

Marine species of *Ainudrilus* and *Heterodrilus* (Oligochaeta: Tubificidae: Rhyacodrilinae) from Hainan Island in southern China

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Abstract Six species of Rhyacodrilinae (Oligochaeta: Tubificidae) are reported from intertidal and shallow water subtidal habitats around Hainan Island in southern China. Four species are new to science: *Ainudrilus pauciseta* n. sp., *Heterodrilus chenianus* n. sp., *Heterodrilus nudus* n. sp., and *Heterodrilus uniformis* n. sp. Japanese material of *Ainudrilus lutulentus* (Erséus, 1984) is also briefly described. Hitherto, 27 species belonging to Tubificidae have been recorded from Hainan.

Keywords *Ainudrilus*; *Heterodrilus*; Tubificidae; marine oligochaetes; taxonomy; new species; faunal diversity; southern China; Japan

INTRODUCTION

To increase the knowledge of marine and brackish-water oligochaetes in China we made a collection visit to Hainan Island, the southernmost province of the country, in March 2000. In two previous accounts (Wang & Erséus 2001, in press), 21 species in the subfamilies Phallo-drilinae and Limnodriloidinae were reported on the basis of the collected material.

The present paper reports on six species of Rhyacodrilinae, including one new species of *Ainudrilus* and three new species of *Heterodrilus*. Japanese material of *Ainudrilus lutulentus* (Erséus, 1984) is also briefly described herein.

MATERIALS AND METHODS

All oligochaete specimens from Hainan were collected from intertidal and subtidal sediment samples. The latter were repeatedly stirred with habitat water, and the organic suspensions decanted into a fine-mesh sieve (250–300 µm). Live, sexually mature oligochaetes were sorted under dissecting microscopes and then fixed in Bouin's fluid. After c. 1 day in the fixative, they were transferred into 70% ethanol. Additional material of *A. lutulentus* was collected in Japan by Dr K. Ogawa (University of Tokyo). All worms were later stained with paracarmine, cleared in xylene, then mounted whole in Canada balsam. The measurements and drawings in this paper refer to these mounted, slightly compressed specimens.

Holotypes, some paratypes, and other reference specimens are deposited in the Institute of Hydrobiology (IHB), Chinese Academy of Sciences (CAS), in Wuhan, China; the remaining material is lodged in the Swedish Museum of Natural History (SMNH), in Stockholm.

Types and other reference material from previous studies, in SMNH and C. Erséus's collection were also consulted.

LIST OF STATIONS

The following stations located in or near Sanya and Haikou cities were sampled in March 2000; sites yielding no Rhyacodrilinae are omitted. All oligochaete species encountered at these stations are also listed (members of Phallo-drilinae and Limnodriloidinae, in parentheses, were previously reported from these sites by Wang & Erséus (2001, in press)).

Station SY00-1B: Tributary of Sanya River, north of bridge of Huan Lu Road, 18°16.25'N, 109°30.89'E, barely subtidal (c. 0.5 m), sand and silt with filamentous algae and *Limnoperna* mussels, 14 March 2000; *Ainudrilus lutulentus* (Erséus, 1984).

SY00-2A: Main flow of Sanya River, at children's park in middle of Sanya City, 18°15.34'N, 109°30.25'E, soft organic sediment, 14 March 2000; *Ainudrilus lutulentus*, *Ainudrilus pauciseta* n. sp. (*Doliodrillus tener* Erséus, 1984, *Doliodrillus divarticulatus* Erséus, 1985).

SY00-5A: East end of bay near Teng Hai, east of Sanya City, 18°16.29'N, 109°43.66'E, lower intertidal, coarse sand, partly under boulders, 16 March 2000; *Heterodrillus keenani* Erséus, 1981 (*Pectinodrillus molestus* (Erséus, 1988)).

SY00-7A: The West Coral Islet (Ximaozhou) (west of Sanya City), reef flat at east side of island, 18°14.24'N, 109°22.51'E, lower intertidal, medium sand, 17 March 2000; *Heterodrillus chenianus* n. sp., *H. keenani*.

SY00-7B: Same as SY00-7A, but upper intertidal, coarse sand with some coral rubble, 17 March 2000; *H. chenianus* n. sp.

SY00-8A: The West Coral Islet (Ximaozhou) (west of Sanya City), reef flat at north-west side of island close to tourist resort, 18°14.56'N, 109°21.97'E, barely subtidal (c. 0.5 m), poorly oxygenated coarse sand with smell of H₂S, 17 March 2000; *H. chenianus* n. sp., *Heterodrillus uniformis* n. sp. (*Bathyrillus ampliductus* Erséus, 1997, *Limnodriloides macinnesi* Erséus, 1990).

SY00-8B: Same as SY00-8A, but well oxygenated coarse sand, 17 March 2000; *H. chenianus* n. sp., *H. keenani*.

SY00-8D: Same as SY00-8A, but lower intertidal, medium sand with seagrass, 17 March 2000; *H. chenianus* n. sp., *H. keenani*.

SY00-9A: Lower end of estuary south-east of Teng Qiao Town (north-east of Sanya City), 18°23.13'N, 109°45.67'E, lower intertidal, medium to coarse sand, 18 March 2000; *H. chenianus* n. sp. (*Aktedrillus yiboi* Wang & Erséus, 2001).

SY00-9C: Same as SY00-9A, but 18°23.18'N, 109°45.71'E, lower intertidal, silty medium sands with black mud, 18 March 2000; *A. pauciseta* n. sp. (*D. tener*, *Doliodrillus adiacens* Wang & Erséus, in press, *Doliodrillus fibrissaccus* Wang & Erséus, in press, *Limnodriloides parahastatus* Erséus, 1985).

SY00-10: Brackish-water shrimp pond connected with estuary south-east of Teng Qiao Town, 18°22.93'N, 109°45.57'E, lower intertidal, medium to coarse sand with black mud and filamentous algae, 18 March 2000; *A. pauciseta* n. sp. (*D. fibrissaccus*).

SY00-13A: Wuzhi Island c. 20 km east of Sanya City, east end of sandy beach on northern side of island, 18°18.93'N, 109°45.83'E, subtidal, c. 1 m depth, heterogeneous sand with some H₂S, 19 March 2000; *H. chenianus* n. sp.

SY00-13B: Same as SY00-13A, but 18°18.90'N, 109°45.85'E, lower intertidal, heterogeneous sand with H₂S, 19 March 2000; *H. chenianus* n. sp., *Heterodrillus nudus* n. sp.

HU00-16: Dong Zhai Harbour natural reserve east of Haikou City, immediately south of dock of Bo Luo Island, 19°57.30'N, 110°35.17'E, upper intertidal among small mangrove trees, clay and mud, 21 March 2000; *A. pauciseta* n. sp.

HU00-18: North end of Haikou City, mud flat immediately south of sewage treatment plant, 20°04.28'N, 110°19.55'E, uppermost intertidal in marsh, clayey soil with succulent plants, 22 March 2000; *A. pauciseta* n. sp.

HU00-19A: Haikou City, bay (surrounded by wall) in Wan Lu Yuan Park, 20°02.10'N, 110°18.66'E, barely subtidal (c. 0.5 m), mud with some sand, 22 March 2000; *A. lutulentus*, *A. pauciseta* n. sp. (*D. tener*, *D. divarticulatus*, *Doliodrillus* sp.).

SYSTEMATIC ACCOUNT

Subfamily Rhyacodrilinae

Genus *Ainudrilus* Finogenova, 1982

Remarks

This genus was established by Finogenova (1982) for *Ainudrilus oceanicus* Finogenova, 1982 (junior synonym: *Vadicola aprostatu* Baker, 1982), and later redefined by Erséus (1990a). It is similar to *Rhyacodrilus* Bretscher, 1901, but lacks diffuse prostate cells on the atria. The genus is widely distributed, from c. 55°N to c. 55°S, and including the new taxon described here, a total of 18 species are now known from marine, brackish, or freshwater habitats in various parts of the world (Baker 1982; Finogenova 1982; Erséus 1990a,b, 1997c; Pinder & Brinkhurst 2000; Pinder & Halse 2001; Erséus & Grimm 2002; Erséus & Wang 2003; Zhou & Erséus in press; this paper).

***Ainudrilus lutulentus* (Erséus, 1984)**

(Fig. 1)

Rhyacodrilus lutulentus Erséus, 1984: 142–143, fig. 5.*Ainudrilus lutulentus*; Erséus, 1990a: 265–266, fig. 1A–C.**New material**

IHB HANA2000002a, HANA2000003g–q, HANA2000029g–i, 17 specimens: one from SY00-1B, 11 from SY00-2A, six from HU00-19A. SMNH Main Collection 45558–45573, 16 specimens: 14 from SY00-2A, two from HU00-19A. SMNH Main Collection 45574, one specimen from Japan, Honshu, Mie Prefecture, Gokasho Bay, brackish water; 16 May 1990, collected by K. Ogawa.

Brief description of material from Hainan

Based on four complete specimens, 3.8–7.4 mm long, 31–40 segments. Width at XI 0.3–0.5 mm. Clitellum extending over $\frac{1}{2}$ X–XII ($\frac{1}{3}$ XIII). Somatic chaetae (1) 2–3 per bundle, 44–73 μ m long, 1.7–2.4 μ m thick. Penial chaetae 2 per bundle, bifid or simple-pointed, 75–85 μ m long, 3.1–3.8 μ m thick. Pharyngeal glands in IV–V. Vasa deferentia not observed. Atrial ampullae 25–75 μ m long, 45–60 μ m wide; ducts c. 30 μ m long, c. 20 μ m wide. Muscular sacs surrounding atrial ducts inconspicuous. Sperm sac in XI, or XII, when developed. Egg sac extending through 2–4 segments in XI–XIV. Spermathecal ampullae 45–90 μ m long, 30–50 μ m wide; ducts 35–85 μ m long, 14–44 μ m wide.

Brief description of material from Japan (Fig. 1)

Single specimen (stretched) 8.5 mm long, 39 segments. Width at XI 0.2 mm. Clitellum extending over $\frac{1}{3}$ X–XII. Somatic chaetae 1–2 per bundle, 43–68 μ m long, 1.7–2.4 μ m thick. Penial chaetae 2 per bundle, simple-pointed, c. 55 μ m long, 2.9 μ m thick. Pharyngeal glands in IV–V. Vasa deferentia c. 300 μ m long, c. 10 μ m wide. Atrial ampullae (Fig. 1B, aa) 50–60 μ m long, maximally 40–50 μ m wide; atrial ducts c. 22 μ m long, up to 20 μ m wide. Muscular sacs surrounding atrial ducts conspicuous, consisting of numerous strands; this musculature c. 20 μ m thick. Sperm sac in XII–XV. Egg sac not observed. Spermathecal ampullae (Fig. 1A, sa) c. 110 μ m long, maximally 68 μ m wide, spermathecal ducts totally c. 85 μ m long, 10–29 μ m wide; latter complex, tripartite, each consisting of: (1) entalmost thin part, with spermatozoa in lumen; (2) middle part, dilated with conspicuous granulation in walls; and (3) ectalmost, vestibule-like part, with thick internal cuticle and thick outer musculature.

Remarks

Previously, *A. lutulentus* was known only from Hong Kong (Erséus 1984, 1990a). The new material from Hainan conforms well to the previous descriptions. However, on average, the Hainan form (3.8–7.4 mm long, 31–40 segments) is smaller than the Hong Kong specimens (6.5–9.5 mm long, 30–49 segments). Correspondingly, the external and internal organs, such as the somatic chaetae (44–73 μ m versus 65–95 μ m long), penial chaetae (75–85 μ m versus 80–105 μ m long), atrial ampullae (25–75 μ m versus 70–105 μ m long), and spermathecal ampullae (45–90 μ m versus 55–130 μ m long), are also smaller.

The Japanese specimen is similar to the Hainan material in terms of dimensions, and to all Chinese specimens studied in most other morphological aspects. In the Japanese individual, however, the muscular sacs around the atrial ducts are conspicuously thicker (Fig. 1B, as opposed to fig. 1C in Erséus (1990a)), and the entalmost parts of the spermathecal ducts, which were not specified by Erséus (1984, 1990a), are considerably longer, containing spermatozoa in their lumina (Fig. 1A, as opposed to fig. 5e in Erséus (1984), and fig. 1C in Erséus (1990a)).

Distribution and habitat

Southern China (Hainan (new record) and Hong Kong), Japan (new record). Intertidal and subtidal, from soft mud to coarse sand, generally in brackish water.

***Ainudrilus pauciseta* n. sp.** (Fig. 2)? *Ainudrilus geminus* sensu Erséus, 1997a: 39–40, fig. 1;non *Ainudrilus geminus* Erséus, 1990b: 247–248, fig. 2.**Holotype**

IHB HANA2000026a, whole-mounted specimen.

Type locality

China, northern Hainan, mangroves of Dong Zhai Harbour Natural Reserve (Station HU00-16).

Paratypes

IHB HANA2000026b–e, four specimens from type locality; SMNH Type Collection 5606–5610, five specimens from type locality.

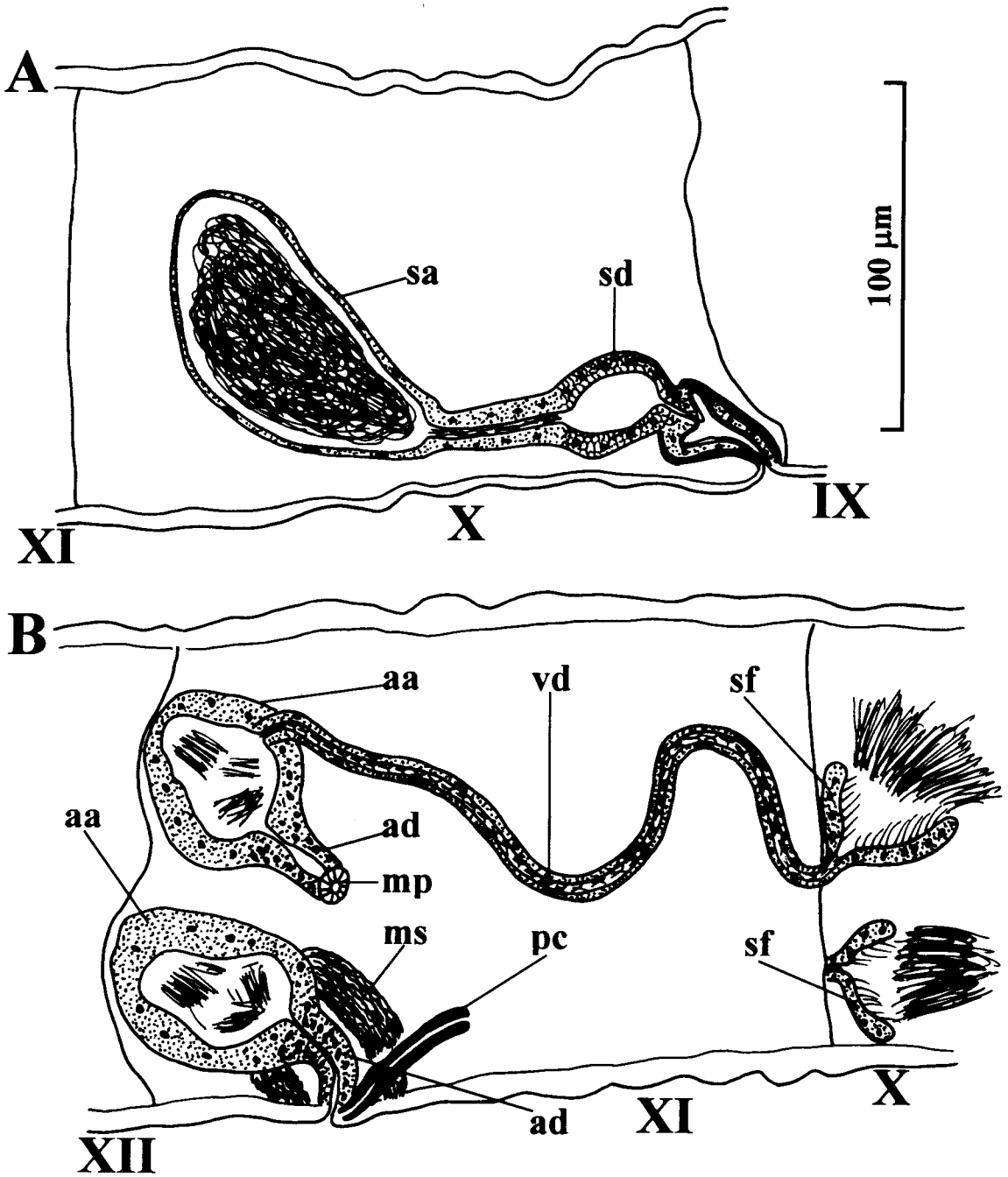


Fig. 1 *Ainudrilus lutulentus* from Japan; drawing based on optical sections of whole-mounted specimen. Lateral views of segments X and XI, respectively, showing **A**, spermatheca; and **B**, male ducts. (aa, atrial ampulla; ad, atrial duct; mp, male pore; ms, muscular sac; pc, penial chaeta; sa, spermathecal ampulla; sd, spermathecal duct; sf, sperm funnel; vd, vas deferens.)

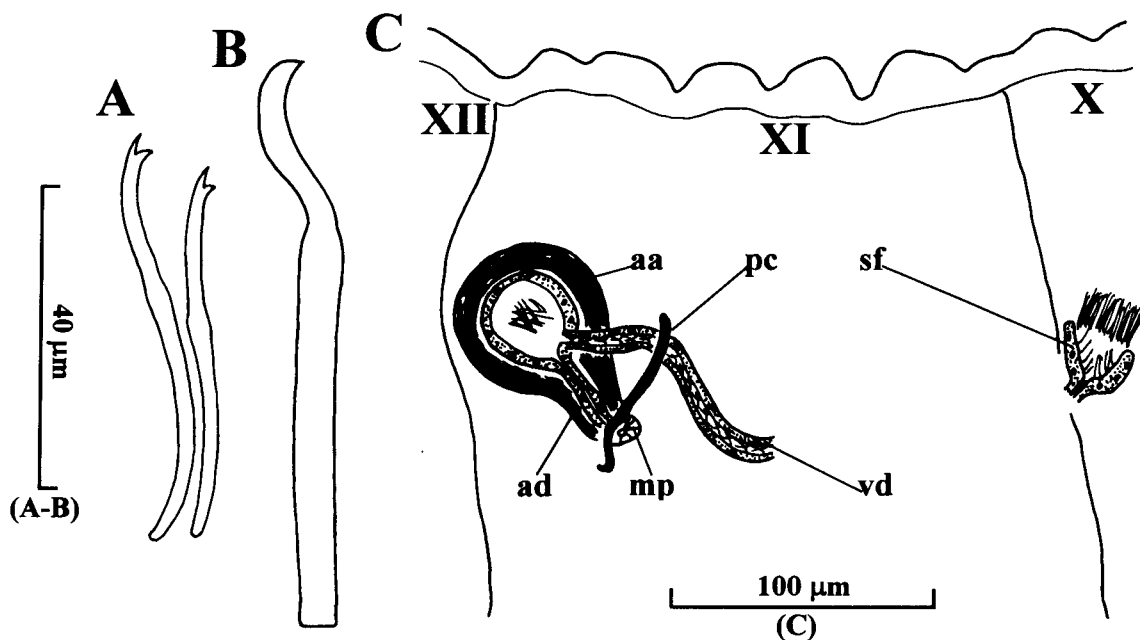


Fig. 2 *Ainudrilus pauciseta* n. sp.; drawing based on optical sections of whole-mounted specimen. A, Somatic chaetae; B, penial chaeta; and C, lateral view of segment XI showing part of male duct. (aa, atrial ampulla; ad, atrial duct; mp, male pore; pc, penial chaeta; sf, sperm funnel; vd, vas deferens.)

Other material

IHB HANA2000003r, HANA2000017 g, HANA2000029j–k, four specimens: one from SY00-2A, one from SY00-9C, two from HU00-19A. SMNH Main Collection 45575–45578, four specimens: one from each of SY00-2A, SY00-9C, SY00-10, and HU00-18.

Etymology

The specific name “*pauciseta*” is Latin for “few setae”, and refers to the small number of chaetae in a bundle.

Description

Eight complete specimens, 3.0–9.0 mm long (holotype: 6.1 mm), 27–52 segments (holotype: c. 35). Width at XI 0.2–0.3 mm. Clitellum generally extending over $\frac{3}{4}X$ – $\frac{1}{2}XIII$. Somatic chaetae (Fig. 2A) all bifid with upper tooth 1.1–1.5 times as long as, and thinner than, lower tooth; 2–3 (4) per bundle anteriorly, 2–3 per bundle in post-clitellar segments. Bifid chaetae 38–56 µm long, 1.8–2.4 µm thick. Penial chaetae (Fig. 2B; Fig. 2C, pc) 1 (2) per bundle, simple-pointed (and not flattened at tip), 46–68 µm

long, 4.4–5.0 µm thick, slightly thinner at ectal end; latter somewhat sickle-shaped. Male pores paired in line with ventral chaetae in posterior part of XI. Spermathecal pores absent.

Pharyngeal glands generally in III–VI, sometimes inconspicuous or absent in III, or VI. Coelomocytes numerous, round to oblong, granulated. Male genitalia (Fig. 2C) paired. Vas deferens c. 10 µm wide, much longer than atrium, joining basal one-third of atrial ampulla. Atrial ampullae (Fig. 2C, aa) roundish to pear-shaped, 53–72 µm long, 48–56 µm wide, with <5 µm thick inner epithelium and 5–12 µm thick outer muscular layer, and with scattered spermatozoa in lumina. Atrial duct 20–30 µm long, c. 25 µm wide, also heavily muscular, opening to exterior through simple pore. Sperm sac small in XI, or XII, when developed. Egg sac in XII–XIII, or XI–XIV, when developed. Spermathecae absent.

Remarks

Among the known members of *Ainudrilus*, there are two other species without spermathecae: *Ainudrilus geminus* Erséus, 1990, originally known from mangroves in Belize (Erséus 1990b), and *Ainudrilus stagnalis* Erséus, 1997, recorded only from a

freshwater site in Australia's Northern Territory (Erséus 1997b). *A. pauciseta* n. sp. is easily separated from these two other species by the smaller number of somatic chaetae in its bundle (up to 3 per bundle, as opposed to maximally 6 per bundle in the other two species) and by its thicker muscle layers around the atria. With regard to the atrial shape, *A. pauciseta* is most similar to *A. geminus*; the atria are club-shaped, with tapering ducts in both taxa. In *A. stagnalis*, the atria are somewhat dumbbell-shaped, with bulbous ducts. *A. geminus* also differs from *A. pauciseta* by the ectally flattened penial chaetae.

Erséus (1997b) reported *A. geminus* from Hong Kong on the basis of one incomplete specimen (formerly registered as SMNH Main Collection 1480, now as SMNH Main Collection 16703). When re-examining this worm, we found distinct muscular layers in the atria, and although the muscles are not as thick as those of the present material, the Hong Kong specimen in this respect shows a close affinity to *A. pauciseta*. However, the somatic chaetae per bundle on the "*A. geminus*" specimen from Hong Kong are more numerous than those in *A. pauciseta*, i.e., they are about as many as those reported for *A. geminus* (Erséus 1990b). To sort out whether the Hong Kong form is identical to our new taxon from Hainan, additional material will be needed. Such material would enable a closer scrutinisation of the variation in the penial chaetae (e.g., it is impossible to judge whether or not the tips of the penial chaetae are flattened in the available material from Hong Kong; see Erséus 1997a), the number of somatic chaetae, and the thickness of atrial muscles.

Distribution and habitat

Known from Hainan and Hong Kong (?), southern China. Uppermost intertidal to subtidal, clay, silt, or muddy sand, generally in brackish water; appears associated with high organic content in sediment.

Genus *Heterodrilus* Pierantoni, 1902

Remarks

This genus was established by Pierantoni (1902) for *Heterodrilus arenicolus* Pierantoni, 1902, and today it contains c. 40 named species, mainly discovered in the past two decades (e.g., Erséus 1981, 1990b, 1997c; Sjölin & Erséus 2001; Erséus & Wang 2003); three of these species are described as new in this paper. This exclusively marine group is largely distributed in the tropical and subtropical zones of the world. *Heterodrilus* has been revised twice (Erséus 1981, 1990b), but as the species number has

almost doubled since the latest revision, a comprehensive phylogenetic and taxonomic study is necessary; this will be conducted elsewhere (Sjölin & Erséus unpubl. data).

Heterodrilus chenianus n. sp. (Fig. 3)

Holotype

IHB HANA2000020a, whole-mounted specimen.

Type locality

China, southern Hainan, sandy beach on Wuzhi Island (east of Sanya City) (Station SY00-13A).

Paratypes

IHB HANA2000020b, HANA2000020a–d, five specimens: one from type locality, four from SY00-7A. SMNH Type Collection 5611–5615, five specimens: one from type locality, four from SY00-7A.

Other material

IHB HANA2000020c, HANA2000010e–f, HANA2000012d–l, HANA2000013a–b, HANA2000015a–d, HANA2000016i, HANA2000021a–b, 21 specimens: one from type locality, two from SY00-7A, nine from SY00-8A, two from SY00-8B, four from SY00-8D, one from SY00-9A, two from SY00-13B. SMNH Main Collection 45579–45598, 20 specimens: one from type locality, one from SY00-7A, one from SY00-7B, nine from SY00-8A, one from SY00-8B, five from SY00-8D, two from SY00-13B.

Etymology

Named for the late Professor Yi Chen, a pioneer in Chinese oligochaetology who also contributed greatly to the development of invertebrate zoology in China.

Description

Twenty-six complete specimens, 5.8–8.6 mm long (holotype: 5.8 mm), 40–60 segments (holotype: 45). Width at XI 0.2–0.4 mm. Prostomium bluntly conical in most specimens. Clitellum extending over 1/3X–XII. Chaetae 2 per bundle in II–IX, single thereafter; sometimes replacement chaeta/chaetae present, doubling number within bundle. Chaetae (Fig. 3A) trifid in II–X, occasionally bifid, with uppermost tooth thinner than middle and lower ones, generally with subdental ligament. Trifids 50–80 µm

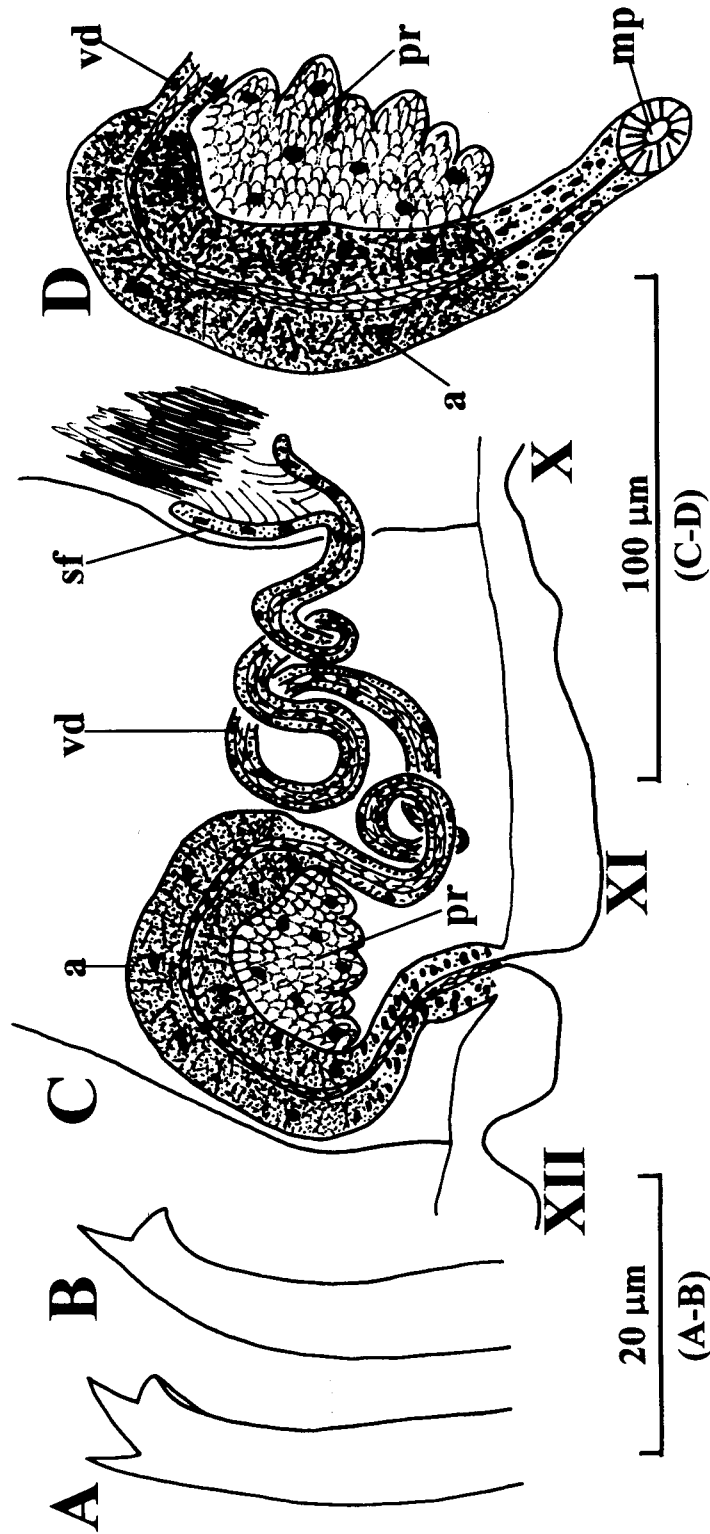


Fig. 3 *Heterodrilus chenianus* n. sp.; drawing based on optical sections of whole-mounted specimen. **A**, Trifid chaeta; **B**, bifid chaeta; **C**, lateral view of segment XI showing male duct with curved atrium; and **D**, male duct with less curved atrium. (a, atrium; mp, male pore; pr, prostate gland; sf, sperm funnel; vd, vas deferens.)

long, 3.6–5.6 μm thick at node. Chaetae from XI and posteriad bifid (Fig. 3B), without subdental ligament, with widely diverging teeth, upper tooth thinner than lower; trifids occasionally present posteriorly, but usually with both uppermost and middle teeth shorter than lower. Bifids 61–73 μm long, 4.8–6.8 μm thick at node. Ventral chaetae (penial chaetae) absent from XI. Male pores paired, in middle to posterior of XI, between lines of ventral chaetae, of other segments, and mid-ventral line, but closest to former. Spermathecal pores absent.

Pharyngeal glands in IV–V ($\frac{1}{2}$ VI) (holotype: IV– $\frac{1}{3}$ VI). Coelomocytes numerous, round to oblong, granulated. Male genitalia (Fig. 3C,D) paired. Vas deferens irregularly coiled, longer than atrium (c. 220 μm long in holotype), 6–11 μm wide, entering apical end of atrium. Atrium somewhat club-shaped, and more (Fig. 3C, a) or less (Fig. 3D, a) curved, totally 60–150 μm long (holotype: 80 μm), 10–29 μm wide, with thin outer muscular layer and narrow lumen; inner epithelium ciliated, entally heavily granulated with few nuclei, and ectally less granulated with numerous nuclei. Prostate glands broadly attached to ventral surface of ental part of atrium. Atrium opening to exterior through simple pore. Sperm sac generally absent, but sometimes present in XII. Egg sac generally well developed, extending through (1) 3–4 segments in XI–XV. Spermathecae absent.

Remarks

Heterodrilus chenianus n. sp. appears closely related to *Heterodrilus virilis* Erséus, 1992 from Hong Kong, which also lacks spermathecae and has irregularly coiled vasa deferentia, somewhat club-shaped atria, and prostate glands that are attached to the ventral side of the ental parts of these atria (Erséus 1992a). This new species, however, is easily discriminated from *H. virilis* by its lack of penes and penial chaetae. Moreover, in *H. virilis*, the bifid chaetae have subdental ligaments, an unpaired transverse epidermal pad is present mid-ventrally in the intersegmental furrow between IX and X (Erséus 1992a, fig. 2D, tp), and the vasa deferentia enter the atria somewhat subapically; in *H. chenianus*, the bifids have no ligament, an epidermal pad is absent, and the vasa enter the atria apically.

Distribution and habitat

Known only from Hainan, southern China. Lower intertidal to subtidal, heterogeneous sand; once found in association with seagrass.

Heterodrilus nudus n. sp. (Fig. 4)

Holotype

IHB HANA2000021c, whole-mounted specimen.

Type locality

China, southern Hainan, sandy beach of Wuzhi Island (east of Sanya City) (Station SY00-13B).

Etymology

The specific name “*nudus*” is Latin for “naked”, and alludes to the absence of spermathecae and penial chaetae.

Description

Specimen incomplete, >2.4 mm long and with >23 segments. Width at XI 0.3 mm. Prostomium bluntly conical. Clitellum well-developed over $\frac{1}{2}$ X–XII. Chaetae 2 per bundle in II–IX, single thereafter. Chaetae in II bifid (Fig. 4A), c. 40 μm long, 2.9 μm thick at node, with somewhat parallel short teeth, and with upper tooth longer than lower. Chaetae in III–X trifid (Fig. 4B), 53–65 μm long, 4.1–6.5 μm thick at node, with uppermost tooth thinner than middle and lower ones, and without subdental ligament. From XI onwards, chaetae bifid (Fig. 4C), 48–70 μm long, 4.4–5.8 μm thick at node, with widely diverging teeth, upper teeth thinner than lower. Ventral chaetae absent from XI. Male pores paired in posteriormost part of XI, between ventral chaetae line and nerve cord. Spermathecal pores absent.

Pharyngeal glands in IV– $\frac{1}{3}$ VI. Coelomocytes numerous, round to oblong, granulated. Male genitalia (Fig. 4D) paired. Vas deferens irregularly coiled, longer than atrium, c. 5 μm wide, entering apical end of atrium. Atrium (Fig. 4D, a) curved, c. 85 μm long, 10–17 μm wide, with thin outer muscular layer and narrow lumen; inner epithelium ciliated, with short granulated ental part and less granulated ectal part. Prostate glands broadly attached to middle part of atrium. Atrium opening to exterior through simple pore. Sperm sac not observed. Egg sac extending through XII–XIV. Spermathecae absent.

Remarks

With regard to the arrangement of somatic chaetae, *H. nudus* n. sp. is similar to *Heterodrilus maccaini* Erséus, 1985, *Heterodrilus maiusculus* Erséus, 1988, and *Heterodrilus ursulae* Sjölin & Erséus, 2001 (Erséus 1985, 1988; Sjölin & Erséus 2001), but the new species is easily distinguished from these other taxa by lacking spermathecae and penial chaetae.

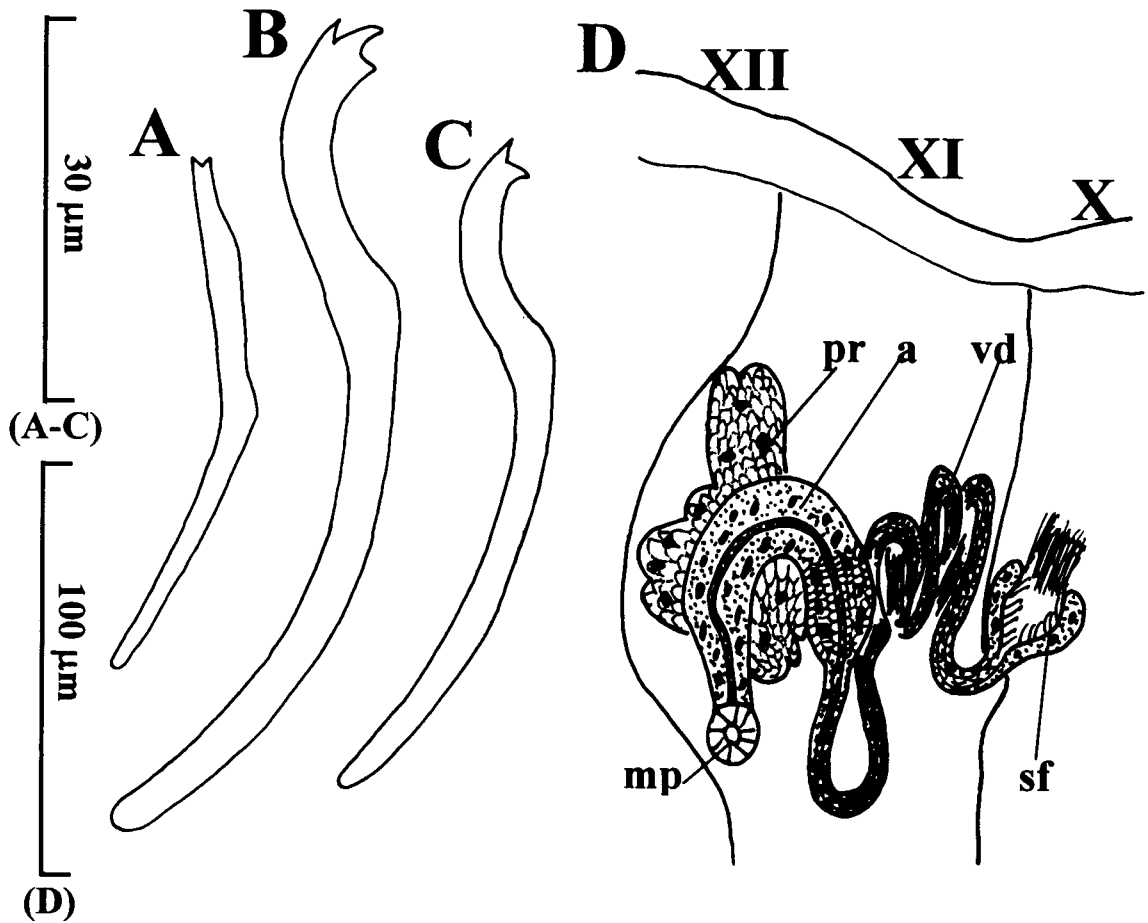


Fig. 4 *Heterodrilus nudus* n. sp.; drawing based on optical sections of whole-mounted specimen. **A**, Bifid chaeta from segment II; **B**, trifid chaeta; **C**, bifid chaeta from post-clitellar segment; and **D**, lateral view of segment XI showing male duct. (a, atrium; mp, male pore; pr, prostate gland; sf, sperm funnel; vd, vas deferens.)

Considering overall similarity, *H. nudus* shows affinity to *H. chenianus* n. sp., described above, and *H. modestus* Erséus, 1990 (Erséus 1990b). All three species lack spermathecae and penial chaetae (although the latter are occasionally present in *H. modestus*), and have long (and irregularly coiled) vasa deferentia, and atria that are somewhat tapering ectally. However, *H. nudus* (Fig. 4A) differs from *H. chenianus* (Fig. 3A) by its anterior bifid chaetae and the absence of subdental ligaments on its trifids; and from *H. modestus* by the presence of anterior bifids only in segment II (such bifids are present to segment VIII or thereabouts in *H. modestus*; see Erséus 1990b), and the well-developed prostate glands (prostates merely as small cells scattered over the atrial surface in *H. modestus*; see Erséus 1990b, fig. 7E).

Distribution and habitat

Known only from type locality in Hainan, southern China; lower intertidal, heterogeneous sand.

Heterodrilus keenani Erséus, 1981

Heterodrilus keenani Erséus, 1981: 117–118, fig. 7; Erséus, 1984: 140–142, fig. 4; Erséus, 1990a: 273; Erséus, 1990c: 48; Erséus, 1993: 339; Erséus, 1997b: 104; Erséus & Davis, 1989: 76, fig. 1C–E.

New material

IHB HANA2000006b, HANA2000010g–h, HANA2000013b–e, seven specimens: one from SY00-5A, two from SY00-7A, four from SY00-8B;

SMNH Main Collection 45599–45605, seven specimens: two from SY00-5A, one from SY00-7A, three from SY00-8B, one from SY00-8D.

Brief description of new material

Nine complete specimens, 3.8–5.1 mm long, 38–47 segments. Diameter at XI 0.3–0.4 mm. Prostomium bluntly conical. Trifids 2 per bundle in II–IX, single in X. Bifids 1 per bundle in post-clitellar segments. Penial chaetae (1) 2 per bundle, 100–110 µm long, 4.4–4.8 µm wide at node. Clitellum over ($\frac{1}{2}$ X) XI–XII. Pharyngeal glands in IV–V ($\frac{1}{2}$ VI). Vasa deferentia long. Atria more or less C-shaped, 135–220 µm long, 14–24 µm wide. Sperm sac extending through 1–4 segments in IX–XII when developed. Egg sac extending through 2–3 segments in XII–XIV when developed. Spermathecal ducts 29–34 µm long, 19–24 µm wide; ampullae spherical, 53–85 µm long, 56–77 µm wide, with loose sperm bundles in lumina.

Remarks

This species was originally described from the Great Barrier Reef (Erséus 1981), and then from various localities in Australia (Erséus 1990c, 1993, 1997b). It was also recorded from Hong Kong (Erséus 1984, 1990a) and Hawaii (Erséus & Davis 1989). The new material conforms well to the previous descriptions (Erséus 1981, 1984). Dimensionally, the Hainan specimens are almost identical with the Hong Kong material, i.e., all these worms are smaller, but have larger atria and longer penial chaetae, than the original Great Barrier Reef specimens (see Erséus 1984). Although the Hong Kong worms were precopulatory, their spermathecae were about the same size as those from Hainan. The spermathecae of the Chinese form are about half as large as those of the original material; the spermathecae of the Great Barrier Reef worms were c. 200 µm in total length (measured from fig. 7C in Erséus 1981).

Distribution and habitat

Southern China (Hainan (new record), Hong Kong), Northern Territory, Queensland, Western Australia, Hawaii. Intertidal and subtidal sand, to at least 70 m.

Heterodrilus uniformis n. sp. (Fig. 5)

Holotype

IHB HANA2000012m, whole-mounted specimen.

Type locality

China, southern Hainan, reef flat of the West Coral

Islet (Ximaozhou) (west of Sanya City) (Station SY00-8A).

Paratype

SMNH Type Collection 5616, one specimen from type locality.

Etymology

The specific name “*uniformis*” is Latin for “uniform”, and alludes to the male duct homogeneity and slight change in width from vasa deferentia to atria.

Description

Holotype incomplete. Paratype 4.2 mm long, 41 segments. Width at XI 0.4 mm. Prostomium bluntly conical. Clitellum over $\frac{1}{2}$ X–XII. Chaetae 2 per bundle in II–IX, single thereafter. Anterior chaetae in II–X (XI) trifid (Fig. 5A), with uppermost tooth thinner and shorter than middle and lower ones, and with subdental ligament. Trifids 61–82 µm long, 3.0–5.6 µm thick at node. Chaetae from XI or XII onwards bifid (Fig. 5B), with subdental ligament, and with widely diverging teeth, upper tooth thinner than lower. Bifids 70–77 µm long, 4.8–6.0 µm thick at node. Penial chaetae (Fig. 5C, Fig. 5D, pc) 2 per bundle in XI, simple-pointed, straight, 97–104 µm long, c. 4.5 µm thick, with inconspicuous proximal nodulus. Male pores paired in line with ventral chaetae in posterior part of XI. Spermathecal pores paired in line with ventral chaetae, in anteriormost part of X.

Pharyngeal glands in IV–V. Coelomocytes numerous, round to oblong, granulated. Male genitalia (Fig. 5D) paired. Vas deferens c. 130 µm long, 15 µm wide, entering apical end of atrium. Atrium (Fig. 5D, a) c. 170 µm long, 17–22 µm wide, with thin outer muscular layer and distinct lumen; inner epithelium ciliated, with inconspicuous granulation. Prostate glands broadly attached to ventral surface of ental part of atrium. Atrium opening to exterior through simple pore. Sperm sac in XII–XIII, or XI–XII. Egg sac in XIII. Spermathecal ducts 24–36 µm long, 19–21 µm wide; ampullae cylindrical, C-shaped, 80–100 µm long, 50–75 µm wide, with sperm masses in lumina, and with granules in thick walls.

Remarks

This new species resembles *Heterodrilus keenani* Erséus, 1981 (Erséus 1981), with regard to: (1) the general morphology of somatic chaetae; (2) the erect, straight and single-pointed penial chaetae; (3) the

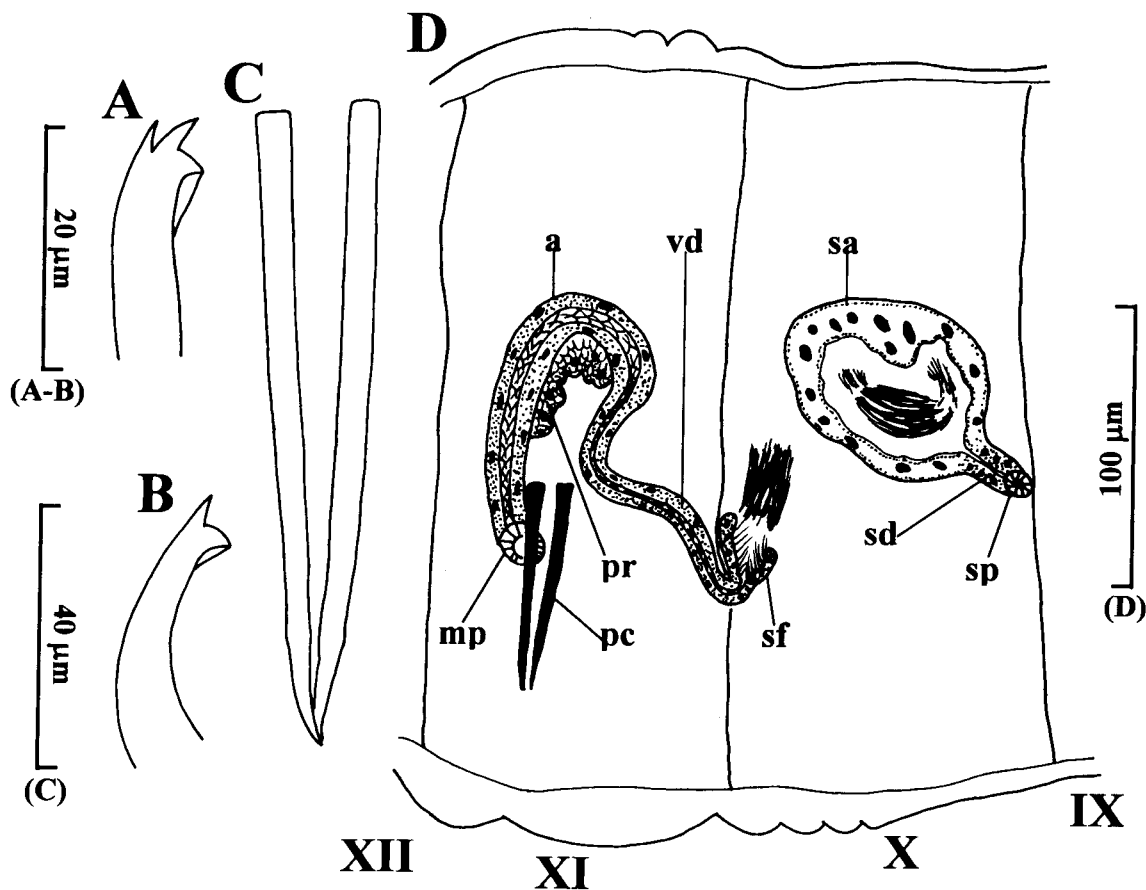


Fig. 5 *Heterodrilus uniformis* n. sp.: drawing based on optical sections of whole-mounted specimen. A, Trifid chaeta; B, bifid chaeta; C, penial chaetae; and D, lateral view of segment X–XI showing male duct and spermatheca. (a, atrium; mp, male pore; pc, penial chaeta; pr, prostate gland; sa, spermathecal ampulla; sd, spermathecal duct; sf, sperm funnel; sp, spermathecal pore; vd, vas deferens.)

slender, C-shaped, simple atria; and (4) the spermathecae. In *H. uniformis* n. sp., however, the vasa deferentia are shorter than, and about as wide as, the atria, whereas in *H. keenani*, the vasa are much longer than, and distinctly narrower than, the atria. This new species is also distinguished by its inconspicuous granulation throughout the atria, as opposed to the distinct granulation in the ental atria of *H. keenani* (see fig. 7C in Erséus 1981, and fig. 4C in Erséus 1984).

Distribution and habitat

Known only from type locality in Hainan, southern China. Barely subtidal, coarse sand.

DISCUSSION

It is somewhat noteworthy that at least three of six species reported here have not yet been found from Hong Kong, which is situated less than 1000 km north-east of Hainan. Intensive studies have been made around Hong Kong, and 13 species representing five genera of Rhyacodrilinae have been recorded (Erséus 1984, 1990a, 1992a,b, 1997a; Sundberg et al. 1992; Erséus & Diaz 1997; Zhou & Erséus in press). It thus appears as if the rhyacodriline fauna of Hainan is somewhat different from that of Hong Kong. Using *Heterodrilus* as an example, two species were recorded from Hong Kong (Erséus 1984, 1992a), whereas four congeners

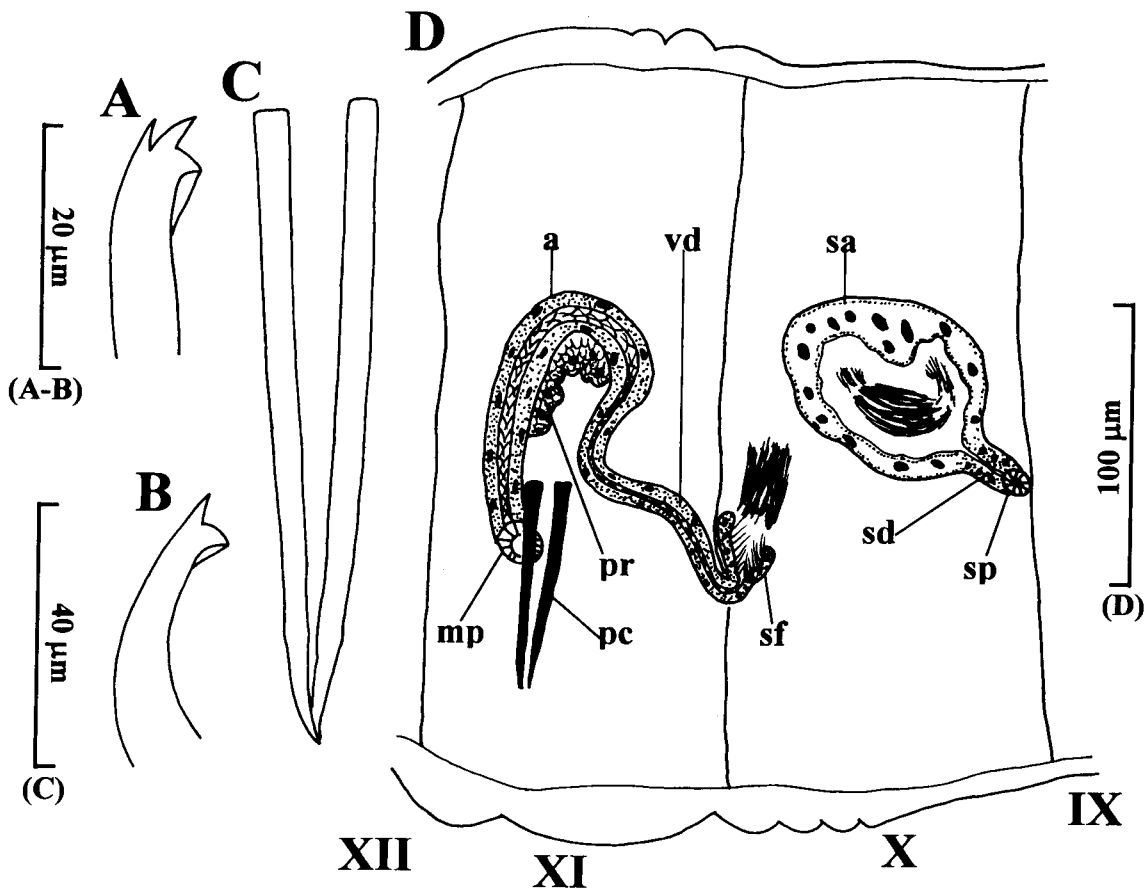


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(three of which were not known from Hong Kong) were found from Hainan in this limited sampling effort. Most specimens of *Heterodrilus* collected during this survey were found only at two small islands—the West Coral Islet and Wuzhi Island (see List of Stations). We suggest that further scrutiny of diverse marine habitats of Hainan most likely will yield additional species of *Heterodrilus*, as well as of other tubificids (see Wang & Erséus 2001, in press). From our studies, it is already evident that the southernmost part of the South China Sea coast of China supports a tubificid fauna that is partly different from, and probably also more diverse than, that present in the slightly more northern parts of this coast (corresponding to Hong Kong and its environs).

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