XIV.—On some Scottish Oligochæta, with a Note on Encystment in a Common Freshwater Oligochæte, Lumbriculus variegatus (Müll.).

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During a visit to the Isle of Bute in the summer of 1920 I took the opportunity of collecting a number of the smaller Oligochæta on the shore at Ascog, and in a pond on the hill just above the village. An account of this collection is given in the present paper; I have also added notes on a few species I have met with since then near Edinburgh. For laboratory accommodation at Ascog I have to thank Prof. L. P. W. RENOUF, at that time Superintendent of the Biological Station, who very kindly placed the resources of the institution at my disposal.

While on leave last summer Dr ANNANDALE, Director of the Zoological Survey of India, undertook, during July, a survey of the invertebrate fauna of Lochs Lubnaig and Vennachar; later, in August, he visited the Isle of Ulva. The Oligochæta in his collections he handed over to me, and the results of my examination are also included here. The number of species of Oligochæta collected by Dr ANNANDALE was not large; the greater number of his tubes contained only *Lumbriculus variegatus* (Müll.). The seven species identified in his collection have all already been recorded from Scotland; there were in addition a number of immature specimens,—some Tubificidæ and some Lumbricidæ—which were indeterminable. The most interesting specimens of his collection were the cysts of *L. variegatus*, described at length below.

Besides a number of records of species already known as British, the present paper includes:—

(i) Descriptions of two new forms—

Vejdovskyella comata (Vejd.), var. *scotica*,

Tubifex (*Peloscolex*) *insularis*.

(ii) Additional particulars of certain forms which are not as yet sufficiently well known to be regarded as commonplace.

(iii) A record of certain forms which have, apparently, not hitherto been found in the British Isles. These are:—

Chætogaster langi, Bretscher,

Nais variabilis, Piguet,

Nais simplex, Piguet,

Nais pseudobtusa, Piguet,

and perhaps also *Chætogaster diaphanus* (Gruith.), which I found at Ascog, since the previous British record of this worm is, according to SOUTHERN (18), doubtful.

(iv) A discussion, in relation to a species of the genus *Lumbricillus*, of the variability of certain features of the Enchytræid organisation which are commonly used for systematic purposes, and of their value in this regard.

(v) An account of the encysted specimens of *L. variegatus* discovered by Dr ANNANDALE.

Fam. NAIDIDÆ.

Genus CHÆTOGASTER, K. Baer.

Chætogaster limnæi, K. Baer.

Ulva; specimens taken from *Limnæa* and from *Ancylus* (N. Annandale).

Chætogaster langi, Bretscher.

(= *C. punjabensis*, Steph. 1907.)

Pond on hill above Ascog, Bute.

Duddingston Loch, Edinburgh. Free-living.

This, the smallest Chætogaster described, is a minute worm which does not reach a greater length than 2 mm.; and as it is at the same time very thin and transparent, it is only to be found by searching through the material with a dissecting microscope.

Meeting with the worm here in Scotland, I was surprised to recognise in it a form with which I was familiar in India, and which I described in 1907 (20) under the name *Chætogaster punjabensis*. My failure to identify the Indian worm correctly was due to my want of experience at that time, and especially to my attributing too much importance to slight differences from the published descriptions.

A feature which has not been recorded for European specimens of this species, but which is found in the Indian, and now again in the Scottish examples, is the presence of a peculiar granular and at the same time refractile body at the posterior border of the cerebral ganglion. This has the form of a saucer or shallow bowl, which fits on to the hinder part of the ganglion. A similar but less marked structure of the same kind is present in *Chætogaster crystallinus* (v. inf.), and apparently also in *C. diastrophus*, in which VEJDOVSKY states (24) that between the posterior lobes of the cerebral ganglion there is a shining sharply contoured chitinous plate (MICHAELSEN in the *Tierreich* (9) queries the "chitinous"); the figure of *C. diastrophus* shows the body to be similar to that of *C. langi*.

The head of *C. langi* has a distinct prostomium; the mouth faces downward and forwards. Usually $n = 8$,* possibly sometimes 9; from my figures of the Indian worm, this is the case in the Punjab also.

The worm is apparently a pure vegetable feeder, living on small green algæ.

The occurrence of this species in two so widely separated parts of the world as Northern India and Western Europe shows—what is now well known—how readily these small fresh-water worms are spread, and how in consequence they are of only slight value in the discussion of questions of zoogeography.

Chætogaster crystallinus, Vejd.

Duddingston Loch, Edinburgh. Free-living.

This is also a small worm, though rather longer and considerably thicker than *C. langi*; the Edinburgh specimens may be 3 mm. when extended. Its chief characters are well known, and are described and illustrated by VEJDOVSKY (24).

There is no prostomium; and the mouth, which faces more forwards than downwards, can dilate widely, as if taking in a gulp of water; the anterior end has then momentarily a

* When asexual reproduction takes place in the Æolosomatidæ and Naididæ, a number of newly formed segments are first intercalated in the middle of the body of the worm, and fission takes place through this "budding zone." The number of segments in front of this intercalated zone is denoted by the letter *n*.

funnel- or trumpet-shaped appearance. The head does not narrow towards the tip of the snout, as in *C. langi*, but is thickest at or just behind the mouth; the dorsal border of the mouth is slightly indented in the middle line, which may serve as a character for recognition.

There is a small "chitinous" plate behind the cerebral ganglion, but this is less evident than in *C. langi*; it appears as a thin curved line only. In all the specimens I have examined I have found in the stomach wall a number of oil-like droplets of a bright orange colour.

$N = 8$; the animal feeds on both animal and plant food; I found small Crustacea, diatoms, and green algæ in the alimentary canal.

Chætogaster diaphanus (Gruith.).

Pond on hill above Ascog, Bute. Free-living.

Length when extended 3·5 – 6 mm. There is really no prostomium, the anteroventrally placed mouth reaching to the tip of the head. $N = 10$ or 12.

The setæ of segment ii are 11 or 12 per bundle, those of more posterior segments 7 or 8, usually 8; the bundles are not, as in some species (*e.g.*, very markedly in *C. bengalensis*) arranged in the form of a horseshoe. In segment ii the longest setæ, which are those in the middle of the bundle, have a length of 213 μ, the shortest, at the sides, being 156 μ; in more posterior segments they measure from 143–185 μ. The outer prong is one-third longer than the inner, and the two prongs are of equal thickness; the curve of the shaft is slight. The nodulus in the middle setæ of the bundles of segment ii is proximal to the middle of the length of the shaft (proximal portion of shaft: distal portion : : 2 : 3 or nearly) but the setæ at the sides of the bundle have the nodulus slightly distal (proximal : distal : : 4 : 3); the nearer the end of the bundle the more markedly distal is the nodulus (for variations in the position of the nodulus in the several setæ of the same bundle in the Naididæ, *cf.* STEPHENSON, 22).

The œsophagus is a distinct narrow tube; when the animal is extended the length of the œsophagus is equal to half that of the pharynx; when contracted, to a quarter that of the pharynx.

A refractile body is present in the cerebral ganglion.

The animal is carnivorous; small Crustacea were seen in the alimentary canal.

Genus NAIS, Müll., em. Vejd.

Nais elinguis, Müll.

Ascog, Bute; above ordinary high-water mark on the shore.

A considerable advance was made some years ago in the study of this genus by PIGUET (15). Besides recognising a number of new species and varieties, this author gave an account of the genital organs in several forms, and described and figured the setæ more accurately than had been customary up to that time. By these means he showed that what had up to then passed as one of the common species of the genus, *Nais elinguis*, comprised at least three species and a number of varieties. Two of these species, that which retains the name *elinguis*, and that separated off by PIGUET as *N. variabilis*, I found at Ascog; and two, *N. variabilis* and *N. communis*, in Edinburgh.

The habitat of the specimens of *N. elinguis* found at Ascog was peculiar; they occurred on the shore, above ordinary high-water mark, in wet and decaying seaweed, along with Enchytræids. So far as I know, it has always hitherto been found in fresh-water ponds, etc.

Since we possess PIGUET'S description, and a previous account by MICHAELSEN (10), I need only give a few notes on these specimens. The prongs of the ventral setæ were about

equal in thickness (agreeing with MICHAELSEN's specimens; in PIGUET's the lower prong was about twice as thick as the upper). The nodulus was at the middle of the shaft, or was somewhat distal (up to a ratio of proximal : distal :: 3 : 2) in the setæ of the anterior group (segments ii–v), while it was more markedly distal (3 : 2 or even 2 : 1) in those of the remaining segments. The cerebral ganglion was deeply bifid behind, concave in front.

Nais variabilis, Piguet.
Pond on hill above Ascog, Bute.
Duddingston Loch, Edinburgh.

The species is one that, before its separation by PIGUET in 1906 (*v. sup.*), had doubtless been confused with *N. elinguis*. It has not, apparently, so far been described by any other author; the following notes on the species as it occurs in Scotland may therefore be of interest.

Length moderately extended 3 mm.; when somewhat contracted 2 mm.; very transparent. $N = 19$, 20, or 24 (this latter is a higher number than PIGUET found for any of his specimens); the animal may reach a length of 34 segments without showing any budding zone.

The anterior ventral setæ (segments ii–v) are 3–4 per bundle, 82–88 μ long, and 2·5 μ thick; the prongs are very nearly equal in length, the superior being slightly longer, while the inferior is the thicker—about half as thick again as the other; the nodulus is slightly distal to the middle of the length of the shaft (proximal portion : distal portion :: 4 : 3 or 5 : 4), or it may be almost at the middle. The setæ of more posterior segments are 2 or 3, occasionally 4 per bundle, in length 74–82 μ, and 3 μ thick. There is only a slight difference in type between these and the setæ of the anterior bundles: the posterior are slightly shorter and stouter than the anterior, the inferior prong of the fork is about twice as thick at its base as the superior, the nodulus is more distal (in general proximal portion : distal portion :: 2 : 1), and the curve of the shaft is slightly more marked in its proximal half.

The dorsal bundles are composed usually of one hair and one needle. The hairs are 184–246 μ long, about equal to or rather longer than the diameter of the body. The needles show only a slight curve distal to the nodulus, which is indistinct, and situated one-quarter of the length of the shaft from the distal end; the forking at the tip is minute, but easily visible with the ordinary high power if the needles lie suitably and nothing obscures the view.

The stomachal dilatation varies. MICHAELSEN (11) and following him PIGUET (16), in their keys for the genus, use the gradual or sudden dilatation of the alimentary tube in segment vii as a distinguishing character of certain species, *N. variabilis* being one of those which are characterised by the suddenness of the dilatation. In the present specimens the dilatation may be either slight or quite distinct; and it may occupy segments viii, or vii and viii. The anus is dorsal.

Chloragogen cells begin in segment vi. The cœlomic corpuscles are spherical, and compacted of refringent particles. The nephridia begin in segment vii. The cerebral ganglion is indented in front and behind; the angle behind, between the elongated posterior processes of the ganglion, is more acute than that in front.

Nais communis, Piguet.
Duddingston Loch, Edinburgh.

This species, also probably previously confused with *N. elinguis*, has been recorded by SOUTHERN from Clare Island (19).

Nais simplex, Piguet.

Pond on hill above Ascog, Bute.

This form was originally described by PIGUET (15) as a variety of *N. variabilis*; it has apparently not been recorded by anyone except its original describer.

My specimens measured 4–5 mm. in length (3 mm. when contracted); the worm wriggles actively, like a Nematode. The number of segments in a single animal may reach 28 or 30; when the budding zone forms it does so behind the 14th, 18th, or perhaps the 20th segment ($n = 14$, 18, or ? 20).

The blunt prostomium has the form of an almost equilateral triangle, with its sides rather longer than the base. Eyes are present.

The anterior ventral setæ (segments ii–v) are five per bundle, 80–90 μ long, and 2 μ thick; the proximal and distal curvatures are slight; the terminal prongs are rather slender, the superior one-third as long again as the inferior, and equal to it in thickness (with the oil immersion the inferior appeared very slightly the thicker); the nodulus is at the middle of the shaft or slightly proximal (proximal : distal : : 3 : 4 or 4 : 5). Behind segment v the setæ are four or three per bundle, about 68 μ long and 3 μ thick; the curves are more pronounced; the prongs are equal in length, the proximal twice as thick as the distal; the nodulus is distal to the middle of the shaft (proximal : distal : : 5 : 3).

The dorsal bundles consist usually of two hair setæ and two needles, sometimes of one hair and one needle, or one hair and two needles. The hair setæ are ·2 mm. long, rather longer than the diameter of the body. The needles, 65 μ long and 2 μ thick, have the nodulus distally placed (proximal : distal : : 2 : 1 or 5 : 3), the shaft distal to the nodulus being slightly curved in the form of a sabre; with the oil immersion lens there is in some, but not in all, a scarcely perceptible forking of the tip.

Here again the stomachal dilatation varies considerably. There may be no distinct stomach, only a slight widening of the tube in segments vii and viii; or there may be a sudden swelling in vii, or a marked stomachal dilatation occupying vii and viii. Chloragogen cells begin in segment vi. The cœlomic corpuscles are numerous, round, and composed of refringent particles. The first nephridium is in segment vii. The cerebral ganglion is indented in front and behind, the angle in front being more obtuse than that behind.

Nais pseudobtusa, Piguet.

Duddingston Loch, Edinburgh.

Genus VEJDOVSKYELLA, Mich.

Vejdovskyella comata (Vejd.), var. *scotica* var. nov.

Pond on hill above Ascog, Bute.

Length from 2 to nearly 3 mm. when extended, 1·5 mm. when moderately contracted. Comparatively sluggish. A single individual may have 24 segments; in one which is preparing to divide $n = 14$ or 16. Prostomium short, semicircular, with sensory bristles. Small eyes present.

The ventral setæ are 3–5 per bundle in the most anterior segments, 3–4 in the remainder; the shaft is slender, the curve slight; the nodulus is proximal to the middle of the shaft—very markedly so in the most anterior bundles, less markedly in the rest; the two prongs are

nearly equal in length, the outer being slightly longer, while the inner is twice as thick at the base. The length of those in segment ii is 100 μ, in iii is 80–90 μ, in the rest the length varies from 65 to 80 μ.

In the type form of the species the number of setæ in the ventral bundles of segment iv is smaller—from none to two—than in other segments. The present variety appears to share this character. I did not know of the peculiarity while I had the living worms at my disposal, but an examination of a permanent setal preparation seems to show that there are, in that particular specimen, two setæ on one side and none on the other in the fourth segment.

The dorsal bundles begin in segment v, and consist of 5, 6, or occasionally 7 stout feathered hairs, and an equal or sometimes rather greater number of needles. The hairs are characteristic; they are thick, rather curved, tapering, but not ending in a fine point, from ·25 or less up to ·34 mm. in length; the longer ones exceed in length the diameter of the body. On the distal half of the shaft, along the convex side of the curve is a fine feathering, a series of fine hairlike projections, 4–8 or sometimes 10 in number (text-fig. 1). The needles are applied to the basal portions of the hairs; they are straight or nearly so, tapering and finely pointed, without nodulus, and from 85 μ to 105 μ long.

TEXT-FIG. 1.—Hair setae from the dorsal bundles of *Vejdovskyella comata*, var. *scotica*. × 200.

The stomachal dilatation is variable; there may be no definite stomach, or only a slight swelling in segment vii, after which the canal narrows again; or the stomach may be a fairly distinct section of the alimentary tube. Chloragogen cells begin in segment v. The blood is very faintly red. The first nephridium appears to be in segment vii.

The features in which this form differs from the type of the species are its smaller size (2–3 as against 4–6 mm.); fewer setæ in the bundles behind segment iv; perhaps the more proximal position of the nodulus; and especially the invariable position of the feathering of the dorsal hair setæ on the convex instead of on the concave side of the hair. KLEIBER (7) has, however, recorded that single setæ of the type form have sometimes a double row of feathering, sometimes none. SOUTHERN (18) finds no swelling on the œsophagus.

Genus PRISTINA, Ehrbg.

Pristina longiseta, Ehrbg.

Small pond in garden, Ascog, Bute.

Genus STYLARIA, Lm.

Stylaria lacustris (L.)

Pond on hill above Ascog, Bute.

Loch Vennachar. (N. ANNANDALE.)

Genus SLAVINA, Vejd.

Slavina appendiculata (Udek.).

Pond on hill above Ascog, Bute.

Fam. ENCHYTRÆIDÆ.

Genus MARIONINA, Mich.

Marionina semifusca (Clap.)

Between tide-marks, Ascog, Bute.

The specimens agree in general with those I previously described from Millport (21). I have devoted some attention to the shape of the nephridia in this species; the anteseptal portion consists of a small cylindrical funnel; the postseptal portion is on the whole cylindrical in shape, somewhat swollen near its ectal end. The duct is practically non-existent, the hinder end of the postseptal mass being contiguous to the body-wall.

The spermathecæ and ducts have the same constitution as in *Lumbricillus pagenstecheri* (*v. inf.*).

Genus LUMBRICILLUS, Oerst.

Lumbricillus pagenstecheri (Ratz.).

Under stones at about high-water mark, in the immediate neighbourhood of a small fresh-water stream running on to the shore, Ascog, Bute.

MICHAELSEN in the *Tierreich* (9) doubtfully identifies several worms, described under this or other names by various authors, with RATZEL'S *Enchytræus pagenstecheri*; the only authors he allows to have undoubtedly had this species under observation are VEJDOVSKY and UDE. As I think there can be no doubt about the identity of my specimens, it seems worth while to supplement existing descriptions.

Length (preserved) 6 mm. segments 43. Prostomium semicircular. The gland cells of the epidermis are very prominent in sections, forming regular papillæ, reminiscent indeed of *Tubifex benedeni* (*v. post*), and discharging granular particles; they are also fairly conspicuous in the entire animal, and can be seen to be arranged in transverse rows.

The setæ are "enchytræine" in shape—*i.e.*, the shaft is straight, except for a short curve through nearly a quarter of a circle at the proximal end (the "lumbricilline" setæ which are more usual in this genus and in the allied *Marionina* have a gentle double curve, the distal and proximal ends being curved in opposite directions). The ventral setæ are 5–6, occasionally 4, per bundle in the pregenital, and 4, occasionally 3 or 5, in the postgenital segments. The dorsal setæ are 4, occasionally 3 or 5, in the pregenital, and 3, then 4, and lastly 3 again in the postgenital segments.

The cœlomic corpuscles are elongated, fusiform in outline, granular, and nucleated.

Septal glands are present in segments iv, v, and vi. The dorsal vessel arises in the anterior part of segment xiv. The copulatory glands are large in segments xiv and xv.

The clitellum embraces segments xii and xiii, and just gets on to xiv ventrally. The testes are considerably lobed, and extend into segments x and xi; the lobes are invested in parts by a membrane, which in other parts has apparently disintegrated; there are a few vacuoles in the substance of the lobes. The male funnels are three to five times as long as thick. The penial bulb is moderately large, of spherical form, with muscular and peritoneal investments; in its ventral portion it has an irregular chitin-lined cavity.

The spermathecal ampulla is thin-walled and spherical; its wall is composed of an epithelial layer with a thin peritoneal investment; it is united to the alimentary tube, but there is no pervious passage (in the specimens sectioned). The duct is longer than the ampulla, thick, with a nodose surface; this is due to the irregularity of the cells which compose its wall. These cells are not a peritoneal investment, but the epithelial layer itself,

continuous on the one hand with the lining of the ampulla, and on the other with a compact glandular crown round the base of the duct. A few rather flattened peritoneal cells are to be seen outside ampulla and duct, but there is no muscular coat over either portion of the apparatus.

Lumbricillus viridis, Steph.

At high-water mark, under stones, near a stream of fresh water, Ascog, Bute.

The specimens corresponded closely in size, in the distinctive colour, and in general habit and movements, with those originally described from Wemyss Bay, Renfrewshire (21). The following additional particulars may be noted.

The gland cells in the epidermis are extremely noticeable in sections; they form papillæ in many places, and appear to be discharging granular matter.

The anterior septa are very stout. Septal glands occur in the segments iv, v, and vi; septum 6/7 is bulged back by the glands. The blood is almost colourless, but has a slight pink tinge. The dorsal vessel may begin in segment xiii, as in previous examples; but in some specimens it begins much farther back—in xvii or in the anterior part of xviii.

The nephridia in the present specimens are ovoid in shape, the anterior end rather narrower; the middle of the postseptal portion is fused with the ventral body-wall; the duct is cylindrical, equal in length to the postseptal portion, and coming off from near the posterior end leads downwards or downwards and forwards.

The cerebral ganglion is rounded behind, or very slightly indented. Copulatory glands are large and lobed, in segments xiv, xv, and xvi; there are small glands in xvii. In my previous specimens they were described as being present throughout the whole of the anterior part of the body, though nowhere forming very prominent masses; as both descriptions are based on the examination of sections, I think we must assume that there is really a considerable degree of variation in these organs.

The clitellum comprises segments xii, xiii, and one-third or two-fifths of xiv, though the surface epithelium is higher on each side of the midventral line as far back as the hinder end of xiv.

The testes are much lobed, and extend into segments x and xi; the lobes are not enclosed in sacs, but at the end remote from their attachment merge into closely aggregated masses of sperm-morulæ. The funnel is about five times as long as broad (seven, nine, or ten times in previous examples). The penial bulb is rather small.

I should, on the evidence of the present specimens, after examination by both sections and dilacerations, describe the spermathecæ as possessing a subspherical ampulla with an irregular and chitin-lined cavity, a duct longer than the ampulla and well marked off, and a very large circle of gland cells round the duct.

Lumbricillus lineatus (Müll.)

(= *Pachydrilus verrucosus*, Clap. 1861.
? *P. maximus*, Mich. 1888.
P. subterraneus, Vejd. 1889.
P. litoreus, Hesse, 1893.
Lumbricillus lineatus, Mich. 1900.
L. evansi, Southern 1909.)

Between tide-marks, Ascog, Bute.

This species (the same which I described under the name of *L. subterraneus* (Vejd.) from the Clyde in 1911 [21]) has given me far more trouble than any of the others, because of its variability.

Most of the forms in my Ascog collection of worms were fairly easily and soon distinguished; having separated off these, there remained a number of catches of small reddish Enchytræids, of varying sizes, taken on the shore at various times and places. Among these, *Marionina semifusca* was distinguished by the form of the testes, and *Lumbricillus pagenstecheri* was also recognisable from the published description. But even so, eight batches remained, none of which agreed in all respects with the diagnoses of known forms.

If the several specific characters of these specimens are separately considered, the extreme forms which each character assumes are quite far enough apart to justify the erection of a number of distinct species—if, that is, there had not been a number of baffling intermediate forms. But not only are the extreme forms connected by intermediate forms, but the different combinations of these variations are so numerous that it appeared to me impossible to do otherwise than unite the whole in one variable species. The only alternative would have been to make eight different species, or perhaps more, since there were notable variations within the same batch of material.

My observations have, I think, a general bearing on the systematics of the Enchytræidæ, and on the value of certain structures as specific characters; and I therefore propose shortly to discuss the question as to what structures are of most value in this regard.

The *number of segments*, as would perhaps be expected, does not seem to be of great value; while in most specimens the number was between 42 and 51, the extremes were 38 and 62.

Size is more variable than one would expect; the extremes, in the preserved condition, are 4–14 mm., and all intermediate lengths occur.

The *setæ* also vary considerably in the number per bundle. The anterior ventral average about six per bundle, the posterior ventral about five, and the dorsal setæ about five; but the extremes were 3–9 for the anterior ventral, 2–7 for the posterior ventral, 3–7 the anterior dorsal, and 2–7 the posterior dorsal—again with all the possible intermediate terms. In my former specimens (21) (which I called *L. subterraneus*), the variations are equally wide, though the numbers are on the whole somewhat higher (5–11 for the anterior ventral, 3–8 the posterior ventral, 4–8 the anterior dorsal, 3–7 the posterior dorsal).

The place of *origin of the dorsal vessel* can only be accepted as of systematic value (to judge from the present species) with a considerable allowance for variation. Here it arises oftenest in segments xiii or xiv, but it was seen to originate in different specimens in every segment from xii to xvii. In my former specimens it was found to vary in place of origin from xiii to xvii.

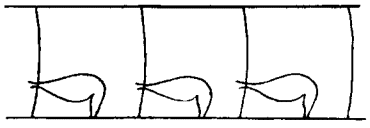
The *nephridia* are much used for specific distinctions, especially the origin of the duct (from the anterior part, middle, posterior part or hinder end of the organ), its direction (downwards, or obliquely forwards, or obliquely backwards), and length. I find that the duct may originate from the middle or from the hinder end, or again in intermediate positions; even in the same batch it might arise at the hinder end or from a little behind the middle. The direction of the duct may be any of those mentioned—directly downwards, downwards and forwards, or downwards and backwards. The shape of the postseptal portion of the gland may be either high and hunched up, or narrow and elongated (these even in the same batch, and to some extent in the same individual), or it may be flattened on the ventral body-wall.

These variations in the nephridia are largely explicable on the basis of differences in the degree of contraction of the animal. Taking a worm in a medium condition of extension, the relative position of the parts of the nephridium might be as in text-fig. 2*a*; if the worm extended this portion of its body still farther, as in crawling forwards, the two ends of

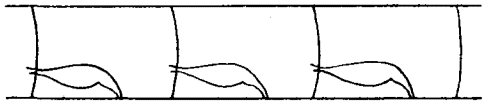
the nephridium being fixed (at the septum and at the nephridiopore), the organ will be stretched out, and the duct will pass backwards as well as downwards from the hinder end; the worm is contracted, and especially if it is curled ventralwards, the duct will be bent forwards, and will appear to arise from the under surface of the organ (text-figs. 2*b*, and 2*c*).

It is probable, however, that the characters of the nephridium itself may vary, even apart from the degree of extension of the region of the body where they lie. Thus CLAPARÈDE, in the original description of *Marionina semifusca*, shows the duct arising from the anterior part of the postseptal portion, and thence going forwards; my Millport specimens showed a similar place of origin for the duct, but it ran backwards (both in sections, and in the living animal); in the present specimens there was practically no duct, the hinder end of the postseptal mass being contiguous to the body-wall. This is a remarkable difference, yet it seems unjustifiable to erect a separate species on this difference alone.

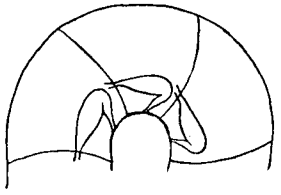
Again, in *Lumbricillus viridis* the nephridial duct comes off as a rule from near the posterior end, and passes downwards or downwards and forwards. But in a young specimen the nephridia were found to extend the whole length of their segments, and the ducts came off from the under surface—in some cases in front of the middle of the postseptal portion—passing downwards to the nephridiopore in front of the level of the setæ.



Text-fig. 2*a*.



Text-fig. 2*b*.



Text-fig. 2*c*.

TEXT-FIG. 2.—Diagram to show the different forms assumed by the same nephridia, according as the worm is (*a*) in moderate extension, (*b*) considerably extended, (*c*) contracted and curled.

DITLEVSEN (5) notes alterations of the place of origin of the duct according to the pressure of surrounding organs; the duct, for example, may be pressed against the postseptal mass. This he thinks has been a fruitful source of error.

Copulatory glands were invariably present in segment xiv, and may occur in a series from xii to xv, or consecutively in three, or in two, of these segments, or they may be present in xiv only. They are usually large in xiv, or at least of moderate size; either large, of moderate size, or small in xiii, large or small in xv, small (only seen once) in xii.

Again comparing matters in *Lumbricillus viridis*, I find that in the present specimens of this species the copulatory glands are large lobed masses in segments xiv, xv, and xvi, and smaller glands are present in xvii. But in the original specimens obtained at Wemyss Bay (21) the glands were nowhere very prominent, and were very much more widely distributed—indeed they occurred throughout the whole of the anterior part of the body.

SOUTHERN (18) found great variation in the copulatory glands of the genus *Lumbricillus*; "in some cases individuals have shown well-developed glands, whilst in others from the same locality they were either small, absent, or in different segments."

DITLEVSEN (5) doubts how far the extent to which the dorsal surface of the nerve cord is covered by the glands may vary, and whether a total covering over of the cord may not be simulated through the pressure of neighbouring organs or of the contractions of the body of the worm forcing the wings of the glands inwards over the cord.

The *male funnels* are among the structures which are most relied on in this family for furnishing specific characters; the important feature is the length relatively to the thickness.

In the present specimens of *L. lineatus*, the organs were most commonly about four times as long as thick; but all proportions from $2\frac{1}{2}$ to 6 times were noted. The funnels are extremely contractile, and a considerable range is doubtless possible in the same specimen. In my previous account of this worm, I note that the funnels may be as much as nine times as long as broad, but that they may shorten—for example, on teasing up the specimen to isolate the various organs—to as little as twice as long as broad; and even in the body they may appear only about four times as long as broad.

SOUTHERN also (18) found the funnel to be a very variable organ in this genus. MICHAELSEN (11) considers it questionable whether *L. subterraneus* is to be kept distinct from *L. lineatus*, though he puts the length of the funnel in the former at nine times, and in the latter at only two to four times its thickness. These figures correspond remarkably with the actual variations I myself found in the Millport specimens.

The characters of the *spermathecæ* are among those most frequently used for systematic purposes. In the present species my notes describe the form of the ampulla as barrel-shaped, spindle-shaped, broadly spindle-shaped, ovoid, somewhat conical, or thickly sausage-shaped. In many there was a notable kink in the side of the ampulla. There is also some variation in the crown of gland cells surrounding the external aperture—in its size, whether or not it is lobed, and whether or not it extends all round the duct. DITLEVSEN has pointed out that the shape of the spermathecæ of fixed specimens, when isolated by dilacerations, often differs, on account of the previous pressure of surrounding organs, from that which is observed in the living animal.

I took no particular note of the shape of the *cerebral ganglion* in the present specimens, since I think it is agreed that difference of form, unless very marked, can be of no value; compare, for example, DELPHY (4, p. 75). The points which used to be relied on were the presence and extent of the anterior and posterior indentations between the right and left halves; but this depends on the degree of extension of the anterior part of the animal. If the anterior end is stretched forwards, the indentations are exaggerated, and each has the form of an acute angle; if contracted, they are shorter and more obtuse.

I do not say that the characters which I have shown to be variable in the present species, and in some other species of the genus *Lumbricillus*, are of no value for systematic purposes—it is possible that they may be, in other genera—but their value cannot be assumed: it will have to be tested by an examination of numerous specimens before they can be utilised. I think, however, that the foregoing considerations may be applied to certain species of *Lumbricillus*, and that such an application will justify the suspicions already more or less strongly expressed by certain authors regarding the distinctness of a number of these species.

SOUTHERN (18, p. 150) has already doubted whether *L. litoreus* and *L. lineatus* should be kept separate. The number of setæ in a bundle is supposed to be greater in *litoreus* (6–10 ventral, 5–6 dorsal) than in *lineatus*, but the difference is only slight. The copulatory glands are supposed to meet over the dorsal surface of the nerve cord in *lineatus*, but not in *litoreus;* we have seen, however, that this has probably little value as a diagnostic point.

MICHAELSEN (11) considers it doubtful whether *L. subterraneus* is to be kept distinct from *lineatus*. Here the difference is in the male funnel, two to four times as long as thick in *lineatus*, as much as nine times in *subterraneus*. I actually found variations of this amount in the worms which I identified as *L. subterraneus* in 1909 (19).

SOUTHERN has recently (18) described a new species of the genus under the name *L. evansi*. It is stated to differ from *L. subterraneus* in the presence of cutaneous glands, in

the shape of the lymph corpuscles and spermathecæ, in the presence of a much enlarged and folded lip of the male funnel, and in being littoral. I do not think that the shape of the lymph corpuscles (oval and frequently pointed in *evansi*, narrow in *subterraneus*) will distinguish the two; in describing *subterraneus* myself, I call the corpuscles "irregularly pear-shaped or oval" (21). The spermatheca of *subterraneus* is variable in shape (*v. sup.*), and often has a kink on one side, which perhaps corresponds to the constriction which SOUTHERN found in the ampulla of *evansi*. As to cutaneous glands, though they have not apparently been mentioned by previous authors, I find them well marked in all my present specimens. As to the habitat, both my Millport specimens and the present ones, which certainly belong to the same species, are littoral, like *L. evansi*.

There remains the enlarged and folded lip of the male funnel. Here I may recount the following observation; on teasing out the organs from a specimen of *L. viridis*, one funnel was seen to have a shining crown, a portion of which became detached in the form of a complete frill—still, however, leaving a frill round the mouth of the funnel. On microscopic examination the detached frill was seen to consist entirely of spermatozoa. I think, from the description and figure of SOUTHERN'S species, that the enlarged and folded lip of the funnel of *L. evansi* is such a frill, and thus the chief distinguishing character of the species disappears. In sections of other forms, when they happen to pass transversely across the mouth of the funnel, one sometimes sees a similar frill, composed of the agglutinated, deeply staining heads of spermatozoa.

FRIEND (6) found every intermediate stage between *L. verrucosus* and *L. lineatus*. WELCH (25) "made a thoroughgoing examination of the literature dealing with a number of European species which seem to exhibit various degrees of mutual affinity," and concludes that *L. lineatus*, *litoreus*, *verrucosus*, *subterraneus* and *agilis* are the same species. DELPHY (4) in the synonymy prefixed to a notice of *L. verrucosus*, also introduces all the above names, including *L. evansi*, Southern.

I believe that the foregoing study of the amount of variation which occurs in the worms I took at Ascog furnishes the definite justification for the fusion of the above species. I might add that from the published description of *L. maximus* (Mich.) from S. Georgia (8) it appears that the only feature of this worm which can definitely distinguish it from the present group of forms is its size, 40 mm.; like these, it is both littoral and an inhabitant of fresh water: the fact that it comes from so remote a region is not against its identity. *Enchytræus albidus* is another littoral form which is found commonly on the shores of Europe and also in the Southern Hemisphere (Patagonia and Tierra del Fuego).

Genus ENCHYTRÆUS, Henle.

Enchytræus albidus, Henle.

Near high-water mark, Ascog, Bute.

Fam. TUBIFICIDÆ.

Genus CLITELLIO, Sav.

Clitellio arenarius (Müll.).

Between tide-marks, Ascog, Bute.

Genus TUBIFEX, Lm.

Tubifex (*Peloscolex*) *benedeni*, Udek.

Between tide-marks, Ascog, Bute.

I was interested in observing, in both the fresh and preserved specimens, and in sections, the cutaneous papillæ of this species. These have already attracted attention. RANDOLPH, for *T.* (*P.*) *velutina*, states (17) that the papillæ consist mainly of bacteria and foreign particles cemented together; but this is certainly a mistake. MICHAELSEN (10), giving a revision of the subgenus *Peloscolex* (characterised by an external papilla-bearing sheath), describes the papillæ as follows:— "All five species secrete an external, probably chitinous investment which is furnished with granular, closely set, oval or short and thick leaf-shaped papillæ, in more or less numerous and regular rings. These papillæ of the sheath are smaller on the anterior segments (present from segment ii) than farther back. The largest, 20–24 μ, I found in *T. velutinus*, the smallest, 6 to at most 18 μ long, in *T. benedeni*; *T. inflatus* with papillæ 8–36 μ long, and *T. ferox* with papillæ 8–24 μ long, stand between these two extremes." MOORE (12) says that the nearly black or deep grey colour results "from the remarkable flattened papillæ filled with greenish-grey granules with which the cuticle is thickly studded. These papillæ are arranged in irregular transverse rows in all regions except the prostomium, peristomium and clitellum, but they differ greatly in size and consequently in conspicuousness in different regions, being largest on the segments following the clitellum, and thence gradually decreasing in size towards the posterior end, where they are small and widely separated. There is also much individual variation in respect to the number and size of these papillæ, and it seems probable that they may be shed and developed periodically, though my opportunities for observing this species over a period of time have been very limited. Certain it is that small individuals with nearly or quite smooth cuticle are frequently found living with fully papillated mature ones, from which they appear to be otherwise indistinguishable. Fully grown worms with the papillæ scarcely developed also occur. . . . When as slightly developed as in the specimens mentioned, the papillæ might be readily overlooked as unimportant." References to the papillæ are also found in the papers by D'UDEKEM (23), CLAPARÈDE (3), and BEDDARD (1). Recently DELPHY (4) has stated that the papillæ are cells which have been pushed to the exterior, in which nuclei are still recognisable; but this I cannot confirm.

I found that the papillæ, transversely oval or nearly circular in shape as looked down on, in reality somewhat disc or leaf-shaped, with their flatter surfaces anterior and posterior, begin in segment ii and cease a short distance from the hinder end. They can be well examined in a freshly macerated specimen, which flattens out under the coverslip; the internal organs disintegrate and escape from the body, which remains as a fairly transparent empty sheath. The papillæ then appear as ovoid bodies projecting from the surface; some, rather triangular in shape, are attached by the base, while others are almost loose; they are darkish in colour, and contain a number of minute refractile globules, which remind the observer of chloragogen granules; some appear to be breaking up and scattering themselves as small roundish particles: little heaps of such particles seem to represent disintegrated masses. In sections the papillæ, 10–15·5 μ in height, with base slightly embedded in the epithelium, or merely adherent to the surface, or even quite free, are of a brownish-purple colour (the purple due to the hæmatoxylin stain); the ground substance of which they consist is fairly homogeneous; they have on their surface a number of black spherical granules, somewhat less than 1 μ in diameter. They

appear to be to some extent joined together at their bases by a general investment. Tangential sections of the body of the worm, which give transverse sections of the papillæ, show that there is a hollow slitlike space in the centre: this is open below, the cell substance projecting upwards as a core into the cavity.

Tubifex (*Peloscolex*) *insularis*, sp. nov.

Between tide-marks, Ascog, Bute.

In general features, size, colour, behaviour (coiling into a corkscrew), this worm resembles the last; there appear, however, to be distinctive differences which suffice to characterise it as a separate species.

The prostomium is rounded. The papillæ are much less prominent, especially behind the clitellum, than in the last species; they appear on examination of the living worm as a number of small dark spots, brownish in colour; they are absent from the first two and two-thirds segments (in *T. benedeni* they are absent from the first segment only). On the anterior segments they are 8–10 μ high, somewhat leaflike; expanded in the transverse plane, and implanted on or slightly in the integument by one end, which is often rather broader than the other which projects freely. In sections they are seen to consist of a brownish-purple homogeneous matrix (the purple due to the hæmatoxylin stain), with adherent black granules as before. According to sections, the papillæ are thrown off entire; but at an earlier stage their substance is continuous with that of the underlying cell, and at times the cell-substance appears to project up into the centre of the papilla as a rather more lightly staining core. Black granules similar to those already mentioned are seen on the surface between the papillæ.

Behind the clitellum there are no projecting papillæ. The black granules are present in numbers, held together in places apparently by some intervening substance, and so forming an almost complete investment.

The ventral setæ occur in the anterior part of the body in bundles of five, or sometimes of four; they are mostly bifid, but the outer prong is very small; occasionally there are two, small, very blunt subequal prongs, and sometimes a single-pointed seta is seen; indeed I have seen all three forms in the same bundle. Ventral setæ are absent in segment xi. Behind the clitellum there are fewer setæ in a bundle—only two; the points are here also various in type.

The dorsal setal bundles are composed of capillary setæ and crotchets. The capillary setæ may be several in each bundle in the most anterior segments, but soon become fewer, one or two per bundle only. The crotchets are here again of various kinds—bifid with very distinct prongs, of which the outer is shorter (these in the most anterior segments); bifid, but the outer prong very small; bifid, with two short blunt points; or finally they may be single-pointed.

There is a well-marked vascular plexus on the inner surface of the parietes in the first five segments; vascular loops are seen in the body-cavity in segments x and xi.

The clitellum embraces most of segment x, and all xi and xii; it is thus more extensive than in *T. benedeni*.

Loose morulæ and spermatozoa occupy segment x; an anterior sperm-sac is present in ix, and a posterior sac extends back as far as xvii or farther. In *T. benedeni* I have not seen it extending beyond xv.

The cup-shaped male funnels are in segment x. The vas deferens, heavily ciliated, about 40 μ in diameter, has a winding course in segment xii, and thence sends back a long loop by the side of the sperm-sac as far as the hinder end of the latter in segment xvii or farther back.

The sperm-sac is a posterior out-pushing of septum 10/11, and in its backward growth pushes succeeding septa before it; the vas deferens lies between the sperm-sac and the posterior evagination of the next septum; but the proper wall of the sperm-sac is so thin (it may even apparently be disintegrated in places) that the duct has the appearance of lying in the sperm-sac, which seems then to be an evagination of the next septum, 11/12.

The atrium, of some length, and surrounded by a strong muscular coat, is seen in segments xi and xii, really, of course, like the vas deferens, within the evagination of segment xi which envelops the sperm-sac. The epithelium of the atrium is in part a spongy mass in which little structure is visible (even nuclei not being apparent), and which leaves a very indefinite central lumen; in other parts the epithelial cells consist of masses of granules, and there is a considerable lumen. The atrium is joined by the vas deferens in segment xii.

The prostate occupies segments xi and xii, and may extend back into xiii; it consists of distinct spongy cells. Each prostate is attached by a narrow neck to the side of the atrium in xii, and there is an apparent continuity between the granular and spongy lining of the atrium and the substance of the prostate; the condition might be described by saying that the prostate appears to be a hernia of the atrial epithelium.

The penis is contained in a terminal chamber, and is invested by a chitinous sheath.

The spermathecal apertures are rather in front of the ventral setæ of segment x. The organs are in segment x, but may push into ix or xi. The ampulla is somewhat of an inverted pear-shape; the duct is sharply distinct from the ampulla, and is implanted at the thicker end; it is of the same diameter throughout. There may be a single thick spermatophore, 16 mm. in diameter, in the spermatheca, or there may be none. A curious and constant feature appears to be the presence of lateral swellings on the body-wall on a level with the spermathecal apertures.

The differences which distinguish this species from the foregoing appear to be the following:—

(1) The papillæ are smaller, begin in the hinder part of the third segment, and distinct papillæ are absent as a rule behind the clitellum. In view of MOORE'S observations (*v. sup.*) it is perhaps not wise to lay too much stress on this feature.

(2) The clitellum is more extensive here, taking up most of segment x, in addition to xi and xii.

(3) The spermatophores are large, ·16 mm. thick, and single in the spermathecæ or absent. *T. benedeni* has numerous spermatophores, of diameter ·05–·082 mm. in my specimens.

(4) The vas deferens extends far back, to segment xvii or farther. In *T. benedeni* it does not extend beyond xiii. The sperm-sac is also rather more extensive in the present form,—to segment xvii, as against xv or occasionally xvi in *T. benedeni*.

Fam. LUMBRICULIDÆ.

Genus LUMBRICULUS, Grube.

Lumbriculus variegatus (Müll.).

Pond in garden, Ascog, Bute.

Many places on Loch Vennachar and Loch Lubnaig; also Ulva and Inchkenneth. (Dr ANNANDALE.)

The most interesting specimens in Dr ANNANDALE'S collection were a number of encysted worms belonging to this species. Cysts were found sometimes in the water, sometimes also

some distance from the actual margin of the lake. In this connection it is worth recalling that owing to the exceptional dryness of the year (1921) the waters of the lochs stood at a lower level than for many years previously. On one occasion cysts were discovered under stones 13 yards above the water-level, with dead Gammarids; the shore of Loch Vennachar at this point was "covered for the most part with a turf of *Littorella* which extended a considerable distance both into the water and on dry land above present water-level; soil sandy with scattered stones, the presence of most of which was probably due to human agency." On another occasion a cyst was found on the lower surface of a stone on slightly damp earth some yards above the water-level at the time. On a third, the ground where the cyst was found is thus described: "Exposed *Littorella* turf; in wet weather below flood mark; ground generally sandy, mixed with a greater or smaller proportion of fine silt at different points; stones (none of great size) scattered on the turf and forming small stony areas."

Dr ANNANDALE describes the cysts in the fresh state as follows:—"The cysts varied greatly in size, the largest being about 1 cm. long. Their walls were transparent and thin, and appeared to consist of consolidated mucus. They were, however, quite definite. The shape of the cysts was irregularly ovoid. Inside each, one or more red-blooded worms were coiled up and contorted together. On being placed in water the cyst walls swelled up, the worms began to move about, finally bursting through at one or more points but leaving the walls otherwise intact. The larger cysts contained as many as ten different worms which differed greatly among themselves in facies, some being of darker colour than others and some even colourless. The process of hatching took at least a quarter of an hour, sometimes very much longer."

My own examination of the preserved cysts yielded the following facts:—The worms contained in the cysts were always fragments (sometimes quite small fragments), and were usually regenerating. As is well known, the animal breaks up with very great readiness, and has extraordinary powers of regeneration; indeed this fragmentation and subsequent regeneration may almost be considered as a normal method of reproduction in the species—a method which takes the place, to a considerable extent, of sexual reproduction; sexual individuals are indeed not very often met with.

The fragments may encyst separately, only one being found in a cyst; or there may be as many as sixteen closely coiled up together—apparently not all from the same worm. The cyst is thin and transparent, and adheres closely in places to the bodies of the worms. The cysts may be about 3 mm. in length by 2 mm. in the shorter diameter; the largest ones, containing numerous fragments, are about 5 by 3 mm. (they would thus seem to have shrunk considerably in the preserved condition). One cyst was found of an irregular shape, with a long, pointed projection; within were two small fragments and some flocculent and disintegrating matter; the projecting tail was prolonged inside the cyst as the dead and disorganised body of a fragment of a worm; the animal would seem to have sustained very severe injuries, and only two small portions had apparently maintained themselves.

The anterior end of the contained fragments often shows no regenerative processes; it may be rounded off quite smoothly, and entirely closed up, while the hinder end has been budding new segments in the form of a long and narrow tail; the diameter of this tail remains for some time less than half that of the body of the worm. In other cases the anterior end seems to undergo the first changes; a mouth may form, and a short prostomium may be established, before the hinder end has produced any new segments.

MRÁZEK (13) has found encystment in *Claparèdeilla*, another genus of Lumbriculidæ.

Here the individuals (not fragments) encyst singly; the cysts may remain single and isolated, or may aggregate together into masses the size of a hazel-nut; the encystment is a means of withstanding the periodical drying up of the tract on the banks of the Elbe where the worms are found. The individuals divide within the cyst. *Lumbriculus variegatus* was also found along with the *Claparèdeilla* in places which were drying up, but the author did not determine whether, and how, it can withstand desiccation; it does not encyst when kept in the laboratory, though the *Claparèdeilla* did so.

MRÁZEK published about the same time (14) a very complete study of the biology of *Lumbriculus variegatus*, in the course of which he says:—"Many of the places where *Lumbriculus* is found, dry up in the hot season. It is a question whether *Lumbriculus* can survive actual desiccation, and how. For the nearest relative of *Lumbriculus*—*Claparèdeilla*,—I have recently shown that encystment is the means by which this worm is enabled to maintain itself in such localities. For *Lumbriculus* in this connection we are at present unable to say anything definite. I have lately investigated a locality where *Lumbriculus* was very plentiful in the spring; in summer the pond dried up; I gathered much material from the bed, and poured water over it at home, but in spite of careful search could find neither worms nor cysts. After three days, however, I observed several small fragments of *Lumbriculus* in the vessels. If the animals had come out of cysts one would have expected the worms to be more numerous; but no more *Lumbriculus* made their appearance out of the material."

Lumbriculus variegatus is exceedingly common; SOUTHERN (18) calls it "by far the commonest aquatic Oligochæte in the British Isles." It seems remarkable, therefore, that encystment has not hitherto been observed—not even by MRÁZEK in the course of his extended study of the œcology of the worm. It is thus presumably a rare occurrence, only called forth in exceptional conditions; 1921 will be remembered as a particularly dry year.

Fam. LUMBRICIDÆ.

Genus EISENIELLA, Mich.

Eiseniella tetrædra (Sav.), f. *typica*.

Ben Ledi and Loch Lubnaig. (Dr ANNANDALE.)

Genus HELODRILUS, Hoffmstr. em. Mich.

Helodrilus (*Allolobophora*) *caliginosus* (Sav.), subsp. *trapezoides* (Ant. Dug.).

Ulva. (Dr ANNANDALE.)

Genus LUMBRICUS, L. em Eisen.

Lumbricus rubellus, Hoffmstr.

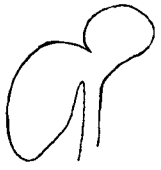
? Loch Lubnaig. (Dr ANNANDALE.)

Lumbricus castaneus (Sav.)

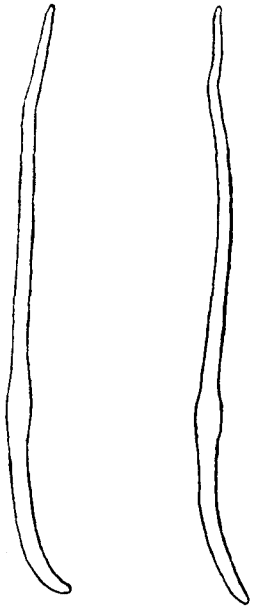
Ulva. (Dr ANNANDALE.)

The spermathecæ differ from those of most Lumbricids in having the ampulla divided into two parts by a deep constriction (text-fig. 3) The ventral setæ of segment x, implanted

on conspicuous whitish papillæ, are modified to form genital setæ, and present the form shown in text-fig. 4. Those I examined were ·6 mm. long and 16 μ thick in the middle;



TEXT-FIG. 3.—Spermatheca of *Lumbricus castaneus*.



TEXT-FIG. 4.—Genital setæ of segm. x. of *Lumbricus castaneus*. ×130.

a slight nodulus persists; the distal portion is almost straight, tapers gently, has a blunt point, and is characterised by a slight kink near the tip.

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