Morphological and Biological Observations on Criodrilus lacuum, Hoffmeister.[1]

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With Plate XXXVIII, figs. 1 to 8.

In Vejdovsky's very complete work, 'System und Morphologie der Oligochæten,' Prag., 1884, which bears the character of a useful text-book on the morphology of the Oligochæta, I find only a scanty and incomplete account of the very interesting terricolous form, Criodrilus. On pages 16 and 58 he says: "Lage der Hoden, Eierstöcke, Samenleiter und Samentaschen, sowie Gurtels unbekannt." "Leider weiss Man sehr wenig von dem Leben eines so merkwürdigen Oligochæten." I think that these assertions by this well-known investigator justify me in publishing my own observations, incomplete though they are, relative to this worm.

Criodrilus lacuum was discovered by the well-known German zoologist Fritz Müller, in 1844, in the so-called "Tegel-see," near Berlin, and in the following year was described and figured by Hoffmeister.[2] It is almost incredible that fully thirty years should have elapsed since its discovery without its being found again. In 1876 this worm, found in a branch of the Danube near Linz, was again mentioned by

[1] Translated from the MS. by Wm. B. Benham, B.Sc.

[2] 'Die bis jetzt bekannten Arten aus der Fam. der Regenwürmer,' Brunswick, 1845, p. 41.

Hatschek[1] in his work, which furnishes contributions to the knowledge of the development and morphology of the Annelids.

Two years later Hatschek[2] recognised this worm, described its development, and provided Vejdovsky with material for his researches.[3]

Like Hatschek, I found Criodrilus in the neighbourhood of Buda-Pesth, and described it in a communication to the Hungarian Academy of Science.[4] Recently it was found by Rosa[5] in Italy, where it lives in the basin of the Po; somewhat earlier, too, it was noted by Panceri.[6]

I have no doubt that it exists in other parts of Europe, and that only its habit of concealing itself has placed it amongst rare and hitherto little known Earthworms. The following description ought to lead to the discovery and to the better knowledge of it.

Criodrilus lacuum. Hoffm.

1845. 'Die bis jetzt bekannten Arten d. Faun. d. Regenwürmer.'

A mudworm 4—12 cm. in length, and about 5—10 mm. in breadth, of a dark brown or greenish colour dorsally, with lighter, sometimes reddish colouration ventrally, with rusty-yellow areolæ, and milk-white, horn-like spermatophores near the male genital pore.

The body is quadrangular (though this is less noticeable

[1] 'Sitzungsber. der Kais. Akad. d. Wiss. in Wien,' Bd. 74, pp. 442—459.

[2] "Studien z. Entwick. d. Anneliden," 'Art. Zool. Inst. Wien,' Bd. 1.

[3] (*a*) 'Monograph. d. Enchytræiden,' Prag., 1879. (*b*) "Ueber der Entwick. des Herzens bei Criodrilus," 'Sitzungsb. k. böhm. ges. der Wiss.,' Prag., 1879. (*c*) 'System und Morphologie der Oligochæten,' Prag., 1884.

[4] (*a*) Amagyar. 'Oligochæt. Fauna,' Buda-Pesth, 1881. (*b*) 'Revisio et distributio specierum terricolarum regionis palæarcticæ,' Buda-Pesth, 1885.

[5] "Nota sui Lombrici del Veneto," 'Atti del R. Inst. Ven. di Sci. lett. ed. arti,' t. iv, s. vi.

[6] "Catalogo degli anellidi d'Italia," 'Atti d. Soc. Ital. d. Sci. Nat.,' 1875, xviii, p. 201.

anteriorly), gradually narrowing posteriorly, and ending in a pointed, yellowish, and often regenerated tail. When the worm is contracted the dorsal surface is usually depressed.

The number of somites is 200—250, or more. The somites are well defined, obscurely triannulated, and somewhat pressed together towards the tail. There is no dorsal pore. The last or anal somite is longer than those just in front. The anus itself is dorsal. There are rounded swellings on the somites X, XI, XII, and XIII.

The prostomium is moderately elongate and as long as the buccal somite, from which it is distinctly separated, without having a prolongation dorsally or a furrow ventrally (Hoffmeister's description—"Die Lippe ist mit dem Mundsegment verwachsen"—is incorrect). The prostomial pore is indistinct.

The four rows of setæ extend along the corners of the body. The distance between the rows is nearly equal. The setæ of each pair are somewhat apart; they are not prominent, and are slightly curved with rough ends.

The genital organs are on the same plan as in the Lumbricinæ, and present no peculiarities. The seminal reservoirs, with their lateral cæca, extend through the somites IX to XII. The true testes last for only a short period, during which they early break up into spermatogonia, so that I could recognise the two pairs, which lie in the somites XI and XII, only by the remnants. The two pairs of ciliated rosettes have an obscure plate-like structure; those of the first pair lie on the septum between the somites X and XI; those of the hinder pair on that between XI and XII, so that they project into the somites XI and XII respectively. The sperm ducts are spirally coiled at the base of the rosettes, unite with one another at the level of the somites XII and XIII, and thence a wider, tortuous, common canal extends on each side to the external pore on the ventral surface of somite XV, between the two couples of setæ. The termination is simple; without an atrium there is only a large gland ("vulva" of Hoffmeister), which probably serves for the construction of the cocoon. There are two pairs of

spermathecæ, which appear to open on the ventral surface between the somites IX, X and X, XI respectively.

The ovaries lie in somite XIII, one on each side of the ventral blood-vessel, attached to the hinder face of the septum between the somites XII and XIII; they contain many ripe eggs, which are chiefly found at the free end of the ovary. I have not found a pointed prolongation at the distal end of the ovary. The oviducts lie opposite each ovary between the somites XIII and XIV; their plate-like funnels project into the former somite, and their very diminutive canal opens to the exterior on the ventral surface of somite XIV.

I have not found separate yolk and cement glands. The horn-like spermatophores (Hoffmeister's "penis-formige Körpchen"), 6 to 8 mm. in length, are found in the neighbourhood of the male pore; their number is variable, and they are usually placed ventrally, although exceptionally they are to be met with on the dorsal surface. As a rule only two are situated on the neural side of somite XIII, close to the ventral setæ; though very often they are some distance from them. They are always in pairs, from two to six in number; only once have I found eight spermatophores, which were arranged irregularly round the male pore. These structures are products of copulation, and appear only during this operation; whether they are formed in the sperm-duct, or by the swellings in front of the genital pore, I am unable to say with certainty. The spermatophore, the shape of which is exactly rendered by fig. 7 (Pl. XXXVIII), consists of an homogeneous, hyaline, mucous substance, in which are embedded numerous fine, enlongated filaments. The lumen is fairly wide and deep, open at the end, and filled with bundles of spermatozoa, which are massed together in a spiral fashion. The fibres in the wall can scarcely be the product of the epiderm cells; moreover, the spermatophores vary so much in number and position that one can scarcely admit that they are formed by the swellings. I think it more likely that they are formed in the spermathecæ, there filled with spermatozoa, and that they are then attached in position during mutual copulation. The broad basal portion clings fast to the

cuticle, but never grows closely with it, so that the spermatophore very easily falls away. That the great areola round the male pore and the swelling in front of it play an important part in copulation cannot be doubted, for, after the laying of the eggs, these structures immediately decrease in size. In specimens which I collected at the end of June I could find neither the swellings nor the areola, and in some even the male pore also had become indistinct.

As to the time of sexual maturity of Criodrilus nothing positive is known. According to Vejdovsky the maturity seems to be attained in the months of June and July, since Hatschek found the cocoons with segmented eggs and embryos in the middle of June, whilst Hoffmeister mentions the worms furnished with "pseudo-spermatophores" at the beginning of July; Vejdovsky himself has not studied mature worms. My researches, however, extending over many years, show that the embryos escaping from the egg in summer may attain sexual maturity as early as February or March in the following year; indeed, in the most favorable seasons copulation may even take place in these months. Copulation and egg laying take place almost certainly in June, since I have found at the beginning of July of this year no cocoons with embryos. The best sign of maturity are the large and very striking spermatophores, which are to be found regularly from March to the end of May, certainly not later. The embryos escape from the cocoons in May, June, and July; at the end of the latter month I have collected only empty egg cases. At first the young worms are to be found amongst the thick roots of aquatic plants, only later in the mud, where they pass the winter and attain maturity. The clitellum, so very characteristic of the Lumbricinæ, is, as Hoffmeister rightly insisted, absent. I have for many years collected these worms at all seasons, yet I have found no trace of a clitellum, nor of the so-called "tubercula pubertatis;" the great glandular areola of the male genital pore appears to replace the clitellum.

The egg cases of the Lumbricinæ are known as roundish-oval chitinous capsules with pointed appendages, and are

presumably secreted by the clitellum. The cocoons of the Criodrilidæ, however, are spindle-shaped, parchment like structures with a colour that changes; they are about 5 cm. in length, rapidly diminishing towards each end. One end, drawn out into strongly fibrous threads, serves for attachment to the roots, or more rarely to the leaves and branches of water plants; the other end truncated, with a dentate edge, allows the embryos to escape. As is the form, so also is the colour different. The perfectly newly laid cocoons are nearly transparent, horny yellow in colour, but after a time they become darker, and towards the time of hatching of the embryos they are blackish in colour. This change in colour, which reminds me of the egg cases of Shark embryos,[1] may here too be traced to chemical changes.

The substance of the egg cases is not wholly chitinous; at any rate a large portion is dissolved in caustic potash; on the contrary, a sort of coagulated yolk and mucus take a large share in their constitution. The substance itself is very easily wetted, so that liquids and gases can diffuse through it.

The inside is filled with a fluid albuminous substance, allied in density to white of egg; in this from eight to twenty eggs are embedded, and in it are found the remains of the substance of the spermatophores as well as innumerable spermatozoa, which are to be met with especially round the developing eggs; their appearance is reproduced in fig. 8, Pl. XXXVIII. The number of eggs is very variable; usually only one third of the fertilised eggs develop; the largest number of embryos in a cocoon was eight, the smallest two.

The structure of these egg cases is especially well shown, if freshly laid eggs, preserved in alcohol, are placed in water in order that they may swell up. When such cocoons are carefully examined the swollen part is found to be banded; these bands appear to correspond with the somites of the anterior part of the body. This correspondence, as well as the fibrous structure of the outermost layer (fig. 2) and the remains of the

[1] L. Örley, "Zur Physiol. der Haiembryonen," 'Termeszet. füzetek,' ix, 1885, Buda-Pesth.

spermatophores in the cocoon, allows one to suppose that the moulted skin of the anterior part of the body takes a share in the formation of the cocoon, just as in Lumbricinæ and Nephelidæ, the egg case probably owes its origin to the moulting of the clitellum. Since, however, the number of bands in this egg case exceeds twenty, it is probable that the somites lying behind the genital pores also take part in the formation of the cocoon.[1] The tough secretion which builds up the chief portion of the cocoon, is probably furnished by the large swellings around and in front of the genital pores, and by the inner lining of the sperm duct. The process of formation of these egg cases, which alone would lead to positive results, I have unfortunately been unable to watch. Worms which I kept in my aquarium always hid themselves under cover of the roots of Sium latifolium, so that I was unable to overlook their operations.

A transverse section through this cocoon shows three layers; an inner yellowish and homogeneous layer, an outer strongly fibrous, and a middle layer of interlaced strands (fig. 4). The fibrous layer is most easily seen at that end of the cocoon which is drawn out into threads (fig. 2), where they are collected together into strands and finally separate out into elastic fibres; the latter serve for attachment to aquatic plants. Towards the swollen portion the fibrous layer becomes thinner at the expense of the middle layer.

The middle layer (fig. 5) consists of innumerable interwoven bundles which are not separated into fibres. The network is densest below and becomes looser above. It looks so very much like a plant tissue, that a young botanist of this country at first disputed as to the substance of the tissue. Some thought it of vegetable origin.

The lowermost or basal layer is made up of very many extremely delicate strata (fig. 6); these show a striated structure, and contain here and there fibrous elements. This layer projects from the free end of the cocoon (fig. 3), is strongly folded, and serves to close the egg case.

[1] See the following paper, in which the Clitellum is described.—Translator.

The young are of a reddish colour, about 2—3 cm. in length, when they leave the cocoon. They escape from the free end of the egg case by the separation of the two "lips," which at first, owing to their elasticity, were closed.

Hatschek supposes a Criodrilus to lay several cocoons, because the number of worms was very small in comparison with the cases which he found. I placed a Criodrilus amongst the roots of Sium latifolium, and in a few days found two quite transparent, and therefore fresh, cocoons. It appears to me, therefore, that a Criodrilus will lay two cocoons, in correspondence with the number of the sperm ducts. It is natural that more cocoons than worms should be found, since empty cocoons appear throughout the year attached amongst the roots; one sometimes finds old, black, very much frayed cocoons in certain places by thousands; of freshly laid cocoons, on the contrary, I have never collected more than double the number relatively to the mature worms.

Habits. — In isolated branches of large rivers, e. g. the Danube, as well as in flowing streams with muddy beds, there are places where the bottom is very nitrogenous owing to the decomposition of organic matter. In such places there are usually many aquatic plants with dense roots, which (at any rate here in Buda-Pesth, in the streams flowing into the Danube) are met with in great abundance. Amongst these plants I found a very large quantity of Sium latifolium, L., the favourite plant of Criodrilus.

If these plants with their roots are taken out in the spring, and the "covert" carefully examined, one finds the long spindle-shaped cocoons and Criodrili engaged in egg-laying, so closely interlaced with the roots that they can only be separated with difficulty. The egg cases are at first sight so very like the Enteromorpha, that young botanists might dispute as to whether they are of vegetable or animal origin. It is only during the breeding season that the worms are to be found amongst the roots, where copulation and egg-laying takes place. After the completion of these operations they return to the mud, where their genital organs commence to

degenerate. I have never been able to study the copulation, though I have looked at many worms. The swellings, around and in front of the male genital pore, are, however, so very swollen during the breeding season, and secrete so much mucus, that I presume the copulation takes place as in the Lumbricinæ. The worms found in the mud are very active, they burrow deep into the mud; I have even met them at a clay bottom, wherever the penetration of the water through the deeper layers renders their passage possible. In very shallow water, areas regularly and finely perforated are to be seen at the sides and bottom of the channel, which disclose their presence; these perforated places can frequently be used as a guide to their discovery. They only live scattered over a territory: as they can swim in a peculiar serpentine way they wander to different places, and settle where the necessaries of their life are present. Their food consists of rotting and decaying vegetable matter, which they swallow mixed with mud. Their size varies according to their habitat and local circumstances, as the statements of other observers affirm. However, even under the same circumstances, very great differences in size exist, so that, I think, in the first place individuality, and in the second place environment must be considered as factors in their varying size.

In the economy of nature they appear to do good service by their destruction of organic matter; their fæces, as in the case of Earthworms in general, increases the goodness of the mud, as is proved by the settlement of many plants in the places where Criodrilus lives. The mud of such a bottom is very rich, and on the overflowing of the stream it will be carried over the fields where it is of further use for the nourishment of plants.

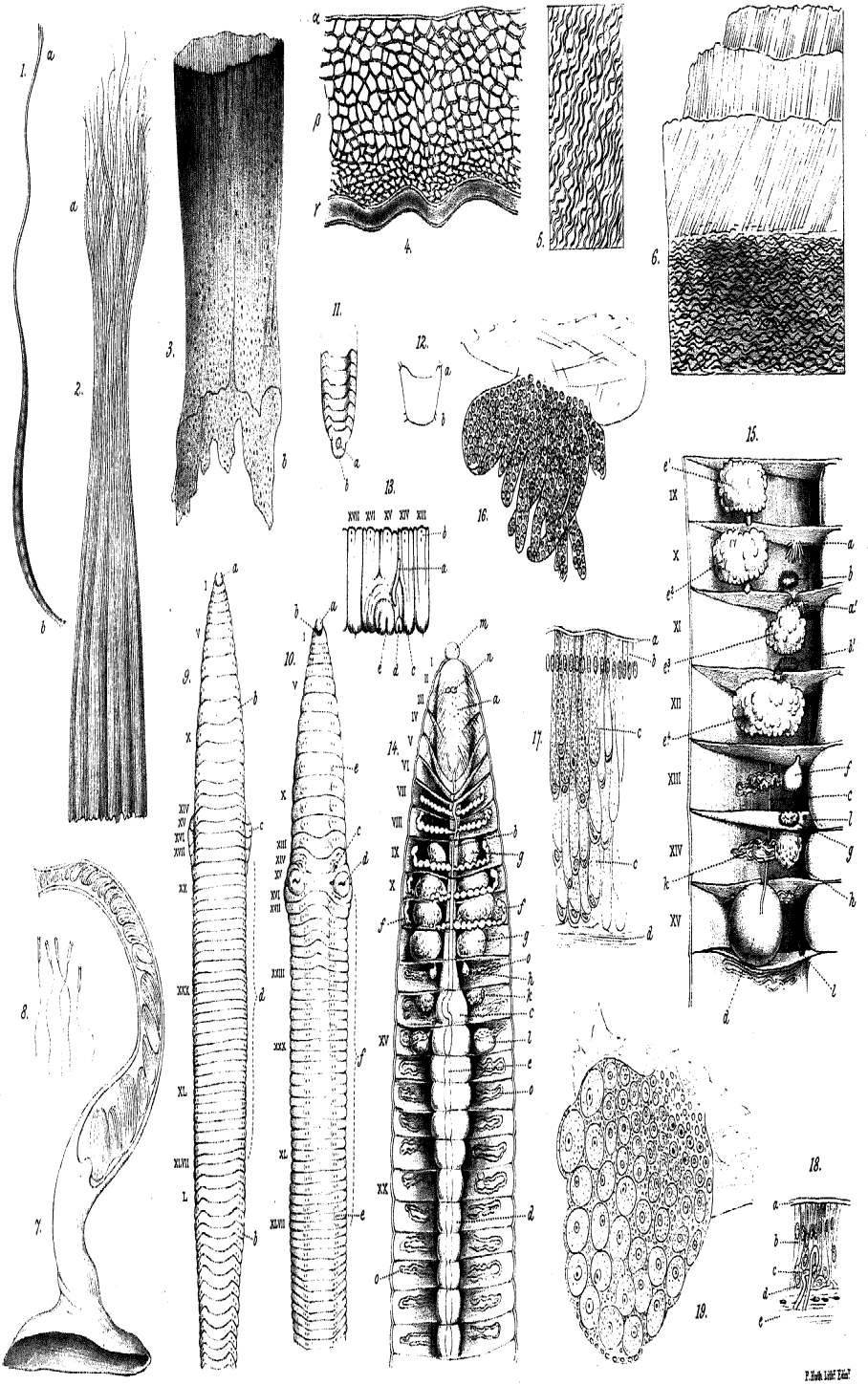
In winter these worms burrow very deep in the mud, so that one can dig them out only from very great depths. Their tenacity of life is great, yet after this season they are very much changed. In winter they soon perish in tanks with pure water, but in autumn they can be kept for a week. In the tanks they twine themselves into a knot and are then very difficult to separate. Their power of regeneration is astonishing. A

worm, cut through the middle, forms a new tail with shortened somites. In autumn more worms with regenerated tails are found than in the spring. Once I found, in October, out of fifty specimens, thirty with regenerated tails. The tail is very brittle, and the reason is very likely to be found in the irregular arrangement of the muscle-bundles.

In company with Criodrilus there lives a very interesting Earthworm, Allolobophora dubiosa, Örley, which has nearly the same habits.

Amongst the Hirudinea, species of Aulostoma and Nephelis are their greatest enemies; these swallow three or four Criodrili at a time.

[For the explanation of figures 1 to 8, Plate XXXVIII, illustrating Dr. Örley's paper, see p. 570.]



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