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New record of three monogononts (Rotifera: Monogononta) from islands of Korea

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Three newly recorded rotifers were collected through surveys of several islands in Korea: *Lecane perplexa* (Ahlstrom, 1938); *Lindia torulosa* Dujardin, 1841; and *Monommata maculata* Harring & Myers, 1930. These species represent 24th, second, and third records of each genus discovered in Korea, respectively. *Lecane perplexa* and *Monommata maculata*, were collected from reservoirs using plankton nets, whereas *Lindia torulosa* was collected from a soil sample. The morphological characteristics of the discovered species are as follows: *Lecane perplexa* is characterized by a straight or slightly concave anterior margin of the lorica, an incomplete transverse fold on the ventral lorica, and a single toe with pseudoclaws and accessory claws; *Lindia torulosa* has an illoricated and vermiform body, a head with rostrum, a pair of auricles, cardate type trophi, and distinctively shaped epipharynx components; and *Monommata maculata* is characterized by long toes, an inner margin of rami with 10−12 serrated teeth, 3−4 large teeth, and interlocking teeth. Here, the morphological characteristics of the three Korean monogonont rotifers, which include trophi photographs, are presented. In addition, partial sequences of the mitochondrial cytochrome *c* oxidase subunit I (COI) of each species are presented.

Keywords: *Lecane*, *Lindia*, *Monommata*, SEM, taxonomy

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Introduction

Through surveys of several Korean islands, the presence of three monogonont rotifers in Korea was recorded, namely, *Lecane perplexa* (Ahlstrom, 1938); *Lindia torulosa* Dujardin, 1841; and *Monommata maculata* Harring & Myers, 1930. The genus *Lecane* Nitzsch, 1827 consists of about 200 species and subspecies (Segers, 2007; Jersabek and Leitner, 2013), and 23 *Lecane* species had been recorded in Korea before this study. In addition, the genus *Lecane* constitutes the largest proportion of recorded Korean monogononts, followed by *Trichocerca* Lamark, 1801 (20 spp.) and *Brachionus* Pallas, 1766 (18 spp.) (National Institute of Biological Resources, 2022). The genus *Lindia* Dujardin, 1841 is the only genus in the family Lindiidae Harring & Myers, 1924. This genus possesses 17 species, all of which are characterized by having cardate trophi (Segers, 2002). In Korea, Turner (1986) first recorded *Lindia tecusa* Harring & Myers, 1922, and the discovery of *Lindia torulosa* in this study represents the second record of the genus *Lindia*. The genus *Monommata* Bartsch, 1870 is one of the 19 genera in the family Notommatidae Hudson & Gosse, 1886. *Monommata* species have two notably long toes. Trophi of this genus is variable, from virgate to intermediate between virgate and forcipate (Nogrady and Pourriot, 1995). So far, 17 *Monommata* species have been recorded worldwide (Segers, 2007), of which two have been known in Korea before this study (Yamamoto, 1953; Chung *et al*., 1992).

Three newly recorded rotifers are cosmopolitan and common species (Nogrady and Pourriot, 1995; Segers, 1995; 2002). However, due to the limited taxonomic studies on Korean rotifers, many common species remain unrecorded in Korea (Jersabek and Leitner, 2013). Moreover, taxonomic studies of rotifers in Korea have mainly been conducted on the mainland, leaving the Korean islands understudied in this context. Because of their high dispersal capacity and adaptability, many rotifers have a global distribution (Wallace *et al*., 2006). For this reason, rotifers can be discovered even on islands far from continents (De Smet, 2002; Jersabek, 2003). The Korean Peninsula is surrounded by 3,348 islands, which have a unique climate

and topography compared to the mainland (Korea Maritime Institute, 2018), suggesting a high possibility for a variety of rotifer species to inhabit these islands.

Here, the morphological characteristics of three new records of Korean monogonont rotifers, which include trophi photographs, are presented. In addition, a partial sequence of the mitochondrial cytochrome *c* oxidase subunit I (COI) of each species is provided.

Materials and Methods

For collecting rotifers in reservoirs, a 50 μm plankton net was used. Plankton samples were immediately preserved at the sampling sites using 4% formalin or 95% ethanol. To collect rotifers from the soil samples, the samples were dried for a few weeks and rewetted using mineral water. Rotifers were sorted and observed under a stereo microscope (SZX7, Olympus, Japan) and an optical microscope (DM2500; Leica, Germany).

For scanning electron microscopy (SEM) of trophi, the trophi were isolated using a commercial bleach (Yuhan-Chlorox, Korea). Whole body specimens for SEM were prepared using the following procedure: (1) the rotifers were fixed in 2% OsO_4 solution for 30 min and rinsed using distilled water, (2) the rotifers were dehydrated through an ascending series of ethanol (30%, 50%, 70%, 90%, 95%, 100%, 10 min each step), (3) 100% ethanol was replaced with hexamethyldisilazane (440191, Sigma-Aldrich, USA) twice, 10 min each step, and (4) the rotifers were transferred to a cover glass and dried overnight (Shively and Miller, 2009). SU8010 (Hitachi, Japan) was used for the SEM at an accelerating voltage of 10−15 kV. All examined specimens were deposited in the storage of National Institute of Biological Resources (NIBR) and Honam National Institute of Biological Resources (HNIBR).

The DNA of the rotifers was extracted using a LaboPass™ Tissue Genomic DNA Isolation Kit Mini (Cosmo Genetech, Korea). Polymerase chain reaction (PCR) was performed using the COI primer 30F/885R (Zhang *et al*., 2021) under the following conditions: initial denaturation at 95°C for 2 min, followed by 40 cycles at 95°C for 30 s, 51°C for 45 s, and 72°C for 1 min. PCR products were visualized using 1% agarose gel electrophoresis, and purified using a LaboPass™ PCR Purification Kit (Cosmo Genetech, Korea). The sequences were assembled and trimmed using Geneious 8.1.9 (https://www.geneious.com).

Systematic Accounts

Phylum Rotifera Cuvier, 1817 윤형동물문
Class Eurotatoria De Ridder, 1957 진윤충강
Subclass Monogononta Plate, 1889 단소아강
Order Ploima Hudson & Gosse, 1886 유영목
Family Lecanidae Remane, 1933 술잔윤충과
Genus *Lecane* Nitzsch, 1827 술잔윤충속

***Lecane perplexa* (Ahlstrom, 1938) (Figs. 1, 2)**
작은월형외발술잔윤충 (신칭)
Monostyla perplexa Ahlstrom, 1938, pp. 101, 102.

Material examined. Reservoir in Goya-ri, Jindo-gun (34°26′31.8″N, 126°10′30.6″E), 05 May 2021, Hee-Min Yang. Voucher Number: HNIBRIV363, HNIBRIV546.
Diagnosis. Loricate. Anterior margin of dorsal lorica straight, ventral lorica slightly concave. Width of dorsal lorica narrower than ventral lorica in the front, and slightly wider than ventral lorica in the middle. Dorsal lorica 65.0−70.0 μm in length. Ventral lorica 70.0−85.0 μm. Width of lorica 55.0−68.0 μm. Transverse fold of ventral lorica incomplete. Foot plate wide and foot pseudosegment squircle. Single toe with pseudoclaws and accessory claws.

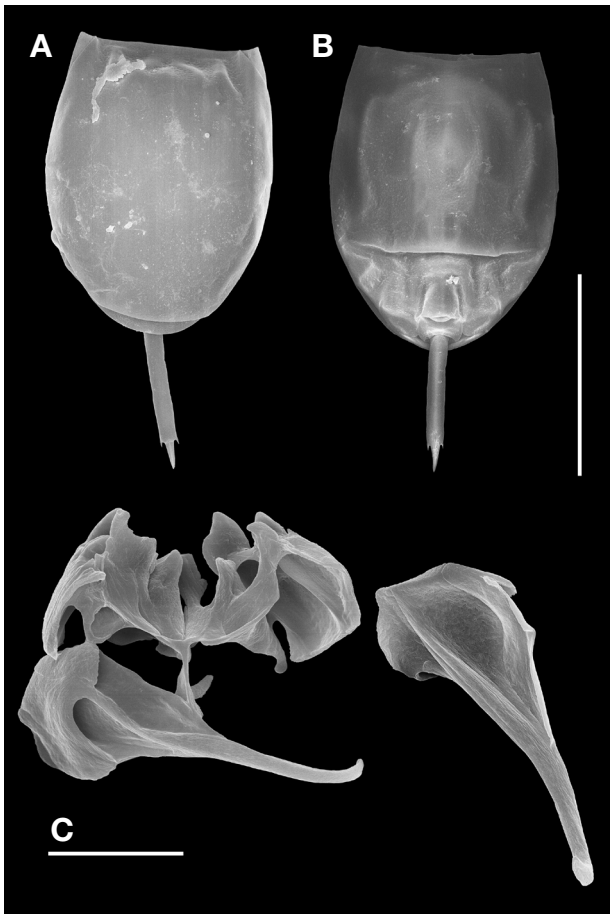

Fig. 1. SEM images of *Lecane perplexa* (Ahlstrom, 1938). A. dorsal view. B. ventral view. C. trophi, dorsal view. Scale bars = A, B: 50 μm, C: 10 μm.

Toe length 35.0 μm. Malleate type trophi. Alula of right ramus containing a hook-shaped projection. Fulcrum short, and inverted T-shaped. Each uncus with two large teeth. Posterior end of manubrium curved inwards.

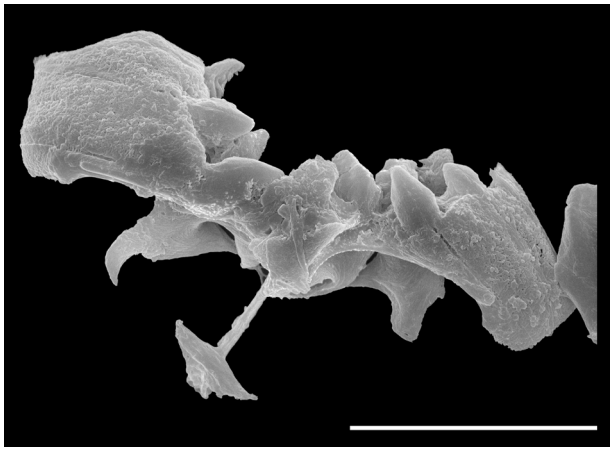

Fig. 2. SEM image of trophi of *Lecane perplexa* (Ahlstrom, 1938). Incus, ventral view. Scale bar = 10 μm.

Distribution. Cosmopolitan.

Remarks. The identification of *L. perplexa* based on morphology is difficult because of its similarity to *L. lunaris* (Ehrenberg, 1832). However, despite the similarities, the two species do have a few characteristics that set them apart. Compared to *L. lunaris*, *L. perplexa* is characterized by a lorica with a flat or slightly concave anterior margin, a smaller body, and a relatively short toe in proportion to its lorica size. Additionally, *L. perplexa* tends to have a shorter foot pseudosegment than *L. lunaris*. *Lecane perplexa* is also confused with *L. rhopalura* (Harring & Myers, 1926) and *L. scutata* (Harring & Myers, 1926). However, *L. perplexa* can be distinguished from *L. rhopalura* by the angulated shape of its antero-lateral corners and the absence of bulging in the toes, and it differs from *L. scutata* by its larger body size and deeper lateral sulci.

Molecular data. A partial COI sequence (759 bp) was obtained from one specimen (GenBank accession number: OQ445411).

Family Lindiidae Harring & Myers, 1924 유연윤충과

Genus *Lindia* Dujardin, 1841 유연윤충속

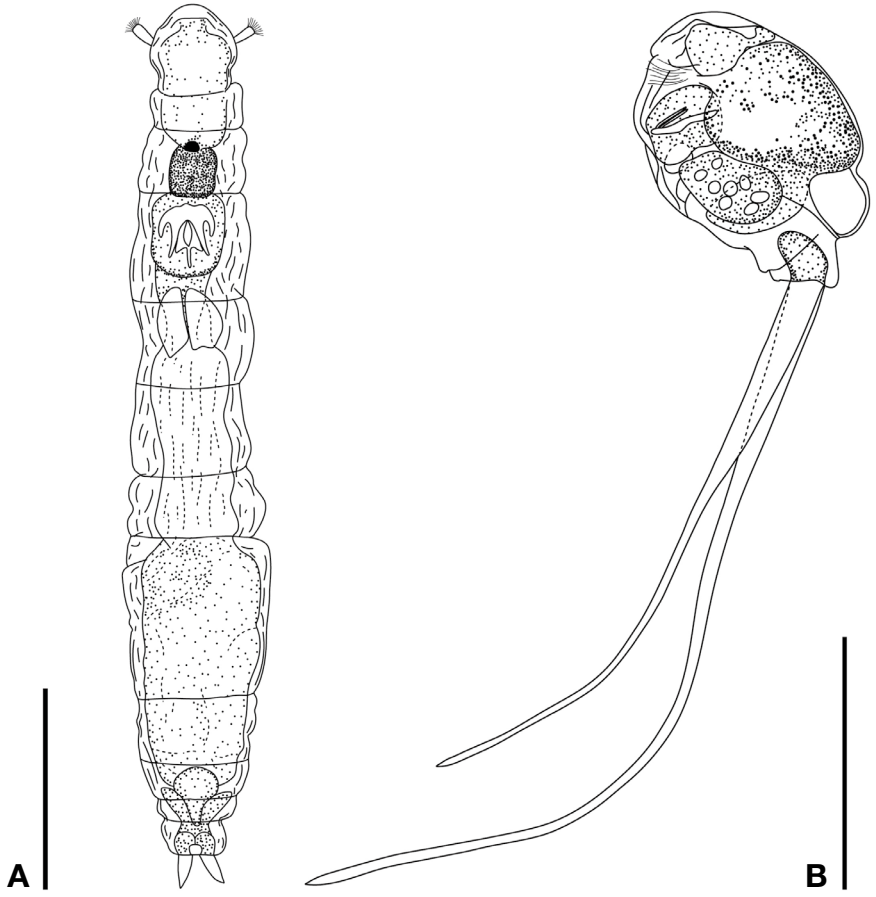

Fig. 3. Line drawings of rotifers. A. *Lindia torulosa* Dujardin, 1841, dorsal view. B. *Monommata maculata* Harring & Myers, 1930, lateral view. Scale bars = A, B: 100 μm.

***Lindia torulosa* Dujardin, 1841 (Figs. 3A, 4C, D)**
주름유연윤충 (신칭)
Lindia torulosa Dujardin, 1841, p. 653.
Notommata roseola Perty, 1850, p. 18.
Notommata tardigrada Leydig, 1854, p. 39.

Material examined. Soil sample from Jawol-ri, Incheon (37°15′43.8″N, 126°18′12.1″E), 26 Apr. 2021, Yong-Uk Ahn. Voucher Number: NIBRIV0000900972.
Diagnosis. Illoricated body vermiform, transparent, elongate, 440–465 μm in length. Head with rostrum and pair of auricles. Retrocerebral organ sac-shaped and with dark color. One eyespot in the posterior part of brain. Stomach and intestine green and orange. Trunk with several transverse folds. Foot with two pseudosegments. Two conical toes, with blunt end. Trophi cardate. Fulcrum thin and elongated in dorsal view. Rami with alulae. Uncus with three teeth, median one largest. Manubrium thick and straight with crescent branch. Epipharynx consisting of a pair of L-shaped rods; each rod between a lamella with serrated anterior margin and leaf-shaped lamella.
Distribution. Cosmopolitan.
Remarks. *Lindia torulosa* is the most common species in the genus *Lindia* (Segers, 2002). This species is cosmopolitan and in Asia, it has been reported in China (Wang, 1961) and India (Sinha, 2014). The morphological characteristics of the Korean specimens were congruent with those of previous studies (Koste and Shiel, 1990; Segers,

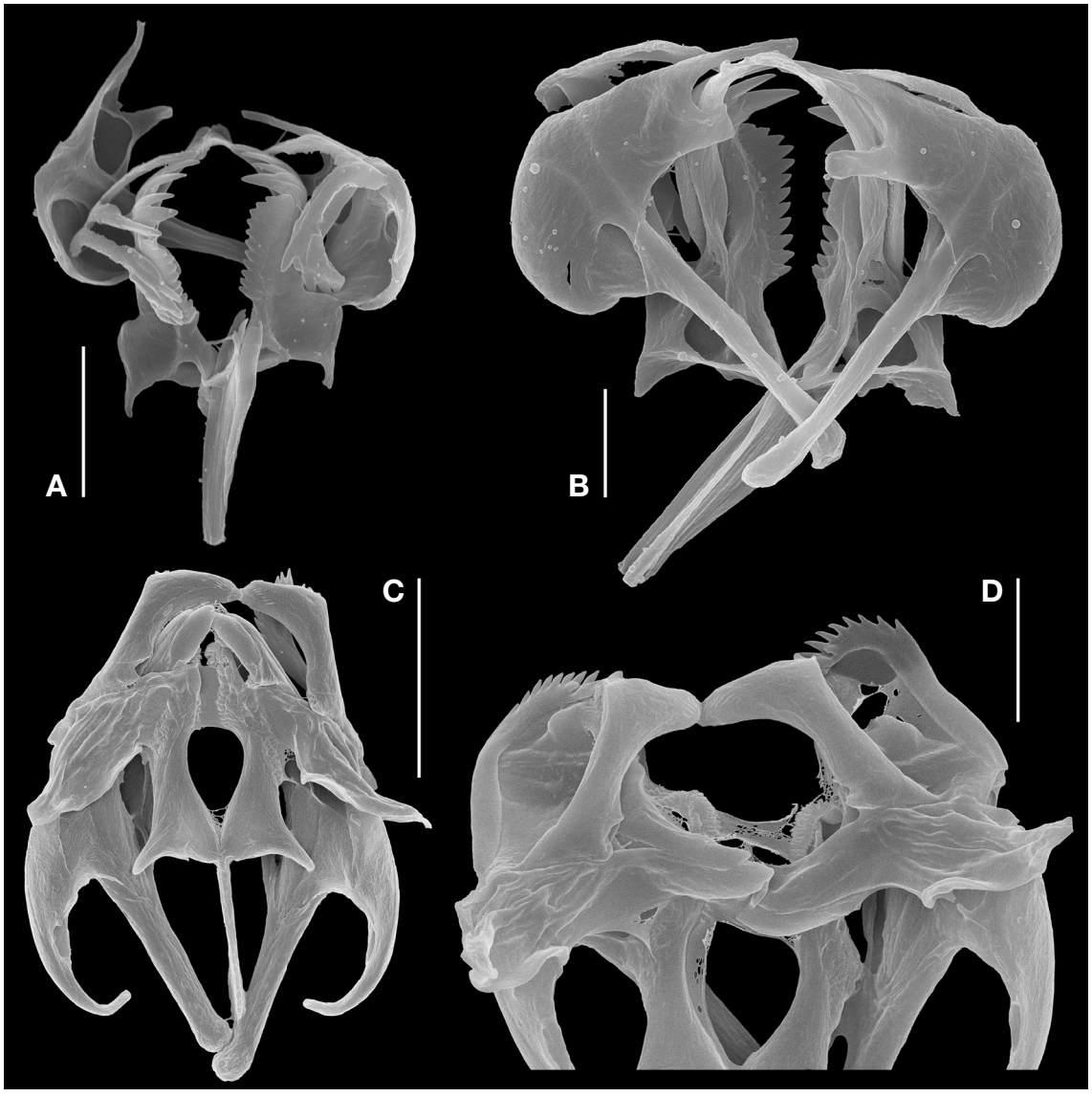

Fig. 4. SEM images of the trophi. A, B. *Monommata maculata* Harring & Myers, 1930. A. ventral view. B. dorsal view. C, D. *Lindia torulosa* Dujardin, 1841. C. dorsal view. D. epipharynx. Scale bars = A, C: 10 μm, B, D: 5 μm.

2002). Specially, all the specimens we observed had stomachs and intestines that were green and orange, but their retrocerebral organs were sometimes colorless.

Molecular data. A partial COI sequence (759 bp) was obtained from one specimen (GenBank accession number: OQ445412).

Family Notommatidae Hudson & Gosse, 1886
몽치윤충과
Genus *Monommata* Bartsch, 1870 긴발윤충속

***Monommata maculata* Harring & Myers, 1930**
(Figs. 3B, 4A, B) 톱니이빨긴발윤충 (신칭)

Monommata grandis: Harring & Myers, 1924, pp. 538–540.

Monommata maculata Harring & Myers, Myers, 1930, p. 385.

Material examined. Reservoir in Balmae-ri, Shinan-gun (34°41′53.5″N, 125°56′02.4″E), 25 Sep. 2021, Geon Hyeok Lee. Voucher Number: HNIBRIV547.

Diagnosis. Body soft. Vitellarium with eight nuclei. Foot glands sac-shaped. Two toes unequal in length. Right toe length 435 μm, left toe 345 μm. Trophi intermediate between virgate and forcipate. Fulcrum thick in lateral view and short. Manubrium with anteriorly expanded lamella and thin elongated rod. Uncus with three thin rod-shaped teeth. Rami with alulae. Inner margin of each ramus with 10–12 serrated teeth, 3–4 large teeth, and interlocking teeth.

Distribution. Cosmopolitan.

Remarks. *Monommata maculata* is easily confused with *M. grandis* because of the morphological similarities of their trophi. However, *M. grandis* has more than 25 comb-like teeth on the inner margin of the ramus, whereas *M. maculata* has 12–14 serrated teeth (Nogrady and Pourriot, 1995). Because the Korean specimens were found in a contracted state, previously documented external characteristics such as lateral antennae with two round pigmented spots were not observed in this study. However, the morphology of trophi is consistent with those reported in previous studies (Harring and Myers, 1924; Nogrady and Pourriot, 1995).

Molecular data. A partial COI sequence (759 bp) was obtained from one specimen (GenBank accession number: OQ445413).

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