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EDITED BY

E. RAY LANKESTER, M.A., LL.D., F.R.S.,

Fellow of Exeter College, Oxford, and Jodrell Professor of Zoology in University College, London;

WITH THE CO-OPERATION OF

W. T. THISELTON DYER, M.A., C.M.G., F.R.S.,

Assistant Director of the Royal Gardens, Kew;

E. KLEIN, M.D., F.R.S.,

Joint-Lecturer on General Anatomy and Physiology in the Medical School of St. Bartholomew's Hospital, London;

H. N. MOSELEY, M.A., LL.D., F.R.S.,

Linacre Professor of Human and Comparative Anatomy in the University of Oxford,

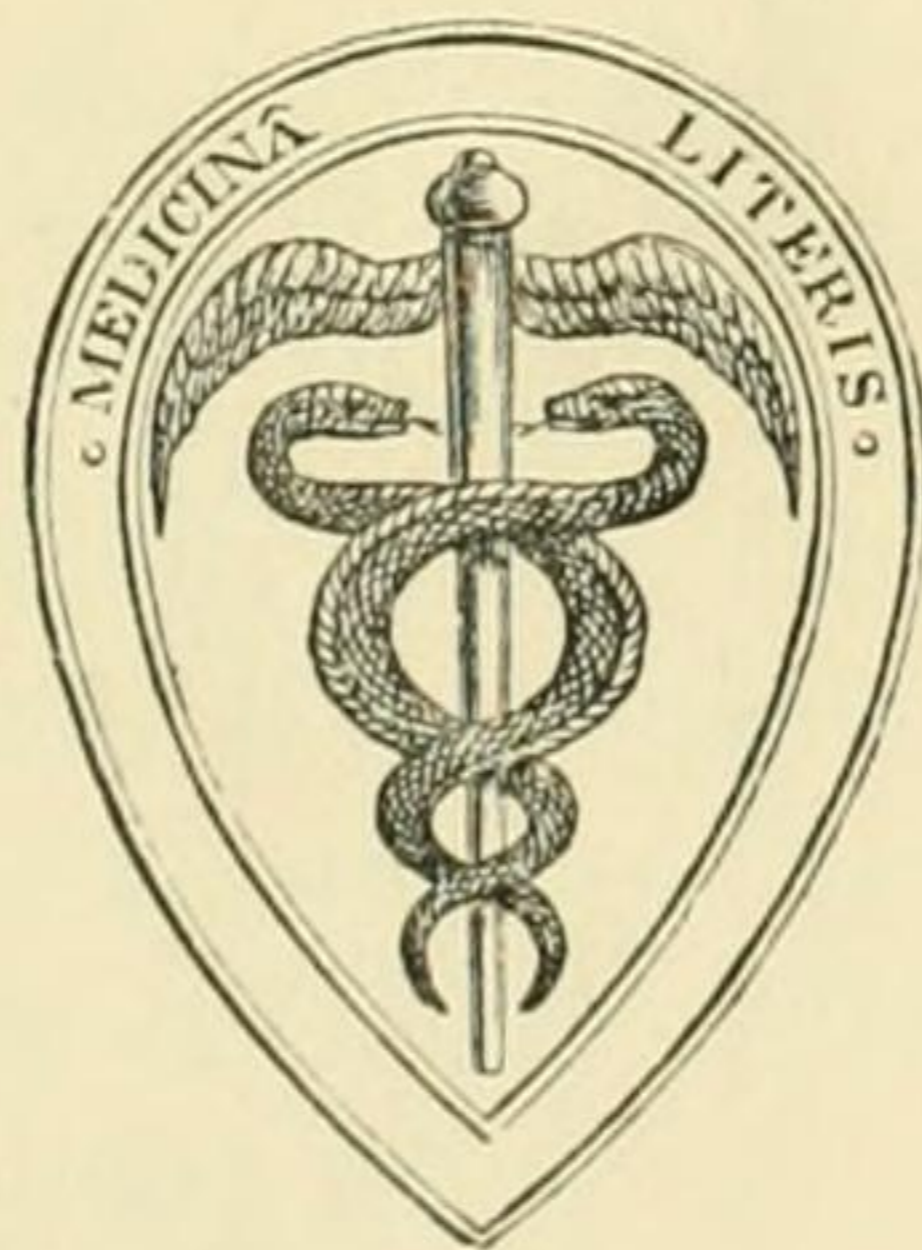
AND

ADAM SEDGWICK, M.A., F.R.S.,

Fellow and Assistant-Lecturer of Trinity College, Cambridge.

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Studies on Earthworms. No. II.

By

William Blaxland Benham, B.Sc.,

Demonstrator in the Zoological Laboratory of University College, London.

With Plates VIII and IX.

IN continuation of Part II of my previous paper on this subject,¹ I shall describe three new genera belonging to Perrier's group of *Intraclitelliani*. Although Beddard has shown² that the grouping of Earthworms according to the relative position of the male pore and the clitellum, does not hold good even within the limits of one genus, yet it is a convenient classification, and, I think, may be used at present till a more satisfactory system is introduced. The genus *Acanthodrilus* to which I refer is post-clitellian in most of its species, but Beddard describes *A. novæ-zelandiæ* and other species as having the male pore situated in the clitellum.

I have received all the worms which I am about to describe from Prof. Ray Lankester, who has for many years taken every opportunity of procuring exotic specimens. The new genera show interesting combinations in one worm of characters which have been regarded as of generic value for different worms: thus *Urobenus* possesses intestinal glands known hitherto only in *Urochæta*, and also cæca similar to those which are known only in *Perichæta*. Again *Trigaster* combines an alimentary tract somewhat like that of *Digaster*, with the four prostates and male pores of *Acanthodrilus*.

Since writing my previous paper on *Microchæta* I have

¹ This Journal, February, 1886, p. 213.

² 'Proc. Zool. Soc.,' 1885, p. 810.

received some more Earthworms from Professor Lankester which belong to this genus, but differ in several points from the species there described: to the new form I have given the specific name *Beddardi*, as it was he who gave the name of the genus to a worm described by Rapp¹ as *Lumbricus microchetus*. These worms were none of them in a good condition for histological study, so that many gaps will appear in the description of their minute structures.

Microchæta Beddardi, nov. sp.

These worms were sent to Professor Lankester from Natal by Mrs. Saunders. In a preserved condition they are dark coloured, with a slightly greenish tinge and with a brown clitellum; they are rather longer but narrower than a large-sized *Lumbricus agricola*, being 14 or 15 inches in length, and about $\frac{1}{4}$ inch in breadth; the number of somites, 365, is easily counted owing to the soft and extended condition of the worms. They are nearly cylindrical, slightly wider anteriorly than posteriorly, with an obtuse aural region.

The prostomium is represented by a portion separated from somite 1 by a shallow groove, and with its anterior free edge crenated (figs. 1 and 2).

In the clitellum the intersegmental grooves are less conspicuous than elsewhere, while the nephridiopores are much more evident. The extent of the clitellum varies slightly in the six specimens in my possession, but usually occupies somites x to xxii, and in one case somite xxiii is included. (M. Rappi has a clitellum extending through somites xiii to xxv.)

The somites iii to viii inclusive are biannulated, but the remaining somites of the worm are simple.

The setæ and nephridiopores have the same arrangement as in *M. Rappi*, *Bedd.*, but the relation between them is more clearly seen than in the previous species, as the setæ are extruded from the body, and the nephridiopores are now seen to be in a line with the lower setæ of the lateral couples.

There are no dorsal pores.

¹ 'Wurtemb. Naturwiss. Jahresb.,' vol. iv, 1848.

I could find no male pores, but, curiously enough, the pores of the oviduct are fairly evident. These are placed in the groove between somites XII and XIII, one on each side of the middle line. By means of a series of transverse sections I found they were the external openings of the funnel-shaped organ described and figured by me ("Studies on Earthworms," No. I, Pl. XVI, fig. 7) for *M. Rappi*, of the function of which I was then doubtful. I believe now that this organ is the oviduct, and that these pores are their apertures (Pl. VIII, fig. 3, *e*).

The pores of the spermathecæ differ in position from those of the former species. They lie in a line with the nephridiopores, usually one on each side, on the anterior edges of somites XI and XII; these pores I could see by the aid of a lens, after I had found the spermathecæ (fig. 3, *b*).

The Internal Anatomy.—The general anatomy agrees with that of *M. Rappi*, but one or two noteworthy differences are presented.

In the alimentary tract the only difference is in the shape and extent of the intestinal glands. In *M. Rappi*, the gland on each side has the appearance of a rounded swelling on the side of the intestine, which it partly covers dorsally, and into the lumen of which the cavity of the gland opens by a wide aperture. The gland occupies the whole length of somite IX, and only a small portion of it lies in the preceding somite (fig. 9). But in this new species the gland is bilobed, being nipped, as it were, by the septum, which divides it into two very nearly equal parts; the larger lobe lies in somite VIII, the smaller lobe in somite IX. Moreover the gland is greatly constricted off from the intestine (fig. 8) so that the communication between the two cavities is reduced to a small aperture.

The genital organs present several important differences. Instead of two pairs of seminal reservoirs and of ciliated rosettes, there is only one pair of each in this new species. The seminal reservoirs lie in somite X, and the ciliated rosettes in somite IX. In the three specimens opened the reservoirs are small, looser in structure, and more irregular than in *M. Rappi*; in one case only is the ciliated rosette not enclosed in

the reservoir. I think, therefore, that the worms are not quite genitally mature.

The ovaries have the same position as before,—on the posterior face of the anterior septum of somite XIII. On the opposite face of this septum, and lying therefore in the preceding somite, is the funnel of the oviduct; this is the organ marked “*x*” in the figures illustrating my paper on *M. Rappi*.¹

It seems at first sight somewhat peculiar that this should be the case; the same sort of arrangement has, however, been mentioned by Beddard for *Megascolex* (*Pleurochæta*).² And in many sections an appearance is presented which, I think, allows no doubt that this interpretation is correct.

The oviduct has not such a folded appearance, nor is the edge fringed by narrow lobes as in *M. Rappi*. By following the duct through a continuous series of transverse sections I was able to trace it from its external pore up to its internal expanded funnel, which is closely attached to the septum XII—XIII, which is itself perforated (fig. 10). The appearance represented in the figure was repeated in several sections; the ovary is seen on one side of the septum lying in somite XIII, and the edge of funnel, formed of columnar cells (doubtless ciliated, though the sections do not show this) on the other side of the septum in somite XII. There is a perforation in the septum, or rather the septum is here incomplete, allowing ova to pass through it into the duct.

I was unable to find the structure which is marked “*y*” in my previous paper. Beddard has noticed a structure in a similar position in *Ac. dissimilis* and other species³ repeated in the two somites in front of the true ovary, and he suggests that they may be remnants of two pairs of ovaries; indeed in one specimen one of these structures contained ova.

The spermathecæ show a remarkable and interesting difference from the arrangement seen in *M. Rappi*. In that species they consist of four rows of from one to four small

¹ This Journal, February, 1886, Pl. XV, fig. 4; Pl. XVI, figs. 7 and 14.

² ‘Trans. Royal Soc. Edinb.,’ xxx, 1883, p. 481.

³ ‘Proc. Zool. Soc.,’ 1885, p. 827.

horse-shoe shaped bodies in the anterior region of somites XII, XIII, XIV, XV. In the present species, as a rule, only four spermathæcæ are present; a pair in each of the somites XI and XII, and each is an elongated pyriform sac (fig. 6); but in one specimen an asymmetrical condition obtains, for here there are, on one side, two pyriform sacs in each of the somites XI, XII, while on the other side there is only one spermatheca in each somite, one of which is crozier shaped (fig. 7). The wall of the spermatheca is thick and muscular; its internal lining consists of tall columnar cells. In these two species then we have a difference corresponding to that shown in *Perichæta aspergillum*, E. P.,¹ where there are numerous small sacs (which, however, surround a larger one), and in *P. elongata*, which has a simple large sac. It may be that as the worm becomes more mature a larger number of spermathecæ will appear, for these specimens are apparently not quite mature. If this were so it would certainly militate against the theory of the homology between the spermathecæ and a portion of the nephridium.

The nephridia closely resemble those of *M. Rappi*, but their tubular portion is less developed, except in the case of the first pair, where the coiled portion has a glandular appearance, as in so many Earthworms, and may perhaps serve in some way as a salivary gland though it has the usual nephridial structure and an external aperture (see Darwin, 'Vegetable Mould and Earthworms,' p. 42). The external pore of this pair is situated, not on the anterior edge of somite II, to which it belongs, but on a slight prominence in somite I (fig. 2).

In the vascular system of *M. Rappi*, the dorsal vessel is doubled in somites IV, V, VI, VII, VIII, in the last of which the walls are much thickened, so as to give a heart-shaped appearance to the vessel. In *M. Beddardi*, there is the same condition, but limited to somites VI, VII, VIII. Beddard has noticed a similar difference in the extent of doubling of the dorsal vessel in specimens of *Ac. novæ-zelandiæ*,² where usually the

¹ 'Nouv. Arch. de Mus. d'hist. nat. de Paris,' viii, 1872.

² 'Proc. Zool. Soc.,' 1885, p. 821.

vessel is doubled throughout the body, except at its passage through the septa, but in one specimen it was a single tube throughout.

Urobenus brasiliensis, nov. gen. et sp.

I have named this worm after my friend Dr. A. G. Bourne, of the Presidency College, Madras, the name being formed by transliteration. Its specific name refers to its habitat. It came, together with a species of *Titanus*, from Pedza açu, and was given to Prof. Lankester by Prof. Edouard van Beneden of Liège.

External Characters.—The worm is 6 inches in length, and about $\frac{1}{3}$ rd of an inch in breadth; it consists of ninety-two somites, which are of nearly equal size throughout the body. The worm is cylindrical, and tapers gradually anteriorly, where it ends in a well-marked though narrow prostomium (Pl. VIII, fig. 11) which is embedded in the buccal somite only to a slight extent. The worm was soft and not much contracted, so that the somites have not the annulated appearance so frequently noticeable in Earthworms.

The clitellum is fairly well developed and does not extend completely around the body, in this respect resembling *Lumbricus*, *Microchæta* and others. The latero-ventral edge is placed between the ventral and lateral rows of setæ; the clitellum extends through somites xiv to xxv (Pl. VIII, fig. 12). The setæ are arranged in four couples in each somite—a ventral couple on each side, and a more lateral couple on each side (figs. 12 and 20); this condition holds throughout the body. The setæ themselves have the ordinary shape of an elongated *f*; the free extremity, however, is slightly more hooked than in *Lumbricus*; there is the usual thickening about midway along the setæ (fig 13, *a*). The setæ from the ventral series of the clitellum have their embedded portion more distinctly curved than the ordinary setæ (fig. 13, *b*). The length of the setæ is 65 mm.

The nephridiopores are placed in the anterior region of the somites in a line with the outermost setæ of the lateral couples (fig. 12, *c*).

I was unable to see either the pores of the sperm-ducts or those of the spermathecæ, but on dissection I found that the sperm-duct opened to the exterior in the anterior region of somite xx slightly dorsad of the ventral couple of setæ on each side (fig. 12, *d*).

The spermathecæ open close to the nephridiopores in the anterior region of somites VII, VIII, IX, on each side.

Internal Anatomy—All the septa are thin and easily torn; the nephridia are delicate, but the spermathecæ are very prominent (fig. 14).

The alimentary canal (fig. 14) consists of six well-marked regions. The thin-walled buccal region occupies two somites, and leads into the pharynx, which extends very nearly up to the end of somite v. There is nothing specially noticeable about these parts; the muscular wall of the pharynx does not extend so far backwards on the ventral as it does on the dorsal surface. This seems a more or less usual condition in Earthworms. The œsophagus, which follows, is somewhat sacculated and is bent forwards upon itself in somite vi, and after another bend back again, enlarges in somite VII to form a proventriculus, such as is found in *Lumbricus*, but which is not so well marked in other Earthworms. Owing to the infundibulate septa, the œsophagus appears to extend through more somites than it actually does, but by carefully tracing the nephridia (for the septa are very thin and easily broken and therefore not reliable for the purpose) it is found that the gizzard (*e*) occupies somite VIII. This has the ordinary structure with the chitinous lining within and the nacreous muscular appearance without. Behind the gizzard commences the tubular intestine (*g*), which is continued through somites IX to XV; this is narrower than the œsophagus and quite straight; it is hidden by the seminal reservoirs in the somites in which these structures lie. In each of the somites IX, X, and XI is a pair of intestinal glands (fig. 14, *f*), similar in shape to those figured by Perrier for his genus *Urochæta*,¹ and called by him “glandes de Morren.” Each of these six

¹ ‘Arch. de Zool. Experim. et gener.,’ iii, 1874.

glands is a reddish, ovoid body opening into the intestine by means of a short, narrow stalk, and constricted near its free extremity in such a way that this portion has the appearance of a short cone, inverted on the end of the ovoid portion.

The structure of these glands resembles mainly that of the calciferous œsophageal glands of *Lumbricus*; they appear in transverse sections to be made up of a number of tubules cut across, lined by an epithelium (the nature of which could not satisfactorily be made out, owing to the condition of the worm), resting upon a basement membrane (Pl. IX, fig. 43). Between and around the tubules are large irregular blood spaces, communicating with an abundant vascular network on the surface of the gland. In the lumina of the tubules I observed oily-looking globules (*a*) of various sizes. Masses of these were found in the alimentary canal itself in the region of these glands. These globules appear to be the secretion of these glands, and from analogy with what is known in *Lumbricus* and *Microchæta* one may consider them as carbonate of lime, though I did not use any tests in this case. Similar glands occur also in *Acanthodrilus*; and Beddard, in his description of them,¹ says that they are made up of lamellæ of connective tissue carrying blood-vessels, which dip into the lumen of the gland. He does not say whether these lamellæ anastomose, so as to give the appearance of tubules, and from his description it would appear that in that genus they do not do so.

In somite xvi the intestine suddenly changes its character; it becomes about three times its previous size, and is deeply constricted as it passes through the septa. These constrictions of the pouched intestine (figs. 14, 16) are not merely caused by the septa, as in the sacculated region, but are due to a series of ten pairs of short and wide-mouthed pouches or cæca from the axial lumen of the intestine. There is a thickening (? glandular) along the vertical wall between two consecutive cæca (fig. 16, *c*). This pouched region extends through somites xvi to xxv.

Behind the last pouch is a rather deeper constriction, after

¹ 'Proc. Zool. Soc.'

which the canal gradually widens out again to form the typhlosolar region or sacculated intestine (fig. 14, *j*). This commences in somite xxvi, and extends for a considerable distance backwards. The wall is much thinner than in the preceding region, and it is only slightly constricted as it passes through the septa. The typhlosole commences and ends concurrently with this division of the intestine. In somite xxvi there are seen two small elongated cæca, the end of one appearing on each side of the intestine (fig. 14, *k*). These spring close together from the ventral wall of the intestine, near the middle line, just at the junction of the pouched intestine with the sacculated region, and pass outwards upwards (fig. 15, *b*). They resemble the characteristic intestinal cæca found in *Perichæta*, being narrow, cylindrical, with the free end rounded. This is the first time, I believe, that these cæca have been found in Intraclitellian worms, or, indeed, in other genera than *Perichæta*.

It is interesting to find a worm combining the two sets of intestinal outgrowths—the “glandes de Morren” found in *Urochæta* and these intestinal cæca of *Perichæta*. It would be interesting to ascertain the structure of these outgrowths, in order to compare them with that of the already known outgrowths of the alimentary tract of various Earthworms; but my specimens are not well enough preserved to show their structure satisfactorily. The typhlosole is a simple dependent fold, containing the usual blood-vessel, and is not a cylindrical valve, as in *Lumbricus*, *Microchæta*, &c.

The Genital Organs.—Of these I was able to find only some of the male organs (not the testes) and the spermathecæ; no ovaries nor oviducts were distinguishable. The seminal reservoirs are four in number, one pair lying in somite xii and xiii, and the second pair in somite xiv (fig. 17, *g*); they have a looser structure than those of *Lumbricus*, and a much more irregular outline; they are not so intimately connected with the septa as in the latter form, and so are easily displaced and broken.

The ciliated rosettes are, similarly, four in number, are

comparatively large, and lie quite freely in their somites. One pair lies in somite XII, the other pair in somite XIII (fig. 17, *h, j*). Apparently, therefore, the posterior ciliated rosette on each side lies in front of its seminal reservoir. Perrier has described a similar condition in *Pontodrilus*, and Beddard for *Acanthodrilus dissimilis*, but in these cases the first rosette is in front of the seminal reservoir. It seems to me that, at any rate in *Urobenus*, this condition is due to the immaturity of the worm; for in *Lumbricus agricola* the seminal reservoirs appear at first as outgrowths from the septa anteriorly and posteriorly in the case of the first pair, or posteriorly only in the case of the second pair, without any connection between those of the two sides in the somite in which the ciliated rosettes lie, so that if the worm be dissected in an immature condition it would present somewhat the appearance seen in *Urobenus*.

Similarly, the freedom of the ciliated rosettes seems to have the same explanation, since these also are free in *Lumbricus* in the above-mentioned condition, but, as is well known, become, in the fully mature worm, completely enclosed in the seminal reservoirs. I have mentioned the same condition in *Microchæta Beddardi*.

A sperm-duct passes from each of the ciliated rosettes to the body wall; here it turns backwards, and the two sperm-ducts on each side unite in somite XIII, and the common duct thus formed runs along the body wall to somite XX, where it opens to the exterior in the anterior region of the somite, between the ventral and lateral couples of setæ.

There are no accessory glands on the sperm-duct, nor copulatory papillæ on the exterior.

The only female organs which I could find are the three pairs of spermathecæ (fig. 17, *f*). Each spermatheca is a white, elongated, pyriform sac, the free extremity of which is rounded, while the opposite extremity gradually narrows to form a delicate duct; it is bent upon itself once or twice in its course, and opens to the exterior in the anterior region of the somite, quite close to, but distinctly separated from, the

nephridiopore. These spermathecæ are placed in the somites VII, VIII, and IX.

The nephridia occur in every somite behind the second (fig. 17, *n*, *n'*). Those of the seven anterior somites differ slightly from those in the rest of the somites. An ordinary nephridium, taken from a somite behind somite IX, consists of a delicate, loosely-coiled, short tubule, containing two, or in some parts three, parallel lumina; the lumen communicates, on the one hand, with the cœlom by means of the funnel, and on the other with a vesicular diverticulum, which opens to the exterior (fig. 18). This vesicle is a long, thin-walled sac, the free blind extremity of which, directed dorsally, is rounded; while the narrow duct, after receiving the tubule of the nephridium, dips into the body wall and opens to the exterior by the nephridiopore, placed in a line with the lateral setæ (fig. 20, *o*). In the preserved condition each of these vesicles contained, at their blind end, a mass of white granular substance, rendering the vesicles very conspicuous on opening the worm. The structure of the tubule and the shape of the funnel (fig. 19) closely resemble those of *Lumbricus*.

The nephridia behind somite XX are smaller, and the tubules even less coiled than in the one just described.

The nephridia in somites III to IX present a somewhat different arrangement of their parts (fig. 17 *n*¹—*n*⁷). The tubule is less developed than in the posterior nephridia, and instead of opening into the neck of the vesicle near the external pore it enters the enlarged portion of the vesicle near its blind end. These seven nephridia have very long narrow vesicles, since the tubular portion is carried far back, and lies (as shown in fig. 14, *l*) alongside of, and partly above, the œsophagus and gizzard. A similar difference between the most anterior and the following nephridia is seen in the case of *Microchæta Rappi*.

Pyriiform Sacs.—In each of the somites behind the ninth, i. e. behind the last pair of spermathecæ, there is a pair of small pyriiform sacs (fig. 17, *p*) placed between the nerve-cord and the ventral setæ. Each of these has its enlarged free end

filled with a white granular substance similar to that found in the nephridial vesicles ; this rounded end is directed outwards, whilst the narrow duct passes at first inwards, then bends backwards and pierces the body wall. By means of transverse sections the external aperture of these organs is found to be situated between the nerve-cord and the ventral couple of setæ on each side (fig. 20, *b*). They were not sufficiently well preserved to make out any details of their structure, but, so far as I could make out, their general structure is as follows:— A delicate membrane surrounds the sac (fig. 21, *a*) and forms its wall, within which is a granular substance (*b*) which was stained only slightly by borax-carmin. In the centre of this substance is an irregular lumen (*d*) lined by short columnar cells (*c*) whose nuclei stained deeply ; whether these are ciliated or not I was unable to determine.

The diagram (fig. 20) shows the position in relation to the setæ of this pyriform sac and its pore on one side, and the nephridiopore on the other side.

These pyriform sacs seem quite similar in shape and position to those found only in the posterior region of the body in *Urochæta* ; what their function may be seems quite impossible to say at present.

The vascular system was not followed to any great extent. The dorsal trunk (fig. 14, *p*) is ampullate posteriorly and becomes wider in the region of the pouched intestine ; passing forwards this character becomes more marked in somites XIII and forwards. In the intestinal region a pair of vessels is given off in each somite to the intestine. In each of the somites XII and XIII is a pair of moniliform lateral hearts, but anteriorly to these somites these hearts are very thin and no longer moniliform ; they pass from the dorsal to the ventral trunk. Beside the dorsal and ventral trunks both a typhlosolar and a subneural trunk are present.

The nervous system exhibits no essential difference from that of *Lumbricus*. The cerebral ganglia are distinct and placed in somite III.

Thus *Urobenus* resembles *Urochæta* in two remarkable

points viz. in the possession of similar intestinal glands, and of pyriform sacs. These led me at first to think that I had to deal with an *Urochæta*, but the various points of difference—e. g. the setæ, which in Perrier's form are notched at the free extremity, the nephridia, the character of the seminal reservoirs, which are elongated and tongue shaped in *Urochæta*, the presence of a distinct prostomium, which is not the case in Perrier's worm, and the general character of the alimentary tract,—all these lead me to form a new genus for the worm under consideration.

Diachæta Thomasii, nov. gen. et. sp.

In a bottle containing several small worms from St. Thomas (West Indies) some were very noticeable on account of their stoutness and of the arrangement of the setæ; this latter peculiarity suggested to me the name *Diachæta*, since the setæ are far removed from each other as in *Plutellus* and *Ac. multiporus*, and moreover alternate from somite to somite, as in the posterior region of *Urochæta*, and in Schmarda's genus *Pontoscolex*.

External Anatomy.—The worm is cylindrical with very obtuse rounded extremities and is greatly swollen anteriorly, instead of narrowing towards the prostomium (Pl. VIII, fig. 22). Its length is about 3 inches, and its breadth about $\frac{1}{3}$ rd inch, but the worm was very much contracted so that these measurements will not represent its size when living. The body consists of 335 somites, of which those behind the clitellum are very short, whilst in the preclitellar region they are of much greater length; some of these anterior ones are traversed by two grooves with a slight ridge between them, on which the setæ are placed (fig. 22).

The prostomium is absent, and the anterior border of the buccal somite is not much narrower than the clitellum. It is marked by numerous longitudinal grooves extending backwards for about half the length of the somite.

The clitellum extends through somites xx to xxxiii, and completely surrounds the body (fig. 24), as in *Perichæta*,

Digaster, &c. The intersegmental grooves in this region are very deep and wide, and the setæ, except those of the ventral row, are not very evident.

Behind the clitellum the body of the worm becomes much narrower and retains this diameter to the end of the body. The five somites immediately in front of the clitellum are very short, and the diameter of the worm is here much smaller, but in front of these it increases and retains the size of the clitellum up to somite II. Somites X, XI, XII, XIII are very conspicuous, and are not annulated as are those immediately anterior to them.

The setæ are eight in each somite and are not in couples, but they are arranged in such a way as to form fourteen rows along the body. In describing this arrangement it will be convenient to adopt M. Perrier's plan which he used in the case of *Plutellus*,¹ of numbering the setæ on each side. The most ventral seta on each side will be called "seta 1," whilst the most dorsal will be called "seta 7." The series of "seta 1" form a continuous line on each side of the ventral mid-line throughout the body, but the remaining three setæ ("2, 4, 6,") on each side of one somite alternate with the three setæ ("3, 5, 7") of the somite in front and of that behind (fig. 23). In this way we get the fourteen rows of setæ.

As will be best seen from the figures (23 and 24) the setæ of the two sides of one somite are themselves not symmetrical. The setæ 1 and 2 of one somite, or 1 and 3 of the next somite, correspond to the ventral couple of *Lumbricus*, &c., and setæ 4 and 6, or 5 and 7 to the lateral couple of the same Earthworm. The setæ are very small, being only about .55 mm. in length; they have the usual shape, but the distal and proximal regions differ in length; the distal (free) region is much shorter than the proximal (embedded) region, and its extremity is more strongly curved than in the ordinary setæ of *Lumbricus* (fig. 25).

External Apertures.—I could find no apertures whatever, except the terminal mouth and anus. But by dissection I find that the nephridia open to the exterior by

¹ 'Arch. de Zool. Exper. et gen.,' t. ii, 1873, p. 245.

pores place slightly ventrad of and anterior to the line of "seta 4" (fig. 23, *a*), i. e. the lower seta of the lateral couple, as in *Urochæta*, *Microchæta*, &c. These pores do not follow the setæ in their alternation, but form a continuous line; the two male pores were also by dissection found to be situated very far back, viz. in somite xxii. Each is placed a little dorsad of and anterior to the line of "seta 3," which is present on one side of this somite, but absent on the other side (fig. 24, *b*). The spermathecæ open at the posterior edges of somites vi, vii, and viii, in the same line with the nephridiopores (fig. 23, *c*).

Internal Anatomy.—There are five strong infundibuliform septa behind somites vi to x, hiding the œsophagus and gizzard, such as are seen in *Titanus*, *Anteus*, *Urochæta*, &c.; the next ten septa behind these are much thinner, and behind somite xx they are exceedingly delicate. The elongated seminal reservoirs are very conspicuous (fig. 26).

The alimentary tract presents no remarkable points. The œsophagus occupies somite v and part of somite vi. The gizzard occupies the rest of somite vi. Then follows the tubular intestine, which is very narrow; it passes through the five strong septa, and in somite xi becomes enlarged; its walls become thin, and are constricted as the tube passes through the septa; this is the sacculated or typhlosolar intestine. The typhlosole is a simple laterally-compressed fold, carrying the usual blood-vessel.

There are no glands nor cæca opening into the œsophagus or intestine.

The only genital organs which I was able to find are a pair of seminal reservoirs with their rosettes and ducts, and three pairs of spermathecæ.

The seminal reservoirs consist of a pair of very long tongue-shaped sacs (as in *Titanus* and *Urochæta*), starting from somite xii, and reaching as far backwards as somite xxxviii (fig. 26, *g*). This is a most exceptional length for the seminal reservoir, for in *Urochæta* the elongated sacs only occupy three somites, and in *Titanus* fourteen somites. As

they pass through the septa the sacs are greatly constricted; so much so in one specimen that the reservoir on one side is cut in two, as not unfrequently happens in *Lumbricus*.

In another specimen the reservoirs are present, but are empty, and are not of so great an extent as in the one figured.

The ciliated rosettes (*f*) lie in somite XI, one on each side of the intestine; they are not enclosed in the reservoirs in front of which they are placed. This arrangement is very similar to the condition found in *Urochæta*.

The single sperm-duct on each side is very delicate; it passes backwards along the body wall to its aperture in somite XXII, without having any accessory glands in connection with it.

I could find no testes, nor ovaries nor oviducts. The spermathecæ are six in number (*d*), a pair lying in each of the somites VI, VII, VIII, and having their apertures in the posterior region of these somites. Each is a simple elongated pyriform sac (fig. 29), bent twice upon itself.

The nephridia occur in each somite behind the second. Each consists of a coiled tubule (fig. 27), which is of much greater extent than in *Urobenus*, and contains parallel lumina within it, having the usual structure. The tubule opens into the cœlom by means of a funnel similar to that of *Urobenus*; the proximal end of the tubule alters its character before passing to the exterior, the lumen becoming wider and the walls muscular, as in *Lumbricus*; but here this vesicular region is more highly developed than in that form, which, however, it resembles in that the vesicle is a continuation of the tubule, and not a diverticulum from it, as in *Urobenus* and *Microchæta*. The nephridiopores have already been mentioned as being in a line with seta 4.

As is so frequently the case, the most anterior nephridium is greatly modified. Resting against the hinder part of the pharynx in somites IV and V is a large, compact, glandular-looking organ (fig. 26, *c*), the slightly-coiled duct of which opens to the exterior on the anterior edge of somite III. The glandular-looking portion of this modified nephridium is made up

of a compact mass of tubules (fig. 28), or rather of a single very greatly folded tubule (*a*), the folds of which are pressed close against one another, and contain parallel lumina, which in some regions appear to be ciliated. From the outer side of this mass arises the vesicular portion or duct (*b*), which is irregular in diameter, bends upon itself three or four times, and then passes forwards as a narrow, straight duct, lying alongside the pharynx, to its external pore. The structure of this nephridium is quite similar to the unmodified posterior ones. In *Urochæta* Perrier describes "glandes à mucosité," which have the same position, and Beddard describes a modified nephridium in *Ac. multiporus*, which opens, not to the exterior, but into the buccal cavity. It seems probable that all these glandular bodies in the anterior region of the body may be modified nephridia.

The vascular system consists of the usual longitudinal vessels, viz. dorsal, ventral, and typhosolar trunks, together with a series of lateral hearts. I could see no lateral longitudinal ("intestino-tegumentary") trunks. The dorsal trunk in the posterior region of the body is only slightly moniliform, but as it passes forwards this condition becomes more marked, especially in somites XVI to XII. In somite XI a pair of moniliform lateral hearts are given off, and similar ones are found in somites X, IX, and VIII, each being smaller than that behind it. In the next two anterior somites the "commissural vessels" are no longer moniliform, and are very much more delicate than the posterior vessels.

The nervous system consists of the usual cerebral ganglia, which are here well marked, and lie in somite III and a series of ventral ganglia. These lie quite close together, so that the intervening cord is very short (fig. 30). This is doubtless due to the greatly contracted state of the worm. Three or four pairs of lateral nerves are given off from each ganglion, but none from the short cord. Probably if the contraction were less and the ganglia longer some of the lateral nerves would appear to come off from the cord.

Just as *Urobenus* has certain resemblances to *Urochæta*,

so also there are several points in which *Diachæta* shows a resemblance to Perrier's genus, viz. in the similarly modified first nephridium, in the single elongated pair of seminal reservoirs (though they are in *Diachæta* very much longer than in the other worm), and the single pair of "free" ciliated rosettes, and in the position of the nephridiopores. But there are noteworthy differences between the two worms. In *Diachæta* the body wall is thick, and not transparent. The anterior extremity is not pointed, as in *Urochæta*, but much swollen and obtuse. There are neither calciferous glands ("glandes de Morren") on the intestine, nor the pyriform sacs on the body wall, nor "intestinal hearts." The nephridia differ considerably. The clitellum is longer than the area supposed by Perrier to represent this structure in *Urochæta* (but certainly this may differ in the same genus).

The setæ are all simple, and have not the bifid form characteristic of *Urochæta*; they alternate throughout the body,¹ except the ventralmost, which remain in line. In *Urochæta* these last alternate as the rest do; but this happens only in the posterior part of the body. It seems, then, that this new worm is very closely allied to *Urochæta*, and in any classification would have to be placed very near to it among the *Intraclitelliani*.

Trigaster Lankesteri, nov. gen. et sp.

This worm, like *Diachæta*, comes from St. Thomas and belongs to the group *Intraclitelliani*. The single specimen was incomplete, as the hinder part was wanting. Professor Ray Lankester had opened it and made sketches of it.

The most striking point externally is the presence of a deep median ventral fossa, situated in the anterior region of the clitellum; this fossa is bounded on each side by a couple of papillæ; the whole arrangement is doubtless used in copulation.

This worm possesses three distinct gizzards, separated from one another by œsophageal regions; it is this character that

¹ In the genera *Pontoscolex*, Schm., and *Geogenia*, Kinb., a similar alternation of the setæ is present in certain regions of the body.

suggested its generic name. Here then we have a condition intermediate between *Digaster* (E. P.) and *Moniligaster*¹ (E. P.), but whereas the former is post-clitellian, and the latter aclitellian, *Trigaster* has its male genital pores situated within the clitellum.

External Anatomy.—The size and number of somites is necessarily unknown, as the only specimen that I have had the opportunity of examining is incomplete.

The setæ are arranged in four couples in each somite (fig. 31); the ventral and lateral couples on one side are nearer to one another than are the ventral couples of the two sides; the eight setæ are all on the ventral surface. The setæ are very small and difficult to see owing to the greatly contracted state of the worm. As seen in a transverse section they are .2 mm. long, and are less curved than in *Lumbricus*. The preclitellar somites are quadriannulated, and the third annulus forms a very distinct ridge (*a* in fig. 32); the setæ are placed in the second annulus (fig. 32).

The prostomium is broad, and occupies the whole dorsal border of the anterior extremity; it is not embedded in somite 1. The setæ commence in somite II.

The clitellum commences behind somite XIII, and occupies twenty-seven somites, extending as far as somite XL. This is an exceptional length for the clitellum, the nearest approach being *Titanus* with fifteen somites. The clitellum is incomplete, there being a groove in the mid-ventral line, in which the two ventral couples of setæ are placed (fig. 31). In the anterior part of this groove is the fossa (*g*) above mentioned.

There are no dorsal pores, nor could I find any nephridiopores.

The male pores are four in number, and although not visible externally are indicated by the fossa, and are easily seen in transverse sections. This fossa appears to extend through somites XVII, XVIII, XIX, and XX and part of somite XVI, but the somites are so short in this region and the setæ so difficult to see that the actual number of somites may be less,

¹ 'Nouvelles Arch. de Mus. d'hist. nat. de Paris,' viii, 1872.

as I may have counted annuli by mistake for somites. The side of the fossa is formed partly by two rather prominent papillæ (*f, f'*), one of which is formed on somite xvii and part of somite xvi; the other is formed by somites xix and xx; between the two papillæ the side of the fossa is formed by somite xviii, which dips down into the fossa at a level with the base of the papillæ.

The papillæ are in a line with the ventral couple of setæ, though I could see no setæ on the papillæ themselves, and there are no special or "penial" setæ connected with this region. Each male pore lies at the base of a papilla, giving four male pores as in *Acanthodrilus*.

The pores of the spermathecæ, though not visible externally, lie in somites vii and viii in a line with the ventral setæ in the posterior region of the somites.

Internal Anatomy.—None of the septa are particularly thick, but those in the anterior region are slightly stronger than the more posterior ones, and tend to hide the gizzard.

The alimentary tract (fig. 33) consists of a short buccal mass, a pharynx which passes through five somites, œsophagus, three gizzards and the intestine. A short œsophagus leaves the pharynx and passes through somite vi; in somite vii it widens out and enters the first gizzard, in somite viii the anterior region of the somite is occupied by a thin-walled œsophageal portion, and the posterior region by a second gizzard. The same arrangement is repeated in somite ix. Behind each of the gizzards is placed a slightly thicker septum; each gizzard has the usual structure and is quite separated from the neighbouring gizzards. The tubular intestine commences in somite x, and extends through this and the two following somites. In somite xiii the intestine becomes rather larger and as it passes through the septa is slightly constricted. This forms the sacculated intestine. There are no œsophageal nor intestine glands such as are found in *Lumbricus*, *Microchæta*, *Urobenus*, &c., but there are three pairs of "grape-like glands" around the pharynx and œsophagus, a pair in each of the somites iv, v, and vi. These organs are

shown in situ in fig. 33 and enlarged in figs. 35 and 36. Whether these structures are "salivary glands" and open into the alimentary canal I am unable to say. I could not find any opening though they were embedded in the muscular wall of the pharynx, nor on the other hand could I find any external opening as the alimentary tract had been removed from the body before I received it. Each of these structures is made up of a much branched tubule, each branch ending in a tuft of elongated processes, each of which contains a lumen (fig. 35). The lumen bends round on itself at the apex of the process (fig. 36), and probably is continuous up and down each of the processes; this lumen is intracellular and in transverse section (fig. 37) has an appearance quite similar to that of a nephridium. There is a very abundant vascular supply to these structures and the capillary loops have numerous dilatations on their course, as in the capillaries on the nephridium of *Lumbricus*, but here they are larger and much more numerous; these dilatations are filled with a granular material (figs. 36, 37) which is probably due to the remains of the blood-corpuscles. I think that there is no doubt that these structures, though apparently in connection with the alimentary canal, are really modified nephridia; even if they do open into the alimentary canal we have the same thing occurring in *Ac. multiporus*. The nephridia in the rest of the body are extremely minute, and this may have some relation to the great development of these anterior ones. Perrier remarks on the great development of the glandular appendages of the alimentary canal of *Perichæta Houletti*¹ and the small development of the nephridia, and suggests that these appendages may take on an excretory function, the products being used for digestive purposes.

The Genital System.—Of the male organs I could find neither testes, nor seminal reservoirs, nor ciliated rosettes, nor sperm-ducts; but in each of the somites XVI and XVIII is a pair of whitish convoluted tubes, having the shape and appearance of the "prostates" of *Acanthodrilus* (fig. 34, *d, d'*). Each

¹ 'Nouv. Arch.' &c., viii.

of these prostates consists of two regions traversed by a lumen. The distal blind extremity has a looser structure and a more granular appearance, whilst the proximal portion, near the external pore, has a nacreous aspect.

The distal portion is coiled, and has a layer of columnar cells (fig. 42, *b*) surrounding the lumen. Beyond this layer is a deeper one of club-shaped granular cells (*a*), very similar to the cells in the epidermis of the clitellum of *Lumbricus*, &c., and as in that region there are capillary blood-vessels traversing this glandular layer. The outer wall of this region is formed by thin but firm membrane.

The epithelium of the lumen in the proximal region (fig. 41) consists of tall, narrow, columnar cells, with a highly refracting cuticle, and, instead of a deep layer of granular cells, there is a muscular layer, consisting of oblique fibres, as well as circular and longitudinal fibres. In this region, too, the capillary blood-vessels ramify amongst the epithelial cells. Outside the muscular layer is a thin membrane, as in the glandular region.

I could find no spermatozoa or other contents in these organs. Their proximal portion is probably extrusible, and represents the penial region of the duct in *Perichæta*, whilst the slightly coiled portion will correspond to the greatly coiled, compact, glandular "prostate" of that genus. The external pores of these "prostates" lie at the base of the papillæ, which form the boundaries of the ventral "copulatory fossa;" a pore being at the base of each papilla.

The two ovaries lie in somite XII (fig. 34), one on each side. The ovary is a grape-like mass of lobules, and is attached to the anterior septum of the somite (fig. 39). Each lobule is supplied by a blood-vessel, around the branches of which are set the ova, embedded in the cœlomic epithelial cells (fig. 40). Each ovum has the characteristic structure.

In each of the somites VII and VIII there is a pair of sub-globular white sacs (fig. 34, *a*, *a'*), opening to the exterior in the posterior region of the somite, close to the nerve-cord, in a line with the ventral setæ (fig. 31, *e*, *e'*). When I examined these sacs by teasing them I could find no spermatozoa in them, but

merely a mass of granular, oily-looking granules. But by means of sections I was able to identify these sacs as spermathecæ. The spermatozoa were now seen in bundles, chiefly in the neck of the sack, while in the sack itself they were less numerous, and mixed with the granular globules. The wall of the spermatheca is muscular, and the cavity is lined by tall columnar epithelial cells.

The nephridia are represented in each somite by numerous vascular tufts on the body wall; more numerous in the genital somites than elsewhere. These are apparently independent of one another, and consist of a slightly-coiled tubule containing a narrow, intracellular lumen. Surrounding each tuft is a network of capillaries (fig. 38) without dilatations. As for their communication, either internally or externally, I am unable to say anything. Though I cut sections through the body wall I could not trace the nephridia through it, owing to the badly preserved condition of the worm, nor could I make out any detail of their structure.

I have already described the glandular structures in the anterior somites, which I take to be modified nephridia.

As for the fact of there being a large number of small nephridia in each somite, several Earthworms are now known to possess more than two nephridia to each somite. Beddard has described *Ac. multiporus* with eight, and I have sections through a *Perichæta* in which there are very numerous, small nephridia in each somite—a condition also found by Beddard in this genus, who has seen their external pores.

Kinberg's Genera.

In my previous paper I gave the characters of eleven Earthworms, as described, though very inadequately, and, as it now appears, wrongly, by Kinberg¹ in 1866. In the April number of the 'Comptes Rendus'² for the present year M. E. Perrier, in a short note, corrects some of Kinberg's descriptions, as observed by himself after examination

¹ 'Ofversigt af. Kongl. Vetensk. Acad. Förhandlgr,' Stockholm, xxiii.

² 'Comptes rendus,' cii, 1886, p. 875.

of Kinberg's type specimens. He comes to the conclusion that the only good genera are *Tritogenia*, which has eight setæ in each somite, and not six, as Kinberg stated; *Geogenia*, with the clitellum occupying somites XIII to XVIII, and carrying modified setæ; and *Eurydame*, which has four setæ, and not eight, in a somite. These have a quincuncial arrangement in the posterior region of the body, and are bifurcated, as in *Urochæta* (E. P.). In other respects Kinberg's descriptions are correct. The remainder of Kinberg's worms belong to other genera. *Mandane* and *Hegesipyle* are species of Perrier's *Acanthodrilus*. *Alyattes* is a species of *Lumbricus*. *Hypogæon* remains indeterminate; whilst the remainder, as mentioned in my previous paper, Perrier considers to be species of *Perichæta*, Schm. (= *Megascolex*, Templeton).

RECENT ADDITIONS TO EARTHWORM LITERATURE.

SINCE my previous paper¹ was published, several additions have been made to the literature of Earthworms, some treating of the histology of known species and others being descriptions of new forms.

Professor F. Vejdovsky's beautiful work on the Oligochæta ('*Systeme und Morphologie der Oligochaeten*') contains a comparatively slight reference to terricolous forms, so far as new anatomical details are concerned. Amongst these are drawings of the structure of the clitellum, details as to the development of the setæ, structure of body wall, the spermatophors, &c., in *Dendrobæna*, *Allolobophora*, *Allurus*, *Lumbricus*, as well as some reference to and drawings of *Criodrilus lacuum*, Hoffmeister.

In regard to the classification of the group, he puts aside Perrier's arrangement, founded on the relation between the sperm pore and the clitellum, and divides the whole of the Oligochæta into seventeen families (p. 63). Many reasons can be adduced for this plan in preference to the more hard-and-

¹ This Journal, 1886, pp. 213—292.

fast arrangement previously adopted, e. g. species of *Acanthodrilus* have been described by Beddard ('Proc. Zool. Soc.,' 1885, p. 814), and by Horst ('Notes of Leyden Museum,' vi), in which the male pores are not posterior to the clitellum, as in the three species described by Perrier, but are within the area of the clitellum. Again, Beddard has described a species of *Megascolex* (*Pleurochæta*, 'Trans. Roy. Soc. Edin.,' xxx, 1883), in which the genital pore has also this position, instead of the usual post-clitellian position of the remaining species of *Megascolex* and *Perichæta*.

It seems better, therefore, to use in the future Vejdovsky's plan, and form the following families for the Terricolous *Oligochæta* :

1. *Pontodrilidæ*.
2. *Criodrilidæ*.
3. *Lumbricidæ* (= *Preclitelliani*).
4. *Eudrilidæ* (= *Intraclitelliani*).
5. *Acanthodrilidæ*.
6. *Perichætidæ* (+ *Pleurochætidæ* of Vejdovsky).
7. *Plutellidæ*.
8. *Moniligasteridæ*.

In February of this year Mr. F. E. Beddard published ('Ann. Mag. Nat. Hist.,' p. 89) a description of a new species of *Perichæta*, and of *Moniligaster*, together with some notes on *Perichæta Houletti*, E. P., and *P. posthuma*, Vaillant. *P. Ceylonica*, Beddard, differs from all other species of this genus with the exception of *P. armata*, Beddard,¹ in possessing a sac, containing one or more penial setæ, on each side of somite XVIII, in which lie the male pores—an arrangement found, too, in *Acanthodrilus*.

Moniligaster Barwelli, Beddard, agrees with Perrier's *M. Deshayesii* in having no clitellum, although the genital organs are mature in both species.

In the new species only the posterior pair of "testes" in somite IX are present. The sperm duct, which appears to have

¹ 'Ann. Mag. Nat. Hist.,' xii, 1883.

no funnel, opens to the exterior at the hinder region of the same somite. In somite VIII is a pair of spermathecæ, occupying the position of the anterior pair of testes of Perrier's form.

In the 'Zool. Anzeiger,' 1886, p 342, Beddard discusses the relation of the ovary to the spermatheca in *Eudrilus*, as described by Perrier ('Nouv. Arch. Mus. d'Hist. Nat.,' 1872, viii), from whose figures and description it appears that the ovary is grafted on to the spermatheca, from the opposite side of which springs a coiled diverticulum.

Beddard comes to the conclusion that the ovary is in continuity with the oviduct—Perrier's coiled "diverticulum"—and, moreover, that the ovary has a very different structure from that of *Oligochæta* in general, in that it is surrounded by a fibrous tunic, continuous with the wall of the oviduct, and the cavity is divided by trabeculæ into chambers, in which lie ova in different stages of development.

At a recent meeting of the Zoological Society of London, Beddard pointed out certain variations in the position of the genital pores of *Perionyx excavatus*, E. P., as seen in a large number of specimens.

The development of the seminal reservoirs in *Lumbricus* is described by Dr. R. S. Bergh ('Zool. Anzeiger,' 1886, p. 231) in a preliminary note.

It consists essentially of a bulging of the septa of the somites X and XI, so as to give rise to the anterior and posterior sacs on each side of the first, and a posterior sac on each side of the second of these somites [as mentioned in a footnote on p. 259, of my previous paper]. There is a similar arrangement in connection with the ovaries—"receptacula ovarum"—which consists of small backward, saclike protrusions of the posterior septum of somite XIII. Each spermatheca is developed as an invagination of the epidermis, forming a sac which is surrounded by the muscular layers of the body wall.

A memoir by Hermann Ude ('Zeit. für wiss. Zool.,' xlv, pp. 85—142) on the dorsal pore of Earthworms, deals chiefly with the structure of the body wall; unfortunately figures are

not very freely given. The various layers of the body wall are considered, and a discussion of the opinions of previous authors with respect to each of the layers, forms a great part of the paper. In the epidermis he describes the columnar cells and the goblet-cells; but in the latter he figures no branched base, which, however, I find to exist: the structure of the clitellum is not described.

Below the epidermis he finds a "basal membrane." In the muscular layers he notes an appearance presented in sections across the fibres, which shows the fibre to be made up of fibrillæ. The fibre consists of a denser peripheral portion, in which lies the nucleus, and a less dense central portion. The bundles of muscle-fibres are surrounded by finely granular connective tissue, the perimysium, in which are found small nuclei, whilst the larger nuclei belong to the muscle-fibres.

He draws attention to the fact that the arrangement of the longitudinal muscles in *Lumbricus agricola*, Hoffm., is not universal in the genus.

The dorsal pore lies on the anterior edge of the somites in which it occurs, and appears in the intersegmental groove. It is absent in the most anterior somites, but the position of the first pore is constant for a given species, e. g. in *L. agricola*, between somites VIII and IX, in *Allolobophora turgida*, Eisen, between somites X and XI. In *Typhæus orientalis*, Beddard, the pore commences only behind the clitellum. It has not been noticed in *Anteus*, *Titanus*, *Urochæta*, or *Microchæta*.

Vejdovsky states that it is generally absent in the *Limicolæ*.

In a fully-developed clitellum the pores become closed by a development of cuticular substance around the edge, which gradually increases and fills the pore. In *Allol. mucosa*, Eisen, however, it remains visible in the clitellum.

Claparède described the epidermis as being invaginated at the dorsal pore, as it is at the seta-follicle; but Ude finds that such is not the case. The dorsal pore is a perforation through the epidermis and muscular layers, and the cœlomic

epithelium passes across these layers and meets the cuticle round the edge of the pore. There is a special set of muscle-bundles, forming a sphincter muscle for the pore.

As to the physiology of the pore, Ude considers that there is not the slightest connection between the dorsal pore and the nephridia, although the former is, to a certain extent, excretory, since the cœlomic fluid can be extruded through it, either in drops, as in *Lumbricus*, or may be even squirted through the pore to a distance of about a foot, as has been noticed in species of *Megascolex* and *Perichæta* by Vordermann ('Natwork. Tijdsche-Nederl. Indie,' vol. ii, p. 111).

The following experiments were undertaken to ascertain whether or not any liquid was taken in through the pore. A worm was dried by lying on blotting paper for some hours; the anterior and posterior extremities were then tied with string and the worm was immersed for fifteen minutes in water. On removal it was found to be greatly swollen, and Ude was led to think, from this, that water was taken in through the pore. But the following experiment caused him to doubt the truth of this opinion. Instead of employing pure water he dissolved some iron oxide in the water, and after the worm had remained in this for some time (after previously being dried) it was killed and the cœlomic fluid was tested for iron by means of cyanide of potassium. No red colour was produced, and hence Ude concludes that no water was taken in through the dorsal pore. The swelling of the worm must therefore have been due to the intaking of water by the genital ducts, nephridia, and mouth. The worm was carefully weighed before and after the various stages of the experiment, and it was found that it weighed about 0.2 grams more (on the average) after immersion than before.

Accompanying this memoir is a bibliography of the subject, and a useful table for determining the species of the genera *Lumbricus* and *Allolobophora* is given. The position of the first dorsal pore is given in each species, and appears to furnish a useful specific character.

Two new species are described, *Allolobophora longa* and *A. hispanica*.

Rosa ('Bull. Mus. Zool., &c.,' Torino, vol. i) has added a new species, *A. celtica*, to his previously described forms.

EXPLANATION OF PLATES VIII & IX,

Illustrating Mr. Benham's "Studies on Earthworms."

Microchæta Beddardi.

FIG. 1.—The anterior extremity of the worm, showing three somites from above. ($\times 1\frac{1}{2}$.)

FIG. 2.—The three anterior somites from the side. ($\times 1\frac{1}{2}$.) *a, a*. The second and third nephridiopores on the intersegmental grooves. *b*. The first nephridiopore, situated on a slight prominence in somite I. *c*. The lateral setæ. *d*. The ventral setæ.

FIG. 3.—Four somites of the clitellum from below. ($\times 2$.) *a*. The nephridiopores. *b*. The spermathecal pores. *c*. The lateral setæ. *d*. The ventral setæ. *e*. The pores of the oviducts.

FIG. 4.—One of the lateral setæ from a preclitellar somite. Nat. size, 0.39 mm.

FIG. 5.—One of the ventral setæ from somite XIX. Nat. size, 0.715 mm.

FIG. 6.—A spermatheca.

FIG. 7.—Two somites of another specimen, showing the asymmetrical disposition of the spermathecæ.

FIG. 8.—A portion of the intestine, with the intestinal glands.

FIG. 9.—A portion of the intestine, with the intestinal glands, of *M. Rappi*.

FIG. 10.—A portion of one of a series of transverse sections of *M. Beddardi*, showing the relative positions of the ovary and its duct: one on each side of the septum XII—XIII. *a*. Portion of the funnel of the oviduct. *b*. Blood-vessel in septum. *f*. Cœlomic epithelial cells, forming the ovary. *o*. Ova amongst these cells. *s*. Septum.

Urobenus brasiliensis.

FIG. 11.—The anterior extremity of the worm (nat. size). *a*. Prostomium

FIG. 12.—Ventral view of the clitellum and neighbouring somites. ($\times 2$.)

a. Ventral setæ. *b.* Lateral setæ. *c.* The nephridiopores. *d.* The pores of the sperm-ducts.

FIG. 13.—Setæ. Nat. size, 0.65 mm. *a.* From the preclitellar region. *b.* One of the ventral setæ from the clitellum.

FIG. 14.—The worm opened along the dorsal surface to show its general anatomy. ($\times 1\frac{1}{2}$.) *a.* Prostomium. *b.* Pharynx. *c.* Œsophagus. *d.* Proventriculus. *e.* Gizzard. *f.* Intestinal glands. *g.* Tubular intestine. *h.* Pouched intestine. *j.* Sacculated intestine. *k.* Ventral cæca, at the junction of the pouched with the sacculated intestines. *l, l.* Nephridia. *m, m.* Spermathecæ. *n, n'.* Seminal reservoirs. *p.* Dorsal blood-trunk.

FIG. 15.—The junction of (*a*) the pouched with (*c*) the sacculated intestine, seen from the ventral surface in order to show the origin of the ventral cæca (*b*).

FIG. 16.—A portion of the pouched intestine, the dorsal wall of which has been removed, seen from above. *a.* The ventral wall of the axial lumen of the intestine. *b.* A pouch. *c.* The glandular (?) ridge at the junction of a pouch with the axial portion.

FIG. 17.—The alimentary tract has been removed to show the genital organs, nephridia, &c. ($\times 2$.) The seminal reservoirs have been removed from the left side; the anterior nephridia have been drawn aside to show more clearly the somites to which they belong. The posterior nephridia are also somewhat displaced. *a.* Prostomium. *b.* Cerebral or supra-pharyngeal ganglia. *c.* First ventral ganglion. *d.* Ventral nerve-cord. *f, f.* The spermathecæ (there should be lines separating the spermathecæ from the nephridia where they dip into the body wall, on the right side). *g, g.* The seminal reservoirs of the right side. *h, j.* The anterior and posterior ciliated rosettes. *k.* The sperm-duct. *l.* Position of the sperm-pore. *n, n¹, n⁷.* The nephridia, of which *n¹—n⁷* are somewhat different from the following ones. *p.* The pyriform vesicles. *q, r.* Interruptions in the muscular coat of the body wall for the ventral and lateral setæ respectively.

FIG. 18.—One of the posterior nephridia. *a.* The vesicular diverticulum. *b.* The tubule. *c.* The entrance of the tubule into the neck of the vesicle. *d.* The duct leading to the nephridiopore. *e.* Nephridial funnel.

FIG. 19.—A nephridial funnel.

FIG. 20.—A diagrammatic transverse section through the body to show the relative positions on one side of the pyriform vesicle, and on the other of the nephridiopore with the setæ. 1, 2. The ventral couple of setæ. 3, 4. The lateral couple of setæ. *a.* Pyriform vesicle. *b.* Its external pore. *n.* Nephridial vesicle. *o.* Nephridiopore.

FIG. 21.—A transverse section through a pyriform vesicle. *a.* Membrane forming the outer wall. *b.* Granular substance. *c.* Columnar epithelium lining the lumen. *d.* lumen.

Diachæta Thomasii.

FIG. 22.—Dorsal view of the first thirty-nine somites, showing the scattered and alternating arrangement of the setæ. ($\times 3$.) *cl.* Clitellum, occupying somites XX to XXXIII. *r.* Ridge in the somites anteriorly to somite x.

FIG. 23.—View, from below, of a portion of the body wall which has been cut along the dorsal mid-line and pinned out, so as to show the alternating and asymmetrical arrangement of the setæ, which are numbered 1 to 7. ($\times 10$.) *a.* The nephridiopores. *c.* The spermathecal pores. *d.* Setæ, 1, 2, 3, corresponding to the ventral couple of *Lumbricus*. *e.* The setæ, 4, 5, 6, 7, corresponding to the lateral couple.

FIG. 24.—Ventral view of three somites of the clitellum, which has been cut along the dorsal mid-line and spread out. *a.* The nephridiopores. *b.* The pores of the sperm-duct. *d.* The ventral setæ. *e.* The lateral setæ.

FIG. 25.—A seta; nat. size 0.25 mm.

FIG. 26.—General view of the worm, when opened from the dorsal surface; the spermathecæ have been straightened out in order to show their position; the gizzard, &c., are hidden by the strong septa. ($\times 3$.) *a.* The supra-pharyngeal ganglia. *b.* The pharynx. *c.* The modified first nephridium. *d, d.* The spermathecæ. *e, e.* The strong septa behind the somites VI to X. *f.* The ciliated rosette. *g.* The seminal reservoir. *h.* The dorsal blood-trunk. *j, j.* Nephridia. *k.* The sacculated intestine. *l.* A lateral heart.

FIG. 27.—A nephridium. *a.* The coiled tubule. *b.* Vesicular portion or duct, being a continuation of the tubule. *c.* The portion of the duct leading to the nephridiopore. *f.* The funnel.

FIG. 28.—One of the first pair of nephridia (“glandes à mucosité” of Perrier). *a.* The glandular-looking mass of tubules. *b.* The vesicular portion or duct. *c.* The external aperture which is placed on the anterior edge of somite II.

FIG. 29.—A spermatheca.

FIG. 30.—A portion of the nerve-cord, showing four closely placed ganglia, with the lateral nerves.

Trigaster Lankesteri.

FIG. 31.—Ventral view of the first fifty somites; the body wall has been cut along the dorsal mid-line and pinned out. ($\times 2$.) *a.* The prostomium. *b.* The mouth. *c.* The lateral setæ. *d.* The ventral setæ. *e, e'.* The spermathecal pores. *f, f'.* The papillæ forming the sides of the median fossa. *g.* The median genital fossa. *h.* The clitellum occupying somites XIV to XL.

FIG. 32.—Two somites further enlarged, to show the three grooves which surround the somites. *a.* A more or less prominent ridge in the anterior somites. *c.* The lateral, and *d.* the ventral setæ.

FIG. 33.—The alimentary tract, together with the septa, removed from the body. ($\times 4$.) *a.* The buccal region. *b.* The pharynx. *c, d, e.* The three

pairs of glandular-looking, modified nephridia. *f, f, f*. Œsophageal regions, separated by the three gizzards, *g, g', g''*. *h, h*. The septa. *j'*. The tubular intestine. *k*. The sacculated intestine.

FIG. 34.—The contents of the somites VI to XX after the removal of the alimentary tract. ($\times 3$.) *a, a'*. The two pairs of spermathecæ. *b*. The ovary. *c, c'*. Vascular tufts, probably nephridia, attached to the body wall. *d, d'*. The two pairs of prostates. *e*. The ventral nerve-cord.

FIG. 35.—A group of tubules from one of the modified nephridia of somite VI. *a*. The base from which the tubules arise. *b, b*. The capillary blood-vessels with their dilatations on the tubules. *c, c*. The branched processes springing from *a*.

FIG. 36.—The free extremity of one of the tubules of a modified nephridium from somite VI. *a*. Connective-tissue wall of the tubule. *b*. Capillary blood-vessel in the wall. *d*. A dilatation of the blood-vessel. *l*. Lumen of the tubule.

FIG. 37.—A transverse section of a tubule of one of the modified nephridia. *a*. A dilatation of one of the capillaries. *b, b*. Capillary blood-vessels. *c*. Connective tissue forming the wall of the tubule. *d*. Perforated cell of the nephridium. *l*. Intracellular lumen. *n*. Nucleus of perforated cell.

FIG. 38.—A portion of one of the vascular tufts, indicated at *c*. in Fig. 34. *a*. Connective tissue. *b*. blood-vessel. *l*. Intracellular lumen.

FIG. 39.—The ovary attached to the septum XI—XII. ($\times 10$.)

FIG. 40.—A lobule of the ovary, with the blood-vessel, *b*, branching amongst the cœlomic epithelial cells, *c*, amongst which are the ova, *a*. (Slightly diagrammatic.)

FIG. 41.—A portion of a section through the prostate, near its external aperture. *a*. Cuticular lining. *b*. Columnar epithelial cells. *c*. Muscular coat. *d*. Membrane forming outer wall of prostate. *e*. Blood-vessels lying in this coat, and branching amongst the epithelial cells.

FIG. 42.—A portion of a section through the prostate near its free extremity. *a*. Deep-lying, club-shaped granular cells. *b*. Columnar epithelial cells. *e*. Blood-vessels ramifying amongst the club-shaped cells. *d*. A membrane forming the external coat of the prostate.

FIG. 43.—A portion of a transverse section through one of the intestinal glands of *Urobenus*. *a*. Various-sized, oily-looking globules (? calcareous) lying in the lumen of the tubules. *b*. Large blood-sinuses surrounding the tubules. *e*. Epithelial cells lining the lumen. *l*. The lumen. *m*. Basement membrane to the epithelium, forming the wall of the blood-sinus.