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NOTES ON
AMERICAN PARASITIC COPEPODA

No. I.

BY R. RAMSAY WRIGHT, M. A., B. Sc.

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In the course of some helminthological investigations concerning the Fresh-Water Fishes of this region, the results of which I hope to publish shortly, my attention has occasionally been attracted to Parasitic Copepoda, the careful examination of which I have hitherto been obliged to defer. The present paper has for its object the consideration of three of these forms.

I.

ERGASILUS CENTRARCHIDARUM, *n. sp.*

The gills of various members of the family Centrarchidæ are found in this neighbourhood to be infested by a small species of Ergasilus, which usually occurs abundantly on infected individuals. I have observed that the same parasite may also occur on the Perch, but it is much more commonly met with on the Rock Bass (*Amblo-plites rupestris*), the common Sun-Fish (*Eupomotis aureus*, Gill and Jordan), and the Long-Eared Pond-Fish (*Lepomis auritus* [L.] Raf.), especially on the first of the three. I have only met with female specimens.

CHARACTERS.

Length of body, exclusive of furcal bristles, ½ mm., of egg-sacs 1 mm. Cephalothorax nearly as broad as long. Median constriction barely noticeable. The longest of the antennulary bristles as long as the antennule. Mandible without palp. Basal joint of natatory limbs naked. Ramus internus of 1st pair, with single bristle on inner border of 1st and 2nd joints, and 5 terminal bristles: of succeeding pairs, with 2 bristles on the 2nd joint. Ramus externus of 1st pair with 1 spine on outer border of 1st, 2 on outer border of 3rd, and a bristle on inner border of 2nd joints: of succeeding

pairs, without the 2 spines on 3rd joint. Furcal bristles 4,—2 principal, 2 subsidiary, of which one very short.

THE APPENDAGES.—ANTENNULÆ.

One of these is represented in Fig. 13, from the posterior aspect.

They are 6-jointed, and originate on the under side of the head at some little distance from each other. There is no antennulary sternum. Of the joints the 2nd is the largest, and with its exception, the 6th the longest. All the joints bear simple bristles, the longest of which are nearly as long as the antennule itself. The bristles of the first four joints are chiefly directed downwards; of the two terminal joints backwards and outwards. Into each bristle branches of the antennulary nerve may be seen to pass.

ANTENNÆ.

As in the other species of the genus, the antennæ form strong prehensile claws by which the animal clings on to the gill-filaments of its host. The antennary sternum is well developed (Figs. 12 and 14, st.), and enters at its extremities into the construction of the hinge-joints, which the antennæ form with their sockets. The basal joint is much inflated (as in *E. gibbus* V. Nordmann) on its outer and lower aspect, while on the opposite it is strengthened by 2 chitinous ledges, which descend from the hinge between it and the succeeding joint (c^2, Fig. 14) to the socket (c^1). When viewed from the surface one of these ledges gives the appearance of a diagonal division in the basal joint.[1] The hinge between the 2nd and third joints is somewhat complicated, but its arrangement, as well as those of the chief flexor and extensor muscles entering the appendage, may be studied in Fig. 14. The terminal joint is particularly short and curved; in this respect unlike the same part in E. Sieboldii.[2]

APPENDAGES OF THE MOUTH.

These have been only satisfactorily described for *E. Sieboldii* by Claus.

[1] Vide Olsson, Ofversigt af Kongl. Vet. Akad. Förhand, 1877, No. 5, p. 76.

[2] v. Claus Zeit. Wiss. Zool., Tal. XXIII., Fig. 14. In a revision of the species of Ergasilus, it will probably be found that apart from the size, form of body, and length of egg-sacs, the form of the appendages will afford valuable specific characters. As far as I am aware, however, Claus' figures are the only ones which possess the necessary accuracy of detail.

The parts are somewhat difficult to study in the present species on account of its small size, but the main facts elucidated by Claus are found to obtain also here. I have not detected any labrum. The basal joint of the mandible is very large, and works in a somewhat oval socket from which a chitinous ledge is continued forwards and outwards. The cutting edge is provided with several strong bristles. No palp is to be seen. The maxilla (mx., Fig. 15) is, however, more intimately attached to the mandible than in *E. Sieboldii*. That it is the maxilla, and not a mandibular palp, is shown by its articulation to a chitinous ledge continued forward from the socket of the maxillipede, and on which the basal joint of the mandible also partly rests.

The second maxillipede is absent: the first 2-jointed and armed on the anterior and inferior faces of the lower joint with short, stout bristles. The maxillipedary sternum is particularly strong.

THE NATATORY FEET.

Except in details, which I have found to be constant, and which ought to be looked to for specific characters, the present species agrees with *E. Sieboldii*. The five sterna belonging to the five thoracic somites are constructed on the same type, and are formed of 2 transverse chitinous thickenings continuous with each other at the sockets of the limbs. The sockets (*a* Fig. 16) project more or less from the surface of the body, and enter into the formation of a very free hinge-joint, with the basal segments of the limbs. These are also movably articulated to the posterior of the two sternal thickenings. The figure shows how the bristles and spines are disposed in the external and internal rami of the 1st natatory limb. The internal rami of the 2nd, 3rd and 4th pairs differ from that of the 1st in having two bristles on the second segment instead of one, while the external rami of the 2nd, 3rd and 4th pairs differ from that of the 1st in the absence of the 2 spines on the terminal segment. The basal joint is not ciliated as in *E. Sieboldii*. The natatory limbs of the fifth pair are represented by a bristle articulated to the end of the comparatively well developed sternum.

I have not been able to determine the precise function of the curious chitinous structures situated at the opening of the oviduct, and which Claus has figured much more accurately than previous authors. They are evidently developed from the lining membrane

of the terminal portion of the oviduct. Three or four short chitinous pieces situated above the opening, and connected with each other, I at first supposed to be a coiled tube similar to that described as passing in various free forms from the receptaculum seminis to the end of the oviduct.[1] But there is no trace of a receptaculum seminis in Ergasilus, and these chitinous pieces serve to form a hinge for the two longer pieces which stretch back within the segment on each side. (Fig. 18). The muscle attached to the shorter chitinous pieces may serve to abduct the egg sacs.

The furcal bristles are differently disposed from any described species of Ergasilus. I am not confident that the arrangement represented in Fig. 7 is constant, but it seems fairly common. Some variability must be assigned to these structures, as Olsson (loc. cit.) has noticed the occurrence of three in *E. Sieboldii*, and I have observed the internal (stronger) bristle bifurcated on one or two occasions.

The egg-sacs, although often unequal, are generally twice the length of the body of the female.

II.

LERNÆOPODA EDWARDSII. *Olsson.*

(Prodromus faunæ Copepodorum parasitantium Scandinaviæ. Act. Univ. Lund., 1868, p. 36.)

Prof. Osler, Montreal, obtained several specimens of a species of *Lernæopoda* from the gills of the brook trout (Salmo fontinalis), which differs markedly from the *S. Salmonea* of Baird, but agrees very well with Milne-Edwards' figure of *Basanistes Salmonea* from *Salmo umbla* (Hist. Nat. d. Crust., Tab. XLI., f. 3). In the above-cited memoir, Olsson proposes the specific name of *L. Edwardsii* for Milne-Edwards' form, and describes its characteristic features from specimens (from unknown host) in the Museum of the University of Lund. It can hardly be doubted that, at any rate, this species of *Basanistes* is a true *Lernæopoda*.[2]

[1] Aug. Gruber, Zeit. Wiss. Zool. XXXII., p. 407 seq.

[2] Apart from the rounded tubercles on the abdomen of B. huchonis, the shortness and thickness of the "arms," and their separate attachment to the chitinous bulla, are regarded as characteristic of the genus; but the different species of Lernæopoda vary much in this respect. In the form described in the text it is easy to prepare the bulla into the halves belonging to each arm.

In size my specimens agree best with *L. Edwardsii* and *L. alpina* Olsson, but the details furnished of the latter[1] forbid their reference to this species, while on the whole they agree very well with Olsson's description of the former. This is, however, not accompanied by details of the appendages, and as Kurz observes[2] it is to these, and not to the form of the body or the angle which the "arms" make with it, that we must look for constant characters on which to ground valid species. I prefer, therefore, to describe the appendages of the present form under the above specific name, rather than attribute too much importance to the difference in shape of the chitinous bulla in Olsson's description.

The shape of the body is sufficiently indicated by the outline sketch, Fig. 1, which also indicates the hump on the cephalothorax, opposite the origin of the arms. The length of the body, exclusive of egg-sacs, is 4 mm., of the egg-sacs 2 mm. (they are probably somewhat more shrunken in proportion by their preservation in alcohol than the body), while the arms are about $2\frac{1}{2}$ mm. long. The position of the 1st and 2nd pairs of antennæ, and of the projecting upper lip, in relation to the anterior border of the cephalothorax, may be seen from the outline sketch from above, Fig. 2. The 1st pair of antennæ are much more easily studied from above than from below, owing to the lateral projections from the upper lip, *x*, Fig. 3, which nearly conceal them from that aspect. They measure 0.07 mm. in length, are indistinctly 3-jointed, and bear on the rounded end of the terminal joint 3 minute spines, of which the median one is distinctly articulated to the antenna, *v*, Fig. 3. The second pair of antennæ may be most conveniently examined from below and from the side. They consist of a thick stem indistinctly 3-jointed, the basal joint being far the longest, and alone provided with a chitinous plate (*ch*, Fig. 3), and of two short branches, dorsal and ventral (*d* and *v*, Figs. 3 and 5), of which the dorsal is the longer and more internal of the two. It is composed of one joint, the rounded extremity of which is provided with numerous curved chitinous points for the most part directed inwards. The ventral and more internal branch has two joints, of which the terminal one (*t*, Fig. 5) is more palp-like than the other parts of the antenna,

[1] Ofversigt af K. Vetensk. Akad. Förhand, 1877, No 5, p. 82, Figs. 9-13.

[2] Studien über die Familie der Lernæopodiden, Zeit. f. Wiss. Zool., B. XXIX., p. 382.

while the basal one bears two discoidal chitinous outgrowths, armed with curved points, of which one is lateral, while the other is ventral, in position (*o* and o^1, Figs. 3 and 5).

The mandibles (Fig. 6) are 0.1 mm. in length, of which one-third belongs to the toothed portion. This differs from any of the mandibles figured by Kurz in the absence of secondary teeth.

The maxillæ (Fig. 7) are tri-articulate, the basal joint inflated on its lateral aspect, and the terminal joint ending in an outwardly-directed curved spine. The palp originates from the distal part of the second joint above a spine, and itself terminates in two sharp points. The maxillæ measure 0.095 mm. in length, of which one-half is occupied by the basal joints.

The maxillipedes of the first pair, as in the other members of the genus, originate behind the second pair, and are independent as far as their attachment to the bulla. This is best described as mushroom-shaped, and its bilateral character is as well indicated by a surface view (after the fragments of gill have been removed from it), (Fig. 8), as by the fact that it is easy to prepare separately the halves belonging to each maxillipede (Fig. 9).

The maxillipedes of the second pair measure 0.73 mm. in length, and present the typical characters described by Kurz for these appendages in other Lernæopodidæ. Their specific characters may be studied in Figs. 3 and 10.

Fig. 11 reproduces the punctated appearance presented by the border of the lower lip, which measures 0.03 mm. from its attached to its free margin; the latter has only a very narrow fringe.

On comparing Olsson's figures of *L. alpinus* with mine, it is apparent that the bulla presents considerable resemblance; the 2nd antennæ also bear a similar spiny excrescence, but have a pointed instead of a blunt ventral branch; while two chitinous appendages project between the maxillæ from the ledge uniting their basal joints. If the figure of the 2nd maxillipede is accurate, it also differs considerably in outline. The details of Milne-Edward's figure of *Basanistes salmonea* are insufficient for comparison, but the resemblance of the 2nd antennæ and the 2nd maxillipedes (3[c], 3[d], Pl. XLI. loc. cit.) is sufficiently striking to justify the conclusion that the form found on the European *S. umbla* and on our Brook Trout are

Loc. cit., Taf. V., Figs. 10, 11, 12, 13.

identical; a conclusion which is rendered more probable by the fact that the hosts both belong to the subgeneric group of the Charrs.

ACHTHERES MICROPTERI, *n. s.*

The specimens for which I have selected the above specific name were found in considerable numbers, both male and female, in the mouth cavity and on the gill-arches of the small-mouthed Black Bass *Micropterus salmoides* [(Lac.) Gill]. As far as the size of the female is concerned, and the character of its fixation in the mucous membrane of its host, it might well be referred to *A. percarum* V. Nord.; but the relatively larger size of the male, the constant downward direction of the arms, the shape of the bulla, some details of structure in the other appendages, and the cylindrical form of the egg-sacs, point to the specific distinctness of this form. I am assured by Prof. D. S. Kellicott that it is also distinct from his *A. Ambloplytis* from the mouth of the Rock Bass; otherwise I should have been inclined to suspect the identity of the two American forms. I have never met with any Achtheres in our common Perch.

The female measures on an average 4 to 4½ mm., the cylindrical egg-sacs 2½ mm. Fig. 1 represents the appendages of the head from the ventral aspect. The antennulæ are attached at some considerable distance behind the mouth: their basal joints are the longest and stoutest of the three. The internal rami of the antennæ seem to present little difference from *A. percarum*, but the ends of the external rami are furnished with toothed sickle-shaped spines.

The mandibles, Fig. 2, have 9 teeth, of which the third is the shortest of the first six, and the last three are successively smaller. The inner edges of the mandibles are sharpened into a knife-edge, which is broadest immediately behind the teeth.

The maxillæ are two-jointed—the distal joint bearing a lateral two-jointed bristle-like palp, and two terminal rami of the same character. The maxillary sternum forms a prominent fold (*mxs.*, Fig. 1), owing to the advance of its appendages in front of the attachment of the antennæ.

The internal maxillipedes are three-jointed: the basal joints are united, the second are stout and furnished with a hook on the inner side (vide left side of Fig. 4), while the third are armed with a strong terminal curved claw articulated to the joint, which on its inner aspect is further furnished with two trenchant serrated ridges.

Of the muscles which move the terminal joint, the flexors are by far the most powerful; whence the ordinary position of these joints.

The arms in length (1½ mm.), transverse wrinkles, &c., resemble those of *A. percarum*, but instead of lying in front of the head have a downward direction as in Lernæopoda. Unlike this genus there is no *continuously* chitinized bulla, and the separation of the plate which represents it from the mucous membrane is much more difficult than in that form. The plate is somewhat hollowed out on its distal surface (cup-shaped in *A. percarum* V. Nordmann), and from it radiate many fine threads of chitin, which undoubtedly are the cause of the extremely intimate coalescence with the mucous membrane. The proximal surface of the plate is strengthened by a reticulum of chitinous bars, which become narrower as they approach the margin of the plate.

I have not had the opportunity of examining any living specimens, and am thus unable to contribute anything to the further knowledge of the soft parts.

Fig. 5 represents the post-abdomen of the female before the spermatophores are attached. The two canals for impregnation open upon its extremity: their walls are chitinous, and are especially thick posteriorly. In many females the spermatophores (Fig. 3) may be found sometimes empty, with the narrow ends of their terminal capsules inserted in these orifices, while in others nothing remains of the spermatophores, except these capsules. It is in this condition that they were interpreted by Claus[1] as receptacula seminis belonging to the female; but when entire they may usually be separated without difficulty from the female post-abdomen; the greater or less ease with which they may be detached from the terminal orifices depending on the amount of cement with which they have been attached to the orifices. Occasionally the cement may be present in such quantities as to deform the post-abdomen. The mode of formation of the brown capsules and of the cement is discussed further on.

The male measures as much as 1½ mm., thus being fully one-third of the length of the female. Usually I have found the male attached to the post-abdomen of the female, occasionally further forward on the body, in one case on the arms. The appendages of the head,

[1] Zeit. wiss. Zool. XI. The similar structures of Lamproglena have been more recently (Zeit. wiss. Zool. XXI.) spoken of by Claus as belonging to the spermatophoral apparatus.

although proportionately smaller, have all the specific characteristics of the female. The antennulæ (Fig. 7) are slenderer, and the internal bristles of the basal joints more distinct, while the hooks on the external rami of the antennæ are simple, and do not present the toothed sickle-shaped form observable in the female. The strengthening chitinous plates (*ch.*, Fig. 7) are also of different form. The mandibles and maxillæ seem only to differ in size.

The peculiar form of the first maxillipedes described by V. Nordmann for *A. percarum* can also be seen here. The deep and narrow sternum of these appendages (Fig. 8). shaped somewhat like a dice box, gives origin to the powerful adductor muscles, which occupy the greater part of the cavities of the basal joints. Of the two muscles which move the terminal claw-like joint, the flexor is much the more powerful, and keeps the claw shut against the toothed chitinous outgrowth of the basal joint.

The second maxillipedes (Figs. 6 and 9) are two-jointed, the distal joint terminating in two claws, both of which are hinged to it, and which are anterior and posterior in position. The anterior shuts into the posterior, which is hollowed out to receive it. The basal joint is strengthened by a diagonal chitinous bar: it is to this that V. Nordmann refers as a "muscle of almost cartilaginous consistence." The basal joints abut against each other in the middle line, and give rise to a cylindrical structure, which forms a striking feature in the profile view of the male (Fig. 6) This is represented from the ventral aspect in Fig. 9, in which an evident orifice may be seen. This may possibly be the outlet of certain little glandular masses situated in the basal joints of the appendages (*gl.*, Fig. 9), but the want of fresh specimens has hindered a satisfactory elucidation of this organ. The glands may possibly be homologous with the arm glands of the female: whether their secretion is employed for the fixation of the male on the female I have not determined. A thorough examination of the male reproductive apparatus of the Lernæopodidæ is very desirable for the purpose of elucidating the formation of the spermatophores in the Parasitic Copepoda, as Gruber has recently done for the Free forms.[1] I regret that my alcoholic specimens have not permitted an exhaustive study of this point.

[1] Zeit. wiss. Zool. B. XXXII.

Fig. 10 represents the abdomen of the male from the ventral surface, and is intended to illustrate the position of the male reproductive organs. The testes occupy the anterior segment of the abdomen, and the 1st portion of the vas deferens is dilated by the accumulated seminal elements. The 2nd portion is convoluted and beset with glandular tissue, till it opens into the pocket containing the spermatophore in course of formation. The ripe spermatophore may be studied in Fig. 11. No indication of the canal or capsule with which the spermatophore is attached to the female can be seen at this stage. The case of the spermatophore passes by a neck-like constriction into the case of the developing spermatophore, and it is through the aperture formed by the rupture of this constriction that the contents pass out. These correspond to the three elements described by Gruber for the Free Copepoda, viz., a globular central mass, ·085 mm. in diameter, representing the axial cement in the free forms, numbers of rod-like spermatozoa (not more than 2 μ in length), occupying the greater part of the rest of the axis of the spermatophore, and lastly, the refractive polygonal discharging corpuscles (the Austreibemasse of German Zoologists).

These I have only observed in preparations taken from alcoholic specimens of the male, and I have not had the opportunity of studying the mode of fixation of the spermatophore on the female. Two kinds of cement have been described in the Free Copepoda, (1) that situated in the spermatophoral dilation of the vas deferens, which serves to fix the ejected spermatophore to the female, and (2) that in the axis of the spermatophore, and which in Canthocamptus, *e.g.*, forms a curved canal through which the spermatozoa are ejected.

That the former kind of cement exists also in Achtheres is readily seen from the pieces of it adhering to the post-abdomen of the female, and which I have referred to above as being often present in considerable quantity. It appears to be formed by the glands grouped round the lower part of the vas deferens. The second sort of cement is ejected from the spermatophore in the form of a somewhat globular mass, composed of a peripheral translucent layer with finely granular contents. It appears to me that this mass undergoes a change similar to what takes place in Canthocamptus only more complicated, viz., that after the fixation of the spermatophore to the

[1] Gruber Zeit. wiss. Zool. 32, Pl. 25, Fig. 15.

female the globular mass is extruded through the opening in the spermatophoral wall referred to above, and inserted into one of the openings of the canals through which fertilization is effected(v. o. Fig. 5) : its peripheral layer then becomes indurated and brown in colour, and is then transformed into the brown capsule, while its contents are poured out to form the convoluted canal through which the remaining contents of the spermatophore pass into the body of the female. That the brown capsule acts as a sort of receptaculum seminis is also possible : because spermatozoa are to be observed in it, even after the detachment of the empty spermatophore.

DESCRIPTION OF THE PLATES.

PLATE I.

FIGS. 1–11.—Lernæopoda Edwardsii. Figs. 12–18.—Ergasilus Centrarchidarum.

FIG. 1.—Outline of body, female.

FIG. 2.—Outline of head and antennae from upper surface ; *ol*, the upper lip ; a^1, antennulae ; a^{II}, antennae.

FIG. 3.—Ventral surface of head ; *d*, the dorsal ; *v*, the ventral branch of the antennae ; *o* and o^1, chitinous outgrowths on the latter ; *ch*, chitinous plate in 2nd joint of antenna ; *mx*, maxilla ; mxp^2, the internal maxillipedes, the second pair according to some morphologists.

FIG. 4.—One of the first pair of antennae.

FIG. 5.—One of the second pair of antennae from the outer side ; *t*, the terminal joint of the ventral ramus.

FIG. 6.—Toothed part of mandible.

FIG. 7.—Maxilla with palp, *mxt*.

FIG. 8.—Chitinous bulla from surface.

FIG. 9.—Inner surface of one half of a bulla in connection with the arm.

FIG. 10.—An internal maxillipede.

FIG. 11.—The free border of the lower lip.

FIG. 12.—Ergasilus Centrarchidarum from ventral surface ; 1—5, the natatory limbs.

FIG. 13.—The 1st pair of antennae from behind.

FIG. 14.—The 2nd pair ; c^1 c^2 c^3, hinges between the various joints ; e^1 e^2 e^3, extensor muscles ; *f*, flexor ; *st*, antennary sternum.

FIG. 15.—Mouth-parts ; *mx*, maxilla ; *mxp*, maxillipede ; *st*, maxillipedary sternum ; *mm*, muscles ; *ch*, points to the chitinous bar which runs from the socket of maxillipede to the socket of the maxilla.

FIG. 16.—1st pair of natatory limbs ; *s*, the sternum ; *a*, the socket ; *b*, the basal joint; *ri*, ramus internus ; *re*, ramus externus.

FIG. 17.—Genital segment and rest of abdomen from below ; *go*, genital orifice ; *ch*, chitinous rods.

FIG. 18.—Attachment of egg-sac to genital aperature, showing the disposition of the chitinous rods.

PLATE II.

ILLUSTRATING ACHTHERES MICROPTERI.

FIG. 1.—Head of female from ventral surface ; lettering as above.

FIG. 2.—Mandible of female.

FIG. 3.—Empty spermatophore detached from female.

FIG. 4.—Internal maxillipedes.

FIG. 5.—End of abdomen, female, to show the canals for impregnation with their orifices, *v o*, to which the brown capsules are often found attached.

FIG. 6.—Outline of male from side ; *m*, the mouth ; *p*, the cylindrical process from the external maxillipedes.

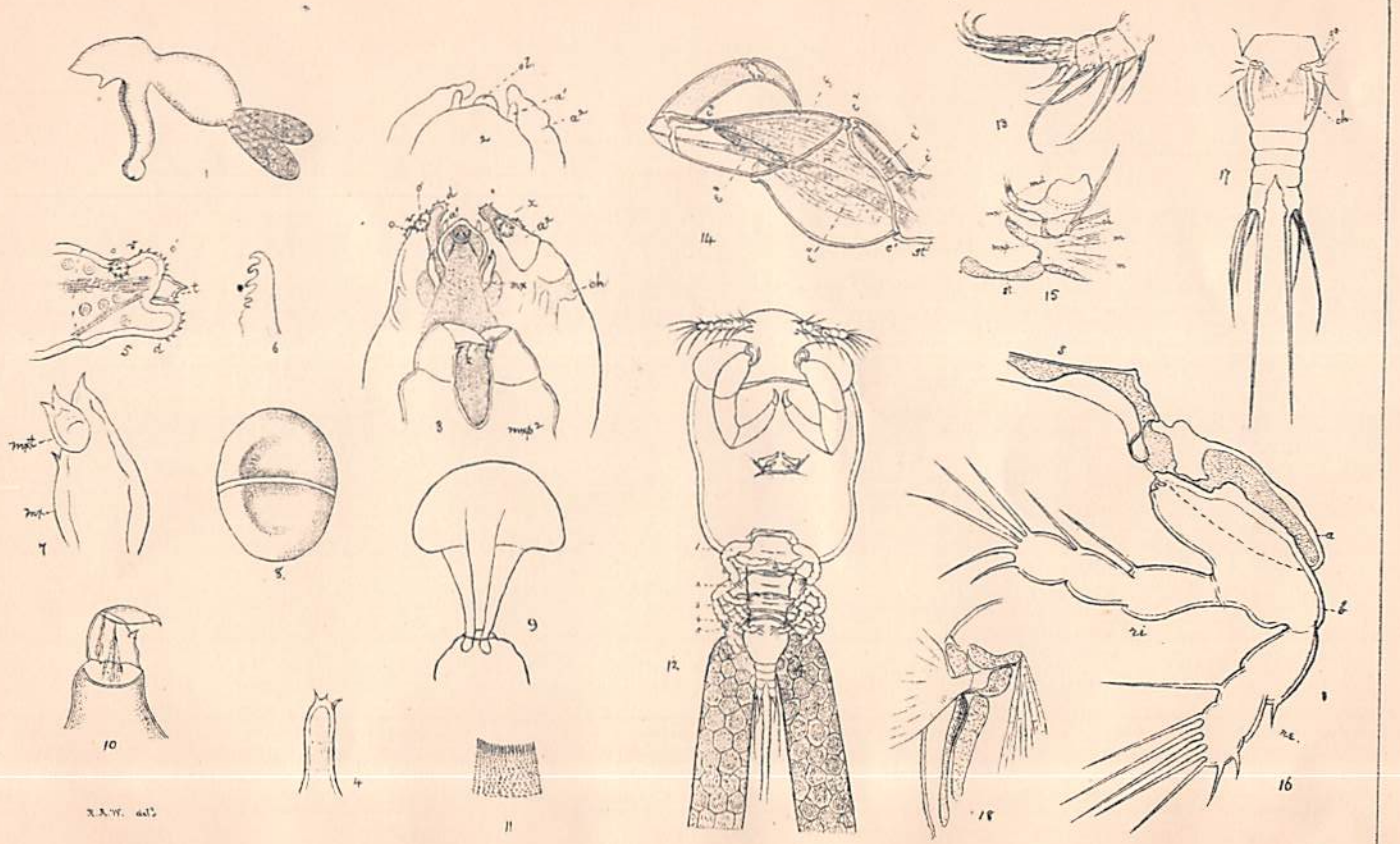
FIG. 7.—The two pairs of antennae of the male from the inner aspect ; *ch*, the chitinous supporting plates.

FIG. 8.—First pair of maxillipedes.

FIG. 9.—Right 2nd maxillipedes from below ; p^1, the cylindrical process.

FIG. 10.—Abdomen of male from below ; the preparation is slightly oblique ; *f*, the furcal appendages ; *gl*, the glandular heaps in these; *a*, the arms ; *in*, the intestine ; *m m*, muscles of the abdominal wall broken ; *t*, the testis ; vd^1, 1st, vd^2, 2nd portion of vas deferens.

FIG. 11.—Spermatophores dissected out, the ripe one ruptured below the neck-like constriction which joins it to the developing spermatophore; the globular cement mass is emerging. behind it are the rod-like spermatozoa ; the discharging corpuscles still line the wall of the spermatophore ; *spp*, the spermatophoral pouch ; *gl*, the glands which secrete the cement which fixes the spermatophore in the first place to the abdomen of the female.



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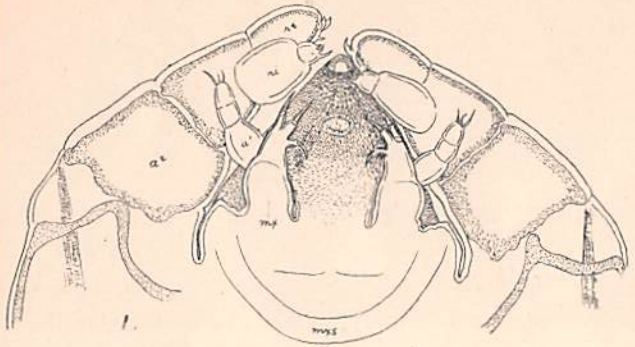

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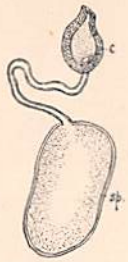

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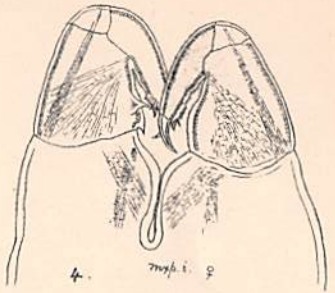

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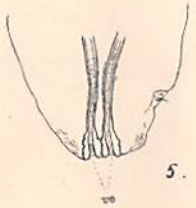

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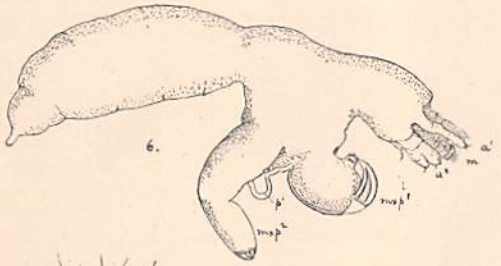

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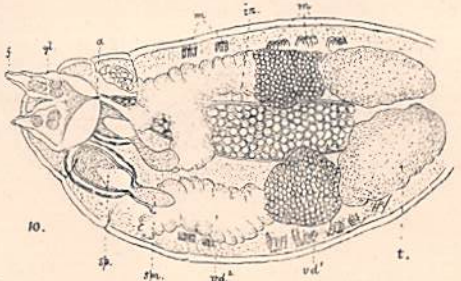
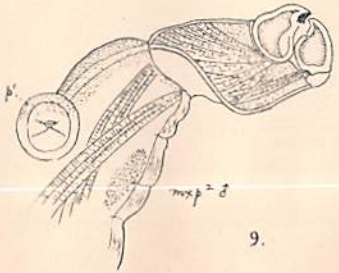


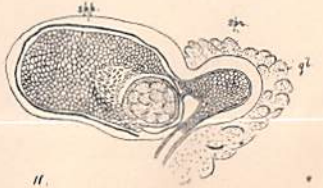
10.

8. mxp¹ ♂

7.



9.



11.

R.R.W. del.