

Studies on Earthworms.  
No. III. *Criodrilus lacuum*, Hoffmeister.

By

**William Blaxland Benham, B.Sc.,**  
Demonstrator in the Zoological Laboratory of University College, London.

---

With Plate XXXVIII, figs. 9 to 19.

---

THANKS to the kindness of Dr. Örley, who, at Professor Ray Lankester's request, sent him a bottle containing a large number of *Criodrilus* preserved in spirit, and including both sexually mature and young specimens, as well as cocoons, I have been enabled to make a study of this interesting worm. The specimens are all in a good state of preservation, and I have been able to add several new facts concerning its anatomy. This is the first time that figures illustrating the general anatomy of *Criodrilus* have been published. Hoffmeister<sup>1</sup> gives a coloured figure of the worm, and of the cocoon, showing their natural size and appearance, but with no details as to setæ, pores, &c.; Vejdovsky<sup>2</sup> has already published excellent figures of various portions or organs of the worm; e. g. the ovary, nephridial funnel, setæ, transverse section of the body, so that I have not repeated these. Dr. Örley<sup>3</sup> added drawings of the prostomium, as well as of that of another worm which he described as *Criodrilus dubiosus*; but in his paper, published in the present number of this Journal, he makes no

<sup>1</sup> 'Die bis jetzt bekannt. Art. aus d. Fam. d. Regenwürmer,' Brunswick, 1845.

<sup>2</sup> 'Systeme und Morph. d. Oligochæten,' Prag., 1884.

<sup>3</sup> 'Mathemat. u. Termeszt. tudományi Közlemenyek,' Budapest, Bd. 16, 1881.

reference to this worm. He, however, mentions *Allolobophora dubiosa* as occurring with *C. lacuum*, so that, presumably, they are one and the same animal. But with all these figures no general view of the worm has been given.

My thanks are due to Professor Ray Lankester, not only for these worms, but also for allowing me to translate Dr. Örley's paper, so that I could corroborate or comment on his observations, and fill in details which he has left untouched. I am quite aware that a great deal more still remains to be done in reference to the anatomy and histology of *Criodrilus*, but I think the following, taken with the description of the previous observers, forms a fairly complete account of its anatomy.

**External Characters.**—I have nothing to add to Örley's statements as to the length and number of somites of the worm; my specimens are all preserved in strong spirit, and are therefore greatly contracted; they are much coiled and twisted and had to be soaked in weak alcohol before they could be conveniently dissected. A deep groove traverses the dorsal surface posterior to somite  $\text{L}$ ; the ventral surface is rounded, and the sides are more or less vertical (Pl. XXXVIII, fig. 12).

The prostomium is distinct, and its terminal pore has been figured by Vejdovsky (loc. cit., pl. xiii, fig. 12). The anterior somites are longer than the posterior ones, and are not so prominently quadrangular in section. On the ventral surface of somites IX, X, XI, XII, and XIII, there are prominent rounded papillæ, in which the ventral setæ are inserted.

The structure of the epidermis is to a certain extent figured by Vejdovsky (loc. cit., pl. xiv, fig. 3). It consists of narrow columnar cells with oval nuclei; their inner ends seem to diverge and between them are seen small rounded cells with rounded nuclei (Pl. XXXVIII, fig. 17, *c.*), which Vejdovsky considers as young epiderm cells. Goblet cells are very rare; they are narrow cells filled with granular matter, with the protoplasm and nucleus at the inner ends. As the worm lives in water the necessity for secreting mucus would not be so great as in Earthworms, properly so-called, and hence the mucous cells are few and far between. The capillary loops of

the blood-vessels pass between the cells of the epidermis (fig. 17, *d*), as in the Leech, and as Beddard has shown to be the case in *Perionyx* and in *Perichæta*.

The longitudinal muscles are arranged irregularly, as in *Microchæta*, *Allolobophora*, and others. Connective tissue is abundant, and forms a fairly thick layer between the muscular layer and the coelomic epithelium.

Previous writers have denied the existence of a clitellum; even Örley, who expressly looked for it, says that he has found no trace of it; yet in all my specimens, which are sexually mature, a considerable difference in appearance is noticeable behind somite xv, and extending to about somite XLVII. The worm is here nearly cylindrical, though slightly concave on the ventral surface, where the intersegmental grooves are not distinctly marked, but tend to run into one another across the middle line as shown in fig. 10. The colour, at any rate in spirit specimens, is rather darker over the dorsal and lateral surfaces of this region than elsewhere. Noticing this, I cut a series of transverse sections through the body, and I then found that behind the somite xv the epidermis gradually changed its character.

In addition to the columnar cells forming the epidermis of the general surface, a layer of elongated, club-shaped cells, of various lengths, is present (fig. 18, *c*), so that the epidermis is here some four or five times deeper than elsewhere, and deeper at the sides than on the dorsal surface. These cells have a very similar appearance to those in the clitellum of *Lumbricus* and *Microchæta*, though they differ slightly in detail. Each cell is filled with numerous highly refracting, small spherical globules, and the protoplasm with the nucleus is confined, apparently, to the inner, swollen end of the cell. As the cells vary in length, the appearance presented is that of three or four layers of such cells, as in *Lumbricus*; but in the latter worm these club-shaped cells contain a granular substance, and the rounded, refracting globules are confined to narrow, elongated cells, intermediate in length between the club-shaped and columnar cells and which are absent in *Criodrilus*.

Another point of difference is presented in the absence of the strands of connective tissue, which in *Lumbricus* separate the club-shaped cells into more or less distinct groups. I think that there can be no doubt that the clitellum is present; but as it commences and ends gradually, and since, from Örley's remarks and from Hoffmeister's drawing, there is no difference in colour in the living worm, it may easily be overlooked in this condition.

The anus is situated quite dorsally (fig. 11), on an enlarged somite, which Vejdovsky considers as representing some seven or eight fused somites, as indicated by the ganglionic swellings figured in pl. x, fig. 21, of his work.

The pore of the sperm-duct is placed on a large hemispherical papilla, or swelling, on somite xv, between the ventral and dorsal setæ, which Örley speaks of as "der Hof," and which I have translated as "areola." It is, in the sexually mature worm, very conspicuous, and has caused, in spirit specimens, the lateral swelling shown in Pl. XXXVIII, figs. 9, 10.

The pore of the oviduct is similarly placed in somite xiv, but on a much less prominent papilla. Both these pores are visible from the side (fig. 13); and near them are usually one or more white spermatophores. These are fully described in the preceding paper, but whereas Örley states that they are generally fixed close to the ventral setæ, the specimens examined by me show them nearer the dorsal setæ; at the same time I do not intend by this, nor by my figure, that it should be inferred that Örley is in error: he has had much greater opportunity for observation than I have, and my figure was drawn some weeks before I saw his paper.

I have been unable to see the nephridia pores, and there are no dorsal pores.

The four couples of setæ are set at the corners of the animal, as shown in fig. 11, and are perfectly evident throughout the body, including the clitellum. They are usually broken off short, so that I was unable to extract them; but in sections they are seen to have the ordinary shape (Vejdovsky, pl. xiii, fig. 13).

**Internal anatomy.**—The alimentary tract differs from

that of other earth-worms, with the exception of *Pontodrilus*,<sup>1</sup> in the absence of a gizzard.

The pharynx extends to the hinder boundary of somite iv (fig. 14), the walls are very muscular, and the usual radiating muscles pass to the body wall, some going as far back as somite vi. In transverse sections I found numerous glandular-looking cells amongst the muscles of the dorsal and lateral wall, but I was unable to find any duct leading to the lumen of the pharynx. There are similar groups of cells in the anterior somites, through which the œsophagus passes; these lie on each side of the subintestinal blood-vessel, but I could find no duct. The œsophagus is a narrow, simple tube, the walls of which are fairly thick and very vascular. In somite XIII the œsophagus enlarges, and in somites XIV to XVIII the diameter is some three or four times greater than in front. This "crop" has a whiter appearance, due to its thicker muscular walls, than the rest of the œsophagus; it is deeply constricted as it passes through the septa, and the wall is greatly folded internally. I almost expected to find that this was a gizzard, but the structure is quite the same as that of the œsophagus. In the nineteenth somite the crop narrows and becomes the intestine, the walls of which are fairly thin, so that the dark food-material is seen through.

Vejdovsky states that there is no typhlosole, but on slitting open the intestine along one side, and examining its interior, a moderate-sized typhlosole is seen on the dorsal wall. Series of sections confirmed this observation, and showed that the epithelium covering this in-pushed dorsal wall differs somewhat from the rest of the lining in that the cells are here longer and more regular in size. The typhlosole then is present, and in it a small typhlosolar vessel or irregular blood space, into which vessels from the intestine wall enter, and from which small vessels pass vertically into the dorsal blood trunk, just as is the case with *Lumbricus*. How far back the typhlosole extends I am unable to say.

<sup>1</sup> Perrier, "Études sur l'organisation des Lomb. terrestres," 'Arch. de Zool. Exper. et Gen.,' ix, 1881.

The absence of a gizzard, both in *Criodrilus* and in *Pontodrilus*, is probably related to the soft nature of their food-material. Both are aquatic in habit. *Pontodrilus*, as Perrier tells us, lives on the seashore, and its food consists of decaying vegetable matter thrown up by the sea. *Criodrilus* lives entirely in the water, and obtains its food, according to Örley, by swallowing the mud which contains decomposing vegetable matter. In both cases the food is soft, and already more or less finely divided, and can be easily digested, so that the necessity for a gizzard does not exist: in *Lumbricus* and other worms, however, which live on land and burrow and swallow the hard soil, some crushing apparatus is needed before the digestive fluid secreted by the wall of the intestine can act on the food.

The vascular system I have not traced to any extent. The dorsal blood-trunk is large, and has the usual ampullate appearance up to somite xv. In the next preceding somite it is bent slightly to one side, and gradually gets narrower till it divides up on the wall of the pharynx. In each of the somites VII to XI a pair of large and long moniliform hearts unite the dorsal to the ventral trunk; and there are lateral vessels in each of the somites posterior to the hearts.

In the neighbourhood of the anus the dorsal trunk divides into two (Vejdovsky; pl. xiv). A subneural vessel is present and a typhlosolar vessel, but neither latero-neural nor intestino-tegumentary vessels exist.

The nervous system presents no points of difference from the usual arrangement. The three "great fibres" are present.

The nephridia are not present in front of somite XIII. A series of sections confirmed the results derived from dissection. In and behind this somite they are large and fairly conspicuous organs, having a slight muscular vesicular portion. Vejdovsky states that they open exteriorly in front of the ventral setæ: he also figures a nephridial funnel (pl. xiii, 21), which somewhat resembles that of *Lumbricus*.

*Pontodrilus* agrees with *Criodrilus* in that there are no

nephridia in the anterior somites, the first nephridium being apparently in somite xiv, so that both these approach the *Limicolæ* in having no nephridia in those somites in which the spermathecae and ciliated rosettes lie, though they are present in the same somites with the oviduct and the posterior part of the sperm-duct.

The Genital Organs.—I have succeeded in finding all the usual organs connected with the genital apparatus, with the exception of spermathecae. The seminal reservoirs or sperm sacs are constructed on the plan of *Allolobophora*, and not on that of *Lumbricus*, as Örley seems to indicate, since there is no median portion connecting the sacs below the intestine (fig. 15). The worms which I dissected are sexually mature, one of them having spermatophores attached to somite xiv. There are four pairs of pouches, as in *Allolobophora*,<sup>1</sup> one on each side of each of the somites ix, x, xi, and xii; they vary in size in these somites, and in different individuals. Each is an irregular loose mass, which is easily torn on opening the worm, and in sections the lobation is seen to be carried to a great extent, the cavity of the sac being subdivided by long, narrow inpushings of the wall of the sac, whilst loose separate masses of developing spermatozoa are seen in the somites in which the reservoirs lie. Those in somites ix and x are formed as anteriorly directed saclike outpushings of the hinder septa of these somites, whilst those in somites xi and xii are posterior outgrowths of the anterior septa of these somites. Each is connected to a septum by a short pedicle (Pl. XXXVIII, fig. 15, e<sup>1</sup> to e<sup>4</sup>).

The testes (which Örley states lie in somites xi and xii) are in reality in somites x and xi, attached to the anterior septa, very close to the ventral body wall, near the nerve cord (fig. 15, a). They have a digitate form, like the testis of *Allolobophora turgida*, figured by Bergh.<sup>2</sup> (Pl. XXXVIII, fig. 16). Owing to their deep position they are very difficult to

<sup>1</sup> R. S. Bergh, "Untersuch. über d. Bau u. d. Entwickl. d. Geschlechtsorgane d. Regenwürmer," 'Zeit. für wiss. Zool,' 1886, p. 303.

<sup>2</sup> Ibid., fig. 1.

find at first, but my dissections are confirmed by transverse sections.

Close behind each testis is a ciliated rosette, lying, therefore, in somites x and xi, and close to the posterior septum of the somite. (Örley wrongly states that they are attached to the anterior septum of somites xi and xii, into which they project.)

The sperm-ducts from the two ciliated rosettes of one side unite at the level of the septum behind somite xi, and the single duct passes to somite xv, embedded in the connective tissue which exists between the coelomic epithelium and the longitudinal muscles of the body wall; hence it is practically impossible to trace it except by means of sections, unless it happen to be filled with spermatozoa, when it will appear whiter than the surrounding tissue. In somite xv is a large and conspicuous hemispherical gland, which may be called a prostate; the sperm-duct passes to the dorsal surface of this gland, dips down through its mass and opens to the exterior by the pore mentioned above, which is situated on a prominent rounded papilla, which seems to be merely the outer half of the prostate. This gland itself consists of cells similar to those forming the epidermis of the clitellum, and quite continuous with them; the muscular layers of the body wall are here thin, and pass over the inner surface of the prostate, so that the gland appears to be formed merely by an hemispherical thickening of the epidermis over this area.

The ovary is a flattened rounded disc attached to the anterior septum of somite xiii, close to the nerve cord (fig. 15, f). It resembles the ovary of *Perichæta* in shape, and is without the tail-like prolongation of the ovary of *Lumbricus* (fig. 19). It is figured in Vejdovsky's work,<sup>1</sup> but I have added a figure here, as he does not show the delicate membrane surrounding the organ.

The ovisac (which seems to be a better name than Bergh's "receptaculum ovarum," since the word "receptaculum" has been applied to a spermatheca) is a botryoidal sac-like

<sup>1</sup> Loc. cit., pl. xiii, fig. 23.

protrusion of the posterior septum of somite XIII, and thus lies in somite XIV. It is filled with ripe ova and has a goodly supply of blood capillaries on its wall. It is very conspicuous in the specimens dissected by me, much more so than the ovary, for which I should probably have mistaken it had not Bergh's paper appeared;<sup>1</sup> and it is curious that Örley makes no mention of it.

The funnel of the oviduct (fig. 15, *g*) projects into somite XIII, close to the point where the ovisac is attached; and the edge of the funnel is more prominent than is usual. The external pore has already been mentioned, as being on somite XIV (fig. 10, *c*).

Örley states that the spermathecae "appear to open to the exterior between the somites IX and X, and X and XI." I can find no trace of spermathecae, though I have searched for them in some half a dozen specimens, of various stages of maturity; nor is any trace of them presented in a series of sections through this region of the body. I must therefore conclude that this is an error of observation on his part; he says no more of them than the above quotation. Can he have mistaken the ciliated rosettes for these organs, and mistaken the testes for the rosettes? It seems to me quite probable from his description of the relation of these structures that such is the case; a portion of a ciliated rosette, removed, teased, and examined, would show mature spermatozoa, which might lead an observer to conclude that he was dealing with a spermatheca. Again, the shape of the testes, as seen with a lens, might without difficulty be mistaken for ciliated rosettes, which he places in the position occupied by the testes, though he has placed these in the wrong somites.

The cocoon and spermatophore are so fully described and figured by Örley, that I have nothing to add to his description of these structures.

His interesting observations on the habits of *Criodrillus*

<sup>1</sup> It is probable, as Mr. Beddard has remarked in a recent number of the 'Proc. Zool. Soc.,' that the structure figured and described by me as the ovary of *Microchaeta* (see this Journal, vols. xxvi and xxvii) is really the "ovisac;" and that I have overlooked the true gonad.

will, I hope, enable this form to be discovered in England and similar observations on the habits of other forms are a great desideratum.

Parasites of *Criodrilus*.—My attention was first attracted to certain curious elongated structures attached to the ovary, and I found them afterwards in various parts of the body. These are narrow bodies, about one tenth of an inch in length, and of a white colour (in spirit). Each is invested by a well-defined cuticle, which encloses a very granular dark medullary protoplasm, in which is a clearer space, probably the nucleus. The shape varies to a great extent; some consist of an elongated ovoid body drawn out at each end into a much narrower portion; others are just the reverse, consisting of two ovoid swellings connected by a narrower portion.

They are apparently Gregarinæ, which have been killed in various states of englenoid movement, such as is exhibited by *Monocystis lumbrici*; the worms had been killed in corrosive sublimate, judging from the white deposit on their surface, and this would cause the various states of movement to be fixed. At one end the cuticle is thickened and presents somewhat the appearance figured by Professor Lankester in vol. 3 of this Journal, Pl. VII, for *M. aphroditæ*.

---

#### EXPLANATION OF PLATE XXXVIII,

Illustrating Dr. Örley's Paper "Observations on *Criodrilus lacuum*," figs. 1 to 8, and Mr. Benham's Paper "Studies on Earthworms," figs. 9 to 19.

*Criodrilus lacuum*, Hoffmeister.

FIG. 1.—Cocoon of *Criodrilus lacuum*. Natural size. *a*. The end by which it is attached. *b*. The free end.

FIG. 2.—The attachable end more highly magnified. ( $\times 300$ .)

FIG. 3.—The free end more highly magnified. ( $\times 300$ )

FIG. 4.—A transverse section through the middle portion of the wall of the cocoon. ( $\times 300$ ) *a*. Outer layer. *b*. Middle layer. *c*. Inner layer.

FIG. 5.—A detached piece of the middle layer. ( $\times 300$ )

FIG. 6.—Strata of the inner layer. ( $\times 300$ )

FIG. 7.—A spermatophore. ( $\times 60$ )

FIG. 8.—Spermatozoa from the spermatophore. ( $\times 500$ )

FIG. 9.—The anterior extremity of the worm viewed from above. ( $\times 2$ , spirit specimen.) *a*. The prostomium. *b*. The dorsal setæ. *c*. Enlargement occupying somites XIV to XVIII, due to the large papillæ on the ventral surface. *d*. The clitellum. Behind somite XLV the quadrangular shape of the worm is shown.

FIG. 10.—The same worm from below. *a*. The prostomium. *b*. The mouth. *c*. The pore of the oviduct. *d*. The pore of the sperm-duct, situated on a large rounded swelling causing the enlargement in this region. *e*. The ventral setæ. *f*. The clitellum.

FIG. 11.—The last few somites of the body, showing:—*a*. The anus, situated dorsally. *b*. The region regarded by Vejdovsky as representing seven or eight fused somites.

FIG. 12.—A diagrammatic outline of a section through the body in the posterior region of the body, showing its quadrangular shape, with the dorsal setæ (*a*) and the ventral setæ (*b*) placed at the corners.

FIG. 13.—The side of the body, showing a spermatophore (*a*) attached to somite XIV. *b*. dorsal setæ. *c*. The ventral setæ. *d*. The sperm-pore, on its enlarged papilla. *e*. The ovipore.

FIG. 14.—General view of the anatomy of *Criodrillus* when opened in the usual way. ( $\times 2$ ) *a*. The pharynx. *b*. The œsophagus, swelling out at *c* to form a strong muscular crop. *d*. The intestine. *e*. The dorsal blood-vessel. *f*. *f*. The lateral hearts. *g*. *g*. The seminal reservoirs. *h*. The ovary. *k*. The ovisac (Bergh's "receptaculum ovarum"). *l*. The hemispherical glandular swelling or prostate around the terminal portion of the sperm-duct. *m*. Prostomium. *n*. Suprapharyngeal ganglia. *o*. The nephridia.

FIG. 15.—The genital organs of the left side greatly enlarged. A portion of the œsophagus is represented on the right of the figure. *a*, *a'*. The two testes. *b*, *b'*. The ciliated rosettes. *c*. The sperm-duct, which dips into the hemispherical prostate, *d*. The seminal reservoirs, *e*<sup>1</sup>, *e*<sup>2</sup>, *e*<sup>3</sup>, *e*<sup>4</sup>, are represented as relatively rather smaller than their true size; they are seen to be attached to the various septa. *f*. The ovary. The septum between the somites XIII and XIV is turned back so as to show the funnel of the oviduct, *g*, and the nephridial funnel, *l*. *h*. The ovisac. *k*. Nephridium.

FIG. 16.—A testis attached to the septum.

FIG. 17.—A small portion of a section through the epidermis, to show a capillary loop, *d*, passing between the columnar cells, *b*, and the small cells, *c*. *a*. The cuticle. *e*. The circular muscles.

FIG. 18.—A portion of the epidermis from somite XVIII, in order to show its clitellar structure. *a*. Cuticle. *b*. Columnar epithelial cells. *c*. Elongated club-shaped clitellar cells. *d*. Circular muscles.

FIG. 19.—An ovary.