ASED http://e-ASED.org
Animal Systematics, Evolution and Diversity

Anim. Syst. Evol. Divers. Vol. 41, No. 1: 44-51, January 2025
https://doi.org/10.5635/ASED.2025.41.1.031

Preliminary Report on Korean *Microporella* (Bryozoa: Cheilostomatida: Microporellidae) with Four New Records

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ABSTRACT

This paper describes four species belonging to the genus *Microporella* Hincks, 1877 from Korean waters. *M. antiborealis* Liu, Liu, and Sun, 2003, *M. elegans* Suwa and Mawatari, 1998, *M. neocribroides* Dick and Ross, 1988, and *M. rota* Chowdhury and Di Martino, 2024 are newly added to the Korean bryozoan fauna. All specimens collected from eleven localities from 2000 to 2020 are redescribed and illustrated using Scanning Electron Microscopy in this study. With the addition of four species reported herein, a total of nine Korean *Microporella* is recorded as follows: *M. antiborealis*, *M. borealis*, *M. ciliata*, *M. cribrosa*, *M. discors*, *M. elegans*, *M. marsupiata*, *M. neocribroides*, and *M. rota*. Seven species, excluding *M. ciliata* and *M. marsupiata*, are distributed only in the Pacific Ocean, including the Indo-Pacific. In comparison, the above two species occur in the Atlantic Ocean.

Keywords: *Microporella*, *M. antiborealis*, *M. elegans*, *M. neocribroides*, *M. rota*

INTRODUCTION

The genus *Microporella* Hincks, 1877, which is known to be cosmopolitan including the polar oceans, is one of the most distinctive and diverse cheilostome genera (Kukliński and Hayward, 2004; Taylor and Mawatari, 2005; Harmelin et al., 2011; Di Martino and Rosso, 2021; Chowdhury et al., 2024), with 119 Recent, 36 fossil species and five (fossil and Recent) species described to date (Bock, 2024). Before using a scanning electron microscope (SEM), tiny morphological characteristics of *Microporella* were hard to observe with an optical microscope, resulting in poor early descriptions and synonym problems (Kukliński and Taylor, 2008; Harmelin et al., 2011). Because Cheilostomatida, including *Microporella*, has complex frontal shields, Scanning Electron Microscopy is essential for imaging specimens and analyzing the skeletal morphology of bryozoans (Seo, 2010; Schwaha, 2020). Recently, *Microporella* has been reviewed and re-described based on tiny morphological features such as the mandible of avicularium, microstructures of the primary orifice, and pore bottom, which are known to be highly diagnostic using SEM, in problematic species with synonyms as well as new species or cryptic species (Gordon, 1984, 1989; Dick and Ross, 1988; Hayward and Ryland, 1990; Soule et al., 1995, 2003, 2004; Suwa and Mawatari, 1998; Suwa et al., 1998; Liu et al., 2003; Taylor and Mawatari, 2005; Kukliński and Taylor, 2008; Harmelin et al., 2011; Di Martino and Rosso, 2021; Chowdhury et al., 2024). These taxonomic studies have revealed the following species-specific morphological features of *Microporella*, which is characterized by rounded polygonal, often hexagonal zooids with a convex, granular cryptocystal frontal shield with scattered pseudopores, a semielliptical, transversely D-shaped orifice with or without serrations on the straight proximal edge and oral spines, a variably shaped ascopore, single or paired adventitious avicularia usually placed laterally or distolaterally, prominent ovicells either with or without pseudopores, ribs, and personate structures (Gordon, 1984, 1989; Dick and Ross, 1988; Hayward and Ryland, 1990; Soule et al., 1995, 2003, 2004; Suwa and Mawatari, 1998; Suwa et al., 1998; Liu et al., 2003; Kukliński and Hayward, 2004; Seo, 2005; Taylor and Mawatari, 2005; Kukliński and Taylor, 2008; Harmelin et al., 2011; Seo and Kil, 2019; Di Martino

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eISSN 2234-8190

and Rosso, 2021; Chowdhury et al., 2024).

In Korea, five species, *M. discors*, *M. borealis*, *M. cribrosa*, and *M. marsupiata*, have been described so far (Rho and Seo, 1984, 1986; Seo and Rho, 1989; Seo, 2005; Seo and Min, 2009; Chae et al., 2016; Min and Seo, 2016; Seo and Kil, 2019). Among the five species, *M. ciliata* is the type species of *Microporella* known to be cosmopolitan and have morphologically variable characters. However, no type material of this species was known to exist. Regarding its distribution, *M. ciliata* is doubtful to be cosmopolitan (Hayward and Ryland, 1999). Instead, the study results showed that *M. ciliata* sensu stricto may be a Mediterranean endemic species (Taylor and Mawatari, 2005). In addition, *M. ciliata* previously reported from China has resulted in five new species, *M. antiborealis*, *M. vacuatus*, *M. monilifera*, *M. inermis*, and *M. cribellata* (Liu et al., 2003). Kukliński and Taylor (2008) redescribed a neotype chosen from the Bay of Naples, Italy for the taxonomic stabilization of *Microporella*. For the same reason, Korean *M. ciliata*, reported from poor photographs and descriptions in Korean waters, must be reviewed. This preliminary study aims to conduct a taxonomic survey of Korean *Microporella*, including the review of *M. ciliata* shortly.

MATERIALS AND METHODS

The specimens of *Microporella* were collected from eleven localities in Korean waters from 2000 to 2020 and preserved in 95% ethanol. They have been kept in the collection of Woosuk University. A part of the colony was taken to identify species, and the external features of the zooid were observed under a stereomicroscope. For more detailed morphological observation, some parts of the specimen were bleached with hot aqueous sodium hypochlorite, washed and gold coated (MCM-100; SEC, Korea), and were observed with SEM (SNE-3200M Mini; SEC) at 15 kV accelerating voltage. Measurements were made on SEM images of zooids using Image J (National Institutes of Health, Bethesda, MD, USA). The sampling localities of the specimens mentioned in this study are given in Fig. 1. The distribution information of studied species was obtained from the cited references and the Bryozoa Home Page website (https://www.bryozoa.net; 4 Nov 2024) and World Register of Marine Species (https://www.marinespecies.org; 4 Nov 2024). *Microporella antiborealis* (MABIK IV00175059) and *M. elegans* (MABIK IV00175060) are stored in the National Marine Biodiversity Institute of Korea (MABIK), Seocheon, Korea, and *M. neocribroides* (NIBR IV0000913146) and *M. rota* (NIBRIV0000836447) in the National Institute of Biological Resources (NIBR), Incheon, Korea.

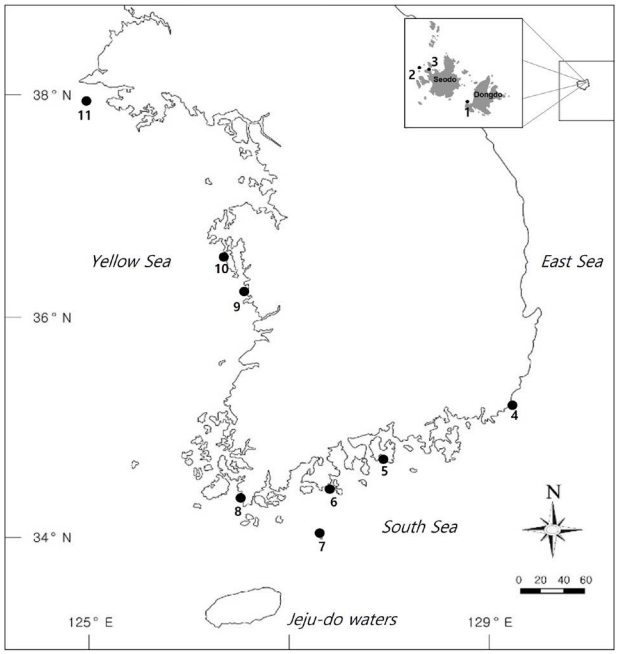

Fig. 1. A map of the collection localities in this study. 1, Dokdo Island: Ferry Terminal; 2, Dokdo Island: Ttongyeo; 3, Dokdo Island: Jinebawi; 4, Songjeong Port; 5, Nodo Island; 6, Gokdu-do Island; 7, Geomundo Island; 8, Jungri; 9, Chunjangdae; 10, Cheongpodae; 11, Baengnyeongdo Island: Junghwandong.

RESULTS

Phylum Bryozoa Ehrenberg, 1831
Class Gymnolaemata Allman, 1856
Order Cheilostomatida Busk, 1852
Family Microporellidae Hincks, 1879
Genus *Microporella* Hincks, 1877

[1]*1. *Microporella antiborealis* Liu, Liu, and Sun, 2003 (Fig. 2A–C)

Microporella antiborealis Liu, Liu, and Sun 2003: 205, pl. 1, figs. 3, 4, pl. 3, fig. 3.

Material examined. Korea: Incheon-si: WSBJ01, Ongjin-gun, Baengnyeongdo Island, Junghwandong, 0.4 m low tide, 24 Nov 2007, 37.9197°N, 124.6545°E; Jeollanam-do: MABIK IV00175059, Yeosu-si, Geomundo Island (Dongdo), 20 m, 25 Oct 2021, 34.0464°N, 127.3191°E.
Substratum. Cobbles and oyster shells.
Description. Colony encrusting, unilaminar. Zooids (Fig. 2A)

Korean name: [1]*온수소공이끼벌레 (신칭)

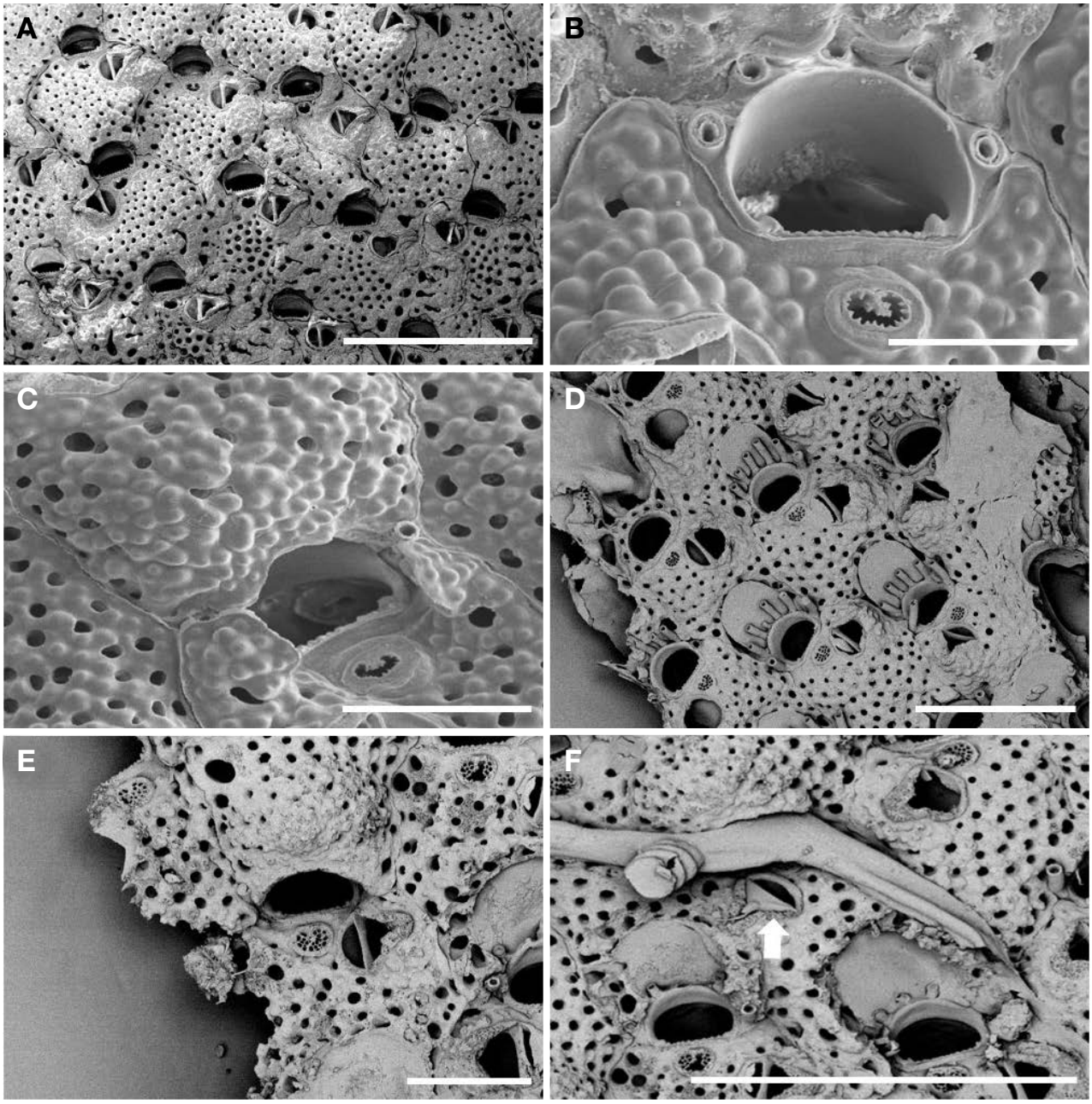

Fig. 2. A–C, *Microporella antiborealis* Liu, Liu, and Sun, 2003. A, Zooids; B, Distal half of zooid, showing orifice, spines, and ascopore; C, Close-up of ovicell showing personate structure. D–F, *Microporella elegans* Suwa and Mawatari, 1998. D, Zooids; E, Ovicellate zooid; F, Mandible (white arrow). Scale bars: A, F = 0.3 mm, B, E = 0.1 mm, C, D = 0.2 mm.

hexagonal to oval, longer than wide, 0.38–0.49 (0.44 ± 0.01) mm long, 0.28–0.39 (0.34 ± 0.02) mm wide, separated by fine line. Frontal wall flatted or slightly inflated, coarsely granular, evenly covered with large and round pores without cribrate plate, except for suboral area. Orifice (Fig. 2B) semicircular, transversely D-shaped, wider than long, 0.06–0.1 (0.07 ± 0.008) mm long, 0.09–0.14 (0.12 ± 0.006) mm wide; proximal margin straight, serrated, with a pair of triangular condyles at proximal corner. Non-ovicellate zooid with five oral spines (Fig. 2B), often some hidden by secondary calcification spreading from distal zooid, but usually obscured in those with ovicells, sometimes three middle spines hidden by ovicell and one on each side lateral one seen (Fig. 2C). Ascopore (Fig. 2B) close to proximal border of orifice, distant equivalent to

about one-third of orifice length, elliptical outlined by narrow, raised rim of gymnocystal calcification, crescentic, with a slight projection downwards from distal edge and finely radial serration, wider than long, 0.02–0.04 (0.03 ± 0.004) mm long, 0.03–0.05 (0.04 ± 0.002) mm wide, Avicularium (Fig. 2A) single, on right or left, located proximolateral to ascopore, 0.08–0.14 (0.12 ± 0.01) mm long, 0.04–0.09 (0.06 ± 0.007) mm wide, embedded in frontal wall; rostrum short triangular, channeled tip, directed laterally, slightly oblique towards basal side at terminal part, with complete crossbar; mandible elongate with flagelloid distal part. Ovicell (Fig. 2C) subimmersed, longer than wide, 0.22–0.30 (0.25 ± 0.01) mm long, 0.21–0.26 (0.24 ± 0.008) mm wide, granulated, with several smaller pores than frontal pores; personate, proximal part extended laterally downwards along orifice but not meeting. Basal surface entirely calcified. Ancestrula not seen.

Remarks. The ovicell in our specimens is subimmersed, while Chinese ones have the hyperstomial ovicell.

Distribution. Korea (Yellow Sea and South Sea) and China.

[1]*2. *Microporella elegans* Suwa and Mawatari, 1998 (Fig. 2D–F)

Microporella elegans Suwa and Mawatari, 1998: 905, fig. 4A–J.

Material examined. Korea: Gyeongsangbuk-do: MABIK IV 00175060, Ulleung-gun, Dokdo Island, Dokdo Ferry Terminal, 8 m, 12 Sep 2018, 37.2395°N, 131.8674°E.

Substratum. Algae.

Description. Colony encrusting, unilaminar. Zooids (Fig. 2D) rounded-hexagonal to oval, longer than wide, 0.40–0.58 (0.52 ± 0.02) mm long, 0.26–0.37 (0.32 ± 0.01) mm wide, separated by fine line. Frontal wall flatted or slightly inflated, coarsely granular, entirely covered with large, round pores with cribrate plate at bottom, except for suboral area; occasionally with elongate marginal pores. Orifice (Fig. 2D, F) semicircular, transversely D-shaped, wider than long, 0.08–0.11 (0.10 ± 0.004) mm long, 0.12–0.17 (0.14 ± 0.008) mm wide; proximal margin straight, serrated, with a pair of robust triangular condyles at proximal corner. Non-ovicellate zooid with five to eight oral hollow spines, often some hidden by secondary calcification spreading from distal zooid, usually proximal pair with enlarged, but either obscured or only one or one pair in ovicellate zooid (Fig. 2D). Ascopore transversely elliptical, 0.03–0.05 (0.04 ± 0.003) mm long, 0.04–0.06 (0.05 ± 0.003) mm wide, surrounded with thin raised rim, covered with a cribriform sieve plate, close to proximal border of orifice by a distance about one-third of across short axis of ascopore (Fig. 2E). Avicularium single, large, rounded-triangular, 0.08–0.14 (0.12 ± 0.007) mm long, 0.06–0.12 (0.10 ± 0.008) mm wide, located lateral or proximolateral to ascopore; chamber large with inflated, densely tuberculate surface, with robust complete crossbar; rostrum directed laterally with channeled tip; mandible long, 0.21 mm long, setiform and without a hook at either side (Fig. 2E, F). Ovicell globose, subimmersed, longer than wide, 0.27–0.28 (0.27 ± 0.001) mm long, 0.20–0.28 (0.24 ± 0.01) mm wide, coarsely granulated, convex, radially ribbed, perforated with several, generally smaller than frontal pores between ribs, imperforate at center (Fig. 2E). Ancestrula not seen.

Remarks. *M. elegans* from Korean waters has morphological features identical to Japanese ones, but they show subtle differences in the shape of the pores and the number of spines.

Korean specimens have the cribrate plate at the bottom of the pores, of which no picture is taken. Five to eight oral spines are shown in Korean specimens instead of five in Japanese ones. Concerning the substratum of this species, Korean specimens were collected from oyster shells, while Japanese ones were collected from shells of the bivalve *Septifer* sp. (Suwa and Mawatari, 1998).

Distribution. Korea (East Sea) and Japan.

[2]*3. *Microporella neocribroides* Dick and Ross, 1988 (Fig. 3)

Microporella neocribroides Dick and Ross, 1988: 76, pl. 12C; Suwa and Mawatari, 1998: 899, fig. 2A–M; Dick et al., 2005: 3753, fig. 19A–D.

Material examined. Korea: Chungcheongnam-do: WSBJ02, Seoncheon-gun, Chunjangdae, intertidal, 12 Mar 2009, 36.1713°N, 126.5255°E; WSBJ03, Taean-gun, Cheongpodae, Jeongjokdo Island, 25 m, 25 Oct 2015, 36.6334°N, 126.2997 °E; Jeollanam-do: WSBJ04, Haenam-gun, Jungri, intertidal, 6 Jun 2000, 34.3414°N, 126.5226°E; Incheon-si: WSBJ05, Ongjin-gun, Baengnyeongdo Island, Junghwandong, 0.4 m low tide, 24 Nov 2007, 37.9197°N, 124.6545°E; Gyeongsangbuk-do: NIBRIV0000913146, Ulleung-gun, Dokdo Island, Cahnggol under Ttongyeo, 35 m, 25 Jun 2019, 37.2441°N, 131.8592°E.

Substratum. Cobbles and shell (*Mytilus galloprovincialis*).

Description. Colony encrusting, unilaminar. Zooids (Fig. 3A) rounded-hexagonal or rectangular, longer than wide, 0.40–0.52 (0.44 ± 0.04) mm long, 0.21–0.30 (0.26 ± 0.03) mm wide, separated by fine line. Frontal wall (Fig. 3D) inflated, sightly convex, coarsely granular, entirely covered with pores with cribrate plate at bottom, with some areolar pores along each lateral margin. Orifice oval, wider than long, 0.07–0.10 (0.09 ± 0.009) mm long, 0.09–0.13 (0.11 ± 0.01) mm wide;

Korean name: [1]*우아한소공이끼벌레 (신칭), [2]*두가시소공이끼벌레 (신칭)

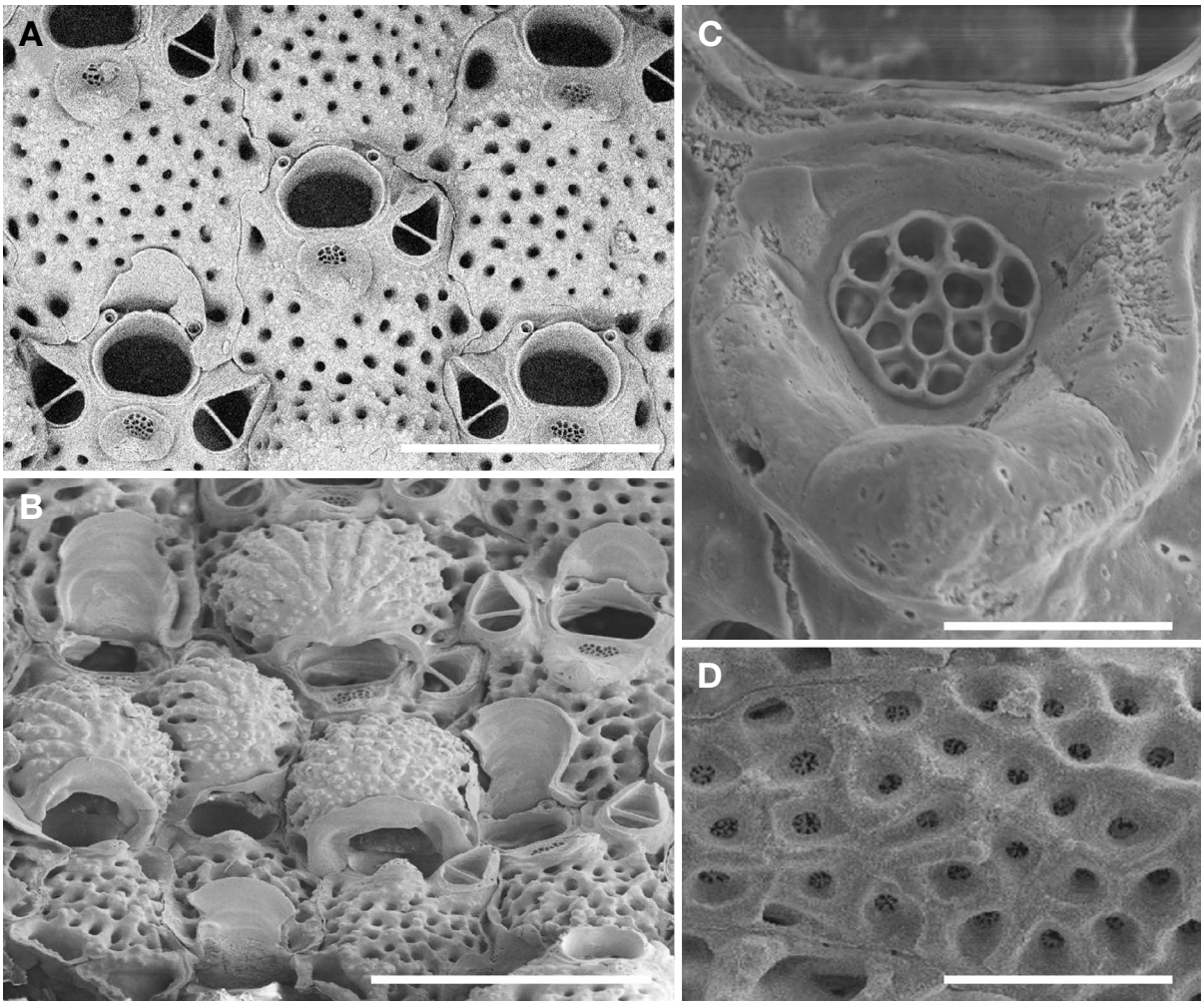

Fig. 3. *Microporella neocribroides* Dick and Ross, 1988. A, Zooids; B, Radially ribbed ovicells; C, Close-up of ascopore; D, Cribrate pseudopores. Scale bars: A, B = 0.3 mm, C, D = 0.1 mm.

proximal margin straight and smooth, proximal corners rounded, condyles lacking. Non-ovicellate zooid with two oral spines at distal to orifice, occasionally three spines, but obscured in ovicellate zooid (Fig. 3A). Ascopore (Fig. 3C) round to elliptical, 0.01–0.03 (0.02 ± 0.004) mm long, 0.03–0.04 (0.04 ± 0.005) mm wide, distant one-quarter of orifice length from orifice, covered with cribriform sieve plate, with a conical umbo proximal to ascopore. Avicularium (Fig. 3A, B) rounded-triangular, single on right or left, often paired, 0.07–0.11 (0.10 ± 0.01) mm long, 0.05–0.07 (0.06 ± 0.005) mm wide, located lateral to ascopore; chamber subimmersed, inflated, smooth; rostrum directed distolaterally, never directed laterally or proximally, with sightly channeled tip, with robust complete crossbar. Ovicell (Fig. 3B) globose, raised, granular, radially ribbed, longer than wide, 0.22–0.29 (0.25 ± 0.02) mm long, 0.22–0.26 (0.24 ± 0.01) mm wide, imperforated except for marginal tiny pores; aperture with a lapel-like rim. Ancestrula and basal wall not seen.

Remarks. The Korean specimens show more similarity to those from Hokkaido (Suwa and Mawatari, 1998) than those from Alaska in the number of avicularia (Dick and Ross, 1988; Dick et al., 2005). Korean and Japanese specimens have one or a pair of avicularia, whereas a single avicularium is shown in the Alaska ones. Our specimens have two oral spines, except for the Baengnyeongdo Island specimen which sometimes has three spines, consistent with Dick et al. (2005)'s description that a zooid can rarely have three to four spines. The small teeth within the cribrate pore of the ascopore are shown only in the Korean specimen.

This species tended to prefer a relatively exposed shore of cobbles and boulders (Dick et al., 2005), and Korean specimens were also collected from cobbles at three localities with

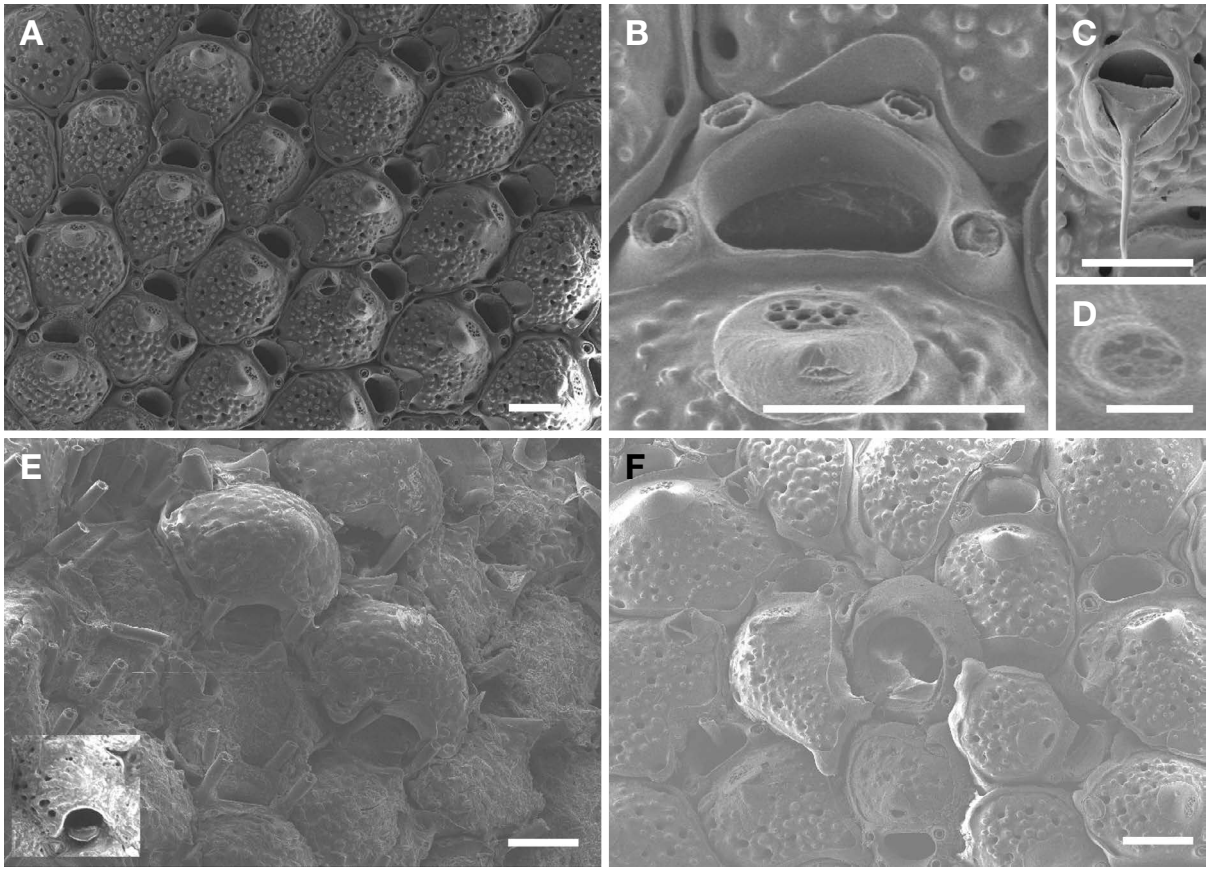

Fig. 4. *Microporella rota* Chowdhury, Di Martino, Lee, Windecker, and Craig, 2024. A, Zooids; B, Distal half of zooid, showing orifice, spines, and ascopore; C, Avicularium with mandible; D, Close-up of reticulate pseudopores; E, Heavily calcified ovicellated zooids with an umbonate in the center of the front (see insert: radially ribbed); F, Ancestrula and periancestrular zooids. Scale bars: A–C, E, F = 0.1 mm, D = 0.01 mm.

similar environments.

Distribution. Korea (Yellow Sea and South Sea), Alaska (Kodiak, Ketchikan), and Hokkaido (Japan).

[1]*4. *Microporella rota* Chowdhury, Di Martino, Lee, Windecker, and Craig, 2024 (Fig. 4)

Microporella cribrosa Osburn, 1952: 380 (part).

Microporella rota Chowdhury, Di Martino, Lee, Windecker, and Craig, 2024: 44, fig. 4.

Material examined. Korea: Jeollanam-do: WSBJ06, Goheung-gun, Gokdudo Island, 26 Oct 2017, intertidal, 34.3984 °N, 127.4947°E; Busan-si: NIBRIV0000836447, Haeundae-gu, Songjeong Port, intertidal, 11 Nov 2018, 35.1801°N, 129.2070°E: Gyeongsangnam-do: WSBJ07, Namhae-gun, Nodo Island, 6 May 2020, intertidal, 34.7314°N, 127.9400°E; WSBJ08, Gyeongsangbuk-do: Ulleung-gun, Dokdo Island, South of Jinebawi, 8 Jul 2020, 20 m, 37.2441°N, 131.8592°E.

Substratum. Shell and stone.

Description. Colony encrusting, unilaminar. Zooids (Fig. 4A) rounded-hexagonal, longer than wide, 0.34–0.47 (0.45 ± 0.03) mm long, 0.22–0.37 (0.31 ± 0.04) mm wide, separated by deep groove. Frontal wall (Fig. 4D) inflated, sightly convex, tubercular, coarsely granular, smooth gymnocyst along proximal edge of orifice obliquely raised or incurved; frontal pores about 8–12, various sized, reticulate or simple, distributed on frontal shield proximal to ascopore; some areolar pores along each lateral edge distinguishable from much smaller frontal pores. Orifice (Fig. 4B) semicircular, transversely D-shaped, wider than long, 0.06–0.08 (0.07 ± 0.006) mm long, 0.08–0.11 (0.10 ± 0.008) mm wide; proximal margin straight and smooth; proximal corners rounded, with no condyles. Non-ovicellate zooid with four to five oral spines, sometimes a pair of lateral ones enlarged, thicker than other spines. Only a pair of lateral spines visible in ovicellate zooid and the others hidden by ovicell (Fig. 4B, E). Ascopores (Fig. 4B, F) of two types present,

Korean name: [1]*그물무늬소공이끼벌레 (신칭)

cribriform and C-shape, close to orifice, separated from it by a distance one-third of orifice length, located on elevated oval prominence; prominence developed proximally into two types of small, smooth, conical umbo; cribriform, round to elliptical, 0.02−0.04 (0.03 ± 0.008) mm in diameter and C-shaped in periancestrular zooids, with small tongue projecting from distal edge and tiny denticles. Avicularium (Fig. 4A, C) usually single, often absent, located lateral or proximolateral to ascopore, 0.07−0.11 (0.09 ± 0.01) mm long, 0.06−0.09 (0.07 ± 0.008) mm wide; chamber inflated with smooth surface, with complete crossbar; rostrum raised, directed distolaterally, with a narrow, channeled tip; mandible with setose end. Ovicell (Fig. 4E) globose, prominent, wider than long, 0.18−0.22 (0.21 ± 0.01) mm long, 0.21−0.24 (0.23 ± 0.01) mm wide, granulated, radially ribbed, often umbonate, imperforated except for marginal small pores, with smoothly rimmed proximal margin. Basal surface entirely calcified (Fig. 4E). Ancestrula (Fig. 4F) tatiform, oval, 0.28 mm long, 0.8 mm wide, with large oval opesia, 0.15 mm long, 0.11 mm wide, surrounded by nine spines; two zooids budded from ancestrula, similar to autozooids but smaller, 0.19−0.21 (0.20 ± 0.01) mm long, 0.17−0.18 (0.17 ± 0.008) mm wide, five oral spines, C-shaped ascopore, and lacking avicularium.

Remarks. Parts of *M. cribrosa* are synonymized with *M. rota* herein because Chowdhury et al. (2024) already reconfirmed it as a new species, *M. rota*, with the two among specimens from California identified as *M. cribrosa* by R. C. Osburn. Korean *M. rota* has a pair of thicker lateral spines than other medial two or three spines and seems to be similar to *M. similis* rather than *M. rota*. Nevertheless, our specimens show the differences from *M. similis* in having no pair of small triangular condyles at the orifice and the cribrate ascopore with simple round pores. In addition, Korean specimens have wheel-like pseudopores and nine spines surrounding the ancestrula, similar to *M. rota*, which has at least eight ancestrular spines.

Distribution. Korea (East Sea and South Sea) and North America (California).

DISCUSSION

The results of this preliminary survey for taxonomic study on Korean *Microporella*, four species belonging to the genus *Microporella* Hincks, 1877 were found for the first time in Korean waters: *M. antiborealis* Liu, Liu, and Sun, 2003, *M. elegans* Suwa and Mawatari, 1998, *M. neocribroides* Dick and Ross, 1988, and *M. rota* Chowdhury, Di Martino, Lee, Windecker, and Craig, 2024.

Some new species have recently been reported from *M. ciliata* and *M. cribrosa* through re-examination with SEM and their regional distribution (Soule et al., 1995, 2003, 2004; Chowdhury et al., 2024). New and cryptic species are recently revealed from problematic species in the bryozoan taxonomy. Since *Microporella* species, such as *M. ciliata*, *M. cribrosa*, *M. discors*, and *M. borealis*, were reported by Korean authors (Rho and Seo, 1984, 1986; Seo and Rho, 1989; Seo and Min, 2009), no more colony was found ever. These species reported with poor descriptions need to be rechecked with detailed morphological features in the succeeding study on the taxonomy of Korean *Microporella*.

All four species identified in this study were distributed in the Boreal-temperate of Japan, China, and North America in the Pacific Ocean. With the addition of four species reported herein, a total of nine Korean *Microporella* is recorded as follows: *M. antiborealis*, *M. borealis*, *M. ciliata*, *M. cribrosa*, *M. discors*, *M. elegans*, *M. marsupiata*, *M. neocribroides*, and *M. rota*. Seven species, excluding *M. ciliata* and *M. marsupiata*, are distributed only in the Pacific Ocean, including the Indo-Pacific. In comparison, the above two species occur in the Atlantic Ocean. This fact implies that *Microporella* species show endemism regarding their regional distribution.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

This work was supported by the management of Marine Fishery Bio-resources Center (2024) funded by the National Marine Biodiversity Institute of Korea (MABIK), and was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR201801104; NIBR 202304103).

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Received December 4, 2024
Revised December 13, 2024
Accepted December 13, 2024