Studies on the Aquatic Oligochaeta of Japan
III. A Description of *Lumbriculus multiatriatus* n. sp., with Remarks on Distribution of the Genital Organs in the Lumbriculidae[1)]

By

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(With Plate I, 2 Tables and 3 Textfigures)

The following description of a new species is based on specimens collected from several localities in Saghalien, and from Sarufutsu in Hokkaido. Differing from the recorded species of the genus *Lumbriculus; L. variegatus, L. inconstans, L. japonicus,* this species has three or four pairs of male pores; in this point it concurs with *Lamprodrilus satyriscus.* The different distribution of the genital organs in the Lumbriculidae has been explained to be due to the reduction of some pairs in an unknown primitive form (Michaelsen, 1920, 1928). From the arrangement of the genital organs of the present species, the writer proposed an opinion about the distribution of the genital organs of the species in this family. Before entering upon the description, the writer would like to express sincere thanks to Prof. T. Uchida for his kind guidance throughout the studies and for help rendered in the preparation of this paper, and also to Asst. Prof. A. Ichikawa for his valuable suggestions. Many thanks are offered to Prof. K. Oguma and Asst. Prof. S. Makino who afforded several facilities for this study, to Mr. H. Horié who kindly placed specimens at the writer's disposal, and also to Messrs. M. Hori, T. Urita, G. Okada and S. Yoshikura, who kindly gave help in various ways during the writer's collecting trip in Saghalien.

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Lumbriculus multiatriatus sp. nov.

(Pl. I, 1-6; Textfigs. 1-2)

Body 51–70 mm long and 1.5-1.8 mm wide in preserved mature specimens. Anterior part of body, dark greenish brown in colour; the other parts also dark greenish brown or dark red. Number of segments, 150-190 or more. Each segment, at least in anterior part, consists of an anterior major and a posterior minor annulus (Pl. I, 1). Prostomium, zygolobous and rounded cone-like, the length being larger than the basal width, as in *L. japonicus*. Clitellum usually occupying segment X to XXI, XXII or XXIII. Eight setae per segment generally, in two ventral and two lateral pairs. Setae distance *bc* about equal to *dd*; *dd* slightly larger than *aa*. Each seta sigmoid and cleft in the distal end, as in other species of the genus. Nodulus located about one-third the setal length from the distal end. Male pores commonly in three or four pairs, rarely in two pairs and exceptionally in one pair (see page 5). They are situated in a pair usually from segment X to XII or XIII (Pl. I, 1; Textfig. 1), nearly on the ventral setae line. Segments bearing male pores are destitute of ventral setae bundles in specimens examined. Female pores usually in two pairs, located on the ventral setae line and in intersegmental furrow. The anterior pair is present in the posterior furrow of the segment just posterior to the segment bearing the hindmost of the male pores. The posterior pair is found in the furrow next to the furrow bearing the anterior pair. The hindmost pair of male pores is commonly situated on segment XII or XIII, and the female pores are commonly found in intersegmental furrows XIII/XIV and XIV/XV (Pl. I, 1), or XIV/XV and XV/XVI. Spermathecal pores commonly in four to five pairs, usually found in a pair in each of the succeeding segments beginning from the segment just behind the anterior pair of female pores. Unlike *L. japonicus*, the spermathecal pores are situated near the ventral setae line (Pl. I, 3).

Chloragogue cells on the alimentary tract, found first in the anterior end of segment VII. Chromophile cells observed in anterior segments to segment VI. The first pair of nephridia is found in segment VII as in *L. japonicus*. Naked (without chloragogue cells) commissural vessels (Pl. I, 2) lying in anterior successive segments, as in other species of the genus. The last pair of the vessels is found in one of segments XXIV-XXVII. Blind transverse vessels (Pl. I, 2)

begin to appear in one of segments XVII-XX. Both the anterior and posterior spermsacs paired. The anterior pair extends anteriorly to segment VII, VIII or IX, while the posterior reaches one of segments XVIII-XXIV. Ovisacs paired and extending further posteriorly from the end of the posterior spermsacs. Atria, covered by prostate gland cells, are usually in three or four pairs corresponding to male pores and situated in a pair in each of segments usually from X to XII or XIII (Pl. I, 4; Textfig. 2). They are more elongated than those of *L. japonicus* and usually extend into the posterior spermsacs. Protrusible penis much longer than that of *L. japonicus* (Pl. I, 6). Testes and male funnels, usually in three or four pairs, corresponding to the number of atria. The testes are attached to the posterior surface of the anterior septum of each atrial segment, while the male funnels are attached to the anterior surface of the posterior septum of each atrial segment. Each vas deferens communicates with a male funnel and an atrium on the same side in a testicular segment. Each atrium of the species receives only a single vas deferens, while that of *L. japonicus* and *L. inconstans* receives two vasa deferentia on the same side. The vas deferens meets with the atrium in its middle portion, and runs along the atrial wall into the prostatic covering, so as to communicate with the atrium in its apical end, as in *L. japonicus*. Ovaries usually two-paired; one pair in each of two segments just posterior to the hindmost testicular segment. Each ovary attached to the posterior surface of the anterior septum. Spermathecae usually in four to five pairs; they are commonly found in a pair in each segment from XIV to XVII or XVIII, or from XV to XVIII or XIX. Each spermatheca consists of a subspherical ampulla and a distinct duct.

Localities. Hokkaido: Sarufutsu; several specimens including three sexually mature ones, were collected under sphagnum on margin of a tundra pond by the writer in August, 1935.[1] Saghalien: Konuma; four mature and three immature specimens were collected under sphagnum in a marsh by Mr. H. Horié in June, 1936; the writer collected 18 mature individuals in company with many immature ones in the same locality on August 4, 1936. Toyohara; seven mature specimens and several immature ones were collected on margin of a

1) These specimens were considered to be abnormal individuals of *L. japonicus* (1936 a, p. 77).

brook in a swamp by the writer on August 4, 1936. Nagahama; several specimens inclusive of five mature ones, were collected in a marsh on the margin of Lake Chibesan by the writer on July 31, 1936. Immature specimens collected by the writer from a puddle of Shiritoru on August 7, 1936 and from the tundra of Shikuka on August 9, 1936 are probably identical with the present species.

TABLE I.
Characteristics of *Lumbriculus* and of *Lamprodrilus*

	Species of *Lumbriculus*	*Lumbriculus multiatriatus* n. sp.	*Lamprodrilus*
Setae,	cleft in the distal end.	cleft in the distal end.	singly pointed in the distal end.
Male pores,	1 pair.	3 or 4 pairs.	1 to 4 pairs.
Female pores,	1 or 2 pairs.	2 pairs.	1 pair.
Ventral setae bundles in segments bearing male pores,	non-existent at least in the adult of *L. japonicus*.	non-existent in the adult.	present.
Spermathecal pores situated,	between the lateral line and the ventral setae.	between the lateral line and the ventral setae.	behind the ventral setae.
Testes and male funnels,	1 or 2 pairs.	3 or 4 pairs.	1 to 4 pairs.
Atria,	1 pair.	3 or 4 pairs.	1 to 4 pairs.
Ovaries,	1 or 2 pairs.	2 pairs.	1 pair.

Remarks. In the possession of several pairs of male organs the present species bears resemblance to *Lamprodrilus* in respect to number, but is more closely related to *Lumbriculus japonicus* in essential points as shown in Table I. With some emendations of the diagnosis (Yamaguchi, 1936 b), this species might be classifiable under *Lumbriculus*. Differences from the related species, *L. japonicus* are indicated in Table II.

Variation of the genital organs. As usual in other species of the genus, variation in the number and position of genital organs is

TABLE II.

Comparison of *Lumbriculus japonicus* with *L. multiatriatus* n. sp.

	L. japonicus Yamaguchi	*L. multiatriatus* n. sp.
Male pores,	1 pair on XI.	3 or 4 pairs, on X–XII or XIII.
Female pores,	1 pair, in XII/XIII.	2 pairs, in XIII/XIV and XIV/XV, or in XIV/XV and XV/XVI.
Spermathecal pores situated	near the lateral line.	closely near the ventral setae.
Chloragogue cells of the alimentary tract commence	in VIII.	in VII.
Chromophile cells present in the anterior segments	to VIII.	to VI.
Testes and male funnels,	1 pair in XI.	3 or 4 pairs in X–XII or XIII.
Atria,	1 pair in XI, each atrium receiving 2 vasa deferentia.	3 or 4 pairs in X–XII or XIII, each atrium receiving a single vas deferens.
Ovaries and female funnels,	1 pair in XII.	2 pairs in XIII and XIV or in XIV and XV.
Nephridia commence to appear	in VII.	in VII.
Blind transverse vessels bigin	from a segment of XIV–XXII.	from a segment of XVII–XX.
The last pair of commissural vessels lies	in a segment of XXXI or more posterior segments.	in a segment of XXVII or more posterior segments.

also observed. The number of male pores varies one to four pairs, but specimens having three or four pairs show exceedingly higher frequency than others, as is shown below:

Number of male pores	Number of individuals
4 pairs	13
3 pairs	17
2 pairs	4
1 pair	1

The male pores are situated on various segments, as is shown Fig. 1. They are situated on a continuous series of segments mostly

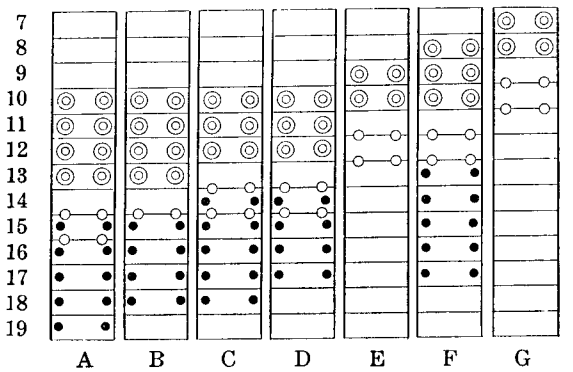

Fig. 1. Diagrammatic figures showing distribution of genital pores in *Lumbriculus multiatriatus* n. sp. A–D, normal specimens; E–G, abnormal specimens. Numerals designate the segments; male, female and spermathecal pores are represented by double ring, single ring and black circle respectively.

beginning from X extending posteriorly. So far as the writer examined, the most anterior pair of male pores as follows:

Position of the most anterior pair	Number of individuals
Segment XI	1
Segment X	27
Segment IX	3
Segment VIII	3
Segment VII	1

The female pores are found in one to two pairs, with specimens bearing two pairs common. The spermathecal pores are usually in

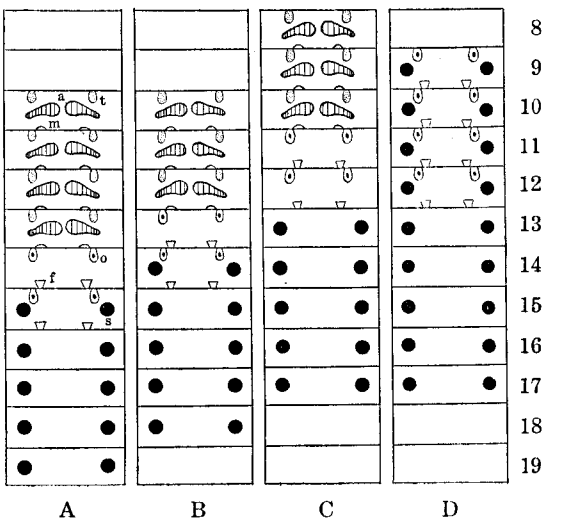

Fig. 2. Diagrammatic figures showing distribution of genital system in *Lumbriculus multiatriatus* n. sp. (vasa deferentia, sperm- and ovisacs are omitted). A and B, usual distribution; C, unusual distribution in which the whole genital organs are located further foreward from their usual positions; D, abnormal distribution referable to female condition. Numerals designate the segments; a, atrium; f, female funnel; m, male funnel; o, ovary; s, spermatheca; t, testis.

four or five pairs, but rarely more than five. The first pair of spermathecal pores is commonly found in the segment just behind the first pair of female pores, but is rarely found in the segment next to the second pair of female pores. Among mature specimens, three are destitute of male pores as was reported in *L. variegatus* (Mrázek, 1907) and in *L. japonicus* (Yamaguchi, 1936 a, b). Internal genital organs correspond to the number of genital pores as shown in Fig. 2.

Remarks on distribution of the genital organs in the Lumbriculidae. The Lumbriculidae are normally furnished with two to six pairs of gonads; one to four pairs of testes and one or two pairs of ovaries. Differing from the Megascolecidae and the Lumbricidae etc., the Lumbriculidae are deficient in intervening segments between the testicular and the ovarian segments except for *Styloscolex*, thence the "demarcating septum" can be considered. The demarcating septum is located in most of the genera in intersegment X/XI, but not always. The different position of the demarcating septum in species belonging to a genus and even in individuals of a species, is known in *Lumbriculus* (Mrázek, 1907; Smith and Welch, 1919; Yamaguchi, 1936 a, b), in *Lamprodrilus* (Hrabě, 1931, 1937) and in *Trichodrilus* (Hrabě, 1936 a, b). Male funnels, female funnels, atria and spermathecae also vary in number and position in genera and species.

With regard to the number of testes, male funnels and atria, and the position of those organs relative to the demarcating septum, the arrangement of the genital system seems to be roughly classified as the following seven types:—

Type I. More than two pairs of testes, male funnels and atria, each male funnel in a segment communicating with an atrium in the same segment (Fig. 3, A_1–A_4). This type is observed in *Lamprodrilus* (Fig. 3; 1-3) and in *Lumbriculus multiatriatus* n. sp. (Fig. 3; 5-6).

Type II. Two pairs of testes and male funnels, and one pair of atria. Atria situated in the segment just in front of the demarcating septum, and communicating with two male funnels in the same side (Fig. 3; B_1–B_2). This type is observable in genera, *Lumbriculus* (Fig. 3; 7), *Rhynchelmis* (Fig. 3; 9), *Trichodrilus*, *Bythonomus*, *Stylodrilus*, *Eclipidrilus* and *Bichaeta* (Fig. 3; 12).

Type III. One pair of testes, two pairs of male funnels, and one pair of atria, This type differs from Type II by the absence of the anterior pair of testes (Fig. 3; C). In *Rhynchelmis*, *Premnodrilus* and *Sutroa*, this type is observed (Fig. 3; 10, 13).

Type IV. One pair of testes, male funnels and atria in the segment just in

front of the demarcating septum (Fig. 3; D). This type is also common as seen in *Lamprodrilus*, *Lumbriculus*, *Rhynchelmis*, *Teleuscolex*, *Agriodrilus*, *Hrabea* and *Kincaidiana* (Fig. 3; 4, 8, 11, 14).

Type V. One pair of testes, male funnels and atria. Atria situated in the segment just behind the demarcating septum (Fig. 3; E). *Dorydrilus* is the only genus belonging to this type. The same type is seen in the Phreodrilidae, Tubificidae and Naididae (Hrabě, 1936 a).

Type VI. Two pairs of testes and male funnels, and a single median atrium. This type may be included in Type II as a modified form bearing an unpaired atrium. *Mesoporodrilus lacustris* and *Tatriella slovenica* (Hrabě, 1936 a) belong to this type. The genital organs of most genera in the Branchiobdellidae also belong to this type.

Type VII. One pair of testes, male funnels, and a single median atrium. This type is observed in *Mesoporodrilus asymmetricus*. This type resembles Type VI, but differs from it by the absence of the anterior pair of testes and male funnels. On the other hand, it may be included in Type IV as a modified form furnished with an unpaired atrium.

Michaelsen (1920) pointed out that the genital organs of *Rhynchelmis erlodi* (Type IV in this paper) can be derived through the condition of *Rh. tetratheca* (Type III) from the condition of *Rh. limosella* (Type II) by reduction of anterior pair of testes and male ducts. In 1928 he considered the *Lamprodrilus*-type of genital organs (Type I) as more primitive than the *Trichodrilus*-type (Type II). Stephenson (1930), on the other hand stated "The existing species of *Lamprodrilus* have two, three or four pairs of testes and male pores; it seems not improbable that the original number was two pairs (as in the majority of species of the genus), and that the higher numbers (in *L. satyriscus*) represent a secondary multiplication." A case comparable to these two genera is also observable in the genus *Lumbriculus* and even in a species of the same genus as described by Mrázek (1907), Yamaguchi (1936 a) and in this paper.

With regard to the question the following experimental works must be noticeable. In 1928 Weitzmann directed attention to the presence of small masses of indifferent cells,[1] "Keimzellenanhäufungen" on the posterior ventral surface of the septa in *Lumbriculus variegatus*. These cell masses were found in a pair in every segment and gave rise to gonads in regeneration. Together with Haffner's experiment (1928) on commissural vessels of the same species and

1) Turner (1935) reported in *L. inconstans* such paired cell masses. The writer also found them in *L. multiatriatus* n. sp.

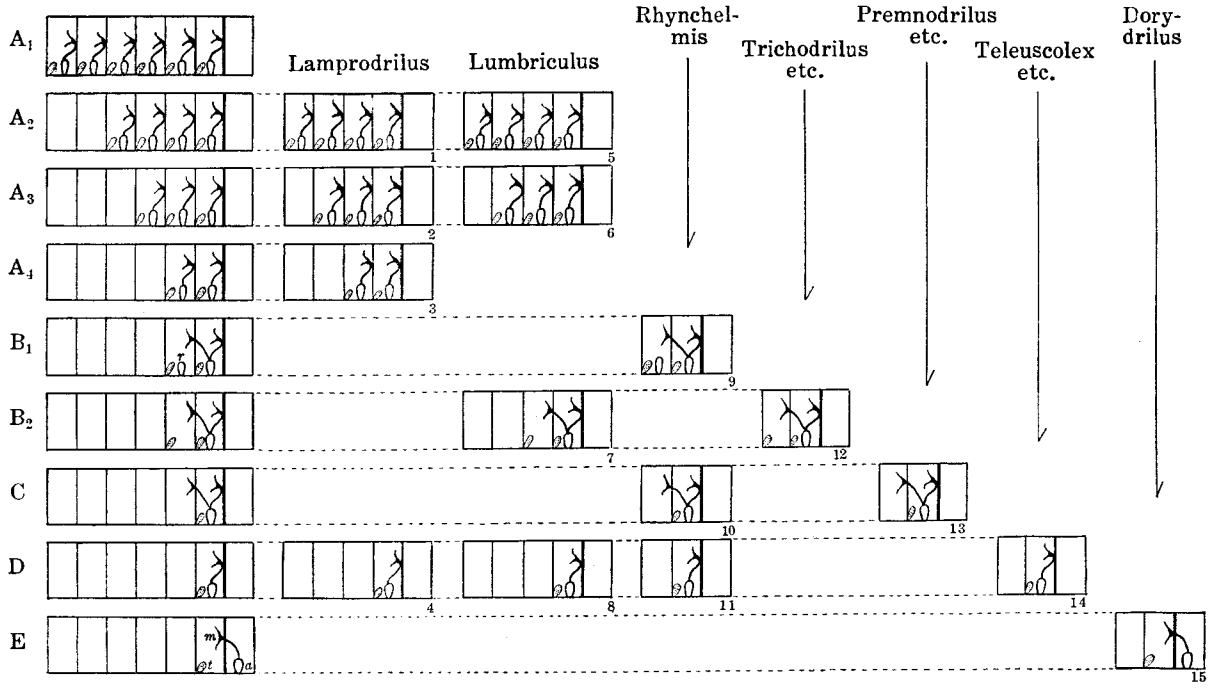

Fig. 3. Diagrammatic figures showing different types of male genital organs in genera of the Lumbriculidae. Demarcating septum shown by a heavy intersegmental line. A_1-E, scala of complication of testes, male funnels and atria; a, atrium; m, male funnel; r, rudimentary atrium; t, testis. A_1-A_4, Type I, A_1 showing the condition of the supposed ancestor lumbriculid. B_1-B_2, Type II; C, Type III; D, Type IV; E, Type V. Types VI & VII are excluded from this figure. 1, *Lamprodrilus satyriscus* f. *typica*; 2. *L. satyriscus* f. *decatheca* and f. *ditheca*; 3, majority of species of the genus; 4, *L. pygmaeus* f. *intermedia* (Hrabě, 1931) and *L. mrázeki* (Hrabě, 1937); 5 & 6, *Lumbriculus multiatriatus* n. sp.; 7, *L. japonicus* (Yamaguchi, 1936 a, b) and *L. inconstans*; 8, *L. variegatus*; 9, *Rhynchelmis limosella*; 10, *Rh. vejdovskyi*, and *Rh. orientalis* (Yamaguchi, 1936 a); 11, *Rh. erlodi*, and *Rh. glandula* (Altman, 1936); 12, *Trichodrilus*, *Bythonomus*, *Stylodrilus*, *Eclipidrilus* and *Bichaeta* (Hrabě, 1936 a); 13, *Premnodrilus* and *Sutroa*; 14, *Teleuscolex*, *Agriodrilus*, *Hrabea* (Yamaguchi, 1936 a) and *Kincaidiana* (Altman, 1936); 15, *Dorydrilus* (Hrabě, 1936 a).

Penners' work (1934) on gonads and nephridia of *Tubifex*, this fact seems to indicate the equipotency of segment of the Oligochaeta.

Judging from these facts, Michaelsen's reduction-theory seems to be more admissible than Stephenson's. The types of the male genital organs of Lumbriculidae can be schematized as Fig. 3. The left series (A_1–E) of these types designates the scala of complication, A_1 being the supposed ancestal type. But their phylogenetic meanings must be postponed for a further consideration.

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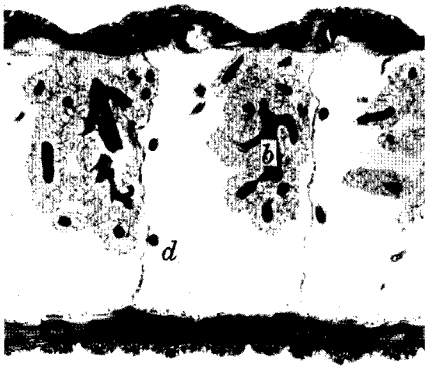
Explanation of Plate I

(*Lumbriculus multiatriatus* n. sp.)

1. Ventral view of anterior part of body, ×10.
2. Longitudinal section showing branched caecal transverse vessels(b) with covering of chloragogue cells, and dorso-ventral commissural vessels(d), ×60. Right of the figure corresponds to the anterior direction.
3. Transverse section through segment XV, showing position of spermathecal pore, ×84; l, lateral line; v, ventral setal line; s, spermathecal ampulla; sp, spermathecal pore.
4. Longitudinal section through atria, gonads, female pores and spermatheca, ×27. Right of the figure corresponds to the anterior direction.
5. Distal portion of atrium in longitudinal section, ×100.
6. Horizontal section showing penis, ×120.



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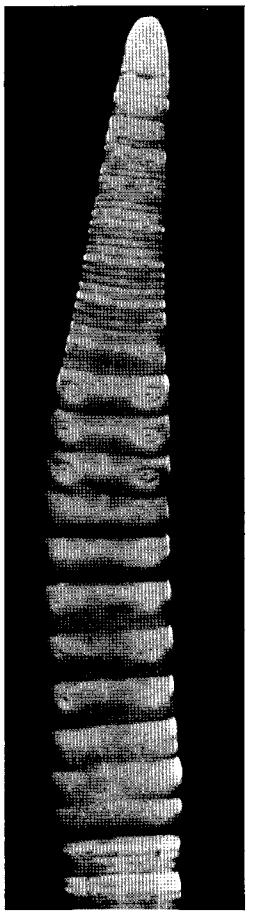

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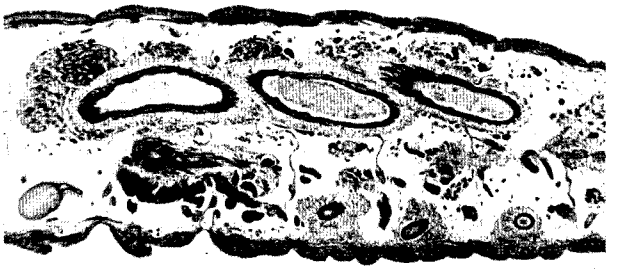

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H. Yamaguchi photo.

H. Yamaguchi: Aquatic Oligochaeta of Japan