Studies on the Aquatic Oligochaeta of Japan

VI. A Systematic Report, with Some Remarks on the Classification and Phylogeny of the Oligochaeta

By

Hideji Yamaguchi

(Biological Laboratory, Hakodate Branch, Hokkaido Gakugei University)

(With 1 Plate, 5 Tables and 25 Text-figures)

Contents

I) Introduction

After the publication in 1934 of my systematic work on the Japanese Branchiobdellidae I intended to extend my studies on other forms of the Oligochaeta and took up the aquatic Oligochaeta for the object of study. Material for the

studies was obtained from various localities of Hokkaido, Honshu, Kyushu and Saghalien, during years 1930–1939. Accorded with progress of the studies, some results were already reported in my previous papers (1936, 1937 a–d, 1938).

The present paper is the conclusive report for the studies, and is divided into two parts: The first part consists of taxonomic diagnosis of 39 species, belonging to 9 families and 29 genera, including a new genus and 5 new species. In the second part, some remarks were made in regard to the arrangement of the genital organs of the Oligochaeta, which seems to be valued as an important phylogenetic significance, from the viewpoint of the phylogenetic classification of families.

In the preparation of the paper, I wish to express my gratitude to Prof. Tohru Uchida, for his continuous guidance and criticism, at whose suggestions and encourragement the present studies were undertaken. My cordial thanks must be offerred to Professors S. Hozawa, T. Kawamura, T. Komai, M. Ueno, D. Miyadi, K. Oguma, T. Inukai, A. Ichikawa, S. Makino, and K. Aoki who kindly gave valuable advices and several facilities for the studies. Further, sincere thanks must be extended to Prof. E. Marcus of S. Paulo, who kindly gave informations as to the diagnosis of some tubificid species. Finally I wish to express warm thanks to the gentlemen who collected specimens and kindly placed them at my disposal; whose names will be found in text, accompanying with localities where speciemens have been collected.

Parts of the expense of the studies were defrayed through grants of the Foundation for Promotion of Scientific and Industrial Researches of Japan, and those of the Educational Department of Japan.

(I) Taxonomic records

A) Material and Methods

The material based on the studies has been collected from various localities, mostly during my collecting trips. Many specimens have been collected from bottom muds of ditches, brooks, ponds, paddy-fields, marshes or lakes. Some others were obtained from waterly sphagnum covering margins of marshes or brooks. Specimens of several naidiforms appeared as plankton in ponds or lakes. Some of those were found on surface of water-plants or fresh-water snails. Inhabitants of subterranean water were found in water pumped out from deep wells. Marine forms have been collected from sea-shores between the high and the low tide marks.

Observation were made generally both on living and preserved specimens. In examination of living ones, a dilute aquatic solution of chloreton (0.005–0.01%) was frequently used for the purpose of narcoticism. Preserved specimens were generally obtained by the following method. At first, living worms were placed in water, and to which the chloreton solution was added little by little, until the

worms would be narcotized. Next a narcotized worm was fitted to a straight groove on a wax-plate, the wide of the groove being slightly larger than the width of the worm. Subsequently, the surface of the body is smeared and wetted with a fixative by means of writing brush of soft hairs. When the body wall of the worm become hardened by fixation, the worm was transferred by the brush into the fixative in a glass dish. Then the worm would be completely hardened in straightly extended state in the dish. The specimens such treated revealed to be convenient to make preparations for histological and cytological purposes. As fixatives, 10% formaline or Bouin's solution was used. Both total and sectioned preparations were made. In total preparations, specimens were mounted by xylol-balsam or glicerin-gelatin. The sections, transverse and longitudinal, were usually made from the anterior part which contains the whole genital organs. Thickness of sections covered 10–15μ. Delafield's haematoxylin and eosin staining were usually adopted.

In mud-dwellers, such as Tubificidae and Lumbriculidae, their alimentary canal usually contain muds. It is very obstructive for cutting by microtomes. It is, therefore, the following treatment was used before narcoticism and fixation. Those worms were set free in clean water in a glass dish during one or two days until all contents of the alimentary canals would be discharged. In observation of setae, especially those of Naididae, the fresh material was treated by weak aquatic solution of Natrium hydrooxide or acid aquatic solution of pepcin ; the treatment by the latter showed excellent results.

For microscopical observation on the circulatory system in living worms of small size, was used, as a trial, a deep blue light-filter of C. Zeiss, one of the couple for infra-red photography. This method seems to be quite available for discrimination of fine vessels and for taking photograph them.

B) List of species examined

C) Descriptions

The Aeolosomatidae

1) *Aeolosoma bengalense* Stephenson

(Text-fig. 1)

A. bengalense, Stephenson, 1923, Oligochaeta in Fauna of British India, p. 41.
A. sp., Aiyer, 1926, Ann. Mag. Nat. Hist. vol. 18, p. 131, fig. 1–3.
A. bengalense, Marcus, 1944, Bol. Fac. Fil. Cien. Letr. Univ. S. Paulo, XLIII, Zoologia n. 8, p. 16, pl. 2A, B.

Material: Specimens collected from an aquarium in Sapporo in Aug. 1936.

Body about 2–3.5 mm long in extended state. Prostomium large, flat, and distinctly broader than the succeeding segments. It is very mobile, but is usually seen rounded triangular in outline in the dorsal aspect. Oil-droplets, usually yellowish green in colour, frequently yellow, bluish green rarely brownish yellow. They are usually spherical in shape, but frequently irregular, and present all over the body, being especially numerous on the dorsal surface of the prostomium. On the ventral surface of the prostomium the oil-droplets are confined to the margin. Each oil-droplet was observed to attach to a spherical body as well as Aiyer's figure

(1926). Spherical oil-droplets are measured about 8–12μ in diameter while irregularly shaped ones have usually more large size. Setae, in four bundles per segment, two dorsal and two ventral, beginning just behind the posterior end of the buccal funnel. Specimens ready to divide asexually were observed to bear segmentary 10–13 sets of setae bundles in the anterior half, and 8–11 sets of those in the posterior. All the setae are capilliform and flexible. They are mostly straight, having slight sigmoid curve. Each bundle consists of variable number of long and short setae. There were counted one to four (usually three or four) long and three to five (usually four or five) short ones in a single bundle. The long setae are sometimes as long as the diameter of the body and sometimes slightly longer than the latter. The short setae are usually about half as long as the long ones. A long seta from the fourth segment of an individual was measured 280μ, and a short one from the same bundle was 120μ. No definite septa, except between the first and the second segment. Oesophagus, nearly straight and occupying segments II and III. Stomach with thicker and more granular wall than the rest of the alimentary canal, yellowish-coloured, beginning behind the third setal bundle. Intestine continued to the stomach, commencing behind the seventh or eighth setal bundle. Cerebral ganglion, transversely elongated and rounded in front and indented behind. No genital organs could be observed in any specimens examined.

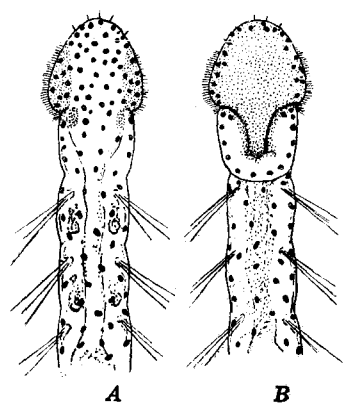


Fig. 1. *Aeolosoma bengalense* Stephenson.
A, dorsal aspect of anterior part of body, B, ventral aspect of anterior part of body, the both about ×37.

Notes : So far as the writer is aware, the present species seems to be new to Japan. The writer's specimens agree with the descriptions given by Stephenson (1923) and Aiyer (1926), except slight difference in length of bodies and setae.

2) *Aeolosoma japonica* n. sp.

(Text-figs. 2 and 3)

Material : Many specimens collected in an aquarium in Sapporo in Jan. 1938.

Body, about 2–3 mm long in extended state. Prostomium flat and broader than the succeeding segments. Though it is easily changeable in shape, its outline is usually circular in the dorsal aspect. Oil-droplets, yellowish orange in colour, usually spherical in shape and 5–12μ in diameter. They are present all over the body wall except the ventral surface of the prostomium. Four setal bundles per

segment, two dorsal and two ventral, beginning just behind the posterior end of the buccal funnel. Each bundle consists of long and short capillary setae. The long setae are almost straight, having somewhat sigmoid curve. The short setae are more or less needle-like, providing with sigmoid curve. The short one is about one-second the length of the long one. A long seta in a bundle was measured

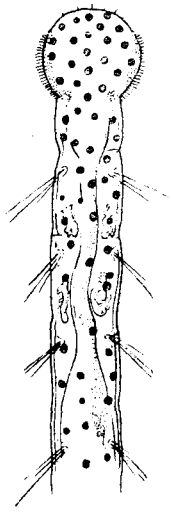


Fig. 2. *Aeolosoma iaponica* n. sp. Dorsal view of anterior region, ca. ×37.

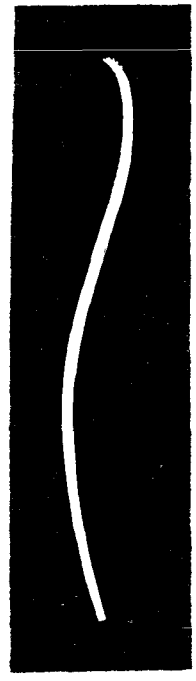


Fig. 3. *Aeolosoma iaponica* n. sp. Special sigmoid setae found in posterior part of body, ca. ×1200.

210μ, while a short one in the same bundle was 120μ long. There are one to three (usually two or three) long and one to five (usually three to five) short setae in a bundle. Near the posterior end of the body, one or two special sigmoid setae with teethed distal end (Fig. 3) are found in a bundle. The special setae are as long as three-fifth the short capillary setae. Stomach beginning behind the third setal bundle; intestine continued to the stomach, commencing behind the seventh or eighth setae bundle. Nephridia beginning in the space between the first and the second setal bundles. No genital organ could be observed.

Notes: So far as the writer is aware, teethed sigmoid setae are also present in *A. travancorense* Aiyer and *A. sawayai* Marcus. The teethed sigmoid setae of the present new species seems, however, to be different from those of the both species, comparing with the figures given by Marcus (1944). On the other hand,

the new species seems to resemble *A. tenebrarum* Vejd. in the form of the prostomium, the colour of oil-droplets and the occurrence of sigmoid setae in the posterior part of the body. But the former is easily distinguished from the latter by the difference of the body length and the composition of the setal bundle.

The Naididae

3) *Chaetogaster limnaei* Baer

C. limnaei, Michaelsen, 1900, Oligochaeta p. 22 ; Piguet, 1906, Rev. suisse zool. T. 14, p. 205 ; Michaelsen, 1909, Süsswasser-fauna Deutschlands H. 13, p. 11 ; Piguet et Bretscher, 1913, Catalogue d. Invertb. d. l. Suisse Fasc. 7, p. 20 ; Kawamura, 1918, Fresh-water Biology of Japan (in Japanese) fig. 321 ; Stephenson, 1923, Oligochaeta in Fauna of British India p. 50 ; Michaelsen, 1927, Tierw. Nord- und Ostsee Lief. 9, Teil 6, p. 8 ; Ude, 1929, Tierw. Deutschlands Teil 15, p. 24, fig. 3 ; Kondo, 1936, Ann. zool. Japon. Vol. 15, p. 383, pl. 23 fig. 3 ; Yamaguchi, 1940, Report on the land-water Fauna of Manchuko (in Japanese) p. 383, fig. 1.

Material : Specimens collected by Dr. S. Makino from a pond at Akkeshi (Hokkaido) in Aug. 1935, which had attached on the fresh-water snail, *Limnea* sp. Specimens obtained from the surface of snails, *Limnea* sp. in Lake Biwa in Mar. 1938.

Notes : The species is cosmopolitan and is known to be distributed in whole Europe, India, Asia and North America. In Japan, it seems to be widely distributed in the whole country, though not so many localities have been recorded. According to previous investigators, setae are variable in number per bundle and in length in European specimens, as in the following list.

Authors	Number of setae per bundle	Length of setae in segment II.
Michaelsen (1900)	8 12	
Piguet (1906)	8–12 14 20 6 8	93μ 118 69
Michaelsen (1927)	6 14	

The similar variation is also found in the Japanese specimens, as listed below :

Localities	Number of setae per bundle	Length of setae in segment II.
Akkeshi	17–20	150 μ
Lake Biwa	15–18	120

As is clear from the comparison with the both lists, the length of setae of segment II in the Japanese specimens is larger than that of the European specimens, as well as that of Manchurian specimens (Yamaguchi, 1940).

4) *Paranais litoralis* (Müller)

P. litoralis, Michaelsen, 1900, Oligochaeta p. 18 ; 1909, Süssw.-fauna Deutschlands H. 13,

p. 12, 1927, Tierw. Nord- u. Ostsee Lief, 9, Teil 6, p. 8 ; Ude, 1929, Tierw. Deutschlands Teil 15, p. 25, fig. 20 ; Kondo, 1936, Ann. zool. Japon. Vol. 15, p. 384, pl. 23 fig. 8.

Material : Specimens, collected from Mokoto-Numa, a brackish lake in Hokkaido, in July 1938.

Notes : This species has been recorded from Germany, Denmark, England, Holland, South-Russia and Japan. The previous record of the species in Japan was given by Kondo (1936). The species is easily distinguishable from the Japanese species of the genus, *P. naidina* Kondo and *P. heterochaeta* Kondo, by the character that dorsal setae bundles begin from segment V.

5) *Pristina aequiseta* Bourne

(Text-fig. 4)

P. aequiseta, Michaelsen, 1900, Oligochaeta p. 34.
Naidium tentaculatum, Piguet, 1906, Rev. suisse zool.T. 14, p. 219-222, pl. 9 fig. 18-20, 26.
P. aequiseta, Piguet, 1909, Rev. suisse zool. T. 17, p. 211 ; Piguet et Bretscher, 1913, Catalogue d. Invertb. d. l. Suisse Fasc. 7, p. 52 ; Stephenson, 1923, Oligochaeta in in Fauna of British India p. 71, fig. 24 ; Ude, 1929, Tierw. Deutschlands Teil 15, p. 30, fig. 27-28 ; Stephenson, 1931, Proc. zool. Soc. London (1931) p. 42 ; Marcus, 1943, Bol. Fac. Cien. Letr. Univ. S. Paulo XXXII, Zoologia n. 7, p. 104, fig. 81 A-D.

Material : Specimens appeared abundantly in an aquarium during Sep.-Oct. in 1936 in Sapporo, and also were found in other aquarium in Sapporo in Dec. 1937.

Body whitish in colour, bearing proboscis-like prostomium, and 2–3 mm long and 0.1–0.12 mm wide. The number of segments in individuals without showing any budding zone, appeared to vary between 24 and 27. In individuals preparing to divide asexually, the budding zone were found just behind segment XIII, XIV, XV, XVI or XVII (XIV–XVI in common). The seven anterior segments are newly formed in the posterior daughter individual. Dorsal setae bundles begin, as same as the ventral, in segment II. Ventral setae are all doubly pronged crotchets, being 3–10 in number per bundle. Its distal prong is longer but thinner than the proximal, except in the posterior part of the body, where the distal prong about equal to or slightly shorter than the proximal one. The crotchets on segment II (Fig. 4, V_2) have a proximal nodulus and largest length ; those on segment III (Fig. 4, V_3) are shorter than those on segments II and IV, being provided with a distal nodulus. Those on the remaining segments have also a distal nodulus. In segments IV and V, each ventral bundle consists of a smaller number (3–5) of crotchets which have large thickness, forming giant setae (Fig. 4, V_5). Each of the dorsal bundle consists of one or two hairs and one or two needles (Fig. 4, N). All the hairs are slightly curved and provided with very fine saw-teeth on the convex side. The saw-teeth, however, cannot be called obvious ; they may

be over-looked when one does not use a high power objective such as 1/12 inch oil immersion lens. The hairs are about equal in length to the diameter of the body. Unlike *P. longiseta* Ehrg., there is no specially elongated hair. The needles are slightly curved and doubly pronged in their extremity. No eye-spot. Sensory hairs are present on the prostomium and the posterior end of the body. Pharynx lying in segments II and III ; stomach in segment VIII, occupying the anterior half of the segment. The first nephridia are in segment IX. Coelomic corpuscles contain a number of slightly refractile granules and fewer number of brown bodies resembling oil-droplets.

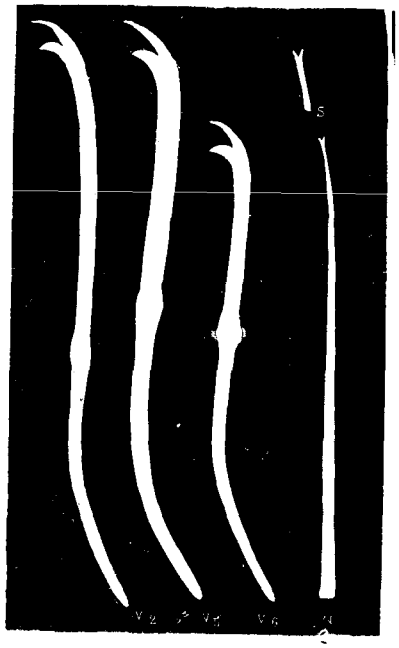
Fig. 4. Setae of *Pristina aequiseta* Bourne. V_2, ventral seta on segment II ; V_3, V_4, V_5, V_6, those on segments III, IV, V, VI respectively ; N, needle seta ; ca. ×1200. S, tip of a needle, ca. ×2200.

Notes : The writer's specimens agree mostly with the descriptions of the species, given by the previous investigators. But the saw-teethed hairs have never been described in the present species, so far as the writer is aware. It seems to be probable to be over-looked by the previous investigators. On the other hand, it happened to the writer that *P. capiliseta* Kondo (1936), which has denticulate capilliform setae, may be probably synonymous with the present species. But it is still in question because the following difference is found ; in the writer's specimens needles and crotchets are about equal in length or the former is slightly shorter than the latter, while needles of *P. capiliseta* are conspicuously shorter than its crotchets according to Kondo's figure.

6) *Pristina longiseta* Ehrenberg

(Text-fig. 5 ; Pl. VII, fig. 1)

P. longiseta, Michaelsen, 1900, Oligochaeta p. 34 ; Piguet, 1906, Rev. suisse zool. T. 14, p. 290 pl. 10 fig. 22, 23, pl. 12 fig. 21-25 ; Michaelsen, 1909, Süssw.-fauna Deutschlands H. 13, p. 25 (forma typica) ; Piguet et Bretscher, 1913, Catalogue d. Invertb. d. l. suisse Fasc. 7, p. 50 ; Stephenson, 1923, Oligochaeta in Fauna of British India p. 70, fig. 23 ; Ude, 1929, Tierw. Deutschlands Teil 15, p. 29, fig. 25, 26 ; Stephenson, 1931, Proc. zool. Soc. London (1931) p. 41. fig. 18 ; Kondo, 1936, Ann. zool. Japon. vol. 15, p. 388, pl. 24 fig. 18.



Material: Many specimens collected from an aquarium in Sapporo in Dec. 1937.

Notes: The species is widely distributed in the world. It was recorded from Germany, Switzerland, Denmark, Belgium, Finland, British India, East-Africa, North America, South-America and Japan. The first record of Japan was made by Kondo (1936). The species is easily distinguished from the foregoing species by the possession of specially elongated long hair setae in segment III.

Fig. 5. Setae of *Pristina longiseta* Ehrenberg. V_2, V_5, V_6, ventral setae on segments II, V, IV respectively; N, needle seta; all ca. ×1200. S, distal extremity of a needle, ca. ×2200.

7) Pristina rosea (Piguet)

Naidium roseum, Piguet, 1906, Rev. suisse zool. T. 14, p. 223 255, pl. 9 fig. 22, 28, 1909, Rev. suisse zool. T. 17, p. 175, pl. 3 fig 18.
Pristina rosea, Michaelsen, 1909, Süssw.-fauna Deutschlands H. 13, p. 28.
Naidium roseum, Piguet et Bretscher, 1913. Catalogue d. Invertb. d. l. Suisse Fasc. 7, p. 25.
Pristina rosea, Ude, 1929, Tierw. Deutschtands Teil 15, p. 30, fig. 29; Kondo, 1936, Ann. zool. Japon. vol. 15, p. 386, pl. 24 fig. 16.

Material: Specimens collected from a filter pond in water-works plant of Osaka in Mar. 1938.

Notes: The species has been originally described from Europe, and was recorded from Japan by Kondo (1936), his record being based on specimens collected from the same locality where the writers' specimens were obtained. As already described by Kondo, the body is pale chalk-white or colourless, instead of red colour of European specimens.

8) *Nais communis* Piguet

(Text-fig. 6)

N. communis, Piguet, 1906, Rev. suisse zool. T. 14, p. 247, pl. 10 fig. 9, pl. 11, fig. 14–17, 19,

pl. 12 fig. 11 ; Michaelsen, 1909, Süssw.-fauna Deutschlands H. 13, p. 18 ; Piguet et Bretscher, 1913, catalogue d. Invertb. d. l. Suisse Fasc. 7, p. 37 ; Ude, 1929, Tierw. Deutschlands. Teil 15,p. 46, fig .56; Stephenson, 1931, Proc. zool. Soc. London (1931) p. 30.

Material : Many specimens, found in an aquarium in Sapporo, Dec. 1937. Specimens, collected among moss in a small brook in Otsu in Mar. 1938. Those, collected from filter water in the water-works plant on Osaka in Mar. 1938.

Body, about 8–9 mm long and 0.1–0.15 mm wide in extended state. The anterior part of the body (segments II–IV) is pigmented brownish. The number of segments was 22–36 in 15 individuals which did not show any trace of a budding zone. The budding zone was observed in 6 specimens, being situated just behind segment XX in 5 ones and just behind segment XVIII in another one. Prostomium, rounded conical in shape. The eye-spots are placed laterally, exactly at the level of the mouth ; they are represented by ovoid or somewhat irregular mass of dark violet pigment. No "Nebenaugen" was observed. Sensory hairs are present on the prostomium and the posterior end of the body. Ventral setae commence from segment II, they are all bifid crotchets, the distal prong being longer and thinner than the proximal. Nudulus, situated slightly proximal to the middle of the shaft of crotchets on segments II–V (Fig. 6 V_2, V_5), and slightly distal in those on the remaining segments (Fig. 6 V_6, V_m). The number of the ventral setae is 3–6 per bundle Dorsal bundles begin from segment VI. Each dorsal bundle consists of one hair and one or two needles (Fig. 6 N). The hairs are nearly straight and smooth ; their length being equal to or slightly shorter than the diameter of the body, and about as long as three times of the needles which are slightly curved and bifid in thier distal ends, the two prong being not so long but very obvious. Pharynx occupying segments III–V. From the middle of segment VII, the alimentary canal is gradually widened to form the stomach which seems to reach the end of segment IX. The first nephridia in segment VII.

Fig. 6. Setae of *Nais communis* Piguet. V_2, V_5, V_6, N and V_m, ca. ×1200 ; S, ca. ×2200. References as for Fig. 5.

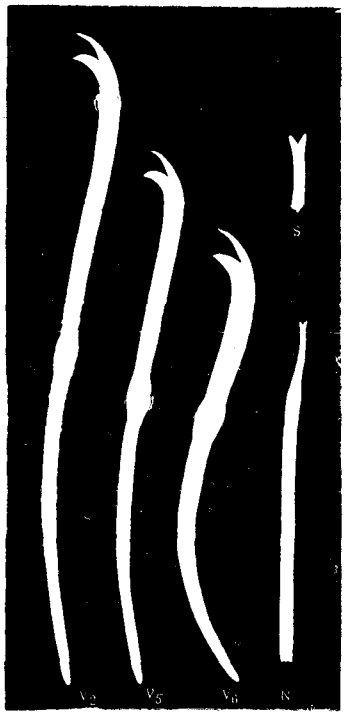
Notes : The description is based on specimens from Sapporo. Though the present species is very common in Europe

and India and is also recorded from Java, Kamtschatka, North and South America, it seems to be new record in Japan. The present species resembles *N. variabilis* Piguet, but the both species are easily distinguished by the position of the nodulus of the ventral setae on segments II-V, and by the relative length of hairs and needle setae.

9) *Nais variabilis* Piguet

(Text-fig. 7, Pl. VII fig. 2)

N. variabilis, Piguet, 1906, Rev. suisse zool. T. 14, p. 253, pl. 10 fig. 10–13, pl. 11 fig. 18, 21, pl. 12 fig. 12, 1909, Rev. suisse zool T. 17, p. 195, pl. 3 fig. 9 11 ; Michaelsen, 1909, Süssw.-fauna Deutschlands H. 13, p. 18 ; Piguet et Bretscher, 1913, Catalogue d. Invertb. d. l. Suisse Fasc. 7, p. 38 ; Michaelsen, 1927, Tierw. Nord- u. Ostsee Lief. 9, Teil 6, p. 10 ; Ude, 1929, Tierw. Deutschlands Teil 15, p. 47, fig. 57 ; Kondo, 1936, Ann. zool. Japon. vol. 15, p. 384, pl. 23 fig. 10.



Material : Specimens containing those collected from Lake Chibesan in Saghalien in July 1936, collected from Lake Toro in Hokkaido in Aug. 1937, obtained from a pond near Nemuro in Aug. 1937, found in an aquarium in Sapporo in Dec. 1937, and collected from Mizoro pond in Kyoto in Mar. 1939. Several specimens collected from a pool on Mount Kirishima in Mar. 1939.

Notes : The species is also one of well-known naidiforms in Europe, and has been recorded from Japan by Kondo. It seems to be widely distributed and very common in Japan.

Fig. 7. Setae of *Nais variabilis* Piguet. V_2, V_5, V_6 and N, ca. ×1200 ; S, ca. ×2200. For references, see under Fig. 5.

10) *Nais pardalis* Piguet

(Text-fig. 8)

N. bretscheri var. *pardalis*, Piguet, 1906, Rev. suisse zool. T. 14, p. 270, pl. 10 fig. 20, pl. 12 fig. 4, 5, 17.

N. pardalis Piguet, 1909, Rev. suisse zool. T. 17, p. 206, pl. 3 fig. 14–16. ; Michaelsen, 1909, Süssw.-fauna Deutschlands H. 13, p. 17 ; Piguet et Bretscher, 1913, Catalogue d. Invertb. d. l. Suisse Fasc. 7, p. 40 ; Ude, 1929, Tierw. Deutschlands. Teil 15, p. 48, fig. 58.

Material : Many specimens, collected from Lake Toro in Hokkaido in Sep. 1937. Specimens from a pond near Nemuro in Aug. 1937. Several specimens, obtained from a pool at Sano (Miyazaki prefecture) in Mar. 1939, and from a pond in Fukuoka in April 1939.

Body, about 5 mm long in preserved specimens. The number of segments was counted from 14 to 25. Eye-spots are present. The budding zone was found to be located just behind segment XIII or XIV. The five head segments are newly formed in the budding zone. Each ventral setal bundle consists of 2–4 (commonly 3 or 4) bifid crotchets. The crotchets of segments II–V (Fig. 8 V_2, V_5) are longer and thinner than those of the remaining segments, and have each a proximal nodulus. The distal prong in segments II–V is longer than the proximal, the both prongs being equal in thickness at their bases. The crotchets on segments beginning from VI afterward have a distal nodulus in each ; the distal prong is thinner and very slightly longer than the proximal. Dorsal setal bundles begin from segment VI, each consisting of one hair and one or two needle setae. The needle is divided in its distal extremity into two paralleled prongs with an equal length (Fig. 8 N, S). The hair setae are as long as three times of the needles in a same bundle.

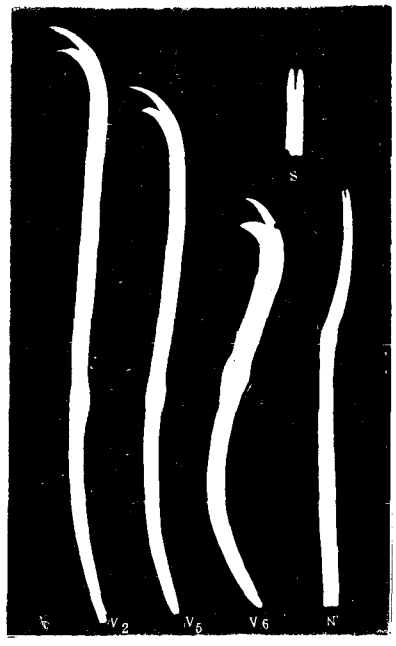


Fig. 8. Setae of *Nais pardaris* Piguet. V_2, V_5, V_6 and N, ca. ×1200 ; S, ca. ×2200. References as for Fig. 5.

Notes : So far as the writer is aware, the present species has hitherto never been recorded from Japan. The description is based on specimens collected from Nemuro and Lake Toro. The species is easily distinguished from other species of the gunus by the possession of the parallel prongs of the needles, except *N. bretscheri* Michaelsen which is characterized by the possession of the so-called giant setae.

11) *Nais obtusa* (Gervais)

(Text-fig. 9)

N. obtusa, Michaelsen, 1900, Oligochaeta p. 25 ; Piguet, 1906, Rev. suisse zool. T. 14, p. 234, pl. 10 fig. 2–4, pl. 11 fig. 5, pl. 12 fig. 8, 1909, Rev. suisse zool. T. 17, p. 188, pl. 3 fig. 2–7; Michaelsen 1909, Süssw.-fauna Deutschlands H. 13, p. 20; Stephenson, 1923, Oligochaeta in Fauna of British India p. 60 ; Ude, 1929, Tierw. Deutschlands Teil 15, p. 49, fig. 59.

Material : Many specimens, obtained from a march "Ponto" at Koitoi (Hokkaido) in Aug. 1935. Specimens, collected from Lake Chibesan in Saghalien in July 1936. Several specimens, collected from a small pond near Nemuro in Mar. 1937, and from Lake Ikeda in Kagoshima prefecture and from a small pool at Nagasaki in April 1939.

Body length, 2–3 mm in preserved specimens ; the number of segments, 21–23. Eye-spots present. The budding zone was observed to situate just behind segment XV, XVI, XVII or XVIII. The ventral setae bundles consist of 2–5 (commonly 3 or 4) bifid crotchets, the distal prong being thinner than the proximal. The crotchets on segemts beginning from VI (Fig. 9 V_6) are very thicker than those on the anterior segments II–V, the distal prong is longer than the proximal, while the both prongs are about equal in length in the remaining segments. The nodulus is situated slightly proximal to the middle of the setal length or about at the middle in the crotchets of segments II–V, and distal in those on the remaining segments. Dorsal setal bundles begin from segment VI. Each dorsal bundle consists of 1 or 2 needles and 1 or 2 hairs, the needles being singly pointed (Fig. 9, N), and their length is as long as half the length of hair in a same bundle. Stomach suddenly widened in segment VII.

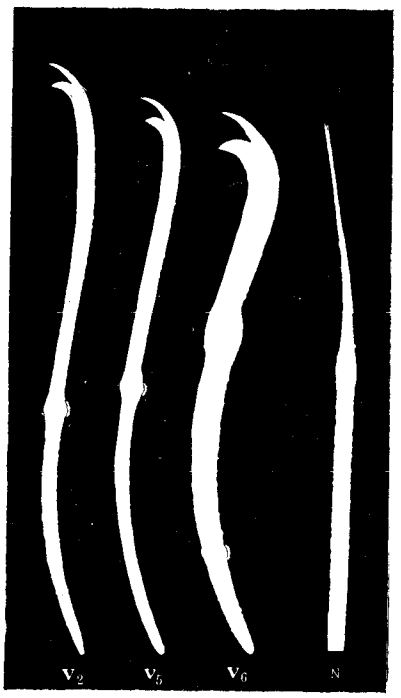


Fig. 9. Sete of *Nais obtusa* (Gervais). References and magnification as for Fig. 5.

Notes : The description is based on examples obtained from Koitoi. Though the present species is widely distributed in the world, it has not been recorded from Japan. The most striking character of the

species seems to be the possession of the singly pinted needles.

12) *Nais bretscheri* Michaelsen

(Text-fig. 10)

N. bretscheri, Michaelsen, 1899, Zool. Jahrb., System. Bd. 12, p. 121, 1900, Oligochaeta p. 26; Piguet, 1906, Rev. suisse zool. T. 14, p. 267, pl. 10 fig. 19, pl. 12 fig. 6, 16, 1909, Rev. suisse zool. T. 17, p. 205, pl. 3 fig. 13 ; Michaelsen, 1909, Süssw.-fauna Deutschlands H. 13, p. 17 ; Piguet et Bretscher, 1913, Catalogue d. Invertb. d. l. suisse Fasc. 7, p. 29 ; Ude, 1929, Tierw. Deutschlands Teil 15, p. 43, fig. 53.

Material: Specimens, collected from a small pond in Sapporo in Dec. 1937, and from a pond in Nagasaki in April 1939.

Body, about 4 mm long and about 0.25 mm wide in preserved specimens. The anterior part of the body is pigmented as observable in *N. variabilis* and others. One pair of eye-spots present. Stomach suddenly widened in segment VII. Ventral setae bundles composed of 2–4 doubly pronged crotchets per bundle. The crotchets are distinguishable into three forms, the anterior (Fig. 10 V_2, V_5), the middle and the posterior crotchets. The anterior crotchets are distinct from others by the possession of a proximal nodulus, and are located in the anterior part of the body. Their distal prongs are evidently longer than the proximal, but the both prongs being about equal in thickness. The middle crotchets have a distal nodulus in each, the distal prong being longer than the proximal (Fig. 10 V_6, V_7). The both prongs are about equal in thickness or the distal prong is thicker than the proximal. Though the middle crotchets are generally thicker than the anterior crotchets, some of the former an exceedingly thick, being distinguished as giant

Fig. 10. Setae of *Nais bretscheri* Michaelsen. V_2, V_5, ventral setae on segments II and V respectively ; V_6, that on segment VI (ordinary middle seta) ; V_7, that on segment VII (giant seta) ; Vp, posterior seta ; N, needle seta ; all ca. ×1200. S, tip of a needle seta, ca. ×2200.

setae (Fig. 10 V_7). The posterior crotchets are provided with a thinner distal prong and a thicker proximal prong, the both being about equal in length (Fig. 10 V_p). Distribution of those crotchets in an individual is as in the following:

Segments	Anterior crotchets	Middle crotchets	(Giant setae)	Posterior crotchets	Total
II	3	—		—	3
III	4	—		—	4
IV	3	—		—	3
V	3	—		—	3
VI	—	2	(1)	—	2
VII	—	3	(2)	—	3
VIII	—	3	(1)	—	3
IX	—	2	(1)	—	2
X	—	2	(1)	1	3
XI	—	2	(1)	2	4
XII	—	1		2	3
XIII	—	1		3	4
XIV	—	1		3	4
XV	—	—		3	3

Dorsal setal bundles composed generally of 1 hair and 1 needle, the hair being 2–2.5 times of the needle in length. The needle is divided in its distal extremity into two paralleled prongs which are about equal in length and in thickness.

Notes: The description is based on the material obtained from Sapporo, and it seems to be the first record in Japan. The present species is easily distinguishable from other species of the genus by the presence of the giant setae and the needles with parallel prongs.

13) *Stylaria lacustris* (Linnaeus)

S. lacustris, Michaelsen, 1900, Oligochaeta p. 33; Piguet, 1906, Rev. Suisse zool. T. 14, p. 287, 1909, Rev. suisse zool. T. 17, p. 209; Michaelsen, 1909, Süssw.-fauna Deutschlands H. 13, p. 15; Piguet et Bretscher, 1913, Calatogue d. Invertb. d. l. Suisse Fasc. 7, p. 48; Stephenson, 1923, Oligochaeta in Fauna of British India p. 85, fig. 31; Michaelsen, 1927, Tierw. Nord- u. Ostsee Lief. 9, Teil 6, p. 1; Yoshizawa, 1928, Sci. Rep. Tohoku Imp. Univ. 4 ser. vol. 3, p. 587-613, fig. 1 28; Ude, 1929, Tierw. Deutschlands Teil 15, p. 41, fig. 49; Kondo, 1936, Ann. zool. Japon. vol. 15, p. 384, pl. 23 fig. 9.

Material: Specimens, collected Lake Toro in Hokkaido in Sep. 1937, and those from Lake Biwa in Mar. 1938. Those, obtained from the pond "Mizoro-ike" at Kyoto in Mar. 1938. Those, collected from the pond "Konyo no ike" in Hyogo prefecture in April 1938. Those from the marsh "Ponto" at Koitoi in Hokkaido in Aug. 1935.

Notes: The species is one of well known forms in Europe, and seems to be

widely distributed in the world. In 1928, Yashizawa recorded it from Japan, describing detailed features based on Japanese examples. The most striking feature of the species is the presence of a considerablly elongated prostomium.

14) *Slavina appendiculata* (Udekem)

(Text-fig. 11)

S. appendiculata, Michaelsen, 1900, Oligochaeta p. 32 ; Piguet, 1906, Rev. suisse zool. T. 14, p. 282, pl. 12 fig. 20 ; Michaelsen, 1909, Süssw.-fauna Deutschlands H. 13, p. 13 ; Piguet et Bretscher, 1913, Catalogue d. Invertb. d. l. suisse Fasc. 7, p. 47; Stephenson, 1923, Oligochaeta in Fauna of British India p. 82, fig. 28, 29 ; Ude, 1929, Tierw. Deutschlands Teil 15, p. 42, fig. 51, 52.

Material : Specimens, obtained from Lake Chibesan in Saghalien in July 1936. Several specimens, found in an aquarium in Sapporo, Sep. – Oct. 1936. Specimens, collected from Lake Toro in Hokkaido in Sep. 1937.

Body, 7–13 mm long in extended state. The surface of the body is covered with foreign particles so that the internal organs are in general obscure even in living state. The number of segments was counted to 33–47 in worms without showing any trace of a budding zone. In specimens preparing to divide, the budding zone was found just behind segment XXIII, XXIV, XXV. Eye-spots present. The skin bears a number of sensory papillae which show truncated conelike projections, each bearing a number of minute stiff colourless hairs which resemble the sensory hairs on the prostomium in general in the Naididae. The sensory papillae are segmentally arranged in transverse rows in the dorsolateral side. The principal rows are located in the level of the setal bundles. Two accessory rows are usually found between the principal rows. Ventral setal bundles composed of bifid crotchets only, the distal prong being slightly longer and thinner than the proximal. Nodulus, located proximally in all the crotchets. The crotchets of segment II (Fig. 11 V_2) are longest, their nodulus being located about one-third the setal length from the proximal end. In each ventral bundle, 3–4 (rarely 2) setae were counted. Dorsal setae bundles begin from segment VI. Each dorsal bundle consists of 1 or

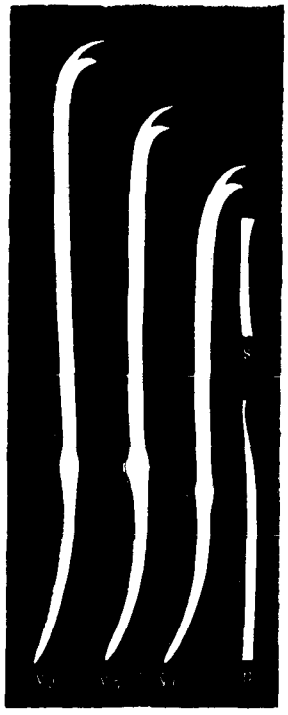


Fig. 11. Setae of *Slavina appendiculata* (Udekem). V_2, V_5, V_6 and N, ca. ×700 ; S, ca. ×2200. References as for Fig. 5.

2 hairs and 1 to 3 needles. The hairs are slightly curved and smooth, their length being somewhat larger than the diameter of the body, except those on segment VI. The hair setae on segment VI are very long, about as long as two to three times the usual hairs. The needles (Fig. 11 N) are relatively short, their length being about one-fourth or one-fifth the length of the usual hairs. The distal end of the needles are not bifid, but not sharply pointed ; the extremity is rather slightly enlarged (Fig. 11 S). The digestive tract is gradually widened in segment VII, forming the stomach. The pharynx lies in segments II–V. Chloragogue cells begin in segment V. The first nephridia are in segment VII.

Notes : It seems to give the new record of the species in Japan. The description is based on specimens from Sapporo.

15) *Aulophorus* sp.

Material : Specimens, collected at Rendaiji-Onsen in Sihzuoka Prefecture, by Mr. S. Ito.

Notes : All specimens were ill-preserved, so that it could not be determined their precise systematic position. But it is not doubtful that they belong to the genus *Aulophorus*, because one pair of palpi were observed on the branchial fossa in two specimens.

16) *Dero* sp.

Material : Two specimens from a pond at Fukuoka, April 1937.

Notes : The specimens were found among specimens of *Nais pardalis* Piguet. They have branchial fossa but no palpus. From the characters, it is clear to belong to the genus *Dero*. But specific name could not be determined owing to their ill-preservation.

17) *Branchiodrilus hortensis* (Steph.) var. *japonicus* Yamaguchi

(Pl. VII, fig. 4)

B. hortensis var. *japonicus* Yamaguchi, 1938, Ann. zool. Japon. vol. 17, p. 530, fig. 1–2, pl. 29.

Material : Many specimens collected from Lake Toro in Hokkaido in Sep. 1937.

Notes : The writer's previous paper is based on this material. The present species may be the largest form in the Naididae, the body being 20–47 mm long and 0.5–0.6 mm wide. The most striking feature of the species is the possession of filiform gills in nearly all segments, each segment being provided with a pair of the gills.

The Tubificidae

18) *Tubifex hattai* Nomura

T. hattai, Nomura, 1926, Sci. Rep. Tohoku Imp. Univ. 4 ser. vol. 1, p. 193 288, fig. 1–18.

Material: Specimens from a ditch at Sapporo in Aug. 1936, and from a pond at the same city in May 1938. Those from a ditch at Tokyo, May 1937. Those from Osaka, sent by Mr. M. Kondo.

Notes: The species seems to be very common in Japan. It will be usually found, associated with several species of other tubificids, in ditches where the surface of muds becomes pinkish to redish in colour.

19) *Peloscolex* sp.

Material: Several specimens collected from mud at 10 meters deep in Lake Biwa in Mar. 1937.

Body brownish gray in colour, except the clitellum which occupies from segments X to XII and appears in milky white in colour. Dorsal setae bundles consist of hair setae and at least in the anterior region together with crotchets. The latter, bifid in the distal end, the both prongs being mostly parellel in situation. Each dorsal bundle composed with 5–7 hairs and 4–6 crotchets in the anterior region. Ventral bundles consist of 1–4 (usually 2) bifid crotchets ; the both prongs have about equal thickness in the preclitellar region, while in the post-clitellar region the proximal prong is considerably thicker than the distal prong. Sensory papillae, arranged in two rings in each segment, one ring being situated near the inter-segmental furrow, the other on the setal line. Spermathecae, one-paired, being distinguished into a duct and ampular portion ; in the latter several long spermatophores were observed. Spermathecal pores open in front of the ventral bundles on segment X. The ventral bundles of segment X are represented by a long straight genital seta in each bundle. A large glandular appendage is associated with genital seta. Male pores, one-paired, open on segment XI, where ventral setae bundle is present. Vas deferens, long, having several turns in segment XI ; atrium with a prostate gland. Penis, conical located in a large penial sac. No chitinous penis theath.

Notes: Except a single specimen, the material has been lost by an accident. The present description is mainly based on the single specimen and is far from complete especially in the genital organs. But the present worm is evidently distinguished from *Tubifex* (*Peloscolex*) *nomurai*, reported from Lake Tazawa by Yamamoto and Okada (1940), by the possession of the genital setae in the former. On the other hand, the present worm seems to, more or less, resemble the European species, *P. ferox*, but the latter is provided with the chitinous penis theath and without genital setae. Other European species, *P. velutinus*, may be closely

related to the present worm, but the both can be distinguished each other by the difference of the features of the ventral setae. It seems to be highly probable that the present worm may represent a new species or subspecies.

20) *Limnodrilus socialis* Stephenson

L. gotoi (part), Hatai, 1899, Ann. zool. Japon. vol. 3, p. 5, pl. 2.
L. socialis, Stephenson, 1912, Trans. Roy. Soc. Edinb. vol. 48, p. 294, pl. 2 fig. 9, 10.
L. gotoi, Nomura, 1913, J. Coll. Tokyo vol. 35, p. 3, fig. 1-24.
L. socialis, Stephenson, 1917, Mem. Asiatic Soc. Bengal vol. 6, p. 93, pl. 4 fig. 6, 7.

Material: Specimens from the bottom muds of the pond at Inogashira-Park in Tokyo, Mar. 1937. Those from a pool in Sapporo, Sep. 1937, and from a ditch in Sapporo, April 1938. Several specimens, collected in April 1938, sent from Osaka.

Notes: The material is referable to *L. socialis* Stephenson (1912) and also to Nomura's *L. gotoi* (1913). Hatai's. *L. gotoi* is not a single species and has been divided by Nomura (1913) into *L. willeyi* Nomura and *L. gotoi* Hatai emend Nomura. But the latter had been already described by Stephenson (1912) as *L. socialis*.

21) *Limnodrilus willeyi* Nomura

L. gotoi (part), Hatai, 1899, Ann. zool. Japon, vol. 3, p. 5, pl. 2.
L. willeyi, Nomura, 1913, J. Coll. Soc. Tokyo vol. 35, p. 34, fig. 25 34.

Material: Specimens from Tokyo, collected in May 1937. Those from a pool at Sapporo, Sep. 1936. Those, obtained from the pond Imuta in Kagoshima Prefecture in April 1937.

Note: The species is known also from India together with *L. socialis*.

22) *Branchiura sowerbyi* Beddard

B. sowerbyi, Beddard, 1892, Q. J. M. Sci. (1892) p. 1, pl. 19; Michaelsen, 1900, Oligochaeta p. 40, 1909, Süssw.-fauna Deutschlands H. 13, p. 30; Stephenson, 1917, Mem. Asiatic Soc. Bengal vol. 6, p. 89, 1923, Oligochaeta in Fauna of British India p. 99, fig. 38, 39; Ude, 1929, Tierw. Deutschlands Lief. 9, T. 6, p. 74, fig. 82, 83.

Material: Specimens sent from Dr. S. Tanaka, which have been collected in Tokyo in April 1933. Many specimens, collected from bottom muds of Lake Biwa (10 meters deep) in Mar. 1938. Specimens from Koriyama, Mar. 1938. Those from a ditch in Hyogo Prefecture, Mar. 1938. Those, found in paddy fields at Teramoto village in Osaka Prefecture, April 1938, sent from Mr. Y. Masuda. Those from bottom muds of a pond of water reservior in water-works of Osaka, Mar. 1938. Those from Mimamitoyoshima village in Osaka Prefecture, Mar.

1938, sent from Mr. Y. Masuda. Those, collected at Muko village in Hyogo Prefecture, Mar. 1938. Those from Osaka, which have been collected by Mr. M. Kondo in April 1938. Those from Oita Prefecture (near Yufu-hotspring), sent from Mr. Nagano. Those from a ditch at Shiroshima-machi in Fukuoka Prefecture, sent from Mr. Nagano. Those, collected from a small brook in Unsen-Park, April 1939. Those from a paddy field at Nagasaki, April 1939. Those from a ditch at Fukuoka, April 1939. Those from Wimuta pond in Kagoshima Prefecture, Mar. 1939.

Notes: According to Stephenson (1923), the present species is quite variable in body size and in number of gills, and the variation seems to be due to difference of surroundings. In the writer's material, such variation was slso observed. The gills are about 50 pairs in specimens collected from the pond of water reservior in water-works of Osaka, 34–38 pairs in those from Wimuta pond, while specimens from Lake Biwa are provided with further smaller number of gills, only 5 pairs of short gills being found in a specimen . If such reduction of gills is caused by difference of surroundings, they might be disappeared in some condition.

On the other hand, the genus *Kawamuria* is represented by a single species, *K. japonica*, which has been reported from Lake Biwa (more than 260 ft. deep). According to Stephenson (1917, 1730), *Kawamuria* may be quite closely related to *Branchiura*, the former being considered as a direct ancestor of the latter. In fact, the diagnosis of the both oligochaetes seems to be hardly distinguishable except whether the gills are absent or present. Further, it seems to be noticeable that no specimen referable to *Kawamuria* has been again collected from Lake Biwa and any other localities, while many specimens of *Branchiura sowerbyi* have been collected by the writer from the same lake, on the contrary with the writer's expectation to obtain *Kawamuria japonica*. It seems, therefore, to be permissive to have a doubt that the specimens which have been referred to *Kawamuria* by Stephenson might be some variants of *Branchiura sowerbyi*, in which the gills completely disappeared in deeper habitats.

23) *Rhizodrilus limosus* (Hatai)

Vermiculus limosus, Hatai, 1898, Ann. zool. Japon. vol. 2, p. 103, fig. 5 ; Michaelsen, 1900, Oligochaeta p. 41.
Monopylephorus limosus, Nomura, 1915, J. Coll. Sci. Tokyo vol. 35 Art. 9, p. 2, fig. 1 30.

Material: Specimens sent from Tokyo, which have been collected in May 1933 by Dr. S. Tanaka. Those, collected at Inogashira-Park in Tokyo in May 1937. Many specimens, obtained from a ditch at Sapporo, May 1938.

Notes: Unlike *Limnodrilus* and *Tubifex*, the worm does not coil by reaction to stimulus. According to Stephenson (1930), the names *Vermiculus* and *Monopylephorus* are synonymous with *Rhizodrilus*.

24) *Aulodrilus japonicus* n. sp.

(Tex-fig. 12, Pl. VII, figs. 5–7)

Material : Two specimens, collected from muds of a small pond at Maruyama (Sapporo) by Mr. H. Aoki in Nov. 1937. Three indivudual, found in an aquarium in Jan. 1938, into which some muds from the pond of Maruyama had been transferred. Several specimens, collected by the writer in the same locality at Maruyama in June 1939.

Body, orange-yellowish in colour, 20–26 mm long and 0.3–0.4 mm wide in extended state. It is very contractile ; for example, one individual of which length reaches 25 mm in extended state may be contracted in length less than 10 mm. Number of segments, 40–85 exclusive of a number of undifferentiated hinder segments near a zone of proliferation of new segments. This zone is situated at some distance in front of the posterior end. Behind the zone, there is a narrow unsegmented terminal region as other species of the genus. The terminal region is highly vascularized and may often reach about 1mm in length in living condition. Prostomium short and conical Four setal bundles per segment, two dorsal and two ventral, beginning from segment II. But no seta is present in younger undiffentiated segments and the unsegmented terminal region mentioned above. The dorsal bundles consist of numerous (usually 8–11) setae per bundle, which are distinguished into crotchets (Fig. 12 d, s) and hair setae. The crotchets are 70–112 μ long, their distal end is bifurcate or pectinate, the proximal prong being stouter than the other. Nodulus situated distal to the middle of the setae. The hairs are 130–180 μ long, and have a bayonet curve. The ventral bundles (Fig. 12 v) consist of bifurcate crotchets only, the proximal prong being stouter and longer than the distal. They are 70–115 μ in length,

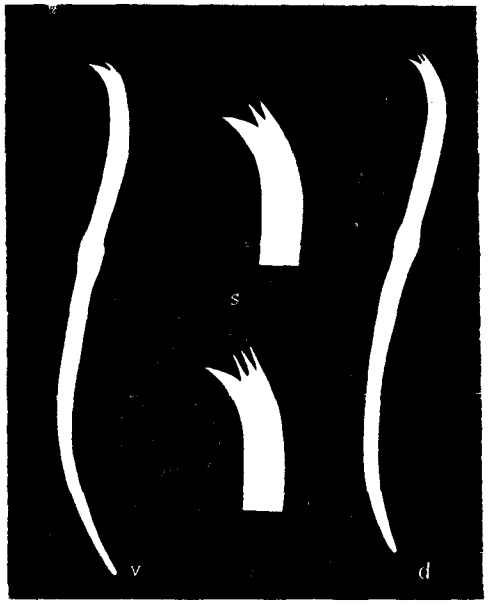


Fig. 12. Setae of *Aulodrilus japonicus* n. sp. v, ventral seta ; d, dorsal sigmoid seta ; both ca. ×700. s, distal portion of dorsal sigmoid setae, ca. ×2200.

and usually 6–12 in number per bundle, nodulus being located distal to the middle of the setae. Unlike all other species of the genus, the digestive tract suddenly dilutes from segment XI. It is entirely covered with chloragogue cells from segment X onward ; but a small number of the cells are found in segments VI–IX. Nephridia appearing from segment XI. Ventral vessel bifurcates at the level between the setal bundles on segments II and III ; the branches communicate with the anterior end of the dorsal vessel in the first segment. The dorsal vessel is ventral in position behind segment X ; it turns dorsal in segment X, and thereafter takes dorsal position in the region anterior to the segment. There are thick and contractile commissural vessels in one pair in each of segments VIII and IX[1] forming so-called hearts. Genital organs were not found except gonads, because of sexual immaturity of all specimens examined. The gonads are three pairs in number, located in segments VIII, IX and X. In specimens examined, the first and the second pairs (in VIII and IX) are about equal in size, and are very larger than the third (in X). It seems to be quite probable that the first and the second pairs may be testes, the third being ovaries, as well as all European species of the genus.

As in general in the genus, the worm lives in tubes formed by small foreing bodies such as sand particles and debris cemented togther with mucous secreted from glands of skin. The tube is about 1 mm in diameter and often over 15 mm in length.

Notes : The description is far from complete for the reproductive organs, but it is evdent that the present worm is referable to a new species of the aberrant tubificid genus *Aulodrilus*. So far as the writer is aware, this genus is represented by the following nine species, including one that was originally described by Piguet (1906) as a member of the Naididae.

Species	Distribution
1) *A. limnobius* Bretscher, 1899	Europe (Bretscher 1899, Kowalewski 1914, Ude 1929) ; Argentine (Marcus 1944)
2) *A. pluriseta* (Piguet), 1906	Europe (Piguet 1906 Černosvitov 1928, Ude 1929, Hrabě 1937)
3) *A. pigueti* Kowalewski, 1914	Europe (Kowalewski 1914, Hrabě 1937)
4) *A. remex* Stephenson, 1921	India (Stephenson 1921, 1923, Aiyer 1925, 1929)
5) *A. kashi* Mehra, 1922	India (Mehra 1922, Stephenson 1923, Mehra 1925)
6) *A. stephensoni* Mehra, 1922	India (Mehra 1922, Stephenson 1923, Mehra 1925)
7) *A. trivandranus* Aiyer, 1925	India (Aiyer 1925, Stephenson 1925) ; Sumatra (Michaelsen and Boldt 1932)
8) *A. pectinatus* Aiyer, 1928	India (Aiyer 1928)
9) *A. prothecatus* Chen, 1940	China (Chen 1940)

1) No species of which hearts are located in segment IX is described in the genus.

The present new species may be easily distinguished from *A. remex*, *A. kashi*, *A. pigueti* and *A. prothecatus* by the absence of oar-shaped or spathulate setae, and from *A. limnobius* by the possession of hair setae in the dorsal bundles. It may also be distinguished from the remaining species by the possession of pectinate setae, except *A. pectinatus*. But the present species differs from the latter in several characters, as clear from the following list :

	A. pectinatus Aiyer	*A. japonicus* n. sp.
Length of body	5.0–6.5 mm	20–26 mm
Number of segments	32–43	40–85
First nephridia in	VIII	XI
Digestive tract dilute from	VII	XI
Hearts in	VI	VIII, IX
Gonads in	VI, VII	VIII, IX, X

The Enchytraeidae

25) *Pachydrilus nipponicus* Yamaguchi

P. nipponicus, Yamaguchi, 1937, J. Fac. Sci. Hokkaido Imp. Univ. 6 ser. vol. 5, p. 137 fig. 1, pl. 6.

Material: Specimens, collected at the shore of Besshakudomari of Akkeshi Bay, by Dr. K. Hanaoka in Aug. 1932. Specimens from Akkeshi Bay, which have been collected by Dr. S. Makino in 1933. Many specimens, collected by the writer at the shore of Kojima in Akkeshi Bay in Jul. and Aug. 1933. Specimens, obtained from Oshoro, which have been collected by Dr. T. Uchida and Mr. M. Iwasa in May 1932 and by Dr. S. Okuda in Sep. 1933. Those, collected from the shore of Muroran and Shibetsu near Muroran in 1934 and 1935, by Dr. S. Okuda.

Notes : The original description of the writer's previous paper is based on the material from Kojima and Besshakudomari. Lately, the writer found an important misprint in it as to the position of the male funnels. They are located in segment XI, instead of segment X in the original description.

26) *Mesenchytraeus* (?) sp.

Material : Several specimens, collected in a sphagnum near a spring at Hamatonbetsu (Hokkaido) in Aug. 1935. No fully mature specimen.

Body, 20–30 mm long and 0.5–0.8 mm wide, and yellowish white in colour. Segments, 60–67 or more in number. Clitellum could not be observed. Head pore opening near the tip of the prostomium. No dorsal pore. Setae, singly pointed sigmoids without nodulus ; those in a same bundle, about equal in size. Ventral setae bundles consist of 4–7 setae per bundle ; lateral bundles, 3–5 setae per bundle. Male pores, one paired on segment XII in the ventral setal lines. The ventral setae on segment XII, absent in specimens provided with the male pores.

One pair of female pores, located in intersegmental furrow XII/XIII (found only in sectioned preparations). Spermathecal pores, one-paired in intersegmental furrow IV/V. Pharyngeal plate well developed. Pharyngeal bulbs present. Oesophagus merging gradually into intestine. Dorsal vessel arising in segment XVII. Nephridia begin from segment VIII, but segment XII destitutes of the organ. Testes, one paired attached to the posterior face of septum X/XI. Male funnels, also one-paired attached to the anterior face of septum XI/XII, their feature are different from those as usual in the Enchytraeidae, rather showing a lumbriculid type. Sperm ducts, short and almost straight. No so-called penial bulb was observed. Female funnels, one-paired, attached to the anterior face of septum XII/XIII. One pair of sperm sacs, present in segment XII, as elongation of septum XI/XII ; male cells in early stages in development were found in the sperm sacs. Further, a pair of similar elongations are present to originate from septum XII/XIII (ovisacs ?). Spermathecae were not so well developed, they are cylindrical. No communication with the digestive tract was observed.

Notes : The present worm seems to be possibly referable to the genus *Mesenchytraeus* by the presence of the sperm sacs. But it is still doubtful on account of the absence of penial bulb and male funnels of enchytraeid-type in the present worm. If such features are also observable in fully mature specimens, the worm may be probable to represent a new genus.

On the other hand, the presence of male funnels of lumbriculid-type in the enchytraeid seems to be indicated some closer relationships between the Enchytraeidae and the Lumbriculidae.

The Lumriculidae

27) *Lumbriculus japonicus* Yamaguchi

L. japonicus, Yamaguchi. 1936, J. Fac. Sci. Hokkaido Imp. Univ. 6 ser. vol. 5, p. 73, fig. 1-3, 4c, 5, pl. 4 fig. 1-4.

Material : A great number of specimens, collected from muds of a pool near a spring at Maruyama (Sapporo) in May 1935 and April to May in 1936, Specimens, found in moss on shores of small brooks running into a tundra pond at Yamagaru (near Hamatonbetsu, Hokkaido) in Aug. 1935. Specimens from a brook at Maruyama, April 1938.

Notes : The original description is based on the material. The present species differs from *L. variegatus* which is well known in Europe, the former is characterized by the possession of two pairs of testes and male funnels. In addition, the male pores are located usually on segment XI in the former, while on segment VIII in the latter.

28) *Lumbriculus multiatriatus* Yamaguchi

L. multiatriatus, Yamaguchi, 1937, J. Fac. Sci. Hokkaido Imp. Univ. 6 ser. vol. 6, p. 2,

fig. 1-2, pl. 1 fig. 1-6.

Material: Several specimens including three sexually mature ones, collected in sphagnum on margins of a tundra pond at Sarufutsu (Hokkaido) in Aug. 1935. Four mature and three immature specimens, collected under sphagnum in a marsh at Konuma near Toyohara in Saghalien by Mr. H. Horie in June 1936. Seven mature specimens and several immature ones, collected by the writer from a margin of a brook in a swamp at Toyohara in Aug. 1936. Several specimens inclusive of five mature ones, obtained from a marsh on the margin of Lake Chibesan (Saghalien) in Aug. 1936.

Notes: As in the previous report (1937), the species is a remarkable form provided with three or four pairs of testes, male funnels and atria as well as *Lamprodrilus satyriscus*. But it is undoubtedly referable to the genus *Lumbriculus* and seems to be closely related to *L. japonicus*.

29) *Lumbriculus mukoensis* n. sp.

Material: 27 specimens, collected from sphagnum in a small marsh at Muko in Hyogo Prefecture in April 1938.

Body, 28–45 mm long and 0.4–0.7 mm wide in preserved specimens. As in other species of the genus, coloration of the body is brownish dark red in most parts and dark greenish in the anterior part of the body. Prostomium zygolobous and rounded-cone-like, the length being larger than the basal width. Clitellum well developed in segments XIV–XVIII, though it occupying segments X–XIX. Four setal bundles per segment ; each seta sigmoid and doubly pronged, the distal prong being very smaller than the proximal. Nodulus located about one-third the setal length from the distal end. Male pores, one-paired, located on the ventral line and just behind the ventral setae. Examining 27 specimens, the male pores are found on segment XII in 25 specimens, on segment XI in one individual and on segment IX in another one. Then the common position of the male pores is on segment XII. Female pores, in one pair, located on the ventral setae line and in intersegmental furrow XIII/XIV in specimens which have the male pores on segment XII. Spermathecal pores commonly in two pairs, each pair is situated between the dorsal setae line and the lateral line on segments XIV and XV. Chloragogue cells begin in segment VII. The first pair of nephridia is found in segment VII. Chromophile cells are observed in anterior segments to segment VII. The last pair of naked transverse vessel is found in one of segments XX–XXII. The blind transverse vessels which are covered with chloragogue cells, begin to appear in segment XVII or XVIII. Both the anterior and the posterior spermsac are paired. Testes and male funnels are in pairs usually in segments XI and XII ; ovaries and female funnels each in one pair, usually in segment XIII ; spermathecae in two pairs in segments XIV and XV. Each spermatheca consists of a elongated

bulged ampulla and a distinct duct.

Notes: The present new species is easily distinguishable from other species of the genus by the position of the testes, the male funnels and the male pores, the dorso-lateral position of the spermathecal pores and the smaller size of the body.

30) *Lumbriculus variegatus* (Müller)

L. variegatus, Michaelsen, 1900, Oligochaeta p. 58; Mrázek, 1907, Zool. Jahrb. Anat. Bd. 23, p. 381; Ude, 1929, Tierw. Deutschlands. Lief. 9, Teil. 6, p. 100, fig. 133.

Material: One mature specimen and several immature ones, collected from muds of a pond in Aomori in May 1937. All ill-preserved.

Notes: Form the following features observed on the single mature specimen, the material seems to be referable to the present species. Testes, male funnels, atria and male pores, each in one pair, in segment VIII. Nephridia begin from segment XI. If this identification is to be right, it is the new record of the species in Japan.

31) *Hrabea ogumai* Yamaguchi

H. ogumai, Yamaguchi, 1936, J. Fac. Sci. Hokkaido Imp. Univ 6. ser. vol. 5, p. 90, fig. 14, 15, pl. 5 fig. 4 7.

Material: One mature indivudual, obtained from drinking water pumped out from a deep well in Sapporo, collected by Dr. K. Oguma in March 1932. Three individuals including one mature, collected by Mr. H. Hara from subterranean water of other deep well in Sapporo in April 1933.

Notes: From the material, the original description of the speices has been made. The species seems to be a pure subterranean-water form. The worms swim actively by lateral undulating movement; their body is colourless and transparent except the alimentary canal and blood vessels.

32) *Rhynchelmis orientalis* Yamaguchi

R. orientalis, Yamaguchi, J. Fac. Sci. Hokkaido Imp. Univ. 6 ser. vol. 5, p. 86, fig. 11 13, pl. 4 fig. 5, 6, pl. 5 fig. 2, 3.

Material: Several specimens, collected by Mr. H. Ishizuka from muds of a brook at Maruyama (Sapporo) in Jul. 1935. Many specimens, collected by the writer from muds of a pool derived from a spring at Maruyama in May and Oct. 1935. Specimens, obtained from a brook at Nopporo (not so far from Sapporo), collected by Mr. H. Horie in May 1935.

Notes: The writer's original description is based on specimens obtained from the pool at Maruyama. In the specimens, it was found that some individuals have a regenerated head or tail. The regenerated parts are easily distinguishable

by their pinkish colour instead of purple colour in old segments.

33) *Styloscolex japonicus* Yamaguchi

S. japonicus, Yamaguchi, 1937, Ann. zool. Japon. vol. 16, p. 167, fig. 1–3, pl. 10.

Material: Many specimens, collected from muds of a pool derived from a spring at Maruyama (Sapporo) in May 1935, in April 1936 and in April 1937, Specimens, sent from Mr. H. Horie, which have been collected in muds of a brook of Nopporo (not so far from Sapporo) in May 1935.

Notes: From the material, the writer's original description has been made. In the present species, the testes are in segment VIII and the ovaries are in segment X, an intervening segment being present between the testicular and the ovarian segment. Such character is not found in other genera of the Lumbriculidae.

The Haplotaxidae

34) *Haplotaxis gordioides* (Hartmann)

H. gordioides, Michaelsen, 1900, Oligochaeta p. 108.
Phreoryctes gordioides, Michaelsen, 1925, Zool. Jahrb. System. Bd. 51, p. 272, fig. c.
Haplotaxis gordioides, Yamaguchi, 1937, Ann. zool. Japon. vol. 15, p. 68, fig. 1, pl. 4.

Material: A single specimen (fully mature), found in subterranean water pumped out from a deep well at Maruyama (Sapporo) in April, which has been collected by Mr. Y. Sasaki. An immature specimen, collected from a pool derived from a spring at Maruyama in June 1936.

Notes: The present species is known as one of inhabitants of underground water, and seems to be a holoarctic form. The first record from Japan has been made by the writer on the single specimen sent from Mr. Y. Sasaki.

35) *Haplotaxis gastrochaetus* n. sp.

(Text-figs. 13, 14; Pl. VII, fig. 8)

Material: Two immature individuals, collected by Dr. S. Makino from a deep well in Sapporo in Sep. 1936 and in Jul, 1937. A single immature specimen, found by Dr. K. Aoki in drinking water pumped out from a deep well in Sep. 1936. One incompletely mature specimen collected by Mr. H. Hara from subterranean water obtained from a deep well in Aug. 1938.

Specimens, 50–72 mm long and about 0.6 mm thick in the middle part of the body. Segments 93–119 in number. Clitellum could not be observed. The body walls, creamy white in colour and rather opaque. Cuticle of the skin, about 10 μ thick. Prostomium rounded-cone-like; the length is larger than the basal width, and about three times as long as the peristomium. Intersegmental furrows are not evident. No secondary annulation. Unlike other species of the

genus, no dorsal setae is present in the whole of the body. Ventral setae begin in segment II ; two per segment, each is singly implanted. All the setae are very slightly curved sigmoid and singly pointed at the distal end, and have no nodulus. Size of setae differ in different segments: they increase gradually in length and thickness from segment II, on which they are about 200μ long and 10μ wide, toward the

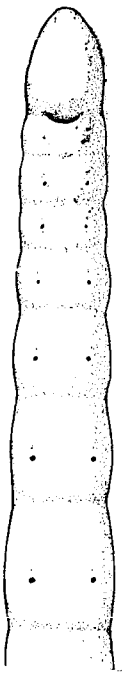


Fig. 13. *Haplotaxis gastrochaetus* n. sp. Ventral view of anterior part of body, ca. ×32.

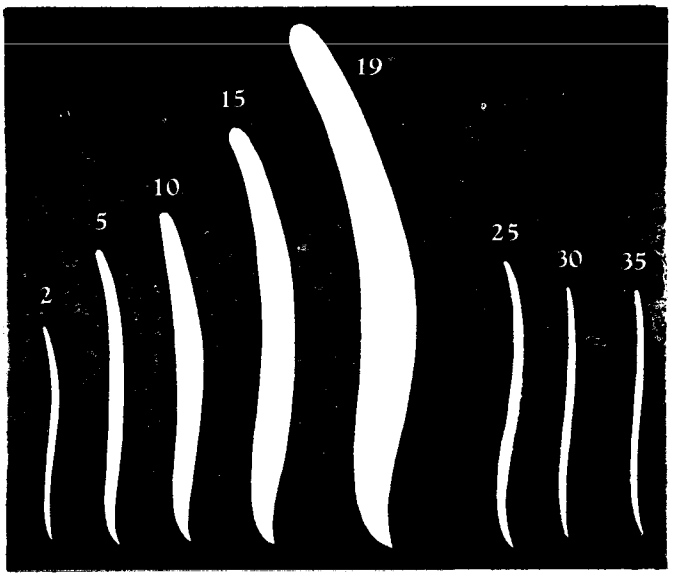


Fig. 14. Setae of *Haplotaxis gastrochaetus* n. sp., ca. ×160. Numerals denote the segment numbers.

posterior. The maximum size appears about in segment XX, where the setae show about 500 μ long and about 45 μ wide (Fig. 14). From the segment, the setae rather quickly decrease in size toward the posterior. Though the setae of the worm are so large, they usually not project from the body wall, so that the setae are hardly visible in rough observation. Nephridial pores are paired, located in front of the ventral setae. In the posterior part of each of segments II to about XX, there is a glandular zone containing some large epithelial unicellar glands. Transverse commissural vessel with many turns are present from segment II at least to segment XXII. Vestigial gizzard present. Testes, two pairs in segments X and XI ; ovaries, one pair in segment XII. Two pairs of spermathecae in certain stages of development, are present in segments VIII ond IX, their external pores situated on the lateral line and intersegmental furrows VII/VIII and

VIII/IX.

Notes: The present worms seem to belong to inhabitants of subterranean water. They show a nematod-like apearance in living state; this feature is probably due to the possession of whitish colour, thick body wall and hardly visible segmentation. Though the description of the worms is far from complete in genital organs, they undoubtedly represent a new species referable to the genus *Haplotaxis* from the following features; 1) The presence of the singly implanted setae, 2) the distribution of the gonads and spermathecae, 3) the possession of the vestigial gizzard, 4) the absence of the dorsal setae in the whole segments, and 5) the presence of large stout setae in a number of anterior segments.

In the morphological characters of the species, the lack of nodulus in the setae is an unique character in the Haplotaxidae which recalls the Enchytraeidae. On the other hand, the occurrence of the large stout setae seems to be also noticeable fact.

36) *Heterochaetella glandularis* n, g. et n. sp.

(Text-figs. 15–19; Pl. VII, figs. 9, 10)

Material: Several specimens, collected from sandy bottom of Mino-o river at Mino-o Park (Osaka Prefecture) in April 1933. All incompletely mature.

Body, light yellowish to brownish gray in colour in living state and whitish in preserved specimens; body size about 85–137 mm long and about 1 mm wide in preserved specimens. Prostomium short and rounded, rather subspherical in shape, and is bordered from a peristomium by a transverse groove. Body segments vary in number from 106 to 176 or more. Each segment is biannulate, forming an anterior minor and the posterior major annulus, except the anterior segments I–IV which are distitute of a minor annulus. Each major annulus can be further distinguishable into three secondary annulus except the anterior segments I–II, in which the major annulus is divided into two secondary annuli. Those secondary annuli may be evidently seen in preserved specimens. Each secondary annulus is provided usually with a light brown transverse zone, so that the secondary annuli can be also recognizable by the coloured zone even in living

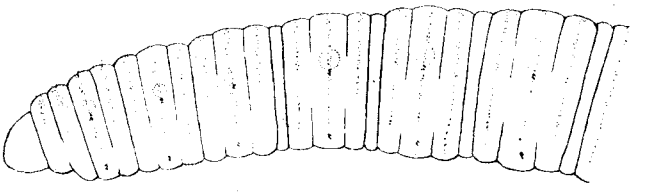


Fig. 15. *Heterochaetella glandularis* n. g. et n. sp.
Side view of anterior part of body, ca. ×10.

individuals. No clitellum was observed. There are eight setae per segment, in four couples, two dorsal and two ventral, beginning from segment II. Each couple consists of two sigmoid setae (Fig. 16), different in length and form : — one bears a nodulus located at a position about one-third to one-foutrh the setal length from the distal end. The seta is bifurcate in its distal end, the distal prong being very smaller than the proximal. Another seta of each couple is more or less shorter and thinner than the former, and is destitute of a nodulus. The distal end of the seta is singly pointed. The both setae are very closely implanted on the body wall, so that the setae distances *ab* and *cd* are negligible. Setae distance *aa* is about one-fifth to one-seventh the circumference of the body ; *dd* is about two to three times *aa* ; *aa* is usually larger than *bl* (*l* representing the lateral line) ; *bl* is always larger than *lc*. The body wall is thin and transparent, several internal organs being observable through it in living individuals. There are many gland cells in the epidermis ; they are found in each secondary annulus, forming the glandular zone which is identical with the coloured zone already mentioned ; its colour seems to be due to the secret within the gland cells. Such gland cells are entirely absent in the minor annulus. In the glandular zone, another kind of unicellular glands are found ; they are club-shaped, and their most parts projecting into the body cavity (Fig. 17). There are a pair of certain subspherical bodies in every segment except the first. They are located at the position just superior to the dorsal setae couples, and project from the epidermis into the body cavity (Fig. 18). Those bodies contain numerous spherical cells

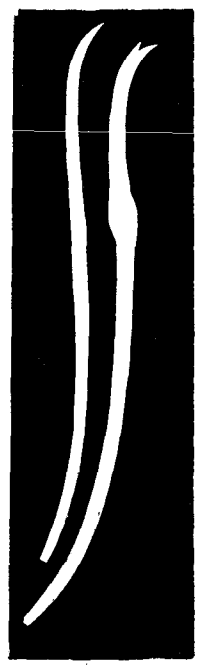


Fig. 16. Setae of a couple of *Heterochaetella glandularis* n. g. et n. sp., ca. ×430.

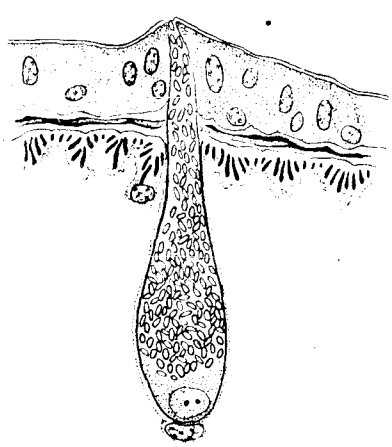


Fig. 17. *Heterochaetella glandularis* n. g. et n. sp. Club-shaped unicellular gland projected from epidermis into body cavity, ca. ×480.

of different size. The alimentary canal is rather simple ; the pharynx lies in segments II–III. No gizzard is present. Differing from the Oligochaeta in general, the alimentary canal is destitute of chloragogue cells in its entire course. Chromophile cells are well developed, attached to the anterior face of septa IV/V, V/VI, VI/VII and VII/VIII, forming septal glands. Excretory organs, mega-nephridial ; they begin to appear from segment IX (rarely VIII), but lacking them in segments XI–XIV. Nephridiopores are located on the first of the secondary annuli, and on the ventarl setal line. The cerebral ganglion is roughly circular in outline in the dorsal aspect ; its posterior boader being incised to form two posterior lobes. The vascular system consists of a dorsal vessel, a ventral vessel, paird comissural vessels and a intestinal plexus. The dorsal vessel exists in the whole of the body, and is covered by large chloragogue cells except in few segments of the anterior end. The ventral vessel extends through the entire length of the body. It is bifid beneath the pharynx ; the branches communicating with the anterior end of the dorsal vessel in front of the cerebral ganglion. The commissural vessels are long, showing many turns and somewhat in regular course (Fig. 19). Each pair of the vessels lies in each segment beginning from segment II. They connect both with the dorsal and the ventral vessel just in front of the septa. The intestinal plexus is present in the hindermost part of the body, where the dorsal vessel attaches to the wall of the alimentary canal. Testes, in two paires in segments X and XI, attached to the posterior surface of septa IX/X and X/XI. Two pairs of ovaries,

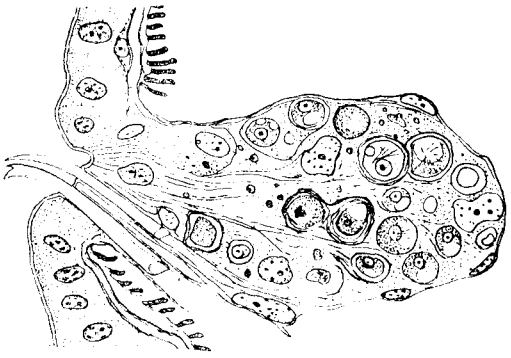


Fig. 18. *Heterochaetella glandularis* n. g. et n. sp. So-called subspherical body associated dorsal setae couple, ca. ×480.

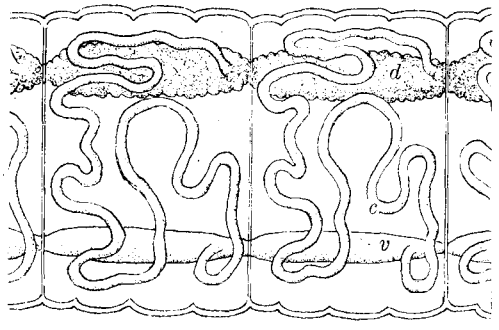


Fig. 19. *Hetrochaetella glandularis* n. g. et n. sp. Semi-diagrammatic figure showing dorsal (d); ventral (v) and commissural (c) vessels.

in segments XII and XIII. Anlages of spermathecae were found in pair in intersegmental furrows V/VI, VI/VII, VII/VIII and VIII/IX, and on the lateral line. Anlages (probably) of gonoduccal funnels were also found in pair on septa X/XI, XI/XII, XII/XIII and XIII/XIV.

Notes : As is clear from the description, the worms agree with the diagnosis of the Haplotaxidae. On the other hand, the worms retain the remarkable chracters :- The presence of doubly pronged setae and the possession of large club-shaped unicellular glands projecting into the coelomic cavity and the so-called subspherical bodies associated with the dorsal setae couples. Those characters, so far as the writer is aware, have never been reported in any haplotaxid. From the facts the worms seem to be referable to a new haplotaxid species representing the new genus *Heterochaetella*.

The diagnosis of the new genus is as the following : Setae in four couples per segment. One seta of each couple, bifurcated sigmoid with a nodulus, and longer than the other which is singly pointed sigmoid without nodulus. Testes, two pairs in segments X and XI ; ovaries two pairs in XII and XIII. Spermathecae, four pairs in VI, VII, VIII, IX. No gizzard.

The new genus differs from other genera of the family in the features of the setae, and is further distinguished from *Haplotaxis* by the absence of the gizzard and from *Pelodrilus* by the number of spermathecae. In addition, the presence of doubly pronged setae may be the first record in the Haplotaxidae. This character seems to give an evidence of close relationship between the Haplotaxidae and several families having bifid crotchets.

The Megascolecidae

37) *Pontodrilus matsushimensis* Iizuka

P. matsushimensis, Iizuka, 1898, Ann. zool. Japon. vol. 2, p. 21, pl. 2.

Material : Specimens, sent by Dr. S. Hozawa, which have been collected on the shore of the island, Miyakojima in Miyagi Prefecture, in 1933. Those from Misaki, collected by Dr. S. Okuda in April 1933. Specimens, collected by Dr. T. Uchida from the shore of Misaki in May 1933. Many specimens, sent by Dr. S. Okuda, collected on the shore of Akashi in Hyogo Prefecture in Jul. 1936, on the shore of Ranshima near Ogura in Mar. 1938, and on the shore of the West- Park in Fukuoka in April 1938.

Note : As is clear from those localities, the present species seems to be widely distributed on the shore of the main island of Japan.

The Criodrilidae

38) *Criodrilus bathybates* Stephenson

C. bathybates, Stephenson, 1917, Mem. Asiatic Soc. Bengal vol. 6, p. 96, pl. 4 fig. 8.

C. miyashitai, Nagase et Nomura, 1937, Sci. Rep. Tohoku Imp. Univ. 4 ser. vol. 11, p. 361-402, fig. 1-43.

Material: Specimens, sent by Mr. S. Miki, collected from the bottom of Lake Biwa at some point near Azuchi in April 1937. Those, collected by Mr. T. Kashioka in sandy muds of a brook of Muko village in Hyogo Prefecture in April 1937. Several specimens, collected by the writer from bottom muds of Lake Biwa at some point (10 meters deep) near Otsu in Mar. 1938. Many specimens, sent by Mr. Y. Masuda, which have been collected in paddy fields of Minamitoyoshima village in Osaka Prefecture, in April 1938. Several specimens, collected by the writer from paddy fields of Muko village in April 1938.

Notes: Under the genus *Criodrilus*, there have been described two species from Japan. The first is *C. bathybates* Stephenson (1917) based on four specimens which were collected from the bottom of Lake Biwa at 180 feet depth. The second is *C. miyashitai* Nagase et Nomura (1937), of which specimens obtained from shallow ditches at Komori-machi in Kyoto Prefecture and channels near Tsuruoka in Yamagata prefecture.

From the writer's observations, the present material obtained from several localities including Lake Biwa is undoubtedly identical with *C. miyashitai* which seems to be the same species named as *C. bathybates* by Stephenson because of the following reasons. 1) Specimens identical with *C. miyashitai* were collected from Lake Biwa near Otsu at 10 m deep and near Azushi at 3 m deep. 2) In the latter place, several cocoons were found, which agree with in features of those of *C. bathybates*, preserved in the Limnological Laboratory of Kyoto University in Otsu. 3) In the writer's material, the ventral setae on segment XIII are replaced by genital setae in mature specimens, while ordinary setae were found on the ventral of segment XIII in immature ones. According to Stephenson, no ventral setae was found on segment XIII. But we must remember that his material consists of incomplete four specimens and they had not attained to complete sexual maturity.

The Lumbricidae

39) *Bimastus parvus* (Eisen) ?

(Text-fig. 20)

Material: Two specimens, found in waterly sphagnum at Chitose (Hokkaido), collected by Dr. M. Kuwabara and Mr. H. Horie.

Body, about 40 mm long and about 2 mm wide in the two specimens. Number of segments, 107 and 112. Brownish pink in colour. Clitellum, occupying nine segments from XXII to XXXI. Prostomium epilobous. Eight setae per segment, two setae closely implanted. Dorsal pores begin from intersegmental furrow V/VI. Male pore on segment XV ; female pores on XIV. Testes and male

funnels, two paired, in segment X and XI ; ovaries and oviduccal funnels, one paired in segment XIII. Two pairs of spermsacs originating from septa X/XI and XI/XII, in segment XI and XII respectively. Contractlie transverse vessels (hearts) in segments VIII, IX and X. Calciferous glands occupied in segments XI, XII and the anterior region of segment XIII. Intestinal gizzard lies mainly in segment XVI and XVII. Spermathecae could not be detected in the material.

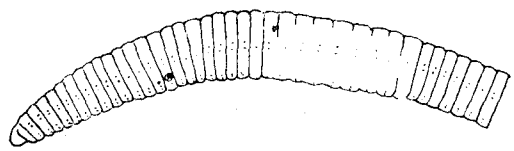


Fig. 20. *Bimastus parvus* (Eisen) ? ; side view of anterior part of body, ca. ×4.

Notes : The description is far from complete because the two specimens have been ill-preserved. But it seems to be referable to the genus *Bimastus* by several important characteristics, and to be probably identical with *B. parvus* (Eisen).

III) Remarks on the classification and phylogeny

A) On the arrangement of the gonads in the genus *Styloscolex*

Styloscolex, established by Michaelsen (1901) is a remarkable lumbriculid genus which differs from all other genera of the Lumbriculidae in the presence of an intervening segment between the testicular and the ovarian segment. So far as the writer is aware, this genus is represented by the following five species.

Species	Distribution	Position of testes	Position of ovaries
1) *S. baicalensis* Michaelsen	Baikal-region	VIII	X
2) *S. tetrathecus* Burow	Baikal-region, Manchuria	VIII	X
3) *S. kolmakovi* Burow	Baikal-region	VIII	X
4) *S. swarczewski* Burow	Baikal-region	VII	IX
5) *S. japonicus* Yamaguchi	Hokkaido	VIII	X

In Megadrili, there is almost always one or two intervening segments between the testes- and the ovarian segments. But such condition is not found

in Microdrili except *Alluroides* (Alluroididae), *Branchiobdella* (Branchiobdellidae) and *Styloscolex* (Lumbriculidae). In *Branchiobdella*, there is one testicullar and one ovarian segment, the both being separated by an intervening segment ; while *Stephanodrilus* and all other genera of the Branchiobdellidae have two testicular, one ovarian segment and no intervening segment between them. According to Michaelsen (1928), the latter condition is probably a original type and the former may be derived from the latter by the disappearance of the second pair of testes. The Michaelsen's opinion will be generally accepted and if we adopt the terms showing the arrangement of the gonads of Megadrili, the condition of *Stephanodrilus* can be named as "holandric", while that of *Branchiobdella* may be designated as "proandric".

The arrangement of gonads of *Styloscolex* seems to be also explained as the result of disappearance of one pair of gonads. If the reduction took place in testes, the condition of *Styloscolex* must be "proandric" ; and if it was the disappearance of ovaries, it must be "metagynous". The metagynous reduction is most common in Megadrili, whereas the case has not been recorded in Microdrili. It is, therefore, very probable that the condition of *Styloscolex* is to be proandric.

B) Revision on the genus *Dorydrilus*

Piguet (1913) described *Dorydrilus michaelseni* as an lumbriculid representing a new genus *Dorydrilus*. So far as the writer is aware, the following three species have been reported under the name *Dorydrilus*.

1) *D. michaelseni* Piguet 1913.
2) *D. (Guestphalinus) wiardi* Michaelsen 1933.
3) *D. (Piguetea) mirabilis* Hrabě 1936.

According to Piguet (1913) and Michaelsen (1933), the male pores are situated on the testicular segment in the genus, while Hrabě stated that the male pores lie on the ovarian segment. The difference in the position of the male pores seems to be one of important characters separating Lumbriculina and Tubificina. It seems, therefore, to be nessessary a revision on the genus.

Michaelsen (1933), describing the species *wiardi*, proposed the following diagnosis of the genus and subgenera.

"Gen. *Dorydrilus* ; 2 paar Hoden und 1 paar Ovarien. 2 paar männliche Ausführungsgange ektal verschmolzen und 1 paar Atrien in hinteren Hodensegment ausmündend. Keine Samenleiterschleifen in die Sämensäke hineinragend. 1 paar Samentaschen im hinteren Hodensegment dicht vor den Atrien.

Subgen. *Dorydrilus* : Kopflappen einfach gerundt. Gonaden im 9, 10 und 11 Segment. Atrien durch einen einstülpbaren Penis ausmündend.

Subgen. *Guestphalinus* : Kopflappen in einen tentakel-artigen Rüssel ausgezogen. Gonaden im 8, 9 und 10 Segment. Atrien durch einen nicht einstülpbaren warzenförmigen Porophore ausmündend."

On the other hand, Hrabě (1936) reported two species of the genus, one was identified with *D. michaelseni* Piguet and the other was referred to a new species representing the new subgenus *Piguetea*. According to him, the diagnosis of the genus and subgenera is as follows.

Diagnosis of the genus *Dorydrilus* : —

"Einfachspitzige S-förmige Borsten je 2 in 4 Bündeln in jedem Segment ausser dem ersten. 1 paar Hoden in IX. Segm. an dem Dissepiment IX/X. 1 paar ovale Atrien im X. Segm. In jedes Atrien mündet nur ein Samenleiter, welcher von vorderen, an dem Dissepiment X/XI angehefted. Samentaschen hinter dem atrial Segment order demselben und dann vor den Atrien."

Diagnosis of the subgenus *Dorydrilus* : —

"Die Samentachen münden vor den Atrien gemeinsam mit diesem im X. Segm."

Diagnosis of the subgenus *Piguetea* : —

"Die Samentaschen öffnen sich am XI. Segment, die Atrien am X. Segment, nach aussen."

As is clear from comparison with the diagnosis given by Michaelsen and Hrabě, Michaelsen's genus *Dorydrilus* and Hrabě.s genus *Dorydrilus* seem to be homonymous. The former is undoubtedly referable to the Lumbriculidae, while it is quite doubtful to refer the latter to the family, which seems to be rather possible to be eligible for Tubificina or a new family situated between the Tubificidae and the Lumbriculidae. Next, it remains a question whether Hrabe's *michaelseni* and Piguet's *michaelseni* may be the same or the different species. In other words, it seems to be uncertain either Piguet's original description is to be right or not. This problem seems to be difficult to dissolve because we do not, at present, reexamine the Piguet's specimens from which his original description was made.

As already stated, the genus Michaelsen's *Dorydrilus* and the genus Hrabě's *Dorydrilus* seem to be homonymous. Then it may be nessessary to give other generic name for the latter. It seems, therefore, to be adopted to name the latter to *Piguetea* which was given by Hrabě as the subgeneric name for species *mirabilis*.

C) On the arrangement of the genital organs and its phylogenetic significance

There is a great diversity in the arrangement of the genital organs of the Oligochaeta, such as gonads, male and female ducts, spermathecae and clitella, as showing in Fig. 21.

But the differences of the arrangement of those organs are not so irregular that they are usually adopted as important taxonomic characters with phylogenetic

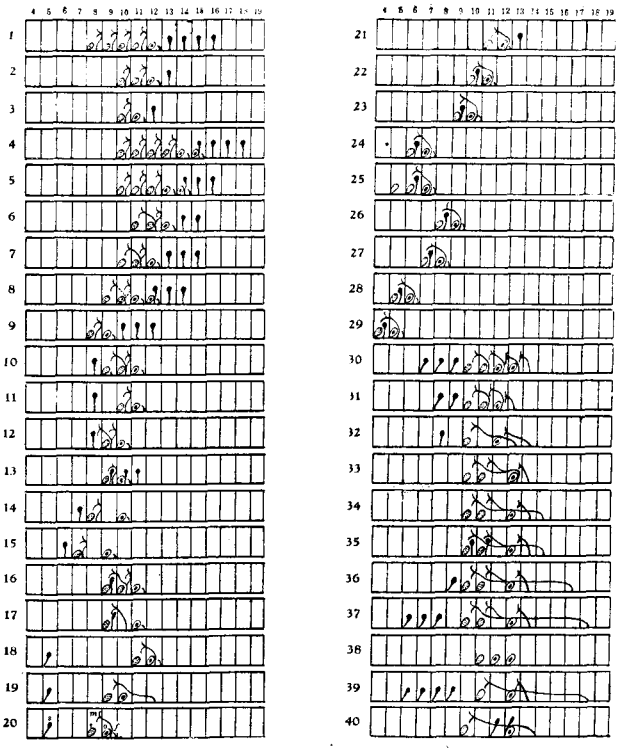


Fig. 21 Diagrammatic figure showing divergent arrangement of genital organs of the Oligochaeta ; f, female duct ; m, male funnel ; o, ovary ; s, spermatheca ; t, testis.

1, *Lamprodrilus satyriscus* f. *typica* Mich. (1905) ; 2, *L. isoporus* f. *variabilis* Svetlov (1936) ; 3, *Teleuscolex grubei* Mich. (1905), 4, 5, *Lumbriculus multiatriatus* Yamaguchi (1936) ; 6, *L. mukoensis* n. sp. ; 7, *L. iaponicus* Yamaguchi (1936) ; 8, *L. inconstans* Smith (1896, 1906) ; 9, *L. variegatus* Müll. (Mrázek, 1906) ; 10, *Rhynchelmis limosella* Hoffmstr. (Michaelsen, 1921) ; 11, *Rh. elrodi* Smith et Dickey (1918) ; 12, *Premnodrilus palstris* Smith (1900) ; 13, *Kincaidiana hexatheca* Altman (1936) ; 14, *Styloscolex iaponicus* Yamaguchi (1937) ; 15, *S. swarczewski* Burow (1931) ; 16, *Stephanodrilus sapporensis* Pierantoni (Yamaguchi, 1934) ; 17, *Branchiodella orientalis* Yamaguchi (1934) ; 18, *Pachydrilus nipponicus* Yamaguchi (1937) ; 19, *Litorea krumbachi* Cejka (Stephenson, 1930 ; the position of the ovaries is illustrated by the writer's supposition.) ; 20, *Buchholzia appendiculata* (Stephenson, 1930) ; 21, *Phreodrilus lacustris* Benham (1904) ; 22, *Tubifex hattai* Nomura (1926) ; 23, *Aulodrilus stephensoni* Mehra (1922) ;

meanings. In the successive pages, there will be found some reviews and discussions about the arrangement of those organs.

a) The gonads

In the Oligochaeta, the testes are usually one or two pairs in number, except *Lamprodrilus satyriscus* Michaelsen and *Lumbriculus multiatriatus* Yamaguchi, the both species having three or four pairs, though one or two pairs are present in other species of the both genera. In Megadrili, such as the Megascolecidae, the Eudrilidae and the Lumbricidae, there are two or one pair of testes, most commonly two-pairs located in segments X and XI. The common case is, in general, regarded as the original condition, from which one-paired condition may be derived by reduction of the anterior or the posterior pair. Then the terms, holandric, proandric and metandric are used.

Michaelsen (1921) reported a similar reduction found in *Rhynchelmis* (Lumbriculidae), and subsequently he (1928) discussed on the reduction of the genital organs in the Lumbriculidae and Branchiobdellidae, and concluded that the genital organs of *Lamprodrilus*-type (with two pairs of testes and two pairs of male pores) are more primitive than those of *Teleuscolex*-type (with one pair of testes and male pores). On the other hand, Stephenson (1930) stated "The existing species of *Lamprodrilus* have two, three or four pairs of testes and male pores ; it seems not improbable that original number was two pairs (as in majority of species of the genus), and higher numbers (in *L. satyriscus*) represent a secondary multiplication." The writer accords with his opinion that the condition having two pairs of testes may be primitive. But the writer has a different opinion about the condition of *L. satyriscus* stated previously in 1937, that higher numbers seem to be ancestral because equipotency of segment in ancestors might be higher than in descendants, as well as that in embryos is higher than in adults. It appears to the writer, therefore, three or four paired testes are an ancestral condition. Two-paired seems to have been derived from the ancestral condition and one-paired further from the two-paired.

24, *A. kashi* Mehra (1922) ; 25, *A. limnobius* Bretscher (Stephenson, 1930) ; 26, *Ilyodrilus bedoti* (Stephenson 1930) ; 27, *Pristina longiseta* Ehrenberg (Piguet, 1906) ; 28, *Nais obtusa* Gervais (Piguet, 1906) ; 29, *Stephensonia travandrana* Aiyer (Stephenson, 1930) ; 30, *Haplotaxis gordioides* Hartmann (Yamaguchi, 1937) ; 31, *H. heterogyne* Benham (1904) ; 32, *Alluroides* (Stephenson, 1930) ; 33, *Criodrilus miyashitai* Nagase et Nomura (1937) ; 34, C. *lacuum* (Stephenson, 1530) ; 35, *Eisenia foetida* (Sav.) (Michaelsen, 1900) ; 36, *Microscolex phosphoreus* (Duj.) (Yamaguchi, 1935) ; 37, *Pheretima hilgendorfi* Mich. (Yamaguchi, 1931) ; 38, *Enantiodrilus borelli* Congn. (Stephenson, 1930) ; 39, *Pheretima* (*Metapheretima*) *welzeli* Ude (1932) ; 40, *Microchaetus modestus* Michaelsen (1900).

Ovaries of the Oligochaeta are usually one or two pairs in number, and the state of one pair is very common. So far as the writer is aware, there is no more than two pairs, except abnormal specimens. According to Woodward(1892, 1893), two to seven pairs of ovaries were observed in abnormal specimens of *Lumbricus* and *Allolobophora*. On the other hand, Mrázek (1907) reported two or three pairs of ovaries in some specimens of *Lumbriculus variegatus* (Müll.) (normally with one pair). Similar abnormal specimens were reported by the writer (1936, 1937) also in *L. japonicus* Yamaguchi and *L. multiatriatus* Yamaguchi. In the latter, some abnormal specimens are destitute of whole male genital organs and provided with three or four pairs of ovaries. Those condition having many paires of ovaries seems to be atavismus.

In Megadrili, there is, in general, two pairs (or one pair) of testes in segment X and XI (or in X, or in XI), and one pair (or very rarely two pairs) of ovaries in segment XIII (or in XII and XIII in two paired case). On the other hand, *Haplotaxis gordioides* Hartmann (Haplotaxidae) has two pairs of testes in segments X and XI and two pairs of ovaries in segments XII and XIII. From the agreement in the arrangement of the gonads of the Haplotaxidae (such as *Haplotaxis gordioides*) and those of Megadrili, Michaelsen and others consider that the Haplotaxidae may be an ancestor of Megadrili, the original arrangement of the gonads being regarded as the condition having testes in segments X and XI, and ovaries in XII and XIII.

In the Haplotaxidae, *Heterochaetella glandularis* n. g. et n. sp. has also two pairs of testes in segments X and XI, and two pairs of ovaries in segments XII and XIII, as well as *Haplotaxis gordioides*, while *H. heterogyne* and *H. gastrochaetus* n. sp. are provided with two pairs of testes in segments X and XI, and one pair of ovaries in segment XII. The condition of *Heterochaetella glandularis* may be expressed together with *Haplotaxis gordioides*, as holandric and hologynous, and that of *H. heterogyne* and *H. gastrochaetus* may be designate to holandric and progynous. It seems to be quite interesting to comparing with the common occurrence of metagynous condition in Megadrili.

From those views stated in preceding pages, it appears to the writer that the ancestor of the Oligochaeta might have been provided with the following primitive condition in distribution of the gonads.

1) There are many pairs of gonads in successive segments, several anterior pairs being testes and the rest being ovaries.
2) There is no intervening segment between the testicular and the ovarian segments.

Then it may be considered that various arrangements of the gonads in the existing species have been derived from the primitive condition by different reductions in testes and ovaries.

As is already stated, the gonads of Megadrili are commonly definite in

position, such as the testes in segments X and XI and ovaries in segment XIII, while those of Microdrili differ in distribution according to families. In the Naididae, there is one pair of testes and ovaries commonly in segments V and VI respectively. The Tubificidae and the Enchytraeidae are also have one pair of testes and one pair of ovaries, but their positions are different from the Naididae ; the gonads are usually situated in segments X and XI in the Tubificidae, and commonly located in segments XI and XII in the Enchytraeidae. The Lumbriculidae, however, show a great diversity in arrangement of the gonads, so that it seems to be difficult to find some rule on the arrangements of the gonads in this family as a whole. But such a difficulty seems to be possible to be avoided by comparing with the position of the gonads for a standard septum which separates testicular and ovarian segments and has been named as "demarcating septum" in the previous paper (1936). Though the term was firstly used in comparison of the positions of the gonads in species of *Lumbriculus* ; subsequently the writer (1937) adopted the term in the Lumbriculidae, discussing the positions of the gonads of the family.

As is already reported by the writer (1936), variation of number and position of the gonads were observed in specimens of *Lumbriculus japonicus* Yamaguchi. There exist most commonly testes in segments X and XI, and ovaries in segment XII ; frequently testes in IX and X, ovaries in XI ; rarely testes in VIII and IX, ovaries in X. Therefore, the demarcating septum lies in commonest in intersegment

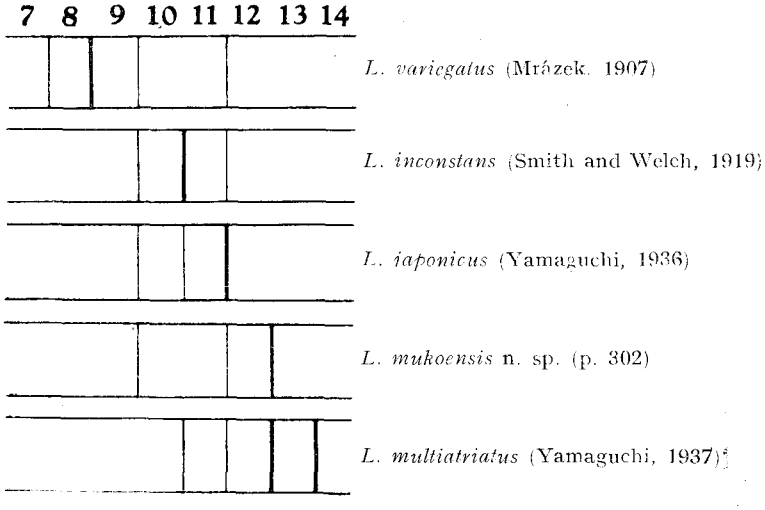


Fig. 22. Diagrammatic figure showing position of demarcating septum in the genus *Lumbriculus*. Numerals designate the segments. Demarcating septum shown by a intersegmental line ; a heavy intersegmental line indicating the commonest position.

XI/XII, frequently in X/XI, rarely in IX/X, indicating the position of the gonads. Similar variations occur also in all other species of the genus, but the commonest position of the demarcating septum in each species definites, as shown in Fig. 22.

As is clear from the figure, the position of the demarcating septum in the genus *Lumbriculus* is not useful as a generic character together with the position of the male pores, but it is useful as a specific character. In other genera of the Lumbriculidae, however, the position of the male pores and the demarcating septum are valued as to afford distinction of genera. The position of the demarcating septum in genera of the family will be found in Table 1. From the table, it is evident that the demarcating septum is commonly found in intersegment X/XI in the family, though it situates from intersegment VIII/IX to XIII/XIV.

Table 1. Localization of the demarcating septum in genera of the Lumbriculidae.

Genera \ Intersegment	7/8	8/9	9/10	10/11	11/12	12/13	13/14
Lumbriculus Grube		+		+	+	+	+
Lamprodrilus Michaelsen				+	+		
Agriodrilus Michaelsen					+		
Teleuscolex Michaelsen				+			
Bythonomus Grube				+			
Trichodrilus Clap.				+			
Stylodrilus Clap.				+			
Hrabea Yamaguchi				+			
Rhyhchelmis Hoffmstr.				+			
Eclipidrilus Eisen				+			
Premnodrilus Smith			+				
Mesoporodrilus Smith				+			
Sturoa Eisen				+			
Kincaidiana Altman			+				
Tatriella Hrabě				+			
Styloscolex Michaelsen	+?	+?					

In the Tubificidae nearly all members have the testes in segment X and the ovaries in XI; the demarcating septum is, therefore, located in intersegment X/XI. But the whole genital organs are shifted several segments toward the anterior in some members. The demarcating septum is situated in intersegment IX/X in *Aulodrilus stephensoni* and *A. japonicus* n. sp. and in VI/VII in *A. pectinatus* Aiyer and other species of the genus. On the other hand, *Ilyodrilus bedoti* has testes in VIII and ovaries in IX, the demarcating septum being situated in VIII/IX.

The Naididae have one pair of testes and one pair of ovaries ; the position of the gonads differs in genera. The demarcating septum is situated in IV/V in *Stephensonia*, in VII/VIII in *Pristina* and *Naidium*, and in V/VI in many genera. Then it is located between the range from intersegment IV/V to VII/VIII.

In the Enchytraeidae one pair of testes and one pair of ovaries lie in segments XI and XII respectively (the demarcating septum in intersegment XI/XII), except *Litorea* and *Buchhozia appendiculata*, the demarcating septum being located in IX/X in the former and in VIII/IX in the latter.

The Phreodrilidae have one pair of testes and one pair of ovaries in XI and XII respectively. The position of the demarcating septum is, therefore, in intersegment XI/XII.

In the Acanthobdellidae, there is testes in segment X and ovaries in XI, according to Michaelsen (1928). The demarcating septum is, therefore, situated in X/XI.

In the Haplotaxidae, there are two pairs of testes in segments X and XI, and one or two pairs of ovaries in segments XII or, in XII and XIII ; then the demarcating septum is located in intersegment XI/XII in all members.

As is well known, the general arrangement of the gonads of Megadrili resembles that of the Haplotaxidae. But the former differs from the latter by the possession of one or two intervening segments between the testicular and the ovarian segments showing difficulty to decide the demarcating septum, except *Enantiodrilus borelli* which is provided with one pair of testes in segment XI and two pairs of ovaries in segments XII and XIII, showing no intervening segment between the testicular and the ovarian segments. In the species, the position of the demarcating septum is evidently in intersegment XI/XII. If the arrangements of the gonads in Megadrili may have been derived from the original condition (testes in X, XI ; ovaries in XII, XIII, holandric and hologynous), it seems to be reasonable to consider that the demarcating septum is generally present in intersegment XI/XII in Megadrili.

In the Branchiobdellidae, there are two pairs of testes in trunk-segment V and VI, one pair of ovaries in trunk-segment VII, except the genus *Branchiobdella*. But those position may designate that the testes are situated in segment IX and X, the ovaries in segment XI, when we reckon the four head segments. Therefore, the demarcating septum is situated in intersegment X/XI in the family. But in *Branchiobdella*, one pair of testes in trunk-segment V (=segment IX) and one pair of ovaries in trunk-segment VII (=segment XI) are present, one intervening segment being located between the testicular and ovarian segment. This condition is, as already stated, to be proandric ; and then the demarcating septum is located in intersegment X/XI as well as in other genera.

The Alluroididae are represented by a single genus *Alluroides* which has one pair of testes in segment X and one pair of ovaries in segment XIII. There is two intervening segments between the testicular and the ovarian segment. This family is generally recognized to be closely related to the Haplotaxidae. Then it appears to the writer that the condition of *Alluroides* might be derived from a haplotaxid condition having testes in segments X and XI, ovaries in segments XII and XIII, If so, the demarcating septum of the genus is to be located in

intersegment XI/XII, and *Alluroides*-condition is to be explained as proandric and metagynous.

In the Aeolosomatidae, the sexual organs have not often been seen, and the accounts about them are discordant. But Stephenson (1930) stated that there may be a diffuse production of sexual cells, and no localized gonads.

Recently Marcus (1944) reported sexual worms of *Aeolosoma headleyi* and *A. kashyapi*. According to him, the reproductive system of *A. headleyi* is primitive in the fertility of germ cells in nearly all segments and evaculation of the spermatozoa through the nephridia of segments III–XV. Both male and female cells are originated from the cells in the budding zone, which also gives rise to mesodermal cells. From those accounts of the sexual specimens of *Aeolosoma*, it seems to the writer that no gonad in definite place is differentiated in the family.

In the Syngenodrilidae and the Moniligastridae, the testes are enclosed each in a special testis sac which is suspended on the septa. According to Michaelsen, the testis sac belongs to the segment just anterior to the sac. But Stephenson (1930) considered the testis sac representing a segment. If accorded with Michaelsen's opinion,the testes are situated in segments X and XI, the ovaries lie in segment XIII, in the Syngenodrilidae. And then the supposed position of the demarcating septum is in interesegment XI/XII as well as other Megadrili, this condition being regarded also as holandric and metagynous. In the genus *Desmogaster* (Moniligastridae), the distribution of the gonads is the same to the Syngenodrilidae ; but other moniligastrid genera differ from the genus in arrangement of gonads. *Euplogaster* has testes in segment IX and ovaries in segment XII, while *Drawida* and *Moniligaster* have testes in segment IX and ovaries in segment XI. It appears to the writer that those conditions might be derived from an original condition (testes in IX, X and ovaries in XI, XII); the demarcating septum being in intersegment X/XI. If so, *Euplogaster*-condition is to be explained as proandric and metagynous, and the condition of *Drawida* and *Moniligaster* becomes proandric and progynous.

On the other hand, Stephenson (1930) supposed an ancestral condition in arrangement of genital organs in the Moniligastridae (including Syngenodrilidae) and other terrestrial families. In the ancestral condition, there may be present three pairs of testes in segments X,XI and XII, and two pairs of ovaries in segments XIII and XIV. If his opinion is admitted, the supposed position of the demarcating septum falls on intersegment XII/XIII. But the writer does not agree with his opinion, because it seems to be difficult to explain the arrangements of the gonads in many other families.

As is clear from the discussion stated in preceding pages, the demarcating septum shows different localization in families as shown in Table 2. It is evident from the table, the septum seems to be confined to situate in intersegment XI/XII in the Haplotaxidae and Megadrili (except Moniligastridae), but the position

of the septum is not stable in Microdrili, especially in the Lumbriculidae which show a great diversity in its position.

Table 2. Localization of the demarcating septum in families of the Oligochaeta.

Intersegment / Families	4/5	5/6	6/7	7/8	8/9	9/10	10/11	11/12	12/13	13/14	14/15
Aeolosomatidae											
Lumbriculidae				+?	+	+	+	+	+	+	
Branchiobdellidae							+				
Acanthobdellidae							+				
Tubificidae			+		+	+	+				
Phreodrilidae								+			
Naididae	+	+		+	+						
Enchytraeidae					+	+		+			
Haplotaxidae								+			
Alluroididae								+			
Syngenodrilidae								+?			
Moniligastridae							+?	+?			
Acanthodrilidae								+			
Megascolecidae								+			
Eudrilidae								+			
Glossoscolecidae								+			
Sparganophilidae								+			
Microchaetidae								+			
Hormogastridae								+			
Criodrilidae								+			
Lumbricidae								+			

The position of the demarcating septum indicates also the position of the gonads as a whole. In fact, the number and position of the gonads differ in genera of the Lumbriculidae and even in species of the genus *Lumbriculus*. In addition to the fact, a species of the genus such as *L. variegatus*, *L. japonicus*, *L. multiatriatus* has remarkable variability in number and position of gonads. The variation found in individuals in such a species has some correspondence with the diversity occurring in the genus and in the family. Those facts seem to give a fresh light on an ancestral condition and direction of evolution.

It appears to the writer that *Lumbriculus multiatriatus* seems to persist some ancestral natures, together with *Lamprodrilus satyriscus*, such as polytesticulate condition and variability of the gonads in number and position.

b) The male and female ducts

The male ducts. The funnels of the male ducts are as a rule corresponding to the testes in number. When two pairs of testes are present, there are two pairs of male ducts and the funnels. The two male ducts on the left or the right side generally unite at some distance from the funnels, and open outside from a male pore, except some members such as the Haplotaxidae and *Hoplochaetella anomala*. In those members, two male ducts of the same side do

not unite but separately open outside. In the condition, testes are equal to male pores in number. Similar condition is also found in the polytesticulate forms, *Lamprodrilus satyriscus* and *Lumbriculus multiatriatus*, which have three or four pairs of testes and male pores (Fig. 21–1, 4, 5). It appears to the writer that the both conditions, united and separated, of the male ducts of the same side seem to be a phylogenetic significance. The separated condition of the male ducts may be considered to be primitive, because the male ducts of each side are separated in the immature worm of *Didymogaster sylavaticus*, according to Miss Brennen (1900).

On the other hand, the male ducts of the left and the right sides open generally on each side as paired pores. But the two ducts open outside by a common apperture on the ventral median line in all members of the Branchiodbellidae, many genera of the Eudrilidae, *Rhizodrilus* of the Tubificidae and *Mesoporodrilus* of the Lumbriculidae. The paired condition seems to be a primitive character.

The position of the male pores shows a great diversity according to families. There are one pair of male pores commonly on segment XVIII or XVII, rarely on XIX in Megascolecidae, as a rule on XV in the Lumbricidae, generally in XII in the Tubificidae. Then the position of the male pores is generally valued as a taxonomic character distinguishing families. But it is not valid to the Lumbriculidae as a familic character because the position of the male pores differs in genera of the family and even in species of the genus *Lumbriculus*.

On the other hand, the relative position between the male funnel and the male pore is also valued as a noticeable character. Many varieties of this character are shown in Fig. 23.

Michaelsen (1929) distinguished such varieties into three conditions, plesioporic, prosoporic and opisthoporic, and he divided the Oligochaeta into three suborders, Oligochacta plesiopora, Oligochacta prosopora and Oligochaeta opisthopora. But it appears to the writer that such varieties are rather distinguishable into two conditions, prosoporic and opisthoporic, because the plesioporic condition is not distinctly separated from the opisthoporic one. The definition of the writer's prosoporic and opisthoporic conditions is as follows : —

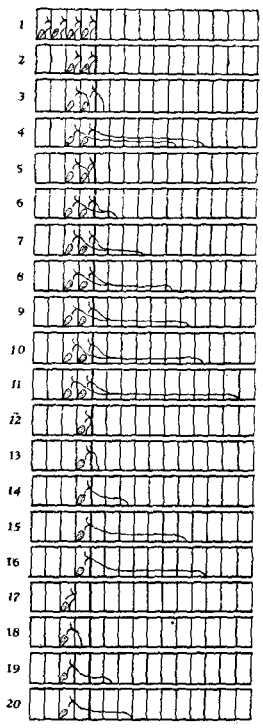
a) Prosoporic condition

All male pores are situated anterior to the demarcating septum. In other word, male pores are present on testes-segment or the last testes-segment, except the genus *Branchiobdella* (Fig. 23–1, 2, 5, 12, 17, 18).

b) Opisthoporic condition

Male pores are situated posterior to the demarcating septum, rarely are found anterior to the septum in addition to the posterior male pores. In other word, male ducts open outside on a segment or segments posterior to the testes-segment bearing their funnels (Fig. 23–3, 4, 6–16, 19, 20).

In the both conditions, each is divided into several types mainly based on



1 *Lamprodrilus satyriscus* Mich., *Lumbriculus multiatriatus* Yamaguchi (Lumbriculidae)
2 *Lamprodrilus isoporus* f. *variabilis* (Lumbriculidae)
3 *Haplotaxis gordioides* (Hartmann) (Haplotaxidae)
4 *Hoplochaetella anomala* Stephenson (Acanthodrilidae)
5 *Rhynchelmis limosella* Hoffm., *Lumbriculus japonicus* Yamaguchi (Lumbriculidae)
6 *Criodrilus miyashitai* Nagase et Nomura (Criodrilidae)
7 *Eisenia foetida* (Sav.) (Lumbricidae)
8 *Microscolex phosphoreus* (Duj.) (Acanthodrilidae)
9 *Pheretima hilgendorfi* Mich. (Megascolecidae)
10 *Pheretima megascolecioides* (Goto et Hatai) (Megascolecidae)
11 *Rhinodrilus garbei* Mich. (Glossoscolecidae)
12 *Teleuscolex, Lumbriculus variegatus* Müll (Lumbriculidae)
13 Naididae, Tubificidae, Phreodrilidae and Enchytraeidae in general
14 *Litorea krumbachi* Cejka (Enchytaeidae)
15 *Pheretima* (*Metapheretima*) (Megascolecidae)
16 *Glossoscolex, Andioscolex* (Glossoscolecidae)
17 *Styloscolex* (Lumbriculidae)
18 *Branchiobdella* (Branchiobdellidae)
19 *Alluroides* (Alluroididae)
20 *Microchaetus modestus* Michaelsen (Microchaetidae)

Fig. 23. Diagrammatic figure showing varieties in relative position between testes and passage of male ducts in Oligochaeta. Demarcating septa shown by heavy intersegmental lines which are arranged in a vertical line.

the difference in number and position of testes. The prosoporic condition is divided into the following 5 types:

1) Lamprodrilus-type (Fig. 24 A, B).

Testes two-paired, or more, male pores situated on each testes-segment. This type is found in the genus *Lamprodrilus* and *Lumbriculus multiatriatus* Yamaguchi.

2) Trichodrilus-type (Fig. 24 C).

Testes two-paired, male ducts of each side unite. Male pores situated on the last testes-segment. This type is commonly found in Lumbriculina such as *Trichodrilus, Bythonomus, Stylodrilus, Stephanodrilus, Rhynchelmis limosella* Hoffm. and *Lumbriculus japonicus* Yamaguchi.

3) Teleuscolex-type (Fig. 24 D).

Testes in one pair. Male pores located on the testes segment. The type is found in

the Lumbriculidae such as *Teleuscolex, Hrabea, Kincaidiana, Rhynchelmis elrodi* Smith et Dickey and *Lumbriculus variegatus* Müll.

4) Styloscolex-type (Fig. 24 E).

Testes one-paired and male pores located on the testes-segment, as well as the Teleuscolex-type. But the both differ in relative position between the testes and the demarcating septum. The male genital organs of *Styloscolex* belong to this type. (See p. 312.).

5) Branchiobdella-type (Fig. 24 F).

Testes one-pair. Male pore situated on the segment next to the testicular segment. This type is only found in *Branchiobdella*.

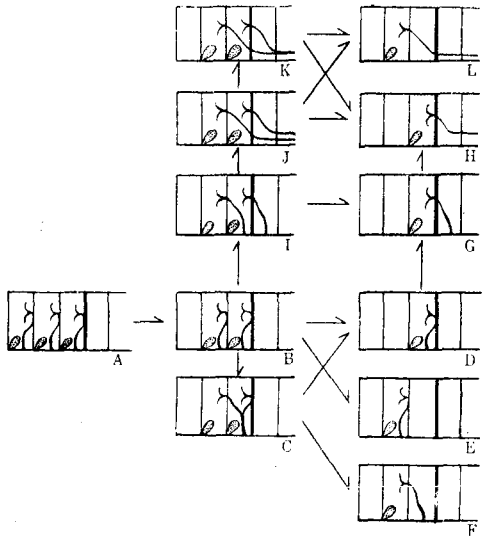


Fig. 24. Diagrammatic figure showing scala of complication of testes, male funnels and passage of male ducts. Demarcating septum shown by a heavy intersegmental line.

A and B, Lamprodrilus type; C, Trichodrilus type; D, Teleuscolex type; E, Styloscolex type; F, Branchiobdella type; G, Tubifex type; H, Metapheretima type; I, Haplotaxis type; J, Hoplochaetella type; K, Pheretima type; L, Kerria type.

In the opisthoporic condition, the following 6 types may be included.

1) Haplotaxis-type (Fig. 24 I.)

Testes two-paired; male ducts of each side do not unite; male pores are found on two segments, one located just anterior to the demarcating septum and the other situated just posterior to the septum. This type is found in *Haplotaxis*.

2) Hoplochaetella-type (Fig. 24 J).

Testes two-paired (holandric). Male pores lie on two segments which are situated at some distance posterior to the supposed demarcating septum. This type is found in *Hoplochaetella* and other acanthodrilids.

3) Pheretima-type (Fig. 24 K).

Testes two-paired (holandric). Male ducts of each side unite. Male pores situated at some distance posterior to the supposed demarcating septum. This type is found in *Pheretima* and many genera of Megadrili.

4) Tubifex-type (Fig. 24 G).

Testes one-paired. Male pores situated on the ovarian segment just behind the demarcating septum. This type is generally found in the Tubificidae, the Phreodrilidae, the Naididae and the Enchytraeidae.

5) Metapheretima-type (Fig. 24 H).

Testes one-paired (metandric). Male pores situated at some distance posterior to the supposed demarcating septum. This type is found in *Metapheretima, Andioscolex, Glossoscolex, Litorea.*

6) Kerria-type (Fig. 24 L).

Testes one-paired (proandric). Male pores situated at some distance posterior to the supposed demarcating septum. This type is found in some of Megadrili such as *Kerria, Andiodrilus, Microchaetus modestus* Mich. *Alluroides* (Microdrili) seems to belong also to this type.

It seems to be quite interesting that those varieties of the arrangement of the male genital organs may have some important phylogenetic significance. According to Stephenson (1930), the condition of the Lumbriculidae (prosoporic) may be more primitive than others. And he considered that the family may be the most primitive. But Hrabě (1936) did not agree with the Stephenson's opinion, and stated that the condition of the Tubificidae (Tubifex-type) may be more primitive than the prosoporic. And according to him, the direction of evolution may be from Tubificidae to Lumbriculidae, and the genus *Dorydrilus*[1] might be appeared as a transmitting form between the both families. Though the presence of the closer relationship between the both families seems to be probable, the writer does not agree with Hrabě about the direction of evolution, and rather supports Stephenson's opinion from the following reasons.

By the contributions of Vejodovsky (1884), Gatenby (1916) and Mehra (1924, 1925), it has been cleared that the male ducts (at least the funnels and the large portion continued them) are originated from mesodermal cells on the septa. On the other hand, the epithelium inside of the atrium is ectodermal origin according to Vejodovsky (1884). But Gatenby (1916) and Mehra (1924, 1925) recognized it as mesodermal origin. Lately Hrabě (1936) concluded that the epithelium inside of the atrium originates from the epidermis based on invagination, and that the prostatic cells are also ectodermal origin. It seems, therefore, to be not improbable that the male duct is composed of a coelomoduct and a invagination of the

1) As already stated in p. 312, it seems to be a doubtful genus.

epidermis. And then the position of the male pore seems to be determined by the position of the epidermal invagination. It seems to be considered that such invagination occurs on the testes-segment in the Lumbriculidae, on the ovarian segment (next to the testes-segment) in the Tubificidae, and on a hinder segment widely apart from the testes-segment in general in Megadrili. In those codnitions, that of the Lumbriculidae seems to be more primitive than others.

Subsequently, it is also interesting that the relation between the varieties in the arrangement of the male genital organs. According to Michaelsen (1921), the condition of *Rhynchelmis elrodi* (Teleuscolex-type) has been derived from that of *R. limosella* (Trichodrilus-type) by the reduction of the anterior pair of the testes and the male duct. Further, he (1928) stated that the condition of *R. limosella* has been probably derived from that of *Lamprodrilus* (Lamprodrilus-type), and that the condition of *Branchiobdella* (Branchiobdella-type) has been derived from that of *R. limosella* by the reduction of the posterior pair of testes and male ducts. This Michaelsen's reduction theory seems to be available to explain several types found in the Oligochaeta.

In the genus *Lumbriculus*, there are three types, Trichodrilus-type in *L. japonicus*, Teleuscolex-type in *L. variegatus* and Lamprodrilus-type in *L. multiatriatus*. The type of *L. japonicus* may be explained to have been derived from the type of *L. multiatriatus*. The type of *L. variegatus* may be explained to be reduced from the type of *L. japonicus* or directly from the type of *L. multiatriatus*.

On the other hand, it seems to be difficult to suppose the origin of Styloscolex-type, because it is not clear that the reduction took place in testes or ovaries. But this type seems to the writer to be derived from Lamprodrilus-type by the reduction of the posterior pair of testes and male ducts, as already stated in p. 312.

It seems to be doubtless that Metapheretima-type may be reduced from Pheretima-type by the disappearance of the anterior pair of testes and male ducts. But the former may also be derived from Tubifex-type, because the male genital organs of *Litorea* (Enchytraeidae) are Metapheretima-type. Then the Metapheretima-type seems to be due to convergence.

On the other hand, Pheretima-type and Hoplochaetella-type may have been derived from Haplotaxis-type.

Finally, the origin of Haplotaxis-type and Tubifex-type seems to be most important. For the problem, the writer is of the following opinion. Haplotaxis-type may have been derived from *Lamprodrilus*-type, while *Tubifex*-type may evolved from Teleuscolex-type, as parallelism, because it seems to be more primitive that male ducts open on the testes-segment with their funnels as already stated. The writer's opinion is diagrammatically shown in Fig. 24 ; the scala of the arrangement of the male genital organs in the figure will be possible

to suppose the direction of evolution.

The female ducts. The female ducts are as same as ovaries in number. The both, the left and the right sides of the female ducts open outside, as a rule, on each side in independent pores, except some members.

In some of the Megascolecidae, they open outside by a common pore in the ventral median line. Such unpaired condition seems to be not primitive for the paired condition.

The female pores are usually situated on the hinder end of the ovarian segments in general in Microdrili, while they are commonly situated on the segments next to the ovarian segments in Megadrili. But some members, such as *Alluroides* and *Platydrilus agnes* have the female pores on the segment posterior to the ovarian segments, two intervening segments being present between the ovarian segments and the segment having female pores. In those conditions, the first condition found in Microdrili seems to be most primitive.

The relative position of the male and female pores. In Microdrili, the male pores are situated anterior to the female pores (prosoandric), except *Litorea* (Enchytraeidae). But the male pores are located posterior to the female pores (opisthoandric) in Megadrili with a few exceptions. The both conditions are due to the difference of distances, one from the testes-segment to the male pore, and the other from ovarian segment to the female pore.

If it is the most primitive condition in which the gonads and gonoduccal openings are present in the same segment as already stated, the prosoandric is to be primitive condition because the testes-segments are always located in front of the ovarian segments. In Megadrili, *Eiseniella tetraedra* and some others are exceptionally prosoandric ; it appears to the writer that this fact may be regarded to persist an ancestral character in them.

c) The spermathecae

Spermathecae are generally paired, and their openings are also generally paired. But unpaired median openings are found in all members of the Branchiobdellidae, and several of the Lumbriculidae and others.

The number and position of the spermathecal pores shows a great diversity in the Oligochaeta, and is generally used for taxonomic purpose. There are one pair of the pores in intersegmental furrow IV/V in the Enchytraeidae, generally on segment X in the Tubificidae, and on segment XII in the Phreodrilidae. In the Haplotaxidae, two to three pairs are found in intersegmental furrows IV/V to VIII/IX. VI/VII to VIII/IX or VII/VIII to VIII/IX. In the Megascolecidae, the Acanthodrilidae and the Sparganophilidae, there are one to seven pairs which are situated anterior to the testes-segments, while they are present posterior to the testes-segments, frequently situated at a large distance behind the testes-segments in the Eudrilidae and the Microchaetidae. In the Hormogastridae and the Lumbricidae, they are commonly found in the testes-segments. But, in the

Lumbriculidae, they are found anterior to or posterior to the testes-segments, or in the testes-segments. It appears to the writer that such diversity found in the Lumbriculidae seems to be considered to be an ancestral character.

d) The clitella and their relative position to female pores and to spermathecal pores

The position of the clitella differs according to families. The clitellum occupies the region of the gonad-segments in general in Microdrili, while it develops on segments posterior to the region of the gonad-segments in Megadrili.

The female pores are situated in the clitellar region in Microdrili and most of Megadrili. But they are located in more anterior segments for the clitellum in Lumbricina. The former condition seems to be primitive in comparison with the latter, because physiological relation between the female pores and the clitellum may be simple in the former. The relative position between the clitellum and spermathecal pores shows many varieties which may be classified into the following three conditions :

1) Plesiothecal condition. Spermathecal pores lie in the clitellar region. This condition is found in general in Microdrili, and some of Megadrili.

2) Prosothecal condition. Spermathecal pores situated anterior to the clitellar region. This condition is common in Megadrili, and found in some of Microdrili such the Enchytraeidae and the Haplotaxidae.

3) Opisthothecal condition. Spermathecal pores situated posterior to the clitellar region. This condition is present only in the Eudrilidae.

In those three conditions, the plesiothecal one seems to be most primitive, because it may be the simplest among them in physiological relation between the spermathecal pores and the clitellum.

D) Revision on the classification and phylogeny of the Oligochaeta

In classifying the order Oligochaeta, some taxonomic categories between the order and families have been given by several investigators, such as Benham (1890), Beddard (1895, 1901) and Michaelsen (1921, 1928, 1929, 1930).

"Microdrili" and "Megadrili" were first used by Benham (1890), and subsequently Beddard (1901) adopted the terms in his system of the classification. At present, the terms are also frequently used in convenience of grouping together families. According to Stephenson (1930), Microdrili include the Aeolosomatidae, the Naididae, the Tubificidae, the Phreodrilidae, the Enchytraeidae, the Lumbriculidae, the Branchiobdellidae, the Haplotaxidae and the Alluroididae, while Megadrili comprise the Moniligastridae, the Megascolecidae, the Eudrilidae, the Glossoscolecidae and the Lumbricidae. On the other hand, Michaelsen (1921) proposed to divide the Oligochaeta into two suborders and to establish a category,

"Familien-reihe", superior to families. His system of the classification (1928) is shown in Table 3. Subsequently he (1929) abandoned the names "Archioligochaeta" and "Neoligochaeta" and emended his previous system, proposing the

Table 3. Classification of the Oligochaeta, given by Michaelsen (1928).

Ordnung	Unterordnung	Familien-reihe	Familien
Oligochaeta	Archioligochaeta	Naidina	Aeolosomatidae
			Naididae
		Enchytraeina	Enchytraeidae
		Tubificina	Tubificidae
			Phreodrilidae
	Neoligochaeta	Lumbriculina	Lumbriculidae
			Branchiobdellidae
			Acanthobdellidae
		Phreoryctina	Phreoryctidae
			Alluroididae
			Syngenodrilidae
			Moniligastridae
		Lumbricina	Glossoscolecidae
			Sparganophilidae
			Microchaetidae
			Hormogastridae
			Criodrilidae
			Lumbricidae
		Megascolecina	Acanthodrilidae
			Acanthodrilinae
			Octochaetinae
			Diplocardiinae
			Ocnerodrilinae
			Eudrilidae
			Pareudrilinae
			Eudrilinae
			Megascolecidae

following three suborders according to difference of the relative position between the male funnels and the male pores.

1) Oligochaeta plesiopora (Naidina, Enchytraeina and Tubificina)
2) Oligochaeta prosopora (Lumbriculina)
3) Oligochaeta opisthopora (Phreoryctina, Lumbricina and Megascolecina)

However he(1930) further revised his system and proposed a suborder for the Enchytraeidea, as follows:

Suborder 1. Plesiopora plesiotheca (Naidina, Tubificina)
,, 2. Plesiopora prosotheca (Enchytraeina)

Table 4. Comparison with severl characters

Families and their groups / Characters	Microdrili							
	Archioligochaeta							
		Lumbriculina			Tubificina			
	AEOLOSOMATIDAE	LUMBRICULIDAE	BRANCHIOB-DELLIDAE	ACANTHOB-DELLIDAE	TUBIFICIDAE	PHREODRILIDAE	NAIDIDE	ENCHYTRAEIDAE
Number of testicular segments	mumer-	1-4	1-2	1	1-2	1	1	1
Number of ovarian segments	ous	1-2	1	1	1	1	1	1
Localization of testes		8-13	9 10	10	6-10	11	4-7	8-11
Localization of ovaries		9-15	11	11	7-11	12	5-8	9-12
Localization of demarcating septum		8/9-13/14	10/11	10/11	6/7-10/11	11/12	4/5-7/8	8/9-11/1
Number of segments bearing the male pore	No ture male	1-4	1	1	1	1	1	1
Localization of male pores	and	8-13	10	10	7-11	12	5-8	9-12
Localization of female pores	femal pores.	9/10-15/16	11/12	11/12	7/8-11/12	12/13	5/6-8/9	9/10-12/13
Number of segments intervening between the testicular and the ovarian segments		0-1	0-1	0	0	0	0	0
Number of septa penetrated by a male duct		0-1	0-1	0	1	1	1	1-3
Relative position between the male and the female pores: prosoandric		+	+	+	+	+	+	+
Relative position between the male and the female pores: opisthoandric								
Female pores located: on the clitellum		+	+	+	+	+	+	+
Female pores located: not on the clitellum								
Relative position between spermathecae and the clitellum: plesiothecal		+	+	+	+	+	+	
Relative position between spermathecae and the clitellum: prosthecal					+?			+
Relative position between spermathecae and the clitellum: opisthothecal								
Occurrence of hair setae	+				+	+	+	
Occurrence of bifid crotchets	+	+			+	+	+	(+)
Occurrence of dorsal pores								(+)
Occurrence of septal glands	+?				+	+	+	+
Occnrrence of gizzard								
Occurrence of calciferous glands								
Structure of nephridial funnels	micro.	meso.	meso.	micro.	micro.	micro.	micro.	micro.
Mode of life	aquatic	aquatic	aquatic (epizoic)	aquatic (parasitic)	apuatic	apuatic	aquatic	aqnatic or terrestrial

in families of the Oligochaeta.

	Megadrili													
	Neoligochaeta													
	Phreoryctina				Megascolecina			Lumbricina						
	HAPLOTAXIDAE	ALLUROIDIDAE	SYNGENODRILIDAE	MONILIGASTRIDAE	ACANTHODRILIDAE	MEGASCOLECIDAE	EUDRILIDAE	LUMBRICIDAE	CRIODRILIDAE	HORMOGASTRIDAE	SPARGANOPHILIDAE	MICROCHAETIDAE	GLOSSOSCOLECIDAE	
	1–2 1–2	1 1	2 1	1–2 1	1–2 1	1–2 1	1–2 1	1–2 1	2 1	2 1	2 1	1–2 1	1–2 1–2	
	10–11 12–13 11/12	10 12 11/12 (?)	10–11 (?) 13 11/12 (?)	9–11 (?) 11–13 10/11–11/12 (?)	10–11 13 11/12	10–11 13 11/12	10–11 13 11/12	10–11 13 11/12	10–11 13 11/12	10–11 13 11/12	10–11 13 11/12	10–11 13 11/12	10–11 12–13 11/12	Numerals designate the segments.
	1–2 11–12 13–14	1 13 14	1 13 14	1–2 10/11–12/13 11/12–14	1–2 17–18 14	1 18–19 14	1 16/17–18 14	1 11–15 14	1 13–15 14	1 15/16–16 14	1 18/19–19 14	1 15 27/28 14	1 17–34 14	Numerals designate the segments.
	0 1	1 3	1 1	1 1	1–2 8–10	1 9–10	1 7–9	1 0–4	1 2–4	1 4–5	1 7–8	1–2 4–16	0–2 6–23	
	+	+	+	+	+	+	+	+	(+) +	+	+	+	+	+ mark designates general occurrence, (+) means rare or exceptional occurrence
	+	+	+	+	+	+	+	+	+	+	+	+	+	
	+	+	+	+	+	+	+ +	+		+	+ +	+ +	+	
	(+) + +		+	(+) +	+ + +	+ + +	(+) + +	+ + +		+ +	+	+ + +	(+) + +	
	mega.	mega.	mega.	mega.	mega.	mega.	mega.	mega.	mega.	mega.	mega.	mega.	mega.	
	aquatic or semi-aq.	aquatic or semi-aq.	terrestrial	terrestrial or semi-aq.	mostly terrestrial	mostly terrestrial	mostly terrestrial	terrestrial or semi-aq.	aquatic or semi-aq.	terrestrial	aquatic	aquatic or terrest.	mostly terrestrial	

Suborder 3. Prosopora (Lumbriculina)
,, 4. Opisthopora (Phreoryctina, Lumbricina, Megascolecina)

Thus the revisions on suborders were successively repeated by Michaelsen, though no revision was performed in Familen-reihe. It appeaer to the writer that to group together families by Michaelsen (Familen-reihe) except Naidina, seems to be quite reasonable. It seems, however, to be more natural to divide Phreoryctina into Haplotaxina (Haplotaxidae and Alluroididae) and Moniligastrina (Moniligastridae and Syngenodrilidae), because the latter is quite different from the former by the possession of peculiar testis-sacs suspended on the septa. On the other hand, Michaelsen's suborders seem to be questionable because the plesioporic condition is not distinctly separated from the opisthoporic as already stated in p. 322; and then the writer has another opinion on the division of the Oligochacta into suborders.

Before entering upon discussion, it seems to be nessessary to servey on characters of all families of the Oligochaeta. Table 4 will be convenient to compare with important characters.

Table 5. A revised classification of the Oligochaeta, proposed by the writer.

Subordo	Sectio	Subsectio	Super-familis	Familia
Oligochaeta archiopora			Aeolosomatina	Aeolosomatidae
Oligochaeta prosopora			Lumbriculina	Lumbriculidae Branchiobdellidae Acanthobdellidae
Oligochaeta opisthopora	Monotesticulata (=Michaelsen's Plesiopora)	Plesiotheca	Naidina	Naididae
			Tubificina	Tubificidae Phreodrilidae
		Prosotheca	Enchytraeina	Enchytraeidae
	Diplotesticulata (=Michaelsen's Opisthopora)	Prosoandria	Haplotaxina	Haplotaxidae Alluroididae
			Moniligastrina	Moniligastridae Syngenodrilidae
		Opisthoandria	Megascolecina	Acanthodrilidae Megascolecidae Eudrilidae
			Lumbricina	Lumbricidae Criodrilidae Microchaetidae Glossoscolecidae Hormogastridae Sparganophilidae

The Aeolosomatidae are quite different from all other families by the absence of gonads differentiated as organs, and by the possession of ability to proliferate germ cells in nearly all segments. And further, no male ducts of the type of the Naididae were observed. Nephrio-pores may serve evaculation of spermatozoa. It appears to the writer that the family seems to be separated from the Naidina.

Next, the Lumbriculina are a distinct family-group, characterized by the prosoporic condition as stated by Michaelsen. On the contrary, the remaining family-groups are all to be opisthoporic from the reasons already stated in p. 322.

As is clear from Table 4, the Naidina (excluded Aeolosomatidae), Tubificina and Enchytraeina have generally one-paired testes (monotesticulate), while the Phreoryctina (Haplotaxina and Moniligastrina), Megascolecina and Lumbricina are considered to be originally provided with two pairs of testes (diplotesticulate). On the other hand, the Naidina (excluded Aeolosomatidae) and Tubificina are plesiothecal, while the Enchytraeina are prosothecal.

On the other hand, the diplotesticulate family-groups may be further distinguished into two members, the prosoandric (Haplotaxina and Moniligastrina) and the opisthoandric (Megascolecina and Lumbricina).

From those views, it appears to the writer to be more suitable that the system of the classification of the Oligochaeta is to be revised, as showing in Table 5 and in succeeding pages.

Subordo I. Oligochaeta archiopora

No gonad differentiated as organ ; germ cells are prolifirate in nearly all segments. No true male duct ; spermatozoa may evaculate by nephridia. No true female duct with a female funnel. (Aeolosomatidae)

Subordo II. Oligochaeta prosopora

Testes, male funnels and male pores generally one or two pairs, rarely three or four pairs ; male pores situated, as a rule, on each or the hindmost testes-segment (in other words, male pores always situated anterior to the demarcating septum). Ovaries one or two pairs in normal cases ; female pores open externally in the hinder end of each ovarian segment. No intervening segment between the testicular and the ovarian segments, except *Branchiobdella* and *Styloscolex*. (Lumbriculina)

Subordo III. Oligochaeta opisthopora

Testes, male funels and male pores generally one or two pairs ; each male pore situated on a segment posterior to the testes-segment provided with male funnels which communicate with the male pores (in other words, male pores situated posterior to the demarcating septum or they are present behind and in front of the demarcating septum). Ovaries one or two pairs ; female pores open externally in the hinder end of each ovarian segment, or posterior to the ovarian segment.

Sectio 1. Monotesticulata

Testes and ovaries, as a rule, one-paired and no intervening segment between the testicular and the ovarian segments. Male pore, almost always, situated on the ovarian segment just behind the testicular segment. Female pores open externally in the hinder end of the ovarian segment.

Subsectio A. Plesiotheca

Spermathecal pores, if present, situated near the genital pores and in the clitellar region. (Naidina excluded Acolosomatidae, Tubificina)

Subsectio B. Prosotheca

Spermathecal pores located anterior to the clitellar region, being widely separated from the genital pores. (Enchytraeina)

Sectio 2. Diplotesticulata

Testes, two or one paired (originally two paired). Ovaries one paired, rarely two paired (originally two paired). Male and female pores, as a rule, one or two paired.

Subsectio A. Prosoandria

Male pores located anterior to female pores which open on the segment just behind each ovarian segment, and located in the clitellar region. Spermathecal pores situated anterior to the clitellar region (prosothecal).

(Haplotaxina, Moniligastrina)

Subsectio B. Opisthoandria

Male pores situated posterior to female pores, with very few exception. Female pores located in the clitellar region, or anterior to the clitellum. Spermathecal pores, prosothecal, plesiothecal or opisthothecal.

(Megascolecina, Lumbricina)

As is already stated, there is a great diversity in the arrangement of the genital organs of the Oligochaeta, and the fact seems to have important phylogenetic meanings. From those views, it appears to the writer that the phylogeny of the Oligochaeta may be mainly accorded with the distribution of the genital organs, and the most archaic family may be the Aeolosomatidae which seem to persist the most primitive nature, such as no true male duct, no gonads differentiated as organ, and the possession of ability to proliferate germ cells in nearly all segments.

Next, the second archaic family seems to be the Lumbriculidae, for the following primitive characters may have been preserved in them.

a) A great diversity in number and position of the gonads.

b) Occurrence of more than four pairs of gonads, and more than two pairs of testes (ploytesticulate).

c) Male pores are found on each testicular or the hindmost testicular segment (prosoporic).

d) Oviduct opens externally on the hinder end of each ovarian segment.

e) Male pores are located anterior to the female pores (prosoandric).
f) A great diversity in number and position of spermathecae.
g) The clitellum includes the region of the gonad-segments.
h) Male, female and spermathecal pores lie in the clitellar region.
i) The arrangement of testes and male ducts is quite variable in some species of a genus. The variation corresponds to the diversity of the arrangement of testes and male ducts in genera and in this family.

From those views, it appears to the writer that the ancestor of the Aeolosomatidae may have been first derived from the ancestor of the Oligochaeta separating from the main pedigree. Next, the ancestor of Lumbriculina, that of monotesticulate members (Tubificina, Naidina excluded the Aeolosomatidae, and Enchytraeina), and that of Prosoandria (Haplotaxina and Moniligastrina) may have been successively diversed from the main pedigree which may lately divided into the prosoclitellate group (Megascolecina) and the opisthoclitellate group (Lumbricina). Then a supposed illustration of the phylogenetic tree of the Oligochaeta is shown in Fig. 25.

As is clear from the figure, Oligochaeta archiopora (Aeolosomatidae) has branched from the trunk in the lowest level (Fig. 25 A_1). Oligochaeta prosopora (Lumbriculina) are diveded from the next level (Fig. 25 A_2). It is considered that the primitive distribution of the genital organs of the Lumbriculidae is based on the result of the persistence in their primitive mode of life (aquatic and free living). The Branchiobdellidae and the Acanthobdellidae might have been specially evolved in accordance with parasitic life. The opisthoporic stem (Fig. 25 A_3) is divided into two stems, the diplotesticulate (Fig. 25 B_0) and the monotesticulate (Fig. 25 C_0). The latter is divided into the Tubificidae, the Phreodrilidae, the Naididae and the Enchytraeidae. Out of them, the Enchytraeidae may have been separated in an earlier period and may have adapted to terrestrial life, as the prosothecal branch (Fig. 25 C_2), while the remaning families are situated on the plesiothecal branch (Fig. 25 C_1). The occurrence of hair setae in those families seems to have been evolved accorded with their aquatic life. The diplotesticulate stem is also divided into the opisthoandric stem (Fig. 25 B_1) and the prosoandric branch (Fig. 25 B_2) ; on the latter Haplotaxina and Moniligastrina are situated. On the other hand, the opisthoandric stem is divided into two stems, the prosoclitellar (Fig. 25 D_0) and the opisthoclitellar (Fig. 25 E). The former makes the origin of Megascolecina, while the latter evolved to Lumbricina. Next, the prosoclitellar stem is also branched off the prosothecal branch (Fig. 25 D_1) which is further divided into the Megascolecidae and the Acanthodrilidae, and the opisthothecal branch (Fig. 25 D_2) which makes the origin of the Eudrilidae.

The writer's full accounts on the classification and phylogeny of the Oligochaeta are principally based on Michaelsen's reduction theory, and are originated by the extension of the theory, induced from the use of the conception,

"the demarcating septum". But sufficient discussions are required for further studies.

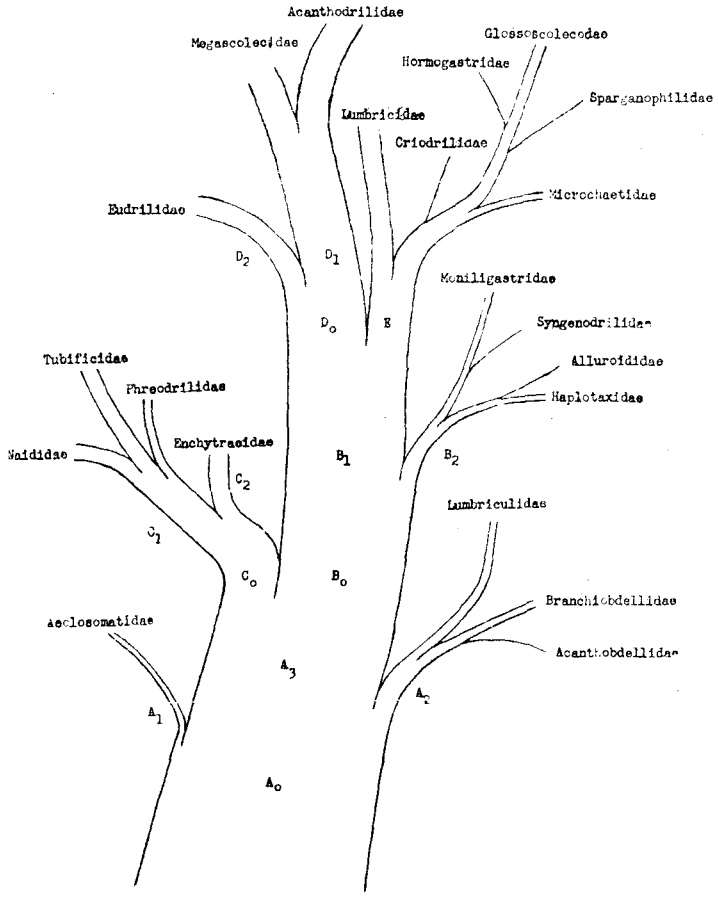


Fig. 25. Supposed figure of phylogenetic tree of the Oligochaeta. The width of the trunk and branches are illustrated in proportion to number of species, reckoned by Michaelsen (1928).

A_0, polytesticulate stem ; A_1, archioporic branch ; A_2, prosoporic branch ; A_3, opisthoporic stem ; B_0, diplotesticulate stem ; B_1, opisthoandric stem ; B_2, prosoandric branch ; C_0, monotesticulate stem ; C_1, plesiothecal branch ; C_2, opisthothecal branch ; D_0, prosoclitellar stem ; D_1, prosothecal branch ; D_2, opisthothecal branch ; E, opisthoclitellar stem.

IV) Literature

Aiyer, K. S., 1925, Notes on the aquatic Oligochaeta of Travancore I. Ann. Mag. Nat. Hist. vol. 16.

————— , 1926, Notes on the aquatic Oligochaeta of Travancore II. Ann. Mag. Nat. Hist. vol. 18.

————— , 1928, On a new species of the oligochaete genus *Aulodrilus* Bretscher. Rec. Ind. Mus. vol. 30.

Altman, L. C., 1936, Oligochaeta of Washington. Univ. of Wash. publ. Biol. vol. 4.

Beddard, E., 1889, On the anatomy, histology and affinities of *Phreorytces*. Proc. Roy. Soc. Edinb. (1889).

—— ——, 1890, On the homology between genital ducts and nephridia to the Oligochaeta. Proc. Roy Soc. London vol. 48.

—— ——, 1892, A branchiate oligochaete, *Branchiura sowerbyi*. Q. J, M. S. (1892).

————, 1895, A monograph of the order Oligochaeta, Oxford.

————, 1901, Oligochaeta (in Cambridge Nat. Hist. vol. 2).

Benham, W. B. 1890, An attempt to classify earthworms. Q. J. M. S. vol. 31.

————, 1904a, On some new species of the genus *Phreodrilus*. Q. J. M. S. vol. 48.

—— —— 1904b, On a new species of the genus *Haplotaxis*, with some remarks on the genital ducts in the Oligochaeta. Q. J. M. S. vol. 48.

————, 1904c, On some new species of aquatic Oligochaeta from New Zealand. Proc. zool. Soc. London (1903).

Bretscher, K., 1899, Beitrag zur Kenntnis der Oligochaetenfauna der Schweiz. Rev. suisse zool. Bd. 6.

Burow, W., 1931 Die, Oligochaeten der Umgebung des Baikalsees. II. Drei neue Styloscolex-art aus dem Baikalsee. Berich. d. Forsh. Inst. f. Biol. j. Geograph. Irkutsk. Bd. 5.

Cejka, B., 1913, *Litorea krumbachi* n. sp. N. gen. Zool. Anz. Bd. 42.

Černosvitov, L. 1928a, Die Oligochaetenfauna der Karpathen. Zool. Jahrb. Systm. Bd. 55.

————, 1928b, The Oligochaeta (in Report of the Percy Sladen expedition to Lake Hulen), a contribution to the study of the fresh waters of Palestine. Ann. Mag. Nat. Hist. ser. 11, vol. 2.

Chen, Y., 1940, Taxonomy and faunal relations of the limnitic Oligochaeta of China. Contr. Biol. Labr. Sci. Soc. China zool ser. vol. 5, No, 14.

Forbes, S. A., 1890, Note on an American species of *Phreoryctes*. American Nat. vol. 24.

Gatenby, J. B., 1916, The development of the sperm duct, oviduct and spermatheca in *Tubifex rivulorum*. Q. J. M. S. vol. 61.

Goodrich, E. S. 1885, On the coelom, genital ducts and nephridia. Q. J. M. S. vol. 37.

Hatai, S., 1898. On *Vermiculus limosus*, a new species of aquatic Oligochaeta. Ann. zool. Japon. vol. 2.

————, 1899, On *Limnodrilus gotoi* n. sp. Ann. zool. Japon. vol. 3.

Hrabě, S., 1931, Die Oligochaeten aus den Seen Ochrida und Prespa. Zool. Jahrb. System. Bd. 61.

————, 1933, Zur Kenntnis des *Pelodrilus kraepelini* (Mich.). Zool. Anz. Bd. 104.

Hrabe, S, 1936, Ueber *Dorydrilus* (*Piguetia*) *mirabilis* n. subg. n, sp. aus einem sodbrunnen in der Umgebung von Basel sowie über *Dorydrilus* (*Dorydrilus*) *michaelseni* Pig. und *Bichaeta sangninea* Bretsch. Pub. Fac. Sci. Univ. Msaryk. Cis. 227.

————, 1937, Zur Kenntnis des *Lamprodrilus mrazeki* Hr. *Aulodrilus pluriseta* Pig. und *Aulodrilus pigueti* Kow. Sbornik Klubu pri. v. Brno roc. 19.

————, 1939a, Oligochaeten aquatiques des Hautes Tatras. Vestnik cs Zool. spol. v Praze Svazek 6 7.

————, 1939b, Ueber die ontogentishe Entwicklung des männlichen Ausführungsganges bei einigen Oligochäten. Sbor. Pri. Klubu v T. 1939.

Hrabė, S. u. Černosvitov, L. 1927, Eine neue Lumbriculiden-Gattung *Anastylus parvus* n, gen, n. sp. aus Karpathorussland. Zool. Anz. Bd. 71.

Iizuka, A., 1898, On a new species of littoral Oligochaeta. Ann. Zool. Japon. vol. 2.

Kawamura, T., 1918, The Fresh-water Biology in Japan (in Japanese), Tokyo.

Kondo, M., 1936, A list of naidiform Oligochaeta from the water-works plant of the City of Osaka. Ann zool. Japon. vol. 15.

Kowalewski, M., 1914, The genus *Aulodrilus* Bretscher 1899 and its representatives. Bull. Inst. Acad. Sci. Cracovie (1914).

Marcus, E., 1944, Sobre Oligocheta limnicos do Brasil. Bol. Fac. Fil. Cien. Litr. Univ. S. Paulo XLIII, zool. No. 8.

Mehra H. R., 1922, Two new Indian species of little known genus *Aulodrilus* Bretscher of the aquatic Oligochaeta belonging to the family Tubificidae. Proc. zool. Soc. London (1922).

————, 1924 The genital ducts of *Stylaria lacustris*. Q. J. M. S. vol. 68.

————, 1925, The atrium and prostate galnds in the Microdrili. Q. J. M. S. vol. 69.

Meyer, A., 1929a, Die Entwickulng der Nephridien und Gonoblasten bei *Tubifex rivulorum* Lam. nebst Bemerkungen zum natürlichen System der Oligochäten. Zeitschr. wiss. Zool. Bd. 133.

————, 1929b, Ein atavistischer Tubifex-embryo mit überzähligen Gonoblasten Paar und seine Bedeutung für die Theorie der Segmentstauchung bei den Oligochaeten. Zool. Anz. Bd. 85.

Michaelsen, W., 1899, Beiträge zur Kenntnis der Oligochaeten. Zool. Jahrb. System Bd. 12.

————, 1900, Oligochaeta (Das Tierreich Lief. 10), Berlin

————, 1901, Oligochäten der zoologischen Museen zu St. Petersburg und Kiew. Bull. Acad. Imp Sci. St. Petersburg Bd. 15.

————, 1902, Die Oligochätenfauna des Baikal-sees. Verh. Ver. naturw. Unterh. Hamburg. (3) 9.

———— 1903, Eine neue Haplotaxiden-Art und andere Oligochäten aus dem Telezkishen-See in nördlichen Altai. Verh. Ver. naturw. Unterh. Hamburg. (3) 10.

————, 1905, Die Oligochäten des Baikal-Sees. Wiss. Erg. einer Zool. Exp. nach dem Baika-see Prof. A. Kortneff 1900-1902. Lief. 1 Kiew u. Berlin.

————, 1909, Oligochaeta (Brauer's Süsswasser-fauna Deutschlands H. 13.), Jena.

————, 1921, Zur Stammesgeschte und Systematik der Oligochäten insbesondere der Lumbriculiden. Arch. Naturgesh. Bd. 86. Abt. A.

————, 1925, Zur Kenntnis einheimischer und ausländischer Oligochaeten. Zool. Jahrb. System. Bd. 51.

————, 1926a, Zur Kenntnis der Oligochäten des Baikal-Sees. Russ. Hydrobiol. Bd. 5.

————, 1926b, *Pelodrilus bureschi*, ein Süsswasser-Höhlenoligochät aus Bulgarien. Arb. Bulgar. Naturf. Ges. Bd. 12.

————, 1927, Oligochaeta (Tierw. Nord- u. Ostsee. Lief. 9, Teil 6).

————, 1928, Oligochaeta (Kükenthal u. Krumbach's Handb. d. Zool. Bd. III.

————, 1929a, Oligochäten der Kamtschatka-Expeidtion 1908–1909. Ann. Mus. Zool. Acad. Sci. l'URSS. 1929.

————, 1929b, Zur Stammesgeschichte der Oligochäten. Zeitschr. wiss. Zool. Bd. 134.

————, 1930, Nachtrag zur Oligochaeta(Kükenthal u. Krumbach's Handb. d. Zool, Bd. III).

————, 1932, Ein neuer *Phreoryctes* von der Tropeninsel Poeloe Berhara. Mis Zool. Sumatra. vol. 71.

————, 1933, Ueber Höhlen- Oligochaeten. Mitt. Höhlen u, Karstf, Berlin, (1933)

Michaelsen, W. u. Boldt, W. 1932, Oligochaeta der deutschen limnologischen Sunda-Expedition. Archiv f. Hydrobiol. Suppl.-Bd. 9.

Mrâzek, A., 1907, Die Geschlechtverhältnisse und die Geschlechtsorgane von *Lumbriculus gariegatus* Zool. Jahrb. Anat. Bd. 23

Nagase, I. and Nomura, E., 1937, On the Japanese aquatic Oligochaeta *Criodrilus miyashitai* n. sp. Sci. Rep. Tohoku Imp. Univ. 4 ser vol. 11.

Nomura, E., 1913, *Limnodrilus gotoi* and *Limnodrilus willeyi* n. sp. J. Coll. Sci. Tokyo vol. 35.

————, 1915, On the aquatic Oligochaeta *Monopylephorus limosus* (Hatai). J. Coll. Sci. Tokyo vol. 35.

————, 1926, On the aquatic Oligochaeta *Tubifex hattai* n. sp. Sci. Rep. Tohoku Imp. Univ. 4 ser. vol. 1.

————, 1929, On *Limnodriuls motomurai* n. sp. an aquatic Oligochaeta. Ann. zool. Japon. vol. 12.

————, 1932, *Limnodrilus grandisetosus* n. sp. a freshwater Oligochaeta. Sci. Rep. Tohoku Imp. Univ. 4 ser. vol. 7.

Piguet, E., 1906, Observation sur les Naididees. Rev. suisse Zool. T. 14.

————, 1909, Nouvelles observations sur les Naididees. Rev. suisse Zool. T. 17.

Piguet. et Bretsher. 1913, Oligochaeta (Catalogue d. Invertb. d. l. suisse Fasc. 7)

Smith, F., 1985, Notes on species of North Americaln Oligochaeta. Bull. Ill. State Lab. Nat. Hist. vol. 4.

————, 1900, Notes on species of North American Oligochaeta, IV, On a new lumbriculid genus from Florida, with additional notes on the nephridial and circulatory systems of *Mesoporodrilus asymmetricus* Smith. Bull. Ill. State Lab, Nat. Hist. vol. 5.

————, 1906, Notes on species of North American Oligochaeta V. The systematic relationships of *Lumbriculus* (*Thinodrilus*) *inconstans* (Smith). Bull. Ill. State Lab. Nat. Hist. vol. 7.

————, 1918, A new North American Oligochaeta of the genus *Haplotaxis*. Bull. Ill. State Lab, Nat. Hist. vol. 13.

Smith, F. and Dickey, B. 1918, A new species of *Rhynchelmis* in North America. Trans. Amer. Micr. Soc. vol. 37.

Smith, F. and Welch, P. S. 1919, Oligochaeta collected by the Canadian Arct. Exp.

1913–1918. Rep. Canadian Arct. Exp. 1913–1918 vol. 9.

Stephenson J., 1911, On some aquatic Oligochaeta in the collection of the Indian Museum. Rec. Ind. Mus, vol. 6.

————, 1917, Aquatic Oligochaeta from Japan and China. Annandale N. zool. Results of Tour in the Far east. Mem. Asiatic Soc. Bengal vol. 6.

————, 1923, Oligochaeta in the Fauna of British India, London.

————, J., 1925, Oligochaeta from various regions including those collected by the Mount Everest Expedition 1924. Proc. zool. Soc. London (1925).

————, 1930, The Oligochaeta. Oxford.

————, 1931a, Oligochaeta from the Malay Peninsula. Jour. Fed. Malay States Mus. vol. 16.

————, 1931b, Oligochaeta from Burma, Kenya and other parts of the world. Proc. zool. Soc. London (1931).

Svetlov, P., 1936, *Lamprodrilus isoporus* Mich. (Lumbriculidae) aus dem Ladoga und dem Onegasee. Zool. Anz. Bd. 113.

Ude. H., 1929, Oligochaeta (Tierwelt Deutschlands Teil 15), Jena.

————, 1932, Beiträge zur Kenntnis der Gattung *Pheretima* und ihre geographischen Verbrietung. Arch. f. Naturgesch. N, F. Bd. 1.

Vejdovsky, F., 1884, System und Morphologie der Oligochaeten. Prag.

Yamaguchi, H., 1931, Variation on the nmuber and position of the male pores in *Pheretima hilgendorfi* Michaelsen (in Japanese). Zool. Mag. vol. 3.

————, 1934, Studeis on Japanese Branchiobdellidae with some revisions on the classification. Jour. Fac. Sci. Hokkaido Imp. Univ. 6 ser. vol. 3.

————, 1935, Occurrence of the luminous oligochaete, *Microscolex phosphoreus* (Dug.) in Japan. Ann. zool. Japon. vol. 15.

———— 1936, Studies on the aquatic Oligochaeta of Japan I. Lumbriculids from Hokkaio. Jour. Fac. Sci. Hokkaido Imp. Univ. 6 ser. vol. 5.

————, 1937a, Oligochaeta (The fauna of Akkeshi Bay III) Jour. Fac. Sci. Hokkaido Imp. Univ. 6 ser. vol. 5.

————, 1937b, Studies on the aquatic Oligochaeta of Japan II. Occurrence of the subterranean oligochaete *Haplotaxis gordioides* (Hartmann) in Japan. Ann. zool. Japon. vol. 16,

————, 1937c, 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. Jour. Fac. Sci. Hokkaido Imp, Univ. 6 ser. vol. 6.

————,1937d, Studies on the aquatic Oligochaeta of Japan IV. *Styloscolex japonicus* n. sp. Ann. zool. Japon. vol. 16.

————, 1938, Studies on the aquatic Oligochaeta of Japan V. The description of a new variety of *Branchiodrilus hortensis* (Stephenson). Ann. zool. Japon. vol. 17.

————, 1940, Aquatic Oligochaeta in Manchuria (in Japanese) Rep. Limnol. survey in Manchuria.

————, 1949, On *Branchiura sowerbyi* Beddard (in Japanese) Jour. Hokkaido Gakugei Univ. vol. 1.

Yoshizawa, H., 1928, On the aquatic Oligochaeta, *Stylaria lacustris* L. Sci. Rep. Tohoku Imp. Univ. 4 ser. vol. 3.

Postscript

Later on the preparation of the present paper, the writer read Sperber's (1948)[1] monographical work on the Naididae in Sweden. According to him, the Naididae are no doubt the closest relatives of the Tubificidae but neither of these families have been derived from the other. The same conclusion was also obtained in the present paper (Fig. 25).

Michaelsen (1928, 1929) regarded the Naididae as descended from the Aeolosomatidae, while Stephenson (1930) comes to the opposite conclusion : Naididae→Aeolosomatidae as a result of reduction. But Sperber concludes that the Aeolosomatidae are, following Marcus (1944) apparently very primitive in many respects, and not closely related to the Naididae or any of the Oligochaeta families. It agrees with the writer's proposition to establish the Suborder Oligochaeta archiopora for the Aeolosomatidae.

On the other hand, Sperber regards that the Lumbriculidae and Naid-Tubificid stem undoubtedly originate from a common, very primitive Oligochaeta ancestor. The conclusion fits to the present writer's opinion (Fig. 25).

Referring the Sperber's paper, the writer found to have over-looked Černosvitov's paper (1936)[2] in which the Opisthocystidae have been proposed. This family is closely related to the Naididae and the Phreocrilidae, and is represented by the genus *Opisthocysta* having testes in XXI, ovaries in XXII and spermathecae in XXIII. This family is to be added undoubtedly to place on the monotesticulate stem (Fig. 25, C_0).

---

1) Sperber, C, 1948, A Taxonomical study of the Naididae. Zool. Bidrag f. Uppsala Bd. 28.

2) Černosvitov, L, 1936, Oligochaeten aus Südamerika. Systematishe Stellung der *Pristina flagellum* Leidy. Zool. Anz. Bd. 113.

Explanation of Plate VII

1-4) Photomicrographs of naidiforms, taken from living state. 1. *Pristina longiseta* Ehrenberg; 2, *Nais variabilis* Piguet; 3, *Slavina appendiculata* (Udekem); 4, *Branchiodrilus hortensis* var. *iaponicus* Yamaguchi, a budding zone will be seen in middle part of body; 1–3, ca. ×40; 4, ca. ×3.

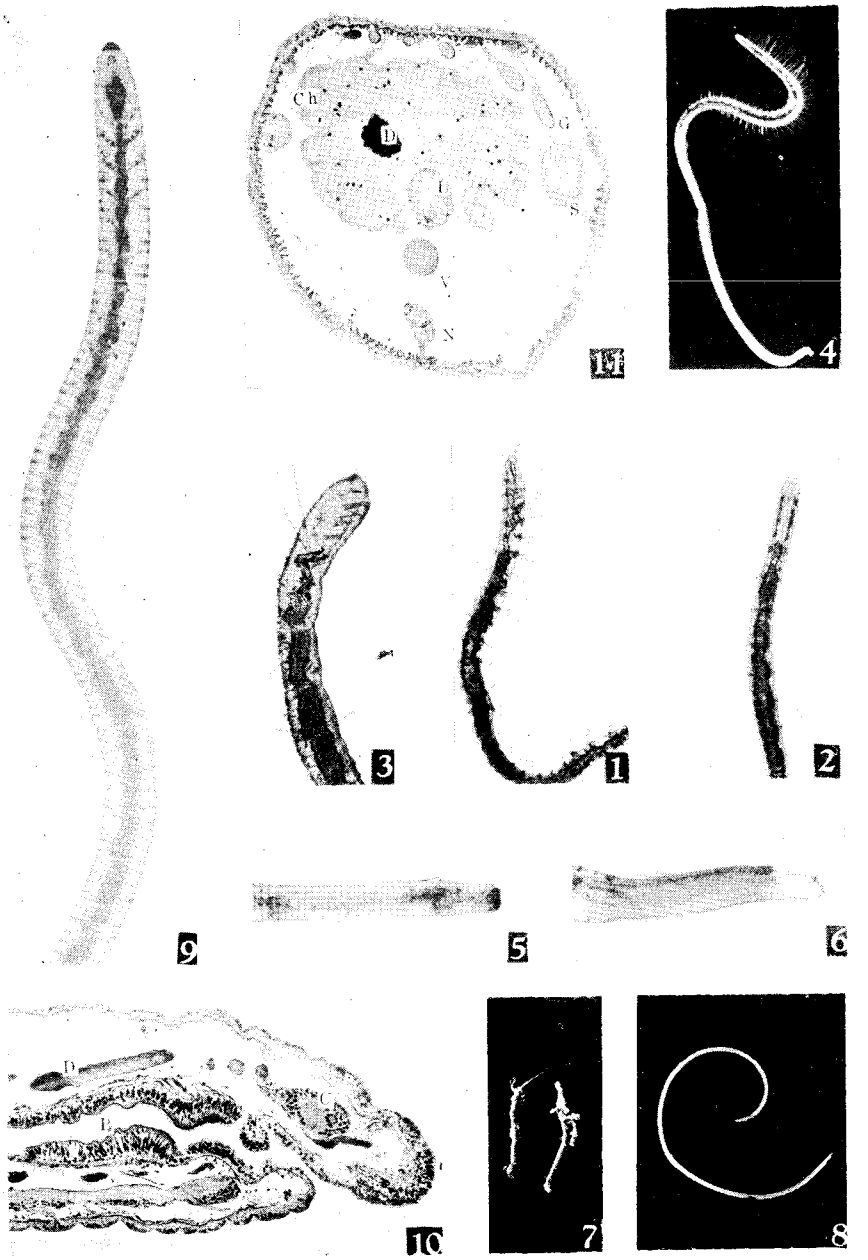
5-7) *Aulodrilus iaponicus* n. sp. 5, photomicrograph of posterior part of body, taken from living state, ca. ×40. 6, the same, taken from stained total preparation, ca. ×40. 7, photograph of tubes formed by the worms, ca. ×1.

8) *Haplotaxis gastrochaetus* n. sp. Photograph of a living individual narcotized by chroleton, ca. ×1.

9-11) Photomicrographs of *Heterochaetella glandularis* n. g. et n. sp. 9, anterior part of a stained specimen mounted by balsam, taken from dorsal side, ca. ×6. Four pairs of gonads are found in small stained mass located in segments X–XIII. 10, longitudinal section of anterior part of body, ca. ×35. 11, transverse section of middle part of body, ca. ×70.

Abbreviations

C, cerebral ganglion; Ch, chloragogue cells; D, dorsal vessel; G, unicellular gland projecting into the coelom; I, intestine; N, ventral nerve cord; P, pharynx; S, so-called subspherical bodies associated with the dorsal setal couple; V, ventral vessel.



H. Yamaguchi : Aquatic Oligochaeta