

# New Records of a Branchiobdellidan and Four Microdrile Oligochaetes (Annelida: Clitellata) from Inland Waters of Taiwan

## 台灣內水域新紀錄一種蛭蚓類及四種貧毛類

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### Abstract

In addition to known host *Neocaridina* spp., this paper reports the first record of the ectosymbiont branchiobdellidan *Holtodrilus truncatus* (Clitellata: Branchiobdellida) on *Caridina pseudodenticulata* (Decapoda: Atyidae) from Taiwan. Both host shrimp species occurred sympatrically at collection sites, suggesting that *H. truncatus* has no species specific preference for host. Eight species of free-living microdrile oligochaetes were also collected from the collection sites. Of these, four species, *Nais pardalis*, *Pristina proboscidea*, *Pristina amphibiotica* and *Aulodrilus japonicus*, are new records to Taiwan.

### 摘要

本研究描述1種台灣新紀錄的蛭蚓類 *Holtodrilus truncatus* (Clitellata, Branchiobdellida)，其宿主除已知的 *Neocaridina* spp. 外，首次發現亦寄宿在與 *Neocaridina* spp. 共域棲息的 *Caridina pseudodenticulata* (Decapoda, Atyidae)，因此 *H. truncatus* 並無宿主專一性。另外亦採集到8種自

由營生性的貧毛類，其中4種 *Nais pardalis*、*Pristina proboscidea*、*Pristina amphibiotica* 及 *Aulodrilus japonicus* 為台灣新紀錄種。

**Key words:** Clitellata, Branchiobdellida, oligochaetes, Taiwan, freshwater

**關鍵詞：**環節動物門、蛭蚓目、貧毛類、台灣、淡水

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## Introduction

Branchiobdellidans are obligatory ectosymbionts, living mostly on freshwater astacoidean crayfishes in the Holarctic region, but some are on other crustaceans as their hosts (Gelder 1999; Brinkhurst and Gelder 2001). Such branchiobdellidans on non-crayfish hosts in East Asian include *Caridinophilus unidens* Liang, 1963 living on the freshwater atyid *Caridina* shrimp (Liang 1963) in Yunnan Province, and of *Holtodrilus truncatus* (Liang, 1963) on *Neocaridina* shrimp in Hunan and Guangdong Provinces (Liang 1963; Liu 1984) in China. A similar symbiotic association between branchiobdellidans and freshwater shrimps has been reported from the central Japan by Niwa *et al.* (2005) and Niwa and Ohtaka (2006). Recently, a branchiobdellidan tentatively identified as *H. truncatus* has been found to live on three indigenous *Caridina* shrimp species on Miyako Island of Ryukyu in the southern Japan (Fujita *et al.*, unpubl.). Therefore, it has been postulated that branchiobdellidans might also occur in nearby Taiwan, as the island is rich and abundant in freshwater atyid shrimps and close geographical

proximity to both southern China and southern Japan.

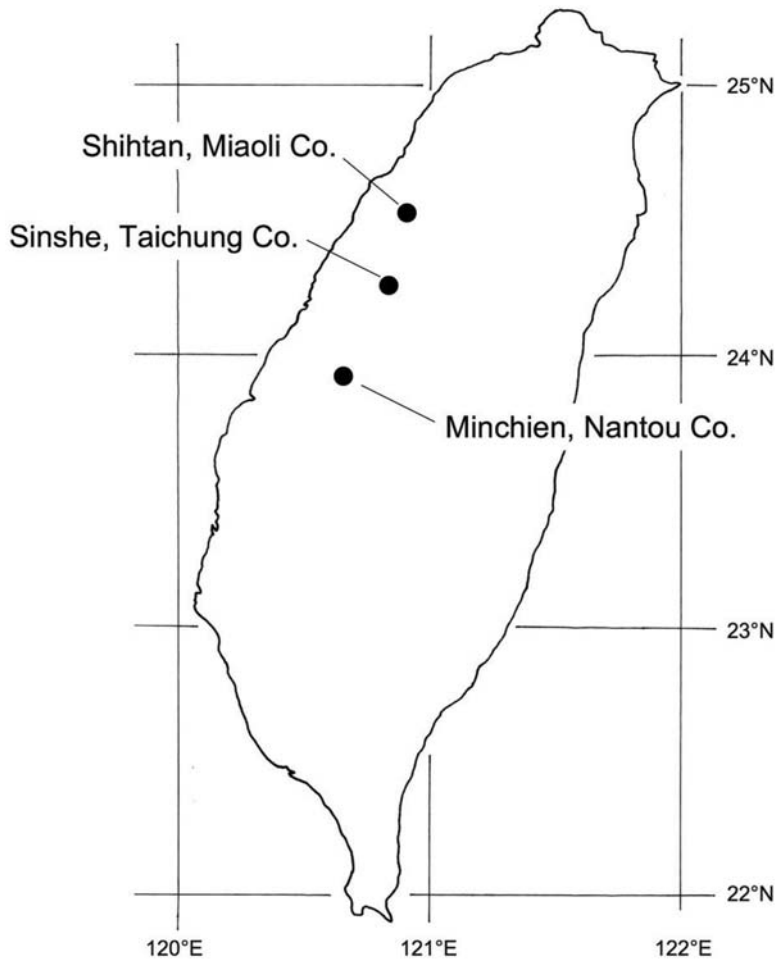
Studies on taxonomy and diversity of oligochaetes in Taiwan and its adjacent islands have been focused on terrestrial forms, and 72 species and subspecies of megadriles (earthworms) have been reported (Tsai *et al.* 2009). On the other hand, 26 species of aquatic microdrile oligochaetes comprising 25 naidids and one enchytraeid have been recorded from Taiwan (Cheng 1995; Yu *et al.* 1995; Erséus and Hsieh 1997; Hsieh *et al.* 1998, 1999; Lin *et al.* 2005; Lin and Yo 2008a, 2008b; Lin *et al.* 2008). These aquatic forms have been found in lowland areas including brackish estuaries and urban rivers mainly from pollution and ecologically related studies.

When we collected freshwater shrimps in searching for branchiobdellidans in Taiwan, we also collect benthic samples to identify free-living freshwater microdrile oligochaetes. This paper briefly describes our findings on branchiobdellidans and microdrile oligochaetes collected from Taiwan.

## Material and Methods

Branchiobdellidan and microdrile oligochaete specimens were collected from two streams and one pond in the northwestern part of Taiwan (Fig. 1). The branchiobdellidans were collected from shrimps sampled, and the oligochaetes were collected with a dipnet (mesh size, 190  $\mu\text{m}$ ) by scooping it through aquatic vegetation and bottom sediments. Substrate samples and shrimp specimens

were fixed in a 10% formalin solution at collection sites. In laboratory the oligochaetes were separated from the sediments and the branchiobdellidans from the shrimps under a dissecting microscope. The specimens were washed thoroughly in distilled water, dehydrated in a graded series of ethanol-water solutions, cleared in methyl salicylate, and mounted in Canada balsam on slides. Some of the slide-mounted specimens are deposited at the Endemic Species Research Institute (ESRI).



**Fig. 1.** A map of Taiwan showing the collecting sites (solid circles).

The Taiwanese *Neocaridina* shrimp has traditionally been identified as *N. denticulata denticulata* (Kubo 1938), but its' taxonomic (specific or subspecific) status remains controversial (Cai 1996; Liang 2004; Nishino and Niwa 2004; Shih and Cai 2007). Therefore, we regarded the shrimps as *Neocaridina* spp. Taxonomy of families and subfamilies of the oligochaetes follows the classification system of Erséus and Gustavsson (2002) and Erséus *et al.* (2008). In descriptions of species, segmental numbers are expressed by Arabic numerals for branchiobdellidans but by Roman numerals (= ganglionic numbers) for aquatic oligochaetes, according to the currently

accepted usages for the two taxa (Brinkhurst and Gelder 2001).

### Systematic accounts

Class Clitellata

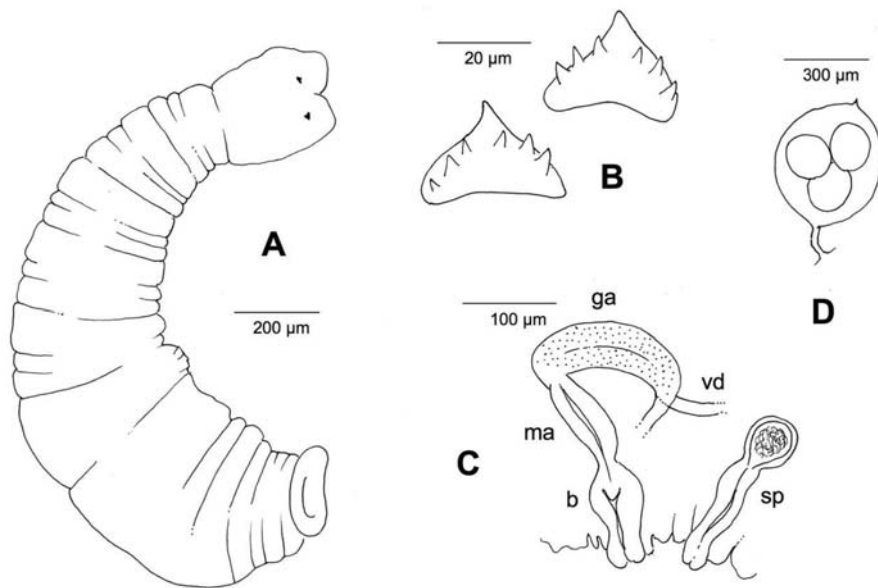
Order Branchiobdellida

Family Branchiobdellidae Grube, 1851

*Holtodrilus truncatus* (Liang, 1963) (Fig. 2)

*Stephanodrilus truncatus* Liang, 1963: 565-567, fig. 4.

*Holtodrilus truncatus* Gelder and Brinkhurst, 1990: 1320-1321, fig. 3; Niwa *et al.*, 2005: 685-686, fig. 1; Niwa and Ohtaka, 2006: 182-185, fig. 2.



**Fig. 2.** *Holtodrilus truncatus* from Sinshe, Taichung Co., Taiwan: A. lateral view of whole specimen (fixed); B. jaws; C. genital organs; D. cocoon; b, muscular bursa; ga, glandular atrium; ma, muscular atrium; sp, spermatheca; vd, vas deferens.

**Material examined.** - Twenty mature specimens (one of the slide mounted specimens was deposited at ESRI as ESRI-OA0001) from

90 host shrimp *Neocaridina* spp. collected on 10 September 2008 from a stream with a gravel-sandy bottom and submerged vegetation dominated

by *Egeria densa* Planch in Sinshe, Taichung County (24°14'N, 120°48'E); 10 mature and 20 immature specimens from 12 *Neocaridina* spp. and 61 *Caridina pseudodenticulata* Hung *et al.*, 1993, collected on 11 September 2008 from a stream with a gravelly bottom but no vegetation, Miaoli County (24°28'N, 120°53'E).

**Brief description.** - Living primarily in branchial chamber of host. Body terete, brownish transparent when living. Body length (mature) 1.3-2.6 mm in fixed state (Fig. 2A). No peristomial lobe or dorsal segmental appendage. Dorsal lip slightly longer than the ventral. Head 0.20-0.28 mm in width, wider than that of segment 1. Posterior attachment disc 0.16-0.21 mm in diameter. Segments 1-6, triannulate, middle annulus shortest. Dorsal and ventral jaws similar in shape and size; each triangular, about 25-35  $\mu\text{m}$  in width at base, with a large median tooth and three pairs of small lateral teeth, sometimes one lateral tooth missing or added (Fig. 2B). Two vasa deferentia entering glandular atrium entally in segment 6 (Fig. 2C). Glandular atrium tubular, 180  $\mu\text{m}$  in length and 50  $\mu\text{m}$  in diameter, prostate gland absent. Muscular atrium terete, 110  $\mu\text{m}$  in length, leading to conical penis surrounded by muscular bursa. Spermatheca in segment 5, duct 130  $\mu\text{m}$  long with a spherical bulb, 50  $\mu\text{m}$  in diameter (Fig. 2C). Cocoons spherical to ovoid in shape, 0.4-0.6 mm in height and 0.35-0.55 mm in width, with a small process dorsally and peduncle cemented onto gill surface (Fig. 2D).

**Remarks.** - *H. truncatus* was originally placed under the genus *Stephanodrilus* Pierantoni, 1906 (junior synonym of *Cirrodrilus* Pierantoni, 1905) on the host shrimp *Neocaridina denticulata*

*sinensis* (Kemp, 1918) from Sichuan in Hunan Province of China (Liang 1963). It was subsequently reported from Shaoguan in Guangdong Province from the same species of the host shrimp by Liu (1984). Gelder and Brinkhurst (1990) transferred the species to a new monotypic genus *Holtodrilus*, because of its unique taxonomic characters. Morphological characters of the specimens collected from Taiwan agreed closely with those described by Liang (1963) and Gelder and Brinkhurst (1990). This study confirmed that *H. truncatus* lives primarily in branchial chamber of the host shrimp as noted by Liu (1984) in China.

This paper reports the first record of *H. truncatus* from Taiwan. Besides it was found on *Neocaridina* shrimps (Liang 1963; Liu 1984), it was also found on a new host *Caridina pseudodenticulata*. *H. truncatus* was found at two out of the five sampling sites where *Neocaridina* and/or *Caridina* shrimps were found together. These two shrimps occurred sympatrically at Shihtan, Miaoli County where *H. truncatus* and its cocoons were found on both shrimps. This phenomenon was anticipated as branchiobdellidans are known to live on many species of crayfishes (Gelder *et al.* 2001).

When the North American red swamp crayfish *P. clarkii* (Girard, 1852) carried the branchiobdellidan *Cambarincola mesochoreus* Hoffman, 1963 was introduced into northern Italy, *C. mesochoreus* was later found on the sympatric native crayfish *Austropotamobius pallipes* (Lereboullet, 1858). In turn, two endemic branchiobdellidans, *Branchiobdella hexodonta* Gruber, 1883 and *Branchiobdella parasita* Henle, 1853, on native *A. pallipes* were also found later on the introduced *P. clarkii* (Gelder *et al.* 1999).

In Yunnan Province of China, a shrimp-

associated branchiobdellidan *Caridinophilus unidens* was recorded from *Caridina yunnanensis* Yu, 1938 by Liang (1963). Recently, a branchiobdellidan tentatively identified as *H. truncatus* on Miyako Island, Japan, was found on three sympatric *Caridina* shrimps: *Caridina rubella* Fujino and Shokita, 1975, *C. rapaensis* Edmondson, 1935, and *C. typus* H. Milne Edwards, 1937 (Fujita *et al.*, unpubl.). Brinkhurst and Gelder (2001) suggest that all crayfishes appear to be potential hosts for branchiobdellidans. A similar case of the shrimp-branchiobdellidan association was found in Taiwan. It still remains a question whether the Taiwanese population of *H. truncatus* is native or introduced.

#### Order Tubificida

Family Naididae Ehrenberg, 1828

Subfamily Naidinae Ehrenberg, 1828

*Chaetogaster diaphanus* (Gruithuisen, 1828)

*Nais diaphana* Gruithuisen, 1828; see Brinkhurst and Jamieson (1971) for synonyms and references.

**Material examined.** - One immature specimen (ESRI-OA0002) and another immature specimen collected from a stream in Sinshe, Taichung County (same collection data as for *H. truncatus*).

**Brief description.** - Body transparent, 0.8-1.5 mm long. Number of segments in zooids 9. Prostomium inconspicuous with narrow and truncated anterior end in fixed state. Dorsal chaetae absent. Ventral chaetae 6-8 per bundle in segment II, 144-190  $\mu\text{m}$  in length, longer than those in VI; each with nodulus proximally, with upper tooth longer but as thick as the lower tooth; absent in III-V; 4-6 per bundle in VI, 62-74  $\mu\text{m}$  long, with nodulus medially and longer upper tooth.

**Remarks.** - *C. diaphanus* is characterized by having long ventral chaetae in segment II. It is a common and widely distributed species found not only in freshwater but also in brackish water environments (Brinkhurst and Jamieson 1971). In Taiwan, this species was recorded from Taichung City by Lin and Yo (2008a).

*Nais pardalis* Piguët, 1906

*Nais bretscheri* var. *pardalis* Piguët, 1906; see Brinkhurst and Jamieson (1971) for synonyms and references.

**Material examined.** - One immature specimen (ESRI-OA0003) and another immature specimen were collected from a stream in Sinshe, Taichung County (same collection data as given for *H. truncatus*).

**Brief description.** - Body length 1.2-2.0 mm in fixed state. Number of segments in zooids 16. Prostomium rounded. Eyes present. Dorsal chaetae starting from segment VI and consisting of a 96-144  $\mu\text{m}$  long smooth hair and a 45-56  $\mu\text{m}$  long needle. Needles in bayonet-shape with nodulus distally and two fine, parallel, teeth of equal sized. Ventral chaetae 2-4 per bundle in II-V, 70-83  $\mu\text{m}$  in length, longer, thinner and straighter than those in the following segments, with median or proximal nodulus, and upper tooth longer and thinner than lower tooth; in the following segments 2-5 per bundle, 61-72  $\mu\text{m}$  long, with distal nodulus, and upper tooth as long as or slightly shorter but thinner than lower tooth.

**Remarks.** - Although *N. pardalis* has ventral chaetae in segments after VI, that are often enlarged with longer upper teeth (Brinkhurst and Jamieson

1971), the two specimens from Taiwan have normal chaetae only. It is a cosmopolitan naidine species. (Brinkhurst and Jamieson 1971). *Nais pardalis* reported herein constitutes the first record of this species from Taiwan.

*Dero digitata* (Müller, 1773)

*Nais digitata* (*coeca*) Müller, 1773; see Brinkhurst and Jamieson (1971) for synonyms and references.

**Material examined.** - Three immature specimens (one slide specimen deposited as ESRI-OA0004) collected from mud surface from a vegetable farm pond in Minchien, Nantou County (23°52'N, 120°42'E); one immature specimen from a stream in Sinshe, Taichung County (same collection data as for *H. truncatus*).

**Brief description.** - Body length 4-10 mm in fixed state. Number of segments in zooids 24. Prostomium bluntly conical. No eyes. Dorsal chaetal bundles beginning in segment VI, consisted of a 160-240 µm long smooth hair and a 64-77 µm long bayonet-shaped needle. Needle chaetae with distal nodulus and short bifurcate teeth; upper tooth longer than but as thick as lower tooth. Ventral chaetae 4-6 per bundle in II-V, 104-118 µm in length, longer and thinner than those in the following segments; each with proximal nodulus and long bifurcated distal teeth of which upper tooth longer, than and as thick as lower tooth. Ventral chaetae in the following segments, 3-5 per bundle, 71-88 µm long, with distal nodulus and upper tooth as long as and thinner than lower tooth. Branchial fossa has 4 pairs of gills.

**Remarks.** - *D. digitata* is a cosmopolitan species (Brinkhurst and Jamieson 1971). It was

recorded from Taichung County, Taiwan by Lin and Yo (2008a).

*Pristina proboscidea* Beddard, 1896

*Pristina proboscidea* Beddard, 1896; see Brinkhurst and Jamieson (1971) for synonyms and references.

**Material examined.** - One immature specimen (ESRI-OA0005) and two immature specimens collected from a stream in Sinshe, Taichung County (same collection data as for *H. truncatus*).

**Brief description.** - Body length 1.5-2.0 mm in fixed state. Number of segments in zooids 14-16. Prostomium forming a proboscis. No eyes. Dorsal chaetal bundles beginning in segment II, consisting of hairs and needles. Dorsal hairs 2-4 per bundle, 192-230 µm long, serrated. Dorsal needles straight, 2-3 per bundle, 40-48 µm long, simple-pointed, without nodulus. Ventral chaetae 5-8 per bundle, 56-64 µm long, with nodulus medially to distally; upper tooth longer and as thick as or slightly thinner than lower tooth.

**Remarks.** - *P. proboscidea* has been recorded from South America, Africa, South and East Asia, and Australia (Brinkhurst and Jamieson 1971). In Southeast Asia its predominant habitat was recorded as submerged vegetation from Central Kalimantan, Indonesia (Ohtaka *et al.* 2006). This paper gives the first record of this species from Taiwan.

*Pristina amphibiotica* Lastockin, 1927

*Pristina amphibiotica* Lastockin, 1927; see Brinkhurst and Jamieson (1971) for synonyms and references.

**Material examined.** - One immature specimen

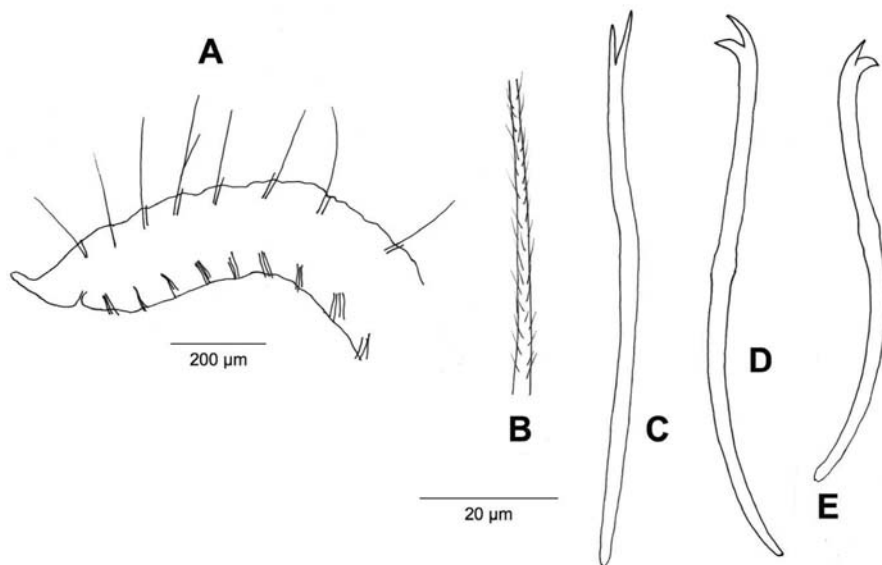
(ESRI-OA0006) collected from stream bed in Sinshe, Taichung County (same collection data as for *H. truncatus*).

**Brief description.** - Body length 1.3 mm in fixed state. Number of segments in zooids 23. Prostomium conical with rounded apex without proboscis. No eyes. Dorsal chaetal bundles starting in segment II, consisted of hair and needle chaetae. Dorsal hairs smooth, 1 or occasionally 2 per bundle, 105-256  $\mu\text{m}$  long. Dorsal needles in bayonet-shape, 1-2 per bundle, 48-64  $\mu\text{m}$  long, with distal nodulus and parallel teeth of which upper tooth distinctly shorter and much thinner than lower ones. Ventral chaetae 4-6 per bundle, 46-56  $\mu\text{m}$  long; those in anterior segments with

a little distal nodulus and upper tooth a little longer but as thick as lower tooth; those in posterior segments with distal nodulus and upper tooth shorter and thinner than lower tooth.

**Remarks.** - *P. amphibiotica* has been recorded from Europe, Africa, China, Indonesia and Japan (Brinkhurst and Jamieson 1971; Ohtaka 2001; Ohtaka and Nishino 2006; Ohtaka *et al.* 2006). This is the first record of the species from Taiwan.

*Pristina synclites* Stephenson, 1925 (Fig. 3)  
*Pristina synclites* Stephenson, 1925; see Brinkhurst and Jamieson (1971) and Kathman and Brinkhurst (1999) for synonyms and references.



**Fig. 3.** *Pristina synclites* from Minchien, Nantou Co., Taiwan: A. lateral view of anterior part of body; B. a part of dorsal hair chaeta in an anterior segment; C. dorsal needle chaeta in an anterior segment; D. ventral chaeta in an anterior segment; E. ventral chaeta in a posterior segment.

**Material examined.** - One immature (ESRI-OA0007) and 20 immature specimens collected

from a pond in Minchien, Nantou County (same collection data as for *Dero digitata*).

**Brief description.** - Body length up to 7 mm long in fixed specimens, forming a chains of zooids. Number of segments in zooids 21-70. Prostomium forming a short proboscis (Fig. 3A). Dorsal hairs 1 or occasionally 2 per bundle, 195-340  $\mu\text{m}$  long, finely hispid except for smooth proximal portion (Fig. 3B). Dorsal needles bayonet-shape, 1-2 per bundle, 64-88  $\mu\text{m}$  long, with weak nodulus and long, bifurcated distal teeth of which upper tooth a little shorter than lower tooth (Fig. 3C). Ventral chaetae in anterior segments 4 or occasionally 5 per bundle, 70-80  $\mu\text{m}$  long, with almost median nodulus (Fig. 3D); those in posterior segments 2-4 per bundle, 64-72  $\mu\text{m}$  long, with distal nodulus (Fig. 3E). Upper tooth in ventral chaetae as long as and thinner than lower tooth in all segments.

**Remarks.** - *P. synclites* closely resembles *P. americana* Cernovsytov, 1937 by having distinctly hispid dorsal hairs, and the Taiwanese specimens of the former might be assigned to the latter. However, we assigned the specimens to *P. synclites*, because the distal teeth in the ventral chaetae are equally long for all segments (Stephenson 1925; Sperber 1948; Torii and Ohtaka 2007). They differed from *P. americana* by having the upper tooth shorter than lower one in segments after IV (Sperber 1948). Hispid hairs have not been recorded in *P. synclites*, but surface condition of hair chaetae may vary (Chapman and Brinkhurst 1986), and thus, they are not regarded as a reliable character for the species distinction. *P. synclites* was originally described from India (Stephenson 1925) and subsequently recorded from Africa (Brinkhurst and Jamieson 1971), continental China (Wang and Cui 2007), North America (Kathman and Brinkhurst 1999), Kalimantan (Ohtaka *et al.* 2000),

Okinawa and Honshu islands, Japan (Torii and Ohtaka 2007) and Taichung County, Taiwan (Lin and Yo 2008a). This species was abundant in the shallow muddy bottom of the farm pond in this study.

Subfamily Tubificinae Vejdovsky, 1876

*Limnodrilus hoffmeisteri* Claparède, 1862

*Limnodrilus hoffmeisteri* Claparède, 1862; see Brinkhurst and Jamieson (1971) for synonyms and references.

**Material examined.** - A mature specimen (ESRI-OA0008) collected from a pond in Minchien, Nantou County (same collection data as for *Dero digitata*).

**Remarks.** - The specimen of *L. hoffmeisteri* examined had a “plate-topped” penis sheath (Brinkhurst and Jamieson 1971). The species is usually found in eutrophic or organically polluted waters (Ohtaka *et al.* 1990) and is a cosmopolitan and common tubificine in the world (Brinkhurst and Jamieson 1971). It has been repeatedly recorded from Taiwan (Erséus and Hsieh 1997; Hsieh *et al.* 1998, 1999; Lin *et al.* 2005; Lin and Yo 2008a; Lin *et al.* 2008) from heavily polluted estuaries (Erséus and Hsieh 1997) and urban freshwaters (Lin and Yo 2008a).

*Aulodrilus japonicus* Yamaguchi, 1953

*Aulodrilus japonicus* Yamaguchi, 1953: 298-300, fig. 12, pl. 7, figs. 5-7.

**Material examined.** - An immature specimen (ESRI-OA0009) collected from a pond in Minchien, Nantou County (same collection data as for *Dero digitata*).

**Brief description.** - Body length 9 mm in fixed state. Number of segments 31 with posterior 1 mm being chaetaless. Prostomium short conical. Dorsal chaetal bundles consisted of hairs and crotchets, both beginning on segment II; hair chaetae smooth, 2-9 per bundle, 112-180  $\mu\text{m}$  long; forsal crotchets 5-11 per bundle, 72-107  $\mu\text{m}$  long, with distal nodulus and upper tooth split into several fine teeth which are much thinner and shorter than single lower tooth. Ventral chaetae bifurcated crotchets, 6-11 per bundle, 80-100  $\mu\text{m}$  long, with distal nodulus and upper tooth about half as long as and much thinner than lower tooth. Upper part of the shafts in dorsal and ventral crotchets protruded laterally.

**Remarks.** - *A. japonicus* resembles *A. pluriseta* (Piguet, 1906) by having dorsal hairs beginning on segment II, no modified genital chaetae, and independent male pores. Brinkhurst Jamieson (1971) once dubiously synonymized the two species. However, *A. japonicus* is distinguishable from *A. pluriseta* by having unique multifold upper teeth in the dorsal crotchets and more posterior position of the midgut, and thus, it should be regarded as a distinct species (Van der Hoek and Verdonschot 2005; Timm and Vřivkova 2007). In East Asian *A. japonicus* is widely distributed in Japan (Ohtaka, unpubl.), the Ryukyu islands (Ohtaka 2003), Lake Hanka in Amur basin (Timm and Vřivkova 2007), and China mainland (Wang and Cui 2007). Its distributional range may be Holarctic because *A. japonicus* has been often confused with *A. pluriseta* in the Netherlands (Van der Hoek and Verdonschot 2005), Estonia (Timm and Vřivkova 2007) and probably in North America (Ohtaka, unpubl.). *A. japonicus* reported herein is the first confirmed record of the species

in Taiwan. *A. pluriseta* previously reported by Lin and Yo (2008a) from Taichung County might be *A. japonicus*; the specimens need to be re-examined.

## Discussion

*Holtodrilus truncatus* has recently been reported to live on *Neocaridina* shrimps in Kinki District, Central Japan (Niwa *et al.* 2005). Its occurrence in Japan was thought to be an unintentional introduction along with the importation of the host shrimp for fish bait from China. This area of Japan is famous for leisure fishing and large amounts of *Neocaridina* shrimps are routinely imported (Niwa and Ohtaka 2006). In addition, live alien shrimps are available as “cleaners” for ornamental aquaria via internet sales and from many of local aquarium shops in Japan. The alien shrimps have gradually become widespread (Nishino and Ikeda, unpubl.), leading to a further distribution of symbiotic branchiobdellidans into non-native area. The international trade of shrimps is also popular in Taiwan (Fisheries Agency 2007) and for the same reasons it is probable that *H. truncatus* was introduced to Taiwan along with the importation of its host shrimps.

The introduction of branchiobdellidans on their commercial hosts to Taiwan and Japanese islands is speculative. However, it is equally possible that the branchiobdellidan species tentatively identified as *H. truncatus*, from Miyako Island (Fujita *et al.*, unpubl.) is native to the island. This interpretation is supported because its hosts are indigenous *Caridina* shrimps (*C. rubella*, *C. rapaensis* and *C. typus*) in three isolated wells according to Fujita (pers. comm.) and no shrimp are known to have been introduced recently onto the island. This line of reasoning would suggest

that *H. truncatus* on shrimps had already become established before the islands of Miyako and Taiwan became separated from the China mainland. No shrimp introduction has been confirmed from outside of the islands. However, Miyako Island is close to Taiwan, and therefore, it is possible that *H. truncatus* is indigenous to Taiwan and closely related to the population on Miyako Island. Further taxonomic and phylogenetic studies of these branchiobdellidans are needed to clarify the origin and biogeographical history of the Taiwanese population.

Incorporating the present records into the past inventory of Taiwanese oligochaetes (Tsai *et al.* 2009), the number of the aquatic microdrile oligochaetes recorded from Taiwan and its adjacent islands increases to 30 species. Erséus and Hsieh (1997) point out that the brackish oligochaete fauna of Taiwan is rather poor, and suggest that the Taiwanese oligochaete fauna is not drastically different from that of continental China (Erséus and Hsieh 1997). However, Taiwan has some unique aquatic environments not encountered in China that need to be explored, such as high mountain ranges with rapid flowing streams and coral reefs facing on the Pacific Ocean. Further studies are required to reveal the full extent of the unique diversity of aquatic oligochaetes on the island.

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