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A New English Genus of Aquatic Oligochæta (Sparganophilus) belonging to the Family Rhinodrilidæ.

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With Plates XIX, XX.

In the summer of 1891, during a stay at the village of Goring-on-Thames, I was on the look-out for Criodrilus, which hitherto has not been found in England. I looked carefully amongst the roots of waterweeds, and in the mud in which these were growing, and ultimately I believed I was successful, for I found a few worms, some three or four inches in length, agreeing closely, so far as regarded external character, with C. lacuum, with the exception that the male pore, which is very conspicuous in the latter worm, was not evident. But on further examination the worms were found to present several internal characters which did not harmonise with those of Criodrilus. However, the worms had passed the period of their sexual maturity, so that the generative system was in a degenerate condition, and I was unable to trace the sperm-ducts to a pore. I had therefore to wait till the following summer, when I paid several flying visits to Goring, with finally good results, for I found more of the worms, and this time sexually mature. The genital organs conclusively showed that a new genus was in my hands, belonging not to the family Lumbricidæ, but to the Rhinodrilidæ (mihi).

For this new worm I propose the name Sparganophilus tamesis. The generic name refers to the fact that all the specimens which I could obtain were found amongst the roots and the lower parts of the leaves of the bur-reed (Sparganium ramosum), which grows in black, evil-smelling mud on the banks of the Thames. The worms were all found in a backwater some little distance below Goring, and I could find none elsewhere, though I examined similar spots on the banks both above and below this backwater, as well as in the river near Oxford. Moreover these worms appeared to be limited to an area of about ten yards in length along the bank, for repeated examination of this backwater met with constant failure with the exception of this prescribed area. When first discovered the worms were accompanied by a number of cocoons. This was in September, 1890. In the next year I visited Goring during the months of July and August. In the former month I was quite unsuccessful, but in the latter I found several specimens, all of which, as I have said, were sexually mature. I am inclined to think that, as is the case with Criodrilus,[1] these worms spend the greater part of the year in the mud at the bottom of the river, and only come to the banks amongst the roots of Sparganium during August and September for the purposes of reproduction.[2]

The cocoon is shown, of natural size, in Pl. XIX, fig. 4; it is a somewhat sausage-shaped body, terminating in a narrow frayed end in one direction, and drawn out to a point at the other, as in Criodrilus; the cocoons, thus, differ in shape from those of the earthworms Lumbricus, Allolobophora, Perichæta, which are spherical, but resemble those of Megascolides very closely in shape.

[1] Oerley, "Morph. and Biol. Observations on Criodrilus," 'Quart. Journ. Micr. Sci.,' xxvii, p. 537.

[2] During August and September of this year, 1892, I have frequently found the cocoons in quantities in the neighbourhood of Oxford, both in the Thames, in the Cherwell, and amongst the roots not only of Sparganium, but also of Sagittaria sagittifolia and other water plants; I have, however, not come across the worm this year.

I. Sparganophilus tamesis, nov. gen., nov. sp.,

is a delicate, pinkish worm, rather narrow for its length of three to four inches. The body-wall is, posteriorly to the clitellum, transparent, and, being provided with a dense network of blood vessels, has a pink colour; but this is complicated by the green colour of the gut, which also shows through. The surface of the body exhibits a lovely violet to peacock-blue iridescence. At the anterior end of the body the pink tint deepens. This is due to the large hearts which exist in the segments here, while the sperm-sacs give rise to a light cream-coloured band immediately in front of the clitellum, which is itself a bright orange. The worm is very strong and active; it feels wiry and firm, almost like a nematode; it wriggles violently and coils itself when handled.

The clitellum is quite distinct in the living animal owing to its colour,[1] and occupies Somites XVI to XXIV, with part of XV and part of XXV; but in spirit specimens it is difficult to determine its limits, though its area is marked by the suppression of intersegmental grooves. Its anterior and posterior boundaries are, even when living, very ill-defined, but near its ventral boundary a translucent band—the tubercula pubertatis—is easily recognisable, extending across Somites XVII to XXII, dorsal of the ventral chætæ. In the preserved specimens a deep groove traverses the dorsal surface of the worm, but in the living state the body is cylindrical, the squareness characteristic of Criodrilus not being observable.

The prostomium is small, slightly conical, and not marked off from the peristomium by any groove; this is the condition usual amongst the smaller aquatic Oligochæta, whereas in the terrestrial forms a groove forms the hinder boundary of the prostomium; this is but feebly marked in the aquatic Lumbricid Criodrilus. There is no prostomial pore, but in longitudinal

[1] The accompanying figures, 1, 2, 3, are lithographed from coloured sketches, and some of the points which showed well in them are now indistinct.

sections a small pit is seen at the apex (Pl. XX, fig. 12). A prostomial pore is present in some aquatic Oligochætes, *e. g.* the Enchytræidæ, and Vejdovsky figures one for Criodrilus,[1] but both Rosa[2] and Collin[3] deny its presence; and I have been unable to find it on a re-examination of my sections of that worm.

The pygidium (fig. 3) is a large truncated conical somite carrying the dorsal anus at its end; the two præpygidial somites are much shorter than the preceding somite, and these three together are about equal in length to the pygidium. In the majority of specimens the "tail" was regenerated, as is so frequently the case in Criodrilus, Pontoscolex (=Urochæta), Lumbriculus, &c.

The chætæ have the usual Lumbricid shape and arrangement in two couples on each side; the distal moiety of the chæta presents three or four transverse irregular ridges (fig. 5), as in Rhinodrilus and several allied forms. In those cases where the chætæ are unworn the point is rather sharply hooked. There is no difference in size and shape between the ordinary and the clitellar chætæ.

§ The Minute Structure of the Integument.

The general structure of the epidermis is similar to that of Lumbricus, &c. The clitellum (fig. 30) is several cells deep, or, more correctly, the club-shaped cells are of several different lengths, some reaching to the circular layer of muscles, others not much further than to the base of the epidermal cells. The clitellum is some ten to twelve times thicker than the ordinary epidermis; and on each side of the ventral surface, just outside the ventral chætæ, becomes still thicker, forming in a transverse section a rounded prominence (fig. 19). This is the tubercula pubertatis, consisting, as I have figured for Microchæta,[4] of very long cells, somewhat like the

[1] 'System und Morphol. d. Oligochaeten.'

[2] "Sul Criodrilus lacuum," 'Mem. d. Reale Acad. d. Sc.,' Torino, 37.

[3] 'Zeit. f. wiss. Zool.,' 46.

[4] 'Proc. Zool. Soc.,' 1892.

ordinary clitellar cells. Although, superficially, the clitellum appears to cease at this spot, yet transverse sections show that the characteristic cells are continued across the ventral surface, but are only one or two rows deep.

It may be mentioned that in Rhinodrilus this clitellum is visibly "complete" in its anterior region, but apparently "incomplete" posteriorly.

In the mature worm, where the clitellum is most fully developed, I could find in sections no lateral chætæ, although the ventral ones are distinct enough; I believe they are, in fact, here absent. But whether they are absorbed or whether they drop out is, I believe, a matter of speculation. I am inclined to think that they drop out. At any rate, in sections of a worm which had passed its maturity, and in which the clitellar cells are degenerating (fig. 20), giving thus the appearance of a subepidermic connective tissue, I find the lateral chætæ very small; they appear to be newly formed, and do not by a long way perforate the body-wall.

II. The Internal Anatomy.

§ With regard to the alimentary tract little need be said. There is no gizzard, not even a thickening of wall; a fairly sharply marked division occurs been œsophagus and intestine. The latter commences in Somite IX, where the gut suddenly enlarges; and a change in the epithelium, as well as in character of the wall, is noticeable. The œsophagus has a fairly thick wall; the lining epithelium, which is considerably folded, consists of tall, ciliated cells. The wall of the intestine is thinner, the epithelium much lower, less folded, and the cilia shorter. The end of the œsophagus projects, valve-like, into the intestine, and here the change in the epithelium is well seen, the cells of this portion of œsophagus being taller than elsewhere. There is no typhlosole in the intestine, nor calciferous glands to the œsophagus.

The buccal region occupies, as will be seen from the figs. 12, 13, about two somites. The pharynx is short, and provided with the usual dorsal sac in Somite IV. One of my series of longitudinal sections is of a worm with buccal region everted; the other series shows the buccal region withdrawn. I have thought it worth while to append sketches of these two phases, as I am not aware that such pictures have hitherto been published.[1]

Fig. 12 represents a condition of rest, though the upper lip (*a. a'.*) is partially everted. The floor of the buccal region is transversely folded, giving a tongue-like appearance. The lining of this region (fig. 15) consists of large round nuclei embedded in a feebly granular protoplasm. I cannot with certainty detect the outlines of the cells, which are probably cubical. The surface is cuticulated. It appears as if these cells were capable of a certain amount of alteration in shape. The epithelium between the lines "*a* and *a'*" in fig. 12 is flattened with elliptic nuclei as in fig. 14. Now, in the everted condition (fig. 13), not only is the region *a a'* lined by flat cells, but nearly all the everted epithelium is similar to this and graduates near the edges of the orifice into the more cubical character shown in fig. 15.

The true pharynx commences at *c* and *d*, and is lined by tall ciliated epithelium, with granular contents and elongated nuclei. These cells are about three times as long as, and much narrower than, those lining the buccal cavity (see fig. 16).

In fig. 13, representing the everted condition, a dorsal sac is represented, opening close to the external orifice of the everted gut; this sac is a normal feature in the pharynx of earthworms, and is not apparently represented in the state of rest (fig. 12). But this is merely owing to the fact that the latter section is more accurately median, whereas the former is inclined to the median plane, so that the dorsal part of the worm is cut through along a more lateral line than is the ventral region. This dorsal sac opens into the general cavity of the pharynx by a wide mouth along the middle line; this mouth narrows laterally and curves forwards, that is, the aperture of communi-

[1] But see Garman on "Diplocardia," in 'Bull. Illinois State Lab. of Nat. Hist.,' iii, pl. i.

cation is crescentic, with the concavity forwards. This dorsal sac is lined by very tall, narrow, ciliated cells (fig. 17) pressed close against one another; the nuclei are at different levels, though I believe there is only one row of cells; the cells are taller and narrower than those lining the floor of the pharynx.

In many earthworms which I have examined from this point of view the floor of the pharynx is cuticulated (see my paper on "Eminodrilus" in 'Journ. Roy. Micr. Soc.,' 1891, pl. iii, fig. 10; pl. iv, fig. 11), only the dorsal sac-like outgrowth being ciliated.

The œsophagus, as the fig. 13 shows, is nipped by the septa; it is lined by cells similar to those on the floor of the pharynx, but rather shorter and less granular.

This region of the gut is hidden, when viewed from above, by three paired white masses, the salivary glands (*sal. gl.*), which are in Somites IV, V, VI. These have the usual structure which I have described for Eminodrilus (loc. cit.), and the anterior ones at least are closely connected to the pharynx, with which they probably communicate.

The lining of the intestine is represented in fig. 18. The cells are much shorter than those of the œsophagus, and most of them are dilated distally, where the protoplasm is modified to form a bright refracting and deeply stained border; beyond this is a light refracting edge, which appears in some of my sections to be a cuticle, but in others exhibits a fine striation. I believe that the intestinal epithelium is, as in other Oligochætes, ciliated, and that owing to the mode of preservation the cells have become fused or otherwise rendered indistinct.

In broken sections the shape of the epithelial cells is well seen, and they are distinctly broader at the outer end; hence, when in situ, there appear gaps between the cells. This I suggest is due to the shrinkage caused by reagents, occurring unequally; the modified striated border shrinking very little, the lower end shrinking much.

§ The nephridia are very distinctly pink in a freshly opened worm, owing to the rich plexus of blood-vessels around them. Each nephridium is a large organ, almost filling the cavity of the somite; this size is due to the great development of large vesicular cells in which the tube is embedded, as in Pontodrilus, Criodrilus, Libyodrilus, Tubifex, and other worms.

The nephridia are absent in the first twelve somites. The first one lies in Somite XIII, and has its funnel in Somite XII; in one specimen, however, I noted a nephridium in this latter somite.

The general character of the nephridium agrees with that which I have described[1] for Lumbricus and other worms.

Sparganophilus agrees, however, with Criodrilus in lacking a muscular duct; the "wide tube" perforates the body-wall (fig. 8, *ne. d.*), as I have figured for Criodrilus (loc. cit.), and opens in front of the innermost chæta (fig. 11, *ne. p.*).

In the structure of the funnel, however, the present worm exhibits a rather more complicated condition than any hitherto figured, in the possession of an extra row of small cubical cells round the margin. As in Lumbricus, the funnel consists of a large "central cell" (figs. 31, 32, *c.*) surrounded by a series of "marginals" (*m.*) arranged in a fan-shaped way, and diminishing in size towards each side, where they pass round to form an incomplete ventral lip; outside these marginals are set the cubical "extra-marginals" (*ex. m.*), which appear as a single row of cells when the funnel is seen from in front, but are really three or four rows deep, and passing round to the back of the funnel, graduate into the flat cœlomic cells normally present. The arrangement is represented in figs. 31, 32, one of which represents a longitudinal section, the other a transverse section of a funnel.

In many cases I have observed in front of the funnel a large spherical mass (fig. 33), consisting of a number of nuclei —most of them deeply stained, irregular, and highly refracting, others with but little chromatin in them—embedded in a

[1] Benham, "The Nephridia of Lumbricus," 'Quart. Journ. Micr. Sci.,' vol. xxxii.

somewhat fibrillated network. The nuclei with little chromatin are chiefly on the surface of the mass, and look as if they had only recently been gathered up; the others are probably dead nuclei destined to undergo degeneration previous to their expulsion by the nephridia. In this mass of "débris" are frequently a number of yellow granules (*y*), perhaps the contents of chloragogen cells which have been collected by the funnel.

§ The Generative System (fig. 11).

The four folded digitate testes have the usual position, the first pair on the anterior septum of Somite x, and the second pair in Somite xi. The four ciliated rosettes, which are less folded than in Lumbricus, &c., lie in these same somites. Both testes and rosettes are quite free in the cœlom, there being no median sperm-sac. There are two pairs of lobulated sperm-sacs, occupying Somites xi and xii; those in the latter somite being slightly the larger. They are attached to the anterior septum of each of these somites, so that they are entirely post-septal; there are no median sacs.

The arrangement of these sperm-sacs is thus very different from what obtains in Criodrilus, in which these organs are situated as in Allolobophora, there being two pairs of preseptal in addition to the two pairs of post-septal sacs.

Still greater difference is exhibited by the relations of the sperm-duct. Passing from the ciliated rosette, in each case, the duct is as usual slightly coiled behind the septum, forming the epididymis; the sperm-duct then dips into the body-wall, penetrates the muscular coats, and attains a sub-epidermic position, which it retains throughout its extent (figs. 19, 20, 22). This superficial position is unknown in any other earthworm, nor does it occur in any Oligochæte; and if we wish to press the homology between sperm-duct and nephridium we may refer to Libyodrilus[1] for a corresponding position of part of the nephridial system, which, however, as Mr.

[1] F. E. Beddard, 'Quart. Journ. Micr. Sci.,' vol. xxxii, Pl. XXXIX, figs. 14 and 16.

Beddard has shown, is not a primary but a secondary condition. As regards the sperm-duct, I would suggest that we have in Sparganophilus an explanation of the long duct so usual amongst earthworms; the sperm-duct probably opened externally in the segment following the funnel, just as the oviduct does in all earthworms, and the sperm-duct in Moniligaster, and many of the aquatic Oligochæta, such as Naididæ, Tubificidæ, &c. In order to convey the spermatozoa backwards a groove might be imagined to appear, which sinking into the epidermis became a canal. This canal lying, as in Sparganophilus, within the epidermis, would extend through any number of segments till it opened to the exterior. Accessory parts, such as atria, would appear later on; the duct sank deeper and deeper till it came to lie in the cœlom, as in the majority of worms. I do not wish to be understood as regarding Sparganophilus as a primitive form, but merely suggest that in this particular feature it retains an archaic character.

The position of the duct is shown in fig. 19, where it is seen lying amongst the bases of the deep clitellar cells, dorsad of the ventral chætæ, and immediately outside the tubercula pubertatis. In fig. 20 the structure of the sperm-duct is seen to be normal; the worm, of which this figure represents a portion of a transverse section, had passed its sexual maturity. The ordinary clitellar cells (see fig. 30) appear to have undergone a certain amount of change, the contents have been poured out in forming the cocoon, and an appearance as of a "cutis" is presented by the nuclei scattered in a loose network of fibrils, the shrunken walls of the cells.

In Somite XVIII the duct becomes more superficial (fig. 21) where it lies immediately below the ordinary epidermal cells. At the hinder margin of this somite it reaches the surface, as seen in fig. 22. The male pore is very minute, and there are no accessory organs to call attention to its whereabouts, and it may be very readily overlooked; in the section drawn the terminal portion, for some half a millimetre in extent, was filled with deeply stained spermatozoa—evidently I captured the worm at its most active period—which mark the duct distinctly.

At the pore the columnar epidermal cells dip in slightly to meet the already superficially situated duct.

The structure of the sperm-sac is represented in fig. 23. The cavity is very greatly subdivided by muscular (?) trabeculæ (*trab.*), which diverge from an axial bundle (*ax.*) continuous with the septum. The spaces between the trabeculæ are occupied by developing spermatozoa; the outermost lobules contain usually the younger stages, whilst the more advanced stages occupy the central lacunæ. This arrangement, however, as a glance at the figure will show, is not absolute, young spermatozoa frequently occurring in the outer lobules, whilst sperm-morulæ are found centrally.

The Female Organs (fig. 11).

The pair of ovaries lie in Somite XIII; the oviducts have the usual relations, and open on Somite XIV, just within the line of the ventral chætæ; a small ovisac occupies the usual position.

The ovary itself is large, and extends across its segment almost to the hinder septum; its narrow neck is relatively long; its tail, too, consists usually of eight ova in a single row. These ova are not noticeably larger than those of Lumbricids, measuring ·3 mm.

The relation of the ovisac to the 13th somite and to the funnel of the oviduct deserves a description, as it is sometimes inferred that the ovisac has no direct communication with the duct.

I give four drawings from a series of transverse sections through the funnel of the oviduct.

In fig. 24, the first section in the series which cuts the funnel, we see the dorsal and ventral lip with a narrow aperture (*ov. f.*) into Somite XIII.

In fig. 25 (next section in the series) the folding of the funnel is evidenced by the discontinuous edge, a portion of which opens directly into Somite XIII (*ov. f.*); another portion (*ov. f′.*), itself folded, communicates solely with the ovisac.

In fig. 26 (two sections further on) the septum separates the two portions of the funnel, and that opening into the 13th somite (*ov. f.*) is very small; in the second section beyond this it is absent. But that part of the funnel communicating with the ovisac (*ov. f'.*) is of much greater extent, and occupies a large part of the outer wall of the ovisac. It is still present in fig. 27, five sections further on, where it lies on the dorsal wall of the ovisac, and does not cease till two sections beyond this, so that it passes through about six more sections than does that part which communicates with Somite XIII. Each section is ·1 mm. thick, so that the size of this funnel is about 1 mm. in extent, of which only about ·5 mm. communicates with Somite XIII.

There is thus an approach to the condition met with in Eudrilidæ, where the funnel opens entirely into the ovisac.

The ovisac itself is thin-walled and slightly subdivided; in the sac of one side were two ova (fig. 28 represents a portion of the fourth section of the series after fig. 27). Each of these exhibits karyokinesis (see fig. 29, which is drawn from the next following section), in which the spindle with the chromosomes arranged at the equator and the "centrosome" and polar rays at its poles are very well seen. The one sketched was sectionised along the axis of the spindle; the other ovum, lying at its side, was cut at right angles to the axis.

Each of these ova measures ·3 mm.—exactly the same diameter as the largest ovum in the ovary; it is surrounded by a thick "vitelline membrane," which in the one sketched was folded at two points, owing, no doubt, to contraction.

These two ova appear to be undergoing changes preliminary to the formation of polar bodies.

I am not aware whether this phenomenon has hitherto been definitely recorded as occurring in the ovisac;[1] but there is little doubt that such is the case, the ova undergoing maturation here just as the spermatozoa attain their complete condition in the sperm-sacs.

[1] Vejdovsky, in his "Entwickelungsgeschichte," finds that the polar bodies in Rhynchelmis are formed in the ovisac, while in Lumbricus and Allolobophora they are not formed till the ova are laid in the cocoon.

There are normally three pairs of spermathecæ in Somites VII, VIII, and IX. Each sac is pyriform, with a long duct opening at the anterior margin of its somite in a line with the lateral chætæ. But the number appears to be subject to variation, as I have notes of three abnormalities amongst the score or so of the worm examined, viz.:

A. Right side :	spermathecæ in	VII, VIII;	left side,	VIII, IX.
B. ,,	,,	VIII, IX;	,,	VIII, IX, X.
C. ,,	,,	VIII, IX;	,,	none.

But in this last case the worm had apparently passed its maturity, as other organs were very small, e. g. sperm-sacs, and it is quite difficult to see the spermathecæ in immature worms; they were, for instance, overlooked by Beddard in Allurus, probably for this reason.

§ The Vascular System (figs. 6—10).

It is in the vascular system that Sparganophilus differs most remarkably from other forms.

The dorsal vessel, which lies freely above the gut, is broad, constricted at the septa, and runs, as usual, throughout the body. In each of the Somites XI, X, and IX it is specially dilated, and frequently slightly curved (fig. 6). In front of Somite IX the vessel suddenly diminishes in diameter to about a third its previous size, and thence runs with a gradually decreasing diameter to the first somite.

The ventral vessel presents no noticeable feature. Supra-intestinal and subneural vessels are absent.

In each of the Somites II to XI a pair of commissural vessels pass from the dorsal to the ventral vessel. Those of Somites II to VI are small equidiametered vessels, whilst those in Somites VII to XI are much larger, moniliform, and slightly contorted; these are the "lateral hearts" (figs. 6, 9).

In each of the succeeding somites, with the exception of Somites XII and XIII, a pair of dorsal tegumentary or "peripheral" vessels is given off by the dorsal vessel, near the hinder septum, which it perforates in order to pass to the body-wall (figs. 6, 8); a similar ventral tegumentary vessel joins the ventral vessel in each somite, and has a similar relation to the septum: these two vessels, however, only communicate indirectly in the plexus on the body-wall. In addition two pairs of intestinal vessels pass from the dorsal vessel to the gut wall, and two or three pass from this to the ventral vessel in the "mesentery" which attaches this to the gut (fig. 8).

From the dorsal tegumentary or peripheral vessel of Somite XIV a longitudinal vessel runs forwards on the body-wall (fig. 6), and a similar vessel from the ventral tegumentary of this somite accompanies it. These two longitudinal tegumentary trunks can be traced forwards to about the second somite, where they break up into small branches, entering the capillary plexus on the walls of the pharynx, to which network the dorsal vessel also contributes. These longitudinal trunks lie on the inner surface of the body-wall throughout their course (fig. 9), and give off branches to the body-wall and nephridia in each segment,—behaving, in fact, just as do the posterior metamerically arranged tegumentary vessels given off from the median trunks. They give off no branches to the gut wall. In the body-wall is an elaborate capillary plexus (not reaching into the epidermis), receiving constituents from the above-mentioned tegumentary vessels. The nephridia are marked by their pink colour in the fresh state, owing to a dense plexus of blood-vessels upon them, and even with a hand-lens one can see the dilatations described by Claparède, Lankester, and myself in Lumbricus upon the nephridial and other somatic vessels. This is especially noticeable in the clitellar region.

The dorsal vessel has a dark red or rather a brownish-red colour, owing to the chloragogen cells surrounding it combining their brownish tint with the red colour of the blood. The intestine appears beautifully red, owing partly to the feeble development of granules in the chloragogen cells, but chiefly to the presence of a perienteric blood-sinus (figs. 7, 8, 9) instead of the more usual network of capillaries. This sinus appears to commence with the intestinal region in Somite IX, in front of which a capillary network of the ordinary character exists. The constituents of this network enlarge, the meshes are thereby reduced, and a gradual coalescence and disappearance of the walls gives rise to a sinus. In Somite VIII and partly in Somite VII a plexus appears superposed on the sinus, with which it communicates, the plexus being a very close one and the vessels large. More anteriorly the sinus is absent, and a plexus of capillaries only surrounds the gut.

The blood-supply of the pharynx is derived, as above mentioned, from a network, with which the dorsal and lateral vessels communicate; the commissural vessels do not, as far as I can ascertain, give any branches to this plexus—they run round the œsophagus to the ventral vessel. This pharyngeal plexus is continuous with the œsophageal plexus just described.

The lateral hearts of Somites XI, XII, give off a branch to the sperm-sacs.

The present worm is, then, remarkable on account of (*a*) the perienteric sinus, and (*b*) of the longitudinal tegumentary vessels.

(*a*) The sinus, which is similar to that found in many mud-loving and tube-forming Polychætes—as, for example, Sabellids, Arenicola, &c.—occurs but rarely among the Oligochæta; in fact, outside the family of Enchytræidæ it is practically unknown, or at any rate unrecorded. Vejdovsky, in his 'System und Morph. d. Oligochaeten,' represents a transverse section of Allolobophora cyanea on pl. XVI, fig. 22, in which a sinus surrounds the intestine; again, in fig. 8 of the same plate, illustrating Dendrobæna rubida, a sinus is represented around the gut; but he does not label this, and it may be merely a diagrammatic representation of the ordinary plexus. Again, on pl. XIV, figs. 2 and 9, two transverse sections through Criodrilus show a perienteric sinus labelled "*ds.*," which letters indicate "Gefassschlinge des Magendarmes" according to the explanation of the plate.

In the body of the work I find no specific mention of any sinus, though in reference to Allurus, Dendrobæna, &c.,

he remarks (p. 115) that important modifications occur in the internal vessels, to which "I shall not now allude further."

Beddard states, on p. 549 of his memoir on Libyodrilus, that "the plexus of blood-vessels on the wall of the œsophagus, which lie immediately below the epidermis (*sic*), was nowhere a sinus, although the individual vessels were so close together as to give this appearance"—his figures represent a sinus.

From my own observations, I find that Criodrilus is provided with a sinus similar to that of Sparganophilus, which, like it, is replaced anteriorly by a plexus; but in the hinder part of the œsophageal region certain portions of the plexus are wider than the rest, so that in section it looks as if one had sections of separate vessels; but closer examination of several sections shows that there is really a continuous sinus. Wiren has described in Arenicola a very similar condition of intestinal vascular system, which had, up to his time, been considered and represented as a network.

I find, amongst the Lumbricidæ, another genus with a distinct perienteric sinus, namely, Allurus; this I find in sections, and by removing a portion of the intestinal wall.

In Dendrobæna rubida, however, I am unable to satisfy myself as to whether a sinus or a network exists, though I am inclined to believe the latter.

The condition of a perienteric sinus is, by some zoologists, regarded as more primitive than that of a network, and this opinion appears to rest on the suggestion that the vascular system is directly derived from the blastocœl or segmentation cavity. What amount of embryological evidence exists scarcely suffices to settle the matter in regard to Oligochætes. Wilson ('Journ. of Morphology,' iii, p. 408), in his memoir on the "Embryology of the Earthworm," states that the first vessel to appear is the subintestinal; this is at first without proper walls, and occupies a place between hypoblast and splanchnic mesoblast; but here and there a cell may be detected in its dorsal wall, and these gradually increase in number till the vessel is provided with its own proper wall. He was unable, after the most careful examination, to detect the precise origin of these walls. He surmises—and this, I think, is from an a priori view probably correct—that the wall arises from the wandering cells of the mesoblast, and the blood-vessels are probably formed, as in the Vertebrata, as spaces amongst the mesoblast-cells, which then give rise to the wall of vessel.

The suggestion that they represent blastocœl seems as little true as that the cœlom does so; of course, both occupy the position of the blastocœl.

From the point of view of comparative anatomy, too, the existence of a sinus does not seem an archaic one, for it is not in simple or "primitive" Polychætes, for example, that this exists, but in the more evidently modified tubicolous forms belonging to the families Serpulacea, Terebellacea, Telthusida, Chlorhæmida, and others. I say these are not primitive forms, and among many reasons for this view I may point to the character of the excretory system in these families; in place of the metameric repetition of simple and similarly formed nephridia, we find suppression of some and enlargement of others; or a differentiation, again, to form excretory organs and genital ducts. A second character upon which I should rely in support of my suggestion is in the accompanying disappearance, or at least extreme reduction, of the septa.

On the other hand, in such simple forms as Polygordius and Protodrilus—whether this simplicity be primitive or due to degeneration is a matter for discussion—we find no perienteric sinus, and indeed but little in the way of an enteric vascular system. In the more generalised Nereis and its allies, which may perhaps more closely represent a primitive Polychæte—not an ancestor of this group, but an early representative of the group, with all the characteristic features well marked—an elaborate plexus around the gut exists.

In fact, the purpose of a vascular system being to distribute nutriment, &c., its usefulness would evidently be increased if the contained fluid were to take a definite course. This would not be the case in a great sinus, though perhaps interchange of gas or fluid will be more rapid where this exists than where it is replaced by a network.

(*b*) With regard to the longitudinal tegumentary vessels arising from the dorsal and ventral vessels in Somite XIV, the only earthworm presenting an arrangement at all like that in Sparganophilus is Criodrilus lacuum. Rosa describes and figures (fig. 4, "Sul Cr. lac.," in 'Mem. d. R. Acad. d. Sci.,' Torino, xxxviii, 2nd ser.) a single longitudinal branch on each side arising from the commissural vessel connecting dorsal and subneural vessels in Somite XII, and running forwards on the body-wall beyond Somite VII. These "vasi ricorrenti" are applied against the body-wall, along the lateral line, and send no branches to the intestine.

Longitudinal vessels, at first sight similar to those in Criodrilus and the present worm, are met with in Urochæta, Megascolex, Microchæta, Lumbricus, and others, where they have received the name "intestino-tegumentary." But in reality these are very different, for they are in relation chiefly with the gut wall, from the plexus in which, in the majority of cases, they arise, though in Lumbricus the two vessels are branches from the dorsal vessel in Somite X. As Bourne[1] has shown, these longitudinally placed vessels correspond with short vessels occurring in each somite behind XIII, which terminate at each end in a capillary plexus, at one end on body-wall, at the other on gut wall. The intestino-tegumentary vessels likewise arise from network on gut-wall, and send branches to body-wall.

The "intestino-tegumentary" vessels, too, lie in close apposition to the œsophageal wall, whereas the tegumentary vessels of Criodrilus and Sparganophilus adhere to the body-wall and have no connection with gut-wall. But just as the intestino-tegumentary vessels are modified representatives of the posterior metamerically arranged short vessels, so it would appear that the tegumentary vessels are very elongated representatives of branches to the body-wall, given off by

[1] "On Megascolex cœruleus," 'Quart. Journ. Micr. Sci.,' vol. xxxii.

the peripheral or tegumentary vessels in each of the posterior somites.

I may note a peculiar appearance occurring in the larger blood-vessels; the blood-clot has not a smooth surface, but a fringe of needle-like processes set at right angles to general surface of clot, and recalling a crystalline structure (see fig. 18).

III. The Affinities of Sparganophilus.

From the character and extent of the clitellum the genus evidently belongs either to the family Geoscolicidæ or to the Rhinodrilidæ.[1] The possession of tubercula pubertatis points more directly to the latter, for except in the family Lumbricidæ these organs are known only in Rhinodrilus, Hormogaster, and Microchæta.[2] Anteus probably is another instance, for both Horst[3] and Perrier[4] describe a band extending along each side of the ventral surface of a certain portion of the clitellum. Urobenus, too, will very probably be found to possess these structures, though my specimens were too badly preserved for me to be certain of their existence.

The situation of the generative pore at the hinder margin of Somite XVIII separates the worm from the Lumbricidæ, whilst it marks a point of agreement with the genera Rhinodrilus and Hormogaster so far as concerns the intersegmental position of the pore.

The arrangement of the sperm-sacs and their number refer Sparganophilus to the Rhinodrilidæ, and several other characters of the family are presented by it.

In one point, however, it differs from the members of this family, viz. in the absence of œsophageal or intestinal diverticula.

Sparganophilus tamesis, then, is one of the Rhino-

[1] For references to descriptions of the genera here named, see my "Attempt to Classify Earthworms," 'Quart. Journ. Micr. Sci.,' vol. xxxi.

[2] Benham, 'Proc. Zool. Soc.,' 1892.

[3] 'Notes from the Leyden Museum,' xiii, p. 77.

[4] Perrier, 'Nouv. Arch. d. Muséum,' 1872.

drilidæ which, having become aquatic in habit, has undergone certain modifications, which give it a resemblance at first sight to Criodrilus, an aquatic Lumbricid; for example, the loss of a gizzard, the disappearance of nephridia from the anterior somites, the vesicular character of the cœlomic epithelial cells surrounding the nephridia, the peculiar modifications in the vascular system—viz. the breaking down of a network on the gut to form a sinus—and the longitudinal tegumentary vessel, and the absence of dorsal pores.

Systematic.

Family Rhinodrilidæ, mihi.

Sparganophilus, nov. gen.

Clitellum extensive, occupying nine or ten somites; bounded latero-ventrally by tubercula pubertatis.

Prostomium not marked off from the peristomium.

Male pores inconspicuous, between Somites xviii and xix, without accessory organs.

Sperm-sacs, two pairs; no median sac.

Spermathecæ simple; three pairs.

No gizzard nor œsophageal diverticula; no typhlosole.

Vascular System.—The only commissural vessels are situated anteriorly; perienteric blood-sinus; no subneural vessel. A couple of longitudinal tegumentary vessels on each side traverse the anterior somites, and have no connection with the gut wall.

Species S. tamesis, n. sp.

Since only a single species is known, it is well-nigh impossible to separate specific from generic characters.

Distribution.—There is but little doubt that the home of the Rhinodrilidæ is America, and the occurrence in England of a member of the Rhinodrilidæ is very striking. Hitherto only one member of the family has been discovered in Europe, viz. Hormogaster, from Italy; the more typical genera, Anteus, Rhinodrilus, and Urobenus, being South American.

Microchæta is confined to the south of Africa. Kynotus, Tykonus, and Callidrilus, Michaelsen,[1] are also Africau. Bilimba, Rosa,[2] is from Burmah; and Glyphidrilus, Horst,[3] comes from Malay. The habitat of Brachydrilus is unfortunately unknown.

The Thames is visited by all sorts of traffic, and it is possible that cocoons may have been brought over with timber; or amongst the roots of some water plants, such as Anacharis alsinastrum, from North America, and like it have increased and multiplied in our rivers.

Beddard has recently ('Annals and Mag. of Nat. Hist.,' ser. 6, vol. ix, 1892) suggested that Anteus and Rhinodrilus are one and the same genus (p. 118), and states that the only points in which the two genera differ are—

(1) The presence of a greater number of calciferous glands; and

(2) The presence of an elongated prostomium in Rhinodrilus.

He rightly suggests that these characters are without generic importance, but he overlooks the absence of spermathecæ[4] in Anteus; and it seems to me that till we know from the examination of sections whether sperm-ducts exist (which they probably do, and perhaps, as in Sparganophilus, they are in the body-wall), and where they open externally, we shall scarcely be justified in uniting the two genera. The character of the nephridial loop in Anteus is very different from that of Rhinodrilus. Michaelsen ('Arch. f. Naturgesch.,' 1892) has

[1] Kynotus, Michaelsen, 'Jahrb. d. Hamburg. wiss. Anstalt.,' ix, 1891; and 'Arch. f. Naturgesch.,' 1891; Rosa, 'Boll. Mus. Zool. Torino,' vii, 1892. Tykonus, 'Arch. f. Naturg.,' 1892.

[2] 'Annal. Mus. Cir. d. Stor. Nat.,' Genova, 1890.

[3] 'Zool. Anzeig.,' 1891.

[4] One or two species of Allolobophora are stated to be deprived of their spermathecæ; I am not aware at what period of life these species were examined. Allurus tetraedrus is usually stated to be deprived of them. I can confirm Vejdovsky in stating their existence. I have found three pairs opening dorsally of the lateral setæ.

recently further extended the genus Anteus to include Urobenus; but it appears to me that the characteristic intestinal cæca in Somite XXVI, as well as the peculiar shape of the œsophageal glands, the pyriform glands, the absence of ornamentation in the chætæ, and other features, are sufficient to separate the two genera: his Anteus papillifer is undoubtedly Urobenus. I would, therefore, still retain the three genera Anteus, Rhinodrilus, and Urobenus as distinct.

EXPLANATION OF PLATES XIX & XX,

Illustrating Dr. Benham's paper on "A New English Genus of Aquatic Oligochæta (Sparganophilus tamesis) belonging to the Family Rhinodrilidæ."

Fig. 1.—Dorsal view of Sparganophilus tamesis; enlarged twice.

Fig. 2.—Ventral view of the anterior end of the worm; enlarged twice.

Fig. 3.—The hinder end of the worm, dorsal view, to show the elongated pygidium; much enlarged.

Fig. 4.—Two cocoons; natural size.

The figures 1, 2, 3, 4, are lithographed from coloured drawings retained in the author's possession.

Fig. 5.—A chæta. Note the ridges.

Fig. 6.—The worm dissected from above, intended to exhibit chiefly the vascular system. The nephridia are omitted. *Com. v.* One of the commissural vessels, which occur only in the anterior somites. *Dors. v.* Dorsal blood-trunk. *D. teg. v.* One of the tegumentary vessels arising from the dorsal trunk, and repeated metamerically throughout the body behind Somite XIII. Their relations to the septa are not accurately shown (see Figs. 8 and 10). *heart.* One of the five lateral hearts. *Int.* Intestine, commencing in Somite IX. *Long. teg. v.* The longitudinal tegumentary vessels arising from the tegumentary vessels of Somite XIV: that connected with the ventral vessel is in outline. *œs.* Œsophagus. *sal. gl.* One of the three pairs of salivary glands. *spth.* Spermatheca. *V. teg. v.* One of the ventral tegumentary vessels.

Fig. 7.—Longitudinal section through three Somites, xi, xii, xiii, in order to show the perienteric blood-sinus. Only structures occurring in the middle line are shown, and no detail is intended. The figure is sufficiently explained on the plate.

Fig. 8.—A diagrammatic transverse section in the posterior region of the body. On the left side a septum is represented, on the right the cœlom is almost filled by the nephridium. *apert.* Apertures in the septum for the passage of the tegumentary vessels, which originate from the median trunks immediately in front of the septum, and pass through the septum to be distributed to the somite behind. *D. ves.* Dorsal trunk. *Dors. teg. v.* The dorsal tegumentary vessel: that part lying in front of the septum is transversely shaded. *Int.* Intestine, with its perienteric blood-sinus. *l. ch.* Lateral chætæ. *Neph.* Nephridium. *ne. d.* Wide tube of the nephridium perforating the body-wall. *ne. p.* Nephridiopore. *ne. v.* The branch from the tegumentary vessel to the nephridium. *Vent. teg. v.* Ventral tegumentary vessel: its portion lying in front of the septum is outlined by dots. *V. v.* Ventral vessel.

Fig. 9.—Diagrammatic transverse section through one of the anterior somites. The figure is sufficiently explained on the plate. On the left side, the dorsal and ventral longitudinal tegumentary vessels are shown simply cut across; on the right side, the branches from them to the body-wall are indicated. As in other figures, that connected with this ventral vessel is merely outlined, the other being solid.

Fig. 10.—A diagrammatic view of four posterior somites: the worm has been opened along the left side, the body-wall on this side being depressed; the arrow points to the anterior end of the preparation. The tegumentary vessels are here represented in their true relation to the septa, which they perforate. One nephridium (*neph.*) is outlined, and its funnel (*ne. f.*) indicated. *ne. v.* is a cut nephridial vessel.

Fig. 11.—A general view of the generative organs. To some extent it is diagrammatic, in that the chætæ and the sperm-duct are shown as if the body-wall were transparent. In the last three somites, too, the nephridiopores are shown (*ne. p.*). *cil. ros.* The two pairs of ciliated rosettes. *clitell.* The extent of the clitellum. *Epid.* The post-septal coiled part of the sperm-duct, the epididymis. *lat. ch.* Lateral chætæ. *ov.* Ovary. *ov. d.* Oviduct, the funnel of which is shown bending into the ovisac. *sp. sac.* Sperm-sac. *sp. d.* Sperm-duct, which lies in the body-wall (see Fig. 19). *sp. p.* Spermiducal pore. *spth.* Spermatheca. *t.* Testis. *vent. ch.* Ventral chætæ.

Fig. 12.—A longitudinal median section through the anterior end of a specimen in which the buccal region is withdrawn, with the exception of a small portion (*a—a'*) of the upper lip. *cer. g.* Cerebral ganglion. *N. c.* Nerve-cord. *prost.* Prostomium. *Pit.* Prostomial pit. *sac.* Dorsal sac of

the pharynx, opening by a wide mouth. *sept.* One of the septa: the first one appears to be between Somites II and III. The relative thicknesses of epithelium in various parts are represented. The letters *a*, *b*, *c*, *d*, merely indicate points or regions to be compared with those similarly lettered in Fig. 13.

Fig. 13.—A longitudinal section through the anterior end of a specimen in which the buccal cavity is everted. The series of sections were not quite parallel to the vertical plane, so that the upper portions are really more laterally situated than the lower; hence the sac of the pharynx appears to open by a narrow orifice: this is merely the narrower lateral part of the orifice, which is wider medially. Most of the letterings as in Fig. 12. *sal. gl.* Salivary gland. *œs.* Œsophagus. *long.* The longitudinal muscles of the body-wall. *circ.* The circular muscles. *a*, *b*, *c*, *d*, indicate regions for comparison with their position in Fig. 12.

Fig. 14.—A portion of the epithelium at *a* in Figs. 12 and 13.

Fig. 15.—A portion of the epithelium of the buccal cavity between *b*—*c* in Fig. 12.

Fig. 16.—A portion of the epithelium from the floor of the pharynx behind *c* in Fig. 12.

Fig. 17.—A portion of the epithelium of the roof of the sac of the pharynx behind *d* in Fig. 12.

Fig. 18.—A portion of the wall of the intestine where the septum (*sept.*) nips it, as at *a* in Fig. 7. *Int. epith.* Intestinal epithelium, the details in which are represented only on the left. Each cell has a dense, deeply staining border, represented in the figure by the darker line; and the light band outside this is probably caused by closely pressed cilia. *circ. mus.*, *lg. m.* The muscular coats of the intestine. The blood-clot in the perienteric blood-sinus exhibits a peculiar fringing of its outer border.

Fig. 19.—The ventral half of a transverse section through Somite XVI, in order to show the epidermic position of the sperm-duct on each side—immediately outside the tubercula pubertatis (*tub. pub.*). *vent. ch.* Ventral chætæ. *cl.* Clitellum. *cl'.* The thin extension of the clitellum across the ventral surface.

Fig. 20.—A portion of a transverse section more highly magnified, showing the structure of the sperm-duct. The specimen of which this is a section had passed its sexual maturity. The epidermis (*ep.*) is evident, the rounded nuclei indicating rather short cells whose outlines are not evident. Below is a peculiar tissue—due, I believe, to degenerate clitellar cells (*cl. deg.*). *b. v.* Blood-vessels in this region. *circ.* Circular muscles. *long.* Longitudinal muscles.

Fig. 21.—A portion of a transverse section in the same series as that of

Fig. 19. It passes through the 18th somite behind the chætæ, close to the spermiducal pore. The sperm-duct is quite superficial. *tub. pub.* Tubercula pubertatis.

Fig. 22.—Section through the male pore, from the same series as Figs. 19 and 21. *sp. d.* Sperm-duct, filled with spermatozoa. *ep.* Ordinary epidermis, dipping in to meet the wall of the duct. *b. v.* Blood-vessels. *cl. c.* Clitellar cells.

Fig. 23.—A sperm-sac in longitudinal section, under a low power. *sept.* Septum. *ax.* Axial group of muscle- (?) fibres, traversing the sperm-sac for some distance. *trab.* Trabeculæ of the same tissue; various stages in the development of the spermatozoa are indicated.

Figs. 24—27 represent selected sections from a series through the oviducal funnel. XIII, XIV, indicate the somites. *sept.* The intervening septum. *Int.* Intestine.

Fig. 24 passes through the opening of the funnel (*ov. f.*) into Somite XIII.

Fig. 25. The next section of the series shows the folding of the funnel, and its bending over into the ovisac. *ov. f.* That part of the funnel communicating with Somite XIII, and which is cut along its edge. *ov. f′.* That part opening into the ovisac.

Fig. 26. Two sections further on: the opening of the ovisac into Somite XIII is past. The funnel (*ov. f′.*) dips into the sac and lines one wall.

Fig. 27. The fifth section beyond the last; still shows a small portion of the funnel in the ovisac.

Fig. 28.—A section through the ovisac two sections further on than Fig. 27. A couple of ova are seen: each exhibits a karyokinetic figure.

Fig. 29.—One of the ova represented in Fig. 28, much more magnified, showing the nuclear spindle, chromosomes, and cytasters. It is probably about to form directive corpuscles. The irregularity in the vitelline membrane is due to reagents.

Fig. 30.—A portion of a section through the clitellum.

Fig. 31.—A longitudinal section of a nephridial funnel. *c.* The nucleus of the central cell. *c. ep.* Flat cœlomic epithelium covering the back of the funnel. *m.* Marginal cells. *ex. m.* Extra-marginal cells.

Fig. 32.—A transverse section of a nephridial funnel. *c.* Central cell. *m.* Marginal cells. *ex. m.* Extra-marginal cells. *c. ep.* Flat cœlomic epithelium.

Fig. 33 represents a section through a spherical mass of cells lying in front of a nephridial funnel (*neph. f.*). *y.* Yellow granules embedded in the mass.

Fig. 1.

Fig. 2.

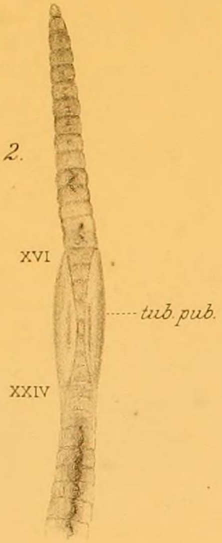


Fig. 4.

Fig. 3.

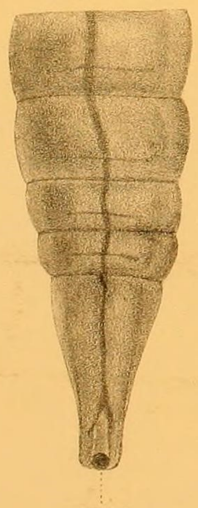


Fig. 6.

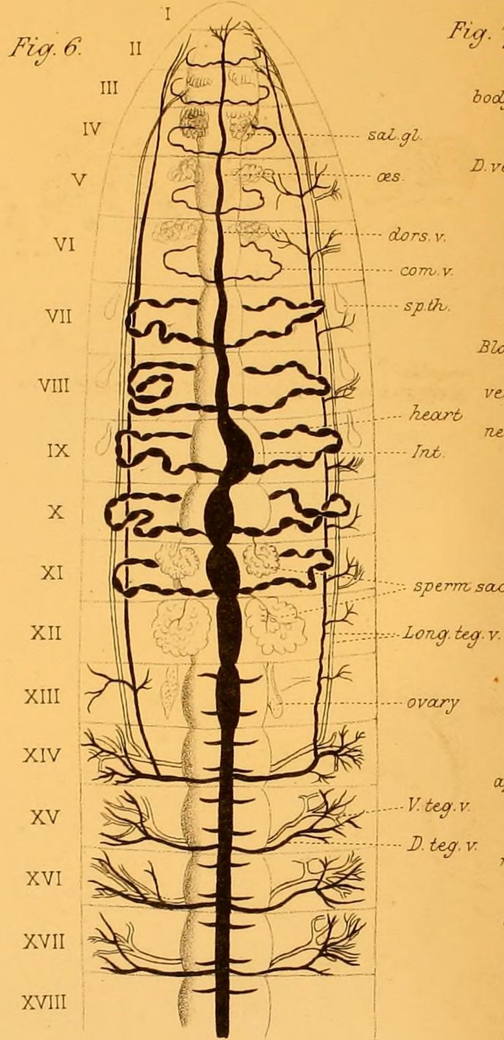


Fig. 5.

Fig. 7.

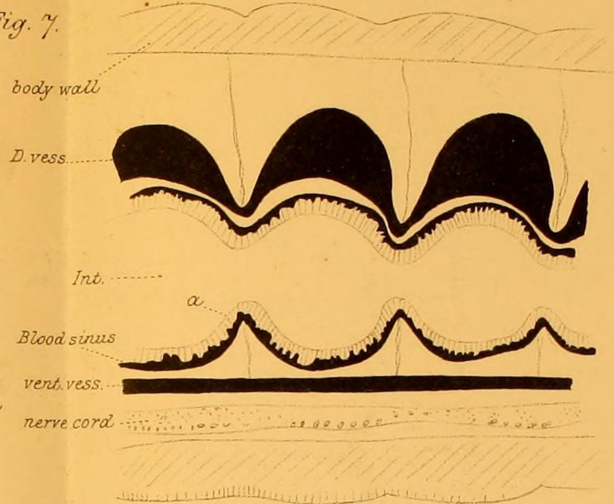


Fig. 8.

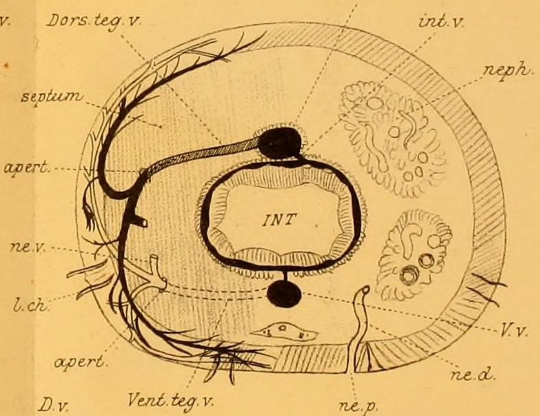


Fig. 11.

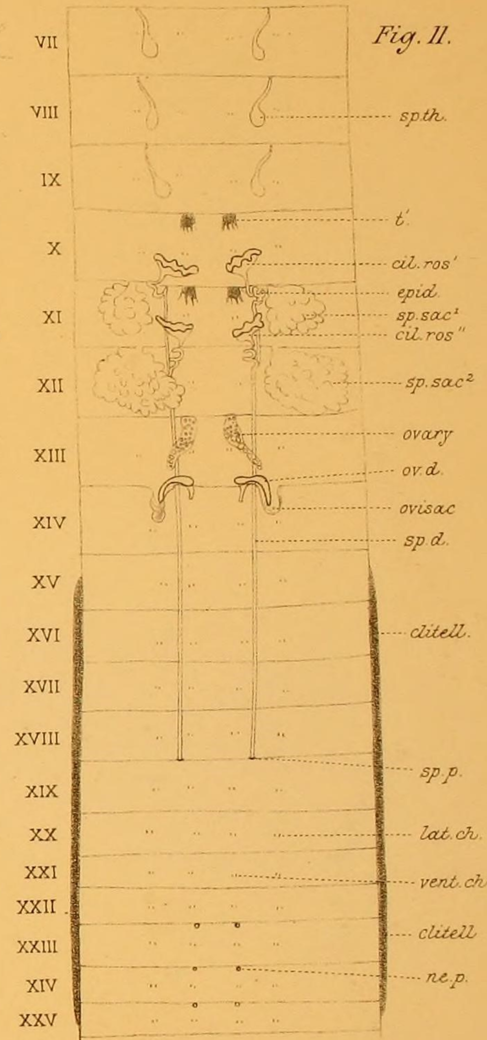


Fig. 9.

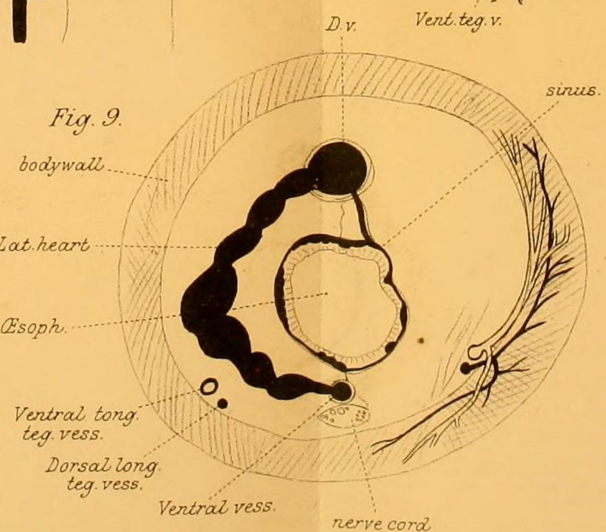
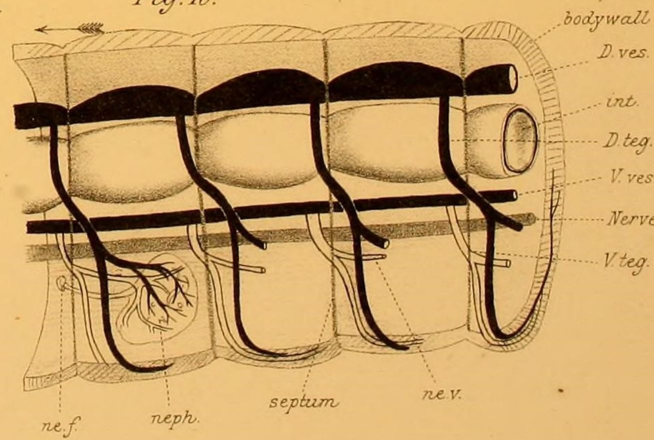


Fig. 10.



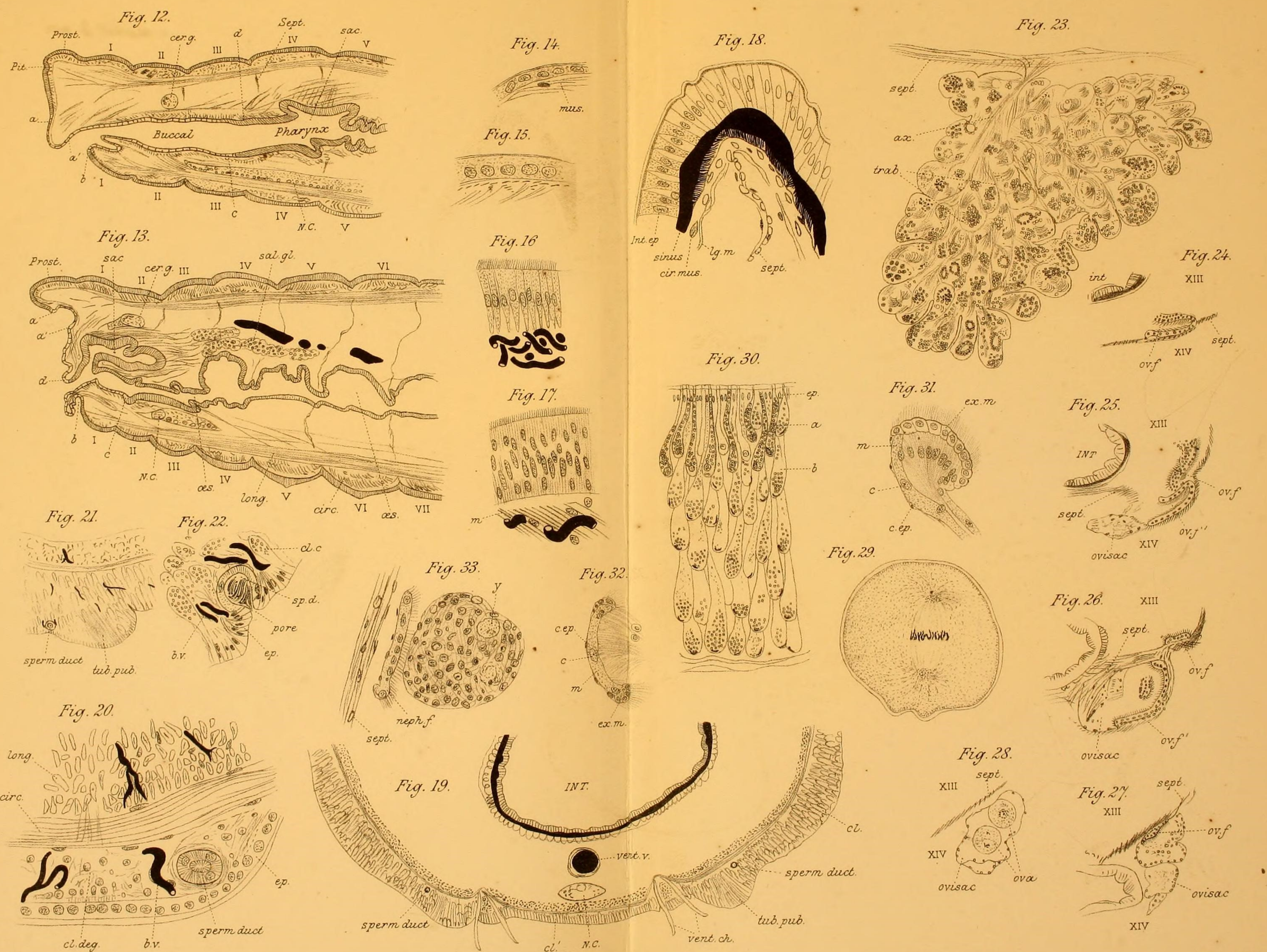


Fig. 12.
Prost.
Pit.
cer.g.
Sept.
sac.
Buccal
Pharynx
N.C.
Fig. 13.
sac
cer.g.
sal.gl.
N.C.
œs.
long.
circ.
Fig. 14.
mus.
Fig. 15.
Fig. 16
Fig. 17.
Fig. 18.
Int.ep
sinus
cir.mus.
lg.m
sept.
Fig. 19.
INT.
vert.v.
cl.
sperm duct
tub.pub.
vent.ch.
N.C.
Fig. 20.
long.
circ.
ep.
cl.deg.
b.v.
sperm duct
Fig. 21.
sperm duct
tub.pub.
Fig. 22.
cl.c
sp.d.
pore
ep.
b.v.
Fig. 23.
sept.
ax.
trab.
Fig. 24.
int
XIII
XIV
sept.
ov.f
Fig. 25.
INT
ov.f
sept.
ovisac
Fig. 26.
sept.
ov.f
ovisac
Fig. 27.
sept.
ov.f
ovisac
Fig. 28.
sept.
ova
ovisac
Fig. 29.
Fig. 30.
ep.
Fig. 31.
ex.m
c.ep.
Fig. 32.
c.ep.
ex.m.
Fig. 33.
neph.f.
sept.