

Taxonomic study of the Kinorhyncha in Japan. II. *Condyloderes setoensis*, a new species (Kinorhyncha: Cyclorhagida) from Tanabe Bay (Honshu)—first representative of the genus in the Pacific Ocean

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Abstract.—A new species of centroderid kinorhynchs, *Condyloderes setoensis*, new species, from muddy sediment at Tanabe Bay, Honshu Island, is described and illustrated using light and electron microscopy. Previously, members of the genus *Condyloderes* were found on the coasts of Scotland and the Netherlands in the North Sea (*Condyloderes multispinosus*), and the coast of India in the Bengal Bay (*C. paradoxus*). *Condyloderes setoensis* is the third species of the genus *Condyloderes* and the first representative of the genus in the Pacific ocean. A key to the three species of the genus is proposed. The genus *Condyloderes* is the fifth genus of the Kinorhyncha known from Japan and the ninth genus known from the Pacific.

Kinorhyncha constitute a taxon of meiobenthic, free-living, segmented and spined marine invertebrates, generally less than 1 mm in length. Previously, the taxon has been considered as a class of the phylum Aschelminthes (see Hyman 1951), but currently is considered an independent phylum with close relationships to aschelminth worms (see Higgins 1971, Kristensen & Higgins 1991). Recently, Adrianov & Malakhov (1994, 1999) included the Kinorhyncha as a class of the phylum Cephalorhyncha.

Only four genera of the Kinorhyncha have been recorded from Japanese waters. The first report of kinorhynchs from Japan was *Echinoderes* sp., found on the Pacific coast near Tokyo (Kawamura 1927). Years later, Abe (1930) described a new species, *Echinoderes masudai* Abe, 1930, from the vicinity of Hiroshima. This species is not currently designated as a valid species because of the very poor description (Higgins 1983, Adrianov & Malakhov 1999). Later, Tokioka (1949) and Sudzuki (1976a, 1976b) reported another species of *Echi-*

noderes, *E. dujardinii* Claparede, 1863. The finding of *E. dujardinii* in Japan is, however, highly questionable because the species is known only from European waters, and the reports of Tokioka (1949) and Sudzuki (1976a, 1976b) seem to represent a misidentification (Higgins 1983, Adrianov & Malakhov 1994). The second genus reported from Japan was *Kinorhynchus*, listed and illustrated by Sudzuki (1976a) and later identified as *Kinorhynchus yushini* Adrianov, 1989 (Adrianov & Malakhov 1999). Recently, Higgins & Shirayama (1990) described a new genus and new species, *Dracoderes abei* Higgins & Shirayama, 1990, from the Seto Inland Sea of Japan. Quite recently, a representative of the fourth genus, *Pycnophyes tubuliferus* Adrianov, 1989, was reported and re-described from Tanabe Bay, in the vicinity of the Seto Marine Biological Laboratory of Kyoto University (Murakami et al. 2001).

Representatives of the genus *Condyloderes* have never been reported in the Pacific Ocean. This genus consists of only two species, *Condyloderes multispinosus* (Mc-



Fig. 1. Map showing the collection site (black spot) of *Condyloderes setoensis* (Tanabe Bay, Kii-Peninsula, Honshu Island, Japan).

Intyre, 1962) Higgins 1969 and *C. paradoxus* Higgins, 1969. The former species was found in the North Sea, in a few localities in Scotland (Fladen, Lock Nevis, Lock Torridon) (McIntyre 1962) and on the coast of the Netherlands (Westerscheld Mouth) (Huys & Coomans 1989). The latter species was described from the Indian Ocean (Kakinaba Bay, Bay of Bengal) (Higgins 1969).

This is the description of the third species of the genus *Condyloderes*. It is also the first detailed morphological study of the genus using Nomarsky light microscopy and scanning electron microscopy (SEM).

Materials and Methods

Eleven specimens of the genus *Condyloderes* were collected in 2000 from a mud sample taken by a meiobenthic dredge at a depth of 15–27 m in Tanabe Bay, located at Kii peninsula of Honshu Island (33°42.2'N and 135°22.9'E), in the vicinity of Seto Marine Biological Laboratory of Kyoto University (Fig. 1). Living kinorhynchans were extracted from the sediment by the “bubble-and-blot” method (Higgins 1983). All specimens were fixed in 10% buffered formalin in seawater. Specimens were transferred into a 70% ethanol–5% glycerol–25% deionized water solution.

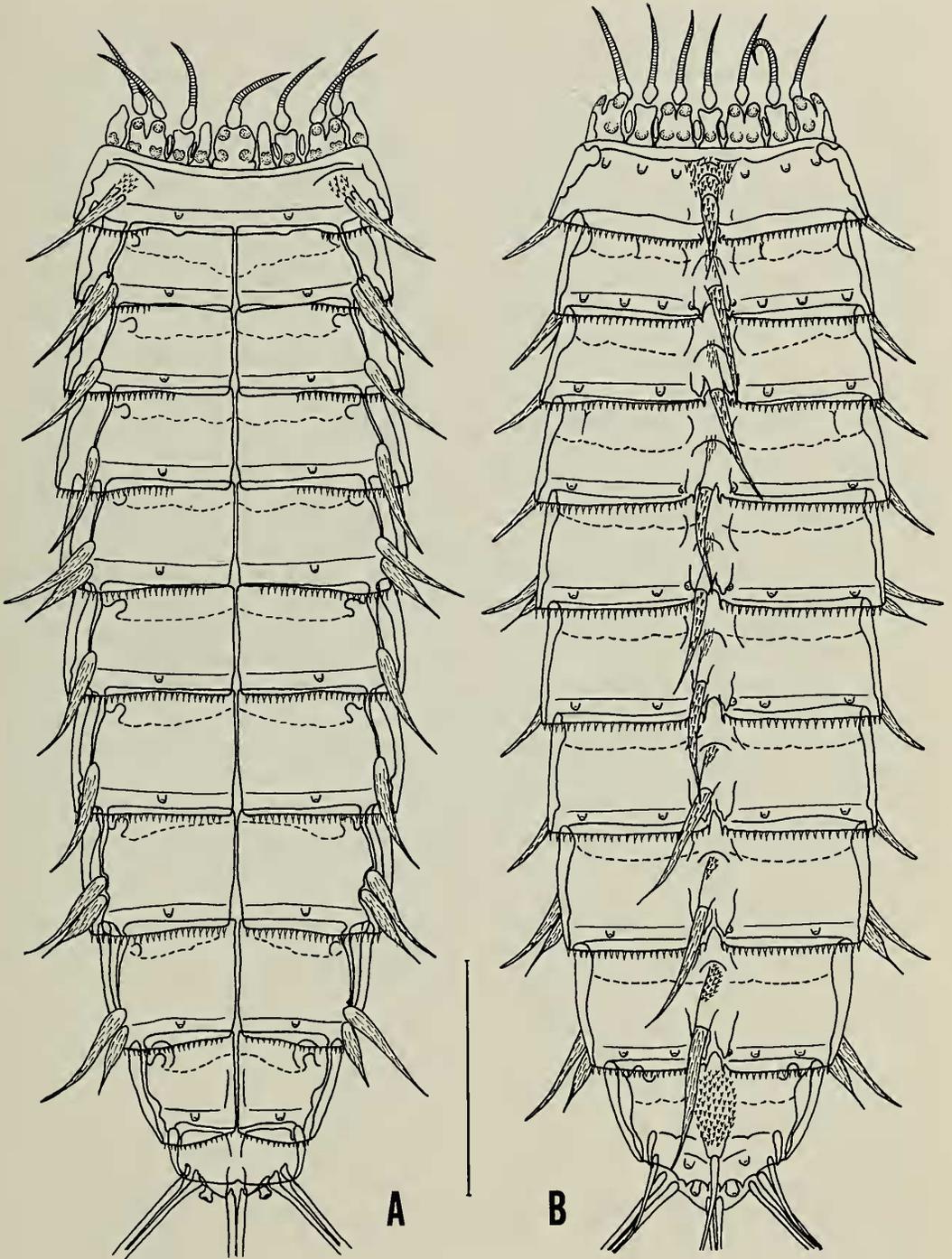


Fig. 2. *Condyloderes setoensis*, holotypic male (AVA-C-JAP-01.C). A, ventral view; B, dorsal view. Scale bar: 50 μ m.

Letting ethanol and water evaporate, the material was preserved in anhydrous glycerol. Eight specimens were mounted individually in Hoyer's-125 mounting medium between two cover slips, and positioned on Higgins-Shirayama plastic slide frames for further examination using differential interference contrast optics (Nomarsky optics). Three specimens were selected for SEM. These specimens were transferred by an Irwin Loop from 10% formalin to a vessel of distilled water and washed using a detergent to clean the body surface. The cleaned specimens were transferred to a minimal volume of distilled water, and ethanol was added slowly until the concentration came close to 100 percent. Thereafter, the specimens were washed with absolute ethanol several times, and finally replaced by tertiary-butyl alcohol. The specimens were dried in a freeze dryer, mounted on stubs coated with Platinum-Paladium, and observed using a SEM (Hitachi S-4300).

In the examination procedures, we followed the standard protocol described by Higgins (1983). Measurements are given in micrometers. Ratios are expressed in percent of the total length (TL) measured on the midline, from the anterior margin of segment 3 (first trunk segment) to the posterior margin of segment 13, exclusive of spines. Maximum sternal width (MSW) is measured at the anteroventral margin of the widest pair of sternal plates as first encountered in measuring each segment from anterior to posterior. Standard width (SW), or sternal width of segment 12, is measured at the anteroventral margin of 12th sternal plates. Measurements are given for the length of trunk segments (L), midterminal spine (MTS), lateral terminal spines (LTS), middorsal spines (DS), lateral spines (LS), lateral accessory, or cuspidate, spines (LAS) and subdorsal spines (SD). The locality data from material examined are referred to the collector's initials (AVA and CM). The specimens in the code CM are deposited in the meiofaunal collection of the Seto Marine Biological Laboratory of

Kyoto University, and those of AVA in the meiofaunal collection of the Institute of Marine Biology in Vladivostok, Russia.

Systematics

- Class Kinorhyncha (Reinhard, 1881)
Pearse 1936
- Order Cyclorhagida (Zelinka, 1896)
Higgins 1964
- Suborder Cyclorhagae (Zelinka, 1896)
Zelinka 1928
- Family Centroderidae Zelinka, 1896
Genus *Condyloderes* Higgins, 1969
- Condyloderes setoensis*, new species
Figs. 2–6

Diagnosis.—*Condyloderes* with 16 neck placids of unequal width, 7 wide placids alternating with 9 narrow ones, wide placids with two anterior and two posterior submarginal knobby projections, narrow placids with one knobby projection; each wide placid incised at anterior margin to accommodate trichoscalid centered above it; mid-dorsal, lateral and accessory lateral spines pilose; lateral accessory, or cuspidate, spines lanceolate, on segments 4, 7, 10 and 11; midterminal and lateral terminal spines sparsely pilose; segments 4–11 with distinct spiny protuberances at base of mid-dorsal spine, protuberances adjacent to deep middorsal incision of posterior margin of tergite; segment 13 with two dorsal and two ventral terminal tubicolous papillae with multi-papillate appearance at the top; tergal and sternal plates with prominent pectinate fringe at posterior margin.

Type material.—Holotype, adult male (AVA-C-JAP.01.C) (Figs. 2, 3A, B); allotype, female with mature oocytes (CM-A-JAP-04.C) (Fig. 3C, D); paratypes (Fig. 4C)—four adult males and one juvenile of undetermined sex; three adult males mounted for SEM (Figs. 5, 6).

Etymology.—Named after the place where it was discovered, i.e., in the vicinity of the Seto Marine Biological Laboratory of Kyoto University.

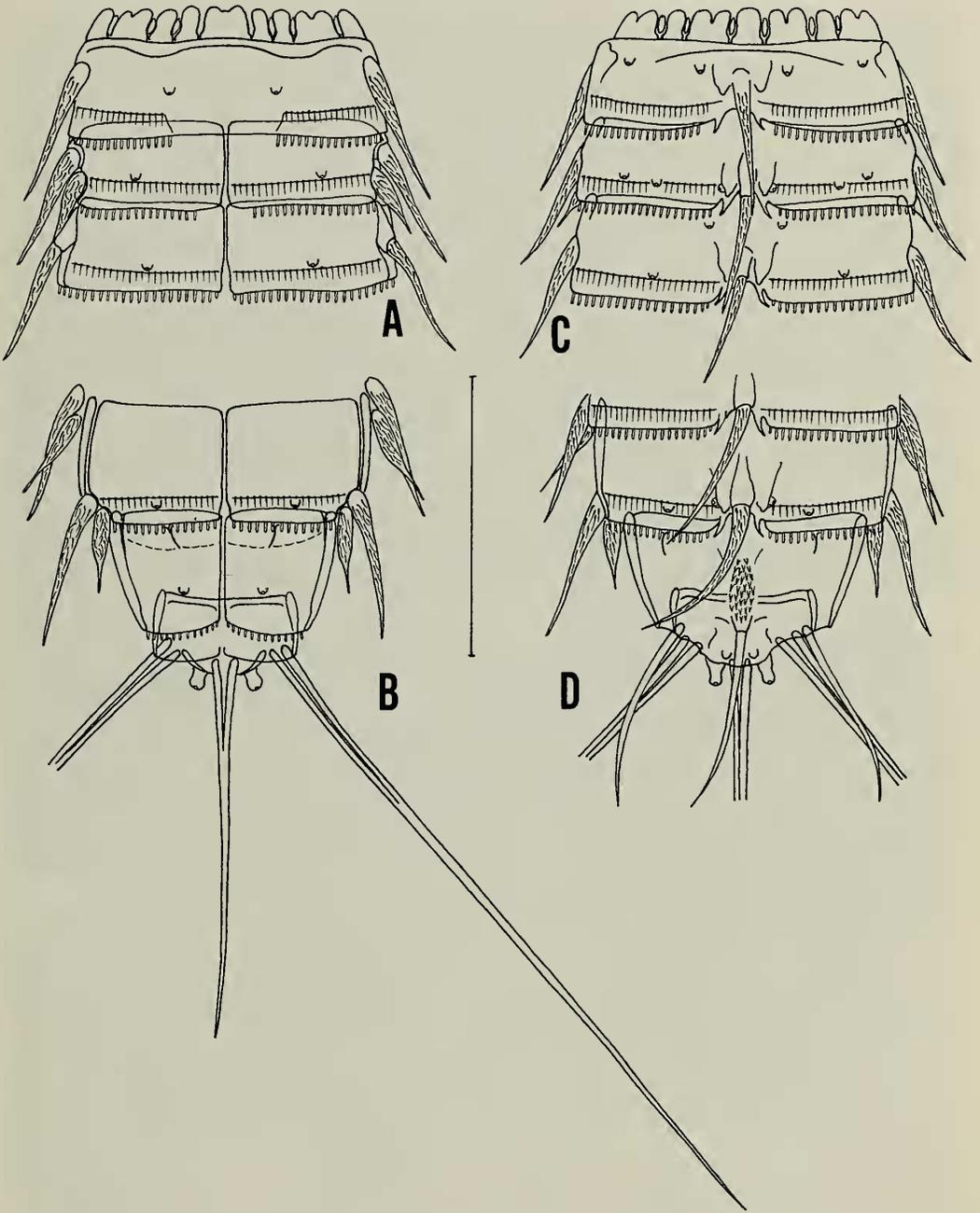


Fig. 3. *Condyloderes setoensis*, allotypic female (CM-A-JAP-04.C). A, B, ventral view; C, D, dorsal view; A, C, segments 2-5; B, D, segments 11-13. Scale bar: 50 μm .

Description

Holotype.—Adult male (AVA-CM-JAP.01.C) (Figs. 2, 4A, B); TL 296 μm ; MSW 786 μm , 29% of TL; SW 56 μm ,

19% of TL; MTS 93 μm , 31% of TL; LTS 180 μm , 61% of TL.

Type locality.—Muddy sediment at depth of 15-27 m, Tanabe Bay, Kii-Peninsula, pa-

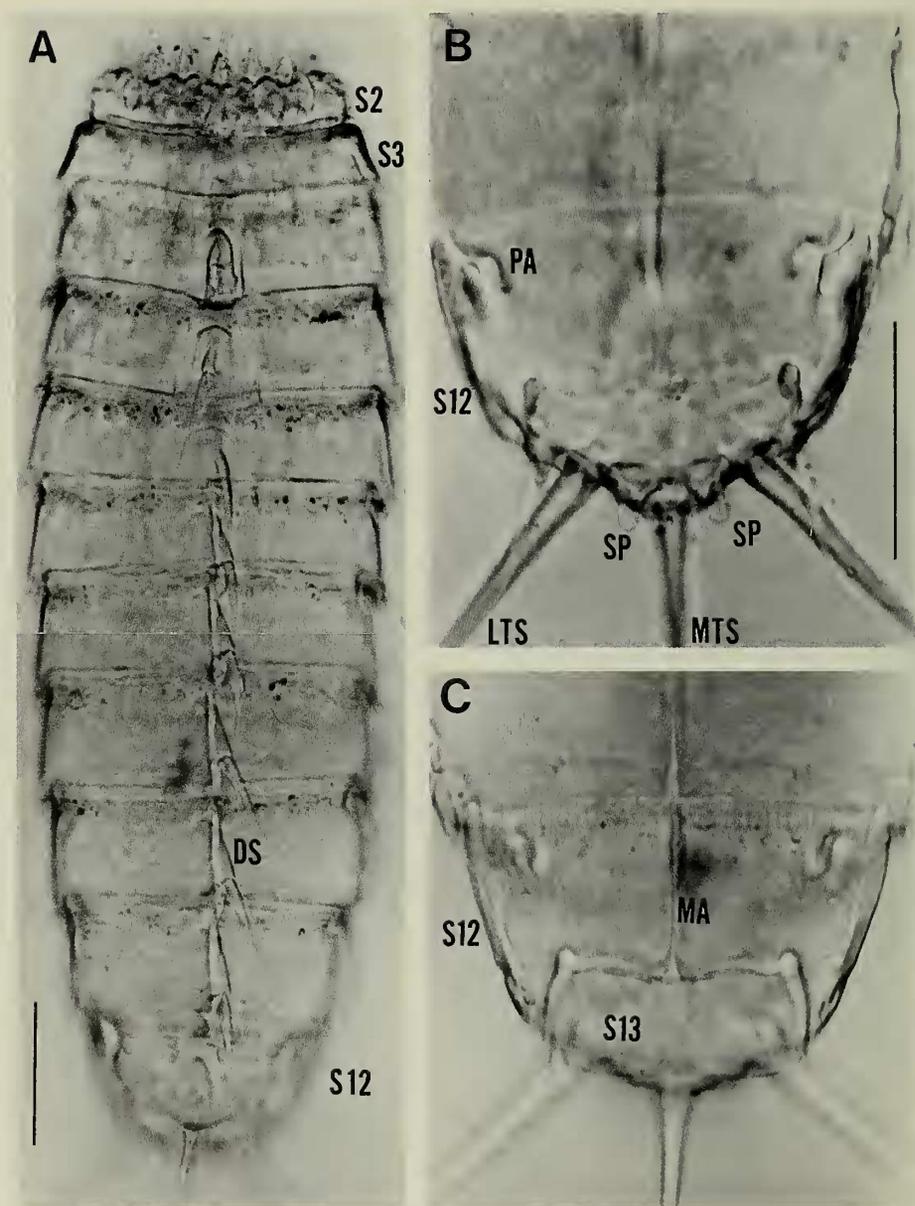


Fig. 4. *Condyloderes setoensis*. A, B, holotypic male; C, paratypic male (AVA-C-JAP-02.C); A, dorsal view of whole specimen; B, C, segments 11-13. Scale bar: 30 μ m. Abbreviations: DS, dorsal spine; LTS, lateral terminal spine; MA, midventral articulation; MTS, midterminal spine; PA, ventral pachycyeli; SP, dorsal terminal papilla; S, prefix followed by segment number.

cific coast of Honshu Island, Japan (33°42.2'N and 135°22.9'E) (Fig. 1).

Segment 1: Head partially withdrawn; posteriormost circlet of scalids composed of 14 trichoscalids.

Segment 2: Neck, with 16 poorly cutic-

ularized placids of unequal width, 7 wide placids alternating with 9 narrow ones; wide placids with two anterior and two posterior submarginal knobby projections; narrow placids with one posterior knobby projection; midventral placid widest, 14 μ m;

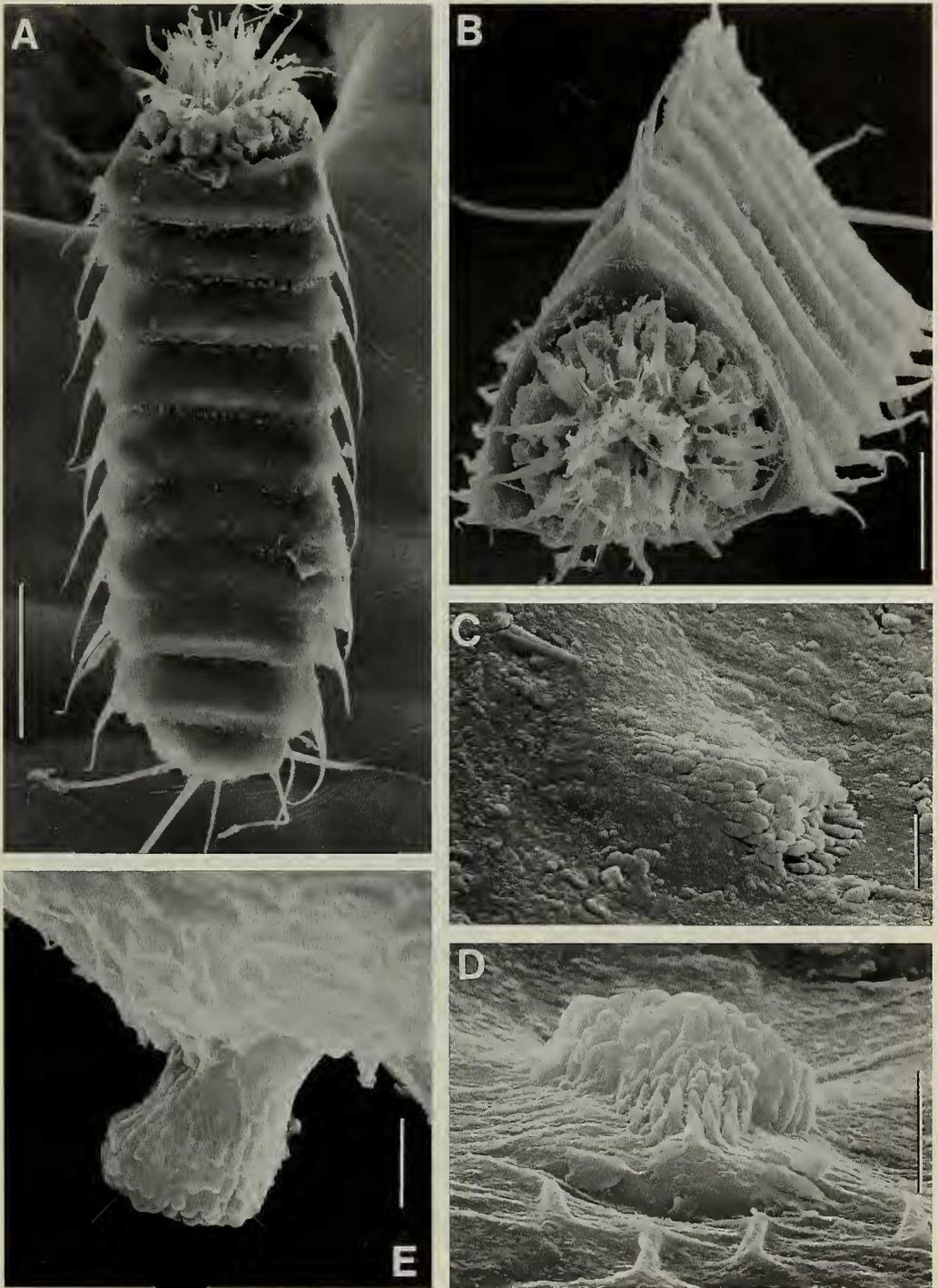


Fig. 5. *Condyloderes setoensis*, male, SEM photographs. A, lateral view from left side; B, frontal view; C, dorsal sensory papilla on segment 6; D, ventral sensory papilla on segment 9; E, dorsal terminal papilla on segment 13. Scale bars: A, 50 μm ; B, 25 μm ; C-E, 1 μm .

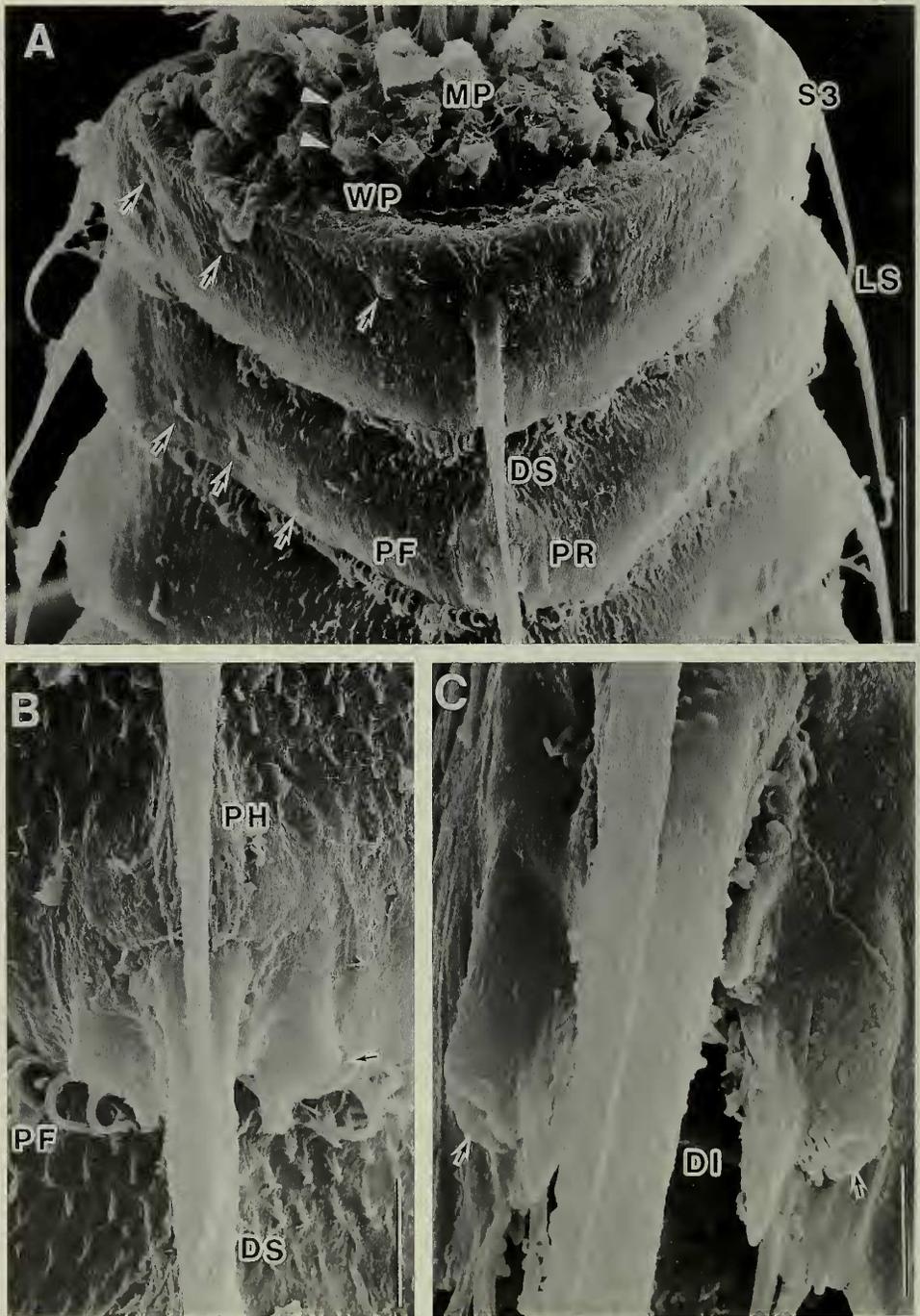


Fig. 6. *Condyloderes setoensis*, male, SEM photographs. A, dorsal view of segments 2-5; B-C, base of middorsal spines, spinose subdorsal protuberances adjacent to middorsal incision. Scale bars: A, 20 μ m; B, 5 μ m; C, 2.5 μ m. Abbreviations: DI, middorsal incision of posterior margin of tergite; DS, dorsal spine; LS, lateral spine; MP, narrow middorsal placid; PF, pectinate fringe; PH, patch of closely set of hairs at base of dorsal spine; PR, subdorsal spinose protuberance; S, prefix followed by segment number; WP, wide subdorsal placid; arrows indicate sensory papillae, arrowheads indicate anterior and posterior knobby projections of placid.

other wide placids 11–13 μm in width; narrow placids about 8 μm in width, placids adjacent to midventral placid slightly narrower than other narrow placids, 5 m in width; each wide placid incised at anterior margin to accommodate trichoscalid centered above it; placids not closely adjacent to each other, with narrow cuticular folds between neighboring placids.

Segment 3: First trunk segment; length 21 μm ; anterior margin slightly concave dorsally and ventrally, 99 μm in width; posterior margin with pectinate fringe interrupted at ventral side; posterior margin deeply incised middorsally; spacious dorsal patch of closely set of hairs at base of middorsal spine; small patch of closely set of hairs at base each lateral spine; middorsal and lateral spines pilose; middorsal spine 31 μm , lateral spines 35 μm ; with one pair of ventral and 3 pairs of dorsal sensory papillae.

Segment 4: Length 27 μm ; with two ventral plates; maximum sternal width 66 μm ; dorsal spine 34 μm ; lateral spines 30 μm ; lateral accessory spines 18 μm , slightly dorsal to lateral spines, basal two-thirds lanceolate, abruptly tapering, becoming filiform distal one-third; small patch of closely set of hairs at base of middorsal and lateral spines; posterior margin deeply incised middorsally, with pectinate fringe interrupted ventrally; with distinct spiny protuberances at base of middorsal spine, protuberances adjacent to middorsal incision of posterior margin; with one pair of ventral, 3 pairs of dorsal sensory papillae and one additional pair of papillae associated with subdorsal protuberances at base of middorsal spine.

Segment 5: Length 30 μm ; maximum sternal width 77 μm ; middorsal spine 37 μm ; lateral spines 30 μm ; similar to segment 4, except for lack of lateral accessory spines; in contrast to segment 4 ventral interruption of pectinate fringe more narrow, tergal plate with only two pairs of sensory papillae, without additional papillae asso-

ciated with subdorsal protuberances at base of middorsal spine.

Segment 6: Length 32 μm ; maximum sternal width 80 μm ; middorsal spine 37 μm ; lateral spines 32 μm ; similar to segment 5, except for presence of only one pair of dorsal sensory papillae and one additional pair associated with subdorsal protuberances.

Segment 7: Length 30 μm ; maximum sternal width 86 μm ; middorsal spine 37 μm ; lateral spines 32 μm , lateral accessory spines 21 μm ; similar to segment 4, except for presence of only two pairs of dorsal sensory papillae; different from segment 4 in having more narrow ventral interruption of pectinate fringe.

Segment 8: Length 30 μm ; maximum sternal width 85 μm ; middorsal spine 38 μm ; lateral spines 32 μm ; similar to segment 5, except for presence of more narrow ventral interruption of pectinate fringe.

Segment 9: Length 30 μm ; maximum sternal width 83 μm ; middorsal spine 40 μm ; lateral spines 32 μm ; similar to segment 8, except for lack of additional papillae associated with subdorsal protuberances at base of middorsal spine.

Segment 10: Length 34 μm ; maximum sternal width 82 μm ; middorsal spine 42 μm ; lateral spines 32 μm ; lateral accessory spines 24 μm ; similar to segment 7, except for lack of one pair of dorsal sensory papillae.

Segment 11: Length 37 μm ; maximum sternal width 77 μm ; middorsal spine 42 μm ; lateral spines 37 μm ; lateral accessory spines 19 μm ; similar to segment 7.

Segment 12: Length 30 μm ; sternal width 56 μm ; middorsal spine thin, 38 μm ; two subdorsal spines thin, not pilose, 38 m; without lateral accessory spines; with spacious patch of closely set of hairs at base of middorsal spine; without spinose subdorsal protuberances at base of middorsal spine; posterior margin of tergal plate incised middorsally and subdorsally; with pair of dorsal and pair of ventral sensory papillae.

Segment 13: Terminal segment, length 22 μm ; maximum sternal width 40 μm , midventral articulation underdeveloped; midterminal spine (93 μm) and lateral terminal spines (180 μm) sparsely pilose; with pair of dorsal and pair of ventral tubicolous papillae with terminal multi-papillate appearance.

Allotype.—Female with mature oocytes (CM-A-JAP-04.C); neck placids with knobby projections, similar to that of male; TL 226 μm ; L-3 19 μm , L-4 24 μm , L-5 27 μm , L-6 30 μm , L-7 30 μm , L-8 30 μm , L-9 30 μm , L-10 32 μm , L-11 34 μm , L-12 30 μm , L-13 19 μm ; anterior margin of segment-3 75 μm ; MSW-4 72 μm , MSW-5 75 μm , MSW-6 77 μm , MSW-7 78 μm (35% of TL), MSW-8 82 μm , MSW-9 80 μm , MSW-10 77 μm , MSW-11 70 μm , SW 56 μm (25% of TL), MSW-13 37 μm ; DS-3 37 μm , DS-4 38 μm , DS-5 38 μm , DS-6 39 μm , DS-7 40 μm , DS-8 41 μm , DS-9 43 μm , DS-10 45 μm , DS-11 48 μm , DS-12 56 μm ; LS-3 35 μm , LS-4 34 μm , LS-5 34 μm , LS-6 34 μm , LS-7 34 μm , LS-8 34 μm , LS-9 35 μm , LS-10 35 μm , LS-11 38 μm , SD-12 48 μm ; LAS-4 16 μm , LAS-7 18 μm , LAS-10 24 μm , LAS-11 18 μm ; MTS 85 μm (38% of TL); LTS 184 μm (81% of TL).

Paratypes.—Four adult males (AVA-C-JAP-02.C; AVA-C-JAP-03.C; AVA-C-JAP-04.C; CM-A-JAP-01.C), juvenile of undetermined sex (CM-A-JAP-04.C). Adults: TL 281–291 μm ; MSW-7 85–90 μm , 29–32% of TL; MSW-9 85–98 μm , 29–34% of TL; SW 57–62 μm , 20–22% of TL; MTS 77–93 μm , 27–32% of TL; LTS 131–188 μm , 46–67% of TL.

Sexual dimorphism.—Males of *Condyloderes* have no penile spines and sexes can be recognized only by observation of gonads. Female differs from males in having relatively longer MTS (38% of TL in female and 27–32% of TL in males) and LTS (81% of TL in female and 46–67% in males), different arrangement of dorsal sensory papillae on segments 3–5, and position

of ventral terminal papillae displaced to midventral line.

Remarks.—Only two species of the genus *Condyloderes* have been described to date, i.e., *C. paradoxus* Higgins, 1969 from Indian coast of Bengal Bay and *C. multispinosus* (McIntyre, 1962) Higgins 1969 from the North Sea (see McIntyre 1962, Higgins 1969). The most easily observed features of *Condyloderes setoensis* that distinguish it from *C. paradoxus* are the absence of accessory lateral spines on segment 6 and the different arrangement of knobby projections of neck placids. In contrast to the species from India, *C. setoensis* possesses wide placids with only two anterior and two posterior knobby projections of equal size, whereas the wide placids of *C. paradoxus* have three posterior and three anterior projections of unequal size. In addition, the narrow placids of *C. setoensis* show only a single knobby projection situated posteriorly, whereas narrow placids of the Indian species bear anterior and posterior projections. Contrary to *C. paradoxus*, *C. setoensis* has pilose dorsal, lateral and lateral accessory spines. The adults of *C. setoensis* are larger (TL of males 281–296 μm) than those of *C. paradoxus* (TL of males 216–264 μm).

Similar to *C. multispinosus*, *C. setoensis* shows the same number of lateral accessory spines situated on segments 4, 7, 10 and 11. Nevertheless, *C. setoensis*, new species, is well distinguished from the European species by the arrangement of knobby projections of the placids and by the size of the accessory lateral spines. In contrast to the *C. setoensis*, *C. multispinosus* has wide placids with three posterior and three anterior projections and narrow placids with one anterior and one posterior projection. The species from Europe possesses relatively short ovoid lateral accessory spines. *C. multisetosus* also differs from *C. setoensis* in having a non-interrupted ventral pectinate fringe on segment 3. In addition, the adults of *C. multispinosus* are obviously larger

(TL 336–370 μm) than those of *C. setoensis*.

Both *C. paradoxus* and *C. multispinosus* are distinguished from the *C. setoensis* by having a well developed midventral articulation between the sternal plates of segment 13.

One of the remarkable features of *C. setoensis* distinguishing it from both *C. multisetosus* and *C. paradoxus* is the presence of two dorsal and two ventral tubicolous terminal papillae on segment 13.

Condyloderes setoensis constitutes the ninth genus of the Kinorhyncha known from the Pacific ocean and the fifth genus recorded in Japan.

Key to adults of *Condyloderes*

1. Lateral accessory spines (LAS) on segments 4, 6, 7, 10–11 . . . *C. paradoxus* Higgins, 1969
 - Lateral accessory spines (LAS) on segments 4, 7, 10–11 2
2. Anterior margin of segment 3 protuberant centrally on dorsal side; segment 13 with two ventral tubicolous terminal papillae; trunk length of adults 336–370 μm *C. multispinosus* (McIntyre, 1962) Higgins 1969
 - Anterior margin of segment 3 even or concave on dorsal side; segment 13 with two ventral and two dorsal tubicolous terminal papillae; trunk length of adults 226–291 μm . . . *C. setoensis*, new species

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