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On the Structure of a New Genus of Oligochæta (Deodrilus), and on the Presence of Anal Nephridia in Acanthodrilus.

By

Frank E. Beddard, M.A.,
Prosector of the Zoological Society of London.

With Plates XXXIII and XXXIIIA.

I. On the Structure of a New Genus of Oligochæta.

THE present paper is based upon the study of only a single example of the worm. It was collected some years ago by Prof. Moseley in Ceylon, and was kindly entrusted to me for description by Prof. W. Hatchett Jackson.

The specimen measures thirteen inches in length by nearly half an inch in diameter at the broadest part (at the end of the 8th or 9th segment). Its intermediate characters lead me to suggest the generic name Deodrilus; the specific name I propose to associate with Mr. Jackson.

§ External Characters.

The prostomium is entirely absent, as it is in some other genera allied to the present.

The first or peristomial segment is traversed by longitudinally running grooves, which give it a characteristic appearance, often seen in worms when there is, as in this genus, no prostomium.[1]

The three following segments are of about equal antero-posterior diameter, though increasing rapidly in their breadth from side to side.

[1] Cf., for example, Beddard (1).

The 5th segment is the first which shows the commencing formation of annuli. A slight furrow crossing this segment partially divides it into two rings ; the setæ are implanted just in front of this furrow.

The 6th ring is similar to the fifth, only that it is slightly longer.

The 7th ring is broader still, and is divided by two furrows into three annuli, the setæ being conspicuous upon the middle one of the three.

The 8th to the 14th segments are very broad, and each is divided by four furrows into five annuli, of which the middle one carries the setæ.

The 14th segment, though of equal diameter to those preceding it, has only three furrows; but there is an indication of the fourth.

The 15th and 16th have three annuli each.

After this point I cannot give accurate details, as the ridges which carry the male generative pores have introduced alterations into the annuli of the neighbouring segments.

Clitellum.—I am unable to map exactly the boundaries of the clitellum, as it did not appear to be fully developed.

On dissection, only two segments (15 and 16) showed a very marked difference in the structure of the body-wall from the others ; here the deep yellow colour was very apparent, and was fully as well developed on the ventral as on the dorsal side.

The genital orifices, as already stated, are borne on two longitudinally running ridges, coinciding in position with the ventral series of setæ on each side.

These ridges, particularly in the immediate neighbourhood of the male pores, had a very glandular appearance. It is quite possible that the clitellum when fully developed extends as far as these ridges do.

In that case it may be stated provisionally that the clitellum extends over four segments (viz. 15—18).

It will be noted, however, that the clitellum differs in its anterior and posterior regions. The first two segments are entirely invaded by glandular substance, while the three posterior

segments will in all probability be found to have a median area upon which there is no great modification of the epidermis. This area is of course bounded laterally by the genital ridges. It seems, therefore, that the clitellum of Deodrilus is constituted upon the same plan as that of Acanthodrilus.

Dr. Rosa has made some use, in his scheme of classification of earthworms, of the form of clitellum, which he terms saddle-shaped ("clitello a sello"), or complete ("cingulo completo"), admitting that Acanthodrilus offers an intermediate condition.

The fact is that it is not possible to classify the various modifications of the clitellum in this way.

There is a considerable series of gradations which renders it impossible to make a fixed demarcation between the different forms of clitellum. To commence at one extreme, we have species of Lumbricus and Allolobophora with a distinctively saddle-shaped clitellum: in these forms the glandular modified epidermis is only to be found on the dorsal and lateral regions of the clitellum; ventrally there is a wide space of equal diameter throughout, which has no trace of glandular tissue.

In such a form as Rhinodrilus Gulielmi the clitellum is divisible into two regions: in the last six segments of which it is composed the glandular substance is arranged quite as in Lumbricus; but in the first four the ventral area is encroached upon by the glandular tissue, though it is not completely invaded.

In Urochæta the clitellum is constituted in a way quite resembling that of Rhinodrilus, but the anterior bare ventral space appears if anything to be somewhat narrower.

In Deodrilus (which, as will be shown later, has points of affinity with Rhinodrilus) the anterior part of the clitellum is completely developed—extends all round the body—but the greater part is still only laterally developed.

Acanthodrilus has a clitellum in which the anterior portion is at least as great as, and may be greater than, the hinder portion, which still retains its saddle-shaped character.

Finally, we have such a form as Perionyx, in which the

six or seven segments of the clitellum are completely occupied by the modified epidermis.[1]

Hence it appears to me to be inadvisable to use the characters of the clitellum to help in associating together, as Rosa has done, his families Lumbricidæ and Geoscolecidæ. The structure of Deodrilus shows that this cannot be done; and there are, among the Geoscolecidæ of Rosa, intermediate conditions leading to Deodrilus.

Genital Papillæ.—Most earthworms are furnished with genital papillæ, which are often very characteristic of the species in which they are found.

Deodrilus is not an exception to this rule, and has two sets of genital papillæ.

The first set consists of a single pair of large flattened papillæ, which are fused together to form a dumb-bell shaped area extremely conspicuous. The outer convex border on each side reaches to the level of the inner setæ of the outer pair.

The papillæ (see Pl. XXXIII, fig. 12, *p*) are situated between the 11th and 12th segments; they occupy the last annulus of the former segment and the first two annuli of the latter: the furrows dividing the annuli and the two segments from each other can be seen as faint lines traversing the papillæ. The furrow separating the last annulus of Segment 11 from the penultimate forms the anterior boundary of the papillæ, while its posterior boundary is formed by the furrow separating the second from the third annulus of Segment 12. The second set of genital papillæ are very much less conspicuous; they are to be found near the male genital pores, and no doubt correspond to the tubercula pubertatis: in front of each of the male orifices are two papillæ—one in front of the other; and behind each is a single papilla. So far as I can ascertain, they belong to Segments 17, 18, and 19; but, as I have already said, it is difficult to be certain about the limits of the segments in this region of the body.

Setæ.—The setæ are entirely restricted to the ventral surface of the body, where they are implanted in pairs.

[1] I do not for the present consider how far the form of the clitellum may be influenced by the position of the generative pores.

On the 8th segment I found that the distance separating the two ventral pairs from one another was $2\frac{1}{2}$ mm.; the lateral pairs were separated by a dorsal area measuring 14 mm. The shape of the setæ is very remarkable, and is illustrated in fig. 18. Their general outline is similar to that of the setæ of other earthworms, but instead of terminating in a hooked extremity they present a truncated appearance, which will be understood by a reference to the figure cited. It occurred to me, when first observing the setæ attached to fragments of stripped-off cuticle, that they might be of the normal form, but with their extremities broken off. It frequently happens, as a result of rough usage, that the majority of the setæ, or at any rate a large number, are broken off short; but it is evident that that is not what has happened in the present case. The free extremity of the setæ showed no signs of having undergone any fracture; and, moreover, the shape of the freely projecting extremity is not such as would be produced by a fracture, or wear and tear.

The setæ illustrated in fig. 18 are drawn as seen on a lateral view; *a* and *b* represent the free extremities of such setæ more highly magnified.

Another peculiarity in the structure of the setæ is the fact that their distal region, i.e. that part which lies external to the slight swelling in the middle of the setæ, is ornamented by minute pointed processes.

The description just given, and the figures which illustrate it, refer to setæ from the first ten segments or so; but I have ascertained that the setæ in the posterior segments are absolutely identical in size and structure with those from the anterior segments.

The first five segments of the body are entirely deprived of setæ; a microscopic examination of these segments did not enable me to find any trace of the presence of setæ.

The disappearance of the setæ from the first few segments of Deodrilus, and of the species of Diachæta which I described recently in this Journal (1), is a remarkable fact. No other instances are at present known among earthworms,

though possibly Microchæta Rappi may prove to be one; at any rate, it is excessively difficult to recognise the setæ upon the first few segments; I have not myself been able to find them at all. They are, however, figured by Benham (**11**, pl. xv, fig. 1); but he makes no definite statement as to their presence on the first two or three segments. Leaving Microchæta aside, the absence of setæ on the anterior segments is correlated with the entire absence of a prostomium. Not a vestige of this structure could be recognised in either of the two forms mentioned. This correlation, however, is not universal, for Urochæta has no prostomium, and yet the setæ are visible, as usual, from Segment 2 onwards. It is furthermore noticeable that in Diachæta Windlei the anterior non-setigerous segments show another modification in the presence of the specialised bundle of transversely running muscular fibres, which I have figured and described as occurring in the segments beginning with the 6th.

In most earthworms the first or peristomial segment is so far unlike the rest that it is grooved longitudinally, and that its epidermis is not clearly distinguishable into two classes of cells, or at least is not so clearly distinguishable as is the epidermis of the following segments. Sometimes this modification appears to affect the 2nd as well as the 1st segment.

In connection with this modification the varying position of the prostomium may be pointed out. Sometimes the prostomium is attached to the anterior border of Segment 1; in other species it encroaches upon this segment, and finally it often completely divides the 1st segment, and reaches the anterior border of the 2nd.

Earthworms, in moving along, use the mouth as a kind of sucker, even protruding a portion of the buccal cavity; this is remarkably the case with Perichæta indica (**3**), which everts what appears to be the whole of the buccal cavity at each movement. Conversely, there is often a temporary withdrawal of the peristomial segment into the mouth-cavity. These two phenomena appear to have led to the different enumeration of the segments of Urochæta adopted by Perrier

(13), Horst (12), and Rosa (10). As the latter has pointed out, Perrier appears to have described a specimen in which the buccal cavity was partly everted; while Horst, in stating that the mucous gland opened on to the first segment of the body, was deceived by the introversion of the peristomial segment.

Among the half-dozen series of longitudinal sections of Urochæta corethrura which I possess there is one in which the 1st and a portion of the 2nd segment are introverted, and the mucous gland appears, therefore, to open into the buccal cavity; in fact, it actually does open into a temporary extension of the buccal cavity.

It is, in my opinion, possible to believe that a temporary introversion, such as that to which I have just referred, may become permanent. In this case what will happen are two events of importance. In the first place the body will be shortened by one segment; in the second place the "mucous gland" will come to open into the anterior section of the alimentary tract.

As to the second point, I may call attention to the remarkable condition of the anterior nephridia in Acanthodrilus multiporus (4). In that worm the anterior segments are occupied by a mass of glandular tubes, clearly of nephridial nature, on each side of the pharynx. Each mass communicates with a long duct, which opens into the buccal cavity. It seems impossible to doubt that the nephridial masses of this Acanthodrilus originally opened on to the exterior, and that their connection with the buccal cavity is only secondary. That this "secondary" connection may be really the original point of opening, masked by the partial or entire introversion of the 1st segment, is surely not incredible.

With regard to the first point, the possible shortening of the body in this way involves really no serious difficulty, though it seems, of course, rather ridiculous to gravely assert that a worm becomes shorter by swallowing its own head. The structure of the epidermis of the 1st segment is more like that of the buccal cavity than it is like that of the succeeding segments.

These remarks, however, apply more particularly to such

worms as Diachæta and Deodrilus, in which there is no prostomium, and in which, therefore, such an inversion will cause no external change of importance.

In worms which have a prostomium this structure may be prolonged backwards, so as to commence as an outgrowth of the 2nd segment; if, in such a case, the peristomial segment were permanently invaginated the prostomium would be left attached to the 1st segment of the body, i. e. in the more usual position; on the other hand, a permanent eversion of the commencement of the buccal cavity in a worm in which the prostomium arises from the anterior margin of the peristomial segment would lead to the apparent prolongation of the prostomium back to the 2nd segment.

§ Reproductive Organs.

I have not found the testes nor the ovaries and oviducts. Two pairs of sperm-sacs were to be seen attached to the anterior wall of the 10th and 11th segments; these organs are racemose in form, as in so many genera.

The vas deferens funnels appear also to be limited to a single pair, which open into the 11th segment.

The atrium, or prostate gland, is a compact flattened body on each side of the body connected by a short muscular duct with the male pore; it lies in the 18th segment. The atrium appears to be branched, and to resemble the same organ in Perichæta.

Connected also with the male reproductive apertures is on either side a thin-walled sac filled with penial setæ. Two of these setæ are shown in figs. 15, 16; it will be seen from an inspection of those figures that the form of the two setæ selected for illustration differs very considerably. In one the distal extremity is covered with numerous minute points like those which cover the distal half of the ordinary seta. In the other seta these points are entirely absent, and fine wavy lines are found on the distal part of the seta, ceasing, however, some little way in front of the extremity.

I call particular attention to the fact that two such different forms of penial setæ are met with in the same individual, inas-

much as these setæ have been made use of by myself and others as specific characters. I may recall the fact that in Acanthodrilus Georgianus (5) there is an analogous dimorphism of the penial setæ.

§ The Intersegmental Septa.

As is so constantly the case among earthworms, certain of the intersegmental septa are specially thickened, as well as connected with each other and with the parietes by muscular bands.

In the present species the septa between Segments 6 and 13 are thus strengthened, there being, therefore, seven. As in other cases, these septa are very concave forwards, the middle region lying much behind the peripheral attached margin; the septa present, therefore, have the appearance of a series of cups, each fitting within the one which follows it.

§ Alimentary Canal.

The gizzard lies in Segment 6 (cf. fig. 14).

The œsophagus extends as far back as Segment 18; it does not, however, abruptly widen into the intestine, which only commences (fig. 13) in the 20th segment.

In Segments 15, 16, and 17 are three pairs of calciferous glands. As shown in the figure (fig. 13), each of these glands is divided into two by a transverse furrow.

§ Nephridia.

The worm was not in a sufficiently good state of preservation to allow of any observations upon the minute structure of the nephridia.

So far as could be ascertained by dissection, the nephridia throughout the body appear to be of the "diffuse" type.

Lying alongside of the pharynx on each side was a conspicuous glandular body, which is doubtless similar to the salivary gland of Acanthodrilus multiporus, and to the "mucous" gland of Urochæta, Diachæta, &c.

§ Affinities of Deodrilus.

The question of the systematic position of this Annelid necessitates some review of recent attempts to classify the group. As, however, I intend to publish an attempt at the classification of these Annelids with a criticism of existing schemes, I shall make my references as brief as possible.

Deodrilus evidently belongs to the "Intraclitellian" group of Perrier (**13**); but as Perrier's scheme—undoubtedly a great advance upon what had gone before—is not now generally accepted, I shall not urge any reasons why Deodrilus does not fall in with that classificatory attempt.

The most recent schemes are those of Rosa (**9**) and Vaillant (**14**).[1] Rosa has divided earthworms into six families—Lumbricidæ, Geoscolecidæ, ? Moniligastridæ, Acanthodrilidæ, Eudrilidæ, Perichætidæ.

It is only with the second and fifth of these families that Deodrilus can have any connection.

These families are defined by Rosa as follows.

Geoscolecidæ.

(1) Male pores within the clitellum between the dorsal and ventral setæ, occupying segments or intersegmental grooves which are very variable.

(2) Clitellum generally saddle-shaped; length and position variable.

(3) Setæ eight per segment, in pairs or singly, or diversely arranged in the anterior and posterior segments.

(4) Copulatory setæ longer than the others and of a different form.

(5) Gizzard (or gizzards) placed anteriorly.

(6) Sperm-sacs one or two pairs.

(7) No prostates or penial setæ.

[1] Since writing the above I have received through the kindness of the author Mr. Benham's "An Attempt to Classify Earthworms," 'Quart. Journ. Micr. Sci.,' vol. xxxi, pp. 201—315.

Eudrilidæ.[1]

(1) Male pores one pair, on Segment 17 or 18, within or behind the clitellum, corresponding to the ventral setæ.

(2) Clitellum complete, occupying generally Segments 13 (14)–16 (18) = 3—6.

(3) Setæ eight, paired or singly, but always parallel.

(5) Gizzard (or gizzards[2]) anterior in position.

(6) Sperm-sacs generally two pairs.

(7) Prostate and penial setæ present.

The only characters, therefore, which are decisive are (1), (2), and (7).

Deodrilus agrees with the Eudrilidæ in (1) and (7), and it is intermediate between the two in (2).

But there are other facts in its structure which signify that it combines the characteristics of genera which have been included in the Geoscolecidæ and in the Eudrilidæ. The absence of a prostomium is characteristic of certain genera of Geoscolecidæ—Urochæta and Diachæta. It is true that Typhæus, which Rosa refers to the Eudrilidæ, has no prostomium;[3] but it must be remembered that this genus agrees with Urochæta, Geoscolex, and Diachæta in having a single pair of long tongue-shaped sperm-sacs, and only a single pair of sperm-ducts.

In the absence of setæ from the first few segments Deodrilus resembles a species of Diachæta, of which a description has appeared in a recent number of this Journal (1).

Typhæus appears to have no setæ upon the first two segments, but, as stated in my paper upon that worm (6), I am not absolutely certain of the fact.

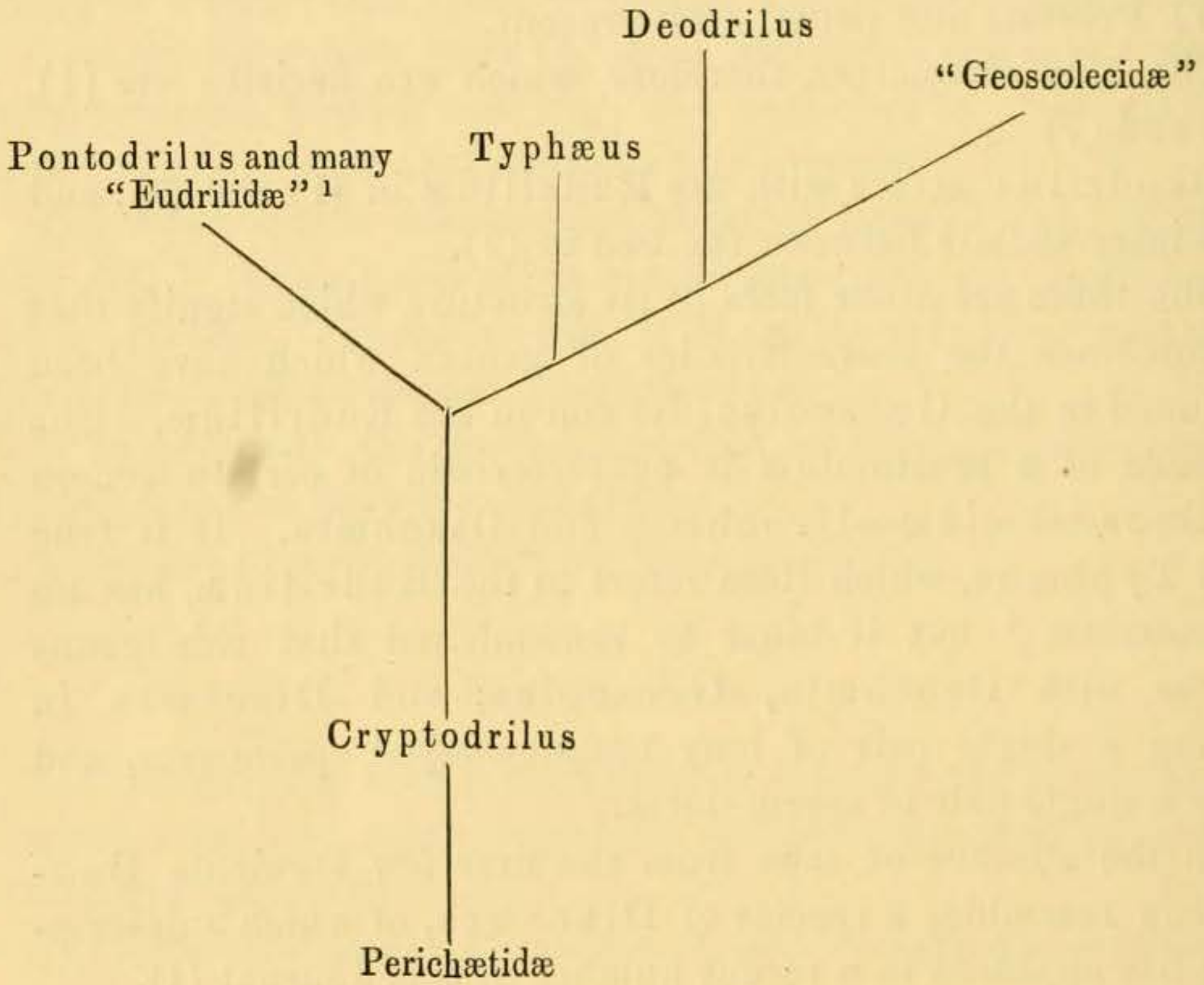
The presence of ornamented setæ affines Deodrilus to Rhinodrilus; nothing of the kind is met with in any of Rosa's Eudrilidæ.

[1] I may remark that *Eudrilus* itself does not agree with this definition in all characters.

[2] I add "gizzards" myself, so as to include Perissogaster, &c.

[3] Loc. cit., p. 111. This statement requires confirmation, since Bourne has lately described a prostomium in Typhæus Masoni.

The diffuse nephridial system has not yet been met with in any of the Geoscolecidæ; in this particular, therefore, as in the presence of prostates and penial setæ, Deodrilus resembles certain genera (e. g. Cryptodrilus) of the Eudrilidæ. Finally, the absence of diverticula to the spermathecæ brings Deodrilus into relations with the Geoscolecidæ. It seems to me that the relationship of Deodrilus to some other forms is best expressed by the following diagram:



Genus—Deodrilus.

Setæ arranged in pairs upon the ventral surface, peculiar in shape, and ornamented. Absent upon the first four segments.

Prostomium absent.

Clitellum occupying Segments 15—18 (or thereabouts), complete anteriorly, saddle-shaped posteriorly.

Gizzard in Segment 6.

[1] I do not for the present particularise the exact limits which I apply to these families.

Sperm-sacs, two pairs, in 10, 11, racemose.

Nephridia diffuse, a mass of tubules in the neighbourhood of the pharynx aggregated into a compact gland.

Atria lobate, each with a sac of penial setæ opening on to Segment 18.

Species—D. Jacksoni.[1]

Large worm, measuring 13 inches.

Copulatory papillæ forming a dumb-bell shaped area between Segments 11 and 12.

Penial setæ of two kinds, one ornamented by minute protuberances, the other transversely striate.

Two pairs of spermathecæ, without diverticula, in Segments 8 and 9 (see fig. 19).

II. Anal Nephridia in Acanthodrilus.

I have already (7) described some of the anatomical and histological characters of the nephridia in Acanthodrilus; their organs are in some species (e. g. in A. multiporus) represented by irregular tufts, which are furnished with numerous funnels, and numerous external orifices in each segment.

I have now to describe a connection of the nephridia with the terminal region of the intestine, which occurs in a species referable, I believe, to my Acanthodrilus multiporus.

The material I owe to the kindness of Mr. W. W. Smith, of Ashburton, New Zealand.

In fig. 1 of Pl. XXXIII, is represented half of a portion of the posterior end of the body of one of these worms, comprising about thirty segments. The body was divided by a cut at right angles to the dorso-ventral axis; the intestinal canal is laid open, and the typhlosole is seen to occupy the dorsal line of the intestine. The figure is twice the size of nature.

The typhlosole ends abruptly about an inch in front of the anus; a faint streak is, however, recognisable, extending for perhaps a quarter of an inch beyond the end of the typhlosole.

[1] Named after Mr. W. Hatchett Jackson.

The part of the alimentary tract lying behind the typhlosole is thus sharply marked off, and the distinction between it and the terminal section is possibly an important one; I should be inclined to regard the "rectum" as being proctodæum. The diameter of the rectum, as shown in the figure, gradually narrows to the anus; its walls are marked by longitudinally running furrows.

In transverse sections the gut is seen to be lined by an epithelium of tall columnar cells, broader towards their extremities and narrower at their attachment. The folds observable (fig. 5) in such sections are, of course, due to the longitudinally running furrows. Outside the epithelium is a circular coat of muscular fibres, and outside this again longitudinal fibres; these latter do not form at all a thick layer, and they are partly interspersed among the meshes of a peculiar form of connective tissue which extends beyond them, and forms the outermost wall of the intestine. This connective-tissue layer is also found beneath the epithelium; in parts it consists of a meshwork of fine fibres with nuclei present, chiefly at the nodal points; in other parts the meshwork becomes very wide, and the tissue presents the appearance of a fenestrated membrane; the fenestræ are, relatively speaking, small, and the tissue lying between them is somewhat gelatinous in appearance, with fine fibrils passing through it (fig. 3); nuclei are present, which are frequently attached closely to the fenestræ, bulging out into these latter as depicted in fig. 3.

At the extreme end of the body these layers are not so conspicuous, owing to the crowding together of the last two or three of the intersegmental septa, and the continuity of these with the intestine.

The cœlomic space, on the ventral side of the body at any rate, is almost filled with the nephridia, which form two principal masses, one on each side of the nerve-cord. In a single section several funnels can be seen connected with the nephridia, and their ducts can be observed to perforate the body-walls, and to open on to the exterior by many pores.

In such sections the outer connective-tissue coat of the intestine may be observed to include numerous tubules cut across in various directions (fig. 5, *n*), indicating therefore a somewhat tortuous course; these tubules appear, in sections taken between two successive septa, to have no relation whatever with the nephridial tufts that have been already mentioned as occupying the cœlom. And yet they are clearly nephridial in their nature.

Fig. 5 represents a slightly magnified section through a portion of the intestine, showing the general appearance of these tubes.

Fig. 4 is a portion of the same more highly magnified, and drawn with the help of the camera lucida.

From this drawing it may be seen that the structure of the tubes is precisely that of the nephridia, although they are for the most part considerably wider. Their walls are granular, with large nuclei interspersed here and there, showing the lumen of the tube to be intra-cellular.

In the section figured a smaller tubule is seen to project into the lumen of the larger tubule, and another small tubule seen in transverse section lies entirely within the larger tubule.

This telescoping of one tube within another at once recalls the peculiar structure of the leech's nephridium, made known by the investigations of Bourne (15) and others. The difference is that in the leech the inner tube is closely invested by the outer, while in the earthworm there is a wide space between the two.

These nephridial tubes, which appear to be so curiously cut off from the general nephridial system, are in reality not so cut off. A series of sections shows that they become continuous with the general nephridial network at the septa; at any rate their branches pass along the septa, and can be traced into the nephridial tufts: these branches are of the same calibre as those of the general nephridial system.

Traced in the other direction, these nephridial tubes may be followed through the lining epithelium of the gut, into the lumen, which they open.

The wide tubes with an intra-cellular lumen become gradually crowded with nuclei,[1] though the boundaries between the individual cells are not to be discerned in my preparations; the lumen, however, is here clearly intercellular, the individual cells being apparently more or less cubical in form. The nuclei are quite similar to those of the portion of the nephridium with an intra-cellular lumen. The tube then bends up towards the epithelium of the gut, and its lumen becomes much contracted, owing to the great increase in the size of the cells which form its walls. In this region of the nephridium the cells are quite indistinguishable from those which form the lining membrane of the rectum.

It seems, therefore, probable that the diverticula of the intestine were developed as diverticula, and that the nephridia afterwards acquired a connection with them, just as the external portion of nephridia opening on to the surface of the body is developed from a separate epiblastic involution.[2]

In the absence of embryological data, I cannot do more than regard as highly probable the suggestion made above concerning the morphological nature of the rectum. The rectum is much more likely to be proctodæum than hypoblastic in origin. If this is not the case, then the facts recorded in this paper have an obvious bearing upon Lang's views (17) of the hypoblastic origin of the nephridia. I should, however, prefer for the present to consider the terminal section of the gut, into which the nephridia open, to be epiblastic in origin.

So far as I am aware, there has been no description of nephridia connected with the rectum in any other Chætopod.

The nearest group in which anything of the kind occurs is the Gephyrea; in Bonellia, and other forms belonging to the

[1] Such a fact as this appears to me to show that the morphological distinction which some have attempted to draw between nephridia with intra-cellular lumen and intercellular lumen, e.g. between those of Oligochæta and Polychæta, cannot be maintained.

[2] Bergh (16) has, however, denied that this is the case in Criodrilus; according to him the nephridium is entirely mesoblastic, and bores its way to the exterior.

Gephyrea Chætifera, we have the branched "respiratory trees," whose structure appears to show that they are nephridial in nature; even in Sipunculus, two rudimentary diverticula attached to the intestine close to the anus may be homologous structures. It is true that some observers, such as Greef and Spengel, have denied that the anal glands of the Gephyrea are to be compared to nephridia; but the view of the former was based, partly at least, upon a misunderstanding of these organs.

There is no regularity that I could detect in the position of the apertures of these tubes; sometimes two could be observed quite close together, at other times an interval separated two adjacent apertures. One point of importance with regard to the position of the apertures is their limitation to three segments; whether the most anterior of these three segments marks the commencement of the proctodæum or not I am unable to say. Behind the last of the three segments in which they occur the limitations of the individual segments were obscured; they begin, therefore, in the last properly developed segment. It is well known that earthworms increase in length by the formation of new segments at the posterior end of the body; it is possible that, as the body increases in length, more of these proctodæal nephridia are developed.[1] In fig. 6 is illustrated the greater part of a single nephridial tube; but it by no means always happens that a tube has so long a course without branching. Very often I have noticed such a tube to divide into two shortly before its opening.

It has been already mentioned that the nephridia which open into the proctodæum communicate with the general nephridial system only at the septa. As may be seen in suitable sections, the surfaces of the septa are covered by innumerable tubes, which anastomose in every direction to form most complicated networks. I have never yet been able to show by a satisfactory preparation the actual form of the network in Perichæta or Acanthodrilus, or in any other form where a network must exist. Spencer (18) has figured

[1] In another specimen I found these nephridia opening into the gut, in the last seven segments at least.

the network of Megascolides, but in quite a diagrammatic way. I think, however, that the figure which I now give (fig. 7) of the network in Acanthodrilus is sufficient to convince anyone of the reality of its existence. Usually the network exhibited the characters shown in that figure; that is to say, the individuality of the several tubes was quite distinct in spite of their anastomoses in every direction and at such frequent intervals. Very often, however, the network exhibited the appearance shown in fig. 2; here it will be observed that the tubes are in very close approximation, so much so that the mass formed by their fusion presents the appearance of an irregular system of lacunæ enclosed within a definite wall. This character, it is perhaps worth remarking, belongs to the nephridia of several invertebrate groups.

In describing the nephridia of Acanthodrilus I stated that the tufts of successive segments were isolated from one another; this is, however, as shown in fig. 9, not always the case. In that figure, which represents a longitudinal section, it will be seen that the nephridia which pass up the septa do not always open at once into the lumen of the gut, but apparently become connected with nephridial tubes derived from other segments, and course along the walls of the gut; a communication is thus established between the nephridial networks of a number of segments. In fig. 8 is illustrated a portion of one of the septa which is invaded by the nephridial tubes on their way to the intestinal walls: it will be seen that in such places hardly any traces are left of the muscles of the septum; the septum appears to be entirely built up of a mass of frequently anastomosing nephridial tubes.

I have not yet examined a large series of earthworms with diffuse nephridia, with a view of finding out whether anal nephridia are present in other species. I believe, however, that they are not present in A. antarcticus—a near relative of A. multiporus.

It is of importance to find undoubted nephridia in a comparatively low type of Chætopod opening into the anal section

of the intestine. Such a discovery strengthens the current opinion that the respiratory trees of Bonellia are really of nephridial nature.

A remarkable fact about these nephridia in Acanthodrilus is the swollen terminal portion, which is lined by cells, and which has the characters (fig. 10) of a diverticulum of the gut. I have distinguished between the terminal section, which opens into the intestine and is lined with an epithelium, identical, so far as I can see, with the epithelium of the intestine, and the next section, the cells of which are rather different. If the nephridial tubes connecting this with the general nephridial system were to disappear, we should have the gut furnished with a series of tubular outgrowths ending bluntly. This is exactly what we meet with in the Tracheata, and even in some Crustacea—the Malpighian tubes; these structures have been compared with nephridia, particularly with the anal nephridia of the Gephyrea. It appears that the Malpighian tubes of Arthropods are formed by outgrowths of the proctodæum,[1] though in the Amphipods Spencer is inclined to regard them as appendages of the mid-gut. It is at least possible that we may trace the Malpighian tubes of Arthropods to these gut diverticula. Seeing how widely spread the Malpighian tubes are among Arthropods, it is not unreasonable to seek for their homologues in lower groups; and the Chætopods are the nearest group to which we can trace the Arthropods. It is true that Peripatus, which appears to stand somewhere near the base of the Tracheate series, has no Malpighian tubes; this seems to imply a great break between the anal nephridia of worms and the Malpighian tubes. It must be remembered, however, that Peripatus is furnished with paired nephridia, which structures are wanting in the Tracheata. Hence, there might possibly be no need for the extra nephridia opening into the extremity of the gut; the ordinary nephridia being absent

[1] Recently Mr. Wheeler (19) has shown that in Doryphora decemlineata the Malpighian tubes, when first formed, open on to the exterior; they are subsequently drawn in along with the proctodæal invagination of the ectoderm.

in the Tracheata, they have been functionally replaced by the somewhat metamorphosed equivalent of the anal nephridia.

It must be admitted, however, that more facts are required before the above remarks can be considered as anything more than a suggestion.

List of Literature referred to.

(1) Beddard, F. E.—"On the Anatomy of a Species of Diachæta," 'Quart. Journ. Micr. Sci.,' vol. xxxi, p. 159.

(2) Beddard, F. E.—"On the Structure of a New Genus of Lumbricidæ (Thamnodrilus Gulielmi)," 'Proc. Zool. Soc.,' 1887, p. 154.

(3) Beddard, F. E.—"On a Living Species of Perichæta, with Remarks on other Species of the Genus," 'Proc. Zool. Soc.,' 1890, p. 52.

(4) Beddard, F. E.—"On the Specific Characters and Structure of certain New Zealand Earthworms," 'Proc. Zool. Soc.,' 1885, p. 810.

(5) Beddard, F. E.—"Contributions to the Anatomy of Earthworms, with Descriptions of some New Species," 'Quart. Journ. Micr. Sci.,' vol. xxx, p. 421.

(6) Beddard, F. E.—"On the Structure of Three New Species of Earthworms, &c.," loc. cit., vol. xxix, p. 101.

(7) Beddard, F. E.—"On the Occurrence of Numerous Nephridia," &c., loc. cit., vol. xxviii, p. 397.

(8) Rosa, D.—'I Lumbricidi del Piemonte.'

(9) Rosa, D.—"Nuova Classificazione dei Terricoli," 'Boll. Mus. Comp. Zool. Torino,' vol. iii, No. 41.

(10) Rosa, D.—"I Lombrichi raccolti nell' Isola Nias," &c., 'Ann. Mus. civ. Genova,' vol. vii, 1889.

(11) Benham, W. B.—"Studies on Earthworms," No. I, 'Quart. Journ. Micr. Sci.,' vol. xxvi, p. 213.

(12) Horst, R.—"Midden Sumatra Expeditie," 'Natuul. Hist. xii Afdeeling. Vermes.'

(13) Perrier, E.—"Mémoires pour servir à l'histoire des Lombriciens terrestres," 'Nouv. Arch. Mus.,' t. viii, p. 142.

(14) Vaillant, L.—'Histoire naturelle des Annelés marins et d'eau douce, t. iii, Paris, 1889.

(15) Bourne, A. G.—"Contributions to the Anatomy of the Hirudinea," 'Quart. Journ. Micr. Sci.,' vol. xxiv, p. 419.

(16) Bergh, R. S.—"Zur Bildungsgeschichte der Exkretionsorgane bei Criodrilus," 'Arbeiten Zool.-Zoot. Inst. Würzburg,' Bd. viii, p. 223.

(17) Lang, S.—"Die Polycladen," in 'Naples Monographs.'

(18) Spencer, W. B.—"The Anatomy of Megascolides australis," 'Trans. Roy. Soc. Victoria,' vol. i, pt. i.

(19) Wheeler, W. W.—"The Embryology of Blatta germanica and Doryphora decemlineata," 'J. Morph.,' vol. iii, p. 291.

DESCRIPTION OF PLATES XXXIII and XXXIIIa,

Illustrating Mr. Frank E. Beddard's paper "On the Structure of a New Genus of Oligochæta (Deodrilus), and on the Presence of Anal Nephridia in Acanthodrilus."

Figs. 1—11.—Acanthodrilus multiporus and nephridia.

Fig. 1. Dorsal half of the posterior twenty or thirty segments of Acanthodrilus multiporus, enlarged to twice the natural size.

Fig. 2. Part of a network of nephridia. The fusion of the tubules is so complete as to produce the impression of a system of lacunar spaces.

Fig. 3. Connective tissue from outer coat of rectum. *n*. Nuclei. *v*. Spaces.

Fig. 4. A portion of connective-tissue sheath of rectum, with contained nephridial tubes. *m*. Muscular fibres. *v*. Spaces. *bl*. Blood-vessels. *n*. Small tubule apparently contained in a larger one.

Fig. 5. Part of a transverse section through rectum. *ep*. Lining epithelium. *n*. Nephridial tubules in connective-tissue sheath.

Fig. 6. Part of Fig. 5, more highly magnified to illustrate structure of different regions of anal nephridia, *N*., *N'n*.

Fig. 7. Network of tubules lying in and upon septum. *a*. Muscular fibre. *n*. Walls of nephridium.

Fig. 8. Mass of tubules passing up septa, the relations of which are shown in Fig. 9. *bl*. Blood-vessels. *a*, *b*, *c*, *d*. Nephridial tubes.

Fig. 9. Longitudinal section through a portion of rectal wall. *o*. Orifice of anal nephridium. *sp*. Intersegmental septum.

Fig. 10. Section through point quite close to opening of nephridium into rectum. *N*. Nephridium. *E*. Epithelium of rectum continuous with nephridium.

Fig. 11. Diagrammatic transverse section of a portion of posterior extremity of body, to show relations of anal nephridia. *n*. Their rectal orifices. *o*. External orifices. *f*. Funnels.

FIGS. 12—14.—Deodrilus.

Fig. 12. Ventral view of anterior segments. VI. Sixth segment, the first setigerous segment. *p*. Genital papilla between Segments 11/12. *cli*. Clitellum. ♂ sperm-duct orifice on 18th segment.

Fig. 13. Dissection of a portion of the body, to show the position and appearance of the calciferous glands, *ca*. *d*. Dorsal vessel. *æ*. Œsophagus.

Fig. 14. Diagrammatic longitudinal section, to show position of various parts of the alimentary tract. *g*. Gizzard. *ca*. Calciferous glands. The roman numerals refer to the segments.

PLATE XXXIIIA.

Deodrilus.

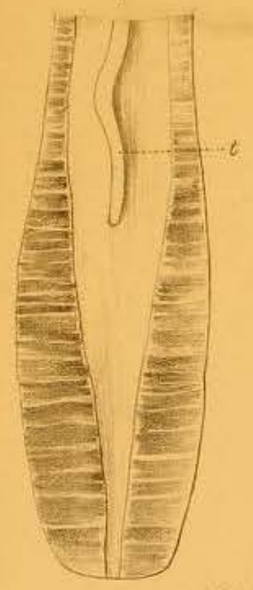
Figs. 15, 16. Penial seta, with chitinous sheath.

Fig. 17. One of the pairs of hearts (*h*.), with their connection with the dorsal (*d*.) and ventral (*v*.) vessel. *æs*. Œsophagus.

Fig. 18. Setæ of body.

Fig. 19. Two segments dissected to show spermatheca (*Sp*.^{1}, *Sp*.^{2}). *n*. Nerve-cord. *v*. Ventral blood-vessel. *l*. Lateral blood-vessel. *o*. Orifice of spermatheca. *m*. Intersegmental septum.

Fig. 1.



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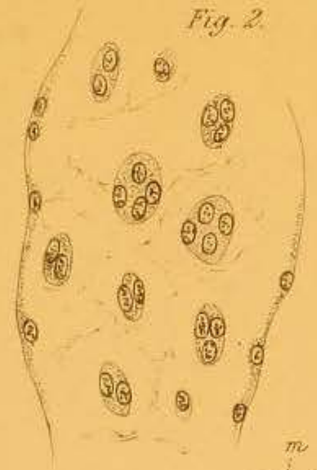

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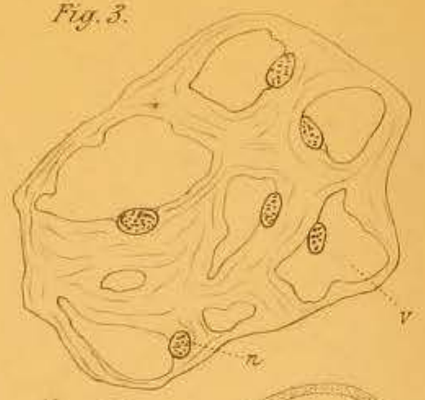

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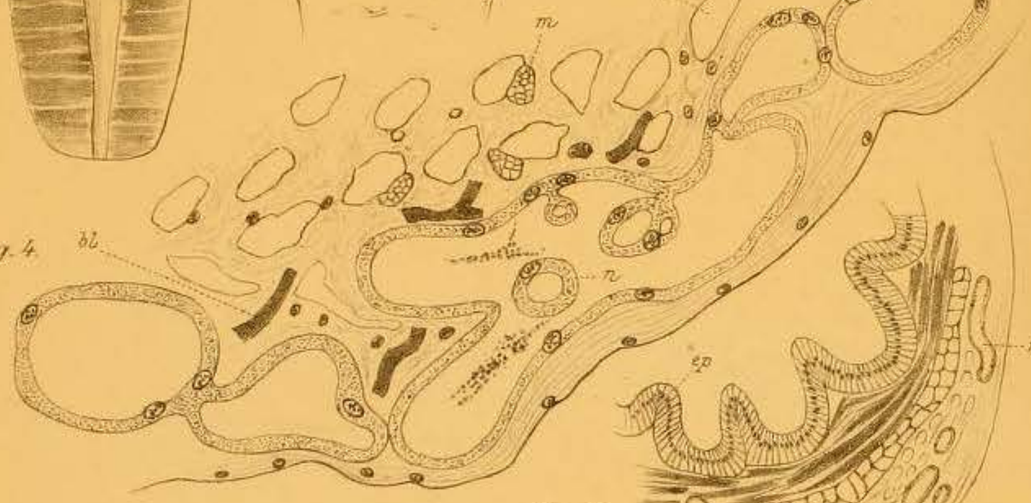

Fig. 5.

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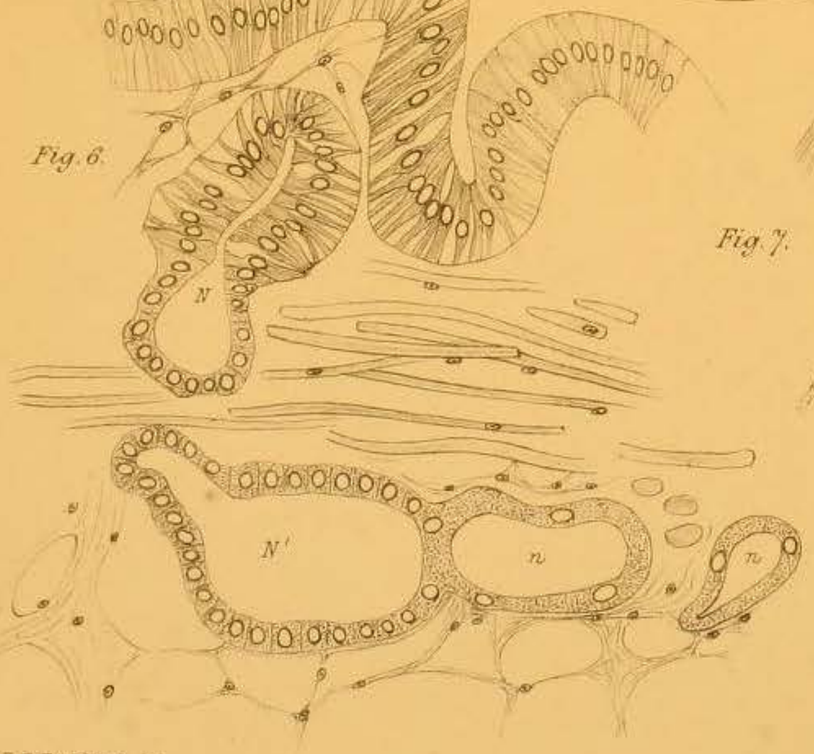

Fig. 7.

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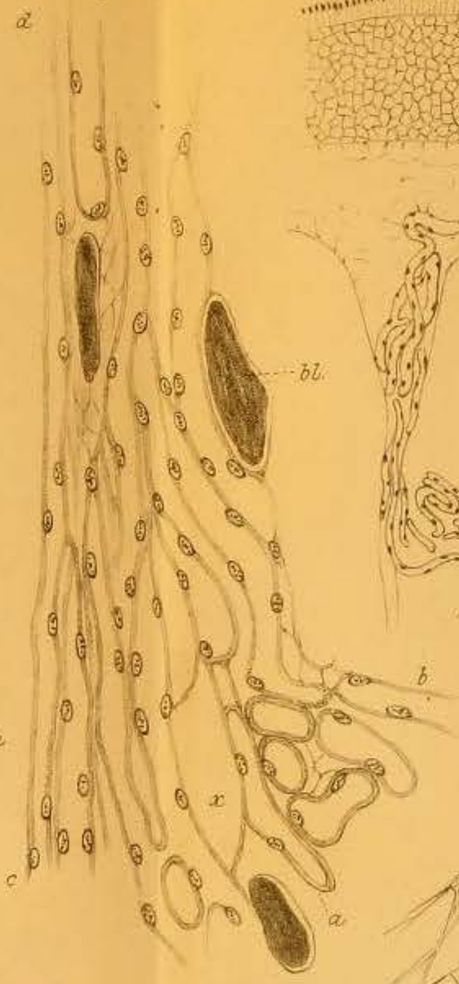

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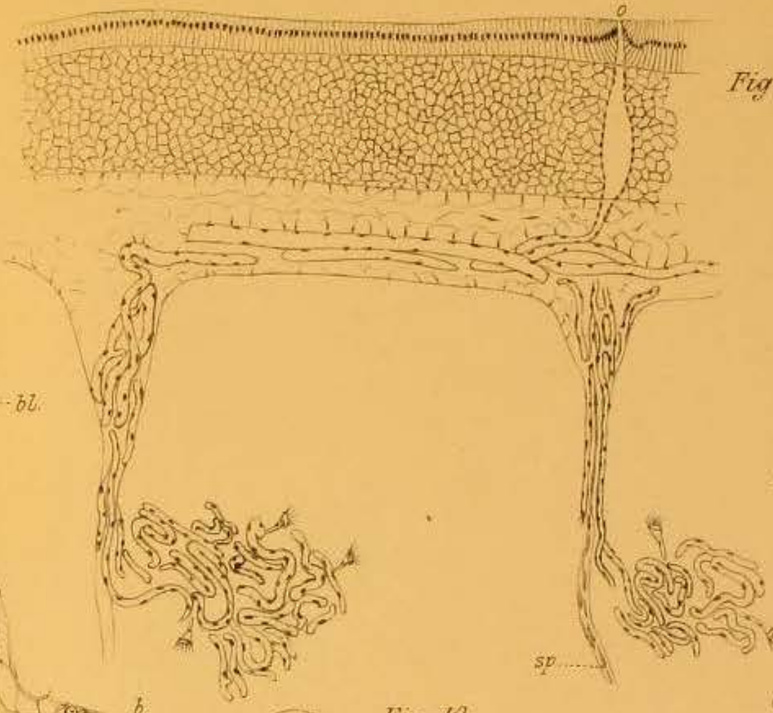

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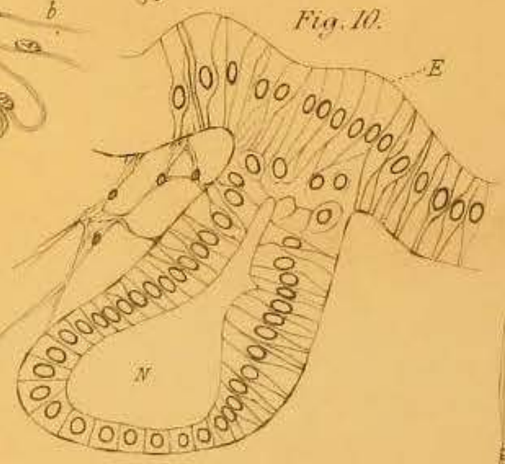

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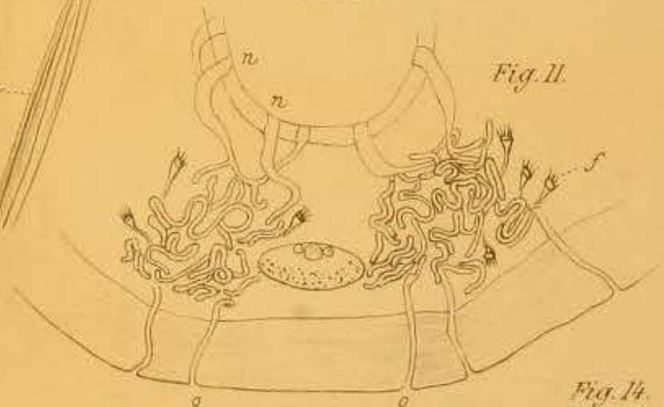

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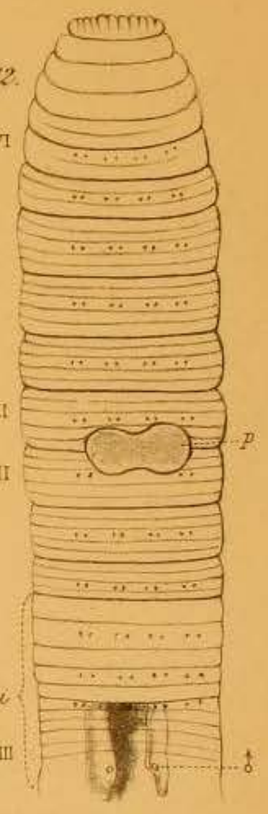

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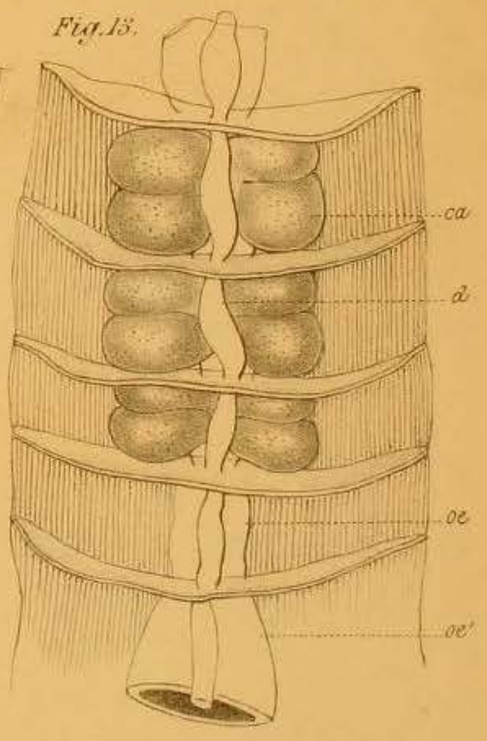

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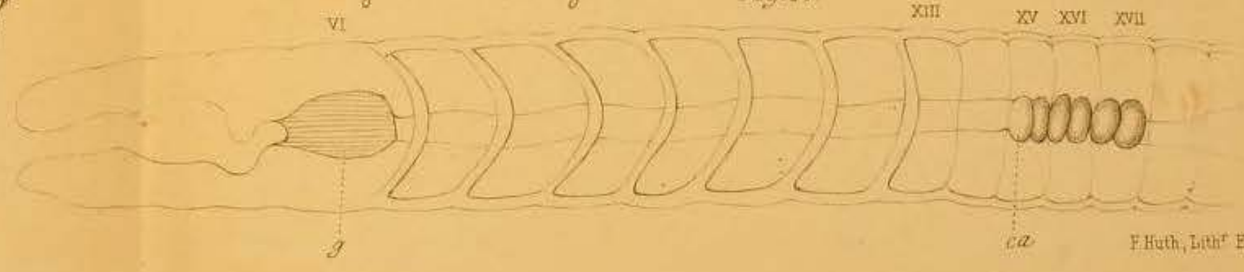

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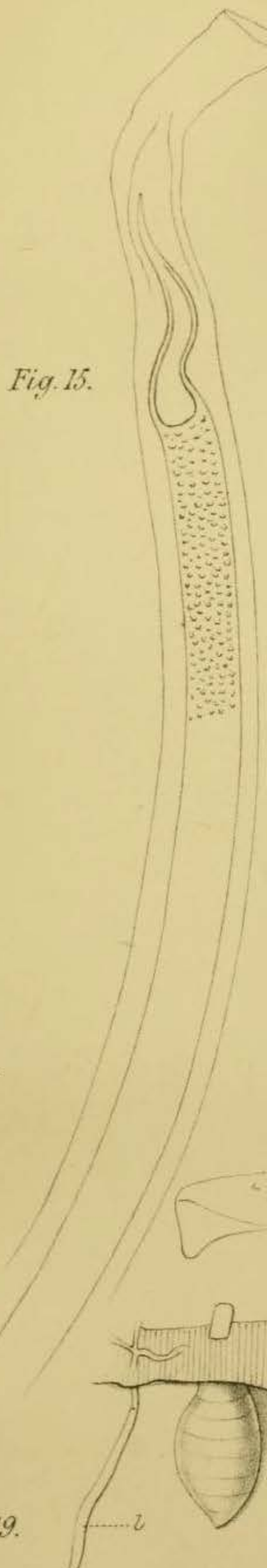
Fig. 15.



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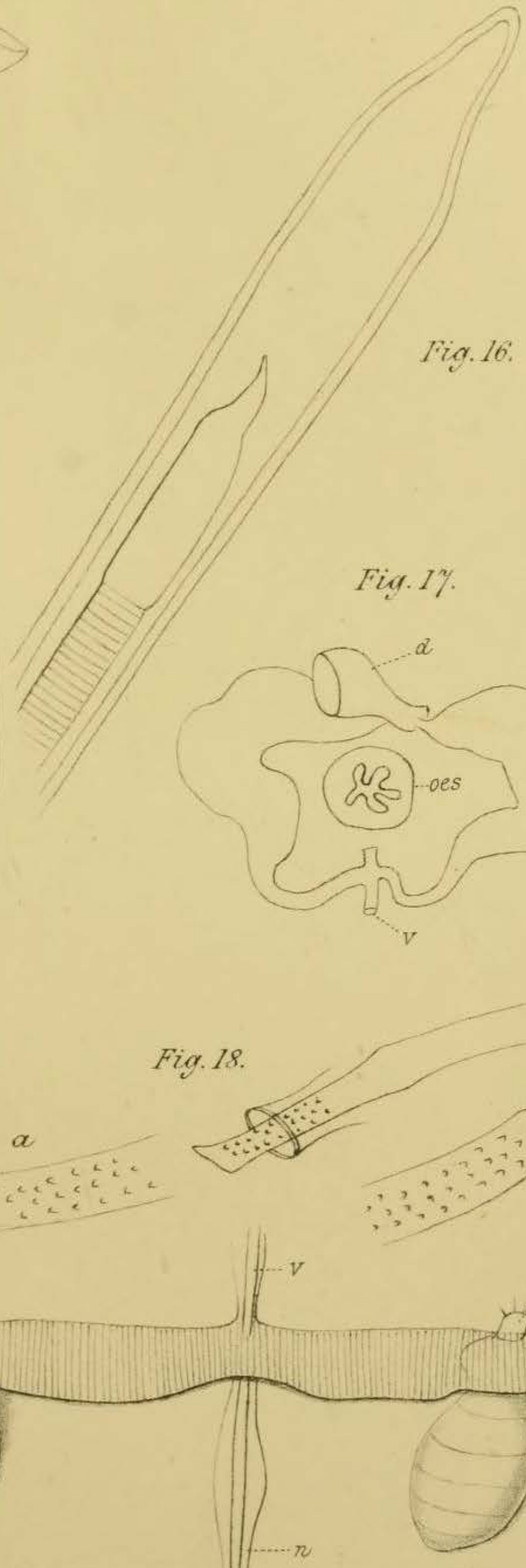
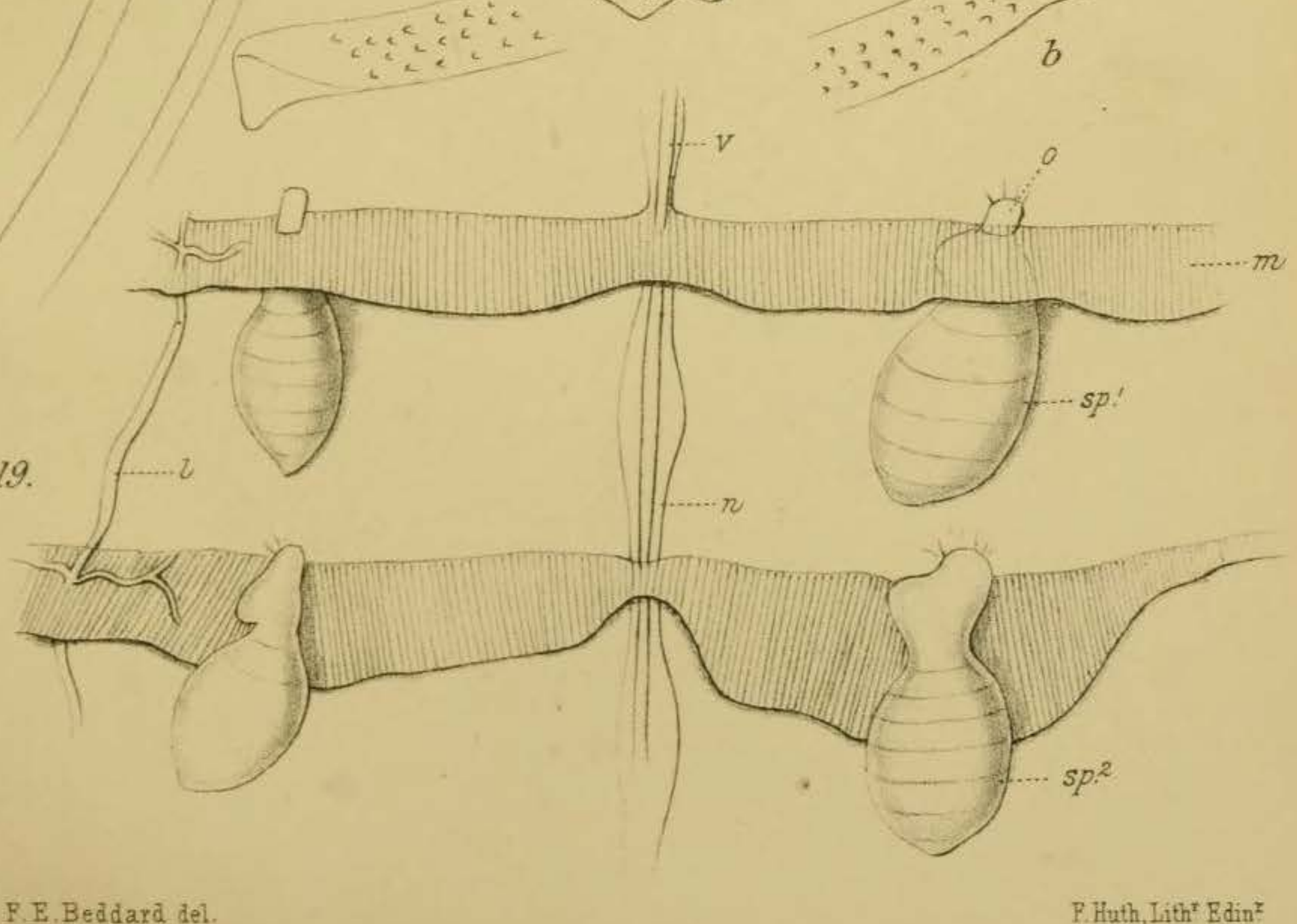


Fig. 17.

Fig. 18.

Fig. 19.



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