Records of Estuarine Tubificidae (Oligochaeta) from Taiwan

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Five species of Tubificidae are reported from the Tan Shui and Shuang Hsi estuaries in northern Taiwan: *Doliodrilus tener* Erséus, *Monopylephorus rubroniveus* Levinsen and *M. limosus* (Hatai) from a salinity range of 12–32‰, and *Branchiura sowerbyi* Beddard and *Limnodrilus hoffmeisteri* Claparède, both primarily freshwater forms, from oligohaline reaches (1–2‰ salinity) of highly polluted rivers. A find of *D. tener* at Kin Men Island near mainland China is also recorded.

Key Words: Oligochaeta, estuarine Tubificidae, Taiwan, taxonomy, biogeography.

Introduction

The taxonomy, distribution, and ecology of marine and brackish-water oligochaetes of southern mainland China and Hong Kong have been repeatedly studied in recent years (Erséus 1984, 1990, 1992a, b, 1997; Erséus and Qi 1985; Sundberg *et al.* 1992; Erséus and Diaz 1997). Taxonomic information on the corresponding fauna in northern China and Japan is also available (Baker and Brinkhurst 1981; Brinkhurst 1985; Ohtaka 1987; Erséus *et al.* 1990; Takashima and Mawatari 1996). To date, however, there is only one report of marine microdrile oligochaetes from Taiwan. *Paranais litoralis* Müller, 1784 (Naididae) and *Monopylephorus parvus* Ditlevsen, 1904 (Tubificidae) were recently reported from a mangrove forest mudflat near Taipei (Cheng 1995).

The second author's studies of the benthos in two Taiwanese estuaries, (1) Tan Shui River, with its tributaries Kee Lung and Hsin Tien Hsi Rivers (Hsieh 1995) and (2) Shuang Hsi River, and in an artificial bay (Tzu Hu Bay) of Kin Men Island near mainland China, provided an opportunity to expand our knowledge regarding the distribution of brackish-water oligochaetes in this region. In this paper five tubificid species are reported, three of which are primarily freshwater taxa that have extended their ranges into the estuaries.

Material and Methods

Sediments were collected and sieved through a 0.5mm screen. Animals retained on the screen were relaxed in 0.2% 2-phenoxyethanol, then fixed in 10% formalin for at least 24 hrs, and thereafter preserved in 70% ethanol. Most of the tubificids were stained in alcoholic paracarmine, dehydrated through a graded ethanol series, cleared

in xylene, and mounted whole in Canada balsam. The anterior regions of two specimens of *Limnodrilus hoffmeisteri* were longitudinally sectioned and stained in Azan. Measurements given below refer to fixed individuals only.

Reference specimens are lodged in the Swedish Museum of Natural History (SMNH), Stockholm, and the Institute of Zoology, Academia Sinica (ASIZ), Taipei, Taiwan.

Family **Tubificidae**
Subfamily **Rhyacodrilinae**
Genus ***Monopylephorus*** Levinsen
Monopylephorus rubroniveus Levinsen, 1884
(Fig. 1A)

Monopylephorus rubroniveus Levinsen, 1884, p. 225; see Baker and Brinkhurst (1981) and Erséus *et al.* (1990) for synonymies and other references.

Material. SMNH 1619, one partially mature specimen, and ASIZ W 187, one immature specimen: Kee Lung River, branch of Tan Shui River estuary, near Taipei, Taiwan, 25°06'36"N, 121°27'46"E, intertidal mud, salinity 12‰, 13 February 1996 (Hsieh, H.-L.; station 2-1).

Remarks. None of these specimens has fully developed genital organs, but the developing male ducts of the partially mature worm are of the cylindrical shape characteristic of *Monopylephorus*, and the spermathecae are located very closely together ventrally and anteriorly in segment X, as expected for *M. rubroniveus* (see Baker and Brinkhurst 1981; Erséus *et al.* 1990). The setae are all bifid, with the upper tooth as long as or somewhat longer than the lower (Fig. 1A), a feature distinguishing this species from *M. limosus* (Fig. 1B; see below).

Distribution and habitat. Widely distributed, known from northwestern Europe, Black Sea, Atlantic and Gulf of Mexico coasts of USA, Brazil, Taiwan (new record), northern mainland China, and Far East of Russia. Brackish water, often in organically enriched intertidal sediments.

Monopylephorus limosus (Hatai, 1898)
(Fig. 1B)

Vermiculus limosus Hatai, 1898, pp. 103-111, figs 1-5; see Erséus and Paoletti (1986) for synonymies and other references.

Material. SMNH 1620, one partially mature specimen: Kee Lung River, branch of Tan Shui River estuary, near Taipei, Taiwan, 25°06'36"N, 121°27'46"E, intertidal mud, salinity 12‰, 13 February 1996 (Hsieh, H.-L.; station 2-1).

Remarks. This worm has poorly developed genitalia, but with regard to somatic characters it conforms to the description of *M. limosus* (see Erséus and Paoletti 1986). It has numerous small coelomocytes throughout the body, and, with the exception of the single-pointed ventral setae of segment II, all setae are bifid with a reduced upper tooth (Fig. 1B).

Fig. 1. A, *Monopylephorus rubroniveus*, seta. B, *M. limosus*, seta. C-D, *Doliodrillus tener* (specimen from the Shuang Hsi River); C, seta; D, lateral view of spermatheca and male genitalia in segments X-XI. Abbreviations: aa, atrial ampulla; ad, atrial duct; bs, blind sac of atrial duct; mp, male pore; ppa, prostatic pad; pr, prostate gland; s, spermatheca; sf, sperm funnel; sp, spermathecal pore; sv spermathecal vestibule; vd, vas deferens.

Monopylephorus limosus is normally a large tubificid. Previous records document a total length range (of mature specimens) of 15-70mm, with between 56 and 150 segments. The present individual is only 14.1mm long, with about 84 segments, but it is preadult and the segments at its posterior end are not completely differentiated.

This primarily freshwater species was originally reported from 'muddy gutters and ditches' in Japan (Hatai 1898; Nomura 1915) and mainland China (Chen 1940; Brinkhurst *et al.* 1990), but it is also known from a polluted river in Italy, where it is likely to be an introduction (Erséus and Paoletti 1986). The Kee Lung River collection verifies that *M. limosus*, never before recorded from a natural brackish-water habitat, is a euryhaline form. After gradual acclimation, specimens of the Italian population proved to live well in artificial seawater (Erséus and Paoletti 1986).

Distribution and habitat. Taiwan (new record), mainland China, Japan, and Italy. Organically enriched sediments, freshwater or brackish water, to at least 12‰ salinity.

Genus *Branchiura* Beddard
Branchiura sowerbyi Beddard, 1892

Branchiura sowerbyi Beddard, 1892, p. 325, pl. XIX, figs 1-15; see Brinkhurst and Jamieson (1971) for synonymies and other references.

Material. SMNH 1621-1622, two specimens, and ASIZ W 188, two specimens: Kee Lung River, branch of Tan Shui River estuary, near Taipei, Taiwan, 25°04'42"N, 121°32'18"E, intertidal mud, salinity 1‰, 16 April 1996 (Hsieh, H.-L., station K7N).

Remarks. *Branchiura sowerbyi* differs from all other tubificids by its numerous filiform gills along the posterior region of the body, and it is thus easy to recognize. Moreover, it is one of the largest tubificids (up to 185mm long, with up to 270 segments). The largest of the present individuals, however, is only 23.5mm, with about 140 segments.

This species may have had an oriental, tropical origin, but it is now widely distributed on all continents, including temperate areas (Brinkhurst and Jamieson 1971). In the People's Republic of China, Brinkhurst *et al.* (1990) found it at nearly every locality investigated, with the exception of clean upland streams.

Distribution and habitat. Cosmopolitan. Freshwater and upper reaches of estuaries; muddy or sandy sediments, abundant at polluted sites.

Subfamily *Limnodriloidinae*
 Genus *Doliodrilus* Erséus
Doliodrilus tener Erséus, 1984
 (Fig. 1C-D)

Doliodrilus tener Erséus, 1984, pp. 159-160, fig. 15; Erséus, 1990, pp. 287-288, fig. 11; Erséus *et al.*, 1990, p. 113, fig. 2K.

Material. SMNH 1623-1625, three specimens, and ASIZ W 189, 15 specimens: Tan Shui River estuary, near Taipei, Taiwan, 25°10'N, 121°27'E, intertidal mud, salinity 22‰, 15 January 1996 (Hsieh, H.-L., station 1-1-1). SMNH 1626-1628, three specimens, and ASIZ W 190, 23 specimens: Shuang Hsi estuary, at Kung Liao Village, northern Taiwan, 25°01'36"N, 121°55'36"E, 2-3m depth, very fine sand, salinity 27‰, 20 May 1993 (Hsieh, H.-L., station E1a). SMNH 1629-1630, two specimens, and ASIZ W 191, four specimens: three stations in Tzu Hu (an artificial bay separated from the sea by a dike), Kin Men Island, near Xiamen (Amoy) City, mainland China, approx. 24°28'N, 118°18.5'E, 1-2m depth, sediment varying (fine sand, medium sand, mud), salinity 30-32‰, 28 February 1996 (Hsieh, H.-L., stations 6, 7 and 11).

Description of new material. Three complete specimens from northern Taiwan 8.3-11.3mm long, with 33-45 segments; three complete specimens from Kin Men Island 6.1-7.1mm long, with 31-41 segments. Setae 50-70 µm long, two to six per bundle anteriorly, two to three per bundle in postclitellar segments, bifid with upper tooth generally somewhat longer than lower (Fig. 1C). Male and spermathecal pores in line with ventral setae.

In segment IX, oesophagus distended, with reticulate blood-plexus. Male genitalia (Fig. 1D) paired. Vas deferens entering apical end of curved atrial ampulla. Latter

85-120 μm long, bipartite; inner part thin-walled and hollow, outer part thick-walled and bearing globular, bulging prostatic pad. Lobed prostate gland (with large cell nuclei) attached to prostatic pad; in some worms lobes, small and devoid of secretion granules, in others (see Fig. 1D), lobes large and heavily granulated. Atrial duct about as long as ampulla, with blind sac located at some distance from male pore and directed posteriorly; male pore simple. Spermathecae (Fig. 1D, s) with short, often bulbous ducts and pear-shaped ampullae; duct with vestibule, ampulla containing bundles of sperm.

Remarks. The new material conforms well with the previous descriptions, but it is noteworthy that the prostate glands are more developed in some of the present specimens than in the worms from Hong Kong and Qingdao (compare Fig. 1D with Erséus 1984, fig. 15b, and 1990, fig. 11J). This variation is evidently correlated with the secretory activity of the prostatic cells.

As this species was previously known from both Hong Kong (Erséus 1984, 1990) and Qingdao on the Yellow Sea coast of China, its occurrence at Kin Men Island and the island of Taiwan was not unexpected. In Tzu Hu Bay (Kin Men) and the Shuang Hsi River estuary, *D. tener* was found subtidally, while all other records of the species have been from intertidal habitats.

Distribution and habitat. Northern and southern mainland China, and Taiwan (new record). Brackish-water, intertidal and subtidal (to about 3 m depth) soft mud and muddy sand.

Subfamily Tubificinae

Genus *Limnodrilus* Claparède

Limnodrilus hoffmeisteri Claparède, 1862

Limnodrilus hoffmeisteri Claparède, 1862, p. 226, pl. I, figs 1-3, pl. III, fig. 12, pl. IV, fig. 6; see Brinkhurst and Jamieson (1971) for synonymies and other references.

Material. SMNH 1631-1636, six specimens (two sectioned), and ASIZ W 192, 15 specimens: Kee Lung River, branch of Tan Shui River estuary, near Taipei, Taiwan, 25°04'42"N, 121°32'18"E, intertidal mud, freshwater, 13 February 1996 (Hsieh, H.-L., station 4-3). SMNH 1637, one specimen, and ASIZ W 193, two specimens: also Kee Lung River, but 25°05'30"N, 121°30'00"E, 4-5 m depth, fine sand, freshwater, 16 April 1996 (Hsieh, H.-L., station K8M). SMNH 1638-1640, three specimens, and ASIZ W 194, 22 specimens: Hsin Tien Hsi, another branch of Tan Shui River estuary, Taiwan, 25°02'12"N, 121°28'36"E, intertidal mud, salinity 2‰, 2 January 1996 (Chen, C.-P., station 4-1).

Remarks. *Limnodrilus hoffmeisteri* has been regarded as a true cosmopolitan taxon and the most common tubificid in the world (Brinkhurst and Jamieson 1971). In their study of the freshwater oligochaetes of the People's Republic of China, Brinkhurst *et al.* (1990) noted that *L. hoffmeisteri* was 'obtained at nearly every site visited.' It is particularly abundant in river sediments with a high organic content. In the Kee Lung and Hsin Tien Hsi Rivers, both heavily polluted, it is the most dominant species in the benthos, with densities up to 900,000 ind./m². The presence at station 4-1 in Hsin Tien Hsi River verifies that *L. hoffmeisteri* extends its range into oligohaline estuarine habitats.

Distribution and habitat. Cosmopolitan. Freshwater and upper reaches of estuaries; muddy or sandy sediments, abundant at polluted sites.

Discussion

Based on the current information, the brackish-water oligochaete fauna of Taiwan appears rather poor, with only a few species and a low degree of endemism. Six of the seven species known (including *Monopylephorus parvus* and *Paranais litoralis*; Cheng 1995) are widely distributed in the world, and although *M. limosus* and *Branchiura sowerbyi* probably have an oriental origin (see Remarks for these species above), only *Doliodrilus tener* may have a distribution still restricted to Southeast Asia. However, the sites sampled cover only a fraction of all the estuarine habitats available in Taiwan. In the Tan Shui River estuary and its tributaries (Kee Lung and Hsin Tien Hsi Rivers), samples were collected from a few exposed mudflats only, whereas other sediments, e.g., those associated with mangrove roots, were not explored. Another probable reason for low diversity in the current findings is that the Kee Lung and Hsin Tien Hsi Rivers are heavily polluted. The situation is similar to that of the Lower Pearl River in the People's Republic of China (Qi and Erséus 1985), where *Limnodrilus hoffmeisteri* proved to be a dominant oligochaete, too.

Doliodrilus tener was found in the Tan Shui estuary proper, which due to tidal flushing has slightly better conditions than its freshwater tributaries, and in Tzu Hu (Kin Men Island) and Shuang Hsi, both considered unpolluted sites. It evidently prefers higher salinities and may be less opportunistic than the other oligochaetes considered here.

Much work remains to be done to reveal the complete diversity of brackish-water oligochaetes in Taiwan. However, based on the available information it is probable that the fauna will not be drastically different from that of mainland China.

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