Bergen, Norway. Museum

REPORT
ON THE SCIENTIFIC RESULTS
OF THE
"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

CARRIED OUT UNDER THE AUSPICES OF THE NORWEGIAN GOVERNMENT AND THE SUPERINTENDENCE OF

SIR JOHN MURRAY, K. C. B.
and DR. JOHAN HJORT

VOLUM III
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CONTENTS.

CEPHALOPODA

FROM THE

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

BY

CARL CHUN

WITH 2 PLATES AND 11 FIGURES IN THE TEXT

the dorsal side of the enormous fins. This is a structure of the skin similar to the one observed by JOUBIN in an Onychoteuthid and explained as a coating of scales. The French scientist applied the name of *Lepidoteuthis* to this large cephalopod, which was taken from the stomach of a whale. I have previously stated (1910, p. 6), that the structure in question is by no means a coating of scales; it is a peculiar structure of the cuticle, which only becomes plainly visible after maceration. This opinion is now considerably strengthened by the interesting new species, which I call *M. hjorti* in honour of the distinguished leader of the expedition. The five specimens taken have suffered a good deal during capture. Only one specimen is fairly well preserved, possessing both tentacles intact, and it has been represented in pl. II. The specimens were captured at the following stations:—

Stat. 52.	1200 m. w.	3 specimens, dorsal mantle-length 95, 85, 71 mm.
„ 62.	3000 —	dorsal mantle, length 68 mm, both tentacles well preserved.
„ 63.	?	dorsal mantle, length 55 mm badly damaged.

Also a young specimen, dorsal mantle-length 30 mm, taken at Stat. 52 1200 m. w. evidently belong to this species.

The measurements of the large specimen from Stat. 52 are as follows:

Ventral length of mantle	92	mm
Dorsal „ - „	95	„
Total breadth of both fins	102	„
Length of body to base of 4th arm	120	„
Length of right fourth arm	73	„
Length of left „ „	75	„
Length of dorsal arms	44	„
Breadth of head	41	„
Length of funnel cartilage	6	„
Maximum breadth of mantle	35	„
Diameter of eye	26	„
„ - lens	9	„

As we see from these measurements our species is above all characterised by an enormous breadth of the fins, which are located on the dorsal side of the pointed mantle and reach nearly to the anterior edge of the mantle. This character appears even in younger specimens and offers a striking point of difference from the other species of *Mastigoteuthis*, in which the fins never are so enormously developed. The fin is generally of a rhombic shape, the corners being somewhat rounded.

The head is blown up by the huge eyes, presenting cheek-like protruding folds towards the short neck. On these folds are situated the two short-stalked olfactory tubercles, 2 mm long and terminating in an acorn-shaped point. The funnel is of moderate size and is surrounded by the cheek-like folds of the head. The funnel cartilage is relatively small, oval or egg-shaped, the exterior and posterior edge protruding slightly without, however, forming a distinct tragus and antitragus.

Fig. 1. *Mastigoteuthis Hjorti.* Stat. 52.

The arms are on the whole moderately long and exhibit the length-relation typical for *Mastigoteuthis* viz: 4, 3, 2, 1, They are feeble, angular, provided with 2 rows of comparatively small stalked and ball-shaped suckers, of which the largest measure 1·3 mm. in diameter. The suckers are characterised by 9 or 10 tack-shaped little teeth fringing the dorsal edge; the teeth are not pointed, and continuously decrease in size towards the sides. Protective keels or webs are poorly developed, and only the ventral arms exhibit a marked development of swimming webs or membranes. The skin of the buccal runs into 7 flaps, of which the ventral ones are triangular, somewhat close together, and fixed to the ventral side of the ventral tentacles.

The tentacles of the specimen captured at Stat. 62 are well preserved on both sides. They are whip-like, having a round stem and an enormously long club 75 mm in length, which exhibits no thickening and is pointed at the end. The protective webs are quite plainly visible, being about 0·5 mm broad and showing broad and densely located transverse muscles. The minute suckers about 0·25 mm in diameter are scantily distributed in two rows on the proximal part of the club; very soon however the suckers are gathered irregularly into approximately 4 rows, then gradually arranged by 12 and finally by 18 or 20 in an oblique row. An accurate enumeration of the suckers is difficult, as the club is round and the suckers occupy nearly two-thirds of its surface.

The gladius exhibits in a small specimen from Stat. 52 a free cone, the terminal part of which is perfectly closed for a length of 23 mm. Generally speaking it seems to be similar to the gladius previously described by me in the case of *M. cordiformis*.

The colour of our specimens is quite striking, for though not in good condition we can plainly see that fins and body both dorsally and ventrally are of a bright purple rose colour; along the rows of suckers and on the buccal skin a dark, almost black, rose colour is visible.

As a character not unimportant to the definition of the species I finally draw attention to the occurrence of light-organs on the eyes. Two light-organs are located on each side of the enormous greyish-blue eye bulb, the diameter of which is 26 mm in the largest specimen. A large light-organ 4 mm, in diameter is situated on the median inner edge level with the mouth of the funnel, and a smaller one 3 mm in diameter is noticeable in front, between the bases of the 2nd and 3rd arm. In several specimens these large and peculiar light-organs are visible through the skin.

As mentioned above this new species is marked in a very peculiar way, the skin being decorated by a pattern of rhombic figures. The rose colouring having been better preserved in the furrows between these figures, the latter become more prominent. We can thus plainly see that the marking is generally caused by diagonal furrows, separating the rhombic figures, which are about 4 mm broad on the average.

In one of the large specimens from Stat. 52 we find on the ventral side about 6 polygons in each transverse row, while the head exhibits 2 oblique rows of rhombuses, starting from the base of the 4th arm, and bordering off a triangular space containing about 5 rhombs around the funnel. In many cases, however, the rhombic character of the marking is not so regular, and we find either polygonal markings or wart-like protuberances. As the specimens have been damaged, in some cases the ventral side in others the dorsal being worn and frayed, the marking is never clearly visible in all parts of the body, but a comparison of the specimens shows that the marking occurs all over the ventral area of the body, including the fins and the bases of the 4th arms, as well as on the dorsal area of the fins.

Grimalditeuthis Bonplandi Vérany.

Loligopsis Bonplandi Vérany 1837, p. 99, pl. 1 a.
Grimalditeuthis Richardi Joubin 1898, p 101, figs. 1, 2.
— *Bonplandi* Pfeffer 1912, p. 628, pl. 47, fig, 1.

At Stat. 53 the net lowered to 2600 m captured a Chiroteuthid, which evidently belongs to the genus *Grimalditeuthis*. The tentacles and the second posterior fin have been lost, the gladius being broadly broken off at the hind part. The anterior fin is however well preserved and exhibits the squarely oval shape peculiar to this genus. The arms do not vary much in length, and their relative size may be characterised by the formula 3, 2, 1, 4. The eyes have during capture been caused to protrude a little, and the stalked olfactory tubercle is situated level with the funnel. An important feature in the genus *Grimalditeuthis* is the symphysis between the edge of the mantle and the funnel cartilage, a feature found in our specimen, which is semi-transparent and exhibits a delicate pigment consisting of purple chromatophores, situated on the dorsal parts of the head, along the gladius and on the arms. The present specimen differs from *Grimalditeuthis Bonplandi*—described by Joubin in 1900 from a beautifully preserved specimen under the name of *G. Richardi*—in lacking the bulb-shaped and strongly pigmented swelling at the end of each arm. Whether this character, however, is sufficient to establish a new species can only be learnt from future collections.

Dorsal length of mantle (from hinder edge of the fin)	56	mm
Length of neck and head	29	,,
Diameter of eye	5	,,
Breadth of both fins	42	,,
Length of the fins	27	,,

Doratopsis Rochebrune.

As mentioned in a previous paper (1910) I agree with Ficalbi in considering the neat and slender forms described as *Doratopsis* as being really larvae of *Chiroteuthis*. Full-grown specimens of *Chiroteuthis* have certainly not been taken by the expedition, but the captures include a number of juvenile forms which I consider as belonging to *Doratopsis*.

Doratopsis vermicularis Rüppell et Vérany.

Loligopsis vermicularis Rüppel 1845.
— — Vérany 1851, p. 123, pl. 40, figs. a, b.
Doratopsis vermicularis Rochebrune 1884, p. 18.
— — Chun 1910, p. 285 ff., pl. 47, fig. 3.
— — Pfeffer 1912, p. 555, pl. 46.

Stat. 64. 1000 m. w. One well preserved slender specimen.

Doratopsis lippula Chun.

Doratopsis lippula Chun 1908, p. 89, 1910, p. 291, pl. XLV, figs. 6, 7.

Stat. 51. 4000 m. w. One somewhat damaged specimen, possessing only 3 or 4 suckers on the ventral arms. The short and broad club, which is also provided with a web, is similar to the same organ described by me in *D. lippula*.

Doratopsis exophthalmica Chun.

Doratopsis exophthalmica Chun 1908, p. 89, 1910, p. 290, pl. XLV, figs. 1—5.

Stat. 90. 200 m. w. 3 specimens, evidently young stages, belong to this species. They were captured at the following stations.
Stat. 53. 1600 m. w.
„ 88. 1500 —
„ 94. 200 —

Doratopsis sp.

Young specimens of *Doratopsis* which cannot safely be identified were taken at the following stations:—
Stat. 23. 200 m. w.
„ 53. 600 —
„ 56. 100 —
„ 58. 200 —
„ 81. 200 —
„ 90. 1000 —

Cranchiidae Prosch.

The Cranchiidae might be expected to play an important part in the spoils of the expedition, but the collections contain mostly young specimens and larvae, which only in a few cases can be identified as belonging to definite genera.

Cranchia scabra Leach.

Cranchia scabra Leach 1817, p. 410, pl. XVIII, fig. 1.
— — Chun 1910, p. 328, pls. XLVIII—LX.
— — Pfeffer 1912, p. 650, pl. 47, figs. 22—28.

Stat. 52. Surface, at night: one specimen of average size, mantle-length 24 mm.
„ 51. 4000 m. w. one small specimen.

Leachia cyclura Lesueur.

Leachia cyclura Lesueur 1821, p. 90, pl. VI.
— — Pfeffer 1912, p. 650, pl. 47, figs. 2—10.

Stat. 23. 1215 m. w. Trawl, one badly damaged specimen, which can be identified by means of the 5 light-organs, situated on the eye.
„ 64. 3000 m. w. Two specimens.

Desmoteuthis pellucida Chun.

Desmoteuthis pellucida Chun 1910, p. 357, pl. LIII, fig. 1, pl. LIV.
Megalocranchia pellucida Pfeffer 1912, p. 716.

Several well preserved and adult specimens belonging to this species were taken. They are peculiar in possessing large orange-coloured pigment-spots, just as I have previously observed in a living specimen.
Stat. 10. 500 to 180 m. 2 young specimens.
„ 45. 200 m. w. dorsal mantle-length 49 mm.
„ 67. 2200 — small damaged specimen.
„ 98. 200 — dorsal mantle-length 52 mm.
„ 98. 1000 — — — 49 „
„ 101. 1000 — — — 60 „

Corynomma speculator Chun.

Corynomma speculator Chun 1906, p. 85, 1910, p. 367, pls. LV, LX, figs. 13—16.
— — Pfeffer 1912, p. 737.

Stat. 51. Surface, young specimen.
„ 64. 2500 m. w. — —

Teuthowenia megalops Prosch.

Owenia megalops Prosch 1847, p. 64, pl. I, figs. 4—6.
Teuthowenia megalops Chun 1910, p. 376.
— — Pfeffer 1912, p. 742, pl. 48, figs. 5—11, 17, 81.

Stat. 10. 200 m. w., one young specimen.
„ 45. 300 — two specimens.
„ 45. 2000 — one —
„ 51. 200 — one —
„ 58. 100 — one —
„ 63. 500 to 200 m., one specimen.
„ 64. 300 m. w., two specimens.

The specimens have nearly all shrunk, some of the characters of the species being however plainly visible.

Toxeuma belone Chun.

Toxeuma belone Chun 1906, p. 86, 1910, p. 380, pl. LVI, fig. 10, pl. LVIII, figs. 1—5.
— — Pfeffer 1912, p. 700.

This form had been taken by the "Valdivia" in the Southern Equatorial Current of the Indian Ocean, and it was very interesting to me that the present expedition had taken four specimens in the North Atlantic. The specimens are in some cases only a little larger than the specimen described by me. The arrow like slender shape of the body, and the slightly telescopic eyes possessing two-stalked light-organs are, however, plainly recognisable in all the specimens.

Stat. 49 B. 3000 m. w.
„ 51. 4000 — Gladius about 64 mm.
„ 53. 2600 —
„ 67. 1200 — Gladius 71 mm.

Galiteuthis Suhmii Hoyle *(Taonidium).*

Taonius Suhmii Hoyle 1886, p. 192, pl. XXXII, figs. 5—11.
Galiteuthis (Taonidium) Suhmii Chun 1910, p. 382, pl. LIX.

Stat. 64, 200 m. w. one specimen; the middle rows of suckers in the club are just developing into hooks.

Fig. 2. *Bathothauma lyromma*, juv.
Stat. 51.

Bathothauma lyromma Chun.

Bathothauma lyromma Chun 1906, p. 86, 1910, p. 389,
pl. LVI, fig. 9, pl. LVII, figs. 1, 2,
pl. LVIII, figs. 6, 7.
— — Pfeffer 1912, p. 753.

The rediscovery of this fantastically shaped Cranchiid, possessing enormous arms, should be of considerable interest. The specimen taken at Station 51, 700 m., has a mantle-length of 21 cm, but shows perfectly well the characters peculiar to the genus *Bathothauma*. As shown in fig. 2 the fins are wide apart even in this young specimen. The well preserved eyes posses enormous light-organs and are located on straight stalks, which have evidently been slightly damaged and broken during capture in the specimen taken by the "Deutsche Südpolar-Expedition".

Two larvae, the mantles of which are some 7 mm. in length, exhibit such a marked likeness to the present young specimen of *Bathothauma*, that I have no hesitation in considering them as belonging to this species. Even if they have shrunk to a certain extent, the position of the fins, which are separated by the broad cone of the gladius, and the extraordinary long and plump eye-stalks plainly contribute to justify this determination.

MYOPSIDA d'Orbigny.

Spirulidae Owen.

Spirula australis Lamark.

Pls. I, II, figs. 2, 3.

Some larvae of *Spirula* must be counted among the most precious spoils of the expedition. Being very inconspicuous they are easily overlooked, but when more closely considered they prove truly invaluable in extending our knowledge of *Spirula*. Some young specimens approaching in appearance the adult *Spirula* are available and we have finally a full grown specimen, mantle-length 26 mm., which, however, I regret to say, is somewhat damaged. This valuable material, comprising 8 specimens in all, was secured in the vicinity of the Canary Islands, by the aid of plankton-nets. It contributes largely to confirm the opinion, previously set forth by me (first of all in my lecture on *Spirula* to the Zoological congress at Frankfurt 1909), that *Spirula* by no means lives near the sea-bottom nor, as is very often supposed, attaches itself to rocks, but is a pelagic decapod, living in deep water. Evidently *Spirula* has a peculiar liking for the Canary current. As long ago as 1836 the corvette "La Recherche" took some very damaged specimens at the surface evidently derived from great depths, which were shortly described by Robert and also by Blainville (in 1837). Finally the only larval *Spirula* described by Joubin (Bull. Inst. Oceanogr. Monaco 1910) was also taken at the Canary islands (Ferro), during one of the cruises of the prince of Monaco.

Before giving a short description of the larvae, aided by reproductions I enumerate the examples captured:—

Stat. 34. 1000 m. w. Youngest larva, 6 mm long, with 5 visible chambers.
„ 35. 2400 — Somewhat older larva with 6 visible chambers.
„ 42. 900 — More advanced larva, total length 9 mm, 7 chambers visible.
„ 45. 3000 — Young stage, dorsal mantle-length 12 mm.

Stat. 42.	300 m. w.	Two young specimens, dorsal mantle-length 16 and 18 mm.
„ 44.	4000 —	Specimen with a dorsal mantle-length of 23 mm.
„ 45.	3000 —	Largest specimen, dorsal mantle-length 26 mm.

I have not yet examined the internal anatomy of the larvae, and describe only their external appearance, which confirms Joubin's description, also founded on external characters, and in certain respects completes it.

The youngest larva (pl. I, figs. 1, 2) is, like the other larvae, well preserved, and having been kept in formalin exhibits no shrinking of the mantle. It has a barrel-like somewhat clumsy shape, and at the posterior end of the body we can on the outside see 5 chambers projecting. As mentioned by Joubin in the case of his specimen, the latter are entirely covered by the mantle, which however is very thin just over the chambers. We may further notice the fact that the posterior part exhibits no thickening and also no obvious pigmentation. The edge of the mantle is very clean-cut, and shows as yet no traces of dorsal and ventral angles in the mantle. Particularly interesting are the small size and the position of the fins. They are spatular in shape, 0·6 mm. broad, and separated from each other by the entire breadth of the chambers. Their bases run obtusely to the axis of the body and do not reach the posterior end, which is never overlapped by the small fins.

The head section of our larva protrudes above the edge of the mantle, the broad and sturdy funnel being perfectly free and reaching the base of the arms. Interesting also is the minute size of the eyes, which are located level with the edge of the mantle. They are oval and have a longitudinal diameter of only 0·26 mm. Joubin has already drawn attention to the small size of the eyes.

The arms are perfectly developed, the 4th arms however being very small and stumpy. The first and second pairs of arms are almost equal in size, the third being somewhat smaller. The inner surface of all the arms is covered with minute suckers, arranged in four or five longitudinal rows. No traces of the tentacles are visible externally. In the adult animal they may be drawn into a kind of sheath and I suppose that they have already been developed. The upper jaws run into a point and, protruding a little, push the inner lips and the buccal skin aside.

The pigmentation of our larva is a little more pronounced about the head, where densely scattered light brown chromatophores with a slight touch of purple red occur. The funnel and arms are entirely devoid of chromatophores, and on the mantle they are also very faint and scarce. The edge of the mantle shows no accumulation of them, and only at the posterior end of the body, about the shell and around the whitish fins, a small gathering of chromatophores is visible.

As regards the more advanced larval stages (pl. I, figs. 3—6) I will mention them quite shortly, as their main features are similar to what has been described above. The mantle still exhibits the barrel-like shape and no trace of angles or indentations are visible in the edge of the mantle. The shell begins to appear more distinctly at the posterior end of the body, and we may see 6 or 7 chambers, which are very sharply defined in the largest larva from Stat. 42. The siphon is now and again faintly visible through the chambers. The latter are always covered by the thin outer skin, which in this posterior region is more profusely pigmented than in the youngest stage. The pigment on the edge of the mantle is beginning to increase and the pigment on the head part has expanded, covering the arm-bases. The fins have grown a little, but their position has not altered perceptibly. As the head is drawn far into the mantle, I can only give prominence to the fact that the tentacles are not visible in any of the more advanced larvae. The arm-cluster is however very nicely displayed, and the tentacles could not possibly be overlooked. A feature, which is faintly noticeable even in the youngest larva, has now become more prominent, for the mantle becomes somewhat thickened about the chambers of the shell and about the bases of the fins, even now indicating the limit of the so-called ovals, which, as we know, later on appear very conspicuous on the dorsal and ventral sides.


Fig. 3. *Spirula.* Young larva from Stat. 35.


Fig. 4. *Spirula.* Advanced larva from Stat. 43.

Compared to the three larvae just described, the young form from Stat. 45 (pl. II, fig. 2) exhibits a marked advance in development. The dorsal mantle-length is 12 mm, while in the oldest larva it is only 8 mm. We notice first of all that dorsal and ventral angles have developed in the edge of the mantle, but rounded and as yet not very prominent. The fins are now larger. Their bases measure 2 mm., slanting dorsally in front and ventrally behind. The fins, 3 mm broad, do not yet overlap the posterior end of the body. The pigmentation of the mantle has advanced, the edge of the mantle and the posterior end of the body being intensely coloured. The intermediate part of the mantle seems to be poorly pigmented, but it had only in part been preserved in the case of one of the older stages. In the other cases it had been to some extent damaged, the silvered layer of the cutis appearing on the surface of the specimens. The shape of the posterior part of the body is further of particular interest (pl. II, fig. 3). Being light-coloured it is sharply distinguished from the intensely pigmented parts surrounding it, and in its centre we notice for the first time traces of a white conical structure, which I have attempted to explain as being a light-organ, surrounded by a hardly perceptible thickening. Although the specimen has been somewhat damaged, the chambers are not laid open but are covered by a thin membrane. The thickening of the mantle having now increased about the shell, the ovals provided with a thin membrane are more sharply defined. On the head the greatly enlarged eyes are conspicuous. They may be seen from the side above the edge of the mantle, and are almost entirely covered by the nearly closed fold of the lid. The diameter of the eyes would be at least 2 mm. The arms show a more powerful development than in earlier stages, but are still devoid of strong pigment like that characterising the other parts of the head.

As regards the other young specimens of *Spirula,* their shape gradually approaches to that of the adult animal. The club-section of the tentacles protrudes only a little, one might almost say timidly, among the arms. The eyes increase in size and the formation of angles in the mantle becomes more marked, the ventral ones commencing to enclose the funnel. Above all the posterior part is approaching its final development. The whitish cone of the light-organ becomes more sharply defined, and is surrounded by the thickened pigmentless moulding, the lips of the latter surrounding the light-organ and forming a faintly pit-shaped depression. Pigment has been intensely developed around the light-coloured pole and has been distributed dorsally as well as ventrally over the chambers of the shell. The pigment is almost as vigorous on the bases of the fins, which until now have been devoid of pigment. I wish finally to give prominence to the fact that the pit-shaped depression around the light-organ at the posterior end of the body becomes more and more conspicuous during development, and also that folds on the arms become visible, and the tentacles protrude more, as the animals grow up. What has been said above would in the main characterise the peculiarities exhibited by the young *Spirula.*

There is, however, one point which i should like to discuss a little further, a point specially emphasised in my description of the adult *Spirula* taken by the "Valdivia", viz. that the shell is never left bare on the dorsal or ventral side. In all the specimens of *Spirula* I find the shell covered by the thin mantle in the region of the so-called ovals. Only in the oldest specimen, the mantle of which was damaged, the chambers are now and again bared, but we recognise the frayed edge of the membrane round the bared chambers, and we may convince ourselves beyond doubt that we have to do with a damaging of this frail structure. Joubin in his description of the youngest larva still starts from the presumption that the chambers are normally uncovered; he attempts to explain this in quite another—and to my mind much more satisfactory—manner, than Pelseneer did. But since I have been able to show that in the fullgrown *Spirula* the chambers are never bare, one may dismiss the idea, that *Spirula* has an exterior shell. As regards the structure and development of this shell I intend to give a more detailed account in a future publication.

I may finally mention that in all those specimens where the mantle is damaged, and especially in the cases where the silvery layer of the cutis has been rubbed off, a reticular division of the muscular surface is visible, which is, however, plainly visible only in the case of the two oldest specimens, while in the young stages it appears rather as a fine granulation. I therefore once more declare myself opposed to the attempts at establishing a separate species viz.: *Spirula reticulata,* the said reticulation being a character common to all representatives of the genus, and appearing only on the surface of damaged specimens.

Sepiolidae Tryon.

Heteroteuthis dispar Rüppell 1845.

Stat. 42. 200 m. w. 8 young specimens.
„ 56. 100 — 300 m. w. 3 larvae.
„ 58. 100 — about 20 young specimens, the largest one among these—a male—possessing somewhat enlarged suckers on the third arm.

Sepiola Rondeleti d'Orbigny 1839.

Stat. 39 B. Trawl 292 m. 1 specimen.
„ 96. 200 m. w. 3 specimens.

Rossia Caroli Joubin.

Rossia Caroli Joubin 1902, Mém. Soc. Zool. France p. 135, fig. 34, 35.
— — Fischer et Joubin Exp. Travailleur et Talisman 1906, p. 331, pl. XXIV, figs. 3—8.

Stat. 70. 1100 m. w. 1 specimen. The "Michael Sars" specimen is a little smaller than the one described by JOUBIN, 1902, but it agrees fairly well with his diagnosis. This is specially the case as regards the shape of the club, which is thin, with 6 or 7 rows of small dark suckers. The body, arms, and fins exhibit a purple brownish colouring.

Loliginidae d'Orbigny.

Loligo media Linné.

Stat. 14. Trawl 69 m, about 20 specimens of average size.
„ 20. „ 153 m, one long-tailed specimen.

Loligo Forbesi Steenstrup.

Stat. 39 B. Trawl 267—280 m. One specimen, badly damaged.

Sepiidae d'Orbigny.

Sepia d'Orbignyi Férussac.

Stat. 34. 1 specimen.

Sepia officinalis Linné.

Stat. 37. Trawl 39 m. 3 specimens.

OCTOPODA.

Philonexidae d'Orbigny.

Tremoctopus atlanticus d'Orbigny.

Stat. 51. Surface. 2 specimens.
„ 53. — 4 —
„ 62. — 3 —

Argonauta Linné sp.

Stat. 45. 200 m. w. One very young larva evidently a female.
„ 49 B. 2000 — One young larva.

Quite young octopod larvae, which belong either to *Argonauta* or to *Tremoctopus* were captured at:—

Stat. 95. 2000 m. w.
„ 98. 300 —
„ 101. 200 —

Octopodidae d'Orbigny.

Octopus (Polypus) n. sp.

Stat. 58. 100 m. w. A small flesh-coloured octopod, in which the eight arms are thrown far back, is interesting in so far that the semi-gelatinous mantle encloses the funnel, only a narrow slit in the mantle being left free, as in the Chiroteuthidae. I have looked in vain for a reference to a similar arrangement, and consequently believe that we have to do with a new form.

Octopus Lothei n. sp.

Stat. 41. Trawl. 1365 m. This large octopod represents a deep-sea form, the body exhibiting a peculiar gelatinous consistency, and the perfectly smooth surface having a light greyish violet colour. Its total length is 445 mm. and the other measurements run as follows:—

Mantle-length to ventral edge of mantle about	70 mm
Posterior end of body to centre of eye	80 „
Posterior end of body to end of funnel	100 mm
Breadth of head	70 „
Length of first right arm	360 „
— - second „ „	355 „
— - third „ „	325 „
— - fourth „ „	275 „

The roundish arms have comparatively small suckers, 4 or 5 mm. in diameter, which only protrude slightly above the surface. The dorsal arms are joined by a broad outer web, running along the dorsal area until it reaches the proximal third part of the arm. Between the first and second arms the web runs along the ventral side of the dorsal arms as far as the points broadening a little in the distal section. This is also the case as regards the ventral web of the second, and also—though not quite so pronouncedly—the third arms.

The slit in the mantle reaches to a point in the median line between the mouth of the funnel and the eyes. The comparatively large eyes are dorsally located and the funnel is not very conspicuous. The present species evidently belongs to a group of Octopoda peculiar to moderate depths, described by VERRILL as *O. Bairdii, O. lentus* and *O. piscator.* The *Octopus* figured by JOUBIN (1900, tab. III, fig. 7) as *Octopus levis*, Hoyle, also belongs to this group, but when comparing the typical specimens taken at Kerguelen with JOUBIN's figure we recognise that the latter cannot be *Octopus levis*, which is distinguished by its reddish brown colour. JOUBIN's drawing is also sufficient to show that the species is devoid of such webs on the arms as we have mentioned above.

Bolitaenidae n. fam.

Octopoda with entirely gelatinous body; the cranial cartilage rudimentary. Eyes widely separated, the optic nerve being lengthened. Olfactory tubercles stalked,

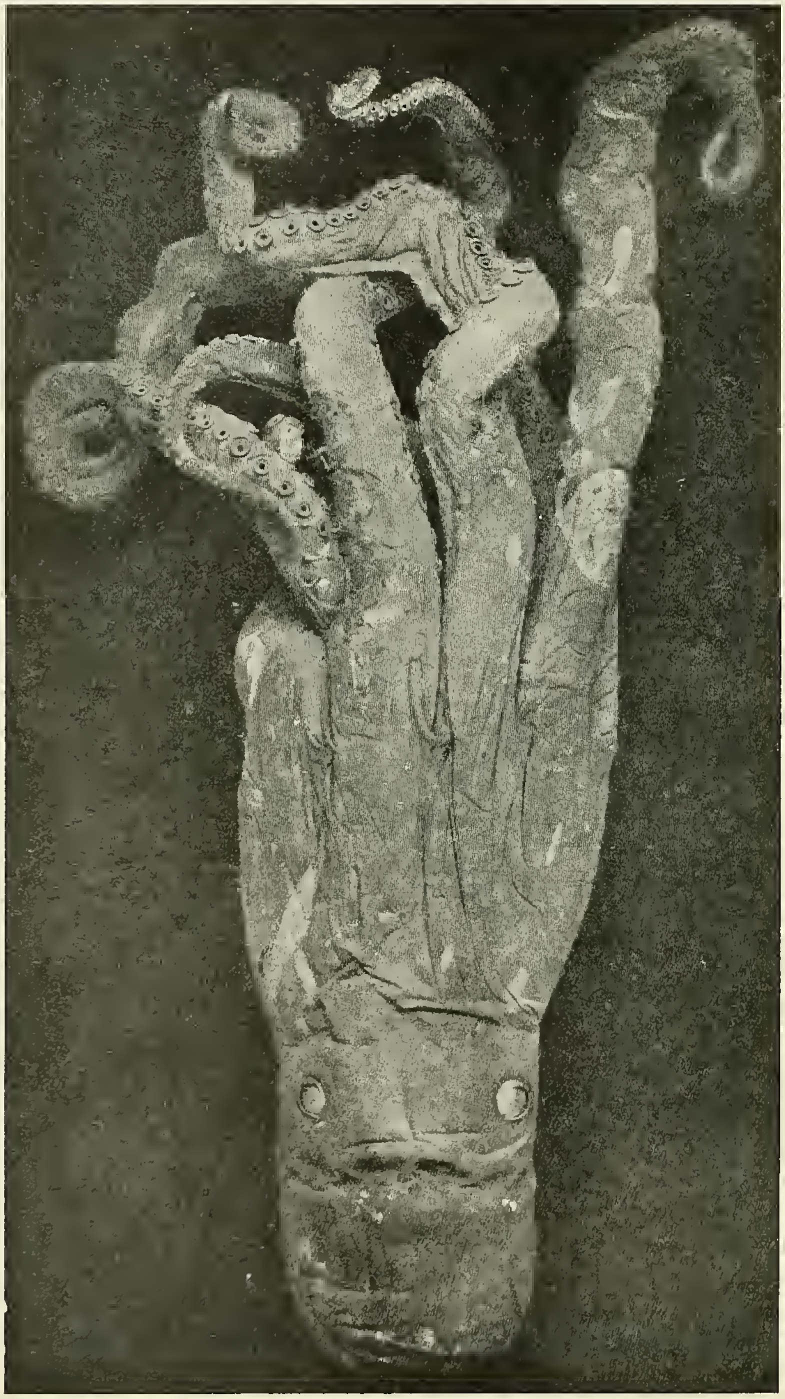


Fig. 5. *Octopus Lothei* n. sp. Stat. 41.

covered by the mantle. The third arms are the longest. The hectocotylisation implies an enlargement of all the suckers on the third right arm *(Bolitaena)*, or of the distal suckers of third right arm *(Eledonella)*. I intend in another paper to discuss more fully the reasons for establishing this new octopod family, comprising typical deep-sea forms, taken in the deep-sea nets of the expedition at various localities.

Eledonella Verrill.

Eyes comparatively small and bullet-shaped. Optic nerve strangely lengthened, arms frail, semitransparent.

Eledonella pygmaea Verrill.

Eledonella pygmaea, Verrill 1884, Trans. Connect. Acad., Vol. II, p. 145, pl. XXXII, fig. 2.

Stat. 45. 3000 m. w. 1 specimen.
„ 53. 2600 — 3 specimens, including a male having the fifth sucker (counting from the point) of the 3rd right arm enormously enlarged. The sixth and seventh suckers are smaller but still larger than the others.
„ 62. 3000 — 1 specimen.

Bolitaena Steenstrup.

Eyes elliptical, medium size. Arms coarse, non-transparent in the specimen preserved. All the suckers on the hectocotylised third arm grown large.

Bolitaena diaphana Hoyle.

Eledonella diaphana, Hoyle, Rep. Sc. Res. Challenger, Vol. XVI, 1886, p. 107, pl. IX, figs. 3—6.

Eyes elliptical, comparatively large; arms robust and in preserved specimens opaque.

Stat. 35. 2400 m. w. young specimen.
„ 53. 1600 — —„—
„ 53. 2600 — two well-preserved adult specimens.
„ 56. 300 — youngest specimen.

Small and transparent young stages of Bolitaenidae were taken at the following stations, but they are not easily referred to definite genera:

Stat. 64. 3000 m. w.
„ 92. 300 —
„ 92. 1500 —

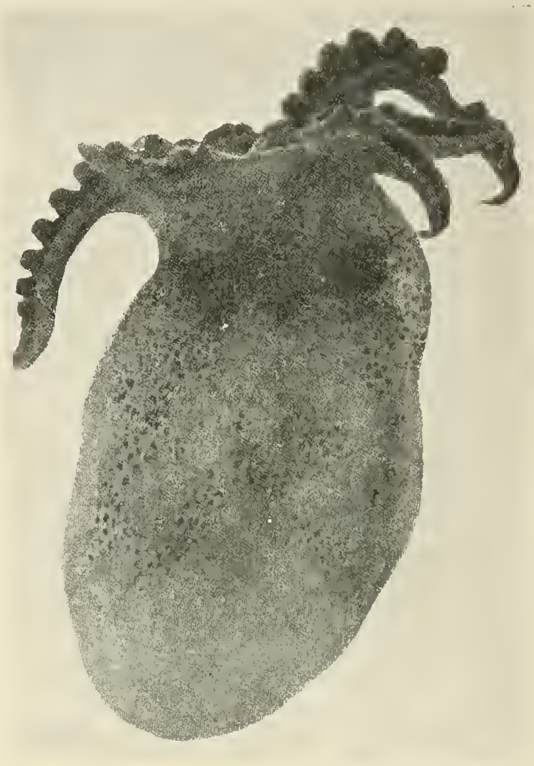


Fig. 6. *Bolitaena diaphana*. Nat. s. Stat. 53.

Cirroteuthidae Keferstein.

Opistoteuthis Agassizii Verrill.

Stat. 4. Trawl, 923 m. 4 specimens, which are very soft and considerably damaged. On the dorsal side the main colour is violet and on the ventral side chocolate brown, the light coloured suckers being very conspicuous. Judging from Verrill's figure (Bull. Mus. Comp. Zool. Cambridge, Mass., Blake Cephalopoda, Suppl. 1883, pl. 1 & 2) the animal is longer in the median line than in transverse section. This does not apply to our specimen inasmuch as both axes are of equal length.

In two specimens I have found an enlargement in certain suckers, and I do not think I am wrong in supposing that this is connected with hectocotylisation. The largest and best preserved specimen exhibits after the sixth proximal sucker 4 or 5 broadened arm-suckers, of which the middle one is largest while the others decrease gradually in size. At the point of the arms 2 suckers are generally enlarged, sometimes abnormally so. Some of these enlarged suckers exhibit pathological alterations, being swollen and devoid of an aperture. The same condition is also found in smaller specimen, not only 4 or 5 proximal suckers but also 2 or 3 distal ones having been enlarged.

Cirroteuthis umbellata Fischer.

Cirroteuthis umbellata Fischer, P. 1883, Journ. Conchyl. XXIII, p. 402.
— — Fischer, H. et Joubin, L. Exped. Travailleur et Talisman, Cephalopodes, 1906, pag. 318, pl. XXIII, figs. 1—5, pl. XXV, figs. 9, 10.
— — Joubin, L., Camp. Scient. Monaco, Cephalopodes, 1900, p. 21, pl. I, fig. 1, pl. III, figs. 1—5, pl. XII, fig. 3.
— — Joubin, L., *Stauroteuthis hippocrepium* Hoyle, Rep. Cephalopoda Albatross, Bull. Mus. Comp. Zool. Cambr. 1904, Vol. XLIII, p. 6, pl. I, fig. 1, pl. II, fig. 1, pl. III, figs. 1—4.
— — Massy, Ceph. Dibranch. Irel. Sci. Invest. 1907. I, p. 4.

Stat. 25. Trawl, 2055 m. Well preserved specimen.
„ 52. „ 2615 m. 4 specimens.
„ 70. „ 1100 m. Badly damaged specimen.

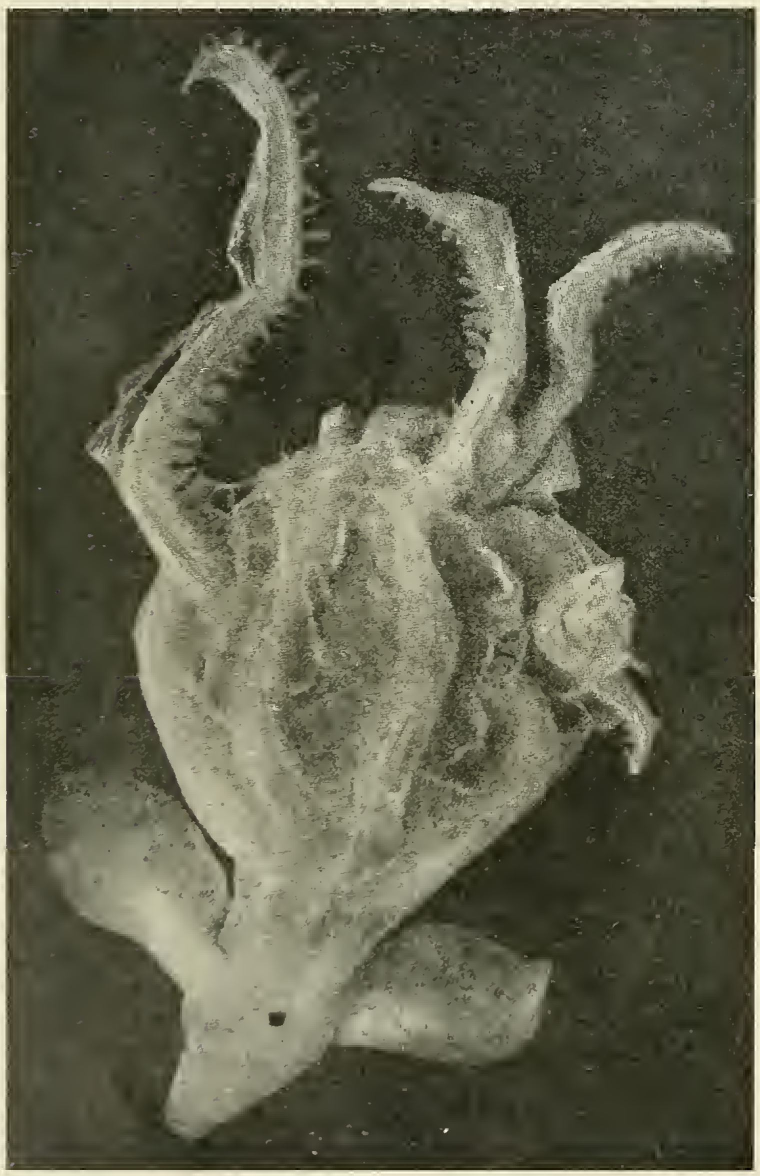


Fig. 7. *Cirrothauma Murrayi.* Photography of the preserved specimen.

I consider these specimens identical with the *Cirroteuthis umbellata* described by P. Fischer. As some of the specimens are considerable larger than the ones previously described some measurements may be recorded:

	Largest specimen	Large specimen	Small specimen
1st arm	300 mm	130 mm	72 mm
2nd „	260 „		
3rd „	230 „	104 „	
4th „	220 „	96 „	70 „
Length of fins	52 „	38 „	28 „
Length of mantle to centre of eye	83		
Diameter of eye		20 „	12 „

We note the fact that all the specimens were taken in the trawl. The coarse structure of the animal, and its likeness to *Opistoteuthis,* seem to indicate that we have to do with representatives of the genus *Cirroteuthis* which live near the bottom and form a transition to the typical bottom form *Opistoteuthis.* They are so like the genus *Opistoteuthis* that the somewhat damaged specimens at first sight might easily be mistaken for the latter.

Vampyroteuthis infernalis Chun.

Vampyroteuthis infernalis, Chun, Aus den Tiefen des Weltmeeres, 2 ed. 1903, p. 88.

Stat. 57. 2000 m. w.
„ 51. 3000 —

Two larvae, which I regret to say have been badly damaged. Their likeness to the genus *Vampyroteuthis* which I intend to describe more fully later, is so obvious, that I refer them to this genus.

Cirrothauma, n. gen.

C. Murrayi, n. sp.

Stat. 82. 3000 m. w. The present memoir ends with the description of a new and wonderful type of Cirroteuthidae, which may probably be counted among the most valuable spoils of the expedition. The specimen is a perfectly gelatinous semi-transparent cephalopod, the fragility of which recalls that of a ctenophore. Notwithstanding this, the specimen had been so well preserved in formalin, that I am able to give a suitable representation of it. Although the web on account of its excessive frailness has been torn, I consider it desirable to reproduce a photograph of the preserved specimen (fig. 7), because it conveys a good idea of this peculiar organism. The photograph shows that the posterior end of the body runs into a flap, the mantle having comparatively large fins. The eyes appear to be strikingly small, the funnel, which is surrounded by a narrow closely fitting slit of the mantle, being long and slender. The arms are of nearly equal length, and are joined together by a web, which leaves only the distal arm-points free. The following table records the size-relations:—

Length of body from posterior end to eyes	40	mm
Ventral mantle-length to funnel	37	„
Length of each fin	39	„
„ - first right arm	108	„
„ - second „	118	„
„ - third „	100	„
„ - fourth „	110	„
Diameter of eye	3	„

The gelatinous body exhibits an exceedingly faint violet colour, and only the parts round the mouth, the proximal section of the arms, and the web exhibit the purple chocolate colour peculiar to many deep-sea forms. The animal being so transparent the arm-nerves may be traced throughout the entire length of the arms, while in the anterior region of the mantle the yellow urinary sacks and the black branchial-hearts are indistinctly visible through the mantle. Also the ganglion stellatum appears as a minute yellowish knot, situated about 10 mm. behind the eyes. Chromatophores are lacking, with the exception of a large rhombic one situated on the ventral side between the two fins.

In founding the new genus *Cirrothauma* on the present specimen, I rely mainly on a character which is unique not only among the Cirroteuthidae but among the Octopoda. If we look at the inner side of the arms (fig. 8), we find them covered with minute suckers poised on long spindle-shaped and clumsy stalks of gelatinous substance. In the middle region of the arms, the length of these stalks is 4 or 5 mm, but towards the arm-points they gradually diminish in size. The same decrease in size is also noticeable in the proximal direction, i. e. the stalks gradually assume the form of clumsy conical humps and finally disappear; the 6 proximal suckers of each arm are sessile. The number of suckers counted on each arm was strangely enough constant, viz. 36.

The adjoined photograph, fig. 8, of the arms serves better than words to illustrate the striking impression created by the sight of the whole arrangement. We may further note that the stalked suckers are evidently out of function, being flattened and devoid of the sucking pit, and smaller than the normal proximal suckers.

If we examine the spindle-shaped sucker-stalks in the middle part of the arms more closely, we find them to consist of a gelatinous connective tissue, isolated strands oi longitudinal muscles appearing on the surface of the latter, branching distally in a dichotomous manner. Out-

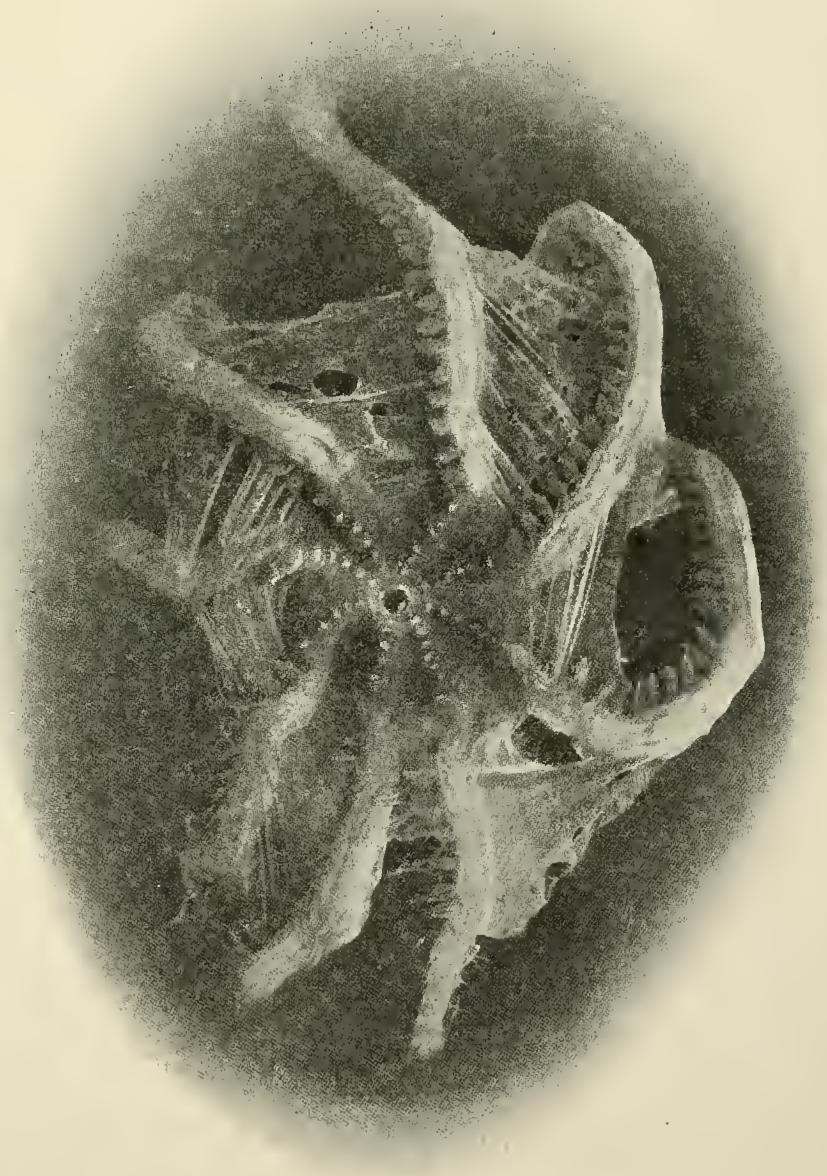


Fig. 8. *Cirrothauma Murrayi.* Oral aspect. The basal parts of the 8 arms visible.

side these we see in addition a system of exceedingly fine ring-muscles, while in the interior the capillary vessels, and also a whitish structure situated in the proximal third part of each stalk, are visible.

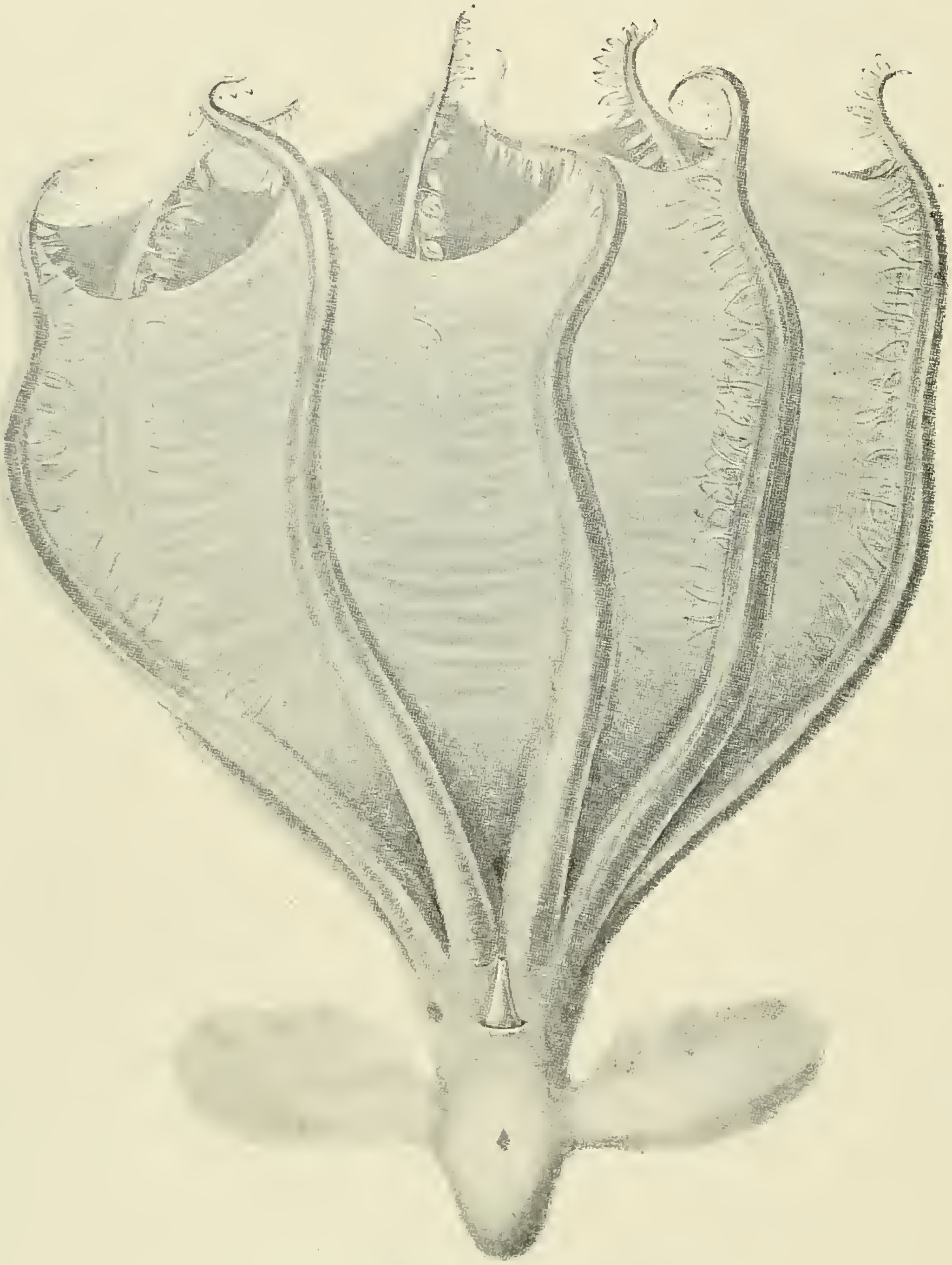


Fig. 9. *Cirrothauma Murrayi.* Ventral aspect.

If we examine sections of this whitish structure we find it to consist of a shell, the point of which has a distal and forward direction. The aperture of the shell is filled by a ball-shaped cellular body, which does not touch the edge of the shell. The latter is thickened towards the point, thinning away towards the edge, and reminds one of the reflectors occurring in the light-organs of many Oegopsidae. It consists of a gristly substance, the scattered nuclei being surrounded by a light-coloured area without pigment-covering. In the ball-shaped cellular body numerous small and round nuclei are visible, but there are no sharp divisions between the cells. Only on the proximal side more distinct grape-like cells occur.

I can only with some reserve venture to give an explanation of this structure. Without entering into hazy suppositions I will only point out that it first of all presents a certain likeness to a light-organ, the shell representing the reflector and the ball-shaped agglomeration of cells filling its aperture corresponding to the luminous body.

We may further mention that slender and transparent cirri alternate with the suckers or with their stalks, the longest of these cirri measuring about 7 mm. Besides this peculiar development of the arm suckers, which is unique among all known Cephalopoda, I may point to another equally surprising feature in the organisation of *Cirrothauma,* viz. that *Cirrothauma* is the only blind cephalopod known. I have already mentioned that the eye, situated between the second and third arms, is strikingly small, being only 3 mm diameter. It does not protrude, and a closer scrutiny proves it to be devoid of a lens. Seeing behind the eye, in the deep layers of the gelatinous mass, a second dark body, I decided to make a preparation of the entire structure, subsequently cutting it in sections. In this paper I will not enter into a detailed description but refer the reader to fig. 10, which illustrates the appearance of the isolated eye.

It is first of all striking that the eye as already stated is entirely buried in the jelly of the gelatinous body, the outer point of the eye being specially coated with a thick layer. The eye-bulb is almost ball-shaped, only a little flattened in front, devoid of pigment in the anterior third part, the rest being of a deep violet colour. The anterior border of the pigment is somewhat irregular, extending a little farther on the ventral side. The bulb is surrounded by a light-coloured space (a), representing the outer water-filled chamber of the eye. It is perfectly closed, and no trace of an opening is visible in our perfect specimen. This chamber overlaps the bulb behind, terminating in a ringshaped thickening, which perhaps may be explained as being homologous to the white body (alb.). The bulb is strangely thin in front and only a little thickened behind in the pigmented part. Above all the entire absence of a lens is confirmed, a fact noticeable on a merely superficial survey. Connected with this is the absence of a ciliary body and iris. The posterior side of the bulb is surrounded by gelatinous tissues, through the centre of which, as will presently be shown in detail, the optic nerve passes.

Behind the eye is located an almost equally large and also light violet coloured body (s. ven.), as previously mentioned. This body somewhat approaches the main axis of the animal, being of an irregular bullet-like shape, bulging a little behind. A large vein (v. ophth.) enters into this body, being presumably homologous to the v. ophthalmica of the normal cephalopod eye. The latter forms, as I have specially observed in *Bolitaena*, an enormous sinus around the optic ganglion. At first sight one might get the impression that the entire dark body represented an optic ganglion, but the sections show that very peculiar conditions are present, the body representing an enormous venal sac, densely filled with blood corpuscles. It is the latter which actually produce the dark colouring, and might easily induce anybody not familiar with the actual conditions to believe that one had to do with an optic ganglion filled with minute ganglion cells.

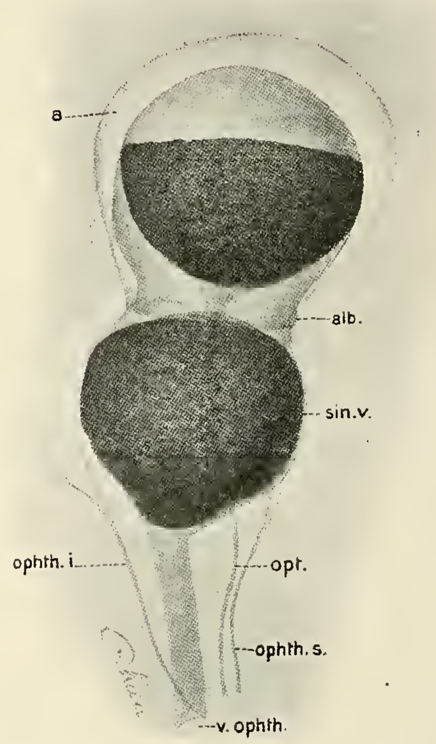


Fig. 10. Rudimentary eye of *Cirrothauma.*
a. External space surrounding the bulb. alb. White body. opth. i. Nervus ophthalmicus inferior. ophth. s. Nervus ophthalmicus superior. opt. Nervus opticus. sin. v. Sinus venosus. v. ophth. Vena ophthalmica.

If we penetrate still deeper, the yellowish brain becomes faintly visible, sending 3 fine nerves towards the bulb. The middle one of these is the optic nerve (opt.), which is not actually rudimentary, but very thin compared with the optic nerve of other Cephalopoda. It runs right through the dark sinus venosus without forming any thickening which might be explained as the ganglion pedunculi. Between the sin. venosus and the bulb a faint knot-like swelling is noticeable, being possibly a rudimentary ganglion of the optic nerve. Single strands run from the latter place to the bulb. The difference from normal conditions is quite obvious. The optic ganglion present in all Cephalopoda has been reduced to a faint thickening of the optic nerve just behind the bulb, and is entirely devoid of typical ganglion cells. Besides the the optic nerve we further notice two nerves approaching the surface of the bulb, branching in order to innervate the feebly developed muscle-lamellae, which are situated in the gelatinous tissues surrounding the eye. The dorsal one of these nerves corresponds to the N. ophthalmicus superior (ophth. s.), the ventral one corresponding to N. ophthalmicus inferior (ophth. i.).

Our description would be imperfect if we omitted to mention the layer, which we may consider as the retina (fig. 11). If we examine the pigmented part of the bulb somewhat closer, we find that this pigment is composed of two layers. The inner one of the layers coats the bulb with a dark and thin continuous layer, the outer one appearing on its periphery as isolated flakes or pigment granules; the dark violet hue of the bulb is mainly due to the latter. Behind the inner layer of pigment densely located nuclei are visible, being roughly arranged in two layers. They may possibly be considered as being the nuclei of pigment cells as well as nuclei of the retina cells. The degree of degeneration to which the eye has been subjected is most strikingly shown by the condition of the rods (st.). In all other Cephalopoda the latter are densely crowded and firmly welded together, exhibiting in transverse section the well known net-like structure. In our specimen however, they are widely separated from each other. They are strangely short and generally a little pointed at the free end, projecting like minute flames from the pigment-layer.

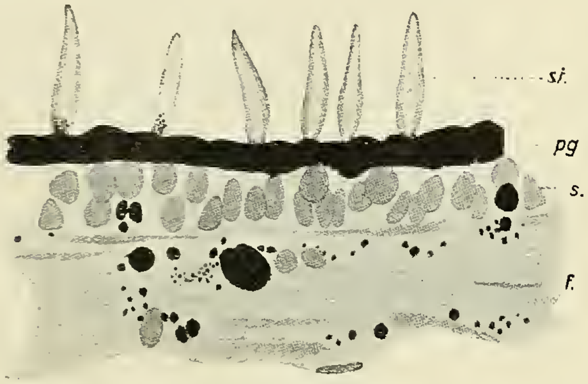


Fig. 11. Retina of *Cirrothauma*.
f. Fibrous layer. pg. Retinal pigment. s. Sense cells.
st. Scattered rods.

If we survey the whole of the conditions described, we recognise a reduction of the eye so far advanced, that nothing similar is known in the Cephalopoda. Among deep-sea Cephalopoda we certainly know forms with comparatively small eyes, but the very structure of the eye is never involved in the reduction. In the present case, however, we miss not only the dioptric apparatus, the lens and the ciliary body which forms the latter, but the optic nerve equally exhibits an extreme degeneration hitherto unknown in Cephalopoda. The ganglion pedunculi and the ganglion opticum are lacking, the white body which I consider as identical with the ringshaped thickening (alb.) being also rudimentary.

Finally, considering that the main layer of the retina (the layer of the rods) also exhibits an excessive degeneration, I think that I am justified in asserting—as I have done—that *Cirrothauma* is the only blind cephalopod known. The degeneration of the eye is much farther advanced than in the case of many blind vertebrates. Whether the development of light-organs in the gelatinous stalks is correlated to the degeneration of the eyes can only be settled if in future we should be lucky enough to bring one of these wonderful organisms to the surface alive and witness the organs mentioned by me actually emitting phosphorescent light.

In conclusion we may briefly discuss the question of the bathymetrical distribution of the Cephalopoda, as illustrated by the "Michael Sars" collections. In the first place we may remark that certain forms live at the bottom, having only been taken in the trawl. Typical denizens of the deep-sea mud are found in the genus *Opistoteuthis* taken at depth of 923 m. I consider the closely related *Cirroteuthis umbellata* only taken in the trawl in depths of 2615 and 2055 m as a bottom dweller, and also the large new *Octopus lothei* captured by the trawl in 1365 m. depth.

All the other Cephalopoda taken by the expedition are pelagic forms. As regards those among them which evidently prefer deep water, we have generally to do with rare guests represented usually by only a few specimens. It is impossible accurately to define the level at which they have actually been floating. During the cruise of the "Valdivia" our general impression was that the pelagic deep-sea Cephalopoda were either much rarer than the pelagic deep-sea fishes, or that they were better able to evade the nets. During the cruise of the "Michael Sars" large closing nets were employed, and the vertical range has been ascertained at least in the case of one species, viz. *Calliteuthis reversa*, which was taken at Station 52 in a haul between 1200 and 1000 m. The other closing-net hauls which yielded Cephalopoda were all made near the surface, as follows:

Stat. 10. 500—180 m. *Desmoteuthis pellucida*, 2 young specimens.
„ 63. 500—200 m. *Teuthowenia megalops*, 1 specimen.

Otherwise all the rare and peculiar Cephalopoda, which from their organisation I consider as deep-sea forms, were taken by the "Valdivia" as well as by the "Michael Sars" only when large open nets were lowered to considerable depths. This applies to those forms the eyes of which according to my investigation exhibit pigment in the state peculiar to dark surroundings, and the body of which is generally provided with light-organs, very often exhibiting a gelatinous swelling.

If we examine the list of captures recorded in this report, we find that the Histioteuthidae, Veranyidae, Bathyteuthidae, Cirroteuthidae, and most of the Cranchiidae occur only in deep hauls. It is further noticeable that the larval forms have sometimes been captured in shallow water, while the adult animals have nearly all been taken in the nets lowered to greater depths.

The facts emphasized as regards the representatives of the Oegopsidae apply equally to a number of Myopsidae. Among the latter I consider the Spirulidae as pelagic deep-sea forms, having at some length attempted to show this, as well as the single specimen of *Rossia caroli*. Among the Octopoda the Bolitaenidae have representatives which are probably distributed only in deep water. Their larvae were only twice taken in nets lowered to 300 m.

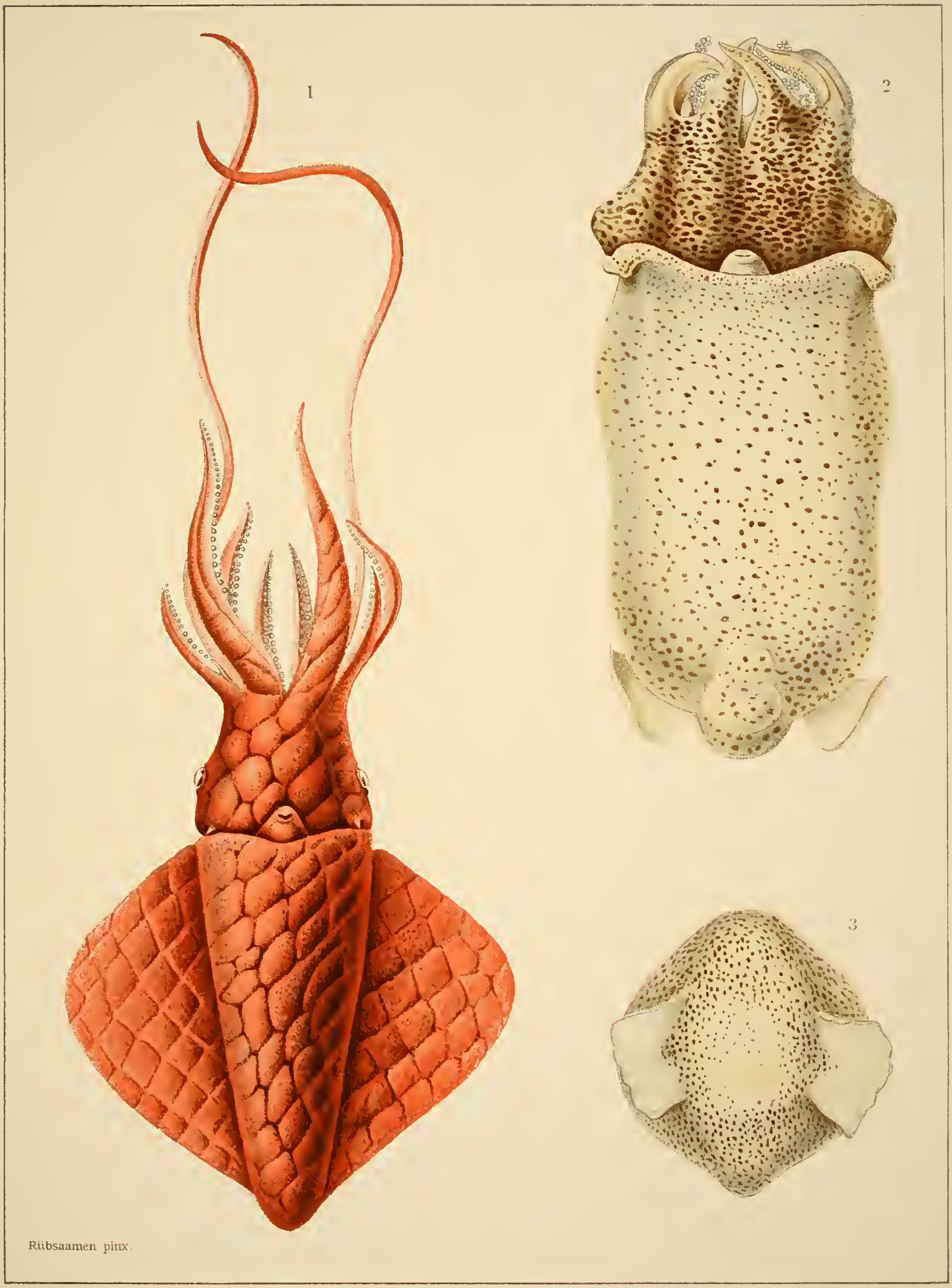
The blind genus *Cirrothauma*, one of the most precious spoils af the expedition, seems to show that among the Cirroteuthidae there are genera eminently suited to deep-sea life.

Experience from the "Deutsche Südpolar Expedition" shows that many fishes and Cephalopoda, provided with light-organs and from their structure probably deep-sea dwellers, arrive at the surface during the night. This applies in no wise to representatives of all deep-sea families, but only to certain groups. The above mentioned expedition captured *Cranchia scabra* and *Pterygioteuthis* at the surface at night, and it is noteworthy that these very forms were also taken by the "Michael Sars" in surface hauls during the night, as shown by the lists recording the captures of *Cranchia scabra* and *Pterygioteuthis Giardi*. Besides these we also notice *Brachioteuthis Riisei* which on the whole seems to prefer the surface layers. That exhausted or dead pelagic deep-sea forms may arrive at the surface has been emphasized by me before, but the expedition captured none of these.

Rübsaamen pinx.

Spirula Larvae.

Meisenbach Riffarth & Co., Leipzig



1. Mastigoteuthis Hjorti. 2. 3. Spirula juv.

Meisenbach Riffarth & Co., Leipzig.

CIRRIPEDIA

FROM THE

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

BY

P. P. C. HOEK

CIRRIPEDIA.

The Cirripedia collected during the cruise of the "Michael Sars" of 1910 to a large extent belong to the pelagic forms: five species of *Lepas* and one of *Conchoderma*. Deep-sea forms are represented in the collection by four species: one of *Poecilasma* and three of *Scalpellum*. All the forms belong to species previously described.

The Atlantic species of Cirripedia are now generally well known. The deep-sea investigations carried out by the "Challenger", the "Travailleur", the "Talisman", the "Albatross" etc., have greatly contributed to our knowledge of this group and the distribution of the species, especially as regards the North Atlantic.

The following species were collected by the "Michael Sars":—

1. ***Lepas anatifera*** Linné.

Stat. 61. June 20, 1910. Lat. 37° 7′ N., Long 38° 34′ W. Surface. Numerous specimens, large and small, attached to drifting wood.

Near Stat. 74. July 3, 1910, near St. Johns. Four specimens of different sizes.

Observations. This species is common in the Atlantic and in the Pacific as well.

2. ***Lepas anserifera*** Linné.

Near Stat. 67. June 27, 1910. Lat. 40° 17′ N., Long. 50° 39′ W. Surface. One specimen, attached to "Sargasso" weed at the surface.

Stat. 69. June 29, 1910. Lat. 41° 39′ N., Long. 51° 4′ W. Surface. One small and two very small specimens, attached to a little black stick; a few specimens attached to a floating piece of *Fucus*.

Observations. A common species in the Atlantic, the Pacific, the Indian Ocean etc.

3. ***Lepas pectinata*** Spengler.

Stat. 10. April 19—21, 1910. Lat. 45° 26′ N., Long 9° 20′ W. Surface. One specimen attached to a bird's feather.

Stat. 25. May 7, 1910. Lat. 35° 36′ N., Long. 8° 25′ W. Surface. Numerous small specimens, with *L. fascicularis.*

Stat. 31. May 10, 1910. Lat. 33° 47′ N., Long. 8° 27′ W. Surface. Small and very small specimens, on a piece of cork.

Stat. 69. June 23, 1910. Lat. 41° 39′ N., Long. 51° 4′ W. Surface, One very small specimen attached to a floating piece of *Fucus* (with a few specimens of *L. anserifera).*

Stat. 86. July 16, 1910. Lat. 47° 29′ N., Long. 30° 20′ W. Surface. Numerous specimens attached to a piece of pumice.

Stat. 91. July 22, 1910. Lat. 47° 32′ N., Long. 16° 38′ W. Surface. Quite a colony of specimens of different sizes, in company with *L. fascicularis.*

Stat. 92. July 23, 1910. Lat. 48° 29′ N., Long. 13° 55′ W. Surface. A few very small specimens attached to a ball formed by *L. fascicularis.*

Observations. This species is common in the Atlantic and in the Pacific, flourishing in warm seas especially.

4. ***Lepas Hilli*** Leach.

Stat. 56. June 11, 1910. Lat. 36° 53′ N., Long. 29° 47′ W. Surface. A group of small, most of them very small, specimens attached to a turtle. A group of specimens of *Conchoderma virgatum*, var. *chelonophila,* was associated with those of *L. Hilli.*

Observations. A goose-barnacle common in the Atlantic and also abundant in different regions of the Pacific.

5. ***Lepas fascicularis*** Ellis & Solander.

Stat. 25. May 7, 1910. Lat. 35° 36′ N., Long. 8° 25′ W. Surface. Small specimens attached to different objects: pieces of cork, of pumice, etc., associated with small specimens of *L. pectinata.*

Stat. 91. July 22, 1910. Lat. 47° 32′ N., Long. 16° 38′ W. Surface. Large fine specimens attached to a yellowish ball as described by DARWIN, associated with a colony of *L. pectinata*.

Stat. 92. July 23, 1910. Lat. 48° 29′ N., Long. 13° 55′ W. Surface. Large fine specimens attached to yellowish ball, associated with very small specimens of *L. pectinata*.

Observations. This species has been observed in nearly all the temperate and tropical seas of the world.

6. *Poecilasma carinatum* Hoek.

Stat. 53. June 8—9, 1910. Lat. 34° 59′ N., Long. 33° 1′ W., Depth 2615—2865 m. Bottom: *Globigerina* ooze.

Three specimens attached to a thick bundle of the long spicules of a siliceous sponge protruding from a soft brownish mass, representing, perhaps, the sponge itself.

Observations. This deep-sea species is now known from different places in the Atlantic, in depths varying from 600 to 2865 metres. PILSBRY transferred this species, to the genus *Megalasma*, founded by me in 1883, but I cannot recognize the advantage of so doing.

7. *Conchoderma virgatum* Spengler, var. *chelonophila* Leach.

Stat. 56. June 11, 1910. Lat. 36° 53′ N., Long. 29° 47′ W. Surface. A group of middle-sized and small specimens was found attached to a turtle, associated with a group of specimens of *L. Hilli*.

Observations. The species *C. virgatum* is found in all the seas of the world. The variety *chelonophila* occurs in the Atlantic only, so far as I know.

8. *Scalpellum velutinum* Hoek.

Stat. 24. May 6—7, 1910. Lat. 35° 34′ N., Long. 7° 35′ W. Depth 1615 m. Bottom: *Globigerina* ooze, a very small specimen and a larger.

Stat. 53. June 8—9, 1910. Lat. 34° 59′ N., Long. 33° 1′ W. Depth 2615—2865 m. Bottom: *Globigerina* ooze. One specimen.

Both of the larger specimens are attached to stones, while the small one is free.

Observations. In the specimen from Station 24 the capitulum has a length of 29 mm, and represents my *S. velutinum;* that from Stat. 53 is larger (length of the capitulum 44 mm), and looks much like my *S. eximium*. GRUVEL had an opportunity of comparing numerous specimens of both forms and came to the conclusion that they belong to the same species. Though my *S. eximium* represents the full-grown stage, and the descriptions of both species were published at the same time, GRUVEL preferred the name *S. velutinum*. This example was followed by PILSBRY and I think it better, therefore, to do so also.

A very small specimen of a *Scalpellum*, the capitulum of which measures 2·7 mm in length, was taken at Stat. 24, and my be considered as also belonging to this species. It much resembles the figure given by GRUVEL of a young specimen of this species.

This species seems to occur throughout the Atlantic. PILSBRY says it has a wide range on both sides of this ocean, but it seems to reach farther north on the American than on the European side. ANNANDALE mentions it as occurring in the Irish Seas: Lat. 51° 22′ N., Long. 12° 0′ W., 695—720 fathoms. According to the same author it is also found in the Gulf of Oman (entrance to the Persian Gulf) and in the Indian Ocean.

9. *Scalpellum dicheloplax* Pilsbry.

Stat. 10. April 19—21, 1910. Lat. 45° 26′ N., Long. 9° 20′ W. Depth 4700 m. Bottom: *Globigerina* ooze. Two specimens attached to stones.

Observations. PILSBRY gives three different figures of this species, but the two "Michael Sars" specimens do not exactly resemble any of these figures, yet there can be no doubt they belong to the same species, being intermediate in every detail in which they do not quite agree between the forms figured by PILSBRY. It is one of the larger species of the genus: the length of the capitulum in one specimen is 32 mm in the other 38 mm.

This species seems to occur at different places in the Atlantic, in depths varying from 2750 to 4700 m.

10. *Scalpellum atlanticum* Gruvel.

Stat. 23. May 5—6, 1910. Lat. 35° 32′ N., Long. 7° 7′ W. Depth 1215 m. Bottom: *Globigerina* ooze. Three specimens, two of which are attached to a spicule of a siliceous sponge.

Observations. The specimens correspond fairly well, but not absolutely, with the description of GRUVEL. The capitulum is covered by a delicate chitinous skin, but the numerous short hairs observed by GRUVEL are wanting. The occludent margin of the tergum and scutum is not so strongly arched as in GRUVEL's figure. In his specimen the apex of the tergum was recurved, but it is rather straight in these specimens. GRUVEL says there is a slight exavation in the lateral margin of the scutum for the reception of the apex of the upper latus, but there is hardly a trace of such an excavation in the "Michael Sars" specimens. According to GRUVEL, the scales of the peduncle are placed in 8 rows, in the specimens I investigated 7 rows only could be made out. The capitulum of Gruvel's specimen had the following dimensions: Length 11 mm, Breadth 6 mm. The specimens collected by the "Michael Sars" measured as follows:

The largest:	Length	12 mm,	Breadth	6·5 mm.
The second:	—	10 „	—	5·2 „
The smallest:	—	8 „	—	4·1 „

The differences are so small, and the general resemblance so striking, that these specimens must be regarded as belonging to Gruvel's species.

Gruvel's specimen was dredged near the Azores at a depth of about 1000 m., and the "Michael Sars" specimens a little to the south and east at a depth of 1215 m.

Haarlem, October 16, 1911.

After finishing the foregoing description of the Cirripedia of the "Michael Sars" cruise, I received in April 1912 two tubes, each with a Nauplius-larva, which Mr. Oscar Sund found among some Decapod larvae. A short description of these Nauplii is given here.

At Stat. 67, June 27, 1910, Lat. 40° 17′ N., Long. 50° 39′ W., two Nauplius-larvae were caught in two different hauls, which in most respects correspond with two of the larvae fully described and beautifully figured by Carl Chun in 1896.

The one shows a great resemblance to the Nauplius called by Chun *Nauplius eques*. I suppose the "Michael Sars" specimen was taken with a plankton-net, the label stating that 50 m of wire were out. Chun caught his larva with an open net which was let down to a depth of 1000 m between Madeira and Africa. Like Chun's specimen, that of the "Michael Sars" has the shield-shaped carapace thorny and the fronto-lateral horns standing off horizontally. The posterior horns approach each other somewhat, and the posterior margin of the carapace is excavated,—not so deeply, however, as in Chun's figure. The dorsal spine is longer than the tail, and only a little shorter than the caudal spine. Both spines, and the tail as well, are covered with thorns on their proximal half. The dimensions also correspond with those of Chun's specimen: length of carapace a little over 1 mm, breadth 0·8 mm, length of caudal spine between 8 and 9 mm.

The other specimen looks much like Chun's *Nauplius loricatus*, taken at a depth of 80 to 100 m, in the Gulf of Naples, the "Michael Sars" specimen being taken at Stat. 67 in Petersen's young-fish trawl with 200 m of wire out. The surface of the shield-shaped carapace of the "Michael Sars" larva is thorny, furnished with a little hump on its anterior half, and bears, at the place of the dorsal spine, a short and strong thorn; the fronto-lateral horns are directed obliquely forwards, the posterior marginal spines of the carapace (which are double in Chun's *Nauplius hastatus* and single in his *N. loricatus*) are single, and the caudal spine is moderately long.

The dimensions of the "Michael Sars" specimen are slightly different from those of Chun's *N. loricatus:*—

	Chun's specimen	"Michael Sars" specimen
Length of carapace...	1·5 mm	1·2 mm
Length of caudal spine	5 „	3 „
Total length.........	6·5 „	5 „

These larvae are interesting because it is only the second time that such big Nauplii have been taken in the Atlantic Ocean. Chun, who collected them there for the first time, was unable to determine to what species of Lepadids they belonged, and I think I may say the same for myself now. The *Nauplius eques* of Chun looks much like Willemoes-Suhm's Nauplius of *Lepas fascicularis*, but neither Chun nor I myself believe that they are identical. Larvae of *L. fascicularis* have not as yet been observed in the Atlantic; moreover the "Michael Sars" collected these larvae in Long. 50° W., whereas the most westerly station where *Lepas fascicularis* was met with during the cruise was in Long. 16° W. *L. anserifera* was found at the same station (67) as these larvae, and *L. pectinata* at Stat. 69, not far off. It is of course possible that these very curious larvae belong to these species.

Haarlem, May 31, 1912.

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PTEROPODA

FROM THE

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

BY

KR. BONNEVIE

WITH 9 PLATES AND 58 FIGURES IN THE TEXT

THECOSOMATA.

Since the important papers of BOAS (1886) and of PELSENEER (1888) who, though working independently of each other, reached very much the same results with regard to the system of thecosomatous pteropods, this system has undergone no essential changes. Later investigators, like TESCH (1904) and above all MEISENHEIMER (1905, 1906) have, however, made very valuable additions to our knowledge of the natural relationship between the various groups of the system.

On a few minor points only the system of MEISENHEIMER differs from that of (BOAS and) PELSENEER, especially with regard to the grouping of the Cavoliniidae, PELSENEER dividing this family into three genera, one of which, *Clio,* is again divided into a number of subgenera, while MEISENHEIMER finds it more correct to give all these subgenera generic rank. At the same time MEISENHEIMER maintains a grouping within the families of thecosomatous pteropods, connecting the two families Limacinidae and Cavoliniidae under the name of Euthecosomata, while the third family, Cymbuliidae is considered a representative of another group, the Pseudothecosomata.

PELSENEER in his short paper on "Biscayan Plankton" (1906) has extended our knowledge of one genus of the family Limacinidae, viz. *Peraclis.*

As will be seen from my description of the material of thecosomatous pteropods taken by the "Michael Sars" Expedition 1910, I have in the systematic grouping of the species followed the line adopted by earlier authors; with regard to the natural relationship between different groups (genera and families), however, my view differs essentially from that maintained in earlier papers. This difference is based upon comparative anatomical results especially regarding a few deep-sea species, and will be thorougly discussed later on. At the same time the reason will be given also for my following PELSENEER with regard to the division of the Cavoliniidae into genera and subgenera, in spite of the proposal of MEISENHEIMER of giving each of these groups generic rank.

The geographical distribution of thecosomatous pteropoda has been so thoroughly treated by MEISENHEIMER (1905, 1906) that very little remains to be said. The rich material of the "Michael Sars" Expedition will, however, be of value, as giving the means of testing in a limited area the correctness of the general views set forth by MEISENHEIMER.

My treatment of the different species will be found very unequal with regard to synonyms, as well as to diagnoses and descriptions of anatomical characters. The reason is that I have not found it necessary to repeat the whole series of indisputable facts already fully discussed in earlier papers, while I have paid much attention to the clearing up of some questions with regard to which earlier authors do not agree, or where my own results have proved to be contradictory to theirs.

Special attention will in the systematic part be paid to the genus *Peraclis,* the species *Limacina helicoides, balea* and *retroversa,* and *Clio falcata,* while for most of the other species nothing will be done beyond stating their distribution within the region investigated by the "Michael Sars", and some biological facts regarding their shape or occurrence *(Clio pyramidata, Diacria trispinosa, Cavolinia inflexa).*

The textfigures showing isolated radula-teeth of the different species are all drawn on the same scale (Obj. 5, Oc. 3) so that they may serve as a demonstration not only of the shape but also of the relative size of the teeth.

Systematic part.

EUTHECOSOMATA Meisenheimer.

Limacinidae.

The various species of this family are known (Pelseneer 1888, 1906, Meisenheimer 1905) to belong to three different genera, viz.: *Limacina*, *Peraclis*, and *Procymbulia*, all characterised by a spirally twisted body, but otherwise differing from each other on essential points.

The natural relations between these genera have been discussed by the two authors mentioned, and this question being of importance for our view on the relationship within the whole group of thecosomatous pteropods, it will be discussed also in this paper.

According to Meisenheimer the genus *Limacina* seems to form the base of one line of development within this group leading over to the family Cavoliniidae, while *Peraclis* together with the new genus *Procymbulia* form the pallial cavity situated not quite dorsally but on the base of development of the "pseudothecosomatous" family Cymbuliidae.

Pelseneer (1906) on the other hand maintains that the genus *Peraclis* must be considered the most archaic group among living thecosomatous pteropods, standing (pag. 148) "tout à la base de l'arbre phylogénétique des 'Pteropodes thécosomes'". This conclusion is drawn from the fact that in *Peraclis triacantha* Pelseneer has found the right side of the body and has also proved the existence of a normal ctenidium like that occurring in archaic forms of the tectibranch group Bulloidea, the group of opisthobranch molluscs to which the thecosomatous pteropods seem to be most nearly related.

As will be shown below, this view of Pelseneer is strongly supported by my results from other species of *Peraclis*, and consequently this genus will be described first as the most primitive of the Thecosomata.

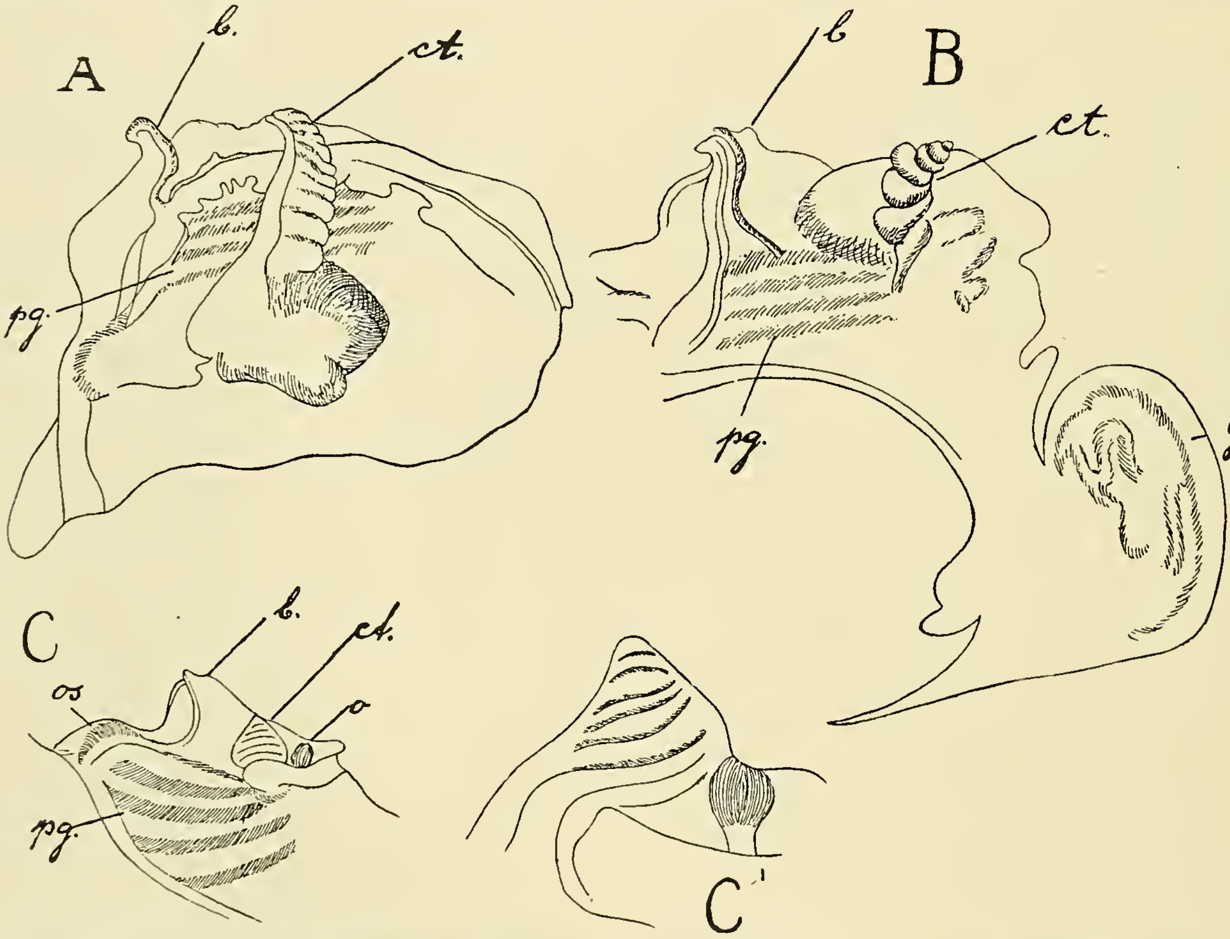

Fig. 1. Mantle-margin with ctenidium and balancer of *Peraclis triacantha A.*, *P. diversa B. and P. reticulata C.* In C^1 the ctenidium and the osphradium (?) are drawn at a higher power. *b.* balancer. *ct.* ctenidium. *p. g.* pallial gland. *o. (os)* osphradium (?). *gl. l.* glandular lobe.

Peraclis Forbes.

This genus is distinguished from the genus *Limacina* by a whole series of characters, such as the subcircular operculum, the prolongations of the head into a proboscis, the symmetrically developed tentacles, the broad and plate-like wings not divided into distinct lateral and median lobes, and the existence of three distinct visceral ganglia.

To these characters may also be added one[1]) already mentioned by PELSENEER, namely the existence within the genus *Peraclis* of a real ctenidium, and finally a very interesting character of the radula, viz.: the existence in each transverse row of a rudimentary lateral tooth outside the one present in all Thecosomata. The formula of the radula in *Peraclis* may be expressed as (1) 1—1—1 (1).

The importance of the two latter characters of the genus is obvious, since they form a connection between the typical thecosomatous pteropods and their tectibranchiate ancestors.

The existence of a ctenidium in the Thecosomata had been denied until it was discovered by PELSENEER (1906) in *Peraclis triacantha.* As a result of my investigations of the "Michael Sars" material I can not only confirm the correctness of PELSENEER's discovery but also supplement it in so far as I have seen similar ctenidia in two other species viz.: *P. reticulata* and *P. diversa.*

In no other group of pteropoda has the existence of a real ctenidium been proved, while rudimentary respiratory organs are found also in the genus *Limacina* as well as in certain species of the Cavoliniidae. It is therefore of interest to note that within the genus *Peraclis* the ctenidium varies in shape and development from the feather-like organ of *P. triacantha* (textfig. 1 A) to the twisted membrane of *P. diversa* (1 B) or the triangular scarcely folded lobe of *P. reticulata* (1 C, C^1). This varying appearance gives the impression of an organ in process of reduction, which well accords with its disappearance within the other genera.

As already mentioned the radula in the genus *Peraclis* shows the interesting archaic occurrence of a rudimentary tooth on both sides of each transverse row (Textfig. 2—4, *r. t.).* This rudimentary tooth has been figured by PELSENEER (1906, pl. II, fig. 44 *al.)* in *P. triacantha*, but in his description of the radula of this species it is not mentioned at all, while in the explanation of the figures it is called "lame accessoire".

I was myself at first doubtful as to the interpretation of these small additions to the common radula-type of thecosomatous pteropods, and not till I had treated a great number of radulae with caustic potash did I venture to believe that they represented rudimentary teeth. After having prepared in the same manner the radulae of very many thecosomatous as well as of gymnosomatous pteropods, I can add that similar structures are found in *Procymbulia*, and as scarcely visible rudiments also in *Limacina helicoides,* but in no other species investigated. Their reactions with caustic potash are exactly like those of the radula-teeth, while all other organs and tissues gradually disappear during a prolonged boiling with this fluid. I therefore consider myself absolutely justified in looking upon these structures as rudimentary teeth, probably inherited from ancestors with a greater number of teeth in each transverse row of the radula.

For a distinction between different species of the genus *Peraclis* the mantle-margin is, like the shell and the radula, of considerable value. In all the species investigated by me a triangular balancer is found on the right side of this margin *(b.* textfig. 1. A—C), but besides this character, common to all of them, each species has in the formation of its mantle-margin also certain specific peculiarities.

Peraclis reticulata d'Orbigny.

Atlanta reticulata d'Orbigny, 1836 (p. 178, pl. 12, fig. 32—35, 39).
Spirialis clathrata Eydoux and Souleyet, 1840, 1852 (p. 220. pl. 13, fig. 17—19).
Peracle physoides Forbes, 1844 (p. 186).
Spirialis recurvirostra Costa, 1865 (p. 125).

The original descriptions of the species cited above were all based upon the shape and structure of the shells, which are characterised and figured as having a smooth surface covered by a finely reticulated epidermis, a character easily distinguishing this from the following species, in which the surface of the shell, also covered by a reticalated epidermis, is not "smooth", being in a very characteristic manner folded or wrinkled along the whole suture.

When therefore MEISENHEIMER (1905) mentions that in specimens of *P. reticulata* taken by the "Valdivia" Expedition he has found the same ridges radiating from the suture that PELSENEER described for his *P. bispinosa*, I should think it more probable that the "Valdivia" specimens do not really belong to *P. reticulata*, but rather to the following species *P. diversa.* The material in my hands includes nearly 700 individuals of *P. reticulata* and among these I have not seen one with ridges along the suture.

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[1]) The rightsided position of the *pallial cavity* may well be considered a generic character of *Peraclis;* but, as will be shown below, this is not one by which it is distinguished from other genera.

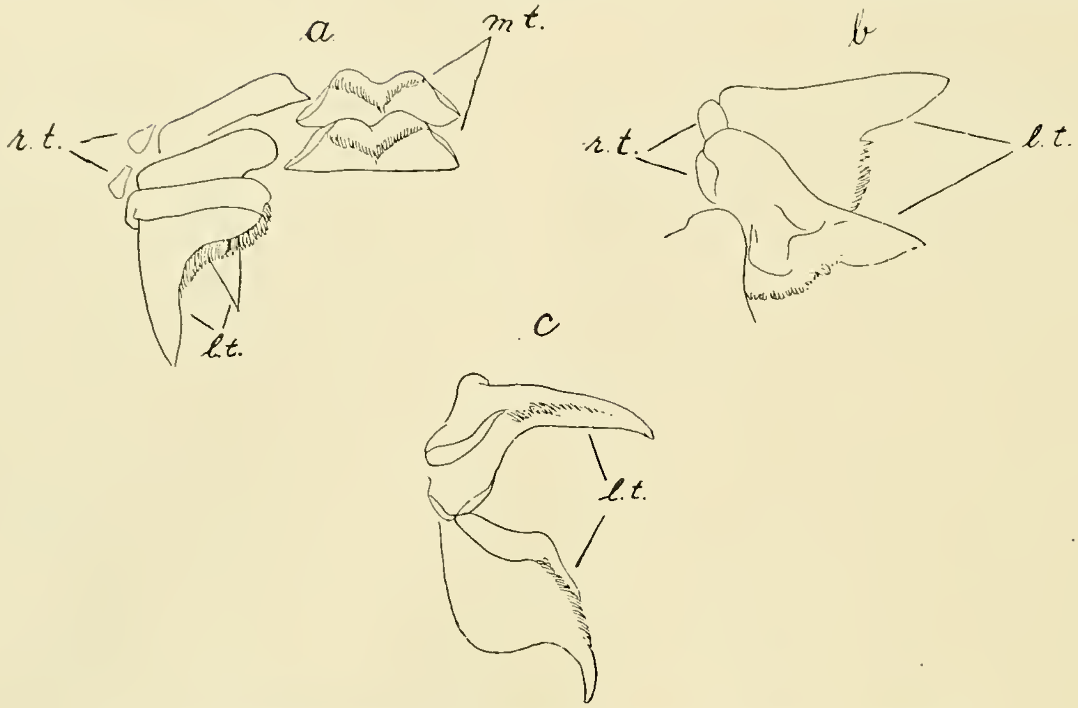

Fig. 2. Radula-teeth of *Peraclis reticulata*: *m.t* median, *l.t* lateral, *r.t* rudimentary.

In addition to the specific characters already known from the shell, I shall here only mention the existence within the mantle-margin of two peculiar cell-groups, looking like sense-organs, one at the base of the ctenidium (*o.* textfig. 1. C, C^1) and the other near the free margin of the mantle to the right of the balancer *(os.)*. The position of the first organ is that of an osphradium, but in structure it differs considerably from similar organs found in other thecosomata.

The radula of *P. reticulata* has the characteristic formula of the genus (1) 1—1—1 (1). Its median teeth are symmetrically denticled on both sides of the median line, while the big irregularly spoon-shaped lateral teeth are finely denticled on a limited part of one border (textfig. 2). As a character of importance for a distinction between different species of *Peraclis* I may mention that in *P. reticulata* the denticled part of the lateral teeth forms a low tongue-like protrusion (fig. 2, b).

Geographical distribution. *P. reticulata* seems to be a widely distributed inhabitant of warmer waters. It has been taken in the Indo-Pacific ocean (d'ORBIGNY, SOULEYET, PELSENEER, TESCH), along the American and African coasts of the Atlantic ocean (DALL, PELSENEER), and in the Mediterranean (FISCHER, JEFFREYS, FORBES, MONTEROSATO, OBERWIMMER).

The results of the "Michael Sars" Expedition (see the table) prove that *P. reticulata*, like some of the small species of *Limacina*, occurs in svarms within the upper layers of the ocean, while outside of these swarms its occurrence is very scattered. It was found at three stations, one specimen near Gibraltar (St. 23), 600 or 700 individuals near the Azores (St. 56), and one specimen at St. 81 (Lat. 48° 2′ N), the most northern locality where it seems at yet to have been taken.

Station	23	56	81
Date	$^{5}/_{5}$—$^{6}/_{5}$	$^{10}/_{6}$—$^{11}/_{6}$	$^{12}/_{7}$
Position N. W.	35° 32′ 7° 7′	36° 53′ 29° 47′	48° 2′ 39° 55′
Depth in m.			
0— 50	—	—	—
50—100	—	650	1
100—250	1	10	—
250—500	—	—	—
500—750	—	—	—

Number of individuals of *Peraclis reticulata*.

As will be seen from the table the big swarm of *P. reticulata* (St. 56) was taken between 50 and 250 m., and the same is true of the specimens from Sts. 23 and 81, A few specimens were also found in the deep-sea samples from St. 56, but probably these were caught during the passage of the gear through the swarm in the surface layers.

Peraclis diversa Monterosato.

Spirialis diversa Monterosato, 1875 (p. 50; pl. I, fig. 1—3).
? *Peraclis bispinosa* Pelseneer, 1888 (p. 36; pl. I, fig. 9—10).
Peraclis reticulata var. *diversa* Dall, 1889 (p. 80).
Peracle diversa Locard, 1897 (p. 29; pl. I, fig. 4—6).
? *Peracle bispinosa* Oberwimmer, 1898 (p. 589).
Peraclis retikulata Meisenheimer, 1905 (p. 12).
? *Peraclis brevispira* Pelseneer, 1906 (p. 146; pl. 12, fig. 45, 46, 48, 49, 51).

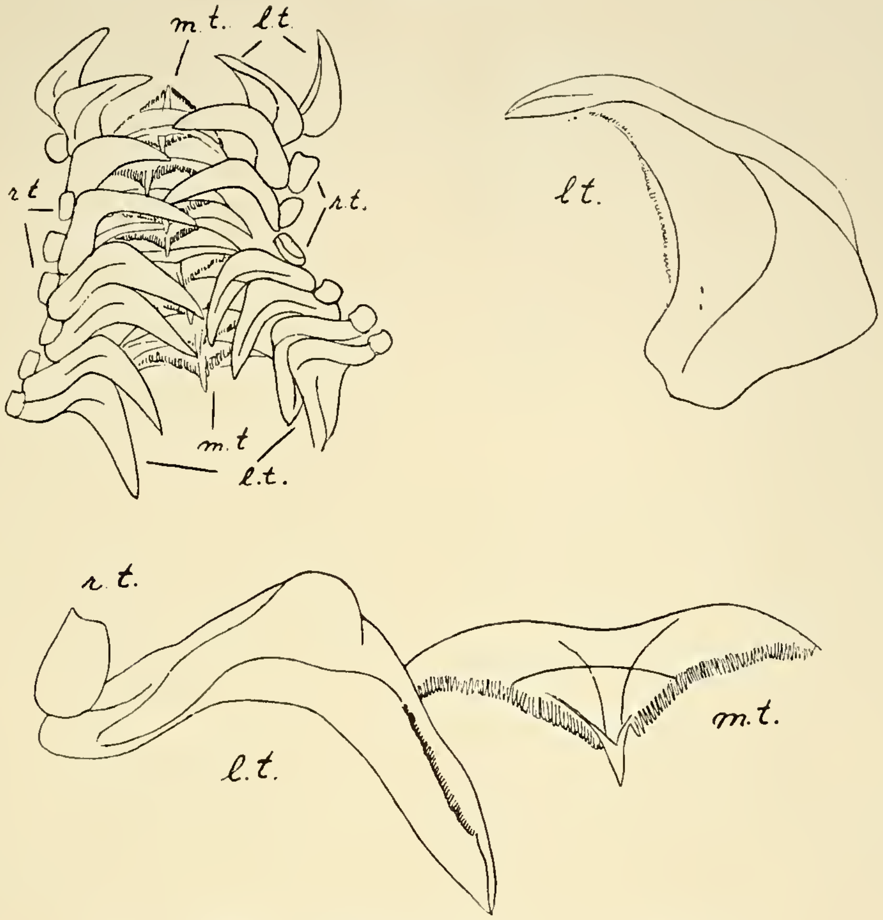

Fig. 3. Radula of *Peraclis diversa*. *m.t.*, *l.t.*, *r.t.* as in fig. 2

The most complete description of this species is given by LOCARD, who, however, had only the empty shells at his disposal. His description[1]) and figures agree so well with the specimens from the "Michael Sars" Expedition that I have no doubt of their identity, although LOCARD as well as MONTEROSATO describe their shells as having a smooth surface, while the "Michael Sars" specimens show fine hexagonal reticulation, all over their shells (pl. I, fig. 1). This reticulum may be destroyed very soon after the death of the individuals, and may therefore not be found on deposit shells.

As already mentioned by LOCARD, the ridges radiating from the suture are on the last half-whorl of the shell bordered by another ridge parallel to the suture and increasing in rigidity towards the outer lip of the shell (pl. I, fig. 1 b). When this lip is broken, the ridge protrudes like a spine, very much like that of *Peraclis bispinosa* Pelseneer, and if by a further growth of the shell this spine should prove to form a constant feature of the lip also in *P. diversa*, the two species ought to be considered as identical.

So far as can be seen from the short description given by PELSENEER (1906) of his *P. brevispira*, that species also seems to be identical with *P. diversa*, the more so because the lateral teeth of the radula have the same characteristic shape in both forms (textfig. 3). The only reason why their identity should still remain questionable is the fact that PELSENEER does not mention the reticulum of the shell, although he must have had fresh specimens at his disposal. His description being, however, rather fragmentary too much weight ought not to be attached to this fact.

As mentioned above the *P. reticulata* of MEISENHEIMER (1905) has both reticulum and ridges, and is probably identical with our species.

A characteristic feature of the mantle-margin of *P. diversa* is the existence of a big apparently glandular lobe (textfig. 1 B, and pl. I, fig. 2 *gl. l.)* protruding from its left side. The denticled border of the lateral teeth is not protruding as in *P. reticulata*, but has a slightly concave outline.

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[1]) I have not been able to find the umbilicus mentioned but not figured by LOCARD.

Geographical distribution. If my understanding of the synonymy is correct *P. diversa* like *P. reticulata*, seems to be a widely distributed species, which has been found scattered in the Indo-Australian and Atlantic oceans within a zone between 40° N. and 30° S. (Pelseneer, Meisenheimer). It has been found in the Mediterranean (Monterosato, Oberwimmer), and along the European (Locard, Pelseneer) and American coasts (Dall). The results of the "Michael Sars" Expedition prove the existence of *P. diversa* in the Northern Atlantic up to latitude 46° 58′ N. (St. 90). As will be seen from the table this species was not taken among the surface plankton, but came mainly from a depth of about 1000 metres. It is of interest to note the conformity of its distribution with the extension of a water-layer with a temperature of about 6°—8° C. and a salinity of 35—35·5 ‰ (see textfig. 37). With regard to *P. brevispira* Pelseneer, Fowler (1906, p. 15) has arrived at quite similar results, namely that it is "a member of the lower epiplankton" and that it probably "ranges also in the mesoplankton as low as the zone of 1000—750 fathoms".

Station	56	58	62	64	66	88	90
Date	10/6—11/6	11/6—13/6	20/6—21/6	24/6	26/6	18/7	21/7
Position N. W.	36° 53′ 29° 47′	37° 37′ 29° 25′	36° 52′ 39° 55′	34° 44′ 47° 52′	39° 30′ 49° 42′	45° 26′ 25° 45′	46° 58′ 19° 6′
Depth in m.							
0— 50	—	—	—	—	—	—	—
50— 100	—	—	—	—	—	—	—
100— 250	—	1	—	—	—	—	—
250— 500	—	—	—	—	—	—	—
500— 750	1	—	2	—	—	—	—
750—1000	—	—	—	—	3	—	1
1000—1250	10	—	1	18	—	1	—
1250—1500	—	—	7	3	—	—	—

Number of individuals of *Peraclis diversa*.

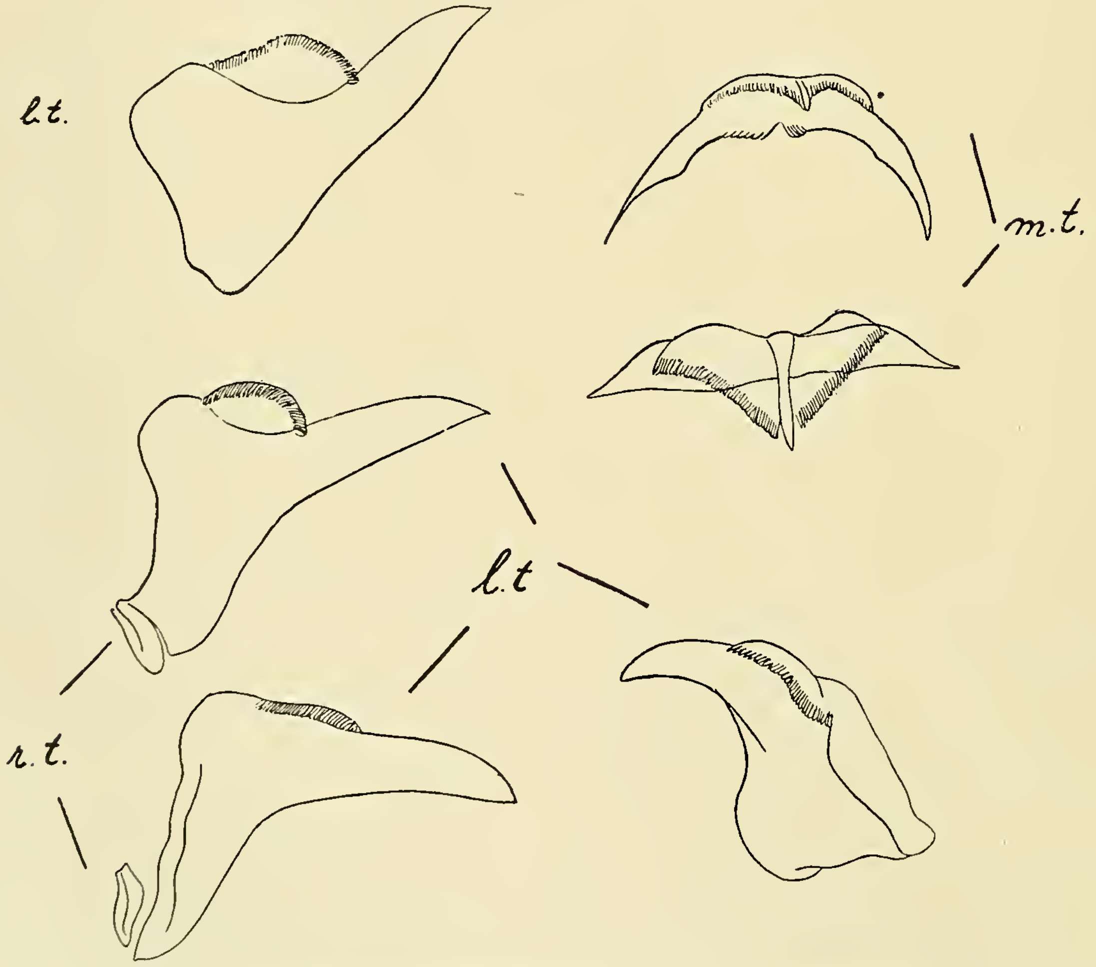

Fig. 4. Radula-teeth of *Peraclis triacantha*. *m.t*, *l.t*, *r.t* as in textfig. 2.

Peraclis triacantha Fischer.

Embolus triacanthus Fischer, 1880.
Limacina triacantha Pelseneer, 1888 (p. 20; pl. I, fig. 1—2).
Embolus triacanthus Dall, 1889 (p. 80).
Protomedea triacantha Locard, 1897 (p. 27; pl. I, fig. 1—3).
Limacina triacantha Tesch, 1904 (p. 10, 19).
Peraclis triacantha Pelseneer, 1906 (p. 146; pl. 11—12).

This species was known from empty shells only until the expedition of the "Research", when a complete animal was found and described by PELSENEER (1906).

In the "Michael Sars" material I have found ten more or less complete animals, an investigation of which has on all principal points confirmed the results of PELSENEER.

Station		23	53	56	92
Date		$^{5}/_{5}$—$^{6}/_{5}$	$^{8}/_{6}$—$^{9}/_{6}$	$^{10}/_{6}$—$^{11}/_{6}$	$^{23}/_{7}$—$^{24}/_{7}$
Position	N.	35° 32′	34° 59′	36° 53′	48° 29′
	W.	7° 7′	33° 1′	29° 47′	13° 55′
Depth in m.					
0— 50		—	—	—	—
50—100		—	1	—	—
100—250		3	—	—	5
250—500		—	—	1	—

Number of individuals of *Peraclis triacantha.*

The mantle-margin has in this species a regularly rounded outline (textfig. 1 A). In the lateral teeth of the radula the denticled part of the border protudes like a semicircular lobe (textfig. 4).

Geographical distribution. *P. triacantha* has been recorded from the Atlantic ocean only—from the European (PELSENEER, LOCARD) and from the American coast (DALL); in his paper on "Biscayan Plankton (1906) PELSENEER says, without further demonstration of the fact, that *P. triacantha* "est répandue dans tout le N. Atlantique". During the "Michael Sars" Expedition it was taken at four stations near Gibraltar (St. 23), near the Azores (St. 53, 56), and at one station (92) in the open ocean, always in depths of 50—500 metres.

Procymbulia Meisenheimer (1905).

The generic characters of *Procymbulia* were based upon the investigation of a single individual without shell brought home from the "Valdivia" Expedition and described by MEISENHEIMER. Among these characters the spirally twisted body proves the genus to belong to the family of Limacinidae. Other characters are: 1) the symmetrical tentacles without sheaths, 2) the proboscis, 3) the development of the fins into a broad swimming-plate, and 4) the existence of three distinct visceral ganglia—which all serve to prove that *Procymbulia* is more nearly related to *Peraclis* than to *Limacina*, while one character viz.: the ventral pallial cavity,

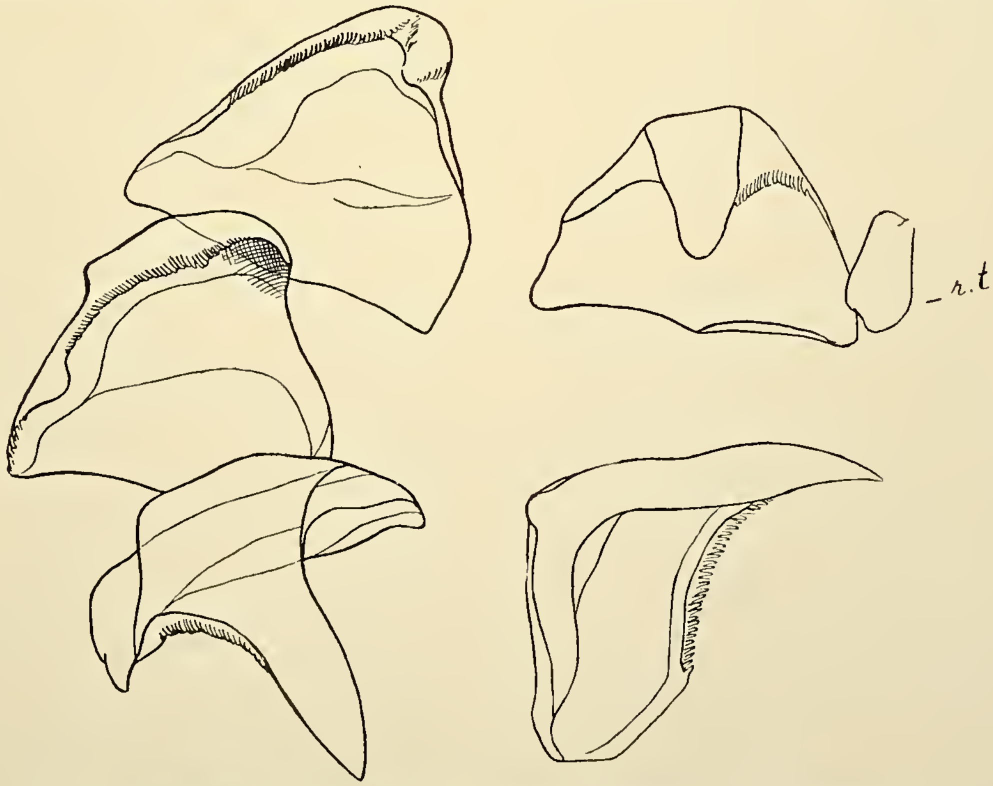

Fig. 5. Lateral teeth of the radula of *Procymbulia michaelsarsi*, *r.t* rudimentary tooth.

decidedly distinguishes this genus from the earlier known Limacinidae,—and points towards a relationship with the family Cymbuliidae.

Of this interesting genus one individual was found during the "Michael Sars" Expedition, but, I am sorry to say, without its shell, and with several other defects, which make it impossible to give a satisfactory description of the animal. The broad trumpet-like proboscis is so unlike that of *P. valdiviae* Meisenheimer, that it will be necessary to erect a new species, even if a complete diagnosis of it cannot as yet be given.

Procymbulia Michaelsarsi nov. sp.

Pl. I, fig. 3.

To the generic characters mentioned above I have but little to add. The radula (textfig. 5), which is very well developed, has the same characteristic appearance as in *Peraclis*, with large spoon-shaped teeth, denticled on one border (the lateral teeth) or on both (median teeth). As in *Peraclis*, we find a small rudiment of a tooth on both sides of each transverse row of the radula [formula (1) 1—1—1 (1)]. The proboscis is different from that of *Peraclis*, showing a dorsal and a ventral lip united at both sides instead of the two lateral lips of *Peraclis*, which are ventrally united. On this point our species also differs from that of the "Valdivia" Expedition. The colour of the proboscis is a very dark brown.

In the single individual at my disposal the margin of the swimming-plate was torn, and the same is true of the mantle, so that important specific characters must be left undescribed.

Locality: St. 92 (48° 29′ N., 13° 55′ W.).
Date: $^{23}/_{7}$—$^{24}/_{7}$ 1910.
Depth: 750 m.

Limacina Cuvier.

The main characters distinguishing this genus from *Peraclis* are generally found in the semilunar operculum, the indistinctly defined head with asymmetrically developed tentacles, the development of the foot into distinct lateral and median lobes, and the asymmetry of the visceral ganglionic mass, which is developed into a larger right and a smaller left ganglion. A character distinguishing *Limacina* from *Procymbulia* and at the same time also from the families Cymbuliidae and Cavoliniidae, is found in the dorsal position of its pallial cavity.

This may be true of all the earlier known typical species of *Limacina*, but, as will be shown below, there is one species *(L. helicoides)* for which the above named generic characters must be modified in so far as on several points it forms connections between *Limacina* and other genera or families.

Limacina helicoides Jeffreys.

Limacina helicoides Jeffreys, 1877 (p. 338; pl. I, fig. 4—11).
" " Pelseneer, 1888 (p. 23; pl. I, fig. 5).
Peracle " Dall, 1889 (p. 80).
Limacina " Meisenheimer, 1905 (p. 8).

Shells of this species have been brought home from several expeditions ("Valorous", "Porcupine", "Travailleur", "Challenger" and "Valdivia"), but always without animals and in small numbers. It has therefore not been possible to decide with certainty the affinities of this species within the group of Limacinidae.

During the "Michael Sars" Expedition more than thirty individuals of *Limacina helicoides* of different sizes were taken, all with complete animals.

Fig. 6.
Shell of *Limacina helicoides.*
(From Pelseneer).

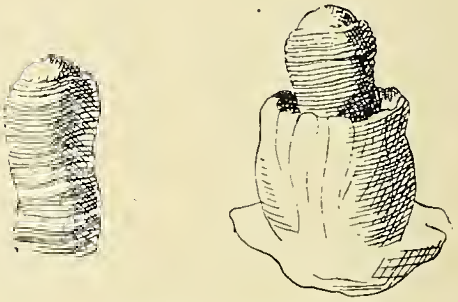

Fig 7. Tentacles of *Limacina helicoides.*

Description: With regard to the shell I have nothing to add to the original description of Jeffreys (1877, p. 335): Shell like a reversed *Helix memoralis*, extremely thin, opaque, brittle, and glossy: sculpture, a few delicate spiral striae, and close-set microscropic lines of growth: colour brownish-yellow: spire depressed, not flat: whorls 4, rather convex: suture slight but distinct: mouth irregularly and narrowly oval, rounded on the outside, acute-angled above, and pointed below: pillar twisted, furnished at its base a little way inside

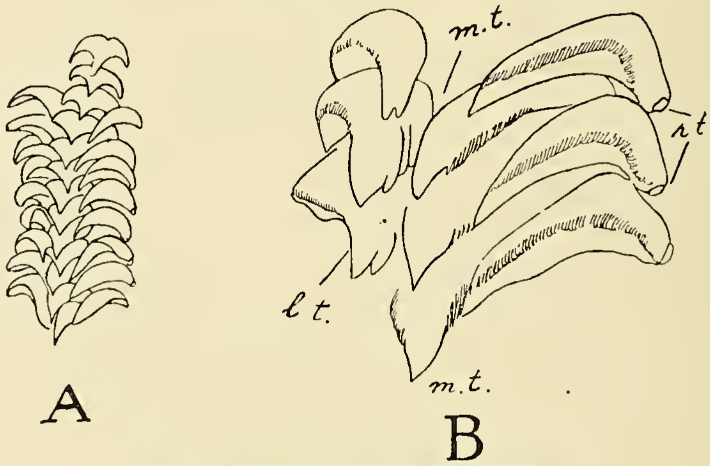

Fig. 8. Radula of *Limacina helicoides.*

with a sharp and curved ridge, which corresponds with a keel on the outside: umbilicus none. (See texfig. 6).

With regard to the animal the following points are of importance: Head indistinct, consisting of a sligthtly protruding horseshoe-shaped lip on the dorsal side of the mouth. Tentacles asymmetrically developed, the right one considerably larger than the left and surrounded by a sheath (textfig. 7). Both tentacles have the dark colour of the wings but with ivory-coloured free ends. With regard to the nature of these convex ivory-coloured end-plates of the tentacles (see also pl. I, fig. 4 *t*) I can as yet give no definite information. At the first glance they look like eyes, but it would perhaps be just as appropriate to consider them light-organs. They consist of big clear cells with large nuclei, and seem absolutely destitute of pigment. I hope in a later paper to deal with the finer structure of this organ.

The radula (textfig. 8) is very small in proportion to the large size of the animal (comp. textfig. 5 and 8 B, drawn on the same scale); all teeth are, with the exception of their clear colourless points, dark brown like the pharynx itself. Median and lateral teeth are very much alike as to size and shape. A very faint rudiment of the second lateral tooth found in *Peraclis* is present also in this species.

The foot is developed into two large wings (pl. I, fig. 4, 6), forming together a swimming-plate without any distinction between lateral and posterior lobes (fig. 5). When at rest the wings scarcely or never cover each other, but are regularly and symmetrically folded (fig. 7, 9) like those of *Peraclis* (fig. 2), so as to fill the whole dorsal part of the shell-mouth. Ventrally this mouth is occupied by a folded, lobe-like projection from the underside of the body (fig. 5, *v. b)*.

Operculum none.

The pallial cavity is placed on the right side (pl. I, fig. 6), following this side from the median dorsal line of the body until not far from the same line on the ventral side. The pallial gland (fig. 6—7 *p. g)* is uniformly developed, without the transverse folding of *Peraclis* (fig. 2, *p. g)*.

The mantle-margin (fig. 4, 6 *m. m)* is bordered by a very thin membrane, under which a pointed thread-like balancer protrudes on the right side of the body (pl. I, fig. 5, pl. III, fig. 24, bal.). At the side of this balancer we see a semicircular membranous lobe (fig. 5, 6, 24, *g)* which probably ought to be considered a respiratory organ. The position of this lobe, at a place corresponding to that of the ctenidium in *Peraclis*, and just fitting into the siphon-like curve of the shell (fig. 5), makes this in fact so probable, that I feel justified in regarding this lobe, which is found also in other species, as a gill, analogous if not homologous to the ctenidium of *Peraclis*.

Heart and kidney are found posteriorly at the left side of the pallial gland (fig. 7, *h)*.

The course of the intestine may be followed in fig. 7 and 9, and will be found diagrammatically demonstrated in textfig. 27. From the stomach (*st.* fig. 8, 9), in which the unpaired tooth has a dorsal position, the intestine (fig. 9 i^1) runs obliquely towards the right side along the surface of the liver (*l.*), passing below the rectum (*r.*), making a dorsal loop towards the left side of the animal (fig. 7 i^2) and back again (fig. 9 i^3),—the rectum finally runs forwards along the right side of the body where the anus (fig. 9, *a*) is situated at the side of the stomach.

The visceral and abdominal ganglia are united to one symmetrically developed mass, from which the abdominal nerve runs towards the right (see textfig. 28).

The genital duct (fig. 9 *g. d.*) runs forwards from the genital gland at the posterior end of the body parallel to the rectum and opens on the right side of the neck. The male and female organs of one individual become developed at different times, and the difference between "male" and "female" individuals is very obviously demonstrated in figs. 9 and 10. In fig. 8 and 9 the male organs are fully developed; the penis is evaginated and the groove, which leads from the genital opening (*g. o.*) may be followed all along the border of the penis to the top of the finger-like protrusion at its distal end. Fig. 10 on the other hand shows a "female" in which the uterus (*u*) is filled with a series of large spheres, each containing a fullgrown larva (fig. 11). As will be seen from the above, *L. helicoides* is viviparous.

Colour: Wings, head, tentacles and mantle-margin are more or less dark, velvet-like, brown, this dark colour being interrupted only by the ivory-coloured ends of the tentacles (fig. 4, 6).

The shell is of a shiny bronze colour.

The dimensions of this species far exceed those of all other known Limacinidae, the shell reaching a breadth of about 10 mm., while the largest individuals measure about 15 mm. across the wings.

As will be seen from the above description, *L. helicoides*, which on account of its asymmetrically developed tentacles and the whole arrangement of its internal organs must be considered a true *Limacina*, differs at the same time from the typical species of this genus in certain interesting points.

The development of the foot into a broad undivided swimming-plate, as well as its folded position during rest,

Station	62	64	66	67	80	81	82	84
Date	20/6—21/6	24/6	26/6	27/6	11/7	12/7	13/7	15/7
Position N. W.	36° 52′ 39° 55′	34° 44′ 47° 52′	39° 30′ 49° 42′	40° 17′ 50° 39′	47° 34′ 43° 11′	48° 2′ 39° 55′	48° 24′ 36° 53′	48° 4′ 32° 25′
Depth in m.								
0— 50	—	—	—	—	—	—	—	—
50— 100	—	—	—	—	—	—	—	—
100— 250	—	—	—	—	—	—	—	—
250— 500	—	—	—	1	—	—	—	—
500— 750	1	—	3	4	—	—	7	7
750—1000	—	—	1	—	—	—	1	4
1000—1250	2	1	—	—	1	1	—	1
1250—1500	—	1	—	—	—	—	—	1

Number of individuals of *Limacina helicoides.*

remind one of *Peraclis* more than of other species of *Limacina.* The same is true also of the position of the pallial cavity on the right side of the body, a point of special interest which will be further discussed later on.

As will be shown below both these characters are found also in a species of the Cavoliniidae, viz.: *Clio falcata*, with which *L. helicoides* seems to have several traits in common. The want of an operculum in *L. helicoides* is also a character pointing towards a relation with the Cavoliniidae.

Geographical distribution. Shells of *L. helicoides* have previously been found along the eastern coast of the Atlantic ocean, from Ireland and the Bay of Biscay (Jeffreys, Pelseneer) to the Congo and Cape (Meisenheimer), and off the Azores (Pelseneer); its existence off the American coast (Georgia) is questioned (Dall).

During the "Michael Sars" Expedition complete animals of this species were taken at eight stations all in the western part of the Northern Atlantic. As will be seen from the table it does not belong to the surface plankton, but was taken in depths of 400 to 1500 m. The hydrographical conditions show that *L. helicoides* belongs to a water-layer with a temperature below 10° C. (textfig. 38). Its occurrence in the western part of the ocean only, and at a depth so shallow as 400 m. is seen to be in accordance with the extension of the water-layer mentioned.

Limacina helicina Phipps.

A few small specimens of this arctic species were taken near Newfoundland, within or near the cold Labrador current.

St. 80. 47° 34′ N., 43° 11′ W. Depth 300 m. 13 individuals.
St. 81. 48° 2′ N., 39° 55′ W. „ 50 m. 1 —

Limacina retroversa Flemming
and ***Limacina balea*** Møller.

With regard to the nomenclature of these two forms the opinions of different authors are widely divergent. They are used as the names of two distinct species or as synonyms of one and the same species. At the same time the names of other species, such as *L. trochiformis*, *L. australis*, *L. mac andrei*, are variously used as synonyms of one or the other or of both these names.

Large quantities of this (or of these two) species are included among the material from the "Michael Sars" Expedition, and I have taken the opportunity of trying definitely to settle the question about the identity or distinctiveness of the two forms originally described as *L. (Heterofusus) retroversa* Flemming, and *L. (Spirialis) balea* Møller, and possibly also about their relations to the other forms whose names have been combined with theirs. The results of my investigations prove that *L. retroversa*, and *L. balea* must be considered as two different species, very nearly related but yet distinct in shape as well as in occurrence.

In the original descriptions *Heterofusus retroversus* was by Flemming (1823) characterised and figured as a "shell with five rounded whorls", which "increase somewhat rapidly in size", while *Spirialis balea* according to Møller (1841) has a shell "with 7 cylindrical gradually increasing whorls".

Just the same difference is pointed out also by Gould (1870) in his description of the genus *Heterofusus. H. balea* is described as having (pag. 505) "whorls seven, sculptured by minute distinct, impressed, revolving lines; last whorl large; aperture about equalling the spire, obtuse in front". *H. retroversus* is described as having "the body whorl very ventricose; the spire of four whorls, but not forming half the length of the shell".

Agreeing with the previous authors with regard to the number and shape of the whorls, G. O. Sars (1878) holds that the most constant character distinguishing the two species is to be found in the sculpture of their shells, —the shell of *L. balea* being finely but very distinctly spirally striated, while in *L. retroversa* such a striation is only very slightly indicated.

Boas (1886) on the other hand maintains that there exists no real distinction between the two species, complete series of transitions being found between forms with long and short spires as well as between those with and without a distinct striation.

For the same reason Pelseneer (1888) also proposes to unite the two forms into one species.

About ten years later, however, Locard (1897) once more describes the two forms as distinct species. He says (pag. 25): "Nous distinguerons donc le *Limacina balea* du *L. retroversa:* à son galbe beaucoup plus étroitement allongé, de telle sorte que pour un même diamêtre la coquille du *Limacina balea* est toujours plus haute; à sa spire composée de tours plus nombreux, croissant plus lentement en diametre et plus rapidement en hauteur; à son dernier tour notablement plus haut et plus étroitement arrondi; à son sommet plus acuminé; à son ouverture toujours plus haute que large, et non pas plus large que haute, etc".

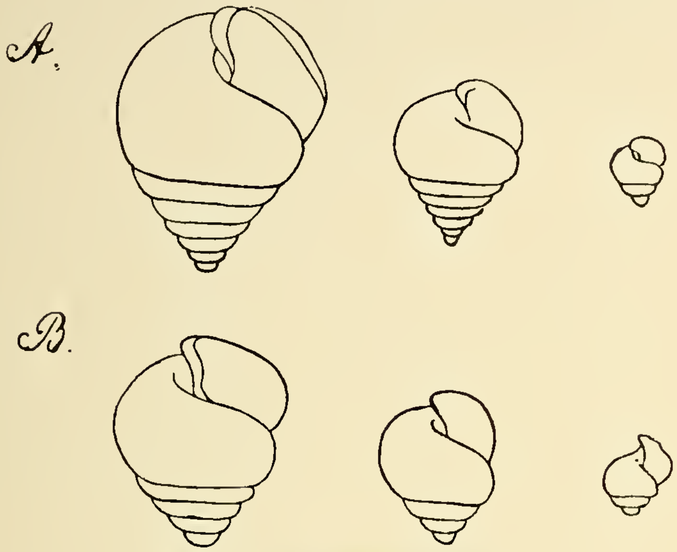

Fig. 9. For explanation see text.

But Locard is not followed by later authors (Posselt 1898, Meisenheimer 1905, 1906, Lenz 1906), who again describe the two forms as varieties of one and the same species.

A definite solution of the question about the relations between *L. balea* and *L. retroversa* may be reached in two different ways:—

1) through a statistical investigation with regard to the value of the transitions in the shape of the shells combining the two originally described forms with each other. Do these intermediate forms prove that *L. balea* and *L. retroversa* are representatives of one and the same species? Or are they to be considered as the fluctuating variations of two species partly overlapping each other?

2) through a demonstration in the shell or in other organs of some minute structures by which the two forms can be specifically distinguished and characterised.

I have tried both ways, and both have given the same positive result, namely that the two forms so intimately intermingled in literature are yet distinctly separated from each other in nature.

During my first preliminary investigation of the material I—following Boas and Pelseneer—considered all samples as belonging to one and the same species, and I noted that immense swarms occurred at no less than 8 stations, two of which, St. 1 and 96, were taken near each other off the Irish coast, but with an interval in time of about $3^1/_2$ months ($^9/_4$—$^{27}/_7$). Already at the first glance, however, these two samples differed very conspicuously from each other, the sample from St. 96 consisting of individuals considerably smaller and darker than those of St. 1 and all other stations. A further comparison of these samples made me doubt the correctness of the opinion maintained by Boas and Pelseneer, and therefore they were made the basis of the following statistical investigation, the material of St. 1 as representing the form *L. balea* Møller, that of St. 96 representing *L. retroversa* Flemming.

Textfig. 9 A shows three stages in the development of the shell of *L. balea*, while in B. the corresponding stages of *L. retroversa* are drawn on the same scale. The difference between the two forms is to be found, as has been pointed out by earlier authors, in the number of whorls of the full grown specimens as well as in the size of the last whorl compared with the length of the spire. Slight and relative as the latter character may be, it can be traced through all stages of the two forms, the difference being, however, less conspicuous between young shells than between older ones. As will be seen from the figures the absolute size of the two forms is also different, *L. balea* being larger than *L. retroversa.*

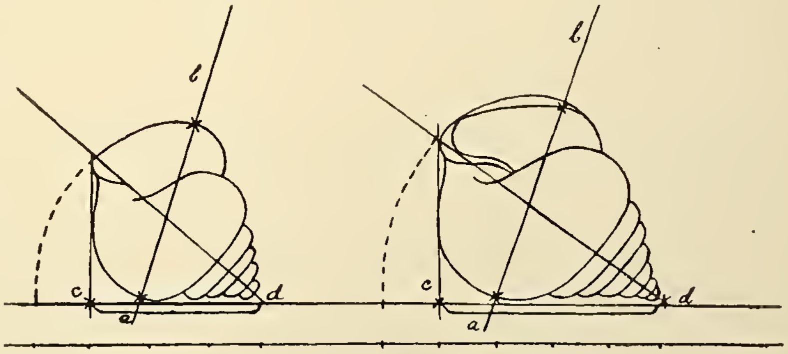

Fig. 10. For explanation see text.

Within each species there is a considerable variation with regard to the slenderness of the shells, the larger individuals, especially those of *L. balea*, being relatively more slender than the smaller ones. As will be seen from

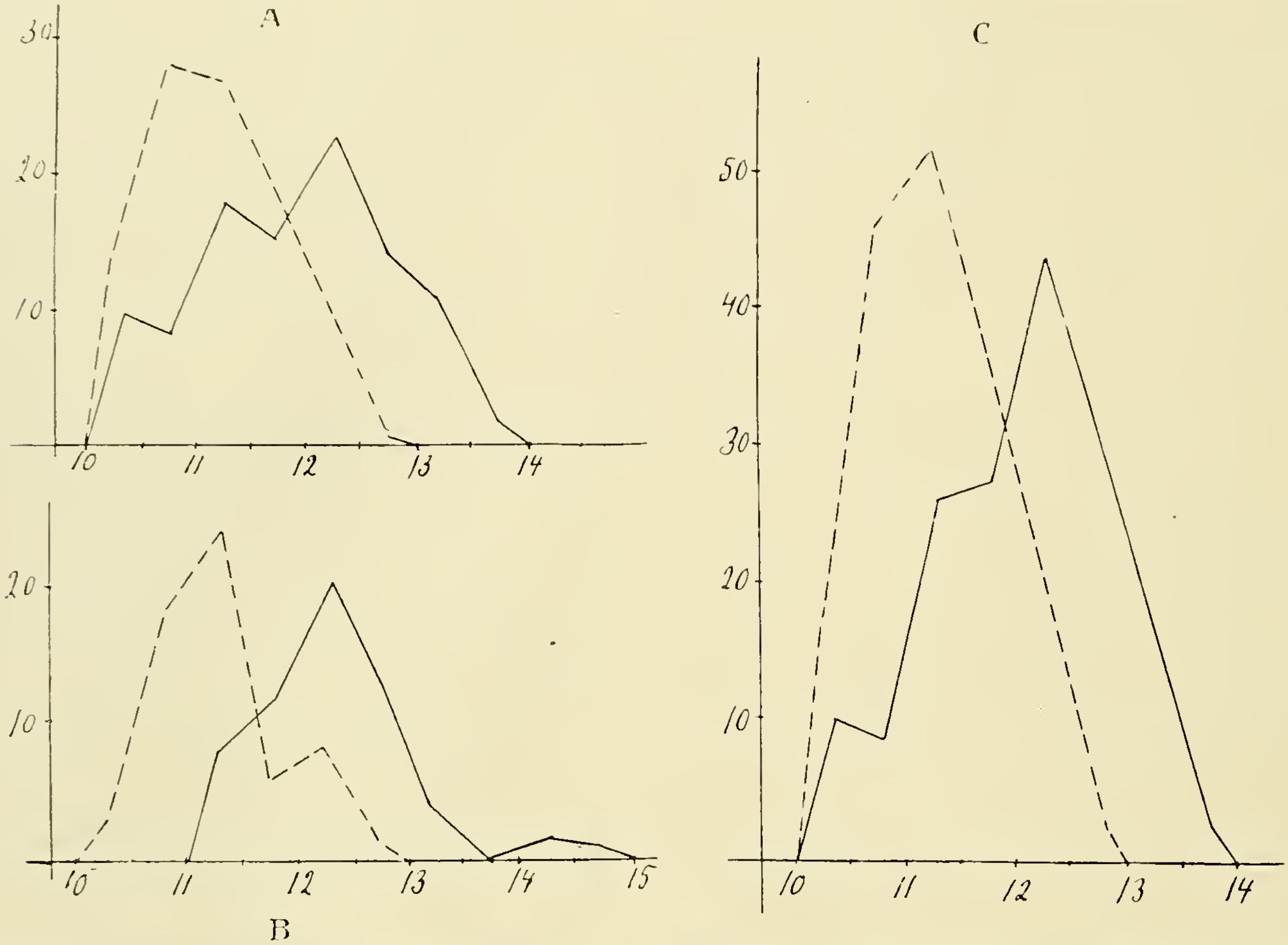

Fig. 11. Curves showing the variation of "slenderness" in *Limacina balea* ——— and in *Limacina retroversa* — — — —. The abscissae give the value of the columella projection, the greatest breadth of the shell being represented by the number 10, while the ordinates give the number of individuals within each group of shells.

A: 100 individuals of each form taken at random.
B: 60 full-grown individuals of each form.
C: Combination of A. and B. 160 individuals.

the above review of the literature it is just the degree of slenderness, i. e. the size of the last whorl compared with the rest of the shell, that has been considered the main characteristic of each species.

In order to prove the range and value of these variations, I have measured, as accurately as the minuteness of the objects admit, the dimensions of 160 specimens of each form. The shells were placed with their mouths upwards (textfig. 10), and the measures used were:

1) the greatest breadth of the last whorl from the outer lip of the mouth to the opposite side (a—b), and

2) the length of the columella projected on the horizontal plane (c—d).

As will be seen from the figure this latter measure will be a function not only of the absolute length of the columella but also of the "slenderness" of the shell, the larger the last whorl in proportion to the whole shell, the shorter is the projection of the columella compared with its absolute length.

Among the 160 specimens of each sample 60 were selected among the full-grown individuals, while the other 100 were taken at random, old and young mixed. Separate tables aud curves (textfig. 11) were made for each of these groups as well as for both groups together.

In these curves the size-relations of the shells are seen to vary in both samples, but their range of variation is different. The greatest breadth of the shell being in each case represented by the number 10, we find the projection of the length in *L. balea* varying about a mean of between 12 and 12·5, while in *L. retroversa* the mean is about 11.

It will further be seen from the same figures, that the difference between the two forms is more conspicuous when only full-grown specimens are used for comparison (textfig. 11 B.), than when younger and older ones are taken together (A. C.); the overlapping of the two curves is relatively small in the first case, while it gradually becomes more pronounced with an increasing number of younger shells.

These statistical results prove clearly enough that the two swarms of *Limacina* met with by the "Michal Sars" Expedition at Stations 1 and 96 are really different from each other with regard to the characteristic shape of their shells.

We then turn to the question whether any specific structure characterises either of the two species to distinguish them from each other.

G. O. SARS (1878) in his detailed description of *Limacina balea* and *L. retroversa* pointed to the striation of their shells as a specific character of high and absolute value, while BOAS (1886) does not acknowledge this distinction. Although I agree with SARS in considering the two forms as distinct species, my results with regard to the striation of the shells are more like those of BOAS.

According to SARS the shells of *L. balea* have: "Superficies subtillissime spiraliter striolata, striis regularibus et aequidistantibus, ubique bene conspicuis," while in the description of *L. retroversa* we find: "Superficies lævissima, nitidula striis spiralibus parum conspicuis in anfractu ultimo omnino evanidis." This difference he found to be constant in all stages of development.

After a minute investigation of the shells in several of my samples I have come to the conclusion that the existence of very fine spirally arranged striae is constant in the shells of both species (see textfig. 12 A—B, 2, where pieces of the shells are shown highly magnified), while it will probably depend upon the fixation of the material whether these striae will be conspicuous or not when the shell is examined under a low power. The material of *L. balea* at my disposal differs with regard to the shell-structure in the various samples; in some samples the spiral striae are, as described by SARS, very conspicuous, while in others they are so fine that the longitudinal[1]) striping (or folding) of the whorls is the only shell-structure, which attracts attention (textfig. 12 B. *1)*. In *L. retroversa*, which form I know from one station only (St. 96), I have found the spiral striae very conspicuous, even when seen under a low power (textfig. 12 A. *1)*.

The above statements will suffice to prove that the striation of the shell is too variable a structure to give any satisfactory character of distinction between the two species. I have therefore turned my attention to the *radula* as the most trustworthy systematic structure of the molluscs. The process of isolating and preparing the radula in species as small as *L. balea* and *L. retroversa* is so troublesome and difficult that distinctive characters drawn from this organ will scarcely prove to be of great use in practical systematic work. A demonstration of such characters would, however, be of great importance as giving the scientific justification for relying upon the less exact but more easily recognisable characters of the shell-form.

After being boiled with caustic potash the radula is in both forms seen to be of the common thecosomatous type (formula 1—1—1), with apparently hook-shaped teeth, the median ones symmetrically denticled on both sides, while the lateral ones are denticled only on one border. The radula of full-grown specimens of *L. balea* is considerably larger than that of *L. retroversa* (compare textfig. 13 with 14 B).

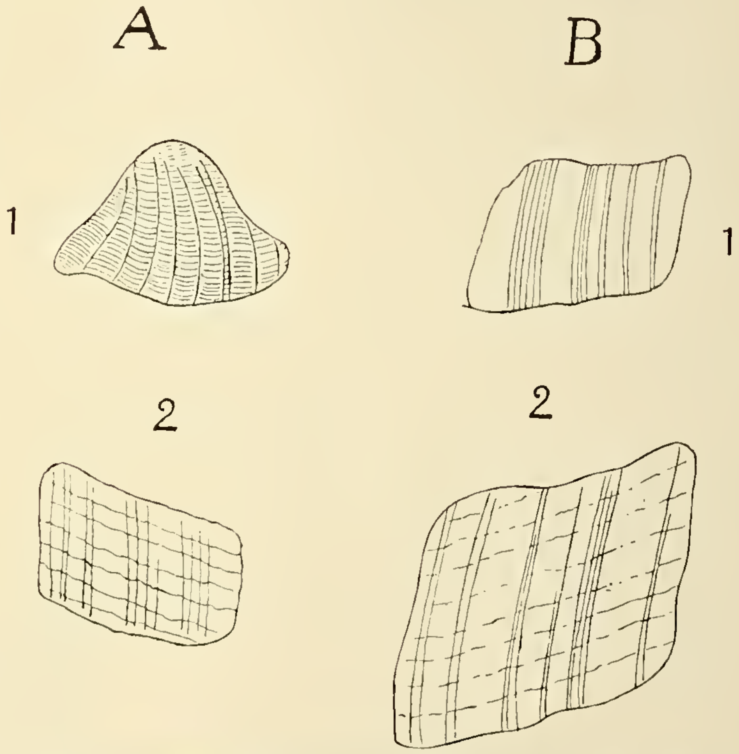

Fig 12.. Shell-fragment of *Limacina retroversa* (A) and of *L. balea* (B), slightly magnified *(1)*, highly magnified .*(2)*

In order to study the real shape of these minute teeth it is necessary to isolate them from each other by a slight pressure and then to examine each tooth by turning it under the coverglass. The lateral teeth as well as the median ones prove to be irregularly spoon-shaped, looking very different when seen from different sides.

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[1]) Parallel to the columella.

The shape of the median teeth may in both species vary somewhat with regard to the length of the spine, but affords no absolute character of distinction.

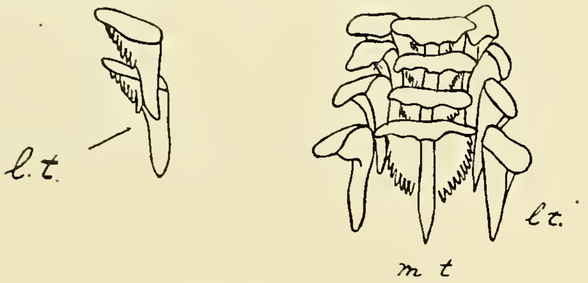

Fig. 13. Radula of *Limacina retroversa*. *l.t*, lateral teeth; *m.t.* median teeth.

The lateral teeth, however, are in fullgrown specimens absolutely different with regard to the arrangement of their denticles, the denticled border of *L. balea* (textfig. 14 B. 3) being in a very characteristic manner divided into two halves, while in *L. retroversa* (textfig. 13) no such division exist.

The existence of such a distinctive character in the radula, together with the statistical results as to the variations of the shell in the two forms, justify us in regarding *L. balea* and *L. retroversa* as specifically distinct.

Having compared the two species, I shall now treat them seperately, trying to establish their relations to other forms which have been referred to one or the other. I am well aware that this task is one of great difficulty, and that in some cases only a detailed examination of the original specimens can ensure an accurate determination.

I have also endeavoured to gather trustworthy information about the geographical distribution of the two species, and in doing so have had to omit all data given by those authors who consider *L. retroversa* and *L. balea* as one and the same species.

In order to give the reader an opportunity of testing the correctness of my opinion with regard to the synonymy I have copied a series of figures given by earlier authors and grouped them according to their similarity, paying special attention to the size and shape of the body-whorl as compared with the spire (textfig. 15 a—i and 17 a—d). The shape of the opening and the size of the umbilicus are characters so relative, and so inaccurately described by most authors, that they can scarcely be taken into consideration.

Limacina retroversa Fleming.

Heterofusus retroversus Fleming 1823, (p. 498, pl. 15. fig. 2).
Atlante trochiforme d'Orbigny, 1836 (Moll. p. 177, pl. 12, fig. 29—31).
Scaea stenogyra Phillipi, 1844 (p. 164, pl. 25, fig. 20).
Fusus retroversus Jeffreys, 1847 (p. 16).
Spirialis Flemingii Forbes & Hanley, 1850 (p. 382, pl. 57 fig. 4—5).
Limacina retroversa Gray, 1850 (p. 33).
— *trochiformis* Gray, 1850 (p. 33).
Spiralis trochiformis Eydoux and Souleyet, 1852 (p. 223, pl. 13, fig. 27—34).
— *retroversus* (pars) Jeffreys, 1869 (p. 115, pl. 4, fig. 4).
Heterofusus retroversus Gould, 1870 (p. 505, pl. 27, fig. 345).
Spirialis retroversus Monterosato, 1875 (p. 49).
— — G. O. Sars, 1878 (p. 330, pl. 29, fig. 3).
Limacina balea (pars) Boas 1886 (p. 43).
— *trochiformis* Boas, 1886 (p. 45).
— — Munthe, 1887 (p. 7, fig. 8—11).
— *australis* Pelseneer, 1888 (p. 25, pl. 1, fig. 6).
— *trochiformis* Pelseneer, 1888.
— *retroversa* Locard, 1897 (p. 23).
— *balea* (pars) Posselt, 1898 (p. 254).
— *trochiformis* Oberwimmer, 1898 (p. 589).
— *retroversa* (pars) Meisenheimer, 1905 (p. 419).
— — „ — 1906.
— *balea* (pars) Lenz, 1906 (p. 2).

In textfig. 15 I have copied a series of drawings by which some of the above named authors have illustrated their species. As will be seen from the list of synonyms I do not hesitate to identify *L. trochiformis* d'Orbig., with *L. retroversa*, Fleming. Such an identification has been

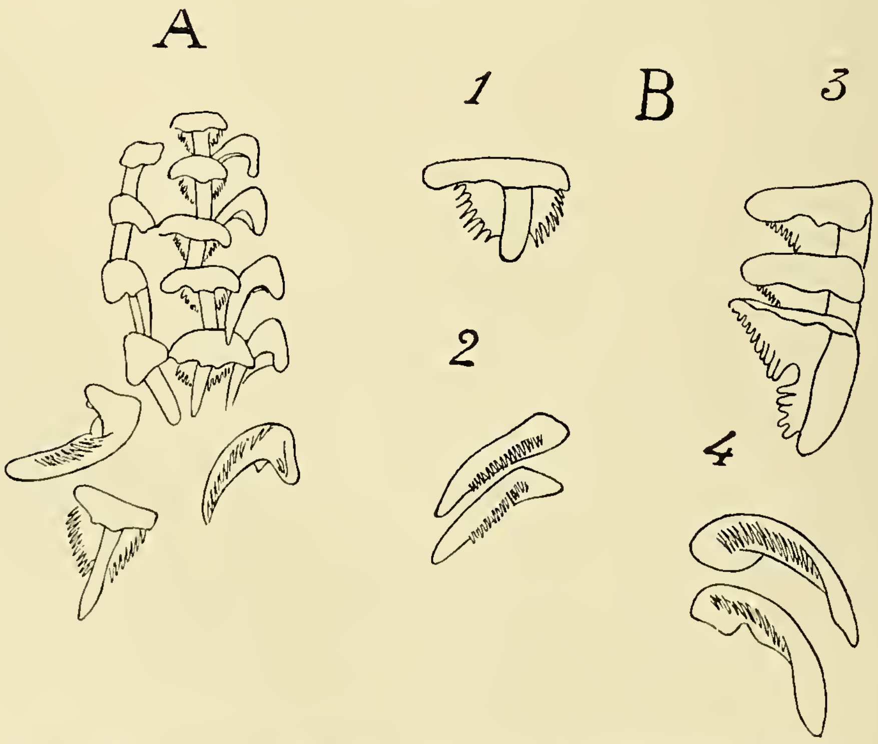

Fig. 14. Radula of *Limacina balea:* A of a young specimen, B of a full-grown specimen; 1, 2 median teeth. 3, 4 lateral teeth.

proposed by earlier authors, subject to doubt in some cases (Boas etc.) though with positiveness in others (Monterosato), while other investigators again (Munthe, Pelseneer, Meisenheimer etc.) warn us against this step. The last-mentioned authors, however, all consider *L. retroversa* as identical with *L. balea*, and their objections are based principally upon the difference between *L. balea* and *L. trochiformis*. A comparison of *d* and *g* in textfig. 15 (showing the original figs. by d'Orbigny and G. O. Sars of *L. trochiformis* and *L. retroversa)* will, I think, remove all doubt with regard to the identity of these two species. Pelseneer's *L. australis* (copied in *i*, textfig. 15) also shows in its shell all the characteristics of *L. retroversa*, while the original *L. australis* of Souleyet is more like *L. balea*.

Geographical distribution. (See the chart, textfig. 16). If I am right in my opinion about the synonymy, *L. retroversa* seems to be widely distributed, but restricted to the warm and temperate waters of the Pacific and Atlantic Oceans. D'Orbigny records it between 28° N. and 34° S., Eydoux and Souleyet "dans toutes les mers", Boas from Malacca and Batavia, and Munthe from the Atlantic and Indian Oceans at a latitude of about 30° S. In the Mediterranean fauna it seems to be a very common type (Philippi, Monterosato, Oberwimmer), and it has been found along the Spanish coast (Locard), as far north as the coasts of Ireland and England (Fleming, Forbes & Hanley, Jeffreys, Gray) and even occasionally off Lofoten on the Norwegian coast (G. O. Sars).

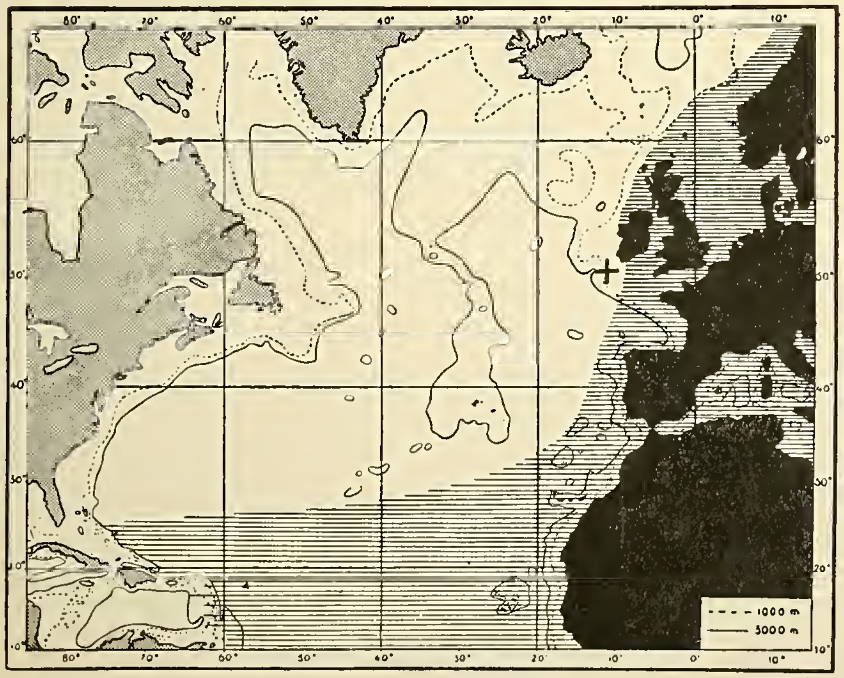

Fig. 16. Distribution of *Limacina retroversa* in the North Atlantic. The hatching represents area of distribution as known from previous investigations + locality of capture during the "Michael Sars" expedition.

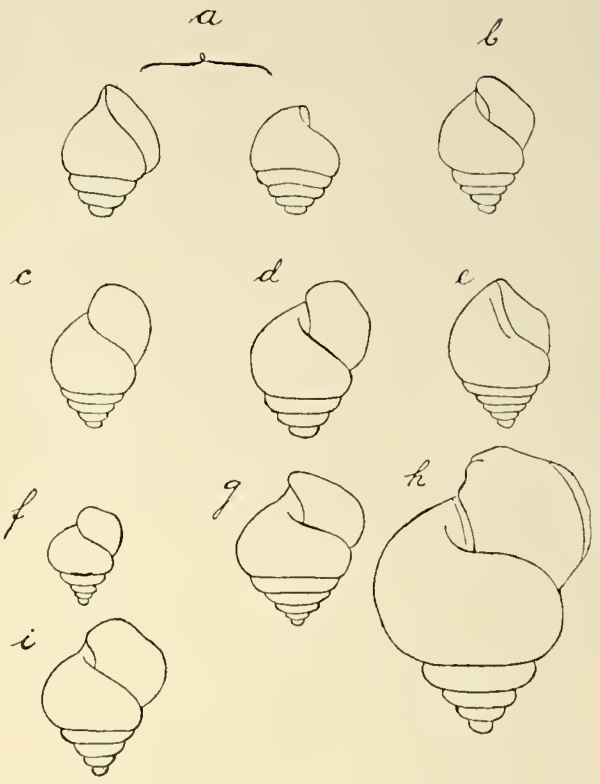

Fig. 15.

a. Heterofusus retroversus Fleming 1823, pl. 15, fig. 2.
b. Scaea stenogyra Phil. 1844, pl. 25, fig. 20.
c. Spirialis trochiformis Eudoux & Souleyet 1852, pl. 13, fig. 31.
d Atlante trochiforme d'Orbigny 1847, pl. 12, fig. 30.
e. Spirialis flemingii Forbes & Hanley 1850, pl. 57, fig. 5.
f. — *retroversus* Jeffreys 1869, pl. 4, fig. 4.
g. — — G. O. Sars 1878, pl. 29, fig. 3.
h. Limacina trochiformis Munthe 1887, fig. 8.
i. — *australis* Pels. 1888, pl. 1, fig. 6.

During the "Michael Sars" expedition *L. retroversa* was taken (about 800 individuals) at

St. 96 (50° 57′ N., 10° 46′ W.).
Date: 27/7 1910.
Depth: 50 m.

Limacina balea Møller.

Limacina balea Møller, 1841 (p. 490).
— — Gray, 1850 (p. 33).
Spirialis Gouldii Stimpson, 1851 (p. 8).
Spiriale australe Eydoux & Souleyet, 1852, p. 222, pl. 13, fig. 20—26).
Heterofusus balea Mørch, 1857 (p. 86).
Spirialis retroversus (pars) Jeffreys, 1869 (p 115).
Heterofusus balea Gould, 1870 (p. 505, pl. 27, fig. 349).
Spirialis balea Sars, 1878 (p. 329, pl. 29, fig. 2).
Limacina balea (pars) Boas, 1886 (p. 43).
— — Munthe, 1887 (p. 5, fig. 5—7, not 1—4).
— *retroversa* (pars) Pelseneer, 1888 (p. 27).
— *balea* Locard, 1897 (p. 25).
— — (pars) Posselt, 1898 (p. 254).
— *retroversa* (pars) Meisenheimer, 1905 (p. 419).
— *balea* (pars) Lenz, 1906 (p. 2).

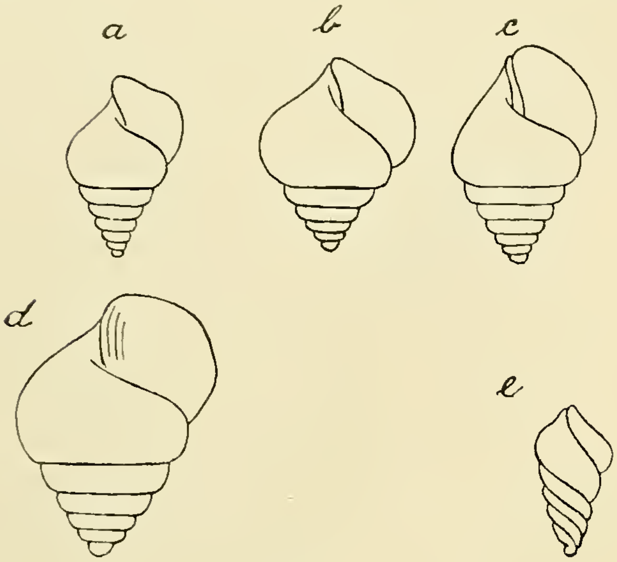

Fig. 17.

a. Spiriale australe Eyd. & Soul. 1852, pl. 13, fig. 21.
b. Heterofusus balea Gould. 1870, pl. 28, fig. 349.
c. Spirialis balea G. O. Sars 1878, pl. 29, fig. 2.
d. Limacina balea Munthe 1887, fig. 5.
e. Spirialis Mc. Andrei Forb. & Hanl. 1850.

Like earlier authors (Boas, Munthe, Meisenheimer etc.) I feel fully justified in uniting *Spiriale australe* Eydoux & Souleyet with *Limacina balea* Møller (see textfig. 17 a – c), the descriptions and figures of these two species differing in no essential point from each other. But I cannot agree with those authors who identify *Spirialis Mac Andrei* Forbes and Hanley, with this species. As will be seen from textfig. 17 *e* (a copy of the original figure), *Spirialis Mac Andrei* is much more slender than *Limacina balea*, and in the original description we find that the body-whorl is "not equal in length to the spire"; such a description would not fit even the most slender individuals of *L. balea*. *Spirialis Mac Andrei* looks more like *Limacina bulimoides* than any other species of *Limacina*.

Munthe (1887) has described and figured under the name of *L. balea* some young shells, which however seem to be very different from the young stages of this form. As will be seen from my textfig. 9 (pag. 13), the young stages of *L. balea* do not differ essentially from the older stages with regard to their shell-form.

Geographical distribution. While *L. retroversa* seems to have a very wide distribution throughout the warmer waters of all oceans *L. balea* belongs to the temperate zones between the Arctic and Antarctic and the circumtropical zone (see Meisenheimer 1905). Omitting all uncertain records in the literature, *L. balea* is known from Greenland (Møller, Mørch, Locard), North America (Stimpson, Gould), the Norwegian coast (G. O. Sars), and doubtfully from the North Sea and the coasts of England and Ireland. In the southern hemisphere it has been taken off Cape Horn (Eydoux and Souleyet, Munthe).

Station	1	66	69	70	80	82
Date	$^{9}/_{4}$	$^{26}/_{6}$	$^{29}/_{6}$	$^{30}/_{6}$	$^{11}/_{7}$	$^{13}/_{7}$
Position N.	49° 27′	39° 30′	41° 39′	42° 59′	47° 34′	48° 24′
Position W.	8° 36′	49° 42′	51° 4′	51° 15′	43° 11′	36° 53′
Depth in m.						
0—50	swarm	—	—	—	—	—
50—100	—	—	100	—	—	400
100—250	—	1100	100	300	—	—
250—500	—	10	—	—	16	—

Number of individuals of *Limacina balea*.

During the "Michael Sars" expedition swarms of *L. balea* were met with on the continental bank off Ireland (St. 1), and also at several stations in the western part of the Atlantic (see textfig. 18), partly at a more southern latitude than might be expected of a species belonging to the temperate zone (St. 66: 39° 30′ N.). A consideration of the hydrographical conditions (textfig. 19) proves however that the occurrence of *L. balea* at this latitude accords with our opinion that it is a northern species, for a wedge of cold water was found just at the place (St. 66)

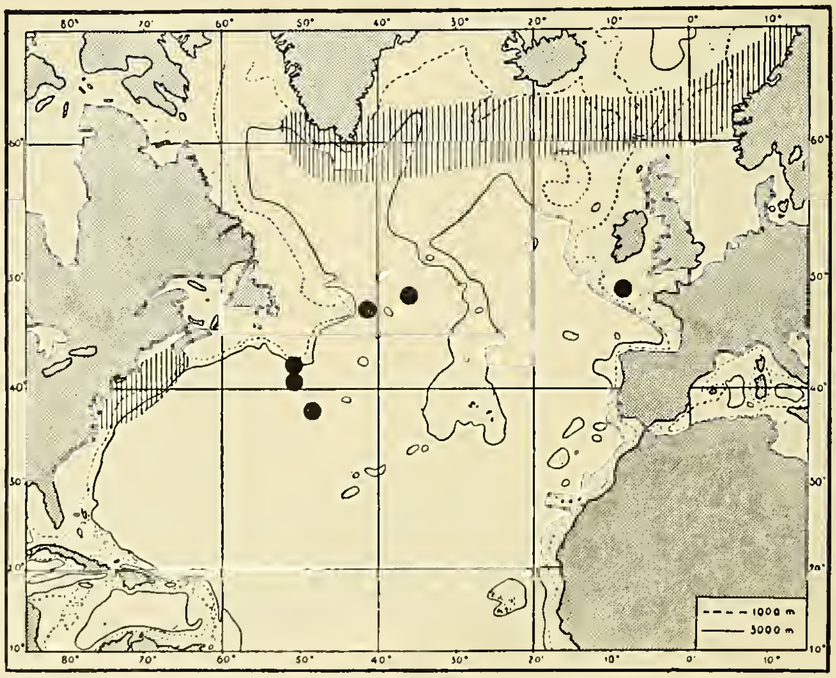

Fig. 18. Distribution of *Limacina balea* in the North Atlantic. For explanation see fig. 16.

where a dense swarm was taken; it is of interest to note that this swarm was not (like that at St. 1) found at the surface where the water was warmer, but at a depth of about 200 metres.

Limacina bulimoides d'Orbigny.

This species was found scattered in the western part of the Atlantic, between the Newfoundland bank and the Azores, and at one station off the Canaries. The columellar margin and the suture were in most of the specimens bright red.

Station	39	52	53	62	69
Date	20/5—21/5	6/6—7/6	8/6—9/6	20/6—21/6	29/6
Position N.	26° 3′	31° 24′	34° 59′	36° 52′	41° 39′
W.	15° 0′	34° 47′	33° 1′	39° 55′	51° 4′
Depth in m.					
0— 50	11	4	—	20	—
50—100	—	12	20	—	—
100—250	—	—	—	—	5
250—500	—	—	—	—	—

Number of individuals of *Limacina bulimoides.*

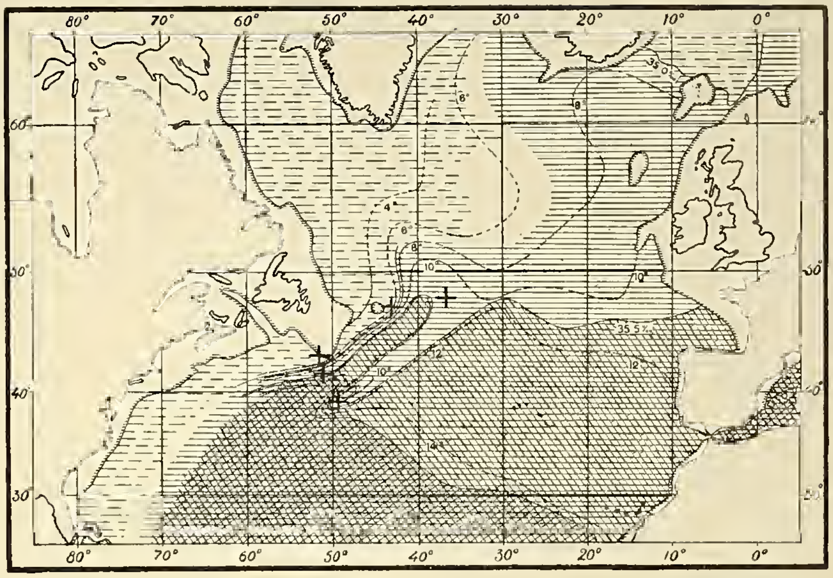

Fig. 19. Chart showing salinities and temperatures at a depth of 200 fathoms during the summer of 1910. Crosses denote localities where *Limacina balea* was taken during the expedition.

Limacina lesueuri d'Orbigny.

The distribution of this species in the Northern Atlantic resembles that of the preceding,—scattered over the western part between the American coast and the Azores, and off the Canaries, not a single specimen being taken in the eastern half of the open ocean. The number of individuals preserved is considerably larger than that of *L. bulimoides.*

Station	39	42	52	53	56	62	64	67	81
Date	20/5—21/5	23/5—24/5	6/6—7/6	8/6—9/6	10/6—11/6	20/6—21/6	24/6	27/6	12/7
Position N.	26° 3′	28° 2′	31° 24′	34° 59′	36° 53′	36° 52′	34° 44′	40° 17′	48° 7′
W.	15° 0′	14° 17′	34° 47′	33° 1′	29° 47′	39° 55′	47° 52′	50° 39′	39° 50′
Depth in m.									
0— 50	11	—	16	—	—	80	1	—	—
50—100	2	4	5	6	50	—	—	—	2
100 - 250	—	1	—	—	—	—	—	—	—
250—500	—	—	—	—	—	(5)	1	3	—

Number of individuals of *Limacina lesueuri.*

Limacina inflata d'Orbigny.

This species was taken during the "Michael Sars" expedition at the same stations as *L. lesueuri,* and at corresponding depths, but (like *L. balea* and *L. retroversa*) it occurs in dense swarms; it may be counted in hundreds, where its constant companion *L. lesueuri* is represented by single individuals.

Station	39	42	52	53	56	62	64	67	81
Date	20/5—21/5	23/5—24/5	6/6—7/6	8/6—9/6	10/6—11/6	20/6—21/6	24/6	27/6	12/7
Position N.	26° 3′	28° 2′	31° 24′	34° 59′	36° 53′	36° 52′	34° 44′	40° 17′	48° 2′
W.	15° 0′	14° 17′	34° 47′	33° 1′	29° 47′	39° 55′	47° 52′	50° 39′	39° 55′
Depth in m.									
0— 50	100	—	10	—	—	300	10	—	—
50—100	swarm	7	20	450	200	250	—	—	2
100—250	—	1	—	—	10	—	—	—	—
250—500	—	—	—	—	—	200	—	4	—

Number of individuales of *Limacina inflata.*

With regard to the Limacinidae, we find in the "Michael Sars" material representatives of all the species previously known from the Northern Atlantic, viz. seven species of the genus *Limacina* and three of *Peraclis*, besides a new species of the genus *Procymbulia.* Some of these species were found in quantities or under conditions which allowed a deeper study of their systematical or biological relations than had hitherto been possible. This is true especially of *Peraclis diversa, Limacina helicoides, L. balea* and *L. retroversa.*

With regard to the geographical distribution of the Limacinidae we have found, besides the arctic *L. helicina*, one northern form, *L. balea*, belonging to the transition zone between arctic and temperate waters and occasionally following the cold water-currents down to more southern latitudes (St. 66); all the other surface-species seem to belong to warm or temperate waters.

While most of the species of Limacinidae were taken in depths less than 250 m., two species, viz. *Peraclis diversa* and *Limacina helicoides*, seem to belong to the deeper layers of the ocean, the former however not descending into the cold bottom-water.

As a peculiar fact, which may in part depend upon accidental circumstances, it may be mentioned that during the "Michael Sars" expedition no species of *Limacina* was found in the eastern part of the Northern Atlantic, the European and African coast-line excluded.

Cavoliniidae.

The species belonging to this family are characterized unlike those of the Limacinidae, by their (externally) symmetrical body and the ventral position of their pallial cavity.

Modern authors (Pelseneer, Meisenheimer, Tesch) seem to agree in the interpretation of Boas (1886) with regard to the development of the Cavoliniidae from the Limacinidae through a rotation of 180° of their body relative to the head. There also seems to be a general harmony with regard to the generic relations within the Cavoliniidae, *Creseis* being considered as the most primitive (*Limacina*-like) type of this family, while *Clio* and *Cavolinia* represent the most extreme differentiation. The agreement between different authors upon these points is in fact so general, that I should consider it superfluous to reopen the discussion of the question, if the results of my investigation of the "Michael Sars" material had not obliged me to look upon the relationship between thecosomatous pteropods in a way somewhat different from that of earlier authors.

As mentioned above, I have found in *Limacina helicoides* a species in which the dorsal pallial cavity occupies also the right side of the body, and among the Cavoliniidae there is another species, *Clio falcata*, with its pallial cavity lying ventrally but also on the right side of the body, so that part of it is seen from the dorsal side of the animal.

The existence of these two species belonging one to each of the two great families of thecosomatous pteropods, but representing at the same time progressive transition stages between them, is of great general interest. On the one hand it proves the correctness of the hypothesis of Boas, in so far as the difference between the Cavoliniidae and Limacinidae is shown at least in part to be caused by a rotation of the pallial cavity, but on the other hand the additional information about these two transition forms still living in the ocean forces one to revise the questions as to what characters ought to be considered archaic and what characters are modern, and therefore also as to the relationship between different genera of each family·

These questions will be fully discussed later, and at present I shall only use the results of my investigation in arranging the genera and species according to the supposed relationship between them. Primitive characters are found above all in different species of *Clio*, but also in *Diacria,* and partly in *Cuvierina*; I therefore consider these groups to be the starting points of diverging lines of differentiation within the family Cavoliniidae, the limits of which agree with those of the genera *Clio, Cuvierina* and *Cavolinia* of Pelseneer. I shall therefore also maintain his division of the Cavoliniidae into genera and subgenera in spite of Meisenheimer's proposal to consider all the different groups as equivalent genera.

Clio.

Subgenus Euclio (Clio) Linné.

Of this group I have investigated three species: *Clio falcata*, *C. cuspidata* and *C. pyramidata*, which, besides the dorso-ventral compression and the lateral carinae of their shells, have also a number of other characters in common. Among these I shall here only mention the existence in all of them of a pointed triangular lobe above the mouth and a certain asymmetry of their pallial cavity.

Clio (Euclio) falcata Pfeffer.

Pl. II, fig. 12—13, 16—20.

Cleodora falcata, Pfeffer, 1880 (p. 96, fig. 19).
— — Boas, 1886 (p. 80).
— — Munthe, 1887 (p. 20).
Clio polita Pelseneer, 1888 (p. 60, pl. II, fig. 4—6).
— — Meisenheimer, 1905 (p. 20).
— *falcata* Meisenheimer, 1906 (p. 422, fig. 4).
— — Lenz, 1906 (p. 5, fig. 1—3).

Very few specimens of this species were previously available; the "Michael Sars" expedition brought home eight complete individuals. The soft parts of this interesting form are very little known, and I shall therefore point out the most characteristic and systematically interesting traits of its anatomy.

The shell (textfig. 20) well known from the description of PELSENEER (1888), is distinguished from that of nearly related species (for example *C. Andreae*, Boas) by its want of longitudinal or transverse striae or any other sculpture, except the two slowly diverging lateral carinae.

About the soft parts of the animal nothing is known except its colour, which is "dunkel-schwarz-violet" (PFEFFER 1880) and the similarity of its "foot" to that of *C. Andreae,* Boas, which according to MUNTHE (1887) represents a transition-form between the narrow tongue-like foot of *Cleodora (Clio)* and the broad foot of *Hyalaea (Cavolinia).*

To this I can add the following details:

The head of *Clio falcata* forms a very distinct triangular lobe pointed at its free end. The mouth is situated below this lobe.

Tentacles asymmetrically developed, the right tentacle being considerably larger than the left one, covered by a sheath and placed more anteriorly (fig. 12, 18 t). Both tentacles are cylindrical with convex ivory-coloured end-plates, like those of *Limacina helicoides.*

Foot forming a large continuous swimming-plate, the dorsal (lateral) part of which is soft and during rest tightly and regularly folded on both sides of the triangular lobe (fig. 12, 18). This soft part of the foot is during rest protected by the more rigid ventral lobe (fig. 13 v.l.), which is like an operculum closing the shell-mouth. So far as I have been able to see the margin of the foot is quite continuous, without any incision or lobe-formation.

The mantle and the pallial cavity are as in all the Cavoliniidae found on the ventral side of the body (fig. 13), the beautifully coloured transverse striae of the pallial gland attracting attention, but while the stripes of this gland take their origin along the lateral line of the left side, on the right side they continue on to the back of the animal (fig. 12 p.gl.), where the mantle-border forms a very conspicuous bow touching the median line of the body. The pallial cavity therefore in *Clio falcata* occupies not only the ventral but also the right side of the body. At the same time this cavity is very deep, covering nearly the whole length of the ventral side.

The mantle-margin is, like that of *Limacina helicoides*, formed by a thin membrane (fig. 13, 20 pl. II, fig. 25 pl. III), inside of which a tongue-like lobe protrudes, homologous to the gill of *L. helicoides.* This gill is in *Clio falcata* as in *L. helicoides* found on the right side of the body.

No balancer was found in this species.

Heart and kidney are seen to form a transverse row across the ventral side just behind the pallial gland (fig. 13 h.k.).

After removal of the mantle the position of the viscera is seen as shown in pl. II, fig. 16—17, and after a further dissection as in fig. 19. The relations of the digestive tract may be traced in the same figures.

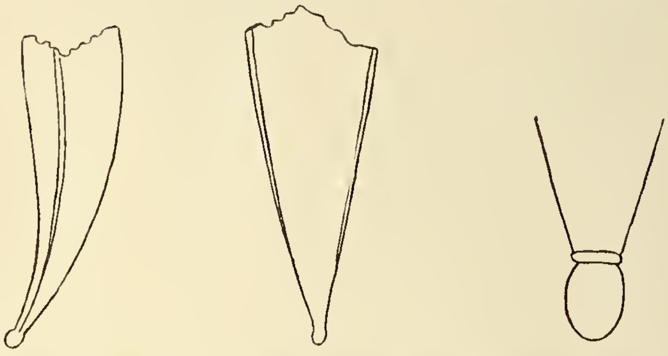

Fig. 20. Shell of *Clio (Euclio) falcata* (from PELSENEER 1888).

The buccal mass and the passage of the oesophagus through the ring formed by the central nervous system (fig. 19) do not show any peculiarities, but just behind this passage the oesophagus describes half a spiral turn so that at its posterior end the originally ventral side is placed dorsally (fig. 19).

The stomach of course follows the posterior end of the oesophagus. It occupies the left side of the body (fig. 16 st.) and its unpaired tooth which (with an untwisted oesophagus) would have been found in the median dorsal line, is placed ventrally (fig. 19 st.t.).

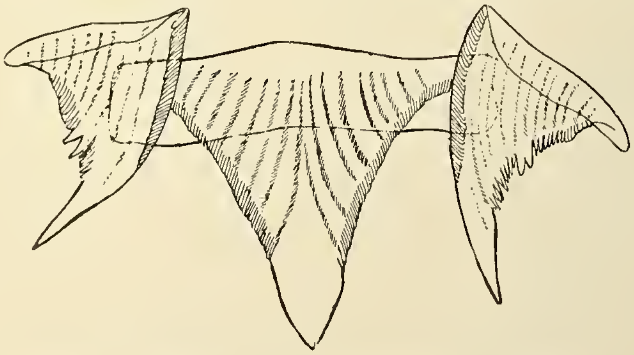

Fig. 21. Transverse row of the radula in *Clio falcata.*

The intestine leaves the stomach in a right-sided direction, soon however turning to the left (fig. 16), then passing from the dorsal side round the left edge of the liver (*1* fig. 16—17) and making a long loop over the ventral and right side of the body (*2* and *3* fig. 16—17). After having thus twice crossed the ventral side it once

Station	51	53	62	82	84	88
Date	5/6—6/6	8/6—9/6	20/6—21/6	18/7	15/7	18/7
Position N. W.	31° 20′ 35° 7′	34° 59′ 33° 1′	36° 52′ 39° 55′	48° 24′ 36° 53′	48° 4′ 32° 25′	45° 26′ 25° 45′
Depth in m.						
0— 50	—	—	—	—	—	—
50— 100	—	—	—	—	—	—
100— 250	—	—	—	—	—	—
250— 500	—	—	—	—	—	—
500— 750	—	—	—	2	—	—
750—1000	—	1	—	—	—	—
1000—1250	1	—	1	—	—	1
1250—1500	—	1	—	—	1	—

Number of individuals of *Clio falcata.*

more turns to the dorsal side (*4*, fig. 16—17), where it crosses the stomach in a direction from left to right, and finally back again, so that the anus is found on the left side of the body (*a* fig. 16). As will be shown below, this long and complicated passage of the intestine proves to be of great interest when compared with that in other forms.

The genital gland occupies the posterior part of the body behind the liver (g.gl. fig. 16—17), while the accessory glands are found anteriorly on the right side (acc. gl.). Unfortunately I did not succeed in following the course of the genital duct between these two glands; but very probably it takes its origin from the left side of the genital gland.

The nervous system is of interest in so far as the visceral and abdominal ganglia form a single symmetrically developed mass—as in *Limacina helicoides*, but while in the latter species the abdominal nerve leaves the gangliar mass in a right-sided direction, in *Clio falcata* it follows the oesophagus on its course towards the left side of the body.

The radula (textfig. 21) is well developed. The large median and lateral teeth are longitudinally striped and denticled along both margins, while the distal end of each of them forms a sharp pointed tooth.

Colour: The whole animal is, with the exception of the pallial gland and the end-plates of the tentacles, of a dark greyish-violet colour (see fig. 13, pl. II). The shell is colourless.

Size: In the largest specimens the shells attain a length of about 15 mm., with a maximum breadth of 6 or 7 mm.

Geographical distribution. The few scattered specimens previously recorded were all taken in the Atlantic Ocean, but at places so far apart as Davis strait and the South American coast (PELSENEER). Deposit shells of this species have been taken off the Azores and the Canary Islands (PELSENEER), and complete animals were found in the Northern Atlantic in latitude 37° 25′ N. (MUNTHE) to 44° 31′ N. (PELSENEER).

During the "Michael Sars" expedition *Clio falcata* was found at six stations, and as will be seen from the table it must, like *Peraclis diversa* and *Limacina helicoides*, be considered a deep-sea species confined to the cold bottom-water or the layers immediately above it.

Clio (Euclio) cuspidata Bosc.

Pl. III, fig. 21, 26.

The structure of this species is well known, so I shall here only mention a few facts of interest for comparison with other forms or unobserved by earlier investigators.

A comparison with *Clio falcata* proves that:

1) The ventral lobe of the foot is somewhat reduced, so that it does not fully cover the dorsal (lateral) lobes, which are more rigid than in *C. falcata*, but still folded during rest (fig. 21).

2) The triangular head-lobe is rudimentary.

3) The membranous mantle-margin is not so broad as in *C. falcata*, but it bears the same lobe-like gill (fig. 21, 26) on the right side of the body.

4) The transverse striation of the pallial gland is less conspicuous.

Station	10	23	29	42	45	49	53	56	58	62	87	88	92	98	101
Date	19/4—21/4	5/5—6/5	9/5—10/5	23/5—24/5	28/5—29/5	1/6	8/6—9/6	10/6 11/6	11/6—13/6	20/6—21/6	17/7	18/7	23/7—24/7	5/8	6/8—7/8
Position N. W.	45° 26′ 9° 20′	35° 32′ 7° 7′	35° 10′ 7° 55′	28° 2′ 14° 17′	28° 42′ 20° 0′	29° 6′ 25° 2′	34° 59′ 33° 1′	36° 53′ 29° 47′	37° 37′ 29° 25′	36° 52′ 39° 55′	46° 48′ 27° 46′	45° 26′ 25° 45′	48° 29′ 13° 55′	56° 33′ 9° 30′	57° 41′ 11° 48′
Depth in m.															
0— 50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50— 100	—	—	—	1	—	—	1	1	—	1	—	—	1	—	—
100— 250	1	3	2	—	13	—	—	—	1	—	—	2	—	—	—
250— 500	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
500— 750	—	—	—	—	—	—	—	—	—	—	1	—	—	4	—
750—1000	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
1000—1250	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—
1250—1500	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—

Number of individuals of *Clio cuspidata.*

5) The longitudinal striae of the radula-teeth are also less conspicuous.

Geographical distribution. This species is by Meisenheimer (1905,1906) recorded as being widely distributed within the warmer currents of the Atlantic Ocean (the Mediterranean inclusive), only occasionally finding its way into the cooler waters of northern (59° 26′ N. Boas 1886) or southern (42° 18′ S. Meisenheimer 1905) latitudes. — It has been found, although not frequently, also in the Indo-Australian and Pacific oceans.

During the "Michael Sars" expedition *Clio cuspidata* was taken at many stations, especially in the eastern part of the Northern Atlantic, usually in the water-layer between 100 and 250 metres, as shown in the table, the table also shows that its occurrence at the Northern latitude recorded by Boas is no isolated phenomenon, for it was taken at two stations (98, 101) near this latitude.

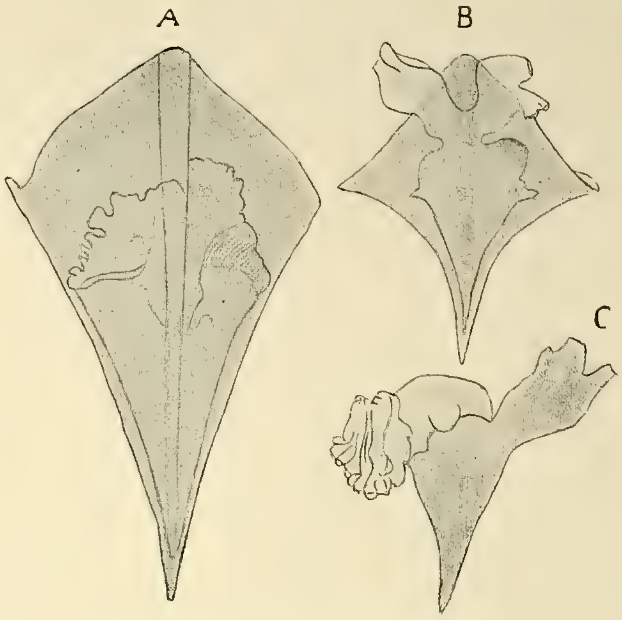

Fig. 22. Varieties of *Clio pyramidata*: A *angusta*, B *lata*, C *convexa*.

Clio (Euclio) pyramidata Linné.

Pl. III, fig. 22—23, 27.

No pteropod is better known and more often described and figured than this species. It is, therefore, a curious fact that a very obvious asymmetry of its mantle has, so far as I have been able to ascertain, escaped attention.

The right side of the mantle-margin is in all well preserved specimens much more fully developed than the left side, and protrudes like a broad folded membrane visible on the dorsal as well as on the ventral side of the animal (fig. 22—23 *m*). Inside of this membrane is found the little lobe-like gill already known in *Limacina helicoides*, *Clio falcata* and *C. cuspidata* (fig. 27 g).

The ventral lobe of the foot is, in comparison with the above-named species, still further reduced, forming only a narrow rounded lobe during rest covering the mouth and the bases of the wing-like lateral lobes.

The transversely striated mantle-gland of *Clio falcata* and *Clio cuspidata* is in this species replaced by the well-known semicircular shield-like gland, whose border is formed by a broad finely striped U-shaped ribbon.

Geographical distribution. *Clio pyramidata* is one of the commonest representatives of thecosomatous pteropods in all oceans, — a widely distributed inhabitant of warm and temperate regions.

The eurythermal character of this species was confirmed during the "Michael Sars" expedition, it having been taken at no less than 23 stations scattered over the North Atlantic, and from various depths. A glance at the table shows, however, that it is not equally distributed, but at some places occurs in dense swarms, as at stations 23, 42, 82, 84. In some of these swarms (indicated by

● var. *angusta*, ⊙ var. *lata*, ⊕ transitional forms.

Fig. 23. *Clio pyramidata*.

Station	10	23	29	34	35	39	42	45	51	52	53
Date	19/4—21/4	5/5—6/5	9/5—10/5	13/5—14/5	18/5—19/5	20/5—21/5	23/5—24/5	28/5—29/5	5/6—6/6	6/6—7/6	8/6—9/6
Position N. W.	45° 26′ 9° 20′	35° 32′ 7° 7′	35° 10′ 7° 55′	28° 52′ 14° 16′	27° 27′ 14° 52′	26° 3′ 15° 0′	28° 2′ 14° 17′	28° 42′ 20° 0′	31° 20′ 35° 7′	31° 24′ 34° 47′	34° 59′ 33° 1′
Depth in m.											
0— 50	**15**	—	—	—	—	—	—	—	—	5	1
50— 100	2	—	—	—	—	**15**	**70**	**2**	—	—	22
100— 250	16	180	23	—	—	—	**80**	**1**	1	—	2
250— 500	—	—	—	1	—	—	11	—	—	—	—
500— 750	—	—	—	—	—	—	—	—	—	—	—
750—1000	—	—	—	—	—	—	—	—	—	—	—
1000—1250	—	—	5	—	—	—	—	—	—	—	—
1250—1500	—	—	—	—	4	—	—	—	—	—	4

Station	56	58	62	64	67	81	82	84	87	88	90	92
Date	10/6—11/6	11/6—13/6	20/6—21/6	24/6	27/6	12/7	13/7	15/7	17/7	18/7	21/7	23/7—24/7
Position N. W.	36° 53′ 29° 47′	37° 37′ 29° 25′	36° 52′ 39° 55′	34° 44′ 47° 52′	40° 17′ 50° 39′	48° 2′ 39° 55′	48° 24′ 36° 53′	48° 4′ 32° 25′	46° 48′ 27° 46′	45° 26′ 25° 45′	46° 58′ 19° 6′	48° 29′ 13° 55′
Depth in m.												
0— 50	—	1	5	—	—	6	—	1	1	—	—	—
50— 100	25	11	12	—	—	56	**115**	**68**	2	17	—	1
100— 250	4	15	4	—	—	2	7	8	—	8	—	1
250— 500	—	—	—	1	1	—	—	30	—	—	—	—
500— 750	4	—	1	14	2	—	—	33	6	1	1	—
750—1000	—	—	—	—	—	—	—	3	—	—	—	—
1000—1250	7	—	2	—	—	—	2	3	7	—	—	—
1250—1500	—	—	—	—	—	—	—	—	—	—	—	—

Number of individuals of *Clio pyramidata.*

fat figures in the table) a great many young individuals were found scattered among the older ones.

Boas (1886) has, like d'Orbigny before him, distinguished certain geographical varieties, viz:

1) Var. *angusta* from the Northern Atlantic and Eastern Pacific.

2) Var. *lata* from the Atlantic between the latitudes of 40° N. and 30° S., from the Western Pacific and the Northern Indian ocean.

3) Var. *convexa* from the southern part of the Indian ocean.

The distinctness of such varieties has, however, not been acknowledged by later authors (Munthe, Tesch, Meisenheimer).

In the material at my disposal I have without difficulty confirmed the existence of all three forms (textfig. 22), two of which *(angusta* and *lata)* I must, with Boas, consider as geographical (northern and southern) varieties of *Clio pyramidata.* The most typical specimens of both forms are strikingly different from each other in size as well in shape. The shell of var. *lata* may, indeed, be very much like that of *Clio cuspidata,* with its sharp carinae, its long lateral spines and its very distinct transverse striation. Extreme forms of both varieties were found during the "Michael Sars" expedition separated from each other, var. *angusta* at a series of northern stations (● on the chart textfig. 23), and var. *lata* along the Spanish-African coast (⊙ on the chart). But at the same time a whole series of transitional forms were found between the American coast and the Azores (⊕ on the chart). At all stations within this zone either transitional forms or both varieties were found intermingled.

The independent existence of a var. *convexa* I am inclined to doubt, although I have had no opportunity of studying material from the region where, according to Boas, this variety is found. The reason is that among my *angusta*-specimens a considerable number has the characteristic shape of var. *convexa* with the lateral carinae concave posteriorly and faintly convex anteriorly.—The specimen figured in textfig. 22 B was taken at St. 82 (48° 24′ N., 36° 53′ W.). Such individuals were always found together with others in which no convexity was traceable.

Station	23	35	39	42	45	46	47	49	52	53	56	58	62	64	67
Date	5/5–6/5	18/5–19/5	20/5–21/5	23/5–24/5	28/5–29/5	29/5	30/5	1/6	6/6–7/6	8/6–9/6	10/6–11/6	11/6–13/6	20/6–21/6	24/6	27/6
Position N.	35° 32′	27° 27′	26° 3′	28° 2′	28° 42′	28° 56′	29° 2′	29° 8′	31° 24′	34° 59′	36° 53′	37° 37′	36° 52′	34° 44′	40° 17′
Position W.	7° 7′	14° 52′	15° 0′	14° 17′	20° 0′	21° 45′	22° 53′	25° 16′	34° 47′	33° 1′	29° 47′	29° 25′	39° 55′	47° 52′	50° 39′
Depth in m.															
0— 50	—	—	—	—	—	1	—	—	5	2	—	—	10	—	—
50— 100	—	—	4	3	7	—	—	—	49	70	84	1	3	—	—
100— 250	4	—	—	—	1	—	—	—	—	3	4	—	—	—	—
250— 500	—	—	—	—	—	—	—	—	—	—	—	—	—	20	5
500— 750	—	—	—	—	—	—	—	—	—	—	2	—	—	92	—
750—1000	—	—	—	—	—	—	1	—	—	—	—	—	—	3	—
1000—1250	—	—	—	—	—	—	—	2	—	—	3	—	—	—	—
1250—1500	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—

Number of individuals of *Styliola subula.*

Subgen. 2: Styliola Lesueur.

Clio (Styliola) subula Quoy and Gaimard.

This species is characterised by MEISENHEIMER (1905) as a warm-water form occurring on both sides of the equator, though it seems to avoid the warmest water. The northern limit of its distribution is found abt. lat. 40° N.

The results of the "Michael Sars" expedition conform to this distribution, *Styliola subula* having been found at numerous stations during the southern crossing of the ocean, the most northerly station (67) in latitude 40° 17′ N., but not a single specimen was found during the northern crossing between Newfoundland and Ireland. It occurred in great numbers off the Azores at Stations 52, 53, 56.

Subgen. 3: Creseis Rang.

Clio (Creseis) acicula Rang.

This species is also considered by MEISENHEIMER to be a warm-water form, but with a wider distribution than *Styliola subula,* being found in the warmest water near the equator as well as in the temperate water of the Gulfstream (48° N.).

Station	47	48	49	52	53	62	64	67
Date	30/5	31/5	1/6	6/6—7/6	8/6—9/6	20/6—21/6	24/6	27/6
Position N.	29° 2′	28° 54′	29° 8′	31° 24′	34° 59′	36° 52′	34° 44′	40° 17′
Position W.	22° 53′	24° 14′	25° 16′	34° 47′	33° 1′	39° 55′	47° 52′	50° 39′
Depth in m.								
0— 50	1	41	—	—	—	5	1	17
50— 100	—	—	—	20	10	—	—	—
100— 250	—	—	—	—	—	—	13	4
250— 500	—	—	—	—	—	—	6	—
500— 750	—	—	—	—	—	—	1	—
750—1000	—	—	—	—	—	—	—	—
1000—1250	—	—	—	—	—	—	—	—
1250—1500	—	—	7	—	—	—	—	—

Number of individuals of *Creseis acicula.*

A comparison of the tables shows a very characteristic difference in the horizontal distribution of *Styliola subula* and *Creseis acicula,* for in the open ocean the two species were found practically at the same stations, but near the African coast (Stations 23, 35, 39, 42, 45) and near the Azores (Stations 56, 58) *Creseis acicula* was absolutely wanting.

Subgen. 4: Hyalocylix Fol.

Clio (Hyalocylix) striata Rang.

This species is very sparsely represented in the material from the "Michael Sars" expedition (see the table), a fact which confirms the results of earlier investigators with regard to its geographical distribution. It is regarded by MEISENHEIMER (1905) as a warm-water species belonging to the zone between 30° N. and 30° S., though occasionally passing beyond that zone.

As only a few of the "Michael Sars" stations lie within this zone, the individuals brought home probably represent stray visitors in northerly waters.

Station	23	48	51	52	64	69
Date	5/5—6/5	31/5	5/6—6/6	6/6—7/6	24/6	29/6
Position N.	35° 32′	28° 54′	31° 20′	31° 24′	34° 44′	41° 39′
Position W.	7° 7′	24° 14′	35° 7′	34° 47′	47° 52′	51° 4′
Depth in m.						
0— 50	—	—	—	—	—	—
50— 100	—	1	—	1	—	—
100— 250	1	—	1	—	1	2
250— 500	—	—	—	—	1	—
500— 750	—	—	—	—	1	—
750—1000	—	—	—	—	—	—
1000—1250	—	—	—	—	—	—
1250—1500	—	—	—	—	—	—

Number of individuals of *Hyalocylix striata.*

Station	23	29	45	47	49	52	53	56	58	64	67	81
Date	5/5—6/5	9/5—10/5	28/5—29/5	30/5	1/6	6/6—7/6	8/6—9/6	10/6—11/6	11/6—13/6	24/6	27/6	12/7
Position N.	35° 32′	35° 10′	28° 42′	29° 2′	29° 8′	31° 24′	34° 59′	36° 53′	37° 37′	34° 44′	40° 17′	48° 2′
Position W.	7° 7′	7° 55′	20° 0′	22° 53′	25° 16′	34° 47′	33° 1′	29° 47′	29° 25′	47° 52′	50° 39′	39° 55′
Depth in m.												
0— 50	—	—	—	—	—	1	1	—	—	—	—	—
50— 100	—	—	—	—	—	1	6	1	2	—	—	1
100— 250	22	1	1	—	24	—	—	—	—	—	—	—
250— 500	—	—	—	—	—	—	—	—	—	1	—	—
500— 750	2	—	—	—	—	—	—	—	—	4	2	—
750—1000	—	—	—	—	—	—	—	—	—	—	—	—
1000—1250	—	—	1	—	1	—	1	—	—	8	—	—
1250—1500	—	—	—	1	—	—	—	—	—	—	—	—

Number of individuals of *Cuvierina columnella.*

Cuvierina Boas.

Cuvierina columnella Rang.

As in the genus *Clio* (subgenus *Euclio),* we find in *Cuvierina columnella*[1]) a small membranous lobe (gill) inside the mantle-margin on the right side of the body; this lobe has been observed by PELSENEER (1888) and by TESCH (1904).

Cuvierina culumnella was found during the "Michael Sars" expedition generally distributed along the African coast and the southern crossing of the ocean from the Canaries to Newfoundland, thus agreeing with what was previously known about its distribution (MEISENHEIMER 1905), but its occurrence at Station 81 (lat. 48° 2′ N.) is farther north than any former record.

Cavolinia Abildgaard.

Subgen. 1: Diacria Gray.

Cavolinia (Diacria) trispinosa Lesueur.

Pl. II, fig. 13—14, pl. IV, fig. 28—34.

Certain features in the anatomy of this species remind one of *Clio falcata*, the foot being developed into a broad and continuous swimming-plate, the dorsal part of which is tightly folded during rest and covered by the large and rigid ventral lobe, while the pallial gland with its vividly coloured transverse striation resembles that of *Clio falcata*. The resemblance is even greater when young individuals of *Diacria trispinosa* (pl. II fig. 13—14) are compared with full-grown specimens of *Clio falcata* (fig. 11—12), for the shape of the body, the development and striation of the pallial gland, and above all its extension on the right side of the body, indicate a close relationship between them. Also in *Diacria trispinosa* a lobe-like gill protrudes from under the mantle-margin on the right side of the body.

During the "Michael Sars" expedition several hundreds of individuals of this species were preserved, a considerable proportion having diminutive soft bodies within fully developed shells (fig. 29, pl. IV).

At first I did not pay much attention to these aberrant forms, considering them as degenerate individuals, but I soon observed a series of transitions between them and the normally developed forms (fig. 29—34, pl. IV). A thorough investigation proved the small soft bodies to be in a state of vigorous development and not degenerate, all the organs being present and well preserved, although of small size (fig. 33).

A consideration of the soft bodies alone leaves no room for doubt that the series shown in pl. IV illustrates the normal development of *Diacria trispinosa.* The shells also show a gradual development, from the hyaline and quite colourless shell of fig. 29 to the normally pigmented one of fig. 34, and I am indeed inclined to believe that the individuals with small bodies within large shells represent normal stages of development, although I have seen no figure illustrating the transition between the two stages represented in fig. 28 and fig. 29.

But here the questions arise: How does the shell grow, and what laws govern the development of its characteristic shape and size, so far ahead of the body? Does additional fluid secreted by the animal suffice to produce an independent marginal growth of the shell, following laws as fixed as those governing the growth of a crystal? The answers to these questions must be left for future investigation.

Geographical distribution. Like *Clio pyramidata* this species seems to be generally distributed, but in lesser numbers, all over the North Atlantic.

During the "Michael Sars" expedition it was taken at no less than 24 stations, covering the whole route along the European and African coasts and the southern

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[1]) Special traits of the anatomy of *Cuvierina columnella* will be considered in a later paper.

Station	10	29	34	39	42	45	49	51	52	53	56	58
Date	19/4—21/4	9/5—10/5	13/5—14/5	20/5—21/5	23/5—24/5	28/5—29/5	1/6	5/6—6/6	6/6—7/6	8/6—9/6	10/6—11/6	11/6—13/6
Position N.	45° 26′	35° 10′	28° 52′	26° 3′	28° 2′	28° 42′	29° 8′	31° 20′	31° 24′	34° 59′	36° 53′	37° 37′
Position W.	9° 20′	7° 55′	14° 16′	15° 0′	14° 17′	20° 0′	25° 32′	35° 7′	34° 47′	33° 1′	29° 47′	29° 25′
Depth in m.												
0— 50	—	—	—	—	—	—	—	—	—	1	—	—
50— 100	—	—	—	3	3	—	1	—	2	22	—	46
100— 250	5	2	3	—	2	15	—	7	—	—	14	23
250— 500	—	—	—	—	—	—	—	—	—	—	1	—
500— 750	—	—	—	—	—	—	—	—	—	—	5	—
750—1000	—	—	—	—	—	—	—	—	—	—	—	—
1000—1250	—	—	—	—	—	—	—	—	—	—	—	—
1250—1500	—	—	—	—	—	—	1	—	—	12	4	—

Station	62	64	67	69	81	82	84	87	88	90	92	94
Date	20/6—21/6	24/6	27/6	29/6	12/7	13/7	15/7	17/7	18/7	21/7	23/7—24/7	26/7
Position N.	36° 5′	34° 44′	40° 17′	41° 39′	48° 2′	48° 24′	48° 4′	46° 48′	45° 26′	46° 58′	48° 29′	50° 13′
Position W.	43° 58′	47° 52′	50° 39′	51° 4′	39° 55′	36° 53′	32° 25′	27° 46′	25° 45′	19° 6′	13° 55′	11° 23′
Depth in m.												
0— 50	12	—	—	—	—	—	—	—	1	—	—	—
50— 100	13	—	—	—	12	3	1	—	11	16	6	—
100— 250	3	2	1	—	—	1	—	11	31	8	12	2
250— 500	—	2	1	1	—	1	—	—	—	—	—	—
500— 750	2	—	—	—	—	—	—	—	—	1	—	—
750—1000	—	—	—	—	—	—	—	—	—	—	—	—
1000—1250	—	—	—	—	—	—	—	—	—	—	—	—
1250—1500	1	1	—	—	—	—	—	—	—	—	—	—

Number of individuals of *Diacria trispinosa*.

as well as the northern sections across the Atlantic ocean, but like all other thecosomatous pteropods, it avoids the cold waters of the Newfoundland banks.

It was taken as far north as lat. 55° 13′ N. though according to MEISENHEIMER (1905) lat. 46° N. represents its normal northern limit.

BOAS (1886) distinguished two varieties of this species, viz. var. *major* and var. *minor*, differing from each other in size and in the position and direction of the lateral spines, which in var. *major* are placed farther back than in var. *minor*, and in var. *major* are directed obliquely backwards while in var. *minor* they are perpendicular to the long axis of the body.

In my material both varieties are represented, but although extreme specimens are very easily distinguished from each other, yet there are so many transitional stages, that it would be impossible to decide where the limit should be drawn between the two forms. Extreme specimens of the var. *major* were during the "Michael Sars" expedition found along the Spanish-African coast, while the var. *minor* was taken at more northerly stations.

Cavolinia (Diacria) quadridentata Lesueur.

This little species seems to be much more limited in its distribution than *D. trispinosa* and to inhabit warmer waters.

Like several other small pteropods it may occur in dense swarms (Station 48).

The results of the "Michael Sars" expedition with regard to the distribution of this species (see the table) agree perfectly well with those obtained by earlier investigators. (MEISENHEIMER 1905).

Station	48	49	50	52	53	67
Date	31/5	1/6	4/6	6/6—7/6	8/6—9/6	27/6
Position N.	28° 54′	29° 8′	30° 8′	31° 24′	34° 59′	40° 17′
Position W.	24° 14′	25° 16′	31° 19′	34° 47′	33° 1′	50° 39′
Depth in m.						
0— 50	64	—	1	1	—	1
50— 100	—	—	—	2	1	—
100— 250	—	—	—	—	—	—
250— 500	—	—	—	—	—	—
500— 750	—	—	—	—	—	—
750—1000	—	—	—	—	—	—
1000—1250	—	—	—	—	—	—
1250—1500	—	3	—	—	—	—

Number of individuals of *Diacria quadridentata*.

Subgen. 2: Cavolinia s. str., Abildgaard.

The relation between this subgenus and *Diacria* is obvious, and has been often discussed by earlier authors. I shall here only mention that the characters connecting *Diacria* with *Clio falcata* are somewhat reduced in

Station	23	29	31	35	39	42	48	51	53	56	62	67
Date	5/5—6/5	9/5—10/5	10/5	18/5—19/5	20/5—21/5	23/5—24/5	31/5	5/6—6/6	8/6—9/6	10/6—11/6	20/6—21/6	27/6
Position N. W.	35° 32′ 7° 7′	35° 10′ 7° 55′	33° 47′ 8° 27′	27° 27′ 14° 52′	26° 3′ 15° 0′	28° 2′ 14° 17′	28° 54′ 24° 14′	31° 20′ 35° 7′	34° 59′ 33° 1′	36° 53′ 29° 47′	36° 52′ 39° 55′	40° 17′ 50° 39′
Depth in m.												
0— 50	—	—	4	—	600	9	1	—	1	—	—	—
50— 100	—	—	—	—	78	Swarms	—	—	—	1	—	—
100— 250	530	6	—	—	—	4	—	2	—	—	1	—
250— 500	—	—	—	—	—	—	—	—	—	—	—	1
500— 750	50 (sh.)	—	—	—	—	—	—	—	—	—	—	—
750—1000	—	—	—	—	—	—	—	—	—	—	—	—
1000—1250	—	—	—	—	—	—	—	—	—	—	—	—
1250—1500	—	—	—	3	—	—	—	—	—	—	—	—

Number of individuals of *Cavolinia inflexa.*

Cavolinia; the mantle-gland is more uniform, although transverse striae are still found (as in *Cavolinia inflexa*), and the ventral lobe of the foot is very small compared with the large and folded lateral lobes; the lobe-like gill is developed also in *Cavolinia (C. gibbosa)*.

Cavolinia inflexa Lesueur.

This warm-water form, which seldom passes beyond latitude 40° N. (Meisenheimer 1905), was met with during the "Michael Sars" expedition in innumerable masses off the Canary Islands (Stations 39, 42) and also near Gibraltar (Station 23), but sparsely in the open ocean.

The localities noted in the table all lie within the limits of distribution indicated by Meisenheimer (1905), but the occurrence of this species in enormous swarms so far north as between lat. 26° and 35° N. has not hitherto been recorded.

Boas (1886) distinguished two varieties of this species, viz.: var. *longa* and var. *lata*, between which, however, a complete series of transitional forms could be traced. Geographically he found the two varieties better separated, for var. *lata* had not been found to the north of lat. 26½° N., though the northern form, var. *longa*, had been taken also to the south of that latitude.

A broader southern and a longer northern form of *Cavolinia inflexa* may be distinguished also among the material from the "Michael Sars" expedition, the swarms from the warm salt water off Gibraltar (Station 23) being very much like the *lata*-type, while the material taken farther north consists of more or less typical specimens of the *longa*-type.

Station	35	42	45	48	49	51	67
Date	18/5—19/5	23/5—24/5	28/5—29/5	31/5	1/6	5/6—6/6	27/6
Position N. W.	27° 27′ 14° 52′	28° 2′ 14° 17′	28° 42′ 20° 0′	28° 54′ 24° 14′	29° 6′ 25° 2′	31° 20′ 35° 7′	40° 17′ 50° 39′
Depth in m.							
0— 50	—	—	—	1	—	—	—
50— 100	—	—	—	—	4	—	—
100— 250	1	1	17	—	—	1	1
250— 500	—	—	—	—	—	—	—
500— 750	—	—	—	—	—	—	—
750—1000	—	—	—	—	—	—	—
1000—1250	—	—	—	—	1	—	—
1250—1500	—	—	—	—	—	—	—

Number of individuals of *Cavolinia gibbosa.*

Cavolinia gibbosa Rang.

With regard to this species also the results of the "Michael Sars" expedition coincide with those of earlier expeditions, *Cavolinia gibbosa* being characterised as a warm-water species which, however, avoids the immediate neighbourhood of the equator (Meisenheimer).

Cavolinia tridentata Forskål.

A warm-water species generally distributed throughout the Northern Atlantic as far as lat. 40° N. Only 15 specimens were brought home by the "Michael Sars" from four stations all within the known limits of distribution.

Station	45	51	53	56
Date	28/5—29/5	5/6—6/6	8/6—9/6	10/6—11/6
Position N. W.	28° 42′ 20° 0′	31° 20′ 35° 7′	34° 59′ 33° 1′	36° 53′ 29° 47′
Depth in m.				
0— 50	—	—	—	—
50— 100	—	—	—	—
100— 250	2	1	—	1
250— 500	—	—	—	—
500— 750	—	—	—	—
750—1000	—	—	—	—
1000—1250	—	—	8 (sh.)	—
1250—1500	1	—	—	—

Number of individuals of *Cav. tridentata.*

Cavolinia longirostris Lesueur.

This warm-water species was taken by the "Michael Sars" at two stations in the vicinity of the Sargosso-Sea:—

Station 51: $^{5}/_{6}$—$^{6}/_{6}$ 1910. 31° 20′ N., 35° 7′ W.
Depth 100—250 m. 1 individual.
Station 52: $^{6}/_{6}$—$^{7}/_{6}$ 1910. 31° 24′ N., 34° 47′ W.
Depth 0—50 m. 8 individuals.

Cavolinia uncinata Rang.

A defective individual of this species was taken near the surface at Station 67 (40° 17′ N., 50° 39′ W.).

As was the case with the Limacinidae, the collection of Cavoliniidae brought home by the "Michael Sars" does not add materially to the number of known species, but several species were taken under such conditions or in such quantities as to widen our knowledge regarding their generic or biological relations (e. g. *Clio falcata, Clio pyramidata, Diacria trispinosa).*

The results of the expedition bearing upon the geographical distribution of the Cavoliniidae will be dealt with later.

Cymbuliidae.

Cymbulia Peron and Lesueur.

Cymbulia peronii de Blainville.

Four individuals and two empty shells of this Mediterranean species were taken by the "Michael Sars" off Gibraltar, and as far north as the Bay of Biscay.

Station	10	29
Date	$^{19}/_{4}$—$^{20}/_{4}$	$^{9}/_{5}$—$^{10}/_{5}$
Position N. W.	45° 26′ 9° 20	35° 10′ 7° 55′
Depth in m.		
0— 50	—	—
50— 100	2	—
100— 250	2	1
250— 500	—	—
500— 750	—	—
750—1000	—	1
1000—1250	—	—
1250—1500	—	—

Number of individuals of *Cymbulia peronii.*

Cymbulia borealis n. sp.

In textfig. 24 I have shown a small *Cymbulia?* of which 14 individuals without shells were brought home by the "Michael Sars", most of them in very bad condition, and none sufficiently well preserved to allow of a thorough investigation.

Enough can be seen however to prove that it is distinct from any of the earlier known representatives of the Cymbuliidae.

The proboscis is short and fixed to the underlying part of the foot. The dorsal and ventral lips are continued into the dorsal margin of the fins through two narrow parallel ridges.

Jaw and radula present (textfig. 25); teeth of the same type as in *C. peronii.*

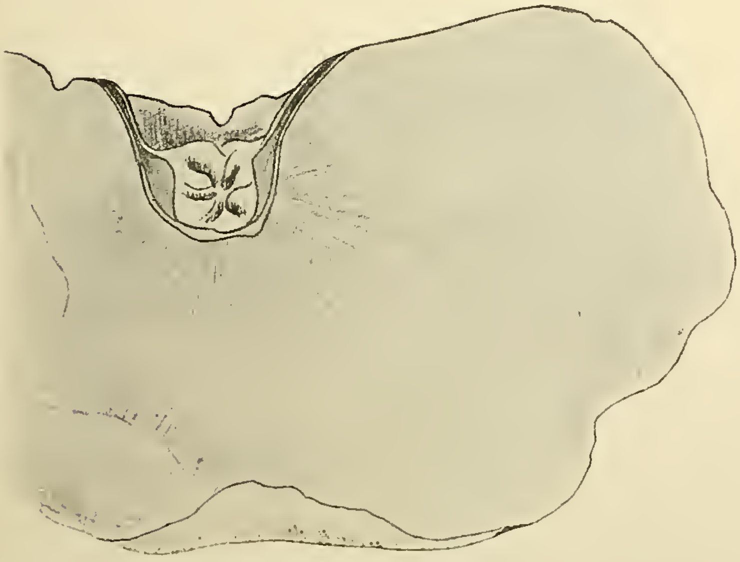

Fig. 24. *Cymbulia borealis* n. sp.

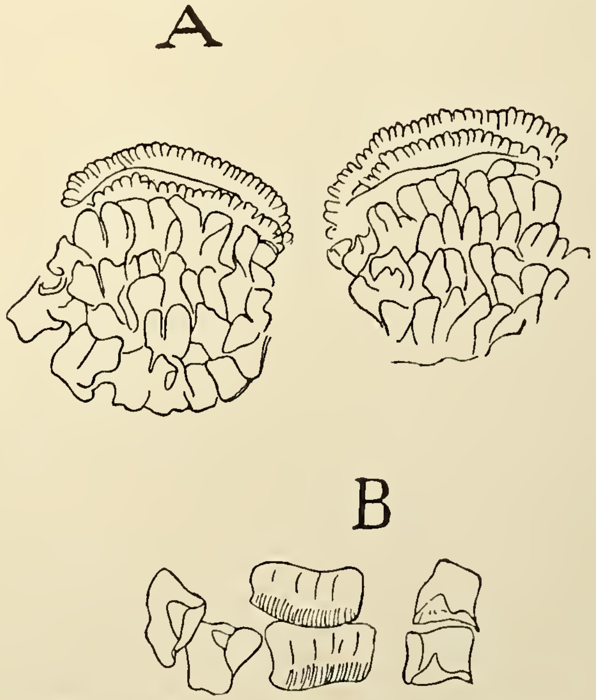

Fig. 25. Jaw (A) and radula (B) of *Cymbulia borealis.*

Station	84	87	88	90	92
Date	$^{15}/_7$	$^{17}/_7$	$^{18}/_7$	$^{21}/_7$	$^{23}/_7$—$^{24}/_7$
Position N.	48° 4′	46° 48′	45° 26′	46° 58′	48° 29′
Position W.	32° 25′	27° 46′	25° 45′	19° 6′	13° 55′
Depth in m.					
0— 50	—	—	—	—	—
50— 100	—	—	—	—	8
100— 250	—	—	—	—	—
250— 500	—	—	1	1	—
500— 750	1	1	—	—	—
750—1000	—	—	—	—	—
1000—1250	—	—	—	—	—
1250—1500	—	—	—	—	—

Number of individuals of *Cymbulia borealis* n. sp.

A difference from the other species of *Cymbulia* is seen in the absence of a ventral lobe on the fin.

Shell unknown.

Dimensions: The largest individuals measure about 15 mm. across the fins, the length of the body being about 3 mm.

Geographical distribution. In contradistinction to *Cymbulia peronii* this species seems to inhabit the colder waters of the Northern Atlantic, having been taken only between latitude 45° 26′ and 48° 29′ N.

General remarks on thecosomatous pteropods.

The "Michael Sars" brought home 27 species of thecosomatous pteropods, 11 of which belong to the family Limacinidae, 14 to the Cavoliniidae and 2 to the Cymbuliidae.

Leaving out of account the two species *Procymbulia michaelsarsii* and *Cymbulia borealis,* both new to science but still imperfectly known, the material includes practically all the species of thecosomatous pteropods previously known from the North Atlantic, some of them in quantities which have enabled us to make statistical investigations of different kinds, others under conditions which have allowed of our entering upon the solution of questions bearing upon the general relationship between the various groups.

The systematical results have already been referred to (see *Limacina balea*, *retroversa* and *trochiformis,* the varieties of *Clio pyramidata, Diacria trispinosa,* and *Cavolinia inflexa).*

In this place I propose to give an account of some general results bearing upon comparative anatomy and geographical distribution.

1. Remarks on comparative anatomy.

As already mentioned (p. 20) the prevalent view of modern investigators with regard to the relationship between the different groups of thecosomatous pteropods is principally based upon the hypothesis of Boas (1886) regarding the phylogenetic development of the Cavoliniidae from the Limacinidae through a rotation (of 180°) of their body relative to the head.

This hypothesis rests upon the fact that important organs (or organ-systems) of the body are found in opposite positions within each of the two families: the dorsal pallial cavity of Limacinidae is found on the ventral side in Cavoliniidae, the anus in the Limacinidae is found on the right side, but on the left side in the Cavoliniidae, and so on, while all the organs of the head, tentacles, mouth, radula etc., correspond in both families.—One organsystem, the genital system, which with its various parts belongs to both head and body, fully bore out the hypothesis of rotation, the genital gland, with the proximal part of the duct being found in opposite positions in the two families, while the distal part of the duct with the penis is always found at the same place beside the right tentacle. While therefore the genital duct of the Limacinidae runs directly from the genitial gland to the opening along the right side of the body, it takes its orgin in Cavoliniidae from the gland on the left side and then sweeps round the ventral side of the neck until it finally reaches the opening.

The hypothesis of Boas was illustrated by three diagrammatic figures (reproduced in textfig. 26), which seemed so clear and convincing, at the same time harmonizing so well with the anatomy of the species investigated, that any further proof of its correctness might seem unnecessary. A similar hypothesis was independently set forth by Pelseneer (1888), and the rotation theory has been generally adopted by later authors.

The whole proces of rotation must according to this theory have taken place in times past, as the most primitive form among the Cavoliniidae was considered to be the one *(Creseis)* in which the position of the visceral organs is directly opposite to that in the typical Limacinidae.

The existence of archaic thecosomatous pteropods living at the present day has however lately been maintained by Pelseneer (1906), who observed the right-sided position of the pallial cavity and the presence of a ctenidium in *Peraclis triacantha.* And in the "Michael Sars" material two species occur, which as will be shown lead from this archaic genus *Peraclis* on the one hand to the two diverging groups of the Limacinidae and the Cavoliniidae on the other.

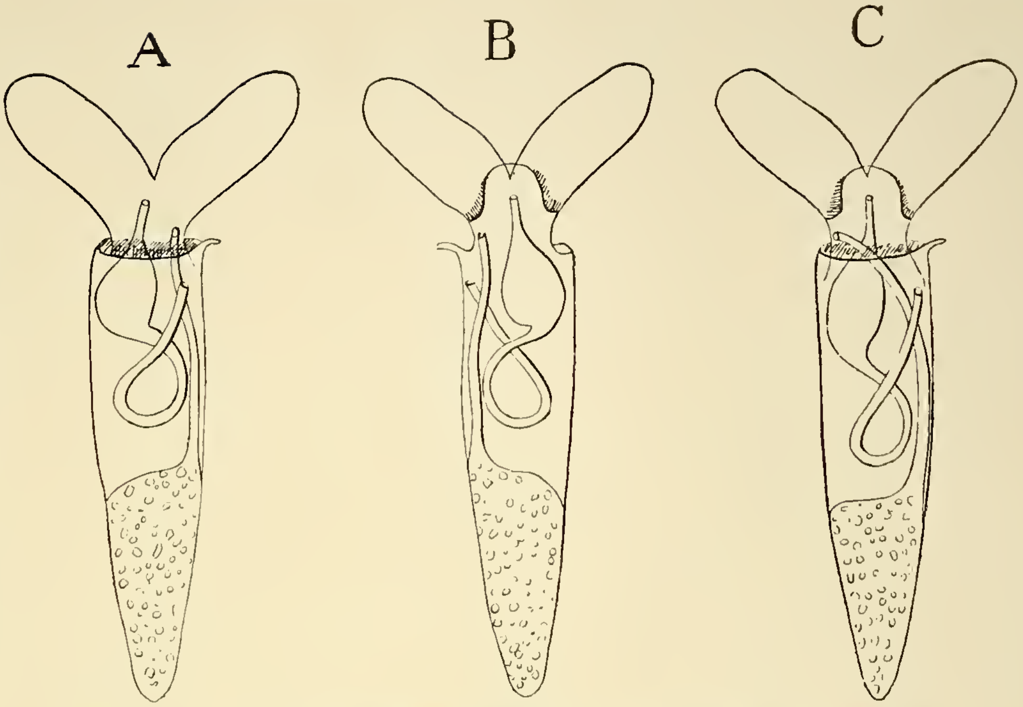

Fig. 26. A: one of the *Limacinidae*, dorsal view. B: *Limacinidae*, ventral view. C: *Cavoliniidae*, ventral view. (After BOAS).

These two species are *Limacina helicoides* and *Clio falcata*, the soft parts of which have not previously been investigated. My reasons for considering these two species as archaic representatives of their respective groups were founded first upon the position of their pallial cavities, and later upon the structure or position of nearly every organ system.

The existence of such archaic species must, of course, influence our view of the relationship within the thecosomatous pteropods, and the whole question as to the position of the organs in the Limacinidae and Cavoliniidae must therefore be subjected to revision.

Pallial cavity. According to PELSENEER (1906) the right-sided position of the pallial cavity in *Peraclis* is, like the ctenidium, to be considered a direct inheritance from the Bulloidea, the supposed ancestors of the thecosomatous pteropods among the Tectibranchiates.

My own results with regard to the genus *Peraclis* have on all essential points supported those of PELSENEER, and I feel fully justified in considering this genus as the most archaic group among the Thecosomata. The right-sided position of the pallial cavity in *Limacina helicoides* and *Clio falcata* thus needs no further explanation, being simply an expression of their relationship to *Peraclis*.

A comparison between the two species, however, proves a divergence in the development of the pallial cavity, which extends from the right side dorsally in *Limacina helicoides* and ventrally in *Clio falcata*. A further divergence in the same directions would result in the directly opposite, dorsal and ventral, position of the pallial cavity in the typical representatives of the genus *Limacina* and in the family Cavoliniidae.

BOAS (1886) discussed the question as to whether the change of position of the mantle and pallial cavity was perhaps due to a displacement of this part of the body alone, independent of others organs, or to a rotation of the body as a whole, and he came to the conclusion that a complete rotation of the body (relative to the head) had taken place without any essential change in the mutual relations of different organ-systems.

With regard to the pallial cavity this view was based partly on the existence of a "balancer" protruding from the mantle-margin on the right side in *Limacina* but on the left side in certain Cavoliniidae *(Creseis)*, showing that the change of position of the pallial cavity was brought about through an actual change of the right and left sides of the body, and not through a gradual closing of the cavity dorsally and a corresponding increase ventrally.

I must confess that I have not been able to discover any "balancer", like those of *Peraclis* or *Limacina helicoides*, in any of the Cavoliniidae[1]) which I have had an opportunity of investigating. But under the mantle-margin I found another organ, the lobe-like gill, homologous in *Limacina helicoides* and all the Cavoliniidae examined.

This organ does not, however, partake of any rotation, it is found in *Limacina helicoides* in the same place as the ctenidium of *Peraclis*, i. e. on the right side of the body, and it occupies the same position in the Cavoliniidae. If, therefore, the whole body had rotated with the pallied cavity, then the gill must have rotated independently in the opposite direction in order to maintain its original position relative to the head.

An investigation of other organ-systems will, however, give further proofs of an independence between them considerably greater than that supposed in the original rotation-hypothesis.

Digestive tract. As shown by earlier investigators, the digestive tract in the typical Cavoliniidae is quite opposed to that in a typical *Limacina* (see textfig. 26 and

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[1]) The specimens of *Hyalocylix*, *Styliola* and *Creseis* at my disposal did not allow of a thorough investigation.

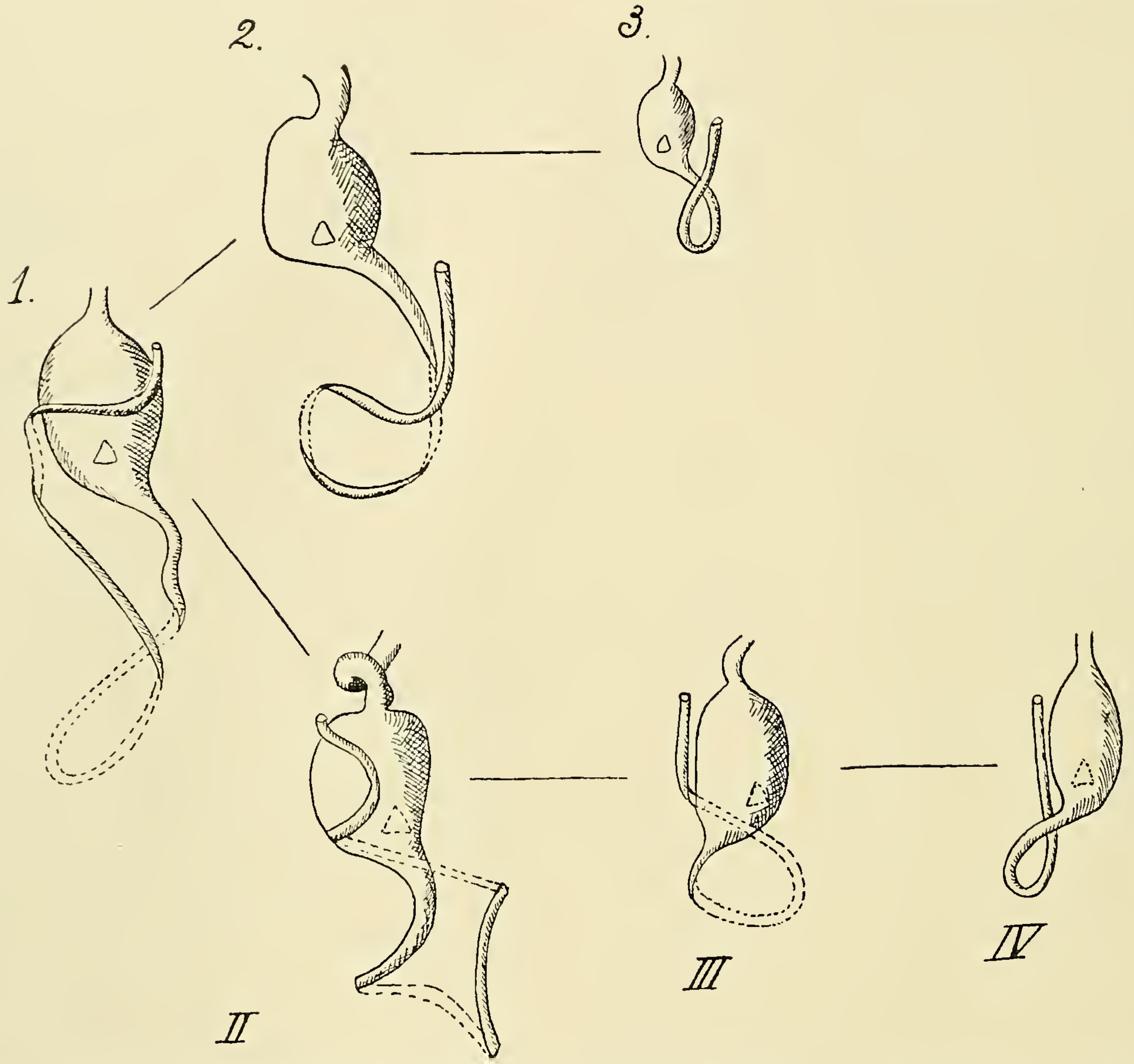

Fig. 27. Diagrams of the digestive tracts of Limacinidae (1—3) and Cavoliniidae (II—IV). 1. *Peraclis diversa;* 2. *Limacina helicoides;* 3. *Limacina balea;* II. *Clio falcata;* III. *Clio cuspidata;* IV. *Clio pyramidata.* All figures are drawn in dorsal view, and parts of the intestine lying on the ventral side of the body are drawn in dotted lines. The unpaired tooth of the stomach is represented by a small triangle.

textfig. 27 3—IV). In *Limacina* the unpaired tooth of the stomach is found on the dorsal side; the intestine leaves the stomach in a direction towards the right and makes a loop in which the rectum assumes a dorsal position; the anus is found on the right side of the body (see textfig. 27, 3). In typical Cavoliniidae, on the contrary, the unpaired tooth is found ventrally within the stomach, the intestine first turns towards the left and the rectum passes forwards ventrally and on the left side of the body, where the anus is found (textfig. 27, IV).

This fundamental difference between the two groups might well be explained according to Boas' hypothesis by a rotation (of 180°) of the whole digestive tract, and considering only the typical representatives of both groups, like *Limacina balea* and *Clio pyramidata* this would, in fact, seem the only possible explanation. And yet an investigation of the more archaic forms proves that the relations of the digestive tract in typical species of *Limacina* and Cavoliniidae are not to be compared directly with each other, but that they ought to be considered as the corresponding final results of two diverging lines of development both taking their origin in a state like that found in the genus *Peraclis.*

The digestive tract of *Peraclis* (textfig. 27, 1) shows all the essential characteristics of the Limacinidae, regarding the position of the unpaired tooth and the anus, as well as the main course of the intestine, which is however considerably longer than that of a typical *Limacina;* it turns round the right edge of the liver, forming a long ventral loop, and then twice crossing the dorsal side, first in a direction from right to left, and then back again to the right side, where the anus is found. During its last dorsal passage the intestine crosses the stomach.

Taking the intestine of *Peraclis* as a point of departure the digestive tract seems to have followed two diverging lines of development, both resulting in a considerable shortening of the intestine.

Such a gradual reduction in the length of the intestine is seen in the genus *Limacina.* In *Limacina helicoides* (textfig. 27, 2) we still find the same course of the intestine as in *Peraclis*, with two ventral loops and a double crossing of the dorsal side, but all these parts of the intestine are shorter than in *Peraclis*, and this gradually leads to the conditions found in the typical species of *Limacina* (textfig. 27, 3), where the intestine is reduced to a short dorsal loop.

A corresponding reduction in the length of the intestine is found also in the Cavoliniidae (textfig. 27, II—IV), but here it is combined with other changes, which result in a state of the digestive tract directly the reverse of that found in a typical *Limacina.*

In *Clio falcata* (II), where the pallial cavity, unlike that of *Peraclis*, occupies the right and ventral side of the body, while the retractor muscle passes along its dorsal side, we also find a change in the position of the digestive tract which most probably should be viewed in connection with that of the pallial cavity. Through a spiral twisting of the oesophagus the stomach is turned round, so that its more convex (originally dorsal) side carrying the unpaired tooth is turned towards the (ventral) pallial cavity, while the opposite, shorter (originally ventral) wall of the stomach lies beneath the retractor muscle. At the same time the whole stomach is displaced from the median line of the body towards the left side.

The long intestine has still kept essentially the course characteristic of *Peraclis.* From the stomach it sweeps towards the right but does not reach the right edge of the broad and flattened body, and after having made a long loop all over the ventral side it crosses, just as in *Peraclis,* the dorsal side of the stomach in a direction from left to right. Instead, however, of opening as in *Peraclis* at the right side of the stomach, which would in *Clio falcata* be the median dorsal line of the body, the intestine once more turns back to the left side, where it reaches the edge of the pallial cavity.

The condition of the digestive tract in *Clio falcata* is of great general interest, as showing the old inherited structures in process of adaptation to the new conditions called forth by the displacement of the pallial cavity.

A further step in the development of the intestine in the Cavoliniidae is represented in *Clio cuspidata* (textfig. 27, III). The oesophagus is shorter than that of *Clio falcata,* but in its course traces of spiral twisting may still sometimes be seen. The unpaired tooth occupies the same position within the stomach, and the whole change of the intestine consists of a reduction of all superfluous loops. Instead of making the first turn towards the right side, the intestine now leaves the stomach towards the left, the ventral loop is shorter, so that it does not reach the right margin of the body, and the last dorsal loop (across the stomach) is omitted, the rectum running directly along the left side of the stomach up to the anus. The stomach in *Clio cuspidata* occupies a more median and more ventral position than in *Clio falcata.*

The digestive tract as found typically in the Cavoliniidae is seen in *Clio pyramidata* (textfig. 27, IV), the stomach being found ventrally in the median line, the whole intestine consisting of a short loop like that in *Clio cuspidata* and exactly the reverse of that in a typical *Limacina.* Without knowing the series of stages connecting *Limacina balea* and *Clio pyramidata* with the archaic genus *Peraclis*, a development from one type to the other through a rotation of the whole digestive tract would seem to be, and has been accepted as, the most plausible hypothesis regarding their phylogeny.

Nervous system. The visceral and abdominal ganglia have proved to be of special interest from the point of view of comparative anatomy, in so far as they are mutually combined in different ways in each of the three great families of thecosomatous pteropods. While in the Cymbuliidae three distinct ganglia are found (see textfig. 28 B), in the typical representatives of the two other families the visceral mass is asymmetrically developed, the right side in *Limacina* (C′, D′), and the left side in the Cavoliniidae (E″, F″, D‴), being the largest.

It has been shown also (Pelseneer, Tesch, Meisenheimer) that with regard to the nervous system the genus *Peraclis* (textfig. 28 A) agrees more closely with the Cymbuliidae than with the typical species of *Limacina.* The asymmetry of the visceral mass in *Limacina* and in the Cavoliniidae has been regarded as the results of a coalescence of the abdominal ganglion with one or other of the visceral ganglia, but no plausible explanation of this asymmetry, or of the difference between the two groups, has yet been given.

On this point also the two species *Limacina helicoides* (B′) and *Clio falcata* (B″) form links connecting *Peraclis* on the one hand with the typical species of *Limacina* and the Cavoliniidae on the other (as shown in textfig. 28).

The visceral mass of *Peraclis* (A) consists of three

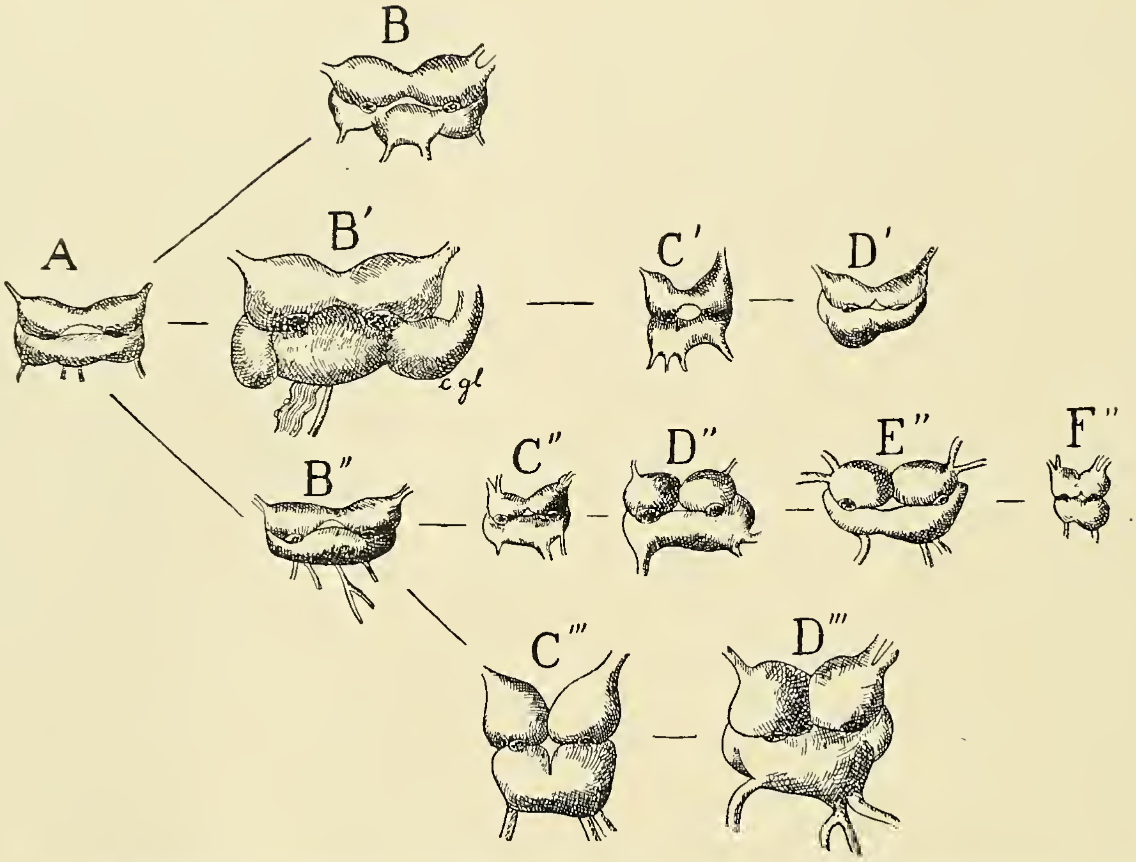

Fig. 28. Nervous system of thecosomatous pteropods seen from the ventral side (somewhat diagrammatic): A. *Peraclis* (from Tesch 1904); B. *Cymbulia* (from Pelseneer 1888); B′ *Limacina helicoides* c. gl. ceretral ganglion; C′ *Limacina helicina* (from Tesch); D′ *Limacina inflata* (from Meisenheimer 1905); B″ *Clio falcata;* C″ *Clio cuspidata;* D″ *Clio pyramidata;* E″ *Clio sulcata* (from Meisenheimer); F″ *Hyalocylix striata* (from Meisenheimer); C‴ *Diacria trispinosa* (from Meisenheimer); D‴ *Cavolina tridentata* (from Meisenheimer).

asymmetrically developed ganglia, distinct from, yet in broad connection with, each other. Similar conditions are found in the family Cymbuliidae (B), the only difference consisting in the deeper constrictions between the three ganglia.

A development in the opposite direction is found when passing from *Peraclis* to *Limacina helicoides* and *Clio falcata*, for in these two species the three visceral (and abdominal) ganglia coalesce into a single symmetrically developed mass without any constrictions (B′, B″). A difference between them is seen, however, in the course of the abdominal nerves, which run obliquely to the right in *Limacina helicoides* and to the left in *Clio falcata*. This difference in the course of the abdominal nerves harmonises with the corresponding difference in the course of the oesophagus in these two species (already referred to), and very probably therefore some causal connection exists between the changes going on within the two organ-systems: the digestive tract and the nervous system.

Now taking the two species *Limacina helicoides* and *Clio falcata* as the points of departure we shall find in each group a gradual increase of the asymmetry first shown in the course of the nerves only, the visceral gangliar mass being more developed on the right side in *Limacina* (C′ D) and on the left side in the family Cavoliniidae (C″—F″, C‴—D‴).

The existence at the present day of archaic thecosomatous pteropods, and the relations of their different organ-systems as demonstrated above, cannot fail to influence our view of the phylogenetic relationship between the more modern representatives of the group.

The rotation-theory of Boas is supported by the new facts, in so far as a development of the Cavoliniidae from the Limacinidae is shown to have taken place and to have been characterised by a rotation (of 180°) of the main organs of the body relative to those of the head.

The whole development is, however, shown to have taken its origin not in the modern *Limacina*-type, but in an archaic type still represented by the genus *Peraclis*, and the change of position of the body-organs must be looked upon not as a rotation of the body as a whole but as a series of parallel changes going on within each organ-system.

But although the independence of the organ-systems during this development from *Peraclis* to the typical Cavoliniidae seems to be much greater than supposed in the original rotation-theory, yet there certainly exist some causal connection between the parallel changes undergone by each of them.

The primary cause of all these changes going on in the Cavoliniidae may probably be found in the erection of the shell and its influence on the state of equilibrium of the pelagic animals, a result of which is seen in their peculiar mode of swimming with the ventral side upwards. In intimate connection with the change of equilibrium a displacement of the pallial cavity to the ventral side would follow, a free and convenient entrance of the water into this cavity being of vital importance to the animal, while the retractor muscle would withdraw to the opposite (dorsal) side. The gill, however, being placed on the right side of the body is equally convenient whether the dorsal or ventral side is turned upwards, and does not change its position during the course of development from *Peraclis* to the Cavoliniidae.

As in the case of other molluscs, the position of the pallial cavity is in some way or other decisive also for the position or course of other organ-systems. The stomach which lies between the retractor muscle and the pallial cavity must as a matter of convenience turn its more convex side (carrying the unpaired tooth) towards this cavity; a rotation of the stomach and the digestive tract is therefore a necessary consequence of the displacement of the pallial cavity.

This rotation is (in *Clio falcata)* brought about through a spiral twisting of the oesophagus. which during its change of course is accompanied by the abdominal nerve, and this probably initiates an asymmetrical development of the visceral gangliar mass, contrary to that of the genus *Limacina.*

The genital gland is in its position so much dependent on the shape of the liver, that a rotation of the whole digestive tract would probably influence the position of this organ also. As mentioned above (p. 22) I have not been able to follow the course of the genital duct in *Clio falcata*, but the shape and position of the genital gland seem to indicate that the duct takes its origin on the left side of the body, so that the relations characteristic of the Cavoliniidae are here already established.

Our view of the relations between the two families Limacinidae and Cavoliniidae, and between the different groups of the Cavoliniidae must be influenced by the knowledge recently acquiered regarding the still living archaic representatives of the groups.

Starting from the view that the whole rotation-process was effected in times past, modern investigators (Tesch, Meisenheimer) have followed Boas and Pelseneer in considering as the most primitive Cavoliniidae a group of species *(Creseis)* in which the position of all the visceral organs is practically opposite to that in the typical species of *Limacina.*

"Als Ausgangspunkt stellt sich die Gattung *Limacina* dar, aus ihr ging unmittelbar unter Streckung des Rumpfes und Drehung desselben um 180° die Gattung *Creseis* hervor." (Meisenheimer 1905, p. 172).

A further grouping of the genera belonging to the family Cavoliniidae is based upon the existence in each genus of what are considered primitive characters, such as:—

1) a circular transverse section of the body;

2) a *Limacina*-like shape of the wings;

3) a uniformly developed pallial gland; and

4) above all a position of the heart and kidney in relation to this gland corresponding to that found in *Limacina.*

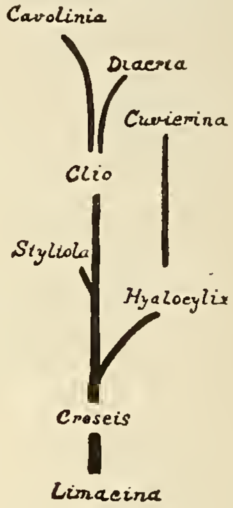

Fig. 29.
Phylogenetic relations of the genera of thecosomatous pteropoda, according to Meisenheimer.

The most modern treatment of these questions is given by Meisenheimer, who expressed his view of the phylogenetic relations of the genera in the scheme reproduced in textfig. 29.

As to what characters are to be regarded as primitive, our recent knowledge of the archaic species may afford some definite information.

1) A circular transverse section of the body is found neither in *Limacina helicoides* nor in *Clio falcata*, and there seems to be no reason for considering it an archaic character.

2) With regard to the shape of the wings my results are directly opposed to the view maintained by earlier investigators. According to my results the archaic form of the foot of thecosomatous pteropods is not the narrow and well defined wings of a typical *Limacina*, but the broad continuous swimming-plate of *Peraclis*, which is present also in *Limacina helicoides* and *Clio falcata*, as well as in the genus *Procymbulia.*

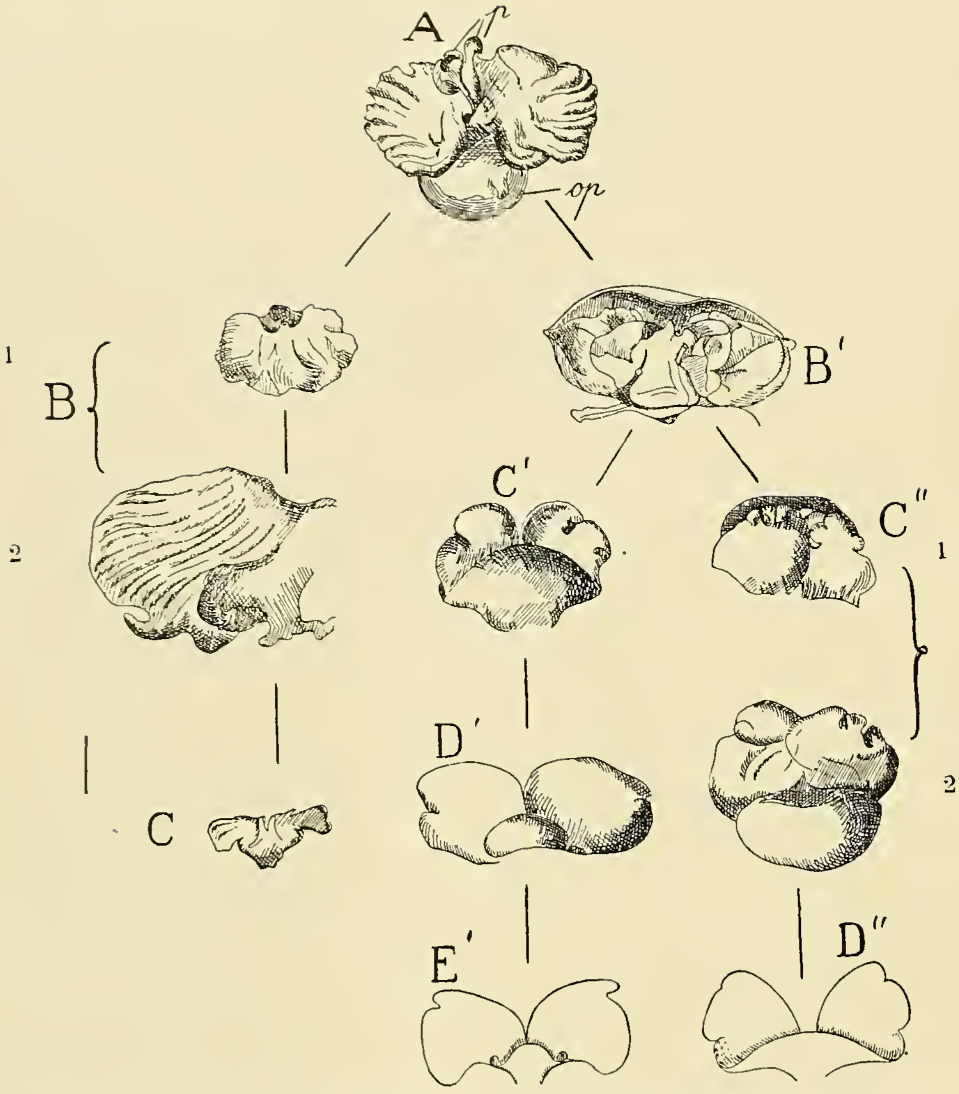

Fig. 30. Head and wings of Limacinidae and Cavoliniidae (somewhat diagrammatic):— A. *Peraclis diversa;* p. proboscis, op. operculum; B. *Limacina helicoides;* 1. young, 2. full-grown (right half); C. *Limacina balea;* B' *Clio falcata;* C' *Clio cuspidata,* D' *Clio pyramidata;* E' *Hyalocylix striata* (from Boas); C'', 1—2, *Diacria trispinosa,* D'' *Cavolinia tridentata* (from Boas). Figs. B' and C'', 1 show the dorsal view, all the others the ventral view.

This swimming-plate is further developed in the family Cymbuliidae, while it undergoes a retrograde development and a special differentiation in the genus *Limacina* and the family Cavoliniidae (see textfig. 30).

The swimming-plate of *Peraclis* (A) is kept tightly folded during rest, and covered by an operculum carried by the median (ventral) part of the plate. A similar folding of the dorsal (lateral) parts of the swimming-plate is found also in *Limacina helicoides* (B) and *Clio falcata* (B'), but in each of the two groups of which these species are the representatives, the soft and folded dorsal part of the wings is gradually replaced by more rigid wing-like lobes, which during rest cover each other without being folded.

At the same time the ventral (median) lobe of the plate, which (with or without operculum) originally served as an organ of protection for the head and the dorsal part of the foot (see textfig. 30, B'), is in the Cavoliniidae gradually reduced to a small rounded lobe. Initial stages of this reduction are found in *Diacria trispinosa* and *Clio cuspidata* (C'' and C'), which form the bases of two parallel series of development.

3) The structure of the pallial gland is different in the three archaic forms *(Peraclis, Limacina helicoides* and *Clio falcata),* and therefore allows of no general conclusions with regard to its original character. But in the Cavoliniidae the transverse striation of the gland, so conspicuous not only in *Clio falcata* but also in *Diacria trispinosa* and *Clio cuspidata,* must be considered older than the uniform condition found in *Creseis* and other forms.

4) The position of the heart and kidney has played a great part in theories about the relationship between different groups of Cavoliniidae. According to Boas these organs, which in the Limacinidae are placed beside the left border of the dorsal pallial gland, should during the rotation of the body have kept their original position relative to this gland, and therefore in the most primitive Cavoliniidae the heart and kidney should be found near the right side of the body beside the (now ventral) pallial gland. Such conditions are found in *Creseis,* which also for this reason has been considered the most primitive group of the Cavoliniidae, while the different relations of the same organs in other forms have been considered the results of a secondary development.

In *Clio falcata,* however, we find relations which do not support this view, showing that the original position of the heart and kidney at the left side of the (dorsal) pallial gland may be changed before the gland has fullfilled its displacement to the ventral side. In this species the heart and kidney form a transverse girdle over the ventrale side posterior to the pallial gland (pl. II, fig. 13), while the gland still covers the right side of the body. This one fact is sufficient to deprive the phylogenetic considerations based upon the position of the heart and kidney of their value. The reason for the varying position of these organs should probably be sought not so much in the phylogenetic development of a species as in the general shape of the body. The heart must have space enough to do its work, and therefore it is always found at the most convenient place. In the broad and flattened *Clio falcata* good conditions are found under the convex shell of the ventral side of the body, while in species with a narrow and pointed posterior end, or with a circular cross-section of the body, such a transverse position would prove inconvenient, and the heart is found in a position parallel to the long axis of the body (as in *Clio pyramidata, Creseis,* etc.).

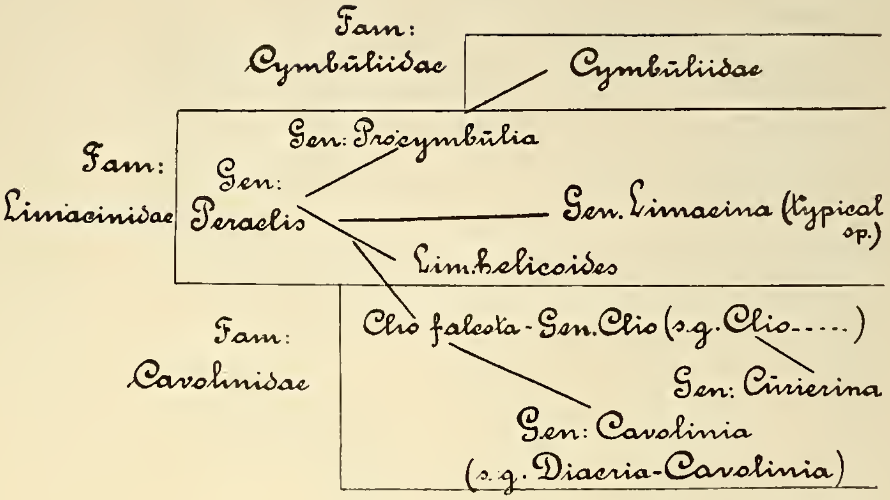

Fig. 31.

Summing up the results of my investigations into the comparative anatomy of thecosomatous pteropods, I consider it very probable that in the course of time a phylogenetic development has taken place from forms like those still represented by the genus *Peraclis* in three different directions, viz:

1) through the genus *Procymbulia* towards the family Cymbuliidae;

2) through forms somewhat like *Limacina helicoides* to the more typical species of the genus *Limacina;*

3) through forms like *Clio falcata* to the family Cavoliniidae.

In the Cavoliniidae a development seems to have taken place in two divergent directions, corresponding to the two genera *Clio* and *Cavolinia,* each including two or more subgenera, of which *Euclio* and *Diacria* represent the first steps of development. (See the diagram, textfig. 31).

With regard to the generic relations of the genus *Cuvierina*[1]) and of the other subgenera of the genus *Clio,* my material did not allow of any thorough investigation.

2. Geographical distribution.

Meisenheimer (1905–06) in his excellent works on Pteropoda has treated so fully the geographical distribution of each species that apparently very little remains to be added by later investigators, and on many points I can merely confirm his results. The special methods used on board the "Michael Sars" in the way of long horizontal plankton hauls at different depths have, however, given results, regarding the numerical occurrence of each species in various regions and at various depths, which may serve to widen our knowledge of their biology and vertical distribution.

Horizontal distribution. In discussing the horizontal distribution of pteropods Meisenheimer divided the surface-waters of the ocean into three large zones surrounding the whole globe, viz: a warm circumtropical zone and two cold circumpolar zones. On the borders between these zones are to be found transitional regions, which are geographically and faunistically well defined, and in their essential characters may be considered as belonging to the cold zones.

As regards the Northern Atlantic, the warm circumtropical zone has its northern limit in a line running from Cape Hatteras off the American coast (35° N.) in a north-easterly direction towards the European coast (44° N.), thus including all the southern part of the Gulf stream. The transitional region includes, according to Meisenheimer, the northern part of the Gulf stream, while the cold circumpolar zone stretches its arms southward along the coasts of Greenland and follows the Labrador current along the American coast, covering the Newfoundland banks.

As will be seen from the chart (textfig. 32) the "Michael Sars" traversed all these three zones, the southern crossing of the ocean lying principally within the warm-water zone and the northern crossing within the transitional zone, the cold zone being touched on the way to and from Newfoundland. The material brought home by this expedition should therefore give a good opportunity of testing the correctness of Meisenheimer's results for this part of the ocean.

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[1]) Through later investigations I have found a twisting of the oesophagus in *Cuvierina* very much like that of *Diacria* and indicating relationship with the archaic species *Clio falcata.*

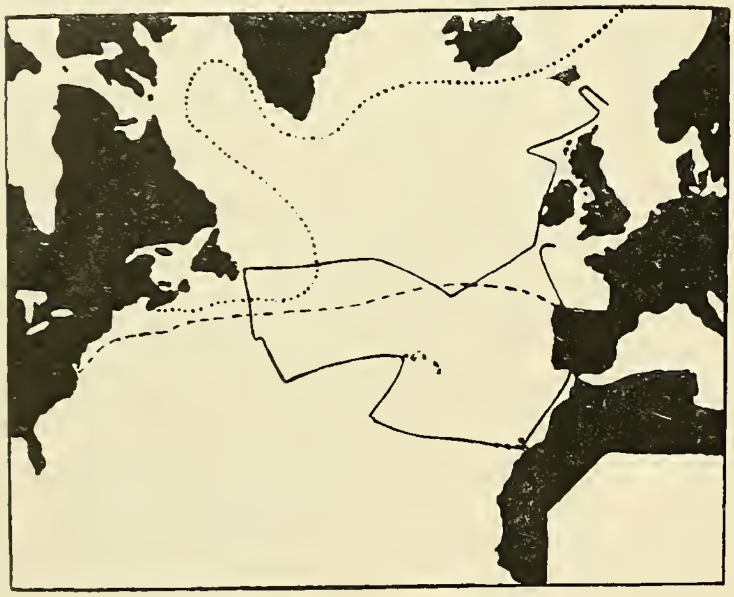

Fig. 32. The route of the "Michael Sars" Expedition ——. Boundary line between the circumtropical and the tranzitional zones - - - - -. Boundary line between the transitional and the circumpolar zones . . . . .

The horizontal distribution of the thecosomatous pteropods from the "Michael Sars" expedition is indicated in the two tables on p. 46 and 47, the first table showing the number of individuals of each species at the different stations, while in the second table the stations are grouped according to their geographical position, and the number of individuals summed up for each of these groups. The European-African coastline is divided according to its position within the warm-water and the transitional zones, while the stations (71 to 79) in the cold zone off Newfoundland form another group. The open ocean is divided into four parts, the stations belonging to the eastern half and the western half of each crossing being taken as a separate group (SE, SW, NW, NE).

A division of the ocean like that just mentioned into a western and an eastern half might perhaps at first seem arbitrary and inappropriate for a study of organisms principally living in the upper layers of the ocean, and therefore independent of the sea-bottom, but a glance at table 1 (p. 46—47), will at once justify such a division, the material from Stations 52 to 84 in the western part of the ocean being very different from that obtained at Stations 45 to 50 and 87 to 92 in the eastern part. The stations off the Azores must with regard to their pteropod-fauna be considered as belonging to the western half of the ocean.

The question as to the effect of temperature upon the distribution of pteropods may best be answered by comparing the northern and southern crossing. (Table II, p. 46—47).

The opinion that the pteropods are a group consisting principally of warm-water animals is strongly supported by the fact that the material brought home from the southern crossing of the "Michael Sars" expedition is richer than that from the northern crossing, not only with regard to the number of species (22 : 15), but still more so with regard to the number of individuals (5050 : 950); during the southern crossing more than five times as many were taken as during the northern crossing.

Considering the relations between the different forms taken during the two crossings, we find a striking difference between the Limacinidae on the one hand and the Cavoliniidae on the other, most of the Limacinidae being represented in the material from both crossings while most of the Cavoliniidae were taken during the southern crossing only.

The Limacinidae include, according to MEISENHEIMER, a series of species found in all the temperature-zones, but each species is absolutely typical of its own zone. Thus *Limacina helicina* is a representative of the cold arctic sea, while *Limacina balea (retroversa* Meisenheimer) belongs to the transitional zone, and the other species of *Limacina* to the warm-water zone.

With a few exceptions the results of the "Michael Sars" expedition agree very well with MEISENHEIMER'S views, and even the exceptions serve on the whole in confirming them.

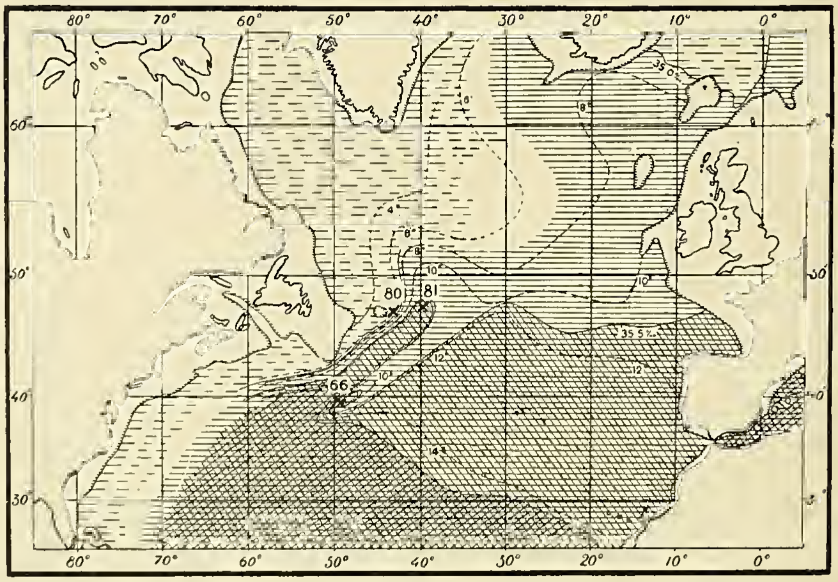

Fig. 33.

As exceptions may be mentioned the occurrence of

1) the arctic species *Limacina helicina* within the transitional zone (Station 80);

2) the transitional species *Limacina balea* within the circumtropical zone (Station 66); and

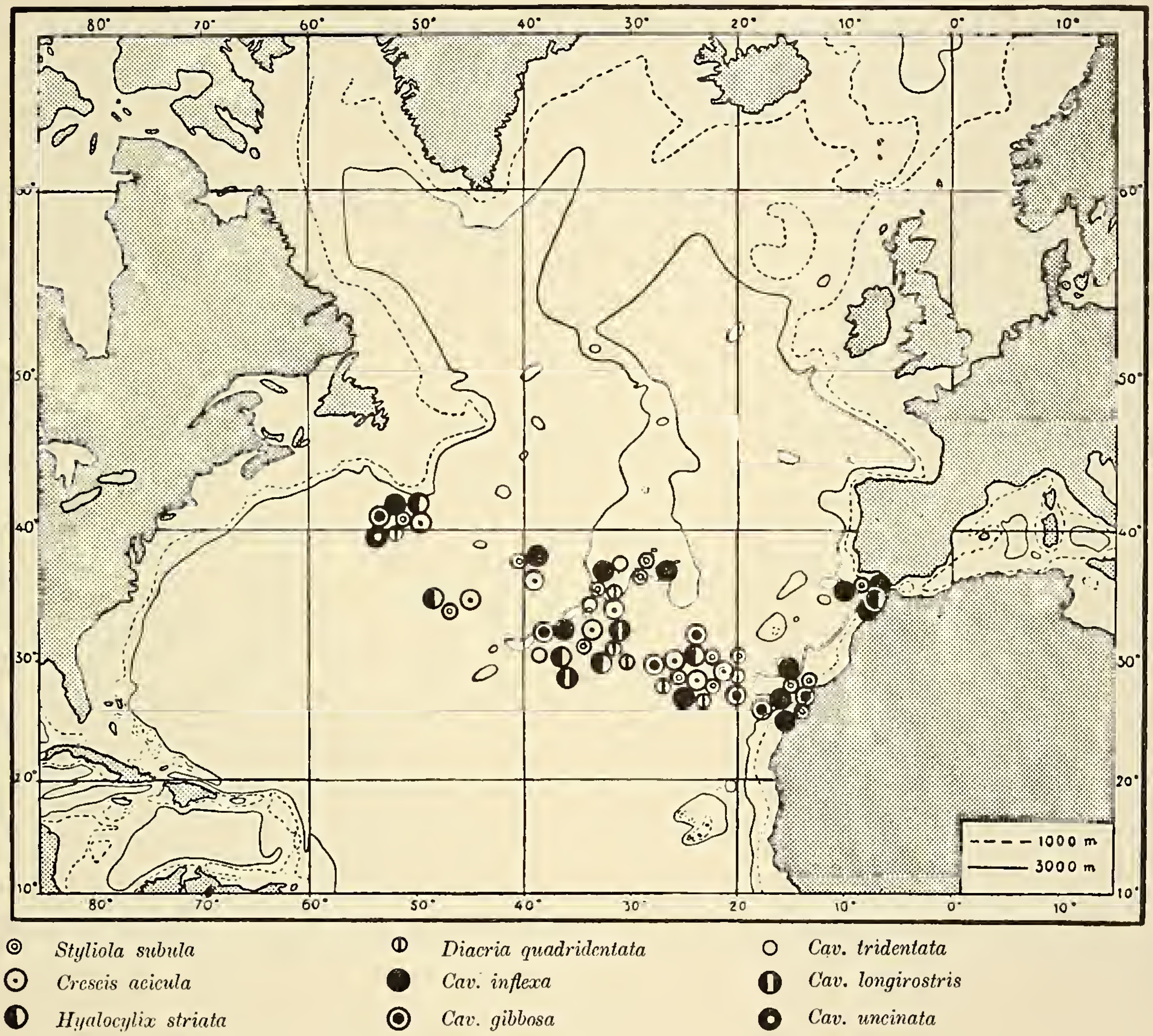

Fig. 34.

3) the warm-water species *Peraclis reticulata, Limacina lesueurii* and *Limacina inflata* within the transitional zone (Station 81).

A glance at the chart (textfig. 33) showing the hydrographical conditions at depths of 200 to 500 metres at the time of the expedition will, however, explain all these exceptions. At this depth Station 80, where *Limacina helicina* was found, lies within the cold zone; a wedge of cold water from the transitional zone penetrates as far south as to include Station 66 *(Limacina balea)*; while at the same time a wedge of warm-water runs northwards to Station 81, where warm-water Limacinidae were taken. The opinion of MEISENHEIMER that these Limacinidae are to be considered as stenothermal forms, occurring only within certain temperature limits, is therefore in no way contradicted by their appearance at latitudes beyond the main boundary lines of these zones.

Besides the stenothermal species of Limacinidae, one species, *Limacina retroversa* Fleming, is eurythermal, for although belonging to the warm-water zone it may be found widely distributed in the northern transitional zone. The two deep-sea species *Peraclis diversa* and *Limacina helicoides* will be considered later.

Most of the species of Cavoliniidae are, according to MEISENHEIMER, stenothermal warm-water species, while two, *Clio pyramidata* and *Clio cuspidata*, are markedly eurythermal, being distributed throughout the transitional and warm-water zones. The correctness of this opinion is very obviously demonstrated in the two charts, textfig. 34 and 35. Several stenothermal species are found scattered along the whole southern crossing, but were not taken during the northern crossing (textfig. 34), while the eurythermal species are distributed along the whole route (textfig. 35). To the two eurythermal species mentioned by MEISENHEIMER must, however, be added a third species, viz: *Diacria trispinosa*. The Cavoliniidae are represented in the deep-sea fauna by *Clio falcata*.

We now turn to a comparison between the eastern half and the western half of the North Atlantic (see table II, p. 46—47).

While the main difference between material from the northern and southern crossings is to be found in the family Cavoliniidae, the distribution of the Limacinidae is seen to be decisive for the richness of the western fauna as compared with the eastern, a difference still greater than that between north and south. (Species 24 : 15; individuals 5600 : 400).

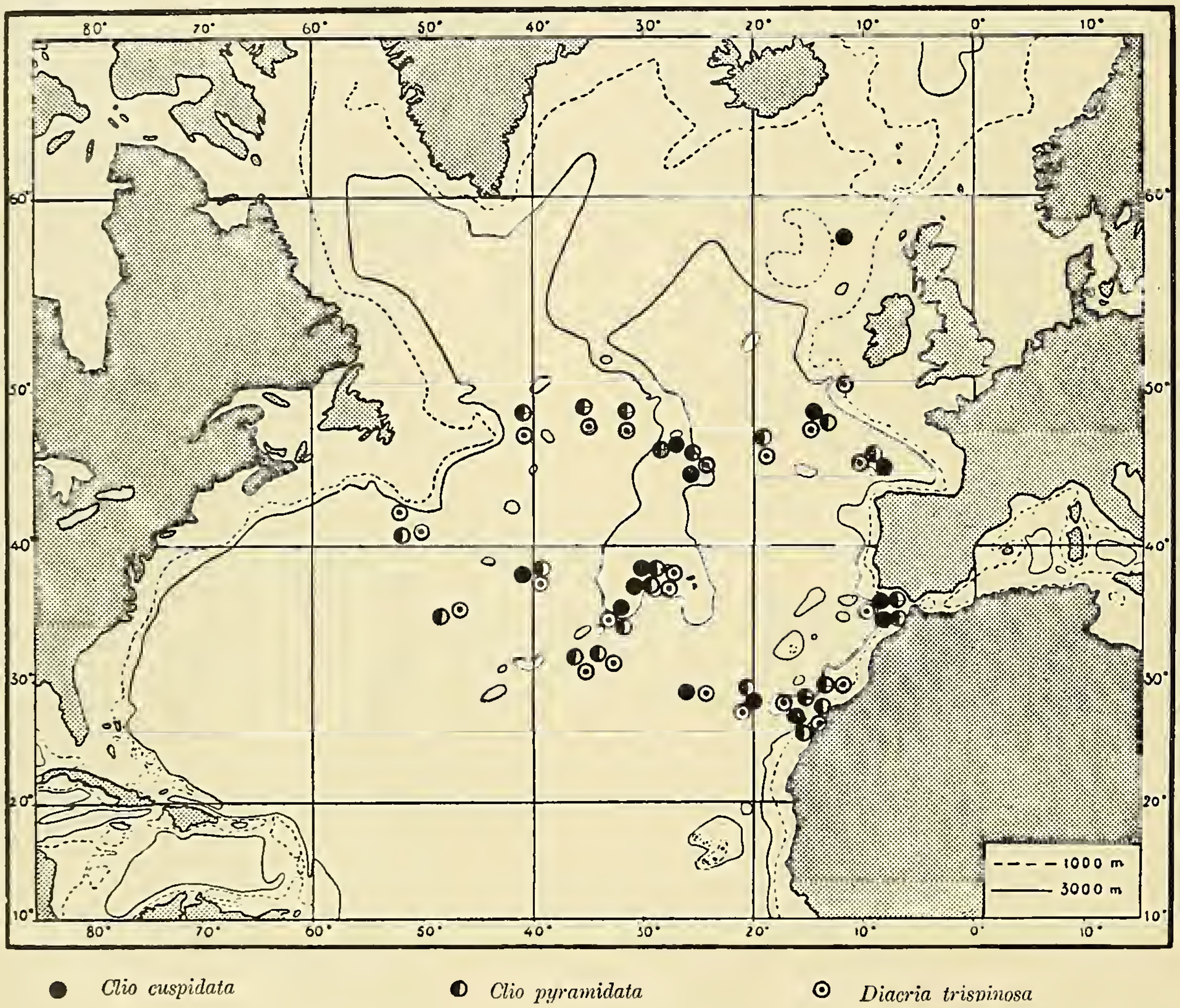

Fig. 35.

The occurrence of the species of *Limacina* in the western half of the ocean only is a fact so obvious (see the chart, textfig. 36) and so peculiar that it may be of interest to analyse it more thoroughly. This analysis will apply especially to the three warm-water species, *Limacina bulimoides*, *L. lesueuri* and *L. inflata*, the occurrence of the northern species, *Limacina helicina* and *L. balea*, in the western half finding its explanation in the cold-water currents mentioned above.

Why should the three warm-water species, so numerous in the western part of the ocean, be absolutely absent in the eastern part? Is this to be considered as merely accidental, or as an expression of some unknown biological relations of these animals? The total absence of some species of *Limacina* in the eastern part of the open ocean is all the more striking because the same species are found abundantly represented along the African coastline.

Fig. 36.

The hydrographical conditions at the time of the expedition give no clue to the meaning of this distribution; there seems to be no reason why the animals should not be able to live in the eastern part of the ocean as well as in the western.

One fact must, however, be mentioned which may prove to be of interest in this connection, viz. the coincident occurrence of the species of *Limacina* with that of the Sargasso weed. Just at the place (Stations 51, 52) where the "Michael Sars" first met with the Sargasso weed, the three species of *Limacina* were also found for the first time since leaving the Canary Islands, and they were subsequently found distributed, sometimes in immense numbers, all over the western part of the ocean. Is this coincidence merely accidental? or is there some causal connection between the occurrence of the Sargasso weed and that of the small species of *Limacina?*

Such a causal connection might exist in one of two different ways: either the animals in their development or in their biology are in some way or other dependent on the floating Sargasso weed, or the animals, like the Sargasso weed, follow the currents running from the

American coast in an easterly direction. The coincidence in the occurrence of both organisms, would in each case find a simple explanation.

Of these two possibilities the latter seems to me the most probable, remembering that the species of *Limacina* have been found also in places where a connection with the Sargasso weed has not been observed, as for example along the African coast. The three warm-water species of *Limacina* may in some way or other be biologically connected with the coastlines on both sides of the North Atlantic, and their occurrence in the open ocean may be dependent upon the existence of currents carrying them along. Like the Sargasso weed, the species of *Limacina* inhabiting the western part of the ocean would in that case be considered as belonging to the American coast-fauna, corresponding to the African coast-fauna, but the currents prevent the African fauna from spreading into the neighbouring eastern part of the ocean.

In the present state of our knowledge we can only raise the question, leaving the answer to future investigations into the biology of these small species of *Limacina*.

Vertical distribution. In table III, p. 48, the collection of thecosomatous pteropods from the "Michael Sars" ekspedition is arranged according to the occurence of each species at different depths.

It will be seen from this table, that most of them must be considered surface-species finding their optimum life-conditions in depths less than 250 m. With regard to their occurrence beyond this depth we may distinguish the stenothermal species, which only occasionally penetrate into the colder waters of the deep-sea, from the eurythermal ones, which seem to be equally at home in the surface layers and in the deeper waters. It is of interest to note that the species with the widest horizontal distribution have also the greatest vertical range. Besides *Clio pyramidata* and *C. cuspidata* we find here also *Styliola subula*, a warm-water species which however, according to Meisenheimer avoids the warmest waters on both sides of the equator.

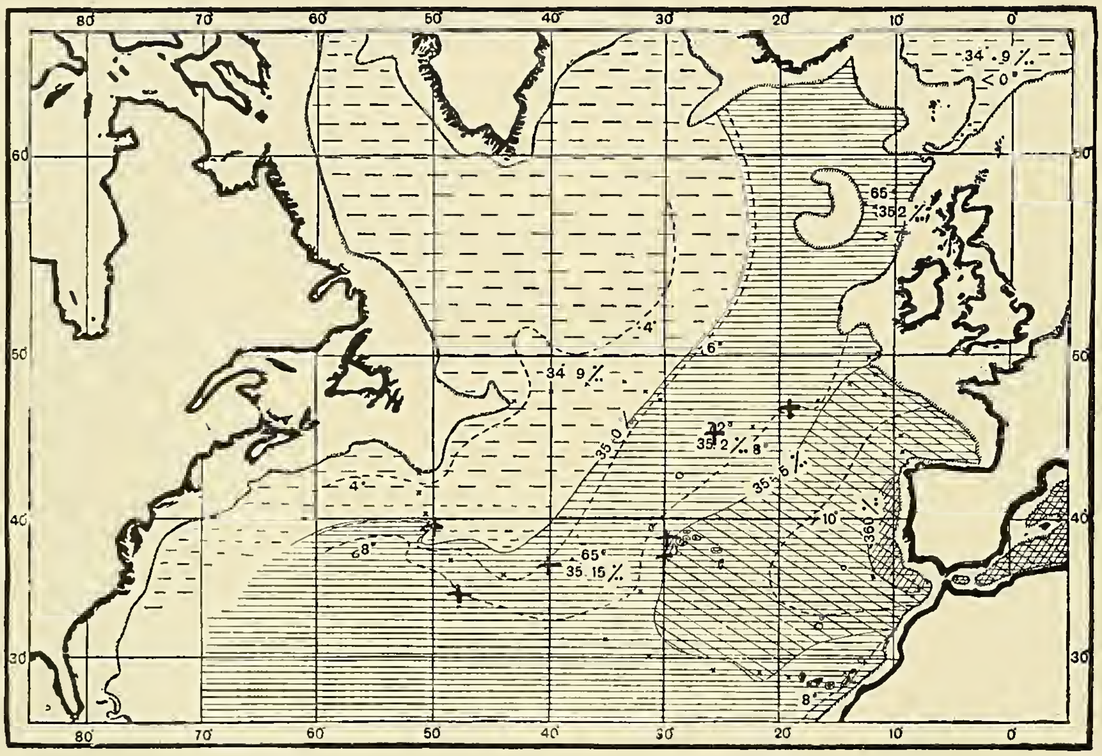

Fig. 37. Hydrographical conditions at 900 metres? The stations where *Peraclis diversa* was taken are indicated by crosses.

Besides all these surface forms there are three species whose vertical distribution is essentially different. These species, which seem to find their optimum life-conditions in the deeper layers of the ocean (from 500 to 1000 m. or more), are *Peraclis diversa*, *Limacina helicoides* and *Clio falcata*. Their occurrence at these depths and their total absence at the surface is clearly shown in table III, which together with table I (p. 46—47) will give an idea of their distribution, which may now be considered in relation to the hydrographical conditions in the ocean at the time of the expedition.

Peraclis diversa from its wide horizontal distribution might be considered an eurythermal species, but textfig. 37 shows it to be strictly stenothermal; except for two or three individuals out of 48 it was taken in waters having a temperature of 6° to 10° C. and a salinity of 35·0 to 35·5 pro mille.

Similar conditions are found with regard to *Limacina helicoides*, which, as shown by tables I and II, was taken during both the northern and southern crossings, but only in the western part of the ocean while, as shown by table III, most of the individuals were taken in relatively shallow water (500 to 750 m.). This distribution is readily understood when the hydrographical conditions are taken into consideration, as shown in textfig. 38; it is seen that *Limacina helicoides* was found in a cold water-layer (4° to 10° C.), having a salinity below 35·0 per thousand. In the western part of the ocean this layer, at the time of the "Michael Sars" expedition, occurred at a considerably lesser depth than in the eastern part.

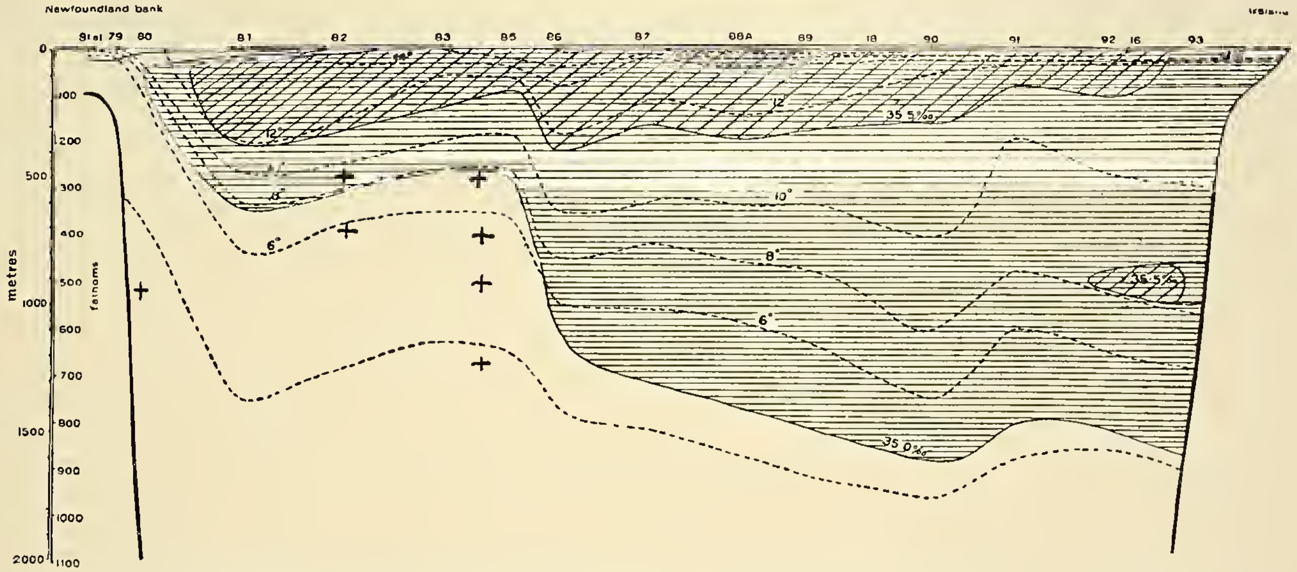

Fig. 38. Hydrographical section along the northern route of the "Michael Sars" Expedition. The positions where *Limacina helicoides* was taken are indicated by crosses.

The third deep-sea species, *Clio falcata*, seems to occur under similar hydrographical conditions as the two species just mentioned, its optimum temperature being also below 10° C.

These three species, which live under conditions so different from those at the surface, though belonging to different groups of pteropoda have certain features in common. They are all characterized by a series of archaic characters in their anatomy (broad and folded plate-like foot, a right-sided position of the pallial cavity, long intestine, symmetrical visceral gangliar mass), they are all dark coloured, and two of them (*Limacina helicoides* and *Clio falcata*) have on the tentacles peculiar white end-plates, which are most probably organs of light-production or of light-perception.

"Bipolarity" of pelagic animals. The discontinuity in the distribution of the same or of corresponding species known only from the arctic and antarctic regions of the sea is a fact well known in the case of pelagic animals but many questions have still to be answered before a full understanding of this fact is reached.

This "bipolarity" has been explained in three essentially different ways (see MEISENHEIMER 1905, p. 87—92):—

1) the corresponding forms at both poles represent the survivors of a fauna previously equally distributed all over the sea (PFEFFER, MURRAY);

2) they originated in a continuous fauna occupying a certain zone between both poles, and then gradually withdrawing to the colder regions of the arctic and antarctic water (MEISENHEIMER);

3) the apparently discontinuous faunas at the poles are still connected with each other through the cold-water fauna of the deep-sea. (ORTMANN, CHUN).

A decision between these different interpretations must be based not only upon the geographical data given by the authors mentioned, but also upon a knowledge of the anatomy of the species living in different parts of the ocean. The more archaic species, according to PFEFFER and MURRAY might be excepted to exist near the poles, while in the theory of MEISENHEIMER the more original forms should be found in the warmer regions of the ocean.

The third theory (maintained for pelagic animals by CHUN), assumes that the deep-sea fauna should give the clue to the solution of the bipolarity question.

The results of my investigations into the comparative anatomy of the thecosomatous pteropods are very much in favour of the last supposition. In the deeper layers of the ocean we have found three species *(Peraclis diversa, Limacina helicoides* and *Clio falcata),* all with obviously archaic characters, and we have found a gradual transition with regard to all the important organs of the body between these archaic deep-sea forms and the typical well-known surface species.

There is therefore every reason to believe that the deep-sea pteropods have retained more of their original characters than the surface species, which have developed in divergent directions according to the varying conditions in the different zones of the surface waters.

It is of great interest in this connection to point out that among the Cavoliniidae the species which are anatomically most closely connected with the deep-sea forms *(Clio cuspidata, Clio pyramidata* and *Diacria trispinosa)* are eurythermal species, which may therefore, anatomically as well as geographically, be regarded as transitional forms between the stenothermal archaic species of the deep-sea and the equally stenothermal modern species of the surface, now adapted to the conditions of a special and more or less strictly limited temperature-zone.

Another fact of general interest for a solution of the bipolarity question is the very wide horizontal distribution of the deep-sea forms. Thus *Limacina helicoides* has been recorded from the coast of Ireland in the North to to the mouth of the Congo and the Cape in the South, while *Clio falcata* has been found at places so far apart as Davis Strait in the North and the Canary Islands and the South American coast in the South. If these forms and perhaps a few others[1]) really represent the survivors of an archaic deep-sea fauna, then we should have to seek an explanation of the bipolarity phenomenon in the corresponding life-conditions of the arctic and antarctic regions of the ocean. It would harmonize very well with the results of modern investigations regarding heredity and species-formation, if similar life-conditions affecting descendants of the same or corresponding ancestors had also produced a similar effect on the organisms.

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[1]) As for example *Clio Andrei, Clio sulcata.*

TABLES

Table I.

Station	1	10	15	23	29	31	34	35	39	42	45	46	47	48	49	50	51	52
Peraclis reticulata	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— diversa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— triacantha	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Procymbulia michaelsarsii	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Limacina helicoides	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— helicina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— retroversa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— balea	Lots	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
— bulimoides	—	—	—	—	—	—	—	—	11	—	—	—	—	—	—	—	—	16
— lesueurii	—	—	—	—	—	—	—	—	13	5	—	—	—	—	—	—	—	21
— inflata	—	—	—	—	—	—	—	—	Lots	8	—	—	—	—	—	—	—	30
Clio falcata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
— cuspidata	—	1	—	3	2	—	—	—	—	1	14	—	—	—	4	—	—	—
— pyramidata	—	33	1	180	28	—	1	4	15	161	3	—	—	—	—	—	1	5
Styliola subula	—	—	—	4	—	—	—	1	4	3	8	1	2	2	—	—	—	54
Creseis acicula	—	—	—	—	—	—	—	—	—	—	—	—	1	41	7	—	—	20
Hyalocylix striata	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	1	1
Cuvierina columnella	—	—	—	24	1	—	—	—	—	—	2	—	1	—	25	—	—	2
Diacria trispinosa	—	5	—	—	2	—	3	—	3	5	15	—	—	—	2	—	7	2
— quadridentata	—	—	—	—	—	—	—	—	—	—	—	—	—	64	3	1	—	3
Cavolinia inflexa	—	—	—	c. 600	6	4	—	—	c. 700	Lots	—	—	—	1	—	—	2	—
— gibbosa	—	—	—	—	—	—	—	1	—	1	17	—	—	1	5	—	1	—
— tridentata	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	1	—
— longirostris	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	8
— uncinata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cymbulia peronii	—	4	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
— borealis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Number of species	1	4	1	8	6	1	2	3	7	8	7	1	3	6	6	1	8	11

Table II.

Station	Ireland	Spanish-African coast	S. E.	Azores	S. W.
	1—9, 93—101	10—43	44—50	51—59	60—70
Peraclis reticulata	—	1	—	c. 650	—
— diversa	—	—	—	12	34
— triacantha	—	3	—	2	—
Procymbulia michaelsarsii	—	—	—	—	—
Limacina helicoides	—	—	—	—	14
— helicina	—	—	—	—	—
— retroversa	c. 800	—	—	—	—
— balea	Lots	—	—	—	c. 1600
— bulimoides	—	11	—	36	30
— lesueurii	—	18	—	77	90
— inflata	—	Lots	—	c. 690	c. 760
Clio falcata	—	—	—	3	1
— cuspidata	5	7	18	4	1
— pyramidata	—	c. 420	3	c. 100	43
Styliola subula	—	12	13	c. 220	c. 130
Creseis acicula	—	—	c. 50	30	47
Hyalocylix striata	—	1	1	2	5
Cuvierina columnella	—	25	28	13	15
Diacria trispinosa	2	18	17	137	39
— quadridentata	—	—	68	4	1
Cavolinia inflexa	—	Lots	1	4	2
— gibbosa	—	2	23	1	1
— tridentata	—	—	3	10	—
— longirostris	—	—	—	9	—
— uncinata	—	—	—	—	1
Cymbulia peronii	—	6	—	—	—
— borealis	—	—	—	—	—
Number of species	4	14	11	19	18
Number of individuals					

53	56	58	62	64	66	67	69	70	80	81	82	84	87	88	90	92	94	96	98	101
—	650	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
—	11	1	10	21	3	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—
1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
—	—	—	3	2	4	5	—	—	1	1	8	9	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	13	1	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c. 800	—	—
—	—	—	—	—	c. 1100	—	200	300	16	—	c. 400	—	—	—	—	—	—	—	—	—
20	—	—	25	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
6	50	—	85	2	—	3	—	—	—	2	—	—	—	—	—	—	—	—	—	—
450	210	—	750	10	—	4	—	—	—	2	—	—	—	—	—	—	—	—	—	—
2	—	—	1	—	—	—	—	—	—	—	2	1	—	1	—	—	—	—	—	—
2	1	1	1	—	—	—	—	—	—	—	—	—	1	2	—	1	—	—	4	1
29	40	27	24	15	—	3	—	—	—	64	124	146	16	26	1	2	—	—	—	—
75	93	1	13	115	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	—	—	5	21	—	21	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	3	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
8	1	2	—	13	—	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—
35	24	69	31	5	—	2	1	—	—	12	5	1	11	43	25	18	2	—	—	—
1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1	8	—	—	—	—
14	12	6	12	10	3	12	4	1	3	8	5	5	4	6	4	6	1	1	1	1

N. Foundland	N. W.	N. E.	Sum total		Sum total	
71—79	80—86	87—92	Northern crossing	Southern crossing	Eastern basin	Western basin
—	1	—	1	c. 650	—	c. 650
—	—	2	2	46	2	46
—	—	5	5	2	5	2
—	—	1	1	—	1	—
—	19	—	19	14	—	33
—	14	—	14	—	—	14
—	—	—	—	—	—	—
—	c. 400	—	c. 400	c. 1600	—	c, 2000
—	—	—	—	66	—	66
—	2	—	2	167	—	169
—	2	—	2	c. 1450	—	c. 1450
—	4	—	4	4	—	8
—	—	4	4	23	22	5
—	c. 330	45	c. 375	c. 150	48	c. 480
—	—	—	—	c. 360	13	c. 350
—	—	—	—	c. 130	c. 50	c. 80
—	—	—	—	8	1	7
—	1	—	1	56	28	29
—	18	95	c. 110	c. 190	c. 110	c. 190
—	—	—	—	73	68	5
—	—	—	—	7	1	6
—	—	—	—	25	23	2
—	—	—	—	13	3	10
—	—	—	—	9	—	9
—	—	—	—	1	—	1
—	—	—	—	6	6	—
—	2	10	12	—	10	2
0	11	7	15	22	15	24
			c. 950	c. 5050	c. 400	c. 5600

Table III.

Depth in m.	Cymbulia borealis	Cymbulia peronii	Cavolinia uncinata	Cavolinia longirostris	Cavolinia tridentata	Cavolinia gibbosa	Cavolinia inflexa	Diacria quadridentata	Diacria trispinosa	Cuvierina columnella	Hyalocylix striata	Creseis acicula	Styliola subula	Clio pyramidata	Clio cuspidata	Clio falcata	Limacina inflata	Limacina lesueurii	Limacina bulimoides	Limacina balea	Limacina retroversa	Limacina helicina	Limacina helicoides	Procymbulia mich. sarsi	Peraclis triacantha	Peraclis diversa	Peraclis reticulata
0— 50	—	—	1	8	—	1	616	67	14	2	—	65	18	35	—	—	420	108	35	Lots	—	—	—	—	—	—	—
50— 100	8	2	—	—	—	4	Lots	3	130	11	2	30	221	418	5	—	Lots	69	32	500	800	1	—	—	1	—	650
100— 250	—	3	—	1	4	21	540	—	142	48	5	17	12	352	22	—	11	1	5	1500	—	—	—	—	8	1	11
250— 500	2	—	—	—	—	—	1	—	6	1	1	6	25	44	1	—	4	4	—	26	—	13	1	—	1	—	—
500— 750	2	—	—	—	—	—	(50)	—	8	8	1	1	94	62	5	2	200	—	—	—	—	—	18	—	—	3	1
750—1000	—	—	—	—	—	—	—	—	—	—	—	—	4	3	1	1	—	—	—	—	—	—	6	1	—	4	—
1000—1250	—	1	—	—	(8)	(1)	—	—	—	11	—	—	5	26	3	3	—	—	—	—	—	—	6	—	—	30	—
1250—1500	—	—	—	—	(1)	—	(3)	(3)	(19)	1	—	(7)	2	8	—	2	—	(5)	—	—	—	—	2	—	—	10	(5)

GYMNOSOMATA.

More than 150 specimens of gymnosomatous pteropods were procured during the "Michael Sars" expedition, of which about 100 belong to the well-known species *Clione limacina.*

Besides the arctic form one other, *Pneumodermopsis macrochira* Meisenheimer, occurs in considerable number (24) but otherwise the material consists of single or a very few specimens of no less than seven different species, probably all new to science.

I must confess that the investigation of these few specimens has given me more trouble than the whole group of thecosomatous pteropods put together, and I fully agree with Tesch (1904) in his remarks with regard to the difficulties to be overcome in the examination of the material and in consulting the literature. The more or less contracted bodies of the animals seldom exceed 5 to 8 mm. in length, with the systematically important organs of the buccal mass, as a rule, in the centre. Consequently these organs are in many cases not described, or even mentioned, while new species are founded upon the varying external appearance of the animals.

The papers of Boas (1886) and Pelseneer (1888) represent a great advance in our knowledge in so far as they have based their systems upon special organs, the form and development of which seemed characteristic enough for systematic grouping. The buccal appendages and the gills having proved of service in both systems, their results agree very well and their systems still form the bases of our classification of the gymnosomatous pteropods.

During my attempts, however, to determine the position of the new forms contained in my material within the old systems I was led to doubt the value of the latter as expressions of the real natural relationship between the species. Thus more than once it happened, that species with practically identical buccal organs should according to these systems be referred to different families because their posterior gills were differently developed, while in a natural system the buccal organs and especially the radula must, as original mollusc-organs, be considered as having a systematic value far above that of the posterior gill, a secondary organ of the highly specialized group of gymnosomatous pteropods.

I therefore undertook the work of investigating the buccal apparatus of all the species at my disposal, even if they were represented by only a single specimen. I soon found that even in much contracted individuals the whole proboscis can be separated by dissection without any essential damage to the appearance of the animal. After having studied and drawn the entire buccal mass, I prepared the radula for a further study by boiling it in caustic potash.

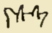
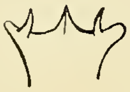
In table IV (p. 50—51), the results of this investigation are combined with the information found in the literature of the subject, so that the systematic value of different organ-systems may here be directly compared with each other.

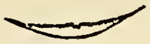
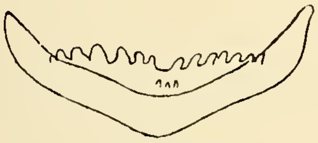
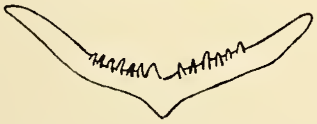
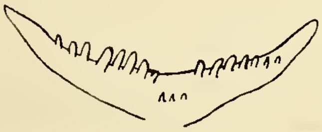
All the species of gymnosomatous pteropods, the radulae of which have been investigated, are in this table arranged according to the similarity of their median tooth. At the first glance these teeth are seen to represent very different types, which occur practically unchanged within the large groups; thus all the forms belonging to the family Pneumodermatidae have one type of median tooth, while another type is characteristic of the Notobranchaeidae. In both families a reduction of the median tooth is seen to take place.

Not quite so uniform are the median teeth of forms which have been included within the two families Clionopsidae and Clionidae, and future investigations may prove that these families do not represent really natural groups. The median tooth of the Clionopsidae is of a type similar to that of the Pneumodermatidae, while that of the Clionidae is more like the type of the Notobranchaeidae, but other organs, as for example the jaw, prove that they are distinct.

Other characters of the radula, such as the number and shape of the lateral teeth, are not so useful systematically as the median tooth. The number of lateral teeth within each transverse row varies somewhat, probably with

Table IV.

Species	Median tooth of the radula	Jaw	Hook-sacs	Gills		Special characters
				posterior	lateral (right side)	
Dexiobranchaea ciliata Ggbr. (From Boas)		A conical or cylindrical papilla carrying small spines	Shallow with short hooks	None	Triangular lobe	Acetabuliferous appendages of different numbers (2—3) and shape
Pneumodermopsis macrochira Meis.				4 radial crests	Unpigmented spot of the skin	
Pneumodermopsis michaelsarsi n. sp.					Triangular lobe with I crest	
Pneumoderma u. sp.? (young radula)			Tube-shaped with short hooks	?	Lobe with 3 crests	
Pneumodermon-larvae (From Boas)	As above.			Membranous ring and 4 crests		
Pneumoderma atlantica n. sp.	None, as other (fullgrown) sp. of Pneumoderma.				Small lobe without crests	
Spongiobranchaea australis d'Orb. (From Boas)			Oviform short and long hooks	Ring		
Schizobrachium polycotylum Meis. (From Meisenh.).			Shallow. Large, solid muscle-mass.	1 ventral crest	None	
Clionopsis Krohnii Tr. (From Boas)		Group of small spines	Shallow; short hooks	Ring and 4 crests	None	Proboscis very long
Clionopsis microcephalus Tesch. (From Tesch.)		?		None		

Species	Median tooth of the radula	Jaw	Hook-sacs	Gills		Special characters
				posterior	lateral	
Clione limacina Phipps		None	Oviform. Hooks of different lengths, all reaching the opening of the invaginated sack	None	None	Buccal cones
Paraclione pelseneeri Tesch (From Tesch)						
Cephalobrachia macrochaeta nov. gen. et sp.						Glandular lip
Notobranchaea inopinata et *macdonaldi* Pels.		A row of small spines	Shallow with short hooks	3 radial crests	None	Proboscis simple
Notobranchaea Valdiviae Meis. (From Meisenh.)						
Notobranchaea tetrabranchiata n. sp.				4 radial crests		
Fowlerina zetosios Pels. (From Pels.)				None		Proboscis a complex organ
Fowlerina hjortii n. sp.				Ring and 4 crests		
Microdonta longicollis nov. gen. et sp.				4 radial crests		Proscobis long simple

the age of the individual, and their shape, constant within each species and sometimes within each genus, is determined by characters so relative (more or less broad basal plates, larger or smaller hooks, etc.) that a system based upon such characters might easily lead to confusion.

Besides the median tooth of the radula, the jaw proves to be a "good" family character. In this particular also the two families Pneumodermatidae and Notobranchaeidae show absolutely different types, the jaw in the former being represented by a conical or cylindrical papilla, while in the latter it is found in the form of a row of small spines placed directly on the ventral wall of the buccal cavity. In those cases where the median tooth of the radula is too much reduced to manifest the family type (as in the genus *Microdonta)*, the jaw may be typical enough to prove the relationship.

The want of a jaw is characteristic of the family Clionidae, while the type of a jaw in the Clionopsidae has not yet been determined.

The systematic importance of the radula and jaw, is so well known in other groups of molluscs that their neglect in the gymnosomatous pteropods is probably due to the difficulty of the determining their form in contracted animals.

Besides these old mollusc-organs there are others, characteristic of the gymnosomatous pteropods, more easily recognizable and therefore playing a greater part in systematic works, such as the hook-sacs, the buccal appendages and the gills.

In table IV the systematic value of these organs is tested by comparing their uniformity, within smaller or larger groups of species, with that of the jaw and radula.

Considering first the gills, which are considered so important especially in the system of Pelseneer, we shall find them to be very inconsistent organs, and therefore not fit to serve as the basis of a natural system. The lateral gill might perhaps be of some importance in so far as it has not been shown to exist outside of the family Pneumodermatidae, but even within this family it may be absent *(Schizobrachium)*, or when present it may vary so much in size and shape that no more than a specific value can be attached to it. The same is, to a still greater extent, true of the posterior gill, which has been found in all the families except the Clionidae, but in each of these families it may be present or absent, and when present it may consist of radial crests varying in number, of a membranous ring, or of both structures together.

More constant organs than the gills are met with in the hook-sacs, the type of which may be constant within whole families or at least within large groups of species, but the same type is met with in different families, and no more than a generic value can therefore be attached to this character.

Besides the organs enumerated, which may practically be considered characteristic of the whole group of gymnosomatous pteropods, there are other organs characteristic of one family only, such as the acetabuliferous appendages of the Pneumodermatidae, the long thread-like proboscis of the Clionopsidae, the buccal cones of the Clionidae, and the complex proboscis of some Notobranchaeidae.

A natural system of gymnosomatous pteropods should accordingly be based in the first place on the old mollusc-organs, the radula and jaw, in the second place on the new acquirements of the order or of certain families, viz. the hook-sacs and the special characters of the buccal mass, which may be important as having generic value, and finally on the adaptive characters of foot and gills, which are of great value in the description of species.

In the following descriptions I shall give the characteristics of the organs mentioned, in so far as they play a part in the diagnoses of families or genera.

Pneumodermatidae.

Radula: Median tooth with 3 denticles; in species where it is wanting in the adults, it may be present in the young stages (textfig. 39),

Jaw: A papilla, conical or cylindrical, wholly or partly covered with spines.

Hook-sacs: 4 different types corresponding to the genera.

Acetabuliferous appendages present.

Laterall-gill generally present.

Pneumodermopsis Bronn.

Radula and jaw of the family type,

Median tooth of the radula well developed.

Hook-sacs shallow with short hooks.

Acetabuliferous appendages consisting of a pair of lateral symmetrically developed arms and a median part varying in appearance.

Pneumodermopsis macrochira Meisenheimer.

Pl. V, fig. 35–44.

The description of this species given by Meisenheimer (1905) is based upon two individuals from the "Valdivia" expedition, both contracted, so that several characters had to be left undescribed.

During the "Michael Sars" expedition 24 individuals were preserved of a species which in essential point agrees so well with the short description of Meisenheimer, that I do not hesitate to refer it to that species, although there may be some minor differences.

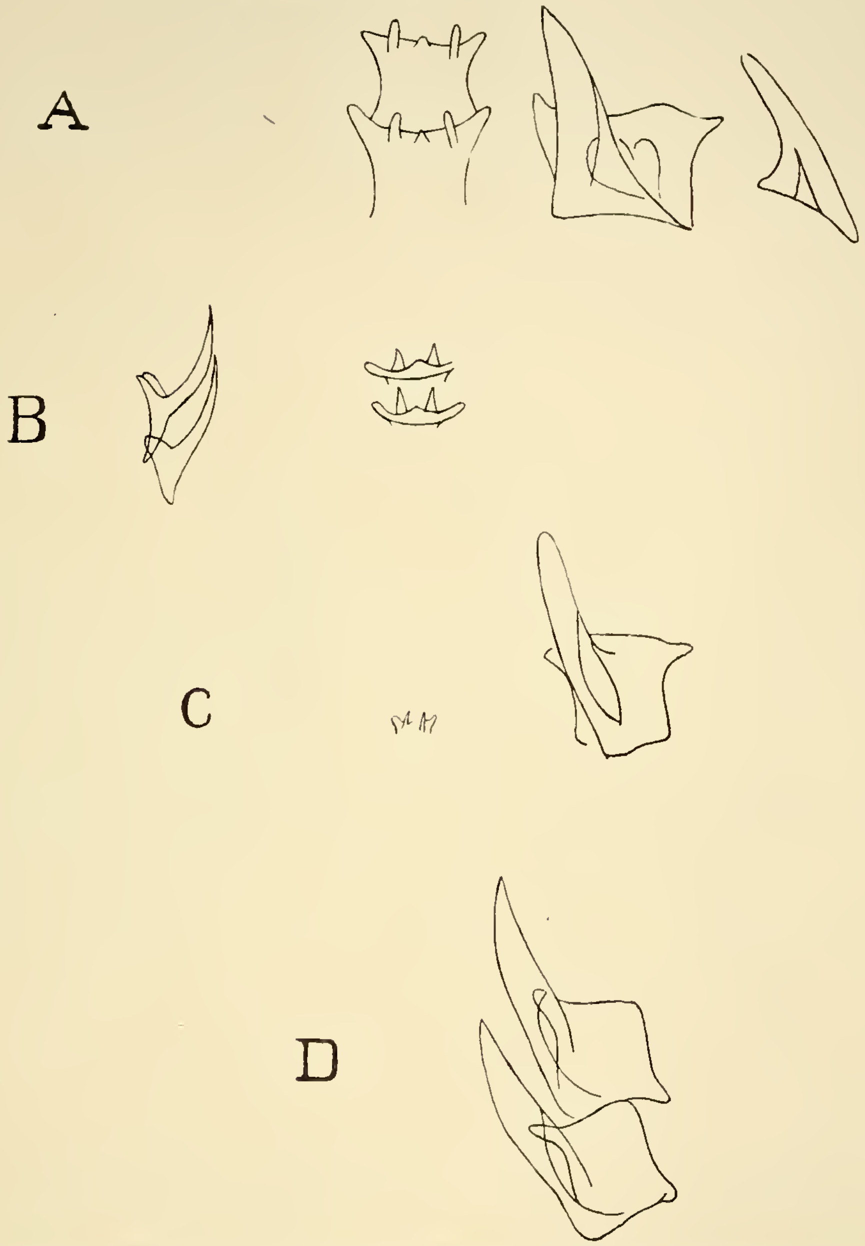


Fig. 39 Median and lateral teeth of A: *Pneumodermopsis macrochira;* B. *Pneumodermopsis michaelsarsi;* C. *Pncumoderma sp,* (young); D, *Pneumoderma atlantica.* All drawn to the same scale.

The whole appearance of the animal varies very much according to the degree of contraction. In most of my specimens the anterior as well as the posterior organs of the body were more or less completely concealed within the middle portion, so that these individuals look like little spheres from 3 to 6 mm. in diameter. In others (pl. V, fig. 37—38) the foot and wings and posterior gill are more or less clearly visible, while in one individual (fig. 35—36) the buccal apparatus is also partly evaginated and the acetabuliferous appendages extended. This great difference in the outward appearance has made it necessary to investigate the buccal apparatus in several individuals in order to determine their identity.

The formula of the radula is 6—1—6, the size of the lateral teeth gradually increasing towards the median line (textfig. 40 B, C). In full-grown specimens (B) they are fixed to large basal plates, which however are not found in younger specimens (C).

The jaw is a conical papilla (textfig. 41 and pl. V. fig. 41) covered with spines of different sizes. The larger spines seem in some specimens to be arranged especially along three ridges meeting at the top of the cone, while

Station	23	29	42	56	62	64	84	87	88	92
Date	$^{5}/_{5}$—$^{6}/_{5}$	$^{9}/_{5}$—$^{10}/_{5}$	$^{23}/_{5}$—$^{24}/_{5}$	$^{10}/_{6}$—$^{11}/_{6}$	$^{20}/_{6}$—$^{21}/_{6}$	$^{24}/_{6}$	$^{15}/_{7}$	$^{17}/_{7}$	$^{18}/_{7}$	$^{23}/_{7}$—$^{24}/_{7}$
Position N. W.	35° 32′ 7° 7′	35° 10′ 7° 55′	28° 2′ 14° 17′	36° 53′ 29° 47′	36° 52° 39° 55′	34° 44′ 47° 52′	48° 4′ 32° 25′	46° 48′ 27° 46′	45° 26′ 25° 45′	48° 29′ 13° 25′
Depth in m.										
0— 50	—	1	—	—	—	—	—	—	—	—
50— 100	—	—	—	—	—	—	—	—	1	1
100— 250	—	2	—	—	—	—	—	—	—	—
250— 500	—	—	5	—	—	—	—	—	—	—
500— 750	1	—	—	1	—	—	—	—	—	—
750—1000	—	—	—	—	—	—	1	—	—	—
1000—1250	—	—	—	—	—	1	—	1	—	5
1250—1500	—	—	—	—	1	2	1	—	—	—

Number of individuals of *Pneumodermopsis macrochira.*

smaller spines are scattered in the intervals between these ridges; the three ridges were, however, not always so clearly visible as in the specimen figured in pl. V, fig. 41.

The hook-sacs are shallow with 16 to 20 short and not very strong hooks (textfig. 41 and 40 A).

The acetabuliferous appendages consist according to Meisenheimer (1905) of a pair of free lateral arms each carrying 44 suckers (one of which is considerably larger than the others), and a median part with 5 suckers. The arm figured by Meisenheimer is. however, so strongly contracted that the details in the arrangement of suckers cannot be distinguished; in my material I have seen several examples of similar contraction.

In a few cases, however, I have found the acetabuliferous appendages more or less fully extended, although concealed inside the invaginated proboscis; one of these appendages is drawn in fig. 39, pl. V, while the median portion of an appendage (from another individual) is given in fig. 40. These figures show that the suckers of the lateral arms are arranged in two groups: a proximal group containing a large number (about 30[1])) of small suckers carried on broad peduncles decreasing in length towards the free end of the arm, and a distal group containing 12 or 13 small suckers and a single large one. The suckers are carried in parallel rows along the upper edge of the arm.

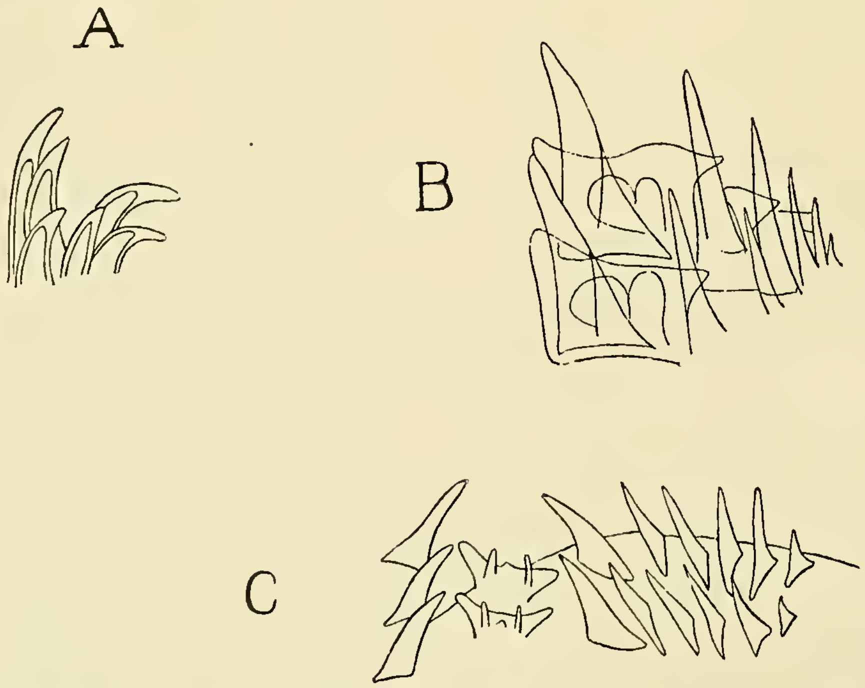


Fig. 40. *Pneumodermopsis macrochira:* A. Hooks, B.—C. Radula. (B. lateral teeth, C. Part of the radula in the young.)

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[1] Whether this number is absolutely constant, I cannot tell.

The median part of the acetabuliferous appendages consists of a short wall connecting the two lateral arms with each other and carrying 5 peculiar suckers on narrow peduncles (fig. 40), three longer ones alternating with two shorter ones. These five suckers on the median part are very irregular in shape and differ in structure from those of the lateral arms (fig. 43—44). They may be protruded so as to have the concave surface of ordinary suckers (fig. 40*) or retracted as in fig. 44, 40**, so as to form a hood-like cover round the end of the peduncle.

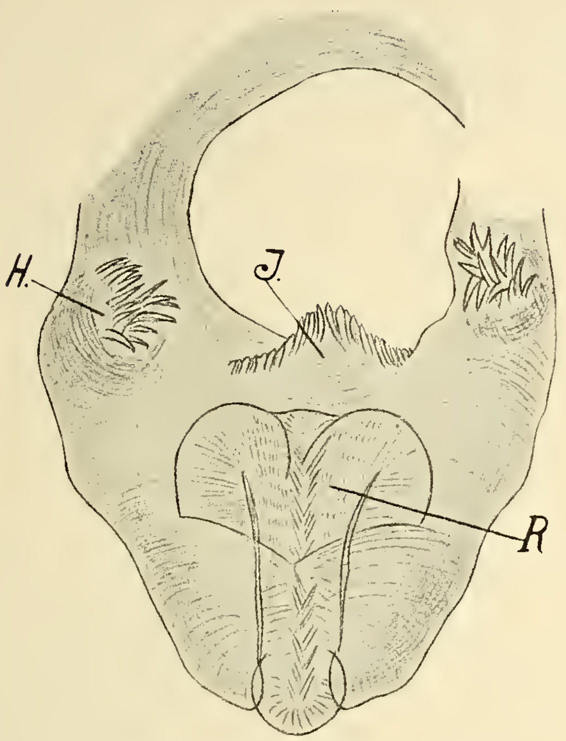

Fig. 41. *Pneumodermopsis macrochira*, buccal organs: J. Jaw; H. Hook sacs; R. Radula.

The median lobe of the foot is large and tongue-like, ordinarily with a blunt apex (fig. 36—37). In one individual however (fig. 38) it was obliquely bent and contracted to a long and narrow point.

In contracted individuals the wings may be absolutely concealed within a collar-like fold formed by the skin of the body (fig. 37). In the specimen shown in fig. 35—36, on the other hand, the soft skin of this part of the body is irregularly expanded, so as to form a series of globe-like protuberances scattered round the base of the wings and foot. Having seen this in only one individual, I cannot tell whether it should be considered a normal phenomenon.

A lateral gill is in most of my individuals represented only by a thin and pigmentless spot on the skin of the right side of the body. In one specimen, however (fig. 38), this part of the skin protrudes like a small triangular fold.

The posterior gill consists of four longitudinal ridges, meeting at the posterior end of the body (fig. 35—36, 38). In contracted individuals this gill is invaginated but even then the four ridges may be seen (fig. 37).

The skin is in contracted specimens covered with small tubercles except at the right side round the lateral gill. These tubercles are, however, not seen in extended individuals, the skin being here smooth and faintly pigmented.

The visceral mass fills the whole body.

Geographical distribution. This species has been described by Meisenheimer from the southern Indian and Atlantic oceans.

During the "Michael Sars" expedition it was taken at no less than 10 stations scattered along the whole route and at various depths (see table). It seems therefore judging from its extended horizontal and vertical distribution to be an eurythermal form.

Pneumodermopsis michaelsarsi n. sp.

Pl. VI, fig: 45—48.

The single individual of this species, taken by the "Michael Sars" expedition, is shown in fig. 45—46, pl. VI. The proboscis with the whole buccal mass was invaginated, and although I have isolated the other buccal organs I did not succeed in loosening the acetabuliferous appendages in toto, so that my description of these organs must be fragmentary.

Radula (formula 6—1—6): lateral teeth narrow and pointed, with small basal plates, increasing in size towards the median line (textfig. 42).

Jaw: a cylindrical papilla abruptly truncated above and bordered by a series of small spines (pl. VI, fig. 47, J).

Hook-sacs: shallow with about 30 short hooks (fig. 47, H).

Acetabuliferous appendages (fig. 48) carrying suckers of the ordinary type; shape of the appendages and number of the suckers unknown.

Foot: lateral lobes short and triangular; median lobe narrow, pointed.

Gills: lateral gill a triangular lobe on the right side of the body, carrying one longitudinal crest running from the

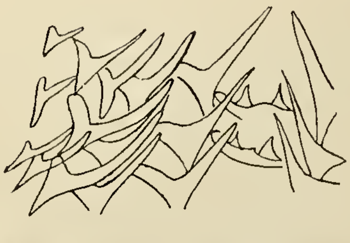

Fig. 42. Radula of *Pneumodermopsis michaelsarsi.*

free angle of the lobe obliquely towards its base; posterior gill consists of four longitudinal crests converging towards a small globular tubercle at the posterior end of the body.

Skin faintly pigmented. The visceral mass fills the whole body except the narrow tapering part carrying the posterior gill.

Pneumodermopsis michaelsarsii is distinguished from the earlier known species of this genus in having a posterior gill, while it differs from *P. macrochira* in the shape of the posterior and lateral gills and of the jaw.

Locality: Station 42 (28° 2′ N., 14° 17′ W.).
Date: $^{23}/_{5}$—$^{24}/_{5}$.
Depth: 250 metres.

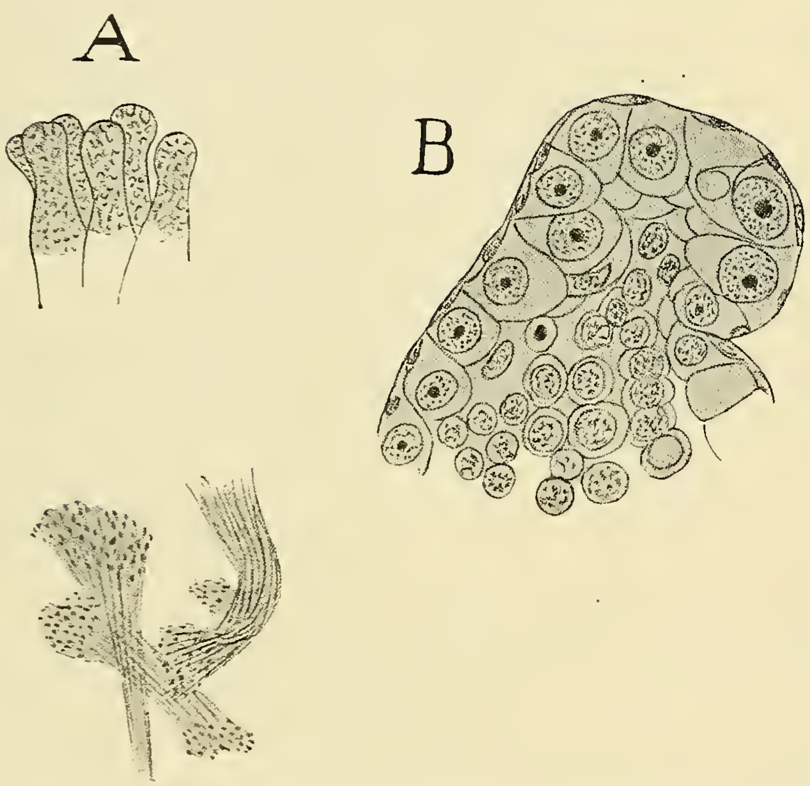

Fig. 43. *Pneumoderma atlantica.* A. Part of the genital gland; B—C. Contents of the gland (more highly magnified).

Spongiobranchaea d'Orbigny.

Radula and jaw of the family type; median tooth present.

Hook-sacs oviform, with curved hooks varying in length, all reaching the opening of the invaginated sac.

Acetabuliferous appendages consisting of a pair of lateral arms.

This genus is not represented in the "Michael Sars" collections.

Pneumoderma Cuvier.

Radula of the family type; median tooth which is wanting in the adult, may be present in the young.

Jaw of the family type.

Hook-sacs tube-shaped, with short hooks not essentially longer at the bottom of the sac than near the opening.

Acetabuliferous appendages: a pair of lateral arms, free or coalescent with the proboscis.

Pneumoderma atlantica n. sp,

Pl. VI, fig. 49—51.

My description of this interesting species is based upon one small individual about 3 mm. in length taken by the "Michael Sars" at Station 62. In shape it was so peculiar (see fig. 49—50) as to be almost unrecognisable.

As will be seen from the figures, the anterior and posterior parts of the body formed an angle with each other, and from the top of this angle a big sphere protruded.

Opening the sphere I found it to be hollow and to contain a peculiar body formed like a mushroom (fig. 49); the disc of this body was carried upon a narrow peduncle connecting its underside with the body-surface and apparently continuing into the body.

The disc itself was composed of a great number of small cones (textfig. 43 A), rounded at the top and mutually connected at the bottom. The contents of the cones are figured in textfig. 43, B-C, and prove that the organ is a hermaphroditic genital gland with eggs and spermatozoa in various stages of development. The shape of this gland, and the arrangement of its contents, are typical of gymnosomatous pteropods, and it seems necessary to conclude therefore, that the gland really belongs to the animal to which it is fixed, and that the peduncle connecting it with the body-wall is the genital duct.

An arrangement like this, with the genital gland lying, as it were, outside the body, seems so strange and unique in the animal kingdom, that the most careful examination will be necessary before acknowledging it as a normal phenomenon. Until the connection between this gland and the internal organs of the body has been accurately determined the question as to the meaning of the structures found in *Pneumoderma atlantica* cannot be considered as definitely settled. I hope to discuss this question in a later paper, and shall here merely draw attention to the fact that an analogous structure has been

Fig. 44. Radula of *Pneumoderma atlantica*.

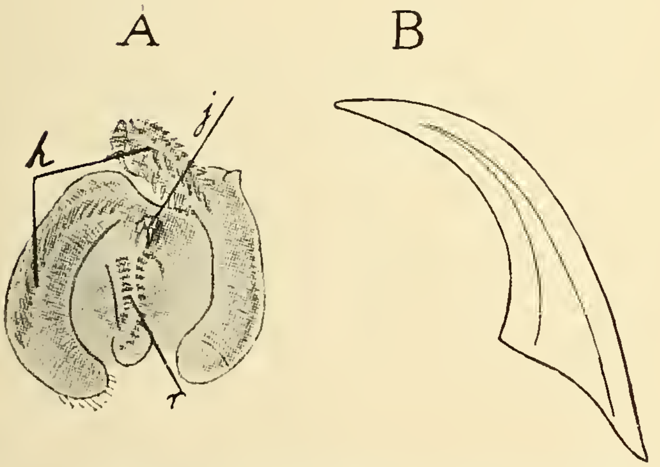

Fig. 45. Buccal organs of *Pneumoderma atlantica:* r. radula; j. jaw; h. hook-sacs; B. One of the hooks.

described by TESCH (1904) is his new species *Clionopsis microcephalus*, which has a genital gland outside the body near its posterior end. A difference between the two species is seen in the want of a cover round the gland in *Clionopsis*, while in our species the gland is surrounded by a closed spherical sac.

It is of interest to note that the two species, in which this strange arrangement has been observed, belong to different families of gymnosomatous pteropods.

To complete our description of the species:—

Radula: formula 4—0—4; lateral teeth hook-shaped, those of the second longitudinal row being the largest (textfig. 44).

Jaw: A short cylindrical papilla composed of two symmetrical halves carrying 6 small spines along each side of its distal end (textfig. 45 j, and fig. 52, pl. VI).

Hook-sacs tube-shaped, about three times the diameter in length. The hooks are largest on the median side of the evaginated sac, where they are arranged in two longitudinal rows, while smaller hooks are scattered over the whole surface (fig. 51, pl. VI).

Acetabuliferous appendages: two symmetrically developed arms fixed to the proboscis, each carrying numerous (about 50) small suckers.

Foot with broad quadrangular lateral lobes, and a short posterior lobe broad at the base and narrow at the point.

Gills: lateral gill a small simple protrusion on the right side of the body: posterior gill not observed.

Pneumoderma atlantica is distinguished from other species of the genus, *inter alia* by the acetabuliferous appendages being fixed to the proboscis.

Locality: Station 62 (36° 52′ N, 39° 55′ W). Surface.

Pneumoderma sp.

Radula: Formula 4—0—4. Two or three rudiments of median teeth (of the family type) are found in the youngest part of the radula (textfig. 46); lateral teeth on broad basal plates, those of the second longitudinal row largest.

Jaw unknown.

Hook-sacs tube-shaped, with hooks like those of *P. atlantica* (textfig. 47 A—B).

Acetabuliferous appendages present; shape unknown.

Foot: Lateral lobes thick and hollow like small hemispheres; postertor lobe very short triangular (textfig. 48 B).

Gills: Lateral gill a transverse fold of the skin on the right side of the body, from which three longitudinal ridges extend forwards; posterior gill unknown.

The peculiar shape of the foot of this specimen might perhaps form the basis of its diagnosis as a new species, but the whole body is so strongly contracted that I think it better at present to have this question undecided.

Locality: Station 42 (28° 2′ N., 14° 17′ W.).
Date: $^{23}/_{5}$—$^{24}/_{5}$.
Depth: 250 metres.

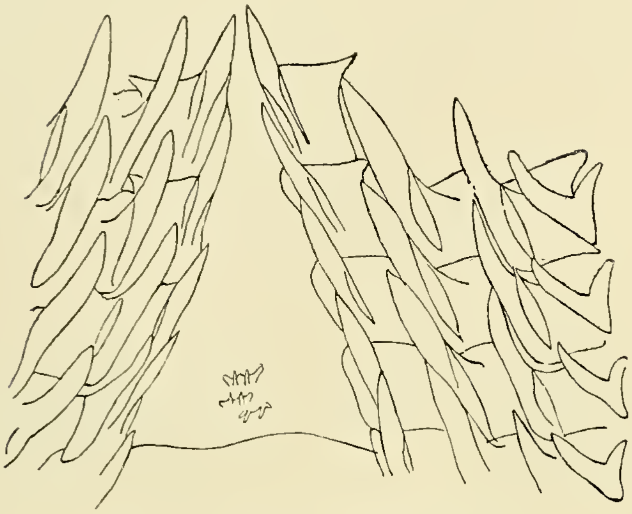

Fig. 46. Radula of *Pneumoderma* sp.

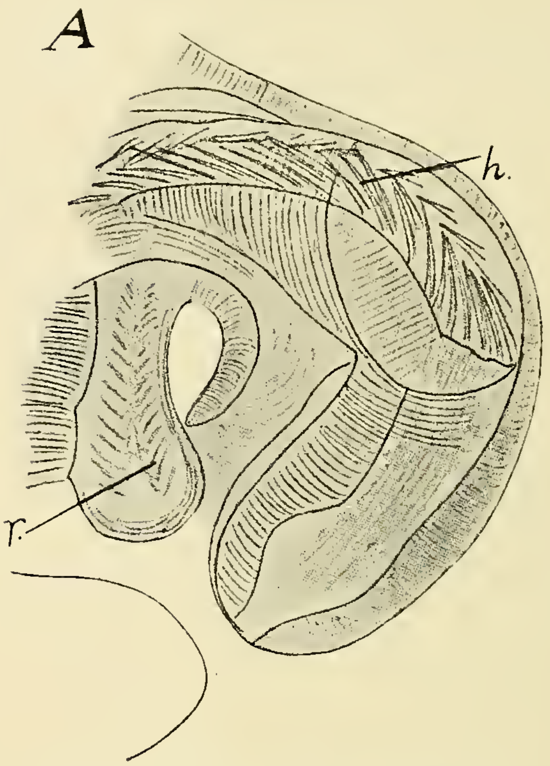

Fig. 47 A. Radula (r) and one hook-sac (h) of *Pneumoderma* sp.

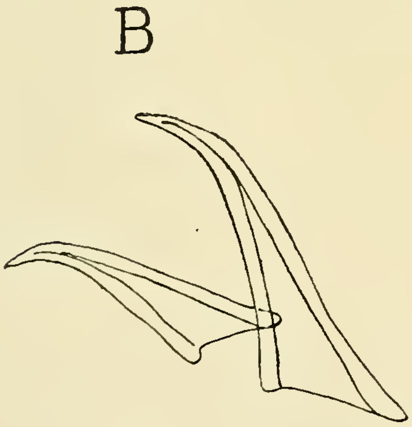

Fig. 47 B. Hooks of *Pneumoderma* sp.

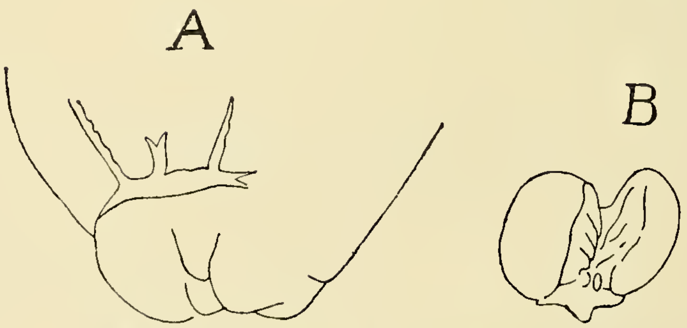

Fig. 48. *Pneumoderma* sp. A. Posterior end of the body with the lateral gill. B. Foot.

Clionopsidae.

Radula: Median tooth with 3 denticles.
Jaw: ?.
Hook-sacs shallow.
Proboscis very long, threadlike.
No acetabuliferous appendages.
No lateral gill.

The above family characters are based upon a knowledge of very few species.

Not represented in the "Michael Sars" collections.

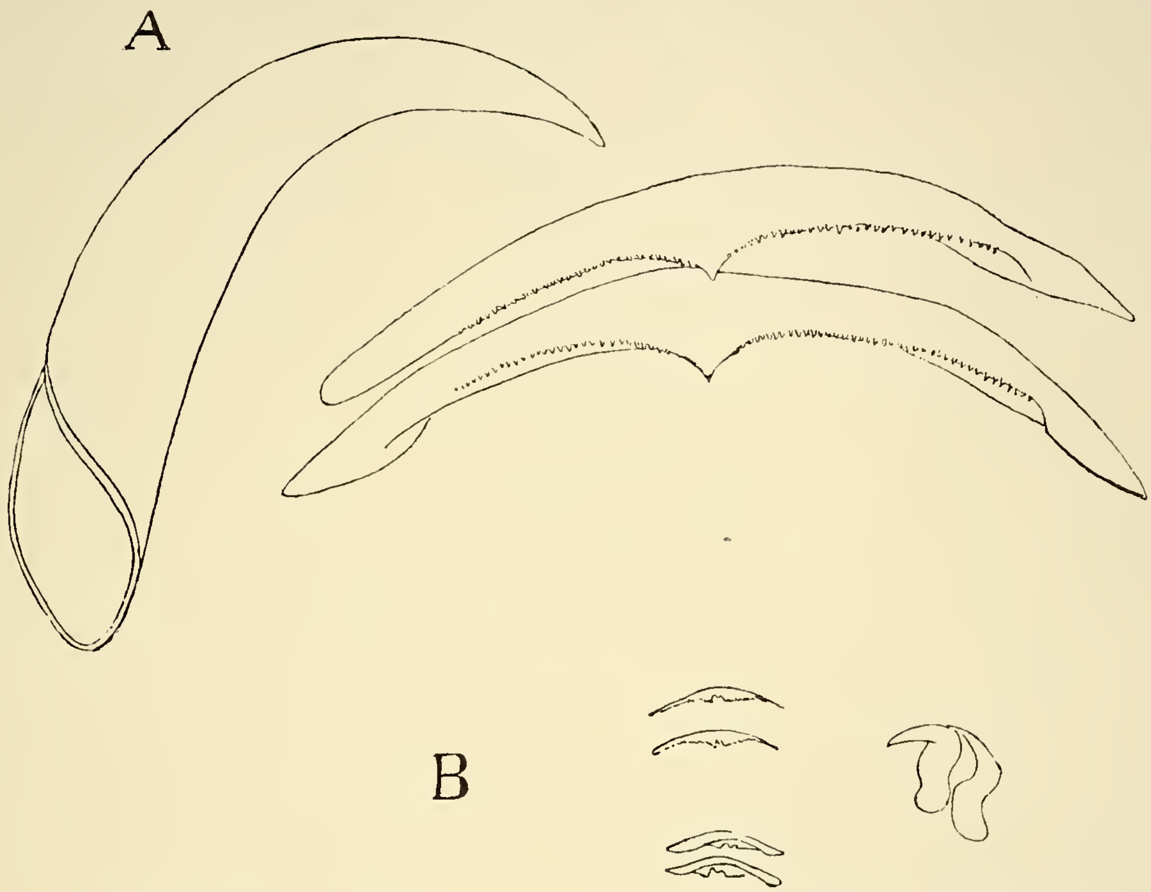

Fig. 49. Median and lateral teeth of A. *Cephalobrachia macrochaeta*, and B. *Clione limacina* (drawn to the same scale).

Clionidae.

Radula: Median tooth triangular, the base of the tooth forming one side of the triangle while the two other sides are formed by its free borders (textfig. 49).

No jaw.

Hook-sacs oviform, all the hooks reaching the opening of the invaginated sac.

No acetabuliferous appendages.

No lateral gill.

Clione Pallas.

Radula with a great number of very small teeth. Free border of the median tooth with a denticle protruding from the bottom of an incision.

3 pairs of buccal cones.

Clione limacina Phipps.

Pl. VIII, fig. 59—60.

Radula: Lateral teeth narrow pointed hooks, the number in each transverse row varying between 10 and 14 (textfig. 50).

Foot with broad lateral and rudimentary posterior lobes.

No gill.

Fig. 50. Radula of *Clione limacina*.

Fig. 51. Horizontal distribution of *Clione limacina* from the "Michael Sars" expedition.

The visceral mass does not fill the posterior part of the body.

This species is so well known that a further discription of its characters is unnecessary. In fig. 59—60, pl. VIII, a specimen with fully extended penis and buccal cones is shown.

Geographical distribution. About 120 individuals of this species were taken during the "Michael Sars" expedition, nearly every station along the northern crossing of the ocean and a few stations along the southern crossing, as far south as lat. 34° 44′ N. (Station 64), being represented.

Clione limacina is known as one of the most characteristic representatives of the arctic (and antarctic) fauna, and when met with on warmer latitudes it has generally been considered an indicator of the presence of cold water currents. Damas and Koefoed (1905) maintained, however, that this did not hold good in all cases, and that probably other factors play an important rôle in the distribution of pelagic species. Among such factors light was regarded as one of the most important, leading to the occurrence of *Clione* near the surface within the arctic regions, and in deeper water in more southern latitudes.

The distribution of *Clione limacina* as found by the "Michael Sars" expedition during the double crossing of the Northern Atlantic seems however to indicate a very intimate connection between the temperature and salinity of the water on the one hand and the occurrence of *Clione* on the other.

As shown in the table this species was taken during the northern crossing at a great number of stations not only in the open ocean (St. 81—92) but also, as the only representative of pteropods, on the Newfoundland banks (St. 71—80). Although the effect of the sunlight would be practically the same at all these stations, *Clione limacina* was found in the open ocean, where the surface-layers are relatively warm and salt, to belong to the deeper waters, while it was taken near the surface of the cold Labrador current. Also during the southern crossing (Stations 64—75) *Clione limacina* was found to belong to a water-layer with a temperature as low as from 4° to 10°C.

Paraclione Tesch.

Radula: Free border of the median tooth forming a long, pointed denticle (Formula: 3—1—3).

2 pairs of buccal cones.

Not represented in the "Michael Sars" collections.

St.	64	66	67	70	71	75	76	80	81
Date	$^{24}/_{6}$	$^{26}/_{6}$	$^{27}/_{6}$	$^{30}/_{6}$	$^{30}/_{6}$	$^{9}/_{7}$	$^{9}/_{7}$	$^{11}/_{7}$	$^{12}/_{7}$
Position N.	34° 44′	39° 30′	40° 17′	42° 59′	43° 18′	47° 22′	47° 11′	47° 34′	48° 2′
Position W.	47° 52′	49° 42′	50° 39′	51° 15′	51° 17′	49° 16′	47° 6′	43° 11′	39° 55′
Depth in m.									
0— 50	—	—	—	—	—	1	1	—	—
50— 100	—	—	—	—	14	—	—	—	—
100— 250	—	1	1	4	—	—	—	—	—
250— 500	—	2	—	1	—	—	—	1	—
500— 750	—	22	2	—	—	—	—	12	—
750—1000	—	11	—	—	—	—	—	—	—
1000—1250	2	—	—	—	—	—	—	—	—
1250—1500	—	—	—	—	—	—	—	1	1

St.	82	84	87	88	90	92	96	98
Date	$^{13}/_{7}$	$^{15}/_{7}$	$^{17}/_{7}$	$^{18}/_{7}$	$^{21}/_{7}$	$^{23}/_{7}$—$^{24}/_{7}$	$^{27}/_{7}$	$^{5}/_{8}$
Position N.	48° 24′	48° 4′	46° 48′	45° 26′	46° 58′	48° 29′	50° 57′	56° 33′
Position W.	36° 53′	32° 25′	27° 46′	25° 45′	19° 6′	13° 55′	10° 46′	9° 30′
Depth in m.								
0— 50	—	—	—	—	—	—	—	—
50— 100	—	—	—	—	—	—	3	—
100— 250	—	—	—	—	—	—	—	—
250— 500	—	—	—	—	—	—	—	—
500— 750	—	—	—	—	—	—	—	14
750—1000	3	3	3	2	1	—	—	—
1000—1250	—	3	3	—	—	3	—	—
1250—1500	1	3	—	—	—	—	—	—

Number of individuals of *Clione limacina*.

Cephalobrachia nov. gen.

Radula with very large teeth. Free border of the median tooth forming a blunt point, with a series of minute denticles on each side.

Hook-sacs very large and forming, when evaginated, a pair of strongly armed branches protruding from the region of the head.

No buccal cones.

Cephalobrachia macrochaeta n. sp.

Pl. VII, fig. 53—58.

Radula: Formula 3—1—3. Median tooth of the genus-type. Lateral teeth horn-shaped without basal plates (fig. 58, pl. VII, textfig. 49 A). The radula is, when evaginated, placed at the top of a large cone, protruding from the ventral side of the mouth (fig. 54, 55, 57 *r. c*).

Hook-sacs of the family type with hooks of different sizes; the largest attain a length equal to one-fourth of the fully extended body. When evaginated the hook-sacs form two powerful arms diverging from near the base of the radula-cone.

As in the other representatives of this family there is no jaw, but in its place, at the ventral side of the radula is found a transverse lip formed by large glandular cells. This lip forms a bow across the whole ventral side of the proboscis (fig. 54, 57 *l*).

The lateral lobes of the foot coalesce in front so as to form a single lobe, fixed anteriorly and with a shallow groove in its upper surface; posterior lobe small and pointed.

Wings large, with a narrow base and tapering also towards the free end, the median part being the broadest.

No gill. In one small specimen two parallel obliquely running lines surrounded the posterior part of the body (fig. 53—54), but they were not observed in the larger specimens, and are therefore probably larval characters.

The visceral mass in all the specimens fills the whole body.

The skin is soft and transparent with minute scattered tubercles.

The three specimens are between 5 and 10 mm. in length, but the largest individual (fig. 56) must have been longer when fully extended.

This new and peculiar species was taken during the "Michael Sars" expedition at three northern stations and all from deep water.

Localities: St. 82 (48° 24′ N, 36° 53′ W). Depth: 500 metres.
„ 88 (45° 26′ N, 25° 45′ W). „ 750 „
„ 92 (48° 29′ N, 13° 55′ W). „ 750 „

Dates: $^{13}/_{7}$—$^{24}/_{7}$ 1910.

Notobranchaeidae.

Radula: Median tooth sickle-shaped, its concave free border (generally) armed with denticles arranged in a median and a pair of lateral rows (textfig. 52).

Jaw: A row of small pointed spines on the ventral wall of the buccal cavity.

No acetabuliferous appendages. No lateral gill.

This family was founded by PELSENEER (1888) for two species, *Notobranchaea inopinata* and *N. macdonaldi*, the characters of which were described and figured without reference to the buccal organs.

Characteristic of both species was the smooth spindle-shaped body, pointed posteriorly and tapering anteriorly towards the neck, which (the proboscis invaginated) was narrower than the regularly rounded head. As mentioned by PELSENEER these forms resemble *Clione* in outward appearance, as well as in the fact that the visceral mass does not reach the posterior end of the body. Other distinctive characters were found in the shape of the wings and foot.

The genus *Notobranchaea* has been dealt with by later authors, and new characters added to its diagnosis, without however leading to a definite solution of the question as to its systematic relations.

TESCH (1904) describes a species from the "Siboga"-expedition, which he identifies with *N. inopinata*. In confirming the data given by PELSENEER he adds that there are two pairs of buccal cones, and that the radula has no median tooth.

MEISENHEIMER (1905) in describing a specimen from the "Valdivia"-expedition doubts the correctness of these statements, for while he found no buccal cones, he observed in the radula a series of very large median teeth. Contrary to PELSENEER's description he found the visceral mass in *N. Valdiviae* filling the whole body.

Buccal organs similar to those observed by MEISENHEIMER in *N. Valdiviae* were found by PELSENEER (1906) in a new form, *Fowlerina Zetosios*, but he considered this form to be nearly related to the Clionidae.

As will be seen from the above statements considerable confusion exists with regard to the systematic characters and relations of Notobranchaeidae.

I have among the "Michael Sars" material had an opportunity of investigating species of *Notobranchaea* as well as of *Fowlerina*, in both forms confirming the results of MEISENHEIMER and PELSENEER (1906) with regard to the buccal organs. The similarity of these organs in both genera is in fact so great that I do not hesitate to combine them into one family, in spite of the very obvious difference in their outward appearance. To these two genera I shall have to add the new genus *Microdonta*, which, however, differs from them in essential characters.

Fig. 52. Median and lateral teeth of: A. *Fowlerina hjortii*, n. sp. B. *Notobranchaea tetrabranchiata*, n. sp. C. *Microdonta longicollis*, n. sp.

Notobranchaea Pelseneer.

Radula: Median tooth of the family type, the denticles of the margin forming two lateral arched rows, with a median row of three small denticles between them.

Lateral teeth hook-shaped, increasing in size towards the middle line of the radula. (Textfig. 52, B)

Jaw: A series of hollow spines forming a continuous row[1]) on the ventral wall of the buccal cavity.

Hook-sacs shallow, with short hooks, dorsally bordered by a group of very large clear cells.

No buccal cones.

Posterior gill generally present.

Foot with a median tubercle.

Proboscis and buccal mass relatively small and slender.

This genus is based upon two species *(N. inopinata* and *N. macdonaldi)* described by PELSENEER (1888), charac-

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[1]) In the two other genera of this family, this row of spines is continued on each side into a series of single spines, forming together a line bordering the entrance of the buccal cavity. I have not been able to determine with certainty whether such a line may be present also in *Notobranchaea*.

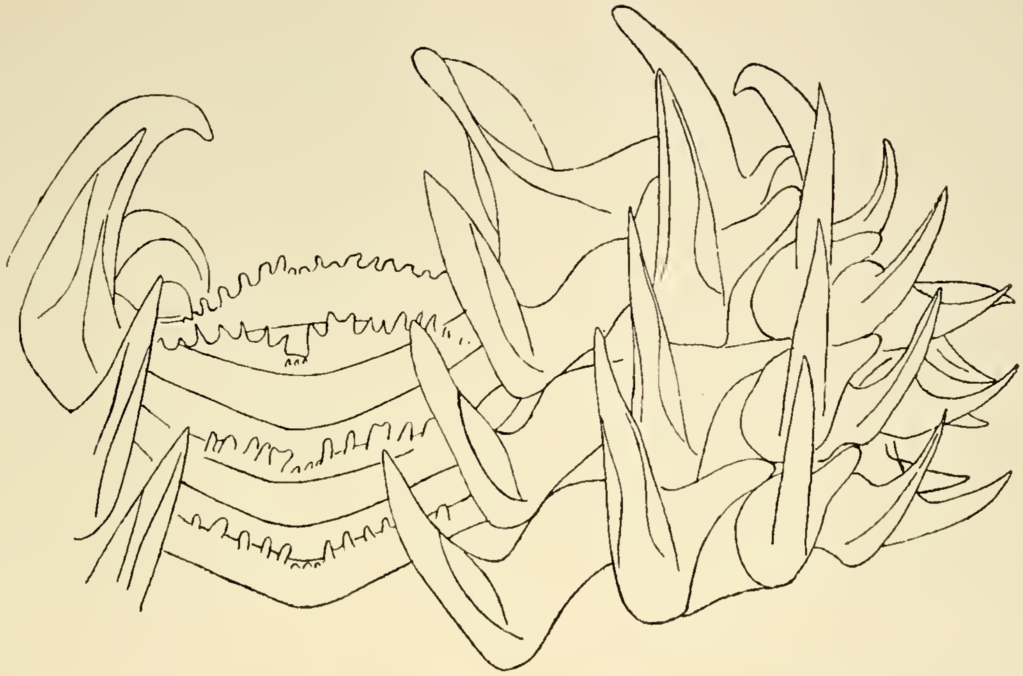


Fig. 53. Radula of *Notobranchaea tetrabranchiata.*

terised by the spindle-shaped *Clione*-like body. TESCH (1904) and MEISENHEIMER (1905) referred new species to this genus, but from my study of the "Michael Sars" material I fully agree with MEISENHEIMER that according to TESCH's description the "Siboga" species does not correspond with that of PELSENEER and that in fact it does not belong to this genus.

In the material from the "Michael Sars" expedition the genus *Notobrànchaea* is represented by two individuals belonging to one species new to science:

Notobranchaea tetrabranchiata n. sp.
Pl. VIII, fig. 61—62.

In outward appearance this species very much resembles the original species of PELSENEER, and therefore also *Clione limacina.* The pointed posterior part of the body is transparent and empty, as in the forms just mentioned, but at the same time it is distinguished from them by having tetraradiate posterior gill, whereas the gill in PELSENEER's two species is triradiate and *Clione* has no gill at all.

Radula: Formula 6—1—6 (textfig. 53). The denticles of the median teeth are somewhat irregularly arranged within each group, while the relation between lateral and median groups is always the same as mentioned for the genus. Lateral teeth large, hook-shaped, each hook when fully developed consisting of regularly arranged substances varying in transparency.

Jaw: A row of 14 spines each forming a hollow cone (textfig, 54).

Hook-sacs small, shallow, with short and slender hooks; the muscular apparatus of the hook-sacs slightly developed. (Textfig. 55.)

Foot: Lateral lobes closely approximated anteriorly and diverging posteriorly so as to form two sides of an equilateral triangle. The median tubercle repeats the same figure in miniature. Posterior lobe narrow and pointed, its front side forming a longitudinal groove.

Wings narrow at the base and broadly truncated at the free end.

Posterior gill consisting of 4 crests meeting in a point at the posterior end of the body.

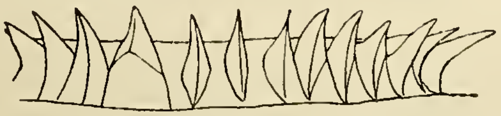


Fig. 54. Jaw of *Notobranchaea tetrabranchiata.*

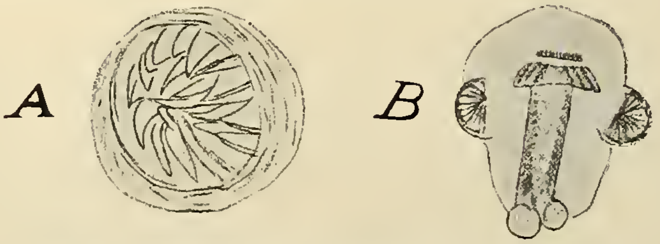


Fig. 55. *Notobranchaea tetrabranchiata.* A. Hook-sac. B. Buccal organs (r radula; j. jaw; h. hook-sac).

Skin: smooth, unpigmented.

Size: 6—8 mm. in length.

Localities: St. 10: 45° 26′ N, 9° 20′ W. Surface. Date: $^{19}/_{4}$—$^{21}/_{4}$ 1910. 1 individual.
St. 92: 48° 29′ N, 13° 55′ W. Depth 150 metres. Date: $^{23}/_{7}$—$^{24}/_{7}$ 1910. 1 individual.

In both individuals the penis is evaginated, forming a broad folded lobe, along the margin of which a narrow groove leads up to a short finger-like protrusion.

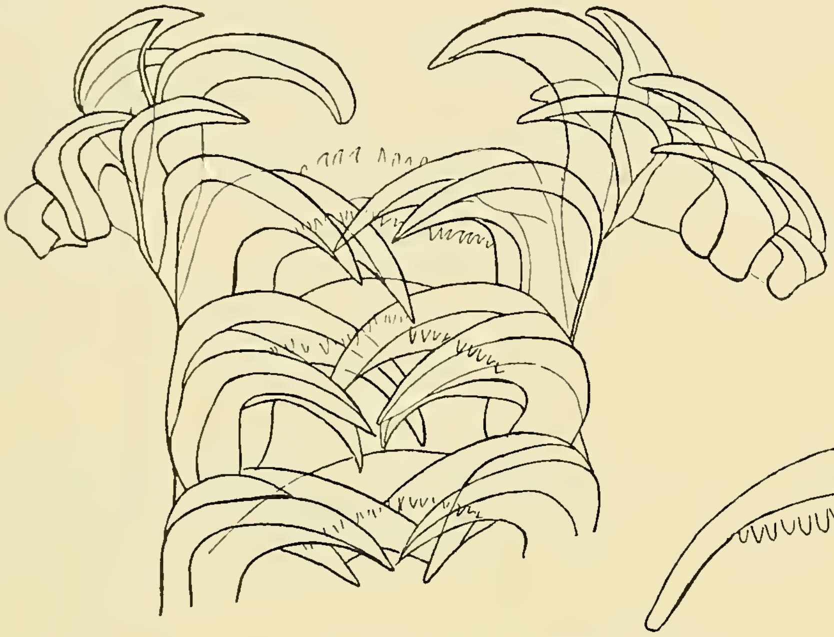
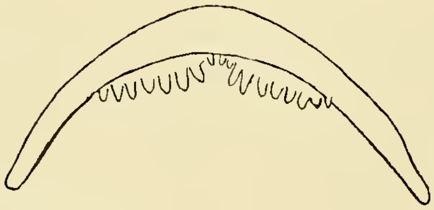


Fig. 56. Radula of *Fowlerina hjortii.* n. sp.



Fowlerina Pelseneer.

This genus was founded by Pelseneer (1906) upon some specimens contained in the Biscayan plankton, the outward appearance of which is very different from that of *Notobranchaea.* (See pl. VIII, fig. 63—68.)

Instead of the slender spindle-shaped body of *Notobranchaea*, we find in the genus *Fowlerina* forms with relatively broad cone-shaped bodies, the apex of the cone being represented by the posterior end of the body and the base by the broad neck-region, which in contracted individuals is folded so as to conceal more or less completely the head as well as the foot and wings.

This difference in the shape of the animals in the two genera is caused by the very different development of the proboscis. In *Notobranchaea* this apparatus consists of nothing but an invaginated cone, the walls of which carry the characteristic buccal organs, while in *Fowlerina* the proboscis forms a large and complete system of muscular layers surrounding each other like the cylinders of a telescope, so that every stage in its evagination imports to the animal a different and characteristic appearance. The illustrations, fig. 63—68, will convey a better idea of this gradual change in external appearance than a verbal description.

Considering the great difference in outward appearance, it is surprising to find the buccal organs, radula, jaw, and hook-sacs, of exactly the same type in both *Notobranchaea* and *Fowlerina.* Their conformity in this important point is, as already pointed out, my reason for including the genus *Fowlerina* in the family Notobranchaeidae, instead of following Pelseneer in placing it among the Clionidae.

Radula: Median tooth of the family type; the arrangement of the denticles like that in the genus *Notobranchaea.* Lateral teeth hook-shaped, increasing in size towards the median line of the radula.

Jaw: A row of conical spines continued on each side by a series of small single spines forming curved lines towards the hook-sacs.

Hook-sacs shallow, with short but strong hooks and a strong muscular apparatus. A group of large clear cells is found at their dorsal margin.

Proboscis: A complex organ, the mouth opening towards the dorsal side.

Tentacles: Two pairs, the anterior pair covered with groups of large club-shaped cells;[1] both pairs may be invaginated within the proboscis-wall (pl. VIII, fig. 67).

Foot without a median tubercle.

In the "Michael Sars" material this genus is represented by six individuals belonging to one species, new to science.

Fowlerina hjortii n. sp.

Pl. VIII, fig. 63—68.

Radula: Formula 6—1—6. The hook-shaped lateral teeth are simpler than those of *Notobranchaea tetrabranchiata*, looking very much like a foot with a slipper. (Textfig. 56).

Jaw: A median row of 14 spines continued on each side by a series of 7 or 8 small single denticles (textfig. 57—58).

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[1] I cannot agree with Pelseneer that this pair of tentacles should be considered homologous to the buccal cones of *Clione.* Nor have I been able to find more than one pair of posterior tentacles.

Fig. 57. Buccal organs of *Fowlerina hjortii:* jaw; hook-sacs.

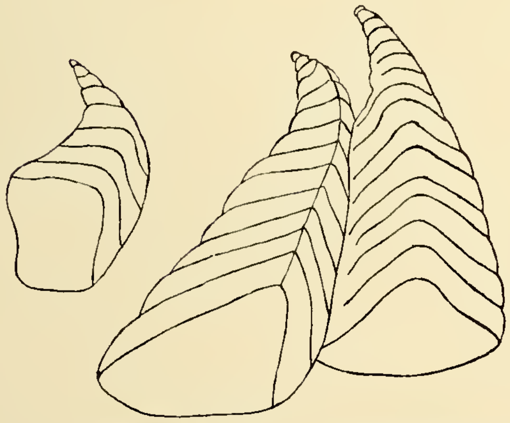

Fig. 58. Spines of the jaw of *Fowlerina hjortii.*

Hook-sacs with 13 og 14 short strong hooks.

Foot: Lateral lobes large, fixed anteriorly and laterally; posterior lobe short, pointed.

Wings truncated with a narrow base.

Posterior gill consisting of a membranous ring near the posterior end of the body. In front of this ring the skin is longitudinally folded so as to give the body a quadrangular cross-section.

Skin transparent, unpigmented.

Size: 5—9 mm. in length.

Localities: St. 10: 45° 26′ N, 9° 20′ W. Surface. Date $^{19}/_{4}$—$^{21}/_{4}$ 1910. 1 individual.
St. 92: 48° 29′ N, 13° 55′ W. Depths: 50, 150, 1000 m. Date $^{23}/_{7}$—$^{24}/_{7}$ 1910. 5 individuals.

Microdonta nov. gen.

Pl. IX.

Radula with small and numerous teeth. Median tooth sickle-shaped without denticles. (Textfig. 52). Lateral teeth hook-shaped.

Jaw: A median row of spines continued on each side by a series of small single denticles.

Hook-sacs shallow, with short, not very strong hooks. A group of large clear cells on the dorsal side of each hook-sac forms a cushion-like protrusion.

Proboscis well developed, long and narrow, mouth opening towards the dorsal side (fig. 69, 71).

Posterior gill may be present.

Foot without a median tubercle.

Microdonta longicollis n. sp.

Pl. IX, fig. 69—78.

In the external appearance this species stands midway between *Notobranchaea* and *Fowlerina.* It has the spindle-shaped body and the narrow neck of the former, while the head and proboscis remind one of the latter, although they are relatively smaller than in that form.

The radula with its small and numerous teeth is in this genus of a rather aberrant type, but still the median tooth has kept the sickle-shape with the concave free margin, characteristic of the whole family of Notobranchaeidae.

Radula tongue-shaped wlth a longitudinal groove along the median line. Formula 10—1—10. (Fig. 74, 78).

Jaw: Median row of 8 or 9 double-pointed spines (fig. 75—77), on each side 5 single denticles.

Hook-sacs shallow, with about 17 hooks (fig. 72—74). The group of clear cells, present also in *Notobranchaea* and *Fowlerina,* forms in this species a large and very conspicuous cushion dorsal to each hook-sac (fig. 74). The meaning or these organs is not at all clear, and I hope in a later paper to discuss their structure and relations.

Foot: Lateral lobes converging anteriorly; posterior lobe narrow and pointed (fig. 70—71).

Wings narrow at the base and tapering towards the distal end.

Posterior gill formed by four radiating crests meeting at the pointed posterior end of the body (fig. 69, 70).

Skin smooth, unpigmented.

The largest specimen was 7 mm. in length, the length of the proboscis being equal to two-thirds of the rest of the body.

Locality: St. 58: 37° 37′ N., 29° 25′ W. Date: $^{11}/_{8}$—$^{13}/_{8}$ 1920. Depth: 50 metres.

Summary of Gymnosomata.

As will be seen from the above descriptions the "Michael Sars" collection of gymnosomatous pteropods includes 9 species belonging to three different families. Of these 9 species only two were previously known, while 7 species are new to science, two of them, *Cephalobrachia macrochaeta* and *Microdonta longicollis* being so divergent from the previously described that they must be regarded as the representatives of new genera.

Only two species, *Pneumodermopsis macrochira* and *Clione limacina* were found in sufficient numbers to allow any conclusions to be drawn regarding their geographical distribution throughout the Northern Atlantic.

It is a strange fact, demonstrating the paucity of our knowledge of gymnosomatous pteropods, that in the small collection of this group so many new species should be found, while forms like *Pneumodermopsis ciliata* Gegenbaur, *P. paucidens* Boas and *Pneumoderma violaceum* D'Orbigny, already known from the Northern Atlantic, are not represented.

Christiania, April 1912.

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EXPLANATION OF PLATES.

Thecosomata Pl. I—IV.

(All figures drawn with camera lucida on dissecting microscope.[1]) Enlargement 8 to 16 diameters).

a = anus
acc.gl = accessory glands
a.n = abdominal nerve
bal = balancer
b.m = buccal mass
d.l = dorsal lobe of the foot
f = foot
g = gill
g.d = genital duct
g.gl = genital gland
g.o = genital opening
h = heart
i = intestine
k = kidney

l = liver
oe = oesophagus
p = penis
pb = proboscis
p.g = pedal ganglion
p.gl = pallial gland
r.m = retractor muscle
sh = shell
st = stomach
t = tentacles
u = uterus
u.t = unpaired tooth (stomach)
v.g = visceral ganglion
v.l = ventral lobe of the foot

Plate I.

Fig. 1 a-b. *Peraclis diversa* Mont., shell and operculum (× 8).
„ 2. The same, without shell. *gl.l.* glandular lobe of the mantle margin (× 16).
„ 3. *Procymbulia michaelsarsi*, n. sp. (× 8).
„ 4—5. *Limacina helicoides* Jeffreys. *v.bl.* ventral body-lobe (× 16).
„ 6—7. The same without shell; a small individual in different positions (× 16).
„ 8—9. The same; fullgrown without mantle; male genital organs ripe; in fig. 8 seen from the dorsal, in fig. 9 from the right side (× 8).
„ 10. The same, fullgrown with young in uterus (× 8).
„ 11. One of the young from the uterus of the preceding individual (× 8).

Plate II.

Fig. 12. *Clio falcata* Pfeffer, without shell, dorsal view (× 8).
„ 13. The same individual, ventral view (× 8).
„ 14—15. *Diacria trispinosa* Les., young, (14) dorsal and (15) ventral view (× 16).
„ 16—17. *Clio falcata*, the same individual as in fig. 12, without the mantle; (16) dorsal and (17) ventral view (× 16).
„ 18. Head and foot of another individual (× 8).
Fig. 19. The same individual as in fig. 12—13, 16—17, after dissection (× 16).
„ 20. Mantle margin of the same individual with the gill (× 16).

Plate III.

Fig. 21. *Clio cuspidata* Bosc., without shell, ventral view (× 8).
„ 22—23. *Clio pyramidata* Lin., (22) ventral and (23) dorsal view. *m* mantle-margin of the right side (× 8).
„ 24. *Limacina helicoides* Jeffr., mantle margin with gill and balancer.
„ 25. *Clio falcata* Pieff., mantle-margin with the gill.
„ 26. *Clio cuspidata* Bosc., mantle margin with the gill.
„ 27. *Clio pyramidata* Lin., mantle-margin with the gill.

Plate IV.

Fig. 28. *Diacria trispinosa* Les., young *(Cavolinia compressa)* (× 8).
„ 29—32 and 34. The same. Individuals showing the gradual increase of the soft body and of the pigmentation of the shell (× 8).
„ 33. Soft parts of the stage shown in fig. 31 (× 16).

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[1]) Fig. 24—27 on compound microscope.

Gymnosomata Pl. V—IX.

ac.ap = acetabuliferous appendage
an = anus
b.c = buccal cones
f = foot
g.d = genital duct
g.gl = genital gland
gl.l = glandular lip
h.s = hook-sac
j = jaw
l.g = lateral gill
l.l = lateral lobe (foot)
m = mouth
m.t = median tubercle (foot)
pb = proboscis
pen = penis
p.g = posterior gill
p.l = posterior lobe (foot)
r = radula
r.c = radula cone
r.s = radula-sac
t = tentacles
w = wings

Plate V.

Fig. 35—36. *Pneumodermopsis macrochira* Pelseneer, in ventral and dorsal view. *l.s* large sucker; pr. protuberances. (× 16).
„ 37—38. The same; contracted individuals (× 8).
„ 39. The same; lateral arm of the acetabuliferous appendage.
„ 40. The same; median part of the acetabuliferous appendage. *, ** differently shaped suckers.
„ 41. The same; jaw.
„ 42. The same; sucker of the lateral acetabuliferous arm.
„ 43—44. The same; sucker of the median part of the acetabuliferous appendage, (43) from below and (44) from above.

Plate VI.

Fig. 45—46. *Pneumodermopsis michaelsarsi* n. sp., (45) from dorsal and (46) from the right side (× 16).
„ 47. The same; buccal organs.
„ 48. The same; part of the acetabuliferous appendage.
„ 49—50. *Pneumoderma atlantica* n. sp., (49) ventral and (50) dorsal view. *sph* sphere surrounding the genital organ (× 16).
„ 51. The same; hook-sac evaginated.
„ 52. The same; jaw.

Plate VII.

Fig. 53—54. *Cephalobrachia macrochaeta* n. gen. and sp., (53) dorsal and (54) ventral view (× 16).
„ 55. The same individual seen from the anterior end (× 16).
„ 56. The same; contracted individual. *gr* groove of the foot-lobe (× 8).
„ 57. The individual of fig. 53—55. Radula and glandular lip.
„ 58. The same; part of the radula.

Plate VIII.

Fig. 59—60. *Clione limacina* Phipps, ventral and dorsal views (× 8).
„ 61—62. *Notobranchaea tetrabranchiata* n. sp., dorsal and ventral views (× 8).
„ 63. *Fowlerina hjortii* n. sp., dorsal view (× 16).
„ 64—65. The same; contracted individual, dorsal and ventral views (× 8).
„ 66. The same; neck and head-region seen from the right side, proboscis half contracted (× 16).
„ 67—68. The same; head seen from (67) dorsal and (68) ventral side (× 16).
„ 69. The same; posterior gill, *a* seen from the side and *b* from the posterior end (× 16).
„ 70. The same; anterior end of a partly contracted individual, ventral side below (× 16).

Plate IX.

Fig. 71—72. *Microdonta longicollis* n. gen. and sp., dorsal and ventral views (× 8).
„ 73. The same; anterior end of an individual with evaginated proboscis (× 16).
„ 74—75. The same; hook-sacs with their groups of clear cells, *c. c.*
„ 76. The same individual as in fig. 73; anterior end of the proboscis.
„ 77—78. The same; spines of the jaw.
„ 79. The same; median part and left side of the jaw.
„ 80. The same; radula.

PLATES.

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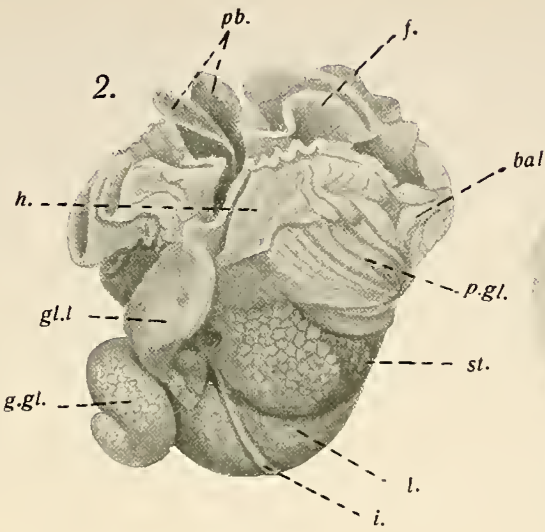

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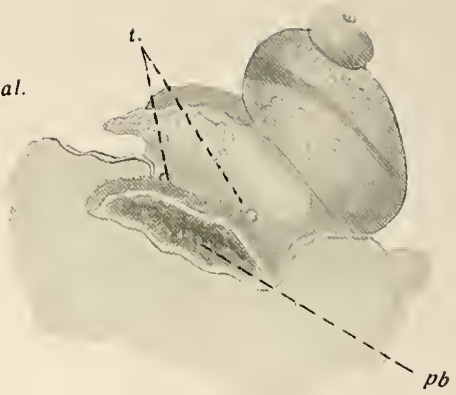

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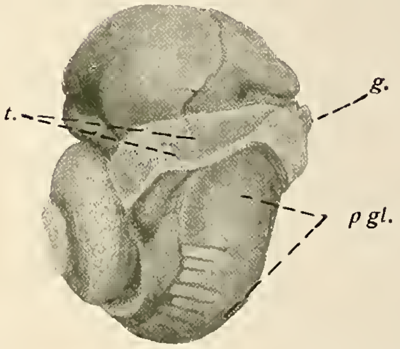

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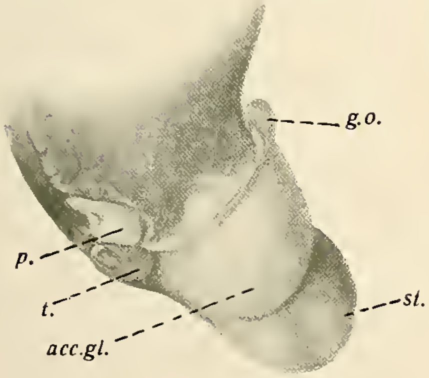

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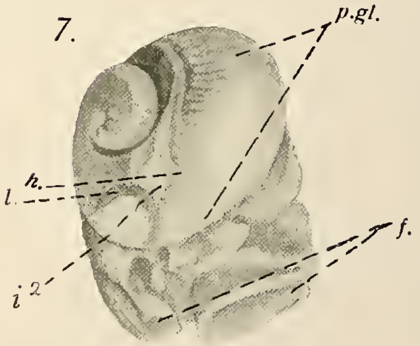

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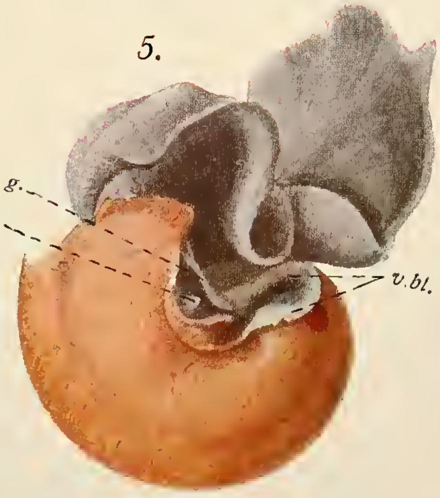

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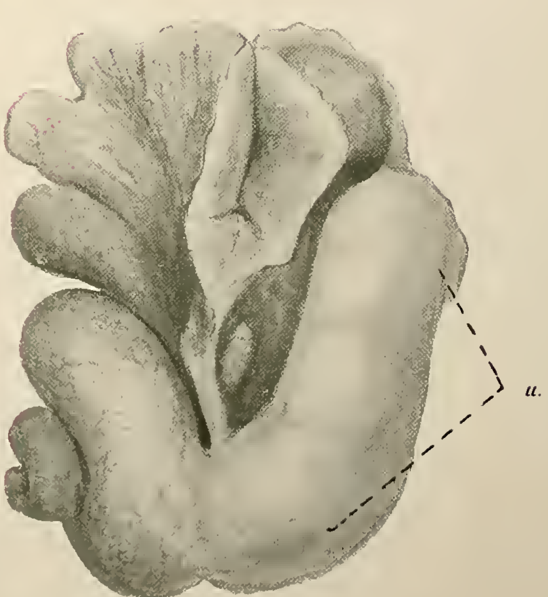

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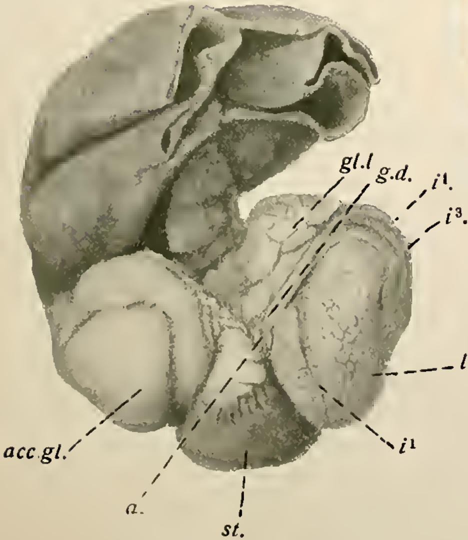

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Rasmussen del.

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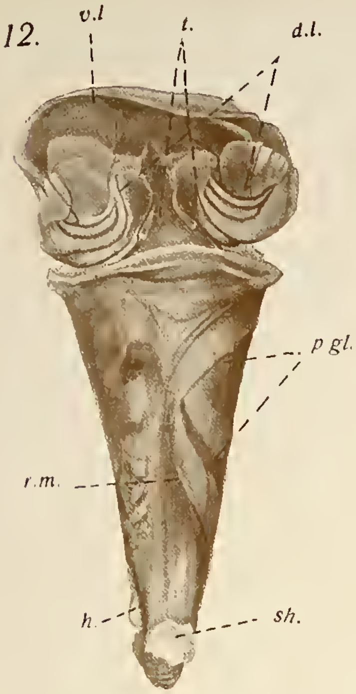

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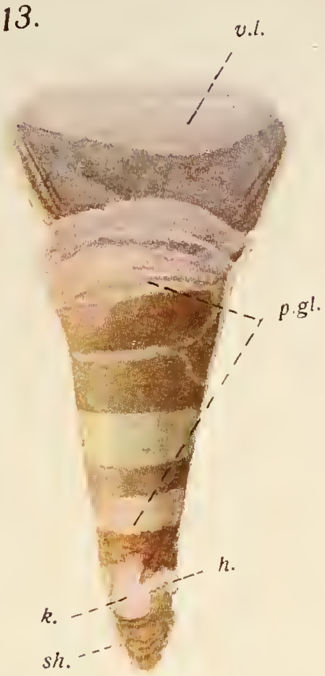

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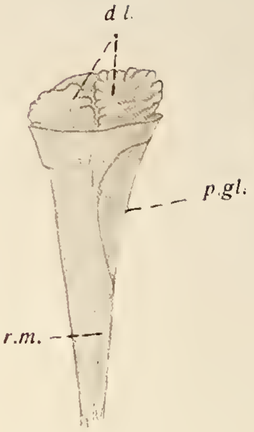

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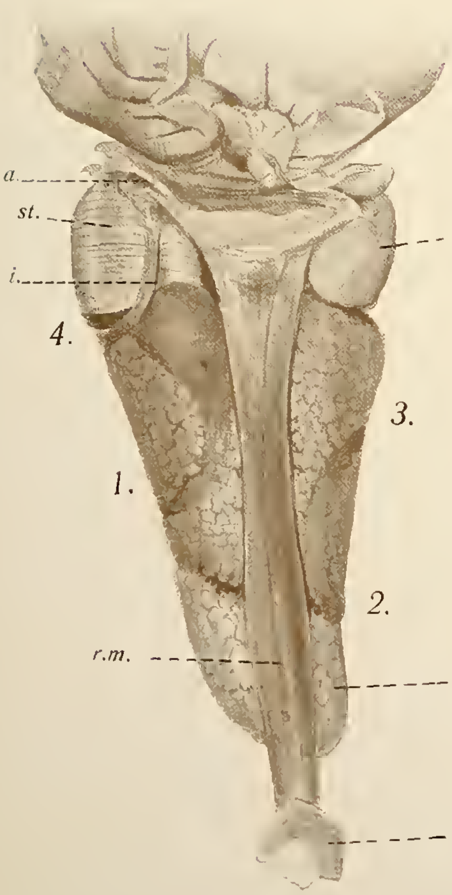

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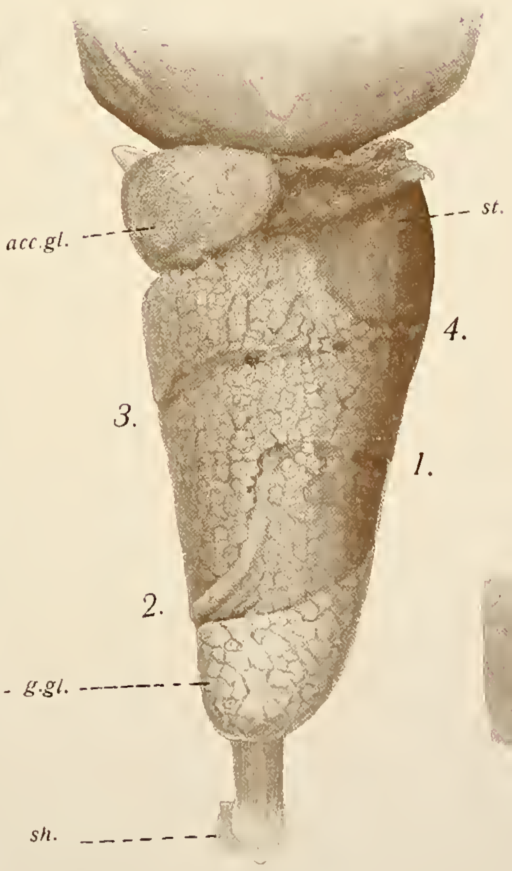

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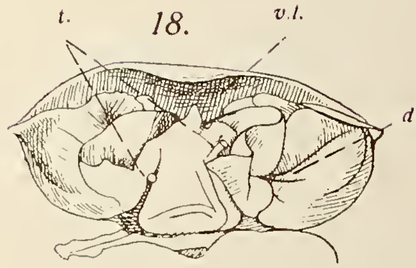

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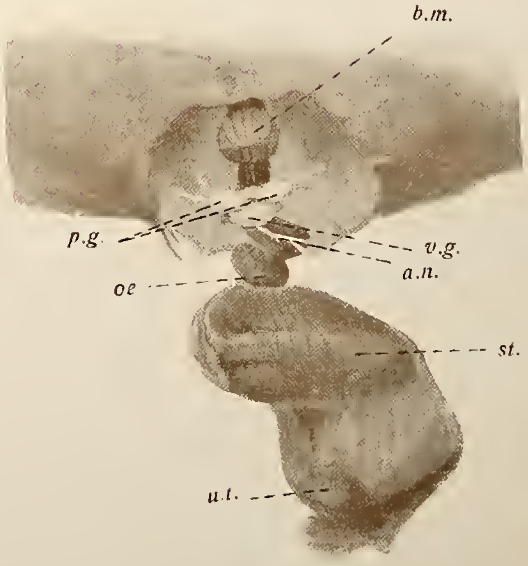

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Fig. 12—13, 16—20 Rasmussen del. — Fig. 14—15 Bonnevie del.

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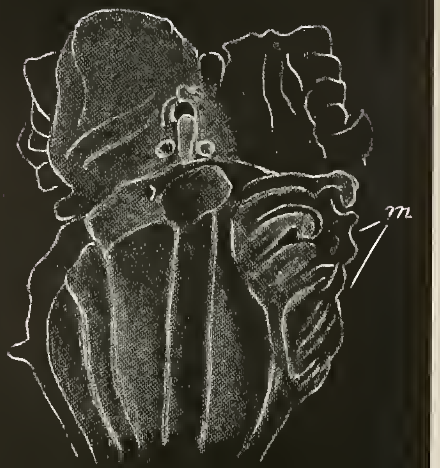

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Larsen del.

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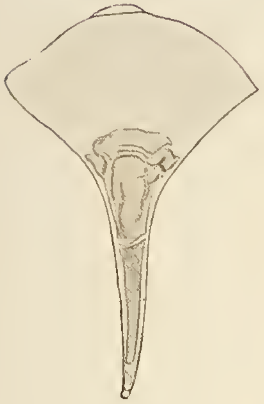

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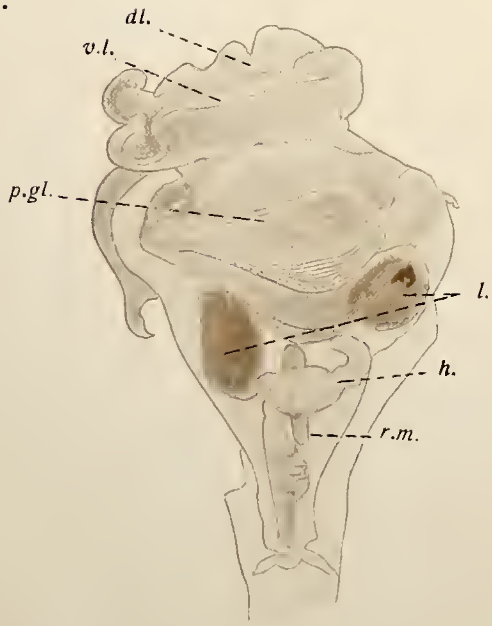

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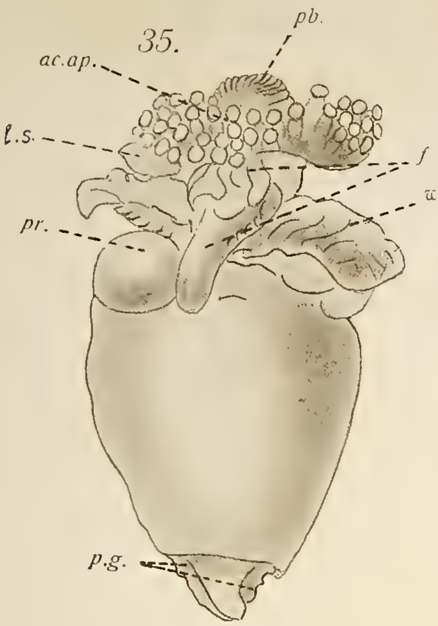

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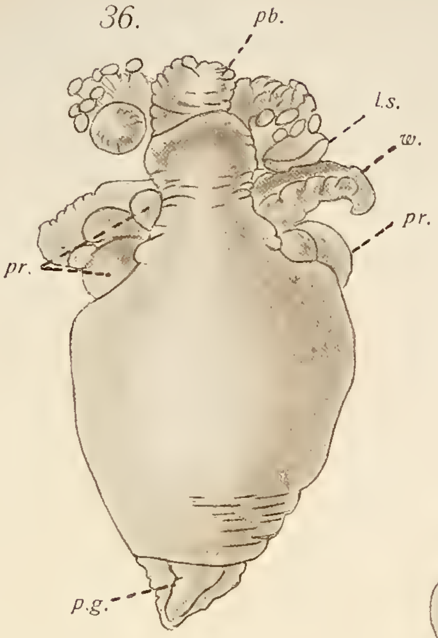

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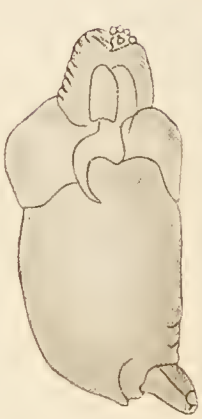

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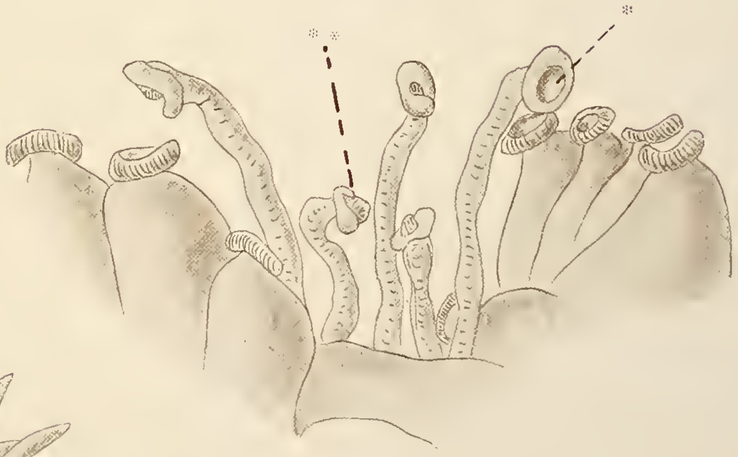

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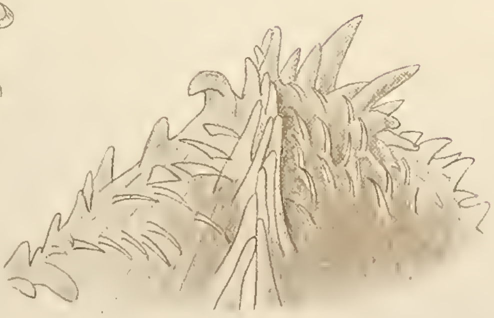

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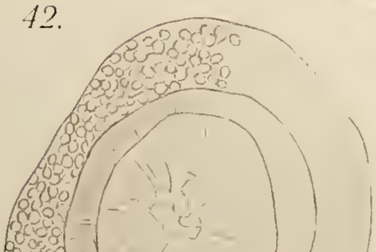

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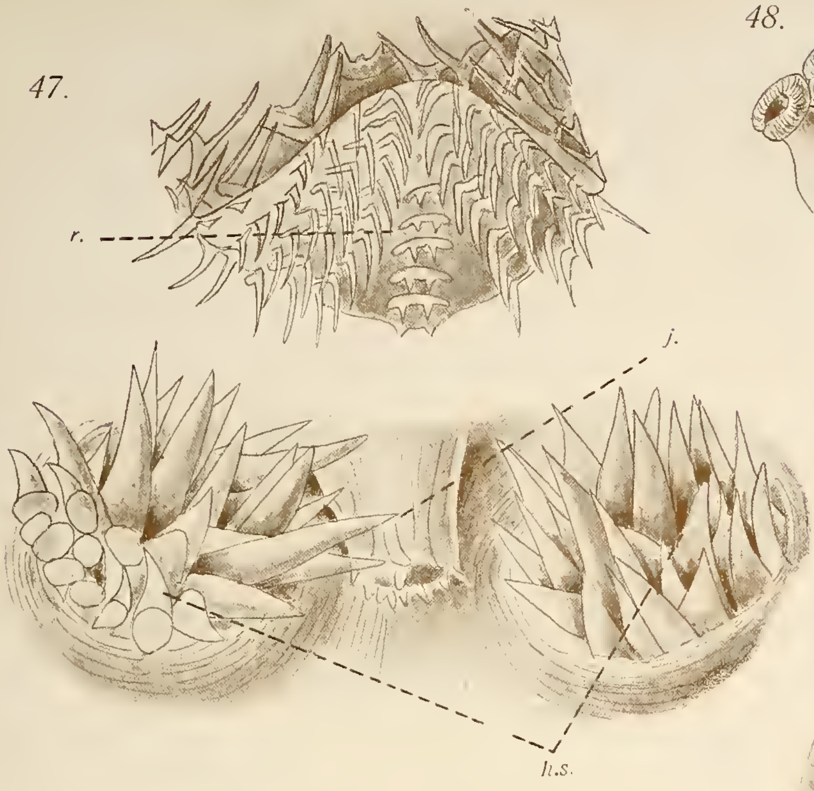

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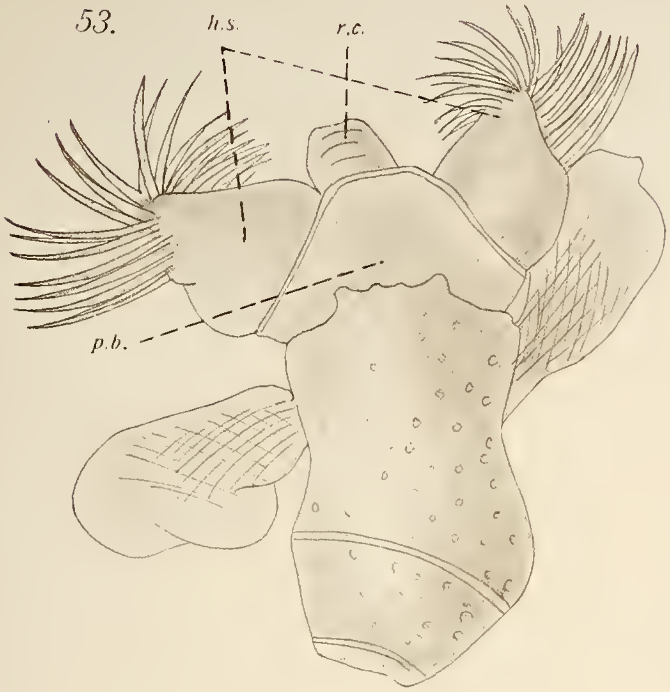

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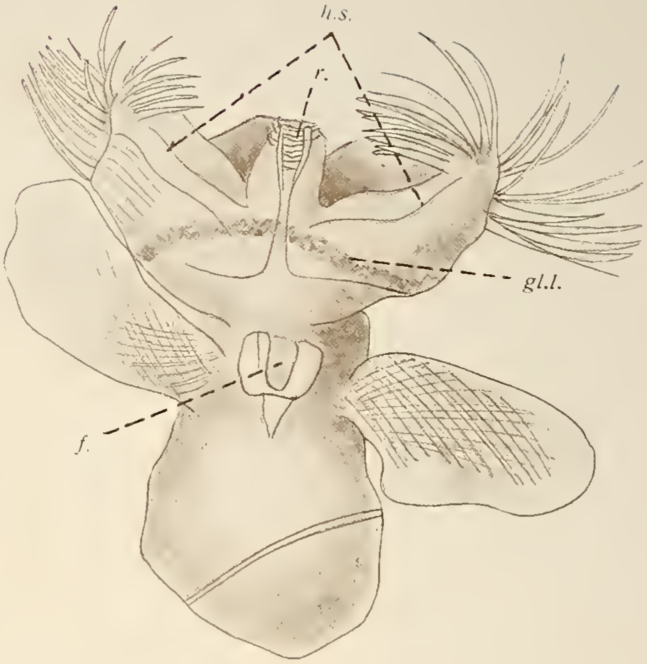

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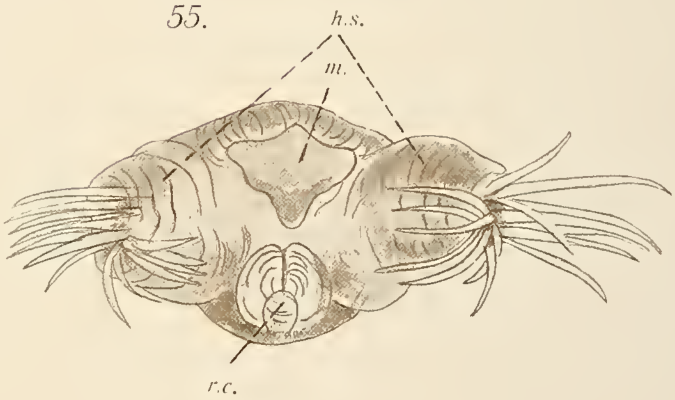

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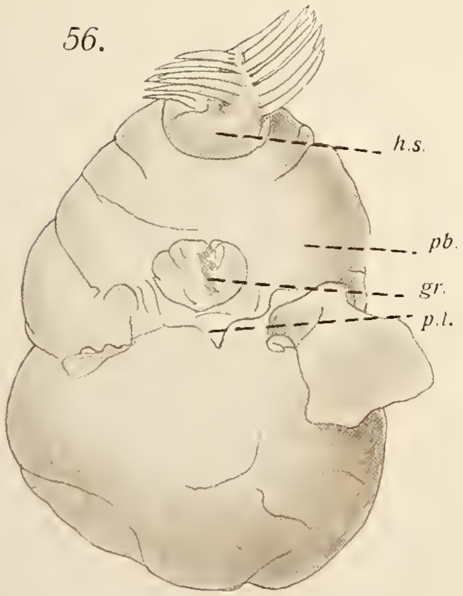

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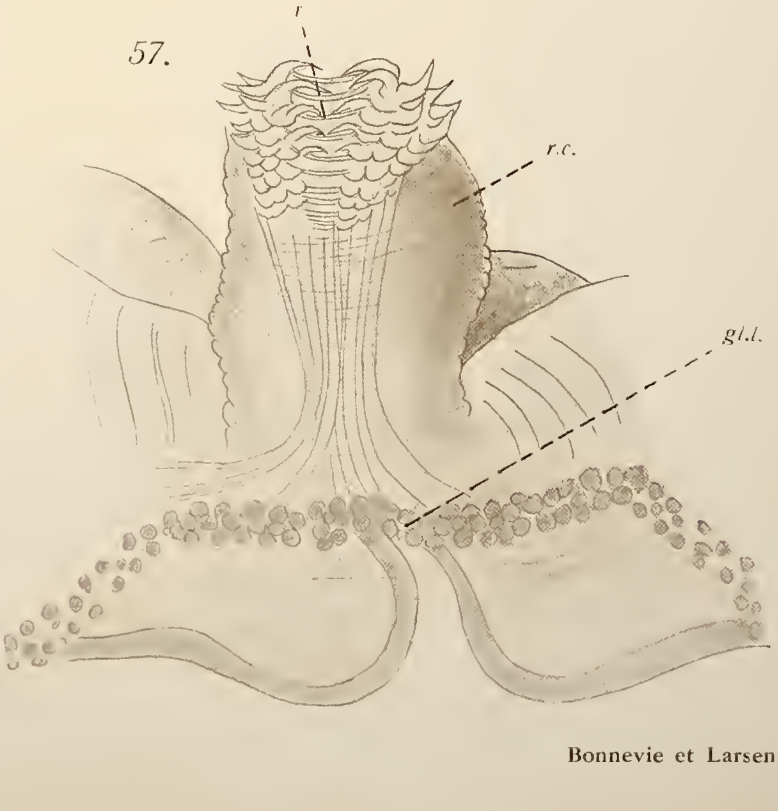

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Bonnevie et Larsen del.

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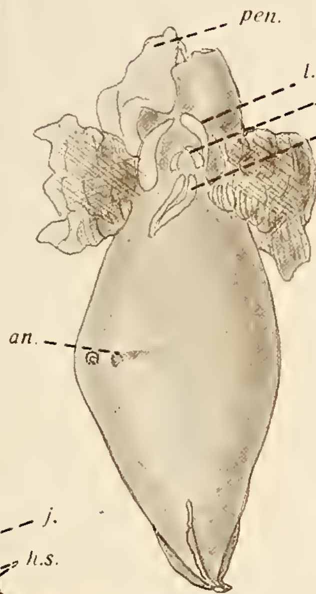

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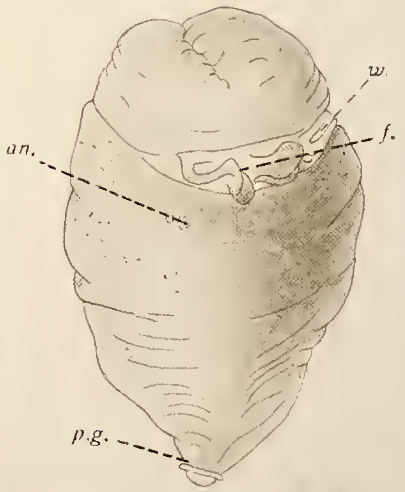

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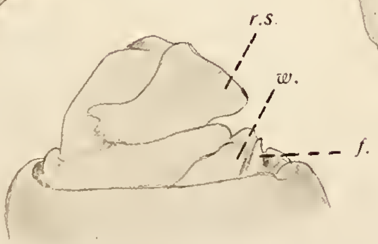

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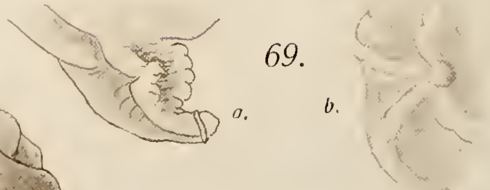

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Bonnevie et Larsen del.

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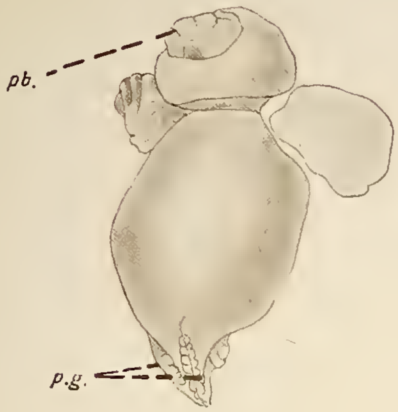

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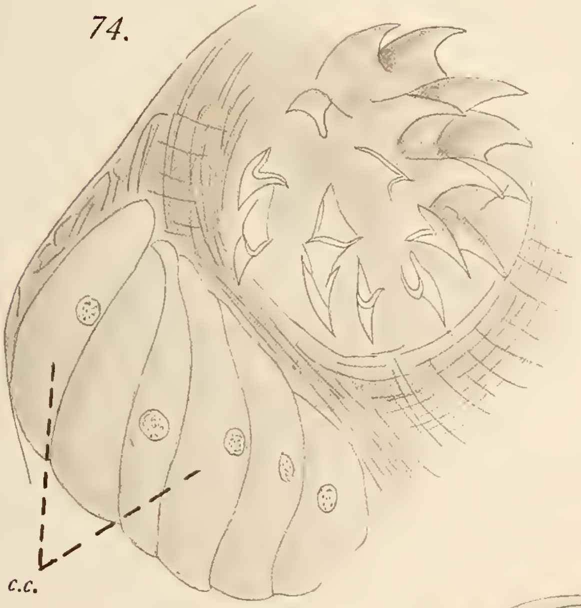

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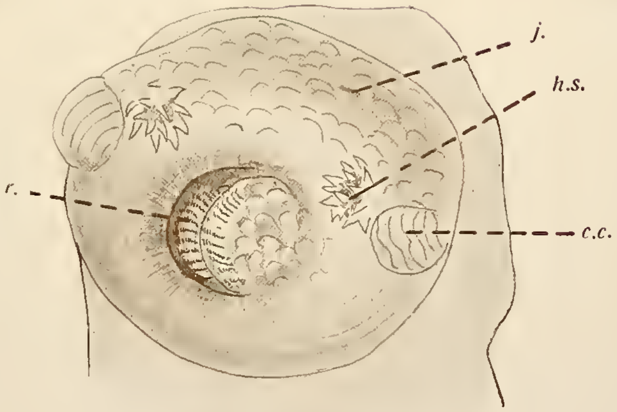

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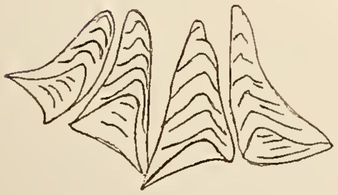

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SCYPHOMEDUSAE

FROM THE

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

BY

DR. HJALMAR BROCH

WITH 1 PLATE AND 12 FIGURES IN THE TEXT

Introductory notes.

From the cruise of 1910 the "Michael Sars" brought home an enormous amount of material of Medusae and Siphonophores, which have been handed to me for examination. In this first part of my report I give the results as regards the Scyphomedusae.

By the systematic use of the same gear in a large series of hauls at different stations, immense numbers of specimens were gathered, which not only afford a good basis for an analysis of systematic details, but also throw light on biological questions, hitherto discussed mostly from a theoretical point of view. Thus the material demonstrates that the intensity of pigmentation corresponds with the bathymetrical distribution of some of the species, also enabling us to determine both the bathymetrical range and the maximum development of little known deep-sea Medusae.

The number of species collected is not large, very few coastal forms having been taken during the cruise. The material includes the following 10 species, two of which seem to be new to science, both typical deep-sea Medusae:

Periphylla hyacinthina Steenstrup.
„ *regina* Haeckel.
Nausithoë atlantica, n. sp.
„ *globifera*, n. sp.
Atolla Wyvillei Haeckel.
„ *Bairdi* Fewkes.
Pelagia perla Slabber.
Chrysaora mediterranea Péron and Lesueur.
Poralia rufescens Vanhöffen (?).
Aurelia solida Browne.

The locality is new for *Atolla Wyvillei*, which had not previously been found in the Atlantic area, northwards of the subantarctic region, and the northern limit of *Periphylla regina* is extended far to the north of previous records. One species *(Periphylla regina)* is new for the Mediterranean, and the occurrence of the genus *Poralia* in the Atlantic is of great zoögeographical interest.

Investigations of the plankton and its biology have taught us to distinguish between holoplanktonic organisms (Holoplankton), confined to oceanic waters during their whole lifetime, and meroplanktonic organisms (Meroplankton) confined to coastal waters. This terminology was first employed by HAECKEL, and is now generally adopted. FOWLER has introduced a new word epiplankton instead of meroplankton, but this word is both superfluous and misleading. Unfortunately some of the younger specialists in single plankton groups use FOWLER'S term, and RITTER-ZAHONY for example has thereby brought confusion into the terminology of the Plankton-Expedition[1]) and the Fauna arctica[2]); he gives us the rather surprising news that many chaetognaths are "epiplanktonic". This word is meant to designate organisms fixed on planktonic plants or animals, and in this sense it is found in every elementary treatise on plankton[3]).

It is especially among the Hydromedusae that we find many well-known examples of neritic organisms, i. e. meroplanktonic organisms which pass through a fixed bottom-stage, while a great many Scyphomedusae are also neritic.

Of the ten species collected by the "Michael Sars" the majority are holoplanktonic, and only *Pelagia perla* is an inhabitant of the photic zone. Seven of them, viz. *Periphylla hyacinthina, P. regina, Nausithoë atlantica, N. globifera, Atolla Wyvillei, A. Bairdi*, and *Poralia sp.*, are true deep-sea Medusae, although one of these *(Periphylla hyacinthina)* also occurs sometimes in depth less than 300 metres.

All these forms are of a purple brownish-black colour, apparently on the whole the typical colour of most deep-sea Medusae. The pigmentation is mostly confined to the gastro-genital system, and varies in intensity according to the bathymetrical habitat of the individual. *Pelagia* in its varying and rather vivid colouring is like the neritic species *Chrysaora mediterranea* and *Aurelia solida*, the surface Medusae showing a far greater limpidity than most deep-sea species.

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[1]) Die Chätognathen, Wiss. Ergebn. d. Planktonexpedition. Kiel 1911.
[2]) Die Chätognathen, Fauna arctica, Bd. V. Jena 1910.
[3]) See for instance STEUER'S Planktonkunde.

The important works of the last fifteen years, mostly based on collections from great marine expeditions, have caused a revision of the classification of the Medusae, but many systematic questions still remain unsettled. The important works of VANHÖFFEN, MAAS, HARTLAUB, BROWNE and BIGELOW[1]) have added so much to our knowledge of the anatomy, ontogeny and classification of the oceanic Medusae that in regard to these points little new could be expected from the "Michael Sars" material, but as the biology of the deep-sea Medusae is still to a great extent enveloped in darkness, as evidenced by recent discussions, this material is likely to fill up many gaps in our knowledge of the life history of the oceanic Medusae.

We have long known that surface and deep-sea organisms form two large and distinctive groups of colour. The vivid colours of surface Medusae contrast with the uniform purplish brown or black of deep-sea Medusae. The intensity of colouring is subject to individual variation. Probably HJORT[2]) was the first to call attention to the fact that among the fishes differently coloured individuals are distributed according to certain rules within the different layers of water, and it was interesting to see whether the Medusae conform to the same rules. This has proved to be the case in regard to the Scyphomedusae. Among the deep-sea Medusae the variation is distinctly correlated to the bathymetrical occurrence, as shown by the large collections of *Periphylla hyacinthina* and *Atolla Bairdi.* The more hyaline the individuals the shallower they occur, and on the contrary, the denser the pigmentation, the deeper do the specimens generally occur. On this connexion it is noteworthy that the colouring of the smaller individuals is generally less dense than that of the larger ones, and hardly any but small specimens are found near the upper limit of the habitat of the deep-sea Scyphomedusae.

CORONATA.

Periphylla Steenstrup.

Periphylla hyacinthina Steenstrup.

BIGELOW[3]) has given a review of the present state of our knowledge as to the specific differences between *P. hyacinthina* Steenstrup, and *P. dodecabostrycha* Brandt. He points out that recent authors do not agree as regards the limits of these species, so that one might call *dodecabostrycha* what another considers *hyacinthina.* He says the only way to throw light on this question is to examine a large number of fresh specimens.—The "Michael Sars" brought home no less than 128 specimens of *Periphylla* from the Atlantic belonging to these two species, and this material furnishes a good basis for a discussion of the characters of the species.

First of all, I wish to call attention to the colour as a specific character. MAAS[4]) in his paper on the Medusae from the cruises of the Prince of Monaco, states like VANHÖFFEN[5]) that the pigmentation of *P. hyacinthina* is denser than that of *P. dodecabostrycha,* giving the lappets of the former a deeper colour than those of the latter. BIGELOW rightly points out that this character is of doubtful value saying: "The extent of the pigmentation does not seem much more valuable as a specific criterion, for not only does this character vary among Medusae in general, but there is also evidence that in Periphylla, the amount of pigmentation increases with growth". I cannot but agree in this view. In the material before me I have tried to separate *P. hyacinthina* from *P. dodecabostrycha* by the aid of their colours, and I have come to the conclusion that 36 specimens must be referred to *P. hyacinthina* and 34 to *P. dodecabostrycha* while all the rest (no less than 58 specimens) could not with certainty be referred to either of the two being intermediate between them, some approaching the one, some the other, but never corresponding fully with either. The accompanying figures show that the different stages of colours form a uniform and regular gradation, and we must therefore endorse BIGELOW's opinion that a separation of the two species cannot be based on their pigmentation.

VANHÖFFEN (l. c.) has drawn attention to another character which besides the pigmentation, will enable us to distinguish the species, viz. whether the bell is high or low. It might perhaps have been sufficient to refer to the figures in BIGELOW's memoir cited above, but I prefer to quote them in full: "We then[6]) find the proportions[7]) of *Periphylla hyacinthina* to be 1·9 : 1, 1·7 : 1, 1·5 : 1, and of *Periphylla dodecabostrycha* 1·55 : 1, 1·5 : 1, 1·2 : 1." There is according to BIGELOW a typical continuity in these figures. It is possible, however, that two

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[1]) MAYER's work "Medusae of the World" was unfortunately inaccessible to me.

[2]) "Michael Sars" Atlanterhavsekspedition 1910 (Naturen), Bergen 1911, p. 95.

[3]) The Médusae. (Mem. Mus. Comp. Zool. Vol. XXXVII), Cambridge 1909, p. 26.

[4]) Méduses provenant des campagnes des yachts Hirondelle et Princesse Alice (Res. Campagne Scientif. Albert I), Monaco 1904, p. 46.

[5]) Deutsche Tiefsee-Expedition, Bd. III, p. 23.

[6]) By reducing VANHÖFFEN's figures to a common standard.

[7]) Of the bell; the figures indicate height: diameter of the entire Medusa (without tentacles).

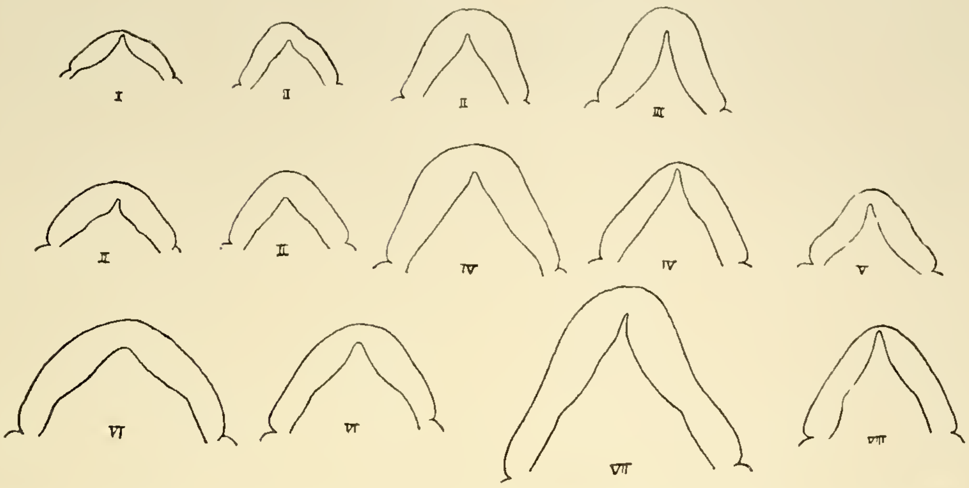

Fig. 1. Projections of natural top-angles in specimens of *Peryphylla hyacinthina* brought home by the "Michael Sars" from the Atlantic. The upper row includes only *dodecabostrycha*-individuals, the lower row only typical, darkly coloured *hyacinthina*-individuals, and the intermediate row only individuals which according to their pigmentation must be placed between *dodecabostrycha* and *hyacinthina*. (I: Stat. 51, II: Stat. 80, III: Stat. 58, IV: Stat. 98, V: Stat. 82, VI: Stat. 19, VII: Stat. 56 and VIII: Stat. 101). Natural size.

distinct groups might come to view if a large number of individuals were measured. Fig. 1 giving camera-lucida drawings of the topangles of a series of specimens, conveys some idea of the variations in the proportions of the upper part of the bell, from the furrow to the summit of the umbrella. It is evident that there are no characteristic differences between the low bells of what VANHÖFFEN would call *P. dodecabostrycha* and the high bells of *P. hyacinthina.* The biometrical measurements show that the variations are quite regular.

Lastly the geographical distribution of the "Michael Sars" specimens (see the table) shows no trace of different areas of distribution for the two species.

As a result of our observations we must confirm the opinion expressed by MAYER[1]) and BIGELOW that *P. dodecabostrycha* cannot be specifically distinguished from *P. hyacinthina,* but is merely a synonym. Besides we find no reason for a separation of the two former "species" as biophysically determined variant groups as "forms".

In addition we may refer to some important results obtained by the "Michael Sars", on the 22nd of May 1911 in the Sognefjord. A haul of six hours duration, with the usual arrangement of the apparatus gave the abundant material noted in the table on p. 7. Many of the small individuals must be referred to the group which I have termed intermediate and some to the typical *dodecabostrycha*-group, although this species has not hitherto been recorded from Norwegian waters. All the specimens, however, really belong to *P. hyacinthina* representing all stages of development from those 7 or 8 mm in diameter upwards. Although, as stated by BIGELOW, the general rule is that "in Periphylla the amount of pigmentation increases with growth", there are exceptions.—Thus a few very small darkly pigmented examples of *Periphylla* were

Station	dodecabostrycha	intermediate	hyacinthina typ.
10	2	—	—
19	—	—	8
34	—	—	1
42	—	1	1
45	—	—	1
51	6	—	1
52	—	—	1
53	4	—	1
56	2	—	1
58	1	—	—
62	—	—	4
64	2	—	1
66	—	5	—
67	1	2	—
70	—	1	1
80	4	16	6
81	10	12	3
82	—	3	6
84	—	3	—
88	—	1	—
92	2	—	—
94	—	—	1
98	—	12	—
101	—	2	3

Table showing the occurrence of *P. dodecabostrycha, P. hyacinthina* and the intermediate stages at the stations of the "Michael Sars" during the cruise of 1910.

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[1]) Medusae of the Hawaiian Islands (BULL. U. S. Fish Comm.), 1903, p. 1137.

taken at Stats. 53, 62 and 82, the diameter above the furrow being respectively 11, 12, and 12 mm, but such exceptions are rare.

Depth (meters)	Stages of pigmentation			Total
	dodeca-bostrycha	inter-mediate	hyacin-thina typ.	
0	—	—	—	0
50	5	1	—	6
100	9	—	—	9
150—250	5	1	2	8
500—600	8	23	6	37
700—800	5	13	3	21
1000—1100	2	11	5	18
1250	—	4	7	11
1500	2	—	10	12
Total	36	53	33	122

Fig. 2. Table showing the bathymetrical distribution of the three stages in pigmentation represented in the specimens obtained by the "Michael Sars" in the North Atlantic. The figures denote number of individuals.

That the pigmentation, however, is correlated with the bathymetrical occurrence of the specimens is clearly shown by the accompanying table of vertical distribution. The stages of pigmentation are placed in three groups, viz. the slightly pigmented *dodecabostrycha*-group, the intermediate group, and the densely pigmented *hyacinthina*-group, and the rule is easily deduced that the darker the specimens, the deeper they generally occur.

The species has a bathymetrical range from a little above 50 metres to about 1500 metres with a somewhat prominent maximum about 500 metres. The faintly pigmented *dodecabostrycha*-individuals prefer the shallower waters down to 500 metres, the dark-coloured, typical *hyacinthina*-individuals predominate below 1000 meters, while the intermediate group is found mostly in the intermediate waters.

Similarly we can generally trace an increase of size towards the deep water, as might be expected from the distribution of the different groups. In the accompanying table the diameter of the bell just above the furrow where the central disc attains its maximum diameter, is indicated, and the figures denote the number of specimens of equal dimensions at the different depths. Not only do we see an increase in size towards the deeper water, but also an increase in number, and it seems as if the largest individuals occurred just below, where the greatest number of individuals were caught, but on this point we must acknowledge that the material is too scanty to allow us to draw final conclusions. The smaller stages seem to be missing in the deepest layers. How is this to be explained in a species which is commonly supposed to pass through a fixed bottom-stage?

It is interesting to note that, in the "Michael Sars" material, the apical projection of the stomach into the mesogloea is mostly confined to larger specimens; in the very smallest specimens there is no trace of a "Stielkanal".

Finally we may consider the geographical distribution of *Periphylla hyacinthina* (see fig. 4). The species is widely distributed, having been taken in all oceans where nets have been hauled in deep water. It has previously been recorded from the Bay of Biscay, from the neighbourhood of the Cape-Verde islands, from the Canaries, from the continental edge east of the United States, from Davis Strait, from south of Greenland, from many localities on the western coast of Norway, and also from the Mediterranean. Thus it is not surprising that the "Michael Sars" with its very effective fishing gear caught *Periphylla hyacinthina* at most of the stations in the Atlantic, and at Station 19 a little east of Gibraltar in the Mediterranean. Further it must be noticed that to the west of the Mid-Atlantic ridge the specimens were found in greater numbers and at stations rather close together, whereas only a few scattered specimens were caught between the Azores and

Depth (metres)	Diameter of disc, above the furrow (millimetres)																Total
	3-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-56	56-60	61-65	66-70	71-75	76-80	
50	1	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	6
100	—	5	3	1	—	—	—	—	—	—	—	—	—	—	—	—	9
150—250	—	2	3	2	1	—	—	—	—	—	—	—	—	—	—	—	8
500—600	4	18	8	4	—	1	—	1	—	—	—	—	—	—	—	—	36
700—800	1	5	7	4	—	1	1	—	—	—	—	—	—	—	—	—	19
1000—1100	2	6	2	2	3	1	1	—	—	—	—	—	—	—	—	1	18
1250	1	3	1	1	1	—	—	—	—	—	—	—	—	—	—	—	7
1500	—	—	4	3	3	1	1	—	—	—	—	—	—	—	—	—	12
Total	9	42	30	17	8	4	3	1	—	—	—	—	—	—	—	1	115

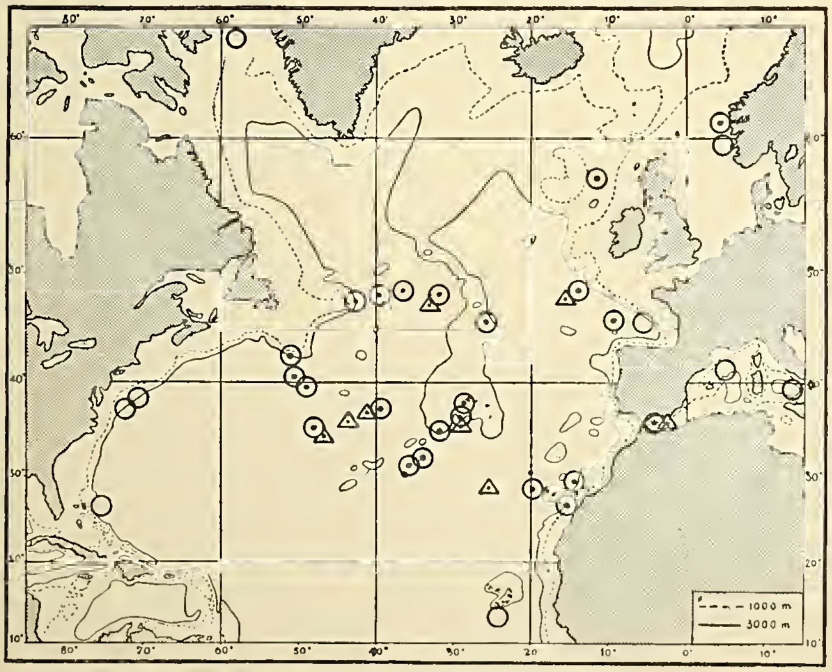
Fig. 3. Table showing the bathymetrical distribution and size of *Periphylla hyacinthina*. The figures denote number of individuals.

the Canaries, and between the Mid-Atlantic ridge and the continental slope to the south of Ireland. It is at present rather difficult to give a satisfactory explanation of this peculiar distribution of *Periphylla hyacinthina*.

The investigations of the "Michael Sars" in the Sognefjord have given us some interesting data as to the occurrence of *Periphylla hyacinthina*, which remind one of what in a previous paper[1]) I called "secondary centres". On the 22nd of May 1911 a haul of six hours duration in the outer parts of the Sognefjord gave the following results:—

Depth in metres	Gear	Number of specimens	Remarks
75	Net 1 meter in diameter	56	40 large specimens, 10—15 cm in diameter 60 small „ 2 - 9 „ - „
150	Youngfishtrawl	90	From 1·5—15 cm in diameter
300	Net 1 meter in diameter	31	From 1—12 cm in diameter
500	Youngfishtrawl	426	15—20 large specimens, about 400 specimens from 1—8 cm in diameter
650	Net 1 meter in diameter	72	2 large specimens 70 small „ 1—5 cm in diameter
750	Net 3 metres in diameter	400	100 large specimens 300 small „

The hauls are of great interest. First of all it is striking how numerous *Periphylla hyacinthina* may sometimes be in the Sognefjord; Dr. JOHAN HJORT pointed out to me that this may in part be due to the submarine barrier at the mouth of the Sognefjord, which of course, interferes with the exchange of water between the fjord and the open ocean thus causing the retention in the fjord of large numbers of Medusae. But this one negative factor cannot produce a "secondary centre", and we must admit our ignorance regarding the positive factors which render such a "pool" a favourable habitat for a certain species. The biophysical factors are in such places evidently combined in such a manner as to enable one species to thrive abundantly, whereas another species cannot exist there at all, although the two species in question may live side by side in the open ocean under apperently identical conditions.



⊙ *Periphylla hyacinthina* "Michael Sars".

○ —„— Previous records.

△ *Periphylla regina*.

Fig. 4. Geographical distribution of *Periphylla hyacinthina* and *P. regina*.

It is of great interest to find out the bathymetrical distribution of the individuals of a plankton species. As for *Periphylla hyacinthina* the catches from the Sognefjord show no differences whatever from those in the Atlantic, the upper limit occurring a little above 50 metres, with a somewhat prominent maximum at a depth of about 500 metres.

Periphylla regina Haeckel.

Only nine specimens can with certainty be referred to this species, besides two doubtful specimens: one from Stat. 49 (500 m) and one from Stat. 81 (1500 m).

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[1]) Die Alcyonaceen des Kolafjordes (Travaux Soc. Impér. Natur. St. Petersbourg, Vol. XLI) 1912, p. 17.

Periphylla regina is distinguished from the preceding species mainly by its rounded bell, which contains the uniformly rounded apex of the stomach. Another criterion is found in the semiglobular pedalia, which contrast sharply with the rather oblong pedalia of *Periphylla hyacinthina*. MAAS[1]) regards the colour as a good specific character; his opinion seems mainly to be based on sketches drawn by ALEXANDER AGASSIZ. VANHÖFFEN[2]) agrees with MAAS in this respect, although, as MAAS[3]) and BIGELOW[4]) point out later, he has not shown the differences in colour clearly in his excellent figures. On this point I cannot agree with previous investigators, for in the "Michael Sars" material (which is excellently preserved and came into my hands in quite a fresh condition, the colours being as vivid as in the living animals) no difference whatever could be observed in the colours of *Periphylla regina* and *Periphylla hyacinthina*. The brownish and bluish velvety black covering the subumbrella had mostly retained its metallic appearance, but it was in fact impossible to find more differences than in VANHÖFFEN's figures. The figure in MAAS's paper, differing interestingly from most other deep-sea Medusae, must have been drawn from a specimen with an unusually variety of colours.

Periphylla regina is only sparingly represented in the material from the "Michael Sars"; the specimens which can be identified with certainty are given in the following table:—

Station	Lat. N	Long W	Depth in metres	Number of specimens	Larger diameter above the furrow
19 (Mediterranean)	36° 5′	4° 42′	900–0	2	10 and 14 mm
49 b	29° 8′	25° 16′	1500	1	40 mm
56	36° 53′	29° 47′	1500	1	34 „
62	36° 52′	39° 55′	1250	1	15·5 „
63	36° 5′	43° 58′	4500–1500	1	55 „
64	34° 44′	47° 52′	1500	1	35 „
84	48° 4′	32° 25′	1250	1	37 „
92	48° 29′	13° 55′	1500	1	43 „

From these data we are compelled to consider *Periphylla regina* as a veritable deep-sea Medusa, which has its optimum far below the reach of daylight, a fact making it probable that the metallic brownish or bluish black colour is the predominating one, being seen also in full-grown specimens of *Atolla*, *Crossota* and other inhabitants of great oceanic depths. The information is too defective to enable us to form an idea as to the upper and lower bathymetrical limits of the species. We can only state that it is one of the deeper living species of the genus, and indeed belongs to the abyssal region of the ocean.

The geographical range of *Periphylla regina* seems to be almost as wide as that of *P. hyacinthina*, but we notice an interesting difference. *P. hyacinthina* has been found in all the great oceans and in the antarctic seas, where it is was taken by the "Southern Cross" and the "Discovery",[5]) its northernmost locality being far up in Baffin's Bay. *P. regina*, on the other hand, has only been found in the tropical and subtropical parts of the ocean, and once[6]) in the subantarctic region. It has not been taken north of Wyville Thomson ridge (compare the map, fig. 5 on p. 7), and thus affords further evidence that this ridge forms a barrier separating the arctic deep-sea region from the Atlantic abyssal region;[7]) that this may not be due to depth alone is shown by the fact that the "Michael Sars" took *Periphylla regina* in the Mediterranean just inside Gibraltar Strait (Stat. 9). Thus in this case the shallower barrier at Gibraltar has not the same limiting power as the deeper Wyville Thomson ridge.

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[1]) Die Medusen (Rep. Explor. West Coasts of Mexico, Central and South America, and off the Galapagos Islands.—Mem. Mus. Comp. Zool., Vol. XXIII) Cambridge U. S. A. 1897, p. 64, pl. X.

[2]) Deutsche Tiefsee-Expedition, p. 23.

[3]) Méduses provenant des campagnes des yachts Hirondelle et Princesse Alice, p. 46.

[4]) The Medusae (Mem. Mus. Comp. Zool., Vol. XXXIII), p, 26.

[5]) BROWNE: Medusae (National Antarctic Expedition. Natural History, Vol. V), London 1810, p. 42.

[6]) HAECKEL: Report of the Deep-Sea Medusae. (Zool. Chall. Exp., Vol. 4). London 1881, p. 85.

[7]) Comp. BROCH: Die Hydroiden der arktischen Meere (Fauna arctica, Bd. V), Jena 1910, p. 230.

Nausithoë Kölliker.

During the cruise of the "Michael Sars" two species of *Nausithoë* were taken, both apparently new to science. They add many interesting facts to our systematic knowledge of the genus. First of all, they confirm the fact first pointed out by Bigelow[1]) that the rhopalia of the typical deep-sea inhabitants of the genus are devoid of an ocellus, which is found, however, in the species of *Nausithoë* inhabiting the surface layers. Bigelow called attention to the absence of an ocellus in *N. rubra* Vanhöffen and ocelli are also missing in *N. atlantica* n. sp. and *N. globifera* n. sp.

The new species are also of great interest because of the position and shape of their gonads; they might both be referred to Haeckel's[2]) genus *Nausicaa.* Maas[3]) has, however, pointed out that *N. picta* Agassiz and Mayer, in the position of its gonads shows every transitory stage between the typical *Nausithoë* and *Nausicaa;* thus Maas in opposition to Vanhöffen[4]) finds that an interradial approximation of the proximal parts of the gonads does take place in the Nausithoidae. In the present case we find two species showing a proximal approach of their gonads, and in one of the species this approach sometimes apparently results in a coalescence.

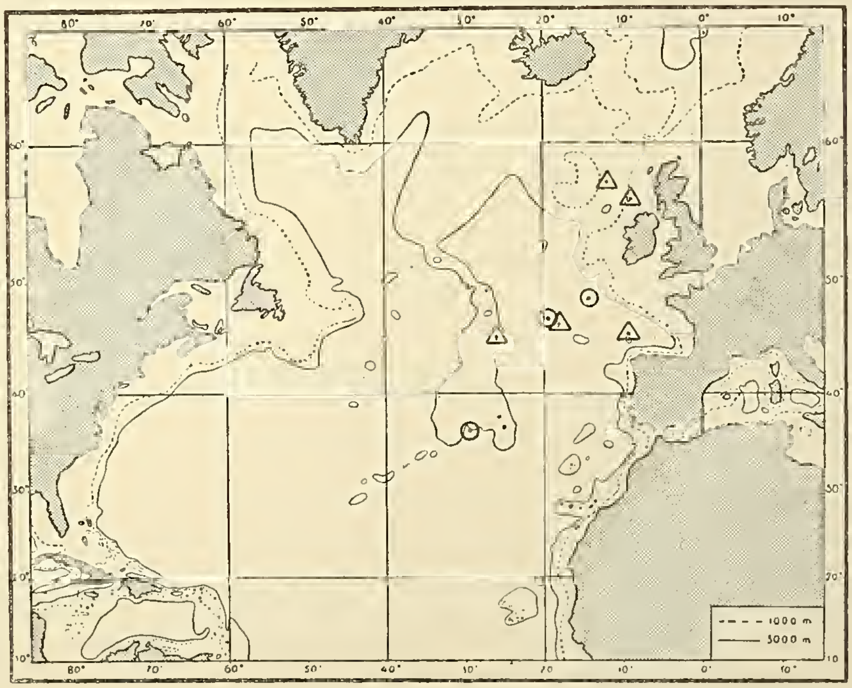
It is rather surprising that no previously known species of *Nausithoë* were taken, and especially *N. punctata* Kölliker, which occurs in several parts of the Atlantic crossed by the "Michael Sars"; the only reasonable explanation seems to be that *N. punctata* is limited to coastal waters, and the "Michael Sars" material includes very few specimens of neritic Medusae.

Nausithoë atlantica n. sp.

Pl., figs. 1—4.

At Stat. 56 two specimens were taken at a depth of 500 metres which bear a strong resemblance to *Nausithoë rubra* Vanhöffen, but prove on closer examination to be specifically distinct. Later six more specimens were taken in the youngfish trawl from a depth of 500 metres. All the specimens being more or less damaged, it is impossible to give full details of the species, but the following description will suffice for the recognition of the characteristic species.

The medusa attains a diameter of at least 28 mm. It is of a dark, yellowish-brown colour, which often becomes almost black. The surface of the umbrella is smooth. The central disc of the umbrella is sometimes rather flat, sometimes rather arched, the arched disc representing probably the natural state, the flat one being found only in damaged specimens. The furrow separating the central disc from the marginal parts, is not very prominent, but we can always trace it, and in the better preserved specimens it is rather distinct. The marginal parts of the medusa on the exumbrellar side are furnished with two rows of pedalia (pl., fig. 1), one row containing the rhopalar, the other the tentacular pedalia. The eight rhopalar pedalia are prominent and almost semi-globular, often a little broader than they are long. The eight tentacular pedalia are of the same breadth as the rhopalar ones, but they are about twice as long and not very distinctly circumscribed. The alternation of the short and rather prominent rhopalar pedalia with the long and not very prominent tentacular ones gives the marginal parts of the medusa a peculiar appearance, unlike any previ-



⊙ *Nausithoë atlantica*
△ —„— *globifera*

Fig. 5.

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[1]) The Medusae (Mem. Mus. Comp. Zool., Vol. XXXIII), p. 36.

[2]) System der Medusen. Jena 1880, p. 485.

[3]) Die Scyphomedusen der Siboga-Expedition (Siboga Expeditie, Monogr. XI), Leiden 1903, p. 20.

[4]) Deutsche Tiefsee-Expedition, p. 32.

ously known species of *Nausithoë* as far as I am aware. Another character of the margin distinguishes this species sharply from *N. rubra*, viz. eight small lappets, inserted between the larger marginal ones, each carrying a rhopalium at its distal end. The outlines of the larger lappets could not be traced with certainty, the margins of the specimens examined being more or less damaged.

The rhopalium itself (pl., figs. 3 and 4) presents the same features as in *Nausithoë limpida* Hartlaub.[1]) On the exumbrellar side a carina runs along the rhopalium; the keel disappears a little higher up the small lappets. The rhopalium consists of litocyst, covering scale, and ventral bulbus; the ocellus found in *Nausithoë limpida*, is absent in *N. atlantica.* In this negative character it corresponds to *N. rubra*, and we see in it an adaptation to life in deep water, as already pointed out by BIGELOW.

Station	Lat. N.	Long W.	Depth in metres	Number of specimens	Measurements in mm, D = total diameter C = diameter of the central disc.
56	36° 53′	29° 47′	500	2	D = 18 C = 10 } one specimen very much damaged
90	46° 58′	19° 6′	500	5	D = 24, 25, 26, 28 C = 13·5, 13, 14, 15 } the fifth specimen very much damaged
92	48° 29′	13° 55′	500	1	D = 26 C = 12

It is rather difficult to trace the ringmuscle on the sub-umbrellar side. The gonads, as mentioned above, occupy the position described by HAECKEL for *Nausicaa*, and later observed by MAAS in *Nausithoë picta.* In adult specimens (pl., fig 2.), we observe a distinct space between the gonads at the four corners of the stomach, but between the radii the limits may be traced or the may wholly fade away, so that apparently an interradial coalescence takes place. In opposition to what takes place in *Palephyra*, in which VANHÖFFEN speaks of a perradial distal approximation of the bean-shaped gonads, we find here an approximation of the proximal parts of the gonads in the interradius. The species might thus be referred to *Nausicaa*, but MAAS has proved that *Nausicaa* cannot be kept separate from *Nausithoë.*

The stomach is rather short, having a rounded quadrangular base. At the corners the walls are a little longer than elsewhere, apparently an indication of "mouth-arms". The gastric cirri are simple and small, and in single rows. We find in all about 80 cirri.

N. atlantica is doubtless a deep-sea medusa, as shown by the table above giving details of the specimens taken by the youngfish trawl.

This species was found in the eastern parts of the Atlantic (compare the map, fig. 5) between the submarine ridge extending northwards from the Azores and the European slope. One of the stations (56) is situated just south of the Azores.

Nausithoë globifera n. sp.

Pl., figs. 5–8.

Seven specimens of an interesting medusa were taken at five stations in the eastern part of the Atlantic. At first sight they seemed to fall systematically between *Atolla* and *Periphylla*, but closer examination showed that they must be referred to *Nausithoë.* The margin is provided with sixteen lappets with unbranched lappet-channels, and between these eight rhopalia alternating with eight tentacles. The rather arched and solid central disc is like the greater part of a globe resting on the marginal parts, and led me to confer the name of *globifera* upon the species.

The medusa attains a diameter of at least 17 mm. The exumbrellar surface of the bell is dotted all over with small groups of nematocysts; no general form could be traced in the nettle-spots, which are colourless. The medusa at once attracts attention on account of its globular appearance and its vivid colours. The stomach is brownish or quite black, rarely somewhat yellowish brown, the conspicuous gonads are light brownish or yellowish, occasionally of a rather reddish colour, and project sharply from the dark background. The opaque ringmuscle, the tentacles, and the rhopalia are also of a light brownish hue.

The high arched central disc (pl., fig. 5 and textfig. 6) contains a solid jelly-like substance, and is covered all over with nettle-spots. The furrow is strongly marked. The pedalia of the marginal parts are not prominent, and in many cases it is rather difficult to trace them. The sixteen lappets (pl., fig. 6) are broad and rounded with equal interspaces. Between them eight rather stout solid tentacles alternate with the eight rhopalia.

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[1]) Méduses (Duc D'Orleans: Croisière oceanographique accomplie à bord de la Belgica dans la Mer du Grönland 1905). Bruxelles 1909, p. 14.

The rhopalia (pl., figs. 7 and 8) are on the exumbrellar side provided with a rather short keel, which is bent abruptly at the transition from the margin to the covering scale. No ocellus could be observed; *N. globifera* shares this character with the two other deep-sea species: *N. rubra* and *N. atlantica*. A small lappet can be traced at the base of the rhopalium, but it is no more developed than in most other species of *Nausithoë*, and is by no means comparable to those of *N. atlantica*.

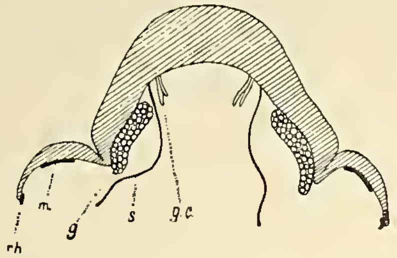

Fig. 6. Median diagrammatic section of *Nausithoë globifera* showing the arrangement of the organs (from a camera-drawing). *rh.* = rhopalium, *m.* = ring-muscle, *g.* = gonads, *s.* = gastric wall, *g. c.* = gastric cirri.

smooth. The entire stomach is almost of the same length as the bell, or a little longer. The numerous rather stout cirri are simple, arranged in a single row, but so crowded that they appear to be in a double row.

At a first glance we might think that the position of the gonads (see pl., fig. 6) would exclude this species from the genus *Nausithoë*. We observe a pronounced arrangement of the eight gonads in pairs, the origin of this arrangement must clearly be looked for in an interradial approximation and a perradial separation of the gonads. In this respect we have a typical *Nausicaa*, but in this species the arrangement is far more specialized than in the preceding one. It is evident that *N. atlantica* illustrates a transition stage, and as regards the gonads, the series from *N. punctata* through *N. picta* and *N. atlantica* to *N. globifera* is so closely related that a generic separation based on this character seems to be out of the question wherever we try to draw the limits. Moreover all the other characters of this species correspond so well to those of the other representatives of *Nausithoë* that I do not hesitate to refer it to this genus.

Station	Lat. N.	Long W.	Depth in metres	Number of specimens	Measurements in mm D = total diameter C = diameter of central disc.
10	45° 26′	9° 20′	?	1	D = 17 C = 9
88	45° 26′	25° 45′	1000	1	D = 14 C = 7·5
90	46° 58′	19° 6′	500	2	D = 15–17 C = 7·5–8·5
98	56° 33′	9° 30′	500	2	D = 15–16 C = 8·5–8
101	57° 41′	11° 48′	500	1	D = 15 C = 7

The nettle-spots of the exumbrella are in the marginal parts of *N. globifera* more densely crowded on the lappets and between the pedalia, and round the rhopalia we find a considerable accumulation of nettle-spots.

On the subumbrellar side the ring-muscle forms an opaque and conspicuous though narrow ring. Inside of this ring (see textfig. 6) we see how the ring furrow of the exumbrellar side causes a very prominent ring on the subumbrella; the large sexual organs are situated on and above the inner side of this ring. The gonads stretch far up into the bell, almost reaching the place of attachment to the stomach. The stomach is of a rounded quadrangular shape, its walls hanging like folded curtains in the cavity of the bell. The lips are slightly thickened and

Seven specimens of *N. globifera* were taken, as shown in the table above:

The specimen from Stat. 10 bore no specification of depth, but at the other stations, the medusa has only been found in hauls from great depths. This species occurred only in samples from the eastern Atlantic, and seems to correspond to the preceding species both in its bathymetrical and geographical distribution, although it has been taken a little farther north (see the map, fig. 5).

Atolla Haeckel.

The description of this interesting genus was given by Haeckel[1]) in the Challenger Report, founded on an antarctic medusa described as *Atolla Wyvillei*. In a pre-

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[1]) Report on the Deep-Sea Medusae, (Zool. Chall. Exp., Vol. 4), London 1881, p. 111.

vious work HAECKEL[1]) introduced a closely related genus *Collaspis*, which, with the single species *C. Achillis*, has later been referred to *Atolla*. Only a few years later FEWKES[2]) described two new species of the genus from the Gulf-Stream, viz. *A. Bairdi* and *A. Verrilli*. The former species was taken by the Plankton Expedition)[3], and some years later MAAS[4]) described two new species *A. gigantea* and *A. Alexandri*. Up to 1897 twenty-six specimens of *Atolla* were known, distributed among the species as follows: 5 *A. Wyvillei*, 1 *A. Achillis*, 5 *A. Bairdi*, 12 *A. Verrilli*, 1 *A. gigantea* and 2 *A. Alexandri*. They were all taken in dredges, and came into the hands of the investigators in a more or less badly damaged state.

Excellent material was obtained during the "Valdivia" Expedition and VANHÖFFEN had an opportunity of investigating in a living condition most of the 54 specimens taken. His report[5]) gives details regarding the genus *Atolla*, including three of the previously known species, besides two new ones, viz. *A. Valdiviae* and *A. Chuni*.—In the same year AGASSIZ and MAYER[6]) again mention *A. Alexandri*. In two subsequent papers MAAS gives further details of nine specimens of *A. Valdiviae*[7]) and *A. Bairdi*[8]). BROWNE mentions *A. Bairdi* from the Biscayan[9]), *A. Chuni* and *A. Wyvillei*[10]) and again *A. Wyvillei*[11]) from the antarctic seas. The last mentioned species is not restricted to the antarctic area, for BIGELOW[12]) has recently examined no less than nineteen specimens from localities near the Galapagos-Islands and South California in the Pacific Ocean.

Lastly we must mention a species lately described by HARTLAUB[13]) under the name of *A. tenella*, from the arctic area. The distinguishing character: "des paires de taches pigmentaires exombrellaires" is also found in *A. Bairdi* and HARTLAUB's description proves the identity of these two species.

If we consider all the specimens of *Atolla* hitherto investigated we find that the number does not exceed 100, which must be assumed to belong to seven species. Two of them, viz. *A. Bairdi* and *A. Verrilli*, have been reported from Atlantic and arctic localities, and *A. Wyvillei* may also be expected from the Atlantic in accordance with its occurrence in the Pacific Ocean.

Atolla Wyvillei Haeckel.

Curiously enough a large typical specimen of *A. Wyvillei* was found among the very many specimens of *Atolla* brought home by the "Michael Sars". It was taken at Stat. 62 in Lat. 36° 52′ N, Long. 39° 55′ W, in 1500 metres. The broad and conspicuous radial furrows of the central disc and the strongly marked longitudinal furrow of the pedalion distinguish this species from the other Atlantic species. The single specimen is darkly pigmented, the pigment of the exumbrella extending a little way up into the radial furrows of the central disc.

The range of the species is considerably extended by this new locality. As already mentioned BIGELOW (l. c.) has pointed out that *A. Wyvillei* occurs near the Galapagos-Islands and off the southern coast of California in the Pacific, though it had previously been considered an antarctic species, and we may therefore expect to learn of its occurrence in the South Atlantic also. It is rather surprising to find that its northern limit must now be drawn at lat. 37° N.

Atolla Bairdi Fewkes.

If we except the single specimen of *Atolla Wyvillei*, all the other specimens of *Atolla*—more than 200—brought home by the "Michael Sars" from the Atlantic Ocean belong to one species. It must be granted that many of them might be referred to *A. Verrilli*, but the separation of *A. Verrilli* and *A. Bairdi* seems, in fact, to be due to the circumstance that nobody has hitherto had sufficient material for a critical examination of the doubtful individuals.

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[1]) System der Medusen, Jena 1880, p. 489.

[2]) Report on the Medusae coll. by U. S. Fish Comm. Steamer "Albatros", in the region of the Gulf-Stream. (U. S. Comm. of fish and fisheries. Rep. of the Commissioner for 1884) p. 934.

[3]) VANHÖFFEN: Die Akalephen der Plankton-Expedition (Ergebn. der Plankton-Expedition. Bd. II), Kiel 1892, p. 16.

[4]) Die Medusen (Rep. Explor. West Coasts of Mexico, Central and South America, Galapagos Islands, by the U. S. Fish Comm. Steamer "Albatros"—Mem. Mus. Comp. Zool. Vol. XXIII), Cambridge U. S. A. 1897, p. 80.

[5]) Deutsche Tiefsee-Expedition, Bd. III, p. 5.

[6]) The Medusae (Rep. Scientific Res. Exped. Tropic. Pacific—Mem. Mus. Comp. Zoöl., Vol. XXVI) Cambridge U. S. A. 1902.

[7]) Die Scyphomedusen der Siboga-Expedition (Siboga Expeditie, Monogr. XI) Leiden 1903, p, 17.

[8]) Méduses provenant des Campagnes des yachts Hirondelles et Princesse Alice (Res. Camp. Scient. Prince de Monaco. Fasc. XXVIII), Monaco 1904, p. 49.

[9]) The Medusae (Biscayan Plankton, Trans. Linn. Soc. London Zoology, Vol. X) 1906, p. 179.

[10]) The Medusae of the Scottisch National Expedition, (Trans. Roy. Soc.), Edinburg 1908, p. 240.

[11]) Medusae (National Antarctic Expedition, Natural History, Vol. V) London 1910, p. 47.

[12]) The Medusae (Rep. scient. res. eastern tropical Pacific "Albatros"—Mem. Mus. Comp. Zool., Vol. XXXIII), Cambridge U. S. A. 1909, p. 38.

[13]) Meduses (Duc D'Orléans: Croisière oceanographic dans la mer du Grønland 1905) Bruxelles 1909, p. 17.

Vanhöffen[1] who has had the opportunity of studying a large amount of material, separates the species according to the presence or absence of radial furrows on the central disc, *A. Verrilli* having radial furrows, while *A. Bairdi* has a smooth central disc. The radial furrows are generally rather indistinct, and in a note Vanhöffen admits that in larger specimens they disappear almost completely "so dass nur am Rande ihre Spuren erkennbar bleiben und solche Stücke der *A. Bairdi* sehr ähnlich werden." Maas[2] also states: "Les exemplaires capturés par le Prince de Monaco se rapportent à une seule espèce, *A. Bairdi* Fewkes, mais dans quelques uns (stn. 1269), on croit reconnaître avec de la bonne volonté des traces des fosses radïaires sur l'ex-ombrelle, on pourrait alors penser aussi à *A. Verrilli,* qui certainement est une espece très voisine." And if we examine the figures of *A. Bairdi* by Fewkes[3] we find the furrows of the central disc distinctly indicated at the margin; we might say that they represent the half-disappeared radial furrows of large *A. Verrilli* according to Vanhöffen.

The limits between these two species are by no means distinct, but the investigation of the "Michael Sars" material has in several ways solved the problem.

Atolla Bairdi.

Depth (metres)	Diameter of disc (millimetres)											Total
	7—10	11—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91—100	101—110	
250	1	—	—	—	—	—	—	—	—	—	—	1
500—550	3	7	2	1	1	3	—	—	—	—	—	17
750	2	9	8	2	2	1	1	—	—	—	2	27
1000—1100	6	21	9	5	1	1	1	—	—	1	—	45
1250	—	—	2	—	—	—	—	—	—	—	—	2
1500—1600	—	4	1	2	1	—	—	1	1	—	—	10
2000	—	—	1	—	—	—	—	—	—	—	—	1
Total	12	41	23	10	5	5	2	1	1	1	2	103

Atolla Verrilli:

Depth (metres)	Diameter of disc (millimetres)									Total
	10—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91—100	
500	7	1	—	—	—	—	—	—	—	8
750	2	—	1	2	2	—	1	—	1	9
1000	13	3	3	1	—	1	—	—	—	21
1200—1250	2	2	—	1	1	—	—	2	—	8
1500	3	3	1	—	1	2	1	—	—	11
Total	27	9	5	4	4	3	2	2	1	57

Fig. 7. Table showing the bathymetrical distribution of the different sizes in the "Michael Sars" specimens of *Atolla Bairdi* and *A. Verrilli.* The figures denote number of individuals.

According to the radial furrows we can separate three groups among the specimens. First, those furnished with distinct radial furrows all over the central disc, second, those with incomplete radial furrows, in many cases visible only at the margin of the central disc; and third, those with a perfectly smooth central disc, showing no trace whatever of radial furrows. The first group comprises almost one-third of the material, and the last group less so that most of the specimens belong to the intermediate group. The question arises whether these intermediate specimens are to be referred to *A. Bairdi* or to *A. Verrilli.* If these individuals were all large, we ought to follow Vanhöffen in referring them to *A. Verrilli,* but the percentages of large and small individuals are the same in each of the three groups. The intermediate group contains every transition stage from *A. Bairdi* to *A. Verrilli,* and we are therefore compelled to consider *A. Verrilli* as a synonom of *A. Bairdi.*

But should *A. Verrilli* not be retained as a separate form? First of all we must make it clear what is required ot groups of specimens or of variants if they are to be considered separate "forms". In reality we have two different kinds of forms.

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[1] Deutsche Tiefsee-Expedition, p. 8.

[2] Méduses provenant des Campagnes des yachts Hirondelle et Princesse Alice (Res. Camp. Scient. Prince de Monaco. Fasc. XXVIII), Monaco 1904, p. 49.

[3] Rep. Medusae Gulf Stream, pls. I, II and IV.

If the same conditions of life always cause one and the same kind of variant, we must keep this group separate from the typical individuals of the species as a distinct "form". Such forms may be looked at in two different ways. We may either consider the forms as biological or biogeographical (in the original strict sense of the word), i. e. each developing stage is confined to different strata or habitats, or as zoogeographical, i e. they characterize special geographical regions ("geographical form").

On these investigations the two "species" are separated by referring all the specimens with smooth central disc, or with merely irregular traces at the margin of the central disc to *Atolla Bairdi*, and the others to *A. Verrilli.*

First let us look at the bathymetrical arrangement of the developing stages (fig. 7). At first sight we might think that the respective stages of *A. Verrilli* would, on the whole, live deeper, but a careful examination of the data soon disproves this; the disposition of the specimens is evidently due to the uncompleteness of the material. The material from the "Michael Sars" is very much richer than that of any former expedition, but in spite of this there are too many missing links to make the chain com-

Station	*Bairdi*	*Verrilli*	Station	*Bairdi*	*Verrilli*	Station	*Bairdi*	*Verrilli*
10	9	1	53	9	5	82	9	5
23	3	—	56	2	6	84	3	1
25	1	—	62	—	1	87	7	1
29	4	4	64	5	2	88	4	3
35	—	3	66	1	—	90	2	2
42	1	—	67	2	—	92	5	1
45	3	6	70	2	—	94	10	2
49	2	3	80	10	7	98	4	1
51	1	1	81	5	5	101	4	—

Table showing the number of specimens of *Atolla Bairdi* and *A. Verrilli* at the stations of the "Michael Sars" (excluding some specimens subsequently found among the plankton samples.)

Atolla Bairdi:

%	Diameter of disc (millimetres)											Total
	1—10	11—20	21 - 30	31—40	41—50	51—60	61—70	71—80	81—90	91—100	101—110	
61—65	1	2	1	—	—	2	1	—	—	—	—	7
56—60	5	8	7	4	5	2	1	1	1	1	—	35
51—55	6	13	10	5	1	1	—	—	—	—	2	38
46—50	4	14	2	1	—	—	—	—	—	—	—	21
41—45	—	6	—	—	—	—	—	—	—	—	—	6
Total	16	43	20	10	6	5	2	1	1	1	2	107

Atolla Verrilli:

%	Diameter of disc (millimetres)										Total
	1—10	11—20	21—30	31—40	41—50	51—60	61—70	71—80	81 - 90	91—100	
56—60	—	5	3	1	3	3	1	1	1	1	19
51—55	1	12	6	3	—	—	2	1	1	—	26
46—50	—	8	3	1	—	—	—	—	—	—	12
41—45	—	2	1	—	—	—	—	—	—	—	3
Total	1	27	13	5	3	3	3	2	2	1	60

Fig. 8. Tables showing the diameter of the central disc in the "Michael Sars" specimens of *Atolla Bairdi* and *A. Verrilli* and the relative size of the central disc referred to the total diameter of the medusa (without lappets) expressed in percentages (%). The figures denote number of individuals.

plete. Indeed, the table tells us that the disposition of the growing stages is the same in both groups of variants.

The groups of different colouring also show the same bathymetrical arrangement in both groups, and thus there is no reason for a separation of *A. Verrilli* and *A. Bairdi* as biological forms.

The occurence of the variant groups as illustrated by the data from the cruise of the "Michael Sars" at once gives us the answer to the question whether we have two geographical forms or not. The accompanying table gives no evidence whatever that the two "species" are confined to special currents or regions, and we have thus no right to consider *A. Bairdi* and *A. Verrilli* as geographical forms.

We may now ask: What is the cause of the more or less distinct radial furrows in a great many specimens of *Atolla Bairdi?* In most cases where radial furrows could only be traced at the margin of the central disc, a slight pressure with the point of the forceps in the middle of the disc will give rise to distinct and regular radial furrows all over the disc. This seems to indicate that the radial furrows of *A. Bairdi* are due to contractions of the central disc. From this we might infer that the central discs of typical specimens of *Atolla Verrilli* are relatively smaller than typical specimens of *A. Bairdi.* An examination of the accompanying table (fig. 8) proves this to be the case; the central disc of *Atolla Verrilli* is generally a little smaller than that of *A. Bairdi.* This affords further evidence that the radial furrows of the central disc in *A. Bairdi* are, at least partly, due to contraction.

Atolla Bairdi is a deep-water medusa and, in the Atlantic Ocean prefers a depth of about 1000 metres. Its upper limit must be drawn a little above 500 metres (see table fig. 9), although a single specimen was taken at a depth of 250 metres. Beyond 1000 metres the number of specimens rapidly decreases, and in catches from greater depths than 1500 metres only single specimens were observed. It is, of course, possible that these single specimens from the deep hauls may have been caught on the way to the surface, but this does not affect what has been said of the general conditions of the species. During the cruise of "Michael Sars" no difference could be observed in the bathymetrical distribution of the individuals at northern and southern stations.

The pigmentation of the individuals is subject to great variations. Many specimens are quite hyaline with the exception of an almost black stomach; nearly the entire subumbrella of other individuals is brownish black, and in such specimens even the greater part of the exumbrella may be darkly pigmented. Of course every transition stage is found between the extremes. An interesting question concerning such typical inhabitants of great depths is as to whether the colours depend upon the bathymetrical occurrence of the individuals. For the purpose of solving this problem four groups of different colouring were kept separate in our material (see the accompanying table). The stages or groups have been limited as follows:—I only the stomach and occassionally the gonads containing pigment; II the ringmuscle also pigmented; III pigment covering other parts of the subumbrella too, but the gonads always visible from the exumbrellar (upper) side of the medusa; IV pigmentation so dense that the gonads are quite invisible from the upper (exumbrellar) side of the medusa.

Depth (meters)	Stages of pigmentation				Total
	I	II	III	IV	
0	—	—	—	—	—
250	1	—	—	—	1
500	23	6	—	—	29
750	5	20	16	7	48
1000	6	36	21	3	66
1250	2	5	3	4	14
1500	1	10	5	4	20
1500	—	—	2	—	2
Total	38	77	47	18	180

Fig. 9. Table showing the bathymetrical distribution of the "Michael Sars" specimens of *Atolla Bairdi* arranged in the four colour-groups (I—IV) mentioned in the text. The figures denote number of individuals.

Although the absolute maxima of the two intermediate groups are situated at the same depth, we see the same displacement of the bulk towards deep water, which is still more pronounced from stage I to stage II, where even the absolute maximum has become displaced. There is no distinct difference to be seen between stages III and IV. On the whole, the same rule holds good regarding the pigmentation of *Atolla Bairdi* as in the case of *Periphylla hyacinthina* (see p. 6), the pigmentation increasing towards deep-water. In species which live at great depths like *Atolla Bairdi* the less pigmented, or almost completely hyaline, specimens have their optimum in the shallower layers the densely pigmented individuals, on the contrary, occurring in the deeper waters.

The cruise of the "Michael Sars" has, on the whole, not increased the geographical range of *Atolla Bairdi,* which was previously known from many parts of the Atlantic Ocean even north of the Wyville Thomson ridge.

DISCOPHORA.

Pelagia Péron and Lesueur.

A great many species of *Pelagia* have been described, but they have gradually been reduced, and recent authors, like Vanhöffen, Maas, Browne and Bigelow, doubtfully acknowledge three species, viz. *Pelagia noctiluca* Péron and Lesueur, *P. perla* (Slabber) and *P. panopyra* Péron and Lesueur. These naturalists seem to agree in their views, and doubt whether the three species really represent more than geographical forms ("varieties").

Recent writers agree with Vanhöffen[1]) that "Eine Revision der Pelagienarten muss aber einstweilen aufgeschoben werden, bis genügend umfangreiches Material aus allen Meeren vorliegt." We shall probably have long to wait for this revision, if investigators follow the example set by previous authors, most of whom, instead of giving a detailed account of the material at their disposal, have given general reasons for using the names *noctiluca, perla* or *panopyra,* the main reason apparently being that the specimens were taken in such or such an ocean. Maas calls attention to the relative development of the mouth-arms and manubrium, which latter seems to differ in the specimens obtained by the "Siboga"[2]) and in those from the Atlantic or Mediterranean.[3])

Our knowledge has not advanced much since Vanhöffen wrote the above sentence in 1902, and if the questions relating to the separation of the species of *Pelagia* are to be solved, it will be necessary for every investigator to give detailed descriptions of his material, and especially to study the variations thoroughly.

Nr.	D.	M.	A.	Nr.	D.	M.	A.	Nr	D.	M.	A.	Nr.	D.	M.	A.	Nr.	D.	M.	A.
1	2	0·5	+	36	7	3	2	71	10	2	3	106	14	4	7	141	22	5	12
2	2	0·5	+	37	7	2	3	72	10	3	3	107	14	3	5	142	23	4	?
3	2	0·5	0	38	7	2	2	73	10	3	5	108	14	4	9	143	23	8	15
4	2	0·5	+	39	7	2	2	74	11	3	5	109	14	4	6	144	24	4	7
5	2	0·5	+	40	7	2·5	2	75	11	2	3	110	14	4	4	145	24	4	?
6	2	0·5	+	41	7	2	2	76	11	3	2	111	15	5	7	146	24	5	10
7	2	0·5	0	42	8	2	2·5	77	11	3	6	112	15	3	7	147	25	7	18
8	3	0·5	0	43	8	1	3	78	11	4	5	113	15	4	1	148	25	5	6
9	3	0·5	+	44	8	3	2	79	11	3	3	114	15	5	5	149	25	6	8
10	3	0·5	+	45	8	3	3	80	11	3	3	115	15	5	?	150	25	6	8
11	3	0·5	0	46	8	2	2	81	11	3	7	116	15	3	6	151	26	8	20
12	3	0·5	0	47	8	2	2	82	11	3	5	117	16	5	8	152	26	7	7
13	3	0·5	0	48	8	2	2	83	12	4	5	118	16	4	8	153	26	6	16
14	3	0·5	0	49	8	2	2·5	84	12	4	4	119	16	4	2·5	154	28	6	18
15	3	1	+	50	8	2	1·5	85	12	4	6	120	16	4	9	155	29	8	15
16	3	1	+	51	9	3	3	86	12	3	3	121	16	3	5	156	32	10	19
17	3	1	+	52	9	3	4	87	12	3	4	122	16	4	6	157	32	6	21
18	3	1	+	53	9	2	4	88	12	3	3	123	17	4	9	158	32	9	31
19	3	1	+	54	9	2·5	3	89	12	3	7	124	18	6	7	159	33	4	10
20	3	1	+	55	9	2	4	90	12	6	5	125	18	3	7	160	33	8	8
21	3	1	+	56	9	2	2·5	91	12	4	4	126	19	4	11	161	36	7	20
22	3	1	+	57	10	3	3	92	12	3	3	127	19	3	7	162	37	10	25
23	3	1	1	58	10	3	4	93	12	3	5	128	19	5	?	163	39	10	20
24	3	1·5	+	59	10	2	4	94	12	2	5	129	19	5	8	164	40	11	21
25	4	2	0	60	10	3	4	95	12	4	6	130	19	4	3	165	45	8	26
26	4	2	1	61	10	3	5	96	12	2	?	131	19	5	9	166	45	8	23
27	5	2	1	62	10	3	5	97	13	3	3	132	20	5	12	167	46	11	26
28	5	2	1	63	10	3	4	98	13	4	5	133	20	7	10	168	52	15	35
29	6	2	1	64	10	3	4	99	13	4	3	134	20	4	?	169	56	7	35
30	6	1	0·5	65	10	3	2	100	13	4	?	135	20	4	?	170	78	19	48
31	6	1·5	1	66	10	3	3	101	13	4	4	136	21	5	11	171	80	20	51
32	6	2	2	67	10	2·5	1	102	13	4	7	137	21	4	14	172	110	17	65
33	7	2	2	68	10	2	2·5	103	14	3	8	138	22	6	8	173	117	30	80
34	7	2	2	69	10	2	2	104	14	4	5	139	22	6	?	174	124	24	92
35	7	2	+	70	10	2	3	105	14	3	7	140	22	4	9				

Table of measurements in mm of the "Michael Sars" specimens of *Pelagia perla* (D = total diameter of the disc, M = length of the manubrium, A = length of the mouth-arms. A + means that the arms are indicated, although not sufficiently large to be measured.)

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[1]) Die Acraspeden Medusen. (Wiss. Ergebn. Deutschen Tiefsee-Exped., Bd. III). Jena 1902, p. 37.

[2]) Die Scyphomedusen der Siboga-Expedition. (Siboga-Expeditie, Monogr. XI). Leiden 1903, p. 29.

[3]) Méduses provenant des campagnes des yachts Hirondelle et Princesse-Alice. (Res. Camp. Scient, Prince de Monaco, Fasc. XXVIII). Monaco 1904, p. 56.

Pelagia perla (Slabber).

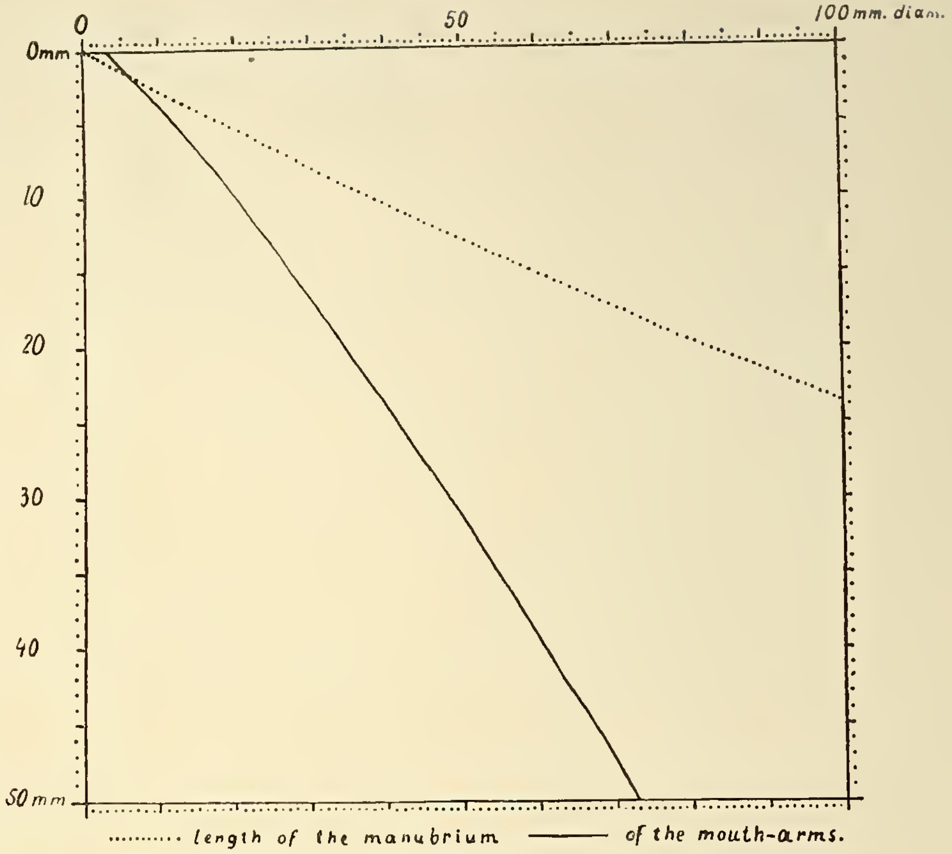

Fig. 10. Diagram showing lines of correlation in the "Michael Sars" specimens of *Pelagia perla*, between the total diameter of the medusa (horizontal scale) and the length of the mouth arms resp. the manubrium (vertical scale).

The "Michael Sars" brought home from the cruise of 1910 more than two hundred and fifty specimens of *Pelagia*, but it is impossible to distinguish more than one species, and I have therefore followed the old custom of maintaining the name of *Pelagia perla*, commonly used for the Atlantic *Pelagia*, all the more as the specimens agree with previous descriptions of this species.

Vanhöffen[1]) has paid great attention to the nettle-warts in his specific diagnoses, and this led me to study their variations in the "Michael Sars" material very thoroughly, in order to see whether a separation into groups might be based on their characters. Every attempt in this direction was in vain; the nettle-warts are generally roundish or ovate, but somewhat larger specimens show all the different variations which have served Vanhöffen and other investigators as specific characters. Further, the different wart-forms vary greatly in number from individual to individual, but so gradually as to afford no guidance in regard to a division into groups.

The larger warts are found in the middle of the exumbrella; towards the margin of the bell they are smaller, and in the lappets, or at the very margin, they become almost invisible or disappear entirely. From this general arrangement very few exceptions could be found, though in some small specimens the warts seemed to be of almost equal size all over the disc. The larger warts of the central parts of the disc are separated by larger spaces than usual, and now and then these spaces attain such dimensions that the central parts of the disc are almost smooth. Another variation is often observed which completely changes the appearance of the warts, for in the larger specimens a coalescence of the larger warts often takes place, the warts forming shorter or longer bands instead of ovate or roundish spots.

Sometimes the warts all over the medusa fade away almost completely, and can only be traced with the greatest difficulty, while in other cases they are distinctly circumscribed and very prominent. In this respect every transition stage is to be found, and we are thus compelled to abandon the nettle-warts as affording specific characters in *Pelagia*.

The next character to be studied in detail, is the relative length of the manubrium and the mouth-arms (see the accompanying table). Here and there the table indicates rather abrupt differences. A careful examination of the individuals shows different degrees of contraction especially of the mouth-arms. This is seen most clearly in large individuals, whose arms though intact vary in length sometimes as much as 25 per cent or more, the short arms being thick and compact, the long arms, on the contrary, thin and relaxed. Smaller specimens also show varying degrees of contraction, although, owing to their smaller dimensions, this is less conspicuous at first sight. The table shows how the manubrium and the mouth-arms increase in length with the growth of the medusa, though at a different rate. Smaller specimens, which are still in Ephyra-stage, or such as have not yet their eight tentacles equally developed, have no mouth-arms at all, or they are merely seen as prolongations of the gastric wall indicated at the four corners of the stomach. In most cases the medusa with a total diameter of about 7 mm has mouth-arms of the same length as the manubrium. Later the growth of the mouth-arms is more rapid than that of the manubrium, as shown by the accompanying diagram (fig. 10) giving the lines of correlation of growth, drawn from the table of measurements.

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[1]) Untersuchungen über semaestome und rhizostome Medusen. (Bibliotheca Zoologica, Bd. 1). Cassel 1888, p. 6.

Station	10	25	51	52	56	81	82	84	86	87	88	90	92	94	Total
Metres															
0	2	2	1	4	33	18	5		92	6	18				182
						10	1	1					1		13
										4	19	1			24
	2									3	6	3		1	15
							1			1					2
500							2			2	3				7
							1					1		1	3
1000							3					2		7	12
						2									2
1500						3									3

Table showing the distribution of the specimens of *Pelagia perla* in the hauls taken during the cruise of the "Michael Sars" 1910.

The different rates of growth give the following result: The larger the medusa, the smaller the manubrium in relation to the mouth-arms.

Do the proportions of the mouth-arms and the manubrium in these specimens differ from those in *P. noctiluca* and *P. panopyra*, in other words: is *P. perla* specifically distinct from the other two species? If this should really be the case, the lines of correlation must lie differently in the two other species than they do in *P. perla*, but we cannot, at present, answer, this question, because the data given by previous authors are in no way sufficient for such investigations. The few measurements given by BIGELOW[1]) are too scanty for an examination of the variations, and MAAS[2]) merely states that the Indian specimens of his collections have longer manubria than the Atlantic specimens, but says nothing about the size of the specimens compared.

The "Michael Sars" specimens are rather variable in colour, some of them having a brownish or yellowish tinted jelly, while the umbrella is mostly hyaline. In the latter case the gastrovascular and genital organs are throughout of a light bluish or reddish colour, the mouth-arms being darker than the other parts owing to their densely crowded and more vividly coloured nettle-warts. The exumbrellar nettle-warts vary in colour from a dark reddish brown to almost colourless.

The colours are characteristic of a typical inhabitant of the photic zone and the "Michael Sars" specimens were taken mostly in the upper layers of water, as shown in the table, the occasional specimens recorded from the

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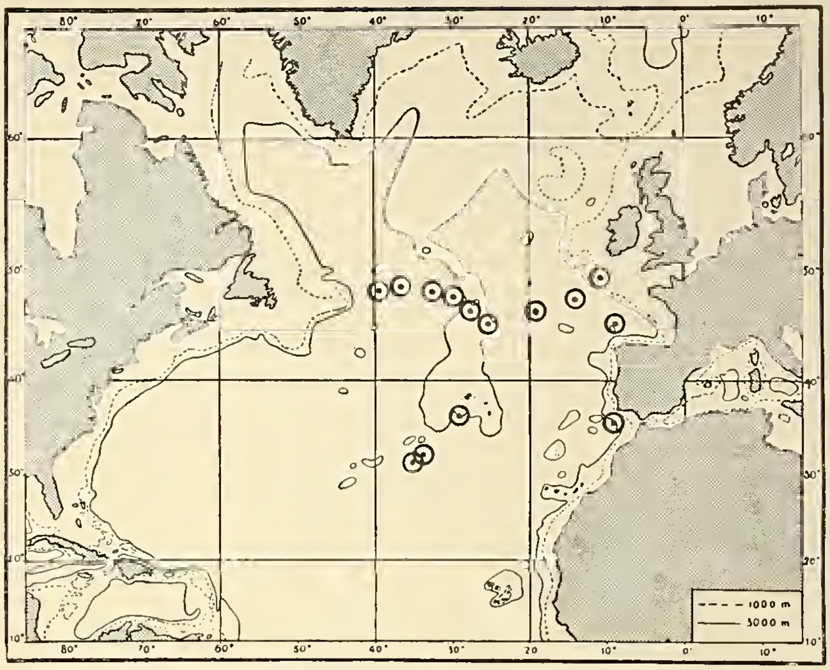
[1]) The Medusae (Rep. scient. res. eastern tropical Pacific "Albatross"—Mem. Mus. Comp. Zool. Vol. XXXIII) Cambridge U. S. A. 1909, p. 43.

[2]) Meduses provenant des campagnes des yachts Hirondelle et Princesse-Alice, p. 57.

deeper layers having probably been caught while the gear was being hauled in.

At Stats. 84, 90, 92 and 94 the species was not found at the very surface, and at first I thought this might be due to the time of day when the hauls were taken, but during the same hours of the day at other stations *Pelagia* was abundant at the surface. Stations 90, 92 and 94 were evidently near the northern limit of the species, and this may explain its scarcity in the surface waters.

The geographical data obtained during the cruise explain some interesting points in the life-history of this holoplanktonic medusa. *P. perla* is a tropical and subtropical species, which is carried northward by the Atlantic current; its habitat is limited by the arctic currents, and it is therefore missing over the Newfoundland banks, and a rare guest in Norwegian waters. It is remarkable that the medusa was rather scarce throughout the southern part of the route of the "Michael Sars" (see fig. 11); only at Stat. 56, south of the Azores, was a larger shoal met with, consisting almost entirely of very young stages. Such large shoals of *Pelagia* are commonly found where currents meet, as has been pointed out by most of the previous authors. On the other hand, older stages were far more abundant in the northern section than at Stat. 56, probably because at most places in the southern section the time of reproduction had not fully set in when this part of the sea was explored.



⊙ Occurrence of *Pelagia perla* during the cruise of the "Michael Sars".
Fig. 11.

Chrysaora Péron and Lesueur.

Chrysaora mediterranea Péron and Lesueur.

In the Bay of Algeciras the umbrella of a medusa was taken on the 1. of May. The umbrella is 75 mm broad, with narrow, brown radial stripes, the central parts of the disc light yellowish, and each lappet with a large, dark brown spot in the centre. The margin is perfect, but of the tentacles only the basal parts are left. Every trace of gonads and stomach has disappeared, but nevertheless the bell may easily be identified as belonging to *Chrysaora mediterranea.*

It is still an open question whether *C. mediterranea* is specifically distinct from *C. hysoscella* (Lin.), as Vanhöffen[1]) has pointed out. Judging from the locality I prefer at present to refer this defective specimen to *C. mediterranea,* with the description of which it agrees quite well.

Poralia Vanhöffen.

This genus was established by Vanhöffen[2]) for a defective medusa taken by the "Valdivia" in the vicinity of Sumatra. Our knowledge of this primitive and interesting genus was considerably widened by the investigations of Bigelow,[3]) who had an opportunity of examining two damaged specimens taken by the "Albatros" in the eastern Pacific.

At Stat. 85 (Lat. 47° 58′ N, Long. 31° 41′ W) a very much damaged specimen of a *Poralia,* was caught in a Nansen's closing net between 2000 and 1100 metres. This specimen probably belongs to *P. rufescens* Vanhöffen, the only known species, and consists of the central parts of the disc, with undivided radial canals, and a damaged stomach. These parts correspond to the descriptions given by Bigelow (l. c.). The subumbrella is of a dark brownish colour; on account of their somewhat lighter colour the 32 radial canals stand out distinctly. Every trace of the ring-canal described by Bigelow has disappeared. In fact, we can do no more than record the presence of the genus *Poralia* in the Atlantic, but this is of great interest, when we consider the previously known localities for the genus (see fig. 12), which seems to be tropical and subtropical and circumterrestrial, and a true deep-sea form.

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[1]) Acraspede Medusen (Nordisches Plankton Lief. V.). Kiel 1906, p. 47.

[2]) Die Acraspeden Medusen. (Wiss. Ergebn. Deutschen Tiefsee-Exped. Bd. III). Jena 1902, p. 40.

[3]) The Medusae (Rep. scient. res. eastern tropical. Pacific "Albatross".— Mem. Mus. Comp. Zool. Vol. XXXIII). Cambridge U. S. A. 1909, p. 44.

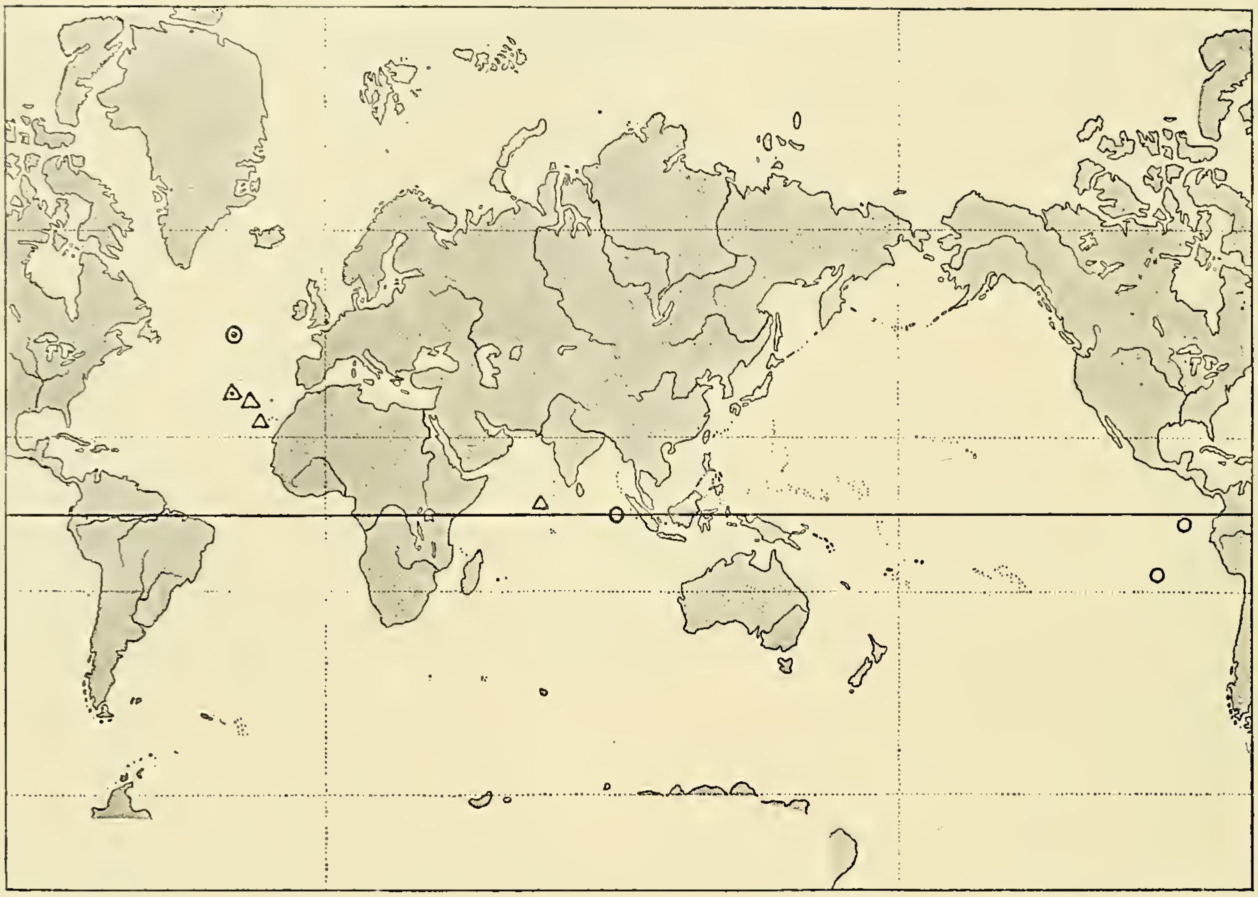

Fig. 12. Distribution of *Poralia* and *Aurelia solida*. ⊙ *Poralia*. "Michael Sars". ○ previous records of *Poralia*. ⚠ *Aurelia solida*. "Michael Sars". △ previous records of *Aurelia solida*.

Aurelia Péron and Lesueur.

Aurelia solida Browne.

At Stat. 56, south of the Azores, the "Michael Sars" procured two specimens of *Aurelia*, which at once attracted our attention on account of their solid jelly and the anastomosing of their radial canals near the margin of the umbrella. An examination of the sense-organs showed that the specimens belong to *Aurelia solida* Browne. These specimens, which are of a violet hue, are larger than those mentioned by previous authors, being 84 and 100 mm in diameter.

Browne¹) first described this species from the Indian Ocean, and later²) from the Atlantic to the West of Madeira, and Maas³) mentions specimens of it from the Azores. The species thus seems to be tropical and subtropical and apparently, a neritic surface-form.

Trondhjem, December 11th, 1911.

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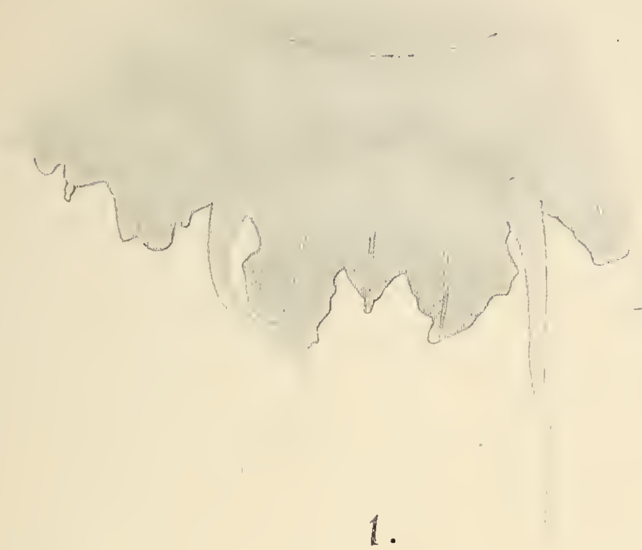
¹) Scyphomedusae. (Fauna and Geography of the Maldive and Laccadive Archipelagoes, Vol. II). Cambridge 1905, p. 960.

²) The Medusae of the Scottish National Antarctic Expedition. (Trans. Roy. Soc. Edinburgh, Vol. XLVI) 1908, p. 249.

³) Japanische Medusen. (Abhandl. math. phys. Klasse der K. Bayer. Akad. Wissenschaften I Suppl. Bd.). München 1909, p. 45.

Explanation of plate.

Fig. 1. *Nausithoë atlantica,* n. sp., part of specimen from Stat. 90, seen from above (× 5).
„ 2. — part of a specimen, seen from below (× 5).
„ 3. — rhopalium, exumbrellar view (× 60).
„ 4. — rhopalium, seen from the subumbrellar side (× 60).
„ 5. *Nausithoë globifera,* n. sp., side view of a specimen from Stat. 101 (× 5).
„ 6. — the same specimen seen from above (× 5).
„ 7. — rhopalium seen from the exumbrellar side (× 60).
„ 8. — rhopalium, seen from the subumbrellar side (× 60).



1.

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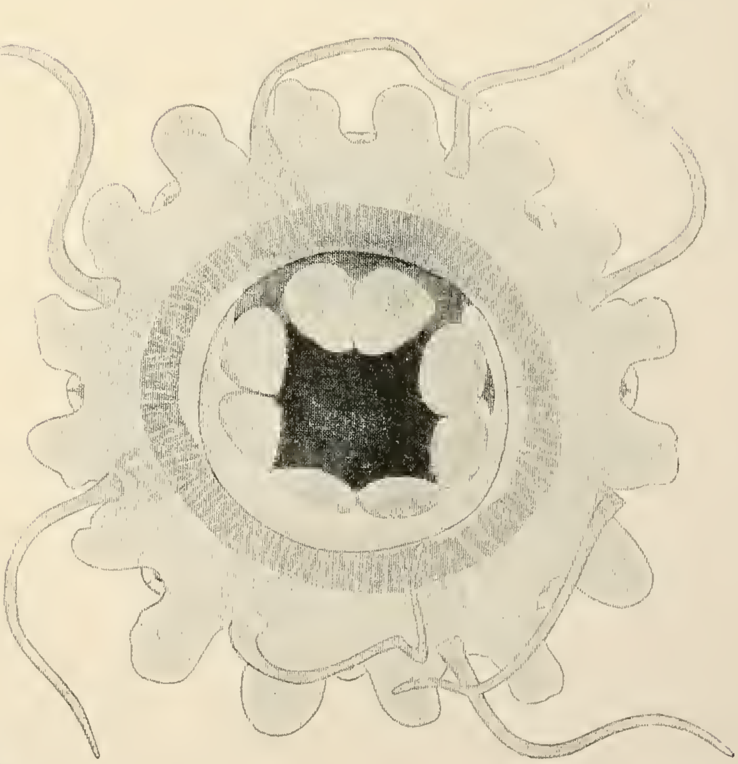

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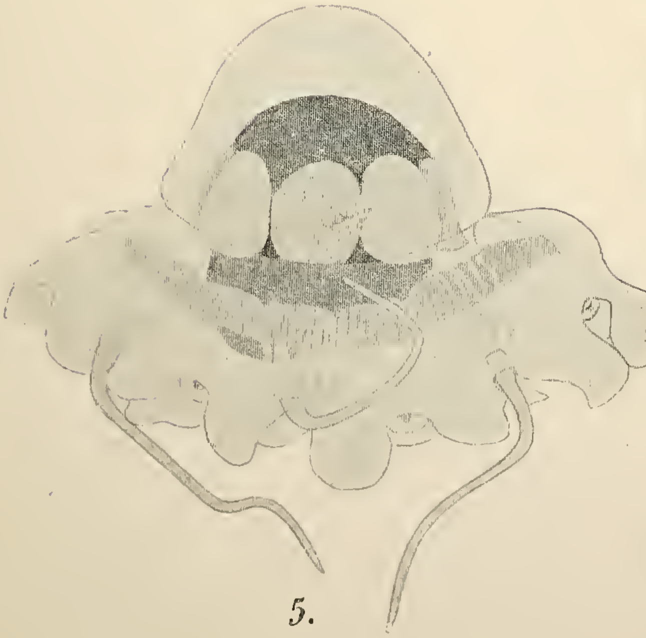

5.

7.

8.

PENNATULACEA

FROM THE

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

BY

DR. HJALMAR BROCH

WITH 1 PLATE AND 4 FIGURES IN THE TEXT

PENNATULACEA.

Veretillum cynomorium (Pallas) Cuvier.

From Stat. 37 (Cape Bojador) there are no fewer than 31 intact colonies of this species, besides another fragmentary colony. They are all more or less contracted, especially the stalks, which are unusually short and thick.

Distichoptilum gracile Verrill (?).

Part of a colony from Stat. 25 in the neighbourhood of Gibraltar (2055 metres), probably belongs to *Distichoptilum gracile*. The fragment, 458 mm long, includes only the polypary, there being no trace either of the stalk or of the upper part.

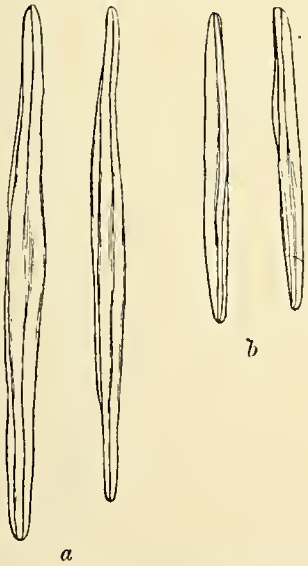

Fig. I. Spicules of the fragment of *Distichoptilum* from Stat. 25 (× 100). *a:* Spicules of the polypcalyx. *b:* Spicules from the sarcosoma of the rachis.

It has a yellowish white stem. The dorsal side is broad, naked and roundish. On the ventral side the naked streak is narrow, decreasing upwards. In the sarcosoma of the ventral side we see numerous red calcareous spicules, which give this part of the rachis a reddish colour; such spicules, though less brightly coloured, are numerous also in the dorsal part of the rachis. On both sides of the stem we find a single row of small polyps completely contracted within their calyces, which are built up of compactly studded, longitudinally arranged, dark-red spicules. At the opening they converge in two lateral more or less prominent spines, between which irregular smaller spines can now and then be traced.

The polyps of the lower part of the fragment are seated strictly opposite; the nearer the top, the more ventrally are they arranged, nevertheless they must on the whole, be characterized as lateral. The axis is round, with flattened sides.

On closer examination the zooids are seen to be placed just above the calyces of the polyps, as described by JUNGERSEN[1]) in *Distichoptilum gracile*, though differing from his description in having no calyces at all. Whether this is a specific character will be a matter for further investigation.

The spicules (textfig. 1) are tripennate. Those of the stem have almost parallel sides, but are smaller than those of the calyces of the polyps, which attain a length of 1 mm, are spindle-shaped, and of a darker red tinge than those of the stem.

Umbellula Güntheri Kölliker.

Pl. fig 1.

Two specimens from Stats. 47 and 48, west of the Canaries.

KÖLLIKER[2]) describes the polyps as being alternately disposed. In the accompanying figures, however, we find the polyps (the terminal one not included) disposed in pairs, the upper pair being strictly opposite, while the lower pair is slightly subalternate. KÖLLIKER found one "rudimentary" polyp within the cluster, but he does not indicate its position either in the text or in the figures. A diagram sketched from KÖLLIKER's descriptions and figures, is given in textfig. 2 *b*, where the probable seat of the "rudimentary" polyp is marked; it may probably turn out to be the young polyp of the cluster, a fifth and secondary one. The "Challenger" specimen represents an intermediate stage between the two "Michael Sars" specimens.

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[1]) JUNGERSEN, Pennatulida: Den danske Ingolf-Expedition, Bd. V, No. 1, 1904, p. 62.

[2]) KÖLLIKER: Report on the Pennatulida: Zool. Chall. Exp., Part. II, 1880, p. 18, pl. IX, figs. 34 *a* and *b*.

The fragment from Stat. 48 comprises a cluster of polyps, and under it a small part of the rachis of a young colony. Just under the terminal (primary) polyp we find a pair of strictly opposite fully developed polyps (textfig. 2 *a*). The next pair are disposed at the lower side and ventrally to the first; they are less than half the size of the first pair, the one seated to the right of the median ventral line of the rachis being the smaller of the two. In the median ventral line of the rachis, just below this second pair, we see a very young bud, a polyp about 1 mm in length. This cluster of polyps thus belongs to a decidedly younger colony than the one examined by Kölliker.

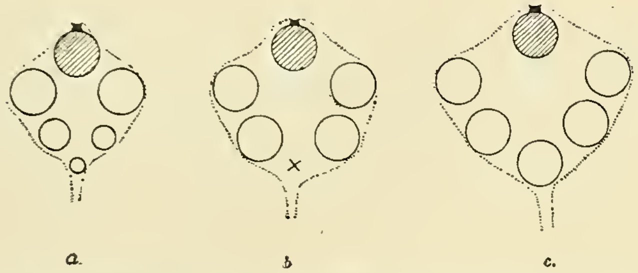

Fig. 2. Diagrams of the polyp-clusters of *Umbellula Güntheri*. *a:* The specimen from Stat. 48. *b:* The "Challenger"-specimen (× probable seat of the rudimentary polyp). *c:* The specimen from Stat. 47.

The beautiful upper part of another colony taken at Stat. 47 (pl., fig. 1) belongs to an older specimen. There are in all six polyps, as in the preceding specimens, the arrangement of the polyps being quite similar (textfig. 2 *c*). The only difference is indeed to be found in the development of the polyps, which are all full grown in the specimen from Stat. 47.

Thus the three colonies of *Umbellula Güntheri* represent three consecutive stages of development. We find that the first budding from the primary polyp results in two secondary polyps which are opposite and strictly lateral. The next pair of secondary polyp arise ventrally just beneath the first pair, and lastly an unpaired secondary polyp buds out in the median ventral line of the rachis just below the second pair. No more polyps seem to develop, at any rate we do not find the slightest trace of any polyp-bud in the specimen from Stat. 47, although the six existing polyps are all full-grown. The tentacles of the fully developed polyps are as long as the bodies of the polyps, and have numerous equal-sized pinnules. The measurements of the polyps give the following results:—

	Stat. 47 mm	Stat. 48 mm
Terminal polyp:		
Length of body............	11·0	9·0
Breadth of body...........	3·5	3·5
Length of tentacles	11·0	9·0
Secondary polyps, 1st pair:		
Length of body............	14·0	14·0
Breadth of body...........	4·5	3·5
Length of tentacles	16·0	13·0
Secondary polyps, 2nd pair:		
Length of body............	15·0	5·0[1]
Breadth of body...........	5·0	2·0[1]
Length of tentacles.	17·0	6·0[1]
Unpaired fifth polyp:		
Length of body............	15·0	1·0
Breadth of body...........	4·5	0·5
Length of tentacles	17·0	not developed
Length of the swollen upper part of the rachis	26·0	23·0

The zooids are pretty numerous on the swollen upper part of the rachis, filling out every interspace between the bases of the polyps except for one narrow streak in the median dorsal line. This bare streak is situated along the axis, which is visible in the broad polypless, dorsal flattening of the rachis.

The upper zooids of the rachis show no trace of tentacles. Just beneath the swollen part of the rachis, where the stem is quadrangular, the zooids are extremely small and flattened. Zooids are found only here and there on the lateral side of the thin stem. After a very careful examination of a second fragment from Stat. 47, consisting of the lower part of a colony, we also found them where the lower part of the stem begins to swell.

The axis is quadrangular, with concave sides and prominent rounded edges; it is a little thicker in the stalk than in the rachis.

The sarcosoma of the stem and the walls of the polyps, as well as the tentacles, are studded with spicules. No formation of calyx could be found, because of the studding of spicules, as described by Kölliker[2]) in the "Challenger" specimen.

The different forms of spicules are very characteristic (textfig. 3). Those of the tentacles are smooth and tripennate with square ends which often seem to be composed of small crystals; these spicules attain a length of 0·6 mm.

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[1]) Measured on the larger polyp of the pair.

[2]) Kölliker l. c. 1880, p. 19.

In the walls of the polyps we find tripennate spicules up to 0·75 mm long, smooth and somewhat irregular, with composite ends. The spicules of the sarcosoma of the rachis are similar in form but smaller. The spicules of the inferior part of the rachis and of the stalk are still smaller and acquire a peculiar structure. They are tripennate, but because of their granular surface, this character is very often indistinctly seen; they seem to be covered all over with irregular wart-like protuberances. This peculiarity is also mentioned in the "Challanger" report. In the inner layers of the stalk we find the usual, elliptic corpuscles.

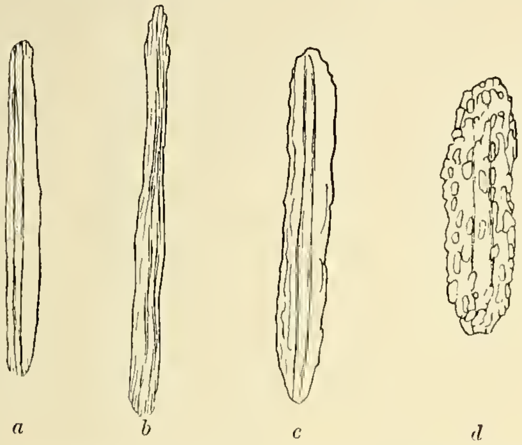

Fig. 3. Spicules of *Umbellula Güntheri* from Stat. 48. *a:* Spicula of the tentacles (× 200). *b:* Of the polyp body (× 100). *c:* Upper part of the rachis (× 200). *d:* Outer layer of the stalk (× 200).

These observations complete those of Kölliker, and together enable us to give the following diagnosis of *Umbellula Güntheri*:—

The colony is provided with a thin, stiff stem. The upper part of the rounded stalk becomes a little thicker and quadrangular. The rachis is very thin and quadrangular, like the axis, which has concave sides and rounded edges. Just below the cluster of polyps the rachis expands and is laterally flattened. The secondary polyps are situated a little beneath the terminal polyp, five in a semicircle, leaving free a broad, dorsal space. The larger polyps are broad and cylindrical, with tentacles as long as the body. The zooids, distributed here and there on the thin part of the stem, are almost invisible and without any trace of tentacles. On the swollen upper part of the rachis they are large and wart-like, filling every interspace between the bases of the polyps. The sarcosoma is studded all over with tripennate spicules, which attain a length of 0·6 mm in the tentacles of the polyps, 0·75 mm in the walls of the polyps, and 0·25 mm in the stalk where they are covered with wart-like protuberances. The stem is yellowish white, the polyps grey with a brownish tinge. Habitat: Abyssal region of tropical Atlantic (and Pacific?).

Umbellula gracilis Marshall.

Pl., figs. 2 and 3.

On the eastern side of the Canaries, at Stat. 41 a complete colony belonging to the group with rounded axes was taken.

The total length is 574 mm, the lower 56 mm comprising the stalk which is 8 mm in diameter. The upper thinner part of the rachis is 1·5 mm broad, but expands about 57 mm below the top. Polyps occur 27 mm higher up, and when expanded are 21 mm long and 4·5 mm broad, their tentacles attaining a length of 18 mm. The proportion between stalk and rachis is 1 : 8·8.

The stalk is almost cylindrical, ending in a short cone; there is no distinct expansion. Numerous zooids appear 56 mm above the base, and we must therefore draw the upper limits of the stalk at this point. The rachis gradually decreases in breadth, till, some 50 mm below the polyps, it attains its smallest breadth. Here the stem is bent in a wide curvature and the cluster of polyps is thus pendulous. The larger polyps are slender and cylindrical, with pretty long tentacles. The pinnules of the tentacles are all of one size.

The arrangement of the polyps does not seem to be very regular. A terminal polyp is found in the cluster at the top of the rachis; although the position is characteristic, we find no trace of the axis, either in the wall of the polyp or at its base. — In a circle round this terminal polyp we find 7 secondary ones; the next 9 polyps compose an almost indiscernible circle. The last 8 polyps, which are situated proximally to the circles mentioned, show no distinct arrangement in rings. At first we do not see any bilateral arrangement of the polyps. Nevertheless a careful examination shows that the proximal six polyps are located in three pairs, leaving free a rather broad dorsal space. Higher up secondary polyps have also budded out in the median dorsal line, thus obliterating the bilaterality.

The zooids fill every interspace between the crowded polyps, where, as well as in the swollen upper part of the rachis under the cluster, they are large and distinct, but it is only with the utmost difficulty that they can be traced in the thinner part of the stem. Here and there we see a tiny threadlike tentacle, but in most of the zooids it is missing. It seems as if the zooids of the thinner parts of the rachis were located on the ventral sides; on the dorsal sides none could be discovered. Towards the stalk, where the rachis again attains greater dimensions, the zooids become more visible, and are located all round the stem. They do not, however, again attain the dimensions of those in the expanded upper part of the rachis.

The sarcosoma contains no spicules with the exception of the characteristic elliptic calcareous corpuscles in the inner layers of the stalk, which are found in all Pennatulida.

It might at first be supposed that the colony above described should be referred to a new species. Among the Atlantic species of *Umbellula*, we have, according to JUNGERSEN[1]) only two species without spicules, viz. *Umbellula Lindahli* Kölliker and *Umbellula encrinus* (Lin.). These species have quadrangular axes. Among the synonyms of *Umbellula Lindahli*, JUNGERSEN placed *Umbellula gracilis* Marshall, though this species from the warm area of the Faroe channel[2]), is said to have a rounded axis. I do not agree with JUNGERSEN, but am inclined to consider the species described by MARSHALL as identical with the one represented here, the only difference being that MARSHALL's younger colony had an indistinctly quadrangular terminal dilated part. I therefore separate *Umbellula gracilis* from the synonyms of *Umbellula Lindahli* as a distinct species, the diagnosis being as follows: —

"The colony is provided with a slender and flexible stem. The stalk is cylindrical or indistinctly quadrangular. The rachis tapers off gradually, till it attains its minimum diameter a little below the cluster, where it is so bent as to make the polyps pendulous. The rachis and axis are both round. The numerous polyps are arranged in a dense cluster, which appears to be indistinctly bilateral; the axis of the expanded upper part of the rachis cannot be seen externally. One or two circles of secondary polyps can be traced round the terminal one. The polyps are cylindrical and slender with tentacles shorter than the body. The zooids are crowded all round the swollen lower part of the rachis; higher up they are apparently located in lateral series, and are again numerous on the expanded upper part, where they are larger and fill every interspace between the bases of the polyps; they have a thin tentacle, often with pinnules. Spicules are wanting except for the elliptic corpuscles in the inner layers of the stalk. — The stalk is (when preserved) yellowish brown, the thin rachis yellowish white, the polyps dark bluish or greyish brown. — Habitat: Abyssal region of the Atlantic Ocean (warm area).

Pennatula aculeata Danielssen.

This species was taken by the "Michael Sars" on both sides of the Atlantic, at the southern edge of the Newfoundland bank (Stat. 70) and on the Atlantic slope southwest of Ireland (Stat. 95). The colony taken on the American side of the ocean measured only 54 millimetres in length, and must thus be characterized as a young colony, while the two specimens, taken at a great depth on the European side are large; the smaller one is 171 mm long, but the larger one is not entire.

An interesting study is furnished by the small number of larger dorsal zooids, especially in the large colonies from Stat. 95. Both in the small colony from Stat. 70 and in the larger ones from Stat. 95 we find about five small zooids on each side of the median line in the middle of the rachis; the number of larger zooids is also constant, and we find in the same place only two on each side of the median dorsal line. The agreement in the development and arrangement of the larger dorsal zooids in the two larger colonies would seem to speak in favour of their belonging to a separate form of the species. The larger dorsal zooids attain a greater length than the calyces of the polyps, as long as 3 or 4 mm. At the base of each leaf we find a very large zooid, which is situated in the same place as the larger dorsal zooids of *Pennatula rubra* Ellis.

All the same I cannot consider these characters sufficient for separating a new form or variant, in as much as JUNGERSEN[3]) describes or enumerates many intermediate stages between the variants here spoken of, and he points out that the larger dorsal zooids ("aculei") are more developed in the greater depths of the ocean. But as they increase in size they are reduced in number. We might therefore perhaps find it reasonable to speak of biophysically determined forms. On the other hand we find no natural limits which, in this case, might justify the separation of the two "forms".

The development of biophysically determined variants has caused us to distinguish them according to the depths at which they are found. But, at the same time, as the intermediate stages do not decrease in number, two separable groups of variants (i. e. "forms") cannot be distinguished in regard to habitat.

Remarks on biology and geographical distribution.

The observations made on board the "Michael Sars" concerning the phosphorescence of *Umbellula Güntheri* recall those made on board the "Challenger". These half-forgotten researches[4]) have passed unobserved by most recent investigators of the Pennatulida, but they give us some idea of the physical character of the light produced by these interesting and typical deep-sea animals, and I there-

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[1]) JUNGERSEN: l. c. 1904, p. 71.

[2]) MARSHALL: Report of the Pennatulida dredged by H. M. S. "Triton", Trans. Roy. Soc. Edin. Vol. 32, 1887, p. 142 plate XXV, figs. 29—35.

[3]) JUNGERSEN, l. c. 1904, p. 11.

[4]) WYWILLE THOMSON: Voyage of H. M. S. Challenger, The Atlantic, Vol. 1, 1877, p. 151.

fore quote them here:—"When taken from the trawl the polyps and membrane covering the hard axis of the stem[1]) were so brightly phosphorescent, that Captain Maclear found it easy to determine the character of the light by the spectroscope. It gave a very restricted spectrum, sharply included between the lines b and D."

In pl., fig. 1, the artist on board the "Michael Sars" has tried to give us an idea of the fascinating sight afforded by the colony taken at Stat. 47, which although drawn up from the immense depth of more than 5000 metres, was still brilliantly phosphorescent.

Niedermeyer[2]) has examined the phosphorescence of *Pteroeides griseum* (Bohadsch), and states that the phosphorescence is limited to darkness, the colony losing its capacity of producing light on being exposed to broad daylight or sunshine, regaining its luminary power on being removed from the light for some hours. These facts make it probable that the phosphorescence is due to chemicals, which are destroyed in daylight.[3]) As to the production of light, I cannot but agree with Niedermeyer, who believes that the phosphorescence is due to intracellular secretion. He states that the phosphorescence of *Pteroeides* is only to be seen after the application of external stimula, but I am more inclined to think that deep-sea animals may produce light without any external irritation.

Fig. 4. Map showing the distribution of the "Michael Sars" Pennatulacea.

+ *Veretillum cynomorium* (+ "Michael Sars" locality).
○ *Umbellula Güntheri* (⊙ "Michael Sars" locality. ? Doubtful locality.)
□ — *gracilis* (⊡ "Michael Sars" locality).
△ *Pennatula aculeata* (A "Michael Sars" locality).

The material brought home by the "Michael Sars" contains only five species of Pennatulida, one of which could not be identified with absolute certainty. Of the four others *Veretillum cynomorium* is a tropical and subtropical species generally found in the littoral area from the Bay of Biscay in the North, to Walfish Bay (South-West Africa) in the South, including the Mediterranean. The "Michael Sars" brought home a great many colonies from Cape Bojador, in the very centre of its extensive geographical range (see the accompanying map).

Pennatula aculeata was also found within its known range of distribution, both bathymetrical and geographical; it had already been recorded from 140 to 2300 metres, and the "Michael Sars" took it in 1100 and 1797 metres.

The new localities for the two species of *Umbellula* are of greater interest, all the more because we know very little about these deep-sea animals.

Umbellula Güntheri is a typical Atlantic organism previously reported from three localities. The "Challenger"[4]) took it near the equator (Lat. 1° 47′ N, Long. 26° 46′ W), and Verrill[5]) tells us that it has been found at two localities near the eastern coast of North-America. According to Studer[6]) *Umbellula Güntheri* occurs in the Pacific near Central-America (Lat. 4° 56′ N, Long. 80° 52′ 30″ E), but this needs further confirmation. The "Michael Sars" obtained this species at two stations to the west of the Canaries, the area of distribution being thus considerably extended towards the East (see the accompanying map).—The bathymetrical range, too, is greatly increased, the

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[1]) Niedermeyer's observations do not quite agree with this remark; he found that the phosphorescense was restricted to the polyps and the zooids. (Studien über den Bau von Pteroides griseum, Bohadsch, in: Arbeiten der Zool. Inst. Wien. Bd. XIX, 1911).

[2]) Niedermeyer: Op. cit., p. 59.

[3]) Some time ago my friend, the Norwegian geologist J. Oxaal drew my attention to this interesting probability.

[4]) Kölliker l. c. 1880, p. 19.

[5]) Verrill, Notice of the remarkable Marine Fauna occupying the outer banks off the Southern coast of New England, No. 9 (Amer. Journ. Science, Vol. 28) 1884, p. 219.

[6]) Studer, Note preliminaire sur les Alcyonaires: Report on the dredging operations by the steamer "Albatross" (Bull. Mus. Comp. Zoöl, Vol. 25) 1894, p, 57.

previous records lying between 3160 and 3710 metres, the lower limits being now extended to, at least, 5500 metres.

Umbellula gracilis was taken on the southern edge of the Faroe channel by the "Triton"[1]) at a depth of 1032 metres (555 fathoms), and by the "Michael Sars" on the eastern side of the Canaries in 1365 metres.

The information regarding these deep-sea animals is scanty, and although it may seem justifiable to assert that most of the species of *Umbellula* have a limited distribution,[2]) there is no denying the possibility that such a statement may be largely due to our defective knowledge of the abyssal region.

Trondhjem, May 13th, 1911.

Explanation of plate.

Fig. 1. *Umbellula Güntheri* from Stat. 48, natural size. Dorsal view of the living animal showing phosphorescence.

Fig. 2. *Umbellula gracilis* from Stat. 41, half size, lateral view.

Fig. 3. The same colony, showing the cluster of polyps from the other side, magnified.

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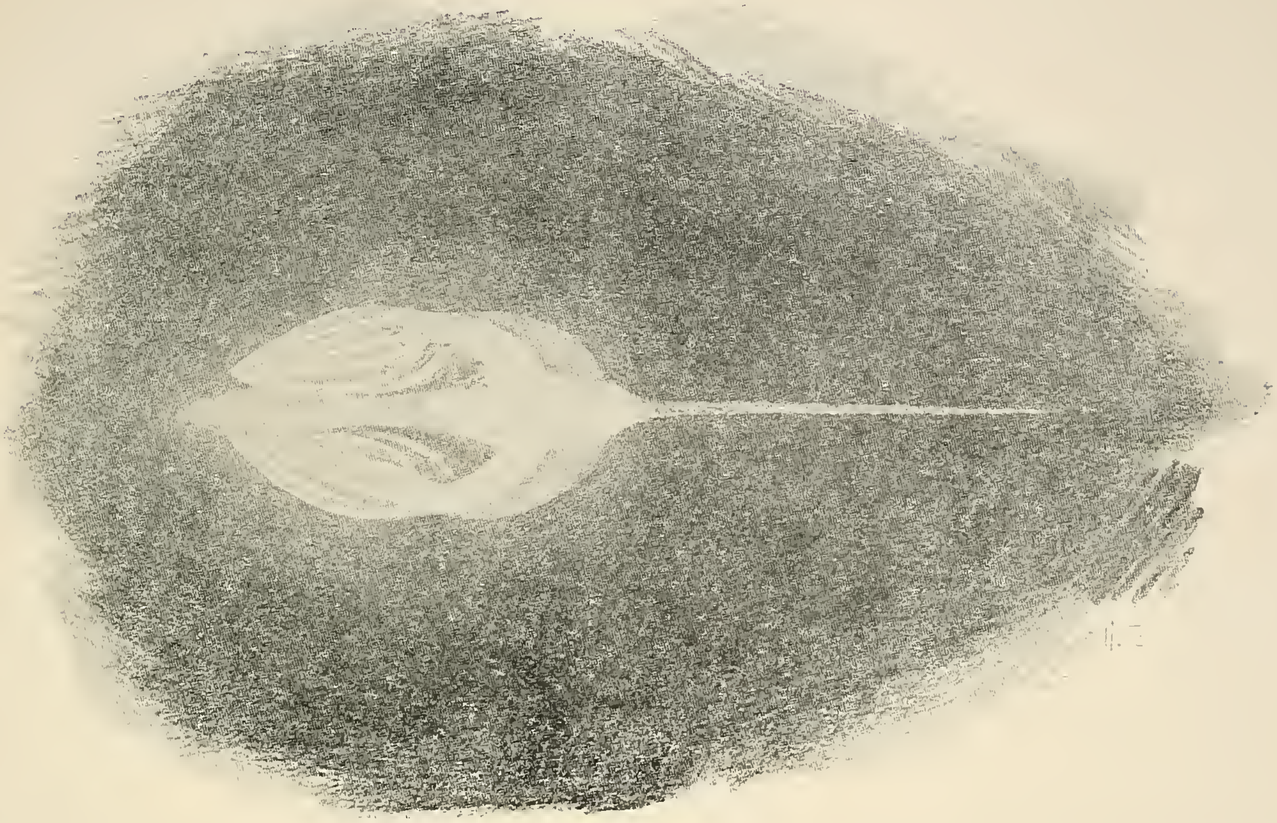
[1]) Marshall l. c. 1887, p. 142.

[2]) Kükenthal und Broch: Pennatulacea (Wiss. Ergeb. der deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia" 1898—1899. Bd. XIII, Lief. 2) 1911, p. 485.



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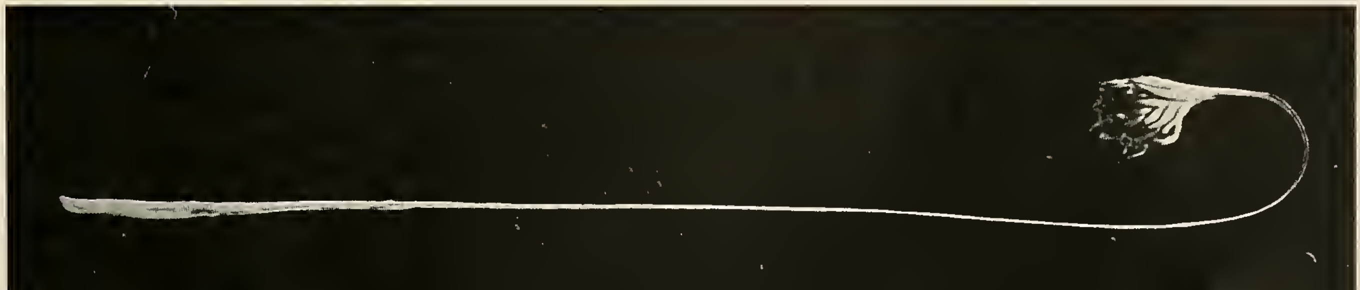

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3

HYDROIDA

FROM THE

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

BY

DR. HJALMAR BROCH

WITH 14 FIGURES IN THE TEXT

HYDROIDA.

The "Michael Sars" brought home some hydroids, taken partly in hauls with a young-fish trawl, partly on drifting sea-weeds. Though the collection is rather small it is of great interest, contributing as it does to our knowledge of the fauna of the subtropical eastern parts of the Atlantic, and to our understanding of the origin of the Sargasso fauna.

Regarding the system employed in the present paper, I must refer to the outlines given in my previous papers on Arctic[1]) and Adriatic[2]) hydroids. The "Michael Sars" material confirms the view defended in those papers: that a system based on the development of the gonophores is neither natural nor convenient, but only serves to disguise the true relationship of the hydroids.

A. ATHECATA.

Perigonimus M. Sars.

Perigonimus Jonesi Osborn and Hargitt.

Near Cape Bojador (Stat. 37) in 39 metres, many fertile colonies growing on *Nemertesia Hartlaubi*.

At first sight one might be inclined to refer colonies of this species to *Bougainvillia ramosa* van Beneden, to which they bear a close resemblance. A closer examination, however, reveals the folded perisarc surrounding the base of the contracted hydranths. The perisarc is very delicate, and is almost invisible in preserved specimens if the polyps are not contracted.

B. THECAPHORA.

THECAPHORA CONICA.

Plumularia Lamarck.

Plumularia setacea (Lin.) Lamarck.

West of Gibraltar (Stat. 20) in 141 metres, many fertile colonies growing on *Nemertesia ramosa*; Sargasso sea (Stats. 64 and 67), some sterile colonies on floating sea-weed.

The fertile colonies from Stat. 20 were bisexual like those from the Adriatic,[3]) and the arrangement of the male and female gonangia is the same, the former being found on the basal parts of the stem, the latter on the distal ones.

Plumularia catharina Johnston.

Sargasso sea (Stat. 67), some sterile colonies on floating sea-weed.

The ramification of the colonies is very interesting (fig. 1). The two basal hydrocladia are opposite, whereas the other branchlets are alternating. The stem is divided into irregular internodes. Two or three basal internodes are sterile, or only provided with nematophores.. The next internodes are separated by oblique nodes, and each of them carries one hydrotheca with its surrounding nematophores; the lower of these internodes is provided with the basal parts of two opposite branchlets, the others having only the base of one hydrocladium at the side of the hydrotheca. The distal parts of the stem are again divided into heterogenous internodes, every alternate one being provided with a hydrotheca and a hydrocladium, the intermediate ones only being furnished with nematothecae.

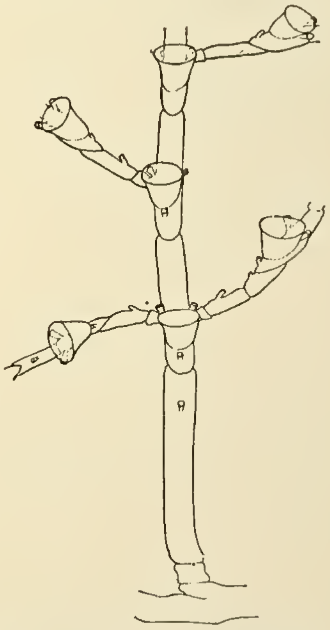

Fig. 1. *Plumularia catharina* from floating sea-weed at Stat. 67. (× 20).

At first sight we might believe that this mode of branching would suffice to separate these colonies from *Plumularia catharina*, which is generally said to have opposite branchlets, and we find that the species of the

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[1]) Die Hydroiden der arktischen Meere. (Fauna arctica, Bd. V). Jena 1909.

[2]) Hydroiduntersuchungen III. Vergleichende Studien an adriatischen Hydroiden. (Det kgl. norske videnskabers selskabs skrifter 1911). Trondhjem 1912.

[3]) Broch: Hydroiduntersuchungen III, p. 20.

Catharina-group are only separated by NUTTING[1] in regard to growth and branching. NUTTING calls attention to the fact that three species of the group, viz. *Plumularia catharina, Plumularia geminata* Allman and *Plumularia clarkei* Nutting, are closely related, and "may eventually be combined in a single species." No doubt, a fourth species of the group: *Plumularia alternata* Nutting, may also be included in *Plumularia catharina,* the variations in which are no greater than in most other species of the Plumulariidae.

Antenella Allman.

Antenella secundaria (Gmelin) Stechow.

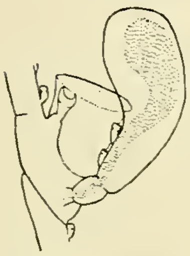

Fig. 2. Gonangium of *Antenella secundaria* from Stat. 37. (× 40).

Near Gibraltar (Stat. 20) a few sterile colonies growing on *Diphasia pinaster* from 141 metres. Near Cape Bojador (Stat. 37) in large quantities with gonangia from 39 metres.

HINCKS,[2] who considered this species to be a variety of *Plumularia catharina* Johnston, reports that its gonangia agree with those of the latter species, and BILLARD[3] mentions the gonangia as corresponding to the descriptions given by HINCKS; but as yet, no illustration has been given of *Antenella secundaria.* A female gonangium from Stat. 37 is shown in outline in fig. 2.

Nemertesia Lamouroux.

In my paper on Adriatic hydroids[4] I pointed out that a large sessile sarcotheca was found on the hydrocladial base in the corner between the branchlet and the stem. The same thing holds good in the representatives of the genus taken during the cruise of the "Michael Sars".

Nemertesia ramosa (Lamarck) Lamouroux.

Near Gibraltar (Stat. 20) some fragments of a sterile colony from 141 metres. Near Cape Bojador (Stat. 37) large quantities, with gonangia, from 39 metres.

The well-developed sessile sarcotheca of the hydrocladial base is seen plainly in fig. 3 *(s).*

Nemertesia ramosa exhibits great variations. Generally the colonies have several series of hydrocladia. Almost without an exception, the outer parts of the main branches are biserial in the colonies from Stat. 37, and in these parts the hydrocladia are inserted alternately; fragments of such colonies closely resemble colonies of *Plumularia.* The fragments from Stat. 20 demonstrate another and rather different phase of variation. Here the hydrocladia near the top of the main branches are placed in opposite pairs; as they are arranged spirally and at right angles to the preceding and following pairs, these parts of the colonies are provided with four series of hydrocladia. Farther down, the branch becomes 6-serial, three hydrocladia in a whorl, the whorls forming six series of hydrocladia.

Fig. 3. Hydrocladial base of *Nemertesia ramosa* from Stat. 37. (× 40).

Although the arrangement of the hydroclades is subject to striking variations, the arrangement of the hydrothecae as well as the nematothecae on the hydrocladia is rather constant. Now and then the distal nematophore of an internode with the distal nematotheca has been detached through a node, and looks like an inserted internode, but such anomalies are rare.

Nemertesia Hartlaubi (Ritchie).

Near Cape Bojador (Stat. 37) in 39 metres, enormous quantities with gonangia.

The stem and main branches are dark brown or almost black, showing only indistinct nodes. Near their upper (distal) ends the internodes carry three or four hydrocladia in a whorl; the hydrocladia are slender and of a whitish colour. The successive whorls form six or eight series of hydrocladia.—The hydrocladia are divided into unequal internodes, each alternate one provided with a nematotheca, the others having in the middle a small hydrotheca, at the mouth of which a pair of nematothecae are placed symmetrically, whereas the unpaired nematotheca is situated proximally in the mesial line of the internode. In the corner between the stem and the hydrocladial base we may observe a sessile sarcotheca (fig. 4, *s*), though owing to its very delicate and hyaline structure it is almost invisible in unstained colonies. The gonangia of both sexes (fig. 4 b) are ovate with a large oblique aperture at the summit; they are inserted at the base of the hydrocladia on the main branches.

This species shows great variation. In some parts of the colony there are three hydrocladia in a whorl, in others four. It is interesting to notice that, throughout

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[1] American Hydroids. I. The Plumularidae (Smithson. Institution, Special Bulletin). Washington 1900, pp. 60—62.

[2] A History of the British Hydroid Zoophytes. London 1868, p. 301.

[3] Hydroïdes (Expeditions scientifiques du "Travailleur" et du "Talisman"). Paris 1906, p. 207.

[4] Hydroiduntersuchungen III, p. 27.

its entire length of one foot or even more the same undivided branch almost without an exception shows the same number of hydrocladia in a whorl. Thus a branch which is hexastichous at the top is generally so where it branches off, but different branches of the same colony have very often different numbers of hydrocladial series.

A variable number of internodes is inserted between the hydrocladial base (the "hypophysis") and the first hydrothecate internode; these inserted internodes are often provided with nematophores, but as often the latter are wanting. Such basal internodes are hardly ever completely missing, and we often find one or two, but seldom three. No general rule, however, could be traced. Between two hydrothecate internodes, one nemetothecate internode may be inserted, or in a few cases two; in still rarer cases this latter may be entirely wanting.

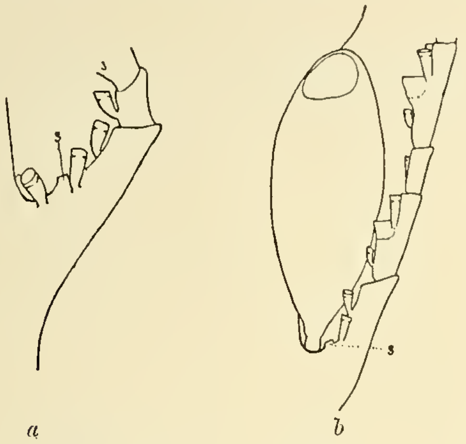

Fig. 4. *Nemertesia Hartlaubi* from Stat. 37. a: hydrocladial base (× 60); b. female gonangium (× 40).

This species has previously been mentioned only by Ritchie.[1] It is closely allied to *Nemertesia antennina* (Lin.), from which it is distinguished by the arrangement of its hydrocladia and its colours.

Nemertesia rugosa (Nutting)?

Near Cape Bojador (Stat. 38) in 77 metres, one small colony, which agrees on the whole quite well with Nutting's description.[2] The sarcotheca of the hydrocladial base (fig. 5, *s*) is more rounded and more strongly built than in most other species, but other differences make the identity of the colony uncertain. The hydrocladia are provided with strongly developed internodal septa, but their division into internodes is far more regular than described by Nutting. The internodes generally have two mesial nematophores and in the present specimen they have only one hydrotheca. Besides this, the length of the cauline processes which form the base of the hydrocladia, varies greatly.

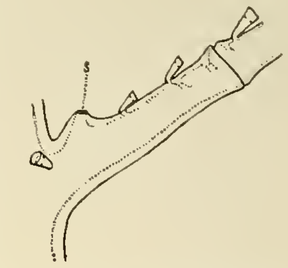

Fig. 5. *Nemertesia rugosa (?).* Hydrocladial base of a colony from Stat. 38. (× 60).

We are thus compelled to await further details about the American specimens of *Nemertesia rugosa,* before we can identify the "Michael Sars" specimen with certainty.

Aglaophenia Lamouroux.

Aglaophenia dichotoma (M. Sars) Kirchenpauer.

Near Cape Bojador (Stat. 37), a great many sterile colonies from 39 metres.

These specimens closely agree with those of *Aglaophenia elongata* Meneghini, from the Adriatic,[3] which, however, were only sparsely branched, whereas the rather slender stems of these colonies branch out luxuriantly and dichotomously.

Although the present species is probably identical with *Aglaophenia elongata,* I hesitate in referring it to the latter on account of the absence of gonangia. The hydrothecae (fig. 6, a) and the armature of the stem (fig. 6, b) agree with *Aglaophenia elongata,* and the Adriatic colonies show the same tendency towards the dichotomous branching so characteristic of the "Michael Sars" specimens. The

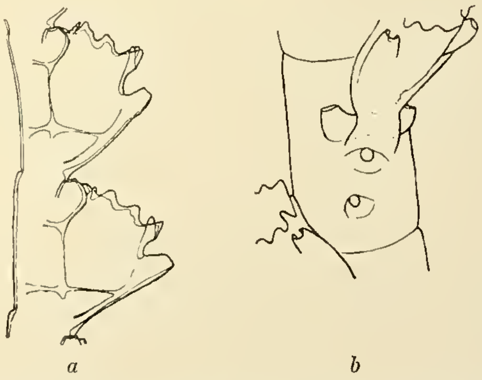

Fig. 6. *Aglaophenia dichotoma* from Stat. 37. a: Hydrotheca. b: portion of the stem showing the arrangement of the nematothecae on the internodium. (× 60).

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[1] Hydroids of the Scottish National Antarctic Expedition (Trans. Roy. Soc. Edinburgh, Vol. XLV) 1907, p. 542, pl. III, figs 4, 4 A and 4 B.

[2] American Hydroids. I Plumularidae, p. 70.

[3] Hydroiduntersuchungen III, p. 34.

small variations found in *Aglaophenia elongata* are also observed in the present colonies, but the marginal teeth of the hydrothecae are a little more prominent. The marginal teeth in some specimens show a tendency to break up into two, thus corresponding to the description of *Aglaophenia heterodonta* Jäderholm[1]) which is no doubt identical with the present species, and will most likely have to be united with *Aglaophenia elongata*. The distinguishing character of *Aglaophenia heterodonta*, viz. the alternate direction of the marginal teeth inwards and outwards in relation to the opening of the hydrotheca, is in somewhat larger colonies subject to such variations that it cannot be acknowledged as a specific character of importance.

Aglaophenia late-carinata Allman.

Sargasso sea (Stat. 64) abundant with gonangia on floating sea-weed.

The arrangement and the dimensions of the cauline nematothecae in *Aglaophenia late-carinata* completely agree with *Aglaophenia pluma* (Lin.) from the Adriatic.[2])

Fertile colonies of *Aglaophenia late-carinata* were apparently hitherto unknown, and the description will accordingly be given from corbulae found in the "Michael Sars" material which seem to be rather aberrant from corbulae previously described (see fig. 7). There is only a single hydrotheca between the corbula and the stem. The most striking feature of the corbula in *Aglaophenia late-carinata* is the prolongation of the outer, or in exceptional cases, of the next pair of leaves. The prolonged leaf is generally curved round the anterior edge of the corbula, and its free distal end often reaches down the opposite side of the corbula to the posterior edge, the entire leaf thus forming almost a complete circle. Now and again we find the leaf curved in such a way as to lie altogether on one side of the median plane of the corbula.

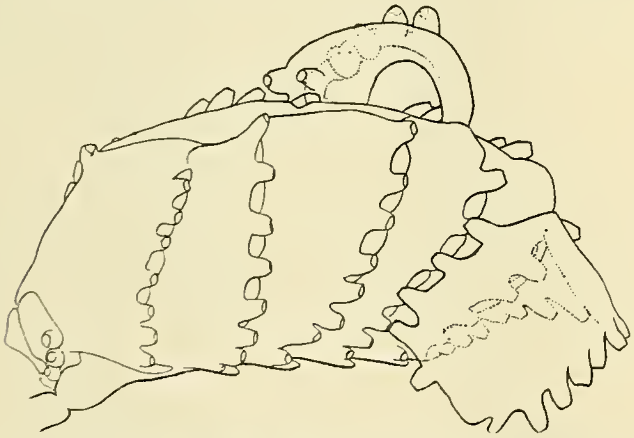

Fig. 7. Corbula of *Aglaophenia late-carinata* from Stat. 64. (× 40).

Aglaophenia septifera nov. nom (= *Aglaophenia Kirchenpaueri* Marktanner—Turneretscher 1890, nec Heller 1868).

Near Cape Bojador (Stat. 37) in 39 metres a few sterile colonies.

The dentition of the thecal margin very closely agrees with that of *Aglaophenia elongata* Meneghini, but the anterior pair of teeth generally far exceed the small mesial tooth in size, and are also larger than all the other marginal ones. Nevertheless the species is easily recognised on account of the anterior intrathecal septum, which extends like a roof, about half as high as the hydrotheca, covering more than the abcauline (anterior) half of its lumen (fig. 8, a). The arrangement of the cauline nematothecae (fig. 8, b) resembles that in the species of the *pluma*-group.

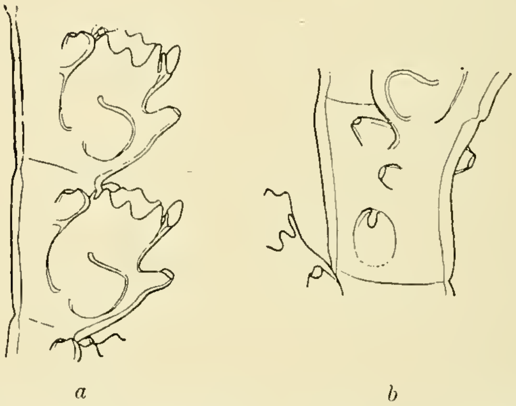

Fig. 8. *Aglaophenia septifera* from Stat. 37. a: hydrotheca; b: portion of the stem showing the arrangement of the nematothecae on the internodium. (× 60).

The present specimens doubtless agree with the *Aglaophenia Kirchenpaueri* of MARKTANNER-TURNERETSCHER.[3]) The specific name was already used in 1868 by HELLER[4]) for a species which is rather difficult to identify, but apparently identical with *Aglaophenia pluma* (Lin.); thus

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[1]) Aussereuropäische Hydroiden im schwedischen Reichsmuseum (Arkiv för Zoologi, Bd. 1) Stockholm 1903, p. 296, taf. 13, figs. 10—12, taf. 14, fig. 1.

[2]) Hydroiduntersuchungen III, p. 32.

[3]) Die Hydroiden des k. k. naturhistorischen Hofmuseums. (Annalen des k. k. naturhist. Hofmus. Bd. V) Wien 1890, p. 263, taf. VII, figs. 9 and 22.

[4]) Die Zoophyten und Echinodermen des adriatischen Meeres. Wien 1868, p. 40, taf. II, fig. 4.

in accordance with nomenclatorial rules the name of *Kirchenpaueri* must be dropped, and I have in a previous paper[1]) proposed the name of *septifera* on account of the characteristic intrathecal septum which so markedly distinguishes the species from the *pluma*-group.

Aglaophenia tubulifera Hincks.

Near Cape Bojador, abundant and fertile in 39 metres (Stat. 37); a single sterile colony from 77 metres (Stat. 38).

Fertile colonies of this species are easily recognised owing to the detachment of the basal pair of leaves which hang outwards and downwards, whereas the other leaves are coalesced so as to form the sides of the corbula. Only a single hydrotheca was found between the corbula and the stem.

The internodes of the stem are provided with only three nematothecae, a mesial one ventrally (anteriorly) near the proximal end of the internode, and a pair on the distal side of the hydrocladial base (see fig. 9, a, in which the hydrocladial base hides one of the paired nematothecae).

Two other species from the Atlantic must be regarded as synonyms of *Aglaophenia tubulifera*, viz. *Aglaophenia insignis* Fewkes, and *Aglaophenia elegans* Nutting. A first glance at the figures in Nutting's work[2]) seems to reveal very great differences, and we might from this be inclined to consider them as "good species". But a closer examination of further material shows every transition stage, and it is rather curious that the very characters which served Nutting as a basis in his separation of groups turn out to be the most variable characters of all. As a specific character Nutting uses the angle between the mesial nematophore and the hydrotheca. If we study a somewhat larger hydrocladium, we see that not only is this angle subject to great variations, but also that the variations follow easily distinguishable rules. The angle between the nematophore and the hydrotheca in the distal parts of the hydrocladium is acute (fig. 9, b), whereas it is more of a right angle the nearer we approach the base of the branchlet (fig. 9, c). Thus in specific diagnoses this character must be used with the utmost caution. Another character used in the separation of groups reads: "free portion of mesial nematophore longer than width of hydrotheca." A glance at figs. 9 b—e will soon convince us of the value of this character, which by the way is a gradual one, for the hydrothecae b, c, and d are from colonies budding on the same stolon, b and c from the very same hydrocladium.

It is probable that *Aglaophenia tubulifera* is the only species hitherto known from the Atlantic, having the proximal leaves of the corbula detached from the others and hanging outwards and downwards. Billard,[3]) who has studied the variations in this species and has had an opportunity of re-examining many of Allman's type-specimens,[4]) has proved the identity of *Aglaophenia filicula* Allman, with *A. tubulifera*.

In his excellent paper on the hydroids of the "Travailleur" and "Talisman" expeditions, Billard (l. c. p. 233) describes a variety of *Aglaophenia tubulifera* with extremely long nematophores. A single colony of this variety was taken by the "Michael Sars" (fig. 9, e), and intermediate stages between the variety and the typical *Aglaophenia tubulifera* seem to be very rare. I propose to name the aberrant form with long nematophores forma *Billardi* in honour of their discoverer, the form with short nematophores being regarded as the forma *typica*. Probably the degree of development of the mesial nematophore is due to the direct influence of biophysical factors, regarding which we are at present in the dark.

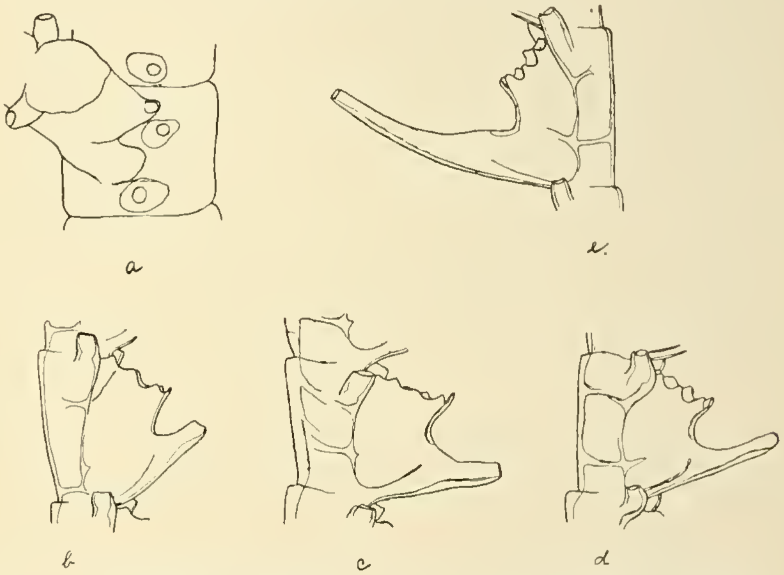

Fig. 9. *Aglaophenia tubulifera*. a: portion of the stem showing the arrangement of the nematothecae on the internodium; b—e: hydrothecae (see text). a—d from Stat. 37, e from Stat. 38. (× 60).

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[1]) Hydroiduntersuchungen III, p. 61.

[2]) American Hydroids I. The Plumularidae, plate XIX, figs. 3—7.

[3]) Hydroïdes (Expéd. scient. "Travailleur" et "Talisman"). Paris 1906.

[4]) Revision d'une partie de la collection des hydroïdes du British Museum (Ann. des. sci nat., Serie 9, Tom. XI). Paris 1910.

Thecocarpus Nutting.

Thecocarpus myriophyllum (Lin.) Nutting.

West of Gibraltar (Stat. 23) a single fertile colony from 1215 metres; near Cape Bojador (Stat. 38) a single sterile colony from 77 metres.

Cladocarpus (Allman).

Cladocarpus (?) Hjorti n. sp.

Near Gibraltar (Stat. 20) in 141 metres, some large sterile colonies.

Some colonies of a large Aglaopheniid apparently belonging to an unknown species, were taken at Station 20, but as they are destitute of gonangia, their position cannot be settled with certainty.

The slender colonies are very large, exceeding half a metre in height, and are only sparingly branched. The hydrocladia attain a length of 45 mm, and are inserted on the stem at intervals of 1 mm. or more. The greater part of the stem is composed of several tubes, but in the outer parts the fasciculation ceases, and the very top of each branch shows a monosiphonic hydrocaulus. The primary tube is provided with a single mesial row of large sessile nematothecae along its anterior (ventral) side (fig. 10); the nematothecae between the insertion of two successive hydrocladia vary in number from 2 to 7, or even 8. These ventral nematothecae give the hydrocaulus as seen from the side a curiously denticled appearance. Near the top (fig. 10, a) the first accessory tube *(t)* already appears covering the posterior (dorsal) side of the primary tube. Series of holes (fig. 10) are observed on each side of the posterior tube where the walls of the latter meet with those of the primary tube; the holes are connected with the lumen of the secondary tube as well as with the surrounding medium. A little farther down (fig. 10, b) these peculiarities are still more obvious, but it was impossible to see whether there were any nematocysts in the lateral holes or not.

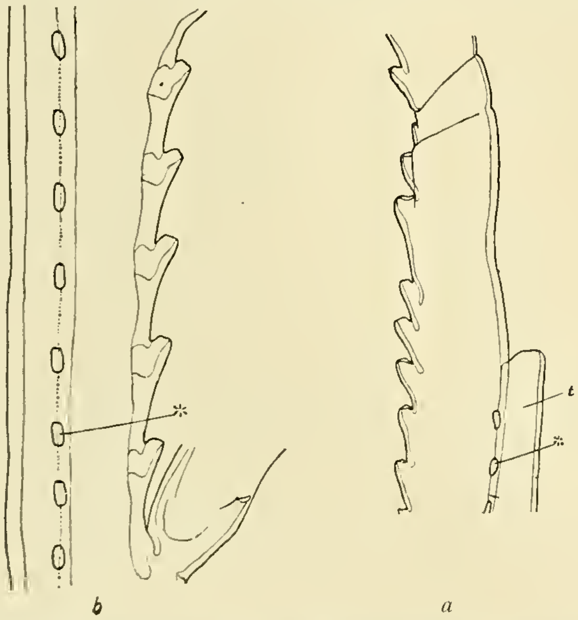

Fig. 10. *Cladocarpus (?) Hjorti* from Stat. 20. a: portion of the stem with the top of the first accessory tube *(t)*. b: portion of the stem farther down. Side view. * lateral holes of the accessory tube. (× 40).

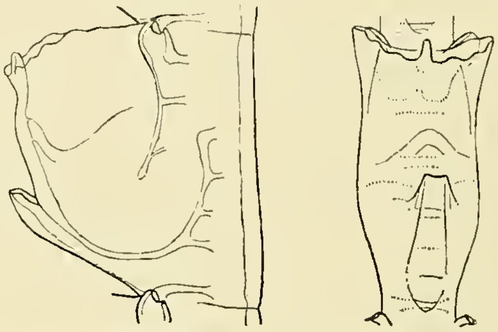

Fig 11. *Cladocarpus (?) Hjorti* from Stat. 20. Hydrotheca. (× 60).

The hydrocladia are inserted on the ventral side of the primary tube; they are directed upwards and outwards and diverge alternately to each side of the mesial plane of the colony. The hydrocladia are not in the lateral plane of the colony as in most other Aglaopheniidae, but are directed more ventrally (anteriorly) than laterally, a fact adding much to the slender aspect of the colonies. The hydrocladia are jointed, and each internode is provided with a hydrotheca and three nematothecae.

The hydrotheca (fig. 11) is very little compressed laterally. The margin is provided with a prominent, though rather slender, anterior tooth. Along the sides of the opening slight sinuations only are seen, and these disappear near the adnate posterior part of the hydrotheca. A thickening of the inner side of the thecal wall (an intrathecal ridge) in traced anteriorly almost midway between the top of the low mesial nematotheca and the margin of the hydrotheca. The supracalycine nematothecae are small.

The septal ridges vary in number. Generally we find two ridges at the base of the supracalycine nematotheca, and sometimes an indistinct third one is observed a little farther down the upper part of the posterior thecal wall. At the lower part of the thecal wall we find three to five septal ridges, besides a strong one at the proximal end of the internode. The adnate wall of the hydrotheca as seen from the side consists of two parts: a distal part terminating in the lumen of the hydrotheca, and a proximal or basal part, ending nearer to the posterior side of the hydrocladium, which is a direct continuation of the free anterior wall of the hydrotheca. A perforation of the anterior wall was not observed between the hydrotheca and the adnate portion of the mesial nematophore.

The construction of the adnate part of the thecal wall of this species closely resembles that of *Thecocarpus myriophyllum* (Lin.), and it is possible that we shall be obliged to place it in the genus *Thecocarpus.* On the other hand, the origin and arrangement of the nematothecae of the stem closely correspond to what ALLMAN[1]) has described in *Cladocarpus dolichotheca* Allman and *Cladocarpus ventricosus* Allman. I have therefore provisionally placed the species in the genus *Cladocarpus.*

Grammaria Stimpson.

Grammaria conferta (Allman).

West of Gibraltar (Stat. 23) two small sterile colonies from 1215 metres.

The upper parts of the colonies are monosiphonic, but the lower parts have accessory tubes, and thus we have a typical *Grammaria* with erect colonies.

The hydrothecae have no diaphragm. Their proximal parts are adnate to the tubes, and, indeed, the only difference from the species of *Filellum* is that the hydrothecae in the latter are more distinctly constricted where they join the stolons. This constriction is, however, indicated in *Grammaria conferta* too.

Grammaria (Filellum) serpens (Hassall).

Near Cape Bojador (Stat. 37) a few hydrothecae growing on an alga from 39 metres. At the southern edge of the Newfoundland bank (Stat. 70), a few hydrothecae growing on fragments of the axis of a gorgonid from 1100 metres.

KRAMP[2]) refers this species to the genus *Lafoëa,* pointing out that "the decumbent, growing part of the hydrotheca may be so short as to cause a great similarity with *Lafoëa dumosa,* and that the stem is creeping or nearly always so, is an insufficient generic character, especially among these forms where the erect stem is a rhizocaulus. Through *Lafoëa dumosa, Filellum serpens* is so closely related to the genus *Lafoëa,* that it should be included in the latter." But the similarity with *Lafoëa dumosa* (Flem) is only a superficial one. Where the hydrotheca of *Grammaria* (or *Filellum)* is adnate to the tube, no difference can be traced between the wall of the tube and that of the hydrotheca; they are in fact no more separable than they are in Sertulariids or Aglaopheniids. This character distinguishes *Grammaria* from the closely related genus *Lafoëa*, and therefore we cannot consider them as one genus.

Sertularella Gray.

Sertularella cylindritheca (Allman), Hartlaub.

Near Cape Bojador (Stat. 37) some sterile colonies growing on *Nemertesia Hartlaubi* from 39 metres.

Sertularia (Lin.).

Sertularia distans Lamouroux.

South of the Azores (Stat. 51) many sterile colonies on floating sea-weed; Sargasso sea (Stat. 67) abundant with gonangia on floating sea-weed.

Diphasia (L. Agassiz).

Diphasia pinaster (Ellis and Solander) Hincks.

West of Gibraltar (Stat. 20) in 141 metres, several large fertile colonies.

Diphasia attenuta Hincks(?)

A fragment of a robust colony from 39 metres near Cape Bojador (Stat. 37), seems to belong to this species.

THECAPHORA PROBOSCOIDEA.

Campanularia (Lamarck).

In this genus we must include some species of *Eucopella.* The diagnosis of the latter is as follows: "Die Polypenstöcke bestehen aus einer Hydrorhiza, von welcher unverzweigte Hydrocauli abgehen. Die Nährpolypen werden von becherförmigen Hydrotheken umschlossen. Die Medusen sprossen an verzweigten Polypostylen."[3]) In this diagnosis I can see no difference from the general features of the *Clytia*-group, like *Campanularia Johnstoni* Alder. On the other hand HARTLAUB[4]) points out that the form of the hydrotheca "keineswegs immer becherförmig ist, sondern nach von LENDENFELD's eignen Abbildungen, vor allem aber nach BALE ausserordentlich variirt

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[1]) Report on the hydroida collected during the exploration of the Gulf Stream (Mem. Mus. Comp. Zool., vol. V) Cambridge, Mass. 1877, pp. 50—52.

[2]) Report on the hydroids. (Danmark-Expeditionen til Grønlands Nordøstkyst 1906—1908, Bd. V). Kjøbenhavn 1911, p. 373.

[3]) VON LENDENFELD: Ueber Coelenteraten der Südsee (Zeitschr. wiss. Zool., Bd. 41) 1885, p. 658.

[4]) Die Hydroiden der magalhaensischen Region und chilenischen Küste (Zool. Jahrb. Supplement V, Plate, Fauna Chilensis, Bd. III). Jena 1905, p. 568.

und ganz wie bei *Silicularia* bilateral symmetrisch sein kann." In fact the first radially symmetrical species which has been referred to *Eucopella* is *Eucopella crenata* Hartlaub, and this species has been placed in the genus *Eucopella* on account of its unknown medusa.

We can find no better illustration of the impossibility of basing a hydroid-system on the gonophores than this. In the same admirable paper by Hartlaub (l. c. p. 556) he says about *Clytia Johnstoni* that "für ihr Vorkommen in der magalhaensischen Region sprechen die von Browne für die Falklands-Inseln beschriebenen Quallen-Genera *Phialidium* und *Phialella*." In *Eucopella crenata* we have another species of *Campanularia* which has been separated from its allies because it produces a hitherto unknown medusa; it has even been transferred to a genus which must be referred to the Siliculariidae, as it has bilaterally symmetrical hydrothecae, a fact hitherto not mentioned in the generic diagnosis. Probably the hydrothecae of the species of *Eucopella* may show the same microscopical structure as other Siliculariids and different from that of the Campanulariids.

Campanularia Johnstoni Alder.

South of the Azores (Stat. 51) common on floating sea-weed, with gonangia; Sargasso sea (Stat. 67) many fertile colonies growing on floating sea-weed.

At Stat. 51 interesting variations were observed in the gonangia; the gonothecae of the same colony may be annulated or almost smooth. In the same colony the marginal teeth of the hydrotheca may often vary from the typical pointed ones to the rounded teeth described by Nutting[1]) from Woods Hole (*"Clytia Grayi")*; the number of marginal teeth may vary greatly.

Campanularia simplex (Congdon).

Sargasso sea (Stat. 67), a few fertile colonies growing on floating sea-weed.

This species is no doubt identical with the variety of *Campanularia volubilis* described by Marktanner-Turneretscher.[2]) The specimens doubtfully identified by Billard[3]) as *Eucopella crenata* must also be referred to this species. Billard was in doubt as to their identity, because the gonangia were wanting; the gonangia indeed show that the specimens from the Atlantic Sargassum and *Campanularia crenata* Hartlaub are specifically different.

The rather long and strongly built stalks of the hydrothecae arise from creeping stolons; they are annulated at the base and under the hydrothecae, but the annulation generally disappears in the middle parts of the stalks. The rather thick-walled hydrotheca is obconical, or rather tubular, with a regularly crenulated margin. The length of the hydrotheca is about 0·5 mm. The gonothecae are very characteristic (fig. 12); they are almost at right angles to their very short stalks. The side next to the stolons is quite flattened, but the opposite side is strongly arched, and the gonangia thus closely resemble scale insects. Seen from above (fig. 12, a) they show an irregularly ovate contour, with a rather large distal aperture. The contents seem to consist of gonophores, which are liberated as free medusae.

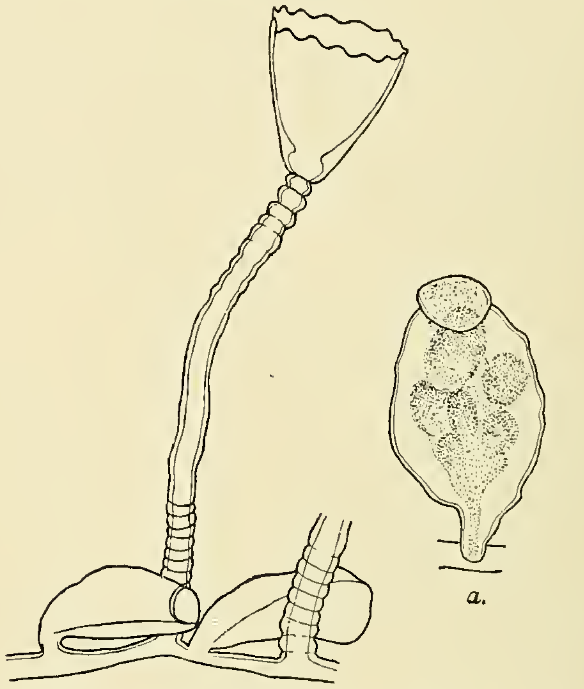

Fig. 12. *Campanularia simplex* from floating sea-weed at Stat. 67. a: Gonangium seen from above (× 40).

Campanularia Hincksi Alder.

Near Cape Bojador (Stat. 37) some small sterile colonies were found growing on *Aglaophenia tubuliformis*, *Nemertesia ramosa* and *N. Hartlaubi* from 39 metres.

Campanularia (?) mutabilis Ritchie.

Near Cape Bojador (Stat. 37) in 39 metres a few hydrothecae growing on sea-weed.

This species was first described by Ritchie[4]) from the Cape Verde Islands and the "Michael Sars" specimens (fig. 13) present only slight and unimportant differences from

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[1]) The Hydroids of the Woods Hole Region (U. S. Fish Commiss. Bull. for 1899). Washington 1901, p. 344.

[2]) Die Hydroiden des k. k. naturhistorischen Hofmuseums, p. 215, Taf. III, fig. 12.

[3]) Hydroïdes. (Expéd. scient. "Travailleur" et "Talisman"), p. 170.

[4]) On collections of the Cape Verde Islands marine faune . . . . The Hydroids (Proc. Zool. Soc. London 1907), p. 504, pl. XXIII, figs. 3—5.

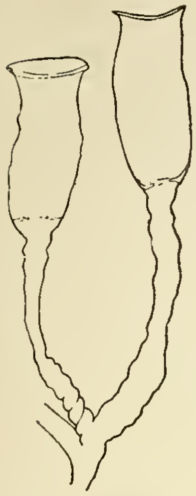

Fig. 13. *Campanularia (?) mutabilis* from Stat. 37. (×40).

Ritchie's colonies, the stalk being a little longer than the hydrotheca, and its middle parts only indistinctly and irregularly twisted; near the base, and just below the hydrothecae, the stalk is a regularly spiral.

Unfortunately both Ritchie's specimens and those taken by the "Michael Sars" are not sufficiently well preserved to allow of any closer examination of the polyp itself, so that we are unable to decide whether this species should really be referred to the Campanulariidae.

Laomedea Lamouroux.

Laomedea dichotoma (Lin.) Lamouroux.

Near Gibraltar (Stat. 20) in 141 metres, a small sterile colony. Near Cape Bojador (Stat. 37) a few sterile colonies growing on *Nemertesia Hartlaubi* from 39 metres.

Laomedea sargassi nov. nom. (= *Obelia hyalina* Clark 1879).

Sargasso sea (Stats. 64, 67 and 69) abundant with gonangia on floating sea-weed.

Sterile colonies of this species cannot be distinguished from *Laomedea fruticosa* Hincks, and in some cases the gonothecae of both species are so precisely of the same shape, that only their contents enable us to identify the colonies and separate the species. This ought to be a serious obstacle to investigators who try to hide the true relationship among the Campanulariids by dividing them into series of artificial genera merely on account of the contents of their reproductory capsules.

The shape of the gonothecae of *Laomedea sargassi* is subject to variations. Sometimes the gonothecae have the shape described by Clark,[1] with a broad aperture stretching across the entire, square, distal end, but in most cases they have the same shape as in our common representatives of the *Obelia*-group: *Laomedea geniculata* (Lin.), *Laomedea longissima* (Pallas), and *Laomedea dichotoma* (Lin.), the terminal part being provided with a short neck and with a narrow orifice, which occupies only one-third to one-half of the distal diameter of the capsule. Clark found only gonongia twice the length of the hydrothecae, but in the "Michael Sars" material they are often three times the length of the hydrothecae, or even a little more.

The name *Laomedea hyalina* being employed for a species belonging to the *Gonothyraea*-group, I have proposed the name *Laomedea sargassi*.

Laomedea bifurca (Hincks)?

A small sterile colony from 141 metres west of Gibraltar (Stat. 20) seems to belong to this species.

II. Remarks on geographical distribution.

The collections from the cruise of the "Michael Sars" in 1910 include representatives of two natural biological groups, namely hydroids from the bottom, and hydroids from floating sea-weed.

Hydroids From The Bottom were taken in the eastern parts of the Atlantic, partly a little to the west of Gibraltar, partly between Cape Bojador and the Canaries. Hydroids were met with at few stations; but in some of the catches they were very abundant.

Near Gibraltar the following species were obtained:

Plumularia setacea.
Antenella secundaria.
Nemertesia ramosa.
Thecocarpus myriophyllum.
Cladocarpus (?) Hjorti.
Grammaria conferta.
Diphasia pinaster.
Laomedea dichotoma.

All these species except two (*Grammaria conferta* and *Cladocarpus Hjorti*) have been met with in the Mediterranean. *Grammaria conferta* is a typical deep-sea hydroid.

Two exceedingly rich hydroid localities were investigated near Cape Bojador, one in 39, the other in 77 metres, the following species being obtained:

Perigonimus Jonesi.
Antenella secundaria.
Nemertesia ramosa.
„ *Hartlaubi.*
„ *rugosa?*
Aglaophenia dichotoma.
„ *septifera.*
„ *tubulifera.*
Thecocarpus myriophyllum.
Grammaria serpens.
Sertularella cylindritheca.
Campanularia Hincksi.
„ (?) *mutabilis.*
Laomedea dichotoma.
„ *bifurca?*

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[1] Reports on the Dredging Operations of the U. S. Coast Survey Steamer "Blake". III. Report on Hydroida (Bull. Mus. Comp. Zool. Vol. V) Cambridge Mass. 1879, p. 241, pl. IV, fig. 21.

With few exceptions the species have been found in the Mediterranean too. These exceptions are *Perigonimus Jonesi, Nemertesia Hartlaubi, Sertularella cylindritheca* and *Campanularia mutabilis,* not taking into consideration the doubtful specimens of *Nemertesia rugosa* and *Laomedea bifurca. Sertularella cylindritheca* seems to be a rather rare species in the eastern Atlantic, being hitherto recorded only from two localities by the "Travailleur" and "Talisman". *Perigonimus Jonesi* was previously recorded only from the western side of the Atlantic. *Nemertesia Hartlaubi* had only been obtained from the Suldanha Bay (Cape Colony), and *Campanularia* (?) *mutabilis* from the Cape Verde Islands.

The "Michael Sars" material confirms the opinion expressed in previous papers[1]) that the fauna of the Mediterranean has immigrated from the Atlantic, the concordance between the Atlantic and the Mediterranean faunas being far greater than that between the Mediterranean and the Indian Ocean faunas.

Our material shows furthermore that the faunistic differences between the eastern and western sides of the Atlantic may prove to be less important than hitherto supposed, but it is greatly to be desired that renewed investigations should be undertaken on the American side too.

The Hydroids of The Drifting Sea-weed

taken during the cruise of the "Michael Sars" belong to the following six species:

Plumularia catharina.
Aglaophenia late-carinata.
Sertularia distans.
Campanularia Johnstoni.
" *simplex.*
Laomedea sargassi.

Plumularia catharina and *Campanularia Johnstoni* afford little assistance in answering the question as to the origin of the Sargasso fauna, because they are widely distributed as bottom-animals.

Of the remaining four species we know that *Sertularia distans* and *Laomedea sargassi* live as bottom-animals in the West-Indies and round the Azores, whereas *Aglaophenia late-carinata* and *Campanularia simplex* are predominant inhabitants of the floating sea-weed round the West-Indies, and have also been recorded from the Mexican Gulf. These data give us an idea as to the geographical origin of the Sargasso hydroid fauna. The hydroids of the Sargasso sea have been carried with the drifting sea-weed from the tropical parts of the Atlantic, especially from the West-Indies, possibly also to some extent from the Azores. The colonies are carried away from these places as fixed stages; larval transport does not seem to play any important part in this connection.

The characteristic hydroids of the drifting Sargasso weed are, after all, confined within narrow limits, fixed by small hydrographical differences; the Sargasso hydroids generally do not enter the Norwegian Sea except such rather cosmopolitan forms as *Campanularia Johnstoni* and *Plumularia catharina,* which must be regarded as typical southern guests in Norwegian waters. It will in this connection be of interest to give some of the results of previous investigations, especially of the "Michael Sars", as to

The Occurrence And Distribution Of Southern Hydroids In The Norwegian Sea And The North Sea.

The general faunistic features of Norwegian waters, and especially those of the arctic regions, have been the subject of several treatises of later days. Recently APPELLÖF[2]) gave a review of the principal results as regards the bottom-animals of the Norwegian Sea and the North Sea, but the special forms of the warmer waters of the Atlantic (the "lusitanic" forms) were only incidentally mentioned, whereas the arctic and subarctic ("boreal") animals were discussed thoroughly. The lusitanic factor plays a great and interesting part in the general features of Norwegian waters, and GRAN[3]) paid great attention to it in his fundamental work on the plankton of the Norwegian Sea.

If we attempt to trace the occurrence of lusitanic bottom species in the Norwegian Sea, we soon discover that our knowledge is very deficient in regard to the continental edges along the Norwegian coast, especially to the north of Stat. The accompanying map (fig. 14) showing the distribution of many southern hydroids verifies this fact, for it includes all the species of Plumulariidae and Aglaopheniidae, which must be regarded as warm water forms, recorded from Norwegian waters. We should not expect the rather sporadic occurrence of these numerous species, which have been the object of special study, particularly by the two investigators M. and G. O. SARS. The map contains sufficient data to give a good idea of the general features of the distribution of atlantic hydroids in Norwegian waters. Like southern planktonic animals the southern bottom animals are mainly confined to the Atlantic, and limited

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[1]) KÜKENTHAL und BROCH, Pennatulacea (Wiss. Ergebn. d. deutschen Tifsee-Exped. "Valdivia", Bd. XIII) Jena 1911, p. 469. BROCH, Hydroiduntersuchungen III, p. 63.

[2]) Havbundens dyreliv (Norges fiskerier. I. Norsk havfiske). Bergen 1905.

[3]) Das Plankton des norwegischen Nordmeeres (Report. Norw. Fish- and Mar. Invest. Vol. II). Bergen 1902.

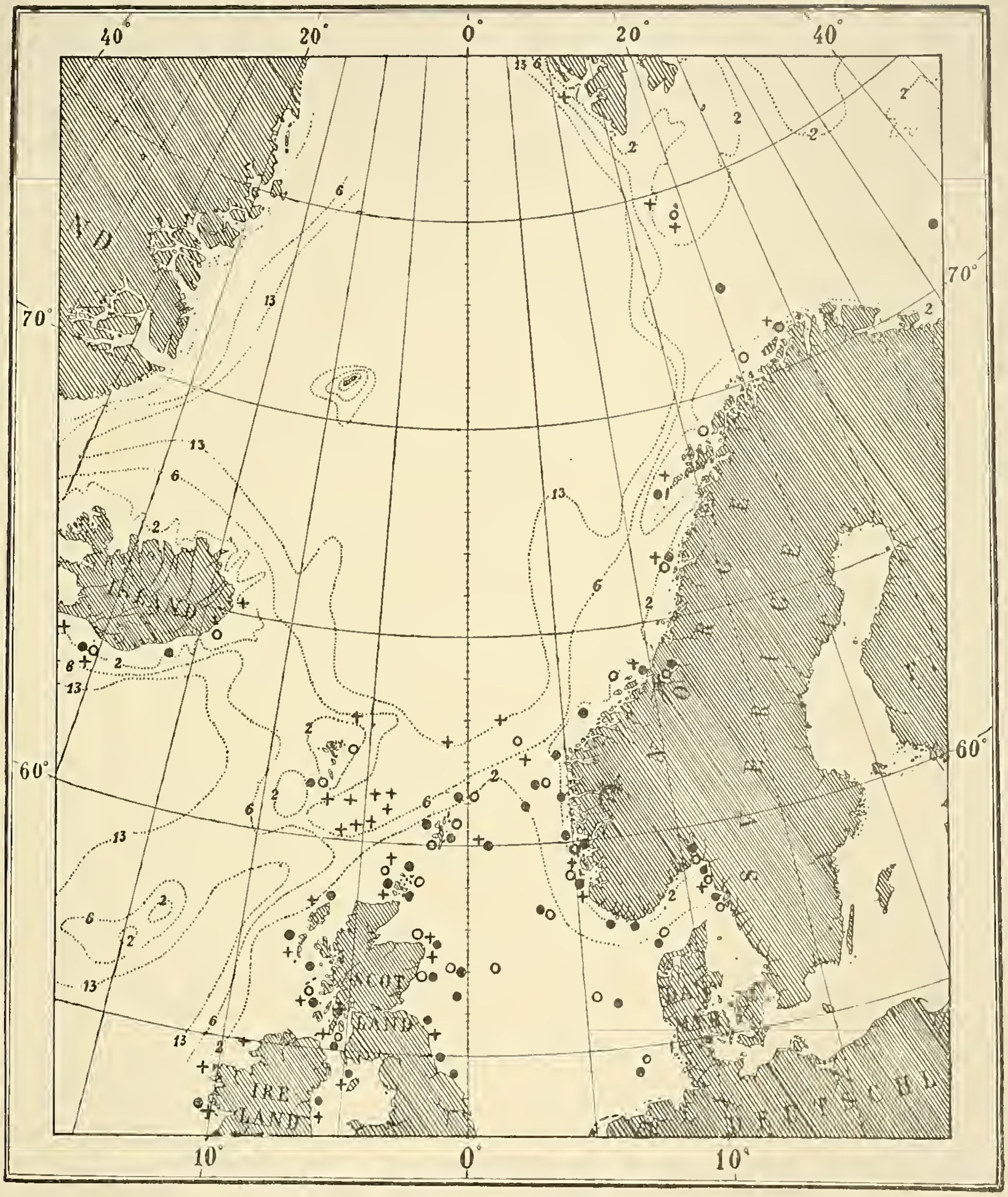

Fig. 14. Map showing the distribution of southern hydroids in the Norwegian Sea and North Sea.
● *Plumularia* and *Schizotricha*. ○ *Nemertesia*. + *Aglaopheniidae*.

by arctic water. Near the Faroe-Channel, where the warmer waters of the Gulf-Stream enter the Norwegian Sea, the records are clustered together, and this would doubtless be the case also along the coasts of Ireland and Scotland, had the authors given detailed localities instead of vague statements, such as "west coast of Ireland", "coasts of Scotland below tide-mark", etc., which could not be utilised in preparing the map.

At the mouth of the submarine channel along the west coast of Norway the localities are also rather densely crowded, as well as in the Trondhjemfjord, where atlantic or lusitanic species occur in such quantities as are absolutely unknown at any other point of the Norwegian coasts. — The northernmost localities situated along the continental edges where the Murman Sea borders the deep basin of the Norwegian Sea are of greatest interest to us.

We find here a few straggling records along the wide expanse from North Cape to the western coast of Spitzbergen, and there is a single record in the far East of the Murman Sea.

A general view of the localities (see fig. 14) shows that the distribution of the southern hydroids follows the course of the Gulf Stream, not because other territories have not been investigated, for such localities as the waters round Spitzbergen, Bear Island and Jan Mayen have been studied very thoroughly, and B. Sæmundson has made known the hydroid fauna of the coasts of Iceland, while the "Michael Sars" brought home much material from the ridges between the Faroe Islands and Iceland. The absence of southern hydroids is due to the predominant influence of arctic waters round Jan Mayen, along the northern coast of Iceland, and along the north-eastern sides of the ridges between the Faroes and Iceland.

On the other hand we see that the southern fixed animals like the hydroids are not absolutely limited to the warm waters of the Atlantic. Perhaps their occurrence outside the strictly Atlantic layers may be due to submarine waves at the lower boundaries of the Gulf Stream. Certain forms may have fixed themselves to the bottom while covered by Atlantic water, and then been submerged in arctic water; but this cannot hold good in all cases, especially as regards the Aglaopheniids, which occur too far down in the cold layers for the warmer Atlantic waves to reach them.

The question arises: How do such exotic forms get down so far into a foreign realm? I am inclined to believe that Appellöf is right, when he says[1]) that the Norwegian Sea was mainly populated by southern animals (fixed or nearly stationary) through transport of the larvae, and that the same process is still going on. The duration of the free-swimming stages of the Plumulariids and the Aglaopheniids seems to be very short, but it may be sufficiently long for transport to some distance, and the larvae may sink to the bottom far from the warm Atlantic waters. Most of these erratic larvae soon perish in the icy bottom layers of the Norwegian Sea, but the resistant power of many hydroids enables them to develop even under such unfavourable circumstances. Whether they can produce young capable of existing there is questionable, for if so we might expect that some Aglaopheniids or Plumulariids would have become constant members of the strictly arctic fauna, but as far as we are aware at present, this is not the case.

The distribution of the Plumulariids must be considered in connection with boundaries between the Atlantic current and the coastal water. Layers of coastal water seem to be no absolute obstacle for many Plumulariids, although some species, of course, are more sensitive than others. *Plumularia pinnata* (Lin.) thrives even in the brackish waters near Drøbak on the Kristianiafjord at a depth of 5 metres, so that we must assume that differences in temperature arrest its progress to the North and East along the Norwegian coasts.

Among the territories adjoining the Gulf-Stream, the North Sea plays an interesting part, especially as to the occurrence of the Plumulariids. On his review of the results obtained during the cruises of the "Michael Sars"[2]) Appellöf points out that there is "a peculiar faunistic area in the central portion of the North Sea which is characterized by water of a lower temperature and with less distinct movements of the Atlantic water, and which, in accordance with these features, possesses a fauna of a different character from what is to be found in the Atlantic water. In this area there is a striking absence of several forms which are found in Atlantic water on the northern portion of the North Sea plateau." Among the exceedingly rare forms, we must include both the Aglaopheniids and the Plumulariids. These warm water forms are found along the eastern and western sides of the North Sea, but in the southern parts their occurrence is very sporadic, apparently because of the low salinity and the shallowness of the water.

Wherever the Atlantic waters enter our regions of the ocean, they are accompanied by warm water hydroids; thus we find them along the coast of Bohuslän, having passed through the submarine channel along the western and southern coast of Norway. It is of great interest to notice that while the main factor in populating the Sargasso sea, is the transport of fixed individuals attached to drifting sea-weed, the progress of Atlantic animals in Norwegian waters is chiefly due to transport of free-swimming larvae.

Trondhjem, March 11th, 1912.

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[1]) Havbundens dyreliv, p. 114.

[2]) Review of Norwegian Fishery and Marine Investigations 1900—1908 (Report Norweg. Fish. and Marin. Invest. Vol. II), Bergen 1909, p. 85.

MURAENOID LARVAE

FROM THE

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

BY

EINAR LEA

WITH 6 PLATES AND 38 FIGURES IN THE TEXT

Contents.

I. Introduction.

During the "Michael Sars" deep-sea expedition in 1910 some specimens of leptocephalids (larval muraenoids) were caught. They belong to rather many different species (26 in all) and it proved difficult to decide, which of them are new to science because so many descriptions of leptocephalids are imperfect in omitting to state the number of muscle-segments. Prior to Grassi's and Calandruccio's epoch-making investigations in regard to the larvae of eels and their metamorphosis, the descriptions of leptocephalids were mainly based upon various dimensions of the body, dentition etc., but as these characters are subject to great variation, they will not suffice for the determination of species. We find an empiric proof of this in Grassi's table in regard to the connection between larval and adult muraenoids.

It is evident from this table[1]) that larvae of the very same adult form have been described under as many as six different names due to the fact that height of body, situation of anus, presence or absence of fin-rays, etc., have been regarded as specific characters. C. H. Eigenmann and C. H. Kennedy (9) have in consequence erred in describing as *Leptocephalus Congri vulgaris* a form which evidently does not belong to this well-known species. Similarly Strömman (33) has described a new form which, according to Dr. Johs. Schmidt (29) who has examined Strömman's type specimen, is identical with the larva of *Congromuraena balearica.* The larva of this eel had previously been described under the name of *L. taenia*, *L. inornatus* and *L. diaphanus.*

Guided by such considerations I have deemed it justifiable to adopt the following principle in naming the species here described: a species is regarded as new when it differs from all species formerly described where the number of muscle-segments is stated.

The name *Leptocephalus*, which according to the rules of priority should be applied to the genus *Conger*, has in this paper been employed as a sort of provisional name for muraenoid larvae, as it is used for instance by Dr. Johs. Schmidt. Those larvae whose parent forms are known have been given the names of the adults (like *L. Congri vulgaris*).

As supplementing the short descriptions we give reproductions of photographs and drawings, taken shortly after the "Michael Sars" returned from the Atlantic.

Formaldehyde (4 %) was used as a preserving fluid during the cruise, but as some of the larvae had become swollen and damaged they were transferred to a fluid composed of 3 parts of alcohol (96 %), 3 parts of formaldehyde (3 %), and 2 parts of glycerine, in which most of the larvae have kept very well.

As for the literature consulted, little attention has been paid to works, in which the species are mentioned without giving the number of segments, many of them especially in Italian are difficult to obtain, and I have had to content myself with what I could find in the libraries of Bergen and Christiania. Those wishing further information, may be referred to the following:—

J. V. Carus: Ueber die Leptocephaliden. Leipzig 1861 (for older literature).

P. H. Strømman: Leptocephalids in the University Zoological Museum at Upsala. Upsala 1896.

Johs. Schmidt: Contributions to the Life-History of the Eel (*Anguilla vulgaris*, Flem.). Rapports et Procès-verbaux du Conseil Permanent International pour l'Exploration de la Mer. Vol. V. Copenhagen 1906.

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[1])

Leptocephalus stenops (Bellotti) in part, also *L. morrisi* and *L. punctatus*	*Conger vulgaris*
— *hæckeli, yarrelli, bibroni, gegenbauri, köllikeri, stenops* (in part)	*Congromuræna mystax*
— *taenia, inornatus, diaphanus*	*Congromuræna balearicus*
— *kefersteini*	*Ophichthys* sp. divers.
— *longirostris. Hyoprorus messinensis*	*Nettastoma melanurum*
— *oxyrhynchus* etc.	*Saurenchelys cancrivora*
— sp. nov.	*Muræna helena*

In the following brief descriptions, the principal stress has been laid on the number of segments, which must be considered the chief character in comparing leptocephalids among themselves, and in referring leptocephalids to their parent forms. This single character, however, does not always suffice either one way or the other, for we find that different species of eel have about the same number of segments (vertebrae), and that the number of segments in different individuals of the same species may vary, so that sometimes it is impossible to determine a species, or to refer a larva to its parent form on the basis of the number of segments alone. I have therefore found it necessary to include other characters, such as the number of rays in caudal fin, in some cases also the number of rays (interspinous elements) in the vertical fins, etc. On the other hand the measurements of the proportions of the body may not be diagnostically important, although occasionally we can make use of them in order to compare larvae of the same species in different developmental stages. These measurements have been made for the purpose of studying the variations in the development of the larvae. In some cases it has been possible to study some features of this developmental variation, where the material included different stages of development or other developmental stages than those previously described.

The descriptions will thus make it possible 1) to distinguish the different species of larvae from one another (number of segments, etc.), 2) to distinguish between the different stages of development of the same species (dimensions of body, development of nostrils and fin-rays, number of teeth, etc.), and 3) to refer the larvae to their parent forms (number of segments and fin-rays, etc.).

At present the last-mentioned determination is possible only in a few cases, one reason being that the number of vertebrae in many of the adult forms is unknown. I have found accounts of the number of vertebrae in the following species:

Muraenoids whose segments are counted.

The numbers given are the lowest and highest found, and reference is made to those authorities, were these extreme values are found. Species, which are not found in the Atlantic, are distinguished by asterisks.

Name	Number of segments	Authority
I. Species, the larval forms of which are known.		
Cyema atrum Günther	73	Autor
larva: *L. Cyematis atri*.......	75—77	—
Anguilla chrysypa (*rostrata*) Raf....	103—113	Petersen (23)
larva: *L. Grassi* Eigenmann and Kennedy	105—108	Eig. a. Kenn. (9)
Anguilla vulgaris Turt.	111—119	Schmidt (24) Petersen (23)
larva: *L. brevirostris* Kaup	111—119	Schmidt (24) Autor
Congromuraena balearica de la Roche	about 130	Schmidt (28)
larva: *L. taenia*, *inornatus*, *diaphanus*	123—137	Autor
**Chlopsis bicolor* Raf..............	133	Supino (33)
larva:	131—136	Schmidt (29)
Congromuraena mystax de la Roche	about 138	— (28)
larva: *L. Haeckeli*, *Yarrelli*, *Bibroni*, *Gegenbauri*, *Köllikeri*, *stenops* (*in part*)	132—147	Autor
Muraena helena Lin.	139—143	Grassi (16)
larva:	140—143	— (16)
Synaphobranchus pinnatus Gronov.	146—151	Schmidt (26)
larva: *L. Synaphobranchi pinnati* Schm.	144—157	Autor
Conger vulgaris Cuv..............	153—164	Smitt (32) Day (7)
larva: *L. stenops* (*in part*), *Morrisii*, *punctatus*	156—159	Autor
Ophichthys serpens Lin............	208	Bellotti (3)
larva:	?	Schmidt (30)
**Saurenchelys cancrivora* Ptrs.	> 200	Supino (34)
larva: *L. oxyrynchus* Bell.	240—249	Bellotti (3), Autor
Gastrostomus Bairdii Gill a. Ryder	110	Zugmayer (37)
larva: *L. Gastrostomi Bairdii*.	> 108	Autor
II. Species, whose larval stages are not yet identified.		
Muraenesox coniceps Jord. a. Gilb.	111	Jord a. Dav. (21)
Echidna catenata Bleek.	116	Günther (19)
Gymnothorax meleagris Shaw.....	120	— (19)
— *nebulosus* Bl.	122	— (19)
**Echidna cocosa* Garm.		
* — *nebulosa* „		
* — *scabra* „	123	Garman (12)
Moringua raitaborua Ham.........	126	— (12)
Gymnothorax undulatus Lacép.....	126	— (12)
Histiobranchus infernalis Gill	130	Günther (19)
Ilyophis Brunneus Gilb............	127—132	— (19)
Ophichthys ocellatus Les.	132	Autor
**Echidna zebra* Bleek.	132	—

Name	Number of segments	Authority
Gymnothorax unicolor de la Roche	134	Jord. a. Dav. (21)
	135	Günther (19)
Ophichtys Gomesi Casteln.	136—140	Günther (19),
Gymnothorax ocellatus Agaz.......		Grassi (16)
— *moringa* Cuv........	141	Jord. a. Dav. (21)
**Conger marginatus* Val.	142	— (21)
Serrivomer sector Garm...........	144	Günther (19)
**Muraenesox cinereus* Forsk.......	145	— (19)
**Ophichthys frontalis* Garm........	149	Autor
**Xenomystax rictus* Garm.	154	Günther (19)
Gordiichthys irretitus Jord. a. Davis	157	Garman (12)
	173	— (12)
	225	Jord. a. Dav. (21)

III. Larval forms, not identified.

Name	Number of segments	Authority
Leptocephalus similis..............	110	Autor
— *Holti* Schm..........	112	Schmidt (26)
— *diptychus* E. and K. .	122	Eig. a. Kenn. (9)
— *euryurus*	116—117	Autor
* — 1) *obtusus* Garm	119	Garman (12)
— *dentex* Cantor.......	about 120	Collett (6)
— *rex* E. and K........	119—123	Eig. a. Kenn. (9)
* — 1) *dentatus* Garm.......	121	Garman (12)
— *amphioxus* E. and K.	122	Eig. a. Kenn. (9)
— *spinocadux*	125	Autor
— *Michael-Sarsi*	127	—
— *caudomaculatus* Eig. and Kenn.	133	Eig. a. Kenn. (9)
— *mysticus*	about 127	Autor
* — 1) *cingulus* Garm.......	131—133	Garman (12)
— *dolichorhynchus*	128—136	Autor
Leptocephalus latus E. and K.	133	Eig. a. Kenn. (9)
— *Histiobranchi infernalis or Ilyophidis Brunnei*	133—134	Autor
— *splendens*	135	—
* — 1) *acus* Garm..........	135	Garman (12)
— *Gilli* E. a. K.	137	Eig. a. Kenn. (9)
* — 1) *cinctus* Garm........	138	Garman (12)
* — 1) *longidens* Garm......	140	— (12)
— *Strömmani* E. a. K. .	141	Eig. a Kenn. (9)
— *thorianus* Schm... .	142	Schmidt (26)
— 2) *Morrisii* E. a. K.....	142	Eig. a. Kenn. (9)
— *mucronatus* E. a. K..	141—147	— (9)
— *megacara*	149—150	Autor
* — 1) *falcidens* Garm.	about 153	Garman (12)
— *ingolfianus* Schm....	153—155	Schmidt (28)
— *discus* E. a. K.......	155—159	Eig. a. Kenn. (9)
— *lanceolatus* Strömm..	158—163	Blegvad (1)
— *enchodon*	158	Autor
— *humilis* E. a. K......	157—162	Eig. a. Kenn. (9)
* — 1) *lychnus* Garm.	165	Garman (12)
— *Gilberti* E. a. K.	180	Eig. a. Kenn. (9)
— *Hjorti* Blegvad......	182	Blegvad (1)
— *rostratus* Schm.	188—191	Schmidt (26)
— *urosema*	190	Autor
— *canaricus*	200—220	—
— *stylurus*	218—229	—
— *latissimus* Schm.	> 240	Schmidt (26)
— *Andreae* Schm.......	about 250	— (28)
* — 1) *sicurius* Garm.	„ 250	Garman (12)
— *polymerus*	„ 443	Autor

The number of vertebrae in *Gastrostomus Bairdii* has been included in the above table, although it is not generally referred to the order Apodes, because our material contains a larva not yet fully metamorphosed having an unmistakable likeness to a muraenoid larva.

This table shows that in the majority of the species belonging to the order Apodes the number of vertebrae varies between 100 and 150, and there are about 27 species of leptocephalids in which the number of segments falls within these limits.

Before describing the various species I wish to explain some abbreviations and other points in the descriptions.

Instead of giving details regarding geographical position, etc., I have merely indicated the numbers of the stations, the table at the end furnishing full information regarding this.

All larvae were taken in nets or pelagic trawls dragged horizontally, and as a rule ten nets were attached at intervals to the wire and hauled simultaneously for long periods. It may be supposed, that a net when dragged horizontally, will go in a distance from the surface of about half the length of wire between net and ship. Thus when in the tables a larva is said to have been taken at a depth of 50 metres, it signifies that it was captured by a net with 100 metres of wire out.

The following abbreviations occur in the tables:—

Head = Length of head measured from point of snout to beginning of side line.
Snout = Distance between point of snout and the anterior margin of the eye.
Eye = Largest diameter of the eye.
Anus = Distance between point of snout and anus.
Dorsal = Distance between point of snout and first interspinous element in the dorsal fin.
Height = Greatest height.
H_1 = Highest (dorsal) hypural.
H_2 = Lowest (ventral) hypural.

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1) Garman has adopted the name *Atopichthys* instead of *Leptocephalus* which he applies on the genus *Conger*.

2) This species is not *L. Morrisii (L. Congri vulgaris)*, which has more than 150 segments; consequently it ought to be renamed, and I propose to call it *L. Eigenmanni*.

II. Descriptions.

I. ***Leptocephalus Anguillae vulgaris.***[1]
(L. brevirostris).

The larvae of the common eel caught during the cruise number 44, and they may according to their degree of development be separated into three divisions: 1) small larvae, not yet having attained their full larval development, 2) full-grown larvae, not yet showing any sign of retrogressive metamorphosis, and 3) larvae showing retrogressive metamorphosis.

mm.		
40	0	
45		
50	0 0 0 0 0 0 0 0 0	"Prelarvae"
55	0 0 0 0 0 0 0 0	
60	0 0 0	
65	0 0 0	
70	0 0 0 0 0 0 0 0 0	Full-grown and metamorphosing larvae.
75	0 0 0 0 0 0 0 0	
80	0 0 0	

The above diagram shows how the larvae group themselves according to size, (each circle representing one larva) into two groups: one in which the individuals are mostly 50 or 55 mm, and another in which the individuals are mostly 70 or 75 mm long. The latter group includes full-grown and metamorphosing larvae of nearly the same size and character as those known from Schmidt's investigations in the Atlantic.

In the following table the larvae are arranged according to size, no. 1 being the smallest, no. 44 the largest. The last column indicates the category to which the larvae have been referred, full-grown being identical with Schmidt's first stage, and "metamorphosing" with Schmidt's second stage.

The table brings out the following differences between the "prelarvae" and the full-grown specimens of stage I: 1) They are much smaller, the difference in length being on an average 20 mm, and the largest prelarva is 6 mm shorter than the smallest of the full-grown larvae; 2) the head in the prelarvae is relatively larger than in the full-grown larvae, viz. 8 or 9 per cent of the length in the former, and only 6 or 7 per cent in the latter; 3) the eye is also relatively a little larger, the difference, however, being so slight as to be noticeable only when we compare the averages (24·1 per cent in the former and 22·7 per cent in the latter). As for the remaining characters the small larvae are practically like the big ones of stage I.

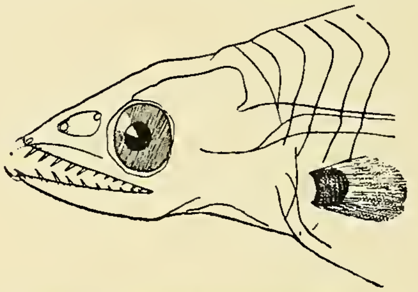

Fig. 1. Head of the smallest eel-larva (no. 1). $^{10}/_{1}$.

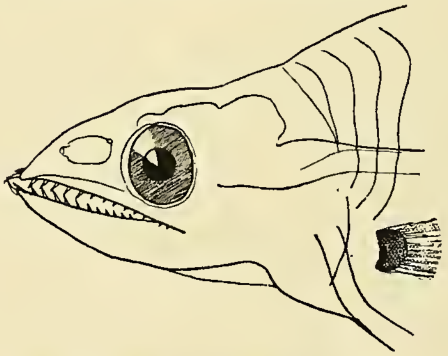

Fig. 2. Head of eel-larva no. 21. $^{10}/_{1}$.

To these differences we may add the following. The heads of the small larvae are rather angular, the end of the snout often an almost straight line. The teeth give the impression of being relatively larger, but then there

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[1] In "Nature" for November 24, 1910, Dr. Johan Hjort has accounted for the catches of eel-larvae made during the "Michael Sars" expedition. The account given here is an extension of the preliminary description.

No.	Station n = night	Depth in metres	Length mm	Height		Dorsal		Anal		Head		Snout		Eye		Muscle-segments			Stage of development
				mm	% of length	mm	% of length	mm	% of length	mm	% of length	mm	% of head	mm	% of head	pre-anal	post-anal	total	
1	64	150	40·5	7·6	19	25·0	62	27·5	68	3·7	9	1·2	32	1·0	27	71	46	117	Prelarva
2	64	500	48	9·7	20	32·0	67	34·0	71	4·3	9	1·5	35	1·1	26	71	44	115	„
3	53 n	50	48	11·3	24	30·5	64	33·0	69	4·3	9	1·3	30	1·1	26	71	44	115	„
4	53 „	50	49·5	11·0	22	32·0	65	35·0	71	4·6	9	1·5	33	1·1	24	72	45	117	„
5	62 „	100	49·5	10·4	21	32·5	66	34·5	70	4·3	9	1·4	33	1·0	23	73	42	115	„
6	52	50	50	9·2	18	35·0	70	34·5	69	4·2	8	1·3	31	1·0	24	70	43	113	„
7	62 n	50	50	9·4	19	32·5	65	35·5	71	4·6	9	1·4	30	1·1	24	72	45	117	„
8	62 „	100	51	9·6	19	31·5	62	35·5	70	4·4	9	1·4	32	1·0	23	70	44	114	„
9	62 „	100	51	8·5	17	32·5	64	35·5	70	4·2	8	1·4	33	1·0	24	71	46	117	„
10	62 „	50	52	9·5	18	35·5	68	36·0	69	4·7	9	1·5	32	1·1	23	74	45	119	„
11	53 „	50	52·5	9·6	18	34·0	65	37·0	70	4·3	8	1·3	30	1·0	23	74	43	117	„
12	62 „	50	53	9·5	18	34·5	65	38·0	72	—	—	—	—	—	—	74	43	117	„
13	62 „	100	54	10·8	20	34·0	63	36·5	68	4·7	9	1·6	34	1·0	21	69	47	116	„
14	53 „	50	54·5	9·9	18	35·0	64	38·0	70	—	—	—	—	—	—	72	45	117	„
15	62 „	50	55·5	10·6	19	—	—	—	—	4·8	9	1·7	35	1·1	23	?	?	119	„
16	53 „	300	56	10·5	19	37·0	66	39·5	70	4·7	8	1·4	30	1·0	21	74	43	117	„
17	62 „	50	56·5	10·8	19	35·5	63	39·0	69	4·3	8	1·5	35	1·1	26	70	48	118	„
18	62 „	50	57	11·3	20	35·5	62	38·5	68	4·9	9	1·5	31	1·2	24	70	45	115	„
19	62 „	50	57·5	11·7	20	41·0	71	41·5	72	5·0	9	1·5	30	1·2	24	72	43	115	„
20	56 „	50	58·5	10·3	18	36·0	62	40·5	69	4·7	8	1·5	32	1·1	23	68	47	115	„
21	56 „	50	60	12·2	20	39·0	65	41·5	68	5·0	8	1·6	32	1·4	28	71	46	117	„
22	81	150	66	12·1	18	43·0	65	45·5	69	4·5	7	1·6	36	1·0	22	69	45	114	Fullgrown
23	88	50	66	12·0	18	42·0	64	45·0	68	4·6	7	1·5	33	1·1	24	72	44	116	„
24	98	150	67	14·0	21	43·0	64	47·5	71	4·9	7	1·5	31	1·2	25	72	42	114	„
25	98	100	68	12·2	18	30·5	45	34·0	50	5·0	7	1·6	32	0·9	18	48	67	115	Metamorph.
26	98	100	69	12·9	19	25·5	37	31·0	45	5·0	7	1·3	26	0·9	18	43	70	113	„
27	98	150	70	14·2	20	43·0	61	45·5	65	4·9	7	1·4	29	1·1	22	67	50	117	„
28	10	100	71	13·1	18	45·0	63	48·5	68	4·7	7	1·5	32	1·0	21	70	44 ?	114?	Fullgrown
29	98	100	71	14·0	20	30·5	43	34·0	48	4·8	7	1·4	29	0·9	19	46	68	114	Metamorph.
30	98	100	71	14·0	20	32·0	45	35·5	50	4·8	7	1·4	29	0·9	19	52	64	116	„
31	88	150	72	13·7	19	46·0	64	50·0	69	4·4	6	1·4	32	1·0	23	72	43	115	Fullgrown
32	98	100	72	13·5	19	33·5	48	37·5	52	5·1	7	1·5	29	0·9	18	53	61	117	Metamorph.
33	98	150	72	13·8	19	44·0	61	48·5	67	4·7	7	1·4	30	1·0	21	71	46	117	Fullgrown
34	90	150	73	14·3	20	46·5	64	50·0	69	4·6	6	1·5	33	1·1	24	72	43	115	„
35	88	100	73	12·8	18	46·0	63	50·0	69	4·7	6	1·6	34	1·0	21	70	46	116	„
36	92 n	150	73	14·5	20	47·0	64	50·0	69	4·9	7	1·6	33	1·0	20	73	43	116	„
37	98	100	73	14·0	19	33·0	45	38.5	53	4·7	6	1·4	30	1·0	21	53	64	117	Metamorph.
38	94	150	74	13·4	18	45·5	62	48·0	65	4·5	6	1·3	29	1·1	24	67	48	115	„
39	90	500	75	12·5	17	46·5	62	50·5	67	4·8	6	1·6	33	1·1	23	72	43	115	Fullgrown
40	92	50	76	13·6	18	48·0	63	52·5	69	4·6	6	1·5	33	1·0	22	71	43	114	„
41	98	100	76	15·2	20	48·0	63	52·0	68	4·8	6	1·6	33	1·2	25	68	46	114	„
42	98	100	78	15·3	20	51·0	65	54·5	70	4·7	6	1·6	34	1·2	26	72	42	114	„
43	90	300	79	14·0	18	51·5	65	54·0	68	4·7	6	1·6	34	1·0	21	74	45	119	„
44	90	500	82	13·3	16	53·5	65	56·5	69	4·9	6	1·5	31	1·4	22	71	44	115	„

are not so many of them, hardly more than 1 + 1 + 5 + 7 in the upper jaw. True rays cannot be traced in the pectoral fin, and rays are wanting on some of the interspinous elements of the dorsal fins. It is only in the largest "prelarva" that the first indications of rays can be seen also on the anterior interspinous elements of the vertical fins. We can see only some thirty rays posteriorly in each of the vertical fins of the smallest larva; the anterior interspinous elements of the vertical fins have no rays, but they are probably present in full number, for the foremost ones which are but slightly developed, are situated just as far forward on the body as they are in the large larvae. Figs. 1 and 2 show the heads of the smallest and largest prelarvae, the brain of the small larva being simpler in shape.

Pl. I represents a full-grown larva and three prelarvae (the largest, the smallest and an intermediate one).

It is unnecessary to describe the full-grown larvae of

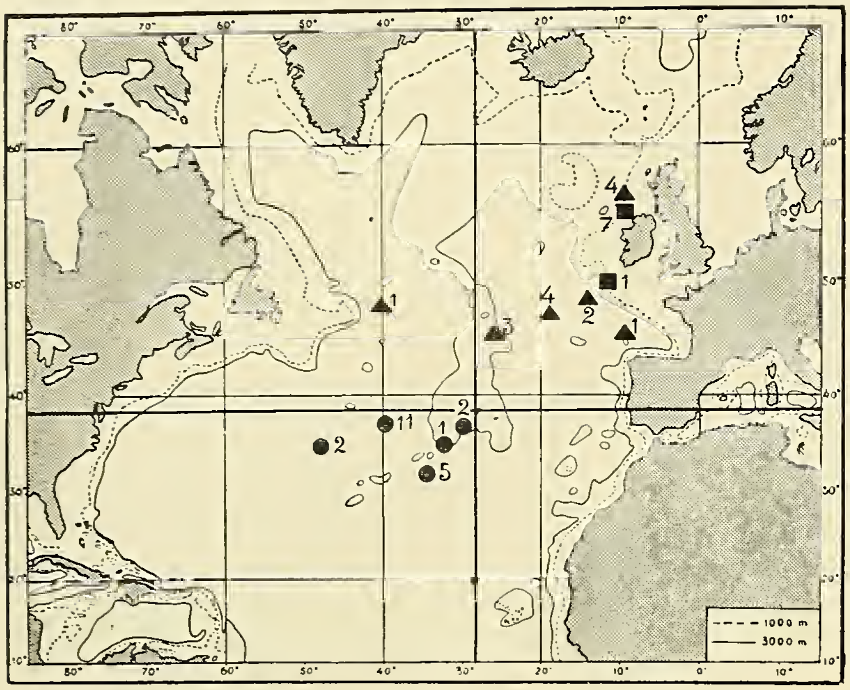

Fig. 3.

stages I and II, which correspond closely with Schmidt's description. They are possibly a little smaller than the annual series examined by Schmidt, the average length of the larvae of stage I being 73·1 mm, (Schmidt's larvae of 1905 being 75·21 mm and of 1906 76·45 mm). Whether this difference is casual or due to the scarcity of the material, or to the lateness of the season (July and August), or to the variation of different annual series, cannot be determined. The average length of six individuals of stage II is 70·6 mm.

The geographical distribution of the larvae of the eel is shown on fig. 3, the occurrence of prelarvae being indicated by circles, of full-grown larvae by triangles, and of metamorphosing larvae by squares. The map is divided into four quadrants by lines crossing the Azores, one from east to west, and the other from north to south, and it is plainly seen that all the prelarvae without exception were taken in the south-western quadrant, whereas all the full-grown larvae except one, were caught in the north-eastern quadrant. Further, all the metamorphosing larvae were taken at depths less than 3000 metres (Stat. 98 where all the larvae in stage II were taken is situated beyond the 1000 metres line), whereas almost all the other larvae and prelarvae were taken at depths greater than 3000 metres partly in the middle of the ocean. A third point of interest is the fact that full-grown larvae were taken very far west, one even at a point much nearer America than Europe. If we compare this map with the map in Schmidt's paper, it is evident that Schmidt's investigations were mostly carried on towards the northern and eastern limits of distribution of the eel-larvae, for they have been taken as far south as 32° N., and as far west as 48° W. (prelarvae) and 40° W. (full-grown).[1])

Fig. 4 shows the number of larvae of the eel taken at different depths during the cruise, and it is seen that most of the small larvae were taken at a depth of 50 metres, whereas most of the large larvae were caught at 100 and 150 metres. It seems necessary to conclude from these catches that both the big and the small larvae live quite near the surface, most of the prelarvae having been taken at night-stations while most of the full-grown larvae were caught at day-stations. Schmidt's observations prove that the larvae of the eel, like very many other animals, undertake daily vertical migrations, living at greater depths during the day than at night. According to Schmidt (Remarks on the Metamorphosis etc. . . . . 1909 p. 14) the full-grown larvae occur during the night in great numbers at 30 metres below the surface.

The "Michael Sars" material does not throw much light on the problems concerning spawning place and period, migrations, age, and growth of the eel, seeing that it does not contain eggs, newly hatched larvae, or spawning eels, but it may possibly be valuable in forming working ideas for future investigations. The material must,

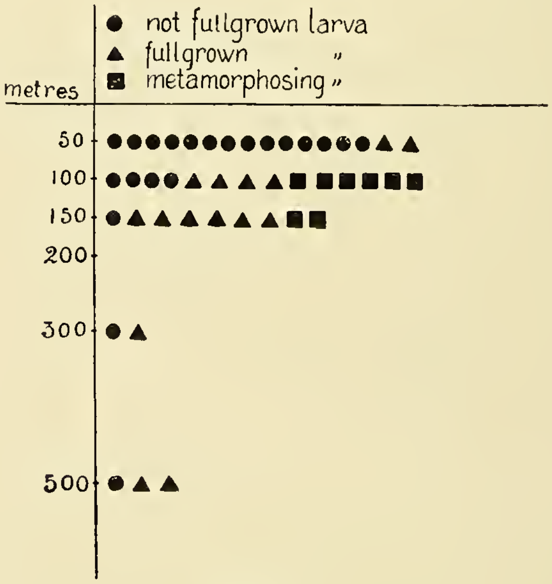

Fig. 4.

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[1]) In a paper from 1912 (no. 31 in the literature list) Schmidt has accounted for further Danish investigations regarding the eel-larvae. They support in the main points the conclusions drawn here.

of course, be looked at in the light of the discoveries made previously in the Atlantic by Schmidt, from whose work "Contributions to the Life-History of the Eel", 1906 (24) the following table is taken, showing period and place of occurrence of the different developmental stages:—

Developmental stage	Period of occurrence	Place of occurrence	Mode of life
1	May to August or Sept.	Atlantic ocean, West of Europe, in deep water	Pelagic
2	August and Sept. inclusive	Atlantic ocean, or nearer the coasts of Europe	„
3	August and Sept. inclusive		„
4	August to Nov. inclusive		„
5	Sept. and Nov. to April or May	Near the coasts of Europe in shallower water	Partly pelagic
6	May to July	Coasts of Europe in fresh, brackish, or salt water	On bottom

In his paper "Remarks on the Metamorphosis and Distribution of the Larvae of the Eel", 1909 (25) Schmidt says on p. 15: "Stage I occurs in spring and summer, especially in the early summer, the later developmental stages (2nd to 4th) in the later summer, autumn and beginning of winter, while the glass-eel period is in winter and spring." The period of occurrence of the full-grown and metamorphosing larvae taken by the "Michael Sars" corresponds on the whole with the period of occurrence of the larvae in the same developmental stages, previously taken in the North Atlantic Ocean, one larva (no 28 in table, p. 9) having been taken in April 19th to the north of Cape Finisterre, the others between July 12 and August 5.

As already mentioned, all the small larvae were taken to the south and west of the Azores, and most of the big ones to the north and east of those islands. This distribution can hardly be regarded as casual, and we may infer from this that the spawning places of the eel are situated still further towards the South and West, i. e. *somewhere between the West Indies and the Azores*. We must at any rate suppose that the small prelarvae were taken nearer the spawning places than the full-grown and metamorphosing larvae.

If this theory be correct, we must suppose that the larvae move in a direction from SW to NE, the larvae found farthest towards the SW being smaller (younger) than those found farther towards the NE. The two smallest prelarvae were taken at Stat. 64 situated farthest towards the SW, whereas the two largest were taken at Stat. 56, situated farthest towards the NE, and if we compare the catches from adjoining stations in a direction from SW to NE, we find that this rule holds good in all cases, except for the stations close to the European coastal plateau. The following table gives the average length of the larvae from two series of stations arranged from SW to NE:—

The first series extends from lat. 34° 44′ N, long. 47° 52′ W, to lat. 56° 33′ N, long. 9° 30′ W. We see that the length of the larvae increases from Stat. 64 to Stat. 90, and then decreases, this decrease being possibly due to the commencement of retrogressive metamorphosis.

The second series extending from 31° 24′ N, 34° 47′ W to 36° 53′ N, 29° 47′ W, includes only small larvae, which show a gradual increase in length. This table is based on so few individuals that the averages cannot be considered of great value. However this may be, the facts fit into the working theory that the spawning ground of the eel is situated somewhere about 30° N and 50° W, and that the larvae move in a north-easterly direction towards the coasts of Europe.

Station	Average length of the eel-larvae
64	44·5 mm
62	53·6 „
88	66 „
90	77·2 „
92	74·5 „
94	74 „
98	71·5 „
52	50 mm
53	52·4 „
56	59·5 „

Through his comprehensive investigations Schmidt has, in my opinion, shown that the eel has a certain spawning period, which may possibly be protracted.

If there were any way of fixing the age of the different larval stages we should be a step nearer the solution of the question as to when the eel spawns.

The diagram on p. 8 strikingly resembles the groups obtained when the youngest classes of other fishes, like the herring or flounder, are arranged according to length, and it seems probable that there may be about a year's difference between the small prelarvae taken between June 6th and 26th and the full-grown larvae caught in the spring or early summer off the coasts of the British Isles. If the spawning place of the eel lies to the SW of the Azores and the young migrate in a north easterly direction, they must require a long time to reach the coasts of Europe. It is therefore not improbable that the full-grown larvae are more than a year old, since they are of about the same size as many other fishes at such an age. In my opinion it is improbable that the small prelarvae are as much as one year old. The rate of growth is in nearly all cases greatest in the earliest periods of the life-history of an animal. According to C. H. EIGENMANN, "The Egg and Development of the Conger Eel" (8), five days after leaving the egg, the larvae of the eel were more than 10 mm long, while embryos taken out of the egg, measured 5 or 6 mm, so that during the five first days the rate of growth was about 1 mm per day. Although this does not refer to the eggs and larvae of the common eel, we may expect to find in that form a similar rapid growth, a little less or a little more. Assuming that the larvae of the eel just after being hatched grow 1 mm per day, and that it takes a year to grow from the size of a prelarva (53 mm) to the size of a full-grown larva (75 mm), corresponding to 0·06 mm per day, we may suppose the average rate of growth of prelarvae, of a size between the newly-hatched larvae and those caught in June to the SW of the Azores to be intermediate between 1 mm and 0·06 mm per day, that is to say about 0·53 mm per day. At this rate it will take 100 days for a newly-hatched larva to grow to a size of 53 mm i. e. so that the prelarvae might have been hatched out in February or March. Granting an error of + 100 days and—50 days[1]) in these estimations, the larvae would be between about 2 and about $6^1/_2$ months old, i. e. they were at the earliest hatched out about the New-year and at the latest in April.

Judging from these estimations and presuming the spawning place of the eel to be not far from where the youngest larvae have been found, it is unreasonable to suppose that the migrating silver-eels caught in Danish and Swedish waters during the autumn, and in the English Channel during December (according to CLIGNY's communications in the Comptes Rendus (5)) could possibly spawn in the neighbourhood of the Azores in the course of the first winter after emigration. Their spawning migrations must cover vast distances, and even at the rate of 15 km per day, they should need months to reach the Azores.

2. *Leptocephalus Synaphobranchi pinnati.*

We find eleven specimens of this species in the material, of which six do not exceed 60 mm in length, whereas the other five must be characterized as full-grown or metamorphosing larvae. The segments, 144 to 157 in number, have a peculiar shape like two arches meeting at the lateral line and forming quite a sharp angle, the point directed forward. The segments are very transparent, except along the lateral line, where they are opaque (at any rate in the preserved specimens), giving these leptocephali a characteristic appearance with quite a light lateral stripe. (See pl. II).

For a detailed description of the full-grown larvae I refer to SCHMIDT's papers, but will describe the six smallest specimens, which represent a developmental stage, hitherto unknown in this species.

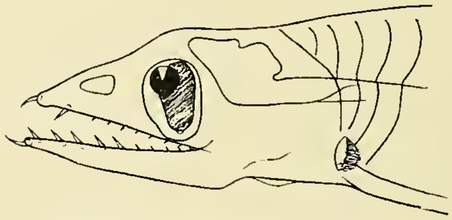

Fig. 5. Head of larva no. 1. $^{10}/_1$.

The smallest and youngest specimen (no. 1) measures 43 mm from point of snout to tip of tail, and has 104 preanal and 46 postanal myomeres, 150 in all. I could count 10 teeth in each half of the upper jaw, and 11 or 12 in each half of the lower jaw. The foremost tooth of the upper jaw is large and curved and directed forward; farther back we find first one big, strong tooth, then after an interspace eight rather small teeth. In the lower jaw there is also foremost a curved tooth, directed forward, followed by five strong teeth and five smaller ones (see fig. 5).

The nostrils are not separated; we can see nothing but a triangular groove, almost intermediate between the point of the snout and the lens of the telescopic eye.

The pectoral fin is fan-shaped, and has a striped structure, but no true spines. In the margin of the posterior portions of the embryonal dorsal and ventral fins, the first traces of interspinous elements can be seen. They arise out of the embryonic fin without any connection with the body, just as described by SCHMIDT in *Leptocephalus hyoproroides* (later renamed *L. thorianus*).

In the caudal fin the rays are present, H_1 having eight, and H_2 nine. These rays are separated from the posterior interspinous elements of the anal and dorsal fins

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[1]) The probability of a large positive error is greater than of a negative one, for the latter cannot exceed 100 days.

by small interspaces. On the caudal fin there are very small pigment-spots invisible to the naked eye.

The anal is placed far back, 34 mm from the point of the snout.

The next specimen in point of size (no. 2) is 47 mm long, resembling no. 1 in all essential particulars; the first traces of interspinous elements can, however, be seen along a larger portion of the edges of the vertical fins. The caudal fin contains 17 rays, H_1 eight, and H_2 nine. There are 106 preanal and 46 postanal segments, 152 in all.

In all these prelarvae there is a large open interspace between the anal aperture and the foremost indications of interspinous elements of the anal fin.

Specimen no. 7 is a fully developed larva 99 mm in length which corresponds perfectly to the description given by SCHMIDT of this stage. It has many relatively week teeth in both jaws, and rather widely separated nostrils. The rays of the pectoral fin are distinct, and those of the vertical fins and the caudal fin are strongly developed (the caudal fin having 17 rays, H_1 eigth, H_2 nine). It attains its greatest height just in front of the anal aperture, which is placed far backward, for we find 97 preanal and 48 postanal myomeres, 145 in all. The head of this larva is represented on fig. 7.

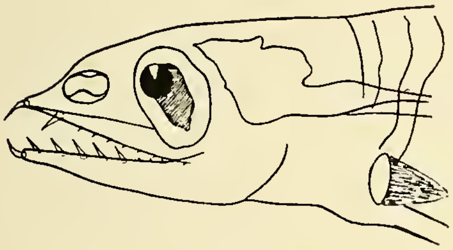

Fig. 6. Head of larva no. 4. $^{10}/_{1}$.

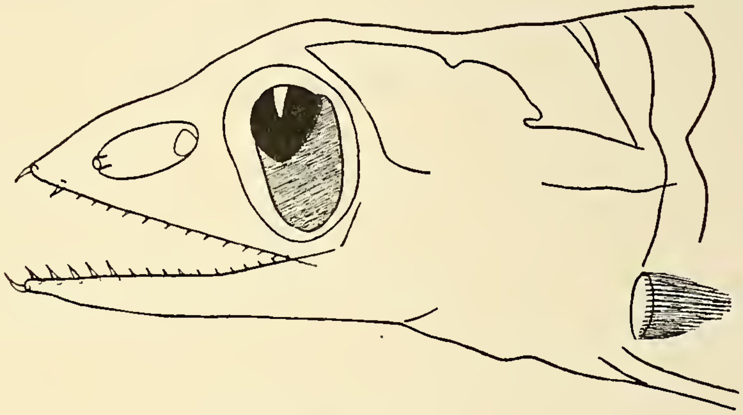

Fig. 7. Head of larva no. 7. $^{10}/_{1}$.

The next specimen (no. 3) has a length of 50 mm, with 102 preanal and 44 postanal segments, 146 in all. Dentition and nostrils resemble those of nos. 1 and 2. The pectoral fin has no rays. In the vertical fins we find a more advanced structure of the interspinous elements, which can be traced farther forward than in nos. 1 and 2; the caudal fins, however, are exactly alike, provided with the same number of rays, H_1 bearing eight, and H_2 nine.

Specimen no. 4 has a length of 51 mm. It has 105 preanal and 42 postanal segments, 147 in all. The nostrils are not yet separated, but we find an hour-glass shaped structure within the contour of the nose-groove (see fig. 6). In the posterior portions of the vertical fins we can now see true rays, 4 or 5 in the dorsal fin, and 3 or 4 in the anal fin.

Specimen no. 5 is 58 mm long, having 108 preanal and 49 postanal segments, 157 in all. In this larva we find no indication of separated nostrils, but there are more numerous and more fully developed rays in the vertical fins, 7 or 8 in the dorsal fin, and 6 in the anal fin. The caudal fin has 16 rays, H_1 bearing seven, and H_2 nine.

Specimen no. 6 has a length of 59 mm, and has 106 preanal and 46 postanal segments, 152 in all. It agrees in all essential points with no. 5; the caudal fin, however, has 16 rays, H_1 and H_2 having eight each, and we find more indications of interspinous elements in the vertical fins.

Specimen no. 8 is 107 mm long, with a maximum height of 9 mm, and has 106 preanal and 49 postanal myomeres, 155 in all. The dentition is complete, and the rays of all the fins are developed, the caudal fin having 17 (H_1 nine and H_2 eight).

Specimen no. 9 appears to be undergoing metamorphosis. It is 107 mm long, with a maximum height of 10 mm. All the fins are provided with strong rays, H_1 of the caudal fin having eight, H_2 nine rays.

Metamorphosis shows itself thus: the anus is placed farther forward than in the previous specimens, there being only 82 preanal, but 70 postanal segments, 152 in all. The snout has a rather rounded profile, and protrudes far beyond the point of the lower jaw, whereas it is quite pointed and protrudes slightly in the previous individuals. Teeth are entirely wanting. Further, the anterior nostril has become very distinctly tubular, and projects from the contour of the head when looked at from above. That the metamorphosis is not very far advanced appears, however, from its great height, its compressed body-form, and because the anus is still placed far back.

Specimen no. 10 is at the same developmental stage as no. 9. It is 112 mm long, with a maximum height

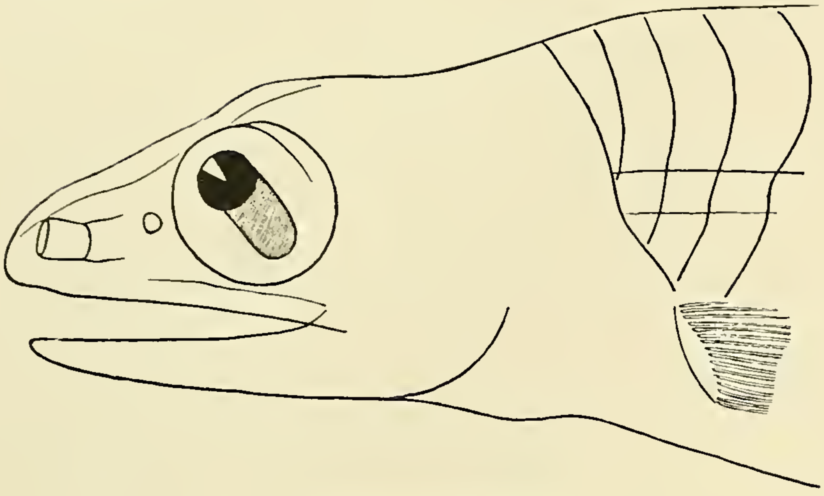

Fig. 8. Head of larva no. 10. $^{10}/_{1}$.

of 10 mm. There are in all 144 segments: 81 preanal and 63 postanal. All the fins contain rays, H_1 of the caudal fin having seven and H_2 eight. Teeth are wanting and the snout is rounded, protruding beyond the point of the lower jaw. The nostrils are as described by SCHMIDT. (See fig. 8).

In our material we find four stages in the development of this species. The first two stages, which may be called preleptocephalic, are represented by nos. 1 to 6. The next stage which may be called the typical leptocephalic stage, is represented by nos. 7 and 8, while the fourth stage, showing the beginning of the metamorphosis, is represented by nos. 9 and 10.

Besides these true larvae, there is a young individual of *Synaphobranchus pinnatus* (no. 11), 114 mm in length, still retaining some larval characters. It is quite compressed and high in comparison to its length, having pigment only in a stripe along the lateral line; its eyes are no longer telescopic and its head ich much more elongate than that of the true larva (see fig. 9); the rays of the anterior dorsal fins are 45 mm from the point of the snout. In the collections from the cruise there are also older individuals of the species, in different sizes. They will be described in another paper.

The following table shows the station and depth, as well as the length and degree of development, for each of the larvae mentioned:—

It appears from this table: 1) that there are two groups of larvae (represented by nos. 1 to 6 and nos. 7 to 10 respectively), the "preleptocephalic" group not being more than 59 mm long, the second group not less than 99 mm long; 2) that individuals belonging to both groups were caught at one station; 3) that five individuals of the "preleptocephalic" group were taken in depths of 50 to 150 m, while three individuals of the second group were taken in 500 to 750 m; 4) that the larvae are

No.	Station	Depth m	Length of the larva mm	Degree of development
1	58	150	43	Prelarva
2	62	50	47	„
3	34	200 to 500	50	„
4	62	50	51	„
5	88	50	58	„
6	88	50	59	„
7	92	50	99	Full grown larva
8	87	500	107	„
9	98	750	107	Larva showing traces of metamorphosis
10	34	500	112	„
11	98	750	114	Metamorphosis nearly complete

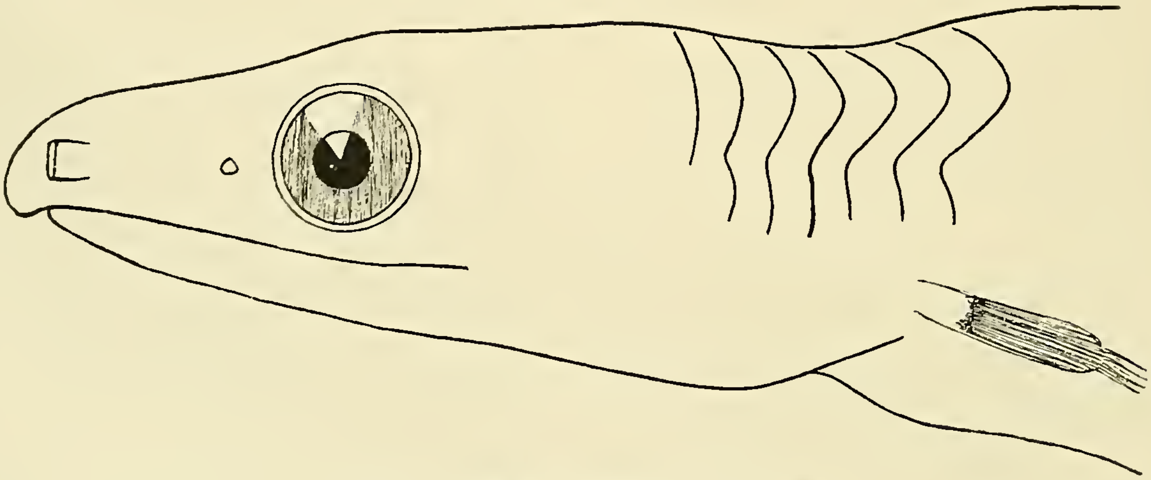

Fig. 9. Head of "semilarva" (no. 11). $^{10}/_{1}$.

widely distributed over the portion of the North Atlantic investigated.

It seems reasonable therefore to assume:— Firstly, that as there are two groups differing greatly in development, in one case taken at the same place, these groups must be annual series, and that consequently it takes a year at least from the time the larva leaves the egg until it reaches its full larval development; secondly, that the small "prelarvae" lives nearer the surface than full-grown larvae.

The great distances between the finding-places for the smaller larvae apparently support the assumption, that the spawning-area of this species is very large.

3. *Leptocephalus Histiobranchi infernalis* (or *L. Ilyophidis Brunnei*).

A larva taken at Stat. 62 in the net at 100 m reminds us very much of *Leptocephalus Synaphobranchi pinnati*, but that form has more than 140 segments, while this larva has only 133 or 134 segments (see fig. 10 and pl. II). Its great resemblance to the larva of *Synaphobranchus* led me to conclude that it must be the larva of a nearly related species, probably *Histiobranchus infernalis*, and the first examination of an adult *Histiobranchus* seemed to confirm this, for I found 132 vertebrae, rays in the pectoral and caudal fins agreed in number, and the hypural bones had the same shape. I therefore took it for granted that the larva was *Leptocephalus Histiobranchi infernalis*. But when I examined a young specimen, which my colleague mag. sc. E. KOEFOED and myself independently determined as *Ilyophis Brunneus*,[1] I found that it also had the very same number of vertebrae, the same number of rays in the pectoral and caudal fins, the same shape of hypural, and even some small lateral processes on the bases of the caudal rays found in *Histiobranchus* and in our larva.

Comparing this larva with the specimens of *Histiobranchus* and *Ilyophis* examined by me, the close agreement as regards the number of segments and the number of rays in the pectoral and caudal fins, is shown in the following table:—

	Larva	*Histiobranchus infernalis*	*Ilyophis Brunneus*
Number of muscle-segments (vertebrae)	133—134	132	132
Number of rays in the pectoral fin	15—16	15—16	14
Number of rays in the caudal fin .... H_1	8	8	8
H_2	8	8	8

Further it may be mentioned that the young specimen of *Ilyophis* and a young specimen of *Histiobranchus* are furnished with the processes at the bases of the caudal rays already mentioned. They are also found in our larva in a less marked form, whereas I was not able to discover them in a large specimen of *Histiobranchus*.

Accordingly I cannot refer our larva to either of these species with certainty, but must leave the question open for the present. It may be that *Ilyophis* is not distinct from *Histiobranchus*; the former has been described from a single specimen, while the latter has not been described in great detail, and the possibility of sexual dimorphism, for instance, is not to be disregarded.

Our larva gave the following measurements:

Length	87	mm
Anus	67	„
Dorsal	61	„
Height	8	„
Head	6·8	„
Snout	2·5	„

The musculature of the body resembles greatly the musculature in *L. Synaphobranchi pinnati*. The segments are curved without the usual dorsal and ventral angles. As preserved the musculature along the lateral line is opaque, while being rather transparent dorsally and ventrally, and this gives rise to the whitish lateral streak. There are 93 preanal, and 41 postanal segments. The alimentary canal has no striking peculiarities. Rays are developed in all the fins. The caudal fin is like that of *L. Synaphobranchi pinnati*, with the posterior margin of H_2 forming an angle of about 45° with the longitudinal axis of the animal. The pectoral fin has the form of a small fan.

Fig. 10. Head of larval *Histiobranchus infernalis* or *Ilyophis Brunnei*. $^{10}/_{1}$.

Pigment is present only on the caudal fin, as scattered dots too small to be seen with the naked eye.

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[1] The specimen in question has well-separated gill-openings, and the branchiostegal rays are longer and more curved than in a specimen of *Histiobranchus* of equal size.

The head has become a little deformed since capture, but we can see that it resembled the head of *L. Synaphobranchi pinnati* very much. Fig. 10 shows the head in its supposed original form, provided with a typical telescopical eye. The snout, quite short but pointed, projects in front of the lower jaw. The jaws are furnished with rather small teeth, the number in each half of the upper jaw being 1 + 1 — 13, and in each half of the lower jaw 1 + 6 + 10. They are all directed obliquely outwards, the posterior being smaller. The lower jaw lacks the sharp angle characteristic of many other leptocephalids.

The nostrils are separated, and both take the form of pores. The anterior one is situated quite near the point of the snout, and the posterior one about half-way between the anterior one and the foremost margin of the eye.

4. Leptocephalus Cyematis atri.

At Stat. 51 one specimen, and at Stat. 56 three specimens were caught, all at a depth of 150 metres, which proved to be the larvae of *Cyema atrum*. Fig. 5 on pl. II. is a reproduction from a photograph of one of these larvae, and we see that the form is very peculiar, of shape as an elm leaf the height of body being about half the total length. The alimentary canal with its marked curves adds to the characteristic appearance of this species.

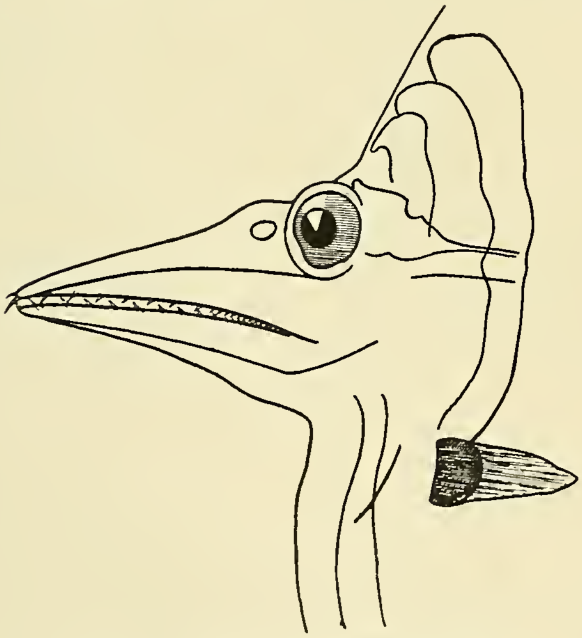

Fig. 11. Head of larval *Cyema atrum*. $^{10}/_{1}$.

The various specimens differ very little in regard to appearance and degree of development. Half of the posterior curve on the alimentary canal is absent in the individual from Stat. 51, otherwise the differences consist only in variations in the number and size of the pigment spots on the muscle-segments (see fig. 5, pl. II). In this respect there are also variations between the right and left sides of the same animal.

The muscle-segments form a very obtuse angle at the lateral line, while they entirely lack the dorsal and ventral angles usually found in other Leptocephali and fishes generally.

The head exhibits a very characteristic appearance (see fig. 11), with its eyes in the acute angle formed between the upper contour of the snout and the precipitously ascending dorsal margin of the body. The angle between the lower contour of the lower jaw and the ventral margin of the body is also acute, approaching 90°. The snout is pointed and long in proportion to the length of the head. There are many teeth, half of upper jaw containing about 20, and half of lower jaw about 16, but they are small, the posterior ones being smaller than the anterior ones, and they are directed obliquely forwards.

The nostrils not being separated (fig. 11) and the absence of rays in all the fins prove that the four larvae have not yet attained their full development. Only in the pectoral fin can indications of the first traces of rays be seen but they are so indistinct that they cannot be counted with certainty. The interspinous elements, however, are well developed in the vertical fins. In the anal fin we find the first directly behind the anus, and the foremost interspinous element of the dorsal fin of every individual is distinctly developed, and placed at relatively the same distance from the point of the snout. The number of the interspinous elements may thus be used for the following comparison between three of the larvae in question and *Cyema atrum*, the fourth larva being unfortunately damaged:—

	Larvae			*Cyema atrum*
	No. 1	No. 2	No. 4	
Interspinous elements in the dorsal fin	84	83	84	86
„ „ „ „ anal „	75	77	75	75

In this particular the larvae accord with the adult *Cyema atrum*, as is also the case when we compare the number of segments or vertebrae (table p. 17).

We see that the number of segments in the larvae corresponds well with the number of vertebrae in the adult *Cyema atrum*, and this is a character of greater value in this species than in any other species of Apodes. For such a small number of segments (vertebrae) does not occur, as far as I am aware, in any other species of

	Larvae			*Cyema atrum*
	No. 1	No. 2	No. 4	
Preanal segments (vertebrae)	45	46	44	42
Postanal —„—	32	32	31	31
Total	77	78	75	73

Leptocephali or Eel. On these points we cannot doubt the connection between the larvae in question and *Cyema atrum.*

The following table contains some further measurements of the four larvae:

	No. 1	No. 2	No. 3[1])	No. 4[2])
Total length	47 mm	47.5 mm	48 mm	54 mm
Greatest height	24 „	24 „	23 „	25 „
Distance between point of snout and anus	32.5 „	33 „	33.5 „	39 „
„ „ „ „ „ „ first dorsal interspinous element	33.5 „	33 „	33.5 „	40 „
„ „ „ „ „ „ anterior margin of the eye	3.6 „	3.9 „	4.1 „	? „
Length of the head	5.5 „	5.7 „	5.9 „	? „
Diameter of the eye	1.0 „	1.0 „	1.0 „	1.1 „

5. *Leptocephalus Congri vulgaris.*
L. Morrisii.

Three spesimens were taken of this species.

Specimen no. 1 is 84 mm long, with a maximum height of 8 mm. It is a fully developed, though not full-grown larva, having 124 preanal and 35 postanal segments, 159 in all. The anus is situated far back, 11 mm from the tip of the tail. The snout is pointed and the nostrils well separated the anterior one tubular, directed forward and a little upward, whereas the posterior one is a roundish aperture. It has many teeth, about 25 in each half of the upper jaw, and about 20 in each half of the lower jaw. Strong rays are present in all the fins, the caudal fin having 12 rays, of which H_1 has five and H_2 seven.

As for pigment there is a series of starshaped spots along the upper edge of the alimentary canal, spots at the bases of the rays of the anal and caudal fins, and a series along the lateral line of the postanal segments.

Specimen no. 2 is 102 mm long, having a maximum height of 9 mm, and is in nearly the same developmental stage as no. 2. They only feature possibly indicating the beginning of a retrograde metamorphosis is that the anterior portion of the body is not quite so high as in no. 1. All the fins have rays, H_1 and H_2 of the caudal fin having six rays each. I was able to count 24 teeth in the upper jaw and 20 in the lower jaw. The pigmentation of both specimens is alike, except that the series of dots along the lateral line extends farther forward in no. 2. The anus is placed far back and there are 123 preanal and 33 postanal segments, 156 in all.

Specimen no. 3 is 126 mm long, and attains its greatest height of 13 mm about 85 mm from the point of the snout. This specimen has reached its full development as a larva, and has rays in all the fins, the caudal fin having 11 rays: H_1 five, and H_2 six. There are 125 preanal and 30 postanal segments, 155 altogether. In one half of the upper jaw I counted 29 teeth, and in half of the lower jaw 20. The snout is pointed. Nostrils and pigment as in no. 1. The following table gives the stations and depths from which the specimens was taken:—

No.	Length	Station	Date	Depth
1	84 mm	10	$^{19}/_{4}$—$^{21}/_{4}$	150 m
2	102 „	42	$^{23}/_{5}$—$^{24}/_{5}$	150 „
2	126 „	92	$^{23}/_{7}$—$^{24}/_{7}$	500 „

No.s 1 and 3 were taken where the depth exceeds 3000 metres, while no. 2 was taken near the coast of Morocco where the depth is less than 2000 metres. If we compare the length of the specimens with the date of capture we see that the length increases from spring to autumn, but the material is too scanty to determine whether this denotes the growth of the larvae, or is only accidental.

Compared with these three larvae the larvae described by SCHMIDT are on the whole larger. The facts that our

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[1]) Tip of tail has disappeared, and the numbers are therefore approximate.

[2]) Point of snout somewhat damaged „ „ „ „

larvae have not yet attained full length, and that two of them were found over great depths, bear out SCHMIDT's conclusions in regard to the immigration of these larvae towards shallower waters in course of their development.

6. *Leptocephalus Congri mystacis.*

GRASSI asserts in his work on "The Reproduction and Metamorphosis of the common Eel (*Anguilla vulgaris*)", Proc. Roy. Soc., vol. LV, 1896, that the larvae of *Congromuraena mystax* are identical with those described under the names of *Leptocephalus Haeckeli, Yarrelli, Bibroni, Gegenbauri, Kölliker*, and *stenops* (in part), in the descriptions of which the number of segments is not stated. The long list of synonyms is a characteristic proof of the difficulty in determining larval Apodes when no account is taken of the number of segments. GRASSI does not mention this point, and I should certainly have added another name to the list of synonyms, had not SCHMIDT in one of his recent works told us that *Conger mystax* has about 140 vertebrae. This information, and the excellent photograph in SCHMIDT's paper (29) enable me to describe 20 larvae taken by the "Michael Sars" under their right name.


Fig. 12. Head of larva no. 1. 10/1.

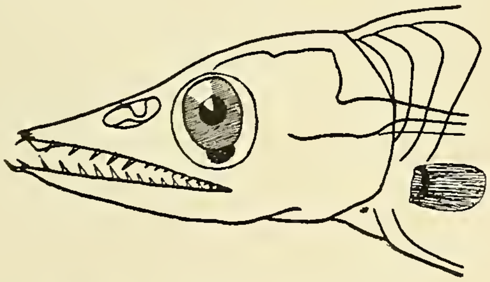
Fig. 13. Head of larva no. 4. 10/1.

The larvae in question, one of which is reproduced in fig. 1 pl. III, differ greatly in size (from 31 to 113 mm long) and represent various stages of development; nineteen of them, not having rays on all the interspinous elements in the fins, are not yet full-grown, while one has begun its metamorphosis. The smallest larva (no. 1 in the table) is pronouncedly a prelarva, for, as far as can be seen, there are no indications of interspinous elements in the fins (the tip of the tail is wanting, so that nothing can be said of the development of the caudal fin), and its nostrils are not separated. In a somewhat larger larva they are almost separated, and in most of the others they are well separated.

The pigmentation is in accordance with former descriptions, for we find spots along the alimentary canal and at the bases of both the anal and caudal fins, and and as a rule there are also a few spots directly in front of the curve on the alimentary canal where it leaves the head.

Figs. 12, 13 and 14, representing the heads of the specimens numbered 1, 4 and 20 in the table, show how the smaller individuals differ from the larger in the development of the nostrils, and in the relative size and number of the teeth.

The results of the measurements of each specimen[1]) are given in the table on p. 19.

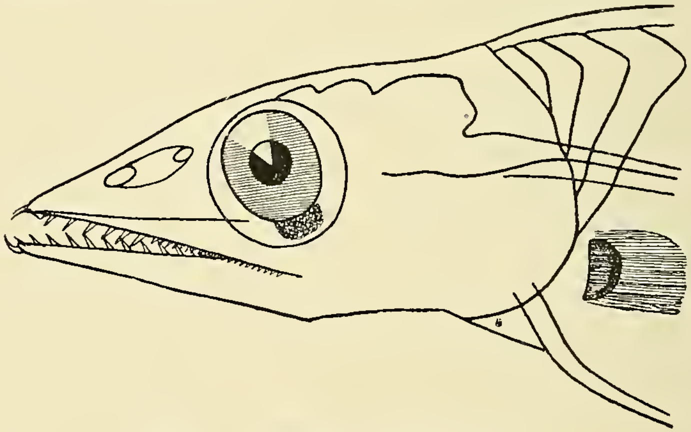
Fig. 14. Head af larva no. 20. 10/1.

No. 11 is the larva which has begun its metamorphosis, as shown: 1) because its height is small relatively to its length,[2]) 2) because of the strong development of the vertical fins, and 3) because the anus is placed farther forward, and there are consequently fewer preanal segments. On the other hand it is evident that its metamorphosis is not very far advanced, for the teeth are intact and the dorsal fin is not farther forward than in the others. Excluding no. 11 the table does not indicate any distinct variation in character, except that the teeth are fewer in the smaller larvae than in the larger, and that the nostrils of the larvae numbered 1, 2, 3 and 4 are not separated.

The number of muscle-segments, however, varies between 132 and 147, and for a while this made me suspect that there were several species among the 20

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[1]) No. 21 in the table is described in a concluding note.

[2]) The larva being quite deformed, I have not been able to measure the height exactly.

No.	St.	Depth in metres	Length	Greatest heigth		Dorsal		Anal		Head		Snout		Eye		Number of muscle-segments			Number of rays in caudal fin		Number of teeth in each half jaw	
			mm	mm	% of length	mm	% of length	mm	% of length	mm	% of length	mm	% of head	mm	% of head	preanal	postanal	total	H_1	H_2	upper	lower
1	39	150	about 31	4·5	14·5?	?	?	29	93·6?	3·2	10·3?	1·5	46·9	0·6	18·8	110	> 30	> 140	?	?	about 11	about 10
2	42	150	57	7·9	13·9	41	72·0	51	89·5	4·4	7·7	1·9	43·2	0·9	20·5	113	20	133	5	5	about 16	15
3	42	150	60	7·9	13·2	45	75·0	55	91·8	4·8	8·1	2·0	41·7	0·8	16·7	121	26	147	5	5	16	about 14
4	42	150	62	8·0	12·9	?	?	56	90·3	5·1	8·2	2·1	41·2	1·0	19·6	119	23	142	5	5	18	17
5	42	150	66	7·2	10·9	47	71·2	59	89·4	5·0	7·6	2·0	40·0	1·0	20·0	116	22	138	5	7	19	16
6	42	150	66	8·7	13·2	?	?	59	89·4	5·0	7·6	2·2	44·0	0·9	18·0	115	26	141	5	6	21	15
7	42	150	67	9·1	13·6	?	?	60	89·6	5·0	7·5	2·0	40·0	1·1	22·0	118	23	141	5	5	20	14
8	45	1000	78	10·0	12·8	57	71·2	70	89·8	5·4	6·9	2·2	40·7	1·1	20·4	114	24	138	5	6	21	17
9	42	150	79	9·0	11·4	61	77·2	71	89·9	5·3	6·7	2·1	39·6	1·1	20·7	115	25	140	5	6	20	16
10	42	150	81	10·2	12·6	61?	75·4	74	91·3	5·5	6·8	2·2	40·0	1·1	20·0	117	24	141	5	5	23	17
11	42	100	about 85	?	?	62	73·0	71	83·5	6·7	7·9	3·0	44·8	1·5	22·4	100	36	136	4	5	23	19
12	42	150	89	12·4	13·9	66	74·1	80	91·1	5·1	5·7	1·9	37·2	1·0	19·6	117	18	135	5	5	20	17
13	42	150	92	12·1	13·1	69	75·0	81	88·1	6·1	6·6	2·3	37·7	1·3	21·3	108	24	132	5 ?	5 ?	24	20
14	42	150	95	11·3	11·9	?	?	84	88·5	6·7	7·1	3·1	46·3	1·4	20·9	121	21	142	6	6	31	20
15	42	150	97	12·6	13·0	?	?	89	91·8	6·3	6·5	3·0	47·6	1·3	20·4	131	11	142	4	6	27	17
16	42	150	98	10·2	10·4	?	?	88	89·8	6·6	6·7	2·6	39·4	1·5	22·7	118	23	141	5	6	27	19
17	42	150	101	12·0	11·9	75	74·3	89	88·1	6·7	6·6	3·1	46·3	1·4	20·9	115	24	139	5	5	27	17
18	42	150	105	12·2	11·6	76	72·4	95	90·5	6·9	6·6	3·1	44·9	1·3	18·8	118	21	139	5	6	22	17
19	42	150	110	13·2	12·0	78	71·9	98	89·2	7·1	6·5	2·8	39·4	1·5	21·1	115	26	141	5	5	23	19
20	42	100	113	14·6	12·9	80	70·8	102	90·3	7·4	6·5	2·8	37·9	1·5	20·3	117	23	140	5	5	27	21
21	58	100	170	19·0	11·2	117	68·9	147	86·5	7·8	4·6	2·7	34·6	1·6	20·5	111	31	142	4	5	30	19

larvae in question, but as the frequency-curve in regard to the number of segments takes the usual form, and my suspicions were otherwise unsupported, I abandoned this idea.

Looking at the matter from a biological point of view, we cannot help wondering at the great difference in size and development of the various individuals. For instance, comparing no. 1 with no. 20 we cannot doubt that the latter is considerably older than the former, but grouping the individuals according to length, there is hardly anything on which to found the supposition that there are two or more distinct groups. The table shows that nearly all the individuals differ in length, but it is only between nos. 1 and 2 that there is any great difference, the rest increasing gradually in length.

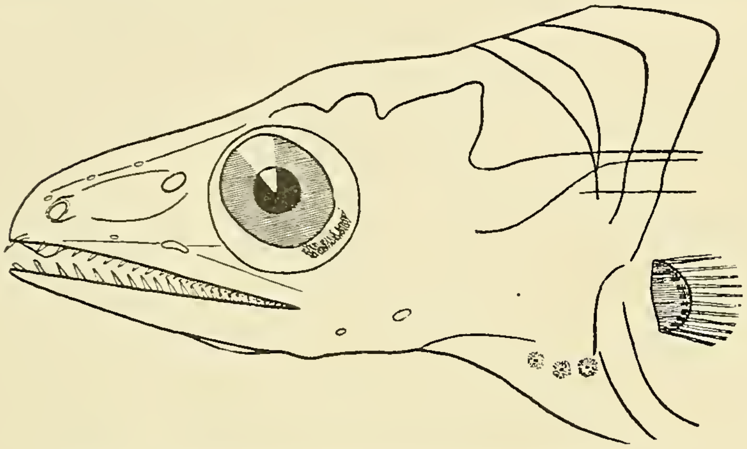

Fig. 15. Head of a large larva of *Conger mystax*. $^{10}/_{1}$.

This phenomenon can hardly be casual, seeing that most of the individuals were taken in the same day at the same station, and we must conclude that individuals differing in size and development existed in the very same locality. In this respect there is a great difference between these larvae and the larvae of *Conger balearicus*, which included individuals practically speaking at the same stage of development (the individuals group themselves round an average in the manner usual for biological variation). We must not, however, draw too comprehensive conclusions from the catches, and it is difficult to decide whether this difference, so conspicuous in our material, is dependent upon differences in the biology of the species in question (for instance a greater or less extension of the spawning time). Our catches can hardly be compared with SCHMIDT's catches in the Mediterranean, for in his paper (29) he states quite generally that "the occurrence of the larvae shows that *Conger mystax* spawns later in the year than *Conger vulgaris*, i. e. later in summer and autumn, at which times of the year the smallest stages are found, and it is possible that this species spawns a little nearer the coast than *Conger vulgaris*".

As to the distribution of this species SCHMIDT believes that it belongs to the Mediterranean, his investigations having proved that the larvae occur commonly in the Mediterranean, while outside this sea only a few specimens have been taken in the Atlantic not far from Gibraltar.

The "Michael Sars" stations where the larvae in question were caught are situated near the coast of Morocco, about seven degrees of latitude to the south of Gibraltar. Considering this distance, and the early stages of the smaller larvae, I am of opinion that it is improbable that they came from the Mediterranean, the more so as the adult animals have been caught in the eastern Atlantic (JORDAN and EVERMAN). It seems to me more reasonable to suppose that the distribution of this species is dependent on certain external conditions to be found in the Mediterranean and in the eastern Atlantic only, for it is an established fact that the larvae have hitherto been found only in these localities.

Our material gives valuable information regarding the vertical distribution of the larvae, for the table shows that

2 larvae were taken at a depth of......... 100 metres
17 „ „ „ - - „ - .... 150 „
1 larva was „ - - „ - .... 1000 „

As nets were dragged at depths of 0, 50, 100, 150, 250, and 400 metres at Stat. 42, where most of the larvae were caught, there is little doubt that at this place the larvae occurred in greatest abundance between 100 and 150 metres.

Note.—I was somewhat in doubt whether a larva from Stat. 58 (no. 21 in the table) belonged to *Conger mystax* or to some closely allied species, because of its size (length 17 cm), which far exceeds the general size of the larvae of this species,[1]) and because the head is relatively smaller than in the other larvae entered in the table, but as it corresponds perfectly to the larvae of *C. mystax* in all the most essential characters, I have considered it right to avoid setting up a new species. The number of segments, the number of rays in the caudal fin, the number of rays in the pectoral fin (10 to 12) and in the anal fin (160 to 175), agree with those on the other individuals.

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[1]) In regard to this matter Dr. JOHS. SCHMIDT says (29): "The full-grown larvae of the Conger-species mentioned *(C. vulg. balearicus, mystax)* differ in regard to size *C. balearicus* has the largest larva (ca. 20 cm.), *C. mystax* the smallest (ca. 13 cm.), whilst the larva of *C. vulgaris* may attain a length of ca. 16 cm.

Fig. 15 on page 20 representing the head of this larva, shows that the snout is rather obtuse at the front, and that there are a few pores on the head. The latter feature is discernible in larva no. 11 in the table.

This larva was taken at Stat. 58, close to the Azores, where the depth is about 1700 metres. If it really is the larva of *Conger mystax*, this occurrence will extend its known range of distribution. A photograph of the larva is reproduced in fig. 2, pl. III.

7. Leptocephalus Congri balearici.

In Grassi's paper regarding the connection between adult eels and Leptocephali among other things he states that the Leptocephali described under the names of *Leptocephalus taenia, inornatus* and *diaphanus* are larvae of *Conger balearicus*, but he does not explain why, neither does he indicate the number of segments and vertebrae in the larvae or the adult animals. Schmidt has been studying the question, and has published his results in a recent paper (29).

The material from the cruise of the "Michael Sars" contains many specimens (83 in all) of the larva which according to Schmidt's investigations is the larva of *Conger (Congromuraena) balearicus*. Schmidt informs us that this species is identical with *Leptocephalus Eckmani* described by Strömman, (33), and is closely related to *L. diaphanus* and *L. inornatus* reported from the Mediterranean. This species has been frequently described, and it is therefore unnecessary for me to enter into details, beyond indicating the number of myomeres and the length of each specimen.

According to the table below the individuals vary in length between 76 and 101 mm. Schmidt (29) states that the full-grown larva of this species is about 200 mm in length, therefore the individuals in our material are not yet full-grown. In all the individuals the fin-rays are not developed; only in the caudal fin and the posterior portion of the vertical fins can the first traces of some rays be seen. On the other hand, we find some indications of interspinous elements in the vertical fins; in the anal fin faint traces are to be discovered directly behind the anus, and in the dorsal fin at about the height of the anus.

Except in one individual the nostrils are separated, but they are placed very near to each other.

The teeth in each half of the upper jaw number 10 to 13, in each half of the lower jaw 9 to 12.

The muscle-segments number on an average 133, varying between 129 and 137, excluding one individual (no. 28 in the table) with only 123 segments. This individual, however, corresponds otherwise in every cha-

No.	Station	Length mm	Segments		
			pre-anal	post-anal	total
1	52	76	120	11	131
2	„	79	121	10	131
3	„	80	122	10	132
4	„	„	?	?	134
5	„	„	124	10	134
6	„	„	122	10	132
7	„	81	124	10	134
8	„	„	123	9	132
9	51	82	121	10	131
10	52	„	121	10	131
11	51	83	120	11	131
12	„	„	?	?	133
13	„	„	127	9	136
14	„	„	127	9	136
15	52	„	125	10	135
16	51	„	122	10	132
17	„	84	121	12	133
18	„	„	123	10	133
19	„	„	119	11	130
20	„	85	123	10	133
21	„	„	?	?	132
22	51	86	126	9	135
23	„	„	122	10	132
24	„	„	125	10	135
25	„	„	123	9	132
26	„	„	123	10	133
27	52	„	125	9	134
28	51	87	113	10	123
29	„	„	124	11	135
30	„	„	?	?	134
31	„	„	123	10	133
32	52	„	120	10	130
33	„	„	120	10	130
34	51	88	?	?	132
35	„	„	125	9	134
36	„	„	123	10	133
37	„	„	?	?	132
38	„	„	123	11	134
39	52	„	128	8	136
40	„	„	124	9	133
41	„	„	122	9	131
42	51	89	125	9	134

No.	Station	Length mm	Segments			No.	Station	Length mm	Segments		
			pre-anal	post-anal	total				pre-anal	post-anal	total
43	51	89	119	10	129	63	51	93	125	9	134
44	„	„	120	11	131	64	„	„	?	?	136
45	„	„	?	?	134	65	52	„	122	10	132
46	52	„	122	10	132	66	„	„	124	10	134
47	51	90	?	?	132	67	51	94	126	10	136
48	„	„	?	?	131	68	„	„	?	?	134
49	„	„	123	11	134	69	„	„	125	10	135
50	„	„	121	10	131	70	„	„	124	10	134
51	52	„	122	9	131	71	52	„	124	10	134
52	51	91	122	10	132	72	„	„	125	9	134
53	„	„	121	10	131	73	51	95	123	9	132
54	„	„	125	10	135	74	„	„	125	10	135
55	„	„	124	10	134	75	„	96	120	11	131
56	„	„	121	11	132	76	„	„	?	?	135
57	„	92	121	10	131	77	„	„	123	9	132
58	„	„	126	9	135	78	„	„	?	?	137
59	„	„	124	10	134	79	„	97	124	9	133
60	52	„	122	10	132	80	„	98	?	?	132
61	51	93	123	11	134	81	„	100	122	11	133
62	„	„	?	?	131	82	„	101	?	?	136

One larva, being damaged, is not entered in this table.

racter so absolutely to the rest, that it cannot be regarded as a different species, but must be looked upon as an extreme or abnormal variant.

The postanal segments number between 8 and 12 i. e. the anus is placed very near the tip of the tail (see fig. 3, pl. III).

Schmidt (29) estimates the number of muscle-segments in this species at about 130, whereas our individuals average 133 segments, but Schmidt, who has examined individuals from the Mediterranean, the northern central Atlantic, and the Mexican Gulf, states that individuals from the Mid-Atlantic Ocean have a few more segments than those from the parts of the ocean close to land.

All our individuals were taken in the surface waters at two adjacent stations, 51 and 52, where the deep is nearly 4000 metres, situated near the easternmost of Schmidt's records for the larvae of this species, scattered over the North Atlantic to the west of the Azores from near Newfoundland on the north to the large West-Indian Islands on the south.

This species seems to be very common in the North Atlantic. Schmidt informs us that in number this is "by far the most important of all eel-larvae in our collections", and Strömman states that of this species, which he has described under the name of *L. Eckmani* "the museum (in Upsala) possesses a particularly large number of examples, collected in the Central Atlantic (altogether 451 individuals).

8. ***Leptocephalus spinocadux*** n. sp.

The single specimen of this species, taken at Stat. 67 in 400 metres, is represented on pl. III fig. 4. Length 121 mm, greatest height, near the anus, 11·5 mm. There are 125 myomeres, 66 preanal, 95 postanal. Anus placed far forward, 68 mm from point of snout.

Head relatively small, distance from point of snout to anterior margin of eye 1·6 mm, horizontal diameter of eye somewhat less than 1 mm, largest diameter somewhat greater than 1 mm.

Snout pointed, contour of jaws straight. The lower jaw is defective, but it does not seem to have protruded beyond the snout. The mouth cleft extends backwards as far as the hinder contour of the lens of the eye.

There are only two teeth, both in the upper jaw, a big one in front and a very small one a little farther back.

The gill-slit is placed just in front of the pectoral fin.

As the had has become a little deformed in the preserving fluid, I have not been able to ascertain the position and form of the nostrils. As far as I can see both of them are placed as represented in fig. 16.

The alimentary canal is very thin and situated close to the ventral contour of the animal.

All the fins contain rays. The pectoral fin has 6 rays, which are quite indistinct. The caudal fin has 6 very powerful rays, H_1 and H_2 having each three. They have a length of about 1·6 mm.

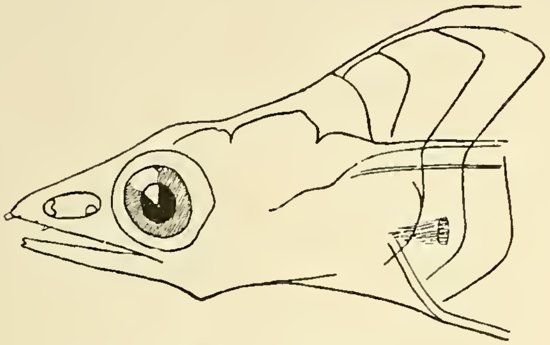
Fig. 16. Head of *L. spinocadux.* 10/1.

Interspinous elements are developed in the margin of the embryonic anal fin, but rays have not yet appeared on the foremost ones.

Proceeding backwards there are first feeble indications of rays, then rays having distinct contours, and lastly near the caudal fin very powerful rays. The last ray of the anal fin is situated close to the lowest caudal fin-ray.

In the dorsal fin too we see rays and interspinous elements most strongly developed posteriorly. Proceeding forwards the rays first become indistinct, then gradually disappear, followed by a space with interspinous elements decreasing in development towards the front, until they are only indicated as a rather dark shadow in the margin of the embryonic fin.

The interspinous elements and rays of the vertical fins form a very acute angle with the longitudinal axis of the body.

As for pigment there is only one row of spots on the anal fin, one little spot at the base of each ray.

9. *Leptocephalus polymerus* n. sp.

In his work "Leptocephalids in the University Zoological Museum at Upsala", Upsala 1896, (33) Strömman describes a species which he calls *L. curvirostris.* As he does not indicate the number of segments it is impossible to determine with certainty whether the two specimens here described under the name *L. polymerus* really belong to that species or to a very near ally.

The smaller specimen, taken at the surface at Stat. 51, is shown in fig. 5 on pl. III, and the head is shown in fig. 17 in the text. The larva is long in proportion to height, body much compressed, decreasing in height backwards, tail terminating in a very fine tip; anus situated far back; head comparatively small, snout pointed. There are as yet no indications of rays or interspinous elements in the fins, and the nostrils are not yet fully separated (fig. 17). The larva is less fully developed than the second and larger specimen taken at Stat. 52 in 50 metres. In the larger specimen the nostrils are separated but placed close together; there are indications of a great number of interspinous elements in the vertical fins, whereas rays are still wanting; anus placed farther forward on the body; teeth rather more numerous.

The pigmentation of the larger specimen agrees with Strömman's description of *L. curvirostris* a series of dots running along the lower margin of the body directly over the alimentary canal, and other series of dots following the lateral line and the bases of the vertical fins. In the smaller specimen we can see traces of a series of dots which seem intended to run along the anal fin, whereas the series along the dorsal fin is absent.

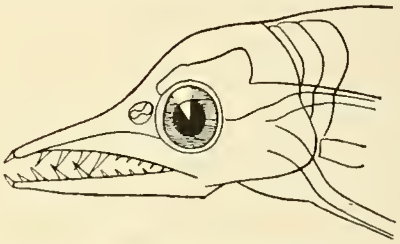
Fig. 17. Head of *L. polymerus.* 10/1.

Measurements of the two specimens are given in the following table:

Total length	208 mm	125 mm
Distance from point of snout to anal aperture	190 „	119 „
Distance from point of snout to foremost dorsal interspinous element	184 „	?
Greatest height.............	8 „	6 „
Length of head	4·6 „	4·0 „
Distance from point of snout to foremost margin of eye	2·3 „	1·9 „
Largest diameter of eye	1·0 „	0·8 „
Number of segments: preanal.	303	305
„ „ „ : postanal about	140	> 100[1])
„ „ „ : total ... „	443	> 405
Number of teeth in one half of upper jaw	2 + 6 + 4	1 + 4 + 4
Number of teeth in one half of lower jaw.............	1 + 5 + 5	1 + 4 + 4

---

[1]) Tip of tail damaged.

10. ***Leptocephalus Michael-Sarsi*** n. sp.

One specimen of this species was taken at Stat. 81 at a depth of 150 metres. It has a length of 99 mm, and as shown in fig. 1 on pl. IV, it is rather high (greatest height 13 mm). There are 52 preanal and 75 postanal segments, 127 in all. Anus is placed far forward, 49 mm from the point of the snout. All the fins contain powerful rays. The foremost ray of the dorsal fin is placed 30 mm from the point of the snout. The caudal fin has 9 rays, H_1 having five and H_2 four. These characters, in conjunction with the shape of the head (see fig. 18) and the lack of teeth, denote that retrograde metamorphosis has commenced. The anterior nostril is tubular, with the aperture directed downwards, the posterior one a small round aperture in front of the eye.

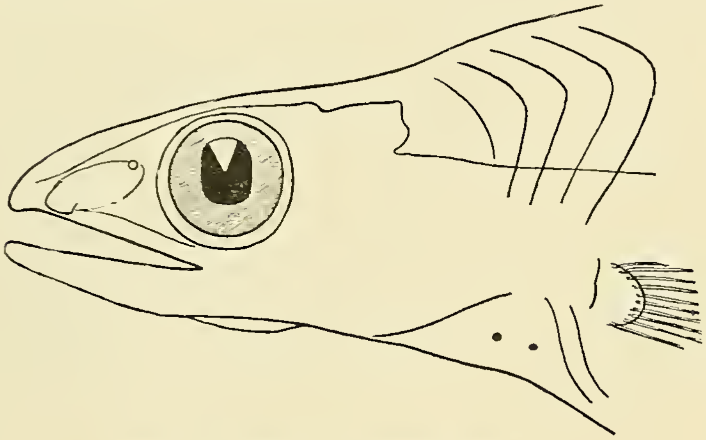

Fig. 18. Head of *L. Michael-Sarsi.* $^{10}/_1$.

There are two spots of pigment in front of the curve of the alimentary canal at the pectoral fin (see fig. 18), a row of spots under the lateral line, as shown in fig. 1, pl. IV, row of dots with large interspaces along the anterior portion of the alimentary canal, and one or two irregular elongated or round spots at the bases of all the rays of the anal fin, the caudal fin and the posterior rays of the dorsal fin.

11. ***Leptocephalus splendens*** n. sp..

One specimen of this beautiful form was taken at Stat. 45 in 150 metres. Its most conspicuous character is its pigmentation, shown in fig. 2 on pl. IV, which needs no further description, beyond saying that there are a couple of spots on the embryonic dorsal fin directly above the posterior heap of pigment at the median line.

This larva, which is 56 mm long, and 8 mm in maximum height, is not yet fully developed; there are no separated nostrils, and only the caudal fin contains developed rays. Besides distinct interspinous elements, the first traces of true rays may be seen in the external margin of the posterior portion of the vertical fins. The interspinous elements become indistinct farther forward, and directly behind the anus there is no trace of these elements either.

Rays may be seen in the pectoral fin.

The vertical diameter of the eye is 0·8 mm, the horizontal diameter 0·7 mm. Distance from point of snout to the anterior margin of the eye is 1·2 mm.

The mouth-opening reaches as far back as directly below the centre of the eye. Snout quite pointed; point of lower jaw protruding a little in front of point of snout.

Teeth as follows:

In each half of the upper jaw first a small "front tooth", succeeded by a strong curved one, and then a strong tooth and 4 very small ones.

In each half of the lower jaw first a large curved tooth, then a strong straight tooth, followed by 4 smaller teeth, but larger than the corresponding teeth of the upper jaw. All the teeth are directed forwards, especially those of the lower jaw (see fig 19). If we look at the point of the snout from above, we see that the teeth are directed sideways also, and that the two big teeth in each half of the upper jaw are curved inwards, having almost the appearance of a thorn on a rosebush.

There is a thickening of the alimentary canal under the pectoral fin (see fig. 19), but the anterior portion is elsewhere thin; farther back it grows thicker, forming curves (see fig. 2 pl. IV). The anus is placed far back, 15 mm from the tip of the tail. There are 135 segments, 81 preanal and 54 postanal. The segments are of the usual form, having a dorsal angle, an angle in the lateral line and a ventral angle. The only peculiarity about the segments is the position of the angles, the dorsal and ventral angles being placed very close to the dorsal and ventral margins of the animal.

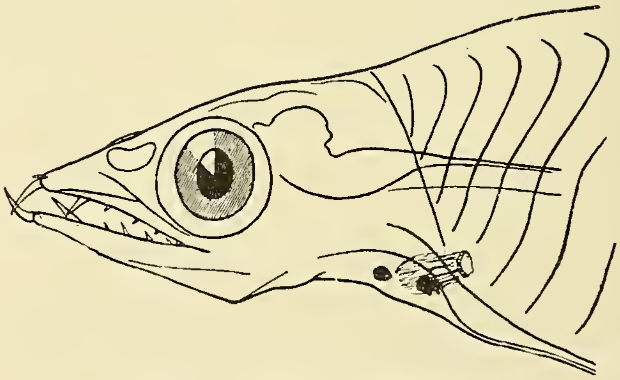

Fig. 19. Head of *L. splendens.* $^{15}/_1$.

*12. **Leptocephalus enchodon*** n. sp.

This species, of which one specimen was taken at Stat. 62 in 150 metres, somewhat resembles a larva of *Conger vulgaris*, among other things in having 158 segments (112 preanal and 46 postanal), but other characters clearly prove it to be distinct.

It is 108 mm long and as shown in fig. 3 on pl. IV it is rather high (13 mm), terminating posteriorly in a point. The head is inclined downwards, so that the greater part of it falls below the level of the median line, which runs midway between the dorsal and ventral margins of the animal. The snout is short, but pointed, profile curved. Upper jaw protrudes a little in front of the lower jaw. There are 20 teeth in each half of the upper jaw, the foremost one being at some distance from the succeeding ones, which form a continuous row. Each half of the lower jaw contains 17 teeth, the foremost of which is very peculiar in form as shown in fig. 20.

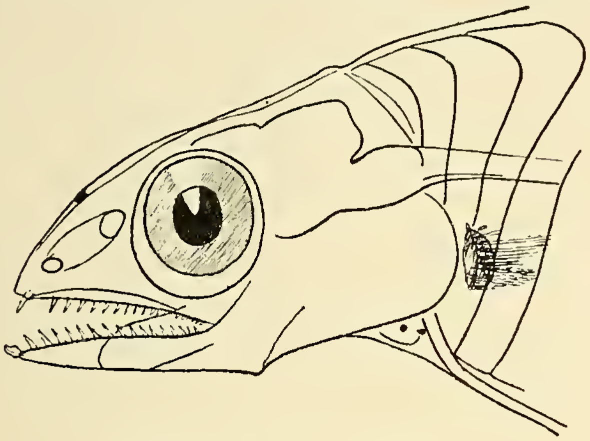

Fig. 20. Head of *L. enchodon*. $^{10}/_{1}$.

The nostrils are quite separated, the anterior one being semitubular, whereas the posterior one, situated in front of the eye, is an oval aperture (see fig. 20).

The first traces of true rays may be seen in the upper two-thirds of the pectoral fin, the lower third having retained its embryonic character. The vertical fins and the caudal fin contain powerful rays. The caudal fin has 10 very long rays (2 mm), H_1 and H_2 having five each. The hindmost rays of the vertical fins are placed close up to the caudal fin-rays. Anus is placed far back, 18 mm from the tip of tail.

The alimentary canal is thin and runs along the ventral margin of the animal. Throughout nearly its whole length there is an interspace between it and the ventral margin of the muscle-segments.

The pigmentation is characteristic. Along the canal there is a series of elongated spots, continued by a series of smaller rounded spots on the anterior interspinous elements of the anal fin. Pigment is dispersed in thin stripes on the anal and caudal fin-rays, as well as on the posterior dorsal fin-rays, most strongly developed at the bases. Over the ventral part of the muscle-segments, a little below the lateral line, there are pigment spots in an irregular zig-zagline from the 14th segment to near the tip of the tail. There are also two spots directly in front of the curvature of the alimentary canal below the pectoral fin (see fig. 20).

*13. **Leptocephalus euryurus*** n. sp.

The "Michael Sars" procured two larvae of this species, representing somewhat different stages of development. The one from Stat. 34, between 200 and 500 metres, near the coast of Morocco, is 46 mm long, with a maximum height of about 6 mm. Fig. 4 on pl. IV reproduces a photograph of this species, which is of nearly uniform height, the dorsal margin of the body being almost continuous with the upper contour of the head, and the tail being rounded.

The segments 58 preanal, and 58 postanal, 116 in all are of the usual shape. The anus is placed almost exactly midway between the point of the snout and the tip of the tail. The head is short and high, measuring 2·7 mm from the point to the anterior edge of the first complete muscle-segment, with a maximum height of 2·2 mm.

The snout is short, but quite pointed, measuring 1 mm from the point of the snout to the anterior margin of the eye, which is small (maximum diameter 0·5 mm), and not quite round, having undulations on the upper and lower edges (see fig. 21); the right eye, with only one undulation on the upper edge, is placed nearer the jaw than the upper contour of the head, and the lens is quite small.

The nostrils are separated, the anterior one being placed almost midway between the anterior limit of the brain and the point of the snout, and is an oval aperture, while the posterior one is smaller and nearly round, and placed higher than the eye. The brain extends forward beyond the anterior contour of the lens of the eye, and does not fill the space between the eye and the upper margin of the head.

The teeth are quite powerful. The foremost teeth in each jaw are broken off in this specimen, but judging by those in the second specimen (represented in fig. 22) they are probably curved, while the succeeding teeth are conical, 8 in the upper jaw, 9 in the lower jaw, diminishing in size backwards.

The gill-opening is a very small slit placed laterally, directly behind the curve of the alimentary canal where the body joins the head.

The lower contour of the lower jaw is curved and does not form an angle. Its point lies a little behind the point of the snout.

The alimentary canal is quite thick, but otherwise normal in appearance.

The pectoral fin is totally absent, not even the slightest trace being found. The caudal fin has 4 rays, H_1 and H_2 having each two rays. Rays as well as interspinous elements have developed in the hindmost portions of the embryonic vertical fins, close to the caudal fin. The rays nearest to the tail fin are most highly developed, and number 8 in the dorsal fin and 4 in the anal fin.

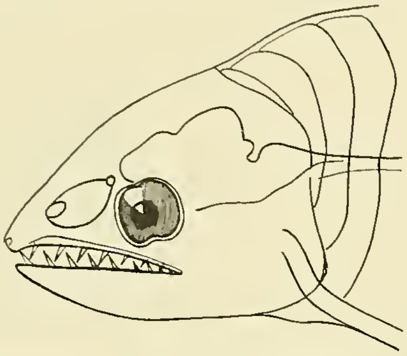
Fig. 21. Head of *L. euryurus*, station 34. $^{15}/_{1}$.

The only pigment seen consists of a row of very small oval dots along the outer margin of the embryonic vertical fins.

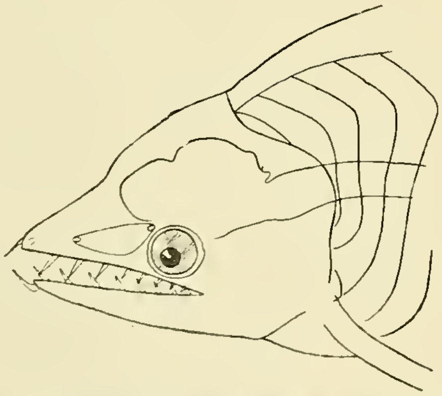
Fig. 22. Head of *L. euryurus*, station 45. $^{15}/_{1}$.

The second specimen was taken at Stat. 45 in 1000 metres, and differs slightly from the first specimen, but they agree in all essential characters.

The eye is slightly smaller than in the first specimen, and the head differs slightly in shape (compare fig. 21 with fig. 22).

This specimen is 55 mm in length, with a maximum height of 7 mm. It has 59 preanal and 58 postanal, 117 in all.

The anus lies almost midway between the point of the snout and the tip of the tail, but a little nearer the head than the tail. The head (shown in fig. 22) has a bend in the upper contour. The snout is short and pointed, measuring 1·1 mm from the point to the anterior margin of the eye, which has a diameter of 0·4 mm, and is placed unusually far down in the head. The position of the nostrils, both of which are pores, is shown in fig 22. As for teeth, it has first quite a long "front"-tooth in each half of the upper jaw then a "corner"-tooth (broken off), and finally 8 quite strong conical teeth, which decrease in size backwards. In the lower jaw it has a long curved tooth at the front, and behind it 8 conical teeth. The lower jaw is not quite so fleshy as in the other specimen. The gill-opening is a narrow slit placed laterally.

Pectoral fin absent. In the posterior portions of the vertical fins may be seen the first feeble traces of interspinous elements, and possibly also one or two rays. The caudal fin too, is feebly developed, but the 4 rays may easily be seen: two on H_1 and two on H_2.

As for pigment it has only a series of small dots along the outer margin of the embryonic anal fin.

14. Leptocephalus similis n. sp.

Two individuals of this species were caught at Stat. 64, no. 1 at 100 metres, and no. 2 at 1000 metres. This species greatly resembles *L. euryurus* and doubtless the parent-forms are closely related.

No. I, represented in fig. 6, pl. IV, is 34 mm long, attaining its greatest height 5 mm on the tail portion. The anus lies nearly midway between the point of the snout and the tip of the tail, 17·5 mm from the point of the snout. There are 54 preanal and 56 postanal segments, 110 in all. The tail is quite rounded.

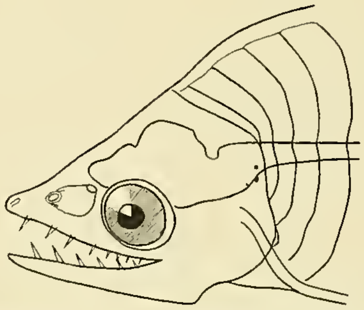
Fig. 23. Head of *L. similis*, station 64, 100 metres. $^{15}/_{1}$.

The head, shown in fig 23, is short in proportion to height, its length being 2·4 mm, greatest height, 1·9 mm. The distance from the point of the snout to the anterior margin of the eye is 0·8 mm. The eye is placed near the mouth, the brain extending over it. The nostrils are separated. The anterior one, which is becoming tubular, is placed almost midway between the point of the snout and the anterior margin of the eye, while the posterior one, an oval aperture, is placed obliquely upwards from the centre of the eye.

In half of the upper jaw there are a front tooth (broken off), followed by 8 teeth, of which the posterior 5 are smaller and placed closer together. There are 6 slanting teeth in each half of the lower jaw; the foremost tooth is absent.

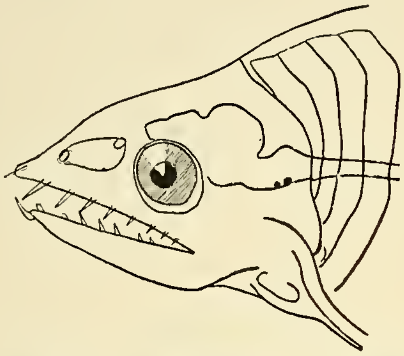

Fig. 24. Head of *L. similis*, station 64, 1000 metres. $^{15}/_{1}$.

The point of the lower jaw does not extend so far forward as the point of the snout.

The gill-opening is a very narrow slit. Pectoral fins are totally wanting. It is only in the portion adjoining the caudal fin that the vertical fins contain rays and interspinous elements. The caudal fin contains 4 rays, H_1 and H_2 having two each, The rays of the vertical and caudal fins are quite short and especially in the vertical fins, they are rather wide apart.

As for pigment there are only a few spots on the brain portion (see fig. 23)

Specimen no. 2 is a little larger, 40 mm long, maximum height 6 mm. It may possibly represent a somewhat later stage of development, as the head is of a rather rounded form (see fig. 24). Also in this larva the anus is placed midway between the point of snout and the tail-tip, 21 mm from the point of the snout. There are 55 preanal and 55 postanal segments, 110 in all.

Length of head 2·7 mm, greatest height 2·1 mm, distance from point of snout to anterior margin of eye 1·1 mm.

The shape and number of teeth are shown in fig. 24. The foremost tooth of the upper jaw (which was broken off in specimen no. 1) is in no. 2 thin and straight. The foremost tooth of the lower jaw (also wanting in no. 1) is curved. The greatest diameter of the eye is 0·6 mm, the horizontal diameter being 0·5 mm.

In regard to gill-opening, fins and pigment the two specimens are identical.

Comparing the two species *L. euryurus* and *L. similis* with the known larvae of *Muraena helena*, described by Grassi (16), many resemblances will be found. The general appearance of the three species are the same; they have all a short but high head, while the body terminates in a rounded tail. Also the absence of pectoral fins is a feature common for these three species. Judging from all this, it is probable, that the two species described here have parent forms which are nearly allied with *Muraena helena*. Looking in the table p. 6, we find one species of the family Muraenidae, whose segment-number corresponds to that of *L. euryurus* viz. *Echidna catenata* Bleek. As I have not had the opportunity of examining an adult *Echidna*, I am unable to say if there is a connection between it and *L. euryurus*, but deeming from the fact, that the vertical fins in our larvae have very few but conspicuous rays it seems more probable that they are the larvae of some species of Muraena.

15. ***Leptocephalus proboscideus*** n. sp.

The larva under consideration, taken at Stat. 53 in 150 metres, is one of the most peculiar in the collection. Its appearance is shown in fig. 1, pl. V, and we see that it is specially characterized by its snout, which is prolonged into a rather flexible proboscis; it is partly broken off, and has certainly been much longer. The head has an extraordinary appearance, as shown in fig. 25, the upper contour forming a rather acute curvature in front of the obliquely directed telescopic eye. The pigmentation furnishes a third characteristic feature distinguishing this larva from similar species. Along the lateral line there are 4 or 5 subcuticular double spots, seen in fig. 1, pl.

Fig. 25. Head of *L. proboscideus*. $^{15}/_{1}$.

V as faint shadows. There are also three spots on the surface of the body forming a triangle: one spot on the lateral line and the other two near the ventral margin of the muscle-segments.

On either side of the alimentary canal we find 13 oval double-spots. Between its first and second and between the second and third pairs of spots there is a single spot on the ventral margin.

The pigmentation of the head is shown in fig 25. We see the pigment at the base of the proboscis, near the point of the lower jaw, two spots on the brain-portion, and one spot on the alimentary canal directly under the pectoral fin. An extremely fine pigmented line, consisting of about twenty minute dots, runs backwards from the spot under the pectoral fin towards the first spot on the alimentary canal.

The form and position of the nostrils are characteristic. They are both at quite a distance from the eye, and the anterior one looks as if it might become a narrow horizontal cleft, whereas the posterior one is an oval aperture; they are not yet fully separated.

The dentition is rather peculiar. Each half of the upper jaw is furnished with a curved tooth anteriorly directed obliquely forward; it is followed by 4 short thick conical teeth directed downward and then 6 small sloping teeth. Each half of the lower jaw is likewise furnished with a curved tooth anteriorly, followed by 7 large teeth, and 8 small sloping ones.

The single specimen has a damaged tail, so that it is impossible to ascertain the length, the number of segments, and the form and development of the caudal fin. In its present state it measures 55 mm from the base of the foremost tooth of the upper jaw to the tip of the broken off body, and there are 75 preanal and 41 postanal segments, so that it must have had more than 116 segments altogether.

From point of snout (proboscis not included) to anus it measures 37 mm, length of head (from base of proboscis) 4·4 mm, length of snout 1·7 mm, and greatest diameter of the eye 1·1 mm.

All the fins in the damaged individual show no trace of rays; the vertical fins seem to lack interspinous elements too.

As far as I am aware, only one species with its snout produced into a proboscis has hitherto been described, viz. *L. rostratus* Schmidt. The larva in question is undoubtedly distinct from *L. rostratus*, which has about 190 segments (a number which our larva can never have possessed); but that they are closely allied is proved by the presence of a proboscis, the position of nostrils far removed from the eye, the telescopic eyes, and the pigmentation of the alimentary canal.

16. Leptocephalus dolichorhynchus n. sp.

Three specimens of a species very closely allied to *L. proboscideus* were taken by the "Michael Sars": two small ones at Stat. 67 in the net at 100 metres, and a large one at Stat. 53 in the net at 150 metres. Fig. 2, pl. V is a reproduction from a photograph of the largest specimen, and shows the peculiar aspect of these larvae distinctly; a comparison between this figure and fig. 1 pl. V brings out the resemblances and differences between this form and *L. proboscideus.* It is quite evident that these two forms are closely allied, and may be grouped together with *L. rostratus* described by SCHMIDT (27). This group is distinguished from other leptocephalids by the point of the snout being elongated into a proboscis, by the eye being telescopic, and by the nostrils being placed far forward on the snout.

Before proceeding to describe the three larvae, the characters that seem to justify us in regarding them as representing a new species may be enumerated.

The number of segments varies between 128 and 136, thus readily distinguishing these larvae from *L. rostratus*, which has about 190 segments. A comparison with the larva described as *L. proboscideus* is in this respect impossible, because the number of segments could not be determined owing to the defective condition of the single specimen. A striking difference is found in the pigmentation of the musculature of the body, the arrangement of which in *L. dolichorhynchus* is shown in fig. 2, pl. V, this arrangement being identical in the three larvae.

We see that in *L. dolichorhynchus* in contrast to *L. proboscideus* the two spots at the ventral margin of the musculature, as well as a third elongated spot on the lateral line above the other two, are wanting. Figs. 2 and 3, pl. V also prove how different is the arrangement of the pigment of the lateral line in the two species; for whereas *L. proboscideus* exhibits spots far beneath the surface and, for the greater part, on the anterior half of the animal, *L. dolichorhynchus* has five spots lying at the surface of the animal and, for the greater part, on its posterior portion.

There is also a difference in the pigmentation of the alimentary canal, *L. proboscideus* being provided with longitudinal chromatophores arranged in two series on either side of the alimentary canal, while the pigment in *L. dolichorhynchus* is arranged in a manner most easily seen from the ventral side: proceeding backward from the head, we find first a chromatophore just under the pectoral fin (figs. 26 and 27), then a spot on each side of the anterior narrow portion of the alimentary canal (one of these spots is shown in fig. 2 pl. V); farther back, on the expanded portion of the alimentary canal, there are seven pigmented groups, each consisting of four spots (two on the ventral median line with one on each side of the alimentary canal) forming a sort of cross, finally there are two chromatophores near the anus, one on either side of the alimentary canal. This arrangement holds good for the two smaller larvae, and also for the larger larva except on one point: the hindmost spot in each of the seven groups of four chromatophores has disappeared, so that each group consists of only three spots, one ventral succeeded by two lateral.

These differences, taken together with a relatively larger head and a relatively larger trunk, justify me, I think, in separating *L. dolichorhynchus* from *L. proboscideus.*

The three larvae have not progressed beyond their prelarval state, and are devoid of every trace of interspinous elements as well as of true rays in the vertical fins. Neither are true rays to be seen in the pectoral fins which are present in the form of fan-shaped lobes with a fine striated structure; neither do we see distinct traces of hypural bones in the two smaller larvae, though in the larger larva these bones have commenced to form, but without the slightest trace of rays. The nostrils are not separated in any of the larvae, their position being indicated by an oval groove situated far in front of the eye.

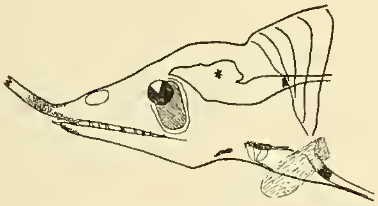

Fig. 26. Head of *L. dolichorhynchus*, spec. 1. $^{15}/_{1}$.

The following table gives some measurements of the three larvae, the total length being measured from the point of the proboscis to the tip of the tail.

	Specimen 1	Specimen 2	Specimen 3
Total length	31 mm	? mm	42 mm
Tip of tail to point of lower jaw	24 „	24 „	33 „
Height	4 0 „	4·0 „	4·8 „
Anus	16 „	17 „	22 „
Head	2·1 „	2·1 „	2·9 „
Snout	0·9 „	0·9 „	1·2 „

Specimen 1 has 61 preanal and 67 postanal segments, 128 in all. It has 5 teeth in each half of the upper jaw, the foremost one being broken, the remaining four small, thick, and directed almost vertically. Each half of the lower jaw is provided with 8 teeth, the foremost slightly curved and directed almost straight forwards, succeeded firstly by two large teeth, and then by five small straight ones, all directed obliquely forwards. Fig. 26 shows the shape of the head and its pigmentation, but besides the pigment indicated in the figure there is some pigment covering nearly 1 mm of the proboscis, beginning about 2 mm from the base.

Specimen 2 has 73 preanal and 59 postanal segments, 132 in all. In each half of the upper jaw there are 5 teeth, and in each half of the lower jaw 7, the foremost being slightly curved, followed by two large straight ones and then four small ones. The head in its main features resembles that of specimen 1, and so does the pigmentation, though the anterior of the two spots on the brain portion is absent.

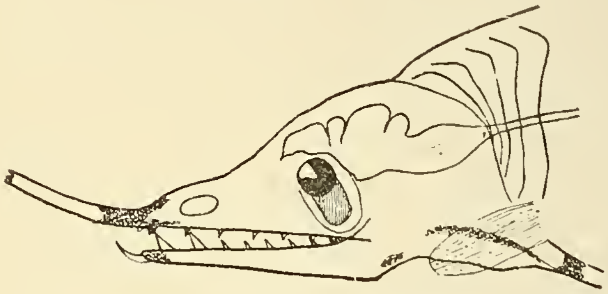

Fig. 27. Head of *L. dolichorhynchus*, spec. 3. $^{15}/_{1}$.

Specimen 3 has 75 preanal and 61 postanal segments, 136 in all. Several features in this the largest individual prove that it is more fully developed than the other two. Hypural bones have commenced to form, the brain is distinctly more differentiated (see fig. 27), the teeth have increased in number, and the profile of the head has altered somewhat. The dentition consists of 7 or 8 teeth in each half of the upper jaw, and 9 teeth in each half of the lower jaw, the form and size being indicated in fig. 27.

The nostrils have advanced somewhat downwards, but show no indication of separating.

The pigmentation of the head is in its main features like that in the other specimens, though the pigment on the brain-portion is arranged rather differently.

*17. **Leptocephalus stylurus*** n. sp.

Six specimens of this species were taken at the same station (no. 39), and in the same net (at 150 metres), including representatives of different developmental stages.

As shown in fig. 3 on pl. V this species is distinguished by the lowness of the body in proportion to its length. The body decreases gradually in height anteriorly and posteriorly, the tail is pointed, the head is low in proportion to its length, and the eye is large.

The features giving this species a very characteristic appearance are: 1) the two swellings on the alimentary canal, seen in fig. 3 pl. V, 2) the 9 or 10 large subcuticular nearly equidistant pigment spots along the sideline of the body, 3) the situation of the anus (on the foremost third of the body), and 4) the position of the dorsal fin. Even in individuals which must be regarded as not yet fully developed, we find the foremost interspinous elements very near the head.

The muscle segments are very numerous, between 218 and 229, 55 to 58 of which are preanal in individuals whose metamorphosis is not yet far advanced.

As a rule, the caudal fin contains 6 rays, three in H_1, and three in H_2, which are considerably longer than the hindmost rays of the vertical fins. The tip of the tail is very pointed.

The teeth are not very large. In each half of the upper jaw we find anteriorly a small curved tooth, then a rather long thin curved tooth followed by 14 to 18 sloping straight teeth, the anterior 8 larger than the rest. In each half of the lower jaw there is first a curved tooth followed by 10 to 16 sloping straight teeth decreasing in size backwards.

Besides the spots of pigment along the lateral line, there are numerous small dots on the two swellings of the alimentary canal, and on the head, or rather in the head, we find pigment on the brain portion at the back, and in the front on the portion between the two nostrils (the pigment on the brain is indicated in figs. 28—31, but it was found impossible to adequately reproduce the pigment on the nostrils). As a rule there is pigment along the lower edge of the upper jaw (see figs. 28—31).

In the following table the individuals are arranged according to their degree of development:

No.	Station	Depth m	Length mm	Greatest height		Dorsal		Anal		Head		Snout		Eye		Number of muscle-segments			Number of caudal rays		Number of teeth in half jaw	
				mm	% of length	mm	% of length	mm	% of length	mm.	% of length	mm	% of head	mm	% of head	pre-anal	post-anal	Total	H_1	H_2	Upper	Lower
1	39	150	93	7	7·5	10	10·8	30	32·3	4·3	4·6	1·7	39·5	0·8	18·6	58	171	229	4	3	16	11
2	„	„	93	6	6·5	10	10·8	32	34·4	4·3	4·6	1·7	39·5	0·9	20·9	58	168	226	3	3	18	14
3	„	„	105	7	6·7	12	11·4	31	29·5	4·6	4·4	1·8	39·2	0·9	19·6	57	167	224	3	3	18	14
4	„	„	100	6	6·0	11·5	11·5	32	32·0	5·1	5·1	2·1	41·2	0·9	17·7	55	163	218	3	3	20	17
5	„	„	127	7·5	5·9	13	10·2	42	33·1	5·2	4·1	2·2	42·3	1·0	19·2	37	188?	225?	3	3	16	14
6	„	„	78	3	3·8	8	10·3	22?	28·2?	4·9	6·3	2·1	42·8	1·0	20·4	?	?	>218	4	3	16	15

Nos. 1 and 2 are not fully developed, for rays are wanting in the vertical fin except near the caudal fin. At this developmental stage the anterior nostril hat not yet grown so distinctly tubular as it does later, and only near the upper margin of the head have I been able to see a few mucous pores, which later increase in number on the head.

Snout in both specimens very much pointed.

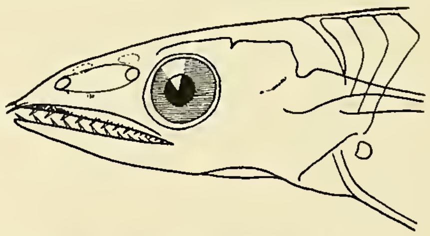

Fig. 28. Head of *L. stylurus*, no. 1. $^{10}/_1$.

No. 3 does not diverge greatly in regard to development from nos. 1 and 2.

It is a little larger, and has more true rays in the vertical fins. Anterior nostril more tubular in shape. Mucous pores observed only along the upper margin of the head. Of the larvae showing no trace of retrograde metamorphosis, this specimen is the most fully developed.

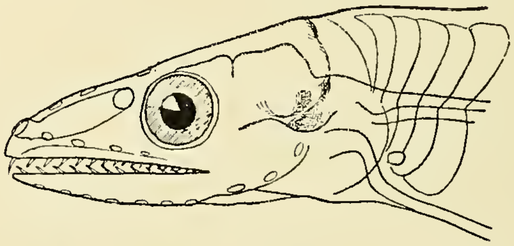

Fig. 29. Head of *L. stylurus*, no. 4. $^{10}/_1$

No. 4 represents the beginning of the metamorphosis, as evidenced by its lesser height and its longer snout with rounded point (see fig. 29 and table). The anterior nostril is very distinctly tubular, approaching nearer to the point of the snout than it does in the previous specimens, and more internal pigment is developed in the hinder portion of the head.

There is a row of mucous pores along the upper contour of the head, another row from the anterior nostril backwards along the upper jaw as far as the anterior margin of the eye, and a third row along the lower edge of the lower jaw.

On all the interspinous elements of the vertical fins, there is a development of true rays.

The retrogressive metamorphosis may be traced still more distinctly in no. 5, in which the point of the snout is still more rounded off and protrudes farther forwards beyond the point of the lower jaw than in no. 4; the snout is relatively longer, and the dorsal fin is inserted nearer the head. The most essential difference is the absence in no. 5 of the small embryonic pectoral fin present in nos. 1—4.

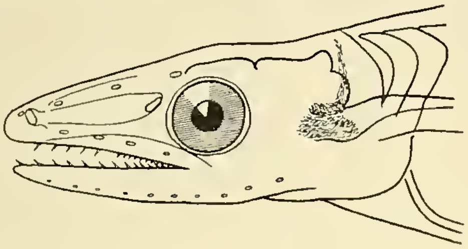

Fig. 30. Head of *L. stylurus*, no. 5. $^{10}/_{1}$

The metamorphosis of no. 6 is far advanced, as shown by the shape of the body, which is not so much compressed as in no. 5, but rather oval in cross-section. The height is relatively small (see table), the head has become a little longer and the rays more powerful.

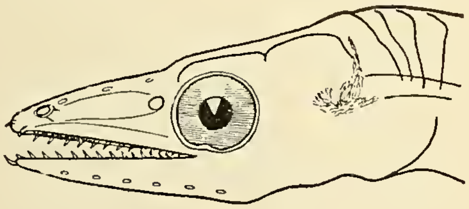

Fig. 31. Head of *L. stylurus*, no. 6. $^{10}/_{1}$.

Like no. 5, this larva has no pectoral fin and thus it is highly probable that the parent form is an eel without any pectoral fin.

The following genera distinguish themselves by the absence of pectoral fins: *Heteroconger, Nettastoma, Saurenchelys, Chlopsis, Todarus*, and the genera of the family Muraenidae. It is highly improbable that the larvae in question belong to any of the last-mentioned family which have very narrow branchial apertures and other characters differing from those found in our larvae. Neither do they belong to the genus *Heteroconger*, the species of which are characterized by a very short snout and by the lower jaw projecting beyond the upper. Among the remaining four allied genera, the larval forms of the following species are known: *Nettastoma melanurum* (larva named *Hyoprorus messinensis* or *Leptocephalus longirostris*), *Saurenchelys cancrivora* (larva named *L. oxyrhynchus*) and *Chlopsis bicolor* the larva of which a short time ago is identified by SCHMIDT (31).

The larval as well as the adult forms of *Nettastoma* and *Saurenchelys* have a much longer snout than those in question, while the larval *Chlopsis* is of the high, leaf-shaped type, described by STRÖMMAN (33) under the name of *L. hyoproroïdes*. The adult *Chlopsis bicolor* has a much shorter snout, according to SUPINO (34) than our larvae. The remaining genus *Todarus* I only know from FACCIOLA'S and SUPINO'S (36) descriptions; unfortunately they do not give the number of segments, but by comparing SUPINO'S drawing of the head of *Todarus* with the head of our most advanced larva I was struck by the likenesses, and it seems to be justified to draw attention to the possibility of the connection between our larvae and this species.

18. Leptocephalus Saurenchelydis cancrivorae.
(*L. oxyrhynchus* Bell.).

I have referred a larva taken at Stat. 45 in 50 metres to the species *L. oxyrhynchus* Bellotti because the differences detectable between our larva and BELLOTTI'S may easily be understood as the effects of development, our larva being farther advanced than that of BELLOTTI. The larva pictured and described by BELLOTTI (3) is relatively higher on the anterior part of the body, anus is placed further backwards, pectoral-fins are present, the snout is more pointed and the pigment on the brain is lacking. By studying the development of the related species *L. stylurus* it will be seen, that these differences exist between the least developed and the most developed larvae of this species and consequently also may be regarded as caused by the development at the larva in question.

On the other hand the number of segments is almost the same in our larva and in BELLOTTI'S (about 249 and 240 respectively).

According to GRASSI (17) and SCHMIDT (31) the species *L. oxyrhynchus* is the larval form of *Saurenchelys cancrivora* and not, as supposed by BELLOTTI (3) of *Ophichthys serpens*, which according to his own determination has about 208 vertebrae.

To the description of BELLOTTI may be added the following.

As shown by fig. 4 on pl. V, this larva has a relatively low compressed body, an elongated head and a pointed tail. The anal opening is placed far forward not only in our advanced specimen, but also in the specimen pictured by BELLOTTI, which is certainly less advanced in its development, The alimentary canal has the two characteristic dilatations which are also present in *L. stylurus* and *Hyoprorus messinensis*. The snout projects beyond the tip of the under-jaw and is pointed.

The total length of our specimen is about 92 mm and the greatest height almost 5 mm.

Distance from point of snout to anus 24 mm and to the beginning of the dorsal fin about 12 mm.

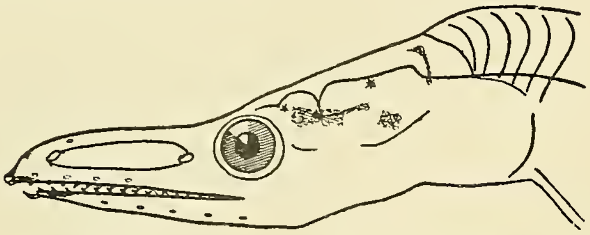

Fig. 32. *L. Saurenchelydis cancrivorae.* 10/1.

Length of head 6·2 mm, distance from point of snout to anterior margin of eye 2·8 mm, and diameter of eye 0·7 mm.

The number of myomeres is about 249, 48 of which are preanal and 201 postanal. The myomeres are of the usual shape with angles dorsally and ventrally.

Teeth are present, but they are small. In each half of the upper jaw there are about 1 + 1 + 16 and in each half of the lower jaw 1 + 16.

The anterior nostril, which is placed rather near the point of the snout, shows indications of a tubular shape. The posterior nostril is a somewhat oval pore placed in front of the eye.

Mucous pores are present on the head as shown in fig. 32.

The rays of the fins are distinctly developed. The dorsal fin commences not far from the occiput, and the anal fin close behind the anus.

As far as I can see the caudal fin contains 6 rays, 3 on each hypural.

I have not been able to discover the slightest trace of pectoral fins.

On the head there is pigment placed on the points of the snout and the lower jaw, and a couple of rather large spots across the brain portion. A series of dots extends along the alimentary canal, and there is a series of small dispersed points on the transparent portion between the anal fin and the muscular system of the body, and dots at the bases of the foremost rays in the anal fin.

19. Leptocephalus urosema n. sp.

Two specimens of this species were taken at Stats. 53 and 56 in 100 metres. One specimen was somewhat damaged, but is was possible to count the segments in the other; there were 64 preanal and about 126 postanal segments, altogether about 190.

In general appearance this species resembles *Hyoprorus messinensis* Kölliker and *L. hyoproröides* Strömman.

Fig. 5, pl. V shows these larvae to be high in relation to length, and they attain their greatest height nearer the head than the tail. At the lateral line the myomeres form a very obtuse angle which is not very much smaller than 180°.

The pigmentation in this species is very characteristic. A big spot on a level with the lateral line, apparently inside the skin, may be seen in fig. 5, pl. V. The distance from this spot to the tip of the tail in the undamaged larva is 5 mm.

We find two pigmented swellings on the intestinal canal, which feature it has in common with *Hyoprorus messinensis*, figured by KAUP (22), and with the two species *L. Saurenchelydis cancrivorae* and *L. stylurus* described in this work.

As for the head it has some pigment along the posterior margin of the eye, on the snout and the lower jaw, and a crescent-shaped spot on the gill portion, as shown in fig. 33.

The intestinal canal shows, besides the two abovementioned swellings, a dilatation in front of the embryonic pectoral fin (seen in fig. 33). The canal is very thin from the foremost swelling to the second one, but between the second and third swellings, it gradually becomes thicker, then tapers off towards the anal aperture. No trace of true rays was found in any of the fins, and there is not even an indication of interspinous elements or hypurals in the vertical or caudal fins. The point of the notochord is straight.

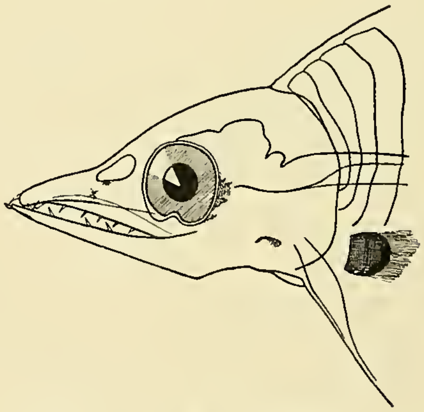

Fig. 33. Head of *L. urosema.* 15/1.

The head shown in fig. 33, has the usual form; the snout is not very long, but slender and pointed.

The teeth are small, but it is evident that these two larvae are only slightly developed. The foremost tooth in the upper, as well as in the lower jaw is curved followed by 5 or 6 straight teeth. The foremost of the straight teeth in the upper jaw (though broken off in both specimens) appear to have been larger than the rest.

There are no separated nostrils, merely an oval aperture in front of the eye.

The following are some of the dimensions:—

	Specimen 1	Specimen 2
Total length	27 mm	27 mm1)
Greatest height	7 „	7 „
Length of head	2·9 „	3·3 „
Distance from point of snout to foremost margin of eye	1·1 „	1·3 „
Largest diameter of eye	0·7 „	0·7 „

20. ***Leptocephalus canaricus*** n. sp.

Four very small larvae of a species distinguished by a large number of segments and characteristic pigmentation, were taken at a depth of 50 metres at Stat. 45, one of which is shown in fig. 1 on pl. VI. The larvae are rather curved and thus difficult to measure, but have approximately the following dimensions:

	No. 1	No. 2	No. 3	No. 4
Total length	25 mm	24 mm	19 mm	15 mm
Greatest height	1·6 „	1·9 „	1·3 „	1·2 „
Length of head	2 „	1·9 „	1·6 „	1·5 „
Length of snout	1·1 „	1 „	0·8 „	0·8 „
Diameter of eye	0·5 „	0·5 „	0·4 „	0·3 „
Number of segments	210	220	208	200

The feature giving this species a very characteristic appearance, is the three large pigment spots situated on the ventral part of the muscle-segments.

The teeth are few, but relatively very large, thus indicating that the larvae are very young. Only in the largest larva have I been able to discover a groove in front of the eye, indicating the development of nostrils.

The alimentary canal in all the individuals is damaged, so that the situation of the anus could not be made out. As far as could be observed, there may be one or two dilatations of the alimentary canal, similar to those in *L. Saurenchelydis cancrivorae* and *L. stylurus*, which, along with the large number of segments, seem to indicate that these larvae may be closely allied to the forms named.

All the fins are at a very embryonic stage. The pectoral fin is present as a small undifferentiated flap, and the vertical fins appear as clear zones. The tail terminates in a point without indicating any development of either rays or hypural elements.

The muscle-segments of the anterior part of the body have the usual appearance with three angles. The dorsal and ventral angles are wanting near the tip of the tail.

These four larvae prove by their whole development to be very young, and they can hardly have been carried far from the spawning place.

21. ***Leptocephalus megacara*** n. sp.

There are two specimens of this species taken at Stat. 64 from 100 metres; one of them is represented on pl. V, fig. 6. Both are quite small and undeveloped, true rays wanting in all the fins, with only very slight indications of interspinous elements in the hind-most portions of the dorsal and anal fins.

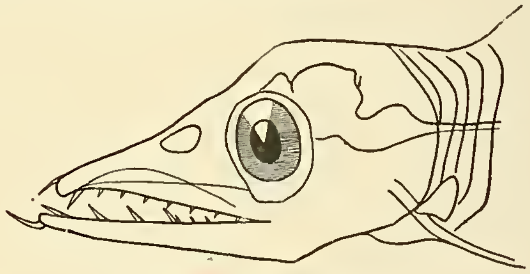

Fig. 34. Head of *L. megacara*. $^{15}/_{1}$.

As shown in fig. 6, pl. V, they are quite high in proportion to length, the myomeres forming a very obtuse angle at the lateral line.

The anus is placed far back, and the alimentary canal is characteristic in being thin anteriorly but rather thick posteriorly.

The shape of the head is shown in fig. 34; the snout is pointed, and the lower jaw projects in front of the upper jaw.

The teeth differ somewhat in form and number in the two specimens. The smaller specimen is provided with a thin but long tooth anteriorly in each half of the upper jaw, then one large tooth and 7 small oblique teeth. Anteriorly in the lower jaw we find a big curved tooth, then 4 large straight teeth, the foremost of which is directed more forwards than the rest, immediately followed by 3 small straight ones. (Fig. 34).

The larger specimen is provided with a curved tooth anteriorly in each half of the upper jaw, next 3 big straight teeth, and finally 6 small straight ones. The lower jaw

---

1) Tip of tail wanting.

has a curved tooth anteriorly, then 4 big straight teeth and after an interspace 3 small straight ones.

The nostrils are represented by a triangular groove near the eye.

The point of the notochord is tilted upward very slightly; H_1 and H_2 feebly developed and situated under the point of the notochord.

As for pigment there are only a few faint dots near the tip of the tail under the lateral line.

The measurements and number of segments are shown in the following table:

	Smaller specimen	Larger specimen
Total length	28 mm	31 mm
Distance from point of snout to anus	25 „	27 „
Greatest height	4 „	4 „
Length of head	3·4 „	3·2 „
Distance from point of snout to foremost margin of eye	1·6 „	1·6 „
Vertical (and maximum) diameter of eye	0·7 „	0·7 „
Number of preanal myomeres	118	119
„ of postanal „	ca. 32	ca. 30
Total number of myomeres	„ 150	„ 149

If we look at the table on pp. 6—7 giving the number of vertebrae in various eels we shall see that the two larvae in question may be the larvae of either *Synaphobranchus pinnatus* or *Serrivomer Beani*. The Leptocephalus of the former being well known, *Serrivomer* is, in the present state of our knowledge, the only alternative. Pending the possible discovery of more fully developed larvae, those just described are, in the meantime, named *L. megacara*.

22—24. *Three very small larvae from the Sargosso Sea.*

Three very small larvae, probably belonging to three different species, represented in pl. VI, figs. 2—4, were taken at Stat. 64. It is impossible to identify them with known species of Leptocephali, and they are too feebly developed to serve as types for new species, so I shall call them merely nos. 1, 2 and 3.

Larva no. 1 is rather high relatively to length, thus resembling the larva of the common eel, but the number of segments exceeds 130, according to an approximate estimation. Length about 17 mm, greatest height 2·4 mm, anus 15 mm from point of snout. Head 2·1 mm long, length of snout 0·9 mm, and greatest diameter of eye 0·6 mm. The pigment consists of some dots along the notochord near the tip of the tail. The embryonic pectoral fin presents itself as a little flap.

Larva no. 2 greatly resembles the larva of *Conger vulgaris*, figured by Schmidt (29); from the number of segments (between 150 and 160) it might possibly be a small larva of *Conger vulgaris*, but it differs in having the anus nearer the tip of the tail; perhaps it is a "prelarva" of *L. enchodon* (p. 25). This larva is more slender than no. 1; it measures 17 mm in length, greatest height 1·8 mm; the anus lies about 15 mm from the point of the snout; length of head 1·9 mm; length of snout 0·9 mm; greatest diameter of the eye 0·5 mm; pigmentation agrees with that of no. 1 (pl. VI fig. 3); embryonic pectoral fin present.

Larva no. 3 is somewhat larger, being 21 mm long and attaining a maximum height of 2·2 mm. It is badly preserved, so that the number of segments cannot be accurately determined. It seems to have more than 120 segments, however, and doubtless does not belong to *Anguilla vulgaris*. It bears a great likeness to larva no. 2, but differs in having a longer snout, and an oval contour of the eye. The anus is placed about 18 mm from the point of the snout; length of head 2·3 mm, of snout 1·0 mm; greatest diameter of the eye 0·6 mm; pigmentation like that of no. 2 (see fig. 4 pl. VI); embryonic pectoral fin present.

Larva no. 1 was taken in the net at 100 metres, no. 2 at 50 metres, and no. 3 at 300 metres; from their size it may be concluded that they cannot have progressed far from the spawning place.

25. *Leptocephalus mysticus* n. sp.

This larva, which I propose to call *L. mysticus* was taken at Stat. 53 in the net at 1300 metres. Its metamorphosis has begun, but if not abnormally developed, the transformation of this species must differ from that of, for instance, *Anguilla vulgaris* since the appearance of pigment in *Anguilla* occur very late in the metamorphosis, whereas this larva is abundantly pigmented though its body is still high and compressed. It is shown in fig. 7 pl. V and its peculiar aspect is due to the fact that the head and the lower portion of the body from the lateral line downwards are abundantly pigmented, while the greater part of the dorsal portion is entirely without pigment, so that the muscle-segments become visible as in other leptocephalids.

The animal is high in proportion to its length (80 mm), and the segments of the body are curved without sharp dorsal and ventral angles. At the junction of the head and trunk a rather acute angle is formed between the dorsal contour of the head and body, similar to that in *Hyoprorus messinensis*.

The dorsal fin is inserted very far forward, whereas the anal fin is inserted in the middle of the body, a little nearer the anterior than the posterior extremity. Both these fins are broad, having powerfully developed rays, as have also the caudal fin (H_1 with six and H_2 with seven rays) and the pectoral fin, the latter placed directly behind the gill-opening, and bearing about 14 rays. The gill-slits curve downwards towards the ventral margin, and as far as I can see, they are confluent at the front.

The head is comparatively flat and broad, showing distinct traces of advanced development. The snout is rounded, and projects a little beyond the point of the lower jaw. The anterior nostril is tubular, placed near the point of the snout, and directed obliquely upwards, while the posterior nostril is a small round pore just in front of the eye. The eye exceeds 1 mm in diameter, and is placed far in front of the angle of the jaws. The jaws retain a few rather small, apparently larval teeth. Series of mucous pores run along the jaws.

I have not been able to determine exactly the number of muscle-segments, but approximately there are 50 preanal and 77 postanal segments, 127 in all. Although this figure agrees with the number of segments in *L. Michael-Sarsi*, there can hardly be any doubt that the two forms are distinct, for they differ in the number of rays in the caudal and anal fins, and the tubular nostril in this larva is directed obliquely upwards, while in *L. Michael-Sarsi* it is directed obliquely downwards.

I cannot refer this extraordinary larva to any known species of Leptocephali, and have been unable to identify it with any adult form, and have therefore described it as distinct.

26. Leptocephalus Gastrostomi Bairdii.

A larva undergoing transformation, perhaps the most peculiar in the collection, was taken at Stat. 64 in the net at 1000 metres. Whereas the trunk has retained very many of its larval characters, from which a conclusion as to its previous leptocephalid appearance may be drawn, the head, especially the maxillary portion, has undergone a development plainly proving the animal to be the larva of a fish belonging either to *Eurypharynx* or *Gastrostomus* or some allied form.

Before endeavouring to determine to what species this peculiar larva belongs, we must give an account of those species with which it may be compared, viz:—

1) *Eurypharynx pelecanöides* Vaillant; 2) *Gastrostomus Bairdii* Gill and Ryder; 3) *Macropharynx longicaudatus* Brauer; 4) An undescribed form taken by the "Michael Sars" in 1910, which for convenience we may call "species A".

There is also the possibility that it may be the larva of some closely allied form hitherto undescribed.

The single specimen of *Macropharynx longicaudatus* described by Brauer is according to Zugmayer (38) who had more abundant material for investigation, merely a young individual of *Gastrostomus Bairdii.*

Vaillant (37) says that in *Eurypharynx pelecanöides*, of which, as far as I have been able to ascertain, only three specimens are known, "la peau est absolument nue, sans ligne latérale distincte". Species A is also distinguished by the absence of a distinct lateral line.

Gastrostomus Bairdii, however, has a lateral line, strongly marked by peculiar organs. I have had an opportunity of examining a number of specimens of this species, and the lateral line could be seen very distinctly with the naked eye in the small specimens as well as in the larger ones.

The larva in question has a very distinct lateral line, and indeed has so many specific characters in common with *Gastrostomus Bardii*, that I have little hesitation in referring it to that species.

Beginning with the organs of the lateral line, we find the structure and arrangement strikingly like those in *Gastrostomus Bairdii*, but apparently the organs are less fully developed. These organs are not accurately shown in the published drawings of *Gastrostomus Bairdii*, so I re-examined eight specimens of this species, and found two types of organs in every specimen. One type consists of a row of three or four light-coloured oval spots, placed obliquely, sometimes inclined to the right, sometimes to the left. The second type consists of a single light-coloured spot placed between two of the oblique rows, as indicated by Brauer (2) in his drawing of *Macropharynx longicaudatus.*

We find the first type of organs distinctly developed in our larva, the 3 or 4 elements being, however, not oval, but subcircular or subangular. There are also in a few places unmistakable indications of organs of the second type between those of the first type. Thus in regard to the organs of the lateral line this larva corresponds closely with *Gastrostomus Bairdii*, and is by this feature distinguished from *Eurypharynx pelecanöides* and species A.

In other respects we also find a remarkable agreement. Zugmayer (38) investigated the vertebral column in *Gastrostomus Bairdii*, and discovered a peculiar feature about the fifth and the sixth vertebra, which he thus describes:—"Les vertebres sont regulières à l'exception de la cinquième et de la sixième, qui sont plus basses que les autres et qui en se rencontrant forment un angle dont le sommet est dirigé vers le haut.[1] Cet angle ne se rencontre cependant que chez les jeunes exemplaires, et il disparait peu à peu au cours de la croissance."

In another place ZUGMAYER states that the number of organs of the lateral line corresponds with the number of vertebrae, and it occurred to me to ascertain whether an analogous relation might be traced in our larva. I found that at the sixth organ (one with 3 or 4 elements) the lateral line bends sharply upwards, curving gradually until it once more runs longitudinally, so I ran the risk of removing the musculature from one side of the unique specimen, and was able to ascertain that the vertebral column, the elements of which were very slightly developed, formed a strong curve upwards at the seventh or eight myomere. When we consider that the anterior three muscle-segments in a *Leptocephalus* correspond to the anterior two vertebrae of the adult individual,[2] it is evident that we have here a very striking feature common to *Gastrostomus Bairdii* and our larva.

Fig. 35. Tail-tip of *Gastrostomus Bairdii*. (After ZUGMAYER).

ZUGMAYER (38) determined the number of vertebrae in *Gastrostomus Bairdii* and found 110. I have had an opportunity of removing the skin from one side of a specimen in order to count the muscle-segments if possible, and counted 107 with certainty, but the segments at the very tip of the tail gradually became so indistinct that it was impossible to be sure of the exact number. GILL and RYDER (13) record 22 preanal and 75 postanal vertebrae, or 97 in all, but they expressly state that the last 2 or 3 vertebrae were indistinct, so they give the number 97 with a query. The same difficulty arose with the larva in question, but I was able to count 108 segments 32 or 33 being preanal, and there are probably not many more. This approximate number of segments in the larva, while not disproving its connection with *Gastrostomus*, is not very conclusive. But we find confirmation in the structure of the tip of the tail with its peculiar organ. ZUGMAYER (38) has given a drawing of the tip of the tail, reproduced in fig. 35, and though not able to trace all the details in the figure, either in the larva or in the adult animals I have examined,[3] I am satisfied that the structure is practically identical. The long black portion has the same shape, the caudal fin has the same relative position, the segmentation in the lighter ventral portion is present, but not quite so distinct and there is even a faint indication of the peculiar papillæ along the dorsal margin. I am therefore in no doubt whatever that the structure of the tip of the tail is another feature common to *Gastrostomus Bairdii* and the larva in question.

It may be mentioned that in this particular the larva is distinguished from species A, which has also an organ attached to the tip of the tail, but totally different in structure.[4]

On the whole therefore it seems reasonable to conclude that this larva is a young individual of the species *Gastrostomus Bairdii*, and it represents a developmental stage hitherto unknown. It adds a new link to the developmental history of this peculiar species, and enables us by comparison with the previously known stages to sketch the development of the species.

The larva has the following dimensions:

Total length	33 mm
Anal	13·5 „
Dorsal	6·5 „
Height	7·2 „
Upper jaw	8·5 „
Lower jaw	7·5 „
Rostrobranchial distance	7·0 „
Branchioanal „	7·0 „

We may add the following description:—

The trunk is compressed, but is stouter than that of the ordinary *Leptocephali*. The segments visible through the pigment are perpendicular to the vertebral column, and the dorsal and ventral angles so common in leptocephalids are absent. The lateral line runs, for the greater part, intermediate between the dorsal and the ventral margin of the body, but near the head it forms the curve already mentioned (see pl. VI, fig. 5). The anus is situated far forward, the anal fin being inserted directly behind it. The dorsal fin is inserted not far from the head. The anal fin and the dorsal fin have distinctly developed rays, the number of which could not be determined. The number in the anal fin exceeds 120, and in the dorsal fin 170.

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[1] The accompanying drawing shows that the fifth vertebra is bent upwards, so that the apex of the angle between the fifth and sixth vertebra is directed upwards; in other words we may say that the anterior portion of the spinal column lies at a lower level than the posterior portion, the fifth vertebra forming the connecting link between them.

[2] According to GRASSI and CALANDRUCCIO (17).

[3] Only in one specimen could I see the small papillæ to the number of ten, lying along the black portion.

[4] That the larva is distinct from species A is shown by other characters: thus in species A the foremost dorsal ray is situated very much farther back than the foremost anal ray, whereas in the larva as well as in *Gastrostomus* the reverse is the case.

The pectoral fin is fan-shaped, with at least 10 rays, and is situated directly above the posterior point of the jaw.

The gill-opening is an oval slit situated directly in front of the pectoral fin.

The shape of the head and the development of the jaws are shown in fig. 5 pl. VI. The eye is small, 0·6 mm in diameter, and its anterior margin is about 0·6 mm distant from the point of the snout.

I have only been able to discover one nostril, which has the form of a round pore and is placed directly in front of the eye. Along the upper jaw we find a row of organs greatly resembling the organs of the lateral line.

In the jaw I have not been able to discern any teeth.

A brown fine-grained pigment covers the entire animal, except for the hindmost ventral portion of the tail, which is transparent.

In order to indicate the process of development from the larval stage here described to the adult animal, I give the following table, the figures for the young and adult *Gastrostomus* being taken from Zugmayer (38):—

	Larva	Young *Gastrost.*	Adult *Gastrost.*
Length of upper jaw in total length	4·4	5	4·8
Rostro-anal distance —„—	2·7	4	3·2
Height near anus —„—	5·3	36	33

This table reveals the peculiar circumstance that as regards these three proportions of the body the young *Gastrostomus* occupies the most extreme position, the upper jaw being comparatively the smallest, the anal being situated nearest the front, and the height near the anus being the smallest. It would seem therefore that in the course of development the height of the animal decreases rapidly, at the same time as the tail-portion extends during the metamorphosis, which has begun in our larva and is complete in the young *Gastrostomus*, consequently the jaw and the height become smaller, and the rostro-anal distance decreases, in proportion to the length. That this last mentioned relation is due to the moving forwards of the anus seems to be evident, because our larva has only some thirty preanal vertebrae, whereas large specimens of *Gastrostomus* have only 22. But as this does not explain the decrease of the jaw, we are compelled to accept that the tail-portion grows faster than the head.

The reverse must take place during the later growth of the animal, when the head (with the jaws) grows proportionally most quickly, the height increasing somewhat at the same time.

Fig. 36. *L. latissimus* Schm.
(After Schmidt).

What was the course of development at earlier stages than that of the larva in question? It seems unquestionable that the earlier larva must have been a *Leptocephalus*, for when we imagine the pigment gone, and the jaw-portion less developed, we have before us a larva with the characters of a *Leptocephalus*. It even seems to me as if the larva in question in a way suggests what this *Leptocephalus* must have looked like.

In the first place the segments were probably comparatively perpendicular to the lateral line, the dorsal and ventral angles lacking. Secondly the snout was quite short, and the jaw probably inclined, with the eye situated in front of the angle of the jaw. The height of the body in our larva, though metamorphosis is in progress, is high, and it may be supposed to have been still higher at an earlier stage, probably decreasing rapidly towards the tail. We must finally refer to a type of leptocephalids, of which only one specimen is known, described by Schmidt (27) first as *L. latus*, and later as *L. latissimus*. This form is shown in fig. 36, and resembles our larva so closely that I think it must be related to *Gastrostomus*, but the number of segments being so much greater than in *Gastrostomus Bairdii*, it is excluded that it can be the larva of that species.

III. Remarks on the biology.

The collection of larval muraenoids dealt with here consists of about 200 individuals, representing 26 species. The individuals are few compared to the number of species, for the four species: *Leptocephalus Anguillae vulgaris*, *L. Congri balearici*, *L. Congri mystacis* and *L. Synaphobranchi pinnati* are represented by 159 individuals leaving only 42 individuals representing the remaining 22 species. As regards these last-mentioned 22 species, therefore, the material was insufficient for a study of their biology, and such a study must be postponed until future investigations provide more ample material of the numerous species inhabiting the North Atlantic. A preliminary attempt to give an idea of the occurrence of the entire group in the Atlantic is made in the following pages, and in the accompanying table we have indicated the number of specimens of the different species taken by the "Michael Sars" at twenty stations in the North Atlantic:—

Species of *Leptocephalus*	Stations near the coast of Africa				Stations south of the Azores					Stations west of the Azores			Stations between Newfoundland and West-Europe						Stations near the coast of Britain		Number of individuals	Number of Stations
	34	39	42	45	51	52	53	56	58	62	64	67	81	87	88	90	92	10	94	98		
L. Anguillae vulgaris	.	.	.	.	.	1	5	2	.	11	2	.	1	.	3	4	2	1	1	11	41	12
„ *Synaphobranchi pinnati*	2	.	.	.	.	.	.	.	1	2	.	.	.	1	2	.	1	.	..	2	11	7
„ *Histiobranchi infernalis*	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	..	..	1	1
„ *Cyematis atri*	.	.	.	.	1	.	.	3	.	.	.	.	.	.	.	.	.	.	..	..	4	2
„ *Congri vulgaris*	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	..	..	3	3
„ — *mystacis*	.	1	18	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	..	..	21	4
„ — *balearici*	.	.	.	.	60	23	.	.	.	.	.	.	.	.	.	.	.	.	..	..	83	2
„ *spinocadux*	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	..	..	1	1
„ *polymerus*	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	..	..	2	2
„ *Michael-Sarsi*	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	..	..	1	1
„ *splendens*	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	1	1
„ *enchodon*	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	..	..	1	1
„ *euryurus*	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	..	2	1
„ *similis*	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	..	..	2	1
„ *proboscideus*	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	..	1	1
„ *dolichorynchus*	.	.	.	.	.	.	1	.	.	.	.	2	.	.	.	.	.	.	..	..	3	2
„ *stylurus*	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	..	6	1
„ *Saurenchelydis cancrivorae*	.	.	.	1	.	.	.	.	.	.	.	.		.	.	.	.	.	..	..	1	1
„ *urosema*	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	..	..	2	2
„ *canaricus*	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	..	4	1
„ *megacara*	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	..	..	2	1
„ small nr. 1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	..	..	1	1
„ — 2	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	..	.	1	1
„ — 3	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.		.	..	..	1	1
„ *mysticus*	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	..	..	1	1
„ *Gastrostomi Bairdii*	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	..	..	1	1
Number of individuals taken at each station	3	7	19	8	62	25	9	6	2	15	10	3	2	1	5	4	4	2	1	13		
Number of species taken at each station	2	2	2	5	3	3	5	3	2	4	7	2	2	1	2	1	3	2	1	2		
Number of individuals taken at each group of stations	37				104					28			18						14			
Number of species taken at each group of stations	8				10					12			4						2			

In this table the stations have been arranged in five apparently natural groups, the number of individuals and species taken in each group being indicated at the foot.

The three southern groups are distinguished at once from the two northern groups by the greater number of individuals, and especially by the large number of species, and this difference is still more clearly brought out by combining the results obtained at the three southern groups as compared with the two northern groups. Thus, 169 individuals belonging to 25 species were taken in the southern groups (Stats. 34 to 67), whereas only 32 individuals belonging to 4 species were taken in the northern groups (Stats. 81 to 98), so that nearly all the species represented in the collection, and the large majority of the individuals were taken in the southern groups of stations. It may be added that, according to Danish and Norwegian investigations (Schmidt 31), *Leptocephalus Anguillae vulgaris* and *L. Congri vulgaris* have probably immigrated into the northern groups from the south.

Judging from the "Michael Sars" material, there can be little doubt that the northern limit of distribution for most of the species occurring in the North Atlantic lies somewhere between the northern and southern crossings.

Besides the frequently occurring species *L. Anguillae vulgaris, L. Congri vulgaris* and *L. Synaphobranchi pinnati,* only 13 larvae belonging to five species have, as far as I am aware, been taken to the north of lat. 45° N., viz.,

Leptocephalus	*Holti,*	1	specimen,	Schmidt (27).
—	*rostratus,*	2	—	— —
—	*latissimus,*	1	—	— —
—	*thorianus,*	8	—	— —
—	*enchodon,*	1	—	Autor.

From localities south of lat. 45° N. in the Atlantic, we have records of a multitude of species besides the 25 species described here, viz.,

Leptocephalus	*immaculatus,*	Strømman	(33)
—	*Scheelei,*	—	—
—	*Forsströmi,*	—	—
—	*undulatus,*	—	—
—	*crenatus,*	—	—
—	*fuliginosus,*	—	—
—	*lanceolatus,*	— —, Schmidt	(29)
—	*hyoproröides,*	—	—
—	*tiluröides,*	—	—
—	*Grassi,*	Eigenmann and Kennedy	(9)
—	*dipthychus,*	— —	—
—	*rex,*	— —	—
—	*amphioxus,*	— —	—
—	*caudomaculatus,*	— —	—
—	*latus,*	— —	—
Leptocephalus	*Gilli,*	Eigenmann and Kennedy	(9)
—	*Strömmani,*	— —	—
—	*Eigenmanni*	— — (renamed by Autor)	—
—	*mucronatus,*	Eigenmann and Kennedy	(9)
—	*discus,*	— —	-
—	*humilis,*	— —	—
—	*Gilberti,*	— —	—
—	*ingolfianus,*	Schmidt	(29)
—	*Andreae,*	—	—
—	*Chlopsis bicoloris,*	—	—
—	*Hjorti,*	Blegvad	(1)

In the Atlantic Ocean between 0° and lat. 45° N. we have records of the capture of 52 species altogether. Although the same species may possibly have been given two names, still the above list illustrates the immense difference between the leptocephalid fauna of the northern and southern parts of the North Atlantic, which is plainly shown by the "Michael Sars" material.

Bathymetrical distribution.

As already indicated, during the expedition of the "Michael Sars" series of nets fastened at intervals to the wire were dragged simultaneously through the water (for particulars see Murray and Hjort (23). The arrangement at different stations was not always the same, but usually the following plan was adopted:—

At the surface,		a silk-net 1 metre in diameter;
with	100 metres of wire out,	a — 1 —„—
„	200 —„—	a — 1 —„—
„	300 —„—	Petersen's young-fish trawl;
„	600 —„—	a silknet $^3/_4$ metre in diameter;
„	1000 —„—	young-fish trawl
„	(1500 —„—	a silk-net $^3/_4$ metre in diameter);
„	2000 —„—	young-fish trawl
„	2500 —„—	a silk-net $^3/_4$ metre in diameter;
„	3000 —„—	a shrimp-net 3 metres —„ —

Any sources of error due to the fact that the nets functioned during the descent and ascent, as well as while being hauled horizontally, have been as far as possible eliminated by prolonging the duration of the hauls, which sometimes lasted twelve hours, but still there is a possibility that some of the larvae have been taken in lesser depths than those assigned to them in the accompanying table.

The depth at which a net may be towed horizontally will depend on the speed of the vessel, on account of the friction of the net and wire against the water, and on the length of wire between the vessel and the net.

Measurements of the angle formed by the wire with the surface of the water enable us to determine the maximum depth that may be attained by such a net, and judging from experiments made at stations where the depth of water was known, it seems probable that the nets were dragged at a depth of from $^1/_3$ to $^1/_2$ of the length of wire but, and for the sake of simplicity the latter figure has been adopted in compiling.

It may be supposed that the surface waters and the greater depths beyond 500 metres were more thoroughly investigated than the intermediate depths between 50 and 500 metres, because surface hauls were far more numerous and larger nets were used in the greater depths, but still the majority of the species came from the intermediate depths referred to.

The table below shows that only two species were caught at the surface, although hauls at the surface were much more frequent than at depths of 50 and 100 metres, where respectively 6 and 8 species were taken. As compared with the two species from the surface no fewer than twenty-five species were taken beneath the surface. This can hardly be accidental, and we are forced to the conclusion that most of the species live below the surface in the North Atlantic. In the literature concerning muraenoid larvae only the following eight species are authoritatively recorded from the surface:—

Leptocephalus diptychus, Eigenmann and Kennedy (9)
— *latus*, — — —
— *lanceolatus*, Schmidt (30), Blegvad (1).

Number of larvae taken at different depths.

Species	Silk nets, 1 metre in diameter			Young-fish trawl 150 m	Silk-net $^3/_4$ m in diam. 300—400 metres	Young-fish trawl 500 m	Silk-net $^3/_4$ m in diam. 750 m	Young-fish trawl net 3 m in diam. 1000—1300 m	Large net 3 m in diam. 1500 m
	0 m	50 m	100 m						
Leptocephalus									
— *Anguillae vulgaris*	—	16	14	9	2	3	—	—	—
— *Synaphobranchi pinnati*	—	5	—	1	—	3[1]	2	—	—
— *Histiobranchi infernalis*	—	—	1	—	—	—	—	—	—
— *Cyematis atri*	—	—	—	4	—	—	—	—	—
— *Congri vulgaris*	—	—	—	2	—	1	—	—	—
— — *mystacis*	—	—	3	17	—	—	—	1	—
— — *balearici*	83	—	—	—	—	—	—	—	—
— *spinocadux*	—	—	—	—	1	—	—	—	—
— *polymerus*	1	1	—	—	—	—	—	—	—
— *Michael-Sarsi*	—	—	—	1	—	—	—	—	—
— *splendens*	—	—	—	1	—	—	—	—	—
— *enchodon*	—	—	—	1	—	—	—	—	—
— *euryurus*	—	—	—	—	—	1[2]	—	1	—
— *similis*	—	—	1	—	—	—	—	1	—
— *proboscideus*	—	—	—	1	—	—	—	—	—
— *dolichorhynchus*	—	—	2	1	—	—	—	—	—
— *stylurus*	—	—	—	6	—	—	—	—	—
— *Saurenchelydis cancrivorae*	—	1	—	—	—	—	—	—	—
— *urosema*	—	—	2	—	—	—	—	—	—
— *canaricus*	—	4	—	—	—	—	—	—	—
— *megacara*	—	—	2	—	—	—	—	—	—
— small nr. 1	—	—	1	—	—	—	—	—	—
— — „ 2	—	1	—	—	—	—	—	—	—
— — „ 3	—	—	—	—	1	—	—	—	—
— *mysticus*	—	—	—	—	—	—	—	1	—
— *Gastrostomi Bairdii*	—	—	—	—	—	—	—	1	—
Number of individuals of all species	84	28	26	44	4	8	2	5	—
Number of species	2	6	8	11	3	4	1	5	—

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[1] One of these larvae may possibly have been taken at a depth of 200 m, according to the label in the tube.

[2] This larva may possibly have been taken at a depth of 200 m, according to the label in the tube.

Leptocephalus Congri vulgaris, (small larvae) SCHMIDT (30)
— *Congri balearici*, — —
— *ingolfianus*, — —
— *Hjorti*, (small larvae) BLEGVAD (1)
— *polymerus*, Autor

The numerous remaining species have either been caught below the surface, or information on this point is lacking.

The table shows further that most of the species (20 in all) were taken between 50 and 150 metres below the surface. And that no larvae were taken beyond 1300 metres in spite of the fact that at 1500 metres a large shrimp net 3 metres in diameter, which according to all experience is best adopted for catching such large organisms as are being discussed here, was used. We therefore seem justified in concluding that most of the species of muraenoid larvae are to be found below the surface, between 50 and 1300 metres, with a strongly marked maximum at depths from 50 to 150 metres.

It appears, however, from the "Michael Sars" material as well as from the Danish investigations (SCHMIDT 30) that one species, *L. Congri balearici*, is a well-marked surface form, and one of the species occurring most frequently.

Distribution in relation to the physical conditions.

In order to elucidate if possible, the peculiar horizontal and vertical distribution of the larvae, I have drawn up the two following tables showing the temperature and salinity of the water in relation to the number of larvae caught; these tables seem to disclose such variations in the number of species as may guide us in forming an idea of the conditions which determine their distribution.

The first table shows the number of individuals and species taken in water of different temperatures.

Number of larvae taken in water of different temperatures.

Species	< 10°	10°—11°	11°—12°	12°—13°	13°—14°	14°—15°	15°—16°	16°—17°	17°—18°	18°—19°	19°—20°	> 20°
Leptocephalus												
— *Anguillae vulgaris*	11	4	3	3	1	2	1	14	—	4	1	—
— *Synaphobranchi pinnati*	3	2	—	1	—	—	3	—	—	—	2	—
— *Histiobranchi infernalis*	—	—	—	—	—	—	—	1	—	—	—	—
— *Cyematis atri*	—	—	—	—	—	—	3	—	1	—	—	—
— *Congri vulgaris*	—	1	1	—	—	—	1	—	—	—	—	—
— — *mystacis*	1	—	—	—	—	—	—	19	1	—	—	—
— — *balearici*	—	—	—	—	—	—	—	—	—	—	—	83
— *spinocadux*	—	—	—	—	1	—	—	—	—	—	—	—
— *polymerus*	—	—	—	—	—	—	—	—	—	1	—	1
— *Michael-Sarsi*	—	—	—	—	—	—	1	—	—	—	—	—
— *splendens*	—	—	—	—	—	—	—	—	1	—	—	—
— *enchodon*	—	—	—	—	1	—	—	—	—	—	—	—
— *euryurus*	1	1	—	—	—	—	—	—	—	—	—	—
— *similis*	1	—	—	—	—	—	—	—	1	—	—	—
— *proboscideus*	—	—	—	—	—	—	—	1	—	—	—	—
— *dolichorhynchus*	—	—	—	—	—	—	—	1	—	—	—	2
— *stylurus*	—	—	—	—	—	—	—	—	6	—	—	—
— *Saurenchelydis cancrivorae*	—	—	—	—	—	—	—	—	—	—	1	—
— *urosema*	—	—	—	—	—	—	1	1	—	—	—	—
— *canaricus*	—	—	—	—	—	—	—	—	—		4	—
— *megacara*	—	—	—	—	—	—	—	—	2	—	—	—
— small nr. 1	—	—	—	—	—	—	—	—	1	—	—	—
— — „ 2	—	—	—	—	—	—	—	—	—	—	1	—
— — „ 3	—	—	—	—	—	—	—	1	—	—	—	—
— *mysticus*	1	—	—	—	—	—	—	—	—	—	—	—
— *Gastrostomus Bairdii*	1	—	—	—	—	—	—	—	—	—	—	—
Number of individuals	19	8	4	4	3	2	10	38	13	5	9	86
Number of species	7	4	2	2	3	1	6	7	7	2	5	3
Temperatures below 15°: 40 larvae belonging to 10 species.							Temperatures above 15°: 161 larvae belonging to 21 species.					

In discussing the results brought out by this table we may first consider those larvae recorded from comparatively cold water (under 10°). As far as *Leptocephalus Anguillae vulgaris, L. Synaphobranchi pinnati* and *L. Congri vulgaris* are concerned, it may be that they were taken in water having a temperature below 10°, into which they have immigrated, but it is quite another matter in respect of the single larva of *L. Congri mystacis;* in this case we may presume that it was caught nearer the surface, while the net with 2000 metres of wire out was being lowered or raised, for all the other larvae of this species were taken in water having a temperature higher than 16°. The phase of development too coincides with the "preleptocephalid" stage of many of the larvae taken in the upper strata of water. The same remarks apply to *L. similis*, one larva of which was taken near the surface, whereas another larva in a similar phase of development and in the same locality came up in a net with 2000 metres of wire out. It is doubtful whether the three remaining species really live at a temperature lower than 10° or not. In the case of *L. mysticus* and *L. Gastrostomi Bairdii* the advanced phase of development indicates that they may have been taken in deep water having a low temperature, and they may have to be referred to the same class as the 11 larvae of *Anguillae vulgaris* and the 3 larvae of *Synaphobranchus pinnatus*, which were also in an advanced stage of development.

At the foot of the table the number of individuals and species taken at the various temperatures is indicated, and it will be noticed that at 15° there is a sudden change both in the number of species and of individuals: only 39 individuals belonging to 10 species were taken at temperatures below 15°, whereas 161 individuals belonging to 21 species were caught in water having a higher temperature. From this table we may therefore conclude that in the North Atlantic the majority of muraenoid larvae occur in water with a temperature exceeding 15°. We may now consider the number of species and individuals taken in water of varying salinity, as set forth in the following table:—

Number of larvae taken in water of different salinities (in $^{0}/_{00}$).

Species	35·0—35·1	35·2—35·3	35·4—35·5	35·6—35·7	35·8—35·9	36·0—36·1	36·2—36·3	36·4—36·5	36·6—36·7	36·8—36·9
Leptocephalus Anguillae vulgaris	—	11	6	3	4	7	12	—	1	—
— *Synaphobranchi pinnati*	—	2	2	—	2	1	2	—	2	—
— *Histiobranchi infernalis*	—	—	—	—	—	1	—	—	—	—
— *Cyematis atri*	—	—	—	—	—	3	—	1	—	—
— *Congri vulgaris*	—	—	1	1	—	1	—	—	—	—
— — *mystacis*	—	—	—	1	—	—	17	3	—	—
— — *balearici*	—	—	—	—	—	—	—	—	—	83
— *spinocadux*	—	—	—	—	1	—	—	—	—	—
— *polymerus*	—	—	—	—	—	—	—	—	1	1
— *Michael-Sarsi*	—	—	—	—	—	1	—	—	—	—
— *splendens*	—	—	—	—	—	—	—	—	1	—
— *enchodon*	—	—	—	1	—	—	—	—	—	—
— *euryurus*	—	—	1	—	—	—	—	1	—	—
— *similis*	—	1	—	—	—	—	—	1	—	—
— *proboscideus*	—	—	—	—	—	—	1	—	—	—
— *dolichorhynchus*	—	—	—	—	—	—	1	2	—	—
— *stylurus*	—	—	—	—	—	—	—	6	—	—
— *Saurenchelydis cancrivorae*	—	—	—	—	—	—	—	—	—	1
— *urosema*	—	—	—	—	—	1	1	—	—	—
— *canaricus*	—	—	—	—	—	—	—	—	—	4
— *megacara*	—	—	—	—	—	—	—	2	—	—
— small nr. 1	—	—	—	—	—	—	1	—	—	—
— — „ 2	—	—	—	—	—	—	—	1	—	—
— — „ 3	—	—	—	—	—	—	—	1	—	—
— *mysticus*	1	—	—	—	—	—	—	—	—	—
— *Gastrostomi Bardii*	1	—	—	—	—	—	—	—	—	—
Number of individuals	2	14	10	6	7	15	35	18	5	89
Number of species	2	3	4	4	3	7	7	9	4	4
	Salinities below 36 $^{0}/_{00}$: 39 larvae belonging to 10 species.					Salinities above 36 $^{0}/_{00}$: 162 larvae belonging to 22 species.				

This table shows that only *L. Anguillae vulgaris, L. Synaphobranchi pinnati* and *L. Congri vulgaris* occur evenly distributed in waters of various salinities. We may suppose that the single specimens of *L. Congri mystacis* (35·6—7) and of *L. similis* (35·2—3) were really caught in water of a higher salinity, while the nets were being lowered or raised. Most of the "Michael Sars" larvae were thus taken in water having a salinity exceeding 36 °/oo, and the same thing may probably be said of the other species of muraenoid larvae found in the North Atlantic, most of which were caught south of the Azores, whereas the isohaline of 36 °/oo and the isothern of 15° at a depth of 100 metres run across the ocean from Gibraltar to the northward of the Azores and to the southward of the Newfoundland banks, as shown in fig. 37. According to the material in hand, the position of this isotherm and isohaline should coincide with the northern limit of distribution of most of the species of muraenoid larvae and an investigation of this tract of the ocean would probably have produced interesting results.

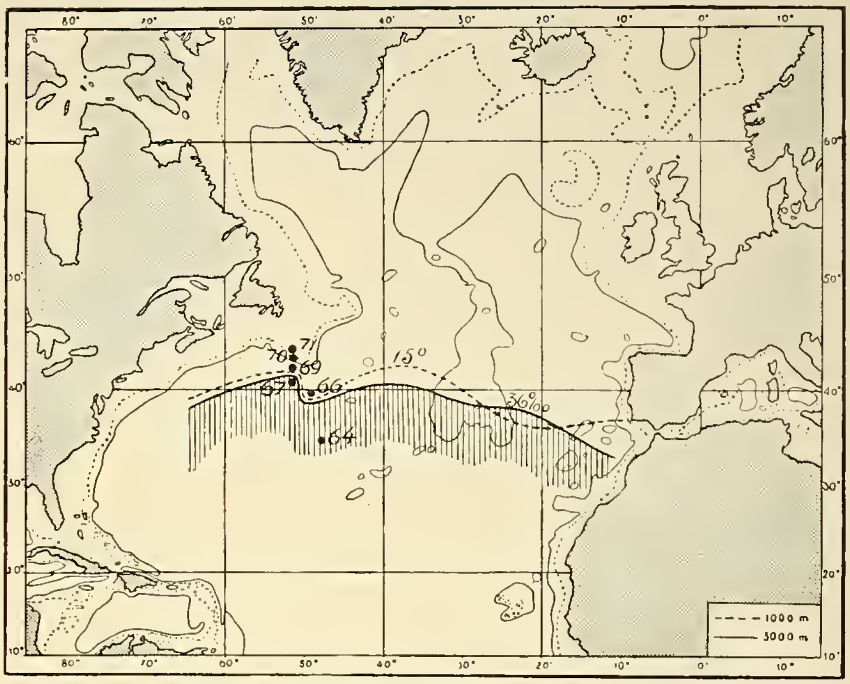

Fig. 37. Isotherm 15° and isohaline 36 °/oo 100 metres below surface. Stations 64—71 marked off.

The "Michael Sars" occupied a series of oceanic stations (Stats. 64—72), cutting across the Z-shaped curvature formed by the isotherm of 15° and the isohaline of 36 °/oo to the south of the Newfoundland banks (see fig. 37). For this series of stations I have drawn a section in fig. 38, showing isotherm of 15° and salinities above 36 °/oo and on which I have indicated where tow-net hauls were made, an open circle being used for each muraenoid larva captured and black dots for negative hauls. A glance at this figure shows that 11 out of the 13 larvae procured at these stations were taken in water having a temperature exceeding 15° and a salinity exceeding 36 °/oo. One of the two "exceptions" is a transforming *Gastrostomus Bairdii*, whose presence in deeper water with a lower temperature and salinity is comprehensible, the other being *L. similis*, of which another specimen was taken at a depth of 100 metres at the same station, so that it was probably caught while the net was being lowered or raised. The 19 hauls taken beneath the surface where the temperature was below 15° and the salinity below 36 °/oo were all negative but for the two "exceptions" just mentioned.

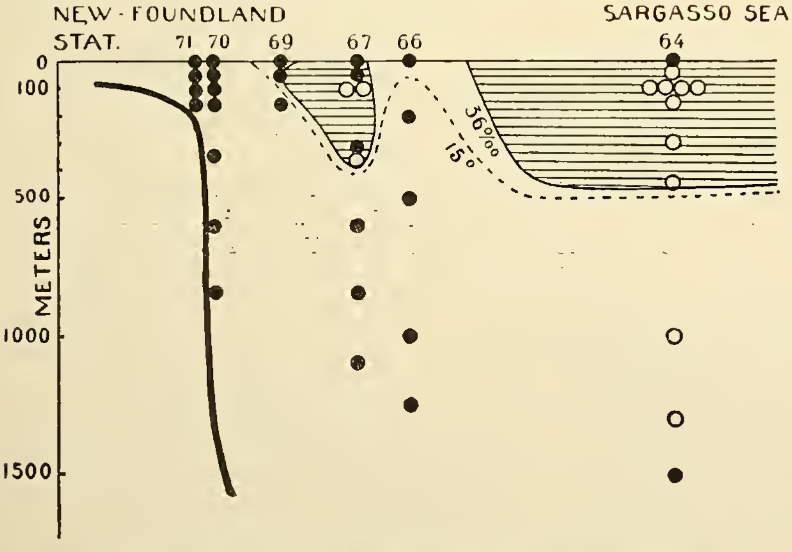

Fig. 38. Section from the Sargasso Sea to New-Foundland. Black dot denotes a negative haul, ring denotes capture of one larvae.

It is of special interest to notice that all the hauls at Stat. 66, situated as shown in fig. 37 in the narrow tongue of cold water protruding southward, were negative.

Although not many larvae were caught at these 6 stations, the positive and negative hauls are distributed so characteristically in relation to the physical conditions as to corroborate the conclusions arrived at in regard to the distribution of muraenoid larvae.

IV. Table of Stations, Literature, Plates.

Table giving particulars of stations where muraenoid-larvae were taken.

Station *denotes a night-station	Date 1910	Locality	Depth in metres	Duration of haul	Metres of wire out	Net used
10	$^{19}/_{4}$—$^{21}/_{4}$	45° 26′ lat. N., 9° 20′ long. W.	4700	1 hours 30 minutes	0	Silk-net 1 metre in diam.
				2 — 15 —	100	— 1 „ - „
				2 — 15 —	200	— 1 „ - „
				2 — 15 —	300	Young-fish trawl
34*	$^{13}/_{5}$—$^{14}/_{5}$	28° 52′ — 14° 16′ —	2170	4 —	400	— „
				4 —	600	Silk-net $^1/_2$ metre in diam.
				4 —	1000	Young-fish trawl
39*	$^{20}/_{5}$—$^{21}/_{5}$	26° 3′ — 15° 0′ —	214	0 10 —	0	Silk-net 1 metre in diam.
				7 —	75	— 1 „ - „
				7 —	150	— 1 „ - „
				7 —	240	— $^1/_2$ „ - „
				7 —	300	Young-fish trawl
42*	$^{23}/_{5}$—$^{24}/_{5}$	28° 2′ — 14° 17′ —		0 — 10 —	0	Silk-net 1 metre in diam.
				7 —	100	— 1 „ - „
				7 —	200	— 1 „ - „
				7 —	300	Young-fish trawl
				7 —	500	Silk-net $^1/_2$ metre in diam.
				7 —	900	Young-fish trawl
45*	$^{28}/_{5}$—$^{29}/_{5}$	28° 42′ — 20° 0′ —		6 — 15 —	100	Silk-net 1 metre in diam.
				6 — 15 —	200	— 1 „ - „
				6 — 15 —	300	Young-fish trawl
				9 — 15 —	1000	Silk-net $^1/_2$ metre in diam.
				9 — 15 —	2000	Young-fish trawl
				9 — 15 —	3000	Shrimp-net 3 metres in diam.
51*	$^{5}/_{6}$—$^{6}/_{6}$	31° 20′ — 35° 7′ —	3886	10—12 hours	0	Silk-net 1 metre in diam.
				10—12 —	100	— 1 „ - „
				10—12 —	200	— 1 „ - „
				10—12 —	300	Young fish trawl
				10—12 —	700	Silk-net $^1/_2$ metre in diam.
				10—12 —	1000	— $^1/_2$ „ - „
				10—12 —	2000	Young-fish trawl
				10—12 —	3000	— „
				10—12 —	4000	Net 3 metres in diam.
52	$^{6}/_{6}$—$^{7}/_{6}$	31° 24′ — 34° 47′ —		2 hours 30 minutes	0	Silk-net 1 metre in diam.
				2 — 30 —	100	— $^1/_2$ „ - „
				2 — 30 —	600	Young-fish trawl
				2 — 30 —	1200	Net 3 metres in diam.

Station *denotes a night-station	Date 1910	Locality	Depth in metres	Duration of haul	Metres of wire out	Net used
53*	$^{8}/_{6}$—$^{9}/_{6}$	34° 59′ lat. N., 33° 1′ long. W.	2615—2865	6 hours	0	Silk-net 1 metre in diam.
				6 —	60	— $^1/_2$ „ - „
				6 —	100	— 1 . - „
				6 —	120	— $^1/_2$ „ - .
				6 —	200	— 1 „ - „
				6 —	300	Young-fish trawl
				6 —	600	— „
				6 —	1100	Silk-net $^1/_2$ metre i diam.
				6 —	1600	Young-fish trawl
				6 —	2100	Silk-net $^1/_2$ metre in diam.
				6 —	2600	Net 3 metres in diam.
56*	$^{10}/_{6}$—$^{11}/_{6}$	36° 53′ — 29° 47′ —	3239	2 — 30 minutes	0	Silk-net 1 metre in diam.
				7 — 30 —	100	— 1 — - „
				7 — 30 —	200	— 1 — - „
				7 — 30 —	300	Young-fish trawl
				10 —	500	Silk-net $^1/_2$ metre in diam.
				10 —	750	— $^1/_2$ — - —
				10 —	1000	Young-fish trawl
				10 —	2000	— „
				10 —	3000	Net 3 metres in diam.
58*	$^{11}/_{6}$—$^{13}/_{6}$	37° 40′ — 29° 20′ —	948—1235	9—10 hours	0	Silk net 1 metre in diam.
				9—10 —	100	— 1 — - „
				9—10 —	200	— 1 — - „
				9—10 —	300	Young-fish trawl
				9—10 —	600	Net 3 metres in diam.
62*	$^{20}/_{6}$—$^{21}/_{6}$	36° 52′ — 39° 55′ —		6 hours 30 minutes	0	Silk net 1 metre in diam.
				6 — 30 —	100	— 1 — - —
				6 — 30 —	200	— 1 — - —
				6 — 30 —	300	Young-fish trawl
				6 — 30 —	600	Silk net $^3/_4$ metre in diam.
				6 — 30 —	1000	Young-fish trawl
				6 — 30 —	2000	— „
				6 — 30 —	2500	Silk-net $^3/_4$ metre in diam.
				6 — 30 —	3000	Net 3 metres in diam.
64	$^{24}/_{6}$	34° 44′ — 47° 52′ —		6 —	0	Silk net 1 metre in diam.
				6 —	100	— 1 „ - „
				6 —	200	— 1 „ - „
				6 —	300	Young-fish trawl
				6 —	600	Silk-net $^3/_4$ metre in diam.
				6 —	1000	Young-fish trawl
				6 —	2000	— „
				6 —	2500	Silk-net $^3/_4$ metre in diam.
				6 —	3000	Net 3 metres in diam.
67	$^{27}/_{6}$	40° 17′ — 50° 39′ —		2 hours	0	Silk-net 1 metre in diam.
				2 —	50	— 1 „ - „
				2 —	200	Young-fish trawl
				2 —	600	Silk-net $^3/_4$ metre in diam.
				2 —	800	— $^3/_4$ „ - „
				2 —	1200	Young-fish trawl
				2 —	1700	Silk-net $^3/_4$ metre in diam.
				2 —	2200	Net 3 metres in diam.

Station * denotes a night-station	Date 1910	Locality	Depth in metres	Duration of haul	Metres of wire out	Net used
81	12/7	48° 2′ lat. N., 39° 55′ long. W.		3 hours	0	Silk net 1 metre in diam.
				3 —	100	— 1 „ - „
				3 —	200	— 1 „ - „
				3 —	300	Young-fish trawl
				3 —	600	Silk-net 3/4 metre in diam.
				3 —	1000	Young-fish trawl
				3 —	1500	Silk-net 3/4 metre in diam.
				3 —	2000	Young-fish trawl
				3 —	2500	Silk-net 3/4 metre in diam.
				3 —	3000	Net 3 metres in diam.
87	17/7	46° 48′ — 27° 46′ —	2157	3 —	0	Silk-net 1 metre in diam.
				3 —	100	— 1 „ - „
				3 —	200	— 1 „ - „
				3 —	300	— 1/2 „ - „
				3 —	300	Young-fish trawl
				3 —	600	Silk-net 3/4 metre in diam.
				3 —	1000	Young-fish trawl
				3 —	1500	Silk-net 3/4 metre in diam.
				3 —	2000	Young-fish trawl
				3 —	2500	Silk-net 3/4 metres in diam.
				3 —	3000	Young-fish trawl
88	18/7	45° 26′ — 25° 45′ —	3120	6 hours 30 minutes	0	Silk-net 1 metre in diam.
				6 — 30 —	100	— 1 „ - „
				6 — 30 —	200	— 1 „ - „
				6 — 30 —	300	— 1/2 „ - „
				6 — 30 —	300	Young-fish trawl
				6 — 30 —	600	Silk-net 3/4 metre in diam.
				6 — 30 —	1000	Young-fish trawl
				6 — 30 —	1500	Silk-net 3/4 metre in diam.
				6 — 30 —	2000	Young-fish trawl
90	21/7	46° 58′ — 19° 6′ —		3 —	0	Silk-net 1 metre in diam.
				3 —	100	— 1 „ - „
				3 —	200	— 1 „ - „
				3 —	300	— 1/2 „ - „
				3 —	300	Young-fish trawl
				3 —	600	Silk-net 3/4 metre in diam.
				3 —	1000	Young-fish trawl
				3 —	1500	Silk-net 3/4 metre in diam.
				3 —	2000	Young-fish trawl
92*	23/7—24/7	48° 29′ — 13° 55′ —		4 —	0	Silk-net 1 metre in diam.
				4 —	100	— 1 „ - „
				4 —	200	— 1 „ - „
				4 —	300	Young-fish trawl
				4 —	600	Silk-net 3/4 metre in diam.
				4 —	1000	Young-fish trawl
				4 —	1500	Silk net 3/4 metre in diam.
				4 —	2000	Young-fish trawl
				4 —	3000	Net 3 metres in diam.
94	26/7	50° 13′ — 11° 23′ —	1565	3 —	0	Silk-net 1 metre in diam.
				3 —	100	— 1 „ - „
				3 —	200	— 1 „ - „
				3 —	250	— 1/2 „ - „

Station * denotes a night-station	Date 1910	Locality	Depth in metres	Duration of haul	Metres of wire out	Net used
94 (continued)	26/7	50° 13′ lat. N., 11° 23′ long. W.		3 hours	300	Young-fish trawl
				3 —	600	Silk-net 3/4 metre in diam.
				3 —	1000	Young-fish trawl
				3 —	1500	Silk-net 3/4 metre in diam.
				3 —	2000	Net 3 metres in diam.
98	5/8	56° 33′ — 9° 30′ —	1000—1360	4 —	0	Silk-net 1 metre in diam.
				4 —	100	— 1 „ - „
				4 —	200	— 1 „ - „
				4 —	300	Young-fish trawl
				4 —	600	Silk-net 3/4 metre in diam.
				4 —	1000	Young-fish trawl
				4 —	1450	Silk-net 3/4 metre in diam.
				4 —	1500	Net 3 metres in diam.

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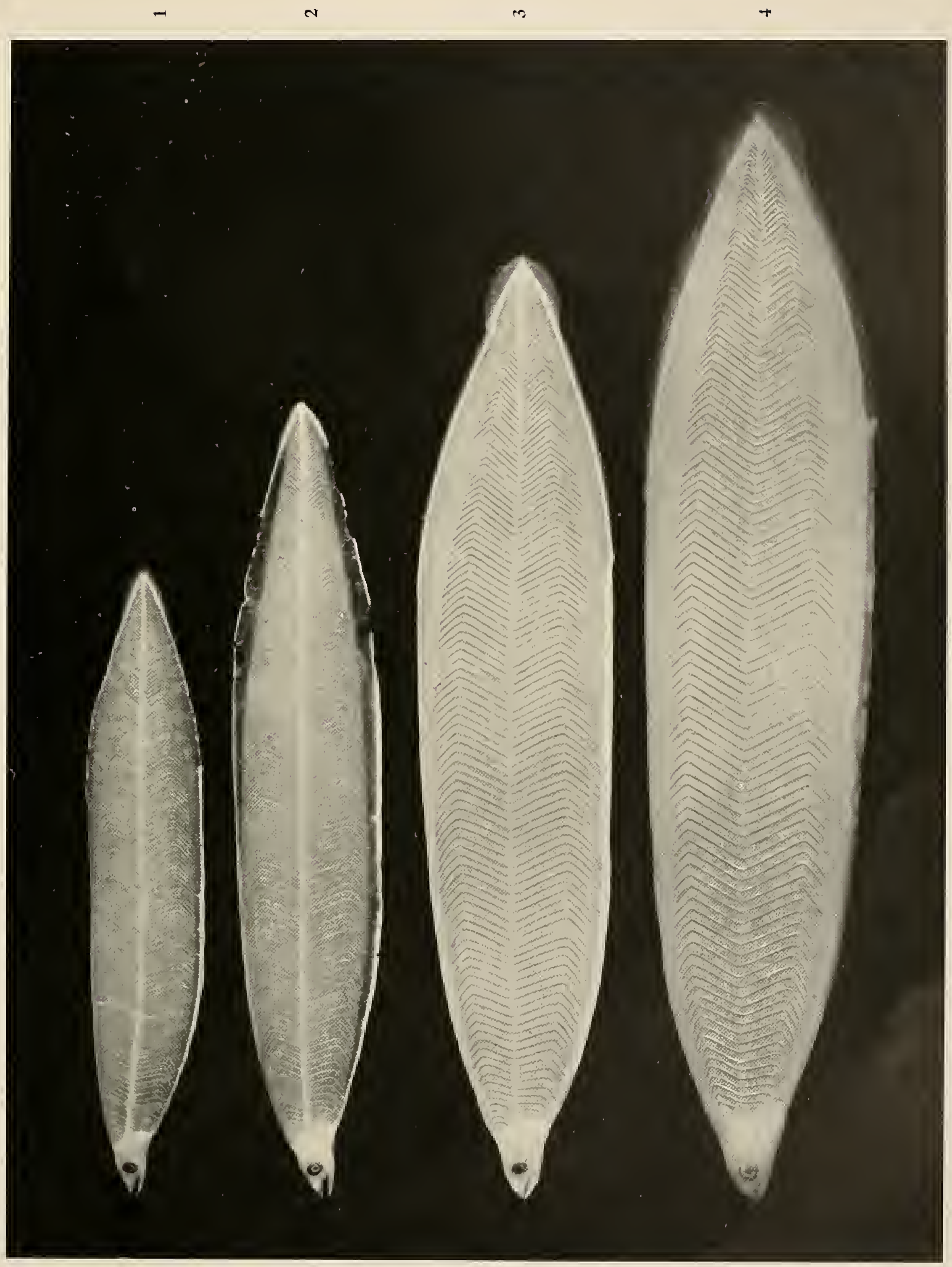
Pl. I.

Nos. 1—3. *Leptocephalus Anguillae vulgaris* from SW of the Azores, no. 1 being the smallest in the collection, no. 3 the largest. $(^{2\cdot5}/_{1})$.

No. 4. *Leptocephalus Anguillae vulgaris,* fullgrown from N of the Azores. $(^{2\cdot5}/_{1})$.



Lea phot.

Pl. II.

Nos. 1—4. Four stages in the development of *L. Synaphobranchi pinnati.* (${}^{1\cdot5}/_{1}$).

No. 5. *L. Histiobranchi infernalis* or *L. Ilyophis Brunnei.* (${}^{1\cdot5}/_{1}$).

„ 6. *L. Cyematis atri.* (${}^{2}/_{1}$).

Lea phot.

Pl. III.

No. 1. *L. Congri mystacis.* ($^2/_1$).
„ 2. *L. Congri mystacis,* large specimen from the Azores. ($^1/_1$).
„ 3. *L. Congri balearici.* ($^2/_1$).
„ 4. *L. spinocadux.* ($^{1\cdot5}/_1$).
„ 5. *L. polymerus.* ($^{1\cdot5}/_1$).

Lea phot.

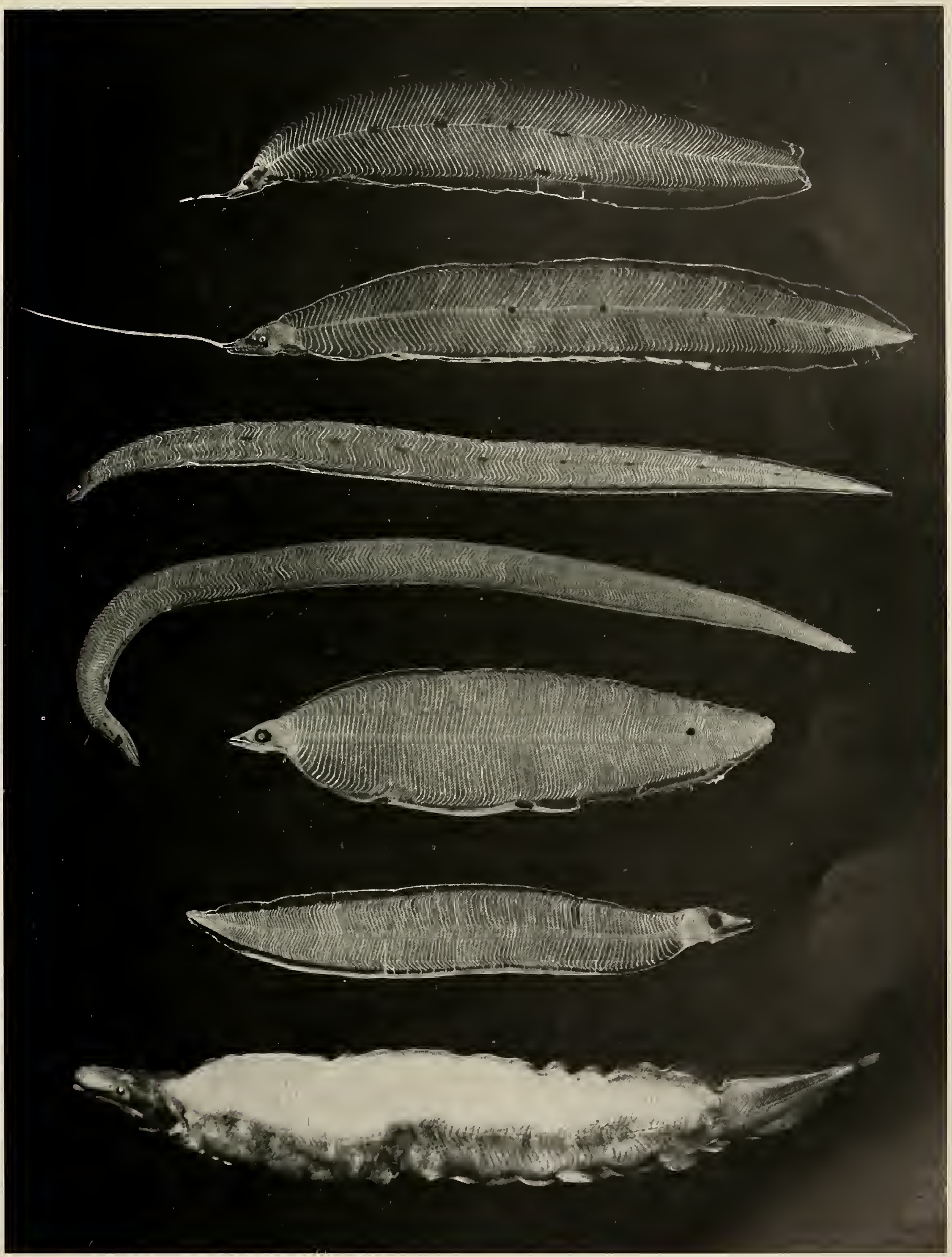
Pl. IV.

No. 1. *L. Michael-Sarsi.* $(^{1\cdot5}/_{1})$.
„ 2. *L. splendens.* $(^{3}/_{1})$.
„ 3. *L. enchodon.* $(^{1\cdot5}/_{1})$.
„ 4. *L. euryurus.* $(^{3\cdot5}/_{1})$.
„ 5—6. *L. similis.* $(^{3}/_{1})$.

Lea phot.

Pl. V.

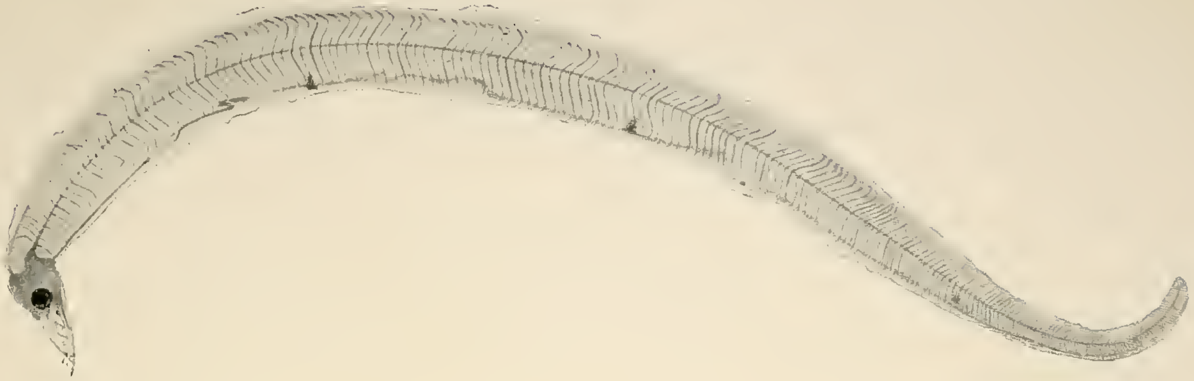
No. 1. *L. proboscideus* ($^{2}/_{1}$).
„ 2. *L. dolichorhynchus.* ($^{4}/_{1}$).
„ 3. *L. stylurus.* ($^{1\cdot5}/_{1}$).
„ 4. *L. Saurenchelydis cancrivorae.* ($^{2}/_{1}$).
„ 5. *L. urosema.* ($^{4}/_{1}$).
„ 6. *L. megacara.* ($^{4}/_{1}$).
„ 7. *L. mysticus.* ($^{2}/_{1}$).



Lea phot.

Pl. VI.

No. 1. *L. canaricus.* $(^{7\cdot5}/_{1})$.
„ 2. Small larva no. 1. $(^{10}/_{1})$.
„ 3. „ „ „ 2. $(^{9\cdot5}/_{1})$.
„ 4. „ „ „ 3. $(^{8}/_{1})$.
„ 5. *L. Gastrostomi Bairdii.* $(^{5}/_{1})$.



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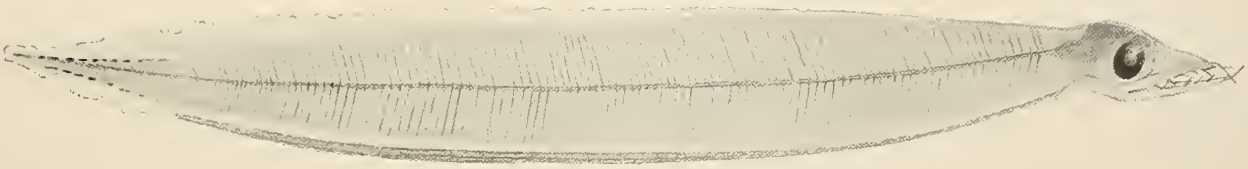

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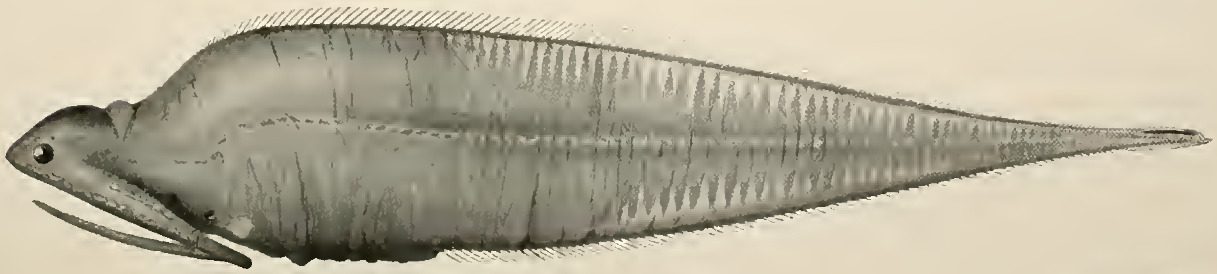

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Rasmussen del.

PYCNOGONIDA

FROM THE

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION 1910

BY

ØRJAN OLSEN

WITH 1 PLATE AND 9 FIGURES IN THE TEXT

During the cruise of the "Michael Sars" in the North Atlantic in 1910 Pycnogonida were collected at six stations, altogether about a hundred individuals belonging to nine species distributed among the genera *Colossendeis*, *Nymphon* and *Boreonymphon*. Two species, one of *Colossendeis* and the other of *Nymphon* were new to science. Two thirds of the material in hand belong to a single species: *Boreonymphon robustum*.

The six stations are:

24	lat. 35° 34′ N.,	long. 7° 35′ W.	May 6—7, 1910.
25 B	lat. 35° 46′ N.,	long. 8° 16′ W.	May 7—8, 1910.
38	lat. 26° 3′ N.,	long. 14° 36′ W.	May 20, 1910.
41	lat. 28° 8′ N.,	long. 13° 35′ W.	May 23, 1910.
70	lat. 42° 29′ N.,	long. 51° 15′ W.	June 30, 1910.
102	lat. 60° 57′ N.,	long. 4° 38′ W.	August 10, 1910.

Colossendeis Jarzynsky 1870.

Colossendeis proboscidea Sabine.

The collection includes eight specimens of this species, all females ranging in length from 37 to 55 mm. One specimen had been placed in a bottle, along with a specimen of *Boreonymphon robustum*, labelled simply Stat. 102, while the other specimens were found in a separate bottle without label. Presumably they were all taken at Stat. 102, in the trawl at a depth of 1000 metres.

This species has a wide distribution in the Arctic Ocean, and was taken by the Norwegian North Atlantic Expedition in 412 fathoms to the west of Storeggen.

Colossendeis angusta G. O. Sars.

Two adult females, 29·5 mm in length were taken, one at Stat. 102 in the trawl at 1000 metres, and the other at Stat. 70, in 1215 metres.

Colossendeis angusta inhabits the Arctic Ocean between Jalmal and Greenland, as well as the Norwegian Sea and the northern part of the Atlantic Ocean. It occurs along the eastern coast of North America as far south as to 38° 15′ N., 73° 15′ W. and as deep as 1242 fathoms (Wilson).

Colossendeis leptorhyncus Hoek.

Three adult males were taken: one at Stat. 24 in the trawl at 1615 metres, one at Stat. 25 B in the trawl at 2055 metres, and one at Stat. 70 in the silk net at about 1100 metres (1700 metres of wire out).

The two first mentioned were each 36 mm in length, the proboscis measuring 23 mm; the individual from Stat. 70 was larger, 42 mm in length. This species was taken by the "Challenger" at several places between lat. 33° and 51° south, and a variety *(C. leptorhynchus*, var. *septentrionalis* Caullery) was found by the "Caudan" at a depth of 1710 metres in the Bay of Biscay. The "Michael Sars" specimens correspond well with Hoek's description except that the proboscis is a little shorter, and the capture of this species at Stat. 70 greatly extends its known distribution.

Colossendeis colossea E. B. Wilson.

Of this species four male specimens were taken: two at Stat. 24 in the trawl at 1615 metres, and two at Stat. 25 B in the trawl at 2055 metres, besides these also a proboscis, 31 mm in length, from Stat. 70 at 1100 metres. The specimens from Stat. 24 are 42 and 43 mm in length respectively, and 426 mm in circumference, while those from Stat. 25 B are 45 and 50 mm in length, and 453 and 507 mm in circumference, respectively. They all correspond closely to the diagnosis given by Wilson, but the proboscis is a little narrower and the accessory feet somewhat shorter; thus the feet of an animal 48 mm in length measure only 85 mm instead of according to Wilson about 100 mm.

C. colossea has previously been recorded from the ocean off Greenland (lat. 61° 44′ N., long. 30° 29′ W.), and southwards along the eastern coast of America as far as lat. 39° 43′ N., long. 70° 53′ W., at depths from 810 to 1300 fathoms.

The "Michael Sars" material extends the known geographical distribution to this species, and shows that it varies very little.

Colossendeis michaelsarsii n. sp.

Pl. I, fig. A.

A female specimen taken at Stat. 41 in the trawl at 1365 metres must be looked upon as the type of a new species, with the following diagnosis:—

Proboscis almost the same length as the rest of the body (abdomen included), swollen at the middle, bent downwards; abdomen nearly one third the length of the body (without proboscis); oculiferous tubercle low, obtusely conical, with two unpigmented ocelli; palpi shorter than the total length of the body, the third joint being about twice as long as the fifth; the two tarsal joints about the same length, and four times as long as the end-claw. The entire length of the body is about 50 mm; the proboscis being 25 mm, the trunk 19 mm, and the abdomen 6 mm in length, and the circumference about 480 mm.

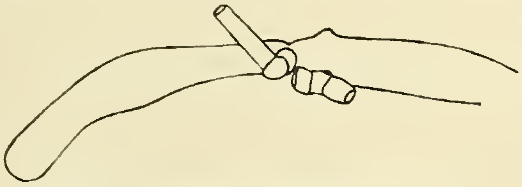

Fig. 1. *Colossendeis michaelsarsii* n. sp. Proboscis and ocular tubercle, side view.

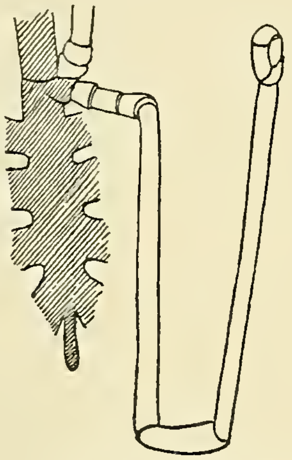

Fig. 2. *Colossendeis michaelsarsii* n. sp. Left false leg.

The proboscis is directed downwards (fig. 1), cylindrical in its proximal third, with a diameter of about 3 mm; at the middle it swells so as to measure $4^1/_2$ mm in diameter, decreasing to $3^1/_2$ mm, and swelling again at the end to $3^2/_3$ mm. The mouth is large and triangular. The trunk is robust, somewhat flattened, with a width of 4 mm, and a height of $4^1/_2$ mm. A distinct sutural line, dividing the lateral appendages from the central portions of the body, is to be seen on the dorsal surface. The proboscis as well as the whole body, dorsally and ventrally, are furnished with tiny hairs, barely visible to the naked eye. The extremity of the abdomen is a little swollen and pointed. The palpi are 41 mm long, the two first joints being wider than they are long (see pl. I, fig. A); third joint is 16 mm in length, and only slightly swollen at the extremities; fourth joint $1^1/_2$ mm long and nearly equally wide; fifth joint 7 mm in length, sixth joint 2 mm, seventh joint 4 mm, eighth joint 3 mm, ninth joint 2 mm and tenth joint 3 mm, slender and tapering. The first two joints are about 2 mm wide, the following three joints about $1^1/_2$ mm, the last five joints tapering gradually outwards. Except for the two proximal joints, the palpi are furnished with short stiff hairs, those on the five distal joints being the stoutest and longest. The accessory feet (fig. 2) are about 72 mm long, and, as usual in this genus, attached close behind the palpi. The first three joints are $1^1/_2$ mm long, and of nearly the same width; fourth joint about 24 mm long and $1^1/_2$ mm wide, somewhat swollen at the outer extremity; fifth joint 6 mm long, but as stout as the fourth joint, and also swollen at the outer extremity; sixth joint 26 mm long, a little more than 1 mm across; seventh joint nearly 4 mm, eighth joint 9 mm, and tenth joint about 3 mm long, tenth joint slender and tapering, seventh, eighth and ninth about 1 mm across. The last four joints are furnished with numerous fine transverse ridges, and form together a spiral-shaped prehensile organ (fig. 3), so that the seventh and the ninth, the eighth and the tenth joints are situated approximately parallel to one another. The accessory feet are covered with sparse, very short hairs, hardly visible without a magnifying glass.

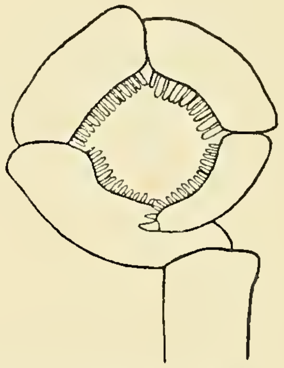

Fig. 3. *Colossendeis michaelsarsii* n. sp. Grasping organ forming the tip of the false leg (right side).

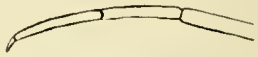

Fig. 4. *Colossendeis michaelsarsii* n. sp. Terminal portion of walking leg.

The fourth joint of the true feet is longest and stoutest, the rest decreasing in length and thickness, the swelling at the extremities of the joints being very slight. On the fourth foot the fourth joint is 59 mm in length and $2^1/_2$ mm in thickness; fifth joint 52 mm long and 2 mm thick;

sixth joint 42 mm long and about $1^1/_2$ mm thick; the first and the second tarsal joints (fig. 4) are a little more than 5 mm long and about 1 mm thick, tapering towards the tip; the endclaw is $1^1/_2$ mm long, pointed, slightly curved; no auxiliary claws. The whole foot is furnished with microscopical stiff hairs which are most prominent on the upper side, and arranged in symmetrical longitudinal rows.

This species resembles most closely *Colossendeis gigas*, which differs from it in the following points:—The proboscis is relatively longer and straight; the accessory feet as well as the true feet are relatively longer; the abdomen is relatively short, only a little more than one-half the length of the body; the lenses of the eyes are wanting; the third joint of the palpi is very little longer than the fifth, and the distal five joints of the palpi show a different reciprocal relation in regard to size; the second tarsal joint is only half as long as the first.—The last mentioned character, however, seems to vary a great deal, the relation between the length of the two tarsal joints of *C. gigas* differing greatly not only among the different specimens, but even in the legs of the same specimen.—

Nymphon Fabricius 1794.

Nymphon brevicollum Hoek.

One female specimen, $5^1/_2$ mm in length, was taken at Stat. 70 in the young-fishtrawl at 1100 metres.

This species inhabits the northern Atlantic; it was found by the "Challenger" to the south of Halifax at a depth of 83 fathoms, not far from the "Michael Sars" record.

Nymphon grossipes Fabricius.

Three specimens (two males and one female) were taken at Stat. 102 in a net (1500 metres of wire out). The female is the largest, having a total length of $8^1/_2$ mm; the two males are about $7^1/_2$ mm long, and one of them bears a great number of newly-hatched young (about $^1/_2$ mm long) and some eggs.

The geographical distribution of this species embraces the northern Atlantic and the Norwegian Sea, the Arctic Ocean off Greenland, Spitsbergen and Novaja Semlja, as well as the Kara Sea.

Nymphon longituberculatus n. sp.

Pl. I, fig. B.

One male was taken at Stat. 38 in the young-fish trawl at 83 metres. The segment of the head is very robust, and its anterior portion is almost twice as wide as the trunk; the neck is short, the oculiferous tubercle exceedingly long, a little longer than the segment of the head (without the proboscis), and with four brown eyes at the point; the legs are relatively short. Total length $3^1/_2$ mm.

Fig. 5. *Nymphon longituberculatus* n. sp. Side view, to show the length of oculiferous tubercle and abdomen relative to the that of the body.

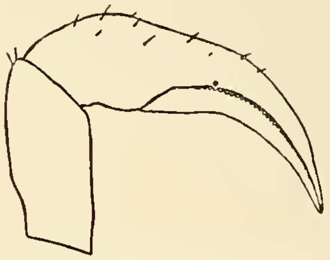

Fig. 6. *Nymphon longituberculatus* n. sp. Left chelifer.

The proboscis with the segment of the head exceeding 1 mm, the trunk nearly $1^1/_2$ mm, and the abdomen about 1 mm in length; circumference 16 mm. The segment of the head, seen from above is approximately triangular with an incision at the front Round the two ventral appendages carrying the pincers, we find a ring of microscopic hairs. The proboscis is of medium length, somewhat stouter than the trunk, directed downwards, cylindrical, rounded at the point; the mouth big, triangular. The neck is very short, the body relatively slender, ventral appendages well separated, somewhat swollen at the distal end. The abdomen is very long, a little bent upwards, clubshaped, tapering towards the point and furnished with some microscopic hairs. The extreme length of the oculiferous tubercle unprecedented among the species of *Nymphon*, is especially characteristic of this species (fig. 5). It is approximately cylindrical, rounded at the end, and having four brown oval eyes. The pincers are strong, the distal joint longer than the scapus, and furnished with a few hairs along the outer margin (fig. 6). The pincers are as long or a little longer than the palmen, and furnished with pointed denticulate spines.

The palpi are five-jointed, slender and delicate, a little longer than the proboscis; second joint is the longest, the two distal joints furnished with small hairs (fig. 7). The accessory feet are ten-jointed and 5 mm long. The two anterior joints are short, as stout or stouter than the remaining joints, which taper outwards. The third and

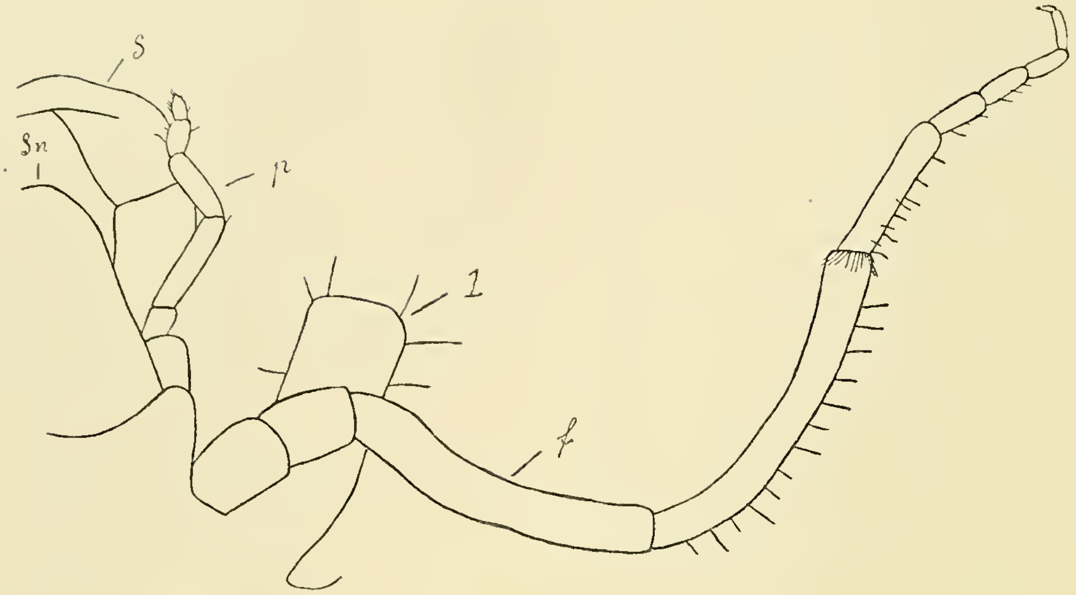

Fig. 7. *Nymphon longituberculatus* n. sp.
Palp *(p)* and false leg *(f)* of left side, *s*, chelifer, *Sn*, proboscis, *l*, first leg.

fourth joints are nearly equal in length and somewhat bent, fourth joint somewhat swollen at the distal end, and furnished with a fringe of hairs (fig. 7); fifth joint about half the length of the fourth, sixth joint about half the length of the fifth; the succeeding three joints are of about the same length, and a little shorter than the sixth; the end-claw short and slender. The inner margin of the sixth and ninth joints is furnished with a row of tall papillae (see fig. 8).

The true legs are relatively short and well separated (pl. I, fig. B). The three proximal joints are about equally stout, (second joint the longest), and furnished with long sparse hairs. The fourth joint is almost as stout as the first three and furnished with sparse short hairs. The rest of the joints taper outwards, are more densely covered with hairs, the fifth joint being the longest, and somewhat swollen at its extremity; the sixth joint which tapers outwards, is a little shorter; the eighth joint is a little longer than the seventh, and the end-claw about half the length of the eighth joint, slightly curved (fig. 9); no auxiliary claws.

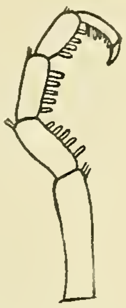

Fig. 8.
Nymphon longituberculatus n.sp.
Grasping apparatus forming tip of right false leg.

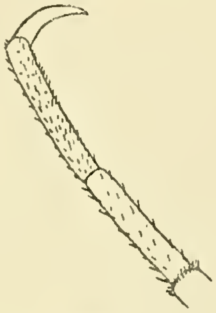

Fig. 9.
Nymphon longituberculatus n.sp.
Terminal portion of left first leg.

Boreonymphon G. O. Sars 1888.

Boreonymphon robustum (T. Bell).

Forty-six adult specimens, and many young ones of different sizes, were taken at Stat. 102 in 1098 metres.

There were 27 adult males and 16 adult females; the sex of the half grown individuals could not be determined without dissection. Most of the adults were 12 to 14 mm in length, but one female was 22 mm and one male 24 mm in length. The last mentioned carried eleven big young ones (up to 8 mm in length), another carried smaller ones (about $3^{1}/_{2}$ mm in length) and a third carried eggs. Several of the other specimens carried young ones of different sizes, from about 1 mm (newly hatched) to 5 mm in length.

Attached to four of the largest specimens were parasitic amphipods, surrounded with a ball-shaped, grey, clayey covering, about 6 mm in diameter, within which they lay rolled up; after being straightened out, they measured about 10 mm in length. They had attached themselves to different places on the various individuals, one being found under the abdomen, another behind the pincers on one of its limbs, a third on the leg, and a fourth on the egg-ball, only a small portion which was left, the rest having apparently been devoured (for this, however, the amphipods can hardly be held responsible).

One a male there were, besides the empty covering of an amphipod, two individuals of *Lepas*, one attached over the base of the abdomen, the other on the ventral side of the femur on the third left foot, the larger one measuring 45 mm in length.

According to SARS, great multitudes of *Boreonymphon robustum* inhabit the ocean between the Faroe Islands and Norway, where the "Michael Sars" took this rich haul. Its range of distribution includes the northern Atlantic, the Norwegian Sea, the Arctic Ocean off Greenland and Spitsbergen, as well as the Kara Sea.

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Fig. B. *Nymphon longituberculatus.*

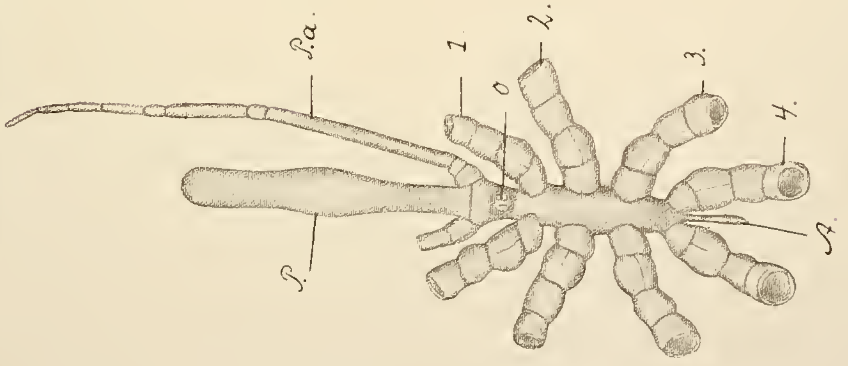

Fig. A. *Colossendeis michaelsarsii.*

During the months of May to August 1910 the Norwegian research steamer "Michael Sars" accomplished a cruise in the North Atlantic under the superintendence of Sir John Murray, K. C. B., and Dr. Johan Hjort, director of the administration of Norwegian fisheries. Dr. Hjort has published a short review of some of the main results of the cruise,[1] in which he says:

"We first experimented with the trawl, and undertook hydrographical investigations to the west of Ireland, over the slope of the coast banks. Our course was then set across the Bay of Biscay, where we made a number of investigations, towards the north-west corner of Spain. From there we followed the Spanish and Portuguese coasts down to Gibraltar, where we obtained a series of current measurements in the strait. Cadiz Bay was next examined and careful hydrographical observations of the currents were made over several sections of these interesting waters, while series of trawlings were at the same time undertaken from the coast down to profound depths.

We then steamed in the direction of the Canary islands, and examined the African banks from the coast to the ocean floor, and subsequently crossing a large section of the Atlantic, visiting the Azores, the Sargasso sea, and eventually Newfoundland. Throughout the whole of this section, comprising 40 stations, we made constant hydrographical investigations and employed many different kinds of instruments for collecting plankton organisms of all sizes. A similar section was run in July from Newfoundland over to Ireland (22 stations), and we concluded our researches by a more thorough examination of the waters between Glasgow, Rockall, the Faroes and Shetland—that is to say, the sea to the south and north of the Wyville Thomson ridge—to study the transition from the Atlantic to the Norwegian sea.

During the four months that the cruise lasted a great deal was accomplished. For oceanographic science it cannot but be interesting to learn that a little steamer, of only 226 tons, could carry out so many and such multifarious researches right across one of the great ocean basins, and I will accordingly give a few figures to illustrate what was done.

In the case of *hydrographical* material we collected 2400 water-samples, more than 900 of which were from below the surface. At 110 stations we took 937 temperature-observations from below the surface, while as many as 1625 observations of the surface temperature were recorded during the cruise. In addition, we obtained 258 measurements of currents and seven measurements of the penetration of light beneath the surface. For the study of *vegetable plankton* we made 140 vertical hauls, and took 38 water-samples for filtration and 58 samples for examination with the centrifuge. For the *larger plankton* there were 95 vertical hauls with nets of different sizes, 193 horizontal hauls with silk

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[1] The Geographical Journal for April and May 1911.
Internationale Revue der gesammten Hydrobiologie und Hydrographie 1911.

nets, 80 horizontal hauls with pelagic trawls and 18 hauls with a large tow-net. *Trawlings* were undertaken on twenty-four occasions at different depths."

The publication of the report on the scientific results achieved by the expedition has been undertaken by the Bergen Museum. In addition to hydrography, the systematic, biological and geographical results, in particular, will form the chief contents of the report, leaving the more detailed anatomical studies to be printed in other publications. The report will be issued in English. It will be profusely illustrated with plates, some of which will be coloured, in addition to figures and charts printed in the text.

The printing of the report had already begun, but the war, the great fire in Bergen, and the financial difficulties which followed upon the war placed obstacles in the way of its continuation. As these difficulties have now been surmounted, its issue is being resumed.

The report will be published in parts as the manuscripts are received by the editor,

For the terms upon which subscribers may obtain this publication the editorial committee would refer to the appended announcement by the publishers, A-S John Grieg, who have undertaken the issue and sale of the work.

Bergen, Norway

For the Trustees of the Bergen Museum

C. Geelmuyden. *H. P. Lie.* *C. F. Kolderup.* *A. Brinkmann.*

The Report will be printed in accordance with the particulars given above. Each volume or half volume will be sent to subscribers on publication, and will be paid for on its receipt. The price of each issue — volume or half volume — will be £ 3, the total cost being guaranteed not to exceed £ 30.

Each subscriber is bound to take the entire work.

The purchase of single volumes or parts thereof will not be permitted.

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