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Two unrecorded marine nematode species of *Paracanthonchus* (Nematoda: Cyatholaimidae) from the East Sea of Korea

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Two unrecorded marine nematode species, belonging to genus *Paracanthonchus* Micoletzky, 1924, are described on the basis of the specimens collected from rocky intertidal seagrass bed on the eastern coast of Korea. *Paracanthonchus macrodon* (Ditlevsen, 1918) is characterized by presence of cuticular differentiation, strongly dilated gubernaculum with numerous cusps, three post-cloacal setae, and arrangement of six (4 + 2) precloacal supplement. *Paracanthonchus kamui* Kito, 1981 is distinguished from other species of the genus by having the 4.25 turns amphideal fovea, six tubular supplement, rib-shaped gubernaculums with proximally hook-shaped and distally broaden. In this study, we provide taxonomic description and illustration of two unrecorded species of the genus *Paracanthonchus* by differential interference contrast microscopy. This is the first report on the species of the genus *Paracanthonchus* from Korea.

Keywords: East Sea, Korea, marine nematodes, *Paracanthonchus*, taxonomy

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Introduction

The genus *Paracanthonchus* Micoletzky, 1924 contains 72 valid species (Gerlach and Riemann, 1974). The taxon is distributed worldwide and occurs in various habitats from the shallow- and brackish-water to deep-sea environments (Miljutina and Miljutin, 2015). The genus *Paracanthonchus* belongs to the subfamily Paracanthonchinae De Coninck, 1965 of the family Cyatholaimidae Filipjev, 1918 was established by Micoletzky (1924) from the genus *Cyatholaimus* Bastian, 1865 on the basis of the type species, *P. caecus* (Bastian, 1865), collected from brackish pool near the Belgian coast. *Paracanthonchus* differs from other genera of the family by its body cuticle with transverse rows of fine dots, buccal cavity with larger dorsal tooth, distally expanded and dentate gubernaculums, and tubular pre-cloacal supplements (Wieser, 1954; Schmidt-Rhaesa, 2014).

Until now, seven species belonging to the genus *Paracanthonchus*, *P. hawaiiensis* Allgen, 1951, *P. heterocaudatus* Huang and Xu, 2013, *P. kamui* Kito, 1981, *P. macrodon* (Ditlevsen, 1918), *P. mamubiae* Miljutina and Miljutin, 2015, *P. multisupplementatus* Gagarin, 2012 and *P. perspicuous* Kito, 1981, have been reported from the Northwest Pacific Ocean (Wieser, 1955; Kito, 1978; 1981; Gagarin, 2012; Huang and Xu, 2013; Miljutina and Miljutin, 2015). Currently, 51 species of free-living marine nematodes representing 19 genera have been described in Korean waters, but taxonomic report on the genus *Paracanthonchus* is entirely unknown from Korea (Rho and Min, 2011; Barnes *et al*., 2012; Hong and Lee, 2014). In the present study, we provide taxonomic descriptions of two unrecorded marine nematodes, *P. macrodon* and *P. kamui*, collected from rocky intertidal seagrass on the eastern coast of Korea.

Materials and Methods

The marine nematodes were obtained from washing of intertidal sediments, which were collected from rocky intertidal seagrass bed on the eastern coast of Korea. Samples were filtered through a sieve with 67 μm mesh in the field after freshwater rinsing for less than a minute for osmotic shock (Kristensen, 1989), and then fixed in 5% formalin in sea water. The specimens were sorted

Table 1. Measurements of *Paracanthonchus macrodon* (in μm).

	♂1	♂2	♂3	♂4	♂5	♀1	♀2	♀3
L	2319	2339	2282	2557	2508	2123	2539	2235
esol	394	369	359	403	388	388	420	365
a	23.77	26.99	23.35	26.71	24.10	27.28	21.43	25.52
b	5.88	6.35	6.35	6.34	6.46	5.48	6.04	6.12
c	12.71	12.89	12.81	12.49	13.26	12.28	13.01	12.16
hd	33.6	36.4	35.1	34.5	37.2	35.7	38.1	33.1
bd	83.8	73.1	75.0	83.6	88.9	69.0	88.8	71.6
M	97.6	86.7	97.8	95.7	104.1	77.8	118.5	87.6
cs	13.5	16.1	12.5	12.3	12.6	13.5	13.4	13.4
(cs/hd)	(0.40)	(0.44)	(0.36)	(0.36)	(0.34)	(0.38)	(0.35)	(0.40)
ampw	10.8	11.9	12.0	11.3	13.0	11.5	11.7	11.8
nr	185.8	188.8	172.8	192.7	177.4	178.1	193.8	188.6
N (%)	47.16	51.20	48.09	47.81	45.68	45.94	46.12	51.64
supl1	24.0	24.7	23.5	23.0	24.0	–	–	–
supl2	24.7	29.4	25.6	26.0	27.4	–	–	–
supl3	24.2	27.4	22.3	21.7	25.3	–	–	–
supl4	20.0	21.9	19.0	17.9	21.1	–	–	–
dbs1-2	50.5	56.6	57.6	56.8	55.1	–	–	–
dbs2-3	26.2	29.3	28.4	27.6	26.9	–	–	–
dbs3-4	25.4	28.6	27.4	26.9	29.7	–	–	–
dps	36.9	49.2	45.0	32.3	43.6	–	–	–
spil (chord)	62.4	67.8	56.7	65.8	62.0	–	–	–
spil (arc)	71.1	76.2	67.6	76.6	71.0	–	–	–
gubL	63.7	61.7	59.7	63.3	66.1	–	–	–
gubp	19.9	18.7	17.8	16.1	17.4	–	–	–
pas1	13.7	14.5	12.5	14.3	13.4	–	–	–
pas2	13.4	13.8	12.1	13.4	11.9	–	–	–
pas3	8.8	8.8	7.2	8.1	7.3	–	–	–
spil/abd	0.99	1.06	0.89	0.98	0.89	–	–	–
abd	71.8	71.7	75.8	77.8	79.9	60.4	79.3	61.7
t/abd	2.54	2.53	2.35	2.63	2.37	2.86	2.46	2.98
v	–	–	–	–	–	1026.2	1178.7	1063.1
vbd	–	–	–	–	–	77.3	107.7	82.3
V (%)	–	–	–	–	–	48.33	46.43	47.57
t	182.5	181.5	178.2	204.8	189.1	172.9	195.1	183.7

from the mixed meiobenthos under LEICA M205 C stereomicroscopy. The specimens were transferred to glycerol and mounted between two cover slips on a H-S slide for morphological observation (Shirayama *et al*., 1993). Specimens were measured, photographed and drawn by Nomarski differential interference contrast (DIC) with an Olympus BX53 microscope equipped with a drawing tube and a DIXI 3000 camera, and quality enhanced portable photoshop software. Measurements are in μm. Abbreviations are as follows: L, total body length; esol, esophagus length; a, body length divided by maximum body diameter; b, body length divided by esophagus length; c, body length divided by tail length; hd, diameter at the level of cephalic setae; bd, body diameter at the base of esophagus; M, maximum body diameter; cs, length of cephalic setae; mandl, length of mandibles; ampw, amphideal fovea width; ol, distance from anterior to anterior edge of ocelli; nr, distance from anterior end to nerve ring; N (%), nerve ring distance from the anterior end as percentage of esophagus length; supl, length of supplement; dbs, distance between supplements; dps, distance of the posterior precloacal supplement from cloacal opening; spil, spicules length; abd, anal body diameter; gubL, gubernaculum length; v, distance from anterior end to vulva; V (%), vulva distance from anterior end as percentage of total body length.

Systematic Accounts

Class Chromadorea Inglis, 1983
Order Chromadorida Chitwood, 1933
Family Cyatholaimidae Filipjev, 1918
Genus *Paracanthonchus* Micoletzky, 1924
등가시선충속 (신칭)

Key to the species of Korean *Paracanthonchus*

1. Cuticle marked homogeneously, amphideal fovea spiral, six (4 + 2) precloacal supplement present ····· 2
2. Gubernaculum strongly dilated with numerous cusps,

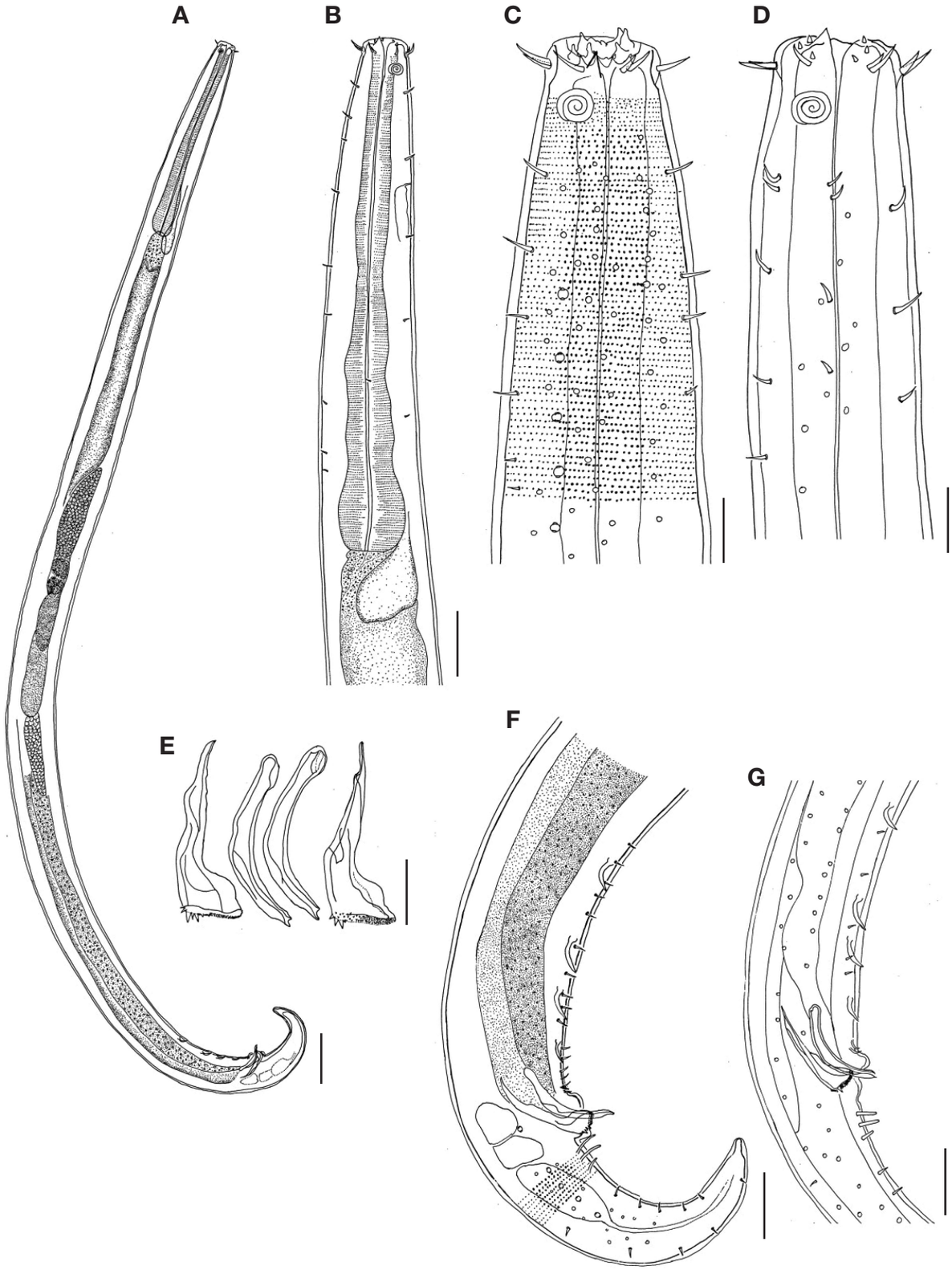


Fig. 1. *Paracanthonchus macrodon*, male, lateral view. A, total body; B, anterior body region; C, fine punctations of cuticle region; D, head region; E, spicules with gubernaculum; F, tail region; G, cloacal region. Scale bars: A = 100 μm, B, F, G = 50 μm, C-E = 20 μm.

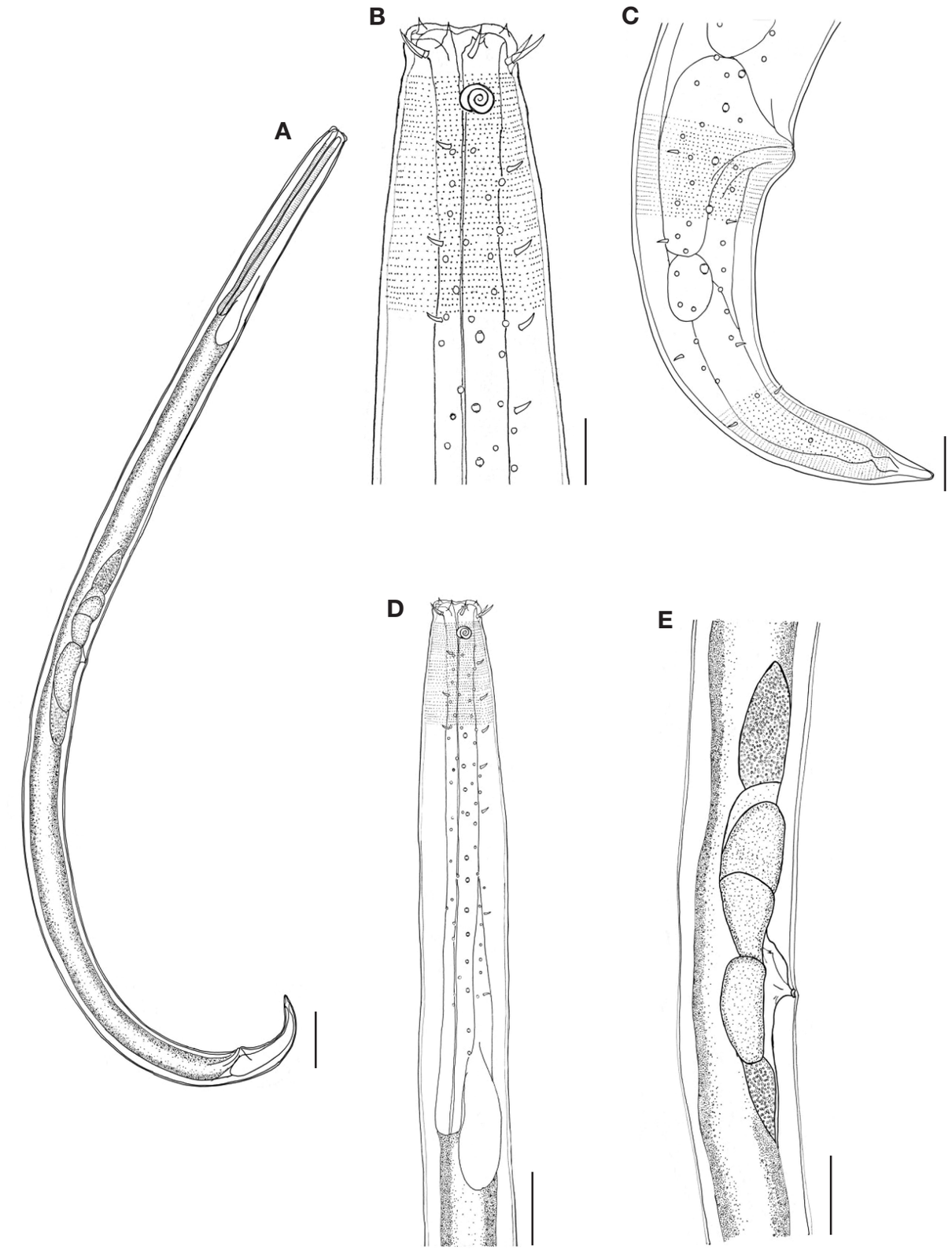


Fig. 2. *Paracanthonchus macrodon*, female, lateral view. A, total body; B, head region; C, tail region; D, anterior body region; E, reproductive system. Scale bars: A = 100 μm, B, C = 20 μm, D, E = 50 μm.



Fig. 3. *Paracanthonchus macrodon*, DIC photomicrographs, male, lateral view. A, habitus; B, head region; C, amphideal fovea; D, cuticle on the anterior region; E, spicule with gubernaculums; F, pre-cloacal supplement; G, post-cloacal setae; H, tail region. Scale bars: A = 100 μm, B-H = 10 μm.

three postcloacal setae present ····· ····· *P. macrodon* (Ditlevsen, 1918)

– Gubernaculum rib-like structure with numerous cusps, without postcloacal setae ····· *P. kamui* Kito, 1981

1. *Paracanthonchus macrodon* (Ditlevsen, 1918)
큰등가시선충 (신칭)

Cyatholaimus macrodon Ditlevsen, 1918, p. 200, figs. 6-8.

Paracanthonchus macrodon: Micoletzky, 1924, p. 138; Kito, 1978, p. 258, fig. 6.

Material examined. 5♂♂ and 3♀♀, Bugu-ri, Uljin-gun, Gyeongsangbuk-do, Korea (37°06′21.39″N, 129° 22′37.42″E), collected on 9 July 2014 by Hyo Jin Lee; Jugwang-myeon, Goseong-gun, Gangwon-do, Korea (38°19′41.65″N, 128°31′45.63″E), collected on 2 Oct. 2014. The specimens are kept in the collection of the author. All are mounted in anhydrous glycerin between two coverslips on H-S slides, sealed with nail polish.

Measurements. See Table 1 for detailed measurements and morphometric ratios.

Description. Males: Body length 2,282-2,557 μm long,

Table 2. Measurements of *Paracanthonchus kamui* (in μm).

	♂1	♂2	♂3	♂4	♂5	♀1	♀2	♀3
L	1991	1774	1893	1966	1915	2044	1851	1988
esol	358	347	356	349	343	351	358	358
a	25.30	28.68	25.34	24.05	26.63	25.67	25.62	23.47
b	5.56	5.11	5.31	5.63	5.58	5.83	5.17	5.55
c	12.91	13.03	12.02	12.12	11.59	13.53	12.50	12.57
hd	29.7	29.9	28.8	29.8	29.4	31.9	30.7	29.8
bd	71.7	57.1	66.5	68.9	65.5	63.1	60.2	71.5
M	78.7	61.9	74.7	81.8	71.9	79.6	72.2	84.7
cs	13.7	12.5	13.3	12.2	12.1	12.2	12.8	12.9
(cs/hd)	(0.46)	(0.42)	(0.46)	(0.41)	(0.41)	(0.38)	(0.41)	(0.43)
ampw	12.7	11.6	11.8	11.6	12.2	11.5	12.5	12.4
nr	163.0	146.7	149.5	155.8	150.5	150.5	155.3	149.4
N (%)	45.52	42.27	41.98	44.59	43.84	42.87	43.40	41.71
ol	25.7	27.8	26.7	25.5	28.5	27.2	27.2	24.3
supl1	16.1	17.1	16.9	16.6	16.1	–	–	–
supl2	15.8	16.9	16.9	16.9	16.4	–	–	–
supl3	15.2	16.1	16.3	15.6	15.7	–	–	–
supl4	14.8	14.3	11.7	12.7	13.1	–	–	–
supl5	10.7	12.8	10.8	9.1	9.8	–	–	–
dbs1-2	34.3	29.7	36.8	25.9	33.5	–	–	–
dbsl2-3	35.6	33.2	38.7	36.2	34.2	–	–	–
dbsl3-4	32.1	24.3	32.4	26.4	30.0	–	–	–
dbs4-5	31.1	24.2	24.2	25.8	26.8	–	–	–
dps	27.6	22.2	20.0	23.2	25.3	–	–	–
spil (arc)	50.1	55.4	61.6	58.4	54.1	–	–	–
gubL	54.7	60.4	58.7	58.9	54.7	–	–	–
spil/abd	0.78	1.07	1.09	0.91	0.90	–	–	–
abd	64.3	51.6	56.8	64.4	59.8	50.6	53.3	55.9
t/abd	2.40	2.64	2.78	2.52	2.76	2.99	2.78	2.83
v	–	–	–	–	–	974.1	907.5	960.9
V (%)	–	–	–	–	–	47.65	49.04	48.33
Egg (w/l)	–	–	–	–	–	50.4/68.9	40.6/59.7	–
t	154.2	136.1	157.5	162.2	165.2	151.1	148.1	158.1

cylindrical, slightly tapering anterior (Figs. 1A, 3A). Maximum body diameter 87-104 μm. Cuticle marked homogeneously, closely arranged in transverse rows of fine punctations, starting at level of cephalic setae. Space of rows relatively narrow at mid-body region, slightly larger and broader at extremities. Cuticle pore about 2 μm wide, distributed throughout body (Figs. 1C, 3D). Between amphideal fovea and never ring region arranged at about six rows within 10 μm; in middle of body about seven to eight rows within same distance. Lateral modified punctuations appeared throughout body, but more distinct and numerous in pharyngeal and tail region. Head with inner circle of six labial papillae about 3 μm long and outer circle of 10 (6+4) cephalic setae, four shorter cephalic setae 8.7-10.8 μm and six longer setae 12.3-16.1 μm, 34-44% of head diameter. Buccal cavity with prominent large dorsal tooth and two minute subventral teeth (Figs. 1C, 3B). Amphideal fovea ventrally wound spiral with 3.75 turns, about 32-35% of head diameter. Amphideal fovea height equal to eight to ten punctuation rows (Figs. 1C, 3C). Ocelli absent. Esophagus cylindrical, 359-403 μm long, slightly broadened at its base. No distinct cardia. Nerve ring encircling pharynx, situated at 46-51% of pharynx length from anterior end. Excretory pore opening located at 100.2-119.8 μm from anterior end, small ventral gland located in esophagus end (Fig. 1B). Cervical setae 6.7-9.5 μm long, and a few somatic setae sparsely distributed throughout body along subdorsal and subventral. Tail rather plumped, conical, with swollen tip, 178-205 μm long, about 2.4-2.6 times of anal body diameter. Three long and stout post-cloacal setae present, anterior two setae longer than backmost setae. Cell bodies of three caudal glands situated in proximal third, subventral and subdorsal setae situated at tail region (Figs. 1F, 3H). Reproduction system diorchic. Spicules paired, arcuate, slightly bent at middle part and tapering distally. Gubernaculum paired, slightly shorter than spicules. Proximal portion rather sharp, and distal one-third broadening with massively enlarged distally L-shaped, distal end plate about 16-20 μm wide, with numerous cusps, and three or four large cusps (Figs. 1E, 1F, 3E, 3G). Six precloacal supple-

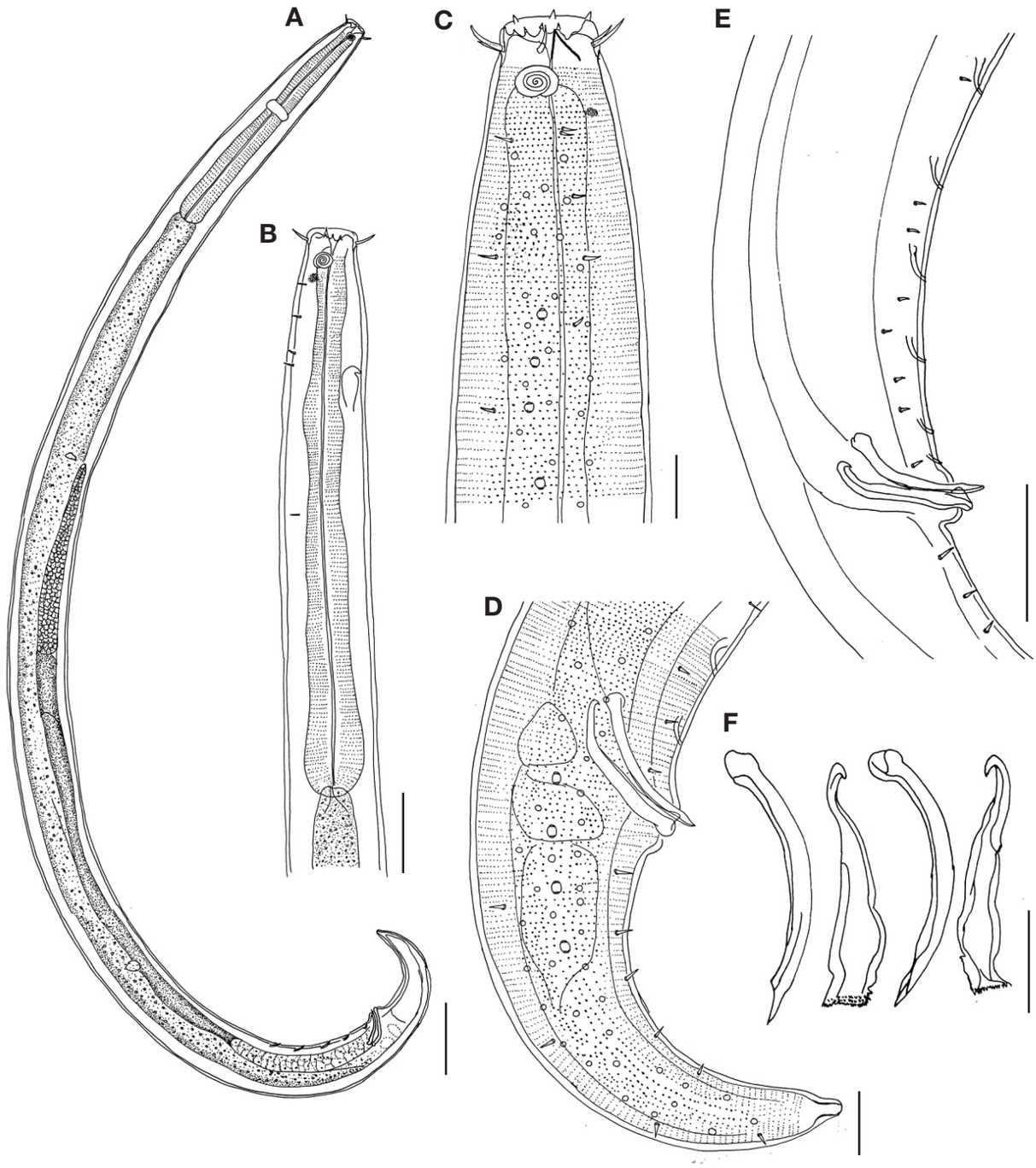


Fig. 4. *Paracanthonchus kamui*, male, lateral view. A, total body; B, anterior body region; C, head region; D, tail region; E, precloacal supplements; F, spicules with gubernaculum. Scale bars: A = 100 μm, B, E = 50 μm, C, D, F = 20 μm.

ments curved tubular shape, arranged in 4 + 2, anterior four supplement typical shape, larger and more widely spaced; posterior two supplement rather delicate and close together. Distance between the first and second supplement longer than distance of between of other adjacent supplements. A series of short setae distributed on both lateral side of subventral region (Figs. 1F, 3F).

Females: Similar to male in general morphology of cuticle structure and anterior region (Fig. 2B, 2D). Body length 2,123-2,539 μm long; maximum body diameter

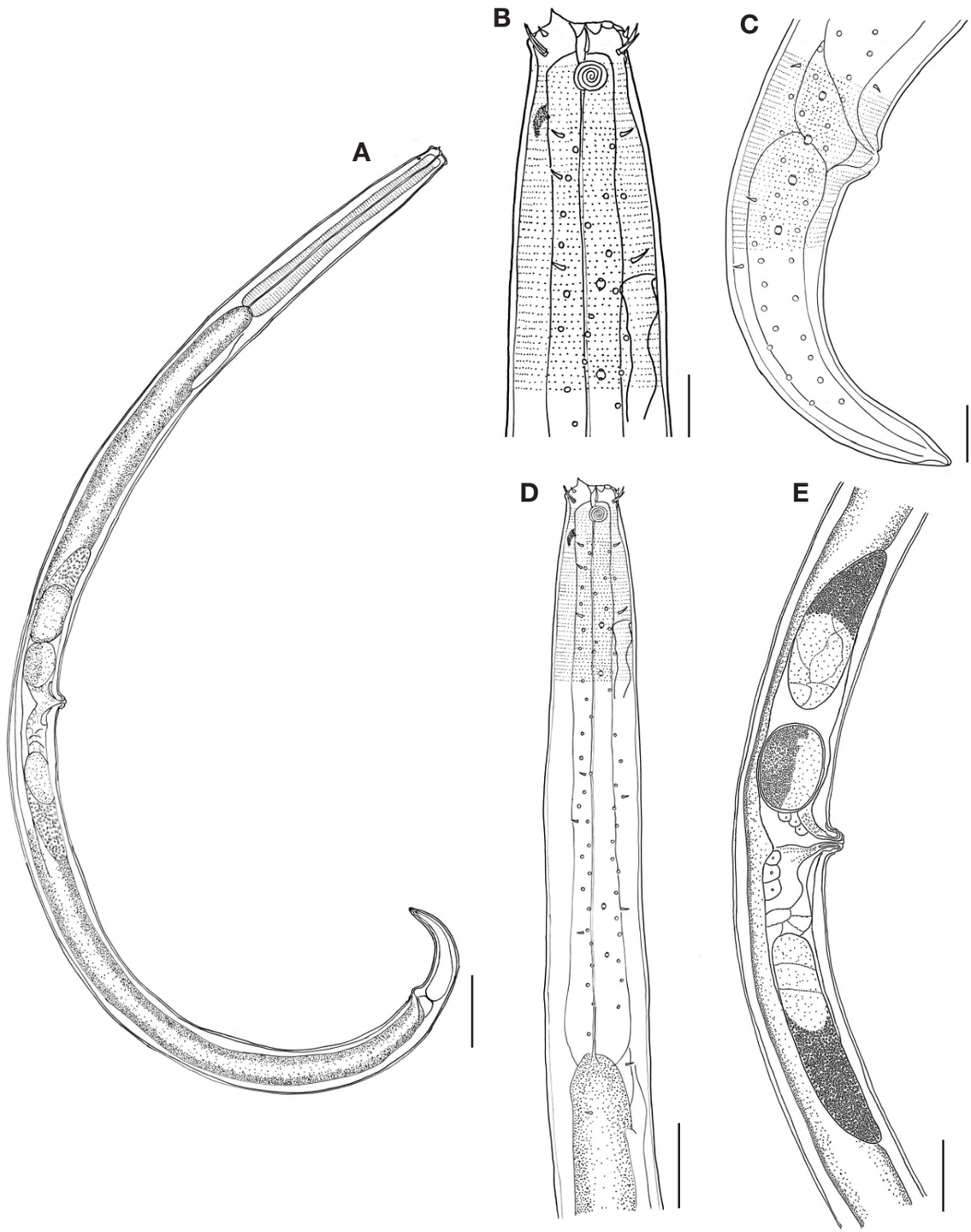


Fig. 5. *Paracanthonchus kamui*, female, lateral view. A, total body; B, head region; C, tail region; D, anterior body region; E, reproductive system. Scale bars: A = 100 μm, B, C = 20 μm, D, E = 50 μm.

78-118 μm (Fig. 2A). Ovaries paired, opposed, outstretched. Vulva 1,026-1,179 μm from anterior end, situated at 46-48% of total body length (Fig. 2E). Tail short and conoid, 173-195 μm long, about 2.5-3.0 times of anal body diameter (Fig. 2C).

Remark. In 1918, Ditlevsen reported the species

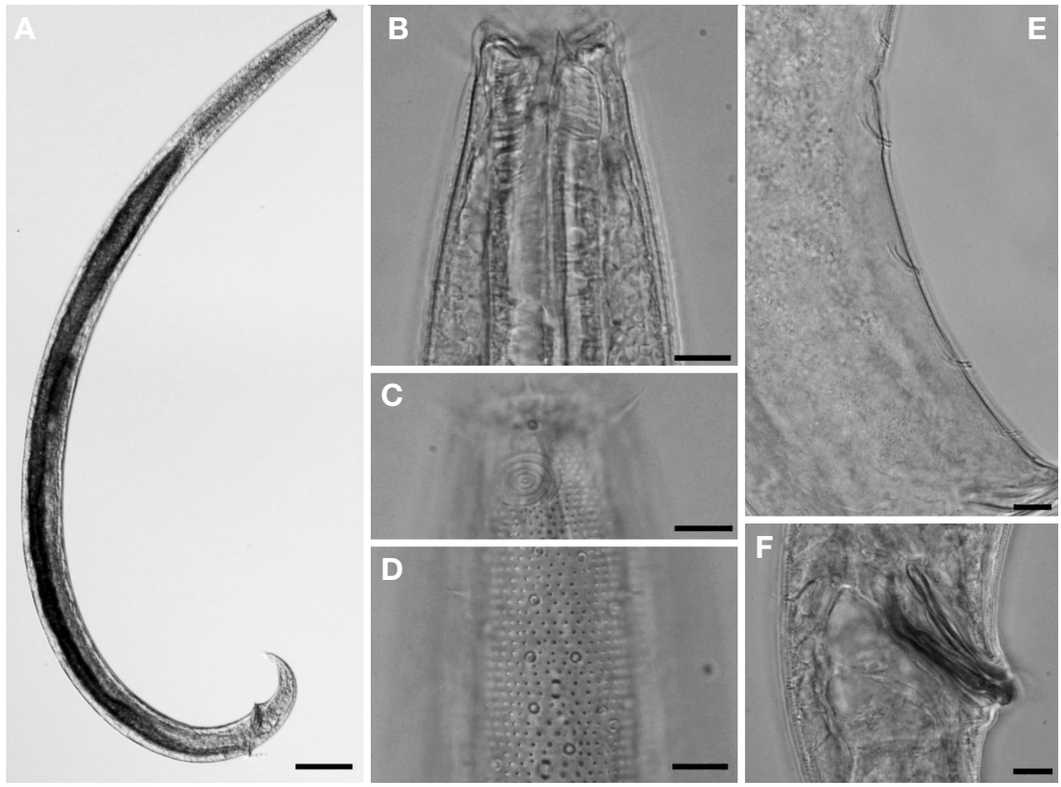


Fig. 6. *Paracanthonchus kamui*, DIC photomicrographs, male, lateral view. A, habitus; B, head region; C, amphideal fovea; D, cuticle on the anterior region; E, precloacal supplement; F, spicules with gubernaculums. Scale bars: A = 100 μm, B-F = 10 μm.

Cyatholaimus macrodon Ditlevsen, 1918 from Oresund in Danish belt Sea. Thereafter, Micoletzky erected the genus *Paracanthonchus* with 5 species including *Paracanthonchus macrodon* (Ditlevsen, 1918). *Paracanthonchus macrodon* has been previously reported from Europe, America and Japan Sea. The present Korean specimens were discovered from the seagrass bed of intertidal rocky shore of the East Sea, Korea. *Paracanthonchus macrodon* is distinguished from its congeners in having the cuticular differentiation, strongly dilated gubernaculum with numerous cusps, presence of three post-cloacal setae, and arrangement of six (4 + 2) precloacal supplement. The present specimens resemble *P. hartogi* Inglis, 1970, *P. parahartogi* Decraemer and Coomans, 1978, *P. stekohveni* Wieser, 1954 and *P. sunesoni* (Allgen, 1942), mainly in possessing six precloacal supplements and a more or less pronounced L-shaped gubernaculum with a large, spiny distal part in lateral view. Paracanthonchus macrodon is clearly distinguished from *P. stekhoveni* and *P. sunesoni* by arrangement of precloacal suppelements. Distance of among the four precloacal supplements is almost equal in *P. stekhoveni* and *P. sunesoni*, but distance of anteriormost and second supplement is longer than other adjacent supplements in *P. macrodon*. *Paracanthonchus hartogi* has a fine striation cuticle without lateral differentiation, whereas *P. macrodon* has fine punctuations and lateral differentiation. Moreover, *P. macrodon* has long and stout three postcloacal setae, but *P. parahartogi* dosen't have postcloacal setae. The present Korean specimens are very similar with the original description by Ditlevsen 1918, except for position of the excretory pore (100.2-119.8 μm vs. 18 μm from anterior end), turns of amphideal fovea (3.75 vs. 2.5 turns) and number of precloacal supplements (six vs. four). The Korean specimens are closely related to *P. macrodon* reported from subtidal zone in the coasts of Oshoro, Japan by Kito (1978) in general features. However, Korean specimens are not accorded by distance of among anterior four precloacal supplements (50 μm, 26 μm, 25 μm vs. 35 μm, 11 μm, 24 μm respectively).

2. *Paracanthonchus kamui* Kito, 1981
신령등가시선충 (신칭)
Paracanthonchus kamui Kito, 1981, p. 273, fig. 12.

Material examined. 5♂♂ and 3♀♀, Bugu-ri, Uljin-gun, Gyeongsangbuk-do, Korea (37°06′21.39″N,

129°22′37.42″E), collected on 9 July 2014; Jangsa-dong, Sokcho-si, Gangwon-do, Korea (38°13′37.77″N, 128°35′16.92″E); Janghohang-gil, Geundeok-myeon, Samcheok-si, Gangwon-do, Korea (37°17′21.24″N, 129°19′8.34″E); Ayajin-gil, Toseong-myeon, Goseong-gun, Gangwon-do, Korea (38°16′11.53″N, 128°33′27.23″ E), collected on 2 Oct. 2014. The specimens are kept in the collection of the author. All are mounted in anhydrous glycerin between two coverslips on H-S slides, sealed with nail polish.

Measurements. See Table 2 for detailed measurements and morphometric ratios.

Description. Males: Body length 1,774-1,991 μm long, comparatively stout and cylindrical, slightly tapers to anterior region (Figs. 4A, 6A). Maximum body diameter 62-82 μm. Cuticle marked with transverse rows of fairly distinct dots starting at level of cephalic setae, but slightly lager and irregular in tail region. In pharyngeal region, distance of rows about 1.7 μm, slightly wide. Cuticle pore about 2 μm wide, distributed throughout body. About six to seven rows arranged in 10 μm at posterior part of body region, and about eight to ten rows situated at middle of body region within same distance (Figs. 4C, 6D). Head with inner circle of six labial papillae about 3.5 μm long and outer circle of 10 (6 + 4) cephalic setae, four shorter cephalic setae 7.8-9.8 μm and six longer setae 12.1-13.7 μm, about 41-46% of head diameter. Buccal cavity with prominent large dorsal tooth and two small subventral teeth (Figs. 4C, 6B). Amphideal fovea with 4.25 turns in ventral direction, about 39-41% of head diameter (Figs. 4C, 6C). Ocelli 4.8-7.0 μm long, situated at lower side of amphideal fovea. Esophagus cylindrical, 343-358 μm long, no distinct cardia. Nerve ring encircling pharynx, situated at 42-46% of pharynx length from anterior end. Excretory pore opening located at 73.5-84.8 μm from anterior end (Fig. 4B). Tail fairly stout, conical, 136-165 μm long, about 2.4-2.8 times of anal body diameter. Cell bodies of three caudal glands situated in proximal third, 4-5 μm setae distributed throughout tail region (Fig. 4D). Spicules slender, arcuate and tapering distally; proximal end with swellon appearance and rapidly narrowing from middle part to distal end. Gubernaculum paired, slightly bent; proximal end with hook-shaped appearance, distally from one-third widening with shape of ribs, distal end expanded, with small and numerous cusps (Figs. 4F, 6F). Six precloacal supplements present; curved tubular shape; posteriormost supplement rather delicate. Distance between adjacent two supplements, relatively constant, but posterior two supplement very close together (Figs. 4E, 6E). A series of short setae distributed on both lateral side of subventral region.

Females: General morphology similar to that of males in structure of cuticle and anterior body end (Fig. 5B, 5D). Body length 1,851-2,044 μm long; maximum body diameter 72-85 μm (Fig. 5A). Reproductive system didelphic, ovaries paired opposed, reflexed. Vulva 907-974 μm from anterior end, situated at 48-49% of total body length (Fig. 5E). Tail short and conoid, 148-158 μm long, about 2.8-3.0 times of anal body diameter (Fig. 5C).

Remark. *Paracanthonchus kamui* Kito, 1981 was firstly described from Japan Sea coast in Hokkaido. *Paracanthonchus kamui* is distinguished from other species of the genus by having the 4.25 turns amphideal fovea, six tubular supplement, rib-shaped gubernaculums with proximally hook-shaped and distally broaden. The present species is most like *P. austrospectabilis* Wieser, 1954 and *P. sonadiae* Timm, 1961 by possessing gubernaculum with slightly dilated distal end, six precloacal supplements, buccal cavity with large dorsal tooth and two small subventral teeth. However, the present Korean species is significantly differs from *P. austrospectabilis* by the distance of among six precloacal supplements and the presence of tiny denticles of the distal plates of gubernaculums. The present species clearly distinguished from *P. sonadiae* by shorter tail length (2.7-3.0 abd vs. 3.1-4.0 abd) and turns of the amphideal fovea (4.25 turns vs. 5.5 turns). The present Korean specimens agree well with Kito's (1981) original description, in general features, especially in the detailed structure of the gubernaculum, in the number and shape of the precloacal supplement, and in the features of the buccal armatures and the amphideal fovea. However, the Korean specimens of *P. kamui* are not accord with the original description by having a longer overall body length (1774-1991 μm in male, 1851-2044 μm in female vs. 1658-1728 μm, 1761-1816 μm) and ocelli situated at 24-28 μm from anterior end.

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