

## Two New Marine Gastrotrichs of the Genus *Tetranchyroderma* (Macrodasysida: Thaumastodermatidae) from South Korea

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**Ji Min Lee and Cheon Young Chang (2007)** Two new marine gastrotrichs of the genus *Tetranchyroderma* (Macrodasysida: Thaumastodermatidae) from South Korea. *Zoological Studies* 46(4): 474-482. Two new marine thaumastodermatid species, *Tetranchyroderma multicirratum* sp. nov. and *T. monokerosum* sp. nov. are described on the basis of specimens collected from sublittoral sandy bottoms of the Yellow Sea and Jeju I., Korea. Both species have cuticular armature with pentaneres only. *Tetranchyroderma multicirratum* sp. nov. is clearly differentiated from its congeners by the character combination of head with papillary protrusions, 3 kinds of cephalic tentacles, and 10 pairs of long subdorsal and dorsolateral cirrata. *Tetranchyroderma monokerosum* sp. nov. is characterized by 1 mid-dorsal rod-like cephalic tentacle, a pair of pestle organs, and 2 pairs of dorso-lateral adhesive tubes. <http://zoolstud.sinica.edu.tw/Journals/46.4/474.pdf>

**Key words:** Taxonomy, Gastrotricha, Thaumastodermatidae, *Tetranchyroderma*, Korea.

The genus *Tetranchyroderma*, belonging to the family Thaumastodermatidae, consists of 56 valid species to date and is known as the most diverse group among marine macrodasysid gastrotrichs. Recently, Todaro (2002) provided a useful key to the genus for the known species including 6 unnamed species, on the basis of such characters as cuticular armature, cephalic tentacles, and adhesive tubes.

In Korea, since Chang et al. (1998a) first recorded 2 new *Thaumastoderma* species, i.e., *T. coronarium* from the Yellow Sea and *T. appendiculatum* from the East Sea of Korea, 12 marine gastrotrich species have been reported, three of which belong to the genus *Tetranchyroderma*: *T. gracilium* Chang, Lee and Clausen, 1998, *T. heterotentaculatum* Chang and Lee, 2001, and *T. hoonsooi* Chang and Lee, 2001 (Chang et al. 1998b, Chang and Lee 2001).

As one of the serial studies on the Korean gastrotrich fauna, we herein describe 2 new *Tetranchyroderma* species from the Yellow Sea

and Jeju I., with comments on intraspecific variations as well as morphological discrepancies between adults and juveniles.

### MATERIALS AND METHODS

Materials were collected from sublittoral sandy bottoms at Manripo (St. 1) in the Yellow Sea and at Hwasun (St. 2) and Siheung (St. 3) on Jeju I., the largest and southernmost island of Korea (Fig. 1).

Samples were taken by scooping the top (~10 cm) sediments into polyethylene vinyl bags or 700 ml volume plastic bottles by scuba or skin diving. Methods for the extraction of the specimens from sediments and preparation of whole mounts and SEM materials are given in Lee and Chang (2003).

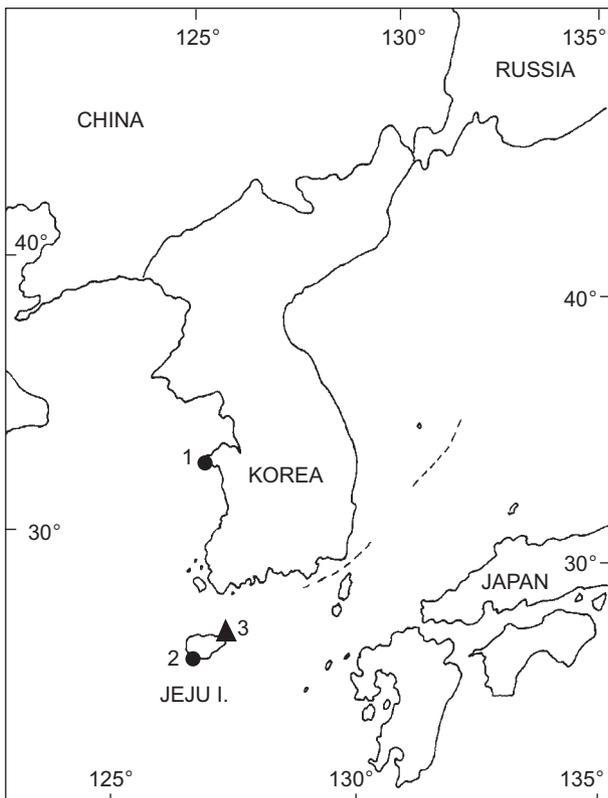
Specimens were observed using a microscope (Olympus BX-50) equipped with Nomarski differential interference contrast optics. All draw-

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ings and measurements were made with the aid of a camera lucida. Minute morphological characters like sensory hairs and inner genital organs were examined and video-recorded in living worms using a CCD camera (Olympus DP-11). High-resolution video images were stored on a JVC (HR-S6700KR) Super-VHS video recorder (with 400 line resolution).

Type specimens are deposited in the National Biological Resources Center, Incheon, Korea, and in the Department of Biology (DB), Daegu Univ., Korea.

Terminology used in the description mostly follows Ruppert (1991) and Clausen (2000). Abbreviations used in text and figures are as follows: Lt, total length, from anterior tip of head to posterior tip of pedicles including adhesive tubes; U, percentage unit of Lt, used for the location (U-) from anterior to posterior, or for the relative length (-U); PhJln, junction between pharynx and intestine; TbA, anterior adhesive tubes; TbL, lateral adhesive tubes; TbP, posterior adhesive tubes; TbV, ventral adhesive tubes; TbVL, ventrolateral adhesive tubes.



**Fig. 1.** Map showing the localities. (1) Manripo; (2) Hwasun; (3) Siheung. (●) *Tetranchyoderma multicirratum*, (▲) *Tetranchyoderma monokerosum*.

## DESCRIPTION

### Family Thaumastodermatidae Remane, 1926 Subfamily Thaumastodermatinae Ruppert, 1978

#### Genus *Tetranchyoderma* Remane, 1926 *Tetranchyoderma multicirratum* sp. nov.

(Figs. 2-4)

*Type material:* Holotype (DB0801): hermaphroditic adult specimen, Hwasun (33°14'26"N, 126°19'50"E; 4-5 m depth), Jeju I., Korea, 6 Oct. 2001, leg. C.Y. Chang and J.M. Lee. Paratypes: 10 adults, 2 juveniles, collection data same as for holotype. All type materials mounted in glycerin on H-S slides. Holotype and 10 paratypes (DB0802-11) deposited in specimen room of Department of Biology, Daegu Univ. Other 2 paratypes (KB131, 132) deposited in National Biological Resources Center, Incheon, Korea.

*Additional material examined:* Two individuals, Manripo (36°47'18"N, 126°8'31"E), 17 May 1999, leg. S.H. Kim; 2 individuals, Hwasun, Jeju I., 3 Apr. 2002, leg. J.M. Lee and E.H. Kwon; 7 individuals (2 juveniles), Hwasun, Jeju I., 7 Oct. 2002, leg. C.Y. Chang and J.M. Lee.

*Diagnosis:* *Tetranchyoderma* with fan-shaped head and oblong body; 13 papillae on anterior head border; with 3 pairs of cephalic tentacles (rod-like, conical with a distal bristle, and modified pestle organ); cuticular armature of pentancreas only; 10 pairs of long subdorsal or dorsolateral cirrata in trunk region; 14 short ventrolateral cirrata per side along entire body length; 4 TbA per side, comprising 1 medial and 3 ventrolateral ones; 15 TbVL per side, 1st one just behind TbA and others from pharyngeal pores to posterior trunk; with a short, bilobed caudum; 3 TbP per side forming a pedicle with 2 distal and 1 medial tubes; copulatory organ tubiform.

*Holotype:* Body small and oblong, flattened dorsoventrally; Lt 227  $\mu$ m including TbP, maximum width 43  $\mu$ m at mid-trunk (U60); slightly thinner at posterior 1/3 of pharyngeal region, and both sides nearly parallel in trunk region; widths of head, neck, PhJln, trunk, and caudal base 57, 35, 40, 43, and 24  $\mu$ m at U14, U32, U47, U60, and U94, respectively.

Head protruding a little anteriorly; bearing 13-14 large papillary projections like a petal along anterior margin, each with a very short hair at tip; each papilla supported by 1 or 2 stiff rods (Figs. 2A, 3B). Three pairs of cephalic tentacles com-

posed of a pair of rod-like tentacles (7  $\mu\text{m}$ ) located dorsally at U13, a pair of conical ones (15  $\mu\text{m}$ ) with a long sensilla at tip situated near posterolateral corner of head (U14), and modified pestle organs like twin balls. Three pairs of small papillae each with a long cilium located on dorsal surface of oral hood: 1 pair situated medial to rod-like tentacles, and 2 other pairs beside conical tentacles. Ten to 12 sensory hairs (5-8  $\mu\text{m}$ ) situated along anterior margin of oral hood; 8 hairs (~25  $\mu\text{m}$ ) per side inserted on lateral or dorsolateral surface from behind oral hood through trunk region (U19-U90).

Oral opening (Fig. 2B) undulating ventrally, bearing a pair of broad, protruding lobes laterally, and with 3 short hairs on mid-ventral edge of oral opening.

Four to 5 epidermal glands per side aligned along entire lateral side, of irregular shape and size (3-11  $\mu\text{m}$  in diameter) (Fig. 2A).

Cuticular armature with pentaneres only (Fig. 4C), arranged in 13-15 columns in mid-trunk region; size gradually increasing from about 10  $\mu\text{m}$  in diameter anteriorly to 23  $\mu\text{m}$  in posterior intestinal region; 4-5 small pentaneres (7  $\mu\text{m}$ ) covering caudal lobes.

Two columns of 10 long dorsal cirrata per side, ranging 35-44  $\mu\text{m}$  in length, more or less evenly spaced from U39 to U90; each column consisting of 6 subdorsal cirrata at U39, U47, U57, U70, U78, and U89 and 4 dorsolateral cirrata at U45, U59, U72, and U84, respectively.

Lateral cirrata (Fig. 2B), 14 per side, shorter

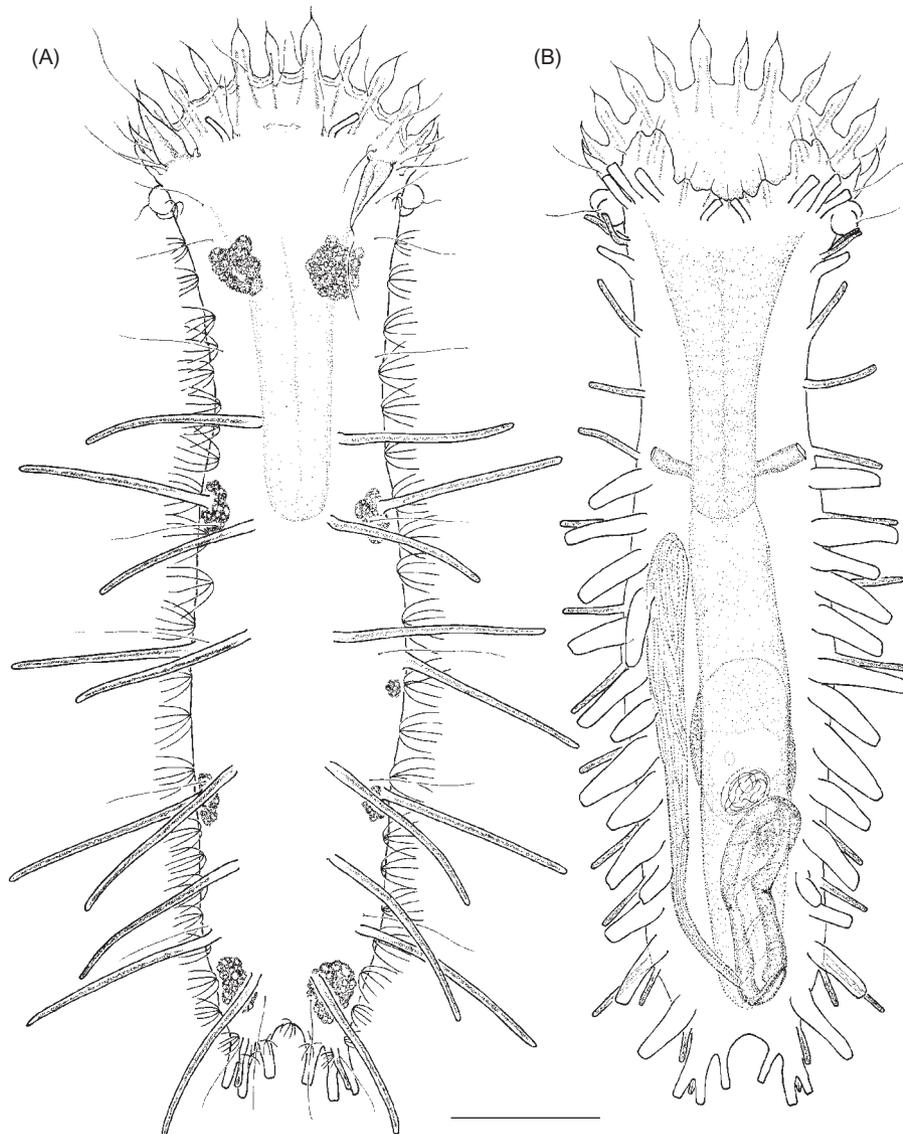


Fig. 2. *Tetranchyroderma multicirratum* sp. nov., adult holotype. (A) Habitus, dorsal view; (B) habitus, ventral view. Scale bar = 30  $\mu\text{m}$ .

(9-17  $\mu\text{m}$ ) and slenderer than subdorsal and dorsolateral ones, located along nearly entire lateral side of body (U21-U93); 1st and 2nd cirrata confluent at their bases, and 12th (17  $\mu\text{m}$ ) adjacent to 13th (10  $\mu\text{m}$ ), but not confluent.

Adhesive tubes (Fig. 2B): Four TbA per side, comprising 1 medial tube at U19 (6  $\mu\text{m}$  long) and 3 longer ventrolateral tubes (8-10  $\mu\text{m}$  long). TbVL, 15 per side: 1st tube slender, 9  $\mu\text{m}$  long, located in anterior pharyngeal region (U23); others more robust than the 1st, ranging 10-21  $\mu\text{m}$  in length, aligned side by side from pharyngeal pores to front of caudal lobes. Three TbP per side, forming a pedicle, consisting of 2 distal tubes (7  $\mu\text{m}$ ) with a small cirratum inserted dorsally between furca, and 1 tube on medial surface (8  $\mu\text{m}$ ).

Reproductive system (Fig. 2B): Testis single on right side, as seen from above, nearly reaching PhJIn. Vas deferens straight, internally joining copulatory organ containing numerous spermatozoa. Copulatory organ elongated tube-type (44

$\mu\text{m}$  long), slightly curved at anterior 1/2, located at U70-U90. Seminal receptacle spherical, located anterior to copulatory organ, including a motile spermatozoon. An ovum (20 x 23  $\mu\text{m}$ ) present dorsally in midintestinal region.

*Juvenile*: Four juveniles among the material examined, with a somewhat formalized general body shape. Smallest and seemingly most immature specimen described herein. Lt (Fig. 3A, B) 143  $\mu\text{m}$ , maximum width 25  $\mu\text{m}$  in intestinal region; pharynx 57  $\mu\text{m}$  in length (40U) with pharyngeal pores, opening ventrolaterally a little in front of PhJIn at U52. Head bearing 3 pairs of cephalic tentacles, 12 large papillary projections, and other important characteristics as in adult. Number and arrangement of adhesive tubes and cirrata slightly differing from those of adults. Long dorsal cirrata (Fig. 3A) consisting of 3 subdorsal (U41, U58, and U74) and 3 dorsolateral cirrata (U50, U68, and U83), of which last subdorsal cirratum shorter (19  $\mu\text{m}$ ) than others (31-40  $\mu\text{m}$ ). Four pairs of lateral

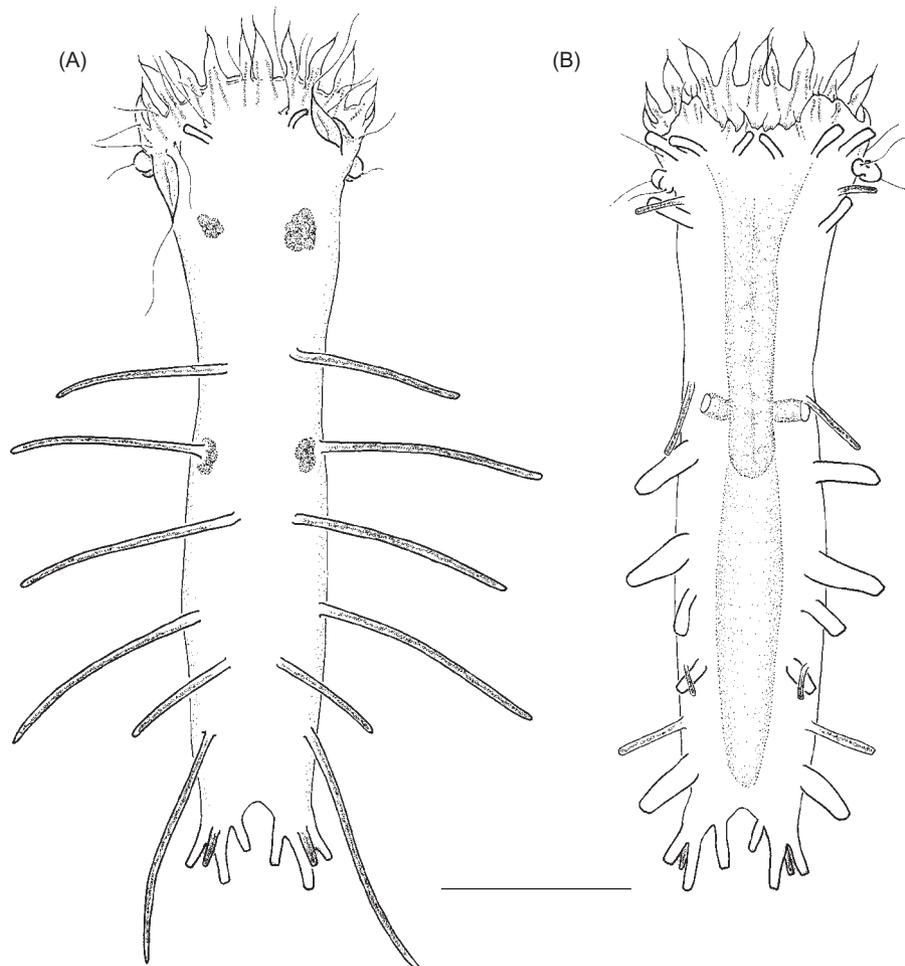


Fig. 3. *Tetranchyroderma multicirratum* sp. nov., juvenile. (A) Habitus, dorsal view; (B) habitus, ventral view. Scale bar = 30  $\mu\text{m}$ .

cirrata (Fig. 3B) including anterior 2 in pharyngeal region and 2 in posterior intestinal region; foremost cirratum (8  $\mu\text{m}$ ) single, 2nd cirratum (13  $\mu\text{m}$ ) slender, located near pharyngeal pores at U44, 3rd cirratum smallest (6  $\mu\text{m}$ ) at U74, last (13  $\mu\text{m}$ ) elongate and outstanding at U80. TbA consisting of 1 medial and 2 ventrolateral adhesive tubes per side. TbVL composed of only 6 tubes per side, 1st one (8  $\mu\text{m}$  long) located in anterior pharyngeal region at U23, 2nd tube at level of PhJIn, and 4 other tubes more or less evenly spaced from U62 to U88 in intestinal region. TbP similarly arranged as in adults, having 2 distal tubes with a small cirratum and a medial tube.

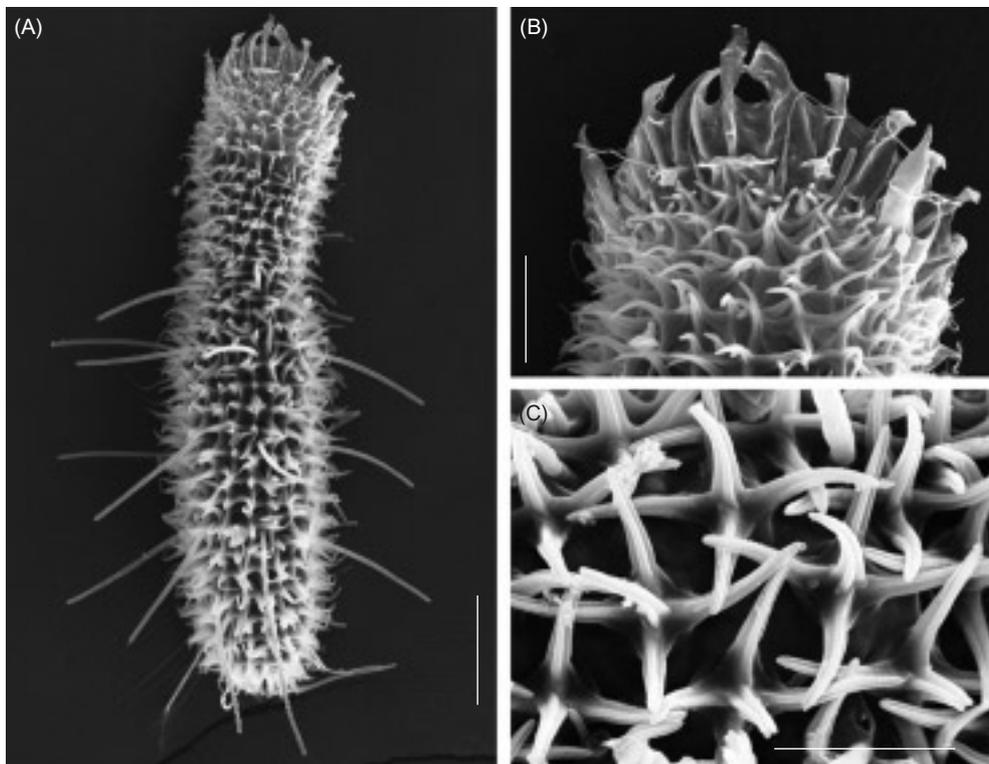
**Measurements and variability:** Body lengths of adult specimens 206-248  $\mu\text{m}$  ( $223 \pm 11 \mu\text{m}$ ,  $n = 13$ ), measured in glycerin mount; maximum widths 35-49  $\mu\text{m}$ .

The number and arrangement of TbA and TbP consistent, with a symmetrical array, each with 4 and 3 tubes per side, while dorsal cirrata, lateral cirrata and TbVL showing some individual variability. Seven of 16 specimens examined lacking 1-2 cirrata on one side, while in 1 specimen, 1 additional cirratum found. Lateral cirrata, in arrangement and number, highly variable, with 11-

16 per side, the foremost lateral cirratum possessing a single one, not confluent with 2nd one, only on one side of 1 specimen. Pharyngeal TbVL showing relatively consistent arrangement as 1 pair, but other TbVL varying from 12 to 15 tubes, sometimes in an asymmetrical array.

**Etymology:** The proposed specific name, *multicirratum*, is from the Latin *multi* (many, plural, doubled) and *cirratum* (cirrata), and refers to the many dorsal and subdorsal cirrata of the present new species.

**Remarks:** The genus *Tetranchyroderma* currently comprises 56 valid species, 28 of which share the character of dorsal cuticular armature consisting of only pentancretes with *T. multicirratum* sp. nov. Within this group, the new species is most characteristic and easily distinguished from them, for it is the only one that has 3 pairs of cephalic tentacles consisting of a rod-like one, a conical one, and modified pestle organ as well as an unique arrangement of elongate dorsal and dorsolateral cirrata. Moreover, *T. multicirratum* sp. nov. is clearly distinguished from its congeners by 13-14 large papillary projections along the anterior margin of head and the tube-shaped copulatory organ.



**Fig. 4.** *Tetranchyroderma multicirratum* sp. nov., SEM. (A) Habitus, dorsal view; (B) head with rod-like tentacles and conical one; (C) cuticular armature of pentancretes. Scale bars (A) = 50  $\mu\text{m}$  and (B, C) = 10  $\mu\text{m}$ .

*Tetranchyroderma multicirratum* sp. nov. evidently differs from the other 3 *Tetranchyroderma* species currently known from Korea. *Tetranchyroderma gracilium* Chang, Lee and Clausen and *T. hoonsooi* Chang and Lee are armed with cuticular armature consisting of only tetrancres. Furthermore, they lack the dorsal and lateral cirrata, and have only a pair of pestle organs and 2 pairs (rod-like and stout lateral) of cephalic tentacles. *Tetranchyroderma heterotentaculatum* Chang and Lee shares the cuticular armature of pentancres with this new species, but it is distinguished from *T. multicirratum* by the longer body (489  $\mu\text{m}$ ), a pair of long rod-like tentacles, 3 TbDL per side, and the lack of dorsal and lateral cirrata.

This species occurred in sublittoral fine sandy bottoms (~1 m depth) on the eastern coast of the Yellow Sea, and in black volcanic sandy sediments at 4-5 m in depth near Hwasun Harbor, Jeju I., often together with *Pseudostomella longifurca* Lee and Chang.

***Tetranchyroderma monokerosum* sp. nov.**

(Figs. 5, 6)

*Type material:* Holotype (DG0901): hermaphroditic adult specimen, Siheung (33°28'21"N, 126°54'51"E), Jeju I., Korea, 20 Nov. 2004, leg. J.M. Jeon and H.W. Lim. Paratypes: 8 adults, 1 juvenile, collection data same as for holotype. All type materials mounted in glycerin on H-S slides. Holotype and 7 paratypes (DB0902-08) deposited in the specimen room of the Department of Biology, Daegu Univ. Another 2 paratypes (KB133, 134) deposited in the National Biological Resources Center, Incheon, Korea.

*Additional material examined:* Three individuals, same locality as for holotype, 11 Oct. 2002, leg. J.M. Lee and J.W. Choi; 1 individual, same locality as for holotype, 6 June 2004, leg. J.M. Jeon and H.W. Lim.

*Diagnosis:* *Tetranchyroderma* with scalloped anterior border and elongate body; a long rod-like cephalic tentacle situated mid-dorsally; a pair of pestle organs present; dorsal cuticular armature with only pentancres; adhesive tubes: 4-5 TbA per side, including 1 medial and 3-4 ventrolateral ones; 2 TbDL per side, located at about 3/5 of body length and at posterolateral edge of body, respectively; a pair of foot-type TbV, consisting of 2 tubes; TbVL of 12 tubes per side; a pair of feeble, trifid pedicles with 2 distal tubes and a dorsal cirratum, flanked by 1 medial and 5 lateral tubes; copu-

latory organ tube-like.

*Holotype:* *Tetranchyroderma* with elongate body, Lt 325  $\mu\text{m}$  including TbP, maximum width 49  $\mu\text{m}$  at mid-trunk (U56). Sides rather parallel, slightly constricted in pharyngeal region, and a little swollen in frontal part of intestinal region, then suddenly narrowing at caudal lobes. Widths of head, neck, PhJIn, trunk, and caudal base 34, 32, 45, 49, and 16  $\mu\text{m}$  at U4, U27, U38, U56, and U98, respectively. Paired pharyngeal pores open ventrolaterally, a little ahead of PhJIn (U33).

Head slightly protruding anteriorly; anterior border markedly scalloped with numerous sensory hairs on both dorsal and ventral surfaces; each projection of scallop with 2-3 hairs at tip (Fig. 5A, B). One rod-like cephalic tentacle (Fig. 6C) slender and long (10  $\mu\text{m}$ ), located mid-dorsally at U3. Paired pestle organs situated at posterolateral corner of head (U7), each accompanied by 2-3 sensory hairs. Sensory hairs (~14  $\mu\text{m}$  long), 12 per side, on lateral or dorsolateral surface along entire body length (U9-U96). Epidermal glands not observed in holotype.

Cuticular armature with pentancres only (Fig. 6E), arranged in 19-22 columns in mid-trunk region; longest prong 7  $\mu\text{m}$  in mid-trunk region.

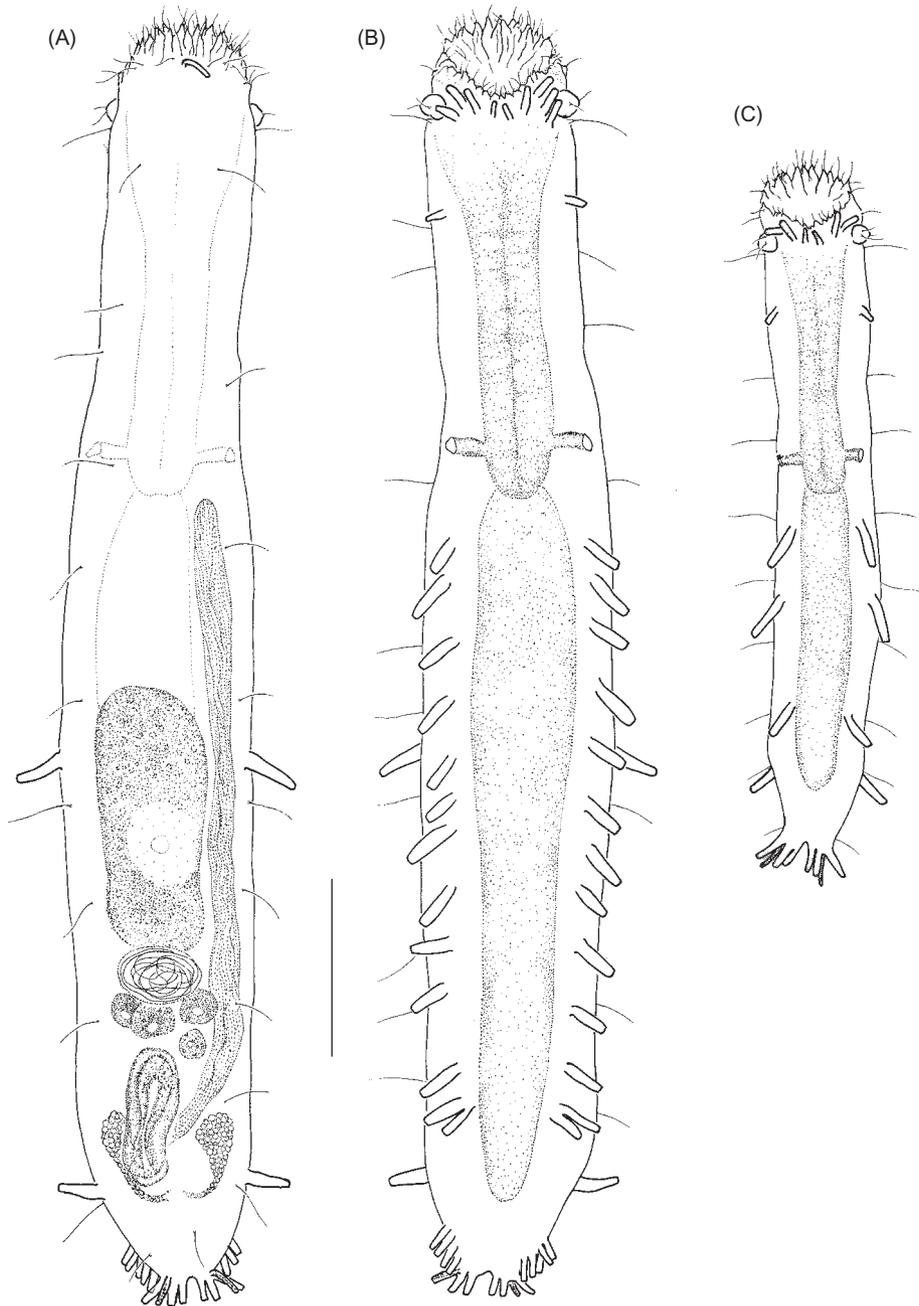
Adhesive tubes (Fig. 5B): 2 TbDL per side, frontal one (13  $\mu\text{m}$  long) situated at ~3/5 of body length (U57), rear one (12  $\mu\text{m}$  long) at posterolateral edge of body (U90). TbA, 4-5 per side, each forming an arc, comprising 1 small medial tube (4  $\mu\text{m}$  long) at U8 and 3-4 large tubes (6-8  $\mu\text{m}$ ) per side ventrolaterally at U6-U8. A pair of foot-type TbV consisting of 2 tubes, located in posterior intestinal region at level of copulatory organ (U85). TbVL, 12 per side; foremost one small, 6  $\mu\text{m}$  long, located in anterior pharyngeal region at U15; another 11 TbVL much larger, ranging 8-14  $\mu\text{m}$  in length, arranged in intestinal region, more or less evenly spaced from U41 to U82. TbP, 8 per side (Fig. 6D), forming pedicles, each with 2 distal tubes and a slender cirratum (8  $\mu\text{m}$ ) dorsally inserted between the other two (7  $\mu\text{m}$ ), pedicles flanked by 1 medial (6  $\mu\text{m}$ ) and 5 lateral (7  $\mu\text{m}$ ) tubes.

Reproductive system (Fig. 5A): Testis single on right side, as seen from above, nearly reaching PhJIn. Vas deferens straight, containing numerous spermatozoa and its posterior end approaching rear of copulatory organ. One mature and 4 small oocytes situated dorsally at mid-trunk. Copulatory organ cylindrical, located at U78-U89. Seminal receptacle oval, located anterior to copulatory organ, containing motile spermatozoa. A

pair of spherical caudal glands with granular contents, situated at level of last TbVL (U82-U92).

*Juvenile*: Only 1 juvenile was found among the material examined. Lt (Fig. 5C) 192  $\mu\text{m}$ , maximum width 32  $\mu\text{m}$  in intestinal region; PhJIn at U46 and paired pharyngeal pores located a little ahead of PhJIn ventrolaterally. Nine sensory hairs (8  $\mu\text{m}$  long) per side, evenly spaced along entire dorsolateral body side. General appendage pat-

tern similar to that of adults, that is, single mid-dorsal rod-like tentacle and a pair of pestle organs, except for absence of foot-type adhesive tubes (TbV) and fewer numbers of all adhesive tubes (TbA, TbL, TbVL, and TbP). TbA composed of only 3 tubes per side, 1 medial and 2 ventrolateral ones, not forming an arc. Only 1 pair of TbDL situated on posterolateral edge of body (U84) (anterior TbDL at mid-trunk in adults not detected). TbVL



**Fig. 5.** *Tetranchyroderma monokerosum* sp. nov. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) habitus of juvenile, ventral view. Scale bars = 50  $\mu\text{m}$ .

consisting of 4 tubes per side, a small anterior one in pharyngeal region and 3 in intestinal region at U50, U60, and U76, respectively. TbP forming a pedicle, each with 3 tubes, composed of 2 distal tubes and a cirratum dorsally, and 1 medial tube; lateral tubes lacking.

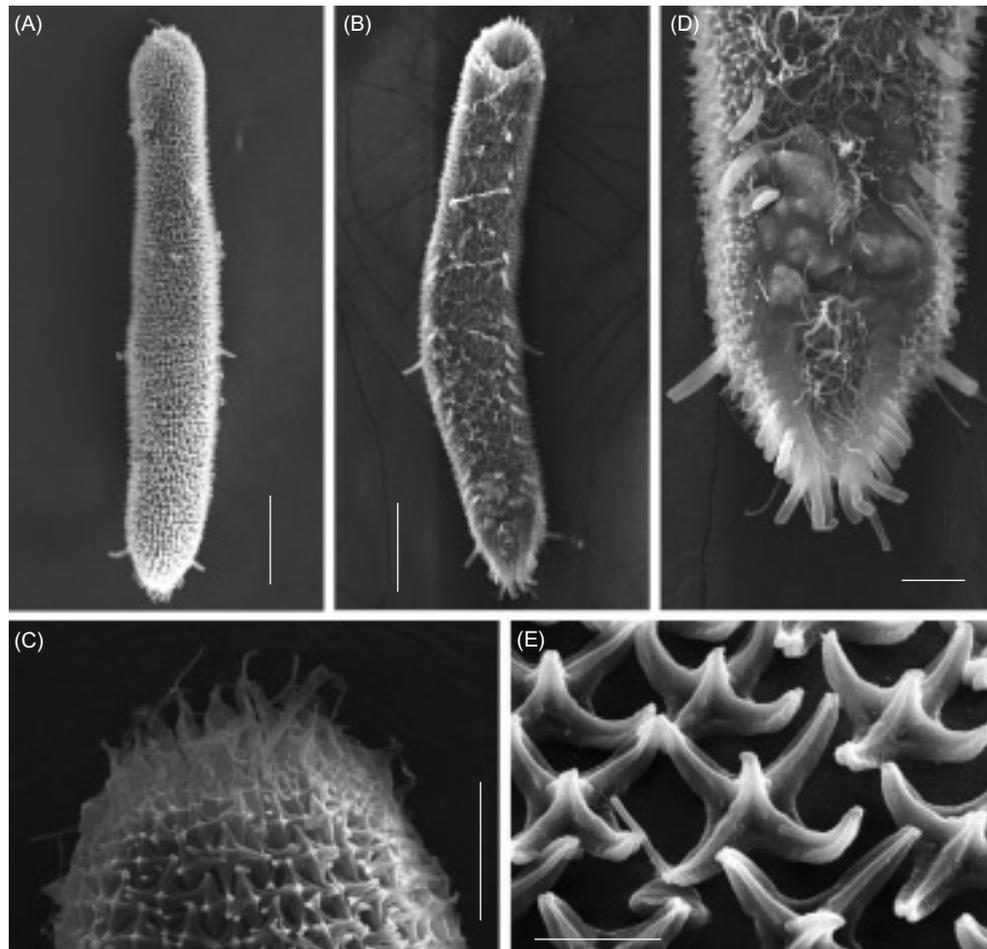
**Measurements and variability:** Body lengths of 9 adult type specimens mounted in glycerin ranging 325-357  $\mu\text{m}$  ( $341 \pm 9 \mu\text{m}$ ,  $n = 9$ ), maximum widths 42-53  $\mu\text{m}$ . Number and arrangement of adhesive tubes showing some variation: TbA composed of 4-5 per side, of which single medial tube consistently present, while number of ventrolateral TbA somewhat variable, sometimes with an asymmetrical arrangement (3 tubes on one side and 4 on the other side). TbVL in pharyngeal region consistently single, but number of TbVL in intestinal region variable, 9-11 per side, with 3 specimens showing asymmetrical arrangement.

Foot-type TbV usually composed of 2 tubes, except for 1 paratype with 3 tubes on right side only. TbP formed of 2 distal tubes per side along with 1 small dorsal cirratum, and 1 medial tube in all specimens examined, while number of lateral tubes variable, ranging 3-5 pairs.

Epidermal glands not observed in holotype and 6 paratypes. However, 2 paratypes and a few additional materials showed 5 glands per side, aligned irregularly on dorsal surface, with generally oval or granular type, mixed in size (3-8  $\mu\text{m}$  in diameter).

**Etymology:** The specific name, *monokerosum*, is taken from the Greek *monos* (meaning single) and *keros* (with a horn), alluding to the rod-like cephalic tentacle in the middle of the forehead, which is reminiscent of a rhinoceros horn.

**Remarks:** Among the known *Tetranchyroderma* species with the dorsal armature of pentan-



**Fig. 6.** *Tetranchyroderma monokerosum* sp. nov., SEM. (A) Habitus, dorsal view; (B) habitus, ventral view; (C) head with rod-like tentacle; (D) ventral adhesive tubes and posterior adhesive tubes, ventral view; (E) cuticular armature of pentancre. Scale bars (A, B) = 50  $\mu\text{m}$ , (C, D) = 10  $\mu\text{m}$ , and (E) = 5  $\mu\text{m}$ .

cles only, *T. monokerosum* sp. nov., in sharing a pair of pestle organs, is allied with *T. hystrix* Remane, 1926, *T. antennatum* Luporini, Magagnini, and Tongiorgi, 1970, *T. enallosum* Hummon, 1977, *T. esarabdophorum* Tongiorgi and Balsamo, 1984, *T. sardum* Todaro, Balsamo, and Tongiorgi, 1988, *T. polyprobolostomum* Hummon, Todaro, Balsamo, and Tongiorgi, 1996, and *T. bulbosum* Clausen, 2000.

The new species is characteristic in possessing the unique, single (unpaired) rod-like cephalic tentacle mid-dorsally. Among the 7 species above, only *T. polyprobolostomum* has the unpaired, rod-like tentacle, followed by 2 mid-dorsal cirrata. However, it is situated in the anterior pharyngeal region (at U11) (Hummon et al. 1996), while that of *T. monokerosum* sp. nov. is an obviously cephalic tentacle in the head region (at U3). *Tetranchyroderma hystrix* and *T. bulbosum* do not have the rod-like cephalic tentacles; on the other hand, the other 4 species have paired rod-like cephalic tentacles anterolaterally. Furthermore, *T. monokerosum* sp. nov. is discernible from all of them in having 2 TbDL per side in the intestinal region.

In having 2 pairs of TbDL as well as pentancre in the intestinal region, *T. polyacanthus* (Remane, 1927) is most similar to the new species, but it differs by the absence of cephalic tentacles. Moreover, the central prong of the pentancre in *T. polyacanthus* is longer than the peripheral prongs, versus nearly same in the new species. This 2 TbDL style of the new species is also reminiscent of those of *T. massiliense* Swedmark, 1956 from Marseille, France, *T. heterotubulatum* Hummon, Todaro and Tongiorgi, 1993 from the west coast of Italy, *T. gracillium* Chang, Lee and Clausen, 1998 from Jeju I., Korea,

and *T. boreale* Clausen, 2000 from Tromsø region, Norway; however, all of these have the dorsal armature of only tetrancres.

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