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STUDIES ON JAPANESE BRANCHIOBDELLIDAE
WITH SOME REVISIONS ON THE
CLASSIFICATION¹⁾

BY

Hideji YAMAGUCHI

(With 2 Plates and 17 Textfigures)

1. Introduction

The Branchiobdellidae form one of the special groups under the Oligochaeta in their structure and habits. They are found attaching to gills and external surface of crayfishes by means of the posterior sucker, so that they might be often considered as leeches. It has been commonly known that Japanese crayfishes are often parasitized by several branchiobdellids, but very little has been known about these worms. Therefore, at the suggestion of Prof. Tohru UCHIDA, the present writer took up a study of these worms about three years ago. From studying Japanese branchiobdellids it seems to be necessary to make some emendations on the classification established by PIERANTONI (1906).

Materials for the studies were obtained from crayfishes collected in various localities of Japan, such as Hokkaido, Korea, and the northern part of Honshu. Observations upon living animals were principally made on materials obtained from Hattaribetsu near Sapporo, Hokkaido. Besides those materials, some specimens of the European species, *Branchiobdella pentadonta* were used for the purpose of comparison. Identification of the crayfishes bearing the

1) Contribution No. 80 from the Zoological Institute, Faculty of Science, Hokkaido Imperial University, Sapporo.

worms, was based on the study on the Japanese crayfishes published by OKADA (1933).

Before proceeding further, the writer would like to express his thanks to Prof. T. KAWAMURA of the Imperial University of Kyoto, Prof. H. KOBAYASHI and Prof. K. SUZUKI, of the Imperial University of Keijo, Prof. Y. OKADA of the University of Literature and Science of Tokyo, Prof. T. INUKAI and Mr. S. MAKINO of our Institute, and also to Messrs. K. MATSUKI, K. MURAKAMI, Y. SAITO, K. WADA and K. WAKAIRO, for placing specimens at his disposal. Hearty thanks must be extended to Prof. T. UCHIDA for his valuable suggestions and help rendered in preparation of the paper, and also to Prof. K. OGUMA for his kind advices and help in various ways. Finally the writer wishes to express his gratitude to Prof. W. MICHAELSEN of Hamburg for sending several specimens of European branchiobdellids, and to Prof. P. J. MOORE of Philadelphia, who kindly gave informations as to the male terminal apparatus of American species.

2. Historical

According to DÖRNER (1865) the oldest document treating the Branchiobdellidae was published by RÖSEL (1755). But ODIER (1823) was the first to establish the genus *Branchiobdella*. Since that time several forms of the worms have been reported by the investigators, HENLE, WHITMAN, MOORE, PIERANTONI, HALL, ELLIS etc. PIERANTONI (1912) established a system of classification of the family, treating 20 species which are divided into the five genera, *Cirrodrilus*, *Branchiobdella*, *Stephanodrilus*, *Bdellodrilus* and *Pterodrilus*. Afterwards MICHAELSEN (1928) and STEPHENSON (1930) enumerated the following nine genera: 1) *Branchiobdella*, 2) *Cirrodrilus*, 3) *Stephanodrilus*, 4) *Bdellodrilus*, 5) *Pterodrilus*, 6) *Cambarincola*, 7) *Ceratodrilus*, 8) *Xironodrilus*, 9) *Xironogiton*.

The Branchiobdellidae have been placed in the Hirudinea by several authors, such as RÖSEL, BRAUN, O. F. MÜLLER, ODIER and HENLE. In 1903 SCHMIDT made clear that the structure of their

musculature is quite different from that of the leeches and is decisive for association with the Oligochaeta. Subsequently PIERANTONI (1912) studying their anatomy placed them under the Oligochaeta. According to STEPHENSON (1930), they have a close relationship to the Lumbriculidae in the Oligochaeta, though modified on account of their parasitic life.

The first literature concerning Japanese branchiobdellids must be that of WHITMAN (1882) who gave brief notes on external features of three species of branchiobdellids without a definite name. About twenty years later, PIERANTONI (1905) reported *Cirrodrilus cirratus* = *Stephanodrilus cirratus*, the description of which was based on several ill-preserved materials obtained from the Japanese crayfish, *Cambaroides japonicus*, possessed by the Natural History Museum of Paris. Subsequently, he (1906) reported two other species, *Branchiobdella digitata* and *Stephanodrilus sapporensis* from *Cambaroides japonicus* collected in Hokkaido. Since the publication of PIERANTONI's paper (1912) describing *St. koreanus* and *St. japonicus*, there has been published no paper about the Branchiobdellidae of Japan, until the publication of the present writer's works, except that KAWAMURA (1918) gave figures of the three species, *St. sapporensis*, *Pterodrilus* sp. = *St. cirratus* and *Branchiobdella* sp. = *St. kawamurai* n. sp. In 1932 the present writer suggested that *Cirrodrilus cirratus* described by PIERANTONI (1905) must be referable to *Ceratodrilus*, with the description of a new form, *Ceratodrilus uchidai* = *St. uchidai*. In the same year he described *Carcinodrilus nipponicus* = *St. nipponicus*, proposing the new genus *Carcinodrilus*, and *Cambarincola homodonta* = *St. homodontus*. Recently *Cambarincola okadai* also was reported by the present author (1933) as a new species.

3. On some taxonomic characters

With regard to the classification of the Branchiobdellidae PIERANTONI (1912) attached much importance to the ventral cirri

and dorsal appendages in the trunk, to the form of the peristomium¹⁾, to the structure of dental plates and to the number of pairs of testes and male funnels. ELLIS (1912) who proposed the genus *Cambarincola* laid stress on the number of anterior nephridial pores, and the accessory sperm tube. Afterward, taking into consideration the number and position of the major pharyngeal diverticula, and the presence of buttress-like supports of connective tissue attached to the intersegmental partitions, he (1920) instituted the two genera *Xironodrilus* and *Xironogiton*. Recently the present author (1932 b) enumerated the funnel-shaped peristomium as one of the generic characters. A discussion of some of the taxonomic characters becomes pertinent.

Dorsal appendages and ridges. According to PIERANTONI (1905, 1912), the presence of the "ventral cirri" is the most remarkable character of the genus *Cirrodrilus* which was represented by the single species *cirratus*. As pointed out by the present writer (1932 a), however, PIERANTONI's specimens were in an ill-preserved condition and are actually nothing but those belonging to *Ceratodrilus* = *Stephanodrilus*.

The dorsal appendages are known to be present in several species belonging to *Pterodrilus* and *Ceratodrilus*. According to MOORE (1894), *Pt. alcicornus* and *Pt. disticus* are provided with dorsal transverse ridges and wing-like or cylindrical appendages located in the free margin of the ridges. *Ceratodrilus thyanosomus* also bears dorsal appendages extending from the dorsal transverse ridges (HALL, 1914). Digitiform dorsal appendages have been described in the two Japanese species, *Stephanodrilus cirratus* and *St. uchidai*, which were at the same time referred to *Ceratodrilus* (YAMAGUCHI, 1932 a). The digitiform appendages of these species are mounted on dorsal transverse ridges which become lamelliform in *cirratus* (Pl. I, D; II, 1, 2, 3), while in *uchidai* the ridges are rather inconspicuous, so that the present writer overlooked them in his previous

1) It was called "prostomium" by PIERANTONI and others.

work (1932 a). According to MOORE (1894), the dorsal transverse ridges of *Pt. alcicornus* are supported by dorsal segmental muscle fibers connecting the anterior with the posterior covering of hypodermis. Similar dorsal muscle fibers are also found in the dorsal transverse ridges of *cirratu*s and *uchidai*. In the former species those fibers are quite conspicuous in highly developed ridges (Pl. II, 4, s). The dorsal segmental muscle fibers seen in these three species are found only in the dorsal side and are distinguishable from longitudinal muscles running the whole body length by their position and short length. The muscle fibers are probably identical to the "Längsmuskelzelle des Nebensystems" described by SCHMIDT (1903) in his study on the musculature of *Branchiobdella parasita*. *Stephanodrilus sapporensis* is destitute of dorsal appendages but is marked by low inconspicuous transverse ridges (Pl. 1, A) supported by a few dorsal segmental muscles. In other species of *Stephanodrilus*, i. e., in *St. inukaii* n. sp., *St. megalodentatus* n. sp. etc., neither dorsal transverse ridges nor dorsal appendages are present (Pl. I, B, C). The dorsal segmental muscles could not be detected in these species. From those facts, it seems to the present writer that the dorsal ridges appear along with the development of the dorsal segmental muscles. In a previous paper (1932 a) it is stated that in *Ceratodrilus uchidai* = *Stephanodrilus uchidai* the digitiform dorsal appendages are present in the six trunk somites, III–VIII, each somite bearing twelve of them. As the result of examination on abundant specimens of the species collected from various localities it has been clear that there are several intergrades in regard both to the number of somites bearing appendages and to the appendages on each somite. Some forms are also provided with appendages in the six trunk somites, III–VIII, but they are variable in number according to the somites (maximum 12 and fewer in the more anterior ones) (Fig. 15, A). In others the appendages are more reduced in number and disappear in several anterior somites (Fig. 15, B), finally disappearing altogether all trunk somites (Fig. 15, C, D). In these several forms the dorsal

transverse ridges are always present accompanying the dorsal segmental muscle fibers. According to ELLIS's (1920) description and figures, *Pterodrilus durbini* seems to be also provided with dorsal transverse ridges, but to be destitute of distinct appendages except two "horns" found in the eighth trunk somite. Moreover, *Branchiobdella kobayashii* n. sp. has dorsal transverse ridges supported by dorsal segmental muscle fibers (Pl. II, 6) while *Br. orientalis* n. sp., *Br. pentadonta* and others are destitute of the ridges. Judging from these fact, those provided with the dorsal transverse ridge, or dorsal segmental muscles are not distinctly separated from those lacking them.

Peristomium. The bilobed or pluri-lobed peristomium which was regarded as one of the generic characters by PIERANTONI (1912) seems to be of no significance for generic value, because the two kinds of peristomia are found in one genus as will be stated below. In the genus *Branchiobdella* a pluri-lobed peristomium is found in *Br. digitata*, *Br. minuta* (PIERANTONI 1912) and *Br. parasita* (WHITMAN 1882), while other species generally have a bilobed peristomium. On the other hand, *Cambarincola chirocephala*, *C. philadelphica* (ELLIS 1920) and *C. okadai* (YAMAGUCHI 1933) are provided with a pluri-lobed peristomium, but other species belonging to the genus are provided with a bilobed peristomium. Though the present writer (1932 b) distinguished the funnel-shaped peristomium from that not funnel-shaped, the distinction is not clear in several species.

Pharyngeal diverticula. ELLIS (1920) enumerated the major pharyngeal diverticula as an important generic character and wrote as following; "These pharyngeal diverticula are not to be confused with the slight invaginations of the pharyngeal wall, nor with a fold in the pharyngeal wall near the posterior end of the pharynx (found in many preserved specimens), due to the pushing forward of the oesophageal portion of the alimentary canal so that the an-

terior end of the oesophagus partly telecopes the posterior end of the pharynx". In *Stephanodrilus cirratus* and *St. uchidai* are usually found four pharyngeal invaginations, two anterior, one dorsal and the other ventral, more or less opposed, and two posterior, one dorsal and one ventral, also more or less facing each other. These invaginations are subequal in depth, but the anterior ones are often more or less deeper than the posterior (Pl. II, 1). *St. makinoi* n. sp. and *St. koreanus* etc. also have four ^{anterior} ~~investigations~~ ^{invaginations} similarly located in the pharyngeal walls, the anterior ones being deeper than the posterior (Pl. II, 5). The latter are not often found. The invaginations found in these species seem to be variable in depth according to the state of preservation; they are usually deeper and quite evident in contracted examples, but shallower and indistinct in well-extended specimens. The four invaginations are recognizable in MOORE'S (1895) figure of *Bdellodrilus illuminatus* and also in ELLIS'S (1920) photograph of *Xironodrilus formosus*. But it was difficult for the present writer to distinguish the "major pharyngeal diverticula" from the "slight invaginations". It seems to be quite doubtful, therefore, whether one should consider the number and position of the "major pharyngeal diverticula" as an important taxonomic character.

4. Classification of Japanese species

As the Branchiobdellids are a special group adapted to parasitic life, the classification of them is one of the most difficult matters. But so far as the writer has observed on Japanese specimens, they are divided into three groups; the first group is characterized by the possession of one pair of testes and male funnels and belongs to the genus *Branchiobdella*, while the other two are provided with two pairs of these organs and seem to be again divided into the genera, *Cambarincola* and *Stephanodrilus*. These genera are distinguished from each other by the following characters.

	<i>Stephanodrilus</i>	<i>Cambarincola</i>
Peristomium	pluri-lobed; dorso-lateral portions divided into 8 long lobes, 4 dorsal and 4 lateral in 2 pairs, and several short intermediate ones often located between them.	bi-lobed or pluri-lobed; when pluri-lobed, dorso-lateral portions divided into only 4 dorsal and two lateral lobes.
Anterior nephridial pores	paired (except <i>St. koreanus</i>).	unpaired.
Dorsal transverse ridges and appendages	present or absent.	absent.
Dorsal dental plate	provided with 7 or more teeth, median one larger than lateral ones.	provided with 5 teeth; a large median and 4 small lateral ones.
Ventral dental plate	similar in dentition to the dorsal plate.	provided with 4 teeth, having no median unpaired teeth, (except <i>C. okadai</i> bearing same dentition as the dorsal plate).
Accessory sperm tube	absent.	present.
Penis	provided in the basal part with a folded narrow eversible efferent canal.	non-eversible.
Muscular penis sheath	obscure.	?

The species described by the present writer (1932 a) under *Ceratodrilus* as *C. cirratus* and *C. uchidai* are distinctly different, in respect to the presence of dorsal appendages, from species belonging to *Stephanodrilus*. As stated above, in individuals of *C. uchidai* collected from some localities these appendages are gradually reduced in number and eventually disappear. Furthermore, these two species are generally equipped with characters common with *Stephanodrilus*. Therefore, *Ceratodrilus* seems to be merged into *Stephanodrilus*. Though somewhat different in dental plates, *C. thysanosomus* described by HALL (1914) is probably referable to the same genus, because the species agrees with the two Japanese species in main characters. But for convenience sake *Stephanodrilus*

including three species, *thysamosomus*, *cirratus* and *uchidai* is separated as a subgenus from other species belonging to *Stephanodrilus*. *Carcinodrilus* having a lobation similar to that of *Ceratodrilus* and thence separated by the writer (1932 b) must be included in *Stephanodrilus*, because the lobation of the peristomium is very different in species which generally coincide in other characters and probably belong to the genus *Stephanodrilus*. A revised diagnosis of *Stephanodrilus* will be given later. Branchiobdellidae hitherto found in Japan are listed as follows:

1. *Branchiobdella orientalis* n. sp.p. 186
- *2. " *digitata*¹⁾ PIERANTONIp. 188
3. " *kobayashii* n. sp.p. 188
4. *Cambarincola okadai* YAMAGUCHIp. 190
5. *Stephanodrilus* (St.) *inukaii* n. sp.p. 192
6. " (St.) *aomorensis* n. sp.p. 196
7. " (St.) *ezoensis* n. sp.p. 197
8. " (St.) *megalodontatus* n. sp.p. 198
- *9. " (St.) *japonicus* PIERANTONIp. 199
10. " (St.) *koreanus* PIERANTONIp. 199
11. " (St.) *homodontus* (YAMAGUCHI) ..p. 200
12. " (St.) *makinoi* n. sp.p. 201
13. " (St.) *sapporensis* PIERANTONIp. 203
14. " (St.) *chosen* n. sp.p. 205
15. " (St.) *nipponicus* (YAMAGUCHI) ...p. 206
16. " (St.) *kawamurai* n. sp.p. 207
17. " (St.) *suzukii* n. sp.p. 209
18. " (*Ceratodrilus*) *uchidai* (YAMAGUCHI) ..p. 211
19. " (*Ceratodrilus*) *cirratus* (PIERANTONI) ..p. 214

5. Description of the Japanese species

Genus *Branchiobdella* ODIER, 1823

Branchiobdella: ODIER, 1823, p. 75; MICHAELSEN, 1909, p. 56; PIERANTONI, 1912, p. 9; ANDRÉ, 1925, p. 42; STEPHENSON, 1930, p. 800.

1) No specimen of the species with an asterisk was accessible to the writer.

The genus is separated from all other genera of the Branchiobdellidae by the possession of only one pair of testes and male funnels. It has been known occurring in Europe, North America and Eastern Asia. European branchiobdellids hitherto found all belong to the genus.

Branchiobdella orientalis sp. nov.

(Fig. 1)

The body is somewhat cylindrical, 6–9 mm long and about 1.2–2.0 mm wide in well-developed worms in preservative. The peristomium is relatively small, and evidently composed of a dorsal and a ventral lip, the latter being somewhat bilobed with a median slight incision. On either side is present a small liplet situated between these lips. The mouth is surrounded by about sixteen papillae. The pharyngeal portion of the head is more or less narrower than the first trunk somite; the sucker is about equal in diameter to or slightly larger than the breadth of the pharyngeal portion. No dorsal transverse ridges and appendages in the trunk. Both dorsal and ventral dental plates (Fig. 1, B, C) are brown in colour, subequal in size and of the same dentition, the teeth of these plates consisting of a large median and five sub-equal small lateral pairs. The anterior nephridial pores are located in the dorso-lateral sides. Though small and inconspicuous, paired glandular areas¹⁾ were found in the ventro-lateral sides of the eighth and the ninth major annuli.

The vasa deferentia are paired in the fifth trunk somite; each of them has a distinct male funnel; the coelomic cavity of the somite is filled with liberated male reproductive cells in various stages of development, though in sections the testes could not be detected. The atrium in the sixth trunk somite is a single long tube which

1) There are always found some paired epithelial glands in the ventro-lateral sides, consisting of a number of long tubular, deeply stained unicellular gland cells gathered in a small area on the body surface (Pl. II. 8). The areas are usually obscure in external aspect, but are frequently elevated as papillae or discs in several species (Fig. 13, 14). For convenience sake the areas have been spoken of as "glandular areas" in this paper.

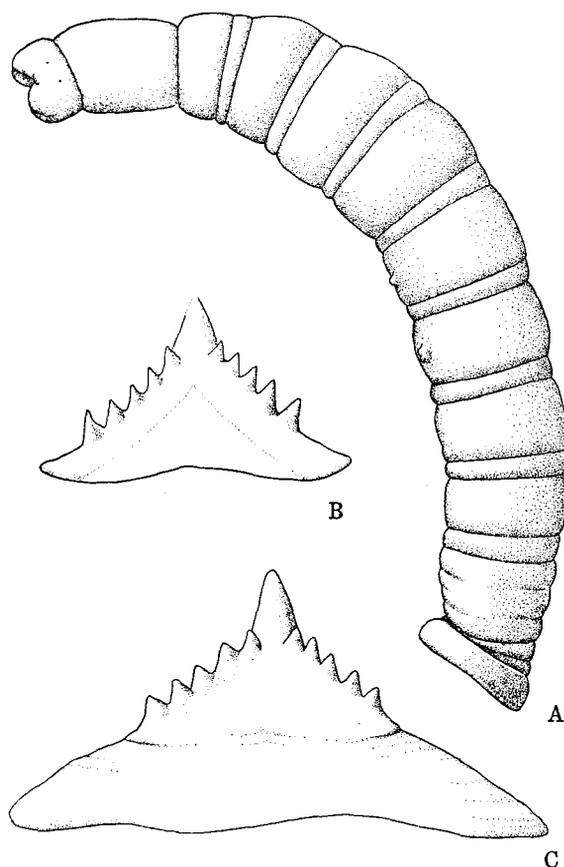


Fig. 1. *Branchiobdella orientalis* n. sp.; A, lateral view, about $\times 18$; B, anterior view of dental plate of young $\times 440$; C, anterior view of dental plate of adult $\times 440$.

can be divided into two portions, a distal U-shaped glandular part composed of columnar cells deeply stained and a portion bordered with well-developed muscular walls, which is again divided into three parts, a short muscular part and a long folded muscular penis sheath (Pl. II, 13, pt) enclosing a long eversible penis, and an enlarged bursa. The penis in eversed and extruded condition has no "Zähnenbesatz". The vasa deferentia are united in the sixth trunk somite into an unpaired duct which empties into the middle of the glandular part of the atrium. The spermatheca is a simple,

flask-shaped sac. Dorsal segmental muscles absent. Two deep invaginations, one dorsal and the other ventral, are present. Host, *Cambaroides similis* (KOELBEL).

Localities. Korea (Hokkanri, Keikidô; Chûnan, Chûsei-nandô; Seishû, Chûsei-hokudô).

Remarks: The present species resembles *Br. parasita* in several points, but the former is distinguished from the latter by the number of small lateral teeth of the dental plates and the absence of the "Zähnchenbesatz" in the penis.

Branchiobdella digitata PIERANTONI

Branchiobdella digitata: PIERANTONI, 1906 b, p. 1, pl. V, 1-5; 1912, p. 18, fig. 11.

PIERANTONI'S original description of the species was based on material obtained from the crayfish, *Cambaroides japonicus*, collected in Hokkaido and deposited in the Natural History Museum of Paris. No specimens referable to the species were accessible to the present writer.

Branchiobdella kobayashii sp. nov.

(Fig. 2)

The body is rather club-shaped, measuring 0.6-1.0 mm long and 0.15-0.2 mm wide in the widest portion of the trunk about the seventh somite in preserved worms. The peristomium is relatively large, having about a length about equal to that of the pharyngeal portion of the head, and is evidently divided into a dorsal and a ventral lip; both more or less incised in the middle line, and the latter more or less larger than the former. In addition, a small lateral liplet slightly incised into about 3 or 4 lobes, is located at the junction of the two lips on either side. There are no papillae around the mouth. The pharyngeal portion is relatively narrow. The diameter of the sucker is larger than the width of the pharyngeal portion. The trunk is gradually widened from the first backwards

to the seventh somite and then becomes narrower towards the posterior end. In the second to the eighth major annuli, the body wall is more or less elevated forming transverse ridges running dorso-laterally. Dental plates, both dorsal and ventral, slightly brown in colour and of dissimilar structure; the dorsal one possesses only a single long median tooth, while the ventral one is provided with five short sub-equal teeth (Fig. 2, B, C). The anterior nephridia open outside by one pair of pores located in the dorso-lateral side. The paired glandular areas were observed in the eighth and the ninth major annuli, each bearing one pair of the areas. They are small and obscure, some of them being often inconspicuous.

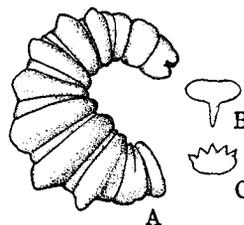


Fig. 2. *Branchiobdella kobayashii* n. sp.; A, lateral view $\times 44$; B, anterior view of dorsal dental plate $\times 440$; C, anterior view of ventral plate $\times 440$.

The male funnels are paired in the fifth trunk somite; liberated active male reproductive cells are found only in this somite (Pl. II, 6). The spermathece is in the fifth trunk somite and of flask-shape. The atrium is situated in the sixth trunk somite, having a similar structure to that of the preceding species, though the muscular penis sheath is relatively short. The dorsal segmental muscles are well developed in the second to the eighth major annuli, corresponding to the dorsal transverse ridges (Pl. II, 6). Host, *Cambaroides similis* (KOELBEL):

Localities. Korea (Chûnan, Chûsei-nandô; Seishû, Chûsei-hokudô).

Remarks: The present species seems to be distinguished from other species by the structure of the dental plates and the presence of the dorsal transverse ridges.

Genus *Cambarincola* ELLIS, 1912

Cambarincola: ELLIS, 1912, p. 481; 1920, p. 225; STEPHENSON, 1930, p. 801.

The genus has several characters in common with *Stephanodrilus*, but differs in the structure of the atrium and of the dental plates etc. Seven species are known in the genus, but *C. homodonta* described by the present writer (1932 c) has been removed to *Stephanodrilus* in this paper. All the other species have been reported from North America except *C. okadai*.

Cambarincola okadai YAMAGUCHI

Cambarincola okadai: YAMAGUCHI, 1933, p. 191, figs. 1-2.

The body is rather elongated and cylindrical; the head being broader than the first trunk somite and distinctly demarcated from the latter by a constriction in preserved specimens. The trunk is gradually widened from the first to the seventh trunk somite, and then becomes narrower towards the posterior portion. Among the specimens examined, the largest is 7 mm long and 0.8 mm wide at the widest portion of the trunk. The dorsal part of the peristomium is provided with four distinct dignitiform lobes, while the ventral part is thick and slightly bilobed. The mouth is surrounded by about sixteen papillae. Both the dorsal and ventral dental plates are brown in colour, of similar size and the same dentition, forming an isosceles triangle with the longest base in anterior view. Each plate has a large conical tooth forming the apex of the plate, and two denticles on each side. The anterior nephridia open in a common median dorsal pore on the third major annulus of the trunk.

Two pairs of male funnels are present, anterior pair in the fifth trunk somite and posterior pair in the sixth. The coelomic cavities of both the somites are filled with liberated male germ cells in various stages of development. The spermatheca is tubular and not bifid, located in the fifth trunk somite. The atrium is in the sixth trunk somite; divided into a glandular part, a muscular portion and a bursa. The glandular part is bifid and is provided with two tubular branches; the distal end of a branch joining with vasa deferentia. The other branch which terminates in a blind end, is an "accessory

sperm tube" named by ELLIS (1912). The structure of the muscular portion and the bursa seems to resemble that of corresponding parts of *Stephanodrilus*, though the writer could not be clear in detail about certain points. Obtained from crayfishes transferred from North America into Japan.

Locality. Lake Chûzenji, Nikko.

Genus *Stephanodrilus* PIERANTONI, 1906

Stephandrilus: PIERANTONI, 1906 b, p. 6; 1912 b, p. 18; STEPHENSON, 1930, p. 800; YAMAGUCHI, 1932 b, p. 63.

Cirrodrilus: PIERANTONI, 1905, p. 2; 1912, p. 8; STEPHENSON, 1930, p. 800; YAMAGUCHI, 1932 a, p. 361.

Ceratodrilus: HALL, 1914, p. 191; STEPHENSON, 1930, p. 801; YAMAGUCHI, 1932 a, p. 361, 366.

Carcinodrilus: YAMAGUCHI, 1932 b, p. 62.

The genus, with the genera newly involved, *Ceratodrilus* and *Carcinodrilus* is revised as in the following diagnosis.

Peristomium composed of a thick, generally bilobed ventral lip, and two dorso-lateral portions divided into several lobes which are sometimes elongated to form digitiform or tentaculiform appendages; these lobes consist of 8 long lobes, 4 dorsal and 4 lateral in two pairs, and sometimes several short intermediate ones located between the long ones. Peristomium often extending to form a funnel-like expansion around the mouth. With or without dorsal transverse bands or ridges. Dorsal appendages present or absent. Anterior nephridial pores paired or rarely unpaired; both dorsal and ventral dental plates sub-equal or dissimilar in size; each plate provided with 7 or more teeth, a large median and 3 or more small lateral ones on either side. Testes and male funnels in trunk somites V & VI; atrium consists of glandular part, muscular portion and bursa; no distinct muscular penis sheath. Glandular part of the atrium not bifid, tubular or bulged form; no paired bursal glands. Penis sub-conical in form, having a narrow eversible efferent duct folded several times at the basal portion. Spermatheca not bifid and composed of two enlarged portions, one in the distal end the

other in about the middle portion, lumen of the two portions connected by a very narrow canal.

The genus is divided into two subgenera:

Subgenus *Stephanodrilus*; without dorsal appendages, e.g. *St. sapporensis*.

Subgenus *Ceratodrilus*; with dorsal appendages, e.g. *St. cirratus*.

***Stephanodrilus* (St.) *inukaii* sp. nov.**

(Pl. I, B; Figs. 3, 4, 5)

The body is about 1 mm long in contracted state and about 1.5 mm long or more in well extended condition. In resting or contracted state it is club-shaped, and more or less flattened in the posterior region; while in fully extended state it is rather cylindrical throughout the whole length with gradually narrowed anterior por-

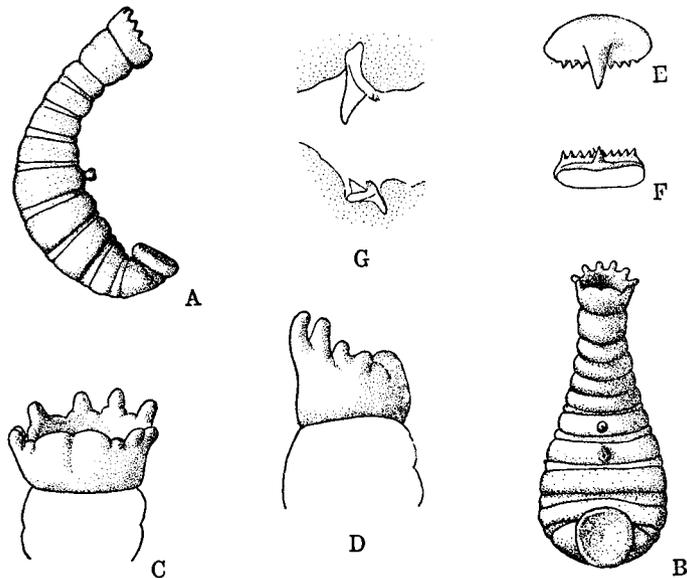


Fig. 3. *Stephanodrilus inukaii* n. sp.; A, lateral view $\times 44$; B, ventral view $\times 44$; C, ventral view of peristomium $\times 110$; D, side view of peristomium $\times 110$; E, F, posterior view of dental plates $\times 440$; E, dorsal plate, F, ventral plate; G, dorsal and ventral plates sketched *in situ* from the right side $\times 440$.

tion. The peristomium is relatively large, and slightly funnel-shaped in its expanded state; it is composed of a large thick ventral lip and dorso-lateral portions. The former is slightly bilobed with a median incision, and a small emargination is found on either side of the lobes. The latter is cleft into four sub-equal dorsal lobes and four sub-equal lateral ones, the dorsal lobes being slightly larger than the lateral ones (Fig. 3, C, D). The diameter of the sucker is more or less large than the width of the pharyngeal portion. The mouth is surrounded by circlet of sixteen small papillae. The dorsal and ventral dental plates are slightly brown in colour and of dissimilar size, the dorsal one being larger than the ventral. The plates are both provided with a median large tooth and small teeth arranged in a transverse row in front of the median tooth (Fig. 3, E, F, G). The number of small teeth is more or less variable ranging from eight to twelve. The median tooth of the dorsal plate is larger than that of the ventral. The trunk is destitute of dorsal transverse ridges and appendages. The anterior nephridial pores lie in pair in lateral sides, so that they are hardly seen from dorsal aspect. The spermathecal pore is situated on a conspicuous papilla. The glandular areas are in two pairs in the eighth major annulus and one pair in the ninth, but some of them are often inconspicuous.

Vasa deferentia in two pairs, anterior pair in the fifth and posterior pair in the sixth trunk somite, each vas deferens having a distinct male funnel. The testes proper are reduced and inconspicuous, but liberated male germ cells in various stages of development are abundantly found in the coelomic cavities of the fifth and sixth trunk somites (Pl. II, 9, 10). The atrium is in the sixth trunk somite and two portions are distinguishable, a distal glandular part and a muscular portion (Fig. 4, A). The former is mainly made of columnar or irregular pyramidal cells with deeply stained cytoplasm. It is a long tube with a blind end, irregularly folded about twice or more, being usually extended over the alimentary canal. The vasa deferentia are united with each other in the sixth trunk somite into an unpaired duct leading to the glandular part

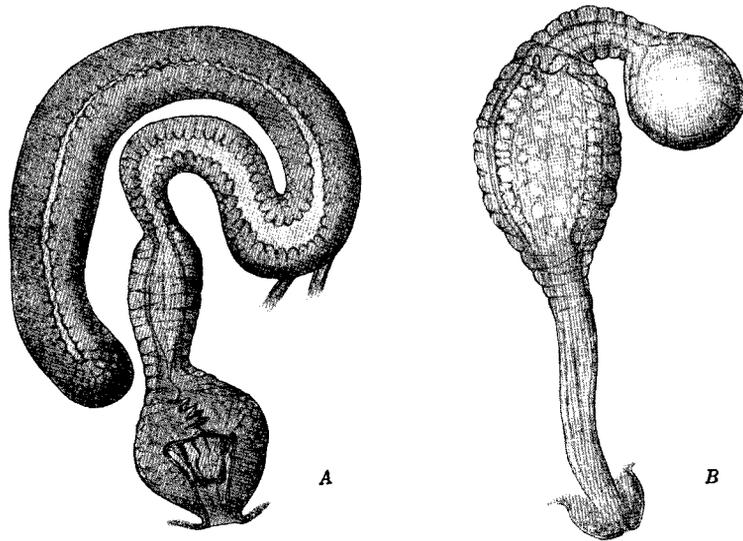


Fig. 4. Atrium and spermatheca of *Stephanodrilus inukaii* n. sp., sketched from a living specimen about $\times 240$; A, atrium, B, spermatheca.

at some distance from its ental end. The muscular portion is further divided into a large approximately spindle-shaped muscular atrium and a large spherical bursa. The muscular atrium is principally made of a single layer of circular muscles, of which the inner side is lined with an epithelial layer irregularly folded longitudinally. The wall of the bursa consists principally of single layered epithelium containing large irregular columnar cells (Fig. 5; Pl. II, 11). The circular muscle bordering the muscular atrium extends to wrap the outside of the ental half of the bursa, then towards the middle portion decreases in thickness, finally becomes inconspicuous and appears again in the ectal portion as a sphincter (Fig. 5, sph). There can be seen no paired bursal glands which are well developed in *Bdellodrilus illuminatus*, *Pterodrilus disticus* etc. The ental end of the bursal wall is elevated to form a sub-conical penis which is provided in the basal part with a narrow eversible canal irregularly folded and opening at the tip of the penis and communicating with the lumen of the muscular atrium. There is no evident muscular penis sheath (sac) with sub-epithelial space as seen in *Brandchiobdella* and *Bdellodrilus*. The surface of the penis, the whole inner

surface of the muscular atrium, the narrow eversible canal and the bursal wall are all covered with a continuous cuticular lining which extended over the whole surface of the epidermis

The spermatheca situated in the fifth trunk somite is not bifid, having two enlargements, one in the distal end and the other about in the middle portion (Fig. 4, B). The distal enlargement is sub-spherical in form and encloses a wide spacious cavity. The middle enlargement is more or less spindle-shaped and also encloses a wide space. In the core of the short cylindrical portion connecting the two enlargements runs a very narrow canal joined the two wide spaces. The proximal part of the middle enlargement becomes gradually narrower towards the spermathecal pore. Well-developed muscles bordering the spermathecal wall are developed in the distal but diminish towards the proximal part. The epithelium lining the entire inner surface of the spermatheca is composed of a row of cells relatively thin in the distal enlarged portion, and becoming thick in the portion joining with the enlargements. At the ectal end of the narrow canal there is present a semi-spherical fleshy process. The epithelium of middle enlargement is rather thin and folded, often containing refractive grains which are probably secretions. The epithelium of the narrow tubular portion near the spermathecal pore is rather thin and folded. The blood is slightly red. The dorsal segmental muscles are not found. Two deep pharyngeal invagina-

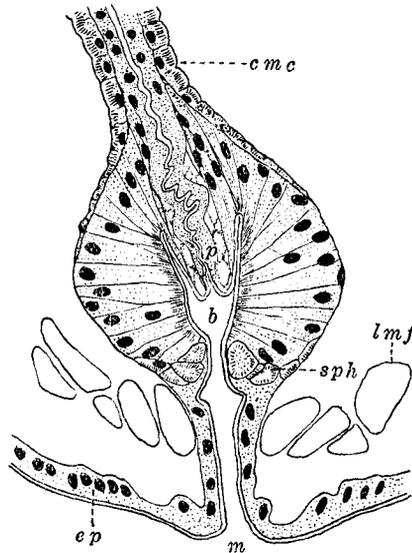


Fig. 5. Slightly schematized figure of transverse section of terminal male organ of *Stephanodrilus inukaii* n. sp., about $\times 540$; *b*, bursa; *cmc*, circular muscle coat; *ep*, epidermis; *lmf* longitudinal muscle fibers; *m*, male pore; *p*, penis; *sph*, sphincter.

tions, dorsal and ventral, and shallow ones located behind them are usually found. Found in the branchial chamber and on the body surface of the crayfish, *Cambaroides japonicus* (de HAAN).

Localities. Hokkaidô (Oshamambe, Kutchan, Muroran, Makomanai, Soranuma, Shimofurano, Sôunkei, Ichinohashi, Rubeshibe, Nokkeushi, Kushiro, Hattaribetsu, Nayoro).

Remarks: The original figures of *Branchiobdella digitata* given by PIERANTONI (1906) generally accord with the present species in external features and structure of dental plates. But the former possesses one pair of testes and male funnel (PIERANTONI, 1906, 1912), while the latter is provided with two pairs of those organs.

Stephanodrilus (St.) *aomorensis* sp. nov.

(Fig. 6)

The body, rather club-shaped, is about 1.3 mm long and 0.2 mm wide in preserved worms. The present species resembles both in internal and external characters the preceding species but differs

in the following points. The dorsal and lateral portions of peristomium are divided into seven lobes, four large and three small ones, each small lobe being situated between two large ones (Fig. 6, B). The anterior nephridial pores are located in the dorso-lateral sides so that they are easily visible in the dorsal view. Host, *Cambaroides japonicus* (de HAAN).

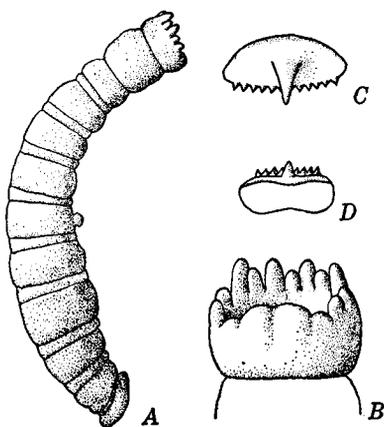


Fig. 6. *Stephanodrilus aomorensis* n. sp.: A, lateral view $\times 44$; B, ventral view of peristomium $\times 110$; C, posterior view of dorsal dental plate $\times 440$; D, posterior view of ventral dental plate $\times 440$.

Localities. Aomori-Ken (Shichinohe, Mekasawa).

Remarks: The present species seems to be closely related to

Stephanodrilus inukaii n. sp., but the species is distinguished from the latter by the peristomium and the position of the anterior nephridial pores.

***Stephanodrilus* (St.) *ezoensis* sp. nov.**

(Fig. 7)

The body, usually club-shaped, is about 2 mm long in contracted specimens and about 3 mm or more in fully extended state. The peristomium is pluri-lobed and the pharyngeal portion is usually narrower than the anterior end of the trunk. The sucker is very much wider than the pharyngeal portion. The mouth is surrounded by several (16?) oral papillae. The dental plates are brown in colour and of dissimilar size, the dorsal plate being much larger than the ventral one. The former plate (Fig. 7, B) consists of a median large conical tooth and a basal plate characterized by a number of fine ridges arranged more or less in parallel to the axis of the median tooth, having a lateral series of small teeth arranged in four pairs in its anterior surface at the base of the median tooth. The ventral plate (Fig. 7, C), though very small and different in shape, is similar to the dorsal one in structure, having small lateral teeth in about four pairs. No dorsal transverse ridges and appendages in the trunk. The anterior nephridial pores open in the dorsal side near the median line, between these pores there are four longitudinal muscle fibers. The spermathecal papilla is relatively large and semispherical in form. The genital organs are generally similar

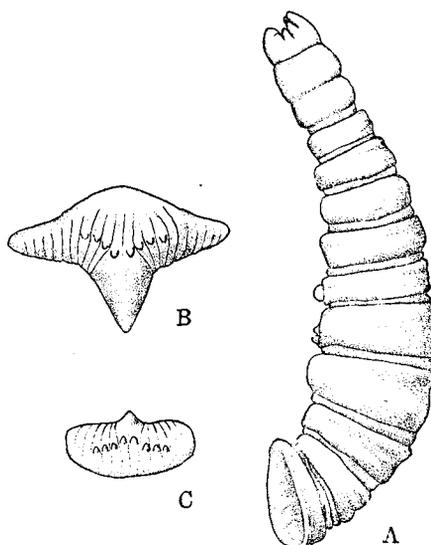


Fig. 7. *Stephanodrilus ezoensis* n. sp.; A lateral view $\times 44$; B, anterior view of dorsal dental plates $\times 440$; C, anterior view of ventral dental plate $\times 440$.

to those of *St. inukaii* n. sp. but the glandular atrium is cylindrical and usually U-shaped. The blood is bright red so that the main vessels are easily visible from outside the body wall in living animals. The dorsal segmental muscules could not be found. Some individuals with no spermathecal papilla and no spermatheca have eggs found in the seventh coelomic cavity and spermatozoa in the glandular atrium. Found in the branchial chamber of *Cambaroides japonicus* (de HAAN).

Localities. Common in Hokkaidô (Oshamambe, Kutchan, Muro-ran, Makomanai, Soranuma, Hattaribetsu, Shimofurano, Sôunkei, Ichinohashi, Rubeshibe, Nokkeushi, Kitahama, Kushiro, Shintoku, Nayoro).

Remarks: The present species resembles *St. inukaii* n. sp. in external features, but differs in size, dental plates and glandular atrium etc.

^e
Stephanodrilus (St.) *megalodontatus* sp. nov.
(Pl. I, C; Fig. 8)

The present species resembles the preceding species in size, external and internal features, but has the following distinctions.

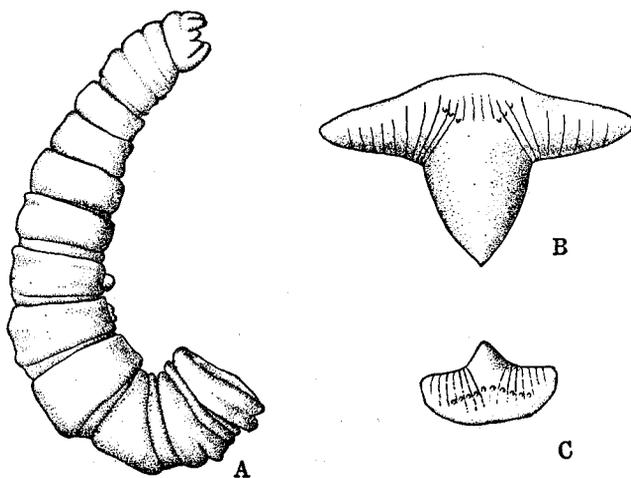


Fig. 8. *Stephanodrilus megalodontatus* n. sp.; A, lateral view $\times 44$; B, anterior view of dorsal dental plates $\times 440$; C, anterior view of ventral dental plate $\times 440$.

The median tooth of the dorsal dental plate is larger and stronger than that of the preceding species, and the small lateral teeth are rather rudimentary numbering about three on either side. The ventral plate is also provided with five to six rudimentary small lateral teeth on either side. The small lateral teeth are often very inconspicuous in the both plates. The anterior nephridial pores are widely separated, situated near the lateral lines, though they are located near the dorsal median line in the preceding species. Found in the branchial chamber of *Cambaroides japonicus* (de HAAN).

Localities. Hokkaidô (Kutchan, Lake Dôya, Makomanai, Soranuma, Shimofurano, Ichinohashi, Shintoku).

Remarks: It is difficult to distinguish the present species from *St. ezoensis* n. sp. by the naked eye. But the two species are different in dental plates and in the position of the anterior nephridial pores.

Stephanodrilus (St.) *japonicus* PIERANTONI

Stephanodrilus japonicus: PIERANTONI, 1912, p. 20, fig. 14.

PIERANTONI's description is based on specimens in the Museum of Hamburg. No specimen of the species was accessible to the writer.

Stephanodrilus (St.) *koreanus* PIERANTONI

(Fig. 9)

Stephanodrilus koreanus: PIERANTONI, 1912, p. 20, fig. 13.

The body, somewhat cylindrical, about 1.8 mm long and about 0.35 mm wide in largest preserved specimens. The dorsal part of the peristomium is provided with four sub-equal tentaculiform appendages, while the ventral lip is slightly bilobed as the result of the presence of a median incision. Two small lobes situated on either lateral side. The mouth is furnished with circumoral papillae. The pharyngeal portion is about equal in width to the first somite. The sucker is slightly wider than the pharyngeal portion. No dorsal transverse ridge and appendages. Dorsal wall of the third major

annulus bears a slight papilla in the mid-dorsal line. The anterior nephridia open outside of a common single pore situated at the tip of the papilla. The dorsal and ventral dental plates are both slightly brown in colour and nearly equal in size, having the same denti-

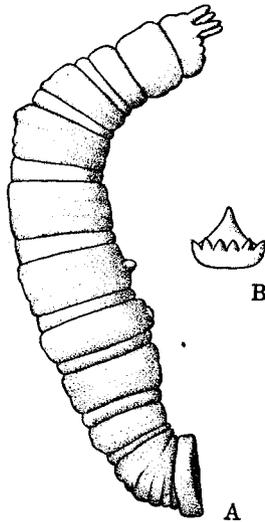


Fig. 9. *Stephanodrilus koreanus* PIERANTONI; A, lateral view $\times 44$; B, anterior view of dental plate $\times 440$.

tion (Fig. 19. B). The teeth of both plates include a large median and a series of six small ones. The spermathecal pore opens on a conspicuous papilla. The glandular areas are present in pair in the eighth and ninth major annuli.

The male funnels are present in pair in the fifth and sixth trunk somites. The coelomic cavities of these somites are filled with liberated male reproductive cells in several stages of development. Testes could not be detected. The spermatheca is marked by three regions; a narrow duct near the spermathecal pore, a middle and a distal enlarged portion as in other *Stephanodrilus*. The glandular atrium is tubular and more or less distended in the ental portion. The muscular atrium and bursa seem to be not different from other

species of *Stephanodrilus*. No dorsal segmental muscles. Two deep pharyngeal invaginations, dorsal and ventral, and shallow invaginations behind the deeper ones are usually observed. Host, *Cambaroides similis* (KOELBEL).

Localities. Korea (Chûnan, Chûsei-nandô; Seishû, Chûsei-hokudô).

Stephanodrilus (St.) *homodontus* (YAMAGUCHI)

Cambaricola homodonta: YAMAGUCHI, 1932 c, p. 454, fig. 1.

Body, rather cylindrical, measuring about 1.5 mm long and about 0.2 mm wide in preserved specimens. In living state the body

reaches about 2 mm or more and becomes more slender in extended condition. The peristomium, relatively small, is pluri-lobed and similar to *St. inukaii* n. sp. The mouth is surrounded by a circlet of sixteen papillae. The pharyngeal portion is, though often narrower, about equal in width to the first trunk somite. The diameter of the sucker is usually smaller than the width of the pharyngeal portion. The dental plates, slightly brown in colour, are similar in shape and size. The teeth of each plate include a large median and eight small teeth. No dorsal ridges and appendages. The spermathecal papilla is evident. Paired anterior nephridial pores located on the dorsal side near the median line, set close to each other¹). Glandular areas found in pair on the lateral side of the eighth and ninth major annuli. The areas are visible as slightly elevated papillae in dorsal view in living animals.

The genital organs are generally similar to those of *St. inukaii* n. sp. No dorsal segmental muscles found. Two deep pharyngeal invaginations, dorsal and ventral, were usually observed. A shallow invagination located behind each of the deeper ones was often found. The blood is nearly colourless. The present species is found on the surface of body of the crayfish, *Cambaroides japonicus* (de HAAN).

Localities. Hokkaidô (Sorunuma, Hattaribetsu, Shimofurano, Makomanai, Muroran, Shintoku).

Remarks: The present species was described as belonging to *Cambarincola* in the present writer's preliminary report (1932 c), but it has become clear that this species undoubtedly belongs to *Stephanodrilus*. The species is closely related to *St. japonicus*, but differs from the latter in the dental plates.

***Stephanodrilus* (St.) *makinoi* sp. nov.**

(Fig. 10)

The body, rather cylindrical, is about 2 mm long. The peristomium is relatively large and is divided into a thick bilobed ventral

1) It was erroneously stated by the present writer (1932 c) that the species has a median common pore of the anterior nephridia.

lip, five dorsal and four (in two pairs) lateral lobes. Out of the five dorsal lobes, four are paired and sub-equal in size, and slightly longer than the median lobe (Fig. 10, C, D). These lobes are evidently found also in young worms. The dental plates, dorsal and

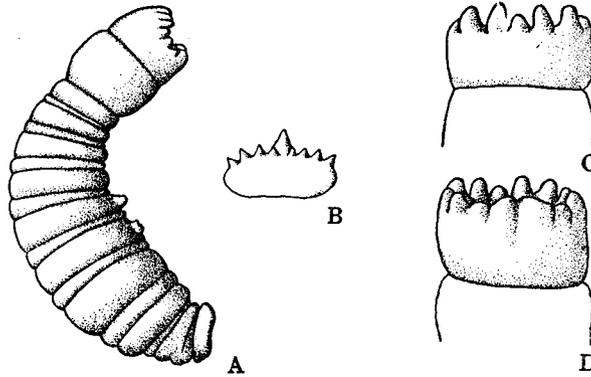


Fig. 10. *Stenphanodrillus makinoi* n. sp.; A, lateral view $\times 44$; B, anterior view of dental plate $\times 440$; C, dorsal view of peristomium $\times 73$; D, ventral view of peristomium $\times 73$.

ventral, are both slightly brown in colour and of sub-equal size. Both plates are each provided with a large median tooth and six to eight small lateral ones (Fig. 10, B), the structure of the plates resembling that of the preceding species. The anterior nephridial pores are located on the dorsal side near the median line; between them are located about two longitudinal muscle fibers. General characters coincide with the preceding species. Host, *Cambarincola japonicus* (de HAAN).

Localities. Hokkaidô (Shintoku, Shimofurano, Rubeshibe, Muro-ran Oshamambe).

Remarks: The present worm quite resembles *St. homodontus*, but is distinct in lobation of the peristomium and position of the anterior nephridial pores.

***Stephanodrilus sapporensis* PIERANTONI**

(Pl. I, A; Fig. 11)

Stephanodrilus sapporensis: PIERANTONI, 1906 b, p. 3, pl. 5, figs. 9-15; 1912, p. 19; fig. 12; KAWAMURA, 1918, fig. 326.

The largest branchiobdellid in Japan. Body rather cylindrical and measuring 9-12 mm long and about 2-3 mm wide in preserved worms and reaching about 18 mm in fully extended specimens. The pharyngeal portion is large and usually oval in shape. The peristomium is relatively small (Pl. I, A; Fig. 11, A). Ventral part of the peristomium is furnished with a distinctly bilobed lip and a small lobe often visible on either side of the lip. Dorsal part of the peristomium is divided into thirteen digitiform lobes, eight long and five short ones alternative in position with the exception that the long lobes on both sides each stand most ventrally adjacent to another long one. The mouth is surrounded by a circlet of sixteen papillae, each of which is provided with a minute rounded process at the summit. Besides, one or two minute processes are also found on the inner surface of each papilla in large worms. The diameter of the sucker is smaller than the width of the pharyngeal portion. The dorsal wall of six major annuli III-VIII is more or less transversely ridged¹⁾ along the mid-segmental line. The ridges are usually visible in living specimens especially in contracted state, but become inconspicuous in preserved larger specimens. Both the dorsal and the ventral plates are sub-equal in size and of the same structure (Fig. 11, B, C). Each plate is deep brown in colour, and is provided with a large median tooth and a series of about 9 (7-10) small teeth on either side. The anterior nephridial pores are situated on the lateral sides. The spermathecal papillae are not conspicuous. Glandular areas were found in two pairs in the eighth and in one pair in the ninth major annuli.

1) The dorsal transverse ridge seems to be a rudimentary form of one of those present in *St. cirratus*, *Pterodrilus alvicornus*, etc.

The male funnels are situated in the fifth and sixth trunk somites. Male germ cells in various stages of development are found in these somites, liberated in their coelomic cavities.²⁾ The spermatheca and the atrium are relatively small; the glandular

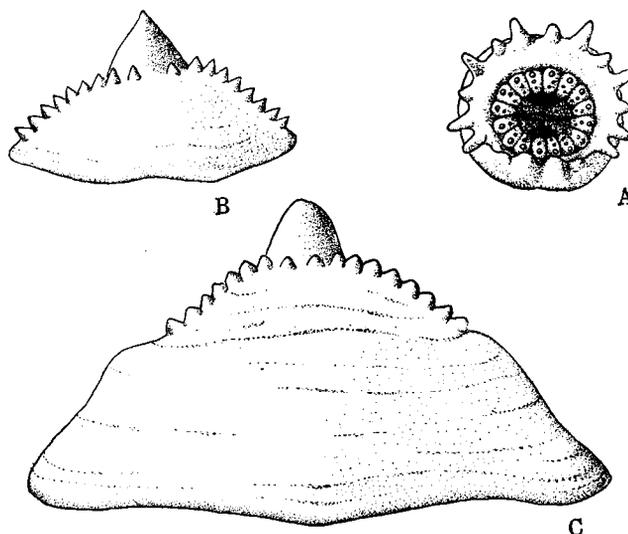


Fig. 11. *Stephanodrilus sapporensis* PIERANTONI; A, oral view of head $\times 10$; B, anterior view of dental plate in young specimen $\times 440$; C, anterior view of dental plate of adult $\times 440$.

atrium forms a slightly enlarged tube usually located on a lateral side of the intestine. Other characters of the genital organs do not differ from species of *Stephanodrilus* treated in this paper. The blood is nearly colourless. Two deep pharyngeal invaginations, dorsal and ventral, are usually present; and a very shallow invagination is often found behind the deep ones. The dorsal segmental muscles are found, each corresponding to a low dorsal transverse ridge.

1) According to PIERANTONI (1906, 1912), the sperm sac is present in this species, but the present author could not detect the organ. Sections show only that male germ cells are found in the coelomic cavity proper.

The species is found on the body surface of the crayfish, *Cambaroides japonicus*, especially on the ventral surface of the abdomen, carapace and basal portion of the ambulatory legs. The cocoons are found attached to the swimming legs of the host. They are oval in shape, with a stalk and about 1.5–2.5 mm in long diameter and 1.2–2.0 mm in short diameter. Length of stalk about 0.3–0.9 mm. Each cocoon contains a number of eggs or embryos (the writer counted forty six embryos in one of them.)

Localities. Very common in Hokkaidô (Shintoku, Lake Akan, Kitahama, Rubeshibe, Ichinohashi, Nayoro, Sôunkei, Shimofurano Makomanai, Muroran, Kutchan, Oshamambe, Hattaribetsu, Garugawa, Sapporo).

Remarks: The present species is easily distinguished from other species by its large size and by its peristomium of crown-like appearance.

Stephanodrilus (St.) *chosen* sp. nov.

(Fig. 12)

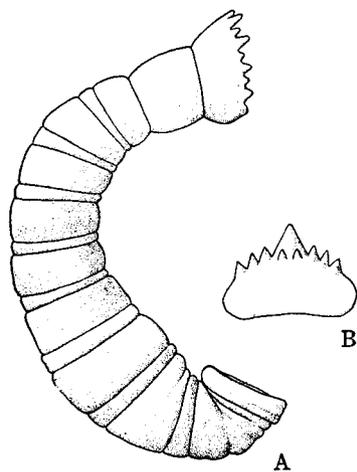


Fig. 12. *Stephanodrilus chosen* n. sp.; A, lateral view $\times 44$; B, anterior view of dental plate $\times 440$.

Body, rather cylindrical, measuring about 1.7 mm in length and about 0.3 mm in width in preserved specimens. Peristomium relatively large, when extended forming a membranous funnel-like expansion around the mouth. It is incised (in the dorsal and the lateral sides) to fifteen digitiform lobes at the free margin, while the ventral part is slightly bilobed. These digitiform lobes, eight long and seven short, situated alternately. The mouth is provided with several (16?) oral papillae. The pharyngeal portion is

more or less wider than the first trunk somite. The sucker and the pharyngeal portion are about equal in width. Both the dental plates are brown in colour and sub-equal in size, showing the same dentition (Fig. 12, B). Each plate is provided with a large median tooth and eight small teeth. The trunk is destitute of any dorsal transverse ridge or appendage. The anterior nephridial pores lie in pair on the dorso-lateral sides. Glandular areas were found in pair in the eighth and also in the ninth major annuli.

The male funnels are situated in the fifth and sixth trunk somites, the coelomic cavities of which are filled with liberated male germ cells in various stages of development. The glandular atrium is tubular and folded one time. Other characteristics of genitalia seem to be similar to those of *St. inukaii* and other species belonging to the genus. Host; *Cambaroides similis* (KOELBEL).

Localities. Korea (Hokkanri, Keikidô; Chûnan Chûsei-nandô; Seishû, Chûsei-hokudô).

Remarks: Though it somewhat resembles *St. nipponicus*, this species is easily distinguishable from it by the structure of the dental plates.

Stephanodrilus (St.) *nipponicus* (YAMAGUCHI)

Carcinodrilus nipponicus: YAMAGUCHI, 1932 b, p. 61, pl. III, figs. 1, 3, 5, Textfigs. 1, 2.

The body is cylindrical, measuring about 2 mm long and 0.4 mm wide in preserved specimens. The peristomium is large and conspicuous, being prolonged to form a membraneous funnel-shaped expansion which surrounds the mouth deep at the bottom. The funnel is divided into a thick ventral lip and a thin dorso-lateral portion. The former is slightly bilobed by a median ventral incision. Besides, a slight incision appears in the anterior margin of the lip on each lateral side. The anterior margin of the dorso-lateral portion of the funnel is divided into fifteen digitiform lobes, of which eight are long and seven are short, long and short ones alternating in position. Of the long lobes, the dorsal four are more or less larger than the rest.

The mouth is surrounded by a fleshy ring with a circlet of sixteen papillae at the base of the funnel. The pharyngeal portion is wider than the first trunk somite. The sucker is usually narrower than the pharyngeal portion. No dorsal transverse ridges and appendages. Both the dorsal and ventral dental plates are brown in colour, the dorsal one being slightly larger than the ventral. There are found on the dorsal plate a large median and about fourteen small teeth, and in the ventral a large median and about twelve small ones. The median tooth of the dorsal plate is larger than that of the ventral, while the dorsal small teeth are slightly smaller than the ventral ones. The anterior nephridial pores are located in pair on the dorso-lateral sides.

The male funnels are in two pairs, one located in the fifth trunk somite and another in the sixth. Liberated male germ cells in various stages of development are found in the coelomic cavities of these somites. The glandular atrium is tubular, very long, and usually folded one or two times. The muscular atrium and the bursa are not specially different from those of other species of *Stephanodrilus*. No dorsal segmental muscles. The blood is nearly colourless. Found in the branchial chamber of *Cambaroides japonicus* (de HAAN).

Localities. Hokkaidô (Makomanai, Soranuma, Hattaribetsu, Ichinohashi, Shintoku, Lake Shikaribetsu).

Remarks: Specimens on which the writer's previous description (1932 b)¹ was based, included some individuals of *Stephanodrilus uchidai* which has also a funnel-shaped peristomium furnished with several digitiform lobes but is provided usually with dorsal appendages. The photographs in the previous paper (pl. III, 4, 6, 7) were of aberrant specimens of *St. uchidai*, which entirely lacks dorsal appendages.

Stephanodrilus (St.) *kawamurai* sp. nov.

(Fig. 13)

Branchiobdella sp.: KAWAMURA, 1918, Fig. 324.

Body rather cylindrical and ventral surface of the posterior half more or less flattened, 2.0–3.5 mm long and about 0.3–0.4 mm wide in preserved specimens. The peristomium is large, having a slightly bilobed ventral lip, two pairs of short digitiform lateral lobes, and

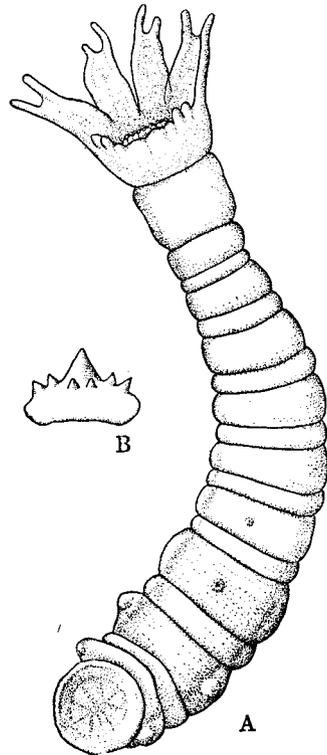


Fig. 13. *Stephanodrilus kawamurai* n. sp.; A, ventral view $\times 44$; B, anterior view of dental plate $\times 440$.

four extremely extended membranous dorsal lobes, each of which is again incised to form two long digitiform appendages (Fig. 13, A). Small lobes in a pair are situated between the lateral lobes and the ventral lip. The mouth is surrounded by a circlet of several oral papillae. The pharyngeal portion is slightly wider than the next following somite. The diameter of the sucker is usually wider than the pharyngeal portion. No dorsal transverse ridges and appendages. Two pairs of glandular areas form conspicuous papillae of which the anterior pair is situated on the ventro-lateral side of the eighth major annulus and the posterior one similarly on the ninth. The dental plates are slightly brown in colour, sub-equal in size and equal in structure (Fig. 13, B). Each plate is provided with a large median tooth and 6 small one. The anterior nephridial pores are separated, located on the dorsal side at about equal distance from both the median and lateral lines.

The male funnels are in pair in the fifth and the sixth somites. Male germ cells in various stages of development are found in these somites. The glandular atrium is a more or less bulged tubular sac. The muscular atrium, bursa and spermatheca generally coincide in characters with those of other species belonging to the genus. No

dorsal segmental muscles. The pharyngeal invaginations are similar to those of the preceding species. Host, *Cambaroides similis* (KOELBEL).

Localities. Korea (Taikyû, Keishô-hokudô; Hokkanri, Keikidô; Chôtanbu, Keikidô; Giseifu, Keikidô; Chûnan, Chûsei-nandô; Seishû, Chûsei-hokudô).

Remarks: The present species is easily distinguishable from other species by the remarkable structure of its peristomium. The species is only figured by Prof. KAWAMURA (1918) from specimens collected at Chôtanbu, Keikidô as *Branchiobdella* sp. The specific name is offered to him as an expression of the writer's hearty thanks for sending materials.

Stephanodrilus (St.) *suzukii* sp. nov.

(Fig. 14)

Body about 3–4 mm long and about 1.5 mm wide in preserved specimens. Peristomium, large and conspicuous, more or less funnel shaped, being usually incised to form fifteen digitiform or tentaculi-form appendages on the dorsal and lateral free margins. On the ventral side of the funnel there is a slightly bilobed ventral lip. Small lobes also found in pair on both lateral sides of the ventral lip, often prolonged to form short digitiform appendages. Out^{of} the fifteen appendages four long ones are plainly distinguished (Fig. 14, A). The mouth is surrounded by several papillae. The pharyngeal portion is wider than the anterior end of the trunk. The diameter of the sucker is equal to the width of the pharyngeal portion. The ventral side of the trunk is flattened, especially in the posterior region. Two pairs of glandular areas are large, showing conspicuous elevations (Fig. 14, A; Pl. II, 8). The dental plates are brown in colour, sub-equal in size and like in structure (Fig. 14, B). Each plate is provided with a large median tooth and a series of 8–10 small teeth. The anterior nephridial pores are separated, located on the dorsal side about midway between the dorso-median and the lateral lines.

Male funnels present in the fifth and the sixth trunk somites containing liberated male germ cells in various stages of development. The glandular atrium is tubular; the muscular atrium, the bursa

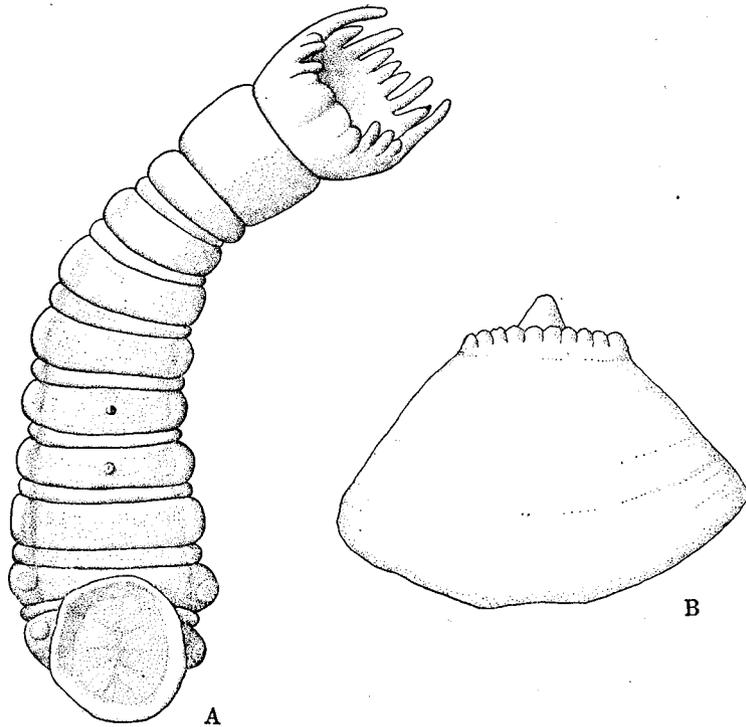


Fig. 14. *Stephanodrilus suzukii* n. sp.; A, ventral view $\times 30$; B, anterior view of dental plate $\times 440$.

and the spermatheca are generally similar in structure to those of other species of the genus. No dorsal segmental muscles (Pl. II, 7). Host, *Cambaroides similis* (KOELBEL).

Localities. Korea (Taikyû, Keishô-hokudô; Chûnan, Chûseinandô; Seishû, Chûsei-hokudô; Giseifu, Keikidô).

Remarks: The present species is easily distinguishable from other species by the structure of its dental plates, peristomium, and its depressed body form.

***Stephanodrilus (Ceratodrilus) uchidai* (YAMAGUCHI)**

(Fig. 15)

Ceratodrilus uchidai: YAMAGUCHI, 1932 a, p. 365, fig. 3.

Body usually about 2–3 mm long in preserved specimens. Peristomium large and conspicuous, always forming a funnel-shaped expansion around the mouth. The ventral portion of the funnel is more or less thick and is slightly incised in the median line to form a bilobed ventral lip. In addition, a slight incision occurs on the anterior margin of the lip on either side. The dorso-lateral portion is always divided into thirteen digitiform lobes or appendages, of which seven dorsal ones are considerably longer than the other three pairs situated near the ventral lip. From amongst the long ones, alternative four are more or less longer than the rest. The seven major annuli of the trunk, from the second to the eighth, are each furnished with a dorsal transverse ridge, with corresponding dorsal segmental muscles, running around the dorsal and lateral sides of each annulus. These ridges are with or without several short digitiform appendages (12 in maximum number). The dental plates are slightly brown in colour, sub-equal in size and similar in dentition. Each plate is provided with a large median tooth and six to eight small lateral ones arranged in series. The anterior nephridial pores are situated on the dorso-lateral sides, between them there are often present eight digitiform appendages. The spermathecal papillae are rather evident. The glandular areas are present in two pairs in the eighth major annulus and in one pair in the ninth. Four deep sub-equal pharyngeal invaginations were usually found in sections.

Male funnels occur in the fifth and sixth somites, of which the coelomic cavities contain male germ cells in various stages of developments. The glandular atrium has a relatively large bulged sac. The muscular atrium, bursa and spermatheca are similar in structure to those of other species of the genus. The blood is nearly colourless. Found on the body surface of the crayfish, *Cambaroides japonicus* (de HAAN).

Remarks: The present species is quite variable in external features especially in the peristomium and in the dorsal transverse ridges. As the variation occurs in series, these specimens all seem to belong to a single species. They are divided into the following two groups.

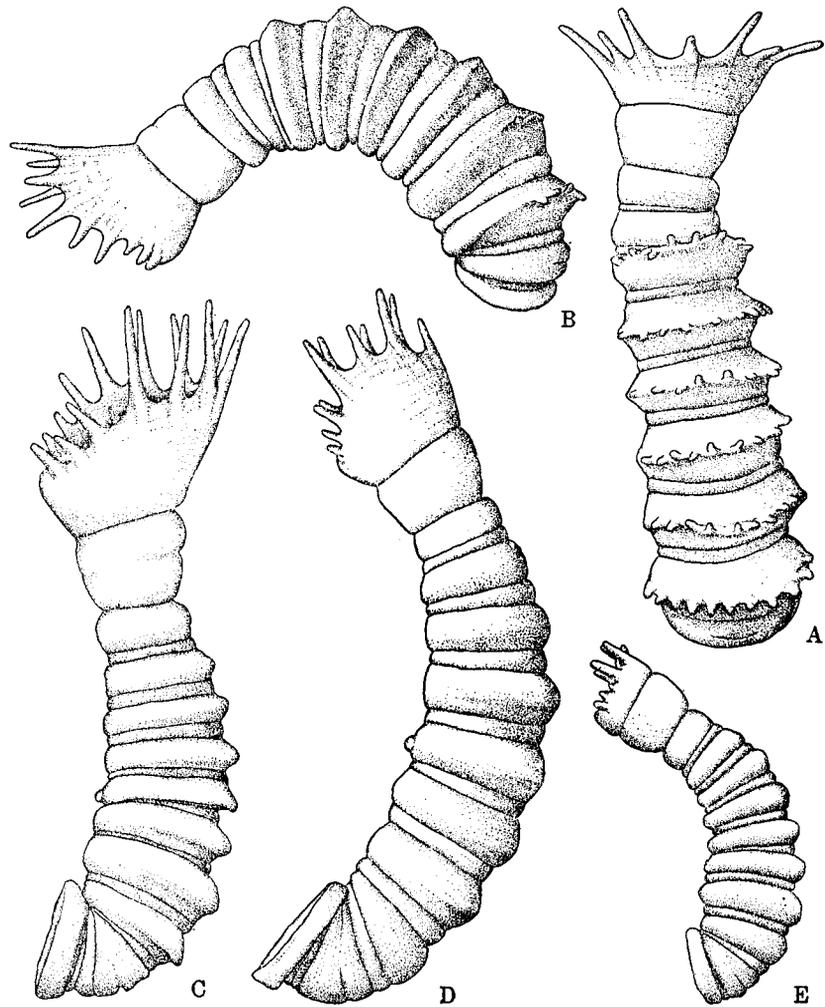


Fig. 15. *Stephanodrilus uchidai* (YAMAGUCHI) of different forms collected: A, at Shimofurano; B, at Kushiro; C, at Ichinohashi; D, at Shimofurano; E, at Oshamanbe. All $\times 44$.

a. Appendiculated form

(Fig. 15. A, B)

The digitiform appendages are found on several dorsal transverse ridges of the six trunk major annuli, from the third to the eighth. These appendages are twelve on each dorsal ridge in some individuals, while in some others the number is reduced in some anterior annuli. A specimen collected at Kushiro bears a small number of appendages only in the three major annuli, from the sixth to the eighth (Fig. 15, B). The peristomium is as in the typical diagnosis, though the size of the funnel varies more or less.

Localities. Hokkaidô (Sorunuma, Sapporo, Makomanai, Shimofurano, Kushiro, Lake Akan, Ichinohashi, Hattaribetsu).

b. Unappendiculated form

(Fig. 15. C, D, E)

No digitiform appendages on the dorsal transverse ridges. Peristomium usually lobed as in the appendiculate form, but specimens collected at Ichinohashi are provided with fourteen appendages in their peristomium (Fig. 15, C). These specimens collected at Ichinohashi have two appendages between the inner pair of the longest four appendages, but those collected from other localities have only one in a similar position. A few specimens, about 1 mm long, collected at Oshamambe bear a relatively small funnel-shaped¹⁾ peristomium provided with thirteen lobes (Fig. 15 E). Each dental plate is provided with a large median and six small teeth. Other characters are similar to those of the type species. These specimens were formerly thought to be young individuals, but sections revealed the presence of well developed spermatozoa and ova.

Localities. Hokkaidô (Shimofurano, Ichinohashi, Hattaribetsu, Makomanai, Kushiro, Lake Shikaribetsu).

1) The peristomium of very young individuals of *St. cirratus* and *St. uchidai* is not funnel-shaped.

Remarks: Unappendiculated forms are abundant in Shimofurano and Ichinohashi, but are rather rare in other localities. On the contrary the appendiculate forms occurring in several localities are relatively rare in the localities above mentioned. The unappendiculated forms from Ichinohashi more or less resemble *St. suzuki* n. sp. in external features, but differ in size and structure of dental plate, and number of peristomial lobes etc.

Stephanodrilus (Ceratodrilus) cirratus (PIERANTONI)

Cirrodrilus cirratus: PIERANTONI, 1905, p. 1, pl. 6: 1912, p. 9, fig. 1.

Pterodrilus sp.: KAWAMURA, 1918, fig. 325.

Ceratodrilus cirratus: YAMAGUCHI, 1932 a, p. 362, fig. 1.

Body rather cylindrical, about 2–3 mm long and about 0.35–0.5 mm wide in preserved specimens. The peristomium is large and funnel-shaped, being similarly incised on the anterior margin as in the preceding species. The mouth is fringed with 16 oral papillae. The pharyngeal portion is wider than the first trunk somite. The sucker is slightly wider than the pharyngeal portion. Dorsal transverse lamellar ridges, with corresponding segmental muscles (Pl. II, 4), are found in the six major annuli, from the third to the eighth. The dorsal segmental muscles are present in the second to the eighth major annuli, especially developed in the third to the eighth. In the second major annulus the muscles are not so developed. The lamellar ridges give rise to 8 long appendages on their free margin. The spermathecal papilla is relatively evident. The dental plates are both brown in colour, sub-equal in size and similar in structure. The dentition of these plates consists of a large median and six to eight small teeth. The anterior nephridial pores lie on the dorso-lateral sides of the lamellar ridge of the third major annulus, with six digitiform appendages between them. The glandular areas and pharyngeal invaginations are similar to those of the preceding species. Specimens collected in the western parts of Hokkaidô are provided with

the supre-oral papillae¹⁾, which are rather invisible in those from the eastern parts. Internal structures are similar to those of the preceding species. The species lives on the body surface of the crayfish, *Cambaroides japonicus*, especially of the first ambulatory legs, of which the articular portions are often parasitized by a large number of the worms.

Localities. Common in Hokkaidô (Sôunkei, Shimofurano, Hattaribetsu, Makomanai, Muroran, Kutchan, Oshamambe, Ichinohashi, Nayoro, Shintoku, Lake Akan, Kitahama Nokkeushi, Rubeshibe).

Remarks: The present species is closely related to the appendiculated forms of the preceding species, but is distinguished by the possession of the well developed dorsal transverse ridges with eight digitiform appendages and the number of appendages between the anterior nephridial pores.

6. Ecological notes

The present writer's observations on the locomotion of Japanese branchiobdellids, *Stephanodrilus sapporensis* St. *inukaii* n. sp., *St. (Ceratodrilus) cirratus* etc., lead generally to agreement with JANZEN (1931). Their locomotion seems to resemble that of *Helobdella staynalis* described by HERTER (1929). The worms in an aquarium usually attach to the substratum by means of the posterior sucker, and stretching out the body they move constantly in every direction as if seeking for attachment. They move about upon the substratum with a leech-like movement. The process of locomotion begins by stretching out the body (Fig. 16, 1). When the anterior end touches the substratum they fasten themselves to the substratum by both extremities, the body being extended (Fig. 16, 2). After tight attachment of the anterior end, they release the posterior sucker from the substratum, and then contract the body bending so as to bring the posterior sucker forwards just behind the anterior one (Fig. 16, 3, 4).

1) See the writer's previous paper (1932 a).

Then, they attach the posterior sucker, separate the anterior end from the substratum, and extend the body forwards (Fig. 16, 5). Thus repeating the action, the worms advance.

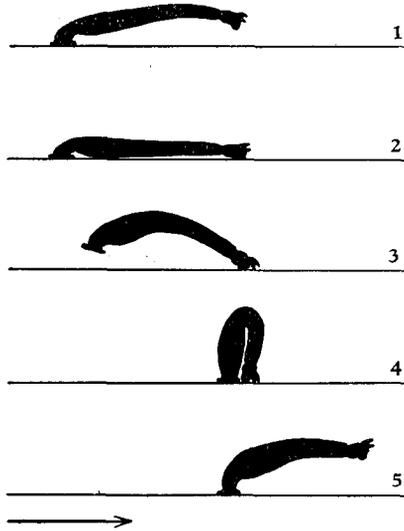


Fig. 16. Diagrammatic figures showing stages of locomotion for *Stephandrilus inukaii* n. sp.; arrow showing the direction of the locomotion.

As is stated regarding American and European species, the Japanese branchiobdellids are also divided into two groups as regards location to which they attach; some live in the branchial chamber and some live on the body surface of the host. In the first group are included *St. ezoensis* n. sp., and *St. megalodentatus* n. sp., while *St. sapporensis*, *St. homodontus*, *St. cirratus* and *St. uchidai* belong to the second group. *St. inukaii* n. sp., and *St. nipponicus* are found on the body surface as well as in the branchial chamber. The cocoons of the inhabitants in gill chambers seem to be attached to the gills of

the host, while those of the other branchiobdellids are attached to the swimming legs, the telson, the uropods, the ambulatory legs and other external portions of the host. From observations of the European species DORNER (1865) stated that the food of the branchiobdellids principally consists of the blood of crayfishes. SMALLWOOD (1906) expressed the opinion that the American species, *Branchiobdella instabilis*¹⁾ and *Bdellodrilus illumatus*, probably do not get food from the body of their hosts, since the digestive tract contains algae and diatoms even in the adult. According to HALL (1914) young branchiobdellids are not parasitic but live on vegetative detritus and small animals, though in the adult they suck the blood of the host.

1) The species has been referred to *Xironogiton* by ELLIS (1920).

So far as the present author's observations go, the intestine of the branchiobdellids inhabiting gills, such as *St. ezoensis* n. sp., are filled with viscid albumen-like fluid which is nearly colourless, transparent, and more or less refractive. In preserved conditions the contents ^{become} a coagulum deeply stainable with eosin. But in the digestive canal of those attaching to the surface of hosts are found Rotifera, Ciliata, Testacea, Diatoms etc., and also even small branchiobdellids belonging to different or to the same species. It seems to the writer probable that the albumen-like fluid is the blood of the host sucked by the worms.

There has been published no paper concerning copulation of the branchiobdellids except the report of ODIER (1823) on *Br. astaci*. During the studies, the present writer found by chance two preserved specimens of *St. inukaii* n. sp. *in copula*. These two animals are connected ventral to ventral at about the middle portion of the body making an X-form like Odier's figures (Fig. 17). Sections of these individuals

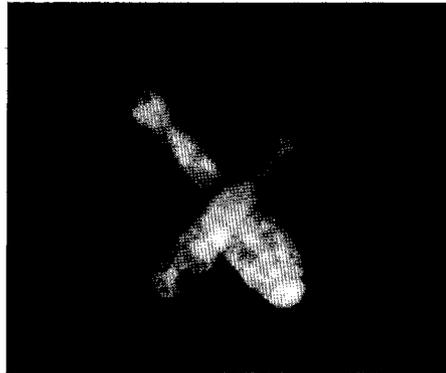


Fig. 17. Photomicrograph, two specimens of *Stephanodrilus inukaii* n. sp. *in copula*, about $\times 30$.

show that the extruded penis of one individual was inserted deeply into the spermathecal pore of the other, while the spermathecal papilla of the latter was deeply pushed into the bursa of the former, the penis of the latter was also extended but not reaching the spermathecal pore of the former (Pl. II. 12).

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Plate XII

Explanation of Plate XII

(All drawn from life)

- A. *Stephanodrilus sapporensis* PIERANTONI, dorsal view $\times 15$.
- B. *Stephanodrilus inukaii* n. sp., dorsal view $\times 80$.
- C. *Stephanodrilus megalodentatus* n. sp., dorsal view $\times 50$.
- D. *Stephanodrilus cirratus* (PIERANTONI), dorsal view $\times 80$.



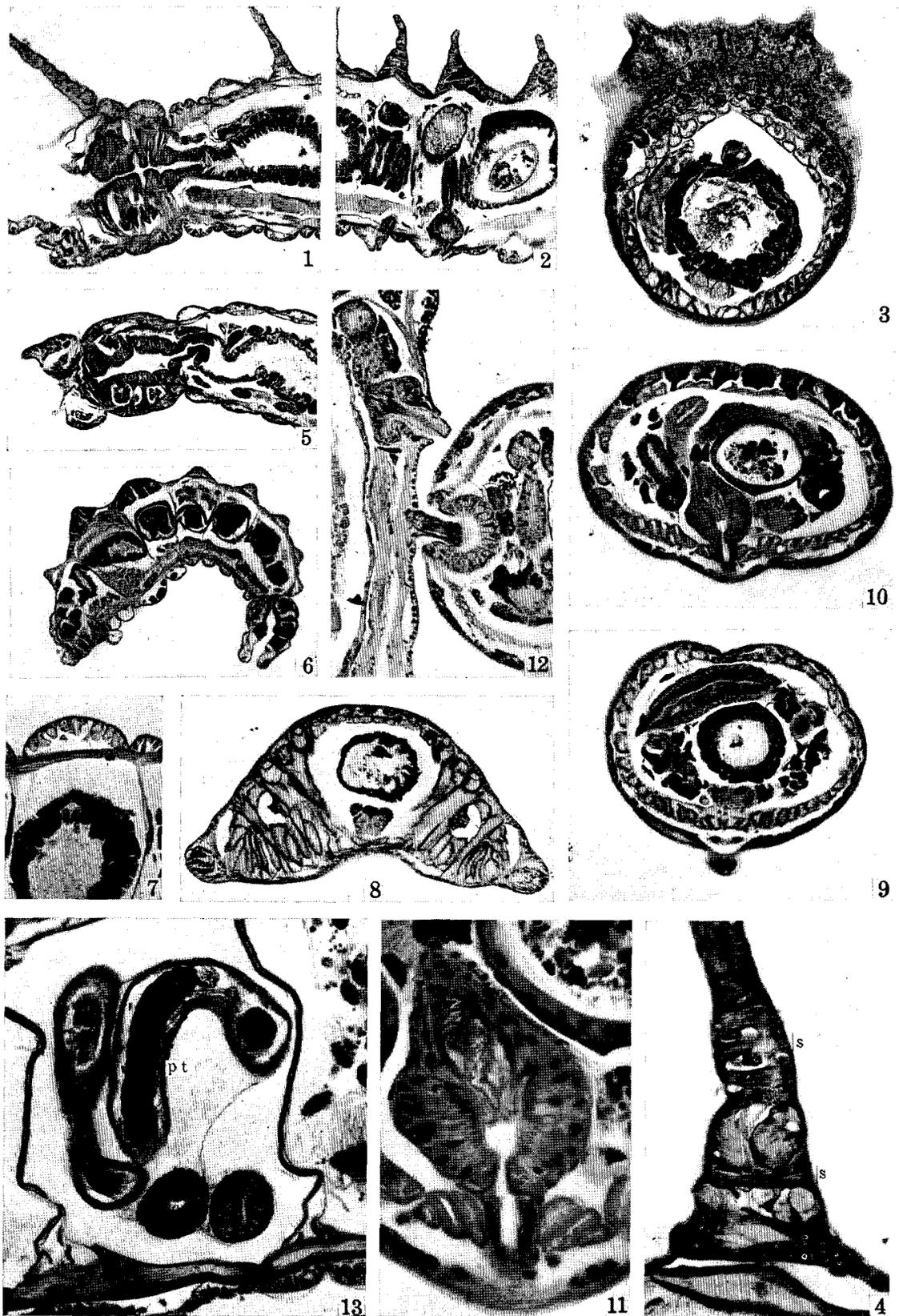
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Plate XIII

Explanation of Plate XIII

(Photomicrographs taken from sections.)

- 1) Longitudinal section of anterior portion of *Stephanodrilus cirratus* (PIERANTONI), $\times 80$.
- 2) Longitudinal section of middle portion of the same, $\times 80$.
- 3) Cross-section through third major annulus of the same, $\times 160$.
- 4) Longitudinal section of mid-segmental transverse ridge of the same, $\times 480$, s, dorsal segmental muscle.
- 5) Longitudinal section of anterior portion of *Stephanodrilus makinoi* n. sp., $\times 80$.
- 6) Longitudinal section of *Branchiobdella kobayashii* n. sp., $\times 80$.
- 7) Longitudinal section of dorsal part in fifth major annulus of *Stephanodrilus suzukii* n. sp., $\times 80$.
- 8) Cross-section through ninth major annulus of the same, $\times 80$.
- 9) Cross-section through fifth major annulus of *Stephanodrilus inukaii* n. sp., $\times 160$.
- 10) Cross-section through sixth major annulus of the same, $\times 160$.
- 11) More enlarged photograph of terminal male organ of the same section as 10., $\times 480$.
- 12) Section of two individuals of *Stephanodrilus inukaii* n. sp. in copula, $\times 160$.
- 13) Longitudinal section of about the sixth somite of *Branchiobdella orientalis* n. sp., $\times 160$, pt, penis sheath.



H. Yamaguchi photo.