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Admirandus multicavus Belogurov and Belogurova, 1979 (Nematoda, Enoplida, Oncholaimidae), a new record of free-living marine nematode discovered from the intertidal zone of Korea

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Abstract: *Admirandus multicavus* Belogurov and Belogurova, 1979, a new record of free-living marine nematode species belonging to family Oncholaimidae is reported based on the specimens collected from the intertidal sediments of Korea. *Admirandus multicavus* is characterized by the following unique characteristics: cephalic setae (1–2 μm long), spicules (71–126 μm long) and gubernaculum (15–31 μm long), midventral preanal supplementary organ, three glandular duct openings of the Demanian system, and stoma length measuring twice the width. A comparative analysis of the biogeographical and ecological characteristics of *Admirandus* species is presented. DIC (Differential interference contrast) photomicrographs of the species are also provided herein. This report represents the first taxonomic analysis of the genus *Admirandus* Belogurov and Belogurova, 1979 discovered from the Korean seawaters.

Keywords: marine nematode, free-living, morphology, DIC photomicrographs, taxonomy

INTRODUCTION

The genus *Admirandus* was created by Belogurov and Belogurova (1979) based on the type species, *A. multicavus*. So far, four species within the genus *Admirandus* have been described previously from various localities and habitats of the estuary of the river, intertidal and shallow subtidal sediments in oceans as follows: *A. belogurovi* Tchesunov, Mokievsky and Thanh, 2010 from the estuary of Be River, intertidal flat with *Avicennia* mangrove trees of the Nha Trang City, Central Vietnam; *A. multicavus* Belogurov and Belogurova, 1979 from the intertidal muddy-sand sediment of Huangdao, Qingdao and Rizhao of Shandong province near the Yellow Sea, China, and from the muddy sediment of Vladivostok, Peter the Great Bay, the Sea of Japan, Russia (Russkiy Island); *A. papillatus* (Kreis, 1932) from the intertidal muddy sediments of Sundays River Estuary, South Africa; and *A. sanjuliensis* Lo Russo, Villares and Pastor de Ward, 2016 from the littoral coasts of the San Antonio Bay, Río Negro Province and Santa Cruz Province, Argentina (Kreis 1932; Furstenberg and Vincx 1989; Huang and Zhang 2009; Tchesunov *et al.* 2010; Mordukhovich *et al.* 2015; Lo Russo *et al.* 2016) (Table 2). However, no biodiversity studies around the Korean seawaters with respect to the genus *Admirandus* have been carried out so far.

During a continuous investigation on the species composition and the distribution of the free-living marine nematofauna around the Korea, *A. multicavus* was discovered from the intertidal sediments habitat. This report provides illustrations and differential interference contrast (DIC) photomicrographs of *A. multicavus* with a comparative table on the biogeographical and ecological characteristics of the members of the genus *Admirandus*. This is the first

Table 1. Morphometrics of the Korean *Admirandus multicavus* specimens.

Characters	Males			Female
	1	2	3	1
L	3976	3782	3380	3443
a	43	38	49	46
b	7	7	7	7
c	29	30	25	20
c′	2.5	2.5	3	2.8
Head diameter at cephalic setae level	28	26	26	25
Body diameter at pharynx level	89	88	64	68
Maximum body diameter	93	99	70	75
Length of cephalic setae	2	2	2	2
Amphideal fovea diameter	8	9	10	9
Amphids diameter as proportion of c.b.d. (%)	25	31	33	30
Buccal cavity diameter	16	15	15	14
Buccal cavity length	44	44	38	45
Length of right ventrosublateral onchium	37	38	34	40
Length of left ventrosublateral onchium	27	29	27	31
Length of dorsal onchium	27	29	27	31
Distance from anterior end to amphids	18	18	15	16
Distance from anterior end to excretory pore	86	74	86	74
Distance from anterior end to nerve ring	266	241	249	245
Body diameter at amphids level	33	30	31	30
Body diameter at nerve ring level	75	71	60	60
Pharynx length	583	536	504	510
Spic	109	121	103	–
L / Spic	36.5	31.3	32.8	–
Gubernaculum length	28	27	27	–
Distance from anterior end to vulva	–	–	–	1705
Body diameter at vulva level	–	–	–	77
V (%)	–	–	–	50
a.b.d.	54	52	45	62
T	135	128	135	173
Conical part of tail length	82	74	89	94

All measurements are in μm.

taxonomic report of the genus *Admirandus* from Korea.

MATERIALS AND METHODS

Field collection. We gathered the meiobenthos from the sieving of the bulk intertidal sediments, which was collected around the western and southern coasts of Korea (Fig. 1).

Sample processing. Initially, meiobenthos were roughly separated from the sediment by decantation methods using a 67 μm mesh sieve in the survey field after freshwater rinsing for less than a few minutes to reduce the attachment from the sediment (Kristensen 1989), and then fixed in 4% neutralized formalin in sea water. After the first step procedure, meiobenthos were separated once again from the rough samples still including a little detritus using the Ludox flotation method (Burgess 2001) in the laboratory, and the concentrated samples were subsequently fixed again in 4% neutralized formalin solution.

Permanent slide preparation. The marine nematode specimens were sorted out under a high magnification of

Table 2. Biogeographical and ecological characteristics of the genus *Admirandus* Belogurov and Belogurova, 1979 including the Korean *A. multicavus*

Taxa	Reference	Geographic distribution	Ocean	Ecological habitat
A. belogurovi Tchesunov, Mokievsky and Thanh, 2010	Tchesunov, Mokievsky and Thanh (2010)	Estuary of Be River, Bay of Nha Trang, Khanh Hoa Province, Central Vietnam	Pacific Ocean	Estuary; intertidal flat with *Avicennia* mangrove trees
A. multicavus Belogurov and Belogurova, 1979	Belogurov and Belogurova (1979); Huang and Zhang (2009); Mordukhovich, Atopkin, Fadeeva, Yagodina and Zograf (2015); this study	Huangdao, Qingdao and Rizhao of Shandong province near the Yellow Sea, China; Russkiy Island, Peter the Great Bay, the Sea of Japan, Russia; Jangseon Beach and Jimak-ri, Korea	Pacific Ocean	Marine; intertidal muddy-sand sediment; muddy sediment (0.3 m depth); Intertidal mud flat sediments
A. papillatus (Kreis, 1932)	Kreis (1932); Furstenberg and Vincx (1989)	Sundays River Estuary, South Africa	Pacific Ocean; Indian Ocean	Marine; intertidal muddy sediments (>45 cm)
A. sanjuliensis Lo Russo, Villares and Pastor de Ward, 2016	Lo Russo, Villares and Pastor de Ward (2016)	San Antonio Bay, Río Negro Province, Argentina; Santa Cruz Province, Argentina	Atlantic Ocean	Marine; littoral coasts

dissecting microscope (LEICA M205 C; Wetzlar, Germany). Specimens for making permanent slides were dehydrated through a graded series of glycerin according to Seinhorst (1959) and mounted on a HS slide with two coverslips (Shirayama *et al.* 1993).

Microscopic observation. The permanently mounted nematodes specimens were observed and photographed using an Olympus BX53 microscope equipped with an Olympus DP26 digital camera (Olympus, Tokyo, Japan). All drawings and measurements were made with the aid of a camera lucida.

Terminology and abbreviations. The terminology used for the description and measurements was followed by Mordukhovich *et al.* (2015). Abbreviations used in the text are as follows: a = body length divided by maximum body diameter; a.b.d. = anal body diameter; b = body length divided by pharynx length; c = body length divided by tail length; c′ = tail length divided by anal body diameter; c.b.d. = corresponding body diameter; L = total body length; Spic = spicule or length of spicule measured along the arc; T = tail length; V = distance of vulva from anterior end as percentage of body length, in %.

SYSTEMATIC ACCOUNTS

Phylum Nematoda Potts, 1932
Class Enoplea Inglis, 1983
Order Enoplida Filipjev, 1929
Family Oncholaimidae Filipjev, 1916
Subfamily Adoncholaiminae Gerlach and Riemann, 1974
Genus *Admirandus* Belogurov and Belogurova, 1979

Type species of the genus *Admirandus*
Admirandus multicavus Belogurov and Belogurova, 1979

Other species of the genus *Admirandus*
Admirandus belogurovi Tchesunov, Mokievsky and Thanh, 2010
Admirandus papillatus (Kreis, 1932) Shimada and Kijihara, 2014
Admirandus sanjuliensis Lo Russo, Villares and Pastor de Ward, 2016

***Admirandus multicavus* Belogurov and Belogurova, 1979 (Figs. 2–4; Table 1)**
Admirandus multicavus: Tchesunov *et al.*, 2010, p. 157, Fig. 1; Mordukhovich *et al.*, 2015, p. 1231, Figs. 1, 2.
Adoncholaimus chinensis Huang and Zhang, 2009, p. 1084, Figs. 1, 2.

Material. Two males (MABIK NA00156664, MABIK NA00156665), in glycerin on HS slide, from Jimak-ri, Gogun-myeon, Jindo-gun, Jeollanam-do, 20 June 2018 (*leg.* H. G. Kim and H. J. Lee) was deposited in the nematode collection at the specimen conservation room of the Marine

Fig. 1. Map showing the sampling location of *Admirandus multicavus* Belogurov and Belogurova, 1979. 1. Jimak-ri, Gogun-myeon; 2. Jangseon Beach, Daeseo-myeon.

Biodiversity Institute of Korea (MABIK), Seochun, Korea. One male (KIOST NEM-1-2549) and one female (KIOST NEM-1-2609), in glycerin on HS slide, from Jangseon Beach, Daeseo-myeon, Goheung-gun, Jeollanam-do, 28 May 2020 (*leg.* H. S. Rho. and H. Lee) was deposited in the nematode collection at the specimen conservation room of the Bio-Resources Bank of Marine Nematodes (BRBNM), East Sea Research Institute, Korea Institute of Ocean Science & Technology (KIOST), Korea.

Locality and Habitat. Intertidal mud flat habitat of Jangseon Beach (34°44′59.00″N, 127°15′02.00″E), Daeseo-myeon, Goheung-gun, Jeollanam-do, Korea. Intertidal muddy sand habitat of Jimak-ri (34°28′17.02″N, 126°22′05.64″E), Gogun-myeon, Jindo-gun, Jeollanam-do, Korea.

Measurements. See Table 1 for measurements and morphometrics.

Description. Males. Body 3,380–3,976 μm long, elongate, nearly cylindrical except head and tail region, tapering very slightly towards both end; 64–89 μm wide at level of pharynx. Head 26–28 μm wide at level of cephalic setae. Maximum body width 70–99 μm wide. Cuticle transparent, smooth. Cephalic end not off-set from remaining body (Figs. 2A, 3A). Six lips each with a minute inner conical labial papilla at their base; six outer labial papillae arranged in one circle. Four conical cephalic setae 2 μm long. In labial region, marginal lamellae horseshoe shaped features around inner labial papilla (Fig. 2A). Very short (1–2 μm) conical somatic setae extended posteriorly from anterior sensilla; posterior to nerve ring somatic setae becoming scanty and decrease in size.

Amphidial fovea transparent, semicircular, pocket-like with transverse slit-like aperture, 25–33% of c.b.d.; distance from anterior body end to aperture 15–18 μm long (Figs. 2A, 3C). Buccal cavity cylindroid, very large with thick wall, length to width ratio 2.5–2.9 times as long as wide. Buccal cavity with the largest right ventrosublateral onchium (34–38 μm long); left ventrosublateral onchium and dorsal onchium smaller and equal in size (27–29 μm long) (Figs. 2A, 3B). Excretory pore opened at 74–86 μm from anterior body end. Pharynx 504–583 μm long, evenly muscular, gradually widening to posterior end. Cardia large, triangular shaped. Nerve ring situated at 241–266 μm long from anterior body end. Males diorchic with opposed outstretched testes, located right side of intestine. Spicules paired, 103–121 μm long, 2.0–2.3 a.b.d. long or 1.1–1.3 times tail length. Gubernaculum slender, curved parallel to spicules, 27–28 μm long (Figs. 2C, 3E). Two rows of 7–8 circumcloacal setae (4–6 μm long) on each subventral side of body (Figs. 2C, 3D). Several short setae on tail. Tail composed of distinct proximal conical portion and distal slender cylindrical one (Fig. 3E).

Female. Similar to male in most respects (Figs. 2B, D, 4A–F). Body 3,443 μm long, elongate, tapering very slightly towards both end; 68 μm wide at level of pharynx. Head 25 μm wide at level of cephalic setae. Maximum body width 75 μm wide. Four conical cephalic setae 2 μm long. Amphidial fovea 30% of c.b.d.; distance from anterior body end to aperture 16 μm long (Figs. 2B, 4C). Buccal cavity cylindroid, length to width ratio 3.2 times as long as wide. Buccal cavity with the largest right ventrosublateral onchium (40 μm long); left ventrosublateral onchium and dorsal onchium smaller and equal in size (31 μm long) (Figs. 2B, 4B). Excretory pore opened at 74 μm from anterior body end. Pharynx 510 μm long. Nerve ring situated at 245 μm long from anterior body end. Ovaries paired, antidromously reflexed, both situated right side of intestine. Three fertilized eggs with coarse granulated cytoplasm in uteri (Fig.

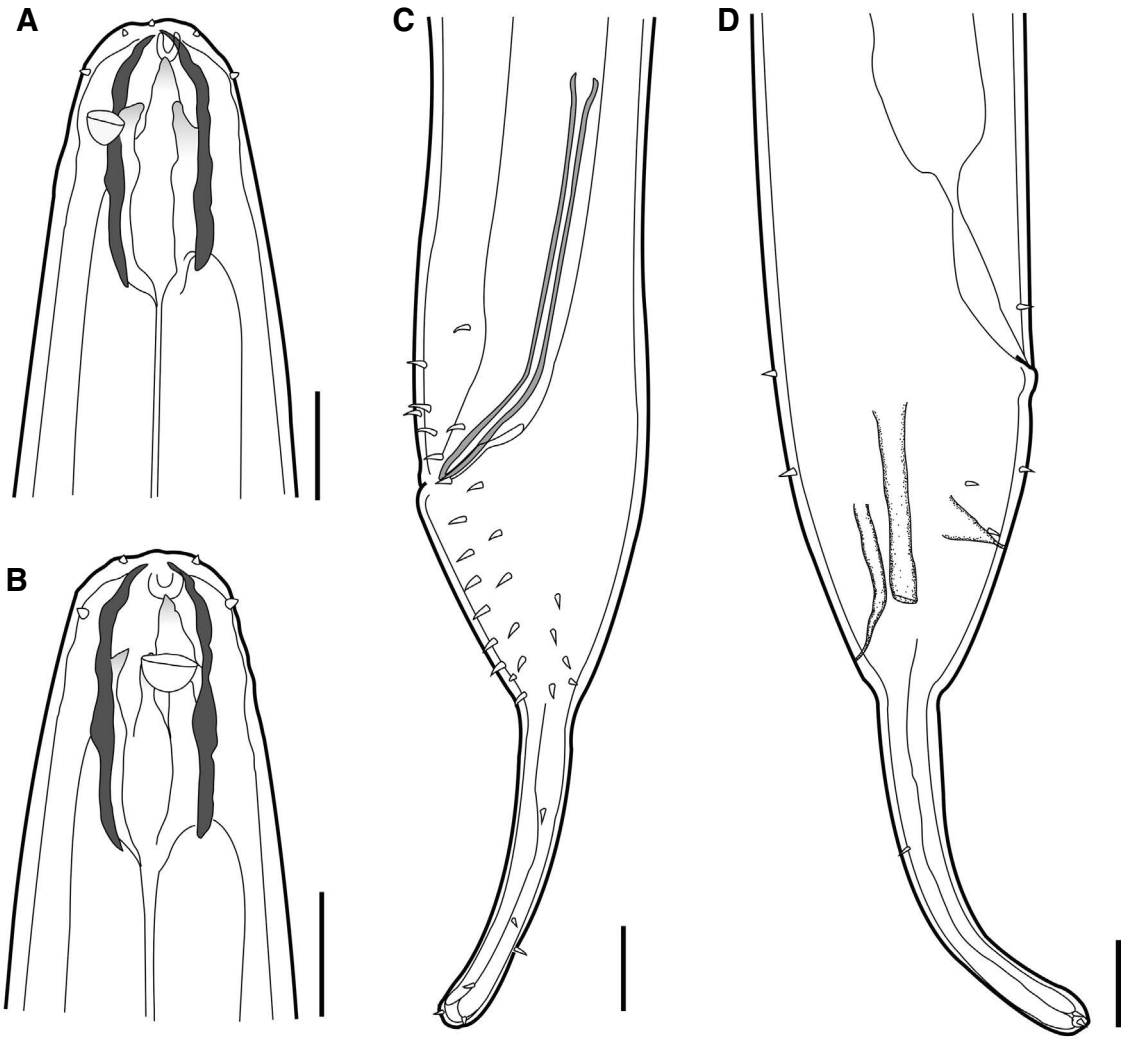

Fig. 2. *Admirandus multicavus* Belogurov and Belogurova, 1979, lateral view (A, C: male; B, D: female). A, anterior region of male; B, anterior region of female; C, posterior region showing the copulatory apparatus; D, posterior region revealing the terminal pores. Scale bars: A–D = 20 μm.

4D). Demanian system well developed, tubular, situated dorsally; duct extends to anal region terminating with slit-like external pores on tail (Fig. 2D).

Remarks. The genus *Admirandus* was established by Belogurov and Belogurova (1979) and classified within the subfamily Adoncholaiminae Gerlach and Riemann, 1974 of the family Oncholaimidae Filipjev, 1916 belongs to the order Enoplida Filipjev, 1929 based on the following combination of the generic characteristics: outer labial and cephalic sensilla papilliform; cephalic sensilla surrounded by marginal lamellae in form of hook-like plates; buccal capsule elongate, length to width ratio *c*. 1.5:1 to 3:1; three onchia in buccal cavity, the largest being located right ventrosublaterally and other two lower ones equal in size; ovaries paired; demanian tube system generally of the *Adoncholaimus* type, but with precloacal or postanal terminal canals and pores situated at one preclocal and two on the tail; presence of terminal canals as long ducts; the spicules curved, relatively long, slender, proximally cephalated, distally pointed, slightly broadening only in front of the distal end; gubernaculum present; midventral preanal supplementary organ present or not; tail anterior conical and posterior cylindrical portions; and precloacal and postcloacal sensilla long, setiform (Mordukhovich *et al.* 2015; Lo Russo *et al.* 2016).

Furthermore, *Admirandus multicavus* Belogurov and Bel-

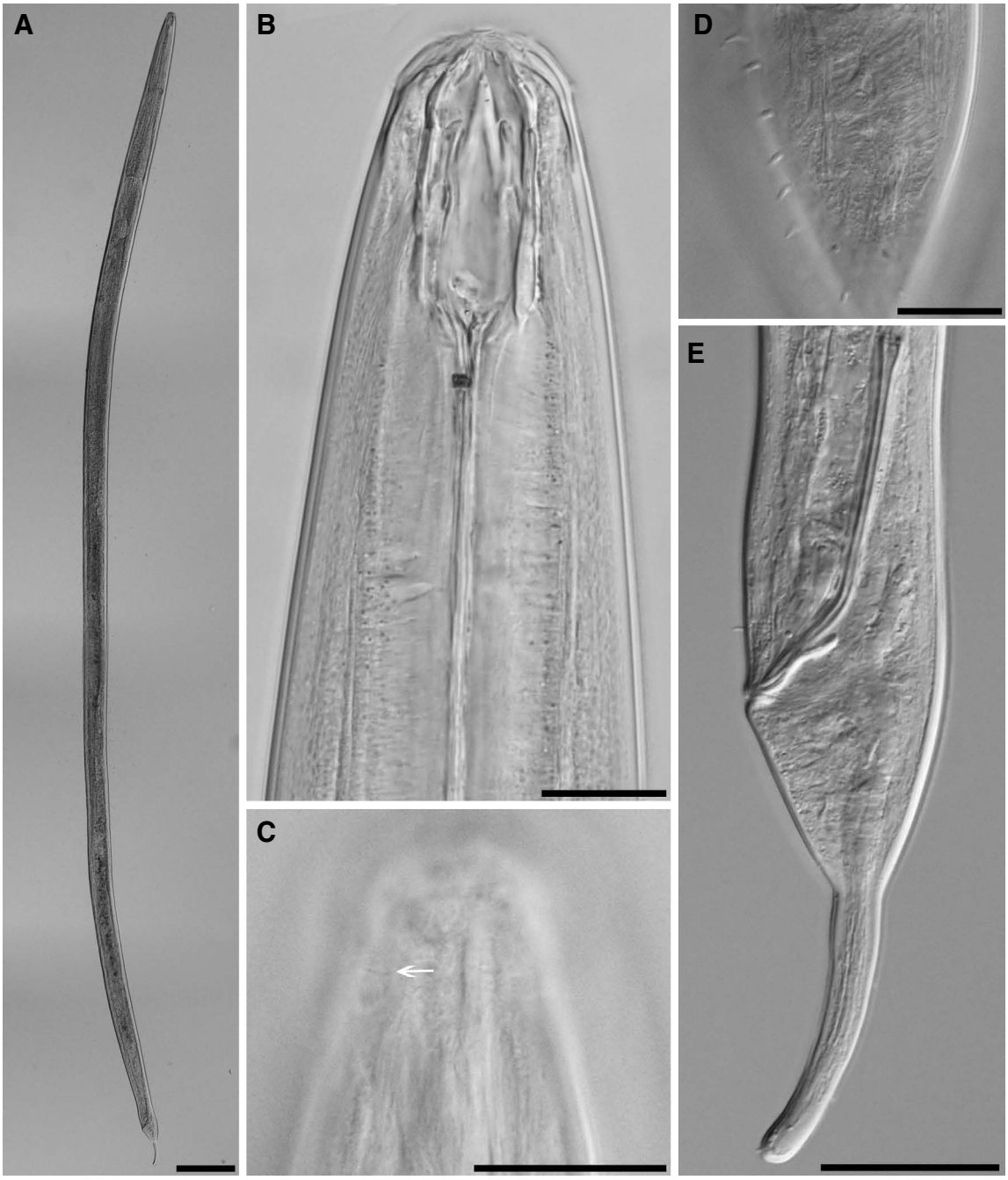

Fig. 3. *Admirandus multicavus* Belogurov and Belogurova, 1979, DIC (Differential interference contrast) photomicrographs of male (lateral view). A, total body; B, head region; C, amphideal fovea (white arrow); D, circumcloacal setae; E. spicule and gubernaculum. Scale bars: A = 200 μm; B–D = 20 μm; E = 50 μm.

ogurova, 1979, the type species of the genus, is characterized by the following combination of species identification characteristics, which are summarized on the basis of the original description of Belogurov and Belogurova (1979), the redescription of Mordukhovich *et al.* (2015), and a key for the species of genus *Admirandus* of Lo Russo *et al.* (2016): (1) the relative length of cephalic setae, spicules and gubernaculum; (2) the presence/absence of midven-

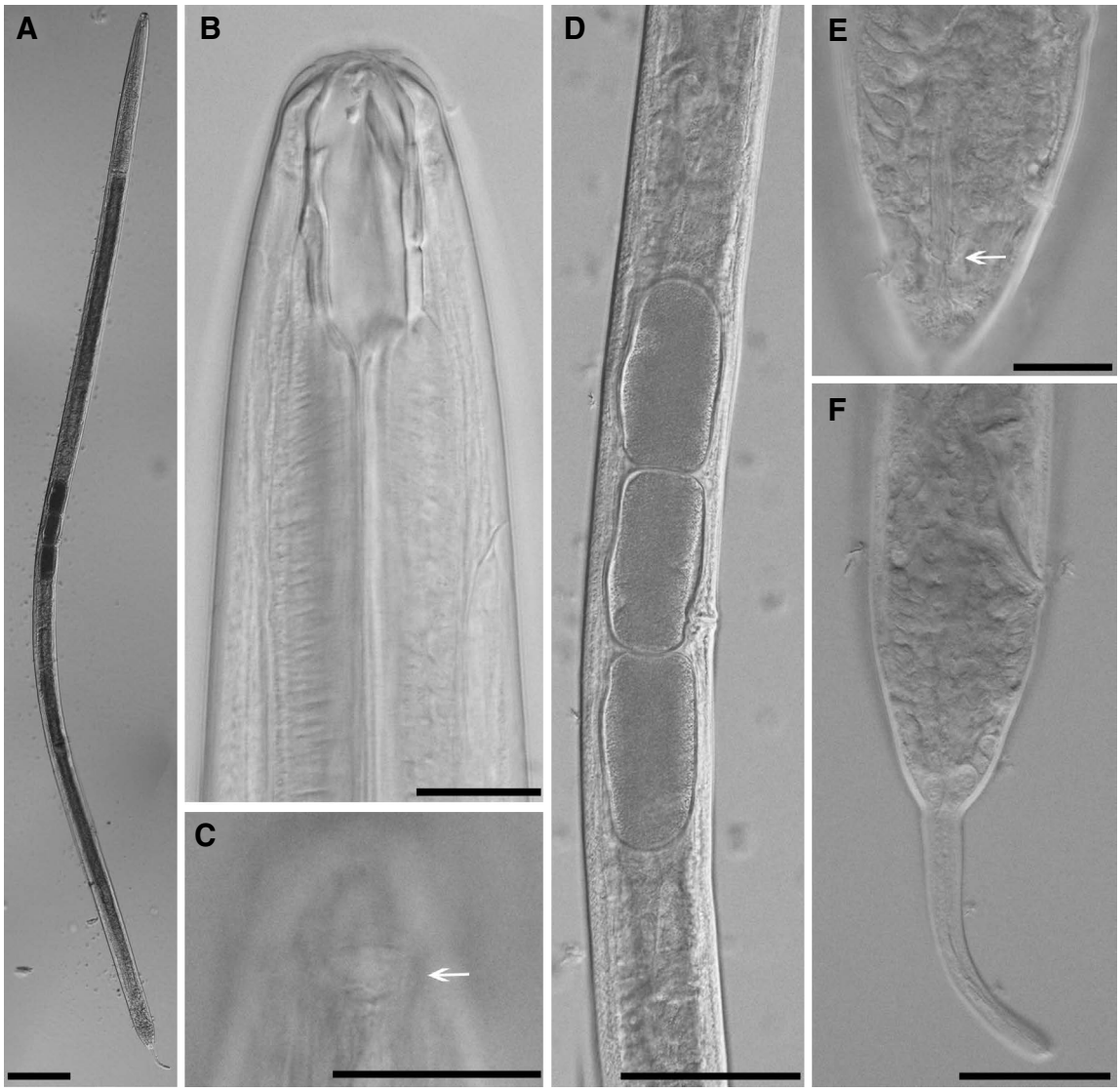

Fig. 4. *Admirandus multicavus* Belogurov and Belogurova, 1979, DIC (Differential interference contrast) photomicrographs of female (lateral view). A, total body; B, head region; C, amphideal fovea (white arrow); D, vulva region; E, posterior region showing the terminal pore (white arrow); F, tail region. Scale bars: A = 200 μm; B, C, E = 20 μm; D = 100 μm; F = 50 μm.

tral preanal supplementary organ; (3) the number of gland opening of the demanian system; and (4) the relative ratio of the stoma length to width.

Recently, *A. multicavus* was redescribed from the intertidal muddy sediment samples of the Russkiy Island, Peter the Great Bay, Russia (Mordukhovich *et al.* 2015). Mordukhovich *et al.* (2015) demonstrated the individuals of *A. multicavus* of the Russkiy Island are similar to the measurements of the original description in general, but there are some discrepancies only in the length of gubernaculum, in the absence of midventral preanal supplementary organ and in the length of cephalic setae.

The Korean *A. multicavus* specimens discovered from the intertidal mud flat habitat around the western and southern coasts of Korea are also shares several similar features in general body shape with the original description and the Russkiy Island specimens of *A. multicavus*, however, we found some differences among them such as the combination of the following characteristics in the male specimens: the body length (3,380–3,976 μm vs. 2,060–2,280 μm and 2,451–2,781 μm, respectively); the length of cephalic setae (2 μm vs. 1 μm and 1.5 μm, respectively); the

spicules length (103–121 μm vs. 71–110 μm and 105–126 μm, respectively); and the gubernaculum length (27–28 μm vs. 15 μm and 19–31 μm, respectively). This is the first taxonomic report of the genus *Admirandus* from the Korean seawaters.

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