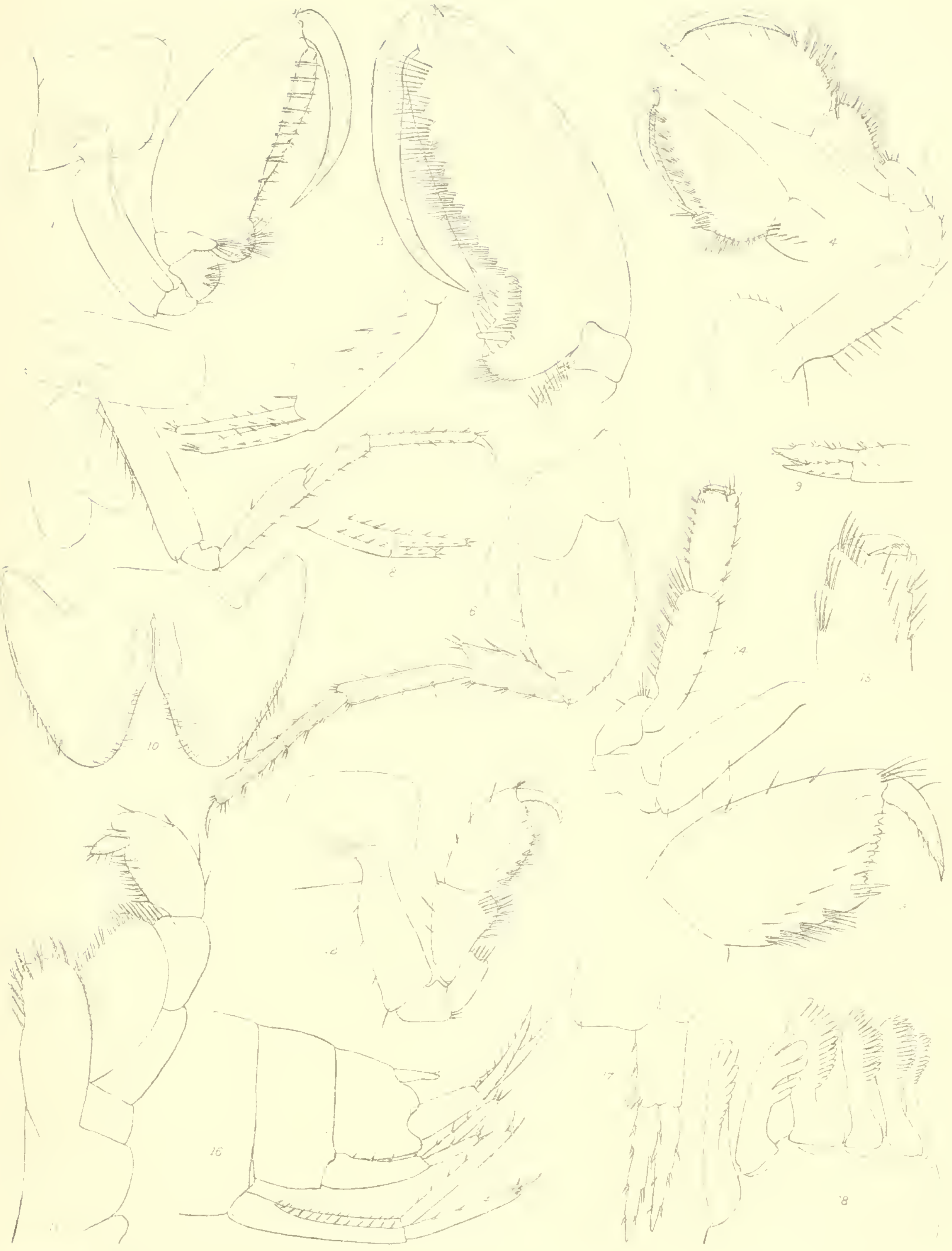
CALLIOPIUS SUBTERRANEUS [illegible]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V.	Part I.	1888.	0	12	0	0	9	0
	Part II.	1888.	0	5	0	0	3	9
	Part III.	1889.	1	7	0	1	0	0
	Part IV.	1890.	0	12	0	0	9	0
	Part V.	1890.	0	6	0	0	4	6
	Part VI.	1891.	0	12	0	0	9	0
	Part VII.	1891.	0	6	0	0	4	6
	Part VIII.	1892.	0	8	0	0	6	0
	Part IX.	1892.	0	12	0	0	9	0
	Part X.	1893.	1	8	0	1	1	0
	Part XI.	1894.	0	2	6	0	2	0
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2nd Ser. ZOOLOGY.] [VOL. VI. PART 3.

THE
TRANSACTIONS
OF
THE LINNEAN SOCIETY OF LONDON.

ON A FRESHWATER SCHIZOPOD FROM TASMANIA.

BY

GEORGE M. THOMSON, F.L.S.

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August 1894.

III. *On a Freshwater Schizopod from Tasmania.* *By* George M. Thomson, *F.L.S.*

Read 2nd November, 1893.

(Plates XXIV.–XXVI.)

In a paper read before the Royal Society of Tasmania on November 14th, 1892, I have given a brief account of the discovery of this interesting Crustacean, *Anaspides tasmaniæ**, and have described it as the type, not only of a new genus, but of a new family of Schizopoda. In some respects, indeed, the structure of this animal is so unique as to entitle it to even higher specific rank; but in many of its characters it is found to be allied, though somewhat remotely, to the *Euphausiidæ* of Sars (*Thysanopodidæ* of Bronn's 'Thierreich'). Owing to long isolation it has undergone very profound modification.

I found this species in a pool near the summit of Mt. Wellington, Tasmania—that is, at a height of over 4000 feet. The pool was in a small crevice only two or three feet deep, but seemed to have somewhat extensive ramifications among the rocky masses of which the upper part of the mountain is composed. The shrimps which came into the more open part were mostly small; the larger ones appeared to hide in the deeper crevices of the pool and would not come out while anyone was near.

I obtained only a few specimens at the time of my visit (January, 1892), but Mr. L. Rodway, of Hobart, was kind enough to make an expedition to the top of the mountain at my request on May 24th, and obtained a further supply from under the thick coat of ice which then covered the pool. He secured them by setting a small baited muslin net, but found the larger specimens very shy, as they tried to get the bait through the meshes of the net without venturing inside. Still he was enabled to obtain both males and females, the former of which were not included in my own collection. Unfortunately, none of the specimens in my possession are well preserved, so that it has been very difficult to make out their anatomical structure, and impossible to arrive at several important details.

In the pools and swampy ground round the spot where these were taken, Mr. Rodway, and subsequently Mr. Morton, F.L.S., of Hobart, obtained specimens of a small Amphipod which I have described in the paper referred to as *Niphargus montanus.* This species, like *Anaspides*, is evidently a very old type, belonging, apparently, to a genus hitherto described only from Europe and composed chiefly of underground

---

* This form was originally described by me under the name of *Anaspis*, but as my friend the Rev. T. R. R. Stebbing informs me that this name is pre-occupied, I have altered it to *Anaspides*, at his suggestion, so that the name of the new order may not have to be changed.

species. Among these was also found a single specimen of *Phreatoicus australis*, Chilton, previously only obtained from water springs and marshy ground on Mt. Kosciusko in New South Wales at a height of 5700 feet. The type species, *P. typicus*, Chilton, is eyeless, and occurs in the subterranean waters of Canterbury, New Zealand. The genus *Phreatoicus*, as Dr. Chilton has shown *, is an archaic one; it is, indeed, a remarkably generalized form of Isopod.

I have given the new shrimp the following systematic position in the above paper, the name *Anaspides* being suggested by the total absence of carapace.

Tribe *SCHIZOPODA.*

Family ANASPIDÆ.

Carapace wanting; the cephalon and all the segments of the body distinct. Maxillipeds and succeeding seven pairs of limbs uniform in general structure, adapted for walking, furnished with external lamellar branchiæ. No egg-pouch (?). Pleopoda with well-developed natatory exopodites; endopodites of first and second pleopoda specially modified in the males as copulatory appendages. Uropoda normal. Auditory organ in the base of first pair of antennæ †. Development?

Genus ANASPIDES.

Anaspis, mihi, Trans. Roy. Soc. of Tasmania for 1892, p. 51.

Integument thin and flexible. Whole body divided into 15 distinct (subequal) segments, viz. one cephalic, eight thoracic, and six abdominal. Eyes well developed. First antennæ with 3-jointed peduncle and two flagella; second antennæ with well-developed scale on the second joint. Mandibles with 3-jointed palps. First maxillæ 2-branched; second pair 4-branched. Maxillipeds pediform, with two rudimentary branchiæ projecting externally from the coxa; exopodite small and rudimentary. Legs generally uniform in structure, 7- or 8-jointed, each furnished with a claw-like dactylos. The coxa of each leg (except those of the last pair) bears two external lamellar branchiæ which project forward, and the basos bears a well-developed natatory exopodite. Pleopoda with a rudimentary endopodite in the females and in the 3rd–5th pairs in the males. First pair in the males with the endopodite developed into a lamelliform organ (penis?); second pair with the same organ produced into a clasping-process. Telson short, rounded. Uropoda with both plates subequal; inner with a slight longitudinal median ridge; outer with an imperfect transverse articulation near the middle.

External Form.

The most remarkable and characteristic features of the body (Pl. XXIV. fig. 1) are (1) its separation into 15 distinct segments without any trace of a carapace, thus recalling

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* "On a new and peculiar Freshwater Isopod from Mount Kosciusko," by Chas. Chilton, M.A., D.Sc. Records of the Australian Museum, vol. i. no. 8, p. 149.

† This character is not in the original diagnosis.

the appearance of an Amphipod, and (2) the external lamellate branchiæ of the thoracic appendages.

The cephalic segment is short and is produced into a triangular subacute rostrum (Pl. XXIV. fig. 2); the front margin, which is slightly hollowed out for the eye-sockets, is entire and rounded; the sides are not produced far downward, but leave the tumid basal joint of the mandibles exposed.

The eight thoracic and the six abdominal somites are distinctly articulated one to another, but there is much room for overlapping between them, so that a considerable power of flexion on the dorsal line is provided. In many specimens the posterior margin has its overlapping portion distinctly marked out from the rest of the segment by its much paler colour.

The first thoracic segment is only about half as long as the cephalon; its lateral portion, which extends further down than the sides of the preceding segment, is separated off by an oblique line into a distinct epimeron, which is widest anteriorly. The other thoracic segments are rather short, so that the thorax and cephalon together only equal in length the whole of the abdominal portion. The sides of all the segments are rounded and do not extend far down; there is no trace of epimeral marking, but the margins are thicker and more strongly chitinized than the remainder of the segment. Viewed externally, the lateral margins of the thoracic segments are nearly hidden by the branchiæ, which project almost to the bases of the second antennæ, and by the plumose exopodites of the 2nd to 6th pairs of peræopoda, which are produced upward and backward on the sides of the body.

The *colour* of these animals is a brownish grey, approximating closely to the sides and bottom of the pool in which they were found. The *integument* is very thin and somewhat tough, thinner indeed than that of any other free-swimming Crustacean with which I am acquainted. This is no doubt due in part to the semi-subterranean abode in which the animals occur. The external layer of the integument is transparent, and underneath it are cells containing the pigment to which the colour is due. There is no calcareous matter in the integument, neither nitric nor glacial acetic acid producing any trace of effervescence, or indeed appearing to alter it in any way. Strong nitric acid alters the pigment to a yellowish colour and rapidly dissolves it. The pigment-cells are somewhat hexagonal in form, and can be removed in a thin layer, presenting a tesselated appearance.

Appendages.

The *eye-peduncles* are short and stout, and are directed obliquely outward; they reach beyond the extremity of the basal joint of the second antennæ, but not so far as the extremity of the basal joint of the first pair. Each peduncle is 1-jointed, cylindrical in form, and very slightly enlarged toward the extremity; its length is about twice its diameter. The ocelli, which are very numerous, occupy about the upper third of the stalk; just below them, particularly on the outer side of the peduncle, are a very few short stiff hairs.

Anterior antennæ (Pl. XXIV figs. 3 and 4).—These organs are normally formed. The peduncle is 3-jointed, with the joints broad and somewhat flattened; the first and second joints are subequal in length, the basal slightly the largest and widest, and having a longitudinal suture tending somewhat obliquely outward along its upper surface; the second joint also bears a slight longitudinal groove on its upper surface, and is fringed on its outer margin with plumose setæ. The third joint, which is also similarly fringed on its outer margin, is broader at its distal than its proximal end, and carries two whip-like flagella. The outer flagellum is from two-thirds to three-fourths the length of the body, and is divided into very numerous articulations. In the youngest specimen examined, the body of which was only about 9 mm. long, there were 36 articulations on the outer and only 8 on the inner flagellum; but in adult specimens the number varies from 70 up to 92, which was the largest number observed. The articulations are furnished with a few short spinose setæ on both sides. On the ten or twelve joints nearest the peduncle the setæ are long and plumose, but they tend to become shorter and more simple on the joints nearer the extremity. On all the joints but those few setose ones nearest the peduncle there are blunt hairs or cilia of a very characteristic appearance, which are probably sensory organs.

The inner flagellum is about one-fourth the length of the outer, and usually consists of about one-fourth the number of articulations; the joints nearest the base have more or less plumose setæ, those further out have the setæ simple. But in the male this inner flagellum is modified in a curious manner (Pl. XXVI. fig. 12). The fifth and sixth joints are much dilated; the former bears a large tuft of slightly plumose setæ, while the latter carries two large stout setæ, which are rugose in their distal half; each is also apparently furnished with a nerve-fibre. The first seven joints also bear a number of short, curved, finger-like setæ, all more or less covered with rugosities, so as to resemble a round rasp or file; these rugosities are arranged in an annular manner and appear to consist of minute stiff hairs. These thickened processes are scattered somewhat irregularly, there being a tuft of about six or seven on the basal joint, then isolated ones or in twos or threes on the succeeding joints, about seven on the sixth joint, and three on the seventh; they are directed toward the upper surface of the flagellum, while the long setæ of the proximal joints are all on the lower surface. The remaining joints are simple, and carry short simple setæ as in the corresponding organ in the female. These peculiar processes in the male are probably sensory in their function; they certainly form a very distinct sexual modification.

The auditory cavity is placed in the basal joint of the peduncle of the first antennæ, its roof being formed by the flattened upper surface. It communicates with the water outside by a duct which opens at the extremity of the joint under a fringe of setæ.

Second antennæ (Pl. XXIV. fig. 5).—The peduncle consists of four (perhaps five) joints, and bears a long flexible flagellum; all the joints are more or less flattened out laterally, but the upperside of the first and second joints is produced into a longitudinal crest or ridge, which gives the base a somewhat triangular section. The first and second joints are short and subequal in length; both bear on their outer extremities a crown of short spines, and the second joint has also a tuft of fine setæ on its inner extremity. This joint also bears an oval plate (the scaphocerite of Spence Bate) fringed with long plumose setæ.

This appendage has a uniformly smooth margin, but it is slightly raised into a median ridge, especially in its basal portion. The third joint, which is subequal with and nearly covered by the scaphocerite, is slightly longer than broad, flattened and thickened on each margin, where it bears a fringe of plumose setæ, those on the inside being the longest. The fourth joint is shorter and narrower than the third, and is also similarly furnished with plumose setæ; at its extremity it bears a very short joint, which, though somewhat narrower than the one bearing it, is considerably broader than the joint of the flagellum which succeeds it. It is probably the fifth joint of the peduncle which is thus almost merged in the fourth.

The flagellum is not quite two-thirds as long as the body of the animal, and is composed of very numerous (45 to 60) joints. Each joint bears at its extremity on both sides a number of setæ, those at the proximal end being long and plumose, but diminishing in size and becoming smooth on the more remote joints; the last joint is blunt and bears numerous short simple setæ.

The *oral aperture* (Pl. XXV. fig. 10) as seen from below is well defined. The *upper lip* is a thick fleshy appendage, rounded in front and widening out below. It seems to have very considerable flexibility and power of movement, and is strongly supplied with muscular bands. Close behind it lie the cutting-edges of the *mandibles* (Pl. XXIV. figs. 10, 11, and 12), which are similar on both sides. These organs are strongly developed, and are so placed as to close the mouth-opening with their exposed side. The cutting-edge is furnished with a double row of strongly indurated teeth, while placed nearly at right angles and interior to it is a ridge fringed with short bristles, culminating in a strongly-produced grinding tubercle with an oval finely-toothed margin. The palp is 3-jointed, and when at rest projects forward between the bases of the first pair of antennæ: the basal joint is broader than long, and furnished with a few short plumose setæ on each side; the second joint is much the longest, is three or four times as long as broad. and bears a tuft of setæ at its upper distal extremity; near its base on the lower side it is produced into a short triangular tooth, while on the distal two-thirds of the same side it bears numerous short setæ arranged in two rows and leaving a long narrow groove, into which apparently the third joint can be folded and so completely protected; the third joint is short, slightly broadened towards the outer end, and densely fringed with short setæ. All the setæ on this organ are furnished with very short hairs, which almost make them appear serrated. The base of the mandible is widely dilated for the reception of the powerful muscles by which it is moved.

The *under-lip* (Pl. XXIV. fig. 9), placed immediately behind the mandibles, is a deeply 2-cleft fleshy plate, rounded on the outer margins, and finely fringed on the upper and inner with minute close-set hairs. The two sides appear to be capable of opening widely apart.

First maxillæ (Pl. XXIV. fig. 6).—These organs are 2-branched; the external branch, which is strongly chitinous, bears on its inner oblique margin a double row of serrated spinose teeth, which are brown-coloured and strongly chitinized; the inner branch is fleshy, smaller, more rounded, fringed with short plumose setæ, and seems to have but little power of movement.

Second maxillæ (Pl. XXIV. figs. 7 and 8).—These are thick, fleshy, and 4-branched, each branch being 1-jointed. The broad basal portion which bears these branches is rounded on its outer edge, which bears a few small spines; at its upper and outer extremity it has a small crown of setæ at the articulation of the outer branch. This basal portion is longitudinally a little bent on itself, so that while the two outer branches on each side work against each other, the two inner lie more in the same plane and move obliquely one against another. The first (outer) branch is short and rounded, and, as is the case with the second branch, ends in a great number of setæ, which are somewhat curved inwards and are toothed along their inner margins. The third branch resembles the narrow second one in form, but the setæ are not toothed. The fourth (innermost) branch is setose along its inner margin, and is expanded on its outer into a thin rounded lamella which partly covers the third branch. These four setose plates are evidently for the purpose of preventing particles of food from escaping from the oral aperture.

Maxillipeds (Pl. XXIV. figs. 13, 14, and 15).—These organs are distinctly pediform, differing from the succeeding pairs of legs only in the degree of their development. They are 7-jointed. The coxal joint bears on its outer side two lamellar branchiæ, each of which is obliquely crossed near its base by a fine line of articulation; the upper of these is more than twice as broad as the lower, which is long and very narrow. On its inner side the coxa bears two small lamellar organs fringed all round with setæ, the inner and narrower of which stands alongside, but at right angles to, the outer. These setose plates serve to close the oral aperture behind. The upper portion of this joint bears at its outer extremity a slender appendage which is subequal in length to the rest of the joint. This exopodite appears at first sight to be unjointed, but is seen to bear a minute articulation at its apex.

The basos is long, and is rounded on the anterior or outer side, while the keeled inner side bears a double row of plumose setæ. The ischium, which is similarly shaped in section, is about half as long, and the meros is as long, as the basos. The two succeeding joints form a distinct—and in spirit-specimens a sharp—geniculation with the meros, being bent in towards the middle line of the body; they are both somewhat shorter than the meros, and are rather densely setose. The propodos is more flattened than the carpos, and is fringed with numerous curved hairs on both margins, while the dactylos ends in three powerful hooked claws, which are almost hidden among setæ.

These organs I have termed maxillipeds, as in position they correspond to those appendages in other Crustacea; but they might more appropriately be called the *first pair of walking legs*.

The next seven pairs of legs resemble the preceding pair in general structure, but differ considerably in detail; they all want the setose lamellæ on the inside of the coxal joint, which indeed appear to act partly as oral organs, but several of them have a small pointed lobe which may be a homologous development. The exopodites and branchiæ are differently developed in all the limbs, while the basal joint is shorter than in the first pair. In the second to the sixth pairs, the long plumose exopodites apparently serve as natatory organs and facilitate progression though the water.

In the *second pair of legs* (Pl. XXIV. fig. 16) the joints are similar in number, shape, and relative length, as well as in distribution of setæ, to those of the first pair. The lamellar branchiæ are, however, much broader and are subequal in size, the lower one being more oval and pointed than the upper. The exopodite is developed into a long peduncular joint, bearing a stout multi-articulate flagellum, fringed on the posterior side of the articulations with long plumose setæ.

The *third pair* closely resemble the preceding, but are in every way larger. The lower of the two branchiæ is slightly larger than the upper.

The *fourth pair of legs* are the longest of all. The lower branchia is half as large again as the upper.

The *fifth pair* are similar to the fourth in most respects, but the setæ are more tufted and scattered. On the coxal plate there projects downward and alongside the basos a small lobe, tufted—especially at the end—with setæ.

The *sixth pair* (Pl. XXV. fig. 1) are shorter, slighter, and less setose than the preceding. The exopodite is, however, relatively strongly developed and is nearly as long as the whole limb, while in the much larger third pair of legs it does not reach the extremity of the meros. The setose lobe on the coxal plate is half as long as the basos.

The *seventh pair* of legs (Pl. XXV. fig. 2) show a sudden diminution in the size of the branchiæ, which are not half so large as in the preceding pair. The exopodite also is reduced to a small branchia-like projection, not reaching the extremity of the ischium and quite destitute of segmentation. The joints of the leg are more slender and the setæ fewer than in the preceding pair, but the coxal appendage—at least in the females—is much more strongly developed.

In the *eighth pair* (Pl. XXV. fig. 3) the diminution is most pronounced; the joints are slender and nearly destitute of setæ, while the branchial plates and exopodite are totally wanting.

The exact relation of the joints of the legs near their point of attachment to the body is somewhat difficult to make out. In the first pair—the maxillipeds—there appear to be eight joints, and if we count back from the dactylos it would seem that the coxal joint is separated into two articulations, the proximal part bearing the branchiæ and the internal processes, and the distal part the exopodite. The same arrangement is seen in the second pair of legs. The eighth pair is also segmented into eight very distinct joints, none of which bear appendages. But in the sixth pair the coxa appears to be reduced to a plate passing on the inner side into the sternum and carrying the branchiæ on its outer side, while the exopodite is borne on a special lobe or process. In the seventh pair the coxa appears to be cleft longitudinally, the inner part bearing the ciliated lobe, while the outer carries the branchiæ and the exopodite. The latter is not on a distinctly separated process, but has a constriction at its base as if indicating a rudimentary joint. The joints of all the eight pairs of legs from the dactylos to the basos appear to be easily homologized; the difficulty of identification seems to lie in the development of the coxa.

In the females *the genital opening* (Pl. XXV. fig. 3) is a transverse slit on the apex of a rounded tubercle which is placed just anterior to the last pair of legs. It stands between, and a little in front of, the coxal joints, and almost on the sternal divisions. The setose processes on the inside of the fifth, sixth, and seventh pairs of legs have probably some relation to this organ.

The five pairs of *pleopoda* (Pl. XXV. fig. 4) on the first to the fifth abdominal segments are all of a similar form in the females. Each consists of a subquadrate basal joint, the outer portion of which appears almost as if articulated on to the rest. Near the outer angle is the large multi-articulate exopodite, which forms an apparently more perfect oar than the corresponding organ on the thoracic legs. Each is formed of numerous short joints carrying several long plumose setæ. On the inner side of the base is a small oblong plate like a rudimentary branchia—the endopodite. In going back from the first to the fifth segment, this endopodite diminishes in size.

In the males the first pair of pleopoda (Pl. XXV. fig. 5) have the exopodite normal, but the endopodite developed into a lamelliform plate which projects inward (figs. 6 and 6 *a*). This plate appears to be furnished with a duct which opens near its extremity. The whole organ is somewhat dilated toward the end, and is furnished with a row of minute spines down the sides of the duct. In the second pair (Pl. XXV. fig. 7, 8, and 9) the endopodites are each produced into an elongated peduncle, which is deeply grooved on its inner face, and bears a double row of stout, slightly-curved spines near its extremity, and a scoop-like terminal process having smooth edges and with the hollow faces meeting in the middle line. Both pairs evidently act as copulatory organs; but I have not been able to trace the passage of the vasa deferentia into the first pair, which I think represent the openings of the male generative organs. The second pair appear to act only as clasping-organs. The succeeding 3rd–5th pairs of pleopoda are similar to the corresponding limbs in the females.

The *uropoda* form with the *telson* a large tail-fin (Pl. XXV. fig. 9), as in most shrimps. In each the basal portion is relatively small, while the exopodites and endopodites are produced into large plates or swimmerets; these are subequal in length, oblong in form, and bluntly pointed: the distal halves of all four plates are densely fringed with long comb-like setæ or spines; the proximal halves of the inner plates are quite smooth on the outer margin, while those of the outer plates have a very few short spines.

The *telson* is short and almost transversely truncate, its length hardly exceeding the breadth at its base. The blunted end is furnished with a fringe of comb-like teeth. The shortness of this telson is a characteristic feature, as in the majority of Schizopods it exceeds the uropoda in length. It is only in certain genera of Mysidæ (e. g. *Euchætomera*) that the latter reach far beyond the end of the telson. The relative width of the uropoda in *Anaspides* causes this tail-fin to act as a very powerful swimming-organ, and this enables the animal to retreat very rapidly from any danger menacing it in front.

The largest specimen of *Anaspides* examined by me was 38 mm. or 1½ inch long, but the length in smaller specimens hardly exceeds 25 mm. I found ova in the oviducts.

Anatomical Structure.

I have met with very considerable difficulty in working out the structure of *Anaspides*, owing to the imperfect state of preservation of my specimens. These when caught were merely put into alcohol of unknown strength, and even this was not changed for two or three weeks. The result was that all the internal organs were more or less disintegrated, and it was a matter of difficulty—and in some cases of impossibility—to separate them one from another or from the adjacent tissues.

In not a single specimen could I isolate the heart throughout its length or trace the course of the principal blood-vessels. The same remark applies to the hepatic tubes, which were completely disintegrated except at their extremities. This has necessarily led to an incomplete and imperfect resolution of many details of structure. The best results in regard to the soft parts were obtained by means of sections.

Alimentary system.—The œsophagus is very short and passes vertically into the stomach (Pl. XXVI. figs. 1 and 6). The latter is an open sac, curving over nearly at right angles to the gullet and passing directly back into the intestine ; it is of very simple structure as compared with the usual structure of this organ in the higher Crustacea. In front, and just where it widens from the œsophagus, the median line is chitinized into a stout ridge which thickens upward into a club-shaped process, covered at its extremity with fine tooth-like rugosities, and projects into the cavity of the stomach (fig. 7). Above this process the median ridge bends over to form the dorsal ridge of the stomach, and this thickening is continued back as far as the fourth thoracic segment. On each side of the base of this line the chitinous thickening is expanded into a two-lobed process, ending in sharp and somewhat widely separated points. At the posterior side of the mouth-opening there arise two stout chitinous ridges densely covered, especially at their base, with setæ or curved bristles, all pointing inward. Thus the opening of the stomach is guarded by so many projecting processes that it must be almost impossible for food to be again ejected at the gullet. On each side of the frontal median ridge the stomach is produced into two curved concavities occupying the front portion of the cephalic segment almost to the bases of the antennæ and the ocular peduncles. The base of the stomach, reaching back from the œsophagus to near the fourth segment of the body, is chitinized, and the bands on each side of it are thickly ciliated (fig. 8). Two other ciliated bands pass up the sides and converge towards the median band, forming along with it the roof of the cavity. The side-walls of the stomach between the chitinous bands are very thin and membranous, and are protected by the dense mass of muscles of the mandibles. The whole of the stomach and part of the fore-gut appear to be covered by a longitudinal sheath of muscular tissue. Except the club-shaped projection in the front of the stomach, there seems to be no special masticatory apparatus, and trituration of the food appears to depend on the up-and-down movement of the whole upper part of the sac. Maceration of the food is certainly very imperfectly effected, as I have investigated the contents of the intestine and found that so far back as the seventh thoracic segment fragments of Copepoda, &c., occurred, in which the integuments and portions of the limbs were still intact. I think it probable that the hepatic tubes open into the alimentary canal just at the posterior end of the stomach or at the very commencement of the intestine ; but neither by dissection nor by longitudinal and transverse sections could I detect the opening, although the tubes themselves were in several cases followed up to this part of the canal.

From the stomach the intestine proceeds back as a straight, simple, and rather wide tube ; for about the posterior half of its length the wall is wrinkled into small folds, as if capable of very considerable backward and forward movement. At about two-thirds of its length, or just about the first abdominal segment, it bears on its upper surface a short oval cæcum—in large specimens about 2 mm. long,—directed forward (Pl. III. fig. 2). This organ is evidently an excretory gland. Its cavity is densely lined with tube-shaped cells placed vertically to the walls, leaving a hollow space in the interior, which is partly filled with loosely-interwoven elongated and pointed cells, and communicates by means of a short duct with the intestine. At about the extremity of the antepenultimate segment of the abdomen the intestine bears on its upper surface another cæcum, shorter than the first and directed backward (fig. 3). This is also lined with glandular tissue arranged in the same manner as in the anterior one, and has a central duct. The function of both these organs is probably urinary. In the last abdominal segment the intestine contracts sharply to less than half its previous diameter, and, entering the telson, bends abruptly upward and backward, and then passes out nearly straight to the anus, which is in the form of a longitudinal slit. Where it contracts the wall is surrounded by a coat of muscles arranged in an annular manner.

The *liver* is quite different in its structure from the corresponding organ in any other Crustacean with which I am acquainted. Owing to the very soft tissue of which it is composed, especially in its anterior portion, and its consequent state of disintegration in all my specimens, I have been able to make out only a portion of its structure. It consists of a number of slender cylindrical tubes, lying horizontally, but slightly interwoven in the body-cavity, above and on both sides of the alimentary canal, and reaching back to halfway between the intestinal cæca. In one specimen I traced as many as eighteen of these tubes forward to about the posterior end of the stomach, but failed in every instance to find any duct or opening into the alimentary canal. These tubes are of a yellowish straw-colour in ordinary spirit-specimens. Their posterior portions, when considerably magnified, exhibit at the extremity a mass of slightly elongated pointed cells, thickly charged with granular contents (Pl. XXVI. fig. 9). At a short distance from the end a duct arises, the cells all round it, which line the walls of the tube, being arranged in a more or less vertical direction.

Excretory organs.—My identification of the so-called "green gland" or renal organ characteristic of all the higher Crustacea is not satisfactory, if indeed it exists at all. I have not identified it in dissected specimens, but in one or two sections I have observed what appears to be a small mass of glandular tissue lying in front of and partly below the anterior lobes of the stomach and close up to the bases of the lower antennæ. At the same time I have not found any duct by which its excretions are liberated. It is just possible that I have mistaken for this the somewhat disintegrated tissue of the preoral ganglion; but if so, its connexion with the large nerves supplying the eyes has not been traced. It is perfectly possible that the organ is wanting or only exists in a rudimentary state, especially if the intestinal cæca usurp its functions, as I have surmised.

Circulatory apparatus.—My observations on this part of the anatomy are very fragmentary, but they are sufficient to attest the primitive character of *Anaspides*.

The *heart* consists of a long simple tube, apparently little dilated in each body-segment, lying close to the dorsal surface and tapering gradually at both ends into a more slender cylindrical vessel. I have traced the whole tube from about the third thoracic segment back past the posterior intestinal caecum. Of the arteries passing from the heart, exclusive of its anterior and posterior prolongations, which may be considered respectively as the cephalic and upper abdominal arteries, I have succeeded in tracing only one prominent artery passing almost vertically downward between the seventh and eighth thoracic segments, which probably supplies the greater portion of the sternal region. But I have failed to find any trace of the valvular openings into the pericardial sinus, by which the blood returning from the branchiæ and other portions of the body is again fed back to the heart. This is of course due to the very imperfect condition of the tissues examined.

The branchiæ, as already mentioned, are all lamelliform and are carried externally. Morphologically there are seven pairs on each side, but those of the first pair of legs (maxillipeds) are very much reduced in size, and probably more or less in function also. The branchia-like endopodites of the abdominal appendages are no doubt functionless as breathing-organs.

Reproductive organs.—I have not succeeded in definitely making out the structure of the testes and vasa deferentia in the very few male specimens at my disposal. The male organ, so far as it was identified, consists of two thin, whitish tubes, lying nearly parallel one to another, above and slightly on each side of the intestine (Pl. XXVI. fig. 5). These extend from the third segment of the thorax, where they are smaller and very much twisted, as far back as the telson. The densely-twisted part of the organ lies in the penultimate segment of the thorax. The vasa deferentia pass outward from the body-cavity by two rather wide tubes, which come down near the outer side of the body to the first pair of abdominal legs.

The ovaries form a somewhat flattened pinkish mass on each side of the body above the alimentary canal, having rounded lobes projecting upward and downward so as almost to meet in the median line. The supra-abdominal artery lies along the margins of these lobes, which extend from the last segment of the thorax to the region of the posterior intestinal caecum. In more sexually mature specimens in which the ova were found lying in the oviducts, the latter were seen to lie lower down in the body-cavity, at the sides or even below the intestine. In the most advanced specimen examined the ova were nearly one millimetre long and were oblong in form. Even in such relatively well-developed ova there was no commencement of differentiation into definite structures. The whole interior appeared to be composed of more or less spherical cells, which were especially densely packed and were smaller in size towards the centre. Even at this stage, the ovum had a strong, homogeneous, well-defined wall, and appeared as if nearly ready to be extruded. In one specimen I found ova ranging from an early morula (?) stage up to the form described, but all the tissues were in bad preservation. I have not succeeded in tracing the ovaries down to the genital opening, which is on the sternum, between the last two pairs of thoracic legs.

Nervous System and Sense-Organs.

The *nerve cord* (Pl. XXVI. fig. 4) was easily traced along the whole ventral surface of the body from the extremity of the abdomen to the mouth, but the organization of its anterior end was not made out satisfactorily either by dissection or by means of sections.

In the abdomen there are six quite distinct paired ganglia, the cords being almost united at the very base of the telson to form the largest of these. From each pair of ganglia at its anterior and outer side there proceeds a dense plexus of nerves to the surrounding masses of muscular tissue, while from its posterior outer side there passes one rather stout nerve obliquely backwards and downwards to enter the appendage. Each pair of ganglia is separated by two very distinct and somewhat widely separated commissures.

In the thorax the ganglia lie much closer together, the commissures, though quite distinct, being parallel and touching throughout their length. The ganglionic portion of the cord is not sharply defined as in the abdomen, the position of the different centres being made out most readily by the nerves which pass into the appendages. There appear to be seven (or eight) fairly well-defined ganglia in the thorax, but immediately behind the gullet is a mass of ganglionic tissue which appears to supply all the mouth-organs, but which I was not able to resolve into its constituent elements; nor could I trace the passage of the commissures round the mouth to the anterior ganglionic mass from which proceed the powerful nerves which supply the eyes and the antennæ.

The *eyes* are well-developed as in the higher forms of Crustacea. I have not examined their minute structure.

The *organ of hearing* (Pl. XXVI. fig. 10) is situated in the basal joint of the first pair of antennæ. It consists of an oblong cavity, occupying about two-thirds of the length of the joint, and communicating with the outside by a duct which opens at the end of the joint under a tuft of terminal setæ. The roof of the cavity is formed by the flattened upper surface of the joint. This roof is lined by a colourless tissue formed of two (or three?) layers of somewhat elongated hyaline cells, standing obliquely or nearly vertically to the surface. The internal layer which forms the lining of the upper part of the cavity appears to form a series of trumpet- or cup-shaped sockets, into which the auditory hairs are jointed. Each of these hairs consists of a club-shaped stalk or pedicel, bearing an elongated bell-shaped cell or capsule (fig. 11). I cannot make out without fresh material whether these cells are open or not; I am inclined to think that they are closed sacs. I have not been able to trace the separate nerve-fibres passing into these auditory tubes, except near their base, but a very considerable nerve enters the antenna, and has been followed by me nearly up to the auditory cavity.

I could not detect any trace of sand-particles such as are common in most of the higher Crustacea, in which the auditory sac communicates with the outside water by a canal, nor of an otolith such as occurs in those forms which have a closed sac. Each auditory tube or hair appears to possess a somewhat complicated structure in its capsular portion. These sense-organs are quite unlike any others hitherto recorded among the

Arthropoda, and will evidently repay close investigation. I think each cavity contains a single row of these auditory hairs.

I have already referred to the tactile and olfactory hairs of the antennæ.

Fragmentary and imperfect as this sketch of the anatomy is, it is sufficient to show that in several respects the structure of *Anaspides* is unique among Crustacea. The abdominal cæca, the numerous isolated hepatic tubes, the simple tube-like heart, and the curious structure of the auditory hairs are features peculiar to this Crustacean, differentiating it not only from other members of the family Schizopoda (from which *Anaspides* is also separated by its want of a carapace and external lamellate gills), but, I think, from all other described Malacostraca.

Affinities and Systematic Position.

Anaspides is manifestly a schizopod shrimp, but its greatly generalized characters as well as its remarkable habitat point it out as a survival of a very old type. The most conspicuous external features are the want of a carapace and the plate-like character of the branchiæ. Both are no doubt associated with its habitat among the clefts of rocky pools, where its enemies were probably few and far between, and in which its body was greatly protected, but the former feature especially seems to me indicative of the great antiquity of the type. Until the full development has been worked out—and we know absolutely nothing about it yet—it is impossible to arrive at any conclusions as to how far the carapace is developed in the embryonic stages; but, with this solitary exception, I know of no Crustacean belonging to the Thoracostraca in which there is absolutely no trace of a carapace in the adult forms.

In general appearance *Anaspides* approaches nearest among Schizopoda to the family Euphausiidæ, with which it agrees in the following external features:—(1) the 7-jointed pediform maxillipeds; (2) the general uniform structure of the walking-legs; and (3) the well-developed natatory abdominal limbs, the first two pairs of which are modified in the males as copulative organs. The points of dissimilarity are numerous enough, but they are features in which it differs from all Schizopods, and not from the Euphausiidæ alone. Sars has shown * that in the Euphausiidæ there are six principal stages of development. After the young animal has passed through the *Nauplius* and *Metanauplius* stages, it enters on the *Calyptopis* stage, so-called by him after one of Dana's spurious genera. In this stage, in which only the cephalic appendages are present, the carapace is attached to the anterior part of the body of the larva, and though it projects backward to cover the portion which afterwards develops into the thoracic segments, it is not anywhere joined to these segments, but only to the cephalon. Even at this early stage, however, it covers and comes to be attached to the somite which bears the maxillipeds. Thus early in the development of a typical Schizopod has the carapace come to be a prominent feature. It may here be pointed out that the resemblance of the body of *Anaspides* to that of a sessile-eyed Crustacean is not confined to the want of a carapace and the occurrence of lamellate branchiæ; it is also suggested

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* Report on the Schizopoda of the 'Challenger' Expedition, p. 150.

by the presence of a well-marked lateral suture on the first thoracic segment, recalling the epimeron of most Isopoda, which, however, is in some instances not developed on the first, though prominent on the succeeding segments.

The plate-like character of the branchiæ is a feature which does not exhibit nearly so radical a digression as the loss of the carapace. In the development of *Euphausia pellucida*, Sars has shown [*] that after the *Calyptopis* stage the larva passes through a *Furcilia* stage, in which the anterior legs and the pleopoda begin to develop. The legs first appear as simple processes or lobes, giving rise on their outer side to a minute knob, which is the rudimentary exopodite. As the endopodite develops and gradually becomes articulated, a simple knob-like protuberance arises at its base, below the exopodite, which as development proceeds bifurcates into two rudimentary plates. This stage appears to correspond with that reached by *Anaspides*, only in the *Furcilia* larva the branchiæ continue to subdivide until they ultimately become arborescent in the adult, because they are sheltered under a carapace and so must expose the largest surface possible to the somewhat limited supply of water with which they are surrounded. In most of the Schizopoda the gills become arborescent.

The archaic character of *Anaspides* is more fully revealed by a study of its anatomy. The alimentary canal shows a much simpler structure than prevails in any other described Schizopod. In *Mysis* [†], which may be looked on as one of the least highly developed forms of the suborder, the stomach is distinctly divided into an anterior (cardiac) and a posterior (pyloric) portion; the latter is much the smaller, is of very complicated structure, and is the part in which the food is chiefly triturated. Opening just behind it and placed dorsally is a small cæcum, which acts probably as a sort of salivary gland. The liver is composed of ten pouch-like masses, five on each side, which unite their contents into a hepatic duct entering the intestine just where it leaves the stomach. The intestine is a nearly straight tube, passing directly to the anus, and having no cæca or diverticula communicating with it anywhere behind the opening of the hepatic duct. In *Euphausia* [‡] the structure of the alimentary canal is essentially similar, but above the pyloric portion of the stomach are two small incurving cæca (not one as in *Mysis*), while the liver consists of a mass of minute hepatic tubes on each side of the intestine and not reaching to the posterior portion of the thorax. These masses of tubes are quite distinct in appearance and aggregation from the long isolated tubes of *Anaspides*. Cæca of the mid-gut are found in all orders of Crustacea as paired or unpaired organs. Their position appears to vary a good deal. For example, in some Brachyura (e. g. *Carcinus*) a pyloric cæcum or diverticulum arises on each side of the stomach in front of the hepatic ducts, which when uncoiled exceeds the intestine in length, while at about one-third of the distance from the stomach to the anus a solitary cæcal appendage arises, also in the form of a long tube. In others (e. g. *Maia*) the latter cæcum is placed at the extreme anterior extremity of the intestine. In the Macroura there is always the usual pyloric cæcum, but in some genera (e. g. *Astacus*)

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[*] *L. c.* p. 163, pl. xxx. figs. 23–27.

[†] G. O. Sars, 'Hist. Nat. des Crustacés d'eau douce de Norvège,' p. 26.

[‡] 'Challenger' Report, p. 73.

there is no appendage of the intestine, though this is present in others. In all the Thoracostraca the liver is in the form of a more or less compact mass composed of numerous small cæca. In Amphipoda (e. g. *Gammarus*[*]) a single pyloric cæcum opens just behind the stomach, and this is also probably salivary in its function; while at the posterior end of the mid-gut two slender cylindrical processes open into the intestine. These cæca are placed along the dorsal surface of the intestine, and reach as far forward as the last thoracic segment. Their function is probably urinary. In *Caprella dentata*[†] a single pyloric cæcum is placed dorsally to the posterior part of the stomach and opens in the front part of the intestine, while near its posterior extremity the intestine carries a small simple cæcum very similar to the posterior one in *Anaspides*.

In the Schizopod under consideration the stomach is hardly separable into a cardiac and pyloric portion, nor is the separation between the hind part of the stomach and the intestine at all well marked. The liver is unique in its structure. There is no trace of a pyloric cæcum[‡], the first organ of the kind being placed as far back as the first abdominal segment. From the imperfectly triturated condition of the food in the part of the intestine which passes through the thorax, I am inclined to believe, as said before, that the gastric function is only imperfectly performed by the stomach, and that the anterior part of the intestine acts as part of the pyloric stomach. If this be so, the anterior cæcum may still function partly as a salivary organ (though this is hardly probable), and the posterior one, which is placed far back in the alimentary canal, may be excretory only and may act as a urinary gland. It is clear, however, that the whole structure of the alimentary canal bears a closer resemblance to the lower Amphipoda (Caprellidæ) than to any of the higher forms of Crustacea, and this is probably to be looked on as another survival of a primitive type of structure.

The circulatory apparatus has been shown to be very elementary in its structure. In the Brachyura the heart reaches its maximum development, occurring in most crabs as a short polygonal vessel placed in such a central position as to readily control by its rhythmic action the blood-supply of the body. In Macroura it is also a well-developed saccular organ, from which the passage of the various arteries can readily be traced. In Schizopods, though not so well developed, it still preserves its saccular character. But in *Anaspides* it is apparently reduced to a simple tube. Only in the Stomatopoda, among the higher Crustacea, is there any approach to such a primitive form.

It is premature, with the imperfect knowledge of this animal still at our disposal and our absolute ignorance of its development, to attempt to frame any genealogical scheme showing its position among the Schizopoda, but from the points referred to I think it probable that the Anaspidæ and the Euphausiidæ were somewhat closely allied in their origin.

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[*] Sars, Crustacés d'eau douce, p. 55.

[†] P. Mayer, 'Die Caprelliden des Golfes von Neapel,' p. 147, Taf. 9. figs. 2, 3, and 4.

[‡] This statement must be accepted with the reservation due to the fact that I could not make out this feature clearly, but it appeared to me as if the upper part of the pyloric portion of the stomach was enveloped in an easily disintegrated tissue of which I could not trace the close connection with the alimentary canal which certainly existed. Whether this tissue represents an imperfectly developed pyloric cæcum, or an anterior process of the liver, I have not succeeded in demonstrating.

In trying to arrive at some conclusions as to the length of time during which *Anaspides* has been isolated, the following facts are of interest. I am indebted for this information on the geology of the district to my friend and former pupil, Mr. A. Montgomery, M.A., Government Geologist of Tasmania. The top of Mt. Wellington, as well as the central plateau of Tasmania, consists of a mass of greenstone (diabase) of about Permo-Carboniferous age. According to Mr. R. M. Johnston, the greenstone existed prior to the deposition of the shell-beds and sandstones which flank its base, while Messrs. Stephens and Montgomery consider it to be younger. Mr. Johnston admits, however, that there was a "newer greenstone" eruption which broke through these marine deposits, so that it is agreed that the Permo-Carboniferous beds were penetrated by greenstones subsequent to their formation, and it is probable that the eruption of these greenstones and the elevation of the marine beds were contemporaneous. The greenstones break through and cover the Upper Coal-measures, which have been referred to the Mesozoic period on account of the plant-fossils contained in them, though no stratigraphical break has yet been discovered between them and the Permo-Carboniferous marine beds at a horizon very little below them. If Mesozoic at all, they must probably be referred to the beginning of that period, and the greenstone eruptions were probably little later. They were certainly older than the oldest Tertiary beds, which may be Eocene. There are no Secondary marine beds, and the Tertiaries are quite littoral, so it appears certain that Tasmania has never been under water to any great extent since some time in the Mesozoic, and possibly since the close of the Palæozoic period. It seems probable that the basaltic eruption, of which the diabase greenstones are the remains, took place early in the Mesozoic period, and that it was of immense extent, the whole of the eastern half of the island being covered with lavas. Sub-aerial erosion has since carved out these, leaving the central plateau and the top of Ben Lomond as remains of the great covering sheet, and exposing the dykes and bosses through which the molten matter was ejected, in the numerous small greenstone hills in the lower country. Mt. Wellington was probably one of the large centres of eruption, as a deep bore at the Cascades near Hobart shows the greenstone to underlie the Permo-Carboniferous beds. The fact that Tasmania has been dry land since Mesozoic times will probably not be disputed by any one conversant with the geology of the country.

It seems to me probable that *Anaspides* has been isolated from some marine form since a period shortly after the eruption of the greenstones referred to. The occurrence of freshwater Crustacea belonging to marine types may be variously accounted for. It is always possible that the animals themselves or their eggs may have been carried by aquatic birds; but I know of no recorded case of such a mode of distribution, nor do I know of any marine form which would survive in fresh water. I have often plunged various littoral species belonging to different families (*Palinurus*, *Atylus*, *Dexamine*, *Sphæroma*, &c.) into fresh water and found that they died in a very short period of time, usually in the course of a few minutes. On the other hand, the adaptability of various marine Crustacea to a freshwater habitat by gradual stages is a well-ascertained fact. The following examples are of interest. In New Zealand I originally described *Idotea lacustris* from brackish water at the mouth of a lagoon which communicates with the sea at spring tides or after heavy rains, and afterwards found the same species further up the lagoon where the water was quite fresh. My co-worker and friend, Dr. Chilton, has since found the species in a mountain stream in the same neighbourhood at an elevation of 1200 feet. It is clear that in this instance this Isopod has within very recent times made its way up the stream, where it is now thoroughly established. The same species has been taken in the Straits of Magellan, and all the other numerous species of the genus and family are marine with the exception of the Scandinavian *Glyptonotus entomon.*

Leander fluviatilis, *Hymenosoma lacustris*, and *Calliopius fluviatilis* occur in New Zealand streams and lakes, and, though not found in the sea, are not uncommon in tidal waters. *Crangonyx compactus*, *Calliopius subterraneus*, and *Gammarus fragilis*, found by Dr. Chilton in the subterranean waters of Canterbury, and *Pherusa cærulea*, found by myself in a stream in the Old Man Range in Otago at an elevation of 3000 feet, are species belonging to marine genera, which have most probably migrated from the sea by gradual stages. I have myself taken *Corophium excavatum*, *Allorchestes recens*, and a species of Schizopod which I identify as *Mysidopsis incisa*, Sars (originally described from a specimen obtained at the entrance of Port Phillip from a depth of 33 fathoms), from the mouths of streams or lagoons where the water is frequently quite fresh. These are a few examples, taken from instances occurring in New Zealand, of a gradual transition of marine into freshwater species, and of which similar examples could no doubt be recorded from all other parts of the world.

In such a manner most probably the ancestral forms of *Anaspides* found their way from the sea in Mesozoic times into the streams and lakes then occurring in Tasmania, in which, to judge from its remarkable specialization, it has been isolated for a great period of time. Its association with *Phreatoicus australis* and *Niphargus montanus* points in the same direction. The former, as already stated, is an Isopod of a very old and greatly generalized type. Its occurrence in two such isolated localities as Mt. Kosciusko in New South Wales, a granitic mass of great antiquity, and Mt. Wellington in Tasmania, and at a very considerable elevation in both, would appear to show that it has survived through long periods of time; coupled with which is the fact of the only allied species being an eyeless form from the underground waters of Canterbury in the South Island of New Zealand.

The very vegetation on the summit of Mt. Wellington suggests the antiquity of the region. Surrounding the locality in which *Anaspides* was found grow numerous forms of plant-life characteristic of the Antarctic Flora of Tasmania, the Australian Alps, and New Zealand, such as *Abrotanella*, *Donatia*, *Carpha*, *Oreobolus*, *Uncinia*, &c., so that could one shut one's eyes to the Australian element which is so abundantly present, it would not be difficult to imagine one's self on a mountain in the south portion of New Zealand or on one of the peaty swamps of Stewart Island.

These facts certainly give no direct testimony to the age of *Anaspides*, but they are suggestive, and may enable us, when its development has been worked out and its own distribution and that of its associated forms are better known, to arrive at some more definite conclusions on the subject.

EXPLANATION OF THE PLATES.

Plate XXIV.

Figs. 1–16. *Anaspides tasmaniæ.*

1. Body of animal, ♀. × 4.
2. Dorsal view of cephalon: (*a*) 1st antennæ; (*b*) 2nd antennæ. × 20.
3. Basal portion of 1st antenna. × 26.
4. Portion of the external flagellum of same, showing setæ and sensory hairs. × 56.
5. Basal portion of 2nd antenna. × 26.
6. First maxilla. × 26.
7. Second maxilla. × 26.
8. One of the comb-like setæ from the outer lobe of the second maxilla. × 56.
9. Under-lip. × 26.
10. Mandible, with palp. × 26.
11. Cutting-edge of same, showing the double row of teeth. × 84.
12. Grinding tubercle of same. × 84.
13. Leg of the 1st pair (maxilliped). × 13.
14. Section of basis of same. × 26.
15. Extremity of propodos, and dactylos of same, underside. × 56.
16. Leg of the 2nd pair. × 13.

Plate XXV.

Figs. 1–10. *Anaspides tasmaniæ.*

1. Leg of the 6th pair. × 13.
2. Leg of the 7th pair, female. × 13.
3. Leg of the 8th pair, female: *g.o.* = tubercle with genital opening. × 13.
4. Second pleopod, female. × 13.
5. First pleopod, male. × 13.
6. Endopodite of same. × 26.

6*a*. Endopodite of same, seen from the inside, young male. × 56.

7. Second pair of pleopoda in male, without the exopodites. × 13.
8. Endopodite of 2nd pleopod in male. × 26.

8*a*. Extremity of same turned inward. × 26.

9. Telson and uropods from above. × 13.
10. Oral aperture seen from the underside. × 10.

i.a., 1st antennæ; *o.a.*, 2nd antennæ; *u.l.*, under lip or metastoma; *man.*, mandibles; *mp.*, maxillipeds.

Plate XXVI.

Figs. 1–12. *Anaspides tasmaniæ.*—Anatomy.

1. Longitudinal (diagrammatic) section through the body of a female specimen (the heart is represented as too near the dorsal surface, the large dorsal muscles not being shown): *o.a.*, mouth-orifice; *in.*, intestine; *h.t.*, liver; *n.c.*, nerve-cord; *c.*, heart; *ov.*, ovaries; *co.*, anterior intestinal cæcum; *co.*$_2$, posterior intestinal cæcum; *an.*, anus.

Fig. 2. Longitudinal section through portion of intestine and anterior cæcum.

3. Corresponding section through intestine and posterior cæcum.

4. Nerve-cord.

5. Testes and vasa deferentia.

6. Outline representing longitudinal section of stomach: *œ.*, gullet; *in.*, intestine.

7. Club-shaped process in front of stomach.

8. Chitinous hairs from the lining of the stomach. Highly magnified.

9. Posterior extremity of a hepatic tube. Highly magnified.

10. Section through base of first antenna showing the auditory cavity.

11. Auditory capsules or setæ. Highly magnified.

12. Basal joints of inner flagellum of first antennæ, showing the remarkable tactile hairs, &c.

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THE COMPARATIVE MORPHOLOGY OF THE GALEODIDÆ.

BY
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IV. *The Comparative Morphology of the* Galeodidæ. *By* H. M. Bernard, *M.A. Cantab., F.L.S., F.Z.S.* (*From the Huxley Research Laboratory, Royal College of Science.*)

(Plates XXVII.–XXXIV.)

Read 7th February, 1895.

Contents.

Introduction.

A COMPARATIVE study of the Arachnidan family, the Galeodidæ [*], has long been a desideratum. The chief sources of our knowledge of this family date back to times before the all-absorbing questions of ancestry had made morphology the fascinating study it now is. The Arthropods, for many reasons, have long been recognized as presenting a rich field for investigation in this direction, and most modern works dealing with the morphology of any Arthropod form contain discussions as to the probable affinity of the family described with other members of the group, and its bearing on the ancestry of the Arthropods in general. Of such discussions, none have been carried on so vigorously as that on the affinities of the Arachnida.

This controversy, for such it is, arose out of an attempt to connect the Arachnids with the ancient aquatic Merostomata, one form of which, *Limulus*, is still extant. This suggested relationship, though widely accepted, has been also strenuously opposed. Some opponents confine themselves to a purely negative attitude, others prefer to see distant affinities with the Insecta. The Galeodidæ are largely responsible for this suggested

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[*] This name was given by Olivier, 1791, and, according to Dufour, referred to the resemblance of the cephalic lobes to a helmet (*galea*). Others, however, would deduce it from the Greek γαλέη, a weasel-like animal, in reference, no doubt, to the light colour and rapid movements of the commoner species. The name *Solpuga* was given later by Herbst, 1797.

Hexapodan affinity, chiefly because they appear to have a head separated from a thorax of three segments; this, taken together with the presence of Malpighian vessels, unknown in the Crustacea but characteristic of the Hexapods, was brought forward as evidence. The Galeodidæ, therefore, might be expected to be valuable witnesses one way or the other.

The present attempt to gather the evidence to be gained from the Galeodidæ began in the following way:—In 1892 * I endeavoured to show that the morphology of the Crustacean *Apus* (and of the Merostomata) could be explained by deducing them from a Chætopod Annelid, which, in adaptation to a new manner of feeding, bent the first segment, with mouth and prostomium, ventrally, so as to push the food into the mouth by means of the parapodia. The necessary conclusion, that *Limulus* was a primitive Crustacean, brought me involuntarily into the question of the origin of the Arachnida, inasmuch as the supporters of the Arachnidan affinities of *Limulus* separated the Merostomata from the Crustacea. I therefore set myself the following problem:—Is it possible, by comparing the known Arachnids one with another, to find out, as I claim to have done in the case of the Crustacea, what modifications of the primitive Annelidan segmentation, in adaptation, probably, to some special manner of feeding, gave rise to the Arachnidan phylum? For I assumed, at the outset, that modifications for better acquiring the materials for growth were the most far-reaching and fundamental in initiating new departures in animal morphology. The Arachnids might still be derivatives of the Merostomata, in spite of the fact that the latter were, as I believe, primitive Crustacea. The only way to settle the question was to ascertain, if possible, how the arrangement of their anterior segments had been derived from a primitive undifferentiated condition. Here, again, *Galeodes* promised to yield valuable evidence, on account of its claim to have a head and three thoracic segments.

The results here recorded were not obtained at once. I had already drafted the description of the anatomy of the Galeodidæ *in extenso*, and had worked over the draft at least twice without discovering any satisfactory explanation of the morphology of the anterior segments of the Arachnida. The difficulties seemed insuperable, in spite of the apparent simplicity of the results. One clue, however, led to another, each one in turn necessitating considerable recasting of the MS. It is, indeed, with reluctance, under the pressure of other engagements, that I now let it go forth; for, though I believe that I have solved the problem I set myself, the paper covers so much ground and deals with so many points that I am painfully conscious not only of blanks which I wished to have filled, but of very uncertain handling of many subjects, where I have neither done justice to my own accumulated material nor to the existing literature. I need hardly apologize for errors which, in a work of this extent, are almost unavoidable, except where I have unconsciously overlooked or misunderstood the views and statements of others.

I have at the outset to fulfil a pleasant duty in thanking the authorities at the Royal College of Science for having placed a table in the Huxley Research Laboratory at my

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* "The Apodidæ," 'Nature' Series: London, 1892.

disposal for three consecutive sessions, during one of which I was granted the Marshall Scholarship. For material I am indebted to Professor Howes, who kindly obtained for me specimens of two genera, *Galeodes* and *Rhax* [I further take this opportunity of acknowledging my great indebtedness to Professor Howes for much invaluable and sympathetic advice]; to Professor Möbius, director of the Berlin Museum, who kindly sent me four large specimens labelled "*Galeodes græcus* (Koch)," but which, according to Mr. Pocock, are *G. arabs* (Koch); to Professor Tichomiroff, of Moscow, who generously sent me some fine specimens of *Galeodes* and *Rhax*; and, lastly, to Miss Hay, formerly of Tashkend, for two specimens of *Galeodes* and one of *Rhax*.

Some of these specimens were cut into sections, a difficult process, owing to the enormous thickness of the cuticle in various parts of the cephalothorax, and others were dissected.

I have further examined the collection of Galeodidæ, containing five genera (*Galeodes*, *Solpuga*, *Rhax*, *Cleobis*, and *Gluvia*), in the British Museum, and owe my best thanks to my friend Mr. R. I. Pocock, who has charge of them, not only for his courtesy in placing them at my disposal, but also for much friendly advice and criticism *. I have followed Mr. Pocock's classification throughout.

Owing to the necessarily limited supply of these rare animals, there are many points left entirely untouched. And, further, owing to the indifferent state of preservation in which the specimens come from the collectors, many important histological questions can only be provisionally answered. Nevertheless, the positive results obtained are of sufficient interest and importance to justify this publication in the hope that, at some future time, if my efforts to obtain material are successful, it will be followed by a supplement supplying at least some of the deficiencies.

HISTORICAL.

In 1797 Lichtenstein and Herbst published an interesting historical account of the Galeodidæ †. All the references to the group to be found in the works of previous writers, ancient and modern, are quoted, and the manner of life of some of the commoner forms is described.

The first comprehensive account of the anatomy of the Galeodidæ, by Modest Kittary, appeared in 1848 (41). It deals with two species called by the author *G. aranoides* and *G. intrepidus*. The description is on the whole very accurate, and many of the results obtained seem not to have received the attention they deserve. Blanchard's

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* I have also serial sections of Pseudoscorpions, Phalangidæ, Araneæ, Scorpions, Thelyphonidæ, and Phrynidæ, for most of which I am indebted to my wife. My thanks are also due to my friend Mr. Martin Woodward for some beautiful sections of *Scorpio* and Spiders. I further dissected *Phrynus*, large Spiders, and Scorpions for the purpose of comparison.

† "Naturgeschichte der Insekten-Gattungen *Solpuga* und *Phalangium*": Berlin, 1797. The authors adduce reasons for believing that the "mice" which plagued the Philistines [I. Samuel, 5 and 6] were "Wind-scorpions," as the Arabs call Galeodes. They record the evil reputation of this animal, which is said to have forced the inhabitants of flourishing regions to desert their habitations, and to be particularly dangerous to sleepers, man and beast. The fact of its having the same name among the ancients as mouse and shrew-mouse suggests an explanation of some of the superstitious about shrew-mice and cattle which still survive among us.

great work on the Arachnids in 'L'Organisation du Règne animal' contains beautiful drawings of the anatomy of *Galeodes*, but unfortunately, beyond the explanation of the plates, the text is wanting. The most exhaustive account of the Galeodidæ is from the pen of the illustrious French naturalist Dufour. His "Anatomie, Physiologie, et Histoire naturelle des *Galéodes*" (31) has the special advantage that the author's previous studies on *Scorpio* enabled him to handle the subject comparatively. In addition to these three works, there have been several small articles dealing with special points. Systematic papers have naturally not been taken into account, the object of this paper being purely anatomical and morphological.

I. THE EXTERNAL FORM AND SEGMENTATION *.

Fusion of Segments.—The general form of the Galeodidæ (Pl. XXVII. figs. 1, 11, 15; Pl. XXIX. figs. 3, 4, 6) is so well known that we need discuss only the points of morphological interest.

The Galeodidæ show the primitive metamerism of the body more markedly than any other Arachnid, the first three segments of the cephalothorax being the only fused segments in the body. The three posterior segments remain movable. The abdominal region consists of ten segments, all of which are free. This limitation of the fusion of segments to the first three is a very important point in endeavouring to fix the systematic position of the family.

In the Scorpionidæ, Thelyphonidæ, and Pseudoscorpionidæ, while the segments of the abdominal regions are free, the segments of the cephalothorax have been fused together. In the Araneidæ, all the segments both of the cephalothorax and of the abdomen are fused into two groups, the first six forming the cephalothorax and the last ten forming the abdomen. *Schizonotus* is the only other Arachnid which, like *Galeodes*, has retained free cephalothoracic segments, but it is not easy to make out the segmentation exactly. There are certainly two free segments, and I should not be surprised if there ultimately prove, on examination of favourable specimens, to be three, as in *Galeodes*.

Segmentation of the Dorsal Surface: Cephalothorax.—Behind the large plates of the cephalic lobes (*cl.*), we can trace three clear segments, *i. e.* the 4th, 5th, and 6th, and the remains of the 3rd not quite obliterated by the cephalic lobes. The details can be gathered from figs. 1–7 (Pl. XXVII.).

The terga of segments 5 and 6 have remained practically unmodified, and are the direct forward continuation of the series of abdominal terga (fig. 1). The tergum of segment 4 has undergone a striking change. The Galeodidæ can bend the body not only between the 6th and 7th segments (at the waist), but also between the 4th and 5th. To facilitate this anterior bending, the greater part of the tergum of the 4th segment is soft and flexible, while what I assume to be its anterior edge has given rise to two spring-like rods, the tips of which fuse anteriorly with the posterior border of a rim

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* Since, in the Arachnida, the limbs are typically arranged as follows :—two pairs grouped round the mouth, viz., the chelicerae and the pedipalps, and four pairs as ambulatory legs—it is a matter of indifference whether we speak of them as cheliceræ, pedipalps, and 1st, 2nd, 3rd, and 4th pairs of legs, or as appendages 1–6. In what follows, both designations are used, the 1st leg meaning the 3rd appendage, and so on.

of chitin projecting from under the cephalic lobes. Laterally, these rods (*r*, Pl. XXVII. figs. 5, 6, 7) are continued downward to the skeletal framework of the ventral surface posterior to the bend (Pl. XXVIII. fig. 15, *r*). These rods, which are supports for the so-called "head," vary slightly in their points of fusion with the chitinous plate or pair of plates just mentioned, which project from under the cephalic lobes (*cf.* Pl. XXVII. figs. 1, 3, 4, 6).

These projecting plates (marked 3 in the figures) are, in all the Galeodidæ, separated by a suture from the posterior border of the cephalic lobes themselves; and in transverse and longitudinal sections they are seen to run under the posterior blind ends of the lobes (Pl. XXVII. figs. 11, 12). In some genera, *e.g.*, *Rhax*, the single piece is but a narrow strip (figs. 6, 7). In *Galeodes* the strip is wider and bent upward at an angle from the cephalic lobes (fig. 5). It is sometimes widest in the median line (fig. 3); at others, at the sides, where it may form a pair of triangular plates (fig. 1). These are, it seems to me, the remains of the tergum of the 3rd segment, the anterior portion of which, together with the terga of the 1st and 2nd segments, has been obliterated by the cephalic lobes.

The Cephalic Lobes.—These two plates, joined by a suture along the middle line, form one of the most striking features of the Galeodidæ. Their anterior edges, which vary in outline in different genera, are generally sharp, and pass at once into the flexible membrane round the bases of the chelicerae. In the genera *Biton* and *Cleobis*, the anterior edge tends to bend over to form a slight "forehead" (fig. 2). From the anterior end of the median suture, the ocular tubercle protrudes. Where there is a slight "forehead," the eyes project forward from it (fig. 2).

The median suture is sometimes, comparatively speaking, indistinct, the plate formed by the two lobes being posteriorly rounded off (*Rhax*, fig. 6). On the other hand, the suture may be very marked, even dividing the posterior margin of the double plate into two lobes (*Solpuga*, fig. 3).

In all the Galeodidæ there is a curious area (*a* in the figures) on each side of the cephalic lobes, which is not easy to explain. Pocock suggests (60) that these are the remains of the proximal joints of the chelicerae. In this interpretation I was at first inclined to agree, but now think that they have arisen secondarily from an infolding of the cuticle to form the strong buttresses upon which the chelicerae rotate (see further, *infra*, p. 321).

Origin of the Cephalic Lobes.—In endeavouring to answer the question, "what are these remarkable plates which so disturb the segmentation at the anterior end of the body?" I have been led to refer them to the translocation of the chelicerae from a postoral to a preoral and dorsal position. I would suggest the following explanation of the changes which have taken place in the arrangement of the segments:—

In order to carry the enormous chelicerae, lateral processes of the first segment have been thrown backward on to the dorsal surface, where they meet in the middle line, giving rise to the so-called "head," which Dufour attributed to these animals. A close examination of this "head" shows that it consists of a pair of chitinous lobes carrying the muscles of the chelicerae; no other muscles run into them, and, moreover, the muscles of the chelicerae are almost, if not entirely, confined to them. Fig. 12 (Pl. XXVII.), which is a transverse section, shows that posteriorly they are a pair of blind pockets resting on the dorsal surface. These cephalic lobes may then be explained as the lateral regions of the first segment which, for the attachment of the muscles, have travelled upward and backward in the process of tilting forward the powerful cheliceræ (as shown in the diagram, Pl. XXVII. fig. 8) into the striking position which they occupy dorsally to the mouth and labrum. The position of the cheliceræ is one of the features which distinguish the Arachnids from all other Arthropods. If the above explanation of the origin of these lobes is correct, we ought, then, to find them, or traces of them, in all other Arachnids.

I have already pointed out (9) the marked likeness between these lobes in *Galeodes* and the cephalic lobes which appear in the embryos of Spiders. Further, by taking account of yolk-displacement, the embryonic procephalic lobes of the Scorpionidæ may be referred to the same structures.

We have, then, to explain the embryonic cephalic lobes of Arachnids as recording the movement of the basal regions of the cheliceræ (which, from being postoral limbs, became preoral) laterally round and above the mouth till they met in the dorsal middle line behind the labrum and the eyes.

The only other Arachnid with the cephalic lobes as pronounced as they are in *Galeodes* is *Schizonotus*, which, as we have seen, resembles *Galeodes* in the non-fusion of the last two (? three) cephalothoracic segments. In the majority of Arachnids, the cephalic lobes have been more or less secondarily obscured. The two chief causes of this gradual obscuration of the cephalic lobes in the Arachnida are (1) their complete fusion with the terga of the 4th, 5th, and 6th cephalothoracic segments, so that the dorsal surface is covered by a single piece ; (2) the secondarily acquired enormous development of the pedipalps as compared with the cheliceræ, so that the cephalic lobes, which were primarily the carriers of the originally powerful cheliceræ, are no longer so pronounced as to be immediately recognizable (*cf.* fig. 9). Many Arachnids still, however, show unmistakable traces of the paired lobes divided by the median suture. In some Scorpions, the formation of the carapace out of a pair of median anterior plates with the triangular remains of the tergum of the 3rd segment, followed by three distinct terga, can still be made out. In *Thelyphonus* the lobes can still be recognized. In the Araneæ, except in the Aviculariidæ, which are in other respects also primitive, they are bent down anteriorly to form a "forehead," and are still here and there traceable on the carapace, *e. g.* of the Drassidæ.

The Ocular Tubercle.—If this view of the secondary origin of the anterior dorsal surface is correct, it is clear that, if the eyes were primitive structures belonging to the primitive dorsal surface, the cuticle immediately round such eyes must be part of that original dorsal surface, and not primarily continuous with that of the new dorsal surface, formed by the meeting of the cephalic lobes in the dorsal middle line. We find some evidence that this is indeed the case. The ocular tubercle in very many Galeodidæ obviously protrudes from between the median suture, and in some species of *Rhax* it often differs markedly in colour, being bright green, while the surrounding surface is red or reddish brown, and in sections there are signs that the eye-tubercle is a discontinuous element in the cuticle (*ot*, Pl. XXXI. fig. 1).

In some other existing Arachnids, the median eyes show signs of not belonging to the surrounding cuticle. In *Scorpio* they appear to be protruding through a median suture, an impression which is somewhat increased on dissection. We have, however, only to look at the drawing of the Silurian *Palæo-*

phonus nuncius (65) (reproduced in Pl. XXVII. fig. 10) to see that this conjecture is correct. The animal had apparently lost its eyes, but the region where the eyes normally are in Scorpions is seen to be an island of the original dorsal surface, gradually being grown over by the cephalic lobes which, in all modern Arachnids, have closed together in the middle line. The ocular tubercle must then be considered to be a primitive feature. And it is worth recording that, of the Araneæ, the Aviculariidæ, which alone retain an optic tubercle, have also retained other primitive features, *e. g.* the coxal glands.

Segmentation of the Dorsal Surface: Abdomen.—The tergites of the abdomen continue without change, except in the matter of size, the series begun by those of segments 5 and 6 of the cephalothorax (Pl. XXVII. fig. 1). As a rule, the tergites gradually decrease in size towards the anal segment. *Rhax*, however, is a remarkable exception, the terga towards the posterior end of the body gradually widening until the large anal segment is completely encircled (*cf.* fig. 13). It is, however, not certain here whether this great encircling plate of the anal segment is really morphologically a tergum. The tergites are, functionally, only more rigid areas of the cuticle for the protection of the circulatory mechanism. The lateral extensions of these areas at the posterior end of the body in *Rhax* may be for the protection of the defenceless end of the body from enemies. The ventral position of the anus in this genus is in keeping with this suggestion.

Segmentation of the Ventral Surface.—Although there are no structures like the cephalic lobes to disturb the segmentation ventrally, it requires a considerable amount of elucidation. The first segment has practically disappeared from the ventral surface, while the limbs which belong to it have been shifted up dorsally above the mouth. Consequently the 2nd pair of appendages become the most anterior pair of limbs ventrally, and have moved forward to the anterior end of the ventral surface. This forward shifting of the pedipalps has apparently forced the ventral portion of the 1st segment still further forward, to form the "labium," or lower half of the beak, which will be described presently. In the majority of Galeodidæ, this "labium" or sternal surface of the 1st segment is no longer visible from the ventral surface, but in the genus *Solpuga* the relations can still be made out (Pl. XXVII. fig. 14).

The second segment is the first obvious component of the ventral surface (figs. 14 and 15), and this is followed by a complete series to the end of the body. The most remarkable feature in these ventral surfaces of the segments is the almost complete absence of the sternites. This obliteration of the sternites along the thorax is due to the coxæ of the legs meeting in the middle line, and there is evidence to show that, along the abdomen, the areas which appear to be sternites are really the remains of limbs, also meeting in the middle line, which have now flattened down to form part of the body-wall (*cf.* section on the abdominal limbs, p. 328).

The remains of sternites in the Galeodidæ are very slight. We can make out the remains of three sternites, which are visible in *Solpuga* (fig. 14); *i. e.* of the first three segments. These together form a long plate, which, anteriorly, supports the labium, and ends posteriorly between the coxæ of the third pair of appendages. This posterior butt-end of the plate is often the only part of it visible from below. The only other remains of a sternite in *Galeodes* is perhaps the triangular piece which occurs in front of the genital operculum, between the coxæ of the last pair of legs. These coxæ, sloping forward, would perhaps allow the sternite to persist in the angle between them.

The obliteration of the sternal plates by approximation of the basal joints of the limbs along the ventral middle line, which is thus a characteristic of the Galeodidæ, is found more or less marked in all Arachnids, at least for certain segments. The causes of it are not easy to see.

Figs. 15–18 (Pl. XXVII.) and 1, 2 (Pl. XXVIII.) show, in series, the ventral surfaces of *Galeodes, Scorpio, Thelyphonus, Phrynus,* a Spider and a Chernetid, the true sternal areas being in all cases shaded. In *Phrynus* (*Tarantula tessellata*, fig. 18) sternites are found along the whole length of the body, except in segments 7 and 8, where they are covered by the large genital operculum. In *Thelyphonus* (17) the sternites of the 1st and 2nd segments forming the labium are now enclosed between the coxæ of the pedipalps. The sternum of the third segment is a fold beneath the solid plate which represents the sternite of segment four, having been displaced by the pedipalp. A very small plate is all that remains of the sternite of segment five. A large triangular plate is sternite six. In *Scorpio* (fig. 16), the first and second sternites are no longer visible externally. The short pointed labium found in sections is all that now remains of them. The sternites of segments three and four have quite disappeared. Sterna five and six are present as a triangular plate in some genera. In others, even this plate has been almost obliterated secondarily, not by the approximation of the coxæ, but by the forward movement of the genital aperture and opercula. The sternite of the 7th segment is covered by the opercula, while the sternites of the eighth and following four segments are clear.

With regard to the abdominal sternites in *Scorpio, Thelyphonus,* and *Phrynus,* I believe the lateral boundary of the sternite to be the attachment of the dorso-ventral muscles; outside these are the areas which I refer to vanished limbs (*cf.* Pl. XXVII. figs. 16, 17, 18 *la*).

In the Pseudoscorpions (Pl. XXVIII. fig. 2, ? sp.) the sternites have vanished from the cephalothorax, persisting perhaps only in the labium, and in a triangular plate between the last pair of legs which is visible in some genera. On the abdomen, the conditions appear to resemble those in *Galeodes*; we have the sternal plates, at least, very frequently, in pairs divided by a median line continuous with that separating the coxæ of the cephalothorax. On the other hand, the dorso-ventral muscles do not always meet in the ventral middle line, but their points of attachment may have shifted.

In the Araneæ, the sterna of the cephalothoracic segments are fused to form a solid plate, but in young Epeirids just hatched (when cleared) this plate is found marked as in the figure (Pl. XXVIII. fig. 1) We here see that sterna 1 and 2 are fused to form the labium, while sterna 3, 4, 5, 6 are well marked. The condition of the abdomen in the Spiders is not quite clear. From the approximation of the spinning-glands in the median line, I should be inclined to think that the sternites in this group, as in *Galeodes,* had disappeared from the abdominal segments.

In the Phalangidæ, the sterna of the cephalothorax have disappeared, either by the approximation of the coxæ, or by the forward thrust of the genital aperture. In the *Acari* all conditions are found: the sterna, in some genera, seem to be well developed on all the segments except perhaps the 1st and 2nd. I have, however, made no study of the group.

We thus have, in the Arachnida, almost every possible variation in this matter. The sterna have almost completely vanished from the cephalothorax of some Scorpions, of the Phalangidæ, and of the Pseudoscorpions. In the Spiders they have been apparently obliterated from the abdomen. In the Pedipalpi, traces of them persist along the whole body, having completely vanished only in the anterior end of the abdomen, where they are covered over by the large genital operculum [*]. Lastly, in the Galeodidæ the sternites have vanished along the whole length of the body, the only persistent traces being the supporting plate of the labium and the triangular piece between the last pair of legs.

These different departures from the primitive conditions of the segments are so very distinct that it is impossible to deduce the existing Arachnids one from another: they can only be different specializations of some common racial form in which the sternites were distinct along the whole length of the

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[*] Laurie (47) describes a plate roofing the genital vestibule to which a pair of dorso-ventral muscles are attached; this is almost certainly the sternite of the 2nd abdominal segment.

body. They were, perhaps, at first obliterated at the anterior end of the body, or rather converted into the labium by the grouping of the two first pairs of limbs round the mouth (see p. 311), and then secondarily, in the genital segment, by the change of a pair of limbs into genital appendages (see p. 328, and Pl. XXIX. fig. 14).

The Number and Character of the Abdominal Segments.—The abdomen in the Galeodidæ consists of ten segments, which, as above stated, are distinct. They are fairly uniform, *i. e.* they taper away in a typical manner, showing no specialization into a tail of any kind. The last segment is little more than an anal papilla except in *Rhax*. The cuticle is adapted for the great extensions to which the abdomen is liable. After a full meal the abdominal region may be nearly twice as thick and twice as long as at ordinary times. While the ventral and dorsal surfaces are protected by more solid chitinous plates (tergites and "sternites" *), the intersegmental and lateral integuments are very thin and flexible. Fig. 6, Pl. XXXIV., shows the remarkable folding of the integument between two segments of a contracted abdomen; this is even more pronounced in the more anterior segments. The fine structure of this flexible integument will be described elsewhere.

Great variations are found in the hairiness of the abdomen. Swollen abdomens often look smooth, owing to the drawing apart of the hairs, which in the contracted state would be crowded together. For this reason, contracted specimens are often very hairy. This, however, does not explain the whole facts. In some, the lateral membranes are smooth, in others hairy. The "sternites" are smooth, in others again hairy. The hairiness of the lateral membrane is often felt-like; that of the "sternites" repeats that of the coxæ of the legs.

The number of segments in the abdomen of Arachnids varies considerably. The greatest number, twelve, occurs in *Thelyphonus, Phrynus,* and *Scorpio,* and, according to Mr. Pocock, in *Schizonotus*.

The abdominal segmentation of the Pseudoscorpionidæ is very difficult to unravel. The anal papilla may perhaps represent a segment, but there are reasons for believing that it does not. But whether the first free tergite, in those cases in which there are undoubtedly eleven tergites, belongs to the abdomen or to the cephalothorax I have been unable to determine. In view of the free cephalothoracic segments of *Galeodes* and *Schizonotus,* and the absence of a marked waist, either interpretation is possible. I suggest that the point may be settled by a careful examination of the dorso-ventral muscles. I do not agree with Hansen (33) in claiming the triangular piece sometimes seen behind the coxæ of the last pair of legs as belonging to the first abdominal segment, but think that it belongs to the last cephalothoracic segment, and, as in *Thelyphonus* and *Galeodes,* has been left bare by the inner anterior slope of the coxæ. But the Chernetidæ show great and puzzling variations. In some there is a clear triangular piece in front of the genital plate; in others the last pair of coxæ seem to reach back so as to cover, ventrally, the anterior segments of the abdomen (10; compare figs. 1 & 2).

In the Spiders there are, as a rule, ten segments, while in the Phalangidæ and in some Acarinæ the number is still further reduced.

This difference in the number of abdominal segments is not a matter of any great morphological importance. The specialization of the Arachnids has clearly taken place at the anterior end of the body, in the grouping of the first two pairs of limbs round the mouth and in the development of the limbs of the four following segments as walking-legs. This cephalothoracic region, specialized for loco-

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* As above stated, I do not consider them to be morphologically sternites, but rather limb-areas, *i.e.* areas where limbs have vanished by flattening down.

motion and prehension, is followed by a well-demarcated abdominal region specialized as a distensible sac-like receptacle for digestion and reproduction. This specialization comprises all the abdominal segments in Galeodidæ, Pseudoscorpionidæ, Araneidæ, Phalangidæ, Acaridæ, while in the Scorpionidæ, Thelyphonidæ, and Schizonotidæ a few of the most posterior segments form together a kind of caudal appendage secondarily specialized for different purposes. In all discussions as to the primitive segmentation of the abdomen, we have to bear in mind that its swollen condition is a secondary specialization. In *Scorpio* and *Thelyphonus,* although the posterior segments of the abdomen take no part in the formation of the visceral sac, they are greatly specialized for other functions. Moreover, these tail-formations differ too greatly to be considered primitive structures. The lengthening of the tail-segments of *Scorpio* was most probably a secondary and compensatory specialization to allow of the use of the terminal sting, as the anterior abdominal segments were becoming sac-like and thus no longer capable of bending backward.

We may, I think, safely conclude from the varied conditions of the abdominal segmentation of existing Arachnids that the abdominal segments of the ancestral form were quite unspecialized. The differences in the number of the segments specialized for distension shows clearly that neither this nor the "tail" is primitive. In *Scorpio,* seven form the distensible sac and five the tail. In *Thelyphonus,* nine form the distensible sac and three a totally different tail; while in *Galeodes* ten, in *Chernes* perhaps eleven, form the distensible sac, no segments at all being specialized into a tail. It is impossible to deduce these forms from any specialized ancestor.

The reduction in the number of segments in some Arachnids is doubtless in some way due to the excessive weight of the distended sac.

We have thus tolerably clear evidence that the original and most important specialization of the Arachnidan abdomen was into a digestive and reproductive sac, while the anterior region was specialized for locomotion.

Diaphragm or Waist.—Between the 6th and 7th segments, *i. e.* between the cephalothorax and abdomen, there is, in the Galeodidæ, no true specialized waist, although there is a strong intersegmental constriction, the abdomen being able to bend up almost at right angles to the cephalothorax at this point. Internally, this constriction has given rise to a very striking "diaphragm," which has already been described and figured by Kittary (41). It forms a very complete wall between the interior of the cephalothorax and that of the abdomen, and is pierced by the dorsal vessel, the alimentary canal, the nerve-cords, and the tracheæ. Close examination shows that this diaphragm is due, as stated, to a strong indrawing of the intersegmental membrane between the above-mentioned segments, so that it is composed partly of a chitinous infolding and partly of muscle-bands.

It is clear that if the opposite two internal faces of such a deep segmental constriction fuse together, they form a diaphragm: if they remain unfused, they form a waist. In the Galeodidæ we seem to have an unspecialized arrangement, the intersegmental infolding being fused only in its deeper parts, forming the diaphragm, while the outer parts of the fold remain open, making some approach to a waist.

Waists or diaphragms appear to be characteristic of the Arachnids. The Pedipalpi and the Araneæ have highly specialized waists. *Scorpio* has secondarily lost all traces of its waist and has only a diaphragm. The Pseudoscorpions show very deep constrictions laterally and ventrally, but not dorsally; these constrictions thus do not form a true waist. The Phalangidæ and Acari are the only forms which appear to have lost all traces of the former waist. This is perhaps to be correlated with the diminution of the abdominal region characteristic of the former and of many of the latter.

The origin of the waist or diaphragm in the Arachnida is not far to seek. It divides the body into the two well-defined regions above described, the anterior knit together by muscles to form a specialized locomotory mechanism, the posterior a distensible bag for the digestive and the reproductive apparatus. It seems to me that the development of the former region would necessarily draw in the intersegmental constriction between the two regions.

The function of the diaphragm will be better explained in the section on the alimentary system. It supplies, as we shall see, a kind of neck to the digestive bag, which serves to protect the organs of the cephalothorax from undue pressure on the part of the contents of the abdomen when it is greatly distended.

The Segments—Special Structures.

Having thus reviewed the general segmentation of the body, we have to describe certain special structures connected with the segments, such as the beak, the eyes, and the limbs.

First Segment: the Beak.—The beak * is a marked feature in the Galeodidæ. It projects anteriorly from between the basal joints of the pedipalps, ventrally to the chelicerræ. The mouth being at its tip, we may safely assume that it is composed of a labrum and of a ventral labium fused together along their edges. It is represented in Pl. XXVII. figs. 11, 14, and in sections in Pl. XXVIII. figs. 3, 4, 5, 6.

The labrum, which is in all Arachnids a structure *sui generis*, is keeled dorsally and very firm; the keel may originally have been due to the pressure of the chelicerræ on each side. It is, moreover, quite immovably fixed to the coxal joints of the pedipalps (Pl. XXVIII. fig. 3), which are themselves rigidly attached to the ventral skeleton. Anteriorly, an arrangement of feathered setæ projects from the labrum in such a way as to form a sieve for the straining of the animal-juices, which form the characteristic food of the Arachnids. The setæ are arranged in a vertical row on each side of the mouth, the two rows lying very close to each other (Pl. XXVII. fig. 14). The setæ of the same side are joined together by cross-pieces, so that the sieve has regular rectangular meshes (Pl. XXVIII. fig. 6).

The labium, which is applied all along to the base of the labrum, so as, with it, to form a beak, ends anteriorly in two fleshy lobes (Pl. XXVII. fig. 14), each provided with a long, feathered, tactile hair. The tip of the labium seems to be movable by means of muscles, but the exact mechanism is difficult to make out. In the ventral middle line, the labium is strengthened by a chitinous plate folded along the median line. This is a prolongation of the sternal plate between the coxæ of the pedipalps; the whole plate may be considered to be the fused sternites of the 1st, 2nd, and 3rd segments (*cf.* Pl. XXVII. fig. 14 with Pl. XXVIII. fig. 3, and p. 311).

I have not hesitated to call the parts composing the beak the labrum and labium, because I can see no reason why they should not be so. They form the upper and lower margins of an anterior mouth; the labrum has the typical position of a labrum or prostomium (*i. e.* if we take into account the shifting forward of the chelicerræ), and the labium is the protruded anterior margin to the sternal surface bounding the mouth posteriorly. As already suggested, this protrusion is no doubt due to the distortion of

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* "Rostre buccale," "labium haustelliforme," "languette sternale," &c. of authors.

the first segment, by the shifting forward of the pedipalps, when the cheliceræ left the ventral surface. I therefore cannot follow Croneberg (28) in his endeavour to deduce these parts from fused limbs. Such a derivation brings hopeless confusion into the segmentation, where none really exists. The solid chitinous framework round the posterior portion of the beak is necessary to counteract the action of the muscles which expand the œsophagus for the pumping-in of the food (Pl. XXVIII. figs. 3, 4, 5). The significance of this position of the pumping-apparatus in the Galeodidæ, viz. within the beak, will be referred to later, in the section on the alimentary canal.

From the description above given of the origin of the beak of *Galeodes*, it is clear that it must be considered to be a primitive Arachnidan characteristic, since it arose as a natural consequence of the shifting of the chelicerae and of the pedipalps to positions above and at the sides of the prostomium. We have abundant evidence among the Arachnida that the beak was, as contended, a primitive structure. In *Thelyphonus*, where the fusion of the basal joints of the pedipalps has rendered a beak, as such, unnecessary, it nevertheless persists: that is, it is in a position where it could not well have been secondarily developed. Examination further shows that here also its floor contains, like that of *Galeodes*, a chitinous plate somewhat folded anteriorly, which can be traced in sections to the transverse infolding of the cuticle at the anterior end of the large sternite of the 4th segment (*cf.* p. 312). This infolding is apparently the sternal surface of the 3rd segment, crushed in by the enormous backward growth of the coxæ of the pedipalps (Pl. XXVIII. figs. 11, 12, 13, 14). This beak, like that of *Galeodes*, contains the sucking-apparatus.

The Pseudoscorpions * and the Gamasidæ † are the only other Arachnids known to me which possess well-developed beaks, but the mouth-parts of all the other Arachnids can be best deduced from a primitive beak which has been variously modified.

Starting from *Galeodes* (Pl. XXVIII. fig. 5), with the mouth at the tip of the beak, we have a complete series which shows the gradual reduction of that organ. In the Chernetidæ (fig. 10) the mouth lies ventrally, in a labrum with a dorsal keel, the pointed labium fitting into the oral aperture; the lining of the mouth is finely striated transversely. The next stage is that of *Scorpio* (fig. 9), in which the dorsally-keeled labrum, though of considerable length above, is shortened ventrally, the mouth having travelled back towards the body, so that it is impossible longer to speak of a beak. The shortened labium is, however, still a pointed median process, as in the Chernetidæ.

In *Phrynus* (fig. 7) we have a process almost the opposite of that in *Scorpio*, viz. a great reduction of the labrum, while the long pointed chitinous support of the labium remains as an anterior prolongation of the first clear sternite. This labium has two divergent setæ at its tip, as in *Galeodes*. In marked contrast to *Thelyphonus*, where the beak has been enclosed between the pedipalps, in *Phrynus* the labrum and labium seem to have been forced apart by these same limbs. The mouth, which is immediately under the labrum, is thus no longer bounded ventrally by the labium, but by the pedipalps, which meet in the middle line. The labrum, though greatly reduced, is quite distinct and shows the dorsal keel; it can best be seen by removing the dorsal shield and bending back the chelicerae.

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* It is worth recording also that the larval Pseudoscorpions are provided with an enormous sucking-beak; *cf.* Metschnikoff (55).

† Judging from Winkler's figure (76, Taf. iii. 15), this is a typical beak comparable with that of *Galeodes*, and contains the sucking-apparatus along the greater part of its length. Winkler, however, calls the labium the maxillæ. The long pointed process which he calls the under-lip must be some specialized structure, although its superficial resemblance to the process in *Phrynus*, which I believe is a true under-lip, is certainly suggestive of an interpretation of the mouth-parts of *Phrynus* differing from that given in the text.

The Spiders (fig. 8) show still further modifications: the labrum is round and fleshy and directed downward; it is opposed by a distinct labium also bent downward and formed by the anterior edge of the sternal plate. The opposed inner oral surfaces are finely striated transversely, as in the Pseudoscorpions and Thelyphonidæ. The coxal joints of the pedipalps function as maxillæ on each side of the mouth. We thus have, in the Araneæ, the mouth placed more ventrally than in any other Arachnid *. As a concomitant change, we have the chelicerae bent downwards from the almost directly forward position which they occupy in most other Arachnids. The Aviculariidæ, however, which have retained other primitive features (*cf.* p. 311), still have the chelicerae pointing directly forward.

The mouth-structures of the Arachnida seem to me, then, to be deducible from a beak such as we have in *Galeodes,* although there can be no doubt that this particular beak is itself considerably specialized. As we shall see in the section on alimentation, all these beaks and mouth-parts are specialized for the straining of the juices crushed out of the prey by the chelicerae, and in some cases by the pedipalps also. The basal joints of the pedipalps (in *Scorpio* those of the first and second limbs as well) are as a rule specialized to prevent the escape of such juices and to conduct them towards the mouth. The series of figures and diagrams illustrating the mouth-parts (Pl. XXVIII. figs. 5, 7, 8) also show the changing positions of the pumping-apparatus; this will be discussed in detail in the section on the alimentary canal.

The Positions of the Eyes.—The varying positions of the ocular tubercle with the median eyes are shown in Pl. XXVII. figs. 1, 3, 6. We gather, from the embryology of *Scorpio,* that the eyes of *Scorpio* had originally the same anterior position, but that they at a later stage travelled back along the suture, reaching their utmost limit of backward movement in a genus which takes its name from this fact (*Opisthophthalmus*).

It is a curious fact that in most Scorpions and in some Galeodidæ the line of the suture runs over the tubercle. This can be explained only as a secondary acquirement.

In addition to the median eyes, *Galeodes* has one or two pairs of lateral eyes, which appear, in many cases at least, to be rudimentary. Their position is shown in Pl. XXIX. fig. 4, *le* (14). If the above account (p. 310) of the secondary origin of the anterior dorsal surface of Arachnids is correct, the lateral eyes of the Arachnids are all either secondary formations or else have wandered off from the ocular tubercle on to the cephalic lobes (*cf.* section on the sensory organs, p. 348).

Summary of the Modification of the First Segment.—We have, then, in the 1st segment a pair of limbs (which will be described later), a pair of median and one or two pairs of lateral eyes, a labrum and labium, together forming a beak with a mouth at its tip, the labium being an anterior prolongation of the ventral surface. The present position of these parts has been brought about by the development of the first pair of limbs into seizing-organs, which have travelled upward and forward from the sides of the mouth till they meet in the middle line above the labrum. The basal regions of these chelicerae form the cephalic lobes, which cover the original dorsal surface of the segment and extend backwards over the 2nd and part of the 3rd segments. The only part of the original dorsal surface of the segment now visible is the ocular tubercle. The concomitant travelling forward of the basal joints of the limbs of the 2nd segment to the sides of the mouth has forced forward the ventral portion of the 1st segment till it has opposed

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* The position assigned by Stecker (67) to the mouth of *Gibbocellum* is clearly an oversight.

the labrum and fused with it, the two together forming a beak. These modifications of the 1st segment of the Arachnidan body (which have been again modified in the different families) appear to me to be the essential characteristic of the class.

Second Segment.—The 2nd segment carries the pedipalps, developed primarily as sensory organs, as will be described in the section on the limbs. Dorsally this segment is completely obscured by the cephalic lobes of the 1st segment; indeed, nearly all that remains of it is now comprised in the basal regions of the pedipalps and the cuticle immediately surrounding them.

Third Segment.—Passing to the 3rd segment, viz. that which carries the first pair of ambulatory legs, we find, dorsally, portions of the tergite protruding from under the cephalic lobes, while ventrally this segment is the smallest of the five segments composing the under-surface of the cephalothorax. The limbs which it carries are, as we shall see, in process of transformation from walking-legs with claws into a second pair of sensory limbs. This segment is further interesting because the openings of the coxal glands occur on it behind the coxæ.

In *Phrynus* and *Thelyphonus* we find the tendency to reduction and compression of this segment carried still further; indeed, in the latter, neither the coxal joints of its limbs nor its sternum any longer take part in the formation of the ventral surface. This compression of the 3rd segment is of great morphological interest in connexion with the origin of the endosternite (see next page).

4th, 5th, and 6th Segments.—The following three segments are freely movable, a primitive feature shared to some extent with *Schizonotus.* Posterior to the coxæ of the first of these occur large stigmatic openings of the tracheal system, the significance of which will be discussed in the section on Respiration. These segments carry the three posterior pairs of limbs, which, in the Galeodidæ, are those specialized for locomotion.

The Abdominal Segments.—The segments themselves require but little further description. The 1st segment has a median genital aperture, covered by a pair of opercula opening posteriorly and towards the median line. These opercula, as will be shown below, are the vestigial remains of vanished limbs. The 2nd and 3rd segments have (also under opercula closely resembling those of the genital aperture) a pair of stigmatic openings into tracheæ. The stigmatic opercula in the genus *Galeodes* are armed posteriorly with rows of short stout spines projecting backward, "the stigmatic combs." These serve, I think, principally to keep the stigmatic apertures in communication with the surrounding air, which would certainly be difficult when the abdomen is contracted. In the genus *Galeodes*, the 4th segment has a single median stigma, which, however, is sometimes closed, although still connected with the tracheal system by a much diminished tracheal tube. In *Rhax*, this median stigma has vanished altogether. A study of the ventral surface leads almost irresistibly to the conclusion that the three pairs of opercula on the first three segments were once followed by a complete series which have vanished progressively from before backward.

The anus opens, except in *Rhax*, through a terminal median slit stretching almost completely across the anal papilla.

II. The Internal Apodematous Skeletal System.

The skeleton of the segmented animals was primitively limited to the external cuticle which formed what is called an exoskeleton. In specialized forms, the modifications of the sgements have, in many cases, given rise to infoldings of this exoskeleton, so that a kind of endoskeleton has been developed. Such an endoskeleton, or system of apodemes, attains a remarkable and varied development in the cephalothoracic region of the Arachnids, *i. e.* in that region specialized for locomotion where the muscles are most highly developed. The posterior infoldings, viz., those which limit the closely knit locomotory region posteriorly, together form the waist, which need not be again described. The complicated infoldings between the six segments anterior to this wrist, however, claim attention.

The Ventral System of Apodemes.—We find in the Galeodidæ a ventral system of apodemes forming a nearly rigid framework, or, rather, two frameworks joined by a flexible membrane between the 4th and 5th segments. These frameworks are largely formed by the coxæ of the limbs, which meet in the middle line and practically form the ventral surface, having apparently obliterated nearly all traces of the original sternal surface (see above, p. 311). Perhaps the flat keel thrown up into the body along the middle line may represent the remains of the sterna. Figures of this complicated inner surface have been given by both Kittary and Blanchard, but the details are obscured by the endosternite (*i. e.* by the largest pair of apodemes between the 3rd and 4th segments) which these authors have drawn in position. Pl. XXVIII. fig. 15 gives a view of the whole ventral surface of a *Galeodes arabs*, with the endosternite removed but placed at the side (fig. 15 *a*).

This ventral skeletal framework is, as stated, due to the rigidity of the coxal joints and to their meeting in the middle line; it needs no special notice. Certain modifications of the transverse ridges will be mentioned below. One pair of infoldings, however, require special mention.

The Endosternite.—This characteristic Arachnidan structure rises as a pair of simple infoldings of the cuticle between the 3rd and 4th segments (Pl. XXVIII. fig. 17). The two cuticular folds meet and interlock in the middle line (fig. 18) above the nerve-cords and beneath the alimentary canal (Pl. XXVII. fig. 12). Sloping backward from their origin, after meeting, they expand into plates to allow of increased surface for muscular attachment. Where the apodemes arise from the cuticle, they are very hard and thick, breaking and tearing the sections, but in the expanded part they are softer, and offer but little resistance to the microtome razor. Histologically, they agree entirely with the outer cuticle, of which they are obviously infoldings.

The position of the apodemes forming the endosternite behind the 3rd segment, which is much compressed, is what one might expect. The three anterior segments have become firmly fused together, probably in the process of forcing the limbs of the first two segments into positions in front of and at the sides of the mouth. In this process the 3rd segment seems to have suffered most compression. But compression of a segment naturally means, as a rule, a strong muscular strain on the constriction behind it. Hence the formation of powerful apodemes behind it. The apodematous system of the Crayfish supplies us with examples of the same rule (5).

We may thus in *Galeodes* recognize two regions of special compression, one comprising the first three segments, which resulted from the translocation of the mouth-limbs; this gave rise to the endosternite. The other comprises the three remaining cephalothoracic segments; this has given rise to the waist and diaphragm. These two separate phases of the specialization of the Arachnida are still clearly distinct in the Galeodidæ, which are almost, if not quite, alone in the retention of this primitive feature.

In front of the endosternite of *Galeodes*, there is on each side a small fibrous plate suspended by means of tendon-like strands, as shown in Pl. XXVIII. figs. 15 *a*, 16 (*p*). Assuming these tendons to be the remains of muscular attachments, it seems not unlikely that these plates are the last remains of apodemes or constrictions between the 2nd and 3rd segments. Sections show them to be a sponge-like arrangement of tendinous fibres (fig. 19) with irregular spaces. (Compare sections on the muscular system and coxal glands, where these fibrous plates will be referred to again.)

Having already discussed the relation between the endosternites of the Arachnids in a separate paper (13), it is not necessary to do more here than to give my conclusions.

There must originally have been a well-developed system of intersegmental membranes along the whole body. In the abdominal region these have persisted to lend to that part of the body its great powers of distension. In the anterior region, however, which is specialized for locomotion and prehension, muscular action has drawn these membranes in to form an endoskeletal system for muscular attachment. Owing to the different degrees and methods of compression of the cephalothorax in the Arachnids, the endosternite necessarily varies greatly in the different families.

In *Scorpio* the endosternite proper arises, as in *Galeodes*, from between the 3rd and 4th segments, but is now complicated by secondary fusion with the diaphragm. In the Spiders, the segments of the thorax being all evenly compressed, the endosternite consists of four pairs of apodemes which meet in the centre, the second pair of which correspond with the endosternite of *Galeodes* and *Scorpio*, while the 1st pair is perhaps represented in *Galeodes* by the fibrous plates above described. In *Phrynus* the endosternite is difficult to unravel; it may perhaps represent only the first pair of apodemes of the Spiders with secondary attachment of dorso-ventral muscles. In *Thelyphonus* we have a long fenestrated endosternite which may correspond with that of the Spiders; the component apodemes not, however, meeting in a point.

Other Special Apodematous Structures.—In the constriction between segments 4 and 5, two pairs of chitinous processes have to be mentioned. A round hollow rod rises from the inner end of each stigmatic aperture, and holds up the endosternite, so that the muscles attached to its ventral and lateral surfaces should not pull it down upon the tracheæ (Pl. XXVIII. figs. 15, 16, 18, *chr*). Further, two very solid folds of the lateral wall rise from the anterior outer corners of the coxæ of the 5th segment. These are continuous with, and form rigid ventral attachments of, the rods (remains of the terga of the 4th segment) which, on the dorsal surface, fuse with the posterior edge of the tergum of the 3rd segment projecting from beneath the cephalic lobes; these appear to act like springs to support the so-called "head" (*cf.* p. 309, Pl. XXVII. figs. 1–6, and Pl. XXVIII. fig. 15, *r*).

Along the anterior surface of each coxa there is a secondary fold which projects internally and forms a solid buttress; round the distal points of these buttresses the limbs rotate (Pl. XXVIII. fig. 15 *b*).

This support is especially strengthened in the case of the 5th limb, which has probably to work upon or sweep round the body more actively than either the one in front of it or that behind it.

These buttress-like supports to the limbs appear to be a feature common to all the Arachnids; the folding-in of the cuticle to form them is visible to the naked eye on the anterior faces of the coxæ of any large Spider or Scorpion.

There are similar buttresses for the support of the cheliceræ, each of which thus also rotates round a single solid point. Their position is, however, remarkable. They occur laterally inside the cephalic lobes and under the remarkable areas found at each side of the "head" in all the Galeodidæ (Pl. XXVII. figs. 1, 3, 6, 7 *a*). I at first thought that these areas were the remains of the coxæ of the cheliceræ (*cf.* Pocock, 60). If so, these buttresses might be homologous with those of the other limbs. But, as will be more fully explained in the section on the limbs, the evidence is rather in favour of these particular buttresses being independent formations (see below).

III. The Limbs.

The limbs of *Galeodes* have been so often figured and described that no detailed account of them is required here. We therefore confine ourselves to points which are either new or else of special morphological interest.

The Cheliceræ.—The cheliceræ in *Galeodes* are two-jointed, having, in addition to the shaft, a ventrally-placed movable segment.

There is strong reason for believing that this limb, in all Arachnids, was originally three-jointed. We find, for instance, three joints in *Scorpio* and in the Phalangidæ. The two-jointed condition is therefore due to secondary loss of one joint.

On the inner face of the cheliceræ of *Galeodes* (Pl. XXVII. fig. 11) we find a very clearly marked area which, on comparison with the corresponding limb of *Scorpio*, is to all appearance the remains of a former proximal joint (*cf.* Pl. XXIX. fig. 1, *b'*, *c'*). On the outer side, but belonging to the cephalic lobes, there is the curious cuticular area (Pl. XXVII. fig. 1 *a*) characteristic of the Galeodidæ, which Pocock thinks may perhaps also be part of the lost proximal joint. In support of this view, it must be noted that under this sclerite, and as a fold of it, there occurs the buttress-like support to the limb, like the buttress-supports in the coxæ of the other legs. In spite of this fact, however, this homology does not commend itself, for the following reasons:—

In the first place, this buttress-support of the cheliceræ can hardly be the homologue of the buttresses in the coxæ of the other limbs, inasmuch as its position in that case would be difficult to explain. The two anterior pairs of limbs have been simply folded forward, the cheliceræ above, and the pedipalps below or at the sides of the mouth, so that the anterior surfaces of their coxæ face one another towards the median plane. The homologue of the buttress-folds ought, therefore, to be found along the coxal areas on the inner faces of these limbs, where, indeed, those of the pedipalps still are (Pl. XXVIII. fig. 15). On the other hand, any homology between the buttresses on the outside of the cheliceræ of *Galeodes* with those of the pedipalps would mean that the chelicerae had rotated through nearly 180°, which seems highly improbable. It is safer, then, to conclude that these cheliceral buttresses in *Galeodes* are new formations, articulating, not the 2nd joint with the coxa, but the coxa with the body, the 2nd joint and the coxa fusing together. It is possible also that the secondary infoldings necessary to form these buttresses gave rise to the areas (*a*) at the sides of the "head."

I would like in this connection to suggest that the stridulating apparatus formed by a series of folds running along the smooth areas on the inner surfaces of the chelicerae of *Solpuga* and other genera (Pl. XXIX. fig. 1 *c.'*, *str.*) may have started from the two hard edges of a buttress infolding, which, as I have shown, ought at one time to have been present in this place *. That the Galeodidæ stridulated by rubbing the chelicerae one against another was described by Pallas † a hundred years ago. Hansen (33) has recently studied the series of stridulating ridges, which are quite coarse enough to have arisen in the way suggested.

The chelicerae are enormously developed as the only seizing-limbs, the pedipalps having no accessory seizing-apparatus. Observers relate that, in order to bring the beak up to the wound in its prey, the animal works the chelicerae with a sawing motion, holding tight with one to drive the other deeper in ‡.

In no other Arachnid are these limbs so powerful as in the Galeodidæ, although in the Spiders and Phalangids and many Acarids they are, as in *Galeodes*, the only seizing-organs. In other Arachnids —Scorpions, Phrynidæ, Thelyphonidæ, and Pseudoscorpions—the chelicerae have become secondarily subordinated to the pedipalps as the principal organs of prehension.

Another difference of great interest is the position of the movable digit of the chelicerae. The Aviculariidæ and the Spiders generally, the Phrynidæ, *Schizonotus* and *Thelyphonus* have the digit folding downward; on the other hand, the Scorpions, Pseudoscorpions, and Phalangids have the chelicerae in the form of pincers, which open from side to side; lastly, in *Galeodes* and some Acaridæ the pincers open and shut dorso-ventrally. Now, starting from the claw-like limb (Pl. XXIX. fig. 1 *a*) as the most primitive, a rotation through 90° would bring the movable digit into the position of that of *Scorpio*; but it would require to twist through 180° in order to bring the movable digit into the position found in *Galeodes*. This, it seems to me, puts rotation as the solution of the difficulty out of court.

We can, however, account for the different forms of the chelicerae without any excessive rotation. If we start from a primitive limb of three joints (as shown in the diagram Pl. XXIX. fig. 1 *a*), one form would be produced by the two distal joints fusing to form a long claw-like joint which bent down upon the proximal joint (fig. 1 *b*, *c*). The second form would be produced by the two distal joints forming pincers which articulate with the body by means of the proximal joint (fig. 1, *b'*, *c'*). Some evidence in favour of this view we find in the following facts:—(1) the 3-jointed limbs are only retained in cases where they form pincers; (2) there are no visible traces of any fusion of joints to form the proximal joint of

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* I think traces of this fold may also be seen in markings on the inner faces of the proximal joints of the chelicerae in *Scorpio*.

† Lichtenstein & Herbst (48), p. 58:—"Wenn man sie eingesperrt hat und also reizt, so kann man an der Wuth und Unerschrockenheit, womit sie auf Alles losgeht Wunder sehen. Sie erregt alsdann durch das Aneinanderreiben ihrer Fangscheeren eine Art von Gezwitscher und ist in lauter heftigen Bewegung."

‡ The same, p. 28:—"Kurz, die Solpuge hat das fürchterlichste Gebiss unter allen Geschöpfen, nach Verhältniss schrecklicher als der Tiger, das Krokodill, die Brillenschlange und der Hayfisch."

the cheliceræ, say, of the Aviculariidæ or Pedipalpi; (3) a longitudinal section through the chelicera of *Phrynus* (Pl. XXIX. fig. 2) shows a distinct sclerite (*j*) where such a sclerite might be found if a joint had disappeared at that spot. Further investigations, however, are necessary. In the meantime I put forward the above suggestion as an alternative to the highly improbable assumption that any limb could rotate through 180°.

On the inner sides of the cheliceræ, thick rows of feathered setæ, running longitudinally along the digits, serve to conduct the juices of victims towards the mouth (*cf.* p. 357). These setæ give a very hairy character to the cheliceræ, and though the hairs end towards the hard red points of the digits, the pores of vanished hairs can be seen traversing the chitin right to the tips.

The Reputed Poisonous Character of the Bite.—There being no specialized poison-glands, I would suggest that to the exudation through these pores is due the dangerously poisonous character which is attributed by nearly all writers, both ancient and modern, to the bite of this animal [*]. I do not think that this almost universal testimony can be refuted without actual experiment. Unlike the Spiders, whose needle-like jaws can convey the venom from poison-bags with muscular walls into the slightest wound, the Galeodidæ must bite through the skin and plunge the tips of their pincers into the soft tissues before the poison takes effect. This is in accord with all the ancient accounts that only the tenderest parts of the body are bitten.

If this suggested origin of the poisonous effect of the bite of *Galeodes* from the exudation through open setal pores prove correct, it is not without interest for the morphologist. Pl. XXIX. fig. 2 shows the tip of the movable digit of *Phrynus*, with a special bunch of setæ on its outer edge. In the Pseudoscorpions these are absent, but are replaced by a series of tubes leading into specialized spinning-glands. In the Spiders these setæ are also absent, but there is one large poison-gland opening also practically on the same spot, while in *Galeodes* there are no setæ at the tip of the digit, but a great number of setal pores presumably exuding poisonous matter without any special gland formation. The bearing of this upon the probability of the origin of both spinning- and poison-glands from setiparous glands is obvious (see further, pp. 376 and 383).

The Flagellum.—The cheliceræ, in the Galeodidæ, are provided with remarkable sensory flagella (*i. e.* highly specialized setæ) which vary greatly in shape in the different genera (Pl. XXVII. fig. 11). It is not certain that these are confined to the male alone, as was once thought. The true explanation of the inconstancy of their appearance I have not been able to ascertain. The cheliceræ are said to be much smaller in the males than in the females.

The extraordinary combs on the fixed digits of the cheliceræ in the Pseudoscorpions may be homologous with these flagella; they stand out at about the same spot, and in both cases are associated with a tuft of feathered setæ. The combs, however, are not formed like true setæ, but, as is easily seen in transverse sections, are folds (apparently rigid) of the hard outer glassy layer of the chitin; they are therefore extremely thin and transparent.

The Pedipalps.—While the cheliceræ have folded together over the mouth so as to lie parallel to the median line, the coxæ of the pedipalps make an angle with the median line slightly less than 45°, the beak being wedged in between them (Pl. XXVIII.

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[*] *Cf.* the accounts given by Lichtenstein and Herbst, and by Dufour.

fig. 15 *a*). The distal portions of these limbs, however, which are leg-like, are arranged parallel to the median plane.

The pedipalps are carried in this leg-like fashion in the Araneæ, the Phalangidæ, and the Schizonotidæ; whereas in the Thelyphonidæ, Phrynidæ, Scorpions, and Pseudoscorpions they lie in the horizontal plane. This latter is probably a secondary specialization, in adaptation to a life under stones or bark.

Starting from some primitive leg-like appendage, such as that figured (Pl. XXIX. fig. 5), we can deduce the pedipalps of the Arachnids along two different lines of specialization. From the position of these limbs, they would tend to become sensory organs, as well as seizing organs accessory to the chelicerae. In the Phalangidæ, they seem to be little specialized in either direction, being provided with a claw. In the Galeodidæ and the Araneæ their specialization is almost entirely sensory, while in *Schizonotus, Thelyphonus*, and *Phrynus* we have variously developed forms of seizing claws and pincers. This specialization reaches its extreme in *Scorpio* and *Chelifer*, in which the pedipalps have developed enormously powerful pincers. This chelate condition of the pedipalps has thus, I think, departed furthest from the primitive leg-like pedipalp of the ancestral form.

In *Galeodes* the pedipalps are very long (Pl. XXIX. fig. 3), in *Rhax* very short (fig. 4); in both cases they are powerful limbs, and, without having any definite claws or seizing organs, almost certainly help to hold prey by encircling it. The chief function of these limbs is undoubtedly sensory. They are extremely hairy, specially noteworthy being the long silken hairs (a few of which are shown in Pl. XXIX. fig. 3, and their insertions in the cuticle in Pl. XXXII. figs. 13, 14, 15). Most important, however, are the sensory (olfactory) organs at their tips. These organs are found in free knob-like joints in *Galeodes* (Pl. XXIX. fig. 3, Pl. XXXI. fig. 12), but in *Rhax* these joints are fixed (Pl. XXIX. fig. 4); in section, and often to the naked eye, the lines of fusion in this latter case are quite visible. The sensory organ itself will be described in detail in another section (on sensory organs). It is enough here to say that close examination of it shows that it is not an organ "pour grimper ou s'accrocher" as suggested by Dufour, and recently again insisted upon, but a sensory, probably olfactory, organ according to the older view.*

The coxæ are provided with hairy processes on their inner faces distally; these processes are immovable (Pl. XXVII. fig. 14, *sp*). In *Rhax* they are long and cylindrical, in *Galeodes* short and pointed. These are almost certainly sensory (tactile) in their functions.

Sensory processes or pads are found at this point on nearly all Arachnids. I have found none in which they are so limb-like as in *Rhax*. In the Pseudoscorpionidæ alone do they appear, at least in some genera, to be movably articulated. They have, in these animals, the laminate form which they have in *Scorpio*, where they appear to be simply prolongations of the inner faces of the coxæ. In the Pseudoscorpionidæ, they perhaps assist in holding prey in front of the beak (10; *cf.* fig. 5).

Like the coxæ of the other limbs of *Galeodes* (except the chelicerae), those of the pedipalps are rigidly fixed to the body. They are firmly cemented to the sides of the beak (Pl. XXVIII. fig. 3).

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* Lichtenstein & Herbst (48), p. 52:—"Der scharfe Geruch, der seinen Sitz hauptsächlich in dem hohlen Knopf an der Spitze der Vorderfühler hat, locket sie dahin," *et seq.* See also the description of the action of the pedipalps quoted by Murray (57).

The only other Arachnids with fixed coxal joints to the pedipalps are, I think, *Thelyphonus* and *Schizonotus,* and (?) some Pseudoscorpions. In *Thelyphonus* the beak is enclosed between the enormous coxal joints of the pedipalps, which thus form on their upper and inner sides a sort of channel in which the beak lies. In *Phrynus,* we have the coxal joints movable, but the beak as such has aborted in such a way (Pl. XXVIII. fig. 7) that the inner opposite faces of the coxæ can meet in the middle line. In the Spiders, the coxal joints function on each side of the mouth as accessory mouth-parts *. In the Chernetidæ, it is difficult to say for certain whether the coxal joints of the pedipalps are movable, but their lamellate sensory processes (above described) are certainly, in some cases, movable, and serve to hold and crush prey in front of the beak. In *Scorpio,* the coxæ are movable, but do not appear to be able to close together, owing to the retention of the large labrum between them. These various arrangements will be referred to again in the section on the alimentary system, inasmuch as they are different adaptations to the special manner of feeding of the Arachnids.

The Relative Developments of Cheliceræ and Pedipalps.—In the Galeodidæ, the cheliceræ have certainly been secondarily developed into their present enormous proportions. In the primitive form, there is no reason to believe that there was any great difference between the development of the cheliceræ and that of the pedipalps, except, perhaps, in length; sections through their basal regions would probably have agreed in size. We can best explain the conditions in *Galeodes* by assuming that the cheliceræ have greatly developed, while the pedipalps have retained more nearly their relative importance with regard to the remaining limbs.

In the Araneæ and the Phalangidæ, the same relations subsist as in *Galeodes;* the cheliceræ are the principal seizing organs, and are correspondingly developed. In those forms, however, in which the pedipalps have become the seizing organs, they have, from their greater initial length, more or less monopolized this function, and have been correspondingly specialized. We have thus a series in which the pedipalps progressively increase, while the cheliceræ recede in importance, having henceforth to fulfil only the quite subordinate function of squeezing juices out of prey already killed or maimed by the pedipalps. In *Schizonotus* the pedipalps are in the upright, clawing position, and in this animal and in the related *Thelyphonus* the distal joints have formed a simple kind of nipper. In *Phrynus* no such pincer is formed at all; the pedipalps are clawing limbs. In these three we find the pedipalps highly developed, while the cheliceræ are probably in process of reduction, and tending to flatten out in the median plane (Pl. XXVIII. fig. 9). Lastly, in *Scorpio,* the pedipalps are enormously developed, the original clawing action having developed powerful pincers †, while the cheliceræ have greatly diminished in size (Pl. XXVII. fig. 9 *b*).

The series of figures 9 *a*, 9 *b*, 9 *c* (Pl. XXVII.), and 9 (Pl. XXVIII.) represent cross-sections of *Galeodes, Scorpio, Obisium,* and *Thelyphonus* (drawn with camera lucida). The great diminution of the cheliceræ in *Scorpio* and *Thelyphonus* is seen to be a secondary specialization. Both *Galeodes* and *Scorpio* depart in opposite directions from the *Obisium* type, in which the bases of the limbs are shown of nearly equal importance in cross-section, such being in all probability the primitive condition.

The great modifications of the anterior segments brought about by the original translocation of the cheliceræ are still further complicated by the development and specialization of the pedipalps as a 2nd

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* These are not biting jaws, working within or at the sides of the oral aperture; such jaws (except, according to my friend Mr. Michael, in some Acari) are unknown among the Arachnids.

† If the pedipalps of a Scorpion are turned upwards into the sagittal plane, the distal joint will, in closing, be found to move in a clawing direction, *i. e.* towards the body.

pair of seizing limbs. Such limbs must have powerful bases from which to work. The method in which the bases of the great seizing pedipalps have developed in adaptation to their new requirements varies greatly in different Arachnids. This fact leaves little doubt that the specialization is a secondary one.

In *Schizonotus,* the enlarged basal joints of the pedipalps have grown out anteriorly far in front of the cheliceræ. They, however, still lie ventrally to the cephalic lobes—that is, meet in the middle line. In the Pseudoscorpionidæ the arrangement differs from that in *Schizonotus,* in that the coxal joints of the large pedipalps do not project beyond the front of the body, but posteriorly, thrusting back the four following or ambulatory limbs, which are pushed further from the mouth than in any other Arachnid (Pl. XXVIII. fig. 2 does not show this so markedly as it is seen in some genera). In *Thelyphonus,* the large coxal joints of the pedipalps have found room for development backward, by displacing the 3rd pair of limbs, the coxal joints of which no longer appear on the ventral surface (Pl. XXVII. fig. 17). And in *Phrynus,* the enlarged coxæ of the pedipalps have partially displaced the coxæ of the 3rd pair of limbs, though they are still visible from the ventral surface. In both these cases, the comparatively small cheliceræ have sunk in between the coxal joints of the pedipalps. But in all these cases the bases of the pedipalps meet ventrally in the middle line.

In the Scorpions we reach an extreme of specialization. The basal regions of the enormous pedipalps are thrust out anteriorly and laterally. The crowding forward of the walking-legs to the anterior end of the body not only prevents any backward development of the coxæ of the pedipalps, but has even forced them apart so that they no longer meet ventrally in the middle line, nor take any part in the formation of the ventral surface of the cephalothorax.

These changes in the relative development of the cheliceræ and the pedipalps have naturally led to great modification in the cephalic lobes, which owe their origin to the translocation of the former. In my preliminary notice of these cephalic lobes, I thought that, as the cheliceræ became subordinated to the pedipalps, the cephalic lobes carrying them became wedged in completely between the shoulders of the pedipalps, but that is not the case; the cephalic lobes still form the whole of the anterior dorsal surface. The relations can be made out by comparing the sections (Pl. XXVII. figs. 9 *a*, 9 *b*, 9 *c*, and Pl. XXVIII. fig. 9).

Thus, starting with the condition found in *Galeodes,* the Spiders and Phalangids, in which the cheliceræ are the only true seizing organs, we have every stage in the gradual specialization of the originally simple leg-like pedipalps into complicated seizing and crushing limbs.

The 3rd Pair of Limbs. 1st Pair of Legs.—The 3rd pair of limbs, like the pedipalps, are leg-like, but have apparently lost their locomotor functions, and are specialized into a second pair of sensory limbs. Like the pedipalps, they are long in *Galeodes,* but short in *Rhax.* In *Galeodes,* they are also very thin (Pl. XXIX. fig. 3). The presence of a pair of reduced claws at their tips shows that they were at one time ambulatory legs. Their specialization into feelers in addition to the existing pedipalps must be due to the great activity of these hunting animals *. The special sensory cells at their tips will be described in the section on the sensory organs. No other Arachnid has two pairs of feelers.

In the Scorpions, Araneæ, Pseudoscorpions, and Phalangidæ, the 3rd pair of limbs are true ambulatory legs, while in the Phrynidæ and Thelyphonidæ the tendency shown in *Galeodes* to become sensory feelers has reached an extreme of specialization. This is doubtless a compensating modification, owing to the secondary transformation of the pedipalps into seizing organs. In these animals, the first pair of legs become long, filiform, many-jointed feelers. It is not immediately apparent why, in the

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* The animal kingdom presents other examples of a high development of sensory organs with rapidity of motion in the pursuit of prey.

Scorpions and the Pseudoscorpions, in which the pedipalps are seizing organs, the 1st pair of legs have retained their original locomotory functions unmodified. The comparatively slow, deliberate manner of hunting prey may account for the fact that they require no more specialized feelers than the pedipalps themselves, which are, as everyone who watches them alive knows, highly sensitive.

The Remaining Limbs.—The remaining three pairs of legs are long and powerful, the last two having the femur divided by an extra joint, as Gaubert (32) has pointed out, but whether the reasons he has given for this are correct I am unable to judge, having never seen the animals alive. The last of the three pairs of legs carries the remarkable racquet-shaped sensory processes which will be described in detail in the section on the sensory organs.

General Remarks on the Cephalothoracic Appendages.—These six pairs of limbs are the appendages of the first six segments, *i. e.* of that region of the Arachnidan body which is specialized for locomotory, sensory, and predatory functions, while the region immediately following is typically developed into a nutritive and generative sac, and, as such, loses its limbs. These six pairs of limbs are characteristic of all adult Arachnids, although the possession of six pairs of appendages on a specialized anterior region of the body would not constitute an animal an Arachnid. The *arrangement* of these limbs, and especially of those nearest the mouth, supplies the most important diagnosis of the class. In no case does the first pair of limbs form feelers; in no case [? certain specialized Acaridæ] do the limbs form biting jaws projecting into, or arranged close to, a mouth-aperture. In all cases, the first pair of limbs are jointed, seizing and crushing limbs, transposed from behind to a position in front of and above the mouth, which is typically a beak. Special feelers are sometimes dispensed with, at other times developed out of the 2nd, at others out of the 3rd, at others, again, out of the 2nd and 3rd pairs of limbs; while, in most cases, the 2nd pair of limbs assists the 1st in the capture and crushing of prey, the juices of which alone are sucked in by a mouth which is typically provided with a straining apparatus.

These characters constitute the Arachnids a class removed entirely from all other Arthropods, in which, typically, the first pair of limbs are sensory feelers, while a certain number of those which follow form true jaws, not only to crush food but to push it into the mouth, round which they are ranged.

Certain Acari, in which the mouth-limbs (perhaps fusing with a primitive beak) form a piercing sucking apparatus, distantly approach, by secondary specialization, those Arthropods of other groups (Crustacea and Hexapoda) whose mandibles and maxillæ are also secondarily specialized into a sucking proboscis.

These six pairs of cephalothoracic appendages, constant in the (adult) Arachnida, show certain interesting variations in their arrangement on the body. These can be gathered at a glance from the diagrams (Pl. XXVII. figs. 15–18 and Pl. XXVIII. figs. 1, 2). None of the arrangements can be considered primitive. That represented by certain Acari and Araneæ, inasmuch as the sterna are preserved and the limbs regularly arranged, must be considered as nearest to the original. The circular arrangement in the Spiders is certainly secondary. The regular arrangement of the legs in two straight series in *Galeodes* is primitive, but the disappearance of the sterna is a secondary specialization.

Another point of interest is the fixation of the coxæ which occurs to some extent in most Arachnids. In *Galeodes* all are fixed, as is also the case in *Thelyphonus* and the Phalangidæ. In *Scorpio* the coxæ of the first pair of legs are alone movable, those of the other three are fixed. In the Spiders, Phrynidæ, and (?) some Pseudoscorpions all are movable *.

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* In fig. 2 (Pl. XXVIII.) the coxæ certainly appear to be fixed; but there is great variation in the arrangements of the coxæ in this order.

Taking the limbs as a whole, the variations are considerable, and no single Arachnid can claim to have retained the primitive conditions. It seems only possible to deduce them separately from a primitive ancestral form in which the limbs were evenly developed and evenly arranged along the two sides of the body, separated by a median row of sternal plates, as shown in the diagram (Pl. XXIX. fig. 14).

The character of the limbs, suggested in this diagram and in figure 5, Pl. XXIX., is not unlike that of the ambulatory limbs of the Silurian Scorpion *Palæophonus* (Pl. XXVII. fig. 10), whose semiaquatic, *i. e.* littoral, existence makes its retention of the primitive type of ambulatory leg not improbable.

Vestiges of Abdominal Appendages.—Careful study of the ventral surfaces of Galeodidæ has led me to the conclusion that the "sterna" along the abdominal segments represent rudimentary limbs which have simply flattened down.

Figs. 6, 7, 8, 9, 10, Pl. XXIX., show a continuous series of plate-like structures on the abdominal segments bearing all the characters of vestigial appendages. That these are the vestiges of limbs which formed at one time a continuous series with those on the cephalothorax we gather from the following facts :—

(*a*) Fig. 7, Pl. XXIX., shows a chitinous fold across the genital operculum, repeating the interarticular fold of the preceding appendage (*cf.* diagram, Pl. XXIX. fig. 11).

(*b*) The genital opercula are generally admitted to be vestigial appendages. The two pairs of stigmatic opercula repeat the genital opercula so closely that they must also be vestigial appendages. These are followed by a series of six plates, the first three of which may at once be claimed as vestiges, inasmuch as six pairs of limbs are almost universally admitted to have been present on the abdomen of Arachnids. But we have here in all nine pairs of plates obviously forming a homonomous series. If the first six of these are vestiges of limbs, we may safely conclude that the last three are so likewise (compare especially figs. 8, 9, 10, where the plates repeat exactly the stigmatic opercula).

(*c*) These vestiges are often covered with hair differing entirely from the hair on the rest of the abdomen, but repeating exactly the character of the hair on the coxæ of the cephalothoracic limbs.

(*d*) The same is the case with colour. These vestiges often differ very markedly in colour from the rest of the abdomen, and from the terga, but repeat exactly the colour and general appearance of the coxæ of the cephalothoracic limbs.

(*e*) These vestiges meet in the middle line like the coxæ of the cephalothoracic limbs, while internally the dorso-ventral muscles, which in other Arachnids (e. g. *Scorpio*) are attached just inside the areas which admittedly represent vestiges of the limbs associated with the lung-books, in *Galeodes* meet in the middle line.

(*f*) The stigmatic apertures, which are always associated with rudimentary limbs, have also moved into the ventral middle line.

These arguments and figures leave, I think, little doubt that there were once at least nine pairs of limbs on the abdomen of *Galeodes*, but none of the vestiges any longer appear as limbs. The genital and stigmatic opercula are now nothing more than folds, while the following vestiges are flattened completely down and look like sternal plates.

On the posterior edges of the stigmatic opercula in the genus *Galeodes*, a row of short stout spines occurs, the paired origin of which is obvious (Pl. XXIX. fig. 10). These are the stigmatic combs. A less specialized group of setæ appear in nearly the same spot on segment 5 of the same figure, and singular modifications, presumably of these rows of setæ, occur in the specimen of *G. intrepidus* on the 5th, 6th, and 7th segments, also figured (Pl. XXIX. fig. 8).

Lastly, the hypothetical restitution of the abdominal limbs at an earlier stage in their degeneration, shown in Pl. XXIX. fig. 11 (which will be discussed further in the section on the tracheæ), suggests that the sclerite surrounding the anus may also be a fused pair of limb-vestiges.

Abdominal limbs in Arachnids are well known in the mammillæ of the Spiders, in the pectines of the Scorpions, and in the "penis" of *Phrynus* (77). Further, from the presence of the lung-books, vestiges of limbs can be safely recognized in the areas covering these breathing-organs.

Until a comparatively recent time, the traces of abdominal limbs were thought to be confined entirely to the first six abdominal segments; in *Scorpio* we have the genital opercula, the pectines, and four pairs of lung-books. But I claim to have found clear traces of the former presence of tracheal invaginations, and therefore of limbs, on all the abdominal segments of certain Chernetids (10) and on eight segments of *Thelyphonus* (15).

These facts fully agree with what we have just seen of *Galeodes*, where fairly clear vestiges of at least nine pairs occur.

While, then, *Scorpio* * and the Spiders show traces of only six pairs of limbs having been present on the abdomen, three Arachnids, belonging to very different families, bear testimony to more than six. *Thelyphonus* shows traces of 8 pairs, *Galeodes* of 9, and *Chernes* of 10. We may therefore conclude, what indeed we might have safely concluded on almost any theory as to the origin of the Arachnids except one, that the primitive form had limbs on all the abdominal segments. The only theory according to which the abdominal limbs could not have existed in the posterior segments will be discussed in detail in the last section.

We have further some evidence as to the original character of these limbs, which are now, in the Galeodidæ, reduced entirely to plate-like structures. In some Phrynidæ the first pair still persists in the so-called "penis" (77, and Pl. XXIX. fig. 13) as a pair of jointed limbs folded together in the middle line and illustrating the formation of the genital operculum. In the Phalangidæ, the long penis or ovipositor is almost certainly a specialization of a pair of filamentous appendages. In *Scorpio*, the limbs of the 2nd segment, the pectines, are filamentous and still bear traces of three joints; we learn from this that the plates covering the stigmata were once filamentous and jointed limbs. This gives us a series of such filamentous appendages as far as the 6th segment in *Scorpio* and as far as the 8th in *Thelyphonus*. That such filamentous limbs did exist on the 4th and 5th segments we have direct evidence, viz. their persistence as mammillæ in the Spiders, which are especially leg-like in the Aviculariidæ.

As a rule, then, the vestiges of the abdominal limbs in Arachnids are now little more than plates or folds, covering the genital and stigmatic apertures, or else are flattened down as hardly distinguishable portions of the ventral segmental sclerites. In a few cases, however, the original leg-like character has not been completely obliterated, these cases occurring in very distinct families and on different segments, always in adaptation to the specialization which characterizes these families.

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* I have often thought that the tail-sting of *Scorpio* was a composite structure, representing a pair of legs (of the anal segment) fused posteriorly over the anus. Limbs meeting over the anus and pointing backward are found in *Scolopendra*. Such an origin would explain the remarkable fact that the poison-glands are paired. *Cf.* further, the anal plates of *Galeodes*, and the diagrams, Pl. XXIX. figs. 8–12, 14.

Apart, then, from any special theory as to the origin of the Arachnida, the evidence tends to show that the primitive form had appendages which were leg-like, and serial with those of the cephalothorax, on every segment of the abdomen.

IV. The Cuticle and its Derivatives, and the Hypodermis.

The Chitinous Cuticle.—The cuticle of *Galeodes* is very highly developed, and shows many variations in adaptation to the needs of the different regions of the body. As a rule, it is very thick and rigid in the anterior regions of the body, but soft and flexible on the abdomen, with distinct but not very thick terga and "sterna."

In this last point *Galeodes* comes halfway between the Spiders (with no terga * or sterna) and the Scorpions, Pedipalpi, and Pseudoscorpions, which have well-developed sclerites on the abdomen, continuing dorsally the cephalothracic shield and ventrally the vestiges of sternites persisting between the coxæ of the limbs.

The cuticle has the characteristic structure of the chitinous cuticle as found among Arachnids, but it presents peculiarities which are of interest. Taking first a thick solid portion (Pl. XXIX. figs. 15 and 17), we have an outermost highly refractive pale yellow or glassy layer (*g*), the colour of which deepens to bright red-brown when especially thickened, as at the hinges, around the bases of hairs and spines, in the spines, in the jaws and their teeth, &c. No structure can be made out in the outermost part of this layer; its inner part, however, can be seen to be finely striated, as if perforated by innumerable fine canals which taper away into it. When, as in especially hard parts of the cuticle, this layer is very thick, these canals show as a tangled mass of lines (fig. 17). This hard refractive layer forms a continuous covering *over the whole body*, supplying the outer coating of all the spines and hairs, and the innermost lining of the tracheæ (Pl. XXX. figs. 17 *a* & 17 *b*).

Following this layer, and, as a rule, fairly distinct from it, occurs a varying number (often 30–40) of principal layers of whitish and comparatively soft chitin. They look as if they gradually increased in hardness and refractiveness as they approach the outermost layer, while the innermost layers often take slight stain. These are sometimes called the chitinogenous layers. A high power seems to show that these principal layers are made up of an enormous number of fine laminæ. They are traversed by innumerable canals containing protoplasmic processes which sometimes stain deeply. These canals seem to end distally in the hard refractive outermost layer. The fine canals above described in the glassy layer are in all probability the distal ends of the canals in the thick softer layers. These "chitinogenous" layers can be followed into the hairs and spines, and into the tracheæ, where they form the solid hoops characteristic of these latter organs (Pl. XXX. fig. 17 *b*).

Both these layers are modified in order to form the lens of the eye. The outermost refractive layer appears to split up into a multitude of deeply staining layers, with one (the outermost) extremely thin glassy membrane. The inner layers become

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* Except in *Liphistius*, cf. Pocock (59).

suddenly thickened, without, however, breaking their continuity (*cf.* Pl. XXXI. fig. 7). A similar sudden thickening of the chitinogenous strata forms the crenulations of the tracheal tubes (Pl. XXX. fig. 17 *b*).

Hypodermis.—The cells secreting these layers of chitin are not always demonstrable; in some places, especially where the innermost layers take stain, they appear to be embedded in the chitin which they are secreting. At other places, especially where the cuticle is very thick, the hypodermis-cells are very regular and distinct, with large staining nuclei. They are sometimes cylindrical and rest on a basal membrane running parallel with the cuticle (Pl. XXX. fig. 4); at others they are plate-like, and so closely applied to the chitin that they are seen only in well-stained preparations. In this latter case staining processes from the cells run at right angles through the chitin, and in cases where (in sections) the hypodermis has parted from the chitinous layers, these processes break off, are left in the chitinous layers, and are seen in small groups of deeply staining points (Pl. XXIX. fig. 15). The concentrated grouping and staining of these points suggest that the processes themselves came from the nuclei. The fact that in those cases where the cells are not demonstrable they are probably altogether, both cytoplasm and the nucleus, embedded in the chitin, shows that there is nothing improbable in the nuclei sending processes into the cuticle in the cases in question.

Migration of Pigment-cells into the Cuticle.—The incorporation of other matter into the cuticle is clearly seen in *Galeodes.* In almost all parts, streams of black dots may be seen running up the traversing canals (Pl. XXIX. fig. 17). These may be pigment-granules. No doubt, indeed, exists as to the wandering of pigment-cells into the cuticle at certain definite places, *e. g.* in the pedipalps. An enormous number of dark green pigment masses are formed in the distal portions of these limbs, and they find their way to the chitin either of the outer cuticle or of the tendons and the tracheæ. Among the tissues they are either small round bodies, or grouped to form long, straggling, tangled syncytia. On reaching the cuticle, they become fusiform and applied lengthwise to the chitin, through which they ascend by sending processes into it. These processes tend to spread out between the principal layers of the chitin (Pl. XXIX. fig. 16; *cf.* also Pl. XXVIII. fig. 6). In this way, the whole of the fusiform body may come to lie within the cuticle, between its separate layers. I know nothing more of its fate, either here or on the tendons or tracheæ. The gravitation of these cells towards the chitin is of itself interesting. It is not easy to avoid suggesting that the cells are collecting and removing waste matter from the ends of these long limbs, where they are most plentiful and where the circulation is probably sluggish.

Taking the cuticle of an adult *Lycosa* for comparison, the chief point noticed was that it was much more brittle than that of *Galeodes.* Microscopic examination shows that a greater number of the chitin layers are hard and refractive than in *Galeodes.* I have counted ten distinct hard red-brown layers, whereas the softer white chitin layers so numerous in *Galeodes* are comparatively few. It is thus very difficult to get sections of this Spider. It is possible that this increase in the hardness of the whole cuticle permits of its being thin and therefore lighter in adaptation to the semi-aerial life on webs characteristic of the Spiders (though this would not apply to *Lycosa*).

The cuticle of *Scorpio* (*Euscorpio*) is characterized by the specialization of a very clear glassy layer of varying thickness as its outer layer, beneath which follow several layers of hard, red-brown, highly refractive chitin (Pl. XXX. fig. 1 *h*). These, again, are followed immediately by a varying but generally considerable thickness of staining chitin, between the laminæ of which pigment is found deposited. The staining layers are found to be traversed by fine canals. This cuticle, like that of *Galeodes*, cuts much more easily than does that of *Lycosa*; though it is much thicker, it is much less brittle.

Where the cuticle is thin and flexible, as on the abdomen, we naturally find a striking change in the arrangement of the layers. The outermost hard refractive layer is thrown into minute transversely arranged folds (Pl. XXX. fig. 6) in all parts wherever the skin is required to bend, *i. e.* at the sides of the body and between the consecutive tergites and "sternites." Over these latter it lies flat.

Immediately under this folded refractive layer, a great number of very thin staining layers occur which appear to be thrown into irregular wavy folds, and do not in any way repeat the regular folding of the refractive layer as seen in section. Pigment masses are occasionally found deposited between these staining layers. I have not discovered the origin of these pigment masses; as a rule, the pigment of the dorsal surface is seen within the hypodermis-cells.

This folding of the outermost layer seems to be universal over the abdomen of the Spiders, which have generally lost the smooth, non-flexible tergites and sternites. The curious ridging of the flexible cuticle in the Spiders has been much discussed, and the ridges have been thought to be thicknesses of skin rather than folds (*Wagner*, 74). It seems, to judge by *Galeodes*, that both statements are true; the skin itself is not folded but simply regularly thickened by foldings of its outermost refractive layer, these folds not being repeated by the subjacent layers (Pl. XXX. fig. 3).

These subjacent staining layers present a remarkable feature. The usual lamination parallel to the surface of the skin is obliterated for a certain depth under the outermost refractive layer by an immense number of fine canals which open through pores in the outermost layer. The apertures of these pores appear to lie in the troughs formed by the ridges; the surface view of these pores has already been figured and described by Wagner. This marked porosity of the cuticle in the abdomen of the Araneids, which may be a specialization of the canal system described in the cuticle of *Galeodes*, may perhaps be brought into relation with the loss of the excretory functions of the Malpighian vessels, which appear to have become specialized for the removal of the fæces from the mid-gut diverticula (11). It is also probably a protective adaptation to render distasteful their otherwise attractive sac-like abdomens filled to distension with rich food.

Beneath this porous layer there are to be found a few layers of staining chitin, probably permeated by the hypodermis cells.

These remarkable lines and ridges on the cuticle of the whole abdomen of Spiders are found also on all soft-bodied Mites. This is perhaps a further point of connection between the Acari and the Araneæ, such striation occurring, so far as I know, in no other Arachnids (6).

So far as I can ascertain, it is the outermost refractive layer of chitin which, by being thrown into ridges and folds and conical processes, cause the remarkable sculpturing of the cuticle of the Phalangidæ, the lower layers taking no definite part in it.

Scorpio (*Euscorpio*) has no ridged and furrowed cuticle, such as *Galeodes*, Spiders, and Acarids. The flexible membranes at the sides of the body between the terga and sterna are thrown into irregular folds covered by the glassy layer arranged as shown in Pl. XXX. fig. 2. This white and highly refractive outermost layer shows no lamination, but is apparently traversed, at least for some distance, by canals. The inner chitinogenous layers stain deeply, but take no part in the formation of the papilla-like folds (?) of the glassy layer.

In the Pseudoscorpions, the soft lateral membranes evidently vary, some having the outermost refractive layer thrown up into papillæ, others into irregular (?) longitudinal foldings.

Setæ and Spines.—The Galeodidæ are remarkable for their rich covering of setæ, spines, &c. These attain their greatest development, as a rule, on the limbs. Commencing with the short stunted spine standing up from the hollow of a ring of thick red-brown chitin and itself bright red-brown (Pl. XXX. fig. 8), we have short stiff setæ with blunt, slightly forked ends *, and thin flexible setæ tapering finely to a point, and often attaining an extraordinary length (Pl. XXIX. fig. 3), club-shaped setæ, &c. Most of the setæ show a disposition to form regular rings which, when further developed, might lead to the feathering which characterizes certain setæ on the cheliceræ and beak. The setæ, as such, require a careful study, in order to ascertain their special physiological significance.

The attachment of the setæ to the cuticle is apparently uniform; I could find no difference between the method in which the spines and the finer setæ were fixed in the cuticle. All alike are suspended by the outermost hard or glassy layer, which runs over them as an outer covering. The figures (Pl. XXX. figs. 4–8) will explain what I mean by "suspended." The setæ rise from the bases of hard chitinous craters, there being no break in the continuity of the outer refractive layer †. On the other hand, the inner softer chitinous layers are not continuous with the inner lining of the setæ, but the two are connected by numberless fine radiating fibres (*rf.*) which, like all flexible chitin, take stain, while the layers which they connect often remain unstained. These radiating fibres either bring about by their active contraction, or else restrain by their elasticity, the play of the seta. Radiating from the extreme butt-end of the seta to the walls of the chamber, they completely divide it into an upper and lower portion. In the long sensory setæ on the limbs the upper chamber communicates with the cavity of the body by a separate channel (*cf.* *c* on Pl. XXX. fig. 7 *a*; Pl. XXXII. figs. 13, 14).

In order to make room for the play of the butt-end of the seta, the channel through the cuticle is enlarged in various ways. Where the cuticle is thick, the setal pore widens out suddenly, the staining fibres radiating from the shelf thus formed, the widened area being lined by a layer of hard refractive chitin (Pl. XXX. fig. 4). When the cuticle is thin, the hard refractive chitin forms a sort of globular chamber into which the base of the seta is suspended in the usual way, the chamber being often much deeper than the surrounding cuticle (fig. 5). The strong chambers prevent the seta from being forced back into the tissues of the animal. There is a further precaution against the same danger in the case of the spines, inasmuch as they widen out, spear-head-shaped, above the ramparts surrounding their bases (fig. 8).

The setæ at the tip of the labrum are specially modified. They are joined by short trabeculæ so as to form a stiff rectangular lattice-work (Pl. XXVIII. fig. 6). They form two series arranged on each side of the mouth and running dorso-ventrally. As the tips of the setæ are feathered and the barbs interlace, the arrangement forms a sieve to prevent

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* In 'Nature' (vol. xlvi. p. 223, 1892) I compared these to buttoned rapiers.

† Wagner's account of the connection between the setæ and the cuticle in Spiders (74) differs from this.

anything but the juices of the prey from entering the alimentary canal. On the sieves in and around the mouths of Arachnids, *cf.* the section on the alimentary system.

The flagellum is also clearly a modified bristle; its position and form in *G. arabs* are shown in Pl. XXVII. fig. 11 *f.*

The only other Arachnids which can compare with *Galeodes* in hairiness are the Araneæ, especially the Avicularidæ. This is very interesting in view of the other features, which appear to be primitive, common to the two. I have found no difference in the principle of suspending the setæ and spines of *Lycosa.* The hard chitinous chambers in which the bases of the larger setæ are suspended in the softer abdominal region are very much more powerful than in *Galeodes,* and the chitin is dark red-brown. A comparison of the setæ themselves would lead us too much into details, of great biological interest, but not of sufficient morphological importance to claim attention here.

Of the remaining Arachnids, none are specially remarkable for hairiness; on the contrary, the Scorpions, Pedipalpi, and Pseudoscorpions are very free from setæ. Many Acari, e. g. *Trombidium,* however, have very specialized setæ, and the same is the case with others, at least in their larval stages (*Michael,* 56).

I am inclined to think that the hairy condition was primitive, and that it has been secondarily lost in certain families in adaptation to special conditions of life. There is hardly any Arachnid which has not retained patches of dense setæ in some regions of the body, especially around the mouth. Further, there can, I think, be little doubt that the Scorpions have secondarily lost a hairy covering which has, however, left clear traces of its former presence. If a small Scorpion be cleared in cedar oil or glycerine, its cuticle will be seen to be traversed by enormous numbers of large pores. In section, these pores are found not to open at the exterior; they are, in fact, canals through the so-called chitinogenous layers, which stop short at the hard outer glassy layer (Pl. XXX. fig. 1). When we remember that the outermost layer passes continuously over the bristles, it is obvious that on the gradual degeneration and final disappearance of a bristle we should obtain the structure just mentioned, the last part to disappear being naturally the canal through the chitinogenous layer.

Perhaps as good a demonstration as can be given that these pores through the chitinogenous layers were once setal pores is furnished by the pedipalps of *Phrynus.* In this animal, the pedipalp, in a marked contrast to that of the Spiders, is almost hairless. But the cuticle is channelled through by countless pores. There are, further, longitudinal rows of tubercular elevations of the cuticle, raising small groups (2, 3, or 4) of these channels, like so many irregular fingers pointing in all directions. All doubt that these pores are really setal pores is dispelled by finding an occasional fine seta rising out of one of them, generally from the slope or just below the summit of a tubercle. These setæ are fine cuticular processes with the characteristic structure.

The setal pore would, no doubt, itself also disappear in time unless it could be utilized for other purposes. I should like to suggest that these canals containing protoplasmic processes from the hypodermis which runs up as far as to the outer hard layer may now be sensory organs, perhaps for the appreciation of changes of temperature.

Again, the so-called lyriform organs may be setal pores modified after the degeneration of the original setæ (see further on this, p. 355).

The claws are somewhat remarkable, owing to the fact that their tips articulate with the shafts. A long tendon acts as flexor to this movable tip. I have found no extensor.

The claws on the first pair of legs, which act as a second pair of palps, though small and not jointed, are protrusible and are moved by powerful tendons (Pl. XXXII. fig. 10).

Tendons.—The development of long tendons for the movement of the limbs is especially noteworthy in Arachnids. *Galeodes* is no exception in this respect. These tendons appear in some cases to be closed cuticular invaginations. They can often be seen to be hollow. They further attract the small pigment-bodies already alluded to. The long distal tendons may be adaptations in the interest of strength, by permitting the muscle-masses to be situated in the larger proximal joints, where they can develop to greater size than would be possible in the smaller distal joints. The short tendons on the proximal joints specialize the actions of the muscles in accordance with the highly developed locomotory powers of so many of the Arachnids.

V. The Muscular System.

The division of the body into two specialized regions, the anterior for locomotion, the posterior for digestion and reproduction, has naturally led to great modification in the dermo-muscular tube, which may be assumed to have been the primitive arrangement in all articulate animals. Nevertheless, we can still refer many of the muscles of *Galeodes* to the elements of a typical Annelidan musculature. We have, for instance, both circular dermal muscles and longitudinal dermal muscles and a series of segmentally-arranged dorso-ventral muscles.

The Muscles of the Body: the Circular Musculature.—In the cephalothorax, the muscles which most obviously belong under this heading are the skin-muscles at the sides of the body, where the cuticle is soft and flexible, just above the bases of the anterior limbs, at the sides beneath the so-called "head" (Pl. XXVII. fig. 2). The distal end of the coxal gland passes among these muscles, and is then very difficult to follow. These muscles probably bring about a certain amount of movement of the "head."

As might be expected, it is in the abdomen, where the cylindrical segments are least differentiated, that the circular muscles are retained over considerable areas. The lateral flexible membrane on each side of the body is lined by a layer of circular fibres. Anteriorly, these fibres form only a single layer; posteriorly, however, the layers gradually thicken. The increase in the development of the circular muscles towards the posterior end of the abdomen is correlated with a corresponding diminution in development in the longitudinal muscles (*cf.* Pl. XXX. figs. 11, 15). These abdominal circular fibres show at times only a longitudinal striation, at others a transverse striation also; they are capable of enormous extension when the abdomen is distended after a meal.

These circular muscles are found under the flexible lateral membranes in *Scorpio* and the Pedipalpi, and both in the cephalothorax and abdomen of the Pseudoscorpions. They are also present in the abdomen of Spiders (*Lycosa*), where they seem to be evenly developed under the cuticle.

The Longitudinal Muscles.—These are also well developed in *Galeodes*. Dorsally, they run in two strong bands on each side of the median line from the tergum of the 3rd segment, part of which lies under the posterior end of the cephalic lobes, to the diaphragm, and then along the abdomen, on each side of the heart, gradually diminishing in development towards the stercoral pocket, where the circular muscles correspondingly increase in development (Pl. XXX. fig. 15). These muscles are very powerful in the anterior abdominal segments, and here belong clearly to a system of muscles which raises the whole abdomen at right angles to the ground; this, according to Walter (75), being an attitude of defence commonly assumed. It is worth noting that *Galeodes* can bend the body not only at the waist but also between the 4th and 5th segments. The Galeodidæ have thus retained more of the original play of the segments upon each other than any other Arachnid, no other being able to bend the cephalothoracic region. The raising of the abdomen seems to be common to the larger Arachnida, and in *Scorpio* it has been retained and specialized in connection with the "sting."

The ventral longitudinal muscles are more specialized than are the dorsal, and anteriorly are not always easy to recognize as such. Commencing in the soft skin at the side between the cephalic lobes and the coxæ of the pedipalps and first legs, a band runs backward on each side to be attached to the transverse fold behind the stigmata (Pl. XXX. fig. 9). From here bands run backward to the next transverse fold and on to the diaphragm. The bands here, both in front of and immediately behind the diaphragm, are very broad and powerful, and apparently counteract the elevators of the abdomen. In the 1st abdominal segment they seem to be continued up the sides of the body (fig. 11) *. In the 2nd segment they take up a more ventral position, almost meeting in the middle line in the 4th segment, from which point they again widen out until in the anal segment they appear to end in the dilators of the anal aperture (*G. arabs*).

Longitudinal muscles occur in other Arachnids more or less modified. They are perhaps most highly developed in the abdomen of *Scorpio*, owing to the specialization of the posterior segments into a tail armed with a stinging-apparatus. This abdomen and tail, as is well known, can (like the abdomen of *Galeodes*) be raised in the median plane. In Spiders the dorsal muscle-bands are probably atrophied; the ventral longitudinal muscles, however, stretch right across the posterior portion of the abdomen, at least in young specimens, while anteriorly they taper into bands on each side of the genital aperture (74). Dorsal and ventral longitudinal muscles are also demonstrable in the Pseudoscorpions and Acari.

All these abdominal longitudinal muscle-bands consist of transversely-striped fibres, although, like the circular fibres, they must be capable of enormous stretching, *i. e.* when the abdomen is distended. They serve, no doubt, to re-telescope the segments (*cf.* contracted and distended abdomens, Pl. XXIX. figs. 8 & 9).

Dorso-ventral Muscles of the Cephalothorax.—These, which are morphologically almost more interesting than the dermal muscles, are found well developed in *Galeodes*.

In the cephalothorax there is a system of five pairs of dorso-ventral muscles belonging to segments 4, 5, and 6. These slope and cross each other, running even from one segment into the next.

The general arrangement of these muscles can be gathered from Pl. XXX. fig. 9, which was reconstructed from a series of sections and is therefore diagrammatic. Hardly any attempt is made to indicate their relative strengths. It is highly probable that some of

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* Birula (23) states that normally they are attached to the area in front of the chitinous ridges on the genital opercula (Pl. XXIX. fig. 7). This quite confirms my assumption that these ridges are primitive interarticular membranes, as shown in fig. 11.

these are true dorso-ventral muscles much modified and shifted in adaptation to the special movements required. For instance, none of them meet ventrally in the middle line as the undoubted dorso-ventral muscles of the abdomen do, and as these ought to do, owing to the approximation of the coxæ in the middle line. All these muscles are situated more or less laterally; hence it is also possible that some of them may be adaptations of circular muscles. The point requires to be specially worked out. The general action of these muscles can be gathered from the figure.

The relations between these dorso-ventral muscles and the alimentary canal will be discussed in the section on the latter system. We may, however, mention that this inter-relation teaches us that the four pairs of alimentary diverticula in the cephalothorax, which are characteristic of Arachnids, indicate the former presence of at least four pairs of dorso-ventral muscles in the cephalothorax, running in the dividing planes between the last four segments. Whether any, and, if so, which of the five pairs of dorso-ventral muscles in the posterior cephalothoracic segments of *Galeodes* answer to the hypothetical four, it is now difficult, if not impossible, to ascertain. The last, inasmuch as it runs *behind* the last cephalothoracic diverticulum instead of in front of it, probably belonged to the constriction which formed the diaphragm.

In *Scorpio* only one pair is retained, viz. that in the last cephalothoracic segment; it runs down in front of, but not in contact with, the diaphragm, and is attached to the endosternite. This again probably belonged originally to the intersegmental constriction which formed the diaphragm.

In *Phrynus, Thelyphonus,* and the Araneæ four pairs of dorso-ventral muscles have been retained more or less modified as the dorsal attachments of the endosternite, and are now largely fibrous; they suspend the endosternite, on which the alimentary canal rests, and separate the alimentary diverticula in the typical manner. If the endosternite of *Galeodes* were attached by fibres to the dorsal wall, these would apparently represent the dorso-ventral muscles of the constriction behind the 3rd and 4th segments. I find in my dissecting-notes that there is such a fibrous attachment, but I unfortunately did not record the exact position.

In the Spiders the powerful muscles from the dorsal wall to the sucking-stomach are probably not adaptations of dorso-ventral muscles, but to be derived from the original œsophageal or pharyngeal muscles which are now variously developed, *i. e.* according to the position of the sucking-apparatus in relation to the nerve-mass (on the position of the sucking-stomach in Spiders, *cf.* the section on the alimentary canal).

In the Psudoscorpions there is one pair behind which the 1st alimentary diverticulum expands. It therefore apparently belonged originally to the constriction between the 2nd and 3rd segments.

The different ways in which these cephalothoracic dorso-ventral muscles have been retained is quite in keeping with the various methods of longitudinal compression which the cephalothorax has undergone (*cf.* the various developments of the diverticula in the alimentary canal).

In the Scorpions, Pseudoscorpions, and Thelyphonidæ, muscles descend from the anterior dorsal surface near the median line to the labrum. These are, apparently, the original longitudinal muscles running to the labrum, which now run dorso-ventrally owing to the present depressed position of the labrum.

Dorso-ventral Muscles in the Abdomen.—There are six pairs of dorso-ventral muscles in the abdomen of *Galeodes* belonging originally to the constrictions between the first seven segments (Pl. XXX. fig. 9). The majority of them seem now to have two points of attachment, viz. partly to the segmental constrictions—the primitive arrangement—and partly to the middle of the segments, which is a specialization found in many other Arachnids. Dorsally, these muscles are inserted on each side of the heart at no great distance from each other; ventrally, they are inserted in the median line, Those descending between the stigmata draw up the fold between the opercula, and thus, by bringing the inner edges of these latter closer together in the median line, help to close the stigmata (in Pl. XXX. fig. 16 these muscles are attached to the ridge *m.* but anteriorly to the plane of the section). This medio-ventral insertion of the dorso-ventral muscles has been already correlated with the approximation of the coxæ in the middle line.

The last two pairs of dorso-ventral muscles are in contact for a short distance in the middle of their course (Pl. XXX. figs. 9, 14).

The chief function of these muscles can hardly fail to be associated with the contents of the abdomen. They serve to compress and hold it together, especially when greatly distended by large quantities of liquid food pumped into the alimentary diverticula. Their relations to the abdominal diverticula will be referred to in the section on the alimentary canal.

Taking the cephalothoracic with the abdominal dorso-ventral muscles, we have in *Galeodes* traces of a series from the constriction between the 3rd and 4th segments to that between the 6th and 7th abdominal segments, in all *ten pairs.*

These dorso-ventral muscles are a marked feature in the abdomens of Arachnids. They are apparently least developed in the Spiders, in which animals the abdominal sac is very highly specialized. Wasmann (74 *a*) figures four pairs in the abdomen of *Mygale.* Schimkévitch (62) describes three pairs for *Epeira.*

In *Scorpio* there are in the abdomen seven pairs of powerful muscles attached either wholly or chiefly to the flat surfaces of the plate-like tergites and sternites. Dorsally they are, as in *Galeodes,* attached on each side of the heart; while ventrally, instead of meeting in the middle line, they diverge widely so as to be attached on each side at the inner edges of the limb-areas (Pl. XXVII. fig. 16, *la*). The first of these dorso-ventral muscles in the abdomen of *Scorpio,* corresponding with the pair which in *Galeodes* run down to the fold between the genital opercula (Pl. XXX. fig. 9), have become attached to the endosternite *through* the diaphragm; this has been brought about by the forward thrust of the genital aperture between the coxæ of the legs, right under the endosternite.

In the Pseudoscorpions there are also seven pairs of dorso-ventral muscles in the abdomen attached, as in *Scorpio,* to the flat surfaces of the sternites and tergites. In these cases, judging from *Galeodes,* each pair of such muscles originally belonged to the intersegmental constriction next behind it.

In *Phrynus* there appear also to be seven pairs of dorso-ventral muscles, while in *Thelyphonus* there are apparently eight pairs. In both cases, as well as in *Scorpio,* the muscles are attached ventrally in two rows, with a row of sterna between them, close to the inner edges of the limb-areas (*cf.* Pl. XXVII. figs. 16, 17, 18, *la*). In *Thelyphonus* there are therefore in all twelve pairs of dorso-ventral muscles, four in the cephalothorax and eight in the abdomen.

We thus have, in all, traces of twelve pairs (or thirteen, if those in the cephalothorax of the Pseudoscorpions are rightly homologized) of these very primitive muscles in the Arachnids, *Thelyphonus* having retained the greatest number. This is important; it shows that *Thelyphonus,* with its tail of three segments, is less specialized than *Scorpio,* with its tail of five segments. In the ancestral form the 8th abdominal segment was not specialized into a tail-segment.

The connection between these dorso-ventral muscles and the alimentary diverticula will be discussed in the section dealing with the latter system.

The "Veno-pericardial" Muscles.—These, which form a series characteristic of the Arachnids, are entirely absent in *Galeodes.* They will be described in the section on the respiration, and the reason of their absence in *Galeodes* will be discussed.

Special Musculature of the Limbs.—This need not be described in detail; we may confine ourselves to certain points of special interest.

The muscles moving the cheliceræ on the body are entirely confined to the cephalic lobes; the significance of this has already been pointed out (*cf. supra* p. 309 and Pl. XXX. fig. 9, where the shaded portion represents this musculature).

The muscles moving the other limbs on the body are not numerous, owing to the fixation of the coxæ, within which the chief muscles for moving the limbs upon the coxæ lie. Nevertheless, certain muscles, especially those for elevating the limbs, run from the body-walls or from the endosternite and help to move the trochanter and (?) femur. These cannot here be described in detail; one muscle, however, deserves attention.

A large muscle (Pl. XXX. fig. 10, *ep*) runs from the inner and upper surface of the endosternite on each side to raise the pedipalps. This muscle is of great length and its fibres are very thick. The endosternite is an infolding between the 3rd and 4th segments, whereas this elevator of the pedipalp should be attached to an infolding between the 2nd and 3rd *, as it apparently is in the Spiders. This first pair of apodemes of the endosternite of the Spiders is now presumably represented in *Galeodes* only by a pair of small fibrous plates fastened by bands to the endosternite (p. 320). The elevator of the pedipalps might at one time have been attached to these plates and have shifted secondarily in course of time on to the second pair of apodemes, *i. e.* on to the endosternite, the great expansion of which supplies a large surface of attachment.

The other limb-muscles coming from the endosternite run into the 3rd and 4th limbs, as they might be expected to do from the nature of the endosternite as an infolding between the 3rd and 4th segments (Pl. XXX. fig. 10).

The limb-muscles of other Arachnids cannot here be discussed; great differences naturally prevail, owing chiefly to the different arrangements of the coxæ. In the Arachnids with movable coxæ, *e. g.* Spiders, all the body limb-muscles are attached to these coxæ, while the limb-muscles proper (*i. e.* of the proximal joints) lie in the coxæ. In other Arachnids again, e. g. *Phrynus*, the posterior faces of the movable coxæ are prolonged as stout sclerites into the body and attached by muscles. But it is impossible here to go into details; the various developments of the endosternite alone would make any close comparison difficult and complicated.

The Muscles of the Alimentary Canal.—The anterior portion of the chitin-lined œsophagus is converted into a sucking-apparatus, which is expanded by a very powerful array of muscles attached to the walls of the beak; the contractions are brought about by a much weaker system of circular muscles (Pl. XXVIII. fig. 3). While the dilators of the œsophagus are clearly transversely striated, the constrictors are but very faintly so, if at all. On reaching the central ganglionic mass, the narrow œsophagus is surrounded by a thin layer of circular muscles. I have failed to find any cross-striation in these muscles.

On emerging from the central nervous mass, a pair (?) of muscles attach the œsophagus to the posterior fold of the cephalic lobes; their contraction would tend to draw it backward through the nerve-mass. These muscles may counteract some of the more sloping of the dilator muscles of the pumping-apparatus, which would tend to pull the œsophagus forward (Pl. XXVIII. fig. 5).

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* On the justifiable assumption that originally the muscles for each limb belonged to the segment which carries it.

There seems to be no doubt that these muscles are specializations of the primitive dilators and contractors of the œsophagus of the ancestral form.

The mid-gut is provided with a layer of circular muscles, which appear not to be transversely striated. They can be demonstrated the whole length of the mid-gut as far as the stercoral pocket, and can be seen as nearly regular hoops round the alimentary diverticula throughout the whole body. A distended diverticulum which has lost all its contents, and consists simply of a hyaline membrane with thin muscular hoops, may be easily mistaken, at first sight, for a large tracheal tube.

Well-developed longitudinal muscles also occur outside the circular (Pl. XXXIII. fig. 10, and Pl. XXXII. fig. 19, *lm*).

I have been unable to make out the exact arrangement of the muscles of the stercoral pocket. Dufour (31) has given an elegant drawing of the stercoral pocket with longitudinal and circular muscles crossing each other at right angles. I have not been able either to confirm or to revise this.

The Muscles of the Diaphragm.—I have not been able to make out any special arrangement in the muscles of the diaphragm. Anteriorly, the chitinous infoldings seem to be smooth and without a muscular layer. Posteriorly, however, there seems to be a thick felt-work of muscles, which, owing to the origin of the diaphragm as an infolding of the cuticle, are probably dermal muscles. This felt-work seems to be specially thick round the aperture through which the mid-gut passes, and I have little doubt that it acts like a sphincter muscle to constrict the mid-gut. The pair of dorso-ventral muscles descending just posterior to the diaphragm appear to have shifted forward (see Pl. XXX. fig. 9).

The portion of the diaphragm immediately under the mid-gut and above the neural aperture bends suddenly forward and runs along as a support to the mid-gut, but chiefly, I presume, in order to constitute a more resistant attachment for the muscles of the genital glands, just as the endosternite slopes backward for the powerful pedipalpar muscles.

The diaphragm of *Scorpio* seems, like that of *Galeodes*, to be smooth chitin anteriorly, but posteriorly to be covered with a fine layer of muscles. The action of the two pairs of dorso-ventral muscles, the one in front and the other behind, both in contact with the diaphragm, the former almost, the latter quite, could hardly fail to constrict the alimentary canal, both being attached to the endosternite on which the alimentary canal rests. The contraction of these muscles would squeeze the alimentary canal between the upper edge of the aperture through the diaphragm and the endosternite. Whether this action really takes place I cannot say, but I think it most probable (*cf.* section on the alimentary canal).

Pl. XXXIII. fig. 6 shows a pair of muscles in the waist of a Spider, the contraction of which would certainly constrict the alimentary canal.

Histologically, the muscle-fibres do not differ from those of other Arachnids. They are in all cases separated from each other by fine connective-tissue membranes (Pl. XXX. figs. 12). The fibres themselves are enveloped in an extremely delicate sarcolemma. In cross-section the contractile striated bands radiate from a central mass of sarcoplasm, in which is embedded a single row of nuclei.

On reaching the cuticle, the contractile bands separate somewhat, so that the area of attachment is greater than the sectional area of the muscle itself.

VI. The Nervous System.

The great condensation of the anterior end of the body of Arachnids, in the interests of locomotion, and in contrast to the sac-like specialization of the abdomen as a receptacle for food and the genital products, is reflected in the nervous system. In *Galeodes*, in spite of the fact that the cephalothorax in this animal has retained three free segments, the central nervous system is a compact mass composed of a number of fused ganglion-centres grouped round the œsophagus.

The Central Ganglionic Mass.—The dorsal or brain portion of this mass consists of several ganglionic centres, of which the most important are those from which the optic nerves arise (Pl. XXXI. fig. 2). Behind these there appear to be the centres of the nerves innervating the mid-gut (see, however, below), while in front there is a nerve-centre in the middle line above the œsophagus, which belongs to the labral nerves (Pl. XXXI. fig. 6, L). On each side of this, and also slightly above the œsophagus, are the centres of the cheliceral nerves (*ch*).

The ventral or trunk portion of the nerve-mass consists of a far greater number of ganglionic centres. The first and largest are those from which the pedipalpar nerves (*pp*) arise, situated just below the cheliceral centres and slightly at the sides of the œsophagus. The pedipalpar nerve-centres are followed along each side of the nerve-mass by a row of four nerve-centres supplying the four pairs of legs (Pl. XXXI. fig. 2, $_{1,2,3,4}$). Between these pedipalpar and leg nerve-centres, and immediately below the œsophagus, there appear to be several median nerve-centres; these are very large and important, anteriorly between the pedipalpar centres, and posteriorly between those of the last pair of legs. These median centres are in direct connection with the nerves running into the abdomen.

Not only is the condensation of the anterior end of the body thus reflected in the fusion of the ganglionic centres, but the arrangement of these latter appears to reflect the changes which have taken place in the arrangement of the anterior pairs of limbs. As we have already seen, the Arachnids are Arthropods specialized by the shifting forward of the first two pairs of limbs, the tilting up of the cheliceræ to a position above the mouth and prostomium, and to a less extent of the pedipalps, to a position at the sides of the latter. This forward and upward movement is clearly recorded in sections of the brain. The cheliceral nerve-centres, as is well known *, belong primarily to the infra-œsophageal system, and have secondarily moved up the œsophageal commissure to positions more or less supra-œsophageal. In *Galeodes* the cheliceral ganglia have travelled far up along the œsophageal commissures, so as to be practically supra-œsophageal. In this process they seem to have pushed the optic ganglia backward; at least, this action is suggested by an examination of sagittal sections such as that shown in Pl. XXXI. fig. 2.

The variations in the forms of the central ganglionic mass in Arachnids reflect the various specializations of the cephalothorax, and show, as we should expect, many differences in the relative positions of the ganglia.

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* *Cf.* Metschnikoff (54) and Balfour (1).

In the Spiders the six segments of the cephalothorax have been evenly fused together; hence the ventral part of the ganglionic mass spreads back along the floor of the cephalothorax, while the supra-œsophageal portion lies quite anteriorly (Pl. XXXI. fig. 3 *a*). The same ganglionic centres are visible as are found in *Galeodes* (fig. 3 *b*), but in slightly different, and apparently more primitive, positions. Owing to the forward projection of the cephalic lobes, in order to give the mandibles their downward slope, the optic ganglia have been drawn to the front more over the cheliceral ganglia, which appear to lie somewhat lower at the sides of the œsophagus than in *Galeodes*. Indeed, in young spiders (Epeiridæ?) just hatched the cheliceral ganglion lies on each side well below the upper level of the œsophagus, and seems, with the pedipalpar ganglion, to belong to the œsophageal commissure.

Again, the median (abdominal) ganglionic centres stretch backward beyond those of the last pair of legs; indeed it seems in the Araneids as if it might be possible to count how many original segmental ganglia the median abdominal ganglion represents, by counting the number of connective-tissue strands which pierce it in the median line.

In *Scorpio* the whole ventral surface of the cephalothorax has been pushed forward by the genital aperture, with the result that the coxæ of the pedipalps, except at their most distal ends, are no longer in contact with the ground, the coxæ of the 1st and 2nd pairs of legs being pushed forward under them. This remarkable specialization of the cephalothorax has been reflected in the central ganglionic mass, the ventral portion of which lies right forward directly under the supra-œsophageal portion (fig. 3 *c*). This is well shown in Blanchard's 'Arachnides,' pl. vi. The forward thrust of the ventral portion of the nerve-mass has brought the ganglionic centres of the nerves of the 1st pair of walking-legs under those of the pedipalps, while those of the chelicerae are well above the level of the œsophagus, and appear to be pushed round backward so as to lie in a plane posterior to that in which lie the ganglia of the pedipalps and of the 1st pair of walking-legs. (Fig. 3 *c* is hardly pronounced enough in this respect.)

This thrusting forward of the ganglionic centres composing the ventral portion of the central nerve-mass, owing to the shifting forward of the limbs, is still more marked in the Phalangidæ, in which the nerve-mass lies very largely in the transverse plane (fig. 3 *d*).

In the Pseudoscorpions the same ganglionic centres are discoverable. The enormous backward development of the coxæ of the pedipalps, driving back the coxæ of the remaining legs, finds some reflection in the brain. The ganglionic centres of the six limbs all seem to radiate from the proximal end of the root of the pedipalpar nerves (fig. 3 *e*). The cheliceral nerves seem to rise from the upper ends of the œsophageal commissures without being quite supra-œsophageal. The supra-œsophageal portion lies forward over the anterior half of the ventral portion.

The central nervous system of *Gamasus*, according to Winkler's description (76), is of great morphological interest. While the concentration of the limbs at the anterior end of the body has condensed the infra-œsophageal portion, the cheliceral ganglia are said to have retained their positions at the lower ends of the œsophageal commissures. Inasmuch, however, as the muscles moving the powerful chelicerae are inserted far back on the dorsal wall, the cheliceral nerve, in order to reach them, has to traverse the supra-œsophageal portion. This, if correct, has been brought about by the secondary shifting of the cheliceral muscles carrying the nerves, which originally pointed forward, backward over the brain until they have become surrounded by brain-substance. This is a very high specialization of a primitive condition, pointing back to a time when the cheliceral ganglia were infra-œsophageal.

The nervous centres of the Pedipalpi at my disposal were not well enough preserved for the purpose of making trustworthy comparisons.

If, then, we start from the primitive arrangement in which all the segmental ganglia were ventral in position, the nerve-centres of the Arachnids can be deduced from it by progressive forward concentration. The first movement was doubtless made by the cheliceral ganglia, following the tilting forward of the limbs they innervate, which, as we have explained, was probably the original specialization of the Arachnids as a class. The Spiders show but little advance on this. The Galeodidæ, in spite of the comparative freedom of the three posterior segments, show greater concentration of the ventral segmental ganglia than do the Araneæ with their more uniform fusion of the cephalothoracic segments. *Scorpio* shows still greater specialization, the ganglia are pushed forward so as to form an almost cubical mass surrounding the œsophagus. Lastly, in *Phalangium*, the forward movement of the limbs and genital aperture has thrust the segmental ganglia of the cephalothorax forward and upward till they lie almost in the transverse plane.

Principal Nerves.—The nerves leaving the central nerve-mass of *Galeodes* are :—

(1) The optic nerves, which run forward from behind, remaining in contact with the brain before bending upward to the eyes (Pl. XXXI. figs. 2, 5, *on*).

(2) The cheliceral nerves (figs. 4, 5, *ch*), which rise just in front of the optic nerves, and soon give off a branch (*ch'*) to the cheliceral muscles.

(3) The powerful nerves to the pedipalps, which are double, dividing into smaller dorsal and larger ventral branches soon after leaving the brain (fig. 6, *pp*).

(4, 5, 6, 7) The nerves to the other limbs, all of which are double, a fact which was recognized by Kittary, but only noticed for the two posterior legs by Blanchard. In each of the last two limbs the smaller branch accompanies the mid-gut diverticulum.

(8, 9) Three long nerves, which run straight backward from the posterior ventral end of the nerve-mass, one in the median line and the other two on each side of it. They run through the neural aperture of the diaphragm (*D*). The lateral nerves (*g*) supply the genital glands : while the median (*ab*) is the main abdominal nerve, which, after passing through the neural arch of the diaphragm, swells into a large ganglion, the abdominal ganglion ; it then runs backward immediately under the central canal of the mid-gut, innervating it and the stercoral pocket, and also apparently sending up nerves among the digestive tubules.

(10) Nerves which appear to leave the posterior end of the dorsal (supra-œsophageal) portion of the mass to supply the mid-gut. So far as I can make out, these do not leave the brain in compact bundles of fibres, but spring from the whole posterior surface of the brain wherever the alimentary canal is in contact with it. I have assumed that the centre is the mass which lies behind the optic ganglia, but I failed to find any very clear connections.

(11) The paired (or unpaired) nerves which leave the brain between the cheliceral nerves and supply the labrum (Pl. XXXI. fig. 6, L).

(12) Paired nerves leaving the anterior end of the ventral portion of the nerve-mass, supplying the labium.

(13) Two small nerves leave the brain on each side between those running into the 2nd and 3rd legs (or else branch from these in some way), and run to the stigmatic apertures (fig. 6, *stig.*).

Peripheral Nerves.—Of the peripheral nervous system I have been able to find only traces. A network of fibres runs in close contact with the hypodermis, supplying the cuticle and hairs. These nerves are sometimes marked out in white in parts of the dorsal surface where pigment has collected. I have not succeeded in tracing these integumental nerves to their sources.

The heart is very richly supplied with nerves. In portions of that organ dissected out, cleared, and examined *in toto,* it seems to be enveloped in a network of nerve-fibres which is especially developed in its dorsal wall. Fig. 7, Pl. XXXIV., is a small portion of the heart (ventral aspect) showing a layer of nerve-fibres (*n*) running longitudinally. The exact source of these heart-nerves I have been unable to discover.

A not very close network also surrounds the digestive tubules of the mid-gut, the main canal of which is very richly supplied anteriorly, apparently direct from the brain, but posteriorly also from the great abdominal nerve (Pl. XXXI. fig. 6, *ab*).

The Abdominal Ganglion.—The abdominal ganglion lies just above the genital aperture, and in all probability supplies it with nerves, although the genital glands themselves have their own independent nerves coming direct from the central nerve-mass.

It is possible that this position of the abdominal ganglion may be due to the abdominal musculature, which is only developed to any great extent in the first two or three abdominal segments (*cf.* p. 336).

The nerve which in other Arachnids is of importance for comparison is the abdominal nerve, as its ganglionic swellings may be primitive ganglia of the ventral nerve-chord which have persisted as separate centres, and have not been incorporated in the cephalothoracic nerve-centre.

In the Araneæ there are no large swellings on the abdominal nerve. In this group, as we have seen, the posterior median component of the central nerve-mass appears to consist of five or six fused segmental ganglia, *i. e.* if the connective-tissue strands which penetrate it dorso-ventrally represent primitive divisions.

In *Phrynus,* also, there are apparently no ganglionic swellings in the abdominal nerve.

The same is true of the Pseudoscorpions.

In *Thelyphonus* there is a large swelling at the posterior end of the abdomen, apparently in association with the muscles for elevating the three tail-segments and for moving the caudal appendage.

In *Phalangium* a ganglionic swelling is figured by Blanchard. This may be in association with the highly specialized ovipositors and penes, with their own musculature, which characterize this group.

In *Scorpio,* in which animal alone the musculature of the abdomen is highly developed, there are seven ganglionic swellings of the abdominal nerve*, which may again be associated with the developed musculature for the movement of the tail-segments.

The "Sympathetic."—The only other nerves to which I should like to refer are the "sympathetic." Both St. Rémy† and A. Schneider‡ describe a stomatogastric nerve as branching off laterally from the brains of Spiders. Schimkévitch also describes a pair of nerves proceeding backwards from the brain, but, like myself, failed to establish their places of origin. Blanchard figures nerves running backward from the brain on to the mid-gut of *Galeodes,* and scattered nerves running backward on to the mid-gut from the brain of *Mygale.* I have myself, as above stated, failed to find any clear connection between the brain and mid-gut in either *Galeodes,* the Spiders, the Scorpions, Pseudoscorpions, or Opilionidæ. Although the brain is, in all or nearly all cases, in contact with the mid-gut and its lobes, until I read the works of St. Rémy and Schneider I had concluded that the nerves leave the posterior surface of the brain and spread out over the mid-gut, not in definite bundles, but as single fibres, which easily

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* *Cf.* Newport (58), "On the Nervous System, &c., of Macrourous Arachnids," Phil. Trans. vol. cxxxiii. 1843, and Blanchard (24), 'Les Arachnides.'

† St. Rémy (61), 'Contributions à l'Étude du Cerveau chez les Arthropodes trachéates,' Poitiers, 1890.

‡ Schneider (64), "Système stomatogastrique des Aranéides," Tab. Zool. ii. 1891.

escape observation among the connective tissue. Further research is much needed. In the meantime, perhaps, we are not wrong in assuming that the great nerve-mass in the brain, behind the optic ganglia (which shows as a crescent in horizontal sections of Spiders, behind and half encircling the optic lobes), would be the "sympathetic" ganglionic centre.

The nerves of *Galeodes* are always in very close association with tracheæ, a fact which is interesting in connection with the close association of the nerves with the blood-passages in *Scorpio*.

Histology.—One observation seems to be worth recording. The cross-sections of the large nerve-trunks show the usual fine network which represents so many tubes cut across. But, in other parts of the body, where nerve-fibres can be seen isolated, they are exquisitely fine fibrils with fusiform nuclei (Pl. XXXII. fig. 7). These are most easily seen in the racquet-organs (fig. 1, *nf*), but can be found also in other parts of the body. What, then, are the tubes? I would like to suggest the following explanation. In order to protect the nerve-fibrils from mechanical stimuli along their courses, they run in a delicate connective-tissue framework (comparable to that which envelops the muscle-fibrils, Pl. XXX. fig. 12). The hollow tubes are filled with fluid, and the fibrils run along closely applied to their walls, the whole arrangement being an adaptation to protect the nerve from mechanical stimulus of any kind along its course. In the racquet-organs the fibrils are in no such danger; they are enclosed, at least in the shaft, in a stout cylinder of chitin, and run singly to their destinations. An examination of the points of departure of large nerve-trunks from the brain leaves little doubt that the tubes, which are at this point very large and irregular, are not the nerves themselves. The fibrils themselves are, as a rule, too fine to be distinguished in the walls of the tube, but their fusiform nuclei are often quite distinct.

I have found the same nerve-fibrils in *Scorpio*, but have been unable to demonstrate the individual nerve-fibrils in Spiders. An examination of the general structure of the nerve-strands as they leave the brain, however, leaves little doubt in my mind that the irregular tubes are but fluid-channels in the walls of which the—as a rule invisible—nerve-fibrils run. The absolute necessity of isolating the fibrils in their courses from the periphery to the brain seems certainly to require some such arrangement.

VII. The Sense Organs.

The Galeodidæ, which are for the most part great hunters, are well provided with sense organs.

We have to describe (1) the large median eyes, (2) the vestigial lateral eyes, (3) the protrusible organ at the tips of the pedipalps, (4) the racquet-organs on the last pair of legs, (5) sensory setæ, (6) certain specialized areas containing organs of unknown significance, presumed to be sensory.

(1) *The Median Eyes*.—The large pair of median eyes stand on a tubercle anteriorly in the dorsal suture, between the cephalic lobes. This tubercle, as we have seen, is probably the remains of the original dorsal surface (*cf*. p. 310).

The lenses are round glassy prominences. In the genus *Galeodes* they are very large compared with the size of the ocular tubercle, and somewhat tilted so as to look sideways, their axes making together an angle of 90°. In the genus *Rhax* (Pl. XXVII. fig. 6) the lenses are small and lie rather wide apart, looking almost directly upward.

The lens is formed by the sudden thickening of the chitinous laminæ of the cuticle, and is thus itself laminate *. As it stains deeply, it is probable that these layers are largely protoplasmic or permeated with fluid in the interest of transparency. The outermost layer of the chitin is generally wrinkled (fig. 9), as if it had shrunk by the abstraction of such a fluid. The whole eye, indeed (*i. e.* the soft parts), is abundantly provided with canals for the free circulation of fluids through all the tissues (fig. 8, *lc*).

In the angle between the globular lens and the cuticle from which it is developed a thick fold of pigmented hypodermis forms a kind of iris. It is apparently rather more pronounced than Leydig's 'iris-artige Gürtel' in the eyes of Spiders, which was only a ring of pigmented hypodermis. In *Galeodes* it is a thick and very definite fold arranged right round the retina (Pl. XXXI. figs. 7, 8, 9). Its apparent function will be presently described.

The general character of the eye can be obtained from the figures. The most remarkable feature is the thinning away of the retina in the axis of the eye, and its great development round the periphery. The relative measurements were as follows:—greatest depth of lens 25, depth of retina in the axis of the eye 3, at the periphery (posterior) 20, (anterior) 12.

The whole of the soft parts of the eye are enclosed in a well-developed connective-tissue membrane, which stretches across below the ocular tubercle (Pl. XXXI. figs. 7, 8, *m*).

The optic nerve enters the postero-median region of this ocular chamber, and immediately swells into a ganglionic mass. From the dorsal surface of this ganglion the fibres bend sharply to right and left to run in all directions to the retina-cells. Pigment-cells, with rather large round granules, begin to accompany them almost immediately they leave the ganglion, like single or double strings of beads.

The space around this ganglion, and for some way up at the sides of the retina, *i. e.* between it and the chitinous walls of the ocular tubercle, is filled with blood-cells and traversed by connective-tissue fibres. High up round the lens the circular iris-like fold of the hypodermis is filled by a close reticulum of coarse threads like a sponge (*sp*). This spongy cushion, which completely surrounds the lens in the angle between it and the chitinous body-wall, may perhaps have something to do in effecting or regulating, by means of fluid pressure, slight movements of the eye. From the flexibility of the cuticle, close round the lens (fig. 7, *fl*), some slight movements seem possible, and I have found no other mechanism for the purpose.

From the fluid space beneath the retina and around the ganglion an enormous number of channels, anastomosing freely with each other (fig. 8, *lc*), run up between the retinal cells as far as the hypodermal cells which secrete the lens. These, no doubt,

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* Bertkau (18) says that in Spiders there are more laminæ in the lens than in the cuticle. This is not the case in *Galeodes*; so far as it is possible to count the laminæ accurately, the numbers agree.

supply nourishment to the retinal cells and to the hypodermis, and fluid to the lens. The abstraction of the fluid from these canals causes the collapse of the retina and its shrinking from the lens and from the circular iris-like fold of the hypodermis, in the way shown in figs. 7, 8 (Pl. XXXI.).

Owing to the unsatisfactory state of preservation of the tissues, I have not succeeded in making out the histology of the retina. The collapse of the fluid-channels above mentioned, which perhaps kept the retinal elements distinct, in all cases confused the field. Certain important points were, however, clear:

1. There was no developed vitreous body, the hypodermis-cells (*hy*) being confined to a single thin layer of closely-packed cells with large nuclei, separated from the distal ends of the retinal cells by a very fine membrane.

2. The clear ends of the retinal cells, which were very short in the axis of the eye, but longer round its periphery, showed no differentiation into rods.

3. A short way below the commencement of the pigment-layer is found a zone of large nuclei, which are apparently the nuclei of the retinal cells. I could make out no retinulation or grouping of retinal cells round a rhabdom. I could indeed find no traces of rhabdoms, and from the very crooked courses of the retinal elements in the axial portion of the eye I doubt whether any such could have been present. It appeared to me as if the retinal cells ran singly, closely entwined by strings of pigment-granules, which, here and there, were clumped together. These pigment-clumps may, in some cases, indicate the presence of the nuclei of the pigment-cells, in the pseudopodia of which the strings of small pigment-granules are probably enclosed.

4. While the hypodermis-cells secreting the lens are naturally clear and free from pigment, those which form the iris-like fold, and which from thence line the rest of the ocular tubercle, are closely packed with very large round pigment-granules.

A comparison of the eye of *Galeodes* with the homologous eyes in *Scorpio* on the one hand (Lankester and Bourne, 45), and of the Spiders on the other (Bertkau, 18), shows how little reliance can be placed on eyes in establishing points of relationship. It is not too much to say that, according to the descriptions given, the median eyes of these three Arachnids, the Scorpions, Spiders, and Galeodidæ, are built on entirely different plans. A similarly complete difference between the lateral eyes of the Pseudoscorpions and those of the Scorpions has also been pointed out (10).

(2) *The Vestigial Lateral Eyes.*—The most interesting point about these eyes is their extreme irregularity. These lateral eyes occurred in all specimens of Galeodidæ which I have examined, sometimes in two pairs. They lie under the remarkable area at the sides of the cephalic lobes, and thus look forward and downward. This fact again suggests that these areas are quite secondary modifications developed for the purpose above described (p. 321) *since* the lateral eyes left the ocular tubercles.

These lateral eyes vary in size and shape, the anterior being sometimes long and elliptical, while the posterior is small and round; sometimes they have run together to form a long narrow single eye (Pl. XXIX. fig. 4, *le*, *Rhax melana*). The lens has entirely atrophied, and the eyes are inserted into pits on the inner side of the thick cuticle (14). It is on this account that I call the eyes vestigial, although, from the development of their nerves and the masses of pigment enveloping the retinal cells, they seem, at least in some cases, to be functional. I have not been able to make out any more of the finer details of these eyes than those which are given in the paper referred to.

The great diversity in number, arrangement, and structure of the lateral eyes of Arachnids lends some support to the view that they are secondary developments. A review of their positions and numbers throughout the Arachnida inclines one to the belief that we have in the Aviculariidæ the most primitive condition. There we find an ocular tubercle with two large round median eyes, one on each side of the median line. These median eyes are of the typical appearance of the median eyes of the Arachnida, which generally seem to have a blue-greenish colour. On each side of the median line, symmetrically arranged, on the base of the tubercle, are three eyes differing in size, shape, and appearance, as well from the median eyes as from one another. These are generally red or yellow, and often very lustrous. Whether these accessory eyes of the tubercle are later developments than the median eyes or not it is impossible to say, but I am inclined to think that, whenever they arose, they belong in their place of origin to the ocular tubercle.

In no other Arachnid are they now found on the tubercle, having, it appears, wandered off laterally on to the cephalic lobes.

In the Spiders they have not wandered far from the principal eyes, but are grouped in various ways in front of and at the sides of the principal eyes, which, as a rule, retain their positions close to the median line. This arrangement might clearly have been brought about by the obliteration of the optic tubercle.

In *Phrynus* the little groups of three lateral eyes on each side appear to have wandered off from the tubercle a short way outward and backward, leaving the median eyes in the original position, *i. e.* as in *Galeodes*, on a tubercle anteriorly in the suture between the cephalic lobes.

In *Thelyphonus* the optic tubercle is obscured, but the median eyes retain their position upon the somewhat modified anterior edge of the cephalothorax. The brilliant lateral eyes are in groups (three in each in my specimens, as in *Phrynus*), but each group has travelled further back than in *Phrynus*, and is at the edge of the dorsal surface, and far behind the median eyes.

In *Scorpio* the median eyes frequently occur on an ocular tubercle, arranged at very different points along the suture between the cephalic lobes. The lateral eyes appear to have wandered off when the tubercle was in its original (anterior) position, inasmuch as, while the median eyes have wandered backward, the lateral eyes are arranged near the anterior corners of the dorsal surface. They are in groups of from five to two.

The Phalangidæ have retained the ocular tubercle, which is very prominent, owing to the tilting of the eyes so as to look out sideways from the median line. As in many Scorpionidæ, it has shifted back along the cephalic suture. Lateral eyes occur in rare cases (*Cyphophthalmus*), but it is a question whether, in these cases, the lateral eyes are not the median eyes wandered apart.

In the Chernetidæ the median eyes have degenerated. The lateral eyes, arranged singly or in pairs, are alone present at the lateral edges of the dorsal surface. It is, perhaps, possible that the lateral eyes here, as in *Cyphophthalmus*, are the homologues of the median eyes, and that these median eyes wandered apart, on the obliteration of the ocular tubercle *. It is simpler, perhaps, to believe that the eyes spread out from the tubercle, those in the middle line having degenerated.

When the Acari have eyes they appear to be always laterally placed, and the same remarks apply to them as to *Chelifer*.

These lateral eyes are generally, if not in all cases, innervated from branches of the median optic nerve, which supports the hypothesis that they wandered off the ocular tubercle.

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* Metschnikoff ("Entwickelungsgeschichte des Chelifer," Z. w. Z. xxi. p. 71) makes no observations on the origin of the eyes.

(3) *The Protrusible Organ at the Tips of the Pedipalps.*—The invagination at the tips of the pedipalps, the sensory nature of which is evident directly its structure is taken into account, requires to be described in detail.

The chitinous mechanism is as follows:—A pair of soft-skinned lips (Pl. XXXI. fig. 10) open transversely across the tip of the limb. The ventral lip has no hard framework, but the dorsal is only soft where it is in contact with the ventral; it soon becomes a solid chitinous arch or lid, which moves on hinges at its ends (fig. 11). This lid is opened by a muscle in the next proximal joint (fig. 12, m_1); a long tendon from the muscle being attached to the lid on that side of the line passing through the hinges which is opposite to that on which the lips occur. The aperture leads into a deep conical invagination, running through the whole length of the joint, which is free in *Galeodes* (Pl. XXIX. fig. 3, and Pl. XXXI. fig. 12), but fused with the next proximal joint in *Rhax* (Pl. XXIX. fig. 4). The folded walls of the invagination gradually converge, and run down the tibia as a long tendon. This tendon is attached to a very powerful muscle (m_2), which almost fills up the proximal end of the tibia. The contraction of this muscle draws down the invagination and tightly closes the lips.

The whole of this chitinous invagination is covered by an epithelium continued down the tendon as far as the muscle, where it becomes lost to sight. The green pigment-cells (*cf.* p. 331) gravitate towards the tendon as towards the outer cuticle.

The epithelium covering the inner ventral face of the flattened conical invagination is deep, contains several layers of small nuclei (Pl. XXXI. figs. 13, 13 *a*), and is sensory. The sensory cells send fine hair-like processes through the cuticle, which project into the invagination, clothing its ventral wall like a fine velvet. These hairs are about 1 μ thick and 75 μ long; the surface formed by their tips is wavy, perhaps for the purpose of increase (Pl. XXXI. figs. 13 and 14).

The cuticle, traversed by these hair-like processes, is regularly channelled through by rows of pores close together, so that it has, at times, a net- or lattice-like appearance. It is considerably thickened, perhaps to keep the sensory area spread out. It is, nevertheless, liable to be folded longitudinally, the longitudinal bars of the latticework being thicker than the transverse (fig. 14). The dorsal surface of this sensory invagination is entirely free from such hairs, and is extremely thin and delicate. When the lips are closed the tips of the sensory hairs rest against this membrane.

When the lips are open the uppermost sensory hairs project through the gape. They are not, however, confined to this part, but continue right down to near the extreme base of the pit, where it runs into the tendon (*cf.* fig. 12). Figs. 15, 16, 17 show the organ fully protruded, this protrusion probably being effected by blood-pressure *. In this condition the sensory hairs deep down in the base of the invagination are brought into closer contact with the outer air.

As to the function of these organs there has been some difference of opinion. In

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* In its evaginated condition the outer skin is very smooth and glistens like satin, which fact would account for the following description of an eye-witness:—" When the palpi are applied to any object, a sort of phosphorescent flame seems to be emittted from them."—Murray's 'Economic Entomology,' p. 42.

describing the sharp sense of smell of these animals, Lichtenstein and Herbst (48, p. 52) state that it is chiefly localized in the hollow knob at the tip of the feeler. Dufour, however, who discovered the retractile organ itself, interpreted it as being a sucker. Koch had adopted the earlier view, which, from the above description, seems almost certainly the correct one. That it is not an organ "pour s'accrocher ou grimper" (Dufour, and recently re-stated by Bertkau, 20, and Gaubert, 32) follows from the fact that it has no teeth and no circular or radial muscles, and is lined with fine hairs on only one side, which hairs extend right down into its base, where they could take no part in any external action. Further, when fully distended (Pl. XXXI. figs. 15, 16, 17) it does not make a complete circle as a sucker must do, and is not conveniently placed, opening not downward but outward. All the observations on living animals show that the pedipalps are organs of fine sensation [*].

So far as is at present known, the only other Arachnids with invaginations at the tips of the pedipalps are the male Spiders. In these they are specialized as sexual organs; the transition between a sensory invagination and a spermatophore carrier is not difficult to imagine when we remember that the Spiders have lost the highly sensory organs which, presumably, were at one time present on the limbs, either in front of or behind the genital aperture (compare the pectines of *Scorpio* and the racquets of *Galeodes*).

In other Arachnids there is no doubt that the pedipalps, as occupying the foremost position of all the limbs, are the seat of fine sensation. The Scorpions and Pseudoscorpions use their pincers with great caution, as if feeling with them. Hansen has described and figured fine tactile hairs on the pincers of *Scorpio*. Long delicate hairs appear to rise from the bottom of cup-like pits on the pincers of some Pseudoscorpions. In *Phrynus*, within the most distal joint or claw of the pedipalps, there is a sensory area surrounded by hairs of different shapes [†].

(4) *The Racquet-organs.*—Five of these, as is well known, are found, in most, if not in all, genera, on each of the last walking-legs, two on the coxa, two on the trochanter, and one on the femur.

On comparing this with the pectines of *Scorpio* we find a striking parallel, inasmuch as the pectines in many genera show clearly that they consist of the same three joints, *i. e.* of the coxa, the trochanter, and a small portion of the femur of a pair of legs behind the genital aperture. We may perhaps conclude from this that, in the original Arachnid, the limbs both in front of and behind the aperture were provided with sensory organs on these joints.

The racquet-organs stand straight out ventrally from the cuticle of the leg as tubular outgrowths, slightly folded round their bases for the sake of flexibility. This tubular shaft varies greatly in length, being long in *Galeodes*, which runs high off the ground on its long and powerful legs, but very short in *Rhax*, which has comparatively short

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[*] "Les palpes s'agitent alors comme pour interroger l'espace" (Dufour). See, further, the account in Murray's 'Economic Entomology,' quoted in the preceding note.

[†] In the Ann. & Mag. N. H. ser. 6, vol. xi. 1893, I stated that this area sloped away sideways under the cuticle into a pocket which ran down into the next joint, and was provided, as in *Galeodes*, with sensory hairs. I have been unable to find any trace of this pocket in sections, and have re-examined the cleared specimen in which it seemed so apparent. It was some time before I found the clue to the discrepancy; the cleared specimen is apparently preparing to shed its skin, and the sensory area is repeated beneath the cuticle and reaches into the next joint, thereby giving the appearance which deceived me.

legs. There may also be some difference in the length of the shaft in males and females.

In sagittal sections the sensory processes of the pectines of *Scorpio* are seen to belong to the ventral, if not to the anterior, face of the limb, which is folded backward. They are not on the posterior face, where they ought to be if they were the derivatives of gills like those of *Limulus*.

The shaft suddenly expands into a fan, which is apparently capable of bending on the former. The more median fans are symmetrical with the shaft; those lying externally are asymmetrical, the inner or median edge being almost on a line with the shaft.

The distal edge of the fan has a fold running along its whole length. The investigation of the exact nature of this fold has been a task of some difficulty. The following description differs from that given by Gaubert (32), whose account seems to me rather too simple and diagrammatic. It is true that his drawings refer to the racquet-organs of *Galeodes barbarus*, whereas mine refer to those of *Galeodes arabs* and *Rhax* (sp.).

Compared with the depth of the whole fan (excluding the shaft) the fold is very shallow, $\frac{1}{20}$ to $\frac{1}{25}$, and not $\frac{1}{6}$, as in Gaubert's drawing [*]. The fold appears to be very similar in *Rhax* and *Galeodes*; the form in section can be gathered from Pl. XXXII. fig. 2. We have a sharp, stiff ridge (in cross-section a digitiform process), bordering the furrow anteriorly, while the posterior boundary is bolster-shaped (in section a knob-like process), which either stands straight up or bends over towards the stiff digitiform process (Pl. XXXII. fig. 3).

The nerve-endings in the specimens examined by me are not where Gaubert figures them, *i.e.* in the base of the furrow, but on the bolster-shaped ridge, in such a position that when it stands up so that the furrow is open the nerve-endings are along the most distal edge of the ridge; when, however, the bolster rolls inward against the sharp, stiff ridge, the nerve-endings would be protected by this latter ridge (*cf.* the figures).

The chitin of the whole racquet-organ is very thick and tough, and my attempts to make thin sections almost completely failed. The lateral edges of the fans are specially thickened (Pl. XXXII. fig. 4, *ch*). On the flat surfaces the ordinary staining layers of the cuticle can be made out, and an outermost refractive layer which has a very wavy external surface. The waviness is very pronounced near the furrow-edge of the fan, and may be due to the movement of the two ridges bordering the furrow in opening out and closing one against another. An irregular row of markings occurs on each face of the fan; these are apparently apertures for the passage of fine sensory hairs, which are, as a rule, destroyed. I have, however, found one or two *in situ* (*cf.* fig. 4, *sh*).

Internally the racquets show the following arrangement of tissue:—The powerful nerve, whose fibres are closely mingled with fine tracheal tubes, spreads out like a fan on leaving the shaft. The nerve-fibrils appear to run distinct, bathed in blood-fluid, for, between the fibrils, blood-cells are freely scattered. The fibrils themselves have long fusiform nuclei in their course; whether more than one to a fibril, and if so at what distance apart, I have been unable to make out (Pl. XXXII. fig. 1, *nf.*).

After traversing about halfway through the depth of the fan, the nerve-fibres no longer

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[*] Plate 3. fig. 5. It is necessary to refer to Gaubert's details, as his account is, so far as I know, the first attempt to describe the minute anatomy of these organs.

radiate so regularly outward, but have to bend about among a great network of blood-lacunæ which are limited by connective tissue (Pl. XXXII. figs. 1, 5, *ret*).

This irregular arrangement gradually becomes regular again. It appears to be as follows, my description being based upon racquets cleared in cedar oil and studied by the highest oil-immersion lens applicable (3 mm. apochromatic of Zeiss):—A thick epithelium runs in wavy folds, as shown in the diagrammatic cross-section, fig. 8. The nerve-fibres all run on the posterior side of this epithelium, largely within the posterior folds themselves. In the anterior folds, *i. e.* between the epithelium and the cuticle, the space is apparently filled with blood-fluid, in which are a few blood-cells.

Still nearer the outer edge of the fan (figs. 1 & 6) the folded epithelium flattens out again, and the nerve-fibres radiate again freely outward. They terminate in a long row of minute pores through the chitin of the outermost face of the bolster, but do not appear to project. As above described, when the bolster rolls inward towards the furrow these nerve-endings are bent down under protection of the stiff ridge. In one of my mounted specimens the bolster is standing up throughout a part of its course, apparently unable to roll round, owing to the presence of a foreign body; on each side of this tract, however, the bolster is rolled round and the nerve-endings are bent backward.

Fig. 9 (Pl. XXXII.) is the surface view of the edge of a racquet-organ of a *Rhax*, which shows the nerve-endings bent sharply round, perhaps abnormally so, owing to the pressure of the cover-glass. The protecting ridge (*pr*) has also in this case been flattened out.

I could find no trace of any muscular fibres which could effect the movements in the ridges. I therefore think that the erection of the bolster-ridge is due to fluid pressure. It seems also not improbable that the folded epithelium effects this erection by means of the fluids contained in the folds.

There is no histological resemblance between the racquet-organs of *Galeodes* and the pectines of *Scorpio* (*cf.* Gaubert). The "teeth" of the latter, however, in sagittal sections, look as if they were erectile by means of fluid pressure.

(5) *Sensory Setæ.*—The Galeodidæ are very richly provided with setæ, of which there are several specialized forms—specialized, that is, as sense-organs. I must confine myself to two, having made no special study of these structures.

1. We have the plumose hairs, which appear to be sensory, but are not necessarily so; they are generally found grouped on the inner sides of the cheliceræ, and serve, perhaps, as a felt-like barrier to prevent the escape of nourishing fluids. The elaborate sieve in front of the mouth is probably due to the concrescence of plumose hairs. On the other hand, the two long plumose hairs, one on each tip of the under-lip, look like sensory organs. In all these plumose hairs fine staining channels can be seen running out laterally from the central axis of the hair into each barb.

2. While it is probable that all the longer hairs are to some slight extent sense-organs, there are some which are highly specialized as such, notably the long fine hairs on the pedipalps and on the first pair of legs, which, as above stated, is in process of becoming a second pair of feelers.

Pl. XXXII. fig. 12 is a drawing of the tip of the first pair of legs (3rd appendage) of a small *Galeodes*, cleared in cedar oil. It shows the base of each hair surrounded by a specialized arrangement of cells. Fig. 13 is an enlarged drawing of a few of these, as seen in the cleared specimen, while figs. 14 and 15 represent others in section.

We find the base of the hair slung, in a chamber in the solid cuticle, by the hard refractive outermost layer, as above described (p. 333). Its innermost end is attached by elastic (?) fibres to the wall of the chamber. These radiating fibres thus form together a septum across the chamber, dividing it into an upper and a lower portion. The upper portion is kept supplied with body-fluid by means of a separate channel (fig. 14, *c*). which I have already mentioned. The hair itself owes its origin to a group of cells which are attached to it only by protoplasmic processes, apparently to avoid overcrowding round its small base. One, two, three, or more nerves run from the base of the hair and swell into large ganglion-cells proximally to the group of the secreting-cells. These two groups together (the secreting- and the ganglion-cells) are protected under a dome-like arrangement of cells (fig. 14, *ro*) which projects into the hollow of the limb, and is closed on all sides except proximally, where the nerves run out to join the nerve-trunks in the limb. Fig. 15 represents a small terminal hair where the protecting roof is not required.

The exact innervation of the hair I have not succeeded in making out. I am disposed to think that the nerves terminate in the septum of radiating fibres, and for the following reasons:—(*a*) I can find nothing like a nerve running up the axis of the hair; (*b*) the radiating fibres would naturally be the first to be strained or relaxed—strained on the side towards which the hair is bent by contact with an object, and relaxed on the opposite side; (*c*) the development of a special channel between the portion above the septum and the cavity of the limb may perhaps imply great physiological activity of this fibrous septum.

(6) *Other Organs of unknown significance.*—At the tips of the pedipalps and of the pair of legs, which, in the Galeodidæ, are gradually losing their claws and becoming feelers (*cf.* the Pedipalpi), remarkable sensory organs have apparently been discovered simultaneously by Bertkau (20) and Gaubert (32). In each case they occur on the upper, or dorsal, and slightly on the outer sides of the limbs. They occur in considerable numbers, but not in regular arrangement nor in any well-defined areas.

Gaubert has given a description of these organs, with a figure showing their distribution on the first leg of *Galeodes barbarus*, and Bertkau has given drawings of the appearance of the organs in section on the pedipalps of *Solpuga flavescens*. The observations I have been able to make on these organs are, unfortunately, very far from complete, especially in reference to their soft parts.

I have found three kinds:—

1. (Pl. XXXII. figs. 11 *a*, 11 *b*.) A sort of barrel-like pit in the cuticle, which appears to open externally, and from the base of which a fine pointed process rises, but does not quite reach the external aperture. Passing through the lower boundary of the barrel, the fine process is continued downward into a large bag-like cell, apparently full of fluid. At the base of this cell lies a mass of dense granular protoplasm with a large nucleus. These bag-like cells are of all lengths, and are supported in a framework of connective tissue, the cells of which often appear to belong to the bags, and indeed I cannot be sure whether

some of the nuclei in close proximity to the large nucleus just mentioned do or do not belong to the organ under discussion or to the connective-tissue cells. Owing to the large size of the bag-cells compared with the size of the external openings, the former are greatly crowded together, and at the edges of the sensory area the necks of the bags are very long, and bend away at right angles under the cuticle (fig. 11 *b*). These appear to be the commoner form in a small species (or ? young specimen) of *Rhax* from Tashkend. (Figs. 11 *a*, 11 *b*, are enlarged from fig. 10.)

2. (Pl. XXXII. figs. 16 *a*, 16 *b*.) A small conical pit with the base of the cone outermost, passes at its slit-like apex into a larger conical passage, the base being in this case innermost. I have found it almost impossible to decide whether the outer pits open at the surface of the cuticle; I am inclined to think not, but that an exquisitely fine membrane spreads over the mouth. I have found, for instance, small bodies apparently suspended over the mouths of the pits in a manner which is difficult to explain, except on the assumption that they are resting on a fine membrane; but I am not at all certain of this. From the narrow slit-like apex, where the cones pass into one another, a short chitinous tube depends, from which the soft parts are often torn away. When the soft parts are *in situ*, the appearance of the whole is as shown in the figures, and perhaps corresponds with organs described by Bertkau. The outer apertures (?) of these organs measure about 12 μ across, and are found on slight eminences, comparatively speaking, rather far apart. They seem to be always present in limited numbers, generally along the *outer* edges of the sensory areas under discussion. In fig. 12 a row of them occurred along the left edge of the dotted area, and on the right a few were found even among the hairs. They occurred also in the section fig. 10.

3. Smaller conical pits (whether with or without membranous covers I have again failed to decide) which pass very rapidly into a slit-like canal within the cuticle; this again rapidly changes into a tube of varying length which runs down freely among the soft tissues subjacent to the cuticle. These pits seldom appear circular when they reach the outer surface of the cuticle; they look, on surface view, heart-shaped, leaf-shaped, sometimes oval. They occur in great numbers (fig. 12), and, according to Bertkau, are occasionally so numerous that their apertures (?) seem to run together to form small common depressions.

The exact details of the proximal ends of these organs I have been unable to make out. The appearance is as if the soft parts had been crowded away from the cuticle, with which, therefore, they remain connected by means of long tubes. These tubes show remarkable modifications just before reaching their proximal organs. Some of Bertkau's figures appear to refer to the same, and give fairly well the general appearance of the whole structure. Figs. 17 *a* & 17 *b* give their appearance (seen by an oil immersion in optical section on the limb, fig. 12), but I am as uncertain whether I have interpreted the details correctly as I am as to what the functions of these organs may be. In these figures (17 *a*, 17 *b*) it seems as if the protoplasmic process running from the large bag-like terminal cell had been ruptured before it reached the tube to the cuticle. I failed here also to make out for certain the position and character of the nuclei of the bag-cells.

These last-described organs, which appear to be the commonest forms, were not found on the first leg of the small *Rhax* above referred to (Pl. XXXII. fig. 10).

Lyriform Organs.—I have been able to confirm Hansen's description (33) of the group of slit-like markings at the ventral edges of the cheliceræ. These were the only organs of the kind Hansen succeeded in finding in the Galeodidæ. I have also accidentally found an isolated lyriform organ among the hairs on the ventral side of the first leg of a *Galeodes*. I have made no special search for them. What these organs are, morphologically and physiologically, is at present unknown. I would suggest their probable derivation from setal pores.

As evidence in favour of this explanation of the lyriform organs, the following points deserve attention :—

1. These lyriform organs, when simple, not only agree in size with the setal pores, but also show the same variations in this respect as do the setal pores.
2. They occur singly or in scattered groups, the individual members of which either vary or agree in size, or, lastly, in closely-arranged groups.
3. They occur in places where hairs generally occur or might be expected to occur, and often among the hairs. In the latter case their size agrees well with that of the adjacent setal pores.
4. They sometimes appear to run in rows parallel with rows of hairs, and where they occur it looks as if a row of hairs was wanting.

In addition to these arguments, I would point to the pores which appear to open at and round the tips of the mandibles of *Galeodes*. These seem to be open, owing, perhaps, to the wearing away of the hard outer layer of the cuticle; and if so they may account for the poisonous character attributed by many persons to their bite. These pores are certainly setal.

There is no inherent difficulty in this suggestion; as a seta aborts, the pore with the nerve which once ran to the seta might persist and be adapted for other purposes.

On the other hand, however, I have found "lyriform organs" which have not so arisen. On the coxa of the last leg of a small *Thelyphonus*, zigzag cracks occur in the thick chitin, many in the shape of an open W. Setæ often occurred *near* them. Close examination showed that in the angles of the zigzag came the corners of the polygonal cells of the tesselated hypodermis. These organs, then, were merely slits in the chitin between the secreting-cells. I could see the nerve-fibres running among the hypodermis cells, but the chitin of these slits was so dense and refractive that it was impossible to see whether a nerve came to the surface between them or not. I think it is almost certain that they are sensory organs of some, perhaps very simple, kind.

These organs, which certainly do not rise from setal pores, do not alter my view that the ordinary lyriform organ with a cylindrical channel through the chitinous cuticle, as occurring on the underside of the cheliceræ of *Galeodes*, did arise in the way above suggested.

VIII. THE ALIMENTARY CANAL.

The Mouth and Œsophagus.—The mouth, as has already been described, is situated at the end of a beak, and is guarded by an elaborate sieve-like arrangement of bristles (Pl. XXVII. fig. 11, Pl. XXVIII. figs. 5, 6). It opens into a long œsophagus, which runs through the beak and passes through the ganglionic mass to enter the mid-gut. Within the beak the œsophagus, which in transverse section is triangular with the apex pointed downwards (Pl. XXVIII. fig. 3), can be alternately expanded and contracted, by means of a system of radiating and circular muscles, making thereby a sucking-apparatus of considerable length. This sucking-apparatus is therefore anterior to the brain. On reaching the central nervous mass, the œsophagus narrows, and its musculature is apparently confined to a layer of circular fibres, which are continued along the whole length. After passing through the nervous mass, it widens again, to end posteriorly in a blind corner (Pl. XXXI. fig. 5). The opening into the mid-gut is situated on the dorsal surface of the œsophagus (Pl. XXXI. fig. 1). No salivary glands enter this œsophagus.

The specialization of a portion of the œsophagus into a sucking-apparatus is common to all Arachnids, but a comparison of its position in the different forms leaves little doubt that in *Galeodes* we find the primitive condition. We find, for instance, the pumping-apparatus contained in a beak in such widely different groups as *Galeodes, Thelyphonus* *, and *Gamasus* among the Acarids. The Pseudoscorpions also have a beak, but the sucking-apparatus is condensed at its posterior end, although still anterior to the brain (Pl. XXVIII. fig. 10). In the Scorpions, in which the beak is much modified, and in the Phalangidæ, the sucking-apparatus or its homologue is also in front of the brain. But in these cases the shifting backward of the mouth and the shortening of the beak have also shortened the sucking-apparatus. In *Phrynus* the beak is aborted, and part of the sucking-apparatus is in front of, and part behind, the brain (Pl. XXVIII. fig. 7) The Spiders have the sucking-apparatus posterior to the brain, although a few expanding muscle-fibres still remain in front of the brain (fig. 8). In this case, that portion of the œsophagus which projects backward beyond the central nerve-mass is very considerable. The shifting back of the portion specialized for sucking is no doubt to be traced to the shifting backward of the mouth, which goes furthest in the Spiders †.

Specialization of the œsophagus itself seems to have gone furthest in some Phalangids, in which the portion of it posterior to the brain is developed into an enormous "crop."

I know of no salivary glands in the Arachnids. The single pair of mid-gut diverticula in front of the diaphragm in *Scorpio* have been usually taken for such glands, but this is incorrect, the epithelium of this first pair of diverticula not differing in any essential from that lining the following (so-called "liver") diverticula.

This absence of salivary glands in the Arachnids is perhaps to be explained in the following way:— In the Insecta, where the mandibles and maxillæ have been much reduced and highly specialized as organs of mastication, grouped closely round the mouth, the acicular glands (from which I would deduce the salivary glands as well as the spinning-glands and tracheæ) might easily be specialized as secreting-glands opening within the oral aperture. But in the Arachnids, where the first pair of limbs, and later the second also, are primarily highly-developed seizing-organs (the chelicerae being typically 3-jointed, the pedipalps 6-jointed), and where there is typically no attempt to group them closely around and within the oral aperture as masticatory organs, the absence of salivary glands is what we might expect. It is true, the basal joints of the pedipalps of the Spiders have been secondarily developed as a pair of mouth-organs; but they are not chewing-jaws. In this case, it is of great interest to find that groups of glands which are probably derivatives of setiparous glands ‡ have been modified to form the so-called "maxillary" glands, whose function, however, is not yet clear.

This complete absence of chewing-jaws round the mouth in Arachnids (except, according to Mr. Michael, in some Acari) is closely associated with their method of feeding. The Arachnids suck in liquid food by means of their pumping-apparatus. The chelicerae and pedipalps are variously specialized in order to crush the juices out of prey close in front of the mouth. This method of feeding has had

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* *Galeodes* and *Thelyphonus* are, however, connected by *Schizonotus*.

† Stecker, in his paper on *Gibbocellum*, figures the mouth behind the basal joints of the pedipalps. This is such an obvious error that one can hardly help taking it for a misprint.

‡ *Cf.* figs. in Schimkévitch, 'Anatomie de l'Epéire' (62).

far-reaching consequences, and, indeed, we owe to it the special morphology of the group, viz.: the character and position of the anterior seizing-limbs, and the division of the body into an anterior locomotory region and a posterior highly distensible food-bag.

In adaptation to this liquid food we have apparatus (1) for preventing the escape of the juices crushed out in front of the mouth, and (2) for straining them so that no solid matter finds its way into the alimentary system.

Special Apparatus for conducting and straining juices.—The juices flowing from the wound made by the cheliceræ are conducted towards the tip of the beak by bushy rows of plumose hairs which run along the digits of the cheliceræ on their inner sides. The juices are strained by the sieve-like arrangement at the tip of the beak already described (Pl. XXVIII. fig. 6). In one of my series of sections, the outside of this sieve is thickly covered with moth's feathers and scales. A few of these were also found in the digestive tubules, and in each case embedded in small masses of blood-plasma, which, apparently on account of their presence, had not been taken in and turned into food-globules by the digesting-cells (11).

Thelyphonus also has a beak, but it is enclosed between the basal joints of the pedipalps, which are fused below it, but are open above it (Pl. XXVIII. fig. 12). The cheliceræ crush the prey into the channel thus formed by the coxæ of the pedipalps, and the juices are drawn in by the powerful pumping-apparatus. They are strained by transverse rows of fine hairs, which line the aperture (figs. 12, 13, *st*). In *Phrynus* the pedipalps are not fused below, but their inner faces are covered with fine hairs and they can be apposed. Their upper inner faces are provided with specialized "gutters," *i. e.* one on each side, for conducting the juices to the mouth, as Gaubert (32) has already pointed out.

The Phalangidæ are also said (McLeod) to have similar gutters, or, as they have been somewhat inappropriately called, "pseudotracheæ." In *Scorpio*, the coxæ of the pedipalps, which are generally adapted among the Arachnids to prevent the escape of fluids, have been forced apart by the squeezing forward of the two following coxæ, which, again, may have been forced forward by the anterior translocation of the genital aperture. To prevent the escape of juices, therefore, processes of the coxæ of the first and second pairs of legs have developed forward, and together form a sort of spoon-like structure under the mouth (Pl. XXVIII. fig. 9, l_1). Fine hairs prevent the juices from escaping between these coxal processes, and a pair of "gutters" (*Euscorpio*) conduct back any which happen to be escaping in that way (Pl. XXVII. fig. 9 *b*, *g*).

The Spiders apparently apply the oral aperture to the wound in the prey, the dense tufts of hairs on the parts bordering the mouth and on the coxæ of the pedipalps hindering the escape of the juices. The straining-apparatus is very highly developed. The entrance to the œsophagus between the labrum and labium is a long transverse slit provided with transverse rows of fine straining-hairs; between these rows of hairs are gutters sloping upward and inward to open, in some cases, through windows into a central gutter which itself gradually widens into the œsophagus proper. The latter is prevented from collapsing under the powerful sucking-action by its solid chitinous dorsal wall.

The only exception I know to this order of things is the case of an unknown Phalangid (already mentioned), which I cut in sections for some special purpose, and found, to my astonishment, that behind the brain the œsophagus formed a large muscular 'crop' which was full of solid particles. As there were none in the stercoral pocket, I presume that this is some special arrangement of the sucking-apparatus, and that the solid matter is again ejected through the mouth.

The Mid-gut.—The œsophagus, in *Galeodes*, is not in a continuous straight line with the mid-gut, but doubles back slightly on itself, so that, with the mid-gut, it forms an S-shaped bend (Pl. XXXI. fig. 5), the lower loop of which gives rise to the blind pocket above described. This bend in the œsophagus may perhaps be an indication of the compression of the first three segments.

The mid-gut itself pursues a straight course backward to the commencement of the hind-gut. It is lined, apparently throughout, by an epithelium of cylindrical cells, which vary in depth in different parts (Pl. XXXIII. figs. 10, 11); they are specially long just before reaching the hind-gut.

In nearing the diaphragm, the canal narrows considerably, and in passing through it, its lumen is very small (Pl. XXXIII. fig. 1, and also figs. 2, 3, 4, which are drawn to scale). After passing the diaphragm, the lumen increases greatly in size, and then gradually narrows again in the 4th abdominal segment, remaining narrow until it joins the hind-gut (Pl. XXXIII. figs. 1 & 5).

The mid-gut of *Galeodes,* as of all Arachnids, is supplied with diverticula for the reception of the liquid food. These originally segmental diverticula were, in their simplest condition, probably inherited structures. It is not impossible that there is some relation between their present enormous development in the abdomen, where they fill up every available space, and the pumping-apparatus—that is, the latter may have helped to specialize the former by its force-pump action.

For convenience, we divide these diverticula into two groups, the cephalothoracic and the abdominal, although, morphologically, they belong to one and the same series. But, while the diverticula in the muscular cephalothorax show signs of degeneration, those in the abdomen, which is specialized into a distensible sac, are, as stated, developed to an astonishing extent (*cf.* Pl. XXXII. fig. 18 with Pl. XXXIII. fig. 5).

The Cephalothoracic Diverticula.—In the cephalothorax, the mid-gut of *Galeodes* gives off four pairs of thin diverticula towards the four pairs of legs: the two anterior pairs do not run into the legs themselves, and are apparently atrophying; they are often found folded back upon the gut (Pl. XXXII. fig. 18). The two posterior pairs penetrate into the limbs as far as into the trochanter. These two usually have a branch about halfway down their lengths. This tendency to branch in the posterior cephalothoracic diverticula is interesting as leading on to the highly-branched diverticula in the abdomen. The anterior segments of the body were here again clearly those first specialized. These cephalothoracic diverticula are provided with powerful circular (*cm*) and longitudinal fibres (Pl. XXXII. fig. 19, *lm*).

These four pairs of diverticula, running towards or into the four legs, seem very typical of Arachnids, being found in *Galeodes,* the Spiders, *Phrynus, Thelyphonus* (Laurie), and *Phalangium* (Blanchard), and lead us to conclude that in the primitive form the œsophagus ran through two segments, while in the 3rd segment the mid-gut commenced, sending out lateral diverticula in this and in the following three segments, omitting for the moment all mention of the abdominal diverticula.

That these diverticula were originally separated one from another by dorso-ventral muscles we have sufficient evidence. Although, in *Galeodes,* these muscles in the cephalothorax are no longer, with certainty, recognizable (*cf. supra,* p. 336), in the Spiders we have the dorsal suspensors of the endosternite regularly separating the diverticula; the same is apparently the case in *Phrynus* and *Thelyphonus.*

In those Arachnids in which there are no longer the four typical cephalothoracic diverticula, as *Scorpio* and *Chernes,* this is due to secondary reduction. In the former case (*Scorpio*) it must be accounted for by the extraordinary longitudinal compression of the cephalothorax. Instead of the typical four pairs of diverticula, we find in *Scorpio* only one pair, which have often been taken for salivary glands.

In the Pseudoscorpions also there is only one pair of diverticula in the cephalothorax, but in these animals the diverticula are not so specialized; they are only shallow lateral outpushings of the mid-gut, which might easily run into one another, so that the segmental divisions may have become obliterated.

Passing on from these four pairs of diverticula, the last two, as above stated, showing a tendency to branch, we find in *Galeodes*, immediately in front of the diaphragm, numerous small branched accessory diverticula (Pl. XXXII. fig. 18, *ad*), resembling those behind the diaphragm. These are interesting, as they seem to show the action of the pumping-apparatus in causing diverticula to appear irregularly, wherever, in fact, there is room among the tissues for their development.

Behind the diaphragm, the whole cavity of the abdomen which is not occupied by the genital glands, the stercoral pocket, tracheæ, &c. is filled to distension with diverticula.

The Abdominal Diverticula.—The abdominal diverticula are hooped by fine circular muscles, like those of the cephalothorax. These circular fibres are 4–5 μ apart in the contracted normal condition of the diverticulum, with the epithelium *in situ*, but 8–15 μ apart in distended diverticula, with the epithelium disorganized by food (*cf.* 11).

The distinction often drawn between the mid-gut diverticula in the cephalothorax and the "liver" diverticula in the abdomen is erroneous. As I have shown elsewhere (11), the epithelium of these diverticula throughout the whole mid-gut from the posterior end of the œsophagus to the commencement of the hind-gut is essentially similar, and is throughout digestive in its function. The differences which appear in the epithelia of the cephalothoracic portions of the mid-gut and of the abdominal are not differences in kind; they are due to the fact that the latter have far more food pumped into them to digest. The diverticula throughout the Arachnida are typically mere extensions of the digestive surface, and are nowhere converted into hepatic or pancreatic glands.

This uniformity of the epithelium in the diverticula throughout the whole alimentary canal is true of *Galeodes*, the Spiders*, *Scorpio*, and *Chernes*. Laurie (47) claims a difference between the epithelium of the cephalothoracic and abdominal diverticula in *Thelyphonus*. I would suggest that the difference noticed by him is accidental, and due chiefly, as above suggested, to the state of the contents and consequent activity of the cells. I can see no essential difference between the two in my own sections of *Thelyphonus*.

It is a difficult and tedious operation to dissect out the connections of the diverticula with the central canal in the abdomen. I do not believe that any clear idea of the arrangement of the diverticula can be obtained in this way. It was only after carefully reconstructing serial sections of the abdomen that the following remarkable arrangement was discovered.

As shown in Pl. XXXIII. fig. 1 (*cf.* also the section fig. 4), close behind the diaphragm, a large group of diverticula open into the alimentary canal on each side somewhat dorsally. There is no difficulty in finding the apertures of these diverticula in sections, on account of their size and importance.

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* In the Spiders there appear to be a few highly-specialized cells scattered irregularly in the epithelium of the abdominal diverticula, which are not simply digesting-cells.

There is no other opening into the central canal. For a long time I was convinced that a second pair of apertures existed in the 7th segment. A great accumulation of fæces (Pl. XXXIII. fig. 7, *f*) is frequently found outside the central canal, far back, near the stercoral pocket, but in adjacent diverticula. This, I concluded, must pass into the hind-gut without having to travel forward again all the way to the 1st segment. But fresh series of sections have shown that there is no entrance here into the mid-gut.

Behind this anterior pair of openings the tubules which fill up the abdomen open into two lateral canals, which run backward more or less symmetrically from the anterior pair of openings to nearly the end of the body (Pl. XXXIII. fig. 1). The tubular diverticula opening into these lateral canals show no regular arrangement, but branch out dorsally and ventrally, *i. e.* above and below the great tracheal trunks which run along outside the lateral canals (Pl. XXXIII. fig. 5). They are arranged in irregular groups, alternating with tufts of branches from the main tracheal trunks. In distended animals, the diverticula hang down on each side of the great medio-ventral blood-sinus, which is continuous with the neural aperture through the diaphragm (Pl. XXXIII. figs. 3, 4, *n*, and Pl. XXXIV. fig. 8, *vs*). This blood-space is especially large under the stercoral pocket in such cases, and is here often found filled with a solid mass of coagulum.

The lateral canals run outside the series of dorso-ventral muscles. Posteriorly, they are applied in a remarkable manner to the end of the mid-gut, being bound together over it and under it by muscle-bands. The arrangement is seen in Pl. XXXIII. figs. 1 & 7. Where the lateral canal at this place is in contact with the mid-gut, its epithelium is modified into a kind of supporting tissue (fig. 7, *mep*). It appears as if each cell had become vacuolated, while its wall stiffened. Between this curious supporting epithelium and the actual wall of the mid-gut is a layer of fine blood-lacunæ with coagulum, granules (? digested matter), tracheæ, and (?) cells. It is in this part of the lateral canal that the accumulations of fæces above mentioned are found (*f*), which led me at first to believe that there must be an opening here into the mid-gut (*mg*).

These lateral canals, therefore, supply a means of constricting the mid-gut just anterior to its entrance into the hind-gut. The muscle-bands (*tm*) binding the two above and below the mid-gut are connected by means of the rigid-looking, highly modified epithelial cells of the inner walls of the lateral canals. The muscles with these epithelia form a hoop round the end of the mid-gut. Some power of constricting the mid-gut at this place is, as we shall see, a necessary adaptation to the Arachnidan method of feeding.

The number and arrangement of the abdominal diverticula in other Arachnids are of great interest, inasmuch as they were originally segmentally arranged.

Scorpio.—We find, in serial sections as well as in dissection, five pairs of primary diverticula leaving the central canal at regular intervals in the first five segments of the abdomen. As with the first pair in *Galeodes,* these diverticula open into the mid-gut latero-dorsally. From their openings into the mid-gut, the diverticula immediately branch out in all directions, forming the compact lobes of the so-called liver. These lobes are strictly segmental, and are separated from each other by the dorso-ventral muscles (Pl. XXXIV. fig. 1, *dvm*). The fifth pair of lobes run backward, filling up the rest of the distensible portion of the abdomen.

In this regular serial alternation of the diverticula with the dorso-ventral muscles, *Scorpio* has undoubtedly retained a primitive feature which has been lost in *Galeodes*. Before connecting the two forms, we will describe the condition in the Thelyphonidæ and Pseudoscorpions.

Thelyphonidæ.—As Laurie has described (47), there are four pairs of diverticula from the central canal, alternating regularly with the dorso-ventral muscles. The fourth pair stretches back on each side inside the rows of dorso-ventral muscles, and is itself constricted by them, while the central canal becomes transformed into what is functionally a hind-gut (Pl. XXXIV. fig. 2).

Pseudoscorpions.—The canal gives off one median ventral and two lateral diverticula in the first segment; the latter run backward on each side of the central canal and are regularly constricted by the dorso-ventral muscles (Pl. XXXIV. fig. 3).

I have placed these four types of the alimentary canal side by side in Pl. XXXIV.: *Scorpio* fig. 1, *Thelyphonus* 2, *Galeodes* 4, and *Chernes* 3.

From the segmental character of the diverticula separated from each other by dorso-ventral muscles, we are, I think, justified in assuming that in the primitive form there were originally at least seven pairs in the abdomen before reaching the chitin-lined hind-gut, which appears to have begun between the 7th and 8th segments. We should then have the primitive arrangement, consisting of seven pairs of diverticula separated from one another by six pairs of dorso-ventral muscles. I have shown this hypothetical primitive condition in fig. 5 and also, slightly altered, in Pl. XXXIII. fig. 12.

To what are we to attribute these various modifications of the primitive segmental arrangement? It is at once apparent that in all cases the posterior diverticula degenerate, while the few anterior diverticula which persist are of increased size and importance. We shall not be far wrong if we see in them various adaptations to the method of feeding. I would throw out the following suggestion.

The forcing of the liquid food into the alimentary system has to be regulated, otherwise it would be driven straight out through the hind-gut and anus. We accordingly find the central canal so narrowed in its course that masses of fæces could easily be utilized to stop the passage. Thus the food would tend to be pumped chiefly into the anterior diverticula, which would become highly developed, while the posterior would degenerate. The longer the hind-gut is, the further back would such stoppage occur, and the greater the number of the diverticula which could develop. Hence the great number in *Scorpio*. In *Galeodes*, where the dorso-ventral muscles, meeting ventrally in the middle line, are near together, the greatly enlarged anterior diverticula grew backward outside them; but in *Thelyphonus* and *Chernes* these muscles are wide enough apart to allow the anterior diverticula to grow backward between them alongside of the central canal.

Phrynus is said to have four pairs of abdominal diverticula. I can find only three pairs; the arrangement in other respects closely resembles that of *Thelyphonus*, the smaller number of diverticula being perhaps connected with the shortening of the hind-gut by the loss of the tail.

There seems to be great difference of opinion as to the number of abdominal diverticula in the Spiders. Wasmann (74 *a*) figures two pairs in *Mygale*. Bertkau, who studied this subject with great care, concluded that, in addition to certain small diverticula, entering irregularly into the central canal immediately behind the waist, there are five primary diverticula—a median ventral, which may compare with the median ventral diverticulum in the Chernetidæ, and two pairs of lateral. These median ventral diverticula may perhaps be treated as accessory outgrowths of the mid-gut due to the action of the force-pump arrangement of the œsophagus *.

In the Phalangidæ and Acari we have altogether different conditions. In the former we have a reduction to six abdominal segments, and in the Acari very variable reduction—in some cases the abdomen consists of only three segments †. We should therefore hardly expect abdominal diverticula to be developed in such cases.

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* Bertkau (16) calls these diverticula "glands," under the influence of the old name, the "liver."

† *Ixodes*, which has carried the distensibility of the abdomen to an extreme, develops 10 segments, which, as in the Spiders, early become obscured: Wagner (73).

For a comparative account of the epithelium lining these digestive diverticula and of the "peritoneal" cells covering them externally, which latter are generally absent in *Galeodes*, occurring only here and there, but are common to all other Arachnids, *cf.* "Notes on some of the Digestive Processes in the Arachnids," Journ. Royal Microsc. Society, 1893.

The Malpighian tubules open into the mid-gut in the 4th segment, where the gut narrows (see Pl. XXXIII. fig. 1, and the section on excretion, p. 380).

The Hind-gut and Stercoral Pocket.—The passage from the mid- to the hind-gut takes place in the region of the 7th segment; it can easily be made out in sagittal sections of distended specimens. The long club-shaped cells suddenly cease, and the chitin-lined hind-gut commences (Pl. XXXIII. figs. 8, 11). The posterior portion of this hind-gut is specialized into what is called a stercoral pocket, which is simply a great enlargement of its dorsal wall. In the contracted condition of the abdomen it reaches far forward, but much less so when the abdomen is distended.

In order to increase the surface of the stercoral pocket in *Galeodes*, its wall is thrown into elaborate folds, between which the fæcal masses are pressed, having, as I have shown elsewhere (11), digestible material absorbed out of them. Great masses of fæces are retained in this pocket for such final absorption. I have only seen traces of an extremely thin tesselated epithelium on the outer side (*i. e.* on the side towards the body-cavity) of the thin chitinous membrane, with minute, rather closely arranged nuclei. In addition to this epithelium, there is a thin layer of muscle-fibres, but their exact distribution round the pocket is very difficult to make out; I could find no such regular basket arrangement as that figured by Dufour (31).

Further, when we remember that many of these animals live on scorching sands, where an economy of fluid matter is a necessary condition of existence, we may well believe that one function of this hind-gut is to dehydrate the fæces [*].

The anus is a large median slit, sometimes placed ventrally (*Rhax*), but, as a rule, posteriorly, in the anal segment.

The great variation in the hind-gut of Arachnids is a point of no small interest.

The Spiders have the posterior abdominal segments much shortened; hence we find the stercoral pocket developed dorsally, as in *Galeodes*, as a receptacle for the fæces [†].

In *Scorpio* the hind-gut, commencing in the region of the 7th segment, runs through the long specialized tail-segments as a straight tube, showing no enlargement as a stercoral pocket.

In *Chernes* we seem to have a long coiled hind-gut, showing further a slight enlargement anterior to the anal aperture.

In *Thelyphonus*, the hind-gut runs through the three tail-segments as a thin tube, while an anterior enlargement functions as stercoral pocket. The greater part of this enlargement appears to me to be chitin-lined, the chitin commencing a little behind the entrance of the Malpighian tubules

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[*] It has long been recognized that this is a conspicuous function of the mammalian hind-gut (*cf.* Edkins, Journ. of Physiol. vol. i. p. 459).

[†] Kischinouye (40) claims that the stercoral pocket of the Spiders is of mesodermal origin, and Laurie (47) that that of *Phrynus* is endodermal. In view of the presence of a chitin-lined hind-gut in *Galeodes*, *Scorpio*, and *Thelyphonus* reaching, at least in the two former, to the 7th abdominal segment, I think there must have been some error in interpreting the phenomena (*cf.* note, p. 380).

(Pl. XXXIV. fig. 2). As in the hind-gut of *Galeodes*, the chitinous wall is thrown into countless folds, which are found caked with coagulum, and thus much obscured. Laurie attributes the whole of this stercoral pocket to the mid-gut.

In *Phrynus*, my sections (not very well preserved) seem to show a similarly sudden change in the 7th segment, from mid-gut to hind-gut, as is seen in *Galeodes*.

The relative lengths (measured in segments) of the different portions of the alimentary canal in the ancestral Arachnid may be stated as follows :—

The œsophagus ran through two segments.

The mid-gut had originally four pairs of segmental diverticula in the cephalothorax (reduced to one pair in *Scorpio* and *Chernes*), and presumably seven pairs in the abdomen. It thus ran through eleven segments. We shall see further (footnote, p. 367) that there is reason to believe that there were originally 12 pairs of diverticula.

The hind-gut, therefore, ran from the 14th or 15th segment to the end of the body, and has been variously specialized in adaptation to the progressive shortening of the abdomen.

Review of the Alimentary System.—In endeavouring to understand these variations in the morphology of the alimentary canal in the Arachnids, we have to appeal to its physiology.

The typical food of the Arachnids is essentially fluid, *i. e.* the body-juices sucked from prey seized, held, and crushed in front of the beak or mouth. These juices are, in nearly all cases, carefully strained by special apparatus in front of or in the mouth. By means of a special pumping-apparatus (developed primarily in the beak) this liquid food is forced into the mid-gut and its diverticula, giving rise even to accessory diverticula where space among the tissues could be found for them. This method of filling the mid-gut with fluid requires regulation. We find, for instance, that but a small quantity of this food runs into the cephalothoracic diverticula, whose serious distension would interfere with the highly-developed musculature of this region of the body. Undue distension of the cephalothoracic diverticula is perhaps prevented by their muscular tissue (Pl. XXXII. fig. 19), which appears to be much more powerful than that of the abdominal diverticula. After simply filling the cephalothoracic diverticula, the food flows on into the abdomen, where the highly specialized diverticula are filled to their fullest capacity. Galeodidæ are often found with enormous abdomens, reminding one of females distended by eggs; on dissection, the distension is found to be due to food. The abdomen of Spiders can even be seen to swell while they drink; and carmine particles mixed in the water are found at the tips of the diverticula (Bertkau). Most remarkable of all, the ticks, when once attached to a host, having practically an unlimited supply of food, distend so enormously that their skins are specially strengthened, as much, perhaps, to prevent them from bursting themselves as from being easily burst by the scratching action of the host.

With regard to the mechanical movements of the distensible bag-like receptacle for the liquid food, when there are rigid tergites and sternites, the segments telescope into each other, while laterally there is a strong flexible membrane (*Galeodes, Scorpio, Chernes, Pedipalpi*). In the Spiders, many Acari and Phalangids, the whole abdominal integument seems to be equally extensible. In *Scorpio* only seven, and in *Thelyphonus* nine, segments are capable of distension (*cf.* Pl. XXIX. fig. 14).

The constriction of the mid-gut by means of the diaphragm takes place in *Galeodes* (*cf.* Pl. XXXIII. figs. 2, 3), *Scorpio*, and Spiders (Pl. XXXIII. fig. 6), and very probably in all Arachnids which have diaphragms or waists. This is an arrangement quite in keeping with the distension of the abdomen by forcing liquid food into it by means of the pumping-apparatus. The constriction serves to prevent the food from flowing back into the cephalothorax. In *Galeodes* and the other Arachnids with the sucking-apparatus in front of the nerve-mass, the long, narrow œsophagus, as it passes through the brain, is supplied with circular muscles which would prevent the fluid from returning into the pumping-apparatus. In the Spider *Lycosa*, and, according to Schimkévitch, in *Epeira*, there is a well-developed sphincter for constricting the passage immediately behind the sucking-apparatus. In the Spiders the constriction by the muscles in the waist must therefore be primarily to relieve the cephalothoracic diverticula from pressure when the abdomen is fully distended.

We can thus understand the progressive rudimentation of the cephalothoracic diverticula seen in many Arachnids. Their presence is more or less a hindrance to the musculature, which is as highly specialized in the thorax as the mid-gut is in the abdomen. Further, the comparatively feeble development of the epithelia of the cephalothoracic diverticula is, as above suggested, referable to the limited amount of food which they receive.

One further arrangement is necessary, and this is to prevent the liquids being forced through the central canal of the mid-gut into the hind-gut or stercoral pocket. As the pressure must be very great to drive the food to the tips of the innumerable diverticula, distending them to their utmost, there must be some arrangement to keep it from escaping into the hind-gut.

In *Galeodes*, we find (Pl. XXXIII. fig. 1) that the central canal narrows greatly in the fourth abdominal segment. Here, then, the canal might be constricted, perhaps by its own circular muscles, especially if fæcal masses were present and helped to choke up the passage (in fig. 5 two masses of fæces are seen in the passage). In this way, it is obvious that the food would be driven most easily into the anterior pair of openings, and from these, along the lateral canals, into the diverticula. We find a similar narrowing of the canal in *Thelyphonus*, sufficient, if fæces were present, to force the fluid to the end of the persistent lateral diverticula. Further, the singular arrangement above described, and shown in Pl. XXXIII. fig. 7, is clearly for constricting the extreme end of the mid-gut. In hungering and contracted specimens we find the end of the mid-gut closed by folds of the hind-gut (fig. 9).

In *Scorpio*, the fresh liquid food is probably prevented from escaping posteriorly by muscular constriction of the hind-gut, assisted by the presence of fæcal masses in the central canal. In a small, contracted specimen of *Euscorpio*, I found that the canal, at the junction of the mid- and hind-guts, made a loop which would assist in arresting the progress of fluid.

In the Pseudoscorpions, the fluid would be readily pumped into the large primary diverticula. The long narrow hind-gut is generally filled with fæces.

The Fæces.—The waste products of digestion, the fæcal "crystals," which, as I have shown (11), are substantially identical in all Arachnids, would find their way back from the anterior diverticula straight into the central canal, in which fæcal masses are found in considerable quantities. Posteriorly to this first and only pair of apertures, however, the fæces must travel forward along the lateral canal to the anterior opening. The raising of the abdomen at right angles to the body might perhaps assist in bringing the fæces forward towards these apertures; but how the fæces themselves travel up those diverticula which depend on each side of the body (Pl. XXXIII. fig. 5) is a problem which I have been entirely unable to solve. The difficulty becomes still greater when the epithelial cells leave the walls of the diverticula, the tips of which become mere bag-like receptacles for fæcal crystals. The circular muscles, which are easily demonstrable, may perhaps bring about some kind of peristaltic action. If longitudinal muscles are also present on the abdominal diverticula, as they are on the cephalothoracic, the process would be facilitated.

This problem presents itself in all Arachnids: How do the fæces find their way from the tips of the diverticula back into the central canal? The Spiders appear partly to have given up the attempt, and some proportion of the fæcal "crystals" appear to pass out through the walls of the diverticula (especially at their tips), and are apparently carried away by the Malpighian vessels (11).

IX. THE HEART AND THE CIRCULATION.

The Dorsal Vessel.—The dorsal vessel, or heart, of *Galeodes* is a long tube extending from about the 4th or 5th segment anteriorly to the 13th posteriorly. It is extremely delicate, and, for the size of the animal, unimportant, this fact being attributed, according to the well-known principle, to the great development of the tracheal respiratory system.

In spite, however, of this feeble development of the dorsal vessel in *Galeodes*, it has retained certain primitive features, viz., great length and a great number of ostia, viz. eight pairs—two in the cephalothorax and six in the abdomen. These ostia, in the abdomen at least, are strictly segmental and occur under the posterior third of each tergite (Pl. XXX. fig. 15), just in front of the dorso-ventral muscles. The longitudinal section of the last chamber of a heart of a *Rhax* whose alimentary canal was empty, and the abdomen consequently somewhat telescoped together, is given on Pl. XXXIV. fig. 6.

In addition to these eight pairs, there appear also to be indications, viz., a swelling of the aorta, of an extra chamber anteriorly (Pl. XXXI. fig. 5, *h*), which would imply that there were originally at least three pairs of ostia in the cephalothorax.

The ostia are on the dorso-lateral surface of the heart, and the valves are formed by fine membranes attached posteriorly to the lips of the ostia and floating forwards on the blood-stream. The lower membrane (or edge of the valve-tube) is attached anteriorly to the floor of the chamber (Pl. XXXIV. fig. 6). On contraction of the heart, these membranes would be forced up against the dorsal surface of the lumen and the aperture would be closed.

The anterior end of the heart is produced into an aorta, which runs through the mass of tubules developed at certain times (? or in different species) by the proximal ends of the coxal glands, and appears to discharge the blood direct on to the central nerve-mass (Pl. XXXI. fig. 5).

The posterior opening of the heart, which is valvular, the valve being formed by a simple membranous infolding of the walls (Pl. XXXIV. fig. 6), is immediately in front of the stercoral pocket. The heart is continued into a vein, which appears to end just behind the stercoral pocket. In transverse sections, the heart is seen to be suspended by strands of connective tissue which, dorsally and dorso-laterally, are attached to the body-wall, but ventrally radiate outwards on each side into regular wing-like arrangements of strands, which lose themselves among the digestive tubules (Pl. XXXIV. fig. 8). These wing-like strands may act as elastic expanders of the chambers of the heart; their chief function is, however, almost certainly to keep the heart from being too compressed when the abdomen is tightly distended with food.

Suspended on these strands and scattered about all around the heart large cells are found, the function of which I have not ascertained; they may be connective-tissue cells specialized as reserve cells, and suggest an incipient fat body, such as is found on each side of the heart in many Hexapoda. The heart itself is very delicate, and consists of but a single layer (ca. 6 μ thick) of striated muscles lined on the inner side by a fine refractive membrane (Pl. XXXIV. fig. 6). Outside the heart ventrally there is a single layer of nerve-fibres closely applied to it and running longitudinally (Pl. XXXIV. fig. 7, *n*).

Thelyphonus has nine pairs of ostia, two in the cephalothorax and seven in the abdomen, with distinct traces of an extra chamber in front.

Scorpio has seven pairs of ostia, all in the abdomen, with traces of a chamber (Newport) in the cephalothorax.

The heart of *Scorpio* is thus more specialized than that of either *Galeodes* or *Thelyphonus, i. e.* it has lost more of its primitive segmental pairs of ostia. It is further, owing probably to the localization of the respiratory organs, much more strongly developed than that of *Galeodes.*

In a specimen of *Euscorpio* the dorso-ventral diameter of the heart was to that of the abdomen as 1 to 7; in a small *Thelyphonus* the proportion is 1 to 9, whereas in a specimen of *Rhax* it is 1 to 21. These measurements were taken between the successive pairs of ostia where the heart is a simple tube. Further, the *Rhax* was fasting, so that this difference is not due to any great distension of the abdomen on the part of the last-named.

The ostia of the heart in both *Thelyphonus* and *Scorpio* are situated, as in that of *Galeodes,* on its dorsal surface; but their valves have a more special mechanism, being apparently muscular. As in *Galeodes,* the heart is prolonged anteriorly into an aorta running towards the brain and posteriorly into a vein (? or artery) which runs into the tail.

The aspect of the heart, suspended by the connective-tissue strands, is very similar in the two cases. In addition to the dorsal and lateral suspenders from the body-wall, the heart is powerfully expanded by means of bundles of connective-tissue fibres, no doubt homologous with the wing-like bundles in *Galeodes.* In the cases of *Thelyphonus* and *Scorpio,* however, these bundles are continued into muscle-fibres (the veno-pericardial muscles of Lankester and Miss Beck), which run through the mass of alimentary diverticula to be attached to the connective-tissue enveloping the lung-books. This is a specialized mechanism to save the heart from being compressed when the abdomen is distended with food. In view of the great specialization of the abdomen as a distensible vegetative sac, this mechanism deserves further description.

The heart, in both *Thelyphonus* and *Scorpio,* appears to be contained in a pericardium. But the pericardium, of *Scorpio* at least, is really a connective-tissue membrane embracing and binding together the distensible diverticula of the alimentary canal in the interest of the circulation. It runs laterally down the sides of the alimentary masses and keeps the passage open between them and the outer body-wall (Pl. XXXIV. fig. 9, *m*), and originally it ran also between the segmental diverticula of the mid-gut. These latter segmental infoldings have now, however, practically disappeared, leaving interesting traces behind. Dorsally, they still persist as deep conical pockets, into which the wing-like expanders of the heart run to be attached by means of muscle-fibres to the ventral portion of the membrane which arches over a blood-space. The muscle-fibres connecting these two infoldings are probably the remains of the infolding of the membrane between the diverticula. Into these segmentally arranged blood-spaces, which are the ventral remains of the infoldings between the diverticula, the respiratory organs project.

The veno-pericardial muscles, as those muscles are called which mark the original inter-diverticular blood-passages, therefore perform three functions: (1) they hold down the membrane which covers the alimentary system and thus prevent that system, which, as we have seen, is liable at any moment to enormous distension, from pressing on the heart; (2) they raise the same membrane ventrally, and thus prevent the alimentary system from pressing upon the lung-books and hindering the free circulation of the blood along the floor of the body; and (3), being attached by means of the numerous radiating fibres above mentioned to the heart itself, they may be active muscular expanders of the same.

A pair of these veno-pericardial muscles accompanies each pair of ostia. They run down through the mass of digestive diverticula, close to the dorso-ventral muscles, which agrees with the suggestion that they run where there once was an inter-diverticular infolding of the membrane. I was at first inclined to believe that they had borrowed these fibres from the dorso-ventral muscles, but now think that they are developed out of the remains of the membrane. I am led to this belief by noticing that, in *Thelyphonus*, while the dorso-ventral muscles run outside the long fourth pair of diverticula (Pl. XXXIV. fig. 2), the "veno-pericardial" muscles run inside between these diverticula and the hind-gut, but where segmental diverticula once existed but have now disappeared. The veno-pericardial muscles persist as their last vestiges.

In *Thelyphonus* we have two pairs of these muscles in the cephalothorax, attached ventrally to the endosternite, and in the abdomen seven pairs*, raising up the membrane ventrally in each segment to form a pair of blood-spaces. Further, in *Scorpio*, we also have seven pairs in the abdomen. The morphological importance of these series of ventral blood-spaces connected by fibrous and muscular strands with the heart, and always accompanying the ostia, will be discussed in the section on respiration.

In both *Scorpio* and *Thelyphonus* the circulation is further specialized by the presence of short connections between the heart and the membrane surrounding the diverticula. They are short muscular (valvular?) funnels by which the blood can be pumped directly under the membrane, where it can circulate through a system of blood-spaces with thin membranous walls among the diverticula (Pl. XXXIV. fig. 9). There are nine pairs of these in *Thelyphonus*. Lankester describes seven pairs ("arteries") in *Androctonus*: I have only succeeded in finding five pairs in a small *Euscorpio*; there may, however, be seven, as in *Androctonus*, although five is the number of alimentary diverticula which they have to supply.

In the Pseudoscorpions the heart seems to vary, according to the observations recorded, as to the number of ostia. According to Croneberg (27), there are three pairs; according to Winkler, one pair; and according to Daday (29), there are four pairs and a certain number (4) round a rosette-like terminal portion.

In a series of cross-sections of *Obisium*, in which the heart was well distended, it was found to commence (from behind forward) in about the same transverse plane with the hind-gut (Pl. XXXIV. fig. 3). The posterior aperture was very wide (36 μ), and, being dorso-ventrally flattened, would, seen from above, have a fan shape, which may be Daday's rosette. The posterior lips were irregular, which may be due to valvular infoldings. From the posterior opening, the heart, suspended in the typical way, rapidly narrowed to $\frac{1}{3}$ (12 μ) of its posterior width, and then widened again (20 μ) to form one chamber. This chamber has the typical appearance, and is fastened by the wing-like groups of fibres converging downward towards the dorso-ventral muscle, apparently to lose themselves among the diverticula. From this point the heart narrows to form an aorta. The whole structure is thus very minute, with, as Winkler stated, only one pair of ostia. As in *Galeodes*, its insignificance perhaps has some connection with respiration by means of tracheæ.

In *Phrynus* we have six pairs of ostia, which correspond with six pairs of abdominal ostia in *Galeodes*. We find the same mechanism as in *Thelyphonus* and *Scorpio* to protect the circulatory system from undue pressure when the abdomen is distended, viz., the veno-pericardial muscle-strands.

The heart of the Spiders is fairly well known; it is entirely confined to the abdomen. From it, as in the last three families mentioned, an anterior aorta runs into the cephalothorax. There is a highly-developed pericardium, no doubt specialized from a membrane enveloping the alimentary system, surrounding and protecting the heart from undue pressure when the alimentary tubules are distended by a full meal. In some Spiders, e. g. *Epeira*, these tubules may even grow up on each side of the pericardium so as to force it, with the heart, away from the dorsal wall†. For the protection of the heart, the pericardium is fastened back by a system of strands, which appear to lose themselves among the alimentary tubules. There are three (*Epeira*) or four (*Mygale* ‡) pairs of ostia.

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* This implies that there were once at least twelve pairs of primary alimentary diverticula (see the diagram Pl. XXXIII. fig. 12).

† *Cf.* Schimkévitch (62), pl. ii. fig. 9.

‡ Wasmann (74 *a*).

The small one-chambered heart of some Acari can be deduced, as I have shown elsewhere, from that of a Spider which failed to develop the full number of abdominal segments (6).

From a comparison of these hearts, we learn then that there were originally at least ten pairs of ostia in the ancestor of the group, at least three in the cephalothorax (two persisting as functional only in *Galeodes* and *Thelyphonus*), and seven in the abdomen (retained in full only in *Thelyphonus* and *Scorpio*). In the other Arachnids, varying numbers of ostia have been suppressed and the muscular heart itself correspondingly shortened, although in all cases the aortic prolongation of the heart towards the central nerve-mass persists. In all cases, except in *Galeodes* and *Thelyphonus*, the muscular heart is confined to the abdomen. This connection between *Thelyphonus* and *Galeodes* is especially interesting. The two forms are further connected, as no two other Arachnids are connected, by a transition form, *Schizonotus* —at least in so far that the latter appears to have retained distinct cephalic lobes and free cephalothoracic segments.

The Circulation.—The various developments of the heart in the Arachnids are only understood when the circulation is taken into account. It is only then that we can appreciate the intimate connection between the circulatory, the respiratory, and the alimentary systems. None of these systems can be properly studied alone.

In *Galeodes* the blood, after bathing the brain and circulating in the anterior end of the body and anterior appendages, has to pass back on its return from the anterior end of the body towards the abdomen through an array of muscles, large tracheal tubes, and excretory tubules of the coxal glands. The proximal end of the last of these is sometimes developed into a great spongy mass of tubules which stretches right across the cavity of the body behind and above the brain. Pl. XXXIII. fig. 5, *cg*, represents only a portion of this spongy mass. Through this all the blood must filter on its return from the anterior end of the body.

It is necessary to assume that subsidiary streams are diverted into the limbs. On reaching the diaphragm, some of the blood probably rises to the dorsal surface in front of the diaphragm, to re-enter the heart by the two pairs of cephalothoracic ostia. The rest passes through the neural arch (Pl. XXXIII. figs. 3, 4, *n*), bathing the large abdominal ganglion on its way, to flow backward through the great ventral sinus (Pl. XXXIV. fig. 8, *vs*) which stretches through the abdomen under the alimentary canal. This sinus is bordered on each side by depending diverticula. As the anterior part of the abdomen is much crowded with the genital organs, tracheæ, and alimentary diverticula, the sinus is protected by a membrane (*cf.* Pl. XXXIII. fig. 4, *n*), which is not found more posteriorly. It ceases, in fact, in the 2nd segment, and the blood escapes from the sinus in all directions between the alimentary tubules, to find its way up dorsally, and posteriorly round by the stercoral pocket to the heart. In its passage through the diverticula, it is often confined here and there to special vessels of irregular shape and thin membranous walls, which serve probably to guide it towards parts which would otherwise be out of the regular stream (*cf.* Pl. XXXIV. fig. 8).

The most important point which we notice here is the complete disorganization of the regular segmental alimentary diverticula, with the accompanying complete obliteration of the original inter-diverticular blood-spaces, there being no veno-pericardial strands. The atrophy of all the primary diverticula except the first, and *its* development into a mass of branching tubules, naturally necessitated a change in the original circulation.

On reaching the median ventral blood-sinus, instead of flowing up between the original inter-diverticular blood-passages, it was now required to flow through the maze of branched tubules. Such a change as this necessarily affected the respiratory invaginations, which originally projected into these inter-diverticular blood-passages (Pl. XXXIII. fig. 12). The dispersal of these regular streams into a diffuse streaming among the tubules no doubt played some part in causing the respiratory invaginations to develop into long tubules branching freely among the tissues. The same principle applies to the cephalothorax, where the blood-streams are much divided by the tissues and had therefore to be sought out by the respiratory invaginations.

In *Scorpio*, though a certain number (5) of the primary abdominal diverticula persist, they are no longer simple, but consist of a mass of branching tubules. This change necessarily affected both the circulatory and the respiratory systems, in a manner, however, strikingly different from what we have described in *Galeodes*, although both are but modifications of the same original system.

The blood is propelled forwards into a series of membranous sinuses closely surrounding and penetrating the brain. On leaving the brain anteriorly, it is conducted along apparently membranous channels accompanying the principal nerves, both the nerves to the limbs and the long ventral ganglionic chord. These channels are not ordinary blood-vessels, but appear to be rather guiding-membranes; that which accompanies the ventral chord, however, presents remarkable histological features which show it to be an organ of some unknown physiological significance which deserves investigation. This remarkable channel runs dorsally to the nerve-chord, here and there sending a branch between the chords, which opens into the ventral lacunar system. The physiological connection between this vessel and the nerve-chords is seen at the ganglia. Over these latter the vessel spreads out and sends branches into their interior. The vessel then runs on above the chords to the next ganglion. The object of this and of the other vessels accompanying nerves is apparently to provide them and the ganglia with a stream of oxygenated blood. In *Galeodes* we find the nerves invariably accompanied by large tracheæ.

From this system of nerve blood-channels, the blood escapes into the general lacunar system of the body, either directly or, as in the case of that accompanying the nerve to the third leg, after first passing through the coils of the coxal glands (12). As in *Galeodes*, the blood passes through the neural arch of the diaphragm and then runs along a median ventral blood-sinus (Pl. XXXIV. fig. 9, *vs*).

From this sinus it no doubt originally ran up between the primary segmental diverticula along the dorso-ventral muscles (Pl. XXXIII. fig. 12) to the heart, being aërated by the respiratory invaginations. The present segmental divisions of the abdominal alimentary system and the persistence of the veno-pericardial strands (Pl. XXXIV. figs. 1 and 9, on the left) show clearly that this primitive arrangement persisted long enough to allow the respiratory invaginations to become highly specialized. With the increasing specialization of the distensible abdominal alimentary system, the inter-diverticular passages became squeezed up and the blood had to flow out laterally from the median sinus, passing across and not along the respiratory invaginations, on their way. In adaptation to this change, the respiratory invaginations developed in process of time a system of laminated air-chambers (the "lung-books"). Between these laminæ (Pl. XXXIV. fig. 9, right) the blood, on its way up to the pericardium, would in future have to pass. The inter-diverticular blood-passages gradually closed up, and the infolded membrane degenerated into the strands above described, the veno-pericardial muscles (Pl. XXXIV. fig. 9, left).

This system, however, would no longer suffice when the primary diverticula broke up into branched tubules, a change which in *Scorpio* probably took place much more recently than in *Galeodes*. Each of these alimentary tubules must be supplied with blood. It is obvious that they cannot receive it, as they do in *Galeodes*, from the stream flowing along the ventral median sinus, for in *Scorpio* all this blood is required to flow laterally through the specialized lungs. The blood for the digestive tubules is received direct from the heart. On each contraction of the heart the blood is forced, through several pairs of latero-ventral openings (Lankester, "arteries" in *Androctonus*), among the alimentary tubules. At these vents the heart is in contact with the "pericardium," so that the blood is discharged under the latter and can only find its way back to the heart after circulating (1) through the mass of digestive tubules, and (2) (Pl. XXXIV. fig. 9, *cf.* arrows on the right) through the upper laminæ of the lung-books, whence it escapes into the lateral blood-passages, which convey the blood, close under the skin, to the "pericardium." Among the digestive tubules the blood circulates freely, with, however, membranous vessels here and there (as in *Galeodes*) for the purpose of guiding it to all parts.

This cannot be considered as a primitive arrangement, inasmuch as the breaking up of the primary simple alimentary diverticula into the branching tubules must have itself been a secondary modification.

These specializations have clearly necessitated the formation of the continuous membrane round the whole alimentary system, which keeps the complicated streamings apart. It is this membrane which, where it passes under the heart, functions as a pericardium.

In the Pseudoscorpions we have an entirely different specialization; the heart, as in all Arachnids, propels the blood on to the brain, and after flowing among the tissues, coxal glands, spinning-glands, &c., in the cephalothorax, finds its way back along the floor of the body to the abdomen. On its way it is apparently divided into two latero-ventral streams by the development of a large median ventral diverticulum of the mid-gut. Each of these streams has to pass through a felt-work of extremely fine tracheal tubules (27 and 10), which have developed at the tips of the original simple tracheal invagination of the 2nd and 3rd abdominal segments. The blood is thus aërated, as it flows into the abdomen, by two pairs of specialized tracheæ.

Reasons have, however, already been given for believing that these posterior tracheæ persisted until comparatively recently, inasmuch as we still have the seven pairs of functional inter-diverticular blood-passages persisting along the dorso-ventral muscles (Pl. XXXIV. fig. 3).

The blood flowing ventrally and laterally along the abdomen finds its way up, partly through the lateral muscle or inter-diverticular blood-passages, and partly through the coils of the hind-gut, above the genital glands, into a dorsal median sinus, from which it is drawn by the fan-shaped posterior end of the heart (*cf.* p. 367).

The circulation in the Araneæ has been carefully studied and described by Claparède (25), and it agrees with the scheme common to all Arachnids which we have so far described. The blood discharged forward by the heart flows back freely through the lacunæ of the cephalothorax; passing through the waist (there being no neural arch, as in those Arachnids which possess diaphragms), it flows on each side of the alimentary canal (Pl. XXXIII. fig. 6). On reaching the abdomen a great part of it flows immediately to right and left through the specialized lung-books of the 2nd segment (which have been pushed forwards). The rest appears to run on, in the Tetrapneumones, to flow up through a second pair of lungs, or, in the Dipneumones, freely through the alimentary diverticula towards the pericardium. According to Claparède, the posterior prolongation of the heart is an artery, as may perhaps be the case in *Scorpio*. In both cases I should consider it as a secondary specialization, in the interest of the spinning-glands or tail. It may be noted that the ostia in the hearts of both the Spiders and *Scorpio* would apparently admit of blood flowing either forward or backward. In *Galeodes* it can flow only one way, *i. e.* forward (*cf.* Pl. XXXIV. fig. 6).

The Blood-corpuscles.—The blood-corpuscles are, as a rule, round cells with large nuclei. They measure from 4 to 10 μ. I have been unable to determine their origin, as no blood-forming gland, nor any processes of division of the corpuscles, could be detected in my preparations.

In *Scorpio* the blood-corpuscles are very uniform in size and shape, ca. 8–12 μ. As one source of these free cells, I have elsewhere (11) suggested the detached mid-gut cells, which find their way into the hind-gut and are either lost in vast numbers or else pass out into the body through the wall of the hind-gut. It appears to me highly improbable that these active, living, and, to the last moment, digesting cells can be lost in such numbers, and even more unlikely that they again become epithelial cells after travelling into the hind-gut.

This detachment of digesting-cells appears to be very general among Arachnids, although I have found no cells in the stercoral pockets either in *Galeodes* or the Spiders. Whether in these animals also they become blood-cells or, after digesting their food contents, are themselves rejected with the fæces, is a matter deserving investigation. In *Thelyphonus*, I have noticed large, clear, nucleated cells in the blood-plasm in the heart, which are much larger than the ordinary blood-cells; perhaps these were mid-gut cells escaped through the wall of the hind-gut.

X. Respiratory System.

Respiration in the Galeodidæ is effected by means of tracheal tubes ramifying among the tissues. These open to the exterior through three pairs of stigmata, and, in some cases, through an extra median stigma (Pl. XXX. fig. 13).

The Stigmata.—The first pair open behind the coxæ of the second pair of legs (on the 4th segment). It is protected by an elaborate arrangement of setæ forming tree- and bush-like fringes, which allow the air to pass in while barring the entrance against foreign particles (Pl. XXX. fig. 18). Some of the flat-headed setæ shown in this figure within the aperture, appear to open at their tips, and may be sensory, *i. e.* olfactory.

The 2nd pair of stigmata open slantingly on the 2nd abdominal segment, either under folds of the integument, or, in a few cases, on the surface of the body, and near the median line, while the 3rd pair open still nearer the median line. These are simple chitinous slits (Pl. XXX. fig. 19), being protected under folds of the skin. In the genus *Galeodes* the posterior edges of these folds are furnished with remarkable rows of bristles, the "stigmatic combs" (Pl. XXIX. fig. 10, Pl. XXX. fig. 16, *co*). These, perhaps, serve to keep a passage open for the air when the abdominal segments are telescoped together.

On the 4th abdominal segment in some Galeodidæ there is a single median stigma, which often appears to be altogether closed (see the figures). It seems to be quite absent in the genus *Rhax*.

The position of these abdominal stigmata can best be explained on the assumption that they were apertures on the posterior faces of the coxæ of the limbs. If the limbs of the 2nd and following abdominal segments folded back in the median line, like the genital appendages themselves (Pl. XXIX. fig. 11), the stigmata would be brought together. This would also explain their slanting positions under folds of the integument.

The fact that, in the Galeodidæ, we actually have stigmata in the act of aborting on segment IV., associated with the remains of limbs closely resembling those vestiges of limbs which function as stigmatic opercula on segments II. and III., leads almost inevitably to the conclusion that stigmata have already disappeared from between the similar rudiments of limbs found on segments V. and VI., and perhaps also from those still further back. That there were stigmata at least as far back as the VIth abdominal segment in *Galeodes* may also be inferred from the presence of six pairs of ostia in the abdominal portion of the heart, and six pairs of dorso-ventral muscles. These latter, as we shall see further, imply at least six pairs of inter-diverticular blood-passages through which the blood once flowed upwards to the heart (Pl. XXXIII. fig. 12). There is evidence to show that in the primitive Arachnid a pair of respiratory invaginations projected into each of these inter-diverticular spaces, aërating the blood as it passed. The same argument would lead us to infer that there were at one time three pairs of stigmata in the cephalothorax, as we have one aborted and two functional cardiac chambers. The cephalothoracic stigmata persisting in the Galeodidæ would be the first of these pairs.

A comparison of the stigmata of the Arachnida yields interesting results.

In *Thelyphonus,* which has the longest heart with traces of ten cardiac chambers, nine being still functional, there are no stigmata now in the cephalothorax, although, if we may judge from the heart and the veno-pericardial muscles, there were certainly three pairs, as we infer that there were in *Galeodes.* Along the abdomen we have two pairs of functional stigmata, and five pairs of stigmatic scars, reaching back to the VIIIth segment. These scars occur in connection with faint vestiges of limbs closely resembling the similar vestiges of limbs in *Scorpio* (15 and Pl. XXVII. figs. 16, 17). Above the first four of these scars (as above the functional stigmata) there is a blood-space held up by a veno-pericardial muscle-strand. This arrangement implies that there was formerly an open passage up between the segmental diverticula of the alimentary canal to the heart. The presence of scars on the VIIIth segment suggests that there was at one time an extra (*i. e.,* 11th) pair of ostia and veno-pericardial connections which have now vanished. Even though the stigmatic scars no longer persisted, I should have felt justified in concluding from these points in the internal anatomy of *Thelyphonus* that there had at one time been stigmata on ten segments, from the 4th cephalothoracic to the VIIth abdominal (Pl. XXXIII. fig. 12).

While the limbs forming the genital opercula folded back on to the median line, those which followed retained their lateral transverse positions; we therefore have (in *Thelyphonus*) no approximation of the stigmata such as we have in *Galeodes* (*cf.* Pl. XXIX. figs. 11 and 13).

In *Scorpio* there are seven pairs of ostia and seven pairs of veno-pericardial muscles, all, owing to the great secondary compression of the cephalothorax, confined to the abdomen. These imply again that there were once seven open inter-diverticular passages into each of which a tracheal invagination once projected. Four pairs of invaginations only have been retained, viz., on the 3rd to the 5th segments. The limbs to which the stigmata belonged, though not folding back into the median line like the genital opercula, clearly sloped backward in various degrees (Pl. XXIX. fig. 12).

The Araneæ offer, in some respects, a curious parallel to *Galeodes.* There are never more than two pairs of stigmata, viz., on the 2nd and 3rd abdominal segments. In some cases the posterior pair have met in the middle line, which suggests that the limbs on which they occurred were also folded backward near the middle. This is rendered still more probable from the fact that the spinning-mamillæ, also the remains of limbs, approximate in the middle line.

In the foregoing cases we have in all traces of the remains of stigmata on 11 segments, 3 cephalothoracic and 8 abdominal; some still persist, some show merely as scars, others are only inferred from the presence of cardiac chambers and veno-pericardial muscles. Taking these systems of organs, respiratory and circulatory, together, with perhaps the series of dorso-ventral muscles which give rise to the inter-diverticular passages, as, owing to their close physiological connection, we are justified in doing, we conclude that the primitive ancestral form of the Arachnida possessed 11 pairs of primitive respiratory invaginations, each of which projected into an inter-diverticular blood-space. The blood, in returning along the ventral floor of the body, flowed laterally and then up *along* the respiratory invaginations through the inter-diverticular passage, entering the heart by the ostium situated above each of these passages (Pl. XXXIII. fig. 12).

The various arrangements on which this scheme is founded may be best seen tabulated as follows:—

	Segments.	*Thelyphonus.*	*Galeodes.*	*Scorpio.*	*Pseudoscorpions.*
Cephalothorax ..	4.	c.ch. (?)	c.ch.? stig.		
	5.	c.ch.; v.p.	c.ch.		
	6.	c.ch.; v.p.	c.ch.		
Abdomen ..	I.	c.ch.; v.p.	c.ch.	c.ch.; v.p.	c.ch. Ram's-horn organs.
	II.	c.ch.; v.p.; stig.	c.ch.; stig.	c.ch.: v.p.	stig.
	III.	c.ch.: v.p.; stig.	c.ch.; stig.	c.ch.; v.p.; stig.	stig.
	IV.	c.ch.; v.p.; st.sc.	c.ch.: stig.	c.ch.; v.p.; stig.	st.sc.
	V.	c.ch.; v.p.: st.sc.	c.ch.	c.ch.; v.p.; stig.	st.sc.
	VI.	c.ch.; v.p.; st.sc.	c.ch.	c.ch.; v.p.; stig.	st.sc.
	VII.	c.ch.; v.p.; st.sc.	......	c.ch.; v.p.	st.sc.
	VIII.	st.sc.	......	......	st.sc.
	IX.	......	......	......	st.sc.
	X.	......	......	......	st.sc.

c.ch. = cardiac chamber.
v.p. = veno-pericardial muscles.
stig. = stigmata.
st.sc. = stigmatic scar.

In the last column of this table I have placed the Pseudoscorpions inasmuch as they appear to stand alone. Like *Scorpio*, they have lost all traces, external and internal, of the former existence of cephalothoracic stigmata. But the compression of the segments to which the loss is attributable is quite different in the two cases. In *Scorpio*, the compression was from behind forward, owing to the forward thrust of the genital aperture; in the Pseudoscorpions, from before backward, the four posterior limbs having been squeezed back by the enormous coxæ of the pedipalps. In the Pseudoscorpions we have the ram's-horn organs opening under the genital opercula, which I suggest (10) may have been a primitive form of tracheal invagination. In the two following segments are two pairs of highly specialized stigmata, while on the seven following segments occurs a remarkable series of scars, a row on each side segmentally repeating the functional stigmata, the last pair being found on each side of the anal papilla. Internally, the heart has degenerated, but there are seven functional blood-passages running up between the alimentary diverticula along the dorso-ventral muscles (Pl. XXXIV. fig. 3).

We have then traces, either internal or external, of 11 pairs of stigmata in *Thelyphonus*, 10 in the Pseudoscorpions, 9 in *Galeodes*, 8 in *Scorpio*, ranging thus from the 4th cephalothoracic to the 10th abdominal segment, *i. e.*, in all in 14 segments.

We might, indeed, have inferred *a priori* from the traces of limbs found on all the segments of *Galeodes* and (?) on the last segment in *Scorpio* (*cf.* Pl. XXIX. fig. 12) that these limbs at one time had some primitive form of trachea (or even more primitive gland from which the trachea may be deduced) associated with them, since, in all the tracheate Arthropods, stigmata are invariably associated with limbs.

The only segments, then, on which hitherto we have found no traces of the former occurrence of stigmata are the three most anterior. The presence of limbs, again, suggests that there were at one time primitive tracheæ or the structures out of which tracheæ developed on these limbs also. Certain Acaridæ are reported to have tracheæ associated with the 1st pair of limbs, but there is no record of tracheæ on the 2nd and 3rd segments. It will be remembered that the fusion and compression of these three anterior segments was, according to our theory of the origin of the Arachnida, the first specialization of the Class, the first step in adaptation to a method of feeding which led to the differentiation of the phylum from their Annelidan ancestors. This compression may therefore account for the disappearance of all traces of the stigmata. (On the suggested homology of the coxal glands on the 3rd segment with the tracheæ, see p. 380 and footnote.)

The Tracheal System.—The tracheal tubes of the Galeodidæ form a connected system, the segmental origin of which is obscured (Pl. XXX. fig. 13).

From each stigma of the first pair one large trunk runs forward, another upward, and another backward. The distribution of these need not be described in detail; it can be gathered in outline from the figure. It is, however, especially to be noted that the trunk running backward branches and pierces the diaphragm, and, as shown in the figure, is in direct connection with the abdominal system.

The arrangement of the latter and its connection with the stigmata can also be gathered from a comparison of figs. 13, 14, 15 (Pl. XXX.). Figures 13 and 14 were reconstructed from both dissections and sections which were made especially to ascertain whether there was any trace of a segmental arrangement, that is, whether there were any remains of special tufts of tracheæ in the same transverse planes with the dorso-ventral muscles. These muscles mark the positions of the original inter-diverticular blood-spaces, into which the primitive tracheal invaginations once projected. Although the alimentary canal is now so specialized that these spaces have quite vanished, yet it appeared as if the tracheal tubules which are given off by the main longitudinal trunks on each side of the alimentary canal irregularly along its whole length tended to be rather more thickly grouped at the points where alone they are indicated in fig. 14 *.

The pericardial trachea (*pct*) is connected anteriorly by a forked piece with both longitudinal trunks, and in the 2nd segment by a large single trunk from the trachea rising from the right stigma (*G. arabs*). Birula figures it also on the right side for *G. ater*. In fig. 13 (Pl. XXX.) it is (? wrongly) drawn coming from the left side.

I have found no trace in *Rhax* of the aborting trachea in the fourth segment shown in the figures of *Galeodes*. In other respects the systems of the two genera resemble each other. There is, however, an additional connection in *Rhax* which is of some interest. It is indicated in fig. 13 (Pl. XXX.) in the 1st abdominal segment by dotted lines, and from it one of the branches rising to the pericardial trachea seems to spring. We appear to have here, in the 1st and 2nd segments, remains of two of the original tracheal invaginations which once ran straight up from the stigmata alongside the dorso-ventral muscles towards the heart. These presumably aërated the original inter-diverticular blood-passages in their own segments.

In *Rhax*, just within the aperture of the two pairs of abdominal stigmata, the thin chitin is strengthened by very beautiful star-like thickenings, which change gradually into the typical hoops (Pl. XXX. fig. 19).

Galeodes is the only Arachnid in which the primitive tracheal invagination has developed into these long branching and anastomosing tubes. A study of the figures shows that the whole system, though now highly specialized, has been developed from the fusion of a complete series of branching tracheæ arising from segmental stigmata, commencing anteriorly in the 4th segment. We found, from our study of the circulatory systems in *Galeodes* and *Thelyphonus*, that we were justified in assuming such a series for the primitive ancestral form.

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* Birula (22) mentions swellings on the main longitudinal trunk, but they do not appear to be segmentally arranged.

Other Arachnids have tubular tracheæ, but none closely resembling those of *Galeodes*. As a rule the tubular tracheæ arise as tufts of exquisitely fine tubules from the swollen end of a simple tracheal invagination. These tubules do not appear as a rule to anastomose one with another. This tuft-arrangement is a second distinct specialization of the primitive tracheal invagination.

A third equally explicable development of the primitive simple invagination is the so-called lung-book, the origin of which was presumably as follows * :—As the alimentary diverticula became more and more complex and distended, the inter-diverticular passages became closed. There was no mechanism which we can see to keep them open. The blood, therefore, which originally flowed from the ventral sinus up between the diverticula was compelled to flow out laterally, and so up between the skin and the alimentary system; in doing so, it would naturally run in the furrows which still marked off the diverticula. This new direction of the blood-stream was not conducive to respiration, for instead of flowing up the inter-diverticular passage alongside the tracheal (? branched) invaginations which projected into this passage, it was now driven past the invagination at right angles to it. This defect was rectified by the invagination developing flat leaf-like outgrowths arranged horizontally, between which the blood, flowing out laterally, could pass. These lung-books are therefore secondary specializations of the more simple tracheæ which once projected into the inter-diverticular spaces. In some Spiders, the specialization has taken place only in one (viz., the anterior) pair, while the posterior pair have persisted more nearly in their original form. The disappearance of the original inter-diverticular space, except in the 2nd segment, and the development of a crowd of branching digesting tubules have, in the Dipneumones, caused the simple tracheal tubes in the 3rd segment to develop as tufts of tubules †.

The different forms of tracheæ have thus been closely dependent upon the variations in the alimentary and circulatory systems.

Where the alimentary diverticula simply closed up against one another, gradually shutting off the channel up to the heart along the dorso-ventral muscles, the diverticula, however, still remaining fairly distinct, the blood flowed from the ventral sinus outward laterally, and lung-books were developed, while veno-pericardial muscles mark the remains of the old inter-diverticular passages, and are still so far functional as to keep the passages open through which the blood flows out laterally through the lung-books.

When, again, the regular alimentary diverticula gave place to a confused mass of tubules without any segmental arrangement, the original regular blood-stream was dispersed irregularly among the tubules, and the tracheæ grew out in all directions to follow it (*Galeodes*).

In the Pseudoscorpions, on the other hand, we have quite a different arrangement; on the squeezing-up of the inter-diverticular blood-passages the respiratory tubules of the first pair grew forward in a dense tuft into the cephalothorax, and thus met the ventral blood-stream flowing back through the body, while those from the posterior pair grew backward and followed the stream (10).

I would thus deduce all the forms of tracheæ from some simple form of chitinous invagination occurring on each limb. It is obvious that the different existing forms cannot be deduced one from another; lung-books cannot develop tufts or the *Galeodes* system of large tubes, nor can either of these produce lung-books. And yet there can be no doubt that the respiratory organs are all homologous structures. The stigmata of *Galeodes* are obviously homologous with those of *Thelyphonus* and *Scorpio*, inasmuch as their respective series overlap, and they occur in the same relation to limbs and in the same relative positions on the limbs. We are compelled thus to assume some common structure from

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* On the supposed origin of these from invaginated gill-plates see p. 398.

† It is interesting to record that this method of explaining the development of lung-books, arrived at by comparative morphology, has recently been confirmed by embryology. Jaworowski (35) has discovered that the tracheal invaginations of Spiders first form branched tracheal tubes, and that the lung-books are a secondary specialization.

which both could be deduced. Do the Arachnids throw any light upon the original nature of this structure?

In the diagrammatic restoration of the abdominal limbs of *Galeodes* (Pl. XXIX. fig. 11) I have marked a row of structures which, from their positions with reference to the limbs, appear to form a homologous series:—

On the 3rd segment are the apertures of the coxal glands. Although these open in *Galeodes* on the soft membrane, in the Pseudoscorpions they open (on the 5th segment) on the hard posterior faces of the coxæ. These may perhaps not really belong to the series*. On the next segment there is a pair of stigmatic openings into tracheæ. On the next two segments, judging from the circulatory system, we are justified in assuming that there were once stigmata opening into tracheæ. On the genital segment the limbs have been folded together to guard the median genital aperture, but opening on the inner faces of the limbs, in a position exactly corresponding with the tracheæ, are a pair of glands (*gg*) which appear to yield a secretion playing some part in the reproductive process; they perhaps yield a sticky substance to glue the eggs together. In *Phrynus* and *Thelyphonus* a pair of glutinous glands, capable in the former of yielding irregular threads, is found in what appears to be the same spot (Pl. XXIX. fig. 13). Following these glands, there are, on the three segments, tracheæ, or their remains, opening in positions exactly corresponding with the apertures of these glands. Lastly, in the Spiders, on the same (4th) segment in which the aborted tracheal invagination occurs in *Galeodes*, and nearly on the same spot, the 1st pair of median spinning-glands is found.

If, then, these form a true series—and, with some qualifications to be mentioned later, I think they do—we have some additional evidence as to the homology between tracheæ and spinning-glands, *i. e.* I believe with setiparous glands from which spinning-glands can best be deduced (see further, pp. 323 and 383).

The development of tracheal invaginations on the legs of Phalangids (Hansen), which may, however, only mean the finding of new apertures on the part of long existing tubes, is certainly not opposed to this theory. No known "dermal" glands occur in such positions on the legs of Arachnids, but spines and setæ with large setal pores are very common, and each one would form a place where the tracheal tubes could without difficulty "rise to the surface." An examination of the way the seta is suspended in the setal pore by a thin flexible fold of chitin shows that this is the probable solution of the occurrence of these leg-stigmata (see the figures of hairs on Pl. XXX.).

I shall have to return to the subject of the origin of tracheæ in the next section.

Histological (Pl. XXX. figs. 17 *a*, 17 *b*).—The large tracheal tubes of *Galeodes* show, in section, the structure of their walls. We have the glassy layer of the cuticle lining the whole tube. This is found in distended specimens forced up to form great blisters projecting into the lumen of the tracheæ. These blisters are full of coagulum. It is hardly possible that this can be a normal adaptation in cases of extreme distension. It is more probable that, in the death-agony, muscular contraction forces the blood through the walls of the tracheæ so as to blister up the innermost hard layer. Following this layer is the chitinogenous staining layer. This forms the thick hoops much in the same way as it forms the lens (Pl. XXXI. fig. 7). The laminæ seem to swell and thus to form ridges over which the hard layer passes. In the two figures given, both drawn from sections under the microscope, the ridges are not at equal distances, and some difference seems to exist between the thicknesses of the chitinogenous layer between the ridges. Outside this latter layer comes the plate-like epithelium with the nuclei. These are clear disc-like vesicles, often with only one very minute staining-point; they are thus not easy to demonstrate.

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* On this see note, p. 380.

XI. Excretory Organs.

The Galeodidæ have two highly-developed organs of excretion—(1) the coxal glands, and (2) the Malpighian vessels.

The Coxal Glands.—These have been often described under various names: "glandes salivaires," Dufour (31); "glandes stomachales," Blanchard (24); their true nature being recognized by Macleod (53) and Sturany (70). No full account of them, however, has ever been given.

From the aperture, which is found in the folds of the skin between the coxæ of the 3rd and 4th segments, the duct runs backward. After making many coils behind the central nerve-mass, it bends forward again almost as far as to its aperture, appearing, in *Rhax*, to end at the chitinous plate above described (Pl. XXVIII. fig. 16, *p*, *cg*).

Laurie has found the coxal gland of *Thelyphonus*, and I have found that of *Phrynus* also, opening behind the 3rd limb. According to Sturany, the coxal gland of the Dipneumones opens in the same place. These, then, form a group distinct from the Scorpions, Tetrapneumones, Phalangids, and Pseudoscorpions, in which the coxal glands open behind the 5th limb, although the two groups are connected by cases in which traces of coxal glands are found on both the 3rd and 5th limbs (19, 70). The complete absence of all traces of coxal glands on the 4th limb could, if these glands are homologous with tracheæ, be explained by assuming that the original specialization of the invagination on this limb was for respiration, an arrangement which has persisted in *Galeodes*.

In all the *Galeodes* examined, the duct of the gland, on reaching the chitinous plate, develops a great mass of tubules which fill up the spaces between the other tissues. The masses of tubules of the two ducts fuse to form a barrier right across the cephalothorax; through this the blood must filter on its way back through the body towards the abdomen.

A simpler condition was, as above described, found in a hungering *Rhax*. Whether the more complicated condition found in the genus *Galeodes* is a periodical or a permanent variation, I have been unable to ascertain. It was noticed by Dufour.

The main duct is, as a rule, comparatively free from connective tissue. Where, however, it is thrown into coils, the connective tissue is more pronounced in order to regulate the flow of blood between them; these blood-passages are richly supplied with tracheæ (Pl. XXXIV. fig. 10). The cells which compose the wall of the main duct are long ovals, as shown in the same figure. They appear to rest upon a hyaline membrane which dips down between the rounded outer ends of the cells. In this rounded outer end the staining strands within the protoplasm are arranged in a characteristic manner. Within the body of the cell they stream inwards like a tangle of hair, showing no regular striation. This streaming ceases after running through about $\frac{2}{3}$ or $\frac{3}{4}$ of the length of the cell, and the rest is clear, with, however, a granular wall facing the lumen of the tube. The nucleus lies in this clear space, and is sometimes deeply stained and small (2–3 μ), sometimes large (6 μ) and vesicular, with deeply-staining granules.

This description of the main duct agrees fairly well with that of *Chernes*, although in the latter case certain details were not visible, and the lumen of the tube was relatively much smaller. On the other hand, the long oval cells differ greatly from those composing the main duct in the coxal glands of *Scorpio*, *Phrynus*, and *Mygale* (Lankester), which are large flat cells, each presenting a considerable area on the external surface of the duct. This difference, however, may be simply a matter of support. In *Galeodes* the duct is not bound together by connective tissue; hence the compacter arrangement of the cells composing the wall. The nature of the striation found in the coxal glands—viz., that it is due to the arrangement of the protoplasm in the outer layers of the cells themselves—is also seen in the long cells of *Galeodes*, but is not so clear in the case of *Scorpio*.

A close examination of these cells, and of the contents of the lumen of the duct, confirms a previous observation (12) that the nuclei absorb the excretory matter, swell up, and are finally discharged as large clear vesicles.

I thought at first that the clear matter in the inner ends of the cells might be discharged or perhaps even the distal ends of the cells themselves might break off. The latter hypothesis would account better than the former for the finely granular and often vesicular appearance of the discharge. But the variations in the size and character of the nuclei, the fact that groups of small deeply-staining nuclei are found in the act of dividing (Pl. XXXIV. fig. 11 *a*), and further that the discharge can be found at times to consist of vesicles closely agreeing in size with the large vesicular nuclei, suggest that it is the nuclei which absorb the excretion and are then discharged. If this is the case, there should be a small resting nucleus in each cell; I have only rarely succeeded in finding one. Fig. 11 shows a cell with two nuclei, one of which, the larger vesicular nucleus, seems to be on the point of escaping. The measurements given in the figures refer to *Galeodes*; in my sections of *Rhax*, I found the small staining nuclei averaging 3 μ, while the large vesicular nuclei were 6 μ, and the discharged vesicles 6 μ and larger. The different sizes of nuclei appear in patches; where only small staining nuclei are found, the inner ends of the cells do not contain so much clear matter.

I have already described a similar phenomenon in *Scorpio*, where the discharge of the nuclei seemed quite as apparent. I have since reinvestigated the subject with other specimens, and have only been confirmed in my opinion. The point is, however, one of such importance that I hesitate to make any dogmatic assertions; there are, perhaps, other ways of interpreting the phenomena. The whole subject requires investigation with material specially preserved.

For a long time I thought that the duct in *Galeodes* was actually in communication with the hollow sponge-work of the chitinous plate (Pl. XXVIII. fig. 16, *p*), as the tubules of the terminal portion appear to be developing out of it (the plate). But I have now convinced myself that this is not the case. The chitinous plate merely forms a support for this and other tissues.

Histologically, the end tubules forming the great spongy mass in *Galeodes* (Pl. XXXI. fig. 5) differ considerably from the main duct. They are bound together by connective tissue which contains a tangled mass of blood-lacunæ and tracheæ. The blood seems to run largely in folds of the limiting membrane (Pl. XXXIV. figs. 13, 14). The tracheæ often appear to have thick protoplasmic walls; at times it seems as if four or five tracheæ of various sizes ran through the same protoplasmic mass. There is no striation of the protoplasm of the epithelial cells, which are hyaline, with large, deeply staining nuclei, and crowded together. The nuclei here also seem to be fragmenting in groups, and then measure $3 \times 2\,\mu$. At their largest they are about $3\frac{1}{2} \times 3\,\mu$, and the chromatin is then more granular. They appear never to become swollen and clear like the large nuclei of the main duct.

These end-tubules are perhaps the homologue of the branching tubes from the proximal end of the coxal gland of *Scorpio*. In both cases they are supplied with blood by a special arrangement of the parts. It is not easy to ascertain their morphological significance. Are they simply secondary developments of the proximal end of the main duct, or are they primitive cœlomic structures comparable with the end-saccules of the antennal and shell glands of the Crustacea? These are questions which cannot be answered without further investigation. I am myself disposed to regard them as secondary developments of the proximal ends of the ducts. In each case the epithelium in a way repeats the character of that of the main duct. In *Scorpio* the cells forming the main duct are large and flat, in *Galeodes* they are thin and cylindrical. Similarly, in the end-tubules of *Scorpio* the cells are squamous, with protuberances containing the nuclei; in *Galeodes* the cells of the end-tubules are crowded and more or less cylindrical. In *Scorpio*, further, the epithelium can be seen gradually passing from the striated form of the main duct into the non-striated form of the end-tubules. Further, the duct of the coxal glands in *Obisium* appears to me to end blindly and to have no terminal differentiated portion. Sturany found no internal opening in that of a very young Tarantula, and Loman (50) did not succeed in demonstrating an internal aperture to the gland in the Phalangids.

On the other hand, Laurie claims to have found the gland opening into the cœlom in a Scorpion embryo. Until this is confirmed, however, the bulk of evidence seems to point to the coxal gland as a blindly-ending tube, with, in certain cases, a branched differentiated portion, which somewhat resembles the end-saccules of certain Crustacean glands.

The external aperture of the coxal gland is not easy to find, being obscured by the folds of the soft skin behind the first pair of legs. On an excised piece of skin, however, the aperture can be seen as a round hole with thickened edges. In such a preparation from a *Galeodes*, a curious knob-like structure developed from the wall of the duct protrudes through the aperture.

Homology of the Coxal Glands.—What is the homology of these coxal glands which occur in nearly all the Arachnids on either the 3rd or the 5th segment of the cephalothorax, but never on the 4th segment or in the abdomen? Many investigators, relying chiefly upon embryological evidence, claim them as true nephridia, inherited from the Annelidan ancestors of the Arachnida.

For my own part, I believe that the Arachnids are to be derived directly from Annelids, *i. e.* without the intervention of any specialized intermediate form. If so, where are the primitive nephridia? It is no doubt possible that the coxal glands in the cephalothorax are persistent nephridia, and very probable the ducts of the genital glands in the abdomen are adapted nephridial ducts. On the other hand, in the Annelida, the nephridia tend to disappear from the anterior segments of the body as the posterior segments develop, especially when the anterior region shows great structural modification. We should therefore hardly expect nephridia to persist in the cephalothorax of the Arachnids. My own suggestion that these coxal glands might be developments of the setiparous sacs and therefore homologous with the tracheæ on the other segments, which would explain (1) their appearing in line with the tracheæ and spinning-glands, (2) their occurrence in the cephalothorax, and (3) their absence from the 4th segment and from the abdomen, has hitherto met with no favour. The general opinion, which I am still unable to share, seems to be that they must be regarded as true nephridia *.

The Malpighian Tubules.—These are well developed in the Galeodidæ. They open into the mid-gut in the region of the 4th abdominal segment, one on each side. The apertures are large, as indeed are the main ducts of the glands, and, near the entrance, the epithelium lining them closely resembles that of the mid-gut. It is instructive to note that the entrance is at the point where the fæcal masses commence to form. (Pl. XXXIII. fig. 1.)

The main ducts run forward and backward on each side of the central canal of the mid-gut, somewhat ventrally, to near the diaphragm anteriorly and the stercoral pocket posteriorly. They give off a thick felt of fine tubules which encircles the posterior part of the mid-gut, just before its junction with the hind-gut, while larger and more important branches ramify among the digestive tubules. The finer branches are less than 10 μ in

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* I have been severely blamed (Kingsley 36, Laurie 47) for persisting in suggesting that coxal glands may be derivatives of setiparous glands. I take this opportunity of explaining why I do so in spite of the array of well-known authorities who, on embryological grounds, claim them to be true nephridia. It is quite possible that they are, but I do not think the evidence is sufficient on either side to admit of dogmatic assertion. They are said to be mesodermal in origin, but the endosternite and the stercoral pocket have also been claimed as derivatives of the mesoderm. These latter appear to me as very good illustrations of the great difficulties which lie in the path of the embryologist. The study of *Galeodes* shows beyond doubt that the endosternite is an infolding of the cuticle, and the stercoral pocket is an outgrowth of the chitin-lined hind-gut. In the same way, the difficulties in investigating the developing coxal glands are very great. In the adult animal the aperture of the gland is by no means easy to find. It was long thought that there was no aperture in the adult Scorpion, and I have only found the aperture in *Galeodes* in two specimens. The investigation cannot, therefore, be an easy one.

On the other hand, I do not think that my suggestion involves any great morphological heresy, but, on the contrary, it is, under the circumstances, a very natural one. It arose out of my endeavour to show in detail how *Apus* could be deduced from a chætopod Annelid (4, see also "Systematic Position of the Trilobites," Quart. Journ. Geol. Soc. vols. l., li.). The primitive Crustacea should therefore have originally possessed tufts of setæ on both the dorsal and ventral branches of the limbs. On the ventral branch such tufts may perhaps be found in the tooth-like bristles of the gnathobases; but on the dorsal they are now scattered, or vanished. This assumption has recently been amply justified. In the Trilobite *Triarthrus Beckii*, tufts of setæ have been found on the dorsal branches of head-limbs answering well to those which I postulated for the immediate ancestors of *Apus*. These tufts have vanished from the vestigial dorsal branches of the head-limbs of *Apus*, but we find instead glands, in all three pairs, which seem to me more likely to be derivatives of setiparous glands than of nephridia. There is some reason, indeed, for believing that it is especially when parapodial appendages degenerate (see pp. 403–404) that the glands of their supporting acicula become modified for other uses.

The 1st gland belongs to the 1st segment, and in its structure is very like a setiparous sac, still attached by muscles to the body-wall. It opens on each side into the mouth-aperture (4). This I would attribute to an acicular gland of a vanished parapodium of the 1st segment.

The 2nd gland opens on the base of the 2nd antenna; it is only developed as a gland in the young *Apus* (Claus), but degenerates in the adult. In the higher Crustacea it persists as the antennal gland. Its position is not clear, because the morphology of the limb is not yet understood. The basal swelling on which its aperture persists in *Apus* is difficult to homologize with any part of a typical parapodium.

The 3rd gland opens upon the vestigial remains of the dorsal branch of the parapodium of the 5th segment, where we now know from *Triarthrus* that a tuft of setæ once existed. It develops into the shell-gland.

These three glands appear to form a series, of which the 1st, by its structure, suggests a modified setiparous gland, and the last by its position on the dorsal branch of a limb where we know that a tuft of setæ once existed.

diameter. Whether the ramifications anastomose I have not been able to discover. The tubules themselves are very irregular, the terminal portions swelling into irregular-shaped knobs or vesicles.

It is important to note that these ramifying excretory tubes are confined to the digestive mass; at least, I can find no trace of them projecting beyond, *i. e.* into the blood-spaces under the skin. The peristaltic action of the muscular tunic of the alimentary canal and diverticula would produce a certain waste which would have to be removed.

The Malpighian tubules are formed of a very low, finely ciliated epithelium (except near their apertures, where they continue the character of the mid-gut epithelium), with large round or oval nuclei, 2–3 μ in diameter. The epithelium rests on a granular membrane, which appears to blister off from the epithelium so as to form small lacunæ between it and the cells. This seems not to be the case everywhere, but where it occurs gives the impression of being a normal and not a pathological or post-mortem phenomenon, as the cells do not break away from the membrane altogether, but remain attached. I only observed this on portions of the tubes dissected out and examined *in toto*. As in the coxal gland, the contents of the interior appear as masses of clear round or oval vesicles with slightly granular envelopes. These excreted vesicles do not show the same close resemblance to the nuclei of the lining cells as do the vesicles in the lumen of the coxal glands, although appearances in favour of a similar origin were not altogether wanting. This whole subject requires new and extended investigation on better preserved material, and conducted solely with the one object of discovering whether the discharge of nuclei in excretory processes is the true explanation of the phenomena.

In *Scorpio,* the Malpighian vessels arise at the boundary between the mid- and hind-guts, where the fæcal masses appear to form (in the 7th abdominal segment), and no doubt, as in *Galeodes*, belong to the mid-gut. They arise close to each other on the dorsal wall, and run straight forward on the dorso-

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Further, (1) the well-known progressive backward degeneration of the anterior nephridia in Annelids, and (2) the claim that the chitinogenous cells utilize excretory matters in the formation of the cuticle, are additional arguments in favour of the deduction of the antennal and shell glands of the Crustacea from setiparous glands. The secondary opening of ectodermal invaginations into internal spaces is so common an occurrence that it presents no serious difficulty.

On turning to the Arachnids, the general resemblance between the coxal glands and the antennal and shell glands of the Crustacea is sufficiently striking. Might they not also be setiparous in origin? They appear to belong to the same series as the tracheæ and spinning-glands, and are always associated with limbs. This hypothesis, further, best explains their singularly limited distribution.

I freely admit that these arguments would have but little weight as against direct embryological evidence, if that evidence were really satisfactory. But, apart from the difficulties of observation above noted, the evidence from embryology does not appear to me to be conclusive. For instance, if setiparous sacs could become specialized for excretory purposes into complicated organs no longer purely ectodermal, there is no way of knowing whether the course of the development of such organs repeats its phylogenetic history or whether the definitive form is not at once laid down. In the Arachnids, which have no larval stages, each appearing with its definite characteristics even in the egg, it seems to me highly probable that all the more important organs are laid down in their definite form at their first appearance, and that their ontogeny teaches us but little of their phylogenetic history. For this reason I cannot follow Kingsley in being satisfied with the embryological evidence. I believe that the ultimate decision rests with comparative anatomy.

lateral wall of the gut to near the diaphragm. They give off numerous branches which ramify among the "peritoneal" cells ("fat body"). This fact seems to connect them very closely with the digestive functions. At the same time, it must not be forgotten that the mid-gut and the digestive tubules are all provided with muscles, the waste of which would have to be got rid of. The tubules are lined with a ciliated epithelium closely resembling that of the same tubes in *Galeodes*.

In *Thelyphonus*, the tubes enter the mid-gut just posterior to the constriction in the 6th segment, in the region of the 7th segment, near the commencement of the enlargement of the gut which functions as stercoral pocket, and which I believe to be the true hind-gut (Pl. XXXIV. fig. 2). Arising at the sides of the gut, they at first run backward, and twist about ventrally and laterally, closely applied to the wall of the gut. They then run straight forward, and give off branches among the digestive tubules.

In *Phrynus*, the true chitin-lined hind-gut commences in the region of the 7th segment. I have, however, been unable to ascertain the exact points of entrance of the Malpighian vesicles. They can be seen twisting about the canal, as in *Thelyphonus*, close to the gut, and probably open in the 7th segment.

The Malpighian vessels in the Spiders are well developed and ramify freely among the digestive tubules within the "fat body," *i. e.* among the "peritoneal" cells. I have not myself been able to ascertain their exact points of entrance. As in *Galeodes*, the tips of the tubules are often swollen (Wasmann, Plateau, Schimkévitch). The tubules appear to be ciliated as in *Galeodes*, although it is extremely difficult to see the cilia. But the central core of fæcal matter with which they are filled is never in actual contact with the deeply-staining epithelial cells; a clear space, which, under high powers, looks like a band of cilia, separates the two. It is difficult to see how the fæcal bodies would find their way along the tube, excepting by means of ciliary propulsion. Whether the tubes in the Spiders have retained their original excretory function or not is difficult to say; they appear to have undertaken another function—viz., that of assisting to remove the fæcal masses from the blind tips of the alimentary diverticula (11).

The loss of Malpighian vessels as excretory organs in the abdomen may perhaps be correlated with the absence of the coxal glands in the thorax in the majority of Spiders. Compensation for the loss of these two principal excretory organs has probably to be sought in the highly developed poison- and spinning-glands, and perhaps in the fact that, in the Spiders apparently alone among Arachnids, the skin of the abdomen is traversed by countless pores opening to the exterior. Excretory matter might perhaps be discharged through these pores by the action of the hypodermal cells.

The Pseudoscorpions (which have both spinning-glands and cement-glands) appear to have no Malpighian tubules. The part functioning as hind-gut commences in about the 2nd–3rd abdominal segment, and is coiled in the median plane (Pl. XXXIV. fig. 3).

The Phalangidæ also appear to have no Malpighian vessels; the hind-gut is large and fills up a great part of the abdomen. In both these forms the digestive system shows no very complicated branchings, and excretory matter might easily be removed by the blood circulating freely among it.

In the Acari, the Malpighian vessels appear to be present in some forms and absent in others. Michael found no traces of them in the Oribatidæ, while Winkler has found them in the Gamasidæ. Wagner has found them in *Ixodes*, developed from the endoderm.

There can be little doubt that the Malpighian vessels are homologous structures throughout the Arachnida. In *Scorpio*, *Thelyphonus*, and *Phrynus*, as we have seen, they open in the region of the 7th abdominal segment. The vexed question as to whether they belong to the mesenteron or proctodæum is finally decided by *Galeodes*, in which they obviously belong to the former. They are thus not homologous with the Malpighian tubules of the Hexapoda. It is possible that they may be specialized diverticula, homologous with those which anteriorly subserve digestion. In *Scorpio* they appear to enter the gut dorso-laterally, as do the digestive diverticula.

Review of the Glands in the Arachnids.—The Galeodidæ appear to differ from all other large Arachnids in possessing no other conspicuous glands, such as poison- or spinning-glands, although the former were at one time claimed for *Galeodes*. Their well-developed coxal and Malpighian glands appear to suffice to remove waste products. In addition to these must be added the glands which open within the genital aperture and which may secrete some glutinous substance (Pl. XXXIII. fig. 4, *gg*).

In *Phrynus* there are well-developed coxal glands and Malpighian tubules. To these, however, must be added spinning-glands, which appear to correspond with the glands opening within the genital aperture in *Galeodes*. They belong to the limbs forming the genital operculum, and yield the coarse silk on the egg-cocoon (Pl. XXIX. figs. 11, 13, *gg*).

The Pseudoscorpions have coxal glands, but no Malpighian vessels. On the other hand, they have enormous spinning-glands, opening at the tips of the movable digits of the chelicerae, as discovered by Croneberg, and cement-glands opening behind the genital aperture. These glands appear to develop periodically and probably not concurrently, and it may be safely assumed that they utilize a large proportion of the waste products.

The silk-spinning powers thus feebly developed in *Phrynus*, and more strongly in the Pseudoscorpions, have reached their most marvellous development in the Spiders, where, in many cases, a perpetual flow of silk seems to suffice to utilize all the waste products, so that the coxal glands can degenerate, and the Malpighian vessels change their functions. From this point of view, the web-spinning of the Spiders for the netting of prey is but a development of the cocoon-spinning of the Pseudoscorpions.

In addition to the spinning-glands, the Spiders have well-developed poison-glands.

In *Scorpio*, in addition to the coxal glands and Malpighian vessels, there is a pair of large poison-glands in the 'sting' on the anal segment. And in *Thelyphonus* also, in addition to the well-developed coxal glands and Malpighian vessels, there is a large pair of glands (stink-glands) which open on the soft membrane round the anus, on each side of and slightly above the anal aperture. It is highly probable that these poison- and stink-glands, like the spinning-glands, utilize waste products. The stink-gland of *Thelyphonus* is probably homologous with the poison-gland of *Scorpio*. That these three glands, poison-, spinning-, and stink-glands, are the common derivatives of the setiparous glands is, if not universally, at least widely accepted.

One of the more striking instances of tufts of hair in one Arachnid occupying the exact position of spinning- and poison-glands in others is to be seen in the hairs on the dorsal surface of the tip of the movable digit in the chelicerae of *Phrynus* (Pl. XXIX. fig. 2, *set*). These stout hairs seem deeply set in pits. In the Pseudoscorpions, at exactly the same spot, are a group of minute apertures for spinning-glands, and in the Spiders there is the aperture of the poison-gland. Lastly, in *Galeodes* these setæ have vanished, while the setal pores appear to remain open, showing no specialization into glands of any kind, but, as I have suggested, possibly exuding matter which is highly poisonous.

If the tracheæ are added to the spinning-, cement-, and poison-glands as homologous structures, we find that there must have been two series on each side. In the Pseudoscorpions, for instance, we have median cement-glands (*cf.* the stigmatic combs of *Galeodes*) with lateral stigmata in the 2nd–3rd abdominal segments, and in the Spiders we have median and lateral spinning-mamillæ. In all, we can count five consecutive segments of the abdomen with spinning- or cement-glands near the median line (*i. e.* if the spinning-glands of *Phrynus* are median and do not belong to the distal ends of the limbs), with lateral stigmata and spinning-glands occurring at the same time and on the same segments.

These four series, two on each side, can, it seems to me, only be deduced in different ways from the setiparous areas on the parapodia of the original Annelidan ancestor, as shown in fig. 18 B (Pl. XXXIV.). This will explain the present variations of positions and the serial arrangement of the glands in Arachnids in a very simple manner.

To this point I shall return in the section on the Phylogeny of the Arachnida.

XII. Reproductive Organs.

The Female Organs.—The female reproductive organs do not depart from the well-known Arachnidan type. Two spacious ovaries run along each side of the abdomen. Posteriorly they end blindly in the 6th or 7th segment, or, curling, they end blindly somewhere in the 2nd or 3rd (Pl. XXX. fig. 11, *i. e.* if this figure is not that of a male, see below). Anteriorly, they narrow to form the much-folded chitin-lined oviducts, which enter a common atrium, also chitin-lined.

This atrium, the walls of which are much folded, appears to be attached anteriorly by muscles to the diaphragm, and is rather spacious posteriorly. In one of my series of sections (*Rhax nigrocincta*) it is distended with blood-plasma (?). In this same specimen the oviducts run along the lateral wall of this atrium and open into its posterior portion. The external genital aperture, on the other hand, is at its anterior end.

This aperture is a longitudinal slit between the genital opercula. The thin cuticle of the inner edges of the opercular folds is often protruded to form a pair of lips (Pl. XXIX. figs. 7, 8, 9, 10).

I have not satisfied myself as to the exact position of the aperture *. There seems to be considerable variation. I found several of the specimens in the British Museum with a slit-like aperture anteriorly between the genital opercula (Pl. XXXIV. fig. 15, g'). If this anterior opening is the genital aperture, then the posterior (g'') may be the openings of the glands marked *gg*, Pl. XXIX. fig. 11, and Pl. XXXIII fig. 4. In other cases there can be no doubt that the genital aperture is between the posterior lip-folds, and that the glands open within it and on each side of it (23). Birula makes no mention of any more anterior opening.

The only trace of accessory glands which I have discovered is the pair of glands above mentioned, just within the genital aperture (Pl. XXXIII. fig. 4, *gg*). They lie within the cavities of the opercula themselves. Birula suggests that these may be receptacula seminis, but this I doubt. The semen is contained in spermatophoral envelopes which find their way in enormous numbers into the oviducts themselves. These pockets would not hold more than one or two at the most. From the position of these glands, I am myself disposed to consider them as homologous structures with the cement- and spinning-glands of the Pedipalpi (*cf. gg*, Pl. XXIX. figs. 11, 13). Birula describes other glands †.

The ovaries are covered by unstriped muscle-fibres, which in *Galeodes ater* (Bir.) and *Araneiodes* (Pall.) consist, according to Birula, of a layer of circular and a layer of longitudinal fibres. In my own specimen, this appears to be rather an irregular felt. The epithelium is short and columnar, with large oval nuclei (Pl. XXXIV. fig. 16). The oviducts and the atrium are covered with a very thick layer (felt) of muscle-fibres, which, in some cases at least, are clearly transversely striated.

The eggs are found developing as buds on the outer wall of each ovary, *i. e.* not on the side turned towards the longitudinal axis of the body. My material is not well enough

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[*] In the specimen of *Rhax nigrocincta* above mentioned, by a curious abnormality, the genital aperture occurred asymmetrically at the side of the body, along the dorso-lateral edge of the right genital operculum.

[†] The recent paper by Birula has thrown welcome light on many points connected with this subject. His connected account makes the fragmentary character of my own contribution less a matter of regret than it would otherwise have been.

preserved for trustworthy observations on the egg and yolk formation. With regard to the latter, I have seen most of the interesting phenomena described by Birula. In addition to the follicular membrane surrounding the eggs, the latter develop tough membranes of their own with a definite structure (*cf.* Pl. XXXIV. fig. 16, *em*), the outermost portion being finely laminate, the innermost radially striated as if highly porous.

I have found no ripe eggs within the ovary. On the other hand, the "ovaries" are often found distended with the large oval glittering spermatophores which, when first seen, I took to be eggs. Birula seems to be the only writer who recognized them to be spermatophores; both Dufour and Kittary describe them as eggs. Such an error is well calculated to throw our knowledge of this subject into confusion. Indeed, we are still not clear on many points. Are the animals with their glands distended with spermatophores (*cf.* Pl. XXX. fig. 11) males or females? Mr. Pocock has shown me several which, from other characters, he thought were males, with their glands similarly distended from end to end with spermatophores. So far as our knowledge goes, the males have no such capacious sacs, although they may be specially developed at the breeding-season. All that we can really say is that certain specimens are found with glands distended with spermatophores. As far as I can gather from Birula's account, such specimens might be either males or females, since the glands in both may be so distended. The question of sex seems to depend entirely upon our finding eggs in process of development, or testes. The specimens having the spermatophores, according to my experience, had no eggs; but, on the other hand, the only specimen showing testes had no such large receptacles to be distended in the manner described (Pl. XXX. fig. 11), although, as above stated, such sacs may perhaps develop as soon as needed. To judge from Birula's description of the genital glands in the male of *G. ater*, my figure, which represents a specimen of *G. arabs*, would be that of a male. The curious posterior distension of the portion where the gland curves round to run forward may be secondary, and due to the enormous quantity of spermatophores produced.

An undoubted ovary, with developing eggs, I found filled from end to end with small cells; even the atrium was similarly crowded. These, according to Birula, are amœboid and devour the spermatophoral envelopes, the superfluous sperm-cells and unfertilized ova. Considering that one spermatophore apparently contains enough sperm to fertilize all the eggs which could bud on the limited surface of the ovary, the waste must be enormous when the latter is distended with spermatophores, which seems sometimes to be the case. The eggs are said to develop into embryos within the ovary, and the embryos are said to be deposited, apparently in a very immature condition, in holes in the ground.

Male Organs.—I have been still less fortunate in making out the male organs, and, further, what I have seen does not appear to agree with Birula's description. Perhaps the differences are specific. Dufour found two types of male glands. I have succeeded in finding the filiform testes twisting about among the alimentary diverticula in only one specimen (*G. arabs*). The tubes were surrounded by a membrane hooped with fibres, as are the alimentary diverticula. These fibres are probably muscular.

The lumen of these membranous tubes is completely filled with round cells arranged in groups *, each group being, perhaps, the product of a sperm mother-cell. I have not seen the transformation of these into the filiform condition, nor the formation of the spermatophoral envelopes. Kittary, in describing what I take to be these tubes, thought them to be full of future eggs, and he described the spermatophore as a ripe egg. Dufour figures two types of male organs, but does not seem to have seen any spermatophores; when he found them in the ovaries he described them as eggs, and was even unconsciously misled into drawing eggs, budding from the wall of the ovary, oval like the spermatophores. Birula, has, however, as above stated, discovered the true relations.

The sperm is arranged in a number of distinct longitudinal bundles within the spermatophores, each bundle showing a fine longitudinal striation, due to its composition out of filamentous sperm-cells which are arranged longitudinally. The silky look of the spermatophoral envelope is due to the fact that it is so thin and delicate that it fits closely to the contained sperm and takes a slight imprint of the fine striation due to the ultimate sperm-cells.

Copulatory organs are altogether wanting. Birula states that in *G. ater* and *G. aranoides* the genital apertures of male and female were alike.

The genital glands of *Galeodes* do not therefore differ greatly from those of other Arachnids. Whether the paired ovaries meet and fuse, or the testicular tubules anastomose or not, is a point of no morphological significance. Their different developments in this respect seem to depend largely on the development of the alimentary diverticula. In *Galeodes* the alimentary system keeps the genital glands apart; in the Pseudoscorpions they can easily fuse in the space left in the middle line beneath the hind-gut. In *Scorpio* the alimentary diverticula are arranged in definite segmental masses, between which the genital glands can spread, and thus may join across the middle line. In the Spiders the ovaries seem to fuse posteriorly in some cases and not in others. In *Phrynus*, according to Blanchard, the ovaries do not fuse; in *Thelyphonus*, according to Tarnani, they also do not normally fuse, although this author describes in a note a singular case of transverse anastomosing between them. In the Phalangids and the Acari the genital glands appear generally, if not always, to fuse posteriorly.

There can, then, I think, be little doubt that the anastomosing of these glands in the Arachnids is a secondary development, and that the primitive condition is that in which the glands are paired tubes without any transverse fusion.

Copulatory organs are also generally absent in the Arachnids, excepting in the highly-specialized Phalangids. The so-called penis of *Phrynus* appears to be formed of the remains of a pair of jointed limbs of the genital segment. They may have sexual functions in addition to the two ascertained functions, (1) to hold fast the cocoon, and (2) to spin the threads which strengthen the cocoon. Spinning-glands open near their tips (77). This 'penis' can hardly be an intromittent organ. The remarkable ram's-horn organs of the Pseudoscorpions have been thought to function as penes, but I believe them to be a primitive form of trachea (10).

In the Pseudoscorpions the cement-glands belonging to the 2nd and 3rd abdominal segments serve somewhat the same purpose as the spinning-glands of *Phrynus*; they are said to stick the eggs on to the abdomen. From this primitive habit the cocoon of *Phrynus* may have developed.

In the Spiders, glands still more posteriorly placed, and opening on the spinning-mamillæ, prepare

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* These cells appear very like the homologous bodies in the testes of *Scorpio*, and also not unlike the bodies figured by Tarnani (71) as occurring in tubules in the abdomen of *Thelyphonus* (♂), which he describes as "glands" opening into an unpaired reservoir in connection with the genital apparatus. Are these not the sperm-cells?

the cocoon. It has been suggested to me by my friend Mr. Pocock that this was the primitive function of the spinning-mamillæ, and that from it all the web-spinning of the Spiders has been secondarily developed.

XIII. Summary: an Attempt to Elucidate the Phylogeny of the Arachnida.

In a comparative study like the foregoing, it has been impossible to avoid drawing conclusions as to the relative order in time of the appearance of the different specializations. Some must obviously have preceded others and led up to them. Hence, at the close, we find it possible to arrive at some conclusion as to the primitive ancestral form, and we are in a position to construct a hypothetical form which possesses (1) only those specializations which are common to all the members of the class, (2) these same specializations only in that stage of development which comparison leads us to believe to have been the most primitive. The different specializations of the ancestral form must all be at stages from which the more complicated specializations of the different members of the group can be deduced.

It is obvious that we can have no clear view of the position of the Arachnida among the Arthropoda until we have arrived at some fairly accurate conclusion as to the common ancestor of the former. It remains to be seen whether the type we can reconstruct on the lines just laid down has any points of affinity with any existing specialized type of Arthropod, or whether we have to seek its nearest relatives in the common ancestors of all the Arthropods, the segmented Chætopod Annelids.

The way for such speculations is, however, not altogether clear, inasmuch as a vigorous and long-sustained attempt has been made to demonstrate a relationship between the Arachnids and the Merostomata. For clearness of argument I propose therefore, in the following hypothetical reconstruction of the ancestral form, after each section, to show how it bears for or against such relationship.

Figures 14 (Pl. XXIX.) and 12 (Pl. XXXIII.) show the most important characters, external and internal, of our reconstructed ancestral form. This appears to possess most of the specializations common to the group in their least specialized condition.

1. *Number of Segments.*—We may fairly assume that the common ancestor possessed 18 segments (*Scorpio*, *Thelyphonus*), the greater number of segments being evidently the least specialized number. In the majority of the Arachnids, this number is, as a rule, more or less reduced in adaptation to certain specializations which will be mentioned presently; the full number is only retained where the terminal segments have been secondarily developed into a kind of tail.

This number agrees with that of the segments of the Eurypterids, from which it is thought *Scorpio* might be descended.

2. *Fusion of the Segments.*—A comparison of the different Arachnids shows that the first fusion embraced the three anterior segments. These were bound together by the distortion of the first segment, which, by the formation of the cephalic lobes, was tilted upward and backward so as to cover the 2nd segment and part of the 3rd (Pl. XXVII. fig. 8). *Galeodes* and (?) *Schizonotus* are the only known Arachnids which have remained

at this stage. In other Arachnids, the 4th, 5th, and 6th segments have been secondarily fused in various degrees of compactness. (In the Pseudoscorpions, I do not think it quite certain that the 6th segment is fused; see *ante*, p. 313.) In the Spiders, the fusion is remarkable in being fairly even, but the lines of constriction still appear dorsally radiating from a centre. The compactness of the fusion has reached its extreme in *Scorpio* and *Phalangium*.

In this gradual incorporation of body-segments in the area of primitive fusion, the Arachnids resemble other Arthropods, but they stand quite alone in the method of the initial fusion. In no other Arthropod did the fusion commence by the distortion and backward dorsal prolongation of the 1st segment, for the purpose of developing the 1st pair of appendages as powerful prehensile organs. In this the Arachnids are separated fundamentally from all other Arthropods.

Had this essential feature in Arachnidan morphology, revealed by the study of the Galeodidæ, been earlier recognized, the possibility of a close relationship between the Arachnids and the Merostomata would not have occurred to any one. They are, in this all-important matter—viz., the primitive specialization of the undifferentiated segmentation of their common Annelid ancestor—poles asunder (*cf.* Pl. XXXIV. figs. 17 A, B). Whereas the Merostomata were primitively differentiated by a backward ventral distortion and bending of the first segment, leading to subsequent fusions of following segments, the Arachnids, as we have seen, were specialized by the backward dorsal distortion and displacement of the same segment. We fortunately have nearly all the stages of the former process preserved to us in the remains of early Trilobites and of their larvæ. It reaches its extreme in *Limulus* and the *Gigantostraca*, in which the ventral displacement of the mouth and distortion of the first segment beyond all recognition have gone furthest. Similarly, in the Arachnids, *Galeodes* enables us to trace the stages in the process of the specialization of the anterior segments, which reaches its extreme in *Scorpio* and *Phalangium*. Thus not only do the Arachnids and the Merostomata stand poles asunder in the principle of the earliest specialization, but *Limulus* and *Scorpio* are in this respect extreme forms, and thus still wider apart.

A question, however, arises as to whether it would be possible for an animal specialized to the one extreme, say to that of *Limulus*, gradually to become modified by the forward movement of the mouth till it resembled the other extreme. I think it is safe to assert that this is impossible, because, in both the extreme cases, the primitive segmentation is no longer traceable, and any subsequent adaptation would not revive the early and vanished segmentation, but would merely change its existing specialized shape. For instance, many Crustacea have secondarily re-acquired a mouth pointing anteriorly. This has not taken place by any reappearance and re-tilting of primitive segments: they were lost as such beyond recovery. The mouth has regained its anterior position by the modification of existing parts, thereby still further enveloping the primitive segmentation in mystery. It is doubtful whether, but for the Trilobites and the Phyllopods, the early method of specialization of the segments forming the Crustacean head would ever have been discovered. Hence, while it may not be impossible for the mouth of a *Limulus* to return once more from its extreme posterior to the anterior position, in doing so it could not once more undo all the specialization of its segmentation. For in order to develop into a *Galeodes*, which is in this respect the most primitive Arachnid, it would have to recover its long-lost Annelidan segments almost in their primitive condition, and then, after tilting the 1st back on to the dorsal surface, further develop this primitive Arachnidan specialization till it reached the Scorpion stage. So that an animal having carried one specialization to an extreme would have to undo it all, in order to try a specialization the exact opposite of its own. I think it fairly safe to say that this is impossible.

3. *Terga*.—The primitive form possessed a well-marked tergum on each segment,

beginning from the 3rd, and stretching back the whole length of the body. This condition is still traceable in *Galeodes*, but in the great majority of Arachnids it is obliterated by fusion, the terga in front of the waist fusing to form a shield. The different forms of the shield, further, require us to assume that it arose in the different families from different arrangements and fusings of the primitive free terga.

This is incompatible with the large cephalic shield of a *Limulus* [or the smaller but not less compact shield of the Eurypterids], which is far too specialized a structure to have given rise to the free terga of *Galeodes*, or the many different arrangements of fused terga which now form the various cephalic shields of Arachnids.

Further, the cephalic shield of *Limulus* and the Eurypterids, so far as the evidence from *Apus* and the Trilobites goes, did not arise from fused terga, *i. e.* if we use the term "tergum" to signify a definite plate-like thickening of the dorsal surface of a segment connected with the terga of the neighbouring segments, and with the "sterna," by means of flexible membranes.

4. *Sterna.*—There can be little doubt that the ancestral form possessed segmental sternal plates all along the ventral surface, which have been variously modified and obliterated in the different Arachnids (Pl. XXIX. fig. 14). The first obliteration was doubtless due to the distortion of the 1st segment, whereby the first sternite became the rod-like support of the labium (p. 315), and the 2nd was more or less crushed between the coxæ of the pedipalps. The 3rd either persists but slightly altered (Spiders), or has been variously modified and obliterated, in *Thelyphonus* by transverse infoldings, in *Scorpio* by lateral compression from the coxæ of the legs. The sternite of the genital segment was also, no doubt, early obliterated, perhaps partly owing to the folding back of the limbs of that segment over the genital aperture and partly to the formation of a waist.

From these two points of initial obliteration of sternites we have almost all stages of further obliteration, culminating in the Galeodidæ.

It is quite impossible to deduce a racial form with a regular series of segmental sterna from an animal like *Limulus* or *Eurypterus*, in which the original sternites of the first six segments have been so completely obliterated. In order to develop into a typical Arachnid, *Limulus* would have again to undo its specialization and once more develop its lost sternites, lost on the cephalothorax by the extreme backward prolongation of the mouth, and, having recovered them, specialize them along the lines followed by the different Arachnids. This, I think, is next to impossible. If the mouth of a Limuloid did travel once more to an anterior position, deep traces (scars, as it were) of its former Limuloid specialization would persist; it could not return so exactly backward along the path of its development, and once more recover its segmental sternites in their original position, order, and undifferentiated condition as would be necessary for it to develop into an Arachnid. The subsequent modifications of a *Limulus* or of a Eurypterid would be the modifications of a *Limulus* or *Eurypterus*, and not of a form showing primitive undifferentiated segments, from which alone, I believe, the Arachnids can be deduced.

5. *Intersegmental Membranes.*—The presence of terga and sterna implies also the presence of flexible intersegmental membranes. These still persist in various degrees in the Arachnids, although in the anterior region they have been to a great extent folded in, owing to the muscular compression of the cephalothoracic segments. In *Galeodes* several such membranes persist between the terga of the cephalothorax. In *Scorpio* and *Chernes* the terga have fused to form a cephalic shield, but the lateral membranes persist. The

disappearance of the intersegmental membranes in the cephalothorax of Arachnids is to be correlated with the formation of the endoskeleton. In the Spiders they have almost completely gone; we accordingly find in this group the most complicated endoskeleton.

Between the 6th and 7th segments the intersegmental membrane typically forms the waist or diaphragm.

In the abdominal region these membranes persist and lend the segments the great distensibility which is required by the specialization of this part of the body into a vegetative sac.

These intersegmental membranes, required for the primitive Arachnid, are not easily obtainable from a Limuloid or Eurypteroid ancestor with its hard, well-jointed, and highly specialized exoskeleton and rigid head-shield.

6. *The Endosternite.*—The translocation of the first two pairs of limbs to positions above and at the sides of the beak, and, generally, the great muscular development of the first six segments, have led to deep infoldings of the intersegmental membranes to form different kinds of endoskeletal structures, according to the different specializations and degrees of compression of these segments. We have the endosternite and the waist or diaphragm.

The nearest equivalents in other Arthropods to these endoskeletal structures are the infoldings separating the head and thorax, and the thorax and abdomen, of the Hexapoda, and the endophragmal system of *Astacus* and its nearest relatives. These are all structures formed in the same method—viz., by the longitudinal compression of segments leading to an infolding of intersegmental membranes, in each case in response to some special method and area of compression.

The endoskeleton of *Limulus,* which has been compared with that of the Arachnids, has had an entirely different origin, and is therefore not an homologous structure. It receives its full elucidation in *Apus* as the fusion of the intersegmental tendinous tracts of the ventral longitudinal muscles from which the contractile tissue has atrophied. This origin is in as perfect harmony with the specialization of the primitive segmentation of the Merostomata as is the rise of the Arachnidan endoskeleton with the specialization of the Arachnida.

7. *The Waist or Diaphragm.*—The two chief regions of the body are separated by a waist or diaphragm, the origin of which can perhaps be traced primarily to the folding together of the appendages of the 7th segment towards the median line over the genital aperture to function in various ways as sexual organs. It is not improbable that the slight constriction caused by this arrangement was taken advantage of to cut off the hinder region as a vegetative sac, with a narrow neck into which the fluid food could be pumped in great quantities without fear of interfering, by undue distension of the alimentary canal, with the mechanism of locomotion and prehension of the anterior (6) segments. From this point of view, it is probable that the diaphragm, which is most perfect in *Scorpio,* implies the former presence of a waist. The primitive waist, however, need not have been so pronounced as that of the Spiders and Pedipalpi, which is almost certainly a specialization of this arrangement. The Galeodidæ seem to combine the two, forming both a slight waist and a fairly complete diaphragm. On the one side, then, we have the constriction completed to form a true waist; on the other, the

constriction obliterated, and a diaphragm stretching all across the body. In this respect *Galeodes* stands, perhaps, nearest the racial form. Where there is no waist or constriction, it must be considered to have been secondarily obliterated.

A structure showing such variations can, it seems to me, be deduced only by the infolding of the membrane between two primitive undifferentiated segments. It must date back to a time when the 6th and 7th segments were joined by an undifferentiated intersegmental membrane capable of being drawn in at any point or at all points. Evidence of this may be found in the very simple character of the intersegmental membranes between the segments of *Scorpio* or *Galeodes* immediately posterior to the waist. This primitive condition, which was necessary to the formation of a waist, is not supplied by *Limulus*, in which the posterior region hinges in a rigid and highly specialized manner on the anterior, or by the Eurypterids, where the segments of the tail-region almost certainly articulated with each other, and with the head-region, for specialized motion in the sagittal plane for swimming.

8. *The Division of the Body into Regions.*—One of the earliest specializations of the primitive Arachnid was its division into two regions. The anterior, consisting of six segments, was specialized for locomotion and prehension, and consequently sensation. The posterior region, composed of the remaining segments, became a vegetative sac, capable of great distension for the reception of large quantities of the liquid food sucked in and of the genital products. The simple undifferentiated character of the abdominal segments, and their different specializations of a varying number of terminal segments into tails, show that when the sac was first formed the segmentation was of the simplest kind (Pl. XXIX. fig. 14).

In this division into regions, the Arachnids resemble *Limulus* and the Eurypterids. In each case the anterior region is locomotory and prehensile, and consists of six segments, while the posterior region contains the remaining segments. Is this interesting agreement, however, any sign of close genetic relationship? Can the two regions in *Limulus* be the origin of the two regions in the Arachnids? The two regions in *Limulus* are clearly very pronounced specializations for certain purposes, but those purposes are not the same as those which gave rise to the two regions in Arachnids, and this fact is fatal to any close relationship between the two. The head-region in *Limulus* is not only for locomotion and prehension, but it is also developed into a remarkable shield-like expansion not only for protection but also for the reception of the digestive glands and of the genital products, which thus crowd forward right to the anterior end of the body. The posterior region in *Limulus* consists of the fused remains of a number of free flexible segments, once, no doubt, of great locomotory significance in swimming. In *Limulus* they persist now chiefly as carriers of gills, and in the Eurypterids they served apparently as an organ of propulsion through the water.

Admitting in theory that specializations fundamentally affecting the whole morphology of an animal group may, after reaching an extreme, become very greatly modified towards an earlier and simpler condition, I hold it to be impossible that any such specialization should be completely undone in order to allow the animal to run its course a second time along a different line of specialization. And yet this is what is implied if the specialized abdominal regions of *Limulus* or *Eurypterus* are to become the abdominal regions of the Arachnids: they must have reverted to their primitive undifferentiated metamerism, for it is only from such undifferentiated segmentation that the abdominal regions of the different Arachnids can be deduced. The full force of this argument will be further seen when (1) the limbs and (2) the internal abdominal organs are appealed to.

9. *The Beak.*—The possession of this organ in such diverse Arachnids as *Galeodes*, *Chernes*, and *Thelyphonus*, and the easy deduction of the mouth-parts of Spiders,

Scorpio and *Phrynus*, from such an organ, render it almost certain that a beak was present in the original Arachnid. The construction of the beak out of a labrum or prostomium in its original anterior position, and of a labium formed by the protrusion of the ventral surface of the 1st segment, seem necessarily to imply an undifferentiated condition of the anterior segmentation in the immediate ancestors of the primitive Arachnid. The beak points back to a simple Annelidan condition of the segmentation (Pl. XXXIV. fig. 17 A).

This, to my mind, renders the derivation of the Arachnids from *Limulus* or *Eurypterus*, with their extremely specialized anterior segmentation, well-nigh impossible. It seems to me hardly possible that any *Limulus*-like animal with the ventral position of the prostomium (Pl. XXXIV. fig. 17 B) and the obliteration of the sternites (*cf. supra*) could ever again recover the anterior position of labrum and labium with so little sign of previous modification. What direct evidence we have as to the recovery of an anterior position of the mouth from the ventral position of *Apus* and *Limulus* shows that this is attained by the rudimentation of the prostomium or labrum. We have in *Limulus* a slight tendency to move forward from the position of the labrum in the Trilobites, owing to the crowding round the mouth of so many jaws, the consequence being that, as compared with the labrum of the Trilobites, it is a very rudimentary organ. And further, in Eurypterids it appears completely to have vanished, or at least is not discoverable. After having once taken up the ventral backward position, it could not so completely undo that specialization as to tilt forward so as to point anteriorly as it is found to do in the Arachnids, leaving no traces whatever of its former structure and position. The labrum of the Arachnids occupies very nearly the same position it originally held in the Annelidan ancestor, and there is no sign that it has ever occupied any other.

10. *The Ocular Tubercle.*—An ocular tubercle, *i. e.* an island of the original dorsal surface left between the cephalic lobes as they approached and fused in the middle line, must have been present in the primitive form. It is now very largely obliterated, but persists in *Galeodes* and the Aviculariidæ and in some Scorpions, in which latter its origin is most clearly shown. It is quite peculiar to the Arachnids as a class.

This ocular tubercle is unknown in any other Arthropods, as, indeed, we might expect, since no other Arthropod underwent the same peculiar distortion of the primitive segments. *Limulus* and the Eurypterids naturally show no traces of such a structure, whereas were they primitive Arachnids we should expect to find it in its least differentiated condition, somewhat as we find it in the Silurian Scorpion *Palæophonus* (*cf.* text & Pl. XXVII. fig. 10, *ds*).

These several points so far discussed deal entirely with the external specialization of the primitive segments. They separate the Arachnids completely from all other Arthropods, and furthest of all from *Limulus*, whose essential morphology, or, in other words, whose early differentiation of the primitive ancestral metamerism, was the very reverse of that of the Arachnids. As Arthropods, no relation whatever exists between them; as segmented animals, however, they are both derivatives from the Chætopod Annelids, but along different and opposite lines of specialization.

11. *The First Appendage.*—The chelicerae of the Arachnids can be most easily deduced from a claw-like limb of three joints, from which both the existing forms of the appendage can be deduced.

It is not easy to deduce the primitive claw-form of the limb from an ancestor already equipped with specialized pincers, such as those of *Limulus*.

12. *The Second Appendage.*—There can be little doubt that the original form and position of this was leg-like, and that the chelate form was secondarily acquired.

This has little direct bearing on the question of the relationship of the Arachnids to *Limulus,* but it is so far of importance, inasmuch as it is an item in the mass of evidence to show that *Scorpio* is not a primitive form, so that the detailed comparison between *Limulus* or *Eurypterus* and *Scorpio,* which is one of the foundation-stones in the argument for their close relationship, is of little or no value.

13. The position and character of these two limbs, together with the consequent specialization of the segments to which they belong, form the most essential feature in Arachnidan morphology. We have in this arrangement a clear adaptation to a special and peculiar method of feeding. The acquisition of a new and successful method of feeding, *i. e.* of acquiring the materials for growth and reproduction, seems to me the most important of all adaptations for new points of departure in animal morphology. I have already adduced evidence to show that the class Crustacea can be deduced from segmented chætopod ancestors, which bent their first segments ventrally to push the food on which they browsed into their mouths by means of their parapodia. From what we have seen in the foregoing, the class Arachnida may be deduced from a segmented Annelidan ancestor in which the first two pairs of limbs were shifted forward and grouped round an anterior mouth, which mouth, as a consequence of this very shifting of the limbs, came to be situated at the end of a beak. The method of feeding which this arrangement implies, that of seizing and wounding prey and sucking their juices from the wound, is common, with slight variations to all the Arachnida.

That this was the primitive arrangement is certain from the fact that it is not only found in all Arachnids, but is accompanied by many different specializations for preventing the escape of the juices, and others again for straining them. Further, the different forms of the beak, with the differences in the position of the sucking-apparatus, also show that this plan of feeding was the one first adopted by the ancestral form. In this respect the hypothetical ancestor differed from all the other classes of the Arthropoda. Almost all other Arthropods have chewing-jaws projecting more or less into the oral aperture. It is true that some of these secondarily adopt a method of feeding by sucking, but the adaptation starts from the persistent jaws, which become transformed into lancets, &c., for the purpose.

Of all Arthropods thus feeding by chewing-jaws, *Limulus* has reached the extreme, with five pairs of biting-jaws arranged around an oral aperture. The Eurypterids are, if anything, still more highly specialized, inasmuch as the last pair of the *Limulus* jaws have developed more or less at the expense of those in front of them. The question arises, could *Limulus* change its method of feeding from biting into sucking juices? It is perhaps possible; but if it did, these jaws would persist in some form or other as component parts of the piercing and sucking apparatus, in order to maintain the necessary continuity in feeding. Is it, however, at all likely that the distal ends of two pairs of limbs brought prey to a mouth so armed, and crushed it there for the mouth to suck, while the powerful and highly specialized jaws remained useless, and thus atrophied? This is so improbable that the idea may be dismissed.

It is true that in *Scorpio* it is claimed that traces of two pairs of jaws are still to be seen. They form the spoon-like arrangement under the mouth, which prevents the escape of juices. But a comparison with other Arachnids shows that these processes on the coxæ, and even the position of the coxæ themselves, are secondary specializations (*cf.* e.g. *Thelyphonus*). Further, these coxæ were never jaws, inasmuch as they do not work in the mouth, but behind it and below it; the small pointed labium is quite a distinct structure anterior to these so-called jaws. If the small labium could be found below them or wedged in between them, so that they formed any part of the real boundary of the oral aperture, they might perhaps claim to have once been jaws. But, in all Arachnids, the oral aperture is distinct and without jaws. The nearest approach to anything like a pair of jaws working at the sides of the mouth is found in the Spiders, where the coxæ of the pedipalps form a hairy barrier on each side of the oral slit to prevent the escape of juices, functioning in this respect like the coxæ of the pedipalps in *Thelyphonus* and *Phrynus*.

If *Limulus* or *Eurypterus* was anything like the ancestral form of the Arachnids, how is it that *all traces* of such specialized jaws as they possessed should have disappeared? In some important Arachnid family traces of true jaws would certainly have been found, had they ever existed in the ancestral form. Instead of which we find a regular series of coxæ showing a variety of specializations, which only admits of being deduced from a series of uniform unspecialized coxal joints, certainly not from a series of specialized jaws.

14. *The Coxal Joints.*—The primitive form possessed a series of uniformly developed coxal joints, which were originally no doubt movable. The Spiders and *Phrynus* have alone retained this condition. In all other Arachnids we find fixation of some or all of the coxæ, and great variations in their sizes and in their approximation towards the middle line (*cf.* above paragraph on the sternites and Pl. XXVII. figs. 15–18, Pl. XXVIII. figs. 1–2).

As stated in the last paragraph, I hold it impossible that all these varied developments of coxæ could be derived from a series of closely-compressed lamellate jaws working round a ventral mouth. If such jaws *could* open wide enough to become useless in feeding, and thus to atrophy, allowing the mouth to travel forward between them for an entirely different method of feeding (the sternites reappearing in its wake!), we should expect to find, in some Arachnid or other, traces of the former biting-ridges or teeth along the coxæ; we should hardly expect to find the large, round, smooth coxæ looking so exactly like the derivatives of a primitive undifferentiated series. We should hardly expect either that these gaping and atrophying jaws, which would become rigid during this useless time, would once more become movable, once more approach the middle line, obliterating the sternites a second time, and then again become fixed. And yet this must have happened if *Limulus* is to be genetically related with *Galeodes* or *Thelyphonus* as a more primitive form. I repeat that I do not believe it possible for specialized forms, in becoming adapted to a new manner of life, completely to lose all traces of their former specialization.

15. *Vestigial Abdominal Limbs.*—The primitive form, specialized, as we have seen, into an anterior locomotory region and a posterior vegetative sac, retained for a longer or shorter time the remains of the limbs on the latter region, which, owing to its specialization, had become useless for locomotory purposes. Every segment had its vestigial ambulatory limbs, which have now almost completely vanished, except when retained for other functions. We have limbs modified into sexual organs, into sensory feelers (pectines), into spinning-mamillæ, and into genital or stigmatic opercula. Where they have vanished as projecting limbs, they have simply flattened down, leaving in

some cases an area more or less marked to indicate their former presence. From the character of the limbs which persist as such, we learn that they did not differ from those of the cephalothorax, but were filamentous jointed appendages like the walking-legs.

It is practically impossible to obtain these conditions from *Limulus* or the Eurypterids, whose abdominal limbs were too highly specialized ever to give rise to a series of filamentous rudiments such as are found in the Arachnida, and found, moreover, specialized in such various ways and for such different functions that we are obliged to assume that they are all developments of some simple undifferentiated form of limb. It has further to be remarked that the recent demonstration of the existence of Phyllopodan limbs in the rudimentary segments of the Trilobites explains the lamellate character of the abdominal limbs of *Limulus*. We have, then, to ascribe very different origins to the abdominal limbs in *Limulus* and in the Arachnids; in the one they are primitive Phyllopodan limbs, persisting in the interests of respiration, while in the Arachnids they are the remains of a series of filamentous locomotory appendages.

Until quite recent times, again, the rudiments of abdominal limbs in the Arachnida were thought to be confined to the first six abdominal segments, that being the number and arrangement of abdominal appendages in *Limulus*. But the traces of abdominal limbs in the Arachnida are not confined to these six segments, for they occur in all the segments.

16. *The Muscular System.*—The primitive Arachnid possessed a typical Annelidan musculature, specialized (1) for the movement of locomotory and seizing appendages; (2) anteriorly, in adaptation to the new positions of the anterior appendages, thereby leading to the formation of the cephalic lobes; (3) posteriorly, in adaptation to the differentiation of some or all of the abdominal segments into a distensible sac; and (4), in those cases in which the terminal segments were specialized into a 'tail,' for the movements of that appendage. In addition to these, we have the primitive œsophageal muscles developed into the powerful expanders and contractors of the pumping-apparatus. A well-developed series of dorso-ventral muscles extended certainly as far back as to the 8th abdominal segment (*Thelyphonus*), probably still further. Besides, a study of the various existing arrangements of this musculature in the Arachnids leads to the conclusion that they can only be deduced from an original Annelidan condition, each along its own lines.

Inasmuch as the musculature of *Limulus* is also a specialization of a typical Annelidan musculature, it is possible to homologize all those muscles which can be certainly shown to be derivatives of the same Annelidan muscles. The original argument which Prof. Lankester based upon the muscular system breaks down in so far as he confined himself to one Arachnid, *Scorpio*, which is not primitive in the matter of its segmentation. We may add, further, that the muscular system of the Arachnida could never have passed through anything like the extraordinary specialization of the *Limulus* musculature, once again to revert to its primitive condition, to be again specialized into the Arachnidan type.

Further, as a great part of the argument in favour of the relationship between *Limulus* and *Scorpio* is based upon the great external resemblance between the two, when we consider how intimately associated the muscular and skeletal systems are, we are unable to understand the divergence of their muscular systems (*cf.* Beck and Benham). Lastly, while the musculature of *Limulus* can be shown to be a further development of the simple musculature of *Apus*, which is itself a specialization of the

Annelidan type of muscles, that of the Arachnids is a specialization of the muscles of primitive undifferentiated segments, starting from a time when the intersegmental membranes were not drawn in to form an endoskeletal system.

17. *The Central Nervous System.*—The original form possessed a central nervous system somewhat less specialized than that of the Spiders. The concentration of locomotion at the anterior end of the body, and its high development, taken in connection with the degeneration of the posterior region into a vegetative sac, would lead to a crowding together of the ganglia of the locomotory segments along the floor of the cephalothorax, while those of the abdomen degenerated, except where retained for special functions (*cf.* the formation of tails, &c.). The translocation of the first pair of appendages would easily lead to the wandering of their ganglia up the œsophageal commissures until they assumed a supra-œsophageal position. From this primitive differentiation we can deduce all the central nervous systems of the Arachnida; the variations they present being always in harmony with the different degrees of longitudinal compression of their cephalothoracic segments.

No two central nervous systems could well be more unlike than those of *Limulus* and *Scorpio*. They are extremes of opposite specializations. The brain has in *Limulus* retained the ventral position due to the bending round ventrally of the prostomium, while in the Arachnids it has retained the primitive dorsal position, and in *Scorpio* has been forced further backward dorsally than in any other Arachnid, by the crowding forward and upward of the ganglia of the first two pairs of appendages. *Limulus* and *Scorpio* are thus wider apart in this respect than any other two Arthropods, each representing an extreme position of the brain proper. I use the word "brain" to indicate those ganglia which, in a typical Annelid, are supra-œsophageal, the optic and prostomial (and ? certain ganglia innervating the mid-gut).

18. *The Eyes.*—These, grouped originally on an ocular tubercle (*cf.* p. 392), perhaps consisted of two large median and a certain number of accessory eyes, which latter have very generally (except in the Aviculariidæ) wandered away laterally on to the cephalic lobes.

The histological character of the primitive eyes is probably no longer ascertainable. From this point of view, no value whatever can be placed upon a comparison of the eyes of *Scorpio* and those of *Limulus*. We do not know whether the median eyes really correspond in the two, nor whether, in view of the great differences which prevail among the eyes of Arachnids, those of *Scorpio* are primitive. Further, any resemblance between the eyes would not necessarily mean any relationship between *Limulus* and the Arachnids as Arthropods, since the primitive Annelidan ancestor possessed eyes, and some common form of eye might have been transmitted to the two groups of descendants, the Arachnida and the Palæostraca.

19. *The Œsophagus and the Sucking-Apparatus.*—The position of the sucking-stomach in the primitive form was in front of the nerve-mass (*Galeodes, Scorpio, Thelyphonus,* Chernetids). This is in keeping with our description of the original distortion of the anterior segments. The backward dorsal distortion of the 1st segment, while its sternal surface was protruded to form the labium of the beak, naturally drew the œsophagus

forward, the brain being forced backward. In the Spiders, in which the sucking-stomach is behind the nerve-mass, we still have traces of its former position, in the persistence of a few expanding muscle-fibres (Pl. XXVIII. fig. 8).

In *Limulus* we have the arrangement which the distortion of the segments would naturally bring about; the brain lies close to the ventrally-arranged prostomium, and the greater part of the œsophagus, specialized into a kind of masticatory stomach (proventriculus), is thus morphologically behind it, actually above and in front of it. The arrangement is thus the exact opposite of what we find in the primitive Arachnids. If *Limulus* is related as a primitive form to the Arachnids, then the position of the sucking-stomach in the Spiders would have to be considered as original, and that of the other Arachnids as secondary; but, as already shown, the existing mouth-parts of Arachnids are best explained on the assumption of a primitive beak, in which case the condition found in the Spiders is not primary but secondary.

As already stated, the straining apparatus in the Arachnids is so varied that the sucking of living juices must have been the primitive method of feeding. The proventriculus of *Limulus*, on the other hand, is specialized for the trituration of solid food. Both of these appear to be independent developments of some simpler Annelidan œsophagus with its expanding and contracting muscles.

20. *The Mid-gut.*—The mid-gut in the primitive form stretched from the 3rd segment through eleven (or twelve) body-segments, and was provided with at least nine pairs of segmental diverticula, four in the cephalothorax, and five in the abdomen (*Scorpio*). Of these diverticula, those in the cephalothoracic region, *i. e.* in front of the waist, began to degenerate as the body divided into two regions, the anterior for locomotion, the posterior for digestion and reproduction.

The mid-gut of *Limulus* perhaps begins, as in the Arachnids, in the 3rd segment, but it is more specialized. There appear to be only two diverticula which are glandular and not digestive. These two probably correspond with the first two in Arachnids, *i. e.* if the œsophagus of *Limulus* corresponds in length with that of the Arachnids. If *Limulus* is a primitive Arachnid, it has lost seven pairs of diverticula, and those which persist are specialized into glands. It seems to me far easier to believe that the specializations of *Limulus* and of the Arachnids are entirely distinct modifications of some undifferentiated Annelidan type than to endeavour to connect the two as nearly related. The specialization of the mid-gut in *Limulus* is strikingly different from that of the Arachnids. One of the essential features of the Arachnidan morphology is the distensible abdomen, while the head-region is specialized for locomotion and sensation. In *Limulus* the mid-gut and its diverticula are chiefly specialized in the head-region, having lost all traces of diverticula in the abdominal region. The specializations in both cases are extreme, and I repeat again that it is not likely that any extreme specialization should ever swing right back to the opposite extreme, as must have been the case if the Arachnids as a group are deducible from a *Limulus*-like ancestor.

21. *Heart and Circulation.*—In the original form, the contractile heart ran through at least ten segments (4th to 13th inclusive), being continued both anteriorly and posteriorly by non-contractile vessels. There were at least ten pairs of ostia drawing blood from ten pairs of inter-diverticular blood-passages. As the cephalothorax became more specialized, the three pairs in front of the diaphragm degenerated, except in *Thelyphonus* and *Galeodes*. In the abdomen also the great specialization of the diverticula of the mid-gut leads to variations in the number of ostia and to the general closing of the

inter-diverticular blood-passages, traces of which, however, persist in the veno-pericardial strands.

The heart of *Limulus* is not unlike that of the primitive Arachnid. It appears, however, to have commenced in the 3rd segment, and to have extended back to the 10th (incl.). The veno-pericardial connections perhaps arose in the same way as in the Arachnids, and would therefore indicate the former presence of more alimentary diverticula, which have since degenerated. These resemblances between the two animals are perfectly explicable as their common inheritance from their Annelidan ancestors. It is obvious that the hearts are not strictly homologous, inasmuch as that of the primitive Arachnid extended through more segments than does that in *Limulus*.

22. *Respiration.*—The primitive form had respiratory invaginations commencing in the 4th segment of the cephalothorax, and extending at least as far back as to the 8th segment of the abdomen. The series was clearly in close physiological connection with the ostia of the heart and the inter-diverticular blood-passages (*cf.* Pl. XXXIII. fig. 12). A respiratory invagination projected into each of the last-named. A primitive arrangement like this will explain all the present arrangements found in modern Arachnids, both alimentary, circulatory, and respiratory. The form of the respiratory invagination was probably some simple (or perhaps slightly branched) chitin-lined tube from which, in the manner described above, either lung-books, tuft-tracheæ, or branching tracheæ could be deduced in adaptation to the subsequent specialization of the alimentary or circulatory systems.

One of the main arguments for attempting to connect *Limulus* with the Arachnids is the apparent possibility of deducing the lung-books from the gills of *Limulus*. But the backing-up of hypothesis by hypothesis can only give the appearance of strength. The only attempt at evidence in favour of this demonstration is that deduced from embryology, in which it is shown that the gills and the lung-books make their first appearance exactly like one another. It is not easy to see what else could be expected. Given the respiratory invagination opening on the posterior face of rudimentary limbs, a sagittal section passing through such an invagination would naturally give the appearance of a limb with the lung-book on its posterior face like the gills of *Limulus*. The embryological evidence decides nothing, and the ultimate appeal has to be made to comparative anatomy.

The answer to be given, for instance, to the question "Were there ever flat lamellate limbs like those of *Limulus* on the abdomen of the primitive Arachnid?" goes far to settle this matter. What actual evidence we have as to the character of the abdominal limbs shows that they were filamentous jointed appendages like those on the cephalothorax, but hardly so highly specialized. Indeed, neither in shape nor in number do the remains of limbs in the Arachnids correspond with those of *Limulus*.

Again, the sensory plates on the three joints of the pectines of *Scorpio*, which are supposed to be persistent remains of the gills of a Limuloid ancestor, are seen in sagittal sections to be on the ventral face of the limb, and not on the posterior or upper face. They are closely parallelled by the racquets on the same three joints on the last leg of *Galeodes*, which certainly could not have been deduced from branchial leaflets turned into sensory processes, if such a transformation is possible. The branchial leaflets were not on the first three joints, but on a specialized area of the *Limulus* leg comparable with the gill of *Apus* and the epipodite of the Crustacea.

Further, the invagination of four pairs of gills on segments III.–VI. of the abdomen will not account for the position of the tracheæ in any other Arachnid except *Scorpio*. It will not account for the tracheæ in the cephalothorax in *Galeodes*, nor for the two kinds of tracheæ, tuft and branched, in the abdomen, nor for the remains of stigmata found in the Pseudoscorpions and *Thelyphonus* on segments in the abdomen posterior to the VIth *.

On the other hand, the evidence adduced from the circulatory, respiratory, and alimentary systems of Arachnids (which are in such intimate physiological connection) demands a series which *Limulus* could not supply, even though the invagination hypothesis had much more to support it than it has.

23. *The Coxal Glands and Malpighian Vessels.*—The primitive form had excretory glands opening behind the limbs on the 3rd and 5th segments. These may be persistent Annelidan nephridia of these segments. The nephridia have otherwise vanished (? genital ducts). It is not easy to account for this disappearance of glands of such primary importance to their Annelidan ancestor.

The single pair of Malpighian vessels opening into the mid-gut of modern Arachnids are not homologous with the proctodeal Malpighian vessels of the Hexapods, and may perhaps be homologous with one of the numerous pairs of alimentary diverticula of the Ancestral form which became useless for digestive purposes (*cf.* p. 361). Whether these vessels in the Arachnids are really serial with the digesting diverticula in the more anterior segments I cannot say. That such diverticula may become glands is well known, and why not also excretory glands?

Excretory glands, assumed to be nephridia (see, however, footnote, p. 380), occur in the cephalothorax in *Limulus*, where, owing to the concentration of viscera in this part of the body, they are more explicable than is their limitation to the cephalothorax in the Arachnids. They open on the 5th segment (Tower, Zool. Anz. 1895, p. 471) and are apparently homologous with the shell-gland of *Apus*. Proctodeal Malpighian tubules do not occur in *Limulus*; in this respect both *Limulus* and the Arachnids are distinct from the Hexapods.

24. *Spinning-, Stinging-, Cement-, and Stink-glands.*—No other group of Arthropods is so abundantly and so variously supplied with such glands as are the Arachnids. As the probable derivatives of setiparous glands of an Annelidan ancestor they suggest that the primitive form was richly supplied with setæ. This was indeed the case, as we can gather from the great hairiness of the Galeodidæ and the Aviculariidæ, and from the immense number of large pores, closely resembling setal pores, through the integument of *Scorpio*.

The Merostomata, as specialized for a free swimming life, had generally lost their primitive Annelidan setæ. It is very doubtful whether, if they became adapted to a land life, they would be able to redevelop them. This is not all. They would have to be redeveloped in their early Annelidan form, when their secretory glands were still capable of modification into other kinds of glands. For it seems to me that these glands in the Arachnida, occurring in such well-defined series, can only have been derived very early from the series of setiparous areas which occur typically on the parapodia of Chætopod Annelids (see below, p. 404).

25. *Reproduction.*—There is, in the primitive form, a single pair of glands opening together on the first abdominal segment, the limbs of which closed together over the aperture, either to form a sexual organ or a plate-like protection for the aperture. As

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* Jaworowski (35) claims definitely, in his embryological researches, to have proved that the branched tracheæ preceded lung-books, which are but a secondary specialization of the former. On the other hand, Wagner (73) maintains that the primitive Arachnid had no tracheæ in the cephalothorax; *Galeodes* alone proves the contrary, inasmuch as its segmentation shows it to be, in this respect at least, a primitive form (*cf.* also pp. 371–376).

the alimentary diverticula became specialized, the glands underwent variations, their ends often meeting and fusing. The reticulate form found in *Scorpio* arises from a series of such fusings between the alimentary diverticula; it is certainly not primitive.

The reticulate form of the sexual gland in *Limulus* is more highly specialized than was that of the primitive Arachnid.

The Resemblance of Scorpio *to the Eurypterids, due to Convergence.*—The foregoing arguments show very conclusively that there can be no real relationship between the Merostomata and the Arachnids. The great resemblance between the Eurypterids and *Scorpio* must therefore be one of convergence. This is not difficult to demonstrate. In the first place, it is obviously so if *Scorpio* is a specialized and not a primitive form, and this we have abundantly shown. Indeed, the very point in which *Scorpio* most resembles the Eurypterids—namely, the great compression of the anterior limb-bearing end of the body—happens to be its most marked specialization, which has caused it to depart furthest from the primitive condition with free segments.

But the argument can be made very much stronger. It is obvious that if the resemblance between the Eurypterids and *Scorpio* is not a case of convergence, then, as we go back along the lines of their development, we should find this resemblance getting more and more striking, until we reached their common ancestral form. In order thus to trace the two back to their sources, the advocates of their relationship have made a close study of their embryological development, and have very naturally discovered a wonderful parallel. But embryology, in this case, teaches us nothing, because each form is laid down from the first in its definitive shape, so that the likeness of the embryo is but a repetition of the likeness of the adult. But where embryology fails us, comparative anatomy comes to our aid; its study will, I expect, be found to reveal the phylogenetic history of animals and groups of animals with more precision than embryology ever can. This is certainly so in the present case, in which embryology does not in either case teach us anything clear as to what its less differentiated ancestors were like. Thanks to comparative anatomy, we can reconstruct in some important details the ancestors of the Arachnids before the segmentation became too specialized; we can ascertain the leading specializations of that segmentation, marking off for all time the Arachnid phylum from all other derivatives of the Chætopod Annelids. Further, Arachnids still persist in which only three segments are fused together, all the rest being free. Turning now to the Merostomata,—do we know what their earlier, less differentiated forms were like—those forms, for instance, in which only the three anterior head-segments were fused together? If so, does it resemble the Arachnid at that same stage of segmental differentiation more closely than *Slimonia* resembles *Scorpio*? No, the very reverse is the case. We can deduce the Eurypterids with some precision from less specialized, more richly segmented Trilobite-like forms with head-segments in all stages of fusion—five being the usual number. But all resemblance to the Arachnids has gone, whether to those which we claim to be specialized or to those which, having only three segments fused anteriorly, we claim to be less specialized. We thus find that, as we trace the two forms back to their less differentiated ancestors, all resemblance between them completely vanishes; *i. e.*, in other words, the resemblance between the specialized forms is purely convergent.

Relation of Modern Arachnids to the Hypothetical Ancestral Form.—Having thus sketched a form which embodies all the more important specializations common to all the leading types of Arachnids, at what appear to be their least specialized stages, we can now compare the existing Arachnids with this form as a measure of their respective specializations. The task is not easy, inasmuch as every form retains some primitive features, while others are specialized, and it is not always possible to appreciate the morphological worth of the different characters so as to be able to say which precedes the other.

We may at once dismiss the Phalangidæ and the Acaridæ as undoubtedly the most specialized Arachnids, and confine our comparison to the Pedipalpi (esp. *Thelyphonus*), the Galeodidæ, the Scorpionidæ, the Araneæ, and the Chernetidæ. Each of these retains important characters which have some claim to be primitive.

Thelyphonus and *Schizonotus.*—This form has retained perhaps the largest number of the most important primitive characteristics. *Schizonotus* especially retains the cephalic lobes, two (perhaps three) free cephalothoracic segments, and the leg-like position of the pedipalps, which, moreover, have only very rudimentary chelæ. Further, only nine segments of the abdomen are swelled into a distensible sac, with traces of limbs or stigmata on eight of them. Internally, *Thelyphonus* retains the largest number of ostia in the heart and the largest number of alimentary diverticula. On the other hand, the fusion of the bases of the pedipalps so as to enclose the beak, the enormous backward development of these bases, squeezing up the sternite of the 3rd segment with the coxæ of its limbs, so that they no longer show on the ventral surface, are highly specialized characters. In addition, we have to add to this specialization the sensory character of the 3rd pair of appendages, the highly-developed waist, and the caudal filament, which, however, may perhaps be a development of an anal cirrus of the ancestral form.

Galeodidæ.—These are primitive in the retention of the cephalic lobes, of three free cephalothoracic segments, and of variously-sized portions of the tergum of the 3rd segment, peeping out from under the cephalic lobes; further, in the simple form of waist, hardly disturbing the serial arrangement of the segments; in the retention of leg-like pedipalps, of cephalothoracic tracheæ, and of traces of limbs on all the abdominal segments. Internally, the conditions of the endosternite, a long heart, with two (traces of three) ostia in the cephalothorax, the paired and separate genital glands are primitive features.

On the other hand, the Galeodidæ are highly specialized in the great size of the chelicerae, in the approximation of the coxæ of the limbs, and consequent obliteration of the sternites along the whole length of the body, in the swelling of *all* the abdominal segments to form a distensible sac.

Scorpions.—The Scorpions have retained the primitive number of segments, with distinct filamentous remains of the legs of the 2nd abdominal segment (pectines), and ? of the 12th segment (sting), while only seven abdominal segments are distended into the vegetative sac. On the other hand, they are highly specialized in the character of the pedipalps, in the crowding forward of the coxæ of the limbs, in the compression of the whole cephalothoracic, and in the lengthening out of the anal, segments. Internally, the specialization is seen in the loss of three alimentary diverticula and of all the ostia of the heart, in the cephalothorax, in the relative positions of the ganglia composing the central nervous system, in the fusion of the endosternite with the highly specialized diaphragm, in the loss of the waist, all consequent on the compression of the cephalothorax above mentioned. Further, they are specialized in the forward thrust of the genital aperture between the coxæ of the cephalothoracic legs, in the fusions of the genital glands of the two sides, and in the backward movement of the eyes along the cephalic suture.

The Araneæ (*especially Aviculariidæ*).—These are primitive in the even character of the fusion of the cephalothoracic segments, and consequent relative positions of the ganglia composing the central nervous system; in the persistence of sterna on these segments; in the leg-like pedipalps; in the ocular tubercle with all the eyes grouped upon it (Aviculariidæ), and in the retention of filamentous limbs on the 4th and 5th abdominal segments.

On the other hand, they are highly specialized in the profound structural modifications of the whole abdominal region; in the great reduction of the heart; in the highly-complicated endosternite, and in the great backward extension of the œsophagus, so that the sucking-apparatus is behind the brain.

Pseudoscorpions.—These are perhaps primitive in showing only the very earliest beginnings of a waist, and in the retention of stigmatic scars along the whole length of the abdomen. On the other hand, the pedipalps are as highly specialized as those of *Scorpio*, the coxæ of the limbs meet in the middle line and obliterate the sterna, and those of the walking-legs are forced back by the enormous development of the coxæ of the pedipalps. Internally, we have the reduction of the heart, the great length of the (functional) hind-gut, and the distension of all the abdominal segments into a vegetative sac.

It will be seen that these various specializations do not lend themselves to any genealogical arrangement. They diverge entirely from one another, and cannot in any way be deduced the one from the other.

Take, for instance, one character which it appears must have early divided the Arachnids into two branches, viz. the position of the movable digit of the chelicerae. In one group the chelicerae remained claw-like, the two distal joints, I believe, fusing to form the present movable digit; in the other, the distal joints together made a pair of pincers. All attempts at grouping, according to any such single divergence of specialization, are beset with insuperable difficulties the moment we take other characters also into account. By way of example we may take the tendency of the first walking-legs to become sensory in *Galeodes*. This tendency prepares us for the highly-developed sensory characters of the same limb in *Thelyphonus*, yet it is impossible to deduce *Thelyphonus* from *Galeodes*. Their chelicerae are not formed on the same pattern. The same difficulty meets one with each character in turn, and compels us to fall back upon the simpler plan of deducing all separately from the hypothetical racial form.

Relation of the Hypothetical Form to other Arthropoda.—This important subject can only be briefly touched upon. I may perhaps be allowed to suggest a few considerations which I think may serve to elucidate the different origins of the Arthropoda.

It seems to me that the contrast above described (p. 388, Pl. XXXIV. fig. 17) between the primitive segmentation of the Arachnida on the one hand, and of the Trilobites and primitive Crustacea on the other, in adaptation to two different and directly opposite methods of feeding, suggests that the Hexapods and Myriapods may be intermediate specializations. In these last-named Arthropods, the first pair of limbs, like the chelicerae of Arachnids, moved upward and forward, but, as sensory feelers, they did not require the powerful muscular attachment necessary for prehensile limbs: hence there were no cephalic lobes. The next two pairs of limbs were specialized as chewing-jaws within the mouth-aperture, while the fourth pair might either be free to do the same or fuse with the under-lip to form a compound labium. The anterior position of the mouth would render it not easy for many pairs of limbs to function as jaws; in order to enable even two or three pairs to do so, the anterior segments have had to be so compressed, that a distinct region, the head, has been formed.

We thus have the Hexapods with an initial specialization of segments differing from that either of the Arachnids or of the Crustacea. Whereas in the former there was a backward and dorsal distortion of the 1st segment, and in the latter a ventral bending of the 1st segment, in the Hexapods the first four segments were merely longitudinally compressed in order to allow the limbs of the 2nd, 3rd, and 4th segments to function as jaws round an anterior mouth-aperture. This applies also to the Myriapods, but in them we find a varying number and different arrangement of limbs functioning as jaws. This difference between the Myriapods would thus separate them entirely from the Hexapods and also from one another.

One other difference between the Arachnids, the Crustacea, and the Hexapoda appears to me to be fundamental. If my deduction of tracheal invaginations from acicular glands prove correct it would suggest different origins for the limbs in these three derivatives of the Chætopoda.

I would deduce the Crustacean limb from the Annelidan parapodium by ventral displacement, so that the ventral parapodia became the chewing-jaws, the dorsal the swimming (and ultimately walking) limbs, which carried cirri (exopodites) and gills (epipodites). The dorsal portion of the limbs probably long continued as swimming-plates, during which time their special groups of setæ were dispersed, while the supporting aciculæ of the original parapodia were lost (see, however, footnote, p. 380). On the ventral portion of the limbs the setæ may have furnished the bristle-like teeth and other hairs. (Pl. XXXIV. fig. 18, A.)

The ancestors of the Arachnids, like those of the Crustacea, appear to have developed the dorsal parapodia into the walking-legs. But these limbs probably passed through no flat swimming stage. The ventral parapodium disappeared or became merged in the coxal joint of the more developed limb. The acicular gland of the dorsal branch as it became a long limb degenerated, but that of the ventral and less specialized branch persisted as the tracheal invagination (Pl. XXXIV. fig. 18, B). This figure is not altogether an imaginary drawing. While closely watching an *Epeira* in a bottle, protruding and retracting its spinnerets, I noticed that in their most protruded condition they had the shape represented in this figure. The spinning-glands might thus well be the setiparous sacs of the original setæ at the tips of the branches of the parapodia. This origin of the limbs will explain the two series of glands on each side, above referred to (p. 383), one opening at the ends of limbs or laterally, and the other near the median line. In this way we might have spinning-glands placed distally on the limbs, tracheæ derived from the specialized acicular glands of vanishing parapodia laterally along the ventral surface, and spinning- and cement-glands near the median line.

Turning lastly to the Hexapods and Myriapods, we find that the leg can be deduced from the ventral parapodium, while the dorsal parapodium disappeared, leaving, however, the acicular gland as a tracheal invagination, and the setiparous areas either scattered as hairs or persisting in areas (pupa of *Orgia antiqua*) or partly developing into stink-glands (foramina repugnatoria of the Myriapods). Pl. XXXIV. fig. 18, C, is not so unlike the section of a Lepidopterous larva in which the stump-like legs are armed at their distal ends with numerous hooked setæ. Here, again, as in the case of the Arachnids, we should have the acicular glands only persisting where a parapodium has vanished.

These three possible origins of the trunk appendages of the chief divisions of the Arthropods are as distinct as are the specializations of the anterior segments with their appendages for the purposes of feeding above suggested.

I am thus disposed to look upon the Crustacea, the Arachnida, the Hexapoda, and the Myriapoda as distinct specializations of a Chætopod Annelidan type, and in no way deducible the one from the other.

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* The last two papers were not seen by me in time to be dealt with as fully as the important conclusions arrived at by their authors require. I must content myself with stating my conviction [and this applies also to Wagner's paper (73)] that all conclusions based upon transitional phenomena in the development of single specialized types will have ultimately to be tested by a profounder and more extended comparative study of existing forms, including their many instructive generic and specific variations.

EXPLANATION OF THE PLATES.

Plate XXVII.

Fig. 1. A specimen of *Cleobis,* dorsal aspect to show the metamerism. 3, 4, 5, 6, cephalothoracic segments. I–X abdominal segments. Immediately behind the cephalic lobes (*cl*), a pair of triangular sclerites represents the remains of the tergum of the 3rd segment (3). The tergum of the 4th segment (4), transformed into a pair of solid rods, which anteriorly hold up the cephalic lobes, and posteriorly are continued in the lateral walls as strong pillars, rising from the ventral skeletal framework (*cf.* Pl. XXVIII. fig. 15, *r*). The terga of 5 and 6 differ in no important respect from those of the abdominal segments. Flexible membranes form the sides of the body. *a,* specialized area of the cephalic lobes.

2. Side view of the same, showing the flattened cephalic lobes characteristic of *Cleobis.* The eyes project from a slight forehead-like bend of the anterior edge of the cephalic lobes. The rod-like formation of the tergum of the 4th segment supports the posterior edge of the cephalic lobes. The sides of the body are covered with a flexible membrane through which muscle-strands can be seen. The lateral eye is on the specialized area (*a*).

3. Sketch of the cephalic lobes of *Solpuga paludicolla,* Pocock, showing the strong suture and the projecting ocular tubercle. The tergum of the 3rd segment, only partly covered by the paired cephalic lobes. The supporting rods (tergum of the 4th segment) nearly meet in the middle line.

4. Part of the anterior dorsal surface of *Galeodes caspius,* Birula.

5. Lateral view of the same region in *Galeodes arabs,* C. Koch, showing the cephalic lobes at an angle with the tergum of the 3rd segment, a large portion of which remains uncovered in this genus.

6 & 7. Dorsal and lateral views of the same region in *Rhax termes.* The tergum of the 3rd segment reduced to a very narrow border behind the short, round cephalic lobes.

8. A, B, C, D. Diagrams to show the possible origin of the cephalic lobes (*cl*) as lateral portions of the 1st segment (1) shifted on to the dorsal surface (*ds*) above the labrum (L), owing to the translocation of the 1st pair of appendages (*ch*) from a lateral to a preoral position. The ocular tubercle is the remains of the old dorsal surface (*ds*) (*cf.* fig. 10). For the development of the chelicerae, *cf.* Pl. XXIX. fig. 1, *a*, *b*′, *c*′.

9 *a*. Partly diagrammatic section through *Galeodes* (traced with camera lucida), showing the relative sizes and positions of the chelicerae (*ch*) and the pedipalps (*pp*). L, the labrum or beak. 9 *b*. The same of *Scorpio,* showing the small size of the chelicerae (*ch*) as compared with the pedipalps (*pp*). The cephalic lobes have shrunk to a flat carapace on each side beyond the chelicerae. L, labrum; l_1 and l_2, spoon-like processes of the coxæ of the 1st and 2nd legs (appendages 3 and 4); *g*, section through the gutter on l_2. 9 *c*. The same of *Obisium.* *l,* labium. For the sections through these beaks, *cf.* Pl. XXVIII. figs. 3, 9, 10.

10. Dorsal surface of *Palæophonus nuncius,* after Thorell and Lindström, showing the ocular tubercle as portion of original dorsal surface (*ds*), being grown over by the cephalic lobes (*cl*).

11. Part of a dissection from the side of *Galeodes arabs,* right cephalic lobe and right chelicera cut away. The cephalic lobe is seen to end posteriorly as a blind pocket, resting on the tergum of the 3rd segment. The median suture (*s*) is seen as a longitudinal ridge projecting inwards. The inner side of the left chelicera is seen, showing the basal smooth area

(*cf.* text, p. 321, and Pl. XXIX. figs. 1, *a*, *b'*, *c'*). The beak (B) is seen *in situ*, the right pedipalp having been removed. *st*, the strainer composed of bristles, joined together as shown on Pl. XXVIII. fig. 6. *f*, flabellum.

Fig. 12. Transverse section through a *Galeodes* (? *Rhax*), showing the blind pockets of the cephalic lobes (*cl*). *m.ch*, muscles of the chelicerae, which fill up the cephalic lobes. *s*, suture between the cephalic lobes. *e*, endosternite, on which lie the elevator muscles of the pedipalps, and the mid-gut. *n*, nerve-cords. *cg*, coxal glands. *tr*, trachea near the stigmata.

13. The posterior end of a *Rhax*, showing the anal segment, as if surrounded by a large tergite. The anus, indicated by an asterisk, is quite ventral in this genus (*cf.* Pl. XXIX. fig. 6).

14. The ventral surface of the first three segments of a *Solpuga*. The beak seen from below. The chitinous plate (shaded) supporting the labium is seen to be a continuation of the fused sternites between the coxæ of the pedipalps (*pp*) and of the 1st pair of legs (l_1). *st*, the strainer seen from below, as in horizontal section. *br*, the feathered bristles on the labium (*cf.* fig. 11). *sp*, rigid sensory process on the coxæ of the pedipalps.

15. Ventral surface of a *Galeodes*, showing the meeting of the coxæ in the middle line along the whole length of the body, completely obliterating the sterna, with the exception of the plate supporting the labium (*cf.* fig. 14) and the triangular piece between the last pair of legs. The paired sternal areas of the abdominal segments are the remains of limbs which have vanished, the coxæ of which also met in the middle line (*cf.* text, p. 328, and Pl. XXIX. figs. 6–11). *stig*, stigmatic aperture. Remains of sternites shaded. *la*, remains or traces of abdominal appendages. *go*, genital operculum.

16. The ventral surface of a *Scorpio* (*Palamnæus*) showing the approximation of the coxæ and obliteration of the sterna in the first four segments. The true sternites (shaded) persist on all the following segments, excepting where covered by the genital opercula or lost in the specialization of the tail. *la*, the areas marking the former presence of appendages.

17. The ventral surface of a *Thelyphonus*, showing the fusion of the coxæ of the pedipalps (*pp*); the position of the beak is indicated by dotted lines. The sternal plate supporting the labium persists, enclosed between the fused pedipalps (*cf.* sections, Pl. XXVIII. fig. 14, *lr*), and runs back to join the sternum of segment 3, which forms a fold under the anterior end of the large sternite of segment 4. The limbs (l_1) belonging to segment 3 have also been squeezed out of the ventral surface, apparently by the enormous backward development of the coxæ of the pedipalps. A small oval sclerite indicates the sternite of segment 5, and sternite 6 is well marked. On the abdomen the sternites persist, from that of segment II. (covered by the genital operculum, *go*) to the commencement of the "tail" segments. Well-marked sternites persist in segment 8, which in *Scorpio* forms part of the tail.

18. The ventral surface of *Phrynus*. The anterior prolongation of the sternum (sternites 1 and 2) is not squeezed up between the coxæ of the pedipalps, but is forced downward by the meeting of these coxæ above it. The sternites of the three posterior cephalothoracic segments are clear, but divided (? folded) into areas. The appendages forming the genital opercula persist as the so-called "penis."

PLATE XXVIII.

Fig. 1. Ventral surface of the cephalothorax of a young Epeirid just hatched and cleared in cedar-oil, also showing areas marked off on the sternal plate as in *Phrynus*, the chief differences being the absence of the median row of areas and the presence of the clearly-marked sternum of the 3rd segment, which in the Pedipalpi is almost (*Phrynus*, Pl. XXVII. fig. 18) or quite (*Thelyphonus*, Pl. XXVII. fig. 17) suppressed.

Fig. 2. Ventral surface of an unspecified Pseudoscorpion, showing the complete obliteration of the sternites on the cephalothoracic segments.

3. Section through the beak of *Galeodes* near the line *a–b* (fig. 5), showing its fusion with the coxæ of the pedipalps (*pp*); *m*, the flexible membrane between the bases of the cheliceræ and above the beak. *sa*, sucking-apparatus; *lr*, supporting rod of the labium (*cf.* Pl. XXVII. fig. 14), attached by muscles. *fc*, flexible chitin.

4. Section through tip of the beak near *c–d* (fig. 5); the labrum (L) has a thick solid chitinous dorsal keel, the labium (*l*) is divided into two soft lobes (Pl. XXVII. fig. 14).

5. Longitudinal section through the beak. The sucking-apparatus is confined to the beak, and consequently anteriorly to the central nerve-mass (shaded). *a–b* and *c–d*, approximate lines of section of figs. 3 and 4. *m*, the membrane shown in fig. 3.

6. Portion of the straining arrangement of bristles, which projects from the tip of the labrum, covering the mouth-aperture. It is composed of plumose setæ joined by trabeculæ. *pig*, pigment, travelling up through the thick chitin (*cf.* Pl. XXIX. figs. 16, 17).

7. Sagittal section through the mouth of *Phrynus*. The labrum L is much reduced; the labium is little more than the sternal supporting rod, *lr*. The sucking-apparatus is both in front of and behind the central nerve-mass (shaded). *m*, flexible membrane between bases of cheliceræ, the position of which is indicated (*ch*), although they could not appear in a true median section.

8. Sagittal section through the mouth of a Spider; labrum (L) and labium (*l*) bent downward; the sucking-apparatus almost entirely behind the central nerve-mass; *ch*, as in last figure.

9. Diagrammatic section through the mouth of *Scorpio*, the sucking-apparatus is confined to the beak, which, however, is much shortened. *l*, the spoon-like processes of the first leg, l_1, to prevent the escape of juices crushed out of the prey (*cf.* p. 357 & Pl. XXVII. fig. 9 *b*).

10. Diagrammatic section through the beak of a Pseudoscorpion; the sucking-apparatus is concentrated in the posterior end of the beak.

11. The same of *Thelyphonus*, the sucking-apparatus extending along the beak as in *Galeodes*.

12, 13, 14. Three cross sections through the beak of *Thelyphonus*. 12 near the tip; 13 at the beginning of the pumping-apparatus; and 14 at its junction with the body. It is held between the fused coxal joints of the pedipalps (*pp*), which together make a kind of trough in 12, from which the juices of the animals crushed by the cheliceræ (*ch*) are sucked. *lr*, the supporting rod of the labium, the persistent sternum of the 1st and 2nd segments (*cf.* Pl. XXVII. fig. 14). *st*, the fine straining-bristles lining the inside of the mouth.

15. Ventral chitinous framework of *Galeodes arabs* dissected out and cleaned with caustic potash. (The beak and the endosternite are placed in line at the side, fig. 15 *a*.) In addition to the transverse folds between the coxæ, are seen the median folds, which may be the remains of sterna pressed up into the body by the approximation of the coxæ in the middle line; a pair of chitinous rods (*chr*) at the inner ends of the cephalothoracic stigmata (*stig*) support the endosternite (*cf.* figs. 16, 19). A pair of lateral rods (*r*) form the ventral attachments of the modified tergites of the 4th segment (*cf.* Pl. XXVII. figs. 1–6). *b*, the buttresses upon which the limbs rotate. *chf*, chitinous folds, which serve to hold the nerves to the last pair of legs in place (*cf.* Pl. XXXI. fig. 6). *e*, attachment of the right half of the endosternite. *lr*, labial supporting rod.

15 *a*. The endosternite removed to one side, but in a line with its proper position on the skeletal framework (fig. 15). *p*, fibrous plate, attached by tendons to the exo- and endo-skeleton. *cg*, main duct of the coxal gland, which appears to end on *p*. L, labrum or beak.

Fig. 16. Side view of the endosternite, fibrous plate (*p*), the supporting rod (*chr*), and the coxal gland (*cg*). *e*, point of origin of right half of the endosternite.

17. From a section through *e* (fig. 16), showing the endosternite as an infolding of the cuticle.

18. Transverse section through the endosternite, showing the interlocking of the right and left halves (e_r, e_l) in the middle line and the fusion with the supporting rod (*chr*) (*cf.* figs. 15, 16). The fibrous tissue (*ft*), binding the portions together, stains deeply. The nature of the endosternite as a chitinous infolding is apparent (*cf.* fig. 17).

19. Longitudinal section through the fibrous plate (*p*).

Plate XXIX.

Fig. 1. Diagrams to suggest an origin for the two types of Arachnidan cheliceræ from an original 3-jointed limb. *a, b, c,* is the order of development for the type found in the Spiders and Pedipalpi. *a, b'*, the same for that of *Scorpio*, Phalangids, and Pseudoscorpions. *a, b', c'*, for *Galeodes, Gamasus,* and other Acari. In *c'*, *str* represents the position of the stridulating apparatus found in certain Galeodidæ (*cf.* text, p. 322). 1, 2, 3, the three joints and their modifications. *o*, ocular tubercle. *cl*, cephalic lobe.

2 (twisted round by mistake). Section through the tip of a chelicera of *Phrynus*, showing what may be a trace of a lost joint, *j*. *fc*, flexible chitin; *set*, setæ, ? homologous with the spinning-glands of Pseudoscorpions, and poison-glands of Spiders, opening in practically the same spot.

3. Side aspect of the anterior end of a small *Galeodes*, showing the relative sizes and positions of the pedipalps (*pp*) and 1st pair of legs, also the enormously long sensory hairs, only a very few of which are drawn. *ol*, joint containing the olfactory organ at the tip of the pedipalps (*cf.* Pl. XXXI. figs. 10–17).

4. The same of a *Rhax*, showing the relative sizes and position of the same limbs. The terminal joints of the pedipalps (*ol*) are immovable. *le*, lateral eyes.

5. Hypothetical diagram, showing the character and position of the three first limbs in the primitive form (*cf.* fig. 14).

6. Ventral aspect of *Rhax* to show the sequence between the coxæ of the cephalothoracic limbs and the paired ventral plates of the abdominal segments.

7. To show the continuity between the genital operculum (*go*) of a *Galeodes* and the cephalothoracic limbs; the chitinous folds (*cf*) of the former continue the interarticular folds (between coxa and trochanter) of the cephalothoracic limbs (*cf.* fig. 11).

8. Ventral abdominal surface of a *Galeodes intrepidus*, Savigny, in the British Museum (abdomen not distended), showing the ventral plates (limb-areas), continuing the plates forming the genital opercula.

9. The same of a specimen of *G. fatalis* (abdomen somewhat distended), showing the sequence of the paired plates (*la*).

10. The ventral median line of a *Galeodes* (? sp.), also in the British Museum, showing in more detail the characters of the limb-areas. *go*, genital opercula; *stig.o*, stigmatic opercula.

11, 12, 13. Hypothetical restorations of abdominal limbs to explain the position of the stigmata. 11. *Galeodes*. The stigmata on the posterior faces of the coxæ (*stig.o*=stigmatic opercula) have been brought in towards the middle line by the bending backward of the limbs. 12. *Scorpio*. The limbs retained their lateral positions, but sloped backward. 13. *Thelyphonus* or *Phrynus*. The spinning-glands (*gg*) in the genital limb (*go*) ("penis" of *Phrynus*) appear to be homologous with the glands (*gg*) on the same limbs in *Galeodes*. *cg*, aperture of the coxal gland; *stig*, stigmata, persistent or aborted.

Fig. 14. Hypothetical restoration of the common racial form. L, labrum; *l*, labium, the latter being the sternum of the 1st segment; these together formed the primitive beak; 1, cheliceræ, limbs of 1st segment; st_2, 2nd sternite; 2, pedipalps; 3, 1st leg. The abdominal limbs with stigmatic apertures are shown along the whole abdomen, the last pair on segment xii. probably forming the sting of *Scorpio*, thereby accounting for the paired poison-glands (*pg.*) The dotted lines indicate the number of the abdominal segments subsequently specialized for distension, in two cases leaving a few segments to form a "tail." S, *Scorpio*; T, *Thelyphonus*; G, Galeodidæ and Spiders.

15. Thick portion of the cuticle, showing the outermost refractive or glassy layer (*g*), followed by many layers of softer laminated chitin, traversed by canals containing deeply staining protoplasm and pigment. These canals terminate in the glassy layer. The hypodermis-cells have broken away, leaving small groups of deeply-staining points, which are the proximal ends of the protoplasmic processes traversing the chitinogenous layer. On the probable nuclear character of these processes, *cf.* text, p. 331.

16. Cuticle from the pedipalp of a *Galeodes*. Fusiform masses of olive-green pigment (*pig*) send up processes which traverse the chitinogenous layers, similar fusiform masses being already incorporated in the cuticle. *g*, thin glassy layer.

17. Portion of the thick and especially hard and brittle cuticle in which the fine canals traversing the chitinogenous layers become wavy before tapering off into the glassy layer (*g*).

Plate XXX.

Fig. 1. Portion of thick cuticle of *Euscorpio*. *g*, the very thick, clear, glassy layer; *h*, hard refractive layers; *ch*, softer chitinogenous layers. On the blind canal (*sp*) traversing the cuticle, *cf.* text, p. 334.

2. Lateral flexible membrane of *Scorpio*. *g*, glassy layer forming papillæ, the softer staining laminæ (*ch*) thrown into folds.

3. Section through flexible cuticle of abdomen of *Lycosa* (highly magnified), showing the folding of the glassy layer (*g*), rows of pores (*p*) in the furrows; the outer portion of the chitinogenous layers (*ch*) show no stratification, but are traversed by canals leading (?) to the pores.

4. Method of suspension of a hair by the glassy layer, which also forms the outer covering of the hair, and lines the chamber in which the butt-end of the hair is suspended; this end is attached all round by a ring of radiating and deeply staining fibres (*cf.* fig. 7 *b*).

5. The same, when the chitinogenous layers are thin.

6. Flexible membrane of abdomen of *Galeodes*, showing the regular folding of the glassy layer, and the glassy chamber which prevents the hair from being thrust into the soft tissues.

7 *a*. To show the canal (*c*) which keeps the chamber above the fibres (*rf*) in communication with the body-cavity. This canal appears chiefly in long sensory hairs on the pedipalps and first legs (*cf.* Pl. XXXII. figs. 13, 14).

7 *b*. The radiating staining-fibres attaching the chitinogenous layer of the hair to the chitinogenous layer of the cuticle. These appear to be especially numerous in the long sensory hairs.

8. A spine from a limb of *Galeodes*, showing its suspension by the glassy layer, and the spear-head arrangement to prevent the hair from being thrust into the tissues.

9. Diagrammatic longitudinal section reconstructed from serial sections, showing the longitudinal (*dlm, vlm*) and dorso-ventral muscles (*dv*); *m* (shaded) indicates the musculature of the cheliceræ confined to the cephalic lobes; *cg*, aperture of the coxal gland: *e*, point of origin of the endosternite; *stig*, stigma; *r*, ventral point of attachment of the rod supporting the posterior edge of the cephalic lobes (*cf.* Pl. XXVII. figs. 1–7); D, the diaphragm.

Fig. 10. Diagram illustrating some of the muscles of the endosternite; *ep*, elevator of the pedipalps; *p*, fibrous plate; *e*, endosternite (*cf.* Pl. XXVIII. fig. 16 and text, p. 339).

11. Internal aspect of ventral abdominal surface of *Galeodes arabs*. On the left, the arrangement of the ventral longitudinal muscle-bands (*vlm*), on the right the ovary (?) (*ov*). Anteriorly is the diaphragm (D); *h*, aperture for the heart; *in*, for the intestine. The other apertures in the diaphragm are for tracheæ (*cf.* figs. 13 and 14); the median nerve swells into a ganglion (*abg*); the lateral nerves (*n*) belong to the genital gland.

12. Muscle-fibres in section, each fibre surrounded by a fine connective-tissue sheath.

13. Lateral view of the main tracheal trunks of the left side, the pericardial trachea (*pct*) being median.

14. View of the abdominal tracheal system, with the exception of the pericardial trachea, which, however, has 3 points of connection (*pct'*), viz. from a pair of branches in the 1st segment, and from a single branch on the right side in the 2nd segment. The ventral ends of the dorso-ventral muscles (*dv*) attached in the median line are shown cut through. On the right, part of the main tracheal trunk is omitted in order to show the tracheæ supplying the cuticle and the ventral longitudinal and lateral muscles.

15. Pericardial trachea (*pct*), aerating the heart (*h*); the dorsal longitudinal (*dlm*) and the circular (lateral) muscles (*lm*). For the origins of this system, see figs. 13 and 14 (*pct'*).

16. Part of a transverse section through a pair of abdominal stigmata. *m*, the median fold of skin to which, anteriorly to the stigmata (*cf.* fig. 14), the dorso-ventral muscle is attached. Small muscle-bands on each side appear to dilate the stigmatic apertures (*stig*). The stigmatic combs (*co*) appear, *in situ*, cut through in the section.

17 *a* & 17 *b*. Two figures explaining the histology of the tracheal tubes. *g*, the glassy layer of the cuticle continued as the lining of the tube, under which occurs the staining chitinogenous layers (*ch*), which is greatly thickened to form the spiral hoops (*cf.* fig. 17 *b*, with Pl. XXXI. fig. 7, which shows the thickening of the laminæ of the chitinogenous layers to form the lens of the eye); *ep*, epithelium; *n*, nuclei of epithelial cells.

18. Longitudinal section through a cephalothoracic stigma of a *Rhax*. The setæ modified to form a protective sieve. The flat-headed hairs within the aperture appear to be open at their tips, and may be olfactory.

19. An abdominal stigma of the same animal appearing in a sagittal section. It is seen well protected by the stigmatic fold. Digestive tubules (*dt*) are seen penetrating into the fold.

PLATE XXXI.

Fig. 1. Nearly median longitudinal section through *Rhax*. *ot*, optic tubercle; *dm*, divaricator of the left chelicera cut through; t_3, apodeme formed by the posterior portion of the cephalic lobes resting on the 3rd tergite; *mg*, outline of mid-gut; *œ*, œsophagus; *cn*, central nerve-mass; *b*, buttress round which the left pedipalp rotates; *cg*, convolutions of the main ducts of the coxal glands; *e*, endosternite; D, diaphragm; *h*, heart; *tr*, tracheal tube.

2. Sagittal section through the central nerve-mass (the fine details of which can only be diagrammatically suggested), showing the relative position of the principal ganglionic centres. *on*, optic nerve; *ch*, nerve to the chelicera; *pp*, ditto to the pedipalp; 1, 2, 3, 4, ganglia of the 1st, 2nd, 3rd, and 4th legs; *œ*, œsophagus.

3. Showing the relative positions of the same ganglionic centres in different Arachnids. *a*, Spider, showing least specialization (*i. e.* forward and upward tilting); *b*, *Galeodes*; *c*, *Scorpio*; *d*, outline of central nerve-mass of *Phalangium*; *e*, relative positions of ganglionic

centres in a Pseudoscorpion; *o*, optic; *ch*, cheliceral; *pp*, pedipalpar ganglion 1, 2, 3, 4, ganglia of the nerves to the legs.

Fig. 4. Dissection showing the relations of the nerve mass to the endosternite (*e*); *cg*, part of the spongy terminal portion of the coxal gland; *mg*, the mid-gut with its diverticula; *on*, optic nerve; *ch*, nerve to chelicera; *pp*, double nerve to pedipalp; 1, double nerve to 1st leg; *chr*, chitinous rod (*cf.* Pl. XXVIII. fig. 15).

5. The same, with the heart (*h*); the mid-gut (*mg*) raised off the endosternite, showing the blind pocket of the œsophagus (*æ*); *on*, optic nerve; *ch*, cheliceral nerve; *ch'*, nerve to cheliceral muscles; *e*, endosternite; *mg'*, the positions of the 1st–3rd mid-gut diverticula, the 3rd cut short; *cg*, part of the terminal portion of the coxal gland.

6. Central nervous system of *G. arabs* dissected out. L, labral nerves; *stig*, nerve to the stigma; *chr*, chitinous rod (*cf.* Pl. XXVIII. fig. 15); *cg*, position of the principal coils of the coxal glands; *ab*, abdominal ganglion just posterior to the diaphragm; *g*, nerve to the genital gland; l_1, l_2, l_3, l_4, double nerves to the legs; *chf*, folds of chitin under which the nerve passes (*cf.* Pl. XXVIII. fig. 15); D, position of the diaphragm.

7. Nearly median longitudinal section through the eye. *post*, posterior; *ant*, anterior; *fl*, deeply-staining flexible ring of chitin round the lens, allowing of some movement; *i*, iris-like fold; *sp*, spongy tissue filling the fold and surrounding the eye like a cushion; *b*, blood-plasma and cells; *m*, connective-tissue membrane cutting off the eye from the rest of the body-cavity.

8. Much magnified portion of the preceding; *l*, portion of the lens; *hy*, hypodermis layer secreting the lens; *r*, long retinal cells with nuclei; *lc*, canals for the fluid permeating the whole organ; *sp*, spongy tissue in the iris-like fold.

9. Section further in towards the median line cutting the lens almost tangentially; *c*, irregularities in the outer layers of chitin covering the lens as if it had shrunk; *fl*, staining flexible chitin; *og*, ganglion opticum.

10. View of the tip of a pedipalp of *Galeodes arabs*.

11. Side view showing the thickenings of the chitin forming a hinge; *v*, ventral; *d*, dorsal; *ss*, group of specialized sensory cells.

12. Longitudinal section through the tip of a pedipalp; *d*, dorsal; *v*, ventral; *i*, aperture of invagination; *se*, sensory epithelium, shrunk away from the ventral surface of the invagination; *ten*, tendon for opening the lips; m_1, muscle of the same; m_2, muscle attached to tendon drawing down the invagination—the tendon is covered with epithelial, and scattered pigment, cells; *tr*, trachea; *n*, nerve to the hairs and sensory cells (*ss*, fig. 11) on the dorsal side of the limb.

13. Section through the tip of a pedipalp cut slantingly, the sensory epithelium (*se*) (magnified in 13 *a*) shrunk away from the cuticle which carries the fine sensory hairs; *i*, the cavity of the invagination.

14. A portion of this cuticle showing the thick longitudinal constituents of the lattice-work; the fine transverse elements not shown. The fine sensory hairs are so closely packed that their tips together form a wavy and apparently continuous surface.

15, 16, 17. Anterior, posterior, and lateral aspects of the protrusible organ in its protruded condition as seen on a spirit specimen of *G. arabs* from Shaloof, near Suez, in the Nat. Hist. Mus. S. Kensington.

Plate XXXII.

Fig. 1. A racquet-organ, cleared in cedar-oil, showing the zonal arrangement of the interior tissues *nf,* the radiating nerve-fibres (fig. 7); *ret,* the reticulum of nerve-fibres, connective tissue, and blood-lacunæ (figs. 5 and 6, *ret*); *ep,* the folded epithelium (figs. 8 and 6, *ep*); *ne,* row of nerve-endings (figs. 2, 3, 6).

2. Section across the outer edge of racquet, showing the aperture of the nerve-endings (*ne*) along a ridge (*br*). *pr,* protective ridge.

3. Section showing the ridges folded together for the protection of the nerve endings.

4. Surface view, showing thickness of the cuticle (*ch*) along the lateral edges of the racquet-organ and the apertures for fine sensory hairs on its surface (*sh*).

5. Section through the 2nd zone, fig. 1. *ret,* the reticulum of blood-lacunæ, nerve-fibres cut across, and tracheæ; *ch,* thick chitinogenous layer with outer glassy layer (*g*); *b,* blood-spaces; *n,* nerves cut transversely; *tr,* tracheæ.

6. Optical section in the plane of the organ showing transition from the reticulum (*ret*) to the folded epithelium (*ep*) and from that to the outermost zone of nerve-endings (*ne*) (*cf.* fig. 1).

7. Nerve-fibrils with long spindle-shaped nuclei from the innermost zone.

8. Hypothetical transverse section, based upon a reconstruction of optical horizontal sections. The folded epithelium shown as a single layer. *nf,* nerve-fibres cut across; *b,* the blood-spaces.

9. Surface view of the edge of a racquet of *Rhax.* The bolster-ridge (*br*) along which the nerve-endings open has evidently been turned down, while the protective fold (*pr*) has been bent back and crushed down, thus exposing the bolster-ridge with the nerve-endings.

10. Section of the tip of the first leg (*Rhax*), showing one of the rudimentary claws with two tendons for its protrusion and retraction, the tendons moving in a clear blood-space; on the upperside, well protected by connective tissue, are great numbers of long bag-like sensory cells, as shown in the next figure.

11 *a.* Appearance of the sensory cells of fig. 10; 11 *b,* the same at the proximal edge of the sensory area.

12. A thick longitudinal section of 1st leg of a small *Galeodes,* dorsal aspect, cleared in cedar-oil in order to examine the sensory cells *in situ.* They are seen down the centre as minute dots (? apertures) on the cuticle, which are in connection with peculiar sensory cells seen through the cuticle (figs. 17 *a,* 17 *b*). The place of insertion of every hair is seen to be surrounded by a special grouping of cells.

13. The cell arrangement round the insertion of a large hair. The nerve-cells and secreting cells are protected by a wall surrounding the insertion of the hair distally. The next figure,—

14. Shows the section of a large sensory hair on the 1st leg of a *Rhax,*—the nerve-cells and the secreting cells are protected by a kind of roof (*ro*); *h,* the hair; *rf,* the radiating fibres attached to its butt-end; *c,* the canal connecting the chamber above the elastic (?) fibres with the rest of the body; *se,* the secreting cells, which are all thread-like, forming a bag-like network in which the nuclei are suspended; *b,* blood-cells; *n,* a nerve-cell (?).

15. Hair from the tip of the 1st leg of *Rhax* (figured 10); owing to its position, the bag-like reticulum of secreting cells hangs straight down, whereas at the sides of the limb they slope away in a proximal direction (as in fig. 14).

16. Large bag-like sensory cells, surrounded by connective tissue; 16 *a,* the sensory process passing through the cuticle. These cells occur along the edges of the dotted area in fig. 12.

17. The appearance of the majority of the sensory cells in the area shown in fig. 12; 17 *b,* the passage of the nerve-ending through the cuticle (diagrammatic).

Fig. 18. Left side of the alimentary canal dissected from the cephalothorax of *Galeodes arabs*. 1, 2, 3, 4, the four pairs of diverticula; *ad*, a small accessory diverticulum; *h*, heart; *e*, upper edge of endosternite; D, diaphragm.

19. Optical section of one of the above mid-gut diverticula, cleared in cedar-oil. *lm*, longitudinal; *cm*, circular muscles.

Plate XXXIII.

Fig. 1. Diagram of the alimentary system in the abdomen, to show the position of the dorso-ventral muscles cut through. The diverticula filling the whole abdomen (*cf.* fig. 5) have only one pair of apertures (*ap*) into the central canal (*mg*), viz., in the first segment. They, the diverticula (*dir*), open along the rest of the abdomen into two lateral canals (*lc*); *mal*, Malpighian tubules; *stp*, stercoral pocket.

2. A transverse section (camera lucida), taking in a portion of the diaphragm (D), cut tangentially, showing the small size of the aperture for the alimentary canal (*in*); *h*, the heart; *tr*, trachea.

3. Slightly further back (drawn to the same scale), letters as in last figure. *dlm*, dorsal longitudinal muscles; *n*, neural aperture.

4. Still further back, showing the pair of apertures (*ap*) of the diverticula into the central canal, drawn to the same scale; letters as before. Only a very few of the crowded diverticula are drawn, and some are drawn empty. *n*, the neural sinus, continuing the neural arch of the diaphragm conveying the blood from the cephalothorax into the abdomen; the nerve-strands are in its base. *g*, genital atrium, the chitinous lining has left the epithelium; *gg*, accessory glands, opening one on each side of the genital aperture, and belonging morphologically to the opercula (*cf. gg*, Pl. XXIX. figs. 11, 13); *cf*, chitinous thickening shown in Plate XXIX. fig. 7, as continuations of the inter-articular fold between coxa and trochanter of the preceding limbs; *f*, fæces.

5. Section of a distended abdomen (camera lucida), the diverticula drawn empty. *g*, genital glands; *tr*, main tracheæ (*cf.* Pl. XXX. figs. 13 and 14); *dv*, fragment of a dorso-ventral muscle; *vlm*, ventral longitudinal muscle-band; *lm*, lateral muscles; *f*, fæcal masses in the mid-gut.

6. Section through the waist of a Spider, to show the possibility of constricting the alimentary canal (*in*) by means of dorso-ventral muscles. *h*, heart (artery); *n*, nerve.

7. Transverse section through the posterior end of mid-gut (*mg*), where the lateral canals (*lc*) are closely applied to it on each side (see diagram, fig. 1). The mid-gut is surrounded by circular and longitudinal muscles, outside which are tracheal tubes embedded in a spongy layer of coagulum, fluid-passages and ? cells (*cf. sp*, figs. 8, 9, 11). This spongy mass surrounding the mid-gut is embraced by the lateral canals (*lc*), which are joined together above and below the mid-gut by transverse muscles (*tm*). The epithelium (*mep*) of the lateral canals where they are in contact with the mid-gut is modified as described (text, p. 360). The rest of the epithelium is so crowded with food-globules, that the individual cells are no longer distinguishable. *f*, fæcal masses; *mal*, Malpighian tubules; *tr*, tracheæ; *n*, nerves; *dir*, digestive diverticula with epithelium disorganized by food-globules.

8. Longitudinal section through the junction of the mid-gut and hind-gut of a distended *Galeodes*. *mg*, mid-gut; *hg*, hind-gut; *stp*, stercoral pocket; *tm*, muscles binding the lateral canals on each side of the mid-gut (*cf.* fig. 7); *sp*, spongy layer surrounding the posterior end of the mid-gut. The crowded contents of the mid-gut, hind-gut, and stercoral pocket omitted. The complicated folding of the chitinous wall of the stercoral pocket is suggested. The thread-cells (fig. 11) outside the commencement of the hind-gut gradually change to a tesselated epithelium covering the end of the hind-gut and the stercoral pocket.

Fig. 9. End of mid-gut of a fasting *Rhax,* jammed against the stercoral pocket (*stp*), thereby closing the passage; letters as before.

10. Longitudinal section through the wall of mid-gut at the wide anterior portion (segments 2 and 3 of fig. 1). *lm,* longitudinal muscles; *cm,* circular muscles. The epithelial cells stand on a membrane (*m*) thrown into folds by the contraction of the longitudinal muscles. The epithelial cells of mid-gut are being traversed by strings of food-globules (*fg*). Average length of cell $20\ \mu$.

11. Enlarged portion of fig. 8. *mg,* mid-gut cells, which near the junction with the hind-gut are $80\ \mu$ long and 3 to $4\ \mu$ thick; long strings of food-globules traverse them. *hg,* chitin-lined hind-gut secreted by long, thread-like cells which appear to change into a fine tesselated epithelium covering the stercoral pocket. *lm,* longitudinal muscles; *tm,* transverse muscles binding the lateral canals together (fig. 7); *sp,* spongy layer composed of fluid-passages, cells, and coagulum; *tr,* tracheæ; *cm, lm',* the musculature proper of the mid-gut, a continuation of the muscles shown in fig. 10.

12. Diagram showing the primitive relations which existed between the diverticula of the alimentary canal (*mgd*), the dorso-ventral muscles (*dv*), the tracheal invaginations (*tr*), and the heart (*h*) with its ostia. The dotted lines on the right indicate the extent to which this primitive condition is still traceable in three Arachnids, viz. *Thelyphonus, Scorpio,* and *Galeodes;* D, the position of the diaphragm. (N.B. This figure should have been on the next Plate.)

Plate XXXIV.

Figs. 1–5. Diagrams of the abdominal alimentary system. 1. *Scorpio.* 2. *Thelyphonus.* 3. *Obisium.* 4. *Galeodes.* 5. Hypothetical primitive arrangement with at least 7 pairs of diverticula from which the former can be deduced. In *Scorpio* the two posterior pairs have been suppressed, the fifth pair lengthening backward. In *Galeodes* all but the first pair have been suppressed, this single pair stretching backward *outside* the dorso-ventral muscles. In *Thelyphonus* 4 or 5 pairs persist, the 4th or 5th (?) stretching back *inside* the dorso-ventral muscles and being themselves constricted. This process has gone still further in the Pseudoscorpions, reaching to the 2nd segment, the 'hind-gut' being coiled.

6. Longitudinal section through the last chamber of the heart of a *Rhax,* passing through an ostium; VI, VII, sixth and seventh abdominal segments; *h,* heart; *fc,* large cells (? fat cells); *v,* the posterior vein; *fl,* flexible chitin of intersegmental membrane; *cm,* muscle-fibres forming the tunic of the heart, cut through.

7. Ventral aspect of a portion of a heart, dissected out. *cm,* the circular muscle-fibres shown in section in last figure; *n,* layer of single nerve-fibrils with spindle-shaped nuclei.

8. Diagram of the circulation in the abdomen of *Galeodes.* The blood, entering the abdomen through the neural arch of the diaphragm, follows the mid-gut and nerve-strands in the ventral sinus (*vs*), from this it escapes on both sides among the mass of digestive diverticula, reaching the heart after circulating among them; *tr,* tracheæ near a pair of abdominal stigmata; *g,* genital gland; *h,* heart (*cf.* Plate XXXIII. fig. 5).

9. Diagram of circulation in the abdomen of *Scorpio;* the left half represents a section posterior to that of the right half; *h,* the heart, on the right it is discharging blood through a short passage (artery) among the digestive tubules below the visceral membrane (*m*). *Lb,* lung-book, the leaves of which are so arranged that blood both from the ventral sinus (*vs*) and from the alimentary diverticula can flow out sideways between them. *nc,* nerve-cord with an accompanying blood-vessel, which discharges its blood into the ventral sinus (? and among

the digestive tubules). On the left, the visceral membrane is held down dorsally and raised ventrally by muscle-fibres, the "veno-pericardial" muscles. The blood-space below and the pocket above are the remains of the original inter-diverticular spaces (*cf.* fig. 5). *Dv*, portion of a dorso-ventral muscle.

Fig. 10. A portion of the main duct of the coxal gland in *G. arabs*, highly magnified. The connective-tissue envelope contains blood-lacunæ (*b*) and tracheæ (*tr*); a group of the gland-cells are seen with dividing nuclei deeply stained, in the other cells the nuclei are vesicular.

11. A few cells of the same more highly magnified, the nuclei measured by eyepiece micrometer. 11 *a*. A dividing, deeply-stained nucleus, with measurements.

12. A section of the main duct of the coxal gland near the aperture; the cells are less differentiated.

13. A portion of the spongy mass of tubules developed at the proximal end of the main duct of the coxal gland (*cf.* Pl. XXXI. figs. 4, 5).

14. Portion of the same, highly magnified. *bc*, blood coagulum; *t*, tracheæ; *p*, large solid masses of protoplasm (? cells) traversed by tracheal tubes.

15. The genital and stigmatic opercula of a specimen of *Rhax Keyserlingii*, Pocock (in the British Museum). g', anterior aperture (?), which may be the genital aperture; g'', the ordinary position of the genital aperture into which the cement-glands open; *stig*, the positions of the stigmata; *cf.* the sequence *gg*, $stig_1$, $stig_2$ (Plate XXIX. fig. 11).

16. Portion of a transverse section through an ovary. *ep*, ovarial epithelium; *m*, felt of muscle-fibres; *t*, trachea; *f*, follicular membranes, the one on the left is shrunk after the discharge of an egg; *em*, egg-membrane showing two zones; *y*, yolk-granules.

17 A, B. Diagrams to compare the initial modifications of the anterior segments. A, of the Arachnids; B, of the Crustacea and Merostomata; *p*, prostomium. 1, 2, 3, 4, the 1st four segments. In A a sucking-beak results, while in the latter the appendages can function as jaws round or within the mouth.

18. Diagram showing in transverse sections the origin of the limbs and tracheæ (or glands) of the three chief divisions of the Arthropods, from the parapodia and setiparous glands of a Chætopod Annelid. A, Crustacea; B, Arachnida; C, Hexapoda. *d*, dorsal; *v*, ventral branch of the parapodium; *a*, acicular gland; *g*, gill; *ex*, exopodite; *c*, sensory cirrus (*cf.* text, pp. 403–404).

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THE TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON.

A REVISION OF THE BRITISH COPEPODA BELONGING TO THE GENERA BRADYA, Boeck, AND ECTINOSOMA, Boeck.

BY

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V. *A Revision of the British Copepoda belonging to the Genera* Bradya, *Boeck, and* Ectinosoma, *Boeck.*

By THOMAS SCOTT, *F.L.S., Mem. Soc. Zool. France, Naturalist to the Fishery Board for Scotland, and* ANDREW SCOTT, *Fisheries Assistant, University College, Liverpool.*

(Plates 35–38.)

Read 19th November, 1894.

INTRODUCTORY.

IN the course of our study of the British Entomostraca during the past few years, we have observed from time to time specimens of Copepoda belonging apparently to one or other of the genera *Bradya* and *Ectinosoma*, which, so far as known to us, could not be identified with any of the described species of either of these two genera. Moreover, as considerable difficulty was sometimes experienced by us in satisfactorily diagnosing the characters by which these specimens differed from, and by which they agreed with, species already described, it was decided to delay beginning a critical study of the several forms which had been observed until, if possible, a more extended inquiry had been made. With this object in view, gatherings of tow-netted and dredged material from various places around our coasts have been examined as opportunities occurred, and numerous specimens collected. Careful dissections have been made of all doubtful forms, and, wherever necessary, accurate detailed drawings have been prepared. The results of these researches we now propose to lay before the Linnean Society in the form of a revision of the British Copepoda belonging to the genera *Bradya* and *Ectinosoma*, with figures of all the species described.

We have described and figured the few species already described and figured in works on British Copepoda as well as those which, so far as we know, are new to science, in order to bring into prominence certain obscure points not fully illustrated in previous works, as well as to allow of the various species, old and new, being compared with each other, with greater certainty and ease.

Though this revision has been the result of much careful research, it cannot be considered exhaustive; but if it tends to simplify the study of these two somewhat troublesome genera we shall feel amply rewarded for our labours.

We propose to take the genus *Bradya* first, as the structure of the anterior foot-jaws in this genus shows, in our opinion, a closer affinity with the *Calanidæ* than does that of their homologues in *Ectinosoma*.

The following is a list of the species described in this memoir, arranged in alphabetical order:—

Genus BRADYA.

Bradya elegans, sp. n., p. 422.
,, *fusca*, sp. n., p. 424.
,, *hirsuta*, sp. n., p. 423.
,, *minor*, sp. n., p. 425.
,, *similis*, sp. n., p. 424.
,, *typica*, Boeck, p. 421.

Genus ECTINOSOMA.

Ectinosoma armiferum, sp. n., p. 434.
,, *atlanticum*, Brady & Robertson, p. 437.
Ectinosoma curticorne, Boeck, p. 430.
,, *erythrops*, Brady, p. 431.
,, *gracile*, sp. n., p. 429.
,, *Herdmani*, sp. n., p. 432.
,, *longicorne*, sp. n., p. 439.
,, *melaniceps*, Boeck, p. 434.
,, *Normani*, sp. n., p. 435.
,, *propinquum*, sp. n., p. 428.
,, *pygmæum*, sp. n., p. 433.
,, *Sarsi*, Boeck, p. 427.
,, *tenuipes*, sp. n., p. 436.
,, *tenuireme*, sp. n., p. 439.

Genus BRADYA, Boeck (1872).

Description. Body elongate, fusiform; abdomen not distinctly separated from the thorax. The antennules are usually short and composed of five to eight joints.

The antennæ are 3-jointed, and the secondary branches of the antennæ are 2- to 3-jointed, usually slender, and of variable lengths.

The mandibles are each furnished with a well-developed palp, composed usually of a stout basal joint bearing two 1-jointed branches, one of which is apical and the other marginal.

The maxillæ are well developed.

The anterior foot-jaws are of considerable size and composed of five joints; the first two joints are large and the articulation between them is strongly hinged; the first joint also bears three setiferous marginal processes; the three terminal joints are usually very small.

The posterior foot-jaws are smaller than the anterior and are 3-jointed; the end-joint is shorter than the preceding one, and is usually provided with three apical setæ.

The first four pairs of swimming-feet are all somewhat similar in structure; both branches are composed of three subequal joints, and the outer are usually somewhat shorter than the inner branches.

Fifth pair small, composed of two joints, a basal and a secondary joint.

Remarks. The most important difference between *Bradya* and *Ectinosoma* is to be found in the structure of the anterior foot-jaws. In *Bradya* the anterior foot-jaws are composed of five distinct joints, the first two of which are usually large, while the other three are very small; the articulation between the first two joints is strongly hinged, and in all the "spirit" specimens examined by us the large second joint (together with the three small terminal joints) is bent at, or nearly at, a right angle to the first joint. Moreover, the secondary branches of the antennæ vary in the number of joints from two to three, whereas in all the specimens of *Ectinosoma* examined by us the secondary branches were always 3-jointed. The labium in both *Bradya* and *Ectinosoma* is frequently in the form of a hook-like process.

Bradya typica, Boeck (1872). (Pl. 35. figs. 1, 11, 14, 22, 26, 32, 39, 44; Pl. 36. figs. 1 and 12.)

1872. *Bradya typica*, Boeck (2), p. 15.
1880. *Bradya typica*, Brady (3), vol. ii. p. 17, pl. xxxviii. figs. 1–10.
1893. *Bradya typica*, I. C. Thompson (16), p. 22, pl. xix. figs. 8 *b–c*.

Description. Length ·8 mm. ($\frac{1}{31}$ of an inch). Body moderately robust, fusiform; forehead produced into a short, narrow, but distinct rostrum, which reaches to about the second joint of the antennules. Antennules very short, stout, and 8-jointed; the first three joints are subequal and longer than the others, as in the annexed formula, which shows the approximate proportional lengths of all the joints:—

No. of the joints, counting from the head:	1	2	3	4	5	6	7	8
Proportional lengths of the joints:	7	7	6	2	3	3	4	3

The secondary branches of the antennæ are rather longer and more slender than the primary branches, and 3-jointed, the middle joint being very small (Pl. 35. fig. 14).

The mandibles are stout and armed at the truncate apex with a number of slender teeth; mandibular palp well developed, having the basal joint robust and furnished with several plumose setæ at the apex in addition to the two setiferous secondary branches (Pl. 35. fig. 22).

Anterior foot-jaws stout, the first two joints large and subequal, the last three very small (Pl. 35. fig. 26).

The end-joints of the posterior foot-jaws are very small; two elongate but unequal setæ spring from the inner distal angles of the first joints, while the second joints are each provided with a row of small teeth that extend from the lower proximal angle obliquely across the joint to the upper distal angle; a plumose seta also springs from the lower distal angle; the small terminal joint forms the base of a stout, elongate, and slightly curved setose spine, and a spiniform plumose seta springs from the inner margin of the same joint (Pl. 35. fig. 32).

First four pairs of swimming-feet moderately stout; outer branches of the first pair considerably shorter than the inner branches; in the fourth pair both branches are about equal in length (Pl. 35. figs. 39 and 44).

The fifth pair are small; the short produced interior portion of the basal joint, which is about as broad as long, bears two apical setæ—the inner one very long, spiniform, and slightly plumose, the other shorter and more slender; a moderately long and slender seta springs from the slightly produced outer portion of the same joint; secondary joint small, subquadrangular, and furnished with three slender setæ, the two inner ones being very long, while the other is much shorter (Pl. 36. fig. 1).

Caudal stylets short, and about equal in length to the last abdominal segment (Pl. 36. fig. 12).

Habitat. Off Port Cressa Bay, Scilly Islands; and off Hartlepool (*G. S. Brady*). West of May Island, Firth of Forth. Port Erin, Isle of Man (*I. C. T.*).

Remarks. The Firth of Forth specimens differ in one or two minor points from Dr. Brady's description and figures in his excellent Monograph of the British Copepoda, *i. e.* the antennules in the Forth specimens are 8-jointed and the secondary branches of the antennæ are 3-jointed (in this latter particular they agree with Boeck's description), but in all the more important characters they agree with the description and figures contained in Dr. Brady's valuable work.

Bradya elegans, sp. n. (Pl. **35**. figs. 4, 10, 15, 25, 29, 36, 38, 46; Pl. **36**. figs. 4 and 11.)

Description. Length 1·2 mm. ($\frac{1}{21}$ of an inch). Body elongate, slender; rostrum prominent, seen from above broadly rounded.

Antennules very short, stout, 5-jointed, strongly setiform, the second and last joints shorter than the others; the approximate proportional lengths of the joints are shown by the formula:—

$$\begin{array}{r}\text{No. of the joints:}\\ \text{Proportional lengths:}\end{array}\begin{array}{c}1\,.\,2\,.\,3\,.\,4\,.\,5\\ \hline 7\quad 3\quad 5\quad 5\quad 3\end{array}.$$

Antennæ stout; secondary branch shorter than the primary, 2-jointed, the first joint very short, the second elongate and becoming gradually dilated towards the distal end, provided with two elongate, somewhat unequal, and densely plumose apical setæ; the last joint of the primary branch bears a number of setæ that are coarsely and somewhat irregularly plumose (Pl. **35**. fig. 15).

Mandibles somewhat stylet-shaped; both branches of the palp, which are subterminal on the basal joint, are strongly setiferous (Pl. **35**. fig. 25).

Anterior foot-jaws small; basal joint stout, the three setiferous marginal processes nearly alike; second joint much narrower and somewhat dilated distally; the last three joints are very small (Pl. **35**. fig. 29).

Posterior foot-jaws somewhat similar in structure to those of *Ectinosoma Sarsi*, Boeck, but smaller (Pl. **35**. fig. 36).

The first four pairs of swimming-feet are proportionally more slender and elongate than those of *Bradya typica*, Boeck (Pl. **35**. figs. 38 and 46).

The fifth pair are moderately large and broadly subquadrangular; the produced inner portion of the basal joint is cylindrical and twice as long as broad, and armed at the apex with a moderately long spiniform seta, and a stout spine about half the length of the seta; the outer angle of the basal joint, which is not produced, is provided with a single slender hair and a few small spines; the inner margin is fringed with small setæ, and there is an oblique row of similar setæ on the lateral aspect of the joint; the secondary joint is broad and nearly square in outline; the truncate apex, which does not extend beyond the end of the produced inner portion of the basal joint, is irregularly serrate and bears three elongate spiniform setæ arranged widely apart; the middle one is considerably longer than the one on either side; there is also a slender seta on the outer angle, and an oblique row of minute spines near the inner margin (Pl. **36**. fig. 4).

Habitat. Largo Bay, Firth of Forth.

Remarks. This is a slender and very graceful species; the broadly subquadrate form of the fifth pair of feet is very characteristic. The antennæ and mandibles differ somewhat from those of the typical *Bradya*, but otherwise it appears to be a true member of the genus.

Bradya hirsuta, sp. n. (Pl. 35. figs. 2, 8, 17, 19, 23, 28, 34, 40, 47; Pl. 36. figs. 2–7.)

Description. Length 1 mm. ($\frac{1}{25}$ of an inch). Body seen from the side fusiform; abdominal segments more or less hirsute; rostrum prominent.

Antennules short, 5-jointed, the first two joints robust, the others smaller; the proportional lengths of the joints are nearly as shown by the formula :—

No. of the joints : 1 . 2 . 3 . 4 . 5
Proportional lengths : 7 8 3 4 4 .

Antennæ considerably more elongate than the antennules, the last joint armed with a number of spiniform setæ, the distal half of each of which is strongly ciliate along one side; secondary branches 2-jointed, slender, the first joint short, the second elongate and bearing two terminal setæ.

The labium consists of a small hook-like process (Pl. 35. fig. 19).

Mandibles comparatively small and narrow, and armed with a few slender teeth; mandibular palp larger, the basal joint furnished with a single short subapical plumose seta in addition to the secondary branches (Pl. 35. fig. 23).

Anterior foot-jaws small; the first joint is very dilated, the second much narrower, while the three terminal joints are very small (Pl. 35. fig. 28).

The first joint of the posterior foot-jaws bears a long setiferous spine on the upper distal angle, one of the margins of which is fringed with cilia; the last joint, which is very short, bears two moderately stout spiniform setæ and a long intermediate hair (Pl. 35. fig. 34).

The first four pairs of swimming-feet have the marginal spines and terminal spiniform seta strongly plumose on the exterior edges (Pl. 35. figs. 40 and 47).

The fifth pair are strongly setiferous; the produced inner portion of the basal joint bears one long and one short spiniform seta ; the secondary joint extends beyond the end of the produced inner portion of the basal joint, and is armed with three terminal spines; the two outer ones are elongate and slender, while the inner one is strong and robust, and only about half the length of the one next to it; a plumose seta springs from the lateral aspect of the basal joint, near the exterior edge, and both joints bear transverse rows of cilia, as well as being otherwise hirsute, as shown by the figure (Pl. 36. fig. 2).

Caudal stylets stout, elongate, and considerably divergent, their margins ciliate on the distal half (Pl. 36. fig. 7).

Habitat. Largo Bay, Firth of Forth (1891).

Remarks. This species is at once distinguished by its comparatively large size and long divergent caudal stylets, as well as by its hirsute abdomen and fifth pair of thoracic feet.

Bradya similis, sp. n. (Pl. 35. figs. 3, 7, 16, 27, 33, 41, 48; Pl. 36. figs. 3 and 10.)

Description. Length ·69 mm. ($\frac{1}{36}$ of an inch). Body seen from the side slender, fusiform; rostrum of moderate length and slightly curved.

Antennules short, robust, 5-jointed; the first four joints about equal in length, but the terminal joint rather shorter than the others. The proportional lengths of the joints are nearly as shown by the formula:—

No. of the joints: 1 . 2 . 3 . 4 . 5
Proportional lengths: 8 8 8 8 5.

Antennæ longer than the antennules; the first joint is about one and a half times the length of the next and bears a small 2-jointed secondary branch at the distal end; the second and third joints are about equal in length (Pl. 35. fig. 16).

Mandibles nearly as in *Bradya hirsuta*.

Anterior foot-jaws much smaller than those of *Bradya hirsuta*, and with three small marginal processes on the first joint (Pl. 35. fig. 27).

Posterior foot-jaws also smaller and provided with simple setæ (Pl. 35. fig. 33).

The first four pairs of swimming-feet are all somewhat similar, except that the first pair are rather more slender than the others; the marginal spines of all the four pairs are elongate and slightly setose on both edges; the seta on the exterior angle of the second basal joint of the first pair is elongate and slender, while the seta similarly situated on the fourth pair is considerably shorter (Pl. 35. figs. 41 and 48).

In the fifth pair the exterior and interior produced portions of the basal joint are somewhat similar, except that the inner is rather longer than the outer process and is armed with a long stout spine, setose on both margins, and a stout seta, while the outer process bears a single moderately long seta; the basal joint is furnished with one short and one moderately long setose spine and a few small setæ on the lateral aspect, as shown in the figure (Pl. 36. fig. 3); the secondary joint reaches beyond the end of the basal joint and terminates in three more or less distinct lobes; the two inner ones, which are subequal, extend considerably beyond the outer; the inner and outer lobes are each armed with a very stout and moderately long spine, while the spine that springs from the middle lobe is slender and much more elongate than the lateral spines; all the three spines have setose margins.

Caudal stylets comparatively elongate, being about equal to the combined lengths of the last two segments of the abdomen; they are also somewhat divergent, as shown in the figure (Pl. 36. fig. 10).

Habitat. Largo Bay, Firth of Forth.

Remarks. This species resembles the one last described, but is much smaller. The small secondary branches of the antennæ and the structure of the fifth pair of thoracic feet seem to be the chief distinguishing characters.

Bradya fusca, sp. n. (Pl. 35. figs. 6, 12, 18, 20, 30, 37, 43, 45; Pl. 36. figs. 6 and 8.)

Description. Length ·7 mm. ($\frac{1}{36}$ of an inch). Body not so slender as that of *Bradya* *similis*, nor so stout as that of *Bradya typica*; rostrum rather more prominent than in these two species.

Antennules short, stout, 6-jointed, the first five gradually decrease in length, while the last is about equal in length to the third; the annexed formula shows approximately the proportional lengths of the joints:—

No. of the joints: 1 . 2 . 3 . 4 . 5 . 6
Proportional lengths: 7 6 5 4 3 5 .

Secondary branches of antennæ small, slender, 2-jointed, the first joint much shorter than the second; a number of setæ fringe the distal half of the upper margin of the first joint of the primary branches (Pl. 35. fig. 18).

Labium bluntly rounded (Pl. 35. fig. 20).

The anterior and posterior foot-jaws are somewhat similar in structure to those of *Bradya elegans*, but smaller (Pl. 35. figs. 30 and 37).

The first four pairs of swimming-feet are somewhat similar to those of *Bradya typica*, Boeck, but slender (Pl. 35. figs. 43 and 45).

The inner produced part of the basal joint of the fifth pair is elongate, narrow, cylindrical, ciliate on the inner margin, and provided with two apical setæ, one of which is rather longer than the basal joint, while the other is scarcely half as long; the outer angle of the basal joint is considerably produced and bears a small slender terminal seta; a moderately stout plumose seta springs from the lateral aspect of the basal joint and near the base of the secondary joint; the secondary joint, which is about one and a half times longer than broad, extends somewhat beyond the end of the produced inner part of the basal joint, and has a somewhat irregularly trilobed apex; the two inner lobes are subequal and extend beyond the outer one; the three lobes are each provided with a plumose seta; the inner seta is short and stout, the middle one long and slender, and nearly twice the length of the outer. Both basal and secondary joints are furnished with transverse rows of cilia on their lateral aspect, as shown by the figure (Pl. 36. fig. 6).

Caudal stylets about one and a half times the length of the last abdominal segment; colour brown (Pl. 36. fig. 8).

Habitat. Largo Bay, Firth of Forth (1891).

Remarks. The structure of the antennules and antennæ and of the fifth pair of thoracic feet are characters by which the species is readily distinguished; no similar structure has been observed in any of the other species examined by us.

BRADYA MINOR, sp. n. (Pl. 35. figs. 5, 9, 13, 21, 24, 31, 35, 42; Pl. 36. figs. 5 and 9.)

Description. Length ·54 mm. ($\frac{1}{46}$ of an inch). Body moderately stout; the abdomen is more distinctly separated from the thorax in this species than in any of the others described in this memoir; rostrum somewhat slender and prominent.

Antennules short, stout, and 6-jointed; a dusky-coloured pigment-spot occurs on the first joint, as shown in the figure (Pl. 35. fig. 9), but whether it functions as an eye we cannot say. The formula shows approximately the proportional lengths of the joints:—

$$\begin{array}{r} \text{No. of the joints:} \\ \text{Proportional lengths:} \end{array} \frac{1\,.\,2\,.\,3\,.\,4\,.\,5\,.\,6}{14\ \ 9\ \ 12\ \ 5\ \ 7\ \ 9}.$$

The secondary branches of the antennæ are very slender and 3-jointed, and shorter than the primary branches; first two joints, but especially the second, very short (Pl. 35. fig. 13).

Mandibles well developed, the biting part broadly truncate and armed with several blunt-pointed teeth; the branches of the palp are furnished with plain setæ (Pl. 35. fig. 24).

Anterior foot-jaws stout, the first joint furnished with two marginal setiferous processes in addition to several setæ (Pl. 35. fig. 31).

Posterior foot-jaws small; the first joint bears on its distal end two long and stout setæ, which are plumose only on one side, and the second has its inner margin fringed with cilia (Pl. 35. fig. 31).

The first four pairs of swimming-feet are somewhat similar in structure to those of *Bradya fusca*.

The fifth pair somewhat resemble those of *Bradya fusca*, but the inner portion of the basal joint is not so much produced and does not reach the middle of the secondary joint; the two terminal spines of the produced inner part of the basal joint are very unequal in length, and there are a few small teeth round the inner margin and end of this part of the joint; the exterior angle of the same joint is also produced into a long conical lobe that extends well down the side of the secondary joint, and terminates in a slender hair; the secondary joint is broadly oblong, and ends in a trilobed extremity which reaches considerably beyond the basal joint; the middle lobe is larger and more produced than the lateral ones, which are subequal; each lobe forms the base of an elongate and spiniform plumose seta; the middle seta is rather longer and stouter than the other two; a slender seta springs from near the base of the same joint, and there are transverse rows of minute setæ on the lateral aspect of the basal joint, as shown in the figure (Pl. 36. fig. 5).

Caudal stylets short, about equal in length to the last abdominal segment (Pl. 36. fig. 9). Colour brownish.

Habitat. Firth of Forth, off St. Monans; rock-pools on the shore of Hilbre Island, Liverpool Bay.

Remarks. The eye-like dusky pigment-spot at the base of the antennules, together with the structure of the antennæ and mouth-organs, are characters which readily distinguish this from other British species of *Bradya*.

Genus Ectinosoma, Boeck (1864).

Description. Body elongate, fusiform, similar to that of *Bradya*.

Antennules 5- to 7-jointed, not longer than the first thoracic segment, and usually tapering more or less towards the distal end.

Antennæ similar to those of *Bradya*.

Mandibles usually cleft at the apex and armed with strong teeth; mandibular palp similar to that of *Bradya*.

Anterior foot-jaws usually composed of two robust joints, and armed at the extremity with two moderately stout and elongate spiniform claws and a few setæ; the first joint is also furnished with two or three setiferous marginal processes. Second joint usually larger than the other.

Posterior foot-jaws elongate, slender, three-jointed, and in structure resembling those of *Bradya*.

Five pairs of thoracic feet similar to those of *Bradya*.

Remarks. As already pointed out in the description of the genus *Bradya* (ante, p. 420), the difference in the structure of the anterior foot-jaws is the most important and the most constant difference between *Ectinosoma* and *Bradya*, and so great is the resemblance otherwise between species belonging to these two genera that frequently we have found it almost impossible to distinguish without careful dissection whether the specimen that happened to be under examination belonged to the genus *Ectinosoma* or to *Bradya*.

ECTINOSOMA SARSI, Boeck (1872). (Pl. 36. figs. 14, 26, 42; Pl. 37. figs. 1, 21, 38, 52; Pl. 38. figs. 10, 22, 32, 51.)

1872. *Ectinosoma Sarsi,* Boeck (2), p. 45.
1880. *Ectinosoma spinipes,* Brady (3), vol. ii. p. 9, pl. xxxvi. figs. 1–10.
1885. *Ectinosoma Sarsi,* Poppe (9), p. 198.
1888. *Ectinosoma spinipes,* Scott (12), p. 239.
1892. *Ectinosoma Sarsi,* Canu (6), p. 152.
1893. *Ectinosoma spinipes,* I. C. Thompson (16), p. 18, pl. xviii. fig. 8.

Description. Length 1·2 mm. ($\frac{1}{21}$ of an inch). Body, seen from the side, slender fusiform; rostrum prominent, blunt-pointed, and reaching to near the extremity of the antennules.

Antennules short, robust, 5-jointed, gradually tapering towards the distal end, and strongly setiferous. The proportional lengths of the joints are nearly as shown in the formula:—

$$\begin{array}{ll} \text{No. of the joints:} & \frac{1}{16} \cdot \frac{2}{12} \cdot \frac{3}{9} \cdot \frac{4}{6} \cdot \frac{5}{10} \\ \text{Proportional lengths:} & \end{array}.$$

Antennæ large, 3-jointed, joints subequal in length, the terminal joint furnished with a number of stout setæ, coarsely plumose on the upper margin, and with several short spines; secondary branch elongate, 3-jointed, arising from the end of the first joint of the primary branch; the last joint of the secondary branch is equal to nearly twice the combined lengths of the other two joints; the first two joints are each armed with a spiniform seta, that of the first joint is short, but that of the second is elongate and coarsely plumose on the upper edge; the last joint bears two long terminal setæ, also plumose on the upper edge (Pl. 37. fig. 1).

Mandibles armed with a few strong irregular-sized teeth and a small plumose seta; the basal joint of the palp, which is nearly equal in size to the mandibles, bears a few terminal setæ in addition to the apical and marginal 1-jointed branches; the marginal branch is much smaller than the other (Pl. 37. fig. 21).

Anterior foot-jaws composed of two large, strongly dilated joints; the first joint bears three marginal processes on the distal half; the middle process is much smaller than the other two; the end joint bears two unequal and moderately short setose spines on the inner edge and two elongate subequal spiniform claws and a few setæ at the extremity (Pl. 37. fig. 38).

Posterior foot-jaws elongate, moderately stout, tapering towards the distal end; a long plumose seta springs from near the end of the first joint; the second joint is strongly ciliate on the upper margin, while the last joint bears two subterminal plumose spines and one long and one short terminal seta, as shown in the figure (Pl. 37. fig. 52).

The first four pairs of swimming-feet are robust; the interior marginal setæ on both branches are stout and strongly plumose, while the exterior margins are fringed with small spines; the outer marginal spines of the outer branches and the spiniform terminal setæ of both outer and inner branches are stout, and strongly setose on the exterior edges; a stout spine springs from the interior distal angle of the second basal joint of the first pair (Pl. 38. figs. 10 & 22).

The fifth pair are subquadrangular in outline; the produced inner portion of the basal joint is cylindrical and twice as long as broad; its extremity is somewhat bilobed, and reaches to near the end of the secondary joint; the inner margin bears several small setæ; each of the terminal lobes forms the base of a spine, the inner one of which is stouter and more elongate than the other; the secondary joints are subquadrate, but rather longer than broad, and terminate in three unequal lobes, each of which is the base of a moderately stout spine, and is furnished with three apical spine-like teeth; the middle one of the three spines is longer than the one on either side; there are a few spine-like teeth on the lateral aspect of the basal joint, as shown in the figure (Pl. 38. fig. 32).

Caudal stylets short and moderately stout (Pl. 38. fig. 51).

Habitat. All round the British coasts; moderately common.

Remarks. This species is readily distinguished from the other *Ectinosomata* by the form of the animal, and the structure and armature of the swimming-feet.

ECTINOSOMA PROPINQUUM, sp. n. (Pl. 36. figs. 19, 27, 46; Pl. 37. figs. 2, 15, 32, 55; Pl. 38. figs. 9, 23, 34, 54.)

Description. Length 1·1 mm. ($\frac{1}{23}$ of an inch). Body seen from the side fusiform; rostrum prominent and projecting nearly straight forward, somewhat spoon-shaped, or with the sides slightly decurved and the apex rounded.

Antennules short, stout, strongly setiferous, and composed of five joints. The proportional lengths of the joints are nearly as shown by the formula:—

No. of the joints: 1 . 2 . 3 . 4 . 5
Proportional lengths: 11 9 12 7 12.

Antennæ nearly as in *Ectinosoma Sarsi* (Pl. 37. fig. 2). Mandibles also somewhat similar to those of that species (Pl. 37. fig. 15), but two of the terminal setæ of the apical branch of the palp are united for a short distance at the base.

The labium consists of a bifid and strongly-hooked process, a lateral view of which is shown in the figure (Pl. 36. fig. 27).

Both pairs of foot-jaws are somewhat similar to those of *Ectinosoma Sarsi* (Pl. 37. figs. 32 and 55).

The first four pairs of swimming-feet are also somewhat like those of that species; but in the first pair the inner branches are proportionately shorter, while both branches in the fourth pair are of nearly equal length, and the second basal joint of the same pair is furnished with an elongate slender spine on the exterior angle (Pl. 38. figs. 9 and 23).

The produced inner portion of the fifth pair is cylindrical in form, the length of which is equal to about one and one-third times the breadth; the secondary branches are nearly quadrangular in outline—the length only slightly exceeding the breadth; the armature of the fifth pair is somewhat similar to that of *Ectinosoma Sarsi* (Pl. 38. fig. 34).

Caudal stylets short, but rather longer than broad and about equal in length to the last abdominal segment. The posterior margins of the abdominal segments are all more or less fringed with cilia.

Habitat. Firth of Forth, off Musselburgh.

Remarks. This species comes near *Ectinosoma Sarsi*, Boeck, but differs in the following particulars: the proportionate lengths of the joints of the antennules are greater, the mandible is furnished with more small teeth on its biting-edge than that of *E. Sarsi*, the anterior foot-jaws are stouter, the armature of the swimming-feet is somewhat weaker, and the fifth feet are much shorter, being nearly as long as broad.

ECTINOSOMA GRACILE, sp. n. (Pl. 36. figs. 18 and 37; Pl. 37. figs. 13, 28, 45; Pl. 38. figs. 3, 27, 30.)

Description. Length ·7 mm. ($\frac{1}{36}$ of an inch). Body seen from the side very slender, nearly cylindrical. Rostrum prominent. Antennules (Pl. 36. fig. 37) elongate, slender, composed of seven joints; the penultimate joint is nearly equal to the combined lengths of the two preceding joints, as shown by the annexed formula :—

No. of the joints :	1 .	2 .	3 .	4 .	5 .	6 .	7
Proportional lengths :	8	8	5	8	4	11	4.

Antennæ elongate, moderately stout; the secondary branches small and 3-jointed, not reaching to the end of the second joint of the primary branches; the first two joints are short, the other elongate, being nearly twice the entire length of the first two (Pl. 37. fig. 13).

Anterior foot-jaws elongate, moderately stout; the end-joint about twice as long as broad, and armed at the extremity with two long slender claws and two elongate slender setæ (Pl. 37. fig. 28).

Posterior foot-jaws slender, considerably shorter than the anterior foot-jaws; end-joint about half the length of the preceding one (Pl. 37. fig. 45).

Inner branches of the first four pairs of swimming-feet moderately slender and elongate; outer branches very slender and considerably shorter than the inner branches; the first joint is nearly equal in length to that of the next two together (Pl. 38. figs. 3 and 27).

Fifth pair small; apical setæ slender, the middle seta of the secondary joint very long and slender, being considerably longer than the outer elongate and slender seta of the produced part of the basal joint; a moderately long slender seta springs from near the middle and on the lateral aspect of the secondary joint,—this joint extends very little beyond the end of the produced part of the basal joint (Pl. 38. fig. 30).

Habitat. Off St. Monans, Firth of Forth; vicinity of Port Erin, Isle of Man.

Remarks. The structure of the antennules, together with that of the antennæ, the mouth-organs, and fifth pair of thoracic feet, are characters by which *Ectinosoma gracile* may be distinguished from any other species described in this memoir.

ECTINOSOMA CURTICORNE, Boeck (1864). (Pl. 36. figs. 22, 30, 34; Pl. 37. figs. 10, 24, 41, 48; Pl. 38. figs. 8, 20, 35, 44.)

1864. *Ectinosoma curticorne,* Boeck (1).
1885. *Ectinosoma curticorne,* Poppe (9), p. 194, Taf. 6. figs. 1–12.
1890? *Bradya Edwardsi,* Richard (10), p. 214, with 10 figures in the text.
1893? *Ectinosoma Edwardsi,* Schmeil (11), p. 92, Taf. viii. figs. 1–21.
1893. *Ectinosoma curticorne,* I. C. Thompson (16), p. 192, pl. xviii. fig. 8 *e*.

Description. Length ·7 mm. ($\frac{1}{36}$ of an inch). Somewhat like *Ectinosoma Sarsi* in general appearance; rostrum short and stout.

Antennules very short and robust, 6-jointed; a somewhat roundish and dark-coloured blotch occurs on the second joint of the antennules, as shown in the figure (Pl. 36. fig. 34). The proportional lengths of the joints are nearly as shown in the formula:—

$$\begin{array}{ll}\text{No. of the joints:} & \underline{1\,.\,2\,.\,3\,.\,4\,.\,5\,.\,6} \\ \text{Proportional lengths:} & 9\quad 2\quad 5\quad 3\quad 4\quad 5\end{array}.$$

Antennæ nearly as in *Ectinosoma Sarsi*, but the secondary branches are shorter than the primary ones (Pl. 37. fig. 10). The biting part of the mandibles is broad and armed interiorly with several small teeth, but the outer teeth are large; the branches of the mandibular palp are not so wide apart as in *Ectinosoma Sarsi* (Pl. 37. fig. 24).

Anterior foot-jaws somewhat like those of *Ectinosoma Sarsi,* but very much smaller (Pl. 37. fig. 41).

Posterior foot-jaws short, moderately stout; two plumose setæ springing from the end of the basal joint, while the terminal joint, which is very small, bears two lateral plumose and spine-like setæ and a plain and slender terminal hair (Pl. 37. fig. 48).

The first four pairs of swimming-feet are somewhat like those of *Ectinosoma Sarsi,* but smaller; the outer and inner branches of the fourth pair are also of nearly equal length, and the lower marginal seta of the third pair is considerably longer than the others (Pl. 38. figs. 8 and 20). The inner produced portion of the fifth pair extends to about the middle of the secondary joint; the terminal spines of both basal and secondary joints are long and moderately stout, and both joints (but especially the basal joint) are furnished with many small setæ arranged in straight or curved rows, as shown in the figure (Pl. 38. fig. 35). Caudal stylets short, apparently 2-jointed, and equal in length to the last abdominal segment (Pl. 38. fig. 44). Colour chocolate-brown.

Habitat. Firth of Forth, off Burntisland; Cromarty Firth, near the mouth of the River Alness; in the stomachs of young dabs from Blackpool, Lancashire; head of West Loch Tarbert, Argyleshire.

Remarks. This species resembles *Bradya minor* in having an eye-like pigment-spot at the base of each antennule, and may therefore be mistaken for it unless some care is taken and dissections made. It is, however, quite distinct from that species, as a comparison of the parts will show. *Ectinosoma curticorne* appears to form a source of food for the young dabs (*Pleuronectes limanda*) on the Blackpool closed fishing-grounds: as many as sixteen specimens were counted in one stomach.

The difference between *Bradya Edwardsi*, Richard, and *Ectinosoma curticorne*, Boeck, is, so far as we can make out, scarcely sufficient to warrant us in separating them.

ECTINOSOMA ERYTHROPS, Brady (1880). (Pl. 36. figs. 24, 31, 36; Pl. 37. figs. 14, 18, 37, 42; Pl. 38. figs. 13, 15, 39, 48.)

1880. *Ectinosoma erythrops*, Brady (3), vol. ii. p. 12, pl. xxxvi. figs. 11–17.
1890. *Ectinosoma erythrops*, Scott (13), p. 318.
1893. *Ectinosoma erythrops*, I. C. Thompson (16), p. 192, pl. xviii. fig. 8 *c*, *d*).

Description. Length ·73 mm. ($\frac{1}{34}$ of an inch). Body slender fusiform; rostrum moderately prominent, incurved (Pl. 36. fig. 24). Antennules short, setiferous, gradually tapering to the slender extremity, 5- (? or 6-) jointed; the last joint is long and narrow and appears to be composed of two coalesced joints; the proportional lengths of the joints are nearly as shown in the formula:—

No. of the joints:	1	2	3	4	5
Proportional lengths:	11	6	11	5	(7 7)

Antennæ elongate, the last joint sparingly setiferous; the secondary branch, which does not extend much beyond the end of the second joint of the primary branch, has the first two joints very small, while the last is long and slender (Pl. 37. fig. 14).

Mandibles rather smaller, and with the palp more elongate than the same appendages in *Ectinosoma Sarsi* (Pl. 37. fig. 18).

Anterior foot-jaws are also somewhat similar to those of that species, but the last joint is more elongate, and the terminal claws are also proportionally longer (Pl. 37. fig. 37). Posterior foot-jaws small and slender (Pl. 37. fig. 42).

The first four pairs of swimming-feet are considerably longer than those of *Ectinosoma Sarsi*; the inner marginal setæ on both branches are plain and more slender than those of that species, and the terminal spines are also more elongate; the second joint of the inner branches has the outer distal angle produced into a long spine-like process, that extends downward in front of the upper half of the third joint (Pl. 38. figs. 13 and 15). The inner portion of the basal joint of the fifth pair is not much produced; the secondary joint is broadly subcylindrical, with the extremity irregularly trilobed and armed with three long spines, the middle one of which is considerably longer than the other two; two small setæ also spring from near the base of the joint; the inner produced part of the basal joint is furnished with two spines, the inner one being very long and powerful, the other smaller; all the large spines are plumose (Pl. 38. fig. 39). Caudal stylets short, but rather longer than the last abdominal segment (Pl. 38. fig. 48).

Habitat. Firth of Forth, off St. Monans.

Remarks. As all the specimens of this Copepod had been in spirit for some time before being identified, we were unable to see the red pigment-spot to which the species owes its name. The form of the animal, together with the divergent setæ of the fifth feet, serves to distinguish it when mixed up with any of the other members of the genus.

ECTINOSOMA HERDMANI *, sp. n. (Pl. 36. figs. 16, 44; Pl. 37. figs. 3, 16, 29, 54; Pl. 38. figs. 7, 25, 33, 47).

Description. Length ·8 mm. ($\frac{1}{31}$ of an inch). Body, seen from the side, fusiform and somewhat similar to *Ectinosoma Sarsi*, but proportionally narrower; rostrum prominent. Antennules (Pl. 36. fig. 44) 6-jointed, moderately slender, the first joint considerably longer than any of the others, as shown by the annexed formula:—

No. of the joints:	1	2	3	4	5	6
Proportional lengths:	13	7	9	6	4	4

Antennæ somewhat similar to those of *Ectinosoma Sarsi*, but smaller, and the first two joints of the secondary branch are together nearly equal in length to the third joint (Pl. 37. fig. 3).

Mandibles very small, but with a proportionally larger palp than in those of *Ectinosoma Sarsi* (Pl. 37. fig. 16). Anterior foot-jaws robust, somewhat similar in form to those of *Ectinosoma Sarsi*; the first joint bears only two small marginal processes at the distal end, and the terminal claw-like spines are very long and slender (Pl. 37. fig. 29). Posterior foot-jaws elongate and slender; the middle joint is about four times the length of the end one, and is fringed with twelve or fourteen moderately stout hairs (Pl. 37. fig. 54).

The first four pairs of swimming-feet somewhat like those of *Ectinosoma Sarsi*, but much smaller and with the marginal setæ plain (Pl. 38. figs. 7 and 25).

Fifth pair also similar to those of that species, but the inner portion of the basal joint is less produced; the secondary joint is shorter, and the apical spines are longer and are all of nearly equal length (Pl. 38. fig. 33).

Caudal stylets very short and about equal in length to the last abdominal segment (Pl. 38. fig. 47).

Habitat. Firth of Forth, off St. Monans; Port Erin, Isle of Man.

Remarks. The elongate form of this species, together with the somewhat slender

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* In compliment to Prof. W. A. Herdman, F.R.S.

antennules and broadly subquadrangular form of the fifth pair of thoracic feet, the apical spines of which are all of nearly equal length, are characters by which it can be readily distinguished.

ECTINOSOMA PYGMÆUM, sp. n. (Pl. 36. figs. 15 and 41; Pl. 37. figs. 5, 20, 39, 43; Pl. 38. figs. 4, 26, 31, 55.)

Description. Length ·33 mm. ($\frac{1}{76}$ of an inch). Seen from the side the thoracic portion of the body is moderately stout, with the dorsum considerably arched, but the abdomen, which is comparatively narrow, is only slightly tapering; rostrum prominent (Pl. 36. fig. 15).

Antennules 6-jointed, short, moderately stout, gradually tapering to the apex and furnished with numerous hairs; the proportional lengths of the joints are nearly as shown in the formula:—

No. of the joints: 1 . 2 . 3 . 4 . 5 . 6
Proportional lengths: 6 3 4 2 2 2.

Antennæ larger than the antennules; the secondary branch is composed of three nearly equal joints, but the middle one is slightly shorter than the one on either side (Pl. 37. fig. 5). Mandibular palp well developed; basal joint large, with two plumose apical setæ; the subapical branch is much larger than the marginal one; two elongate teeth spring from a notch near the middle of the inner margin of the mandibles, and reach to the truncate and slightly-toothed apex (Pl. 37. fig. 20).

Anterior and posterior foot-jaws somewhat similar in structure to those of *Ectinosoma Sarsi*, but very small (Pl. 37. figs. 39 and 43). The first four pairs of swimming-feet are also somewhat similar to that species, but are more slender; the marginal setæ are plain, the first pair want the transverse rows of small spines possessed by those of *Ectinosoma Sarsi*, and the outer branches of the fourth pair are proportionally longer (Pl. 38. figs. 4 and 26). The fifth pair are small and furnished with elongate fusiform spines, which become extremely slender towards the extremity; the secondary joint, which extends considerably beyond the inner produced portion of the basal joint, is irregularly trilobed, and each lobe forms the base of a spine; the two outer spines are of nearly equal length, but the inner one is scarcely half the length of the one next to it; the outer portion of the basal joint is produced into an elongate and very narrow appendage bearing a slender apical seta (Pl. 38. fig. 31).

Caudal stylets very short, being scarcely equal in length to the last abdominal segment (Pl. 38. fig. 55).

Habitat. Firth of Forth, and in the vicinity of Port Erin, Isle of Man.

Remarks. This is the smallest species of *Ectinosoma* known to us. The structure of the secondary branches of the antennæ and of the mandibles, together with the peculiar fusiform spines of the fifth pair of thoracic feet, appear to be sufficiently characteristic to distinguish it from any of the others described in this memoir.

ECTINOSOMA MELANICEPS, Boeck (1864). (Pl. **36.** figs. 13, 28, 45; Pl. **37.** figs. 11, 22, 40, 49; Pl. **38.** figs. 2, 21, 41, 46.)

1864. *Ectinosoma melaniceps,* Boeck (1), p. 30.
1880. *Ectinosoma melaniceps,* Brady (3), vol. ii. p. 11, pl. xl. figs. 17–20.
1890. *Ectinosoma melaniceps,* T. Scott (13), p. 318.
1893. *Ectinosoma melaniceps,* I. C. Thompson (16), p. 18, pl. xxi. fig. 2 *a*.

Description. Length ·63 mm. ($\frac{1}{40}$ of an inch). Rostrum elongate, slender, curved downward.

Antennules short, 7-jointed, gradually tapering from the moderately stout base to the slender apex; the third joint is considerably longer than any of the other joints, as exhibited by the formula, which shows the proportional lengths nearly of all the joints:—

$$\begin{array}{l} \text{No. of the joints:} \\ \text{Proportional lengths:} \end{array} \frac{1\ .\ 2\ .\ 3\ .\ 4\ .\ 5\ .\ 6\ .\ 7}{9\quad 6\quad 11\quad 4\quad 5\quad 5\quad 2}.$$

Antennæ elongate; basal joint stout and equal to about two-thirds the length of the next one; the second and third joints are more slender than the basal joint, and the last is somewhat shorter than the preceding one; the secondary branch has the middle joint very small, while the first and third are comparatively elongate (Pl. **37.** fig. 11).

Mouth-organs nearly as in *Ectinosoma Sarsi*, but much smaller (Pl. **37.** figs. 22, 40, 49).

The outer branches of the first pair of swimming-feet are equal to about three fourths the length of the inner branches; the first and second joints only of the outer branches are furnished with elongate spines, and the interior marginal setæ of both branches are slender and not plumose; in the fourth pair the outer and inner branches are about equal in length (Pl. **38.** figs. 2 and 21).

The produced inner portion of the basal joint of the fifth pair, which is cylindrical in outline and reaches only a little beyond the middle of the secondary joints, is provided with a moderately long apical seta and stout conical spine serrate on the edges, while the secondary joint bears one slender and three spiniform apical setæ, the second one from inside being very long with a tenuated extremity (Pl. **38.** fig. 41).

Caudal stylets very short (Pl. **38.** fig. 46).

Habitat. Generally distributed, and usually among weeds, in the laminarian zone.

Remarks. This species is readily distinguished by its having a considerable portion of the front part of the head of a dusky colour, as well as by the structure of the antennules and fifth pair of feet.

ECTINOSOMA ARMIFERUM, sp. n. (Pl. **36.** figs. 20 and 43; Pl. **37.** figs. 4, 17, 31, 53; Pl. **38.** figs. 14, 19, 37, 43.)

Description. Length ·97 mm. ($\frac{1}{26}$ of an inch). Body stout; rostrum prominent (Pl. **36.** fig. 20).

Antennules 5- (? or 6-) jointed, very short and robust, strongly setiferous, especially towards the distal end, where there are several strong and very elongate plumose setæ

(Pl. 36. fig. 43). The approximate proportional lengths of the joints are shown by the formula:—

$$\begin{array}{l}\text{No. of the joints:}\\ \text{Proportional lengths:}\end{array}\ \frac{1}{15}\,.\,\frac{2}{9}\,.\,\frac{3}{11}\,.\,\frac{4}{8}\,.\,\frac{5}{3}\,.\,\frac{(?\,6)}{(?\,3)}\,.$$

Antennules stout, well developed, armed with strong plumose setæ; secondary branches 3-jointed, shorter than the primary branches; the middle joint is equal to about half the length of the first and a third of the length of the last joint (Pl. 37. fig. 4). Mandibles stout, furnished at the apex with two strong teeth,—one bifid, the other conical,—and a few small spines; mandibular palp somewhat like that of *Ectinosoma elongatum*, but more strongly setiferous (Pl. 37. fig. 17).

Anterior foot-jaws dilated, apparently 5-jointed; the first joint is considerably larger than all the others together, the terminal joints very small; two of the marginal processes are each armed with a stout spine and a few setæ; the subapical claws are strong and slightly curved, the terminal setæ few and comparatively short (Pl. 37. fig. 31). In the structure of the anterior foot-jaws this species connects *Ectinosoma* with *Bradya*.

Posterior foot-jaws cylindrical and slightly distorted, much smaller than those of *Ectinosoma Sarsi*; the end-joint, which is equal to about one-third the length of the middle joint, bears one stout and strongly plumose, and one long, slender, and plain terminal seta; a short seta also springs from near the proximal end of the upper margin (Pl. 37. fig. 53). The outer branches of the first pair of swimming-feet are short, being only about three-fifths of the length of the inner branches; a long plumose seta springs from the outer angle of the second basal joint, and a moderately stout spine from the interior angle; the fourth pair are somewhat like the first, but the outer branches are proportionally rather longer, and the seta on the outer angle of the second basal joint is plain, and there is no spine on the inner angle (Pl. 38. figs. 14 and 19).

The fifth pair is small; the secondary joint is subquadrate and scarcely reaches beyond the produced inner portion of the basal joint; the middle apical seta of the secondary joint, and the inner one on the truncate apex of the produced inner portion of the basal joint, are stout, slightly curved, and of great length (Pl. 38. fig. 37).

Caudal stylets very short and somewhat wide apart; abdomen clothed with transverse rows of minute hairs (Pl. 38. fig. 43).

Habitat. Firth of Forth, west of May Island.

Remarks. The species now described is readily distinguished from any of the others recorded in this Report, by its robust form, by the structure and armature of the antennules and antennæ, and especially by the form and by the peculiarly elongate setæ of the fifth pair of thoracic feet.

ECTINOSOMA NORMANI[*], sp. n. (Pl. 36. figs. 21, 29, 39; Pl. 37. figs. 12, 26, 34, 51; Pl. 38. figs. 5, 18, 42, 45.)

Description. Length ·55 mm. ($\frac{1}{45}$ of an inch). The thorax seen from the side is broadest at the posterior end of the first body-segment, and from thence the

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[*] In compliment to the Rev. A. M. Norman, F.R.S., &c.

dorsum tapers gradually to the extremity of the abdomen; the anterior part of the cephalothoracic segment curves gently and regularly to the apex of the comparatively small rostrum. On the lower rounded angle of the cephalothoracic segment, and immediately posterior to the base of the antennules, there is a small but distinct and bright-red pigment-spot, as shown in the full-size drawing of the animal (Pl. 36. fig. 21). Antennules small, moderately stout, 7-jointed; the proportional lengths of the joints are nearly as shown in the formula:—

$$\begin{array}{ll} \text{No. of the joints:} & \frac{1 \,.\, 2 \,.\, 3 \,.\, 4 \,.\, 5 \,.\, 6 \,.\, 7}{7 \;\; 7 \;\; 7 \;\; 4 \;\; 3 \;\; 3 \;\; 3} . \\ \text{Proportional lengths:} & \end{array}$$

Secondary branches of the antennæ 3-jointed, and reaching to near the middle of the last joint of the primary branches; the middle joint is very small, while the end-joint is equal to about one and a half times the length of the first joint (Pl. 37. fig. 12).

Mandibles armed at the apex with a stout irregularly trifid process and a strong conical blunt-pointed tooth; a small and moderately stout plumose marginal seta springs from a little below the base of the conical tooth; the basal joint of the mandibular palp bears a single short subapical seta in addition to the two 1-jointed branches (Pl. 37. fig. 26). Anterior foot-jaws very small, but moderately stout; marginal processes small and crowded near the end of the first joint; terminal claws slender, curved, their inner margin ciliate on the distal half (Pl. 37. fig. 34).

Posterior foot-jaws very small, but similar in structure to those of *Ectinosoma Sarsi* (Pl. 37. fig. 51).

The first four pairs of swimming-feet are slender, the outer branches considerably shorter than the inner ones; marginal setæ elongate, slender, and not plumose (Pl. 38. figs. 5 and 18). Fifth pair somewhat like those of *Ectinosoma tenuipes* (to be described), but the lobes of the secondary joints are separated from each other by a deep sinus; there is also a transverse row of cilia at the proximal end (Pl. 38. fig. 42).

Caudal stylets nearly twice as long as broad (Pl. 38. fig. 45). Ovisac large.

Habitat. Firth of Forth, off Burntisland; Barrow Channel, near Barrow-in-Furness.

Remarks. This is not the *Ectinosoma erythrops* of Dr. Brady's 'Monograph of the British Copepoda,' though it agrees with the description of that species in so far as it possesses a red pigment-spot near the lower anterior angle of the cephalothoracic segment. *Ectinosoma Normani* distinctly differs from that species, as well as from the others described in these pages, by the structure of the mouth-organs and of the fifth pair of thoracic feet. The red pigment-spot, though very conspicuous when freshly preserved, disappears after being in spirit for a few days.

ECTINOSOMA TENUIPES, sp. n. (Pl. 36. figs. 25, 32, 35; Pl. 37. figs. 9, 19, 30, 47; Pl. 38. figs. 12, 17, 36, 52.)

Description. Length ·6 mm. ($\frac{1}{41}$ of an inch). Seen from the side the thoracic dorsum is very gently curved and tapers gradually to the moderately stout abdomen; rostrum prominent (Pl. 36. fig. 25).

Antennules 7-jointed, rather longer and much less robust than those of *Ectinosoma*

Sarsi, sparingly setiferous; a long slender sensory filament springs from the third joint, the upper distal angle of which is produced to form the base of the filament (Pl. **36.** fig. 35). The annexed formula exhibits the proportional lengths of the joints very nearly:—

No. of the joints: 1 . 2 . 3 . 4 . 5 . 6 . 7
Proportional lengths: 8 6 9 5 8 4 4.

Antennæ slender; secondary branches 3-jointed, very slender, scarcely longer than the second joint of the primary branches; the first joint is rather shorter than the last, while the middle one is small (Pl. **37.** fig. 9).

Labium with a very slender "hook" (Pl. **36.** fig. 32).

Mandibles armed on one side of the apex with a broad tridentate process and on the other side with a moderately stout spine, while between these is a large conical tooth; the branches of the palp are slender (Pl. **37.** fig. 19). Anterior foot-jaws somewhat like those of *Ectinosoma Sarsi*, but scarcely so stout (Pl. **37.** fig. 30).

Posterior foot-jaws very slender, and the end-joint is nearly equal to half the length of the one immediately preceding (Pl. **37.** fig. 47).

The first four pairs of swimming-feet have the inner branches moderately stout and elongate, but the outer branches are considerably shorter than the inner one and very slender (Pl. **38.** figs. 12 and 17).

Fifth pair small; the produced inner portion of the basal joint is furnished with a short stout spine and a long spiniform seta; the secondary joint is nearly as broad as long and does not reach much beyond the produced part of the basal joint; its outer margin is broadly rounded, but the inner margin is nearly straight; the apex is broadly truncate and indistinctly four-lobed—each lobe forming the base of a seta; the outer seta is stout and elongate, the next is short and very slender, the third seta is stout and considerably longer than the outer one, while the inner seta is short and spiniform (Pl. **38.** fig. 36).

Caudal stylets equal to about two-thirds the length of the last abdominal segment (Pl. **38.** fig. 52).

Habitat. Firth of Forth, off St. Monans.

Remarks. The slender posterior foot-jaws and outer branches of the first four pairs of swimming-feet serve to distinguish *Ectinosoma tenuipes* from the other species described in this memoir.

ECTINOSOMA ATLANTICUM (Brady and Robertson). (Pl. **36.** figs. 17 and 40; Pl. **37.** figs. 6, 23, 35, 50; Pl. **38.** figs. 11, 16, 38, 53.)

1873. *Microsetella atlantica*, B. & R. (5), p. 130, pl. ix. figs. 11–16.
1880. *Ectinosoma atlanticum*, Brady (3), vol. ii. p. 13, pl. xxxviii. figs. 11–19.
1883. *Ectinosoma atlanticum*, Brady (4), p. 100, pl. iv. figs. 10–14.
1887. *Ectinosoma atlanticum*, Jules de Guerne (8), p. 344.
1891. *Microsetella atlantica*, Scott (14), p. 302.
1892. *Microsetella atlantica*, Giesbrecht (7), p. 550, Taf. 44.
1893. *Ectinosoma atlanticum*, I. C. Thompson (16), p. 192, pl. xix. fig. 1.
1894. *Microsetella atlantica*, T. Scott (15), p. 91.

Description. Length ·55 mm. ($\frac{1}{45}$ of an inch). Body very slender; the forehead, seen from the side, is small and sharply rounded to form the small beak-like rostrum (Pl. 36. fig. 17).

Antennules 6-jointed, elongate, slender, and sparingly setiferous; the third joint is considerably longer than any of the others, but the last joint is very small, as shown by the formula :—

No. of the joints :	1	2	3	4	5	6
Proportional lengths :	10	8	18	11	11	3

Antennæ slender; secondary branches 3-jointed, longer than the second joint of the primary branches; the first two joints are small, the other is elongate (Pl. 37. fig. 6). Basal joint of the mandibular palp comparatively small and furnished with a stout submarginal plumose seta; the superior apical branch is nearly as large as the joint to which it is articulated, and is armed with a stout spiniform and semiplumose seta and also with several plain setæ; the inferior marginal branch is extremely small (Pl. 37. fig. 23). The anterior foot-jaws closely resemble those of *Ectinosoma Sarsi*, but are much smaller (Pl. 37. fig. 35). Posterior foot-jaws short, moderately stout, somewhat cylindrical in form, and with the terminal joint very short (Pl. 37. fig. 50).

First four pairs of swimming-feet slender. In the first pair the outer branches are scarcely equal in length to the inner branches, but in the fourth pair both branches are of about equal length (Pl. 38. figs. 11 and 16).

Fifth pair small; the produced inner portion of the basal joint extends to about the apex of the secondary joint; two slender and very long plain setæ spring from the apex of the secondary joint, and one from the produced inner portion of the basal joint; both joints are also furnished with a small seta at the inner distal angle, in addition to a transverse row of small spines, as shown in the figure; a slender seta also springs from the lateral aspect of the secondary joint (Pl. 38. fig. 38).

Caudal stylets short (Pl. 38. fig. 53).

Abdomen clothed with indistinct transverse rows of minute hairs; the posterior margins of the segments of the thorax and abdomen are also fringed as in most of the other species described here.

Habitat. From various parts of the British coasts, both inshore and in the open sea, and in dredged material, as well as in tow-net gatherings—as, for example, in the Atlantic, off the west coast of Ireland and in Kinsale Harbour; in various parts of Loch Fyne; in various parts of the Firth of Forth (we have taken *Ectinosoma atlanticum* both with the dredge and with the tow-net in the Firth of Forth, and it was very common in material collected in a large flannel sieve used for filtering the sea-water that is pumped into the fishpond at the Dunbar hatchery).

Remarks. After a careful study of numerous specimens of *Ectinosoma atlanticum*, we, like Dr. G. S. Brady *, can find no valid reason for separating this species from *Ectinosoma*. It no doubt differs from the typical *Ectinosoma* in the greatly disproportionate sizes of the branches of the mandibular palp and in the structure of the posterior

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* 'Monograph of the British Copepoda,' vol. ii. p. 14 (1880).

foot-jaws; it also wants the prominent rostrum of the typical *Ectinosoma*; but these differences are so small as, in our opinion, to be of no more than specific value. The elongate antennules of this species cannot be considered to be of any more than specific importance, as those of some of the other species now described are also of considerable length.

ECTINOSOMA LONGICORNE, sp. n. (Pl. **36**. figs. 23 and 38; Pl. **37**. figs. 7, 25, 33, 44; Pl. **38**. figs. 6, 28, 29, 50.)

Description. Length ·6 mm. ($\frac{1}{42}$ of an inch). Body moderately robust; seen from the side, the dorsum tapers gradually from the first cephalothoracic segment to the extremity of the abdomen, while the anterior end is boldly rounded to where it merges in the somewhat prominent rostrum (Pl. **36**. fig. 23).

Antennules (Pl. **36**. fig. 38) elongate, slender, and 6-jointed; the first joint is considerably longer than any of the others, as shown by the annexed formula:—

No. of the joints: 1 . 2 . 3 . 4 . 5 . 6
Proportional lengths: 18 8 11 5 5 9.

Secondary branches of the antennæ very slender, 3-jointed, rather longer than the second joint of the primary branches; the first and third joints are subequal in length, but the second is very small (Pl. **37**. fig. 7).

Mandibles armed with a few large apical teeth and a short marginal spine; the basal joint of the palp is provided with a few terminal setæ, and both of the one-jointed branches are comparatively well developed, but the apical is about twice the length of the marginal branch (Pl. **37**. fig. 25). Anterior foot-jaws stout, somewhat similar to those of *Ectinosoma Sarsi*, but the setæ of the marginal processes on the first joint are not plumose (Pl. **37**. fig. 33).

The posterior foot-jaws also resemble those of *Ectinosoma Sarsi*, but are more slender (Pl. **37**. fig. 44).

First four pairs of swimming-feet slender and furnished with plain marginal setæ (Pl. **38**. figs. 6 and 28).

The fifth pair are small, and somewhat resemble those of *Ectinosoma pygmæum*; but the apical setæ are not fusiform, and the middle seta of the secondary joint is considerably longer than the one on either side (Pl. **38**. fig. 29). Caudal stylets short, being about equal in length to the last abdominal segment (Pl. **38**. fig. 50).

Habitat. Firth of Forth, off St. Monans.

Remarks. The elongate antennules, the slender 3-jointed secondary branches of the antennæ, and the slender foot-jaws readily distinguish this from other species of *Ectinosoma*. We do not know of its occurrence beyond the Forth area.

ECTINOSOMA TENUIREME, sp. n. (Pl. **36**. fig. 33; Pl. **37**. figs. 8, 27, 36, 46; Pl. **38**. figs. 1, 24, 40, 49.)

Description. Resembling *Ectinosoma gracile* in general appearance.

Antennules 7-jointed, and somewhat like those of *Ectinosoma gracile*, but more elongate, and the penultimate joint is nearly equal in length to the first, and about twice the length of the preceding joint (Pl. 36. fig. 33). The formula shows approximately the proportional lengths of all the joints:—

$$\begin{array}{l} \text{No. of the joints:} \\ \text{Proportional lengths:} \end{array} \frac{1\ .\ 2\ .\ 3\ .\ 4\ .\ 5\ .\ 6\ .\ 7}{17\ \ 10\ \ 13\ \ 10\ \ 8\ \ 15\ \ 5}.$$

Secondary branches of the antennæ 3-jointed and very slender, rather longer than the second joint of the primary branches; the middle joint very small, but the terminal joint is equal to about twice the length of the first (Pl. 37. fig. 8). Anterior foot-jaws large and moderately stout; terminal joint elongate-ovate, fully twice as long as broad; terminal claws very long, the distal half fringed with cilia on the inner aspect; terminal setæ two, shorter than the claws and very slender (Pl. 37. fig. 36). Posterior foot-jaws elongated and very tenuated, the terminal joint nearly equal to half the length of preceding one, while the middle apical seta is about two and a half times the length of the joint from which it springs (Pl. 37. fig. 46). The inner branches of the first pair of swimming-feet elongate, slender; the outer branches, which are composed of three nearly equal joints, are also slender, but scarcely reach to the end of the second joint of the inner branches; the fourth pair are stouter than the first, and the outer branches extend somewhat beyond the end of the second joint of the inner branches (Pl. 38. figs. 1 and 24).

In the fifth pair the middle seta of the secondary joint is extremely long and slender, being nearly three times the length of those on either side; the inner seta of the produced inner portion of the basal joint is nearly equal in length to the shorter setæ of the secondary joint; the outer seta is slender and shorter than the inner; the two outer setæ of the secondary joint and the longest seta of the produced inner part of the basal joint are somewhat dilated or fusiform at the proximal end,—the longer of the two setæ on the produced part of the basal joint especially being very distinctly swollen near the base; a slender seta springs from near the middle of the hollow at the base of the secondary joint, as shown in the figure (Pl. 38. fig. 40).

Habitat. Firth of Forth, off St. Monans.

Remarks. This species, which somewhat resembles *Ectinosoma gracile* in general appearance, differs quite distinctly from it by most of the characters described above, but especially by the structure of the antennæ, the very elongate and slender posterior foot-jaws, and by the structure of the first and fifth pairs of thoracic feet.

A List of some of the Works referred to in this Memoir.

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EXPLANATION OF THE PLATES.

Plate 35.

Fig. 1.	*Bradya*	*typica*, Boeck.	Female seen from left side.	× 53.
2.	,,	*hirsuta*, n. sp.	,, ,,	× 53.
3.	,,	*similis*, n. sp.	,, ,,	× 53.
4.	,,	*elegans*, n. sp.	,, ,,	× 53.
5.	,,	*minor*, n. sp.	,, ,,	× 80.
6.	,,	*fusca*, n. sp.	,, ,,	× 80.
7.	,,	*similis*, n. sp.	One of the antennules (female).	× 380.
8.	,,	*hirsuta*, n. sp.	,, ,, ,,	× 380.
9.	,,	*minor*, n. sp.	,, ,, ,,	× 380.
10.	,,	*elegans*, n. sp.	,, ,, ,,	× 253.
11.	,,	*typica*, n. sp.	,, ,, ,,	× 253.
12.	,,	*fusca*, n. sp.	,, ,, ,,	× 380.
13.	,,	*minor*, n. sp.	One of the antennæ.	× 333.
14.	,,	*typica*, n. sp.	,, ,,	× 253.
15.	,,	*elegans*, n. sp.	,, ,,	× 253.
16.	,,	*similis*, n. sp.	,, ,,	× 253.
17.	,,	*hirsuta*, n. sp.	,, ,,	× 253.
18.	,,	*fusca*, n. sp.	,, ,,	× 253.
19.	,,	*hirsuta*, n. sp.	Labium.	× 304.
20.	,,	*fusca*, n. sp.	,,	× 304.
21.	,,	*minor*, n. sp.	,,	× 500.
22.	,,	*typica*, n. sp.	Mandible and palp.	× 253.
23.	,,	*hirsuta*, n. sp.	,, ,,	× 253.
24.	,,	*minor*, n. sp.	,, ,,	× 304.
25.	,,	*elegans*, n. sp.	,, ,,	× 253.

Fig. 26.	*Bradya typica*, n. sp.	One of the anterior foot-jaws.	×304.
27.	„ *similis*, n. sp.	„ „	×500.
28.	„ *hirsuta*, n. sp.	„ „	×380.
29.	„ *elegans*, n. sp.	„ „	×380.
30.	„ *fusca*, n. sp.	„ „	×380.
31.	„ *minor*, n. sp.	„ „	×500.
32.	„ *typica*, n. sp.	One of the posterior foot-jaws.	×500.
33.	„ *similis*, n. sp.	„ „	×500.
34.	„ *hirsuta*, n. sp.	„ „	×380.
35.	„ *minor*, n. sp.	„ „	×500.
36.	„ *elegans*, n. sp.	„ „	×380.
37.	„ *fusca*, n. sp.	„ „	×380.
38.	„ *elegans*, n. sp.	Foot of first pair of swimming-feet.	×126.
39.	„ *typica*, n. sp.	„ „	×126.
40.	„ *hirsuta*, n. sp.	„ „	×126.
41.	„ *similis*, n. sp.	„ „	×190.
42.	„ *minor*, n. sp.	„ „	×126.
43.	„ *fusca*, n. sp.	„ „	×126.
44.	„ *typica*, n. sp.	Foot of fourth pair of swimming-feet.	×126.
45.	„ *fusca*, n. sp.	„ „	×126.
46.	„ *elegans*, n. sp.	„ „	×126.
47.	„ *hirsuta*, n. sp.	„ „	×126.
48.	„ *similis*, n. sp.	„ „	×190.

PLATE 36.

Fig. 1.	*Bradya typica*, Boeck.	Foot of fifth pair (female).	×253.
2.	„ *hirsuta*, n. sp.	„ „	×253.
3.	„ *similis*, n. sp.	„ „	×253.
4.	„ *elegans*, n. sp.	„ „	×253.
5.	„ *minor*, n. sp.	„ „	×253.
6.	„ *fusca*, n. sp.	„ „	×253.
7.	„ *hirsuta*, n. sp.	Abdomen and caudal stylets.	× 53.
8.	„ *fusca*, n. sp.	„ „	× 53.
9.	„ *minor*, n. sp.	„ „	× 80.
10.	„ *similis*, n. sp.	„ „	× 53.
11.	„ *elegans*, n. sp.	„ „	× 53.
12.	„ *typica*, n. sp.	„ „	× 53.
13.	*Ectinosoma melaniceps*, Boeck.	Female seen from left side.	× 64.
14.	„ *Sarsi*, Boeck.	„ „	× 40.
15.	„ *pygmæum*, n. sp.	„ „	× 80.
16.	„ *Herdmani*, n. sp.	„ „	× 53.
17.	„ *atlanticum* (Brady & Robertson).	„ „	× 64.
18.	„ *gracile*, n. sp.	„ „	× 48.
19.	„ *propinquum*, n. sp.	„ „	× 40.

Fig. 20.	*Ectinosoma*	*armiferum*, n. sp.	Female seen from left side.	× 40.
21.	„	*Normani*, n. sp.	„ „	× 80.
22.	„	*curticorne*, Boeck.	„ „	× 53.
23.	„	*longicorne*, n. sp.	„ „	× 64.
24.	„	*erythrops*, Brady.	„ „	× 53.
25.	„	*tenuipes*, n. sp.	„ „	× 64.
26.	„	*Sarsi*, Boeck.	Labium.	× 190.
27.	„	*propinquum*, n. sp.	„	× 253.
28.	„	*melaniceps*, Boeck.	„	× 253.
29.	„	*Normani*, n. sp.	„	× 380.
30.	„	*curticorne*, Boeck.	„	× 253.
31.	„	*erythrops*, Brady.	„	× 253.
32.	„	*tenuipes*, n. sp.	„	× 304.
33.	„	*tenuireme*, n. sp.	One of the antennules (female).	× 253.
34.	„	*curticorne*, Boeck.	„ „ „	× 253.
35.	„	*tenuipes*, n. sp.	„ „ „	× 218.
36.	„	*erythrops*, Brady.	„ „ „	× 218.
37.	„	*gracile*, n. sp.	„ „ „	× 170.
38.	„	*longicorne*, n. sp.	„ „ „	× 253.
39.	„	*Normani*, n. sp.	„ „ „	× 218.
40.	„	*atlanticum* (B. & R.).	„ „ „	× 253.
41.	„	*pygmæum*, n. sp.	„ „ „	× 500.
42.	„	*Sarsi*, Boeck.	„ „ „	× 253.
43.	„	*armiferum*, n. sp.	„ „ „	× 218.
44.	„	*Herdmani*, n. sp.	„ „ „	× 253.
45.	„	*melaniceps*, Boeck.	„ „ „	× 253.
46.	„	*propinquum*, n. sp.	„ „ „	× 190.

PLATE 37.

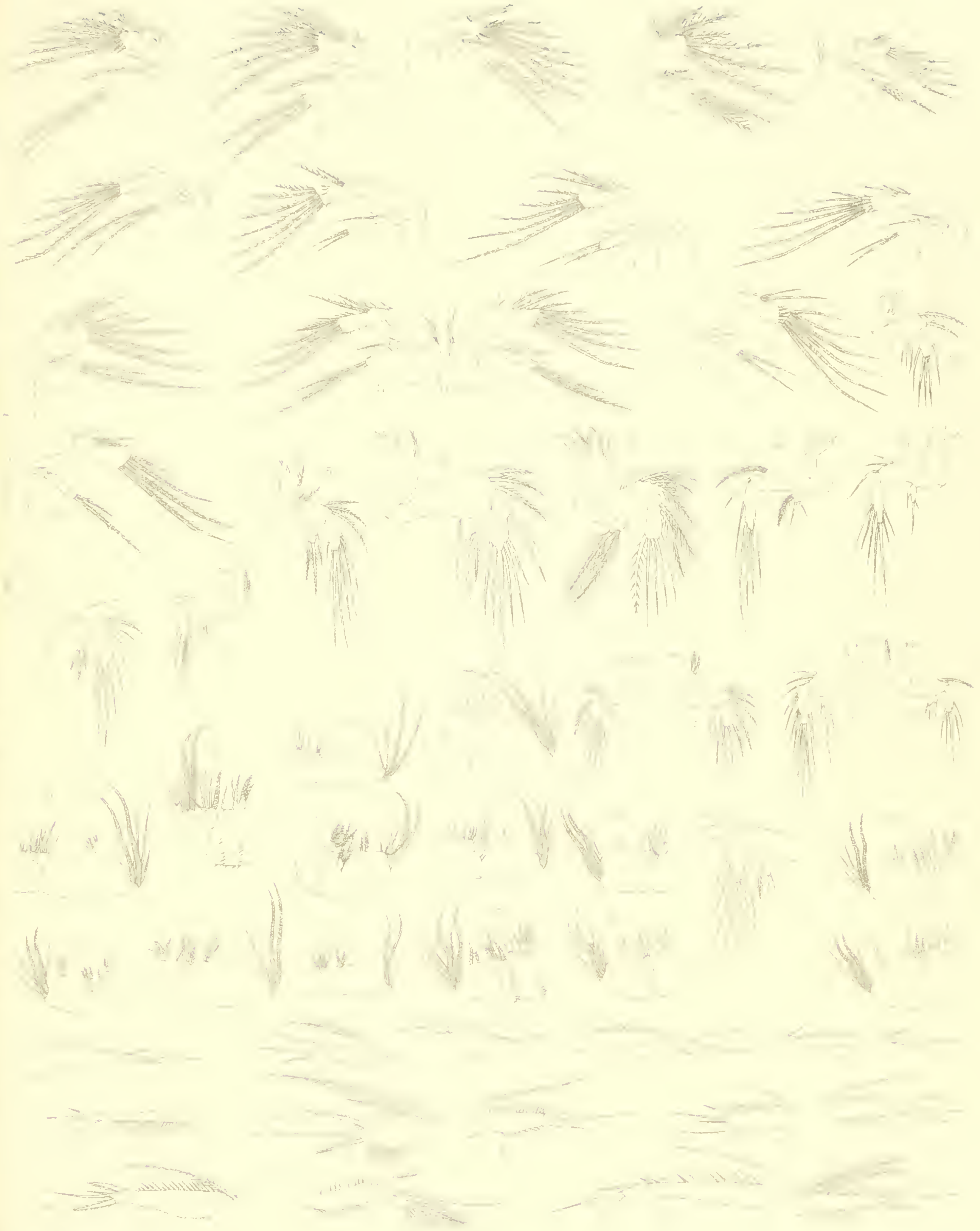
Fig. 1.	*Ectinosoma*	*Sarsi*, Boeck.	One of the antennæ.	× 200.
2.	„	*propinquum*, n. sp.	„ „	× 200.
3.	„	*Herdmani*, n. sp.	„ „	× 300.
4.	„	*armiferum*, n. sp.	„ „	× 170.
5.	„	*pygmæum*, n. sp.	„ „	× 380.
6.	„	*atlanticum* (B. & R.).	„ „	× 300.
7.	„	*longicorne*, n. sp.	„ „	× 300.
8.	„	*tenuireme*, n. sp.	„ „	× 300.
9.	„	*tenuipes*, n. sp.	„ „	× 300.
10.	„	*curticorne*, Boeck.	„ „	× 300.
11.	„	*melaniceps*, Boeck.	„ „	× 300.
12.	„	*Normani*, n. sp.	„ „	× 300.
13.	„	*gracile*, n. sp.	„ „	× 333.
14.	„	*erythrops*, Brady.	„ „	× 300.

Fig. 15.	*Ectinosoma*	*propinquum*, n. sp.	Mandible and palp.	×170.
16.	„	*Herdmani*, n. sp.	„ „	×540.
17.	„	*armiferum*, n. sp.	„ „	×253.
18.	„	*erythrops*, Brady.	„ „	×253.
19.	„	*tenuipes*, n. sp.	„ „	×253.
20.	„	*pygmæum*, n. sp.	„ „	×380.
21.	„	*Sarsi*, Boeck.	„ „	×170.
22.	„	*melaniceps*, Boeck.	„ „	×253.
23.	„	*atlanticum* (B. & R.)	„ „	×253.
24.	„	*curticorne*, Boeck.	„ „	×253.
25.	„	*longicorne*, n. sp.	„ „	×333.
26.	„	*Normani*, n. sp.	„ „	×253.
27.	„	*tenuireme*, n. sp.	„ „	×253.
28.	„	*gracile*, n. sp.	One of the anterior foot-jaws.	×200.
29.	„	*Herdmani*, n. sp.	„ „ „	×380.
30.	„	*tenuipes*, n. sp.	„ „ „	×300.
31.	„	*armiferum*, n. sp.	„ „ „	×200.
32.	„	*propinquum*, n. sp.	„ „ „	×190.
33.	„	*longicorne*, n. sp.	„ „ „	×380.
34.	„	*Normani*, n. sp.	„ „ „	×380.
35.	„	*atlanticum* (B. & R.)	„ „ „	×380.
36.	„	*tenuireme*, n. sp.	„ „ „	×250.
37.	„	*erythrops*, Brady.	„ „ „	×190.
38.	„	*Sarsi*, Boeck.	„ „ „	×190.
39.	„	*pygmæum*, n. sp.	„ „ „	×500.
40.	„	*melaniceps*, Boeck.	„ „ „	×380.
41.	„	*curticorne*, Boeck.	„ „ „	×380.
42.	„	*erythrops*, Brady.	One of the posterior foot-jaws.	×380.
43.	„	*pygmæum*, n. sp.	„ „ „	×380.
44.	„	*longicorne*, n. sp.	„ „ „	×333.
45.	„	*gracile*, n. sp.	„ „ „	×333.
46.	„	*tenuireme*, n. sp.	„ „ „	×253.
47.	„	*tenuipes*, n. sp.	„ „ „	×380.
48.	„	*curticorne*, Boeck.	„ „ „	×380.
49.	„	*melaniceps*, Boeck.	„ „ „	×380.
50.	„	*atlanticum* (B. & R.).	„ „ „	×380.
51.	„	*Normani*, n. sp.	„ „ „	×380.
52.	„	*Sarsi*, Boeck.	„ „ „	×253.
53.	„	*armiferum*, n. sp.	„ „ „	×333.
54.	„	*Herdmani*, n. sp.	„ „ „	×570.
55.	„	*propinquum*, n. sp.	„ „ „	×190.

PLATE 38.

Fig. 1.	*Ectinosoma*	*tenuireme*, n. sp.	Foot of first pair of swimming-feet.	× 140.
2.	,,	*melaniceps*, Boeck.	,, ,, ,,	× 140.
3.	,,	*gracile*, n. sp.	,, ,, ,,	× 140.
4.	,,	*pygmæum*, n. sp.	,, ,, ,,	× 250.
5.	,,	*Normani*, n. sp.	,, ,, ,,	× 140.
6.	,,	*longicorne*, n. sp.	,, ,, ,,	× 140.
7.	,,	*Herdmani*, n. sp.	,, ,, ,,	× 140.
8.	,,	*curticorne*, Boeck.	,, ,, ,,	× 140.
9.	,,	*propinquum*, n. sp.	,, ,, ,,	× 115.
10.	,,	*Sarsi*, Boeck.	,, ,, ,,	× 115.
11.	,,	*atlanticum* (B. & R.).	,, ,, ,,	× 230.
12.	,,	*tenuipes*, n. sp.	,, ,, ,,	× 230.
13.	,,	*erythrops*, Brady.	,, ,, ,,	× 230.
14.	,,	*armiferum*, n. sp.	,, ,, ,,	× 115.
15.	,,	*erythrops*, Brady.	Foot of fourth pair of swimming-feet.	× 230.
16.	,,	*atlanticum* (B. & R.).	,, ,, ,,	× 230.
17.	,,	*tenuipes*, n. sp.	,, ,, ,,	× 230.
18.	,,	*Normani*, n. sp.	,, ,, ,,	× 150.
19.	,,	*armiferum*, n. sp.	,, ,, ,,	× 115.
20.	,,	*curticorne*, Boeck.	,, ,, ,,	× 150.
21.	,,	*melaniceps*, Boeck.	,, ,, ,,	× 150.
22.	,,	*Sarsi*, Boeck.	,, ,, ,,	× 115.
23.	,,	*propinquum*, n. sp.	,, ,, ,,	× 115.
24.	,,	*tenuireme*, n. sp.	,, ,, ,,	× 150.
25.	,,	*Herdmani*, n. sp.	,, ,, ,,	× 150.
26.	,,	*pygmæum*, n. sp.	,, ,, ,,	× 253.
27.	,,	*gracile*, n. sp.	,, ,, ,,	× 170.
28.	,,	*longicorne*, n. sp.	,, ,, ,,	× 170.
29.	,,	*longicorne*, n. sp.	Foot of fifth pair (female).	× 253.
30.	,,	*gracile*, n. sp.	,, ,,	× 253.
31.	,,	*pygmæum*, n. sp.	,, ,,	× 380.
32.	,,	*Sarsi*, Boeck.	,, ,,	× 145.
33.	,,	*Herdmani*, n. sp.	,, ,,	× 220.
34.	,,	*propinquum*, n. sp.	,, ,,	× 145.
35.	,,	*curticorne*, Boeck.	,, ,,	× 253.
36.	,,	*tenuipes*, n. sp.	,, ,,	× 253.
37.	,,	*armiferum*, n. sp.	,, ,,	× 190.
38.	,,	*atlanticum* (B. & R.).	,, ,,	× 253.
39.	,,	*erythrops*, Brady.	,, ,,	× 253.
40.	,,	*tenuireme*, n. sp.	,, ,,	× 190.
41.	,,	*melaniceps*, Boeck.	,, ,,	× 190.
42.	,,	*Normani*, n. sp.	,, ,,	× 190.
43.	,,	*armiferum*, n. sp.	Abdomen and caudal stylets.	× 53.
44.	,,	*curticorne*, Boeck.	,, ,,	× 80.
45.	,,	*Normani*, n. sp.	,, ,,	× 80.

Fig. 46.	*Ectinosoma*	*melaniceps*, Boeck.	Abdomen and caudal stylets.	× 80.
47.	,,	*Herdmani*, n. sp.	,, ,,	× 80.
48.	,,	*erythrops*, Brady.	,, ,,	× 80.
49.	,,	*tenuireme*, n. sp.	,, ,,	× 53.
50.	,,	*longicorne*, n. sp.	,, ,,	×127.
51.	,,	*Sarsi*, Boeck.	,, ,,	× 53.
52.	,,	*tenuipes*, n. sp.	,, ,,	×127.
53.	,,	*attanticum* (B. & R.).	,, ,,	× 64.
54.	,,	*propinquum*, n. sp.	,, ,,	× 53.
55.	,,	*pygmæum*, n. sp.	,, ,,	×127.



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	Part VI.	1891.	0	12	0	0	9	0
	Part VII.	1891.	0	6	0	0	4	6
	Part VIII.	1892.	0	8	0	0	6	0
	Part IX.	1892.	0	12	0	0	9	0
	Part X.	1893.	1	8	0	1	1	0
	Part XI.	1894.	0	2	6	0	2	0
VI.	Part I.	1894.	2	0	0	1	10	0
	Part II.	1894.	1	11	0	1	3	3
	Part III.	1894.	0	10	0	0	7	6
	Part IV.	1896.	1	4	0	0	18	0
	Part V.	1896.	0	10	0	0	7	6

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ON SOME NEW OR RARE PHASMIDÆ IN THE COLLECTION OF THE BRITISH MUSEUM.

BY

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July 1896.

VI. *On some new or rare* Phasmidæ *in the Collection of the British Museum. By* W. F. Kirby, *F.L.S., F.E.S., Assistant in the Zoological Department, British Museum, South Kensington.*

(Plates XXXIX. & XL.)

Read 5th December, 1895.

THE *Phasmidæ* are in many respects a very interesting group of insects, but their study has been comparatively neglected. They attain a larger size than any other existing insects known, and many of the species are of brilliant colours; but they take up much space in a cabinet, and when preserved in spirit, as is too often the case, their colours are discharged, and they become brittle and unsightly grey, yellow, or brown objects. (I never lose an opportunity of protesting against the indiscriminate use of spirit by collectors. It is a most convenient mode of collecting, but is adapted only for hard shining insects like bugs, beetles, and cockroaches, which have no delicate colours to bleach, exposed wings to tear, or pubescence to mat.) Again, the *Phasmidæ* are sluggish insects, highly protective in their appearance, and generally to be found resting motionless on their food-plants. They are therefore difficult to see and collect, and, as they are little studied, they have no market value; and amateurs who send out collectors to obtain butterflies or beetles sometimes expressly discourage their collectors from paying attention to groups of insects which do not interest them.

The *Phasmidæ* are pre-eminently a tropical group, and probably attain their maximum of size and beauty in the Eastern Archipelago, from the Malay Islands to Australia inclusive, though the number of species is perhaps greater in Tropical America; and in both these particulars they resemble butterflies. Four small species only are found in Europe south of the Alps, and of these only one, *Phasma gallicum*, Charpentier, extends as far north as South France, where it appears to be rare. In the United States likewise only a few species occur, only one of which, *Diapheromera Sayi*, Gray, crosses the St. Lawrence into Canada, where it is found at Montreal. Several species are found in China and Japan, but their northern extension in Eastern Asia is not yet accurately known. Southward, they extend to the Cape of Good Hope in Africa, and at least as far as Chili in South America.

Many of the species are apterous in one or both sexes, while others have very large wings. Sometimes they are perfectly smooth and rod-like; but more frequently they have spines on the head, legs, and body, sometimes simple, sometimes broad and triangular, and often accompanied or replaced by large leaf-like expansions, especially in the species of the Eastern genus *Phyllium*, Illiger, which present the exact appearance of green veined leaves, and have always been known as "Walking Leaves." The *Phasmidæ* in general are known as "Walking Sticks," "Stick Insects," or "Spectres;" and many of the wingless species exhibit a very curious resemblance to dead twigs. Others are green, with jointed bodies (*e. g.* the genus *Hermarchus*, Stål), and present an exact resemblance to shoots of bamboo, being seven or eight inches long, and as thick as a finger. Smaller species, belonging to the genus *Græffea*, Brunner, are sometimes extremely injurious to the cocoanut-trees in the South Sea Islands; so much so that the chiefs sometimes issue orders for their destruction by chopping them to pieces. Many *Phasmidæ* exude a liquid from the body when alarmed; but this cocoanut feeder is said to have the power of squirting a fluid, sufficiently acrid to cause blindness if it touches the eyes, to a distance of four feet. Otherwise the *Phasmidæ* appear to be generally harmless, except sometimes, to vegetation; and it is probably only a few species which cause much mischief in this respect.

The largest species known belongs to the genus *Pharnacia*, Stål. It is from Borneo, and the name of *Pharnacia serratipes*, Gray, has been provisionally attached to it in the public Insect Room at the Natural History Museum, South Kensington. Accurate measurements, taken by Mr. C. O. Waterhouse, will be found in the present paper; but in this place I need only say that it measures nearly 13 inches from the front of the head to the extremity of the abdomen. Another specimen, from a doubtful locality, measures only 10½ inches in total length; but without more specimens it is impossible to ascertain positively whether they belong to the same species or not, for except size, and a possible difference in the comparative size of the spines (a character not easily estimated when comparing a dried and a spirit specimen), I have not been able to detect any characters by which to separate them. Moreover, in many *Phasmidæ*, the males differ very much from the females, being much smaller, slenderer, and with the spines, &c., much less developed; and it is therefore unsafe to attempt to pair the sexes, unless they are received from the same locality and in the same collection. The type of *Pharnacia serratipes*, Gray, is a slender winged insect, only 6¾ inches in length; and no one has yet determined whether the two large apterous females to which I have referred belong to *P. serratipes* or to some allied species, of which the males are as yet undiscovered. As a rule, the female insects are much commoner in collections than the males.

Many *Phasmidæ* were described by the older writers, and a considerable number were figured by Stoll in 1813, in his ‘Représentation des Spectres ou Phasmes.’

In 1833 George Robert Gray published the first part of a projected work on the Entomology of Australia, containing 8 plates illustrating some of the magnificent species of that country; and though this work was never continued, Gray published a ‘Synopsis of the Species of Insects belonging to the Family of *Phasmidæ*’ in 1835, describing a considerable number of new genera and species.

In 1839 Burmeister gave a critical *résumé* of the *Phasmidæ* in the second volume of his ‘Handbuch der Entomologie,’ as also did De Haan of the Eastern species, in 1842, in his synopsis of *Orthoptera* in Temminck’s splendidly illustrated ‘Verhandelingen.’

In 1859 the British Museum issued one of its most important entomological publications,—Westwood’s quarto Catalogue of *Phasmidæ*, with 40 uncoloured plates.

Among the more important contributions to the knowledge of this group of insects which have appeared since that date are Bates’s “Descriptions of 52 new Species of *Phasmidæ*,” Trans. Linn. Soc. vol. xxv. (1865), and De Saussure’s “Mélanges Orthoptérologiques" (Mém. Soc. Phys. et d'Hist. Nat. Genève, xx.), and 'Mission Scientifique au Mexique, Recherches Zool.' vi. (1869–70). All these publications are illustrated with uncoloured plates.

Between the years 1855 and 1875 the active and industrious but hasty and self-opiniated Swedish entomologist, Dr. Stål, published numerous papers on *Orthoptera*, including a revision of the *Phasmidæ*. These are scattered through the various publications of the Vetenskaps Akademie of Stockholm, and are not only cast in the form of very complicated tables, with numerous exceptions, which make them extremely difficult to follow, but the genera are frequently based on the examination of one or two species only; and hence it becomes difficult to judge how far the genera, as restricted by him, correspond with those of other authors. Nevertheless his system was considerably in advance of that of Westwood, who had regarded the presence or absence of wings as a character of primary importance; and in 1893 Brunner de Wattenwyl, when working out Fea's Burmese collection of *Orthoptera* in the 'Annali del Museo Civico di Storia Naturale di Genova,' ser. 2, vol. xiii. (or vol. xxxiii. of the whole series), took occasion to sketch out a revision of the Order, including the *Phasmidæ*, which he divided into 12 families. The characters on which he relies are the form of the hind tibiæ beneath, whether carinated to the tip or excavated; the length of the antennæ, as compared with that of the front femora; the length of the median segment; the form of the terminal segments of the abdomen, &c. The median segment is an important character, first utilized by Stål. In the *Phasmidæ* the first segment of the abdomen is anchylosed with the metathorax so as to form one piece with it, and in some cases so closely that the point of division is barely distinguishable. Among other peculiarities, the supra-anal lamina of the female is a structure which may be absent or rudimentary, or, as in the genus *Promachus*, it may be produced into a spine. The operculum of the female is a concave appendage on the lower surface of the abdomen, which is sometimes so short as to be covered by it, and sometimes forms a gutter projecting a long way beyond the abdomen.

In the main, Brunner de Wattenwyl's divisions appear to be natural, though some of them will probably require more or less modification before they can be finally accepted. I have followed them in the present paper, in which I have endeavoured to describe the greater part of the unpublished species in the Natural History Museum, though there are others which I have passed over, because the material at my disposal is at present insufficient.

One or two additional points of special interest may be noticed before I proceed to the systematic part of the paper. The *Mantidæ*, or Praying Insects, are the nearest allies of the *Phasmidæ*; but the former can always be distinguished by the long spines on the front tibiæ, which are used to kill and capture insect prey. No such arrangement is found in the *Phasmidæ*, which are all vegetable feeders. They are insects with imperfect metamorphoses, and sometimes a leg is lost in one of the early stages and is reproduced; it is then much smaller than the corresponding leg on the opposite side, and its spinous or lobate appendages, if any are present in the normal leg, are reduced or absent.

The late Prof. Riley estimated the total number of existing species of insects at ten millions (about 300,000 are known at present); and when it is considered that less than a dozen species of such large insects as *Phasmidæ* are known from a locality so frequently visited as Madagascar, and that our British species of parasitic *Hymenoptera*, among which are the smallest insects known, are numbered by hundreds, although very few entomologists have worked at them at all, Prof. Riley's estimate cannot be regarded as excessive. Excepting the larger butterflies and beetles of the best-explored countries, our knowledge of the insects of the world is far more incomplete than many persons, even though experienced entomologists, might be inclined to suppose.

At present the British Museum Collection of *Phasmidæ* fills 120 cabinet-drawers, but will soon require to be extended. More materials, at all events, are needed before a satisfactory revision of the classification of *Phasmidæ* can be attempted.

Subfamily LONCHODINÆ.

PHARNACIA SERRATIPES.

Cladoxerus serratipes, Gray, Synopsis of Phasmidæ, p. 12 (1835).
Phibalosoma serratipes, Westw. Cat. Phasm. p. 75. n. 192 (1859).

This genus differs from most of the *Lonchodinæ* in having winged males.

Some particulars respecting the supposed females of this insect are given in the introductory portion of this paper. The colour, when alive, was evidently green, and the legs are strongly carinated and spined, nearly as in the male; but the body is otherwise unarmed. The typical male is from Malabar. The dimensions of the large female from Borneo are given below; it will be seen that they are somewhat asymmetrical.

Pharnacia serratipes, ♀. Borneo.

Total length of body		1 foot 10	lines.	
Length of	head	6½	,,	
,,	prothorax	6½	,,	
,,	mesothorax	32½	,,	
,,	metathorax (incl. intermediate)	23	,,	
,,	intermediate	10¾	,,	
,,	front femur, right side	34	,,	
,,	,, ,, left side	37	,,	
,,	middle ,, right side	31½	,,	
,,	,, ,, left ,,	29½	,,	
,,	hind ,, right ,,	35½	,,	
,,	,, ,, left ,,	33½	,,	
,,	front tibia, right ,,	45½	,,	
,,	,, ,, left ,,	49½	,,	
,,	hind tibia (right and left)	44	,,	
,,	front tarsus, right side	13	,,	The right tibia and tarsus are more slender than the left.
,,	,, ,, left ,,	15	,,	
,,	hind ,, right ,,	16	,,	
,,	,, ,, left ,,	14	,,	

PHARNACIA PONDEROSA.

Pharnacia ponderosa, Stål, Œfvers. Vet.-Akad. Förh. xxxiv. (10) p. 10 (1877).

Stål briefly describes the male. The British Museum possesses a female from Luzon which may belong to this species. It is dull testaceous, mottled with brown, and has rudimentary lighter-coloured tegmina, very distinctly longitudinally lined with black along the nervures. The operculum is long, narrow, and pointed. Length 135 millim., of tegmina 7 millim., of operculum 15 millim. The specimen is in too poor condition to make it worth while to describe it in detail.

MYRONIDES PFEIFFERÆ, var. (?).

Lonchodes Pfeifferæ, Westw. Cat. Phasm. p. 44, pl. v. fig. 6.

The types are from Ceram. There is a male specimen in the British Museum from Ternate, differing chiefly in the greater length of the metanotum, which is one-fifth longer than the median segment. In this it agrees with the female from Ceram; in the male from the latter locality the median segment and metanotum are almost exactly of equal length. But I will not venture to describe the Ternate insect as new on a single specimen.

LONCHODES WHITEHEADI, sp. n.

Female. Brown, cylindrical, strongly granulated; head with two short, broad horns between the eyes; prothorax with two raised tubercles in front; all the parts of the thorax and the joints of the abdomen with a short, raised tubercle behind; middle legs shorter than the front or hind legs; front femora very slightly dentated on the inner carina before the extremity; middle femora with two rounded lobes beneath, not dentated, before the extremity; hind femora with only the lobe on the inner carina developed; middle legs with traces of broad yellow bands; metathorax black on the sides and on the hinder part above; abdomen with black triangles on the sides, which probably meet on the back of some of the hinder segments. (Colours altered.)

Dimensions.

Long. corporis	75	millim.
„ capitis	6	„
„ pronoti	3½	„
„ mesonoti	20	„
„ metanoti, cum segmento mediano	13	„
„ segmenti mediani	3	„
„ femorum anticorum	22	„
„ „ medianorum	15	„
„ „ posticorum	20	„

Albay, S.E. Luzon (*Whitehead Expedition*).

The lobate, undentated, middle and hind femora distinguish this from any other species of the genus before me.

LONCHODES BATESII, sp. n.

Female. Cylindrical, brown (colours evidently altered), granulated. Head above grooved, the groove passing between the black points on the vertex between the eyes; outside these are a pair of larger tubercles or short horns, outside which subsidiary grooves run obliquely to the central one. At the back of the head are likewise four rather larger tubercles; the central groove runs between the inner ones, and beyond the outer ones other grooves run, slightly diverging, to the eyes; below these is a row of three small tubercles behind the eyes. Prothorax about as long as the head, with a central groove and two transverse ones, one in front and the other about the middle; and there are also two lateral grooves. The central groove is bordered on both sides, and the lateral ones above, with rows of tubercles. At the back of the prothorax are two oblong black spots in the middle, and a black dot on each side beyond them. The rest of the thorax and the abdomen are not grooved, but carinated, along the median line. Antennæ long, setaceous, very finely pubescent, blackish at the extremities of the joints. Front legs long, slightly compressed; femora with the basal third irregularly serrated above, and a row of fine blackish teeth at the extremity beneath, preceded by a larger tooth. First joint of the tarsi (which is as long as the remaining joints without the claws) black, as are likewise the rest of the tarsi. Intermediate and hind legs much shorter; femora with larger black terminal serrations and preceding lobe, but smooth above; tibiæ with a lobe beneath towards the base; tarsi black, except the greater part of the first joint, which is much shorter than in the front legs.

The blackish apical portion of the middle and hind femora is preceded by a pale band, probably yellow in the living insect.

Dimensions.

Long. corporis	100	millim.
,, pronoti	5	,,
,, mesonoti	24	,,
,, metanoti, cum segmento mediano	15	,,
,, segmenti mediani	5½	,,
,, femorum anticorum	24	,,
,, ,, medianorum	17	,,
,, ,, posticorum	23	,,

Hab. Boroo (Bouru ?).

LONCHODES VIRGATUS, sp. n.

Male. Cylindrical, brown, rather slender. Head granulated, not grooved, with two small pointed horns between the eyes, and two tubercles opposite them on the hinder border. Prothorax with shallow grooves, the longitudinal one not extending to the hind border; of the lateral ones, one is anterior and the other median. The rest of the thorax and abdomen is finely granulated, with scarcely a trace of a longitudinal carina. Front femora beneath with one large and one small tooth before the extremity of the outer ridge, which is produced into a sharp spike; middle femora with a large tooth towards the extremity on each ridge, followed by four small ones on the inner, and two small ones on the outer ridge; hind femora with two or three small teeth on each side before the extremity. First joint of tarsi flattened, depressed, not much longer than the two following joints on all the legs. The left middle leg is deformed, being shorter than the other, only imperfectly dentated, and with only four joints to the tarsi.

Dimensions.

Long. corporis	94	millim.
,, pronoti	5	,,
,, mesonoti	23	,,
,, metanoti, cum segmento mediano	17	,,
,, segmenti mediani	5	,,
,, femorum anticorum	21	,,
,, femoris mediani (dextri)	16	,,
,, femorum posticorum	20	,,

Hab. Boroo (Bouru ?).

Closely allied to *L. brevipes*, Gray, from Malabar, but differs in the character of the toothing of the middle femora. The other femora are also more strongly toothed. The abdominal appendages are nearly similar.

LONCHODES NIGROPUNCTATUS, sp. n.

Female. Cylindrical, brownish grey; clypeus and labrum smooth, yellowish; two black tubercles or short horns on the vertex behind the antennæ, rather wide apart; between them commences a carina which extends to the extremity of the body, all parts of which are irregularly covered with black granulations, largest on the head, behind the horns. Several of the divisions between the segments are spotted with black on each side of the median carina. Prothorax scarcely as long as the head, with the lateral ridges very distinct. Antennæ long, blackish above, except at the base; basal joint very large, compressed, and pubescent; second joint longer and broader than the following ones. Legs long; middle legs rather shorter than the rest; all the femora very slightly dentated at the extremity of the middle carina. First joint of all the tarsi slightly compressed, but not dilated, as long or longer than all the rest put together. Median segment about one-fourth of the length of the metanotum, cut off straight in front. Seventh segment of abdomen rather shorter than the preceding ones, but about as long as the three terminal segments together. Segment 8 rather longer than 9; 10 about as long as 9, slightly concave above, and produced into a short point at the sides.

Dimensions.

Long.	corporis	112	millim.
,,	capitis	6	,,
Lat.	,,	3	,,
Long.	pronoti	5	,,
,,	mesonoti	15	,,
,,	metanoti, cum segmento mediano	19	,,
,,	segmenti mediani	5	,,
,,	femorum anticorum	26	,,
,,	,, medianorum	21	,,
,,	,, posticorum	24	,,

Hab. Lizard Island, N.E. coast of Australia.

Lonchodes Catori, sp. n.

Male. Cylindrical, slender, with long and slender legs. Head, prothorax, and first two joints of the antennæ red; antennæ otherwise rufous-brown. Femora green, red at the base and tip; the tibiæ and tarsi red or reddish, more or less shading into brown above. Anterior femora with one moderate-sized spine beneath, near the extremity, on the inner carina; middle femora with two spinose ridges at the extremity beneath, with three or four red black-tipped spines on each side; hind femora with one tooth, and some smaller denticulations at the extremity beneath. Mesothorax narrowly red at the base, and broadly at the extremity, where it is much expanded. Metathorax narrowly red at the base, and at its extremity for about the same length as the median segment, which is likewise red, with a large square blackish patch covering its basal half. Median segment scarcely one-sixth as long as the metathorax. Abdomen olive-green, narrowly reddish at the ends of the segments, and tinged with rufous towards the extremity.

A specimen which appears to be an immature female of this species is much greener, being merely tinged with rufous on the prothorax, median segment (which wants the dark blotch), and towards the extremities of the meso- and metathorax, and of the femora and abdomen, &c. It measures 70 millim. in length. The dimensions of the male are as follows:—

Dimensions.

Long.	corporis	88	millim.
,,	capitis	4	,,
,,	pronoti	3	,,
,,	mesonoti	22	,,
,,	metanoti, cum segmento mediano	18	,,
,,	segmenti mediani	6	,,
,,	femorum anticorum	24	,,
,,	,, medianorum	19	,,
,,	,, posticorum	22	,,

Sandakan, N. Borneo.

A very pretty species, allied to *L. geniculatus*, Gray, and *geniculosus*, Westw., which I believe to be distinct species; but in both these the head is green. The insect formed part of an interesting collection presented by Douglas Cator, Esq.

CHONDROSTETHUS, gen. nov.

Long and slender, with long and slender legs; head long, bicornuted, antennæ longer than the front legs, at least in male, scape twice as long as broad, depressed and carinated, especially in female; second joint shorter, less depressed, about 1½ times as long as broad, and narrowed from base to extremity; tibiæ slightly longer than femora; front legs longer than the others, middle legs shortest, all the femora with small terminal teeth beneath; first joint of tarsi longer than all the rest together, except in the middle legs, where they are of about the same length; front femora at base, front tibiæ at base and before the extremity, basal joint of front tarsi, and base of middle tibiæ furnished with long, but not broad, foliations; median segment about half as long as the metathorax, anterior edge straight; metanotum with a rounded warty excrescence on each side at the extremity in the male; hind legs extending about to the extremity of the three segments of the abdomen beyond the basal segment; three terminal segments of abdomen in male of nearly equal length, hardly dilated, the last slightly longer than the two preceding, tectiform, and excavated at the extremity.

CHONDROSTETHUS WOODFORDI, sp. n. (Plate XXXIX. figs. 1, 1 *a*, ♂; figs. 2, 2 *a*, ♀.)

Brown; prothorax as long as the head, with a longitudinal groove, and transverse grooves in front and in the middle; there are also several incomplete grooves on each side of the longitudinal one. In the female these grooves are much stronger than in the male, and the back of the prothorax is alternately marked with black and yellowish. In the female, too, the insect is strongly granulated (very slightly in the male), especially on the head, prothorax, and mesothorax; on the lateral borders these take the form of a series of small tubercles. The male is much more slender than the female.

Dimensions.

	♂. millim.	♀. millim.
Long. corporis	75	124
„ pronoti	3	4·5
„ mesonoti	18	31
„ metanoti, cum segmento mediano	12	19
„ segmenti mediani	4·5	7
„ femorum anticorum	22	33
„ „ medianorum	14	23
„ „ posticorum	20	26

Hab. Solomon Islands (*Woodford*).

The genus *Thrasyllus* was founded by Stål on a male insect from the Philippines, which he called *T. macilentus*. The present species agrees with the characters given by Stål in many respects, especially in the very long antennæ, and the excrescences on the metanotum; the latter, however, are described by Stål as squamiform rudiments of wings. The tibiæ and tarsi are described as compressed and dilated; but in the male before me they are hardly to be called compressed, and there is only the faintest indication of a dilatation at the extremity of the front tibiæ. As this character is usually much more strongly marked in the females than in the males, the female of Stål's insect would probably more resemble those of the genus *Dixippus*; and having both sexes of *C. Woodfordi* before me I have thought it more satisfactory to treat it as the type of a new genus.

Greenia, gen. nov.

Cylindrical; head with two acute spines between the eyes, rising from a ridge; body granulated; legs moderately long and slender, unarmed, except for a small rounded lobe on the upper surface towards the base of the middle femora in the female, terminal segment carinated (at least in female) and ending in a wide obtuse fork.

This curious genus is not closely allied to any other. Bates described and figured both sexes of a Phasmide under the name of *Lonchodes furcatus* in Trans. Linn. Soc. xxv. p. 335, pl. xliv. figs. 5, 6, from Ceylon. Among some *Phasmidæ* recently brought from Ceylon by Mr. E. Ernest Green, to whom the British Museum has been indebted for so many interesting additions to its entomological collections, I find a female of this species, and have much pleasure in calling the uncharacterized genus to which it belongs after Mr. Green, who is, I may mention, at present engaged on a monograph of the *Coccidæ* of Ceylon, a large and practically unworked subject, of great importance to planters and agriculturists. Mr. Green's insect agrees in all essential points with Bates's figure, except that it is apparently less strongly granulated. In the absence of a series, it would be foolish to describe the insect as new, on this doubtful character only.

Hermogenes, Stål.

Hermogenes, Stål, Rev. Orth. iii. p. 8, note (1875).

Prisomera, pt., Gray, Syn. Phasm. p. 15 (1855); Westw. Cat. Phasm. p. 47 (1859); Brunn. Ann. Mus. Genov. xxxiii. p. 81 (1893).

Under the present genus we may include:—

1. *Lonchodes personatus*, Bates, Trans. Linn. Soc. xxv. p. 336, pl. xliv. fig. 7 (1865), from Bouru.
2. *Phasma femorata*, Stoll, Phasm. p. 44, pl. xiv. fig. 54 (Amboina).
3. *Phasma* (*Acanthoderus*) *verrucosum*, De Haan, Orth. p. 136, pl. xiv. fig. 1 (Sumatra).

(The type of *Prisomera*, Gray, is his *spinicollis* from Ceylon, which is not congeneric with these.)

Female. Body cylindrical, granulated, not spiny, but sometimes with lobate excrescences on the back; antennæ slender, generally shorter than the front legs; legs short, femora spiny beneath, legs more or less compressed, especially the front tibiæ; all the femora dentated beneath at the extremity; front and intermediate femora and tibiæ more or less foliaceous; first joint of front tarsi not much longer than the second.

HERMOGENES CRISTATUS, sp. n.

Female. Cylindrical, brown, rugose; antennæ testaceous, spotted with brown at the joints. Head with a very slight, quadrifid transverse ridge between the eyes; a raised foliaceous crest, much broken and divided, at the ends of the pro- and mesothorax; two strong spines at the end of the second segment of the abdomen (reckoning the median segment, which is about one-third of the length of the metathorax, as the first), and two long ear-like lobes at the end of the seventh. Antennæ with the scape much flattened. Front femora with a foliaceous expansion of the lateral carinæ beneath, and terminating above in a short strong spine, surrounded by two or three smaller ones. The outer lower carina is produced into a very large cultriform process, followed by a shorter spine. Front femora much widened and compressed, with a very large rounded lobe, towards the extremity above, which is directed forward, and dentated above and in front. Middle femora flattened and foliaceous, with two small rounded projections at the base above, a large one near the middle, directed forward, and dentated above and in front, and a strong tooth at the extremity; this is preceded by a yellowish band. Beneath is a row of strong teeth, decreasing in size towards the extremity. Middle tibiæ with two foliaceous crests, each slightly depressed in the middle, towards each extremity. Hind femora with a strong tooth at the extremity above, and a row of teeth, decreasing in size, towards the extremity below; about the middle is a yellow spot. Hind tibiæ with slight foliaceous expansions on the carinæ at their base below and at their extremity above. Tarsi without foliaceous expansions, the first joint hardly longer or broader than the others.

Dimensions.

Long. corporis	110	millim.
,, capitis	5	,,
,, pronoti	6	,,
,, mesonoti	27	,,
,, metanoti, cum segmento mediano	18	,,
,, segmenti mediani	6	,,
,, femorum anticorum	19	,,
,, ,, medianorum	15	,,
,, ,, posticorum	20	,,

Hab. Baram District, North Borneo.

Collected by Mr. C. Hose.

Allied to *H. verrucosus*, De Haan, from Sumatra.

HERMOGENES HOSEI, sp. n. (Plate XL. figs. 1, 1 *a*.)

Female. Cylindrical, dark brown, rugose and granulated; prothorax with a depressed cross, the hinder part rising into a slight median carina, which is continued, rather indistinctly, along most of the thorax and abdomen. Fifth segment of abdomen with a transverse foliaceous raised lobe at the extremity; sixth with a short longitudinal raised foliaceous lobe on each side of the median line near the base of the segment. Front femora with four long foliaceous carinæ beneath, the two middle ones unarmed, the inner one forming an irregular waved row of large rounded serrations, and the outer one with a strong cultriform projection, followed by a smaller one, towards the extremity. At the upper extremity of the front femora are some short strong teeth. Front tibiæ much compressed, with raised foliaceous expansions above and below, the upper one expanded into a long lobe, rounded above, towards the base, and terminating in one or more short teeth, one under the other; lower expansion slightly enlarged at its base. Middle femora with two projections near the base above, a large foliaceous expansion near the middle, irregularly serrated above, and followed by a slighter projection; and a very prominent tooth at the extremity; beneath there is a large tooth, followed by some small denticulations towards the extremity. Middle tibiæ with two raised rounded projections towards the base, and three more pointed ones towards the extremity. Tarsi not lobate; the first hardly longer than the others.

Dimensions.

Long. corporis	111 millim.
,, capitis	6 ,,
,, pronoti	6 ,,
,, mesonoti	25 ,,
,, metanoti, cum segmento mediano	18 ,,
,, segmenti mediani	6 ,,
,, femorum anticorum	19 ,,
,, ,, medianorum	16 ,,
,, ,, posticorum	19 ,,

Hab. Baram District, North Borneo, collected by Mr. C. Hose.

Allied to the last species.

DIXIPPUS SUMATRANUS.

Phasma sumatranum, De Haan, Orthoptera, pl. xiii. fig. 6 (1842).

Phasma (*Bacteria*) *nodosum*, ♀, De Haan, *l. c.* p. 133 (1842).

Male. Slender, cylindrical, reddish brown. Prothorax with a depressed cross, the central line of which is continued on the vertex, and then divides into a Y, the arms of which run to the eyes. The front ends in a slight transverse ridge in front of the eyes, with a rudimentary horn on each side. Segments of the abdomen slightly carinated, more distinctly so towards the apex; the two penultimate segments much expanded, the last twice as long as broad, and cleft nearly to the base, the femora slightly dentated at the extremity of the femora beneath, most strongly on the middle femora.

Dimensions.

Long. corporis	100 millim.
,, capitis	4 ,,
,, pronoti	3 ,,
,, mesonoti	23 ,,
,, metanoti, cum segmento mediano	18 ,,
,, segmenti mediani	4 ,,
,, femorum anticorum	24 ,,
,, ,, medianorum	20 ,,
,, ,, posticorum	24 ,,

The British Museum has a long series of both sexes from Baram, North Borneo, collected by Mr. C. Hose. The female is well represented by De Haan's figure; but the male from Java, to which he refers it, is evidently distinct. The males of *Phasmidæ* are very different from the females, and can rarely be satisfactorily paired with them without evidence.

DIXIPPUS SODALIS, sp. n.

Male. Long, slender, olive-brown, very finely and closely granulated. Head scarcely longer than broad, with two short horns projecting forward, above and a little in front of the eyes, and with a row of four small tubercles at the hinder extremity above. Antennæ with the scape much thickened, and twice as long as broad; the greater part of the flagellum, except towards the base, is blackish. Front tarsi blackish from beyond the middle of the first joint to the extremity; the first joint is about as long as the three following, which successively diminish in length. Legs slender, with two pairs of large teeth at the extremity of the middle femora beneath, and two very small pairs on the other femora. Abdomen with the terminal segment but slightly expanded. Apical segment cleft to the base, about three times as long as broad.

Dimensions.

Long. corporis	95	millim.
,, capitis	3	,,
,, pronoti	3·5	,,
,, mesonoti	25	,,
,, metanoti, cum segmento mediano	18	,,
,, segmenti mediani	4	,,
,, femorum anticorum	25	,,
,, ,, medianorum	15	,,
,, ,, posticorum	21	,,

Hab. Baram District, Borneo.

Collected by Mr. C. Hose.

Closely resembles the male of *D. sumatranus*, with which it was received, but differs by the short horns, and the different shape of the terminal segments of the abdomen.

DIXIPPUS CORNUTUS, sp. n.

Female. Cylindrical, brown, speckled, and varied with grey; finely and thickly granulated. Head oblong, scarcely narrowed behind, and hardly granulated; face mostly green; two large horns on the vertex between the eyes, bordered with black on the inside; and there is a short black streak between each horn and the eye. Prothorax with cross-shaped grooves, and two more transverse grooves on the front half; behind it a well-marked but slender carina runs down the rest of the body. Mesothorax slightly expanding behind, with lateral carinæ; and towards its extremity two short black carinæ run backward from each side, meeting on the central carina at four-fifths of its length. Median segment one-third as long as the metanotum, the front curving slightly backward on the sides; at about half its length is a slightly marked brown carina, on each side, curving inward to the middle. Segment 7 of abdomen only slightly shorter than 6; segment 8 about two-thirds as long as 7, and as long as 9 and 10 together; 10 rather longer than 9, and widely concave at the extremity above. Legs short and thick, slightly compressed; all the femora lobate-dentate at the extremity beneath on each carina, and the base of the tibiæ furnished with a central lobe beneath, which fits in between the femoral lobes; first joint of the front tarsi strongly lobate above; middle and hind femora with the grey dusting forming a broad band towards the extremity; segment 7 of the abdomen moderately lobate beneath on the lateral carinæ at the extremity; segment 6 only slightly so.

Dimensions.

Long. corporis	115	millim.
„ capitis	6	„
„ pronoti	5	„
„ mesonoti	24	„
„ metanoti, cum segmento mediano	20	„
„ segmenti mediani	5	„
„ femorum anticorum	26	„
„ „ medianorum	18	„
„ „ posticorum	20	„

Hab. Hong Kong.

Not unlike *D. nodosus*, De Haan, but with shorter legs, much longer horns, and the middle femora not lobate above.

DIXIPPUS (?) INSULARIS, sp. n.

Female. Cylindical. Brown, granulated, head with a low transverse crest on the vertex, between the eyes, curving downward and inward at the ends; a row of raised warts, larger than the others, before the extremity of the head. Scape of the antennæ very broad and flattened, broadest in the middle, and about half as long again as broad; down the middle of the body runs a low median carina, except on the prothorax, which is marked with a shallow cross-shaped depression. Front femora beneath with a central ridge, and a pair of outer carinæ, closely approximating, at the sides, the outermost denticulated towards the extremity, and the innermost serrulated throughout its length. The front tibiæ are greatly compressed, and the upper ridge is slightly waved and at the extremity it projects obtusely forward. The first joint of the front tarsi has a flattened foliaceous ridge above, which raises it to the height of the tibiæ; it is nearly as long as the remaining joints together. The four hinder femora are slightly denticulated at the extremity beneath; and their tibiæ are slightly lobate near the base beneath, and are also slightly thickened towards the extremity. The median segment is rather long for true *Dixippus*; and the fifth and sixth segments of the abdomen are somewhat expanded.

Dimensions.

Long. corporis	140	millim.
,, capitis	6	,,
,, pronoti	6	,,
,, mesonoti	32	,,
,, metanoti, cum segmento mediano	20	,,
,, segmenti mediani	8	,,
,, femorum anticorum	33	,,
,, ,, medianorum	22	,,
,, ,, posticorum	27	,,

Hab. Thursday Island.

The type is not in very good condition, but I think it well to describe it, as very few *Phasmidæ* are known from the New Guinea district.

It has considerable resemblance to *D. crawangensis*, De Haan, from Java, but is much stouter.

PHASGANIA EVERETTI, n. g. et sp. (Plate XL. figs. 2, 2 *a*.)

Female. Cylindrical, brown, granulated dorsally and laterally as far as the middle of the mesothorax, with larger lateral tubercles on the sides of the mesothorax. Head unarmed, rather long, rounded and depressed, about as long as the prothorax, the rest of the body with a slight longitudinal carina, except towards the end of the mesothorax, which is much dilated behind, and marked with several slight transverse carinæ, as is also the median segment, and the extremities of the metathorax and of most of the abdominal segments. Prothorax scarcely thickened, and metathorax not at all. Median segment about one-fourth as long as the metathorax. Abdomen with segments 3–6 much thickened, nodose, the 7th as long as the 6th, but only half as broad, even at the extremity, which is broadest; the 8th narrower, and about two-thirds as long as the 7th; the 9th broader than long; the 10th narrower, slightly longer than the 9th; and the 11th forming a spine, longer than the 9th and 10th together, and projecting far beyond the operculum. Legs, especially the two front pairs, much compressed and carinated, but the carinations are only slightly lobate towards the base of the middle tibiæ beneath; the first joint of the front tarsi, however, which is longer than the three following joints, bears a foliaceous expansion, as in *Dixippus*. The middle femora are armed at the extremity beneath with a closely approximating pair of two very strong teeth; the front and hind femora are only armed with one conspicuous tooth and some smaller denticulations.

Dimensions.

Long. corporis	135	millim.
,, capitis	6	,,
,, pronoti	5	,,
,, mesonoti	31	,,
,, metanoti, cum segmento mediano	24	,,
,, segmenti mediani	7	,,
,, femorum anticorum	30	,,
,, ,, medianorum	21	,,
,, ,, posticorum	24	,,

Hab. N.W. Borneo (*Everett*).

This interesting species, which I have named after Mr. A. Everett, who has done such good work in collecting in the East, is allied to *Dixippus,* but its rounded head and the peculiar formation of the abdomen will readily distinguish it. In several respects we find a resemblance to it in the female of (*Lonchodes*) *brevipes*, Gray, which has the metathorax not expanded, but some of the abdominal segments swollen, and the last slightly produced over the operculum. (*L.*) *brevipes*, and perhaps (*L.*) *uniformis*, Westw., may ultimately form a new genus allied to *Phasgania.*

STHENOBÆA TUBERCULATA, sp. n.

Female. Cylindrical, moderately stout, rufo-testaceous; antennæ spotted with black at the joints; head long, slightly attenuated behind, with a transverse crest in front, between the eyes, slightly raised at each angle; front femora obtusely serrated above, and front tibiæ both above and below; first joint of the front tarsi rather longer than the three following, and furnished with a leaf-like expansion; middle and hind femora serrated or rather waved in a similar manner, and with leaf-like expansions on the upper surface of the femora near the base, largest on the middle femora. Several conspicuous black tubercles arranged, not uniformly, but irregularly in rows on the upper surface and sides of the thorax and abdomen, and much more numerously in a row on each side of the median line on the under surface; operculum very broad and concave, as long as the terminal segment.

Dimensions.

Long. corporis	91	millim.
,, capitis	5	,,
,, pronoti	3	,,
,, mesonoti	23	,,
,, metanoti, cum segmento mediano	11	,,
,, segmenti mediani	3	,,
,, femorum anticorum	28	,,
,, ,, medianorum	23	,,
,, ,, posticorum	22	,,

Hab. Rejang River, Sarawak.

Presented by Mr. H. Brooke Low.

A rather isolated species.

BACTRICIA, gen. nov.

Apterous in both sexes: very long and slender; head with two strong spinous processes on the vertex in the male; lamellated processes in the female placed near together; legs pubescent, especially the tarsi; first joint of tarsi as long or longer than all the rest, not appendiculated, but carinated in the female; legs unarmed in male, armed with strong subtriangular spines in female, on the carinæ above and below; median segment one-fifth the length of the metanotum in male, one fourth in female; styles of male large, broad, almost spatulate, and strongly curved, crossing each other; operculum of female very long, longer than the last three segments of the abdomen together; obtusely rounded and slightly expanded at the extremity.

The type is

BACTRICIA TROPHIMUS. (Plate XXXIX. figs. 3, 3 *a*, ♂; figs. 4, 4 *a*, ♀.)

♂. *Bacteria Trophimus,* Westw. Cat. Phasm. p. 30. n. 85. pl. v. fig. 5 (1859).

♀. *Bacteria bituberculata,* Westw. l. c. p. 180. n. 467 (1859); Schaum, Monatsb. Akad. Wiss. Berlin, 1857, p. 423; Peters, Reise nach Mossambique, v. p. 558 (1862).

The female figured is from Natal, but appears to agree with the description given by Westwood of the typical specimen in the Berlin Museum. Unlike as the sexes appear at first sight, they present so many points of resemblance on a close examination, in everything except the form of the horns, and in the appendages of the legs in the female, that I feel justified in placing them together. Besides the typical male, there are two other males very closely resembling it, also from Natal, in which the cephalic horns are reduced to mere tubercles. In the absence of a sufficient series, I content myself with simply recording the fact.

I am not certain of the real affinities of this genus, and place it in the *Lonchodinæ* with some doubt.

There are one or two other East-African species allied to *Bactricia* in the British Museum, but in poor condition and only in single specimens. One of these, from Natal, appears to be referable to *Phibalosoma calametum*, Bates (Trans. Linn. Soc. xxv. p. 341), and differs from *Bactricia* in the sides of the tarsi being raised.

In (*Phasma*) *calcaratum*, De Haan, the median segment is likewise very short.

PROMACHUS SORDIDUS, sp. n. (Plate XL. figs. 4, 4 *a*.)

Female. Dark brown, rugose, with a depressed line on the head and prothorax, and a crossed depression on the latter; the rest of the body strongly carinated on the median line. Femora with three or four rows of small teeth on the carinæ. Head with two strong spines at the back, followed by two in front of the prothorax and two behind; mesonotum with three strong spines on each side, two central ones just behind the level of the middle lateral ones, and two more central ones at the extremity. Metathorax, median segment, and the remaining segments of the abdomen all with a single spine towards the extremity, on the central carina, gradually diminishing in length towards the end of the body. Metathorax with a long spine, preceded by a short one on the sides, and another strong spine lower down, in front of the hind coxæ. Segments 2-6 of the abdomen each with a moderately long spine on the sides. Abdominal spine extending for nearly half its length beyond the operculum.

Dimensions.

Long. corporis	55	millim.
,, capitis	4	,,
,, pronoti	3·5	,,
,, mesonoti	19	,,
,, metanoti, cum segmento mediano	6	,,
,, segmenti mediani	3	,,
,, femorum anticorum	15	,,
,, ,, medianorum	13	,,
,, ,, posticorum	16	,,

Hab. Thursday Island. Collected by the late Rev. R. Toy. Described from two specimens, in one of which, which is slightly smaller than the type, the spines and denticulations are less strongly developed.

Allied to *P. doreyanus*, Bates, but this species has the legs unarmed, except slight denticulations at the ends of the femora beneath; there is only one spine instead of two at the back of the metathorax; the mesothorax is more slender, and the first pair of lateral spines is wanting, besides other differences.

BACUNCULINÆ.

Several genera referred by Brunner de Wattenwyl to his family *Bacteriidæ* would be more naturally placed here, such as *Bacteria*, Serv., and *Phanocles*, Stål, which seem to be nearly allied to *Calynda*, Stål. In the place of Brunner's *Bacteriidæ*, I propose to institute a subfamily *Palophinæ*, to include large species, with winged males.

CAULONIA SPINOSISSIMA, sp. n. (Plate XL. figs. 5, 5 *a*.)

Female. Moderately stout, greenish brown, the sutures of the prothorax and the median carina on the meso- and metathorax marked with a black line, which is expanded on the front of each. Head greenish, short, vertical, face rather long; a black median line, on each side of which are three long spines and a longer and more oblique one outside the second. Antennæ very long and slender. Prothorax bilobate, with two spines on each lobe, the front spines separated by the median depression, but beyond the transverse depression the two spines are central, with a groove running on each side beyond them. Mesothorax with six longitudinal rows of spines, of four each, but not placed under each other; a double central row separated by the median line; a longer row lower down, and a lateral row of short ones. Metathorax similarly armed, but the central and lower spines numbering three each, and the intermediate row of large spines two; there are also two central spines on the median segment, and two in front of the hind coxæ. Second segment of the abdomen (reckoning the median segment as the first) with two spines at the base, two at the extremity, and one on each side below the latter. Third segment with the spines similarly arranged, but larger, and the terminal central ones preceded by two small ones; segments 4, 5, and 6 similarly armed at the extremity only; but the spines, except those at the sides, become gradually smaller, and on 6 the lateral spines are absent. Segment 7 has only two short central terminal spines. The remaining segments are more slender, and unarmed. Operculum large, extending considerably beyond the terminal segment. Legs rather long and slender; front femora with a single row of triangular teeth beneath, placed at about equal distances; the 4th largest; four hinder femora with two rows of larger ones of five each on the under surface. On the underside of the body there is a double row of short median spines.

Dimensions.

Long. corporis	58	millim.
,, capitis	2·5	,,
,, pronoti	3	,,
,, mesonoti	14	,,
,, metanoti, cum segmento mediano	11	,,
,, segmenti mediani	2·5	,,
,, femorum anticorum	20	,,
,, ,, medianorum	13	,,
,, ,, posticorum	20	,,

Hab. Archidona.

This species appears to belong to *Caulonia*, but is much more spiny than any previously described. *C. bifolia*, Stål, probably approaches it most nearly in this respect.

PALOPHINÆ.

This subfamily includes, *inter alia*, a series of interesting African *Phasmidæ*, in which the males are slender, with large wings; and the females are stout, with shorter wings. They have usually foliaceous or large spiny prominences on the legs, and the head is crested, or more or less spined. The terminal segment is broad, slightly concave at the extremity, and extends far beyond the operculum in the female. They are generally classed under the genus *Palophus*, Westwood, but have been divided into several genera. The genera already named are the following. (How far they are truly distinct will best be seen when we receive more specimens of both sexes.)

PALOPHUS, Westw.

Palophus, Westw. Cat. Phasm. p. 90 (1859); Brongniart, Nouv. Ann. Mus. Paris (3) xii. p. 193 (1892).

The types are *P. Haworthii*, Gray (South Africa), and *P. centaurus*, Westw. (West Africa). They have a long double pointed crest on the vertex, between the eyes, and the thorax, though strongly granulated, has no raised spines. The second joint of the front tarsi is lobate as well as the first. I have both sexes of these species before me, but only females of any of the allied forms. These two species are perhaps not congeneric; for in the female of *P. Haworthii* the wings are no longer than broad, while in that of *P. centaurus* they are nearly twice as long as broad, and the mesothorax is much longer and slenderer in proportion than in *P. Haworthii*. But I do not propose to separate these species generically, until more specimens are obtained. I imagine that *Palophus minotaurus*, Gerstaecker, from the Gold Coast, is probably congeneric with *P. centaurus*.

ISCHNOPODA, Grandidier.

Ischnopoda, Grandidier, Rev. Zool. xxi. p. 292 (1869); Lucas, Ann. Soc. Ent. Fr. (4) ix. p. 430 (1870).

The type of this genus is *I. Reyi*, Grandid., from the Zambesi. To the same genus belong *Bactrododema brevitarsis*, Stål, from Damara-land, and a fine new species from Tanganyika, which I describe below. The females vary considerably in comparative length and breadth of wing, but have always at least two strong diverging spines (not symmetrical) about the middle of the mesothorax, and the boss on the tegmina is rather long and pointed. The first joint only of the front tarsi is lobate.

ISCHNOPODA EPISCOPALIS, sp. n.

Female. Grey, varied with darker, a high double laminated crest, obtuse above, between the eyes; head thickly tuberculate, the rest of the body coarsely granulated and striated, the rugæ forming irregular striæ on the pro- and mesothorax; two sharp spines, black at the tip, standing obliquely outwards before the middle of the mesothorax; segments 5 and 6 of the abdomen with a slight crest on each side before the extremity; tegmina grey, rather long, with a high rounded elevation near the base, tipped with blackish; wings with the costal area grey, indistinctly varied with darker, and broadly black at the base; wings long and broad, black, with irregular yellowish hyaline bands, converging, anastomosing, and disappearing beyond the middle of the wing. Legs more or less banded with grey and brown; front femora with three triangular elevations below and one about the middle, above; front tibiæ with two raised crests above, and first joint of front tarsi laminated; the first and fifth joints (without the claws) are of about equal length, and longer than joints 2–4 together. Antennæ a little longer than the front femora. Middle femora with large triangular elevations near the base, one pair below, and a single one, just beyond it, above; before the extremity is a pair of smaller teeth on the carinæ beneath. Middle tibiæ with two crests above; first joint of middle tarsi as long as the three following. Hind femora curved, toothed beneath at the extremity, and very slightly so above; hind tibiæ with from two to four triangular teeth above, and sometimes a small one towards the base below; first joint of hind tarsi rather longer than the three following together.

Dimensions.

Long. corporis	215	millim.
,, capitis	11	,,
,, pronoti	11	,,
,, mesonoti	36	,,
,, tegminum	25	,,
Exp. al.	170	,,
Long. femorum anticorum	53	,,
,, ,, medianorum	39	,,
,, ,, posticorum	46	,,

Hab. Tanganyika.

This fine species is closely allied to *I. Reyi*, Grandidier, as figured by Brongniart, but is rather smaller, and the wings are much larger; it is probably quite distinct. There are two female specimens in the collection of the Museum.

Since the above description was written, another new species of this genus has been received from Somali-land, obtained by Mr. and Mrs. Lort Phillips, after whom I have much pleasure in naming it. Mrs. Phillips rescued it from a tame monkey, which caught it and was about to eat it.

ISCHNOPODA PHILLIPSI, sp. n. (Plate XL. figs. 3, 3 *a*.)

Female. Grey, head strongly tuberculate, and with a high double laminated crest above, between the eyes. Behind the crest a narrow but well-marked groove runs backward nearly to the extremity of the prothorax; the rest of the thorax and the basal segments of the abdomen are marked with a slight median carina. The insect is more or less granulated, most strongly on the head and thorax, and the prothorax is marked with a deep transverse groove just behind the front legs. Mesothorax with two strong spines at two-fifths of its length, opposite to each other and nearly upright; behind the left-hand one is a smaller tubercle. Abdomen with segments 4–7 with slight crests on each side before the extremity, those on the 5th segment largest; tegmina grey, moderately long, with a rather pointed pyramidal elevation near the base; costal area of wings grey, with a black band near the base, and a slight elevation towards the costa before the middle; wings about half as long as broad, black, with yellowish-hyaline spots, running from the costa in irregular rows, fading away beyond the middle, at least on the outer half of the wings, right front femora with three laminations above, the terminal one largest, and another beyond the middle in front; left with only the upper terminal one slightly marked, and the front one reduced to a spine; right front tibiæ with two strong triangular laminæ on the front edge; left with 3 smaller ones, the second double; first joint of tarsi about as long as the remainder, and crested for its whole length; middle femora grey, banded with brown, and with foliaceous elevations towards the base and extremity beneath, and two before the middle, above; tibiæ with two foliaceous crests above, one towards the base, the other beyond the middle; hind femora with a triangular elevation towards the extremity beneath, and tibiæ with three or four above.

The metathorax and median segment are unusually well separated in this species.

Dimensions.

Long. corporis	185	millim.
,, capitis	8	,,
,, pronoti	10	,,
,, mesonoti	30	,,
,, metanoti	9	,,
,, segmenti mediani	17	,,
,, tegminum	23	,,
Exp. al.	114	,,
Long. femorum anticorum	52	,,
,, ,, medianorum	41	,,
,, ,, posticorum	43	,,

Hab. Somali-land.

Closely allied to *I. brevitarsis*, Stål, but in that species the spines on the mesothorax are oblique, and not parallel; the wings are shorter and the vitreous spots less numerous, &c., &c.

BACTRODODEMA, Stål.

Bactrododema, Stål, Œfv. Vet.-Akad. Förh. xv. p. 308 (1858); Bihang Svensk. Akad. ii. (17) p. 14 (1875), iii. (14) p. 12 (1878); Recens. Orth. iii. p. 32 (1875).

The type of this genus is *B. tiarata*, Stål, from Damara-land. The British Museum possesses two females from the Transvaal, which agree with Stål's description, except that he does not mention the spines on the mesothorax, of which there is a large central pair, and, in one specimen, a shorter pair between these and the front of the mesothorax. From *Ischnopoda* the genus differs in its much shorter, broader, and more lacerated cephalic crests, and in the fasciculated crests which terminate several of the middle segments of the abdomen, which, in *Ischnopoda*, have only a single small leaflet on each side.

Cyphocrania æstuans, Westwood, and *Bactrododema miliaris* and *B. Welwitschi*, Bolivar, may be referred provisionally to *Bactrododema*; but here the cephalic crests are still further reduced, almost to spines. On the fifth segment of the abdomen in two specimens of this section before me is a terminal raised crest.

ENETIA SPINOSISSIMA.

Enetia spinosissima, Kirb. Ann. Nat. Hist. (5) viii. p. 151 (1891).

Hab. Madagascar.

This fine insect is evidently allied to *Achrioptera fallax*, Coq. (Ann. Soc. Ent. France, (4) i. p. 495, pl. 9. fig. 1, 1860); but can hardly be the female of that species, or even congeneric. Both genera, however, belong to the *Palophinæ* rather than to the *Acrophyllinæ*, though their short spiny legs, and the long operculum of *Enetia* ally them to the latter subfamily.

ACROPHYLLINÆ.

VASILISSA, gen. nov.

Male slender, winged; female (perhaps immature) with tegmina only; front legs much longer and slenderer than the others; first joint of their tarsi as long or longer than all the rest together; four hinder legs much shorter, of about equal length; the femora and tibiæ armed with short spines; the basal joint of the tarsi as long or longer than the three following joints, which successively diminish in length; styles of the male shorter than the last segment; of the female about two-thirds as long as the last segment, slender, pointed; operculum very long, pointed at the extremity.

This genus appears to be allied to *Diura*, Gray.

Vasilissa Walkeri, sp. n.

Male. Pale ochreous, perhaps green during life, especially the tegmina; antennæ 24-jointed, scape oblong, about twice as long as broad, the second joint annular, the fourth scarcely longer than broad, the third, fifth, and sixth about twice as long as broad, but increasing in length slightly and progressively; the following joints linear, first increasing and then decreasing in length, the sixth terminal ones much shorter, and therefore comparatively thicker than the others; terminal joint pointed. Head and prothorax of about equal length; mesothorax nearly four times as long as the prothorax; four hind femora with three rows of short black spines below, and an incomplete row of from 2 to 6 placed widely apart on the basal half of the middle line above; four hinder tibiæ set with short hair, and furnished with one row of short black spines beneath. Tegmina and costal area of wings probably green in life. Wings rather short, subhyaline, with two round brown spots on each of the cross-nervures.

Female (described from an immature specimen in which the wings are not developed) similar, but much stouter; the spines on the legs are less numerous, especially on the upper surface of the femora, where they are reduced to two. The antennæ are much shorter than in the male, the longest joint being the 11th, and the length of the others rapidly decreasing towards the base and tip. In the female the hinder lobe of the median segment is pointed, and almost as long as the segment itself; in the male it is rather more than half as long, and sends off a ridge which extends to the front of the median segment.

Hab. Queen's Islet, N.W. Australia.

Collected by Mr. J. J. Walker, R.N.

Dimensions.

	♂. millim.	♀. millim.
Long. corporis	85	135
,, capitis	4	7
Lat. ,,	3	4
Long. antennarum	27	19
,, pronoti	3	5
,, mesonoti	14	25
,, metanoti, cum segmento mediano	12	16
,, segmenti mediani	7	9
,, femorum anticorum	25	32
,, ,, medianorum	18	21
,, ,, posticorum	22	22
,, tibiarum anticarum	25	36
,, ,, medianarum	15	20
,, operculi	—	13

XENOMACHES, gen. nov.

Male. Antennæ extending a little beyond the front femora, 24-jointed; scape and 3rd joint about twice as long as broad, 2nd and 4th joints hardly longer than broad, the rest gradually increasing in length to the 15th, the middle joints being long and cylindrical; the 16th is shorter than the 15th, but the 17th is nearly as long; the next five gradually shorten; the 23rd is again longer, and the terminal joint longer still. The head is long, not narrowed behind, convex above. The prothorax, mesothorax, and sides of the metathorax are set with long conical spines; the front femora are armed with a double row of strong spines beneath, the middle femora only with one or two towards the extremity, and the hind femora with a row on the central ridge, but only one or two at the extremity of the lower lateral ridges. Hinder legs rather short and stout; front legs long; first joint of tarsi nearly as long as the remainder; in the other pairs it is much shorter. Pulvilli very large. The mesothorax is nearly three times as long as the prothorax, and slightly widened behind; the median segment is nearly twice as long as the metanotum. The abdomen is cylindrical, the segments are longer than broad, and the middle ones much thickened; it then tapers rapidly to the extremity, and the cerci are very long, slender, and pointed. The tegmina and wings are rudimentary in the specimens before me.

This genus is allied to *Rhaphiderus*, from which its much stouter build, shorter antennæ, and rudimentary organs of flight will easily distinguish it. The types of *Rhaphiderus* inhabit the Mauritius. The new genus *Xenomaches* is founded on the following species from Rodriguez:—

XENOMACHES INCOMMODUS.

Bacillus incommodus, Butler, Ann. Nat. Hist. (4) xvii. p. 410 (1878); Phil. Trans. clxviii. p. 148, pl. liv. figs. 4, 4 *a–c* (1876).

As Dr. Butler has already described and figured this insect, it will not require further notice here.

MEGACRANIA PHELAUS.

Platycrania phelaus, Westwood, Cat. Phasm. p. 113. n. 288, pl. xxvii. fig. 5 (1859).

The original type of this species (a female from Fiji) is in the British Museum. Three more specimens of what appear to be the same species, from the Solomon Islands, have lately been added. They are less discoloured than the type; the head, legs, and thorax are green, and the abdomen light mahogany-brown, with irregular longitudinal yellowish-grey markings, and shading into darker brown towards the ends of the segments. The male differs little from the female, except in being more slender, and in the greater expanse of the wings (nearly 4 inches).

MEGACRANIA BATESII, sp. n.

Platycrania alpheus, var., Bates, Trans. Linn. Soc. Lond. xxv. p. 347 (1865).

The type of *M. alpheus*, Westwood, from Ceylon, has the thorax but slightly granulated, the tegmina nearly round, and the hind wings very short: "tegm. lin. 7½, alar. expans. lin. 26." But in all the specimens from the Malayan and Papuan Islands the thorax is very strongly granulated, the elytra are more oval, and the wings are much larger. All the specimens in the British Museum are females: they are from the Solomon Islands, Aru, and Kei Dulan. The Philippine specimens, one of which is immature and the other has damaged wings, probably belong to this species. Bates mentions specimens from Goram, Gilolo, and New Guinea, and describes a supposed male from Amboina. The dimensions of the tegmina and wings (on the same scale as Prof. Westwood's measurements) are as follows in the Solomon Island specimen, which is a very fine one, measuring upwards of 5 inches in length:—Length of tegmina, 8 lines; expanse of wings, 2 in. 10½ lines.

ARRHIDÆUS STÅLI, sp. n.

Male. Slender. Head black, with a large reddish spot in front of the vertex, extending from before the antennæ (the two basal joints of which are likewise reddish) to one-third of the distance between the eyes and the occiput; this patch is W-shaped behind. Prothorax and metathorax black or deep chocolate-brown, with a broad rufo-testaceous stripe on each side of the upper surface; the space between is dotted with the same colour. Abdomen luteous, brown above, except on the last four segments; the last three, however, have an irregular reddish stripe in the middle line above, and the cerci are red, lined with yellow on the sides. Tegmina and wings blackish, with yellow costa and nervures. Wings reaching nearly to the end of the sixth segment. Coxæ black, lined or spotted with yellow; femora very slightly denticulated before the extremity.

Female rather stout, yellowish green, head with a broad black band on the sides, expanding in front of the eyes, and extending, varied with yellow, over the upper part of the face; coxæ striped with black below, and front coxæ also above; legs pubescent, reddish, spotted with yellow; middle femora towards the base, and hind femora, very finely denticulated; tegmina and wings brown or reddish brown, with the costal area and the nervures brown. Wings short, only just passing the fourth segment of the abdomen; abdomen wide in the middle, and then tapering; the segments of nearly equal length, except the last three, of which the middle one is nearly twice as long as the other two, which are much shorter than the preceding segments of the abdomen.

Dimensions.	♂. millim.	♀. millim.
Long. corporis	60	86
„ capitis	5	10
„ pronoti	3	5
„ mesonoti	10	16
„ femorum anticorum	24	30
„ „ medianorum	12	15
„ „ posticorum	15	20

Hab. Albay, N.E. Luzon (*Whitehead Expedition*).

Seems to be intermediate between *A. palinurus*, Westw., and *A. nigricornis*, Stål. A species which belongs to this genus, but which has not yet been referred to it, is *Phasma rosea*, Stoll.

CTENOMORPHA ALBOPUNCTATUM, sp. n.

Male. Greenish brown, probably green during life; head with 7 fine longitudinal lines behind, 5 ferruginous, and the outermost but one on each side grey. Mesothorax with 6 or 7 sharp black spines, irregularly paired, and one or two smaller ones; front legs much longer than the others, the femora very finely denticulated above and below; four hind femora with three rows of well-marked spines on the lower surface. Tegmina, and costal area of wings greenish grey, finely reticulated with yellow; tegmina with a black spot on the hump, and a very conspicuous round whitish spot towards the inner margin. Costal area of wings with a short black basal streak; the rest subhyaline, with brown spots on the nervures. Cerci short, oval, compressed. Costa of tegmina and wings with an ivory-white stripe.

Dimensions.

	millim.
Long. corporis	83–87
,, tegminum	8–12
Exp. al.	89

Hab. Queensland.

I suspect that *Diura briareus*, Gray, is the female of this species, in which case the name *briareus* must be retained for it.

HETEROPTERYGINÆ.

Brunner calls this subfamily *Cladomorphidæ*, owing to Stål having incorrectly used the name *Cladomorphus*, Gray, in a different sense to Serville.

HETEROPTERYX AUSTRALIS, sp. n.

Male. Dark brown, striped with testaceous on the head, prothorax, and mesothorax before the wings. Head with 12 spines; two rows of four very long spines towards the back; two shorter spines in front of these, nearly in a line with the outer ones; and two very short ones close together in the median line, beyond the level of the three in front. Prothorax bordered all round, the central part divided equally into two, of which the front lobe bears two very long sharp spines, and the hind one only a few tubercles; the lateral borders have three spines, one at the angle in front, another a little within the hind border; there is also a short one on the pleura lower down. Mesothorax with several longitudinal rows of very large spines; the central series consists of a pair in front, a pair in the middle, and a cluster of four between the bases of the tegmina. On the lateral borders of the central ridge is a strong spine in front, and three or four tubercles behind; on the pleura, and on the outer side of the mesopectus, are rows of three large spines on each, besides numerous tubercles. On the central line of the meso- and metapectus is a well-marked carina, attenuated in front, and on the metapectus are four strong spines on each side, besides smaller ones in the middle. The tegmina have a short spine at the base; the base is black, except along the costa; the outer half is testaceous. There is a strong ridge over the black portion; the testaceous portion is partly reticulated with black. On the metapleura is a very strong spine below the middle of the wings, a shorter one more in front, and several strong ones along the lateral ridge. Beyond the wings, which, so far as can be seen, are fusco-hyaline, with reddish nervules, are two strong spines in the middle, on each of the two following segments, besides numerous small ones. The lateral ridges are also thickly spined. The extremity of the abdomen (the last four segments) is much enlarged in the middle. There are four strong spines, gradually diminishing, besides smaller ones on most of the segments of the abdomen; the last four segments being almost destitute of spines or even tubercles both above and below. The coxæ, femora, and tibiæ are strongly spined on nearly all the carinæ and on the fore hinder legs, on the front legs more sparingly. On the hinder ones, numerous small teeth fill up the interspaces between the others, which are often rather wide apart.

The *female* is a dark brown insect, spined nearly as in the male, but larger and more bulky. It differs from that of *H. Dehaanii*, Westw., by its much larger tegmina, the larger and more regular series of spines on the sides of the abdomen, and the much stronger spines on the legs, &c.

Dimensions.

	♂. millim.	♀. millim.
Long. corporis	85	104
„ capitis	7	9
„ pronoti	8	11
„ mesonoti	14	17
„ tegminum	16	22
„ femorum anticorum	21	22
„ „ medianorum	17	23
„ „ posticorum	25	35

Hab. Australia (locality not specified).

PSEUDOPHASMINÆ.

Genus PSEUDOPHASMA.

Phasma, St.-Farg. & Serv. (nec Illiger), Encycl. Méthod., Ent. x. p. 100 (1828).

The type of *Phasma*, Illiger, was fixed by Latreille as *Mantis rossia*, Fabricius, which was subsequently taken as the type of *Bacillus*, St.-Farg. & Serv. They took *Mantis necydaloides*, Linn., as the type of *Phasma*, and have been followed in this by recent authors; but now that the error has been discovered, the apterous genus *Bacillus* (an inconvenient name at best) sinks as a synonym of *Phasma*; and the winged genus *Phasma*, auct., with *necydaloides* as the type, may be called *Pseudophasma*. This will involve a little alteration of the subfamilies, for Brunner's *Bacillidæ* must now be called *Phasminæ*, and his *Phasmidæ* must be called *Pseudophasminæ*.

STRATOCLES BOGOTENSIS, sp. n.

Male. Black. Head black above, antennæ black, pubescent, face and under surface rufous; ocelli yellow. Two yellow lines run from the ocelli, and two more on each side, one behind each eye, and another, broader, below each eye, all slighly converging to the occiput; there is a green spot above each antenna, and a slender green line at the end of the scape. Prothorax and mesothorax with a green stripe on the back, partly bifid in front; the lateral ridge of the prothorax is also marked with a narrow green line. Coxæ yellow, femora testaceous, tibiæ and tarsi black, pubescent; a broad green stripe runs along the pectus from the front to the middle coxæ, and from the latter to the hind coxæ, and is continued more narrowly along the abdomen; under the wings is a narrow yellowish-green line. Tegmina black, lined with green; opaque portion of wing reddish brown, lined with green towards the costa nearly to the extremity; hind wings smoky hyaline, with a broad curved milk-white band across the middle, not extending to the costa or inner margin. Terminal segments slightly expanded; cerci rather long, crossed at the extremity.

Female nearly as in the male, but larger, and with more green lines on the head, including three meeting in front, behind the ocelli, and an additional line on each side, meeting in front of the ocelli. The green lateral stripes on the pectus and abdomen are much less continuous; the upper appendages are black, and about as long as the last segment but one. The hinder half of the abdomen is testaceous beneath, and projects about as far beyond the abdomen as the cerci, like which it is pubescent.

Dimensions.

	♂. millim.	♀. millim.
Long. corporis	36	46
,, capitis	2	3·5
,, pronoti	3·5	3·5
,, mesonoti	2·5	3
,, metanoti, cum segmento mediano	7	7·5
,, segmenti mediani	1·7	3
,, femorum anticorum	13	10
,, ,, medianorum	10	10
,, ,, posticorum	12	12
,, tegminum	4·5	6
Exp. al.	57	76

Not closely allied to any known species.

ASCHIPHASMINÆ.

Genus Presbistus.

Aschipasma, Brunner, Ann. Mus. Genova, xxxiii. p. 100 (1893).

In 1834 Westwood founded a genus *Aschiphasma*, and in 1835 Gray founded a genus *Perlamorphus*. The type of the former is *A. annulipes*, Westwood; and that of Gray, *Perlamorphus hieroglyphicus*, Curt. MS. *P. peleus*, Gray, was added as a second species, but has no claim to be considered the type of *Perlamorphus*; and as *P. hieroglyphicus*, Gray, is considered to be synonymous with *Aschiphasma annulipes*, Westw., Gray's genus and species both fall. But Brunner, who adopts Westwood's later and incorrect spelling *Aschipasma*, divides the genus as follows:—

1. Femora antica carinata et basi curvata . . . . *Aschipasma*, Westw.
1′. Femora antica subteretia, basi non curvata . . . . *Perlamorpha*, Serv.

As *A. annulipes*, Westw., the type of the genus, belongs to *Perlamorpha*, Brunner, which must, as we have seen, take the name of *Aschiphasma*, it is necessary to rename *Aschipasma*, Brunner, which I therefore designate *Presbistus*, and indicate *Perlamorphus peleus*, Gray, as the type.

PHASMINÆ.

Genus Abrachia.

Abrachia, Kirb. Ann. & Mag. Nat. Hist. (6) iii. p. 503 (1889).

On re-examining my *A. brevicornis*, the type of this genus, I find that it possesses triangular clefts at the ends of the tibiæ, which, coupled with the short antennæ, will bring it at least provisionally into this subfamily. The types are from Theresopolis, Brazil. *Bacteria longimana*, Saussure, from Bahia, is certainly congeneric, and is possibly the same species.

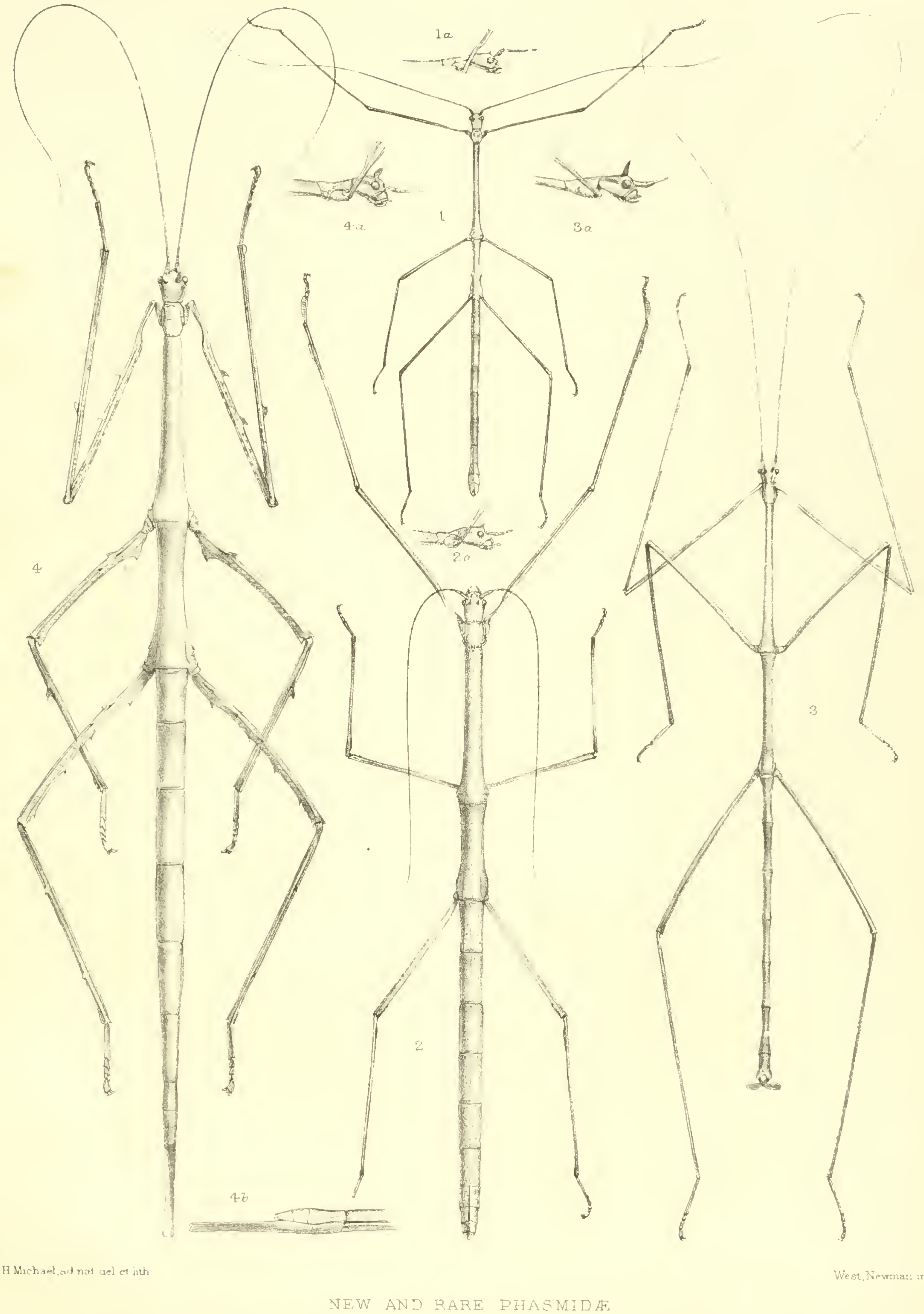
EXPLANATION OF THE PLATES.

Plate XXXIX.

	Page
Fig. 1. *Chondrostethus Woodfordi*, Kirb., ♂. (Head, fig. 1 *a*.)	455
2. Ditto, ♀. (Head, fig. 2 *a*.)	
3. *Bacteria Trophimus*, Westw., ♂. (Head, fig. 3 *a*.)	463
4. Ditto, ♀. (Head, fig. 4 *a*.)	

Plate XL.

Fig. 1. *Hermogenes Hosei*, Kirb., ♀. (Head, fig. 1 *a*.)	457
2. *Phasgonia Everetti*, Kirb., ♀. (Terminal segments, fig. 2 *a*.) . .	461
3. *Ischnopoda Phillipsi*, Kirb., ♀. (Head, fig. 3 *a*.)	467
4. *Promachus sordidus*, Kirb. (Head, fig. 4 *a*.)	463
5. *Caulonia spinosissima*, Kirb. (Terminal segments, fig. 5 *a*.) . .	464



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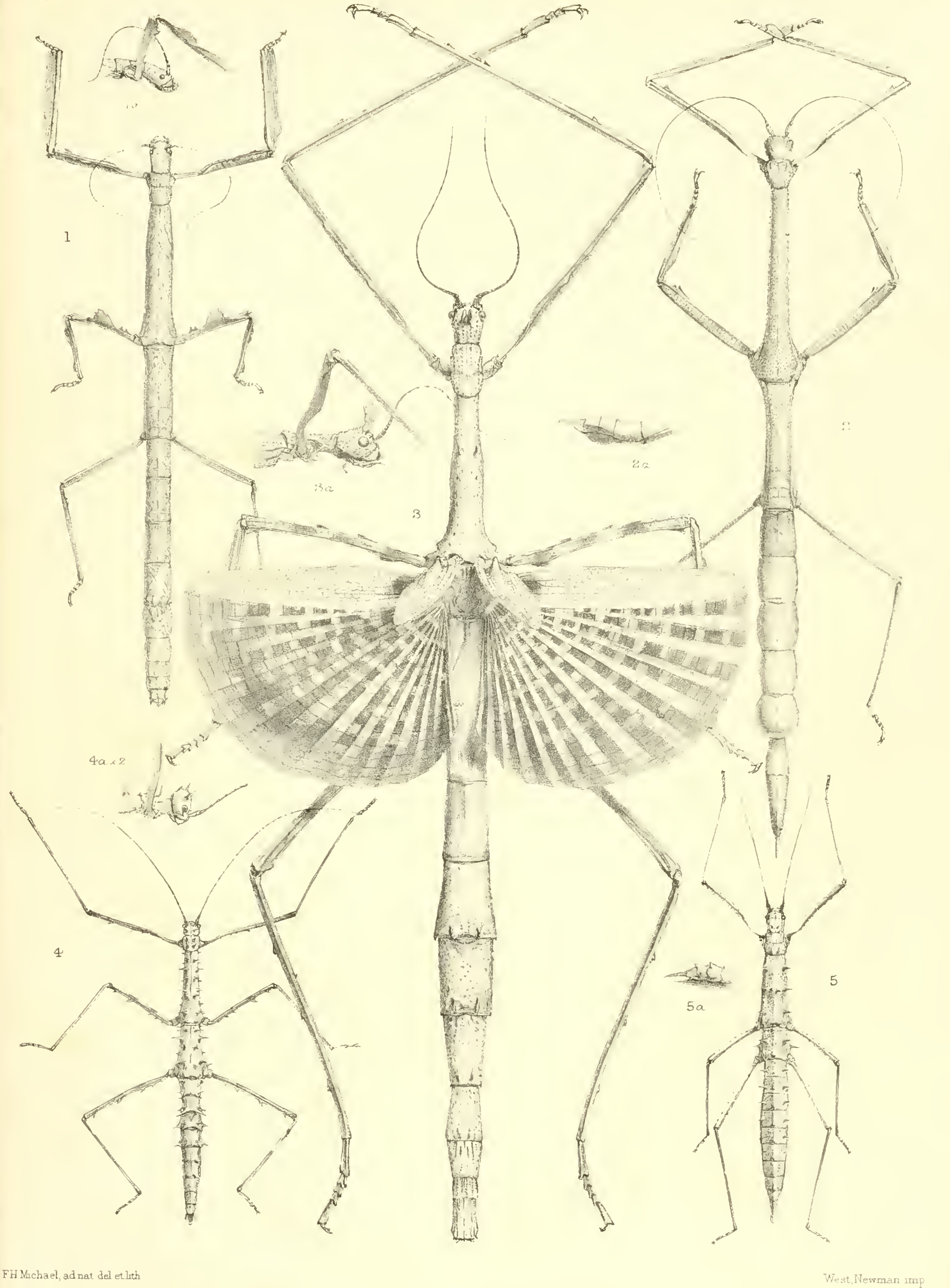

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NEW AND RARE PHASMIDÆ

LINNEAN SOCIETY OF LONDON.

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	Part VI.	1883.	1	0	0	0	15	0
	Part VII.	1883.	0	5	0	0	3	9
	Part VIII.	1883.	0	3	0	0	2	3
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	Part XI.	1884.	0	10	0	0	7	6
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V.	Part I.	1888.	0	12	0	0	9	0
	Part II.	1888.	0	5	0	0	3	9
	Part III.	1889.	1	7	0	1	0	0
	Part IV.	1890.	0	12	0	0	9	0
	Part V.	1890.	0	6	0	0	4	6
	Part VI.	1891.	0	12	0	0	9	0
	Part VII.	1891.	0	6	0	0	4	6
	Part VIII.	1892.	0	8	0	0	6	0
	Part IX.	1892.	0	12	0	0	9	0
	Part X.	1893.	1	8	0	1	1	0
	Part XI.	1894.	0	2	6	0	2	0
VI.	Part I.	1894.	2	0	0	1	10	0
	Part II.	1894.	1	11	0	1	3	3
	Part III.	1894.	0	10	0	0	7	6
	Part IV.	1896.	1	4	0	0	18	0
	Part V.	1896.	0	10	0	0	7	6
	Part VI.	1896.	0	8	0	0	6	0

2nd Ser. ZOOLOGY.] [VOL. VI. PART 7.

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THE INTERNAL ANATOMY OF BDELLA.

BY

ALBERT D. MICHAEL, V.P.L.S., F.Z.S., P.R.M.S.

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VII. *The Internal Anatomy of* Bdella.

By A. D. MICHAEL, *V.P.L.S.*, *F.Z.S.*, *P.R.M.S.*

(Plates **41-43.**)

Read 16th April 1896.

CONTENTS.

Introductory Observations.

The Trophi and Mouth-organs.

The Alimentary Canal and Excretory Organ.

The Salivary Glands.

The Brain and Nervous System.

The Reproductive System.

The Male.

The Female.

INTRODUCTORY OBSERVATIONS.

THIS paper contains the results of work extending over a period of more than three years, and involving the careful dissection of several hundred specimens, besides the preparation and study of numerous serial sections cut in all directions—*i. e.*, sagittal, horizontal, and transverse. The dissections have been made partly on specimens freshly killed, either with boiling water or chloroform; but a large number also have been made on individuals hardened in alcohol and other hardening reagents: this is advantageous for some organs, but usually in Acari I prefer the fresh specimens. The dissections have mostly been stained on the slide with borax-carmine or picro-carmine. The sections have been made from specimens killed with hot water, fixed with picro-sulphuric acid or Flemming's fluid, stained on the slide with hæmatoxylin (Ehrlich's), and mounted in balsam. I may say that Flemming's fluid appears to give somewhat the best results when it penetrates, but that its penetrating power is so inferior to picro-sulphuric acid in the case of Acari that a considerable number of specimens are lost when that reagent is employed. Whereas picro-sulphuric acid can be relied on to penetrate such Acari as *Bdella* with sufficient rapidity it is probably best to use it, although the results will not be quite equal to really good Flemming's fluid-hardened specimens. Other reagents which I have tried have not, I think, produced an equally satisfactory fixing of the histological condition.

The species which I have used has been chiefly *Bdella Basteri* (Johnston, 7 [*]), because, through the kindness of Professor Herdman and the officers of the Biological Station (at Port Erin, Isle of Man) of the Liverpool Marine Biological Committee, I have received supplies of large numbers of this species at frequent intervals and at various seasons; these have enabled me to pursue the enquiry in a manner which I could not otherwise have done; and I beg to tender my best thanks for the assistance. I was anxious to obtain this species because it is, in my judgment, the best suited for research of those that I know, being large (for a *Bdella*)—its total length isa bout 2·5 to 3 mm., and being also very strong and vigorous, with the parts well developed. I have also used *Bdella vulgaris*, *B. capillata* (Kramer), and some others, but could not obtain them in equal numbers or with equal certainty. Wherever in the following paper an organ or structure is mentioned without the species of *Bdella* being named, it belongs to *B. Basteri*.

I have adopted the name of *B. Basteri* for the species because there is no doubt that it is the creature described by Johnston under that title in 1847, while it is quite uncertain whether it is the species referred to by any earlier writer. Thus it has been supposed that *B. Basteri* is the same species which is called *Acarus longicornis* by Linnæus is his 'Fauna Suecica,' but this is very doubtful. I hardly see how the opinion is arrived at. Moreover Andrew Murray[†] considered that Linnæus has described a different species under the same name in the 'Systema Naturæ,' and that this latter is the species to which the name is now generally applied.

Bdella sanguinea, Trouessart, 1894 (21), which that author, following Andrew Murray, places in a subgenus *Molgus* (Dujardin), is, I think, a synonym; indeed, Trouessart himself calls attention to the probability of its being so, but was not able to obtain Johnston's original paper. Trouessart does not describe the hairs on the mandibles, which are important according to Kramer's tables of the genus, therefore I

---

[*] This figure, and all similar figures throughout the paper, refer to the list of authorities quoted (Bibliography) page 523.

[†] 'Economic Entomology: Aptera' (London, 1876), p. 143.

should not like to speak with absolute certainty; but the palpus of his species is similar to that of *B. Basteri* (as I found it), and is not similar to the palpus of any other *Bdella* which I know of.

Bdella marina, Packard [*], is probably also the same species.

Eupalus sanguineus, Trouessart [†], is also a synonym (according to the author himself).

Bdella villosa, Kramer and Neuman [‡], is either the same species or a very closely allied one; but in the figure the fifth joint of the palpus is drawn a trifle shorter than the second, whereas in *B. Basteri* the second is a trifle shorter than the fifth; and the spines at the end of the fifth joint are drawn rather longer than those at the side, whereas in *B. Basteri* they are about equal in length: these, however, are small points, and the probability that the creatures are identical is increased by the fact that Trouessart received some of his specimens of *B. Basteri* (*sanguinea*) from Iceland, and these had the fifth joint of the palpus rather shorter than in the French specimens, so that it seems probable that *B. villosa* is at most a local variety.

I think there is very little doubt that *Bdella arctica*, Thorell, 1871 [§], is the same species, although here again the fifth joint of the palpus is said to be slightly shorter than the second.

Bdella lapidaria, Kramer, 1881 (12. p. 28, Taf. 4. figs. 9, 9 *a*, 9 *b*,), and *Bdella vulgaris*, var. *littoralis*, Moniez, 1890 (15), are both sea-shore species, but they are not identical with *B. Basteri*; Trouessart suggests that they are probably both the same species.

I am also greatly indebted to Mr. M. J. Michael, of the Davos Platz, Switzerland, who has cut the sections which I have used for the present study, and has otherwise assisted me.

The Bdellinæ are usually considered to be a subfamily of the Trombidiidæ; they are a very aberrant subfamily, and are raised into a family by such acarologists as Canestrini (3), Berlese [||], &c., who elevate the old family of the Trombidiidæ into an order under the name of "Prostigmata" (Kramer). Trouessart (20) considers the Prostigmata to be a suborder, separates the Bdellinæ from the Trombidiidæ, but unites them with the Eupodinæ to form a family "Bdellidæ"; his subfamily "Bdellinæ," however, contains the same two genera for which I use the term in this paper, but it also contains one other, *Cryptognathus* (Kramer), which appears to me to be too different to be included. The two genera which I include in the Bdellinæ are *Bdella* (Latreille, 1797) and *Ammonia* (Koch, 1842), distinguished according to Canestrini (2. p. 181), following Kramer's subdivision of the genus *Bdella*, by the long rostrum and long mandibles with very small chelæ of *Bdella*, compared with the shorter rostrum and mandibles and comparatively substantial chelæ of *Ammonia*; but distinguished according to Berlese (1) by the second and third joints of the palpus being more or less fused, and by the presence of a fifth median eye and the absence of hairs between the claws in

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[*] 'The American Naturalist,' 1884, pp. 827, 828, fig. 2.

[†] Comptes Rendus de l'Acad. d. Sci. 1888, t. cvii. pp. 753, 755.

[‡] "Acariden während der Vega-Expedition eingesammelt," Vega-Expeditionens Vetenskapliga Arbeten, Bd. iii. p. 525, Tafl. 41.

[§] "Om Arachnider från Spetsbergen och Beeren-Eiland," Œfversigt K. Vet.-Akad. Förhandlg. 1871, Stockholm, p. 698.

[||] "Acarorum systematis Specimen," Boll. Soc. Entom. Ital. 1885, pp. 121–125.

Ammonia, compared with the five distinct palpal joints, four eyes, and hairy claws pulvilli) of *Bdella*.

The anatomy in this paper is of the genus *Bdella* only; I have not had the opportunity of studying that of *Ammonia*.

The Bdellinæ are sharply distinguished from all other Acari by their antenniform, non-raptorial palpi, ending in hairs.

Karpelles (8), working upon *Bdella arenaria*, Kramer, which is supposed to be identical with *Bdella vulgaris* (Hermann), states that the Bdellinæ are exclusively ("ausschliesslich") vegetable-feeders, and that the remains of mosses are found in their alimentary canal; he also states that certain black matter often found in their canal is earth. I regret to say that I entirely disagree with him; in my opinion all Bdellinæ which I have studied have been predatory, living entirely by sucking the juices of other small creatures, principally Thysanuridæ, which they capture with their mandibles.

Bdella Basteri lives in chinks in the rocks of the sea-coast, and emerges when the tide goes down; often at those times it is abundant upon the decaying seaweed, feeding on the Thysanuridæ which swarm there. Trouessart, in his classification of the Acarina (20), says that the Bdellinæ are "terrestrial Acari feeding upon living prey"; and this eminent acarologist informed me by letter that he found that they lived greatly upon Thysanuridæ, an opinion which he formed quite independently of my own, and without knowing that I took the same view; and he states that Poduridæ are the food of *B. Basteri* (*sanguinea*) in his paper on that species (21. p. 125). It may also be remembered that the name "*Bdella*" is a pure Greek word, signifying a leech, so that it is tolerably evident what Latreille's opinion was. Finally, the trophi, and indeed the alimentary canal also, appear to me to be characteristic of a predatory animal living by suction and not of a vegetable-feeder. Karpelles himself says that the matter passed by the anus (as to which organ see below, p. 490) is liquid, and that he never found excrement balls, which scarcely seems quite consonant with his view that the vascular bundles of plants are found in the canal.

The internal anatomy of *Bdella* may practically be considered an almost, if not wholly, new subject. The external anatomy and the trophi are described by Kramer (11); his descriptions, although not very full, are in my opinion almost always correct, so far as they go: therefore in this paper I have not referred to the external anatomy, except very shortly in one or two instances, where it seemed necessary in order not to break the continuity of study of organs which terminate at the exterior of the creature.

The only paper which I am aware of that touches on the internal anatomy of *Bdella* is that by Karpelles (now Karell) before referred to (8). It is very slight indeed*. In the first place, Karpelles did not find the male, and therefore does not say anything about the male genital organs; but it happens that it is in this set of organs that the greater part of the most striking variations which distinguish the internal anatomy of *Bdella* from that of all other Acari which I know of exist. In the next place, unless *Bdella arenaria* (if really different from *B. vulgaris*) be very different from every *Bdella*

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* The whole nervous system and sense-organs occupy only about 20 lines, the respiratory organs about 4 lines, &c.

which I have examined, I regret to say that I find myself unable to agree with Karpelles as to several of the descriptions which he gives: these divergences of opinion will be found detailed under the headings of the various organs as I come to them; but there is one matter which it is best to deal with here, as no such organ as that described and figured by Karpelles will be found in my description. Karpelles shows an elaborate endoskeleton in the *abdomen*, composed of numerous large and strong chitinous rings and quadrangular frames pressed against or joined to each other, forming a very strong and conspicuous apparatus. I can only say that I have dissected and sectioned and carefully examined several hundred *Bdellæ* of various species and both sexes and of various ages, but I never saw a trace of such an organ, nor have I ever found anything of the kind in any Acarid; but I have frequently seen, both in *Bdella* and other families, in sections of the adult female the exact appearance which Karpelles figures and describes; but in every case within my experience it has arisen in the following manner:—When the eggs are ripe in the body of the female they are often very large, and are in many genera, *Bdella* amongst others, provided with a strongly chitinized chorion: in preparing specimens for section-cutting it is extremely difficult to get the paraffin or other embedding material to penetrate this chorion, it generally will not do so; the chorion, however, although chitinized, is not so extremely brittle as, for instance, the exoskeleton of the Oribatidæ, and the razor cuts it, forming rings and square frames of chitin, which, as the abdomen in females with mature eggs is generally full of them, press against each other and are fixed in the paraffin; but the yolk and other contents of the eggs, not being reached by the paraffin and therefore not being fixed, drop out unless special precautions are taken to prevent it, when the precise appearance of Karpelles' figure arises: but such special precautions can be taken, and if they be the yolk-spherules are found filling the ring; moreover, if the creature is dissected instead of sectioned the eggs are, of course, found whole. I hardly like to suggest that Karpelles may possibly have fallen into this error; but the mistake is really an easy one to make in a case like his: where no male has been found to act as a check it is the more likely to have occurred, so the paper referred to is, as far as I know, Karpelles' first anatomical paper upon the Acarina, and therefore he may not have experienced this difficulty before. If this be not the explanation, I am wholly unable to account for his figure and description of this supposed endoskeleton.

One other publication must be noticed as giving some little information regarding the internal anatomy of *Bdella*. In Berlese's great work on the Italian Acari (1), which is still publishing in fasciculi, the author, when he has finished a group, writes an introduction in which he gives type-plates of the respective families or subfamilies. In his introduction to his order Prostigmata (Trombidiidæ), Professor Berlese gives two drawings of the rostrum and one or two adjoining parts of *Bdella longirostris*; these appear to be drawn chiefly from sections, although it is not so stated; he does not say a word about the internal anatomy in his letterpress, but he provides an explanation of the plates, which gives the names of such internal parts as he draws.

Although the above are all the writings which I know of on the internal anatomy of *Bdella*, yet as the Bdellinæ are part of the great group of Acari which includes the Trombidiidæ, Hydrachnidæ, &c., the various works which have been published on the internal anatomy of other members of that group must also be kept in view; they will be found constantly referred to below, and it will be seen that although *Bdella* differs widely from these types, it resembles them more than it resembles any other Acari. The principal works on the internal anatomy of these allied creatures are those by Croneberg (4, 5), Henkin (6), Pagenstecher (17), Schaub (18), and myself (14).

THE TROPHI AND MOUTH-ORGANS.

(Figs. 1, 2, 4, 29, 30, 31, 32.)

Maxillary Lip and Exoskeleton of Rostrum.—The extremely elongated rostrum of *Bdella* consists of a long, chitinous maxillary lip (fig. 29), very concave upward, *i. e.*, it is a half-tube with its convex side downward; toward its proximal end it swells out greatly, both laterally and below, so as to form a bulb—or perhaps it would be more correct to say a half-bulb, the similar and superposed swelling-out of the mandibles forming the other half-bulb. The edges of this lip, except near the anterior end, curl over inward; the portion so turning inward is flat, forming a partial roof to the rostrum; above the bulbous portion of the lip these two flat pieces, one from each side, fuse, forming a perfect roof to that part of the rostrum (fig. 4); at its posterior edge this roof is strengthened by a curved bar of thicker chitin, which in *Trombidium* Henkin calls the "Chitinbrücke"; and about one-fourth of the distance from the bar towards the anterior end there is a longish spinelying flat upon and articulated near the edge of the roof.

The anterior end of the maxillary lip is truncated abruptly; its edge being almost a semi-circle convex downward, or even with the sides pressed together a little; but the half-moon-shaped space thus left does not remain open to the exterior. Kramer and Karpelles following him draw the anterior edge of the lip as armed with a series of spines, which are a continuation of the edge of the lip itself (see Kramer's fig. 5, *c*; Karpelles' fig. 2), and Kramer suggests from this supposed formation that the lip is a piercing-organ. I do not find the arrangement so simple as this in those species which I have examined: taking *B. Basteri* as an example, I find that inside the edge on each side, partly within the chitinous lip and partly protruding beyond it, is a very fine and extremely transparent membranous flap (fig. 32, *mf*); on the inner side of this flap is a series of strong hairs or fine spines, all curved inward, especially near their tips. Fig. 32 shows the maxillary lip flattened out so as to exhibit these flaps; but when it is in its natural shape the curvature causes the flaps to stand nearly on edge, and they slope slightly inward so as to touch at their anterior edges, and the curved ends of the hairs cross, thus closing the mouth-opening and excluding dust, &c. (fig. 29), when the lingua is not protruded; when it is, it forces these flexible flaps apart. This apparatus is much more correctly drawn by Berlese (1), see his figs. 3, 4 *h*, and 5 *g*; he calls it sometimes "galea," sometimes "lacinia"; it also has considerable resemblance to Henkin's "reusenförmiger Apparat der Mundöffnung" in *Trombidium*.

From near the edge of the chitinous maxillary lip, on its outer (under) side, spring two chitinous apophyses on each side of the lip; from each apophysis a strong, curved, tactile hair (figs. 29, 32, *thl*) springs, which projects beyond the edge of the membranous flap.

Palpi.—To the hind corners of the maxillary lip the well-known "antenniform palpi" of *Bdella* (fig. 4, P) are jointed, not directly to the hard chitin of the lip, but by means of the intervention of some flexible cuticle, which doubtless gives greater freedom of motion to these highly mobile organs. The palpi of *Bdella* differ from the corresponding parts in other Acarina, both in their great length and size, and in the position in which they are carried. The length is almost equal to that of the front legs in most species; and the proportionate length of the joints and the arrangement of the hairs or spines upon them form good and much-utilized specific distinctions. The three proximal joints are usually carried pointing almost perpendicularly upward, while the two terminal joints point almost horizontally forward or a little downward.

The Mandibles (figs. 30 *md* and 31) lie close together upon the roof of the rostrum; they differ from those of all other Acari, except the Ixodidæ and a few isolated species such as *Nicoletiella* (*Labidophorus,* Kramer), in not being enclosed within the chitinous case of the rostrum, but being quite free and resting on the top of it; they are two-jointed chelate organs, the movable joint being placed ventrally, as is usual amongst Acarina. The chelæ are extremely small and fine in most species; and, in such as I have dealt with, simple without teeth. The mandibles are not capable of being retracted into the body, as are those of the Gamasidæ and others; indeed, the bulbous form of their proximal ends would prevent this; but the whole rostrum can to some slight extent be withdrawn into the camerostrum. The inner and lower sides of the mandibles are almost flat; the outer and upper sides curved—in fact one continuous curve forms the two. The shape of the mandibles and distribution of the hairs upon them are relied on for specific distinctions, and indeed the form is considered a generic distinction by some authors.

Between the two mandibles is a thin low partition (fig. 30, *pm*) like a blade on edge; this is the "tasterförmiges Organ" of Karpelles: I do not, however, see any evidence of its being of a palpus-like or tactile nature; I am rather inclined to regard it as a simple partition which separates and guides the mandibles, and prevents their rubbing against each other; it is not attached to the mandibles.

The Epipharynx is an organ of considerable importance and complexity, which appears to have been entirely overlooked by Kramer, Berlese, and Karpelles. It springs from the anterior edge of the propharyngeal plate (figs. 1, 2, *pp*), or, rather, by means of a fold from the membranous sac which encloses the pharyngeal muscles a trifle above the propharyngeal plate; thus it projects into the mouth-cavity and overhangs the opening of the pharynx. It consists in *B. Basteri* of a very elongated, almost triangular piece which ends anteriorly in an extremely fine point; it is about ·25 mm. long, and about ·07 mm. wide at the base. This central triangle is stiff and lancet-like; it is thickest in the median line, where there is a slight tendency to a longitudinal ridge in the posterior part of the organ; to this ridge it slopes up gently from the sides, but the median thickening is not great or conspicuous. The whole of the triangle, except its anterior end, is semiopaque, and is thickly and irregularly dotted with red pigment; the pointed anterior end is of clear hard chitin. The ducts (fig. 2, *dp*) from the pericibal salivary gland discharge on the underside of this triangle close to the hind angles

Along each lateral side of the triangle runs a border of clear, hyaline, flexible membrane, which falls slightly downward, so that the whole organ forms an inverted trough.

From the lowest level of the anterior edge of the propharyngeal plate springs a half moon-shaped membrane (figs. 1, 2, *hm*), which must be regarded as forming part of the epipharynx, although it is lower in level than the triangle; it is thin, transparent, and highly flexible; its upper surface is armed with a large number of spines; the flexibility causes this organ to hang downward, and thus the upper surface becomes the anterior surface, and the spines at its edge, which are about eleven in number, come in front of the opening of the pharynx, and apparently serve to stop all solid particles from entering; such particles may often be seen collected in numbers on the spines.

The Lingua (figs. 2, 4, *li*) is developed in a very special manner in *Bdella*; it springs from near the lower edge of the pharyngeal opening, just as the epipharynx springs from its upper edge. Where it starts from the opening it is a flat tongue with the edges only slightly curled upward; this curling upward very shortly increases, so that the two edges meet and fuse, thus forming a membranous tube, which is the nature of the lingua for the greater part of its length; it is extensile, and can be extruded a considerable distance beyond the mouth-opening (fig. 4), or it can be wholly withdrawn into the mouth by invagination, being drawn inward like the finger of a glove. It is slightly enlarged at the distal end, and is capable of motion and flexion in every direction; it is composed of thick membrane and provided with delicate muscles.

From each side of the lingua, near where it springs from the œsophagus, a fine tendinous "tie" (fig. 2, *tt*) runs upward to the base of the epipharynx, and nearly between these two ties a transverse line of minute tooth-like, but not pointed, projections runs across the base of the lingua; probably the teeth at the edge of the semilunar membrane of the epipharynx meet these projections.

This lingua is the organ through which the juices of the victims are sucked, the pharynx being the pumping-organ; in specimens killed while feeding, or shortly after, the tubular lingua is often found full of the same food-material as that in the pharynx, sucking-stomach, and œsophagus.

Kramer (11) saw and has figured the lingua extended (his fig. 5, *e*); he figures and describes two appendages above its base which he calls "wing-shaped," and supposes to be cuticular, but which I have not ever seen. Karpelles also has figured the lingua (his figs. 2, 4, 7, 8, *œ*), but he calls it the "œsophagus"; it cannot be considered as part of the œsophagus, because it is anterior to the pharynx and is situated in the mouth-cavity, lying, when retracted, within the trough of the maxillary lip.

THE ALIMENTARY CANAL AND EXCRETORY ORGAN.

(Figs. 1, 2, 3, 4, 5, 6, 7, 34, 41, 42, 43.)

In the whole of the "*Trombidium*" group of Acarina, and also in the Gamasidæ and some other families, it is impossible to treat these as separate sets of organs, they are so closely connected as to form one and must be dealt with together.

The mouth-parts have already been described.

The Pharynx is of the usual Acarine type, but exhibits a few special features; it is well, in the first place, shortly to state what that type is. The pharynx is the great sucking-organ in all Acari, and in most of those which live by suction, as practically all predatory Acari do, but especially in the *Trombidium*-group, the pharynx consists of two chitinous half-tubes, like gutter-pipes, concave upward, the upper fitting closely upon and within the lower. The lower is really the continuation of the maxillary lip and forms the floor of the pharynx: the upper is the roof of the pharynx; it is by the movements of this roof that suction is effected. The following is the mechanism: bands of perpendicular muscle arise from the underside of the roof of the rostrum and are inserted on the upperside of the roof of the pharynx, which is raised when they contract: the food rushes into the partial vacuum thus created; the anterior end is closed by a valve which prevents the food returning to the mouth. Between each band of perpendicular muscles there is a transverse muscle, usually round, running straight across the upper tube from one edge to the other; when these muscles contract the edges are drawn together and the central parts of the upper half-tube are driven down upon the lower one, thus forcing the food on into the œsophagus. Even such Acari as can consume solid food, as the Tyroglyphidæ and the Oribatidæ, usually have the pharynx constructed upon some modification of this plan—which, however, is somewhat varied in the case of the Gamasidæ and others, but the modifications are more of detail, in the form of the lumen and the consequent arrangement of the muscles, than of general principle. In most Acari the muscle-bands are numerous, and the "perpendicular" ones or levatores *are almost* perpendicular.

In *Bdella* the first modification of the general arrangement which is observed is that the roof of the pharynx is only slightly chitinized, and is indeed almost membranous; the result of this is that instead of the whole roof rising in response to the action of the perpendicular muscles, each muscle only raises the part into which it is inserted; the muscles apparently contract in succession from before backward: thus an undulatory motion is caused, which swiftly carries the food back to the œsophagus; the anterior perpendicular muscles relaxing, while those posterior to them are contracting, allow the anterior part of the roof of the pharynx to descend upon the floor, forming the valve, which is differently constructed in other allied families.

The next variation from the usual type is that, instead of the numerous bands of small muscles commonly found in the pharynx of Acarina, *Bdella* possesses only a few bands, which are necessarily larger. In *Bdella Basteri* there are six pairs of perpendicular muscles and six transverse muscle-bands, all considerably larger than in most families.

I have preserved the name of perpendicular muscles for the "*levator tecti pharyngis*" or "*distensor pharyngis*" muscles (figs. 2, 3, *mlp*) because the name has been so frequently used in relation to other families; but the next variation from the usual type which has to be noticed is that in *Bdella*, doubtless as the result of the extreme length of the rostrum combined with the small number of pharyngeal muscles, the levator muscles are not really perpendicular: they all arise from the hinder and stronger part of the roof of the rostrum; the posterior pair are an approach to the perpendicular and are short; those that are inserted further forward become successively longer and longer and more and more inclined forward, so that the anterior pair are quite long muscles and almost horizontal. All these muscles are inserted into the roof of the pharynx, either directly or each by means of a single tendon; not by numerous short tendons such as attach the corresponding muscles in *Thyas petrophilus*.

The transverse muscles also vary considerably from the usual type; indeed it is evident that some modification would be rendered necessary by the mere fact of the roof of the pharynx being membranous, and consequently very flexible, instead of chitinous and only slightly so. The result of this would be that if the transverse (or occlusor) muscles only approximated the lateral edges of the roof or upper half-tube, this action would simply crumple it, and would not drive the central part down upon the lower half-tube or floor. This difficulty is obviated by the following arrangement in *Bdella*: the transverse bands are not round in section, but are broad flat bands; each band is arched; the posterior bands are arched upward, while one of the anterior, which is situated where the œsophagus turns sharply downward, is arched forward and seems on edge in the body. Beneath the anterior band there is a thickened plate, or mass, of tendinous material (figs. 1, 2, 5, 34, *pp*) in the roof of the pharynx, which doubtless enables the muscle to force it down more effectually. The plate is just where the pharynx merges into the mouth, and it is hard to say whether it is to be considered as wholly a part of the pharynx or wholly or partly a portion of the mouth; I incline to the former view. I will, in order to distinguish it, call it the "propharyngeal plate." The plate itself is not a mere straight plate of even thickness; it consists of two portions—a central plate of thick tendinous material, and a thinner border. The thick central plate is much narrower than the base of the epipharynx, and is considerably wider posteriorly than anteriorly; its sides have a slightly concave outline when seen from above or below; its thickness varies in different parts, its ventral surface, adjoining the pharynx, being almost straight, while its dorsal surface curves rapidly upward; thus the thickest part of the plate is almost at its posterior end; this end is sharply truncated and has a perpendicular wall. Immediately behind this wall the second transverse band of pharyngeal muscles (constrictors) is placed nearly on edge, instead of having its broad side downward like the other muscles of the same series; like them it is arched but has its concavity forward, thus when it contracts it must force the propharyngeal plate and epipharynx somewhat forward. One fasciculus of distensor (levator) muscles (fig. 5) on each side of the median line is inserted by a very short tendon into the supero-posterior angle of this thick central part of the propharyngeal plate, and another pair on its dorsal surface about a quarter of its length behind the anterior end. The posterior of these tendons may be traced some distance in the substance of the plate. The border is of tissue similar to the central portion. but much thinner; it runs along the sides and rear, but not along the front, where the propharyngeal plate joins the epipharynx; it makes the whole plate form an oblong slightly wider than the epipharynx; the border slopes slightly downward, and the portions of it at the sides of the central plate have a number of diagonal parallel ridges (or folds forming ridges) running backward and outward from the central portion. The transverse muscles are inserted at both ends at the level of the floor of the pharynx; thus, when they contract, instead of pulling the lateral edges of the roof of the pharynx together they straighten losing their arched form, and then press upon the portion of the upper surface of the pharynx lying immediately below them respectively, and thereby effectually close it. I have not hitherto detected similar curved constrictor pharyngis muscles in any of the Acarina.

The Œsophagus follows immediately upon the pharynx, and is, as usual, a long and substantial membranous tube in the median line of the body, running right through the centre of the brain; its course being backward and slightly upward. There is an indication of its being a little plicated into shallow longitudinal folds to allow of expansion and contraction; it hardly stains at all, but certain scattered, very minute nuclei on its exterior surface stain deeply. The folding and certain projections on the inner surface of the œsophagus produce a very irregular lumen (fig. 28) in the greater part of the anterior portion of the organ; although at one point the lumen is circular and extremely minute. Something like this irregular lumen is figured, but not described, by Nalepa in *Tyroglyphus* *.

There is, however, one most important matter in which the œsophagus of *Bdella* is utterly different from the corresponding organ in all other Acarina the anatomy of which is known to me; this is that from the dorsal surface of the œsophagus of *Bdella*, almost immediately behind the pharynx, there springs an immense diverticulum (figs. 3, 4, 34, *rc*); which, where it leaves the œsophagus, is a tube slightly smaller than the œsophagus itself, and is surrounded by an annular constrictor muscle (*mcr*, fig. 34); it, however, almost immediately enlarges to a tube somewhat wider than the œsophagus, and thus continues for a short distance; I call this portion the neck. At the distal end of this neck the organ enlarges, either suddenly or gradually, and forms an immense sac, either elliptical or pyriform; both the sac and the neck are capable of great expansion and contraction, and the size depends greatly upon the amount of their contents for the moment; they are usually considerably larger in the female than in the male. Although, for these reasons, the size cannot be accurately stated, yet it may be more or less gathered from the space which the organ occupies: the dorsal surface of the sac adjoins the ventral surface of the azygous salivary gland; its sides are embraced by the pericibal salivary gland, which also curls over a portion of the dorsal surface which is not covered by the azygous gland; its posterior end presses against the anterior end of the ventriculus, while its ventral surface overlies the œsophagus and the dorsal surface of the supra-œsophageal ganglion of the brain. The organ is simply a membranous sac with stoutish walls. There can, I think, be but little doubt of its function; it is, in my opinion, analogous to the so-called sucking-stomach in such Lepidoptera as *Danais archippus* †, *Sphinx ligustri*, *Pontia brassicæ* ‡, and others, and in the Diptera and some Hymenoptera, such as *Crabro*.

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* "Die Anatomie der Tyroglyphen," Sitzb. k.-k. Akad. Wien, Bd. xc. Abth. 1 (1884), p. 198, and Bd. xcii. (1885), p. 116, Taf. i. fig. 8.

† E. Burgess, "Contributions to the Anatomy of the Milk-weed Butterfly (*Danais archippus*)," Anniv. Mem. Boston Soc. Nat. Hist. 1880.

‡ Newport, in Todd's 'Cyclopædia,' article "Insecta," figs. 430, 431.

This organ has possibly been imperfectly seen by Karpelles (8) and by Professor Berlese; indeed, it is so conspicuous that no one dealing, even in the roughest manner, with the anatomy of *Bdella* could help seeing it. In his great work on the Italian Acarina (1), which is systematic, not anatomical, Berlese does not say a single word about the internal anatomy of *Bdella*, but in the introductory portion of his "Ordo Prostigmata" (Trombidiidæ) he gives a plate of parts of the structure of *Bdella* (chiefly external and the trophi). His fig. 3 is stated to be the rostrum seen from the side, and fig. 4 is stated to be the hypostoma (maxillary lip) seen from below: it is rather a difficult drawing to understand with any certainty, because other organs which lie above the hypostome are shown and there is not anything to indicate that they are seen through the hypostome; thus the pharynx is drawn, and even the muscles on the dorsal side of the pharynx, although both the hypostome and the pharynx itself must lie between them and the eye of the observer. One of the organs figured, a long way posterior to the hypostome, is a sac, which is, I believe, the sucking-stomach; it is lettered "*in*," and in the explanation of the plate "*in*" is given as "ingluvies": this is the whole of the information regarding it. Berlese comes tolerably near the function, but he entirely mistakes its anatomy and position in the body; indeed, his fig. 4 does not agree with his fig. 3: in the latter the œsophagus only is shown, but in the former the œsophagus, which would lie between the eye of the observer and the sucking-stomach, is not shown at all, and the pharynx is shown as leading straight into the "ingluvies," and the hinder portion of the canal as leading directly out of the posterior end of the same organ, thus making it a crop forming part of the main line of the canal itself. This is wholly incorrect, unless the species which he has drawn from differs entirely from every *Bdella* which I have dissected or sectioned, in all of which the sucking-stomach has been a stalked blind-ended diverticulum of the dorsal side of the œsophagus. Karpelles, if he saw the sucking-stomach at all (8), had previously made practically the same mistake; indeed he, if I understand his drawing, did a trifle worse, for he drew the sucking-stomach as not only a part of the main tract of the alimentary canal but also as continuous at its posterior end with the ventriculus, without any constriction between the two.

It is, I believe, now generally admitted that the sucking-stomach, although still called by that name, is not really a sucking-organ, but is a stalked food-reservoir wherein, in the case of *Bdella*, the juices which have been sucked out of the creature's prey by the action of the pharynx, which is the true sucking-apparatus, are stored for a time The sac in *Bdella* is usually full, or partly full, and the contents are precisely the same as those found in the pharynx, œsophagus, and ventriculus—viz., the blood of the prey that the *Bdella* has been sucking. In two or three specimens of *B. Basteri* which were picked off seaweed, where they had been feasting upon Thysanuridæ, and placed immediately in alcohol, a sagittal median section shows this food-mass in the sucking-stomach coagulated and absolutely continuous with a thin rod of the same coagulated material in the mouth, pharynx, and œsophagus, and even joined to the food-mass in the ventriculus. I have hitherto used the name of "sucking-stomach" for the organ, as it so well known in the Insecta; but as it gives an erroneous idea of the function, and as the word ingluvies is more properly used for a crop in the direct line of the canal, I propose the name of "*receptaculum cibi*" for the stalked food-sacs.

The remainder of the œsophagus does not appear to require any special notice; it terminates, as usual, in the ventriculus.

The Ventriculus (fig. 6) is greatly flattened dorso-ventrally, forming a shallow layer near the dorsal surface; it is far best studied in young specimens, as in older ones, where the ventriculus is more distended both by the food in the lumen and by that which has been absorbed by the cells which form the walls of the organ, and where the genital organs are fully developed, the ventriculus is forced into every available space and its true form is difficult to follow: this difficulty, however, does not exist in the younger creatures. Fig. 6 is drawn from a female of *B. Basteri*, mature but only lately emerged from the nymphal skin. It will be seen from this drawing that the ventriculus consists of a short, more or less elliptical sac with a slight median projection forward, and having from its antero-lateral edge two rather short, paired cæcal diverticula directed forward, and from its postero-lateral margin two broad and long paired cæca directed backward. These last-named cæca have the inner edge simple and almost straight; but the outer edge is divided into rounded lobes, which diminish in size from before backward—*i.e.* the anterior lobe is much the largest and the posterior much the smallest. Thus the whole organ forms a sort of irregular, compressed, and elongated horse-shoe.

The histology of the ventriculus is, as might be expected, very similar to that described by Henkin in *Trombidium fuliginosum*; of course there are some differences. The exterior of the organ is a fine tunica propria, so delicate that it is usually impossible to dissect the ventriculus out without breaking it; on the inner side of this tunic is a single row of large columnar epithelial cells with small oval nuclei, about 8μ in diameter, very clearly nucleolated, placed near the exterior ends of the cells. The cells themselves vary greatly in form and size in different parts of the ventriculus, and of course in different individuals; the cells on the dorsal side of the ventriculus usually average longer than those on the ventral side. In an adult well-fed male specimen of *B. Basteri* the cells are ordinarily from about ·04 mm. to about ·12 mm., in the female they are even longer. The exterior portion of the cell is filled with fine reticular protoplasm; the interior part, next the lumen, is generally crowded with food-droplets, precisely similar to the contents of the sucking-stomach; this is even more marked in the female than the male, but in both sexes the inner portions of the cells are usually almost full of them. Digestion appears to be intra-cellular: no food-ball or mass, and indeed very little food, is usually found in the lumen of the viscus, unless the creature has been killed almost when feeding; it is all in the cells. The process described by Henkin, that the inner ends of some of the cells get more or less filled with a granular dark material, and then are constricted off and fall into the lumen of the viscus, occurs also in *Bdella*, but apparently much less frequently and to a much smaller degree than in Henkin's *Acarus*.

Excretory Organ.—We now come to the subject of the hind-gut, but in all the *Trombidium*-group of Acari it is impossible to treat this separately from the excretory organ; the two are either identical or so intimately connected as to render it necessary to describe both together. In my late paper on *Thyas petrophilus* (14), which is frequently referred to in this treatise, I have entered so fully into the history of what former authors have said upon this point that I do not think it would be proper to repeat it all here, and will only give such a short statement of it as is necessary in order that what I have to say about *Bdella* may be easily understood.

Croneberg (4) describes the ventriculus of *Eylais extendens* (Hydrachnidæ) and of *Trombidium* (5) as a viscus closed posteriorly and not connected with any anus; he says that there is not any passage for fæcal matter or solid remains of food out of the ventriculus, and that the anus-like opening, which certainly exists, only gives exit to the excreta of the Malpighian vessels and does not communicate with the alimentary canal. This opinion of the extremely careful Russian anatomist was in direct opposition to the previously expressed opinion of Pagenstecher (17) relative to *Trombidium*; he considered the opening to be the anus, and what Croneberg calls the "Malpighian vessel" to be the rectum and to be in communication with the mid-gut in the ordinary manner. Henkin, in his researches into the anatomy of *Trombidium fuliginosum* (6), failed to find any communication between the ventriculus and hind-gut or Malpighian vessel, whichever it should be called, but he thought that there must be one, although he could not see it; he says that where the Malpighian vessel of Croneberg overlies the ventriculus the walls of the latter organ become vague, and that he should think there must be a communication there, although he could not find it. Next came Schaub: speaking about *Hydrodroma* (Hydrachnidæ) (18), he agrees with Croneberg that the anus-like opening is not an anus, and that it is only the point of discharge of the Malpighian vessel, which does not communicate with the ventriculus or any part of the alimentary canal; but he says that just anterior to the so-called anus there is a much smaller opening, which is the real anus; and he says that to this smaller opening a distinct hind-gut passes from the ventriculus, with which it is in communication. There is no doubt that this smaller opening exists in *Hydrodroma*, and Haller* had seen and figured it before Schaub did. Haller simply calls it a preanal opening, without suggesting its function. No one has seen this smaller opening in any creature of the *Trombidium*-group except *Hydrodroma*, and no one except Schaub has ever recorded seeing this hind-gut distinct from the Malpighian vessel.

A year later Schaub published a paper (19) on *Pontarachna* (Hydrachnidæ): there he only figures a single opening, which he calls the "anus," precisely as previous writers had done in other members of the group; he does not say whether it is the exit of the Malpighian vessel, or of the hind-gut, or of both; nor whether there is a hind-gut distinct from the excretory organs or not. Karpelles (8) ignores all previous authors and treats the excretory organ of *Bdella arenaria* confidently as the rectum, but says that he never could find any food-ball in it.

In *Thyas petrophilus* (Hydrachnidæ) (14) I certainly observed but one opening, and that decidedly communicated with the excretory organ (Malpighian vessel) and

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* "Die Arten und Gattungen der schweizer Hydrachnidenfaune," Mittheil. Schweizer. entom. Gesellsch. 1882, p. 18.

with that only; there clearly was not any separate hind-gut. I was not able to trace any communication between the Malpighian vessel and the ventriculus, although I took great pains in searching for it in numerous specimens, still I do not deny the possibility of its existing at some time of year or at some period of life; all I say is, that I could not find it, and that the walls both of the ventriculus and of the excretory organ appeared to me to be perfectly clear, without any vague places, in those specimens which I examined. *Bdella* would not be at all a favourable genus in which to investigate this question; the walls of the ventriculus and excretory organ are not so firm and substantial as in *Thyas*, and in mature specimens the latter is so enveloped by the former as to make the exact relations of the two difficult to trace. I should not therefore base any opinion on the subject upon *Bdella*; but, so far as it goes, I was not able to trace any communication between the ventriculus and the excretory organ in this creature any more than I could in *Thyas*; still it is possible that such a communication might exist and be extremely difficult to see. It is quite certain that neither any second opening, such as that of *Hydrodroma*, nor any separate hind-gut, such as Schaub describes in that Hydrachnid, exists in any species of *Bdella* which I have investigated: it is equally certain that I have never found any trace of food-material or fæcal matter in the excretory organ of any *Bdella*; the contents have invariably been solely the white crystalline matter (appearing black by transmitted light on account of its opacity) which one usually finds in the so-called Malpighian vessels of Acarina.

In considering the question of whether the mid-gut ends blindly or communicates with a hind-gut and anus, it must not be forgotten that the creatures of this group are almost all strictly predatory and suctorial; they never consume any solid food, but live entirely upon the juices of their victims; this applies to *Bdella*.

Were it not for Schaub's paper on *Hydrodroma* I should consider that the so-called Malpighian vessel in *Bdella* and other allied creatures was the homologue of the hind-gut in other Acari, and from disuse had become a Malpighian organ only; but of course, if *Hydrodroma* really has a hind-gut in addition to a similar Malpighian vessel, it would seem to prove that in all other investigated creatures of the *Trombidium*-group the hind-gut must have become obsolete, and vanished without leaving a trace of its former existence.

In *Bdella* the excretory organ, whether it be the homologue of the hind-gut or not, is exceedingly simple: it is an elongated sac (figs. 34, E & 7), rather widest at the anus, or what is usually called the "anus," narrowest about the middle, and swelling out again somewhat at the anterior end. The organ is distensible, but is neither branched, folded, nor plicated; it is capable of considerable expansion and contraction; it runs along the median line of the body close to the dorsal surface, through the cuticle of which it generally shows as a strong white band; its anterior end is usually about in the perpendicular plane of the coxæ of the second pair of legs, *i. e.*, perpendicularly above the hinder part of the sub-œsophageal portion of the brain; it varies somewhat in length, and it immediately underlies the dorsal skin as far back as the genital aperture, then it turns somewhat downward to reach the anus, which, however, is subterminal. In young males its course may be plainly seen passing between the two great hind cæca of the ventriculus, but separate from them. In mature specimens, especially females, in consequence of the great growth of the ventriculus and cæca and the distension of the cells composing their walls by the absorption of food-material, and partly also in consequence of the pressure of the immense genital organs, the ventirculus and cæca are forced into every available space, and the cæca are pressed against each other in the median line of the dorsum; thus the excretory organ comes to be entirely surrounded by the ventriculus and its cæca, and seems as if it passed through their substance (see figs. 34, 43).

The walls of the Malpighian vessel consist of a strong, clearly marked external layer of more or less hexagonal pavement-epithelium cells, with conspicuous oval nuclei of about 5μ to 10μ, and nucleoli; they are often doubly nucleated; within this epithelium is a layer of almost cubical secreting cells.

The contents of the Malpighian vessel in *Bdella* are small, crystalline, opaque, white, more or less globular concretions of urinary material, similar to that found in the Malpighian organs of other Acari; in *Bdella*, however, they seem, in oldish specimens, to accumulate to such an extent that they adhere together and often form a solid rod almost filling the organ. This white matter usually shows through the dorsal cuticle, and often looks, at first sight, like a white, or pale yellow, stripe running longitudinally in the median line of the notogaster; the rod when formed may sometimes be dissected out and remain quite unbroken and hard. In other specimens the granules do not adhere, but, although scattered, nearly fill the vessels; in some cases, particularly where the specimen is young, the quantity of white matter is small.

The anus (fig. 34, A), if that be its proper name, is a longitudinal slit near the hinder end of the creature, and is closed by two labia (*cf.* fig. 7), to which divaricator muscles (fig. 34, *mda*) are attached.

THE SALIVARY GLANDS (SO-CALLED).

(Figs. 8, 9, 10, 11, 12, 34.)

I retain the expression "salivary glands," because it has been used by so many authors, and is perfectly well understood as referring to the group of glands which I am about to treat of in this section: I have, however, in my paper on *Thyas petrophilus* (14) before referred to, expressed considerable doubts whether this important and varied series of glands really have solely the function which is implied by the name; there does not seem to be any very convincing mode of settling this question, and I hardly see how to carry it further than can be gathered from the probabilities involved in the position of the points where their ducts discharge. In the same paper I have entered fully into what previous authors who have dealt with these glands in Acarina belonging to the *Trombidium*-group of families have said regarding them; as in the case of other organs for which I have done the same, I do not propose to repeat the whole bibliography here, but rather to confine myself to the description of the parts in *Bdella*, referring only to former authors where it seems likely to give greater clearness or to assist in settling doubtful questions.

The general nature of the glands and their arrangement will be found, as might be anticipated, to correspond to a great extent with those of the Trombidiidæ and Hydrachnidæ, but the differences are considerable.

In *Bdella* this system of glands may be said to be divided into three groups; of these there are two groups of paired glands and one single azygons gland. The general arrangement of these glands and ducts will probably be best understood from the drawing (fig. 8); it must, however, be stated that this is a diagram in the sense that (to save space) it is not drawn quite to scale, although kept as near nature as possible. Group 1 consists, on each side of the body, of three glands, which ultimately discharge by one common duct (D), each gland and duct being paired by its fellow on the opposite side of the body. The exact shapes of the respective glands vary a good deal in different individuals, and probably in the same individual at different periods. One of these glands is placed at the posterior end of the main common duct, and is in position a continuation of the duct; this gland is what is known as the "*tubular salivary gland*" (*sgt*) in *Trombidium*, the Hydrachnidæ, and other forms. It is far simpler than the corresponding structure in *Thyas petrophilus*, and in *B. Basteri* consists of a tubular or sausage-shaped gland having a diameter of from about ·03 mm. to about ·06 mm. and a less varying lumen of about ·015 to ·02 mm. It has thick fleshy walls composed of moderate-sized cells with small clear nuclei. The lumen of this gland is extremely small, but perfectly distinct. The point where the duct emerges from the gland is between the first and second legs, usually about halfway or rather nearer the first leg; thence the gland runs almost straight backward near the side of the body; this course is continued for more than half the length of the gland, then it curves sharply inward, and the curve is continued so as to form an approach to a semi-circle; thence the gland runs forward again parallel to its former course, but nearer to the median line of the body; it does not, however, reach anything like as far forward as the proximal end from which the duct starts. Finally, the gland once more turns backward and again runs parallel to its former course, so that the whole gland is more or less S-shaped. The distal end is caecal and rounded; from it and also from the first bend fine ligaments run to the side of the body; that from the first bend, which is the strongest, runs to the cuticle near to the inner edge of the acetabulum of the first leg; this to some extent resembles the arrangement described by Schaub in *Hydrodroma* (18. his p. 123 and fig. 4); the ligaments at and near the distal end of the gland run to the cuticle further back in the body.

In *Bdella Basteri* this gland bears a short caecum (*cæs*). The whole gland in *Bdella* is quite simple, without any of the corrugations found in *Thyas petrophilus* and other forms, and without the terminal bladder or reservoir found in that species.

The Main Common Duct (D) starts from the anterior end of the tubular salivary gland (*sgt*), and runs attached to, and during a large part of its course partly imbedded in, the cuticle of the side of the body. Although so united to the cuticle and so sunk in it, the duct does not really form part of it; on the contrary, the greater part of the duct may occasionally, by careful dissection, be detached from the skin. The duct is substantial in the thickness of its wall, and usually preserves its round form in sections—*i. e.*, it does not collapse: it generally shows more or less of a ringed structure; often it is very plainly ringed: this feature is frequently found in the principal ducts of the Acarina, in which order a ringed tube is more likely to be a duct than a trachea.

The course of the main common duct is as follows: starting from the tubular gland it runs forward a little, and then curves round the outer side of the acetabulum of the first leg; it then runs forward along the shoulder of the creature, usually in a somewhat undulating line, but on the whole tending slightly inward, until it enters the rostrum and approaches very near to the palpus; it then turns suddenly inward toward the median line, and runs across the upper surface of the chitinous roof upon which the mandibles rest, passing beneath the proximal ends of the mandibles; on reaching nearly to the median line the duct turns slightly forward, joins its fellow from the other side of the body, and the two together discharge into a membranous space upon the chitinous roof and between the mandibles near their proximal ends.

The Reniform Gland.—A short distance anterior to the acetabulum of the first leg the common duct receives the special duct (fig. 9, *dr*) from a very large gland (figs. 8, *sgr*); this duct is small and fine, does not show any ringed structure, and enters the upper surface of the common duct. The gland which discharges by this small duct is one of the largest in the creature; it is clearly the homologue of the "reniform salivary gland" in *Thyas petrophilus*, and of Schaub's "larger dorsal mouth-gland" in *Hydrodroma*. Pagenstecher, in *Trombidium*, and Gudden[*], in *Tyroglyphus*, have also figured homologous glands, but without specially naming them. I have retained the name "reniform gland," but the gland in *Bdella* (fig. 9) is somewhat different in form from any of those hitherto described: it cannot be called reniform; it varies somewhat in shape, but is usually irregular, approaching an oval, and is flattened, its thickness not averaging above a third of its breadth; it is placed on edge in the body, which is not the case with any of the other recorded homologous glands, and has the more pointed end forward; its inner surface is nearly flat, but the outer surface is more convex; probably adapting itself somewhat to the form of the side of the body. This gland stains only slightly with hæmatoxylin or carmine: it is composed of extremely large, almost gigantic, cells radiating from a centre; these cells have an extreme length varying from about ·15 mm. to over ·2 mm., and an extreme width of about half those measurements, and have large, clear, elliptical nuclei of about ·03 mm., somewhat regularly arranged, with very distinct nucleoli of about ·015 mm. This gland always contains a chamber more or less wedge-shaped (*cu*) on its outer edge; this chamber is apparently one of the cells broken down and transformed, for it often contains a nucleus, but it is usually filled with dark-coloured and highly-refractive granules, measuring from $4\,\mu$ to $7\,\mu$; it communicates with a small central pocket, from which the duct starts. Sometimes this wedge-shaped chamber appears to invade and absorb the adjoining cells, and then becomes very large.

The anterior Salivary Gland.—Just before entering the rostrum the upper surface of the common duct receives another special duct (fig. 8), which is much shorter and still finer than that from the "reniform gland": the gland (*sga*) from which this duct leads will be the homologue of the "quadrate salivary gland" in *Thyas petrophilus*, and of

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[*] "Beitrag zur Lehre von der Scabies," Würzburger medicinische Zeitsch. 1861, p. 301; and "Zweite vermehrte Auflage," Würzburg, 1863.

Schaub's "smaller dorsal mouth-gland" in *Hydrodroma*, if the place where the duct discharges, and the connection of that duct be, as usual, taken as determining the homologies; but as it may be possible that this gland is more to be regarded as the homologue of the small gland which discharges by the duct "*du*" in *Thyas petrophilus* (fig. 16 in my paper, 14), I have thought it best not to use the name "quadrate salivary gland" for the gland in question: for the sake of clearness I shall call it the "anterior salivary gland" in this paper. It is a rather small, rounded, or heart-shaped gland lying in the anterior corner of the dorsal vertex, and its posterior side is closely pressed against the front end of the reniform gland when the two are *in situ*; so that it is very difficult to distinguish this gland from the reniform in sections, and, indeed, it can only be done by the thin *tunica propria* which envelops the gland, and by the fact that the anterior salivary gland stains more deeply than the reniform, and has a slightly different histological structure. Its secretion is a mass of dark-coloured granules.

The Pericibal Salivary Glands.—The two other paired salivary glands (figs. 10 and 34 *sgp*) lie one on each side of the receptaculum cibi (sucking-stomach), and clasp that organ; they are apparently the "preventricular glands" of Karpelles (8). These glands, which I will call the pericibal salivary glands *, bear considerable resemblance in general form and appearance to the reniform gland, against which their outer sides are closely pressed; like it they stand on edge in the body, and are a flattened oval or almost elliptic; the outer sides adapt themselves to the form of the inner sides of the reniform gland, while their inner sides adapt themselves to the receptaculum cibi (sucking-stomach); they embrace practically almost the whole sides of that organ except the narrow neck, and by an increase in their thickness they curl over the top of its posterior portion. They are composed of large cells radiating from a centre and provided with large and distinct roundish nuclei and nucleoli; the cells, however, are not so large as those of the reniform gland. The contents of these cells stain deeply with hæmatoxylin, and then present more the appearance of a network, and less of granulation than those of the reniform gland. In the centre of the gland, where the apices of the cells come together, there is a very minute open space from which the duct starts. There is a small valve at the commencement of the duct of this, and indeed of each of the paired glands except the tubular, formed by the thickening of the walls of the duct, so as to constitute two labia pressed against each other. The duct itself is long and fine; in well-preserved specimens it exhibits a slightly ringed structure of its inner coat; it passes along the side of the receptaculum cibi (sucking-stomach) in an almost straight line, goes just below the chitinous bridge and chitinous roof, and discharges by a small opening just at the proximal corner of the epipharynx (fig. 2, *dp*). From the position of the mouth of the duct it would appear probable that this gland is a true salivary gland; whether those that discharge by the common duct into the space between the mandibles and above the chitinous bridge have the same function must be more doubtful; it would seem possible that they lubricate the mandibles, but glands of such importance would scarcely be wanted for that purpose only.

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* I do not use Karpelles's name of "preventricular glands," because they are not homologous with the glands which bear that name in the Oribatidæ.

Whether the pericibal gland of *Bdella* can be considered as the homologue of any particular gland in *Thyas, Trombidium*, and *Hydrodroma*, seems to me to be uncertain: the fact that each pericibal gland of *Bdella* discharges by its own special duct into a place different from the point of discharge of the common duct, whereas all those of *Thyas* and *Trombidium* discharge by the common duct, is greatly against such homology; but, on the other hand, the number of glands is the same in all: if there be any homology it would be between the pericibal gland of *Bdella*, the quadrate salivary gland of *Thyas*, and the smaller dorsal mouth-gland of *Hydrodroma*; but this can only be the case if the anterior salivary gland of *Bdella* be the homologue of the small gland to which the duct "*dsa*" leads in *Thyas*.

The Azygous Salivary Gland.—The last of the so-called salivary glands to be described is the azygous (figs. 10 and 34, *sa*, and 12). Whether this gland can be considered to be the homologue of the "azygous salivary gland" in *Thyas petrophilus*, the only species in which an azygous salivary gland has been described, is again a question which admits of differences of opinion: the mere fact that such a gland exists in each would raise a presumption that they were homologous; but not only has the gland in *Bdella* an importance immensely in excess of that of the gland in *Thyas*, but the gland of *Thyas* is situated in the rostrum, whereas that of *Bdella* is in the cephalothorax behind the rostrum; that in *Thyas* is about the middle (dorso-ventrally) of the rostrum, whereas the gland in *Bdella* is pressed against the extreme dorsal surface of the cephalothorax. The duct in *Thyas* discharges much further forward than that of *Bdella*; and, finally, the histology is about as different as that of two glands can well be; the gland in *Thyas* having a minute structure very like that of the tubular salivary glands of *Bdella*, while the gland in *Bdella* is a solid, but not fleshy, organ, with a very small irregular lumen, or sometimes without any distinct lumen, from the fact that its sides may become pressed together, and composed of largish columnar cells, which have the ends which come to the exterior of the organ slightly enlarged; in these enlarged ends are situated the small nuclei, with very distinct and dark-staining, but small, nucleoli (fig. 34). The cell-contents hardly take stain at all; the cell-walls * do not stain, but yet are very easily seen. In *Bdella Basteri* the cells have an average length of about ·04 to ·05 mm., but some near the posterior end are longer, by an average breadth of about 10 μ to 12 μ. The nuclei have an average diameter of about 5 μ, and the nucleoli of under 2 μ. For the same species the cell-contents have the appearance of a very fine network; whereas in some of the smaller *Bdellæ*, e. g., *B. vulgaris*, the gland is even more solid and has the appearance of having an almost tendinous consistency (fig. 12).

The azygous gland is a very large one; in *B. Basteri* it has an average length of about ·4 mm. in the male, and of about ·5 mm. in the female, with a breadth of about ·17 mm., and a thickness of about ·15 mm. to ·19 mm. in its thickest part. In some of the smaller species it is even larger in proportion. In *B. Basteri* the exterior of the gland, when

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* The expression "cell-wall" in this paper is not employed in the restricted sense in which it is used by many modern writers on vegetable histology, viz. as meaning formed (secreted) material only; it is used, for want of any other equivalent expression known to me, in a general sense to signify the partition between cell and cell irrespective of how that partition originates or of what it is composed.

dissected out, is naturally deep red, which makes it conspicuous. The form of the organ varies considerably in different species, and even varies in different specimens of the same species; but such variations in the one species only involve differences in the proportion of length to breadth, and of the comparative lengths of the anterior and posterior points, and such matters; the general plan of the form is always similar in the same species, so far as I have seen.

The shape, being rather complicated, will be much better understood from the drawings than from descriptions. In *Bdella Basteri* the ventral surface of the organ, which is pressed against the dorsal surface of the receptaculum cibi, is almost flat, but cut away from the ventral surface at the anterior end, *i.e.* the dorsal part of the anterior end overhangs; the posterior end bends slightly downward; both anterior and posterior ends are broad pointed projections, with convex sides; behind the anterior projection the gland widens suddenly, and forms a kind of shelf or platform near, but not at, the ventral surface of the gland; upon this platform, commencing a little way behind its anterior edge, are two large rolls of substance arranged longitudinally, and with their inner sides so closely pressed together that they often practically fuse in the adults; but in the nymphs they are distinct, and give the gland the appearance of having had a double origin, or at all events that this part of it has been a horseshoe-shaped structure, which has become pressed together; this horseshoe shape is very apparent in horizontal sections of the gland, even in the adults. These rolls continue for about half the length of the organ; then rolls and platform, and the rest of the organ, gradually merge and lose their identity, all contributing to form the posterior portion. The duct from this gland is short and straight, but is rather large in diameter and somewhat wrinkled longitudinally, and is evidently capable of expansion; it springs from the median line of the gland between the anterior ends of the two rolls spoken of above; in sections it may be traced some way into the substance of the gland. The anterior end of the duct is enlarged, and forms an ovate membranous chamber (fig. 11), which is generally more or less filled with the secretion of the gland. This chamber commences behind the mandibles, but reaches a little between their proximal ends; there this gland-serving chamber discharges into a space continuous with the air-chamber from which the principal tracheal trunks spring. The secretion found in the glandular chamber is a yellow oily liquid, and in specimens which have been in alcohol a yellow fibrous or crystalline ball may frequently be found in the chamber.

THE BRAIN AND NERVOUS SYSTEM.

(Figs. 13, 14, 15, 27, 34.)

The so-called brain—*i.e.*, the great central nervous mass—in the Arachidna doubtless represents an œsophageal collar, consisting of a supra-œsophageal ganglion and a sub-œsophageal ganglion joined together by commissures. In the Acarina, however, the concentration of the ganglia is so extreme, and the commissures are so short and broad, that the distinction of parts is usually almost or entirely lost. Thus, for instance, in the Hydrachnidæ the brain has usually become one elliptical or almost globular organ, pierced by the passage for the œsophagus, but in which it is very hard to distinguish any parts; there is not any sign of commissures, and the fusion between the supra- and sub-œsophageal ganglia is so intimate that it is impossible to say where one terminates and the other commences. This will be well seen in Schaub's figures and descriptions of the brain of *Hydrodroma* *, and in my own figures and descriptions of *Thyas petrophilus* †.

It will be seen by Henkin's figure of a section of the brain of *Trombidium fuliginosum* ‡ that the form there is not so globular, notwithstanding the close connection between *Trombidium* and the Hydrachnidæ; it will also be seen, by my paper on the brain in Oribatidæ and other forms §, that the spherical form is not usually approached so closely in other families of Acarina as it is in the Hydrachnidæ; still the whole usually forms one mass, which may be irregular in shape, but in which all sharp demarcation of parts is lost. *Bdella* can hardly be said to form any exception to this rule; it would scarcely be possible to say where the commissures are; the supra- and sub-œsophageal ganglia practically join one another; still the origin from the two separate ganglia is far more clearly shown, and the two are more distinct, than in any other Acarid with which I am acquainted. Taking *Bdella Basteri* (which is an exceedingly good example) as a type, the sub-œsophageal ganglion (fig. 13, 34, *gsu*) consists of an almost oblong layer of ganglionic matter having an average length (in the male) of about ·4 or ·42 mm., by an average breadth of about ·17 mm. It is much flattened dorso-ventrally, the thickness not being above ·08 mm. where it meets the supra-œsophageal ganglion, diminishing almost to an edge at its posterior end; it lies almost touching the ventral surface, and extends from a little in front of the first pair of legs anteriorly to about midway between the second and third pairs of legs posteriorly.

The supra-œsophageal ganglion (*gso*) is about $\frac{4}{9}$ of the length of the sub-œsophageal; it is situated upon (above), and slightly in advance of, the sub-œsophageal, so that the anterior edge of the former overlaps the anterior edge of the latter. The œsophagus runs between the two; both, but chiefly the supra-œsophageal ganglion, are excavated to afford it a passage; the sub-œsophageal is thickest, dorso-ventrally, just where it meets the posterior edge of the supra-œsophageal, and then thins away toward its own anterior edge, and the under surface of the supra-œsophageal follows and joins it. The œsophagus does not run in a horizontal line through the brain, but in a diagonal, sloping upward and backward; it enters the anterior edge of the brain at its ventral surface and sloping strongly upward emerges at the posterior edge of the supra-œsophageal and lies upon (above) the part of the sub-œsophageal which lies posterior to the supra-œsophageal, *i. e.* about two-thirds of the length of the former.

Looking at the whole brain in a general view, the supra-œsophageal ganglion appears quite sharply divided from the sub-œsophageal and perched on top of it; it is only when one attempts to separate the two, or cuts sections, that the fusion of their peripheral parts is appreciated. What may be called the ground-plan of the supra-œsophageal ganglion, as seen from above, is almost a square, with the corners somewhat rounded, and a projection near the middle of each lateral edge, from which projection the palpal nerve arises.

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* 18; his Taf. v. figs. 2, 3. † 14. figs. 20, 23, and p. 199. ‡ 6; his Taf. xxxiv. fig. 7.

§ "On the Form and Proportions of the Brain in the Oribatidæ and in some other Acarina," Journ. R. Micr. Soc. 1895, pp. 274–282.

Viewed from the side, or in sagittal section, the supra-œsophageal ganglion is almost triangular; this form is caused by its being thin at its anterior edge, and thick, dorso-ventrally, at its posterior, its upper surface sloping rapidly upward from before backward, and then falling, almost perpendicularly, to the sub-œsophageal; the upper surface is somewhat concave, and faces upward and forward; the posterior edge forms a wall standing almost, but not quite, upright upon the sub-œsophageal; round this wall great bundles of tracheæ are wrapped, as hereafter described in the section on the respiratory organs (*infra*, p. 518).

The neurolemma is very fine and delicate, and difficult to see, extremely different from the substantial neurolemma of the Hydrachnidæ. The layer of cortical dark-staining cells, which is so conspicuous in many of the Acarina, is but feebly developed in *Bdella*, and is entirely absent from those parts of the sub-œsophageal from which the six pairs of large nerves, which arise from that ganglion, start.

With regard to the *Nerves* I have, in the above-named paper upon *Thyas petrophilus* (14), stated fully what previous writers have said respecting the nerves of such species of the Trombidiidæ and allied faimlies as have been studied from the point of view of their internal anatomy; I do not therefore intend, in this paper, to refer more to the bibliography of the subject than is necessary for the proper understanding of any doubtful or disputed points, the settlement of which may be facilitated by what I have been able to ascertain in the present investigation: in other cases I shall confine myself to stating what I find in *Bdella*.

The ample supply of specimens of *Bdella Basteri* which I have received has enabled me to devote a large number to tracing the nerves only, sacrificing all other organs: this has been done partly by dissection and partly by sections; but, on the whole, I have found the former method rather the more efficient on account of the extreme difficulty of obtaining any stain which will differentiate the nerves in the Acarina from the surrounding tissues—with me gold chloride, in whatever way employed, has entirely failed to do so. In no case has a single dissection or section been relied on for a nerve or branch of one; I have not put anything into fig. 13 until I have seen it in several cases: I think, therefore, that all the detail which I am able to give may be relied on; I have been able to trace a fair number of the finer branches, but I have little doubt that plenty of others exist which I have not seen. The creatures are so small, and the nerves so extremely fine and difficult to trace, that it can only be by slow degrees, and a certain amount of good luck, that anything like completeness can be obtained in their study.

As might be anticipated, I find that the nerves agree fairly well with what I found in *Thyas petrophilus*, without more difference than would be looked for between two families which are very distinct, although allied, and differ so much in the anatomy of other organs.

I have been able to trace in *Bdella Basteri* one median nerve and ten pairs of bilaterally symmetrical nerves; of these the median nerve and three pairs of the paired nerves arise from the supra-œsophageal ganglion, and seven pairs of paired nerves from the sub-œsophageal; those arising from the supra-œsophageal are all small, those from the sub-œsophageal mostly large nerves.

The median nerve (fig. 13, *nph*) is the pharyngeal nerve; this, as in all other Acarina in which it has been traced, is a thin nerve which arises in the centre of the anterior edge of the supra-œsophageal ganglion immediately above the œsophagus, and follows straight along, or rather parallel to and just above, that organ to its distal end: there it breaks up into a number of fine twigs, some of considerable length; one of these twigs is sent to each muscle of the sucking-pharynx. In *Bdella*, however, a complication of this pharyngeal nerve exists which has not been recorded, and probably does not exist, in any Acarid the anatomy of which has been studied; I believe it to be entirely novel: it is that the pharyngeal nerve, a short distance from the brain, splits into two main branches, an upper and an under—the under goes on, as before described, to supply the pharyngeal muscles, and in fact represents the whole nerve in other families: the upper branch (*nc*) runs between the œsophagus and the receptaculum cibi, and terminates just where the two join; it innervates the ring of sphincter muscle which surrounds the neck of the receptaculum cibi (sucking-stomach), and possibly sends twigs to other portions of the sucking-stomach; but I was not able to make certain of this. In fig. 13 this upper branch of the pharyngeal nerve is shown turned a little to the right; if it were left in its natural position, it would entirely hide the lower branch and there would not be anything to show that two existed.

Of the paired nerves from the supra-œsophageal ganglion those situated a trifle the nearest to the median line are a pair of very delicate nerves (*nv*) which innervate the dorso-ventral muscles near the base of the rostrum; in reality this pair of nerves, the mandibular nerves, and the palpal nerves lie almost in a perpendicular line one below the other, the palpal being lowest, the pair now treated of next, and the mandibular nerves highest; in the drawing the mandibular has been bent a trifle to the left, and the present pair a trifle to the right in order to show them; the present pair is, however, a very little nearer to the median line than the mandibular. Notwithstanding this I think the mandibular must really be regarded as the first, and the present as the second pair, which is the same as in *Thyas*. At a distance from the brain rather less than half the length of the brain itself this nerve (*nv*) branches dichotomously. I was not able to trace its further branching.

The next pair of nerves from the supra-œsophageal ganglion are the mandibular (*nm*); these are situated considerably further towards the lateral edge of the ganglion than they are in *Thyas*; and the reason for this is not difficult to understand. In *Thyas* the mandibles are much compressed laterally and lie together close to the median line; in *Bdella* the proximal ends of the mandibles are swollen into large bulbs, the two of which together are as wide as the rostrum. About as far from the brain as two-thirds of the length of the brain itself there arises from the mandibular nerve a branch-like structure, which will be best understood from the drawings (figs. 13, 14). The nerve gives off what may be called a branch, or may be considered a ganglion; I am inclined to look upon it in the former light: it is a thin sheet of nervous tissue, rather thicker at the edges, and resembles in form a flattened hour-glass, with the corners drawn out into points and the waist not so thin as in that instrument. From each of the two distal corners of this expansion proceeds a very thin nerve-branch; these two are, I think, distributed to some of the mandibular muscles, but I was not able to ascertain precisely which: the main trunk of the nerve proceeds into the mandible in the usual manner.

The third and last pair of nerves which I could trace from the supra-œsophageal ganglion are the optic nerves (*no*); these arise from small eminences about the middle of the respective lateral edges of the ganglion; they are the stoutest pair of nerves which arise from the ganglion, but are not proportionately as thick as they are in *Thyas*, *Trombidium*, *Hydrodroma*, and other forms. I was able to trace one fine branch (*no* 1) about as far from the brain as two-thirds of the length of the brain itself, which branch ends in a very small ganglion. The principal trunk of the nerve proceeds to the hinder and outer of the two eyes (on each side), and there on its outer side expands into a sort of retinal disc (*rd*) (figs. 13, 27), which is almost sessile upon the nerve; the principal trunk then inclines more forward and less outward, and terminates in an almost similar disc for the other eye on that side of the body. These retinal discs, although rather more flattened, are practically the same as those described by Henkin (6) in *Trombidium fuliginosum* (his fig. 11, *vn*).

I was not able to trace any homologues of the thin pair of nerves from the posterior part of the supra-œsophageal ganglion which I found in *Thyas*, still it may be possible that they exist; they were exceedingly fine in *Thyas*.

The nerves arising from the sub-œsophageal ganglion are six pairs of thick and one pair of thin nerves. The courses of the six thick pairs may be most distinctly traced in the ganglion itself, running almost to its centre; they are even conspicuous.

The first pair of thick nerves are the palpal nerves. Croneberg, speaking of *Eylais extendens* (4), considered that the palpi were innervated from the sub-œsophageal ganglion. Nalepa (16), speaking of *Trichodactylus anonymus* (Tyroglyphidæ), considered that the maxillæ were served by the sub-, and the maxillary palpi by the supra-œsophageal ganglion. Schaub (18) (speaking of *Hydrodroma*) stated that the palpi were innervated from the supra-œsophageal ganglion. Henkin (6) did not trace the palpal nerve. In *Thyas petrophilus* the two ganglia are so fused into a ball, and the palpal nerve arises so exactly on the level of the œsophagus that I was unable to say which ganglion it arose from. In *Bdella Basteri*, however, the matter is clear; the palpal nerve (*np*) springs from the upper part of the anterior outer corner of the sub-œsophageal ganglion; it is a thick nerve, much thicker in proportion than the same nerve in *Thyas*; this doubtless is explained by the great size and importance of the palpi. It seems to me most natural to suppose that the palpi would be innervated from the sub-œsophageal ganglion, because that is the centre whence the maxillary nerves of insects arise; but of course in insects the mandibular nerves also arise from the sub-œsophageal ganglion, whereas in the adult Arachnoidea the nerves which serve the mandibles (cheliceræ) spring from the supra-œsophageal ganglion. This, however, is subject to three remarks, viz., first, that Winkler considered that in *Gamasus* he had found the root of the mandibular nerve in the sub-œsophageal ganglion, and that it passed right through the substance of the supra-œsophageal ganglion before emerging—an observation which I have not been able quite to confirm, although I have a great respect for Winkler's general accuracy; secondly, that many writers, such as Lang and others, consider that the very fact of the different innervation prevents these organs in the Insecta and the Arachnoidea being considered homologous; thirdly, that although usually in adult Arachnida the mandibular (cheliceral) nerves, and possibly sometimes the palpal nerves, arise from the supra-œsophageal ganglion, in the young embryo the ganglia whence these nerves spring are not supra-œsophageal, but work upward in the course of development.

In *Bdella* a very thin branch, the destination of which I was not able to trace, arises on the outer side of the nerve almost immediately it leaves the brain. About as far from the brain as two-thirds of the brain itself the palpal nerve gives off a second and considerably larger branch, this time from its inner side; this branch (*np* 2) innervates the maxillary lip; at its distal end, at the lip, it branches and forms two cone-like structures (fig. 15), evidently of a sensory nature.

The next four pairs of large nerves from the sub-œsophageal ganglion are the leg-nerves (N 1, N 2, N 3, N 4); these are of the usual type, and are the largest nerves in the body; each is accompanied on its anterior side by the so-called accessory nerve (*na*) of Croneberg, Schaub, and Nalepa. I think I showed in my treatise on *Thyas petrophilus* that these accessory nerves are really the first branches of the respective nerve-trunks, although in many instances they have come to arise from the brain itself just at the base of the leg-nerve: this, as will be seen by the drawings, is the case in *Bdella Basteri* in some of the legs; but, as before stated, the leg nerve-trunks run far into the substance of the brain. The accessory nerve of the first leg (*na* 1), soon after leaving the brain, expands into an almost triangular lamellar process, similar in nature to that of the mandibular nerve, and two very fine nerve-branches arise from the anterior angles of this expansion. The accessory nerve of the second leg (*na* 2) gives off two thin opposite branches a short distance from the brain; a little further on its course it gives off a rather thicker branch, which extends into a process nearly similar to that from the accessory nerve of the first leg, and like that gives off two fine branches from its anterior corners. The third and fourth legs also are accompanied by accessory nerves (*na* 3, *na* 4); I was able to trace two extremely fine branches from the latter, but not any processes on either similar to those on the first and second accessory nerves. The nerve-trunk to the third leg, about as far from the brain as half the length of the brain itself, gives off a branch on its inner side, and shortly afterwards a thicker branch on its outer side; this branch soon divides dichotomously: the trunk also gives off another branch on its outer side further on. The nerve-trunk of the fourth leg is accompanied by a branch springing from the brain on the inner side as well as the outer, in fact by a second accessory nerve (*nas*). The trunk, nearly as far from the brain as the whole length of the brain itself, gives off a substantial branch. I was able to trace this branch; it goes to the muscles in the body which move the coxa of the fourth leg.

The remaining pair of large nerves are the genital nerves (*ng*); these arise close together in the centre of the posterior edge of the ganglion; indeed, they are so close that just at first their inner edges fuse, making a square, central, posterior projection from the ganglion. I was able to trace five branches on the underside of each of these nerve-trunks; that on the left is shown in the drawing slightly turned over to expose these branches. These nerves run above, and are distributed to, the genitalia, and possibly to some other organs of the hinder part of the body.

The thin pair of nerves from the sub-œsophageal ganglion is a very fine pair (*nd*) arising from the brain about midway between the second and third legs; it innervates the large dorso-ventral muscles which are situated between these two pairs of legs; I found one branch to this nerve. I believe the nerve has not been observed before in any of the Acarina.

I was not able to find the fine, recurrent, median nerve which exists in *Thyas*.

THE EYES.

(Figs. 26, 27.)

There is not much to be said respecting these organs, because they do not appear to vary greatly from the known types of simple eyes in other Arachnida; they are, however, more highly developed than those usually found in such Acari as are provided with those organs.

The optic nerve, as before stated, bifurcates slightly near its distal end—one branch being in effect a continuation of the main nerve, and the other being very short; each branch expands at its end into what I have called a retinal disc (*rd*); this is an almost circular plate, only very slightly cup-shaped—*i. e.*, only slightly concave on the side next the cuticle. These discs are composed of rather loosely packed ganglionic cells and are more than one cell thick; the exterior cells, next the rods, are very distinctly nucleated, the nuclei of the deeper cells being more irregular. Abutting on the outer cells of the disc are a considerable number of rods or retinulæ (*re*) converging to the lens; these rods have rounded posterior ends, and are remarkable for the almost entire absence of pigment between and around them; much more pigment is found in the eyes of such Hydrachnidæ as I have seen, although the rods there are not so distinct nor numerous. The smaller outer ends of the rods abut upon the lens (*ol*), which is bounded exteriorly by the extremely convex cornea, which is more compact and highly refracting than the rest of the lens. The two eyes forming the pair on each side are, from their situation, turned in slightly different directions; they are not as close together as in most Hydrachnidæ.

THE REPRODUCTIVE SYSTEM.

The Male. (Figs. 17, 18, 19, 20, 21, 22, 23, 34, 35, 36, 37, 38, 39, 40, 41, 42.)

The genital organs of the male *Bdella* have far more resemblance to those of *Trombidium fuliginosum*, as described by Henkin, than to those of any other Acarid of which these parts have hitherto been investigated; indeed, his is the only drawing and description which can be said to form any guide to the general arrangement of the parts: still it is only in the general arrangement that this can be said. Henkin's description is, I believe, quite correct in almost every particular. I have dissected *Trombidium fuliginosum* and have much pleasure in confirming Henkin's work; but when we compare it with *Bdella*, we find that although the two types are more like each other than any other known form, yet that they are very different in a large number of most important points; and that in some of these points *Bdella* more resembles other families of Acarina, while in the greater number it is entirely special, and the features in which it differs from *Trombidium* cannot be homologized with any *Acarus* the anatomy whereof is known. Anyone looking at Henkin's figure will be inclined to say that the genital organs of the male *Trombidium* are very complicated; but they may almost be called simple in comparison with those of *Bdella*. Pagenstecher came pretty near to the correct drawing of the male organs of *Trombidium*; but, as Henkin has already pointed out, Pagenstecher mistook the sexes, and what he figures as the female organs are really the male (17. pl. ii. figs. 12, 13, 14).

The male organs of *Bdella Basteri* may be said to consist of: (1) the testes; (2) the embedding-sacs; (3) the testicular bridge; (4) the great mucous glands; (5) the glandular antechambers; (6) the penial canal with its accessories; (7) the azygous accessory gland; (8) the laminated gland; (9) the air-chambers; and (10) the great external labia. The astonishing part of this system is the great size and variety of the accessory glands.

I have, in several instances, purposely given neutral names to the parts; the homologies will be described later on.

The Testes (figs. 17, 20, 35, 42, T) are two more or less pyriform masses on each side of the creature, which, when *in situ*, stand almost upright in the body, the larger ends being upward and the smaller downward: at its smaller (lower) end each testis terminates in a very short duct (*td*, fig. 20) not clearly marked off from the testis; these two unite and form a short common duct which enters the end of the testicular bridge. The testes are in the hind portion of the body, a little behind the genital opening, and are placed immediately below the hind cæca of the ventriculus. When the testes are ripe, they sometimes force their way between the lobes of the cæcum or push it aside, and thus may be found pressed almost against the dorsal surface.

The histology and construction of each of these testes bear considerable resemblance to those of the whole testicular mass, on each side of the body, in *Thyas petrophilus*; and it must be remembered that that organ is divided into two lobes, seeming to give some indication of a double origin (14. pp. 193, 194, pl. viii. fig. 17, pl. ix. fig. 28). In *Bdella Basteri* the exterior tunic of each testis, particularly where it rests against the embedding-sac, and the adjoining part of its outer side (*i. e.*, that part of the testis which is most remote from its fellow on the same side of the body), is composed of largish cells (fig. 35, *tp*), but indistinctly demarcated, containing somewhat solid plasma which stains freely, and having very clear almost circular nuclei of about ·01 mm. diameter, and nucleoli of about 3 μ to 4 μ. These cells usually extend over portions of the inner and other surfaces; but on the portion of the inner surface furthest from the embedding-sac, and the surface opposite the sac, and the adjoining parts of the outer surface, their character is entirely changed in the ripe male; there these cells have become much more clearly marked off from each other, considerably larger, and very irregular in form, the nucleus has entirely disappeared, and the cell-contents have become divided into numerous spermatozoa in various stages of development, according to the age of the cell. These are, of course, the sperm-mother cells (figs. 35, 42); the inner wall of each cell eventually breaks down, and the spermatozoa are discharged into a hollow chamber forming the interior of the portion of the organ which has the nucleated cells as its outer tunic. When the organ is sectioned, it often appears solid; this is because the chamber is so full of secretion and spermatozoa that its lumen is obliterated; often, however, it is only half-full, and then its real nature is seen. It is more than probable that this chamber is composed of a single cell, which is greatly distended, and has become a species of vesicula seminalis to receive the contents of the adjoining cells. My reason for making this suggestion is that the chamber frequently, indeed I may almost say usually, contains a a single, large, most distinct nucleus lying free in the midst of its contents. In some species, e. g. *B. vulgaris*, when the spermatozoa are thoroughly ripe, this chamber seems to occupy almost the whole interior of the testis, particularly of the front one of each pair, and it is crowded with large spermatozoa in a ripe condition. The secretion with which, in addition to spermatozoa, the cell is generally filled must apparently either have arisen in the cell itself or entered from the embedding-sac (in *B. Basteri*); but if the latter be the case, it is not clear where the passage is, nor would this account for the presence of the secretion in the chamber of *B. vulgaris*, which has not any embedding-sac.

The testes are largish and fairly well developed in the nymph when approaching full growth, although of course not nearly so much so as in the adult, and they do not in the nymphal stage contain ripe spermatozoa; but they are very large compared with the other male sexual organs, such as the great mucous and accessory glands and the embedding-sac, which at the same period are either very small or altogether absent.

The Embedding-sac (figs. 17, 19, 35, *es*) is a large hollow viscus: on each side of the body, in an indentation of this viscus, the testes rest; it is on the exterior side of the testes, and when *in situ* is on edge in the body. Although the testes simply lie on the inner side of the embedding-sac, and are easily removed by dissection, yet they are so pressed into the wall of the sac that two hollows (fig. 19) are formed in the wall of the embedding-sac, into which the respective testes fit, and in which they are buried to the depth occasionally of half their thickness. The wall of the embedding-sac is forced up between the two testes, forming a considerable ridge. The lower edge of the embedding-sac rests upon the inner side of the ventral surface of the hind part of the body. In fig. 17 the two embedding-sacs (*es*) are shown with the testes *in situ*, but they are opened out and laid back, in order to show the testes, as the two valves of a cockle-shell might be in order to show the fish; in reality, when in the body of the living creature the two embedding-sacs are closed together, like a living cockle-shell, and quite hide the testes, which are then on their inner surfaces. In fig. 19 one of the embedding-sacs is shown after the testes have been removed. The embedding-sac is somewhat folded and pressed so as to form lobes and folds, which vary in different individuals; it will be seen by fig. 35 that its two surfaces are usually much pressed together, leaving a rather small and irregular lumen, which, however, is doubtless capable of expansion. The walls of the organ are formed of columnar cells varying greatly in size in different parts; they only stain lightly, but have large and clear, much flattened, oval nuclei of about 14 μ and darkly staining nucleoli of about 5 μ.

The embedding-sac has been most frequently empty in the specimens which I have sectioned; but sometimes it has contained a fine granular secretion, which hardly stains at all, but which has apparently been of a slightly viscid character. I have never detected spermatozoa in it; but it is just possible that if the secretion enveloped the spermatozoa and were impervious to stain, the spermatozoa might be present and not be visible, although this does not seem very probable. It is a very strange thing that I have not been able to detect any entrance to or exit from the embedding-sac either forming a connection with the testes or any other organ; it appears to be a closed sac, but it is difficult to believe that it always is so.

The embedding of the true testes in the external wall of a hollow mass is very like the arrangement in the Oribatidæ*. In these Acari the embedding-organ serves as a vesicula seminalis. Perhaps, however, of all published delineations of the genital organs of Acari, that by Prof. Berlese of a sagittal section of *Actineda corniger* (I. prostigmata, pl. vii.) comes nearest to the testis and embedding-sac of *Bdella Basteri*. Berlese does not say a word about the genital organs of his creature in the letterpress; but, curiously enough, he has mistaken the male for the female, and in the explanation of his plate he marks the embedding-sac as being the ovary, and apparently considers the testis, which he draws very well, to be an egg; he shows a communication from the embedding-sac into the penial canal, which he calls the "plicæ vulvares, or labia interna."

The nearly full-grown nymph of *Bdella Basteri* shows, as before stated, the testes well developed, but the creature does not possess any embedding-sac; that seems to be developed in the adult only; and moreover, strange as it may appear, it is a fact that I have been unable to trace any sign of an embedding-sac even in the adults of any of the other species of *Bdella*, three or four in number, which I have been able to examine. The true testes in these species come right down to the ventral surface.

The Testicular Bridge (figs. 17, 20, 34, *tb*) is so much a portion of the testes that it might perhaps have been more correctly described immediately after them; but its exact position would not be so well understood before the description of the manner in which the testes of *B. Basteri* are partially sunk in the embedding-sac.

The bridge is a tubular connection between the two testes on one side of the body and the corresponding pair on the other side; it would not be useful to attempt to give its exact size, because it varies so much according to the amount of spermatic matter in its lumen for the moment and from other causes. It has already been mentioned that the two short ducts from the two testes on one side unite in a common duct which enters the end of the bridge; this common duct is so intimately connected with the bridge that it must be regarded as the commencement of that structure. The bridge curves round immediately behind the penial canal and, in *B. Basteri*, is between that organ and the lower part of the anterior edges of the embedding-sac; but it is quite free from both; is

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* 'British Oribatidæ,' Michael (Ray Soc. 1884), p. 156, pl. F. figs. 1–5.

not in any way sunk in the embedding-sac or joined to the penial canal, although in ripe specimens all the organs become pressed against those adjoining them from the immense development of the genitalia. It forms a passage for the spermatozoa from the testes on each side of the body, and in specimens containing ripe spermatozoa it is usually crowded with the ripest of them. From this one would naturally anticipate that there would be some passage from the bridge into the penial canal, which it immediately adjoins; but, strange to say, this is just what I have been entirely unable to find by any amount of searching; there does not seem to be any entrance from it into the penial canal, and I think I may say positively that there was not any such entrance in any specimen which I have examined.

The testicular bridge is probably the homologue of the short junction or bridge between the testicular masses on the two sides of the body found in *Thyas petrophilus* (14. p. 193, fig. 17), although the situation is very different; the bridge in *Thyas* being at the extreme posterior of the testicular masses, whereas that of *Bdella* is central. There is a kind of progression from the almost horseshoe-shaped testicular mass of *Trombidium fuliginosum* (6. fig. 17) to that of *Thyas*, above referred to, where, although the horseshoe form is more or less preserved, the two sides are almost separated; and further to the organs of *Bdella*, where the two sides are wholly separated posteriorly and only joined by a central bridge.

The histology of the bridge does not vary much from that of the testes; the same layer of darkly staining, clearly-nucleated cells which forms the exterior tunic of the latter extends continuously over the former, and when the genital products are not fully developed constitutes the principal thickness of the organ, the lumen being small. At a later stage the lumen is greatly distended by the spermatic products, and the walls of the organ become thinner; there is never any sign, however, of the cells of the bridge becoming sperm-mother-cells, or of their giving rise to spermatozoa.

The Mucous Glands (*glandulæ mucosæ*) (figs 17, 34 & 36, *gm*, & 37), as I call them, for the purpose of not binding myself to homologies, are almost, if not quite, the largest organs in the body of the adult male *Bdella*. The form of each is that of a great sausage-shaped sac bent upon itself in the middle, so that the two ends almost touch, and the two halves also almost touch at their inner edges and are parallel to each other; the great curved central bend is at the anterior portion of the organ, the ends being directed backward (fig. 36). The bend is not horizontal but perpendicular, so that the one half of the organ lies above, not at the side of the other; the end which, as hereinafter explained, communicates with the testicular bridge is the lower, and is usually more or less swollen and irregular in form, while shortly before the swelling there is a slight constriction. The walls of the organ are extremely thick; they are composed of a substantial tunica propria externally; on the inner side of this a single row of large, more or less columnar, somewhat irregular cells, varying in *B. Basteri* from about ·06 mm. to about ·1 mm. in length and about 15 μ to 25 μ in width, which have extremely dense dark-staining walls where they adjoin each other, *i. e.* on their sides, and much thinner walls at the ends. The exterior end of the cell is filled with a layer or mass of protoplasm about ·02 to ·03 mm. thick on the average, which stains freely and contains the strongly marked, usually nearly circular nucleus, which averages about 10 μ and has a large distinct nucleolus of about 5 μ to 6 μ. The remainder of the cell is either entirely or partly filled with a finely granular secretion, which shows the largest granules near the exterior of the cell, but in the lumen of the organ becomes very homogeneous, and which stains but slightly; or else is completely empty; the latter is the commonest condition. I say very homogeneous in the lumen, but of course a sufficient power shows this secretion to be granular even there, but as the granules are not above $\frac{1}{2}$ μ in diameter and extremely hyaline, it requires a comparatively high power of the microscope and some definition to see them clearly. What apparently takes place is that when the secretion is formed the wall of the inner end of the cell breaks down and the contents are discharged into the lumen of the organ, which is often quite full of it, although at other times empty. After the wall of the inner end of the cell has broken down and discharged its contents the other walls persist, forming deep pockets, so that the whole structure looks like an almost empty honeycomb; into these pockets the secretion continues to be discharged and to find its way thence into the lumen.

These organs do not vary much in the other species of *Bdella* which I have been able to examine; the principle and histology have always been the same; the chief difference which I have found has been that in some species, particularly the smaller ones, the organ is often thicker (*i. e.*, has a larger diameter) in proportion to its length, and that the two parallel portions are consequently shorter and are more pressed against each other; the result of this is that the whole mass, even in section, looks more globular. In some species, e. g. *B. vulgaris*, it would be possible for a person seeing only the section to overlook the fact of its being a sausage-shaped organ folded on itself, and to take it for a globular one, if he had not seen *B. Basteri* or some other similar species to guide him to the true form; of course a careful examination would reveal the true conformation of the organ in any species.

There are two passages, and two only, out of, or into, each mucous gland; these are at the two ends. In the upper more rounded end, but not median in that end, there is a very small but perfectly distinct entrance to the glandular antechamber (vestibulum glandulæ mucosæ) (fig. 19, *vg*), which entrance is ordinarily kept closed by the thick walls of the antechamber itself being pressed against one another. About the centre of the lower more lobose end is a much smaller passage ordinarily very tightly closed by a sphincter, which leads into the testicular bridge. Round this passage a few cells of the mucous gland have usually entirely broken down, their lateral walls even being destroyed; thus an open space is left, which is generally wholly or partially filled with the secretion, unless the lumen of the organ be empty.

The Glandular Antechambers (*vestibulum glandulæ mucosæ*) (figs. 20, 36, 38, *vg*, & 17, 18, & 41) are two paired chambers, one leading from the upper end of each of the great mucous glands into the head of the penial canal: each antechamber is almost in a line with the part of the mucous gland from which it springs, but turns slightly upward to reach the dorsal side of the head of the penial canal and to escape the edge of the testis; it is sharply divided from the mucous gland by the constriction which forms the narrow passage before mentioned, and from the penial canal by a similar constriction; so that it becomes an oval sac, which has extremely thick walls and a small lumen. The greatest length of the organ in *B. Basteri* is usually about ·2 mm.

The histology of the organ bears a resemblance to that of the mucous glands, yet the differences are considerable. The tunica propria is present, but is not nearly so easily seen as in the mucous glands, because the cell-contents and walls in the antechamber hardly stain at all, and therefore do not differentiate. The walls are composed of columnar cells radiating inward, and in *B. Basteri* mostly about ·01 mm. in length; but in that species they are very irregular in arrangement (fig. 38). In some other species, e. g. *B. vulgaris*, they are remarkably regular, and the walls of the cells strong (fig. 41). The cell-contents are very compact and the nuclei extremely small, flattened, and indistinct; indeed it would be difficult to see them were it not for the minute darkly staining nucleoli. In some specimens it will be found that the cells are empty and the nuclei gone, but the lateral walls of the cells still persist, forming a strong open honeycomb-like reticulum.

The secretion within the lumen of the antechamber is similar to that found in the mucous gland, and probably comes thence.

The Penial Canal (figs. 18, 21, 34, 42, *pc*, including *pc*^{1} and *pc*^{2}) is a very complicated organ, and one not at all easy fully to grasp the construction of; it varies considerably in detail in different species; it must probably be considered a development of a ductus ejaculatorius. When looked at from the exterior this complication is not seen; it then appears to be, and its external coating is, a large organ divided into two parts (fig. 18), an inner fleshy portion (*pc*^{1}), and an outer membranous portion (*pc*^{2}). The former of these is almost perpendicular or tends somewhat backward, varying in different specimens, the dorsal end being the more anterior; it is an approach to pyramidal in form, but is curved, the dorsal end curving over toward the posterior end of the creature; it also enlarges gradually, but not regularly, from the dorsal to the ventral end. It is round, or almost so, in transverse section cut through its dorsal part; more compressed laterally in its lower part. In some other species, e. g. *B. vulgaris*, the dorsal end of the penial canal is enlarged and is more turned to the rear. On the exterior of this organ near its lower edge is placed on each side a chitinous sclerite (*as*), which I will call the "amphioid sclerite"*, the anterior half of which is a plate of irregular form somewhat convex exteriorly, so that it looks semiarcuate in longitudinal section; this plate has a pointed anterior end, where it approximates to its fellow of the opposite side. The posterior half turns in a sigmoid manner, and is thicker and rod-like; its hind end almost touches the tube which leads from the outer membranous chamber of the penial canal into the air-chamber on that side of the body. The anterior plate-like half of this amphioid sclerite is bordered by 4 or 5 spines; its principal function appears to be to give attachment to muscles, although it probably is also protective; from it spring the muscles (*mdl*) which divaricate the labia that close the entrance from the azygous accessory gland (*gaa*) to the penial canal. From the posterior dorsal angle of the plate arises a thick tendinous projection, and into the end of this a pair of large retractor muscles (*mr*)

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* Ἀμφί, both; εἶδος, shape.

are inserted. From the posterior edge of the plate arises a series of fine constrictor muscles (*mc*), which pass round the outside of the penial canal. The other principal muscles connected with this part of the canal are a pair of central retractor muscles (mr^1) inserted into the median posterior line of the lower part of the organ, and a network of constrictor muscles which completely envelop the upper end of the organ like a cap; these are not shown in the drawing, as they would entirely hide that portion of the canal. The glandular antechambers (*vg*) enter the upper end of the penial canal as before stated, passing through this muscular layer. The outer portion of the penial canal (pc^2) lies entirely ventral to the amphioid sclerite, and is a membranous structure somewhat wider than the inner portion (pc^1), but its exact width and form depend on the amount of the retraction of the organ for the moment. It forms a thin-walled flexible chamber connecting the inner part of the penial canal with the great external labia (*le*).

The penial canal presents internally a complicated series of folds of a thin flexible membrane, which is marked in most parts by a very fine series of parallel, wavy, linear ridges, projecting considerably in parts; in other places the membrane is provided with very fine spines or hairs, some of which form two paired brushes (fig. 21, *bh*). When sections taken through the edge of the external genital aperture are carefully examined, it will be seen that this membrane is really an invagination of the exterior cuticle of the body, and retains its character of the wavy parallel ridges; but both membrane and ridges have become very much finer and more delicate than on the exterior of the creature. It would be hopeless to describe or even to draw the whole of the complicated series of folds into which this membrane is thrown, nor are they by any means always similar in different specimens; but the main features are generally preserved, and something of them may be gathered from the figures and something respecting them may be said here. First, the membrane folds so as to divide the upper end of the penial canal, which is enlarged in some species, into three lobes or chambers communicating and forming a kind of trefoil; below this the membrane folds in and forms a very narrow constriction; below this again it appears to be invaginated more than once, and to form various folds and recesses; but if it be looked at from behind after its outer walls have been cut open and separated, it will be seen that there is an arrangement in the central line which is depicted in figs. 21, 34; there is a longish, very hyaline, and thin-walled central tube, which is slightly sigmoid in form, but looks straight when seen from the front or rear, down the middle of the exterior of which tube sometimes runs a slight ridge, the thickness of which varies in different parts; this ridge, when present, is a mere folding together of the two sides of the tube when it is slightly flattened. The lower end of the tube is strengthened by two very small, paired, chitinous, slightly undulated rods, each of which supports a small rounded membranous flap or lobe (*mfp*) marked with wavy ridges; each of these flaps appears a mere line when looked at from the anterior, but like a rounded lobe when seen from the side; each flap bears a well-developed chitinous hook, standing slightly upward. Between these rods is a funnel-shaped piece (*pe*), very slightly chitinized at its open enlarged end, which is the upper, but hyaline at its smaller end, which is tubular. I have never had the good fortune to obtain *Bdella* in copula, or with the penial arrangements extruded; but I believe that by the action of its exterior constrictor muscles the inner membranous parts of the penial canal can be evaginated and extruded, and that then the above-mentioned membranous tube would form its distal termination, and that the organ (*pe*) would in some way function as a penis—either forming a true intromittent organ, in spite of its hyaline nature, by passing between the large and widely open external labia of the female genital aperture, or else depositing the spermatic elements on the exterior of that opening,—and that the two hooks on the membranous terminal flaps would serve to hold it temporarily in position.

The outer wall of the penial canal is, except at the lower edge, detached from the inner membrane; it is much thicker, and consists of a tunic not showing any distinct cellulation, but thickly strewn with small very darkly staining dots, which apparently are not nuclei.

The Azygous Accessory Gland (figs. 17, 18, 19, 34, 41, *gaa*) is unquestionably the homologue of Henkin's accessory sac (Anhangschlauch) in *Trombidium fuliginosum*, which organ it greatly resembles, although the form in *B. Basteri* is somewhat more complicated. Pagenstecher had seen and drawn it previously, but having mistaken the male for the female, he described it as a spermatheca: Henkin correctly suggests that it is in the nature of a prostate gland; it certainly is an accessory gland of some sort. The form in Henkin's species is that of a long, thinnish, convoluted tube with an almost globular enlargement at the distal end, and usually a slight swelling, of varying form and position, somewhere near the middle of the tube. In *B. Basteri* (figs. 17, 19) it divides into two regions: the whole organ is compressed laterally, so that it appears much narrower when looked at from above or below than when seen from the side; viewed in the latter direction its distal end is expanded and approaches a discoidal form, but is of much smaller proportion than the globular ending of *Trombidium fuliginosum*; it then becomes a flat bar with almost parallel edges of considerably less width than the disc, and continues so for about twice the diameter of the disc; it then suddenly turns almost at a right angle and again enlarges, forming a shortly pyriform, or almost discoidal swelling, much larger than the first; this completes one region, the whole of which is practically colourless. At this point the organ is suddenly constricted; it quickly enlarges again, but not to its former size; it then gradually diminishes once more until it becomes quite a small tube, in which condition it enters the anterior side of the penial canal near the exterior termination of that organ, or at all events nearer to the exterior genital opening than the entrance of the duct from any other gland into the penial canal is. The whole of this second region is yellow-red or orange in *B. Basteri*. There is not any long convoluted tube as in *Trombidium fuliginosum*. The entrance of this duct into the canal is closed by two closely approximated lips (figs. 18, 41), which can be separated by muscles (*mdl*) arising from the amphioid sclerites (*as*), as mentioned in the description of the penial canal.

In *Bdella vulgaris* the form is very different; there the thin tube exists, although it is not nearly as long as in Henkin's species, indeed it is quite a short duct of small diameter; but it swells out at its distal end, forming a great crescentic organ, much larger in proportion than the gland in the other two species named; in all, however, the form of the organ varies a good deal, although each species maintains its own type.

The duct in *B. vulgaris* does not come from the centre of the crescent, but from nearer the anterior end, and on the concave side of the crescent.

The organ has a substantial tunica propria, within which, in the first described (*i.e.*, the distal) region of the organ, is a single layer of columnar cells, which are slightly larger at their outer flattened than their inner rounded ends: in the largest part of the organ in *B. Basteri* the cells measure about ·06 mm. in length, have almost round nuclei of about 5 μ to 6 μ placed near the outer ends of the cells, and clear darkly staining nucleoli of under 2 μ. With the exception of the nucleoli the organ only stains lightly. In the first region the principal contents of the cells is extremely fine granular matter. In the second, proximal, region of the organ the columnar cells, although still existing, are less distinct and much more irregular; their inner ends are not rounded, but the nuclei and nucleoli are still equally distinct; this portion of the organ appears to be lined with a distinct, somewhat loose, membrane, and the cell-contents are less granular, more reticulate, and coarser. The histology of this organ is very similar to that of the embedding-sacs.

The Laminated Gland (figs. 18, 19, *gl*, & 17, 23, 39).—This gland (if it be a gland) may be the homologue of Henkin's bursa expulsatoria in *Trombidium fuliginosum*. I think, however, that it may be safely said that it does not function as a bursa expulsatoria in *Bdella*; it arises from the penial canal near to the position where Henkin's organ arises, although not in the identical place; it may probably be regarded as an azygous saccular out-pushing of the penial canal which has come to possess thick walls and a most special structure; it is, however, entirely devoid of the well-developed outer layer of muscles which Henkin describes as surrounding his bursa. The essential difference in position of the organs in Henkin's *Trombidium* and in *Bdella* is that in the former Henkin draws and describes his bursa and the duct from the azygous accessory gland as entering the penial canal on opposite sides of that organ, whereas in *Bdella* they enter on the same side close together. There cannot be any reasonable doubt that the azygous accessory gland of the one creature is the homologue of that in the other; but it is necessary to consider whether it is the position of the bursa in *Trombidium* that is different in position from the laminated gland of *Bdella*, or whether it is the duct from the azygous gland that differs. The laminated gland of *Bdella* enters the anterior side of the penial canal. Henkin says that the bursa of his species enters the "upperside," treating the penial canal as being more horizontal than it is in *Bdella*; it slopes somewhat in both, but is more perpendicular in *Bdella*. I have examined Henkin's species, and it seems to me that the upperside would be the anterior if the canal were raised into a perpendicular line, and that therefore the position of the bursa in Henkin's species is not far from that of the laminated gland in mine, and therefore that it must be the entrance of the duct from the azygous gland which is different in the two creatures.

I have called this organ the laminated gland on account of the appearance (fig. 39) in section of being provided inside with a close series of lamellæ projecting into the lumen; it will, however, be seen below that this would not be an exhaustive or wholly correct description of the internal structure.

The laminated gland in *Bdella Basteri* is a sac of nearly even diameter throughout, but with a convex, distal, blind end; it is slightly curved longitudinally, but is circular in transverse section. It is invested by a loose, outer coat of mucus-like substance, bearing little groups of darkly staining dots irregularly scattered; within this it has a thick, dense tunic which is irregular in surface; the interior is provided with what in longitudinal section (fig. 39) appear to be a series of fine crinkled lamellæ, which are fixed by their outer edges to the inner side of the wall of the gland and project far into the lumen, only leaving about one-third in the middle free; these apparent lamellæ are about 1μ thick and about 5μ apart—their projection into the lumen is about ·02 to ·03 mm. If, however, a transverse section, or, indeed, even a horizontal one of the gland be cut, these apparent lamellæ will still be found presenting an almost similar appearance of being parallel lamellæ on edge projecting into the lumen. The explanation of this is that if they are to be regarded as lamellæ perpendicular to the length of the organ then they are joined by numerous short lamellæ, slightly thinner than the principal ones and running obliquely at various angles; probably, however, they are rather to be regarded as a closely-packed mass of long columnar cells, of very small diameter, and of somewhat singular and irregular form, being triangular, rhomboid, or pentagonal in section, but oftenest triangular, and which are never, in any specimens which I have seen, closed at the inner ends, neither have I ever detected any nuclei to these cells, if cells they be, nor any cell-contents; the walls only persist, and this although I have examined numerous specimens of various species caught at almost all times of year (except mid-winter, when I cannot get any) and of various ages.

When the gland is cut open, and the open ends of these cells, if cells they be, are looked at from within, they present the irregular reticulated appearance shown at fig. 23; if the microscope be focussed a little within the mouths of the cells then a singular appearance is obtained, very like the well-known tissue of the rush composed of stellate cells; of course this can only be an accidental resemblance produced by crossing or sloping lines.

The central lumen, beyond the lamellæ, is often, but not always, filled with a quantity of secretion very similar in appearance to that of the great mucous glands; in hardened specimens it is often a rod-like mass, and occasionally shows on the exterior of the rod casts of the parts of the inside of the cells which abut on the lumen of the organ, as if the secretion had been pressed into the mouths of the cells. It is possible that this matter has entered the gland from the exterior and is not secreted, in which case the organ would not be a gland at all; the very dense character of the wall looks a little like it, but I do not think it probable, particularly as there are not any constrictor muscles which would enable the organ to act for expulsory purposes.

The Air-chambers.—These organs (figs. 18, 22, *acg*) are two paired organs, one on each side of the body, which vary considerably in form in different specimens and species. They are far more developed in *B. Basteri* than in any other species which I have examined; in that creature each one is a chamber of somewhat irregular form, round in transverse section, but much longer than the diameter; it averages somewhere about ·15 mm. long and about ·05 mm. to ·08 mm. in diameter, according to what part is measured, for the organ is considerably thicker at one end than the other. The whole organ is lined by, indeed it would be almost correct to say formed by, a strong chitinous intima, which, however, is transparent and only slightly brownish in colour; it is not smooth, but its outer surface rises in a series of small irregular convexities; where two convexities meet at their edges they form a short point directed inward, and from each of these points a strong spine projects far into the chamber; all these spines are centripetal, pointing toward the middle of the chamber.

Each air-chamber is (in *B. Basteri*) almost entirely sunk in the fleshy wall of the embedding-sac on that side of the body, only a short portion of the smaller end of the air-chamber projecting from the embedding-sac; part of the larger rounded end of the chamber occasionally projects a little into the lumen of the embedding-sac. The air-chamber does not penetrate the wall of the embedding-sac at right angles, but in an oblique direction, so that its length lies more parallel to the surface of the embedding-sac than perpendicular to it. In the other species of *Bdella* which I have examined there are not any embedding-sacs, and therefore the air-chambers cannot be sunk in them; but in *Bdella capillata*, Kramer *, the air-chamber, although very much smaller proportionately than in *B. Basteri*, and standing free without being sunk in anything, is otherwise a similar organ to that in *B. Basteri*. In *B. vulgaris* the organ exists but is far more rudimentary, being merely a fold of flexible membrane, forming a small chamber without spines.

In *B. Basteri* a narrow passage, very strongly chitinized on one side, less so on the other (*acp*), leads out of the anterior side of the air-chamber, about one-third or one-quarter of its length from the smaller end; this passage communicates with the portion of the penial canal ventral to the amphioid sclerite—that is to say, with the outer fold of the penial canal immediately adjoining the external labia of the genital aperture.

No solid contents are ever found in the air-chamber; but if a living or freshly-killed specimen be sunk in glycerine and examined immediately it will always be seen that these chambers are filled with air.

The only analogy or homology which I can suggest for these organs is a possible one to the curious so-called "ram's-horn organs" found beneath the genital operculum in *Chelifer cancroides* and other forms.

The External Labia of the Genital Opening.—These organs (figs. 18, 19, 34, *le*) are large, rounded, fleshy labia with a longitudinal opening, and form an almost hemispherical projection on the ventral surface of the creature; they have considerable thickness, and where they meet in the median line each has a perfectly flat and smooth, somewhat chitinized edge; forming, in fact, a curved chitinous plate on edge: these two plates lie against each other so closely that it is often difficult to see the separation in sections; the labia, however, are easily separated with a hair, and then by pushing them open the flat edge becomes ventral. Each labium is bordered by a row of hairs.

The Spermatozoa.—These, when forming in the testes, are minute, almost spherical

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* My specimens agree exactly with Kramer's description of his *Bdella capillata* (13); they do not, however, quite agree with the description and figures which Berlese (1) gives of what he considers to be this species. In Kramer's description the second joint of the palpus is rather longer than the fifth, and the proportion of the third to the fourth joint is as 4 to 7. In Berlese's the fifth joint is longer than the second, and the third than the fourth, and there are too many hairs on the fifth joint for Kramer's description. In all these points my specimens agree with Kramer's.

bodies, which gradually become more elongated; those in and near to the testicular bridge have become more or less filamentous, and have a tendency to a slight head, which stains more deeply than the rest of the spermatozoon. These spermatozoa in and near the testicular bridge always seem to me to be somewhat larger than those anywhere else, even in the penial canal.

The Course of the Spermatozoa from the Testes to the Exterior and the Functions of the different Parts of the System.—The course of the spermatozoa is difficult to trace satisfactorily: to summarize the facts bearing upon it, the two testes on each side have very short vasa efferentia which unite to form a very short common duct; the two common ducts, one on each side of the body, are joined by the tubular and very elastic testicular bridge; this bridge and the common ducts are usually crowded with spermatozoa in their largest and ripest condition. The bridge curves round the back of the head of the penial canal, and we should naturally expect that there would be a connection between the two; if there were, the course of the spermatozoa would be simple enough; but I have never been able to trace any such communication, although I have sought for it assiduously in dissection and in sections cut in all directions of several species of *Bdella*; the two organs, although closely approximated, always seem entirely separate and without communication. How then do the spermatozoa escape? Apparently there is one mode and one only; and that is a very small tubular passage leading from the point where the common duct joins the bridge, on each side of the body, to the distal end of the great mucous gland on that side; here it is firmly closed by a constrictor muscle; on the other side of the constriction is the lumen of the mucous gland. Spermatozoa swarm on the testes and bridge side up to the constriction, but I have never been able to detect one in the mucous gland on the other side of the constriction. The mucous gland discharges into the glandular antechamber, and that discharges into the head of the penial canal. If the spermatozoa come through the mucous glands and glandular antechambers into the penial canal the course is easily understood; but although they occur in great quantities in the bridge and common ducts, and up to the entrance to the mucous glands, and are also abundant in the penial canal, yet I never could detect one in the mucous glands or glandular antechambers. How comes this if they be the channels, and the only channels, of communication? One possible explanation is that I have never obtained *Bdella* at the moment of coition and that the spermatozoa pass rapidly through into the penial canal; but the chambers of the mucous glands, when the cells have opened, seem well fitted to retain them. Another possible explanation is that the secretion of the mucous glands does not stain, which is a fact, and that the spermatozoa become so enveloped in it that they are protected from staining while in the mucous glands and antechambers; but one would have expected in that case that the secretion would have still covered them when they were passed into the penial canal, but they stain there freely enough. If the spermatozoa pass through the mucous glands and antechambers then these are the vasa deferentia; and this view is rendered very probable by the fact that in *Trombidium* the vasa deferentia do actually discharge into the head of the penial canal in the precise place where the antechambers of *Bdella* enter. On the other hand, the vasa deferentia in Acari are usually small organs, and I do not know any instance of their being glandular; the mucous glands of *Bdella* are some of the largest organs in the body. The histology of the mucous glands is essentially that of the accessory glands of the male genital system in many other Acari, e. g. *Gamasus*, the large thick-walled cells immediately striking the observer as similar; but the accessory glands of other Acari are always separate organs, ending blindly and discharging by ducts; and the discharge of spermatozoa through such glands seems *prima facie* to be improbable. I have been very unwilling to accept it as the true explanation; it has even struck me whether it were possible that at some time of year which I have missed, or under some circumstances, the testicular bridge does communicate with the penial canal, and whether in that case it might be possible that the mucous gland not only discharged its principal contents, as it certainly does, through the antechamber into the penial canal, but also discharged some portion through the narrow constricted aperture into the common duct and bridge, where it served to nourish the spermatozoa, which appear so much better nourished in this place than anywhere else. I have not, however, been able to discover any sufficient evidence in favour of such a theory, and it is not by any means a theory to be accepted without evidence, as a gland discharging at both ends to different organs is not a thing which could be anticipated.

The head of the penial canal is enveloped by a thick cap of muscles spanning it in all directions; these doubtless are the ejaculatory muscles, and, probably, serve also to extrude the invaginated parts of the canal. What can be the office of the embedding-sac in *B. Basteri*, and what is the necessity for the number, variety, and immense size of the accessory glands in all species of *Bdella* it is very difficult to understand.

The Female. (Figs. 24, 25, 43, 44.)

In marked contrast to the extreme complication of the generative organs of the male *Bdella*, those of the female are particularly simple, and we do not find a single accessory gland present to take the place of the numerous organs of that nature which are present in the male.

Practically it is only in young specimens that these organs can be studied; when the eggs are matured they fill the abdomen so much that they push everything else out of position; and if the genital organs be dissected out they are a mere lump of eggs which hide everything, and have distended some parts out of all shape, while sections at this time do not reveal much more.

The organs of the female consist of: (1) the ovary; (2) the oviduct; (3) the receptaculum seminis; (4) the external labia.

The Ovary (figs. 24, 25).—This organ is a considerable variation from all homologous organs hitherto described in the *Trombidium*-group of Acarina (*vide* Henkin (6), Michael (14), Schaub (18)); in all these recorded instances the ovary has been almost ring-shaped and flattened, the paired oviducts completing the ring. In *Bdella* the ovary is a mere crescentic lump, which in the virgin female is quite small, but of course provided with ovarian ova; the crescent is a short and slightly curved one (fig. 25, *ov*). As the creature gets a little older the crescent becomes somewhat deeper, more approaching a horseshoe form (fig. 24, *ov*); but after impregnation, and when the ova are mature, the whole becomes one shapeless mass of large eggs which enclose and hide the oviduct. The ova are formed and more or less matured in short pedunculated oocysts, each ovum apparently forming its own oocyst by pushing out the exterior tunic of the ovary, thus forming a sac in which the ovum lies. Exactly how the ovum gets from the oocyst into the oviduct is not by any means clear to me in *Bdella*, or, indeed, in many of the other Acarina, although it is evident enough in the Oribatidæ and most Gamasidæ.

The Oviduct (figs. 24, 25 & 43, *od*, & 44).—In all described Trombidiidæ and Hydrachnidæ there are two oviducts which unite to form a common tube (the vagina); in *Bdella*, however, there does not appear to be any such arrangement; in all species which I have examined there appears to be one single fleshy tube leading from the centre of the ovary to the external labia. Some authors would probably divide this tube into oviduct, uterus, and vagina; in reality, however, I do not see any distinction of regions which is at all permanent: it is one unbroken tube, in some parts a little larger, in others a little smaller, but still the one tube, and the enlarged portions are apt to vary with age and contents. It is only in the young specimens that this tube can be clearly seen or dissected out; when distended by maturing or mature eggs it becomes a great irregular sac, the walls of which have lost their extremely thick and glandular character to a great extent. The oviduct when *in situ* is not straight or perpendicular; it is in effect rolled round the ovary; so that when dissected out the whole forms a rounded mass, which can be uncurled in fresh specimens of the young female, but which it is extremely difficult to stretch out when the eggs are mature. The ovary and oviduct of a young specimen of *B. vulgaris* partly uncurled, so as to show them, are delineated at fig. 25; it will be seen that the oviduct here is longish and is corrugated, showing evident signs of capability of expansion; at its distal end it enlarges considerably, and were this permanent it might, perhaps, be called a uterus, but I do not see that it is so. Beyond this enlarged portion, *i. e.* between it and the external labia, is a short flexible portion of the tube, which might be called the vagina, if that name be used at all. In *B. Basteri* (fig. 24) I have not seen any such enlargement in the young female. The figure is drawn as *in situ*, only a little uncurled, but the oviduct is, I think, much shorter and thicker in proportion than in *B. vulgaris*. The external labia and membranous portion of the duct are not repeated in this figure; they would not vary from the other species.

The oviduct is an organ with extremely thick fleshy walls (fig. 44) (in some places as thick as ·1 mm.) and consists of an almost structureless tunica propria, within which are usually several rows of deeply staining cells, containing a granular protoplasm and small round nuclei (about $3\,\mu$) which do not stain much more deeply than the general cell-contents. The walls vary greatly in thickness in different parts, and according to the amount to which the organ is distended in the particular place at the time. The cells are extremely loose and irregular, crowded together, but not so as to press strongly against one another; thus they have rounded and otherwise curved outlines, and are not forced into hexagonal or other angular forms. The layers are often folded so as to make great projections into the lumen of the duct. The outer layer of cells, adjoining the tunica propria, have a tendency to be columnar, but the deeper layers are more round, the innermost being often more or less comma-shaped, with swollen ends, which project into the lumen. The eggs lie some time in the oviduct, and develop greatly there: yolk-division commences, and proceeds to a considerable extent, before the ova pass into the duct; but it is completed there, and the egg increases in size greatly while there; it is in this organ also that it receives the strong chitinous covering with which it is provided before it leaves the body of the female. The thick walls of the duct are manifestly secretory; in young females, before yolk-division has commenced, the lumen of the duct is generally full of a granular secretion, which probably is a nourishing fluid; it is found in more mature specimens, but then the ova so fill the duct as to allow but little room for other things.

The Receptaculum seminis, or spermatheca (figs. 25, 43, *rs*), is an azygous sac formed by an in-pushing of the wall of the oviduct not far from the external labia, but still not in the flexible membranous portion of the duct which adjoins the labia; it is but slightly seen in immature females, and sometimes not at all in very old ones after the eggs are all, or almost all, impregnated; in females which have arrived at maturity only a short time but have been impregnated, this sac is crowded with spermatozoa. It is not hard or chitinized, but is a soft and flexible organ with its walls composed of rather columnar cells, and its exterior in most parts covered by a layer of fine constrictor muscles.

The External Labia do not differ from those of the male, except in being somewhat larger and rather more spongy in construction.

THE RESPIRATORY ORGANS. (Fig. 45.)

These organs have a general resemblance to the corresponding parts in *Trombidium*, which have been admirably and correctly figured and described by Henkin (6. fig. 7); but they vary considerably from that type; they are almost similar in the different species of *Bdella* which I have examined, any small points in which they do not agree will be noticed.

In *Bdella Basteri* there is, on each side of the body, a long tubular air-chamber (fig. 45, *ac*) which has an almost even diameter, usually of about ·05 mm. throughout. This air-chamber commences immediately behind the mandible, and continues backward in a course which typically should be almost straight, but which generally becomes slightly undulating from the pressure of other organs, until it reaches the genital organs; it even passes among these, usually penetrating between the two arms of the great mucous gland of the male, and between the ovary and the alimentary canal of the female. It ends blindly both anteriorly and posteriorly; both ends are rounded. The anterior end is attached by a double tendinous ligament (*tl*) to a fold of the cuticle close to the lower posterior corner of the mandible. At a distance from the anterior end of the air-chamber equal to about two-thirds of the length of the air-chamber itself, there springs from the dorsal side of the chamber a main tracheal trunk (*tra*), about one-third or one-quarter the diameter of the air-chamber; it turns sharply forward immediately and runs parallel to the anterior part of the air-chamber the whole length of that organ. In the drawing the two are slightly separated in order to show them distinctly, but in nature, when they are *in situ*, they actually touch along their whole length—indeed, for the greater part of their course, they are surrounded by a single enveloping tunic common to both. These two vessels are striated, the air-chamber very finely and regularly, the tracheal trunk much more coarsely and irregularly. The tracheal trunk enlarges somewhat near its anterior end, and when it has arrived at the termination of the air-chamber it turns suddenly upward behind the mandible, forming a somewhat curved air-passage, which is almost divided up into sections by partial constrictions and irregular broken semi-partitions or laminæ projecting into the lumen. At the upper end of this portion of the tracheal trunk is the stigma (*S*), of which there is only the one pair in the body, communicating with the small external air-chamber between the mandibles. There are not any other tracheal trunks in the body, but from the ventral side of the posterior third of the air-chamber, and from the actual posterior end and a small portion of the dorsal side of the chamber, there arise a multitude of extremely fine, unbranched, and unstriated tracheæ (*tr*), which are distributed to all parts of the body; only the commencement of them is shown in the drawing. Some of these tracheæ turn forward and serve the trophi and anterior organs, some run backward and turn forward afterwards; but far the greater number of them run backward toward the posterior end of the creature. A thick fasciculus of these small tracheæ turns across the body immediately behind the supra-œsophageal ganglion of the brain, thus lying upon the sub-œsophageal ganglion and upon the œsophagus itself. The fasciculi from the two sides of the body meet and cross behind the supra-œsophageal ganglion, the posterior side of which is almost hidden by them until they are removed. In *Bdella capillata*, Kramer, which I examined, the arrangement is similar, except that the number of fine tracheæ is very much less than in *B. Basteri*, and that the tracheal trunk does not enlarge until it turns upward; but then it enlarges comparatively more than in *B. Basteri*.

THE DERMAL GLANDS. (Fig. 16.)

Instead of assuming the importance which the similar organs do in the Hydrachnidæ, the dermal glands of *Bdella* are apparently few in number (I have only traced one pair) and are extremely small and difficult to find; when found, however, they bear a resemblance to those of the Water-Mites, but on a very much smaller scale, and are simpler. In *B. Basteri* they consist of minute sacs, averaging about 25 μ in extreme length, placed immediately beneath the hypoderm, each having one small duct placed excentrically, which passes to the outer surface of the cuticle, where its mouth forms a very small pore which is not protected by any special hair or spine, but which is doubtless sheltered by the sharp wavy ridges with which the whole cuticle of *Bdella* is covered. The contents of the sac are a few masses of protoplasm which stain freely, and which are joined by irregular protoplasmic strands. It is possible that they may not be homologous with the dermal glands of the Hydrachnidæ.

THE ENDOSTERNITE.

I have not figured this organ because it is of the type well known in the Acarina, *e. g.* the Gamasidæ and other forms; but I mention its existence, particularly as it is extremely well developed in *Bdella*. It forms a thick tendinous plate, which, in *B. vulgaris*, shows signs of being formed by the compression of a sac; at all events, it has thick upper and under walls, which in a transverse section of the creature show a narrow but distinct lumen between them; which, however, is crossed by "ties" between the upper and under walls. The endosternite lies between the ventriculus, which is above it, and the hind part of the brain (not quite its posterior end), which is below it. It forms a point of attachment for numerous muscles, principally the great muscles of the legs, which are the largest in the body. The endosternite is slung from above by dorso-ventral muscles and muscles from the lateral surface of the body, and by connective tissue; the muscles converge to it from all sides.

The Musculature.

A large number of the muscles have been described in connection with the various organs; I do not propose to enter into any exhaustive description of the remaining ones, particularly as some of them are figured by Karpelles; but there are some which I may mention. I have not drawn any of the musculature except that incidental to other figures, because doing so would have involved having another plate. All the muscles described below are paired muscles corresponding on the two sides of the body.

Longitudinal Muscles.—From the dorsal cuticle nearly above the fourth leg, and almost close to the hind fasciculus of dorso-ventral muscles, two bundles of powerful muscles arise; both of these are horizontal muscles running for their whole length almost immediately under the dorsal cuticle. The anterior of these bundles runs forward above the alimentary canal and the paired salivary glands; it spreads out and is inserted partly in the dorsal cuticle about where the dorsum begins to sink toward the rostrum, partly in the upper proximal edges of the mandible, and partly in the cuticle behind the lower proximal edge of the mandible. The other bundle runs backward, and is inserted in the dorsal cuticle near the posterior end of the body; thus these two sets of horizontal muscles, starting from one point, embrace between them almost the entire length of the body, except the rostrum. They manifestly serve to compress and shorten the body longitudinally and to retract the rostrum.

From the dorsal cuticle just in front of the ventriculus two fasciculi of numerous muscles, much slighter than those last described, arise; one of these is inserted in the rostrum just below and behind the mandible, the other in the cuticle just above and behind the mandible.

From the anterior end of the endosternite a fasciculus of strong muscles runs to and is inserted in the lower posterior edge of the rostrum near the median line.

Perpendicular Muscles.—I was able to distinguish eight fasciculi of dorso-ventral muscles, all strongish, viz.:—

1. A fasciculus arising from the dorsal cuticle in front of the reniform and pericibal salivary glands, and not very far from the median line of the body; this bundle is inclined slightly forward, and is inserted in the hind edge of the rostrum.

2. A fasciculus arising from the same place, but passing almost perpendicularly downward and inserted into the ventral cuticle.

3. A fasciculus arising from the dorsum a little in front of the anterior eye, rather more toward the side of the body than numbers 1 and 2, and inserted in the ventral thickened sclerite or ridge at the posterior edge of the acetabulum of the first leg.

4. A fasciculus arising from the dorsum a little behind the posterior eye, and inserted in a similar manner to No. 3 at the posterior edge of the acetabulum of the second leg.

5. A fasciculus close to the side of the body arising from the dorsum a little behind the vertical plane of the coxa of the second leg; passing diagonally backward and downward and inserted in the ventral surface a little before the third leg.

6. A fasciculus arising from the dorsum just anterior to the genital organs, *i. e.*, just anterior to the great mucous glands of the male, passing almost perpendicularly downward and inserted in the ventral cuticle.

7. A fasciculus arising from the dorsum a little anterior to the embedding-sac in *B. Basteri*, and in a corresponding position in the body of such species as have not any embedding-sac, and inserted in the posterior edge of the acetabulum of the fourth leg.

8. A fasciculus near the side of the body arising from the dorsum about the middle of the embedding-sac, but outside that organ, and inserted in the ventral cuticle some little distance posterior to the fourth leg.

There is also a fasciculus of rather fine muscles arising from the dorsum and inserted in the anterior part of the endosternite, and another of stronger muscles arising from the dorsum and inserted near the posterior termination of the endosternite.

The Muscles of the Mandibles.—The muscles which move the small terminal joint of the mandible, *i. e.* the movable joint of the chela, are shortish; they are wholly contained in the bulbous proximal part of the mandible, and are inserted into the terminal joint by means of very long tendons passing the whole length of the narrow distal part of the mandible. The retractor muscles, which serve to open the chela, are few and arise from the roof of the mandible; the extensors, which close the chela, are more numerous and more powerful; they arise from the lower and outer sides of the mandible. The tendons from each set of muscles unite with their fellows of the same set, and form a single tendon which is inserted as stated above.

The levator muscles of the whole mandible appear to be a group of short, thick, diagonal muscles arising from and just behind the lower posterior edge of the mandible and inserted into its upper posterior edge, which bends sharply but diagonally upward, and extends further backward than the lower edge. There are also some muscles apparently serving to give a slight lateral movement.

The muscles of the legs do not differ sufficiently from what has previously been described by various authors relative to more or less closely allied creatures to make it worth while to describe them at any length. As before stated, the principal muscles which move the whole leg arise from the endosternite; but some few serving to give a somewhat revolving motion arise from the epimera, which are very slight structures, in fact little more than thickened margins to the acetabula of the legs, and from the neighbouring cuticle: all are inserted in the proximal end of the coxa. The muscles which move the individual joints of the legs usually arise just in front of the posterior edge of one joint and are inserted into the posterior edge of the next more distal joint; the exact part of the edge from near which they respectively arise or into which they are respectively inserted depending in each case upon the direction of the motion the muscle is to give.

THE EXTERNAL CUTICLE.

(Figs. 33, 34, 41, 42, 43.)

This can hardly be said to form part of the internal anatomy, which is the subject of this paper; but as it is invaginated in several places, and is thus associated with the inner organs, and is also somewhat peculiar and interesting in itself, I think it best to say a few words regarding it.

The skin of *Bdella* is extremely fine: it is composed of a thin epidermal layer which in *B. Basteri* is only about 1 μ thick; this layer is highly flexible and quite transparent and colourless; the whole of the brilliant red pigment which makes the creatures so conspicuous lies in the deeper layers, *i. e.* hypoderm and fat layer, and on the exterior of the internal organs themselves. The exterior of this epiderm (fig. 33) is marked with the fine, wavy, parallel lines so common in many of the soft-bodied Acarina, *e. g.* the Sarcoptidæ and others; in *B. Basteri* they are about 600 to the millimetre. These lines in *Bdella* are of an exceptional character; instead of being mere markings they are ridges, which are thicker at the base where they start from the cuticle than at their distal edges, so that a section through one of them is like the section of a narrow knife-blade; this appearance is increased by the marvellous sharpness and fineness of the edge. The fine lines springing from the exterior of the cuticle in all drawings of sections of the whole creature (figs. 34, 41, 42, 43) are not hairs, but are these ridges cut through. The height of the ridges is considerably more than the thickness of the solid part of the epidermal layer: in *B. Basteri* the ridges in their highest part are about 2·5 μ high, more than twice the thickness of the layer; but the height of the ridge, *i. e.* the amount of its projection, is not equal in all parts, for the following reason:—Each ridge is not an even one of a fixed thickness and projection throughout, it is a series of small drawn-out swellings of different sizes and lengths joined by their fine ends; the ridge never ceases and never loses its distal knife-edge, but it swells out and contracts irregularly, so that when looked at from above it appears like a string of irregular beads, each bead drawn out to a point at both ends and joined to the next bead by an extremely fine thread. The height of the ridge in section naturally depends on whether the section cuts a large or a small swelling or falls between two swellings. It is not possible to depict this irregularity in drawings on the scale of the figures above enumerated.

The hypoderm is a much thicker tunic than the epiderm, and is of the usual character in the Acarina, with loosely joined living cells of irregular size which have very distinct elongated nuclei and elliptical nucleoli.

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EXPLANATION OF THE PLATES.

Lettering.

A.	Anus (so called). This is really the orifice for the discharge of the excretory organs only, not apparently of the alimentary canal.
ac.	Air-chamber of respiratory system.
acg.	Air-chamber in genital organs of male.
acp.	Passage from *acg* to the outer part of the penial canal.
as.	Amphioid sclerite of penial canal.
B.	Chitinous bar at the rear of the roof of the rostrum. Henkin's "Chitinbrücke."
bh.	Brushes of hair or spines inside penial canal.
br.	Brain.
C.	Cuticle.
cæ.	Anterior cæca of ventriculus.
cæp.	Posterior cæca of ventriculus.
cæs.	Cæcum of tubular salivary gland.
ct.	Connective tissue.
cu.	Cuneiform chamber of reniform salivary gland.
D.	Common duct of three of the salivary glands, viz., the tubular, the reniform, and the anterior.
da.	Duct from the anterior salivary gland.
dp.	Duct from the pericibal salivary gland.
dr.	Duct from the reniform salivary gland.
dsa.	Duct from the azygous salivary gland.
E.	Excretory organ.
el.	External labia of genital organs.
eph.	Epipharynx.
es.	Embedding-sac of male genital organs.
ex.	Excretory (urinary) white matter.
fg.	Food-globules absorbed and lying within the cells of the ventriculus.
gaa.	Azygous accessory gland of male genital organs.
gl.	Laminated gland of male genital organs.
gm.	Glandulæ mucosæ (the great mucous glands); probably modified vasa deferentia.
gso.	Supra-œsophageal ganglion (upper part of brain).
gsu.	Sub-œsophageal ganglion (under part of brain).
H.	Hypoderm.
hm.	Half-moon-shaped spiked membrane of epipharynx.
hp.	Hamuli (hooks) of the membranous lobes of the central tube of the penial canal.
K.	Entrance from the mucous gland to the testicular bridge.
La.	Labia closing the duct from the azygous salivary gland.
lan.	Labia ani.
le.	External labia of genital aperture.
li.	Lingua.
mc.	Constrictor muscles of penial canal.
mcr.	Constrictor muscles of receptaculum cibi.
md.	Mandibles.
mda.	Divaricator muscles of the labia ani.
mdl.	Divaricator muscles of the labia which close the duct from the azygous accessory gland of the male genital organs.
me.	Dorso-ventral muscles.
mf.	Membranous flaps at the distal end of the maxillary lip.
mfp.	Membranous flaps at the end of the central tube of the penial canal.
ml.	Maxillary lip.
mlp.	Levator muscles of the roof of the pharynx (dilatores pharyngis).
mop.	Occlusor (constrictor) muscles of the pharynx.
mp.	Partition between the mandibles.
mr.	Anterior retractor muscles of penial canal.
mrp.	Posterior retractor muscles of penial canal.
n 1.	Nerve to first leg.
n 2.	Nerve to second leg.
n 3.	Nerve to third leg.
n 4.	Nerve to fourth leg.
na 1.	The branch of the nerve of the first leg which is the homologue of the accessory nerve of Croneberg, Schaub, Nalepa, &c.
na 2.	The like of the second leg.
na 3.	The like of the third leg.
na 4.	The like of the fourth leg.
nas.	Second accessory nerve of fourth leg.
nb.	Posterior branch of the fourth leg-nerve.
nc.	Branch of the pharyngeal nerve going to the receptaculum cibi (sucking-stomach).

nd.	Nerve to dorso-ventral muscles between second and third legs.
ng.	Genital nerve.
nm.	Mandibular nerve.
no.	Optic nerve.
no^1.	Branch of the optic nerve.
np.	Palpal nerve.
np^2.	Branch of palpal nerve distributed to the maxillary lip.
nph.	Pharyngeal nerve.
nv.	Nerve to muscles running from the dorso-vertex to the maxillary lip.
O.	Ova.
oc.	Cornea of the eye.
od.	Oviduct.
œ.	Œsophagus.
ol.	Lens of the eye.
os.	Eyes.
ov.	Ovary.
P.	Palpus.
pc^1.	Penial canal, dorsal portion.
pc^2.	Penial canal, ventral portion.
pe.	Penis?
ph.	Pharynx.
pp.	Propharyngeal plate.
pr.	Roof of the pharynx.
R.	Roof of rostrum.
rc.	Receptaculum cibi (sucking-stomach).
rd.	Retinal disks.
re.	Retinulæ (rods) of the eye.
rs.	Receptaculum seminis.
S.	Stigma.
sa.	Azygous salivary gland.
sga.	Anterior salivary gland.
sgp.	Pericibal salivary gland.
sgr.	Reniform salivary gland.
sgt.	Tubular salivary gland.
sh.	Hollows in embedding-sacs to receive testes.
sm.	Sperm-mother-cells.
T.	Testes.
tb.	Testicular bridge.
td.	Duct of the testis.
tdm.	Common duct of the two testes on one side of the body.
thl.	Tactile hairs of maxillary lip.
tl.	Tendinous ligament between respiratory air-chamber and cuticle.
tp.	Exterior fleshy cells of testis.
tr.	Tracheæ.
tra.	Principal tracheal trunk from stigma to air-chamber.
tt.	Tendinous tie between epipharynx and lingua.
tvs.	Portion of testes functioning as a vesicula seminis.
V.	Ventriculus.
vg.	Vestibulum glandulæ mucosæ (glandular antechamber).
W.	Wedge-shaped chamber in reniform salivary gland.

All the figures, except where specially mentioned, have the anterior end, where there is one, nearest to the top of the page.

All the figures, except 12, 25, 41, *and* 42, *represent* Bdella Basteri.

PLATE 41.

Fig. 1. (Right central part of Plate.) The epipharynx, propharyngeal plate, and associated muscles seen from below: × 220. The propharyngeal plate with its membranous wrinkled border is at the lower end of the drawing; the one of the occlusor muscles of the pharynx which curves over and depresses the plate passes transversely above it and is partly hidden by it. The epipharynx with its membranous border is the upper part of the drawing, and its semilunar spiked membrane is shown at its hind margin.

2. (Right top of Plate.) The epipharynx, lingua, propharyngeal plate, and part of the pharynx and pharyngeal sac seen from the right side: × 220. The lingua is cut short; the propharyngeal plate, occlusor (constrictor) pharyngis muscles, and part of the levator tecti pharyngis muscles are seen through the wall of the pharyngeal sac in consequence of its transparency. The duct from the pericibal salivary gland is seen discharging near the hind corner of the epipharynx.

Fig. 3. (Left middle of Plate.) The posterior part of the pharynx, the receptaculum cibi (sucking-stomach), and anterior part of the œsophagus seen from the right side: × 70. The darkish mass inside the receptaculum cibi is the food-contents.

4. (Right top corner of Plate.) The receptaculum cibi, maxillary lip, and left palpus seen from above, × 70. The end of the lingua is shown protruded; the œsophagus is hidden.

5. (Right a little below centre of Plate). The anterior end of this figure points to the right. The pharyngeal plate and its levator (distensor pharyngis) muscles seen from the right side: × 320.

6. (Lower edge of Plate.) Ventriculus from above: × 30. This figure is drawn from a young female, mature, but only one egg showed any sign of yolk-segmentation. In older specimens the form of the ventriculus is generally lost from distension and the pressure of other organs.

7. (Lower edge of Plate.) The excretory (Malpighian) organ from the left side: × 120. The white matter within the viscus is the secretory (urinary ?) matter.

8. (Left top corner of Plate.) The tubular, reniform, and anterior salivary glands on the left side of the body with their common duct: × 120. The reniform gland is seen almost on edge. This drawing is slightly diagrammatic in the sense that it is not quite drawn to scale (to avoid waste of space) and that the parts are a little separated in order to show them.

9. (Lower left corner of Plate.) The left reniform salivary gland and duct seen from the side: × 120. The duct is cut short.

10. (Right centre of Plate.) The azygous and pericibal salivary glands with their ducts *in situ* in the body, seen from above: × 55. A small part of the posterior end of the receptaculum cibi is seen between the pericibal glands.

11. (Right lower corner of Plate.) The azygous and the left pericibal salivary glands with their ducts seen from the inner side: × 120. The azygous is to the left, the pericibal to the right of the figure; the duct from the latter is cut short.

12. (Below centre of Plate.) Sagittal median section through the azygous salivary gland of *Bdella vulgaris*: × 180.

13. (Central upper figure.) The brain and nerves seen from above: × 100. The hole where the œsophagus passed between the supra-œsophageal and the sub-œsophageal ganglia is shown, but the œsophagus itself has been removed, except a small portion anterior to the brain. The nerve to the receptaculum cibi has been turned a little to the right to show the pharyngeal nerve from which it springs and which it would hide. The mandibular nerve is turned a little outward, as it would lie over the palpal nerve. The left genital nerve is slightly turned over to show the branches on its under surface. The whole length of the optic nerve is shown; the other nerves are cut short.

14. The branching of the mandibular nerve: × 200.

15. The termination of the labial branch of the palpal nerve in the maxillary lip: × 400.

16. One of the dermal glands and duct: × 700.

Plate 42.

Fig. 17. The reproductive organs of the male spread out so as to show details: × 70. The embedding-sacs (*es*) are turned to the right and left, carrying their respective pairs of testes with them; *in situ* they would lie close together, present their edges to the observer, and hide the testes between them; the azygous accessory gland would be more closely pressed by the great mucous glands, which would probably hide the laminated gland. The almost globular organ in the centre of the group is the head of the penial canal looked down on perpendicularly; the glandular antechambers are seen entering it. The laminated gland is seen in the median

line directed to the top of the Plate; it enters the penial canal much below the head, but looking down perpendicularly this is not appreciated.

Fig. 18. The penial canal, external labia, laminated gland, air-chamber, and parts of the azygous accessory gland and glandular antechambers seen from the side: × 120.

19. One of the embedding-sacs after the testes and other organs have been removed from it, seen from within: × 70. The hollows in which the testes lay are shown; the azygous accessory gland, laminated gland, penial canal, and external labia are attached; the labia are partly seen from the exterior.

20. The testes which have been removed from fig. 19, together with half the testicular bridge, one of the great mucous glands, the glandular antechambers, &c.: × 70.

21. Central tube, hamuli, and detailed structure of penial canal: × 250. The outer wall of the penial canal is partly cut away so as to show the interior.

22. One (the right) of the chitinous air-chambers which is sunk in the embedding-sac, from the exterior: × 200. The chamber has been dissected out of the sac.

23. A portion of the interior of the laminated gland, showing the principal laminæ and the oblique lesser lamellæ: × 650.

24. Genital organs of young female *in situ*, the oviduct being only slightly uncurled: × 120. The receptaculum seminis is hidden.

25. Genital organs of young virgin female (reared) of *Bdella vulgaris*, slightly spread out; but the curl of the oviduct is natural.

26. Perpendicular section through one of the eyes: × 550.

27. Horizontal section through the terminal part of the optic nerve and the retinal discs: × 200. The section cuts the lower eye through the rods (retinulæ), the cells of the disc only showing near the periphery; the upper eye is cut wholly in the retinal disc.

28. Transverse section of the œsophagus between pharynx and brain, to show the irregular shaped lumen: × 650. A typical section was selected, but probably no two sections were ever really similar; they vary widely.

29. Maxillary lip from below: × 80.

30. The mandibles *in situ*, seen from above: × 80.

31. The left mandible seen from the inner (flat) side: × 80.

32. Terminal portion of maxillary lip from below, showing the membranous flaps inside (above) the lip: × 450. The lip has been flattened out to show the flaps; in reality when the lingua is not protruded the sides of the lip curl upward and the two flaps lie against each other, closing the entrance anteriorly.

33. A small portion of the external cuticle showing the wavy irregular ridges composed of long-shaped raised dots, joined by the lower parts of the ridge: × 550.

PLATE 43.

Fig. 34. Median sagittal section of male: × 50. The section is a thick one, so as to show some organs which are not in the actual median plane where they are not hidden by other organs which are in that plane. Thus one mucous gland is shown with a portion of the azygous accessory gland and the genital nerve passing over it. The cæca of the ventriculus have practically closed over the excretory organ from the pressure of food-contents and other causes. Numerous small tracheæ (not lettered) are seen between the brain and the ventriculus and mucous gland. The œsophagus is seen passing through the brain, and the receptaculum cibi (sucking-stomach) springs from its dorsal side. The cells of the ventriculus are crowded with food-droplets, the excretory organ with the usual white matter.

Fig. 35. Section through the testes and embedding-sac on one side of the body: × 60; showing that the latter is a hollow viscus, although the lumen is small in comparison to the size of the organ The sperm-mother-cells are seen on the right part of the testes, the portion functioning as a vesicula seminis on the left nearest to the embedding-sac; these portions are full of spermatozoa.

36. Median sagittal section through the mucous gland (vas deferens?) and glandular antechamber on one side of the body: × 100. The cells have all discharged their contents and are empty, their walls remaining, forming pockets; the outer fleshy walls with the nuclei persist.

37. Section of a portion of the mucous gland when partly filled with secretion: × 140.

38. Median sagittal section of one of the glandular antechambers of the male: × 400.

39. Median sagittal section through the laminated gland of the male: × 150.

40. Longitudinal section through the air-chamber of the male genital organs, to show the spines projecting into the interior: × 400. In this figure the lower end is slightly the anterior.

41. Transverse section of male *Bdella vulgaris* cut in the plane of the glandular antechambers to show the difference of their cellulation from those of *B. Basteri.* The muscles arising from the amphioid sclerite are inserted into the labia which close the ducts from the azygous accessory and laminated glands; just the end of the last-named gland is seen above the labia. The inner portion of the mucous gland on the right side is shown just at its end, where the minute passage from the testes exists; this is shown by the small circle in the middle of the light spot; the other parts of the mucous glands are cut a little deeper in the wall of that organ.

42. Transverse section of male *Bdella vulgaris* posterior to fig. 41 and taken in about the central plane of the penial canal (the head of the canal bends over in this species). The small part of the azygous accessory gland is seen cut through transversely immediately above the penial canal.

43. Transverse section of female in the plane of the receptaculum seminis: × 30. The oviduct is distended by eggs, some nearly ripe for discharge. The cells of the cæca of the ventriculus are full of food-droplets. The walls of the oviduct have become very thin in consequence of the distension

44. Section through part of the wall of the oviduct of a young female: × 250; showing the thickness of the wall, the mode of folding, and the cellulation.

45. The respiratory organs: × 65. The whole of the air-chambers and principal tracheal trunk are shown, but the finer tracheæ are cut short.


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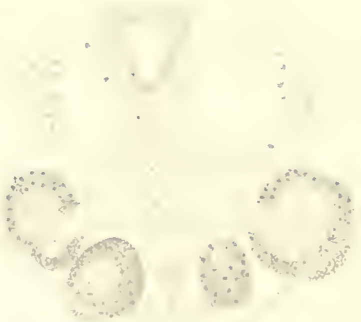
41


40

37


36

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35


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44


42

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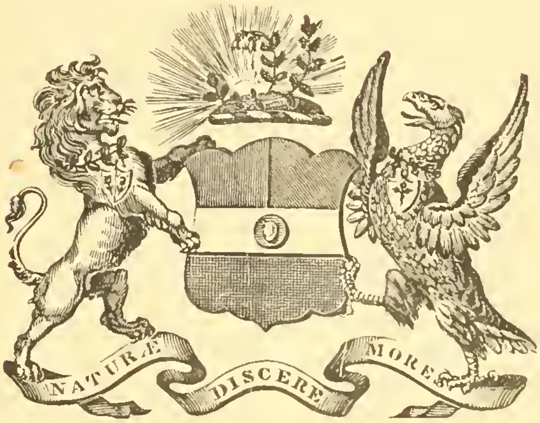

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INDEX.

[NOTE.—Synonyms and Native Names are printed in *italics*. A star is added to names which appear to be used here for the first time.]

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ERRATA.

Page 132, line 17, *for* pumilla *read* pumila, *Scott.*

Page 203, line 33, for *Ichnosoma* read *Ischnosoma.*

Page 209, line 8, *for* Sphæronidæ *read* Sphæromidæ.

Page 247, line 22, for *Phreotoicus* read *Phreatoicus.*

Page 280, first line, *for* vol. xxiv. *read* vol. xxix.

Page 468, line 20, *for* Ann. Nat. Hist. (5) viii. p. 151 (1891) *read* (6) viii. &c.

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