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ZOOLOGICAL RESULTS OF A TOUR IN THE FAR EAST.

AQUATIC OLIGOCHAETA FROM JAPAN AND CHINA.

By J. STEPHENSON, *D.Sc., Lt.-Col., I.M.S., Professor of Zoology, Government College, Lahore.*

CONTENTS.

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(Plate IV.)

By J. STEPHENSON, *D.Sc.*

The following paper describes the Oligochaete worms present in ten tubes brought back by Dr. Annandale from his recent tour. Of these, one was from China; one, containing a quantity of worms sold as food for goldfish, was from Kyoto; and the rest from Lake Biwa.

It is unfortunate that so many of the specimens from Lake Biwa were sexually immature and therefore unidentifiable. This was the case with the whole of the contents of four out of the eight tubes as well as with a number of specimens in some of the others. Some of the immature worms, from their similarity to other sexual specimens in the collection, have been identified with these with more or less of probability; but at least one species of Tubificid and two of Lumbriculid remain. The Tubificid was found at the deepest point of the lake, 320 ft.; the Lumbriculids at 180, 200, 250, 260 and 320 ft.

Of the species which have been identified or newly described *Chaetogaster annandalei* was found within a sponge at a depth of 15 ft.; *Kawamuria japonica* at depths of 260 and 320 ft., and worms probably to be referred to the same species at 250 ft., as well as in shallow water, 6–27 ft.; *Criodrilus bathybates* comes from a depth of 180 ft.; *Limnodrilus socialis* from ditches; and *Branchiura sowerbyi* from 1·75 metres in Lake Tai-Hu, Kiangsu Province, China, as well as from ditches (along with *Limnodrilus socialis*).

GENERAL REMARKS.

Before proceeding to the systematic description of the new species, I may perhaps be allowed to set down a few remarks of more general interest.

(1) *Chaetogaster annandalei.* The genus *Chaetogaster* is already known as a commensal in Sponges. Annandale (1) describes *C. spongillae* in *Spongilla carteri* and *S. decipiens* in Calcutta; it frequents only those parts of the sponge that are dying or dead, its food apparently consisting of the organic debris left by their decay; the healthy, growing parts are quite free of them. Only a few specimens of the present species were found in the small sponges from Lake Biwa submitted for examination; but in this case the sponges were young and compact.

Chaetogaster is also frequently commensal on or in the shell of freshwater Gastropods; one species (*C. limnaei*) may be endoparasitic in the liver of certain Pulmonata; others, however, live freely.

(2) I propose to discuss here the "coelomic sac" of *Kawamuria*, which, as also in *Branchiura sowerbyi*, surrounds the terminal part of the male deferent apparatus.

The sac is ovoid, completely closed, planted on the ventral body-wall over the situation of the penis; it possesses a muscular wall of some thickness. Its probable function, which I take to be the extrusion of the penis, will be understood from fig. 2. The penis is a pear-shaped bladder-like organ, the space between the axial ejaculatory duct and its outer wall being free from the strands which, in other genera with a penis, frequently form a connection between the two. Its extroversion would be effectively brought about by the contraction of the walls of the coelomic sac and the forcing of fluid into this space.

It is difficult to guess any other function for the sac; and it seems not unlikely that sac and penis have evolved together as a connected whole.

But among Tubificids a similar sac occurs elsewhere only in *Branchiura*; and there can be no doubt, on other grounds, that *Kawamuria* and *Branchiura* are closely related; *Kawamuria* might be described as a *Branchiura* without gills and with a penis. But if, as just implied, *Branchiura* has the sac but no penis, what must be the nature of the relationship? It can only be that *Branchiura* has lost a penis that it formerly possessed; since (taking for granted the function of the sac as explained above) we cannot credit *Branchiura* with having produced a sac in the expectation of a penis to follow. In other words the sac in *Branchiura* is a vestigial organ.

There are possibly a few indications of this in its structure; it appears to be somewhat less ample than in *Kawamuria* (cf. figs. in Michaelsen, 13, and Stephenson, 17); the wall is also not particularly strong (seine Wandung ist dünn, mit zarten Muskelsträngen ausgestattet), and is certainly thinner than in *Kawamuria*.

If the above reasoning is correct, *Branchiura* would be a direct descendant of *Kawamuria*, by loss of penis and development of gills. (On the systematic aspect of the connection between the two forms v. inf.).

(3) *Criodrilus bathybates* is remarkable on account of the depth (180 ft.) at which it is found. A certain number of the Lumbricidae, as well as scattered examples in other terrestrial families of the Oligochaeta, may be found regularly or occasionally in marshes, ponds and streams,—usually on the banks or near the shore,—while more than one subfamily of the Geoscolecidae are partly, and the Criodrilinae wholly, limnic; but even these latter seem to occur for the most part in shallow water only. The occurrence of one of the "Megadrili" at the depth of 180 ft. is probably very exceptional, though without going through the literature of all the limnic forms I could not say that it was unique. But it is noteworthy that in L. Baikal, where a systematic investigation of the whole fauna was carried out, no Megadrili at all were obtained, though Microdrili,—Tubificids, Lumbriculids and *Haplotaxis*,—were present at depths even below 1,000 metres. (Michaelsen, 11).

With this deep-water habitat, in the case of *C. bathybates*, is probably to be correlated the absence of a gizzard. While this organ is present, though rudimentary,

in other members of the genus and subfamily, it appears to be entirely wanting here; the examination of a series of microscopic sections might perhaps have given some indication of a thickening of the oesophageal wall in one or other segment, but with only two specimens available I did not undertake this. Mud, being softer and in a finer state of division than earth, needs less grinding up; hence, supposing limnic Megadrili to have originated from terrestrial forms, the gizzard would regress from disuse in the former. So Michaelsen, on the Geoscolecid-Lumbricid group in general (9):—"Einzelne Abtheilungen....rein limnisch sind und, wahrscheinlich in Folge dieser Lebensweise, gewisse Organe....zurückgebildet oder ganz abortirt zeigen. Diese Rückbildung betrifft besonders den Muskelmagen und manchmal auch die Samentaschen." And while the coarser sediment is deposited in the shallower water near the shores, it is only the finest particles that are carried out to the depths; hence the deeper the habitat, the more vestigial we should expect to find the gizzard.

(4) Limnic forms have not as a rule much zoogeographical value. Thus the genus *Chaetogaster* is cosmopolitan.

Michaelsen (13) supposed that *Branchiura sowerbyi* was possibly originally an inhabitant of the tropics, since when he wrote the worm had been found only in artificially warmed water in Botanical Gardens. But it has since been found in natural surroundings in France, and in extratropical India where hoarfrost lies on the ground in the mornings for some weeks in the year, as well as now in China and Japan; and one of the latter countries has perhaps as good a claim as any other to be considered as its place of origin, since *Kawamuria*,—a close relative, or even, as I have argued above, possibly its immediate ancestor,—lives also in Japan. It is at any rate a curious coincidence that the two worms should occur in the same small collection of only half a dozen identifiable forms. But it is unwise to lay stress on isolated facts of this kind; a related genus, *Bothrioneurum*, is represented by one species in the Malay Peninsula, one in S. America, and one in Austria; and both *Kawamuria* and *Branchiura* may have a wider distribution than appears at present.

Species of *Criodrilus* are known from S. America and Costa Rica, and the genus also includes the fairly common *C. lacuum*, found in Central Europe and extending to Syria and Palestine and doubtfully also to India. No species of *Criodrilus* however was found in Lake Baikal, or in the Teleckoë Lake in the Northern Altai (Michaelsen, 10); and it is impossible to say whether the forerunners of *C. bathybates* reached Japan from the direction of America or from that of Europe, or whether the present species is a relic,—the area of distribution of the genus *Criodrilus* having perhaps been at one time circummundane. Michaelsen looks on the Geoscolecidae as having had previously a more extensive distribution, the terrestrial members having (in the Old World) given way before the younger branches of the Megascolecid tree, and especially before the expanding Lumbricidae (Michaelsen, 9). Only the limnic divisions of the family have been able to maintain themselves in the territory which has been appropriated by their younger rivals. A depth of 180 ft. may be supposed to have removed the present species out of the region of competition.

Fam. NAIDIDAE.

Chaetogaster annandalei, sp. nov.

N. Lake, L. Biwa, Japan[1]; 15 ft. In *Spongilla lacustris*, growing on leaves of *Potamogeton*. 29-ix-1915.

The sponges did not apparently form a very favourable residence for the worms: they were young and compact, and the worms were few,—none might be found on teasing up a whole sponge. Had the sponges been older and disintegrating the *Chaetogasters* might have been more numerous.

The worms are minute, a single individual being only ·44 mm. in length, and a chain of two ·66 mm. In diameter they measured ·13 mm. $n=10$ or 11.

There is a well-marked prostomium, i.e. the anterior end of the animal extends forward in front of the margin of the mouth aperture, which is thus on the ventral surface; in a number of the other species of the genus the anterior margin of the mouth coincides with the tip of the snout. The prostomium is here a bluntly triangular projection.

There is a distinct constriction behind the second segment, and thus the appearance of a head is produced; this "head" is small, about two-ninths of the length of the animal (or of the first animal of the chain), and rather conical in shape, broadest behind. The appearance is given of a fairly strong septum behind the "head," but this was not confirmed in sections.

There are no dorsal setae. The number of setae in the ventral bundles is small, 4 or 5 in the second segment (where they are directed forwards), and 3, or often only 2, in the hinder part of the body. They are absent, as usual, from the third to the fifth segment inclusive. In length the setae of the second segment measure 70μ, and those of the other segments 50 to 60μ; in thickness they are about 1·5μ. They are double-pronged, but the prongs are very fine and not distinctly visible with the ordinary high power of the microscope; with the oil immersion they are seen to be of unequal length, the distal being the longer and more curved. The shaft is only slightly and gently curved at both ends; the nodulus is markedly proximal to the middle of the shaft, the proportions being about 3 : 4.

The oesophagus is quite short, and is succeeded by a much dilated "crop," the hinder part of which is opposite the setae of segment vi; or the chief swelling of the alimentary canal may be posterior to this, so that there is a small "crop" and a large "stomach."

The heart is situated dorsal to the oesophagus, in segment iii or in iii and iv. There is apparently no refractile body in the cerebral ganglion, such as has been noticed in a number of the other species of the genus.

Remarks. The minute size of the animal, together with the short oesophagus and the small number of setae per segment, will suffice to distinguish the present form.

[1] Since the above account was written I have found the same species, also from a sponge, in a collection made by Dr. Annandale at the Inlé Lake, Southern Shan States. 24-iv-1917.

Fam. TUBIFICIDAE.

Branchiura sowerbyi, Beddard.

Channel S. of Tong Dong Ding, Tai-Hu, Kiangsu Province, China; 1·75 metres. Several specimens.

Ditches near Kyoto, Japan (along with *Limnodrilus socialis*), one complete and two incomplete specimens.

The anatomy of this interesting form is now well known; besides the original description of Beddard, there are accounts by Michaelsen (13), Stephenson (16, 17), and Keyl (7). Remarks on its affinities may conveniently be subjoined to the discussion under *Kawamuria*.

Dr. Annandale informs me that in the Tai-Hu, which may have been formerly connected with the sea, though now forty miles away and with no direct connecting channel, the water is quite fresh; but notwithstanding, the only worm taken in the open part was a Polychaete. The specimens of *Branchiura* were dredged in a narrow channel between two islands, where vegetation was much more abundant.

The curious fact may be noted that *B. sowerbyi* and *Limnodrilus socialis* were found in the same pool in Lahore (16), that I received specimens of both on the same day from Calcutta, both having been taken within the precincts of the Museum (17), and that now they are again found together in the same tube from Kyoto.

Kawamuria japonica, gen. et sp. nov.

L. Biwa, Japan; the deepest point in the lake, near Chikubushima, 320 ft., on a bottom of fine mud. Numerous specimens, nearly all immature and many fragmentary.

The same place; near White Rocks in central part of the lake; 260 ft., on a bottom of mud with fragments of shell. A number of specimens, mostly fragments, and immature.

Immature Tubificids from the following stations on the lake are probably to be referred to the same species:—

Channel between N. and S. Lakes, 6—27 ft.; bottom of soft mud with a certain amount of weed.

Off Komatsu, near middle of lake, 250 ft.; bottom of firm mud, no weed.

External Features.

Length of a complete specimen about 50 mm.; thickness 1 mm. The worms are squarish in transverse section, with the setae at the angles. The anterior part of the body is yellowish and opaque; behind the genital region the worm is darker, probably due to the thinner body-wall allowing the intestinal contents to modify the colour. The genital products appear as yellowish masses as far back as segment xviii.

The prostomium is bluntly triangular. A number of the anterior segments are more or less distinctly bi- or triannulate.

The clitellum includes the posterior third of segment x and the whole of xi and xii.

On segment xi are seen two pores, each encircling the base of a penis, which projects as a somewhat irregular semitransparent bladder-like sac. Each penis is

situated within the line of the ventral setal bundles and not far from its fellow of the opposite side. There are no penial setae. The spermathecal apertures are just behind the ventral setae of segment x.

The dorsal setae begin in segment ii and consist of hairs and needles. The hairs are usually one per bundle, rarely two, and occasionally they may be absent from a bundle; they are comparatively short,—about ·37 mm. long, or not more than about twice the length of the needles. The needles vary somewhat in length; in segment v they were measured as being ·2 mm., and further back ·15 mm. The distal end terminates in a single point (fig. 1*a*); the nodulus is slightly distal to the middle of the shaft (in the anterior segments), or (further back) at the middle. The total number of setae per bundle is seven or eight in the most anterior segments, soon diminishing to six, five, four or even three.

The ventral setae begin in segment ii and are absent from xi. They are needles with the usual double curve, five to nine per bundle in the anterior part of the body and three or four behind the genital region. In length they measure ·18 mm., and the nodulus is very slightly distal to the middle of the shaft; the tip is blunt and single as a rule, but may show two short stump-like points (fig. 1*b*).

Internal Anatomy.

The alimentary canal is but little differentiated after the pharynx.

The dorsal vessel is ventral in position from its hinder end as far forwards as the clitellar region; the dorsal and ventral vessels may be seen in transverse sections as a pair of canals one on each side of the ventral nerve cord. There is one pair of hearts in segment ix.

As in *Branchiura sowerbyi*, a striking feature of the ventral nerve cord is the size of the giant fibres. Of these there are two which in places reach a really enormous thickness, and in addition one or two others are seen of much smaller size. In the middle of the body the nerve cord has, in one section, a transverse diameter of ·072 mm., while the largest giant fibre measures ·046 mm. in its longest diameter; in segment xiii the cord is ·123 mm. in transverse diameter, and the largest fibre ·05 mm. The giant fibres are however of irregular thickness, and are especially contracted where the cord passes through the septa.

The testes, in segment x, attached to septum 9/10 near the ventral body-wall, are large and tend to be folded round the spermathecae. The ciliated funnel is a large irregular folding of the anterior face of septum 10/11. The anterior spermsac, in ix, is single, small, and situated dorsal to the alimentary canal; the posterior, also single, extends back as far as segment xvii.

The male deferent apparatus is shown diagrammatically in fig. 3. The vas deferens begins as a wide tube, 40μ in diameter at its commencement behind septum 10/11; passing backwards on the inner side of the coelomic chamber, to be described later, it becomes surrounded by a cellular "prostatic" investment—a large mass of cells enveloping the vas deferens, atrium and paratrium; curving upwards, and while surrounded by the prostate, the vas deferens joins the posterior wall of the atrium

about or slightly above the middle of the height of the latter, piercing its wall obliquely. The lining of the vas consists of heavily ciliated cubical cells.

The atrium is a cylindrical chamber, ·08 mm. in diameter, which lies obliquely in segment xi; its hinder end, directed posteriorly and dorsalwards, reaches nearly to the dorsal parietes; its lower and anterior end narrows gradually at first, and then suddenly, to become the ejaculatory duct. The whole of the atrium is enclosed within the mass of prostatic cells, with the exception sometimes of the blind end, which may be bare. The blind end as far down as the entrance of the vas deferens is lined by high ciliated epithelium; in the remaining portion the cells are non-ciliated, clearer than higher up, with a more densely staining cytoplasm (eosin). There is a granular coagulum in the lumen.

The paratrium is also a more or less cylindrical chamber, ·06 mm. in diameter, lying roughly parallel to the atrium, and like it enclosed in the prostatic mass. Its lower end is the narrower,—two-thirds the diameter of its upper portion; it is continued below into the paratrial duct, which joins the ejaculatory duct shortly after the latter has entered the coelomic chamber. Its epithelium varies in character from cubical to low columnar; it is not ciliated. The lumen contains a homogeneous coagulum. The paratrial duct, with a small or even potential lumen, has a thickness of 30-40 μ, is lined by a non-ciliated epithelium, with deeply staining nuclei, and has a strong muscular investment.

The ejaculatory duct is enclosed in its whole length in the "coelomic chamber" (figs. 4, 5), a sac with muscular walls, ovoid in general form, which is implanted on the ventral body-wall and reaches to about half the height of the body; the mass of prostatic cells impinges on or gets an attachment to the upper part of the sac. The duct is suspended in the sac by a stout band of muscular fibres,—not only the band but also the individual fibres are stout; the suspensory band and the fibres of the sac-wall are continuous with a vertical strand which passes upwards through the segment and is attached to the dorsal body-wall. The duct winds considerably in the upper part of the coelomic sac; it has a non-ciliated cubical epithelial lining and a prominent muscular coat; its diameter, 40 μ at first, diminishes further down to about 27 μ.

The "prostatic cells," which have a close histological resemblance to the "pharyngeal gland cells," do not seem to be more than applied to the organs they surround; they thus represent an overgrowth of peritoneal cells, and do not discharge into any part of the lumen of the male deferent apparatus. The whole, with the organs contained within it, constitutes a bulky irregular mass which takes up a large part of the segment.

The projecting portion of the penis (fig. 5) is shown by sections to be as it appears in entire specimens, hollow and bladder-like; its covering epithelium is short, not columnar like that of the general surface of the body; it contains a central tube, the continuation of the ejaculatory duct, which opens at its free extremity. The space included between its outer wall and the duct which runs through its centre is a portion of the coelom continuous with that included in the coelomic sac; and the function of the sac is apparently, by the contraction of its muscular wall, to produce

the extrusion of the penis (cf. fig. 2). The penis arises from the bottom of an invagination of the surface, which may be called the penis-sheath.

The ovary is particularly bulky; attached anteriorly to septum 10/11 near the ventral body-wall, it extends backwards behind the prostate, and pushes septum 11/12 back to the level of 12/13; it appears to be suspended by strands which pass dorsoventrally.

The ovisac is extensive, reaching as far as segment xviii. The funnel is a slight modification of peritoneal epithelium on both septum 11/12 and the adjacent body-wall; the cells are small, cubical or low columnar, compacter than the usual peritoneal lining, thrown into folds, non-ciliated and with deeply staining nucleus. The duct passes straight down through the body-wall, and thus opens in groove 11/12.

The ampulla of the spermatheca is of an inverted pear-shape, broad in comparison with its height; the narrower portion, the stalk of the pear, is above. The whole is placed vertically in the segment and reaches to not far from the dorsal parietes. There are no spermatophores, the contents consisting of a mass of matted spermatozoa. The duct, nearly equal in length to the ampulla, is broad and patent, and almost straight or somewhat bent forwards. The epithelium of the ampulla is cubical to columnar; that of the duct is irregular in height, and the lining thus appears to be thrown into folds.

Remarks. The genus to which the above species is most closely related is *Branchiura*,[1] at present represented only by one species, *B. sowerbyi*.

In the main features of its anatomy *K. japonica* agrees with *B. sowerbyi*, as well as in possessing such a special character as the coelomic sac enclosing the terminal portion of the male deferent apparatus. This structure, known hitherto only in *B. sowerbyi*, seems to be of considerable morphological value; other peculiarities common to both,—the enormous size of the giant fibres of the ventral nerve cord, and the ventral position of the dorsal vessel,—may not have the same significance.

It differs from *B. sowerbyi* in the absence of gills and in the presence of a well-marked penis, as well as in the possession of only a single pair of hearts, in segment ix, instead of two pairs, in ix and x. The last point is perhaps of no great value, but the other two appear to be of more importance.

It is true that Michaelsen has more than once expressed the opinion that the presence of gills is not of much morphological weight. So in 1900 (8) he united *B. sowerbyi* and *Ilyodrilus coccineus* in the same genus, in spite of the absence of gills in the latter. In 1908 he writes (13): "Die Kiemen der *Branchiura* sind ja nichts

[1] The limits of the genus *Branchiura* have undergone several changes. Established in 1895 by Beddard (2) for *B. sowerbyi*, largely on account of the presence of gills, it was united by Michaelsen in 1900 (8) with the worm known as *Tubifex* or *Ilyodrilus coccineus*, and in 1905 (12) with *Taupodrilus* (Benham, 1903, 4); in bringing these various worms together, Michaelsen was guided by the comparatively small importance he attributed to the presence of the gills in Beddard's species. His view was accepted by Benham, who in 1907 (5) described another species, similar to his previous species of *Taupodrilus*, as *Branchiura pleurotheca*. In 1908 Michaelsen (13) himself obtained *B. sowerbyi*, and subjected it to examination, with the result that he found Beddard's description to be erroneous in certain respects, especially in making no mention of the paratrium,—a blind tubular diverticulum of the atrium; it thus became necessary again to separate *Branchiura* from the other species, which (including *I. coccineus*) resume the name *Taupodrilus*. In 1909 Michaelsen (14) gives the presence of gills, the presence of paratrium, and absence of penial setae as generic characteristics, as against *Taupodrilus*, which has penial setae, but no gills or paratrium.

anderes als einfache Ausstulpungen der Hypodermis, in die eine Schleife des integumentalen Blutgefäss-Netzes mit hineingezogen ist. Das sind keine Bildungen von morphologisch sehr bedeutsamen Charakter"; and again in the same paper "(the gills) höchstens artliche Bedeutung haben; sind sie doch nur eine Anpassung an die Sauerstoff-Armut warmer stagnierender tropischer Gewässer." However he later (14) places the presence of gills among the generic characteristics of *Branchiura*; and in another family, the Naididae, gills of the same kind as those of *Branchiura* are well recognized as constituting a character of generic value (*Branchiodrilus, Dero, Aulophorus*); a *Dero* without gills would be a *Nais*.

The presence of a penis however (as distinguished from a pseudopenis, which arises by evagination of the simple tubular end of the atrium, and disappears on retraction) is certainly of considerable importance (Michaelsen, 13), and a character of generic value. I think therefore that there can be no doubt that the present form is to be separated from *Branchiura*, though this is pretty certainly its nearest relation; and I name it after Dr. T. Kawamura, the zoologist in charge of the Otsu Lake Laboratory.

The affinities of *Branchiura* to other genera have been touched on by Michaelsen (13). He supposes a close relationship to *Bothrioneurum*. Both fall into the section of the Tubificids which are characterized by the possession of a diffuse "prostate" covering the vas deferens (or part of it); and both are included in the much narrower section which possesses a paratrium. The only essential difference between the two is, according to this author, the presence of gills in *Branchiura* and their absence in *Bothrioneurum*; and he doubts whether this is sufficient to justify a generic separation ("ob der Besitz von Kiemen ausschlaggebend fur die generische Absonderung der betreffenden Arten sein darf, will mir zweifelhaft erscheinen"). But Michaelsen omits to mention the absence of spermathecae in *Bothrioneurum*, and the presence of spermatophores (which are probably characteristic for the genus, though not yet demonstrated for *B. americanum*, cf. Beddard, 3). And if it is true, as suggested above, that *Branchiura* is descended from ancestors which possessed a penis (*Bothrioneurum* presumably never had one), the distinction between them is still further widened. The coelomic sac, at any rate, constitutes an additional feature of *Branchiura* which is not found in *Bothrioneurum*.

There can of course no longer be any question of an affinity between *Branchiura* and *Taupodrilus*, with which, prior to the discovery of the paratrium, it was confused.

Limnodrilus socialis, Stephenson.

In ditches round the city of Kyoto, Japan; sold as food for goldfish. Numerous specimens.

In 1899 Hatai (6) published the description of a worm found in Tokyo, which he called *Limnodrilus gotoi*. In 1912 I published (16) an account of a species of *Limnodrilus* which I called *L. socialis*; the worm is common in Lahore, and later in the same year I recorded having received it from Calcutta (17); subsequently it was found in a collection made by Annandale in Ceylon (18). In 1913 Nomura (16),

having investigated the three species of *Limnodrilus* found in and near Tokyo, concluded that Hatai had confused more than one species under the name *L. gotoi*, since that author's description did not correspond in certain essential points with any form which was actually found, but appeared to represent a combination of features from two separate species. He retained the name *L. gotoi* for one of them, and called the other *L. willeyi*. A *Limnodrilus* from Ceylon, received through Dr. Willey, then resident in Colombo, is stated in the same paper to be identical with *L. gotoi* as newly defined by the author. In a postscript to his paper Nomura states that he is of opinion that *L. socialis* and his *L. gotoi* are identical.

With regard to Nomura's criticism of Hatai's description, it appears to me to be rather daring to suppose a confusion on Hatai's part between two species which are really (if Nomura is right) so very distinct as his *L. gotoi* and *L. willeyi*. To mention only the most striking points of difference, the two species are at variance in the matter of the anterior sperm-sac (single in one, double in the other), in the presence or absence of spermatophores, and in the length of the chitinous penis-sheath (3—4 times as long as wide in one, 10—11 times in the other); the last two characters at least are of extreme importance either in the differentiation of Tubificids in general or of the species of this particular genus. Hatai remarks that his worm "occurs abundantly in ditches and gutters of this city (Tokyo) throughout the year"; otherwise the fact that such a form was not found in Nomura's collections would be no proof that such a form does not exist; since his collections were made many years subsequently to Hatai's, and Limicolae have a way of disappearing suddenly from a locality and leaving no trace. I found *Branchiodrilus hortensis* for a few weeks in Lahore some years ago, but have never met with it here since; and if I concur in Nomura's conclusion, it is partly because his knowledge of the localities and local conditions enables him to speak with some authority. Hatai's two figures of the chitinous penis-sheath however certainly do seem to belong to two different animals.

The next point is Nomura's identification of his *L. gotoi* with my *L. socialis*. The only differences on which he comments are those relating to the "septal sacs"; which appear to have a slightly different distribution and relative size; and to the dorsal blood-sinus on the intestine in segment ix, absent in his specimens, present in mine. These are points of slight morphological importance, the septal sacs being, as I believe, only aggregates of modified peritoneal cells and the sinus (observed by me principally in the living condition, where the colour of the blood renders it more easily visible) contracting or perhaps disappearing as a definite space in the preserved specimens. There are a number of other unessential differences; but there also two of much greater importance, which Nomura likewise leaves out of the discussion altogether.

Firstly, the figures of the chitinous penis-sheath do not suggest the same shape, Nomura's showing a flange-like expansion round the open end, mine (a section) a strongly upturned margin on one side only; nor do the descriptions seem altogether to correspond. The difference is in some degree due to the mode of presentation; I give herewith (fig. 7) a figure of the isolated penis-sheath of one of the present Kyoto

specimens, drawn under the camera lucida, which explains how the marked upturning of one lip may co-exist with a flange-like expansion of the margin (there seems however to be really no such expansion at the posterior margin of the end of the tube).

Secondly, I stated that the dorsal vessel was ventral in position, lying near and to the left side of the ventral nerve cord, and was only actually dorsal in the first eight segments. Nomura finds that it is near the ventral vessel in the segments containing the genital organs, but "behind these segments it reassumes its position on the dorsal side." And to this may be added that Nomura makes the supraintestinal vessel originate from the dorsal vessel in segment v, and open into it again at the hinder end of the body; in my previous species the supraintestinal was (as usual) confined to a few segments, from v to ix (though another vessel could be traced on the right side of the intestine as far back as xxi). As I was particularly interested in the circulatory system of the Oligochaeta, and especially of the Microdrili, at the time, I think these statements may be accepted (see also 19).

Notwithstanding that Nomura does not bring forward the real points of difference at all, I believe he is right in saying that the worms are the same. I have carefully examined a number of the Kyoto specimens, and I have no doubt that they at least are the same as my *L. socialis*; the dorsal vessel is ventral throughout, except in the most anterior segments (fig. 6); the end of the penis-sheath shows a strongly upturned margin on one side (fig. 7); and there is no trace of a supraintestinal vessel in the middle of the body (fig. 6), though a section is perhaps scarcely conclusive evidence on this point.

Now the species which I received from Kyoto is apparently common,—the specimens were bought in the market, where they were sold as food for goldfish,—and it must certainly have been represented among Nomura's three species,—the only species of *Limnodrilus* in his "fairly extensive collections made in different localities in Tokyo." Of these three, the one in which the length of the penis-sheath is 30—33 times its breadth, and the one in which it is 3—4 times, cannot enter into consideration; hence I believe I am justified in assuming that the form I have received from Japan is his form B (penis-sheath 10 – 11 times as long as broad) to which he restricts the name *L. gotoi*.

The last question concerns the nomenclature of this species. The rule is that when a species is divided into two or more restricted species, the name of the original species must be retained for one of the restricted species. I take it that the rule refers to cases where the original account or diagnosis is a valid description of some group of forms, which by a further refinement of observation is shown to be divisible; the original description includes both. In the present case the original description is (according to Nomura's supposition, which I have accepted) not a valid description of any form or group of forms whatever, and includes neither species (since taking some characters from one, some from another, it is at variance with both). The only course is therefore to drop the name (unless it should hereafter be shown that a form corresponding to the description does actually exist).

If this is done, the name of the species which I have previously described from India and Ceylon, and have now received from Kyoto, and which Nomura describes as *Limnodrilus gotoi*, Hatai emend. Nomura, remains as *Limnodrilus socialis*,[1] Stephenson.

Fam. GEOSCOLECIDAE.

Criodrilus bathybates, sp. nov.

Off Komatsu, about half a mile E. of Komatsu Point, L. Biwa, Japan; 180 ft., on a bottom of mud mixed with pebbles and many shells. Four specimens, all incomplete; two wanted the posterior and two the anterior end. The two anterior fragments apparently in an early stage of sexual maturity.

External Characters.

The length of the longest fragment was 123 mm., and the thickness of the body at its maximum 2 mm. The surface of the worms is a smooth shiny yellowish grey. The transverse section of the body is circular for the greater part of the length, but the hinder end is rather flattened, especially near its extremity, where the dorsal surface is concave and forms a broad shallow groove. The anus is terminal, and, in one of the two specimens which showed it, was seen to be flanked by prominent lateral lips. The nephridia appear as indistinct opaque white masses through the thin body walls.

In the longest fragment there were 165 segments.

The prostomium is large, prominent and zygolobous.

There are no dorsal pores.

The setae are small and closely paired; the relations are the same throughout the body; *aa*=*bc*, but *dd* is rather greater, about $1\frac{1}{4}$ times *aa*.

No clitellum was visible.

The male apertures are in segment xiii; there are to be seen two small whitish papillae, rather elongated transversely, their middle points somewhat above the line of the ventral setae, their lower margin about on a level with the setae. The setae are absent ventrally in this segment. There are no other genital marks.

It will be well to explain here that the numbering of the segments caused some difficulty. The position of the male pores so far forward as segment xiii is exceptional in the Geoscolecidae, and I at first assumed them to be on xv, a not unusual position, since I thought I counted fourteen segments in front of them. But on coming to examine the internal anatomy, this enumeration brought the testes to segments xii and xiii, the vesiculae seminales to xiv, and the ovaries to xv. The second specimen gave the same result, which appeared quite impossible. A renewed examination of the setae and of the segments at the anterior end of the animal showed that in front of the first seta-bearing segment there were two annuli without setae, separ-

[1] Two of my papers giving an account or a record of *L. socialis* reached Nomura while his paper "was in preparation for the press"; and since he recognized the identity of one of his species with mine, it seems a little perverse on his part,—even if he did not wish (as I believe is the proper course) to reject Hatai's name altogether,—to give that name to *L. socialis* rather than to the other, previously undescribed, species. He received *L. socialis* from Dr. Willey, from Ceylon (from whence one of my batches of material had been derived), and called *L. willeyi* the one which he did *not* receive from Dr. Willey.

ated by a rather shallow but quite visible groove, and both of fair extent, as shown in fig 8. It is not very uncommon in earthworms to have one or a few segments at the anterior end without setae (in addition to the first, which of course is normally achaetous); but unless we are to suppose that the internal genital organs have an altogether anomalous position, that cannot be the case here; and we must, I think, suppose that the setae begin normally, i.e. on segment ii, the first segment being unusually long and biannulate,—even though this brings the male aperture into an anomalous position on segment xiii. This seems to me much easier than to suppose that the ovaries are in xv, and the male apparatus correspondingly displaced.

Internal Anatomy.

Septa 5/6 to 12/13 are somewhat thickened, decreasingly so towards the hinder end of the series; 6/7 is perhaps the stoutest.

I could discover no trace of a gizzard; the intestine begins in xii or xiii, but the beginning is indefinite, and there is nothing except the increasing investment of chloragogen to mark it off from the oesophagus. There are no calcareous glands.

The dorsal vessel is single, in the anterior part of the body at least. The lateral vessel, running longitudinally forwards on the body-wall from segment xiv, is conspicuous. The most peculiar feature of the vascular apparatus is the disposition of the hearts; whereas in most earthworms these closely embrace the alimentary tube, here they appear in the dissection as long loops which extend outwards onto the body-wall, reaching when the animal is pinned out to a position well beyond that of the dorsal setae and not very far from the middle line along which the animal was opened. Even when thus stretched out they are still much curled and twisted; so that in their natural position in the living worm they must form extremely convoluted loops. Being in the specimens almost empty of blood, they resembled nephridia at first sight; a closer inspection, and microscopic examination, revealed their true character. They occur in segments vii—xi, and decrease in size from behind forwards.

The nephridia are absent from the anterior part of the body, the most anterior being in segment xv; on one side of one of the dissected specimens there was a minute one in xiv. In each nephridium two parts can be seen; one a somewhat flattened, lobed, opaque white mass near the external end of the organ, the other a twisted tube extending inwards towards the middle line. The white masses are conspicuous structures in the dissection, and can be seen through the body-wall in the unopened worm. The ducts open to the exterior in the line of the ventral setae, just in front of the setae themselves.

The testes are in segments x and xi; they were relatively large in these specimens, and free in the body-cavity. Funnels were identified in both segments. The vesiculae seminales, represented in both specimens by a pair of transparent empty sacs, are situated in segment xii; in both specimens also the one on the left side is the larger.

What is perhaps a pair of "prostate" glands is present in segment xiii; each is

a small and narrow white transversely elongated structure, resting on the body-wall throughout its length and attached at its inner end; they were situated nearer the posterior than the anterior limit of the segment, and occupied the middle of the interval between the lines of the dorsal and ventral setae,—their inner ends (as seen in the dissection, the lower in the natural condition) nearer to the line of the ventral setae than the outer ends to the dorsal setae; the inner end of each appeared to correspond in position to the centre of the male papilla.

The ovaries, large and conspicuous, are in segment xiii; funnels were doubtfully identified. Small ovisacs were present in xiv, depending from septum 13/14.

There were no spermathecae.

Remarks. The worms described above belong pretty obviously to the subfamily Criodrilinae of the Geoscolecidae, and within the subfamily approach nearest to the genus *Criodrilus* itself. *Criodrilus* however has a rudimentary gizzard, and the male pores open on segment xv. That the opening of the male pores on xiii in the present case is not an individual peculiarity is shown by the fact that both specimens manifest this character.

Since however the male pores are far more irregular in position in the Geoscolecidae than in other families,—there are a number of cases where worms are classed together in the same genus even though the male pores differ in position by more than two segments,—and since the rudimentary gizzard of *Criodrilus* is a matter of degree, I think the present species is rightly placed in that genus, to which it otherwise shows a close resemblance.

As will be seen from the above description, the specimens at my disposal were not fully mature.

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EXPLANATION OF PLATE IV.

FIG. 1.—*Kawamuria japonica*; dorsal and ventral setae. *a*, dorsal seta; *b*, tip of ventral seta.

,, 2.—The same; diagrammatic representation of penis and coelomic sac, to show general relations and to illustrate mode of action of sac.

,, 3.—The same; male genital organs, diagrammatic, reconstructed from sections.

,, 4.—The same; section passing obliquely through coelomic sac. × 115.

,, 5.—The same; section passing somewhat obliquely through lower end of coelomic sac and origin of penis; the penis is cut twice, and the section passes through the aperture of the male duct at the distal end of the penis. × 115.

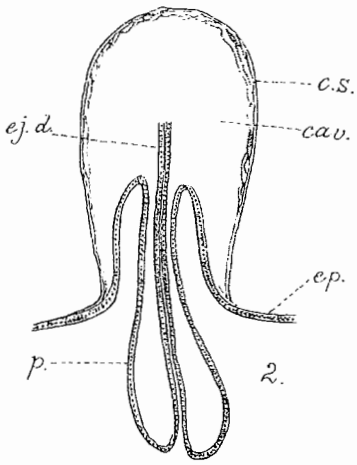
,, 6.—*Limnodrilus socialis*; part of a transverse section through middle of body, to show relative positions of dorsal vessel, ventral vessel, and ventral nerve cord. × 115.

,, 7.—The same; chitinous penial tube. × 115.

,, 8.—*Criodrilus bathybates*; anterior end.

FIGS. 4, 5, 6, and 7 drawn by means of Zeiss's Abbe's drawing apparatus.

at., atrium; *cav.*, cavity of coelomic sac; *chl.*, chloragogen cells; *c.m.*, circular muscular layer; *c.s.*, coelomic sac wall; *d.v.*, dorsal vessel; *ej. d.*, ejaculatory duct; *ep.*, surface epithelium; *f.*, male funnel; *l.m.*, longitudinal muscular layer; *p.*, penis; *pa.*, paratrium; *per.*, peritoneum; *pr.*, prostate; *s.*, septum; *v. def.*, vas deferens; *v.n.c.*, ventral nerve cord; *v.v.*, ventral vessel.



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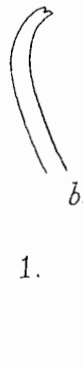

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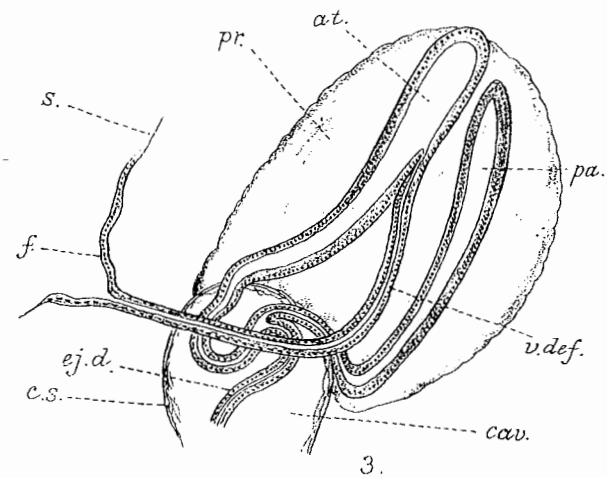

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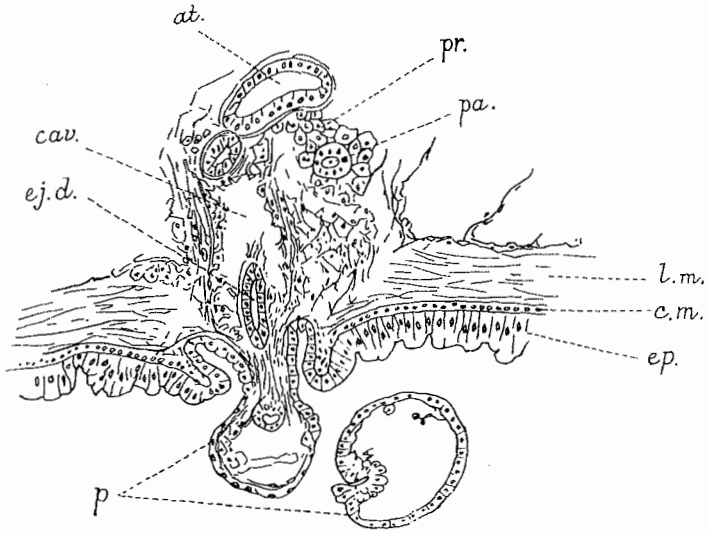

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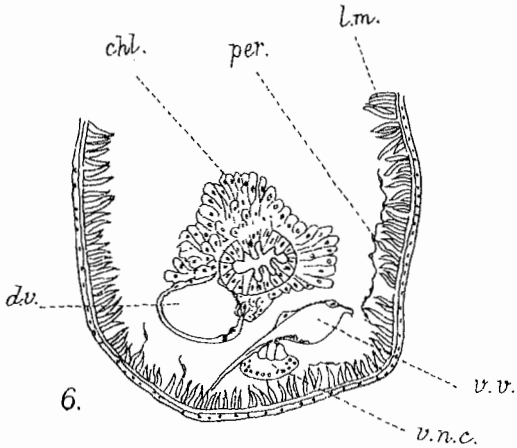

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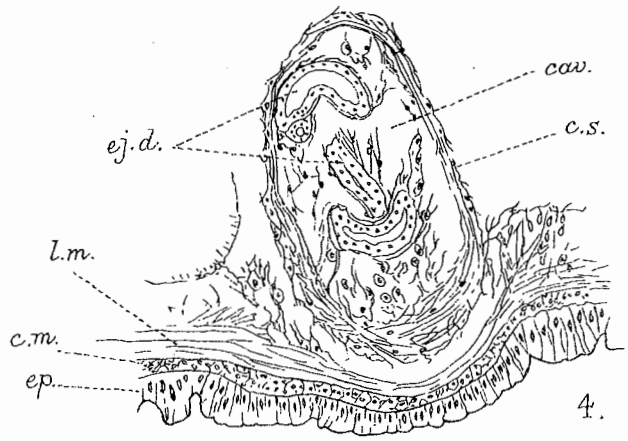

4.

A. Chowdhary, lith.

AQUATIC OLIGOCHAETA FROM JAPAN.