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New Record of *Tubificoides brevicoleus* Baker (Oligochaeta, Tubificidae) from the Pacific Coasts of Hokkaido, Northern Japan

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(With 5 Text-figures and 1 Table)

Introduction

Recent intensive investigations have made clear the presence of many tubificid species in marine environments. According to Erséus and Strehlow (1986), to date about 270 marine tubificids have been described in the world. However, information on the northwestern Pacific region is still scanty. From Japanese coasts, only two species, *Rhizodrilus pacificus* (Brinkhurst and Baker) (Baker and Brinkhurst, 1981) and *Tubificoides imajimai* Brinkhurst (Brinkhurst, 1985) have been recorded. In this paper, *Tubificoides brevicoleus* Baker hitherto known from eastern Pacific coasts is re-described from the Pacific coasts of Hokkaido, northern Japan.

Materials and Methods

All the Japanese specimens used here were collected by the author. Observation was mainly based on the following three sorts of preparations: 1) whole-mounted specimens mounted with Canada Balsam or synthetic resin Bioleit® (Ohken Ltd., Tokyo); 2) pressed specimens wholly mounted with Amman's lactophenol (Brinkhurst, 1971) for observation of setae; 3) serially sectioned specimens which were cut in 8–10 μm thick and stained with Delafield's haematoxylin

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and eosin for anatomical study. In addition, two specimens from the Canadian coasts of the eastern Pacific were studied for comparison with the Japanese form. The present Japanese specimens are deposited at the Zoological Institute, Faculty of Science, Hokkaido University (ZIHU) except for a part which are deposited at the United States National Museum of Natural History (USNM) via Dr. R.O. Brinkhurst.

Abbreviations in figures: Roman numerals (also used in text), segmental numbers; at, atrium; cl, clitellum; es, egg sac; fp, female pore; g, gut; mf, male funnel; mp, male pore; nc, ventral nerve cord; o, ovary; p, penis; psh, penis sheath; pr, prostata; ss, sperm sac; sta, spermathecal ampulla; stp, spermathecal pore; sz, spermatozeugmata; t, testis; vd, vas deferens.

Tubificoides brevicoleus Baker, 1983

(Figs. 1-5; Table 1)

Tubificoides brevicoleus Baker, 1983, p. 1272, Figs. 1C-E, 3D, 4.

Materials examined

Japanese specimens: ZIHU 378-384, five whole-mounted and two sectioned mature individuals; USNM 099301-099302, one whole-mounted and one sectioned mature individuals; intertidal zone in front of the Institute of Algological Research, Hokkaido University, Bokoi, Muroran, Hokkaido, 42°18′N, 141°00′E, 22, 23 June 1982. Fifteen whole-mounted and ten sectioned mature individuals, and seventeen individuals in fluid from above locality, 22, 23 June 1982, 28 May, 11 July 1983. One whole-mounted immature individual, intertidal zone in front of the Akkeshi Marine Biological Station, Hokkaido University, Akkeshi, Hokkaido, 43°01′N, 144°50′E, 18 Aug. 1982. *Canadian specimens*: two whole-mounted mature individuals (one from near the entrance to Belize Inlet, British Columbia, Canada, and the other from Gowgaia Bay, Moresby Is., British Columbia, Canada, 17 May 1980), H.R. Baker collected and R.O. Brinkhurst identified.

Description

Worms in fixed state after narcotization up to 45 mm long, 1 mm wide, 130 segments. Living worms extended over 60 mm in length. Apical three segments with secondary annulations; anterior annuli shorter than posterior. From between 1/2III and beginning of IV to posterior end except for clitellum, epidermis 10-20 μm thick, uneven, thinner than the apical three segments, with a layer composed of secretion and foreign matter; surface of the layer with numerous tiny leaf-like processes. This cutaneous cover on body surface less than 15 μm thick. Clitellum conspicuous, occupying from 1/2X (immediately behind setal line) to end of XII, whitish in color. Epidermis of clitellum dorsally and laterally up to 50 μm thick and very glandular; ventrally thinner (about 20 μm thick) and less glandular. Body wall at outer side of spermathecal pore in X swollen (Fig. 1A).

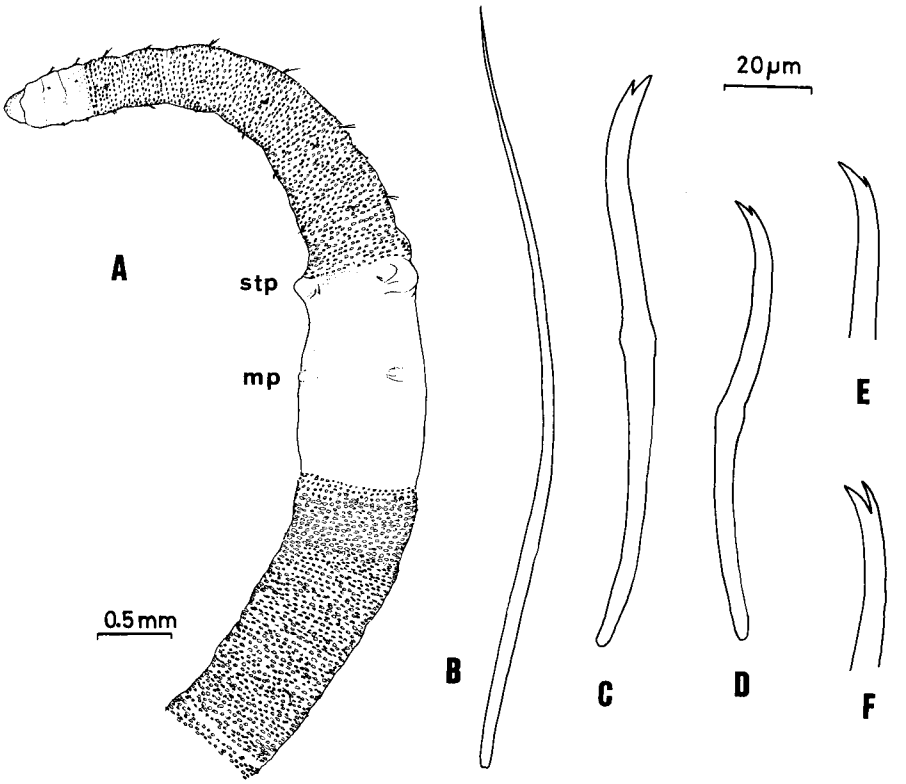

Fig. 1. *Tubificoides brevicoleus* from Muroran, Hokkaido. A, ventrolateral view of the anterior part of body; B, hair seta in VII; C, dorsal crotchet in VII; D, the same in a middle segment; E, the same in a posterior segment; F, dorsal crotchet in II.

Pharynx in II $-1/2$ III; wall thick with pharyngeal glands dorsally. Chloragogen cells from VI, 20–38 μm high, club-shaped.

Preclitellar dorsal bundles composed of 1–2 short, weakly curved smooth hairs (Fig. 1B) and 1–3 bifurcate sigmoid crotchets; teeth of the crotchets not divergent, and upper one about half as long as and thinner than lower (Fig. 1C). Dorsal bundles behind clitellum with 1 hair and 1 crotchet with upper tooth more reduced (Fig. 1D); those in posterior ten or less segments composed of one crotchet only, upper tooth exceedingly short and thin, though always present (Fig. 1E). Ventral setal bundles composed of 2–5 crotchets preclitellary whereas 1 in postclitellarly. Proportion of distal teeth of ventral setae almost similar to those of dorsal crotchets throughout. In II and III, both dorsal and ventral bundles often bear crotchets with upper tooth only a little shorter and a little thinner than lower (Fig. 1F). All crotchets with nodulus medially to slightly distally. Ventral

setae in X not modified; those in XI absent in mature individuals. Setal measurements of large, mature individuals (longer than 40 mm in length; N=3) from Muroran, Hokkaido as follows: In preclitellar segments, dorsal hairs 80-210 μm long, 2.5-3.9 μm thick in maximum; dorsal crotchets 60-144 μm long, 3.7-6.9 μm thick, upper tooth 2.5-3.7 μm long and lower one 4.9-7.4 μm long; ventral setae 68-168 μm long, 4.1-6.9 μm thick, upper tooth 1.6-4.1 μm long and lower one 5.3-7.5 μm long. In posterior segments, dorsal crotchets 78-84 μm long, 2.7-4.1 μm thick, upper tooth 0.4-1.4 μm long and lower one 2.5-3.9 μm long; ventral setae 44-80 μm long, 2.9-4.2 μm thick, upper tooth 0.6-1.5 μm long and lower one 1.6-3.1 μm long.

All genital organs except sperm sac and egg sac paired. Testes and ovaries attached to posterior surface of septa 9/10 and 10/11, respectively. Male funnel in X, markedly large (Fig. 2A). Vas deferens (Figs. 2B, 3A), very long, winding backward as far as XV, connected with convex side of atrium subapically (Fig. 2C); the width fairly constant throughout and the inner wall densely ciliated. Atrium stoutly tubular, occupying XI and XII with median weak neck and with

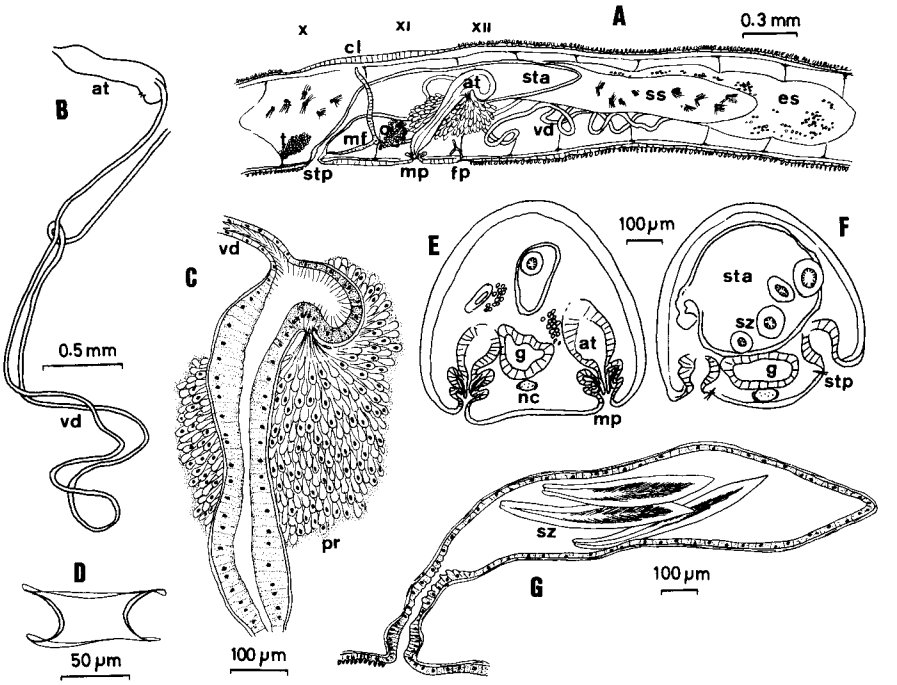

Fig. 2. Genital organs of *Tubificoides brevicoleus* from Muroran, Hokkaido. A, arrangement of genital organs (sagittal section); B, vas deferens and atrium; C, longitudinal section of atrium; D, penis sheath, ectal side below; E, diagram of cross section at the setal line of XI; F, the same at the setal line of X; G, sagittal section of spermatheca.

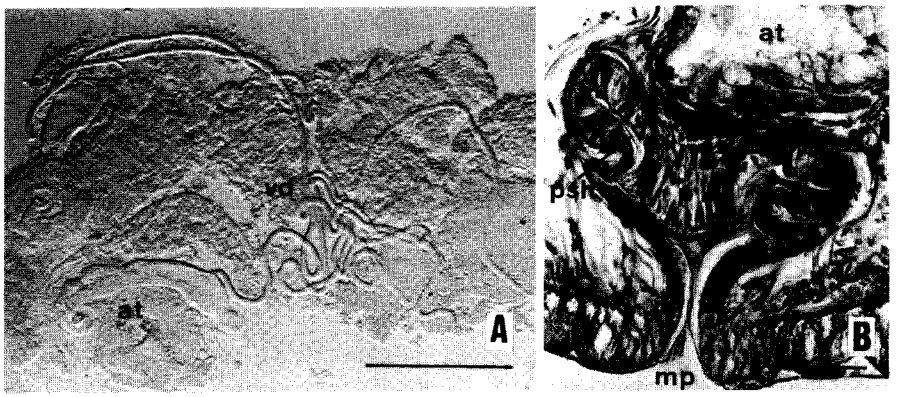

Fig. 3. *Tubificoides brevicoleus* from Muroran, Hokkaido. A, vas deferens and atrium in a compressed specimen; B, sagittal section of penial pouch. Scale bars, 1 mm (A) and 50 μm (B).

a bent apical caecum (Fig. 2C). Inner epithelium of atrium thick and glandular; that of top caecum thin, histologically different from the rest, being more glandular than the other parts of atrium and with long cilia. Inner epithelium of atrium around the opening of vas deferens lower than the other parts. Prostate gland about as large as atrium, connected with concave side of atrium by a narrow junction situated opposite to the opening of vas deferens. Ejaculatory duct inconspicuous. Ectal part of atrium not glandular, two-folded (Fig. 3B), the first fold forming a more or less conical penis with the top sometimes slightly cutinized. Chitinous penis sheath set in penial pouch, short with thick wall, largely expanded at both ental and ectal ends (Fig. 2D). Male pores at the middle of XI on the setal line (Fig. 2E) but lacking setal bundle. Female funnel small and female duct inconspicuously opening behind septum 11/12. Spermathecal ampulla ovoid (Fig. 2G), usually extending backward (as far back as XIV) and sometimes folded in mated specimens. Spermathecal duct short, more or less well marked off from ampulla, thick walled with a distinct sac-like distention at subterminal part where the inner epithelium tall and narrow with nuclei basally. Spermathecal pores close to the ventral setal bundles in X; opening outside of the bundles (Fig. 2F). Up to seven spermatozeugmata observed in ampulla; each of them usually long, more or less spindle-shaped, with one end pointed (Fig. 2G). Sperm sac extended forward in IX and backward up to XVI, and egg sac extended as far back as XIX. Measurements of genital organs in mature specimens from Muroran, Hokkaido (N=10) as follows: male funnel about 500 μm in diameter; vas deferens 6.6-7.8 mm long, 40 μm wide, lumen 20-24 μm in diameter; atrium 530-830 μm long, inner epithelium except caecum part 40-60 μm thick; penis sheath 28-52 μm long, 44-60 μm in minimum diameter and 78-110 μm in ental and ectal diameters; spermathecal ampulla about 500-1,700 μm long, and spermathecal

duct 250-300 μm long.

Remarks

Tubificoides brevicoleus was orignally described by Baker (1983) from eastern Pacific coasts, British Columbia, Canada, and the present report is the first record of this species except for the original localities. This species is distinguishable from related taxa by the long vas deferens and short and thimble shaped penis sheath. The present Japanese specimens agreed with the original description and the present Canadian specimens of *T. brevicoleus* in most characters examined. However, the following differences were detected between the Japanese and the Canadian forms (synoptically given in Table 1): 1) According to the original description of *T. brevicoleus* from Canada (Baker, 1983), the vas deferens was 4-5 times as long as the atrium, though the condition could not be confirmed in the present Canadian specimens. But in Japanese specimens it is usually over ten times (range: 9.0-13.0, N=6) longer than the atrium, thus much longer than that given in the original description. 2) Both ental and ectal ends of the penis

Table 1. Comparison of some characters between Japanese and Canadian forms of *Tubificoides brevicoleus*. All values are shown in μm. Asterisked values were measured on the figures in the paper cited.

		Length of vas deferens	Length of atrium	Penis sheath		Length of spermatheca	
				Length	Width of ends	Ampulla	Duct
Japanese form	Present specimens	6640-7800	530-830	28-52	78-110	500-1700	250-300
Canadian form	Baker (1983)	2500	450-630	30	55	460*	230*
	Present specimens		490-624	34	64- 70	280- 330	200-260

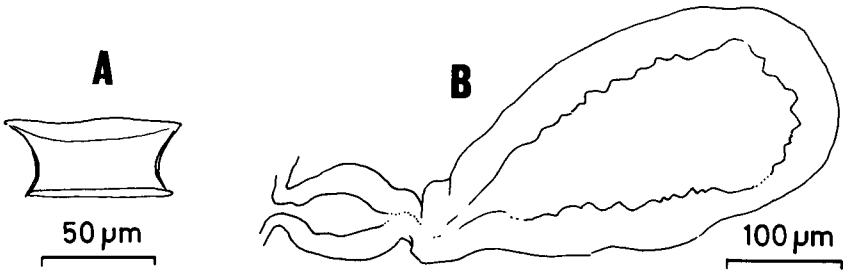

Fig. 4. Penis sheath (A) and spermatheca (B) in the present Canadian specimens of *Tubificoides brevicoleus*.

sheath are a little more expanded in the Japanese specimens than the original figure and the present Canadian specimens (Fig. 4A). The spermathecal ampullae were usually very elongate in mated specimens from Japan. Such a condition was not found in the original figure (mated specimen) and the present Canadian specimens (all un-mated; Fig. 4B). However, this elongate ampulla may be merely caused by filling of spermatozeugmata because simply ovoid spermathecal ampullae closely resembling the original figure were also found in some un-mated Japanese specimens. Brinkhurst (pers. comm.) suggested that there are two types of spermathecal ampullae in *Tubificoides* species with hair setae, namely spherical and ovoid. The ampulla of *brevicoleus* apparently belongs to the latter.

Most *Tubificoides* species with hair and bifid setae in the dorsal bundles are known to have limited geographic distributions (Brinkhurst, 1985). However, *T. brevicoleus* is known from amphi-Pacific coasts, and may be a circum-Pacific species. Among this group, similar widely distributed pattern is known in *T. insularis* (amphi-Atlantic; Brinkhurst, 1985). As in the type locality, the Japanese form was collected from intertidal zones. The sediments of the two Japanese localities were similar to each other, having rather reduced conditions characterized by an accumulation of decaying seaweeds among gravels or sands, and by the occurrence of H_2S. The color of the sediment was deep black. The

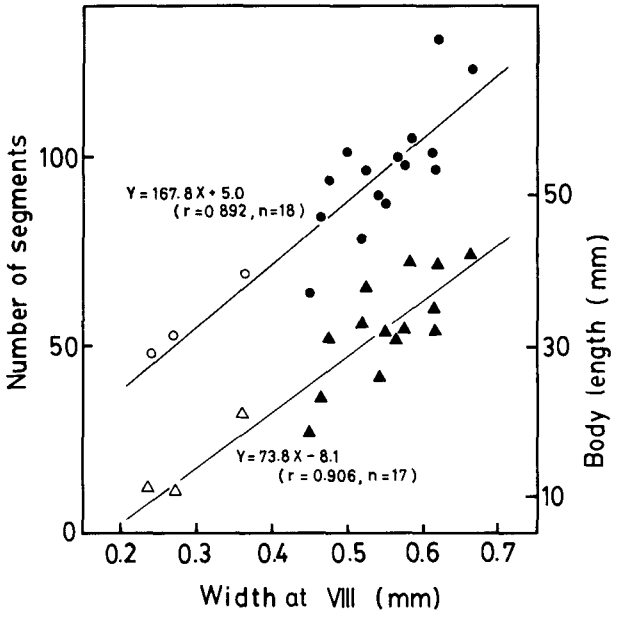

Fig. 5. Correlations of the number of segments (circle) and the body length (triangle) to the width at VIII at fixed state in *Tubificoides brevicoleus* from Muroran, Hokkaido. Solid symbols, sexually mature individuals.

worms were also blackish in appearance when collected, though they became paler during preservation. At the habitat of Muroran, the present species predominated among annelids, followed by other oligochaetes and cirratulid polychaetes. Measurements of seventeen specimens collected on 23 June 1982 at Muroran showed that the body length and number of segments were correlated with the width at segment VIII (Fig. 5). Worms wider than 0.45 mm at VIII, and more than about 20 mm in length, or 65 segments, were always sexually mature.

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