

XIV. "Preliminary Note on the Nephridia of a New Species of Earthworm." By FRANK E. BEDDARD, M.A., F.R.S. (Ed.)
Prosector to the Zoological Society. Communicated by
Professor E. RAY LANKESTER, M.A., LL.D., F.R.S. Received
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The specimens upon which the following observations are based I owe to the kindness of Prof. T. Jeffrey Parker, of Otago University; I received from him a large number of examples of an earthworm which appears to belong to Perrier's genus, *Acanthodrilus*,* though differing from any of the species of that genus as yet described. In the present paper I do not intend to describe the general anatomy of this worm, but to refer merely to the disposition of the "segmental organs" or nephridia, which present certain interesting peculiarities which have not, to my knowledge, been recorded in any other earthworm.

Each of the segments of the body in this species, instead of possessing only a single pair of nephridia, is furnished with four pairs, a single nephridium corresponding to each of the eight setæ; the setæ are not disposed in four series of pairs as in *Lumbricus*, but in eight longitudinal rows of a single seta, each separated by nearly equal intervals. On making a dissection of a large example (12 inches in length) it was quite easy to observe the two nephridia of the dorsally placed pair of setæ, and to trace by help of a lens the duct which perforates the body-wall in the immediate neighbourhood of the setæ; each of these nephridia appeared to be quite distinct from its neighbour; the nephridia belonging to each of the ventrally placed pair of setæ, on the other hand, form a continuous mass closely adherent to the intersegmental septum.

On making a series of transverse sections the appearances observed by a naked-eye inspection were confirmed; a nephridial tube perforates the body-wall and opens on to the exterior in the neighbourhood of each of the eight setæ. In every case the nephridium passes up close to the seta and is imbedded in the loose connective tissue which fills up the gap in the longitudinal muscular coat partly occupied by the seta and its special muscles. At the junction of the longitudinal and the outer, circular, muscular coat the tube bends at right angles and passes in a direction parallel to the fibres of the circular coat, but below it, *i.e.*, between the two muscular coats; this portion of the nephridial tube is considerably longer in the case of the extreme dorsal nephridium—about three times as long. The tube then passes in an oblique direction through the circular coat and opens on to the

* "Nouv. Arch. d. Muséum," t. viii.

xterior by a very minute orifice. Although the orifice is so small its presence is readily detected by the alteration in the character of the epidermic cells; the large, oval, glandular cells entirely disappear, and the narrow columnar cells become more closely packed together, and bend over towards each other on either side of the orifice, precisely as at the points where the setæ protrude on to the exterior of the body. The whole of the nephridium appears to be composed of a variously coiled tubule consisting of rows of cells placed end to end and perforated by the duct, as Claparède has described in *Lumbricus*; in the present species, however, unlike what is found in *Lumbricus*, the terminal portion of the nephridium does not differ at all from the rest, except at the extreme distal end, where it appears that the lumen ceases to be intracellular. This section of the tubule, which is very slightly wider than the rest, is surrounded by a flattened epithelium consisting of very small cells, and appears to be lined by a continuation of the chitinous cuticle which covers the exterior of the body; this last fact, however, I am unable to state with certainty, though it is probable for other reasons. I have observed the appearances described above in a very large number of sections taken from different regions of the body.

I propose at some future time to publish a fuller description, accompanied by figures, of these facts, which have some bearing upon the morphology of the Annelida.

It was supposed for a long time that only a single pair of nephridia were to be found in each segment of the segmented worms. Dr. Eisig,* however, found that in certain Polychætous Annelids belonging to the family Capitellidæ, there were frequently four, five, or even six pairs of nephridia in many of the segments of the body, and that the number of pairs increased from before backwards. In the present paper I have been able to extend Dr. Eisig's discovery to the Oligochæta, though the relation between the disposition of the nephridia in the two groups is not at all a close one.

In the Capitellidæ the nephridia of each segment are deposited in an oblique line passing from near the ventral parapodium of each side to near the nerve cord; their orifices, which, as in most Polychæta, are placed upon the summit of a tubercule, are grouped together in an irregular fashion near to the parapodium; moreover, the young Capitellidæ possess a *larval series* of nephridia—one to each segment—which are replaced by the nephridia of the adult. It is, therefore, a matter of great difficulty to institute a strict comparison between the nephridia of the *adult* Capitellidæ and those of *Acanthodrilus*; I can only call attention to the general fact that the *Oligochæta*, like the *Polychæta*, may possess more than a single pair of nephridia in each segment.

* "Mitth. Zool. Stat. Neapel," Bd. i.

A discussion of certain other questions in the morphology of earthworms, naturally arises out of the foregoing facts. Professor Lankester, in a memoir upon the anatomy of *Lumbricus*,* called attention to the fact that there is a constant and definite relation between the nephridial aperture on the one hand, and the apertures of the genital ducts on the other hand, to the setæ; the nephridia open close to the ventral pair of setæ, the genital ducts and copulatory pouches have a similar relation to the dorsal pair. Claparède had previously expressed the opinion that in the Limicolous Oligochæta, the ducts of the genital system were the modified representatives of the nephridia, basing this opinion on the general similarity of structure and position, and more especially upon the fact that nephridia are absent in those segments of the body which contain the genital ducts; he denied, however, that this comparison could be applied in the case of earthworms, since here the genital ducts coexist in the same segments with nephridia. Professor Lankester, in the paper just referred to, pointed out that Claparède's views could be extended to earthworms, if it were admitted that each segment of the body were typically furnished with two pairs of nephridia, one corresponding to each of the pairs of setæ. Professor Lankester supposed that in *Lumbricus* the copulatory pouches and genital ducts were the modified representatives of the second series of nephridia, which had disappeared elsewhere than in the genital segments. Certain facts in the anatomy of other genera of earthworms, made known by the researches of M. Perrier, appeared to lend very strong support to this hypothesis. M. Perrier† has described certain earthworms (*Acanthodrilus*, &c.) which agree with *Lumbricus* in that the nephridia open on to the exterior of the body by the ventral setæ; in others again (e.g. *Anteus*, *Rhinodrilus*) the nephridia are related to the dorsal pair of setæ; finally, in *Plutellus*,‡ there is an actual alternation in the position of the nephridial orifices, in some segments they open near to one of the dorsal pair of setæ, in others near to one of the ventral pair. All these facts seem to be best explained by supposing the typical presence of two series of nephridia, a dorsal and a ventral, one or other of which has partially or entirely disappeared; in *Lumbricus* the dorsal series has disappeared, in *Anteus* the ventral series; while in *Plutellus*, both dorsal and ventral series have partly persisted. Although this hypothesis serves to explain the series of facts which have been briefly stated above, M. Perrier has come to the conclusion that it cannot be adopted in the way that Lankester has suggested, inasmuch as there are reasons for disbelieving in any homology between the nephridia and genital ducts. If the orifices of

* "Quart. Journ. Micr. Sci.," 1865.

† "Nouv. Arch. d. Muséum," t. viii.

‡ "Arch. d. Zool. Exp.," t. ii.

the nephridia were always constant to a series of setæ different from that to which the orifices of the genital ducts belong—as in the case of *Lumbricus*—then it would be permissible to retain the hypothesis of two series of nephridia. Such, however, is not the case; in *Urochata* and in *Plutellus*, the orifices of the copulatory pouches coincide at the same seta as the orifices of the nephridia; and it also difficult to explain the fact that the vasa deferentia traverse several segments, all furnished with distinct nephridia, on their way to the exterior.

It appears to me that the coincidence of nephridium and copulatory pouch at the same series of setæ is not a serious objection to Professor Lankester's hypothesis. It is extremely possible that the copulatory pouch may be the equivalent of a diverticulum of the duct of the nephridium; such diverticula I have myself described in a large earthworm (*Microchæta*) from the Cape Colony in a paper read before the Zoological Society, and they exist elsewhere. In *Microchæta* there are no proper copulatory pouches; these structures appear to be functionally replaced in four segments of the body by several extremely minute cæcal pouches placed in the immediate neighbourhood of the nephridium of their segments. M. Perrier* has described in a species of *Perichæta* similar accessory pouches having a precisely similar relation to the copulatory pouches; and in my paper I have called attention to the great resemblance between the copulatory pouch of this *Perichæta* with its independent accessory pouches, and the nephridium of *Microchæta* with its large muscular diverticulum and the series of similar cæcal pouches. I have also illustrated the comparison by figures, which will be shortly published.

Whatever may be the value of M. Perrier's criticisms of Professor Lankester's hypothesis, it is quite clear now that there is no intrinsic improbability in this hypothesis. The new facts that have been brought forward in the present paper also serve to render intelligible certain other facts in the morphology of earthworms.

In his earliest paper on the anatomy of earthworms, M. Perrier adopted the hypothesis of two series of nephridia, one corresponding to each pair of setæ in those earthworms that are furnished with four pairs. In *Lumbricus* the two setæ of each pair are closely approximated, but in many other earthworms, as in the *Acanthodrilus*, which forms the subject of the present communication, the two setæ of each pair become widely separated, so that there are eight longitudinal series of a single seta each; in these cases it is important to know what becomes of the nephridial orifice; has it, in fact, any definite relation to one or other of the two setæ of the pair? M. Perrier has addressed himself to this question, and has recorded the fact that in *Anteus*, *Rhinodrilus*, and *Moniligaster*, where the ventral series of nephridia are alone present, their orifices are situated close to the

* "Nouv. Arch. d. Muséum," t. viii, Pl. IV, fig. 72.

outermost of the two setæ which compose the pair; in the genus *Titanus*, where the nephridial orifices are dorsal in position, they open close to the outermost of the two dorsal nephridia. There thus appears to be a constant relation between the nephridial apertures of both the dorsal and ventral series to the outermost seta of each pair. His investigations into the anatomy of *Plutellus* led M. Perrier to abandon this position. In *Plutellus* the setæ are arranged, as in the genera just referred to, in eight longitudinal rows, and it has been already stated that the nephridia themselves alternate from segment to segment, sometimes opening by one of the dorsal, at other times by one of the ventral setæ; there is, however, no constancy to any one in particular of the two setæ which compose the pair; occasionally the nephridial orifice will be found close to the outermost, and occasionally close to the innermost, of the two setæ of its pair. These facts are clearly not explicable by assuming the typical presence of two series of nephridia in earthworms, but they become perfectly clear and intelligible in the light of the facts that I have been able to bring forward in the present paper; in *Plutellus* there are the remains not only of two series of nephridia, but of four, each corresponding to one of the four rows of setæ of each half of the body.

We are therefore now in a position to extend Professor Lankester's hypothesis, and to assume *that to each seta, and not to each pair of setæ, corresponds a separate nephridium*. No doubt Professor Lankester's hypothesis is correct so far as it goes; it is very probable that when the two setæ of each pair come to be placed close together, one of the two nephridia disappears.

Another question raised by the foregoing facts concerns the general problems relating to the distribution of the setæ in earthworms; are we to regard the presence of four series of pairs of setæ as typical for earthworms, or is it possible that this condition has been arrived at by a process of reduction, the primitive condition being a complete ring of setæ round each segment, as is actually found in *Perichæta*?

There are a good many facts which appear to support the former alternative; (1) the undoubtedly close resemblance between the two pairs of setæ of an earthworm, and the dorsal and ventral parapodia of a Polychætous worm; (2) the fact that in the young *Perichæta* the setæ are by no means so numerous as in the adult; we owe this observation to M. Perrier, but unfortunately he has not recorded the exact number of setæ, and whether there was any real approximation to the quadriserial disposition.

Other facts point to the latter alternative. In *Urochæta* the setæ are disposed in eight longitudinal rows, but in the posterior part of the body the setæ do not exactly correspond in position in a series of segments; there is in fact a quincuncial arrangement; in the interval

between the setæ of a given segment are certain peculiar bodies having the appearance of unicellular glands, and surrounded by an inward prolongation of the cuticle. Quite similar structures have been met with by Vejdovsky in *Anachaeta*,* and in this worm *they replace the setæ*; there is therefore evidently some reason for supposing that *Urochaeta* has descended from ancestors in which there was a complete row of setæ round each segment.

M. Perrier is of opinion that the quadriserial arrangement referable to the parapodia of the Polychætous worm is the primitive arrangement, and that the condition found in *Perichaeta* may have been arrived at, first, by a separation of the setæ of each pair, and secondly, by the development of the secondary setæ ("*soies de remplacement*"), which might get to be placed alongside of the primary setæ and form new primary setæ.

It appears to me just as legitimate to suppose a process of reduction from a more generalised condition, and there is strong evidence that this *has* taken place in *Urochaeta*, and that the resemblance between the more common disposition of the setæ and the parapodia of the Polychætous worm is due to adaptive rather than to any genetic causes.

Such an hypothesis would fit in very well with the new facts recorded in the present paper, for I have been able to show that there is no connexion between the *pair* of setæ† and the nephridium, as between the parapodium and nephridium in the Polychæta, and that therefore, in so far as these facts have weight, the dorsal and ventral pairs of setæ do not correspond to the parapodia.

XV. "The Vortex Ring Theory of Gases. On the Law of the Distribution of Energy among the Molecules." By Professor J. J. THOMSON, B.A., F.R.S., Fellow and Lecturer of Trinity College, Cambridge. Received June 4, 1885.

[Publication deferred.]

* "Monographie der Enchytræiden," p. 21.

† It is worth recording the fact that in a species of *Acanthodrilus*, also from New Zealand, where the setæ are paired the nephridial orifice is not placed indefinitely in front of the pair, but has a distinct relation to *one* of the two setæ.

- XVI. "Contributions to the History of the Pleiocene and Pleistocene Deer. Part II. *Cervus Dawkinsi* (Newton) and *Alces latifrons* (Dawkins)." By W. BOYD DAWKINS, M.A., F.R.S., F.G.S., Professor of Geology and Palæontology in the Victoria University, Owens College, Manchester. Received June 17, 1885.

[Publication deferred.]

- XVII. "On Certain Definite Integrals. No. 13." By W. H. L. RUSSELL, A.B., F.R.S. Received June 18, 1885.

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- XVIII. "On Certain Definite Integrals. No. 14." By W. H. L. RUSSELL, A.B., F.R.S. Received June 18, 1885.

[Publication deferred.]

- XIX. "The History of the Kew Observatory." By R. H. SCOTT, M.A., F.R.S. Received June 18, 1885.

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Transactions.

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