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New records of eighteen invertebrate species from South Korea: Ciliates, copepods, ostracods, rotifers, and oligochaetes

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During the field survey to explore invertebrate diversity in South Korea, we identified eighteen species from various habitats (terrestrial, freshwater, and saline water), all new records for the country. These include two ciliates, two copepods, eight ostracods, three rotifers, and three oligochaetes, representing four invertebrate phyla. The specimens were taxonomically examined using taxon-specific methods, such as silver impregnation, staining, dissection, and scanning electron microscopy. This study provides morphological descriptions, remarks, and micrographs and/or illustrations for each species.

Keywords: Ciliophora, Harpacticoida, Podocopida, Bdelloidea, Naididae

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Introduction

Korea's biodiversity has officially exceeded 60,000 species, largely due to substantial government support (National Institute of Biological Resources, 2023). Among these, 10,754 species are invertebrates (excluding insects), and 2,575 species are protozoa. However, many species, including new ones, remain undiscovered. Foissner *et al.* (2008) estimated that 83–89% of ciliate diversity is still undescribed. Furthermore, Bae *et al.* (2021) suggested that approximately 100,000 species may inhabit Korea.

As part of the ongoing project 'Discovery of Korean Indigenous Species' led by the National Institute of Biological Resources (NIBR) under the Ministry of Environment (Chae *et al.*, 2023), we conducted field surveys and discovered eighteen invertebrate species newly recorded in South Korea. These species belong to four phyla and were taxonomically examined using taxon-specific methods. In this study, we provide morphological descriptions, remarks, and micrographs for each species.

Materials and Methods

Ciliates. The two species were collected from coastal waters, the detailed locality information is provided in the "Material examined" section for each species. The sample was transferred to the laboratory and incubated in Petri dishes. Cells were isolated from the raw culture and transferred into six-well plates containing 0.2 μm-filtered seawater and small pieces of mealworms to establish clonal cultures. They were examined using a stereomicroscope (Olympus SZ11, Japan) and light microscopes (Olympus BX53, Japan), under bright-field and differential interfer-

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ence contrast (DIC) at magnification ranging from 50× to 1000×. Synthesized protargol powder (Kim and Jung, 2017) and wet silver nitrate impregnation were used to reveal the ciliary pattern, nuclear apparatus, and silverline system (Corliss, 1953; Foissner, 2014).

Copepods. *Arenosetella bidenta* was collected from the sandy bottoms of shallow water and *Eupelte simile* was obtained from algal beds using a light trap. All specimens were fixed in 95% ethanol. In the laboratory, the samples were sorted under an Olympus SZ11 (Japan) stereo microscope. Specimens were cleared, dissected, drawn, and measured in glycerin. All drawings were prepared using a drawing tube on an Olympus BX53 (Japan) differential interference contrast microscope equipped with Nomarski optics.

Ostracods. Samples were collected at the intertidal, using the algae rinsing method: a bucket was filled with algae and sea water, stirred, and filtered through a 63 μm mesh hand-net. All samples were placed in 250 mL plastic bottles and fixed in 99% ethanol. Sorting was done under a stereomicroscope (Olympus SZX12, Japan) in the laboratory of Hanyang University. SEM photographs of representative valves were taken at Eulji University with Hitachi S-4700 (Japan), after platinum coating. Identifications were done using various publications on the East Asian ostracod fauna (Ishizaki, 1968; Okubo, 1980; 1988; etc.).

Rotifers. The samples were collected from lichens, mosses, mushrooms, soil and tree barks at three different locations in Korea as detailed in the material examined section of each species. The bdelloids were extracted from samples according to a previously described method (Song, 2014). We examined and identified all of the living bdelloids under a light microscope with a magnification of 400× to 600×. The photography and motion records of living specimens were performed using an Infinity 2 digital camera (Lumenera Corporation, Canada). Measurements were made by using GIMP 2.8 (the GNU Image Manipulation Program, USA). The specimens were killed with head, foot, and toes extended, by using the boiling water fixation method (Edmondson, 1959) instead of narcotization as previously described (Song and Min, 2015). The classification scheme is based on those of Melone and Ricci (1995) and Segers (2002).

Oligochaetes. Samples were collected from fine, organic-rich sand and mud sediments in freshwater areas. The collection was carried out at the waterside using shovels and hand nets, and the samples were transported alive to the laboratory. The decision to transport live specimens was made to enable their distinction from other similar organisms and oligochaetes in the sample, in addition to observation of their biological characteristics in their live state. The live oligochaetes were sorted under a dissecting microscope using a Leica S9i research microscope fitted with a Leica DMC2900 Camera & SW Kit (Leica, Wetzlar, Germany). Subsequently, they were fixed in 10% formalin and 80% ethanol. Specimens were initially stained with a 10% formalin solution mixed with Rose Bengal, followed by borax carmine through a series of alcohol solutions and finally mounted in Canada balsam (Ersèus, 1993). Morphological observations and measurements were performed using a BX41 research microscope fitted with an Olympus DP73 camera system. Images were edited with the InnerViewTM-i series image analysis software (Innerview Co. Ltd, Gyeonggi-do, South Korea).

Results and Discussion

Phylum Ciliophora Doflein, 1901 섬모충문
Class Spirotrichea Bütschli, 1889 선모강
Subclass Euplotia Jankowski, 1979
Order Euplotida Small and Lynn, 1985 자라하모충목
Family Euplotidae Ehrenberg, 1838 자라하모충과
Genus *Euplotes* Ehrenberg in Hemprich and Ehrenberg, 1831 자라하모충속

1. *Euplotes versatilis* Tuffrau *et al*., 2000 (Fig. 1)

다재자라하모충 (신칭)

Euplotes versatilis Tuffrau *et al*., 2000: 355–366, figs. 1–18.

Material examined. Korea: Incheon, Jung-gu (37°27′0.9″N, 126°35′38.4″E); collected by Jeong Hyeon Yeo on August 2, 2021.

Identifier. Jeong Hyeon Yeo.

Deposition. NIBRPR0000111148, NIBRPR0000111150.

World distribution. Martinique (France Lesser Antilles) (Tuffrau *et al*., 2000), Korea (this study).

Diagnosis. Small cells (typical) body size 55–70×20–40 μm in vivo, on average 40×25 μm; medium cells size 65×55 μm; giant cells size 110×95 μm after protargol impregnation (n=5) (Fig. 1A–C). Body shape broadly oval. One C-shaped macronucleus, with a single small spherical micronucleus attached (Fig. 1C). 26–32 adoral membranelles; 10 frontoventral, 5 transverse, 2 caudal and 2 marginal cirri (Fig. 1B). 8 or 9 dorsal kineties with 12 or 13 dikinetids in the middle one; dorsal argyrome pattern of single-*vannus*, double-*eurystomus* and complex or mixed type (Fig. 1B–F).

Habitat. Marine.

Remarks. *Euplotes versatilis* exhibits extensive morphological variation due to cannibalism. The small cell (general; on average 40×35 μm) exhibits single-*vannus* type, medium cells (on average 65×60 μm) with double-*eurystomus* type, and giant cells (on average 125×125 μm) with complex or mixed type after silver nitrate impregnation.

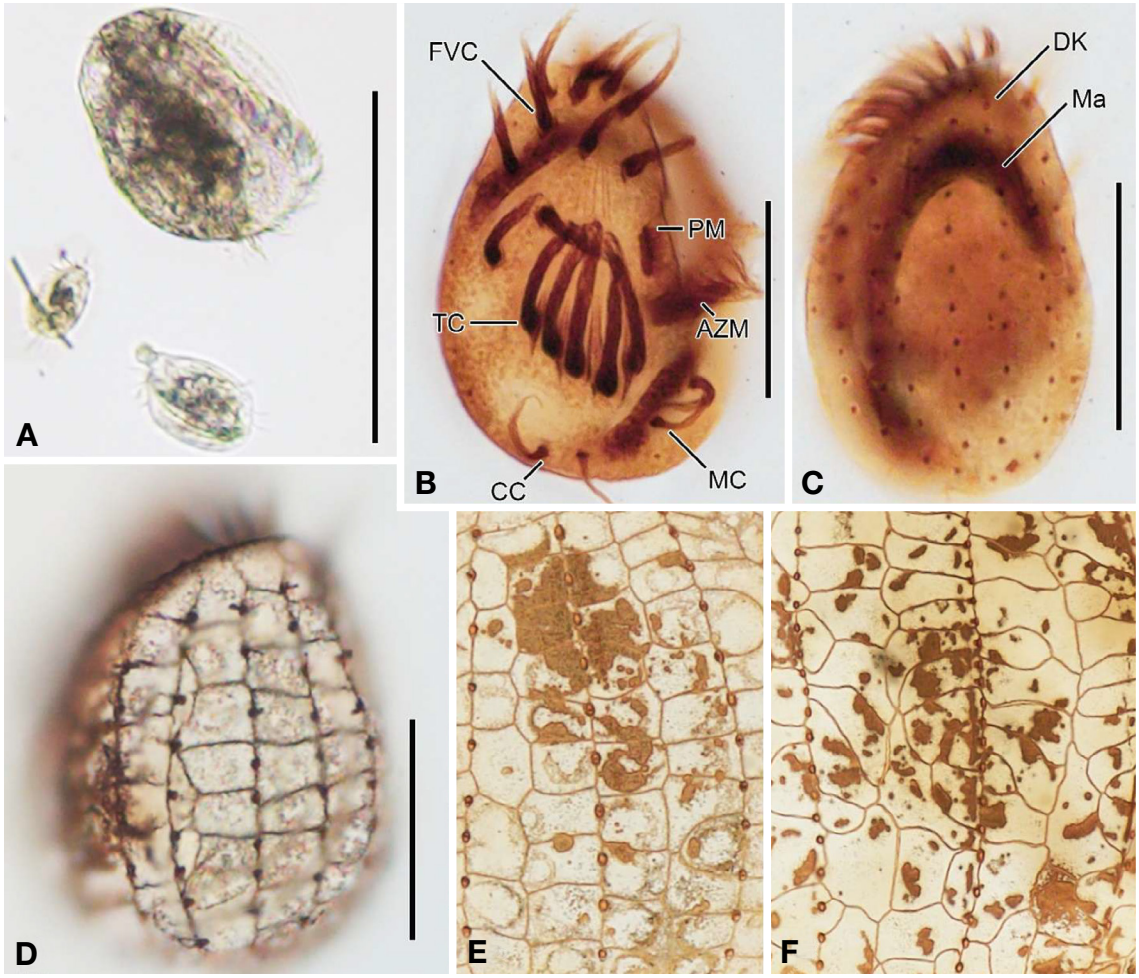

Fig. 1. *Euplotes versatilis* from life (A), after protargol (B, C), and silver nitrate impregnation (D–F). (A) Showing the body shape, cilia, oral apparatus, and the different sizes of the ordinary cells and giants. (B–F) Ventral (B) and dorsal (C–F) views showing the infraciliature and silverline. AZM, adoral zone of membranelles; CC, caudal cirri; DK, dorsal kineties; FVC, frontoventral cirri; Ma, macronucleus; MC, marginal cirri, PM, paroral membrane; TC, transverse cirri. Scale bars: 100 μm (A), 20 μm (B–D).

The Korean population corresponds well with the French type population described by Tuffrau *et al*. (2000) in several aspects: number of adoral membranelles (26–32 vs. 20–30); frontoventral cirri (10 vs. 10); dorsal kineties (8 or 9 vs. 9); dorsal argyrome pattern (single-*vannus*); and habitat (marine). In comparison to congeners, *E. minuta* Yocom, 1930 resembles *E. versatilis* but can be easily distinguished by the absence (vs. presence) of cannibalistic behavior. *Euplotes focardii* Valbonesi and Luporini, 1990, the only congener in which cannibalistic behavior has been described, resembles *E. versatilis* but can be easily distinguished by the number of dorsal kineties (8 or 9 vs. 10) and dorsal argyrome pattern (single-*vannus* vs. double-*eurystomus*).

Class Oligohymenophorea de Puytorac *et al*., 1974 빈막강
Subclass Scuticociliatia Small, 1967 채찍섬모충아강
Order Philasterida Small, 1967 필막모충목
Family Pseudocohnilembidae Evans and Thompson, 1964
Genus *Pseudocohnilembus* Evans and Thompson, 1964

2. *Pseudocohnilembus binucleatus* Foissner, 2002 (Fig. 2)
이핵평행입섬모충 (신칭)

Pseudocohnilembus binucleatus Foissner, 2002: 530–533, fig. 121a–h, table 103.

Material examined. Korea: Gyeongsangnam-do, Tongyeong-si, Hansan-myeon (34°32′6.6″N, 128°43′46.8″E); collected by Jeong Hyeon Yeo on August 22, 2023.
Identifier. Jeong Hyeon Yeo.
Deposition. NIBRPR0000111187, NIBRPR0000111188.
World distribution. Namibia (Foissner, 2002), Korea (this study).

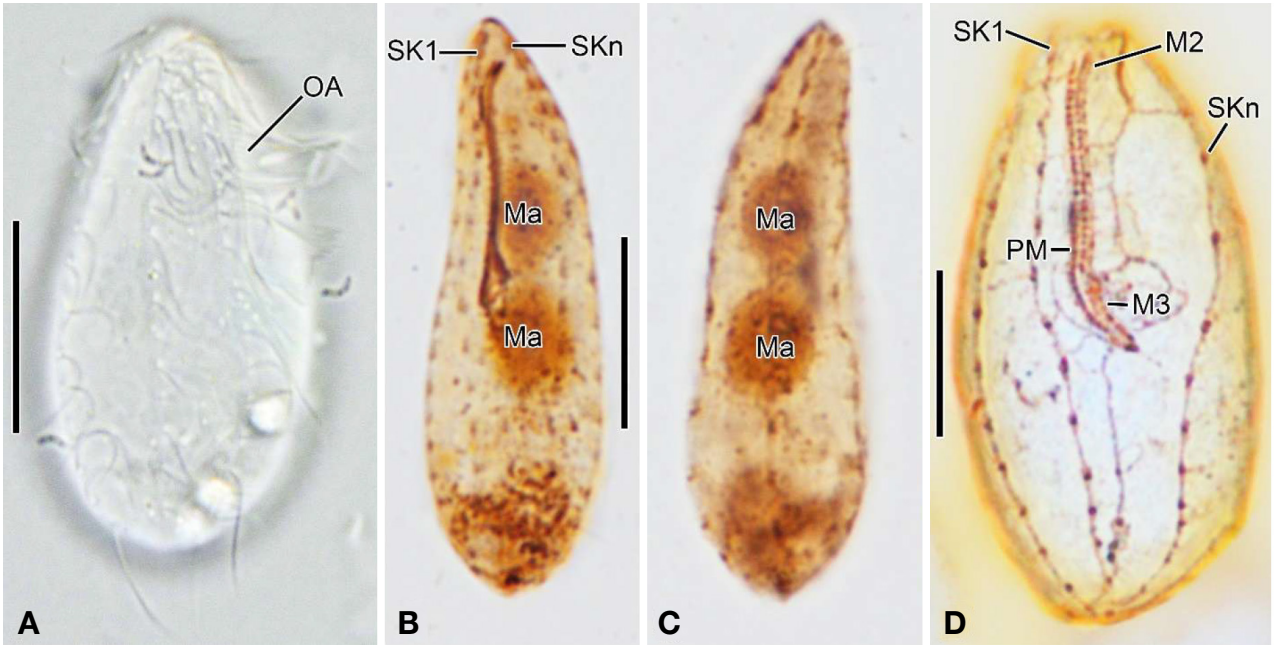

Fig. 2. *Pseudocohnilembus binucleatus* from life (A), after protargol (B, C), and Chatton-Lwoff silver nitrate impregnation (D). (A) Ventral view of a representative specimen, showing the body shape, cilia, and oral apparatus. (B, D) Ventral (B) and dorsal (C) view showing the infraciliature, nuclear apparatus, and silverline. M2 and 3, membranelles 2 and 3; Ma, macronucleus; OA, oral apparatus; PM, paroral membrane; SK1 and n, somatic kineties 1 and n. Scale bars: 10 μm.

Diagnosis. Body size 30–40 × 10–15 μm in vivo, on average 22 × 7 μm after protargol impregnation (n = 5) (Fig. 2A–C). Body shape slender oval with pointed anterior end and broadly rounded posterior end (Fig. 2A–D). Two globular macronuclei, each about 4 μm across on average after protargol impregnation, located slightly above the body center; nucleoli globular to ellipsoidal and evenly distributed; micronucleus is absent or indistinguishable (Fig. 2B, C). Cytoplasm with food vacuoles, crystals, and lipid droplets (Fig. 2A). Somatic and caudal cilia on average 4 μm and 6 μm long in vivo, respectively; invariably seven bipolar somatic kineties; kineties 1 and 7 with 17–19 and 16–18 mono/dikinetids, respectively. (Fig. 2A–C). Oral apparatus occupies about 56% of body length after silver nitrate impregnation, composed of two adoral membranelles and paroral membrane (Fig. 2B, D). Silverline consists of primary meridians (Fig. 2D).
Habitat. Marine.
Remarks. The Korean population corresponds well with the Namibian type population described by Foissner (2002) in several aspects: body size after protargol impregnation (18–27 μm × 20–32 μm); number of somatic kineties (7 vs. 7) and macronuclei (2 vs. 2). In comparison to other species in the genus, *P. persalinus* Evans and Thompson, 1964 resembles *P. binucleatus* but can be easily distinguished by the number of macronuclei (2 vs. 1) (Evans and Thompson, 1964; Song, 2000).

Phylum Arthropoda Gravenhorst, 1843 절지동물문
Class Hexanauplia Oakley, Wolfe, Lindgren and Zaharof, 2013
Order Harpacticoida Sars, 1903 갈고리노벌레목
Family Ectinosomatidae Sars, 1903 날씬장수노벌레과
Genus *Arenosetella* C. B. Wilson, 1932
모래날씬장수노벌레속

3. *Arenosetella bidenta* Ito, 1972 (Fig. 3)
두이빨모래날씬장수노벌레 (신칭)
Arenosetella bidenta Ito, 1972: 331, figs. 17, 18.

Material examined. Korea: Gangwon-do, Gangneung-si, Okkye (37°37′47.0″N, 129°2′57.0″E); collected by Sung Joon Song on May 21, 2002.
Identifier. Sung Joon Song.
Deposition. NIBRIV0000910947.
World distribution. Hokkaido, Japan (Ito, 1972), East Sea, Korea (this study).
Diagnosis. Body size 0.57 mm. Female body cylindrical and somewhat laterally depressed. Anal somite with peculiar chitinous structure as depicted. Caudal ramus longer than wide. Antennule 6-segmented. Antenna with basis and 3-segmented exopod (1, 1, 2 setae). Leg 1 with 3-segmented exopod and endopod; exopod much shorter than endopod, exp-2 with inner seta, exp-3 with 5 setae/spines; endopod with 1, 1, and 4 setae. Leg 3 exp-3 with 1 inner seta. Leg 4 exp-3 with 2 inner setae and enp-2

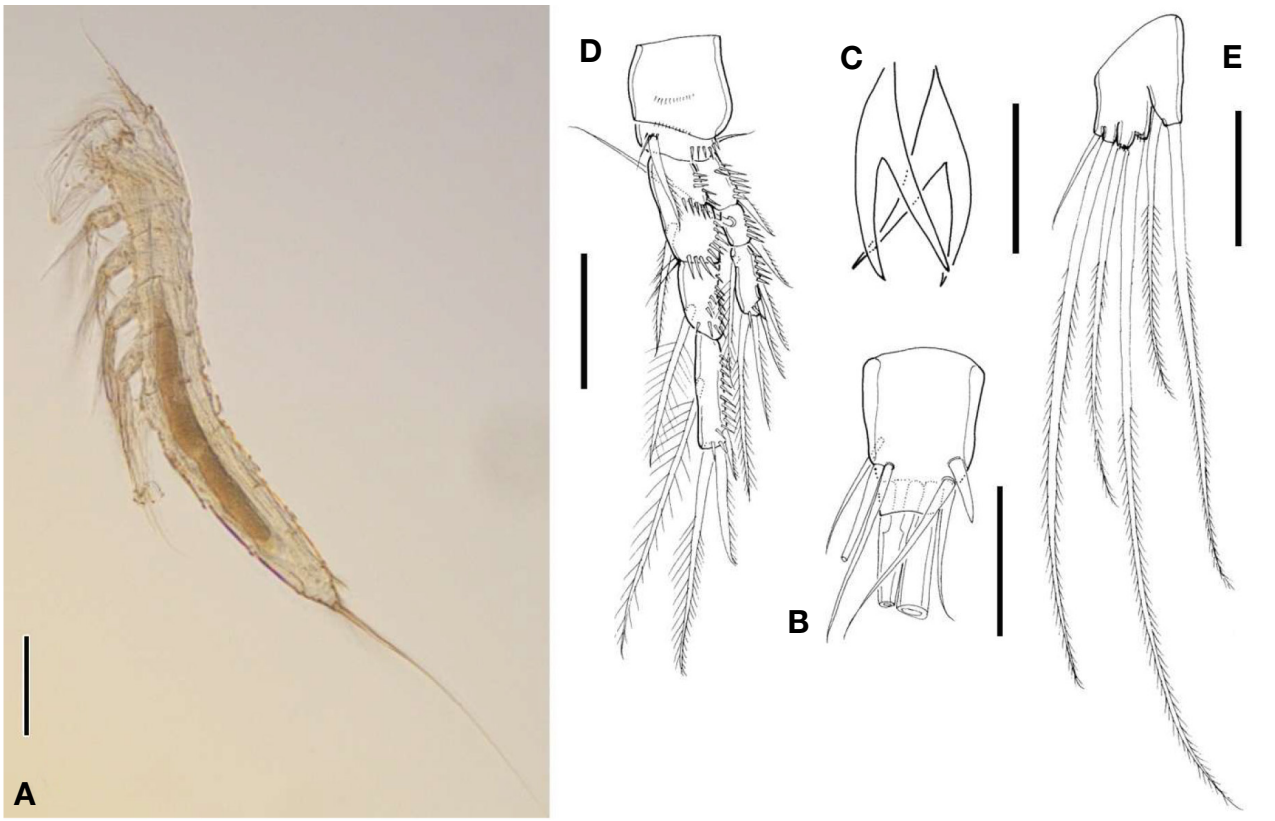

Fig. 3. Lateral view of *Arenosetella bidenta* female (A), caudal ramus, dorsal view (B), chitinous structure of anal somite (C), leg 1 (D), leg 5 (E). Scale bars: 100 μm (A), 20 μm (B, C), 30 μm (D, E).

with 1 inner seta. Leg 5 both rami fused, bearing 5 setae in total.

Habitat. Marine (sandy beach), Estuary (sandy bottom).

Remarks. The Korean material coincides with Ito's (1972) original description collected from the intertidal zone of the sandy beach at Rumoi, Hokkaido. However, Korean specimens have some minor differences compared with Ito's as follows: 1) caudal ramus has a strong spinule on inner surface, and 2) third outermost seta of leg 5 is much shorter than Japanese specimen.

Family Peltidiidae Claus, 1860 갑옷장수노벌레과
Genus *Eupelte* Claus, 1860 진갑옷장수노벌레속

4. *Eupelte simile* (Monk, 1941) (Fig. 4)
유사진갑옷장수노벌레 (신칭)

Paralteutha simile Monk, 1941: 88, pl. 2, figs. 5–11; Ito, 1974, 619, figs. 37–41.

Alteutha simile (Monk, 1941): Hicks, 1986, 358.

Material examined. Korea: Gangwon-do, Goseong-gun, Gajin (38°22′3.0″N, 128°30′45.0″E); collected by Sung Joon Song on March 13, 2006.

Identifier. Sung Joon Song.

Deposition. NIBRIV0000910949.

World distribution. Californian coast, U.S.A. (Monk, 1941), Hokkaido, Japan (Ito, 1974), East Sea, Korea (this study).

Diagnosis. Body size: female 1.39 mm and male 1.17 mm. Female body dorsoventrally depressed, shield form. Rostrum trapezoid with serrate margin. Caudal ramus longer than wide. Antennule 9-segmented, Antenna with basis and exopod 2-segmented bearing 1 and 3 setae, respectively. Maxilla proximal endite with 4 setae. Leg 1 with 3-segmented exopod and 2-segmented endopod; exopod somewhat longer than endopod; exp-3 with 4 claws and 1 seta; and enp-2 with 5 setae. Leg 2-4 enp-2 with 2 inner setae. Female leg 5 baseoendopod with 6 setae, exopod with 5 spines and 1 seta. Male P5 baseoendopod with 2 setae and exopod with 4 spines/setae.

Habitat. Marine (algal bed).

Remarks. *Eupelte simile* was originally described from Californian coast by Monk (1941) under the name *Paralteutha simile*. Later, Ito (1974) fully re-described it based on the specimens obtained from Akkeshi Bay, Hokkaido with detailed figures. The Korean specimens are very similar to Japanese one in almost appendages.

However, our species has some discrepancies with orig-

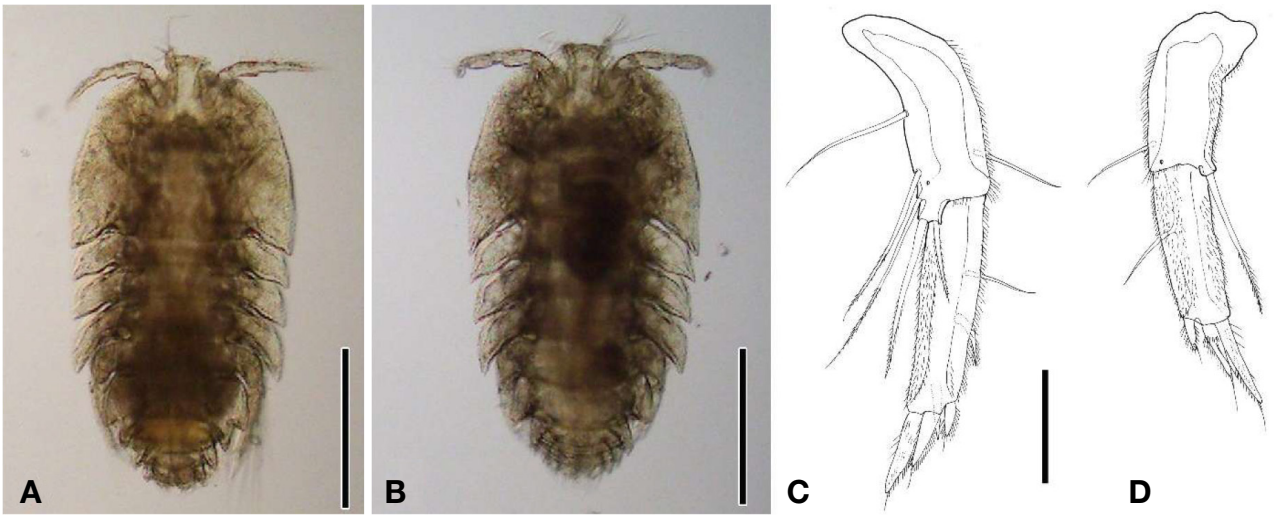

Fig. 4. Dorsal view of *Eupelte simile* female (A), dorsal view of male (B), posterior view of female leg 5 (C), posterior view of male leg 5 (D). Scale bars: 500 μm (A, B), 100 μm (C, D).

inal description by Monk (1941) as follows: 1) rostrum with serrated platform tip (vs. round tip in Monk's), 2) P4 enp-2 and enp-3 with long outer setules (vs. with normal setules), 3) female P5 exopod with 5 spines and 1 seta (vs. 5 spines), and 4) outermost spine of P5 exopod with sharp tip (vs. blunt tip).

Class Ostracoda Latreille, 1802 패충강
Order Podocopida Sars, 1866 절병목
Family Cytheridae Baird, 1850 얇은씨벌레과
Genus *Cythere* Müller, 1785 얇은씨벌레속

5. *Cythere nishinipponica* Okubo, 1976 (Fig. 5)
해면무늬일본씨벌레 (신칭)
Cythere nishinipponica Okubo, 1976: 113, figs. 1–3.

Material examined. Korea: Jeollanam-do, Yeosu-si (34°42′59.0″N, 127°38′12.0″E); depth 5–10 cm, algae rinsing; collected by Hyunsu Yoo on October 9, 2019.
Identifier. Ivana Karanovic.
Deposition. NIBRIV0000904525.
World distribution. Japan (Okubo, 1976), Korea (this study).
Diagnosis. Size approximately 0.7 mm. Surface ornamented with large and small punctuations. Valves asymmetrical in lateral view. Left valve subreniform, right valve subtrapezoidal. Radial pore canals unbranched, straight. Antennula 5-segmented with claw-like setae. Antenna with two claws on the terminal segment. Hemipenis with curved ejaculatory process, with pointed end. Distal lobes asymmetrical, right rounded, left elongated with a terminal spine.
Habitat. Marine.

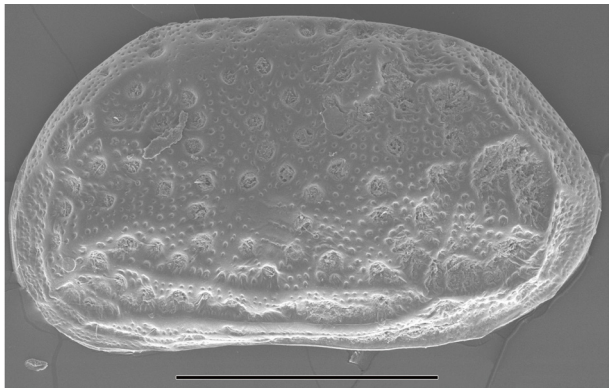

Fig. 5. External view of *Cythere nishinipponica*, male, lateral view of the left valve. Scale bars: 300 μm.

Remarks. Our specimens correspond to the original description of Okubo (1976), both in the shell and hemipenis morphology. It was originally described from the intertidal zone of the Inland Sea, Japan.

Family Hemicytheridae Puri, 1953 반곰보씨벌레과
Genus *Aurila* Pokorny, 1955 반곰보씨벌레속

6. *Aurila ikeyai* Okubo, 1988 (Fig. 6)
작은반곰보씨벌레 (신칭)
Aurila ikeyai Okubo, 1988: 142, figs. 1 (d–i), 5 (e, f).

Material examined. Korea: Busan-si, Kijang-gu, Ilkwang-myeon (35°16′4.6″N, 129°14′43.3″E); collected by Hyunsu Yoo on January 18, 2018.
Identifier. Ivana Karanovic.
Deposition. NIBRIV0000904524.

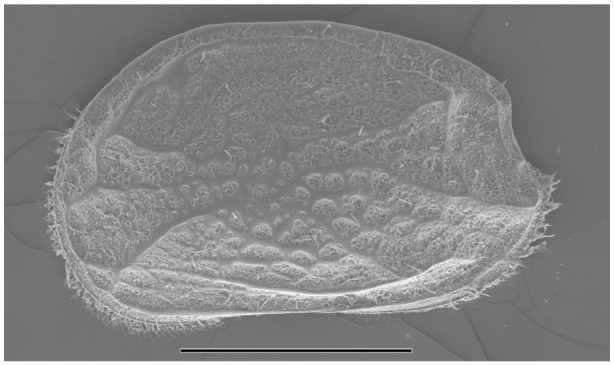

Fig. 6. External view of *Aurila ikeyai*, male, lateral view of the left valve. Scale bars: 300 μm.

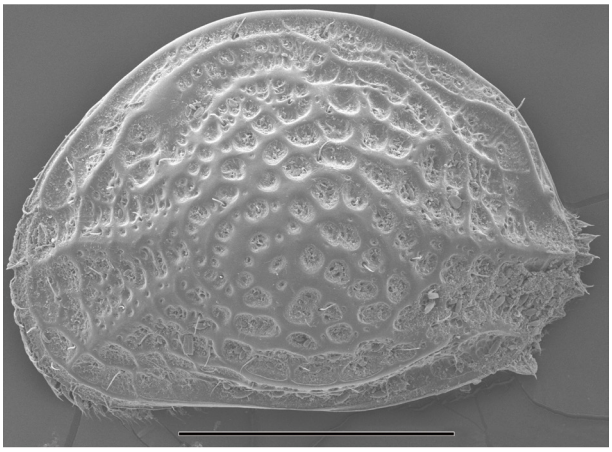

Fig. 7. External view of *Aurila munechikai*, male, lateral view of the left valve. Scale bars: 300 μm.

World distribution. Japan (Okubo, 1988), Korea (this study).
Diagnosis. Size approximately 0.6 mm. Surface ornamented with several pits and ridges. Valves distinctly asymmetrical. Left valve sub-quadrate, dorsal margin slightly convex, right valve sub-trapezoidal, dorsal margin straight. Antennula 5-segmented with strong claws. Antenna with three claws on the terminal segment. Both left and right hemipenis with terminally rounded distal processes. Sexual dimorphism not remarkable.
Habitat. Marine.
Remarks. The species is very similar to *A. hatai* Ishizaki, 1968 but they differ in hemipenis morphology: in *A. hatai* distal lobe of the hemipenis has an elongated tip, while in *A. ikeyai* the distal lobe is rounded (Ishizaki, 1968).

7. *Aurila munechikai* Ishizaki, 1968 (Fig. 7)
작은반곰보씨벌레 (신칭)
Aurila munechikai Ishizaki, 1968: 23, pl. 4, figs. 7, 8.

Material examined. Korea: Busan-si, Kijang-gu, Ilkwang-myeon (35°16′4.6″N, 129°14′43.3″E); algae rinsing; collected by Jaehyun Kim on January 18, 2018.
Identifier. Ivana Karanovic.
Deposition. NIBRIV0000904523.
World distribution. Japan (Ishizaki, 1968), Korea (this study).
Diagnosis. Size approximately 0.6 mm. Surface ornamented with several pits and ridges. Valves distinctly asymmetrical. Left valve sub-quadrate, dorsal margin slightly convex, right valve sub-trapezoidal, dorsal margin straight. Sexual dimorphism not remarkable. Both left and right hemipenis with terminally rounded distal processes, copulatory process folded towards the last third.
Habitat. Marine.
Remarks. The species was originally described on carapace only (Ishizaki, 1968). The soft body was described by Okubo (1988) from Uranouchi Bay. It differs from all other congeners by the shape of the copulatory process, which is folded on its last third.

Genus *Robustaurila* Yajima, 1982
강낭콩구릉무늬씨벌레속

8. *Robustaurila ishizakii* (Okubo, 1980)
제주강낭콩구릉무늬씨벌레 (신칭)
Mutilus ishizakii Okubo, 1980: 405, figs. 6, 7 (c, d), 11 (e–g).
Robustaurila ishizakii (Okubo, 1980) Yajima *et al.*, 1986: 606.

Material examined. Korea: Jeju Island, Seogwipo-si, Munseom Isle, diving (33°13′34.0″N, 126°33′53.0″E); algae rinsing; collected by Jaehyun Kim on January 20, 2018.
Identifier. Ivana Karanovic.
Deposition. NIBRIV0000909883.
World distribution. Japan (Okubo, 1980), Korea (this study).
Diagnosis. Size about 0.6 mm. Surface with ridges and unequal pits: larger on the posterior side of the valves. Eye ridge prominent. Both valves with posterior extensions, more prominent on the left valve. Valves sub-rectangular. Greatest height situated at the front, with dorsal margin sloping evenly towards posterior end. Right valve lower than the left, posterior margin projecting toward posterior end.
Habitat. Marine.
Remarks. The species was originally reported from Japan, and it is very similar to another species from Japan, *Robustaurila assimilis* (Kajiyama, 1913). The latter was

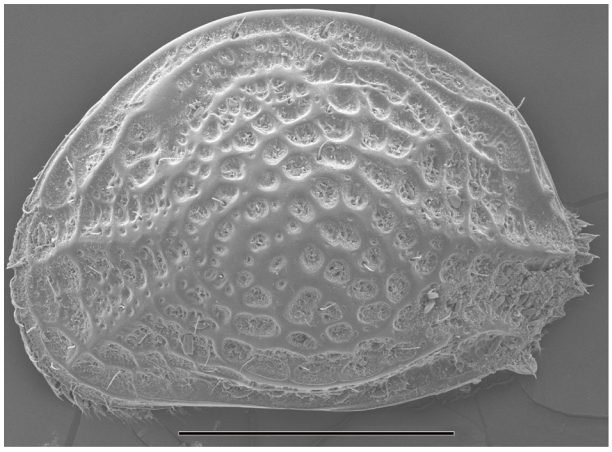

Fig. 8. External view of *Robustaurilla ishizaki*, female, lateral view of the left valve. Scale bars: 300 μm.

already reported from Korea. They mostly differ in ornamentation where *R. assimilis* has less pronounced ridges. Hemipenis morphology is also important, but we collected only females.

Family Krithidae Mandelstam, 1958 무절개씨벌레과
Genus *Parakrithella* Hanai, 1961
무절개방사무늬씨벌레속

9. *Parakrithella pseudadonta* (Hanai, 1959) (Fig. 9)
제주무절개방사무늬씨벌레 (신칭)
Neocyprideis pseudadonta Hanai, 1959: 300, pl. 14, figs. 2 (a, b), 5–9.
Parakrithella pseudadonta (Hanai, 1959): Tanaka, 2016, 37, figs. 3 (c, d), 4 (c, d), 5 (e–h), 6 (b, c), 9.

Material examined. Korea: Jeju Island, Seogwipo-si, Munseom Isle, diving (33°13′34.0″N, 126°33′53.0″E); collected by Jaehyun Kim on January 20, 2018.
Identifier. Ivana Karanovic.
Deposition. NIBRIV0000909874.
World distribution. Japan (Hanai, 1959), Korea (this study).
Diagnosis. Size around 0.5 mm. Surface smooth. Valves sub-reniform, greatest height behind the middle. Anterior margin rounded obliquely. Hingment pseudodont. Posterior margin narrow, sloping steeply to postero-ventral corner. A1 5-segmented; A2 4-segmented, terminal segment with three claws. Hemipenis with broad distal lobes in the basis, tapering distally. Slightly asymmetrical.
Habitat. Marine.
Remarks. The original description was based only on shell morphology (Hanai, 1959), and Okubo (1980) described soft parts for the first time. Our specimens differ slightly in the hemipenis morphology by having a broader basis of the distal process.

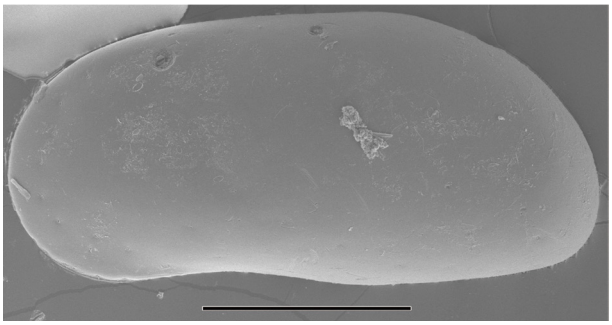

Fig. 9. External view of *Parakrithella pseudadonta*, male, lateral view of the shell from the left side. Scale bars: 200 μm.

Family Leptocytheridae Hanai, 1957 얇은씨벌레과
Genus *Calistocythere* Ruggieri, 1953 파도무늬씨벌레

10. *Callistocythere angulata* Okubo, 1979 (Fig. 10)
글로벌파도무늬씨벌레 (신칭)
Callistocythere angulata Okubo, 1976: 18, fig. 6, pl. 1 (i–l).

Material examined. Korea: Jeollanam-do, Yeosu-si (34°42′59.0″N, 127°38′12.0″E); depth 5–10 cm, algae rinsing; collected by Hyunsu Yoo on October 9, 2019.
Identifier. Ivana Karanovic.
Deposition. NIBRIV0000909873.
World distribution. Japan (Okubo, 1976), Korea (this study).
Diagnosis. Size approximately 0.5 mm. Surface covered with relatively large pits, often subdivided. Behind adductor muscle scars four small pits arranged in a rhomb forming a large pit. Left valve sub-rectangular, dorsal margin slightly arched, posterior cardinal angle distinct. Anterior and posterior margins rounded, posterior narrower than anterior. Radial pore canals poly furcated.
Habitat. Marine.
Remarks. *Callistocythere angulata* resembles *C. hosonosuensis* Okubo, 1979, which was already reported from Korea. The two species differ mostly in the hemipenis morphology, but also in *C. angulata* being tumide, and has a specific ornament behind muscle scar imprint.

Family Loxoconchidae Sars, 1925 경사씨벌레과
Genus *Loxoconcha* Sars, 1866 경사씨벌레

11. *Loxoconcha optima* Ishizaki, 1968 (Fig. 11)
길쭉한경사씨벌레 (신칭)
Loxoconcha optima Ishizaki, 1968: 30, pl. 2, fig. 2, pl. 6, figs. 8, 9.

Material examined. Korea: Gangwon-do, Gangneung

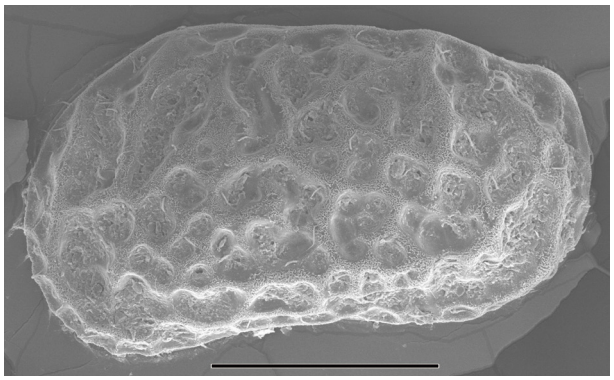

Fig. 10. External view of *Calistocythere angulata*, female, lateral view of the left valve. Scale bars: 200 μm.

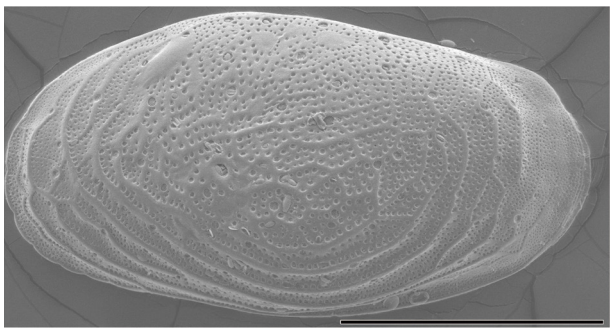

Fig. 11. External view of *Loxoconcha optima*, sex unknown, lateral view of the left valve. Scale bars: 300 μm.

Beach (37°48′20.0″N, 128°54′28.0″E); interstitial; collected by Ivana Karanovic on October 9, 2019.
Identifier. Ivana Karanovic.
Deposition. NIBRIV0000904536.
World distribution. Japan (Ishizaki, 1968), Korea (this study).
Diagnosis. Size approximately 0.5 mm. Valves elliptical in lateral view. Surface ornamented with pits and ridges. Ridges concentrical, especially prominent ventrally. Dorsal margin gently curved, with greatest height in front of the middle. Anterior margin finely crenulated, wider than posterior. Transition between dorsal and posterior margin angular. Shell slightly inflated medially. Eye-tubercle prominent. Pores system around the eye tubercle typical for species.
Habitat. Marine.
Remarks. This species is very similar to *L. taiwanensis* Zhao, 1988 already reported from Korea. It is possible that the two are synonyms, however, according to Ishii *et al*. (2005) each *Loxoconcha* has a specific pore pattern on the shell.

Family Pectocytheridae Hanai, 1957 얇은이빨씨벌레과

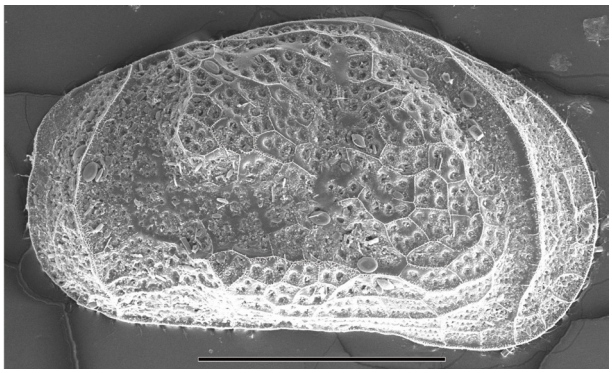

Fig. 12. External view of *Pectocythere quadrangulata*, female, lateral view of the left valve. Scale bars: 200 μm.

Genus *Pectocythere* Hanai, 1957 얇은이빨씨벌레속

12. *Pectocythere quadrangulata* Hanai, 1957 (Fig. 12) 사각형얇은이빨씨벌레 (신칭)
Pectocythere quadrangulata Hanai, 1957: 474, fig. 6 (a, b), pl. 11, figs. 3 (a, b).

Material examined. Korea: Gangwon-do, Gangneung, Aninji-ri, river mouth, St. 2 (37°44′25.0″N, 128°59′5.0″E); interstitial; collected by Hyunsu Yoo on October 4, 2015.
Identifier. Ivana Karanovic.
Deposition. NIBRIV0000909885.
World distribution. Japan (Hanai, 1957), Korea (this study).
Diagnosis. Shell strongly calcified, rectangular in lateral view. Surface covered with pits and two distinct ridges present, one running parallel to the anterior, another parallel to the posterior margin. In dorsal view, laterally inflated. Dorsal margin slightly sloping towards posterior end, angular at transition to the anterior margin. Anterior margin broadly rounded, posterior margin almost square.
Habitat. Marine.
Remarks. This species was originally described from Quaternary deposit of Japan (Hanai, 1957). No soft parts were reported until now (not illustrated here).

Phylum Rotifera Cuvier, 1817 윤형동물문
Class Eurotatoria De Ridder, 1957 진윤충강
Subclass Bdelloidea Hudson, 1884 질형아강
Order Philodinida Melone and Ricci, 1995 선윤충목
Family Habrotrochidae Bryce, 1910 협관윤충과
Genus *Habrotrocha* Bryce, 1910 협관윤충속

13. *Habrotrocha quinquedens quinquedens* De Koning, 1947 (Fig. 13) 다섯니협관윤충 (신칭)
Habrotrocha quinquedens quinquedens De Koning, 1947: 194, pl. 4, fig. 19a–d.

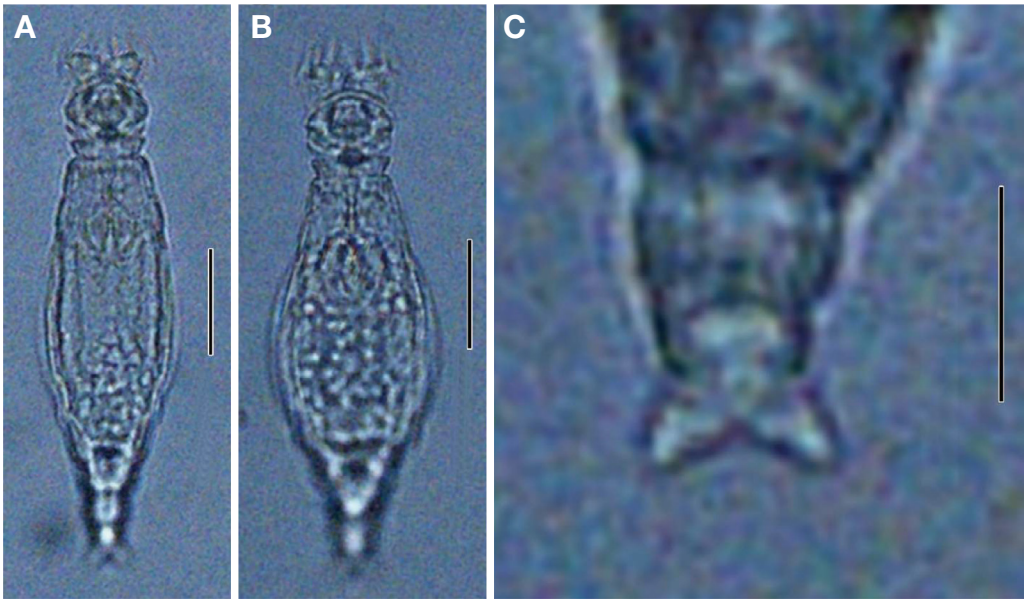

Fig. 13. *Habrotrocha quinquedens quinquedens* De Koning, 1947: (A, B). feeding, dorsal view; (C). foot and spurs, ventral view. Scale bars: 25 μm (A, B), 10 μm (C).

Material examined. Korea: Gangwon-do, Seongsan-myeon (37°42′27.4″N, 128°47′56.5″E); collected by CH Lee and MO Song on May 7, 2023.
Identifier. Min Ok Song.
Deposition. NIBRIV0000910359.
World distribution. Czech Republic (Devetter *et al*., 2020), the Netherlands (De Koning, 1947) and Korea (this study).
Diagnosis. Corona narrower than cingulum pad width. Upper lip rimmed, arched and without a median notch; much lower than trochal discs. Cingulum pad round laterally; with a bulge in the middle laterally. Sulcus slightly narrower than half of pedicel width. Pedicel short. Pharyngeal tube much shorter than trophi length in feeding. Foot very short and about 1/7 of total length in feeding. Spurs conical and with narrow interspace; outer margin rather straight and inner margin plump proximally; interspace slightly narrower than 1/3 of spur base width.
Habitat. Mosses and soil.
Remarks. *Habrotrocha q. quinquedens* is quite rare and was reported only from Czech Republic (Devetter *et al*., 2020) after its original description from the Netherlands by De Koning (1947). This species is new to Asia.

Genus *Otostephanos* Milne, 1916 고리관윤충속

14. *Otostephanos auriculatus bilobatus* Hauer, 1939 (Fig. 14) 두갈래작은귀고리관윤충 (신칭)
Otostephanos auriculatus var. *bilobatus* Hauer, 1939: 173–174, abb. 10.

Material examined. Korea: Gangwon-do, Jeongseon-gun (37°25′28.0″N, 128°34′24.6″E); collected by CH Lee and MO Song on May 25, 2024.
Identifier. Min Ok Song.
Deposition. NIBRIV0000920309.
World distribution. Germany (Hauer, 1939), New Zealand (Donner, 1965) and Korea (this study).
Diagnosis. Median lobe of upper lip narrow and bilobed; each lobe round and without interspace; slightly lower than trochal discs. Fine ring between corona and cingulum expanded, disconnected laterally and lobster claw-shaped in frontal view. Corona slightly wider than cingulum. Cingulum as wide as cingulum pad. Lateral margins of cingulum pad rather parallel. Teeth 10/10. Pharyngeal tube shorter than trophi length in feeding. Spurs conical and with narrow interspace.
Habitat. Mosses and lichens.
Remarks. *Otostephanos auriculatus bilobatus* has been reported only once from New Zealand (Donner, 1965) after the description from Germany (Hauer, 1939). The present study is the third record of it. This subspecies is new to Asia.

Order Adinetida Melone and Ricci, 1995
납작머리윤충목
Family Adinetidae Hudson and Gosse, 1886
납작머리윤충과
Genus *Adineta* Hudson, 1886 납작머리윤충속

15. *Adineta tuberculosa* Janson, 1893 (Fig. 15)
종기납작머리윤충 (신칭)

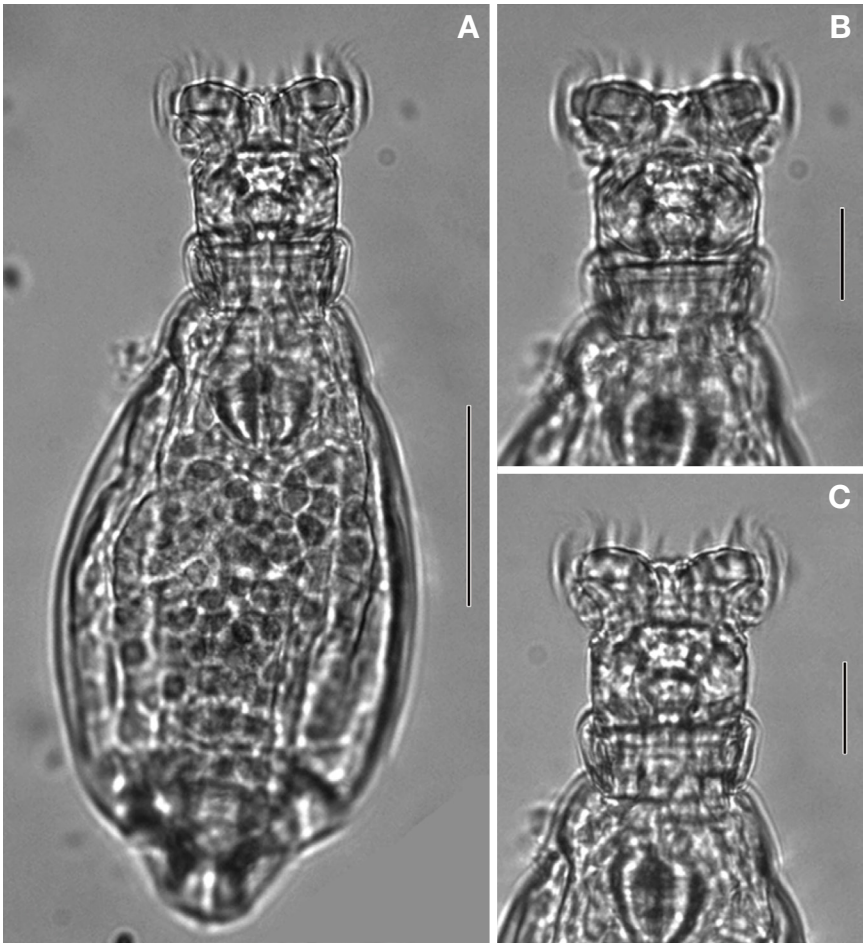

Fig. 14. *Otostephanos auriculatus bilobatus* Hauer, 1939: (A). feeding, dorsal view; (B, C). feeding head and neck, dorsal view. Scale bars: 50 μm (A), 20 μm (B, C).

Adineta tuberculosa Janson, 1893: 73–74, pl. 5, figs. 72–75.

Material examined. Korea: Gangwon-do, Pyeongchang-gun (37°41′41.1″N, 128°45′15.3″E); collected by CH Lee and MO Song on May 20, 2023.
Identifier. Min Ok Song.
Deposition. NIBRIV0000910358.
World distribution. Germany (Janson, 1893), New Zealand (Shiel and Green, 1996), South Africa (Koste, 1996), Switzerland (Donner, 1965), the Netherlands (De Koning, 1929) and Korea (this study).
Diagnosis. Rostrum without sensilla; slightly wider than anterior end of head and much narrower than the greatest head width; ratio of rostrum width to head width about 1 : 1.5–1 : 1.8. Neck, trunk, rump, foot and dorsal area of head covered with coarse granules. Rump much narrower than the greatest trunk width. Foot gradually tapering to spur pseudosegment. Spurs small, narrow and conical; interspace as wide as spur base.
Habitat. Mosses, mushrooms and tree barks.
Remarks. This species can be easily distinguished from its congeners by the coarse granules that cover neck, trunk, rump, foot and the dorsal area of flat head (Janson, 1893). This species is new to Asia.

Class Clitellata Linnaeus, 1740 환대강
Order Haplotaxida Grube, 1850 지렁이목
Family Naididae Ehrenberg, 1828 물지렁이과
Subfamily Tubificinae Vejdovský, 1884 실지렁이아과
Genus *Aulodrilus* Bretscher, 1899 서관지렁이속 (신칭)

16. *Aulodrilus limnobius* Bretscher, 1899 (Fig. 16)
두깃서관지렁이 (신칭)
Aulodrilus limnobius Bretscher, 1899: 388, figs. 8.23G–H.

Material examined. Korea: Gyeonggi-do, Yangpyeong-gun, Gangsang-myeon Daeseok-ri (37°30′6.5″N, 127°27′11.9″E); collected by Jeounghee Lee on June 25, 2022.

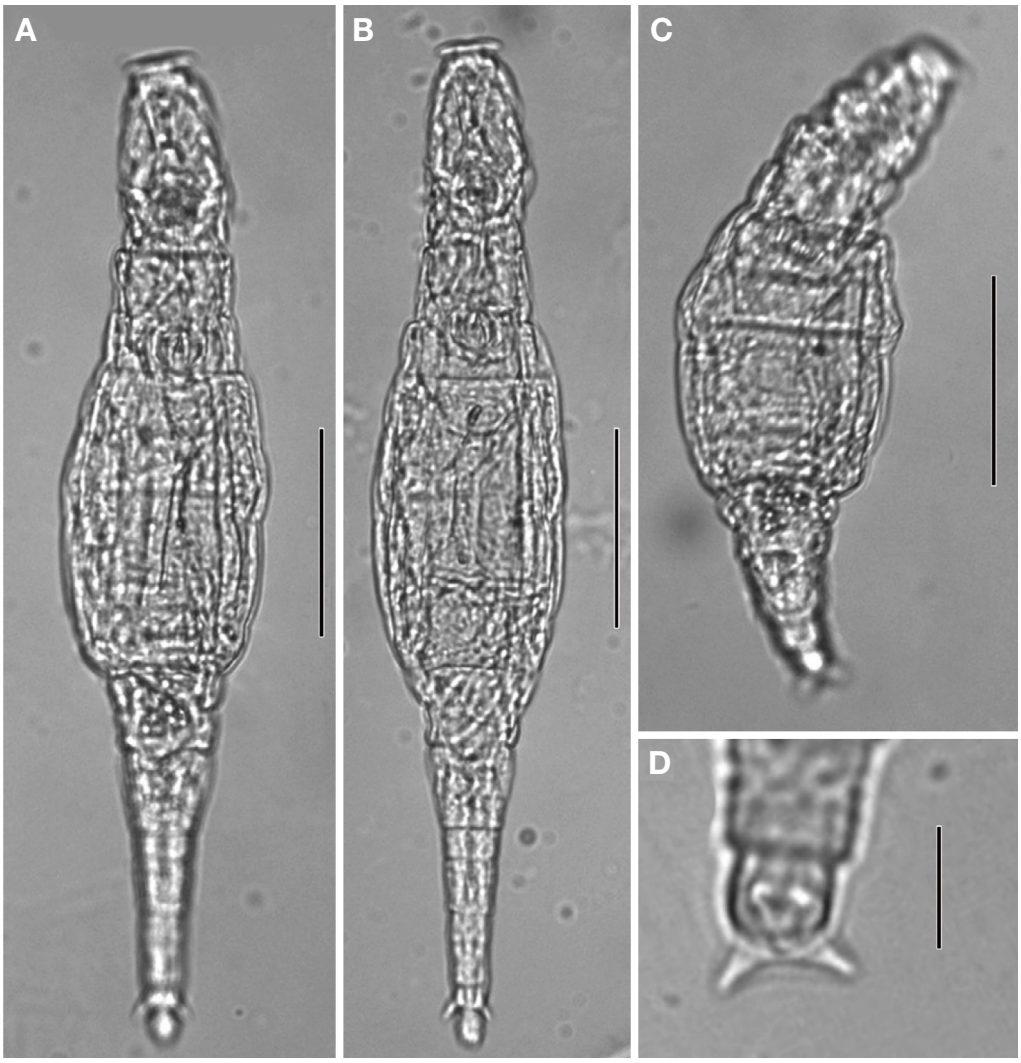

Fig. 15. *Adineta tuberculosa* Janson, 1893: (A–C). creeping, dorsal view; (D). foot and spurs, ventral view. Scale bars: 50 μm (A–C), 10 μm (D).

Identifier. Jeounghee Lee.
Deposition. NIBRIV0000910360.
World distribution. Cosmopolitan (Pinder and Brinkhurst, 2000).
Diagnosis. Prostomium is small (Fig. 16A). Pharynx has a complex, folded configuration. Ventral and dorsal chaetae are only bifid, with the upper tooth shorter and lower. Chaetae 7–10 per bundle in preclitellar and mid-body segments, 2–4 in posterior ones, with distally often dilated, forming lateral wings which appear as narrow oar-shaped blades (Fig. 16B). No modified genital chaetae. Clitellum over 1/2VI–VIII. Spermathecal pores are in front of the dorsal chaetae of VI. Male openings on VII, lateral to the ventral chaetae.
Habitat. Freshwater.
Remarks. This is the first Korean record of this species, which is widely distributed worldwide (Pinder and Brinkhurst, 2000).

Genus *Limnodrilus* Claparède, 1862 실지렁이속

17. *Limnodrilus tortilipenis* Wetzel, 1987 (Fig. 17)
꼬인장대실지렁이 (신칭)
Limnodrilus tortilipenis Wetzel, 1987: 182–185, figs. 1–11.

Material examined. Korea: Jeollanam-do, Sinan-gun, Jaeun-myeon, Guyeong 1 Reservoir (34°44′44.5″N, 126°7′4.4″E); collected by Jeounghee Lee on May 10, 2024.
Identifier. Jeounghee Lee.
Deposition. NIBRIV0000920318.
World distribution. America (Wetzel, 1987), Europe (Munts and Soes, 2012), Korea (this study).



Fig. 16. *Aulodrilus limosus*. (A) total body; chaetae (B). Scale bars: 300 μm (A), 30 μm (B).



Fig. 17. *Limnodrilus tortilipenis*. (A) total body; (B) penial sheath in XI–XVI; (C) top of penial sheath; (D) ventral chaetae. Scale bars: 2 mm (A), 200 μm (B), 100 μm (C), 40 μm (D).

Diagnosis. Prostomium short, triangular in dorsal view (Fig. 17A). All chaetae bifid. Anterior chaetae 6–8 per bundle, with upper tooth longer, thinner than proximal; posteriorly chaetae 3–4 per bundle, with equal teeth or subequal teeth (Fig. 17D). Penis sac with spiralled muscle bands. Penial sheaths not especially thick-walled, extremely elongate, length 20–48 times maximum diameter (Fig. 17B). Base of head resembling corkscrew, with a thin spiral appendage, and two short digitiform projections on distal head (Fig. 17C). Bases of penes originate around posterior portion of XVI.

Habitat. Freshwater.

Remarks. The most notable difference between this species and other species is its very long penial sheaths. This unique feature of *L. tortilipenis* is unmatched by any other *Limnodrilus* species, as it possesses a distinctly different length and shape of the head (Munts and Soes, 2012).

Subfamily Phallodrilinae Brinkhurst, 1971
Genus *Gianius* Erséus, 1992 쎈털물지렁이속 (신칭)

18. *Gianius riparius* (Giani and Martinez-Ansemil, 1981) (Fig. 18) 짧은쎈털물지렁이 (신칭)

Phallodrilus riparius Giani and Martinez-Ansemil, 1981: 202–205, fig. 1A–D.

Gianius riparius (Giani and Martinez-Ansemil, 1981) comb. n. Erséus, 1992: 24.



Fig. 18. *Gianius riparius*. (A) total body; (B) chaetae. Scale bars: 200 μm (A), 40 μm (B).

Material examined. Korea: Gyeongsangbuk-do, Gyeongju-si, Seomyeon, Cheonchon-ri, Deokcheon Reservoir (35°51′54.0″N, 129°2′13.6″E); collected by Jeounghee Lee on March 26, 2021.
Identifier. Jeounghee Lee.
Deposition. NIBRIV0000920317.
World distribution. Spain (Giani and Martinez-Ansemil, 1981), Korea (this study).
Diagnosis. All chaetae 2–4 in anterior bundles and by 1–3 in posterior bundle, with upper tooth short than lower. Penial chaetae 4 per bundle, with thick and straight. Atrial cylindrical and bent, each equipped with two prostate glands. Spermathecae as cylindrical sacs with roundish bulge in distal end, short, narrow duct.
Habitat. Groundwater.
Remarks. This species was first reported from the Iberian Peninsula (Giani and Martinez-Ansemil, 1981). Since then, it has been rarely found in some European regions. It was first discovered in Asia.

Conflicts of Interest

The author of this paper has no affiliation with any interests and is solely responsible for the paper.

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