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Four Korean Cyclostomatous Bryozoans - new additions to the Korean fauna

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Four cyclostomatous bryozoans from Korea belong to the genera *Bicrisia*, *Nevianipora*, *Tubulipora* and *Crisia* are described here for the first time. Of which, *Bicrisia erecta* Mawatari & Mawatari, 1973, *Nevianopora pulcherrima* (Kirkpatrick, 1890) and *Tubulipora similis* Liu in Liu, Yin & Ma, 2001 are newly added to the Korean bryozoan fauna, and *Crisia spissus* n. sp. is new to science. These species in this study are identified based on three features, which are its pseudopore, gonozooids and ooeciostomes. Two genera, *Bicrisia* and *Nevianopora*, are new to the Korean bryozoan fauna. As a result of this study, nine Korean cyclostomatous bryozoans in seven genera, five families are reported.

Keywords: *Bicrisia*, Bryozoa, *Crisia*, Cyclostomata, *Nevianopora*, *Tubulipora*

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Introduction

Cyclostomatous bryozoans are the only surviving order of the class Stenolaemata (Taylor & Gordon, 2003) and makes up only a small portion of living marine Bryozoa (Hayward & Ryland, 1985). Of the two orders of living bryozoans with calcareous skeletons, species belonging to the Cyclostomata are considerably less abundant and diverse than those of the Cheilostomata. Bock & Gordon (2013) estimated that the modern biota contains 543 species of cyclostomes compared with 4,921 cheilostome species (Taylor & Grischenko, 2015).

Cheilosomatous bryozoans tend to dominate in the Korean bryozoan fauna as well. Approximately 200 species of bryozoans, including only five cyclostomes, has been reported from Korean waters. Five species of the Korean cyclostomatous bryozoans are as follows: *Tubulipora pulchra* MacGillivray, 1885, *Crisia eburneodenticulata* Smitt ms in Busk, 1875, *Disporella novaehollandiae* (d'Orbigny, 1853), *Patinella radiata* (Audouin, 1826) and *Hornera jeongsangi* Zágoršek, Chae, Min, Yang & Seo, 2017. Based on many years of sampling, the collection known as the Marine Bryozoans Resources Bank of Korea (MBRBK), deposited at the Jincheon campus of Woosuk University, contains many cyclostomatous materials not described and illustrated in the monographs published by Seo (2005; 2010; 2011). This is the succeeding taxonomic study since Zágoršek, Chae, Min, Yang & Seo (2017).

Materials and Methods

Some cyclostomatous bryozoans were found in the collection (MBRBK) of Woosuk University in Jincheon. These specimens were collected during SCUBA diving expeditions from four sites from 2009 to 2013, and all specimens were preserved in 95% ethanol. Specimens prepared for examination by scanning electron microscope (SEM) were bleached with hot aqueous sodium hypochlorite, washed, and gold coated, prior to examination using a SEC Co. Ltd SNE-3200M Mini-SEM. Sample localities mentioned in this paper are given in Table 1.

Results

Phylum Bryozoa Ehrenberg, 1831
Class Stenolaemata Borg, 1926
Order Cyclostomata Busk, 1852
Family Tubuliporidae Johnston, 1838

Genus *Tubulipora* Lamarck, 1816

1. *Tubulipora similis* Liu in Liu, Yin & Ma, 2001 (Fig. 1)

Liu *et al*., 2001: 384-386, pl. 5, 4-6; Gordon, 2016: 605.

Material examined. NIBRIV0000833741, Janggundo Island, Yeosu, 22 Jun 2009 by SCUBA diving from 10 m in depth.

Substratum. Seaweed.

Description. Colony encrusting, its form very variable (Fig. 1A): discoidal, fan-shaped, oval, sometimes divided into same sized lobes, adhering to seaweed loosely, broken easily. Zooid arranged radially from primary disk, tubular, arranged irregularly and discontinuously, pseudopores and fine transverse grooves, not fused at orifice, sometimes in fascicles of two to four. Peristomes up to 250-654 μm long, straight or gently curved, diameter 75-102 μm. Primary disk of ancestrula more or less circular, smooth, surrounded by distinctly quadrangular teeth (Fig. 1B), 100-119 μm diameter, curving strongly to right or left; first two autozooids with strongly curved peristomes (Fig. 1C). Gonozooids spreading among zooecial rows, inflated, with dense oval pseudopores (Fig. 1D). Ooeciostome more or less median in position, variably flared, partly to a zooid tube or independent, not fused with zooid tubes, opening directly upwards (Fig. 1D). Star-shaped spicule found inside marginal lamina, 19-23 μm long (Fig. 1E).

Remarks. This species is reported from Korea for the first time. This species is characteristic of having its distinctly quadrangular teeth surrounding the primary disk and its flared-shaped the ooeciostome. Only one species, *Tubulipora pulchra* MacGillivray, 1885 belonging to the

Table 1. Sampling localities of four species in Korea waters.

Species	Locality	Coordinates	Date	Depth	Substratum
Tubulipora similis	Janggundo Island, Yeosu	34°44′0.85″N, 127°44′8.83″E	22 Jun 2009	10 m	seaweed
Nevianopora pulcherrima	Eoyudo Island, Tongyeong	34°39′31.66″N, 128°34′24.47″E	23 Jul 2013	35 m	stone
Bicrisia erecta	Sangchujado Island, Seogwipo	33°57′15.03″N, 126°19′18.09″E	13 Nov 2009	20 m	bryozoa (*Crisia eburneodenticulata*)
Crisia spissus n.sp.	Daegueulbido Island, Tongyeong	34°34′46.49″N, 128°32′54.38″E	25 Jun 2013	No data	No data

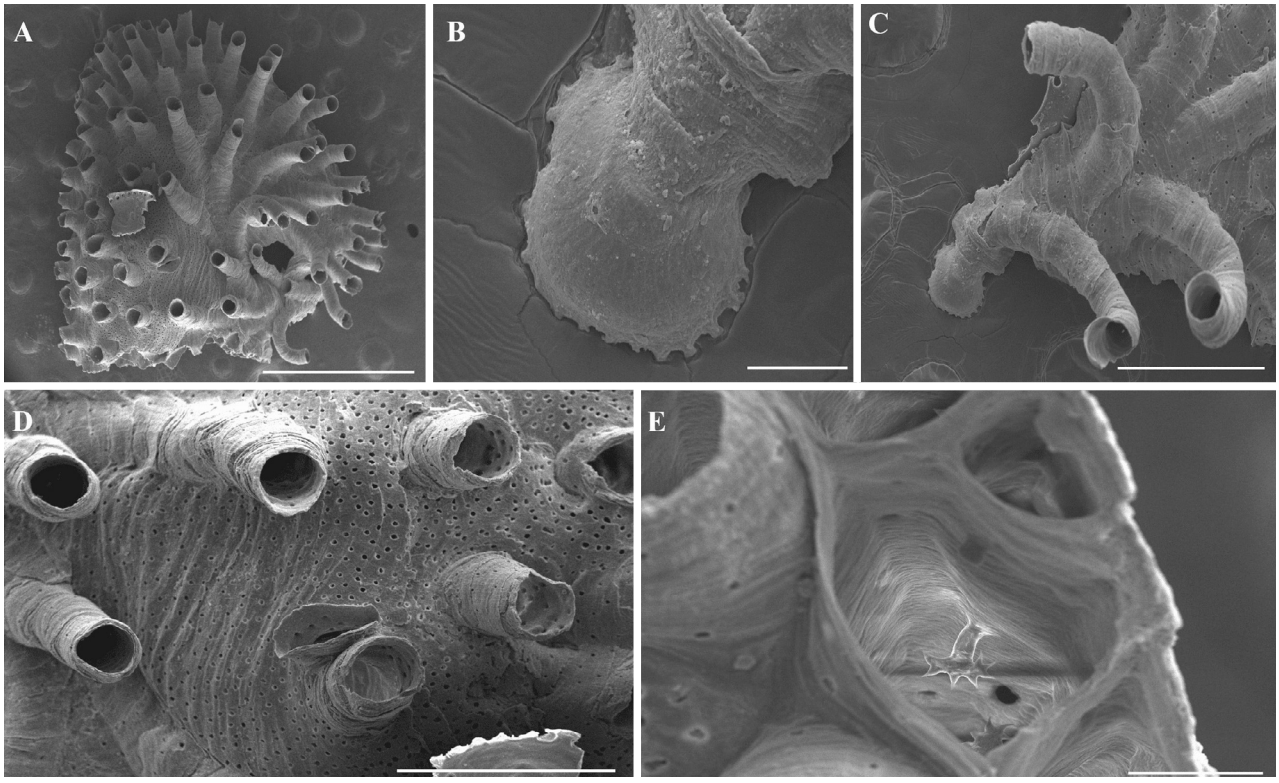

Fig. 1. *Tubulipora similis* Liu in Liu, Yin & Ma, 2001. A. colony. B. the primary disk, detail. C. the ancestrula and early astogenetic stages. D. ooeciostome and ooeciopore on gonozooid, detail. E. star–shaped spicule. Scale bars: A = 1 mm; B, E = 50 μm; C, D = 300 μm.

genus *Tubulipora*, was reported from the coastal waters of Korea so far. *Tubulipora similis* Liu in Liu, Yin & Ma, 2001 is similar to *Tubulipora pulchra* MacGillivray, 1885 in the colonial form including primary disk, but differs from *T. pulchra*, as it has a compressed-shaped ooeciostome. This species has been reported only from China.

Distribution. Korea (South Sea) and China.

Family Diaperoeciidae Canu, 1918
Genus *Nevianipora* Borg, 1944

2. *Nevianipora pulcherrima* (Kirkpatrick, 1890) (Fig. 2)

Idmonea pulcherrima Kirkpatrick, 1890: 22, p1.4, fig. 6.
Tubulipora pulcherima: Harmer, 1915: 129, p1. 9, figs. 1-5.
Nevianopora pulcherrima: Brood, 1976: 292, figs. 12 H, L; Hayward & Ryland, 1995: 534, fig. 2A.

Material examined. NIBRIV0000833742, Eoyudo Island, Tongyeong, 23 July 2013 by SCUBA diving from 35 m in depth.

Substratum. Stone.

Description. Colony dichotomously branched, more or less reticulate arrangement, sometimes cross bars (253 μm height) between the branches (Fig. 2A, B). Zooid in alternate series of two or three, rarely four, increasing in height from within outward (Fig. 2A). Peristomes short, concentric stria, 33 ± 9 μm long, diameter 134-198 μm, inner margin dentate (Fig. 2C); median peristomes commonly separated from their neighbor of the same series, appear more or less isolated in the middle of the branch. Frontal surface nearly flat, pseudopores, show lines diamond to hexagonal around zooids. Basal surface pseudopores, marked with longitudinal lines and horizontal lines (Fig. 2D). Gonozooid pseudopores, variable, flattened or slightly convex, either simple or bifurcating with the branch. Ooeciostome urn-like, pseudopores, transverse grooves, slightly, directed distal of the colony (Fig. 2E). Stout rooting processes usually given off from the middle of the branches (Fig. 2F).

Remarks. The genus *Nevianipora* is reported from Korea for the first time and consists of 12 species worldwide. This species is characteristic in having its cross bars between the branches and a beautiful urn-shaped ooeiostome. Brood (1976) noted *N. pulcherrima* is common in most samples from 20 to 200 m. The Korean material was also collected from a depth of 35 m. The species has been found only from the Indian and Indopa-

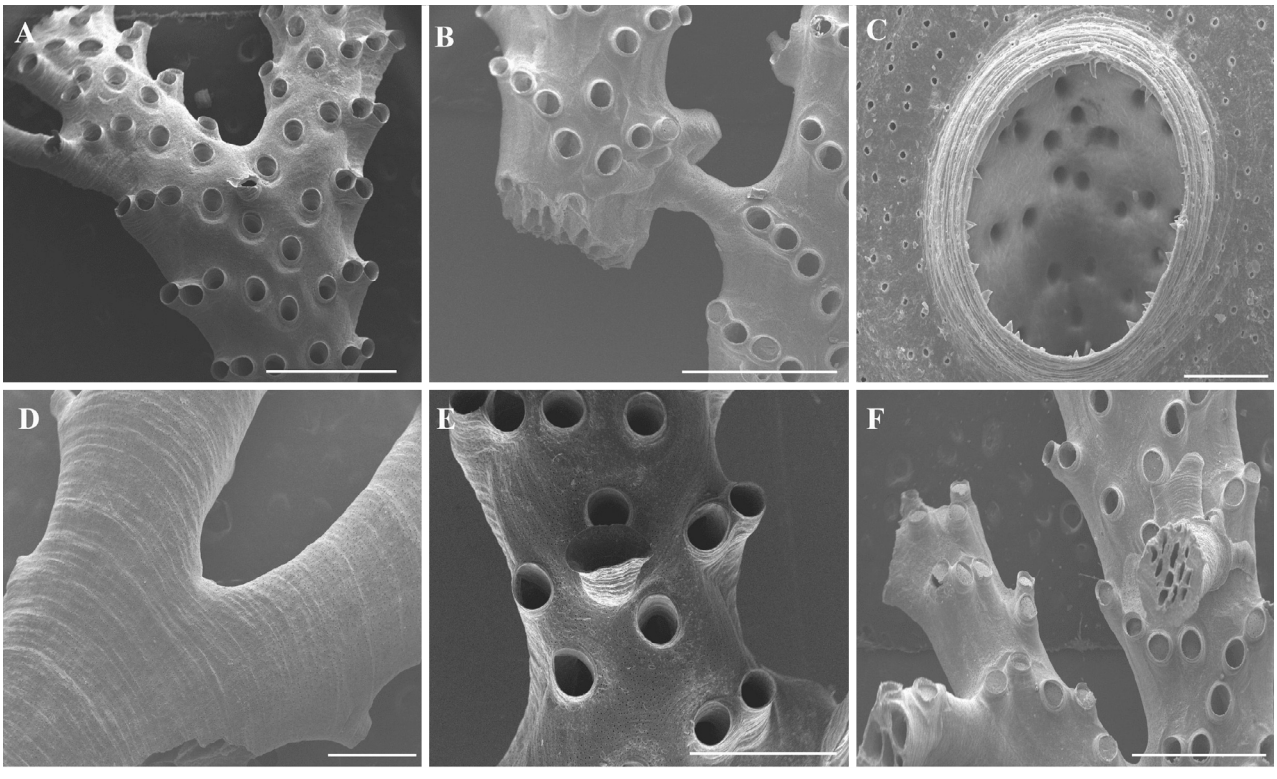

Fig. 2. *Nevianipora pulcherrima* (Kirkpatrick, 1890). A. arrangement of zooids, showing gonozooid and ooceciostome. B. cross bar between the branches. C. dentate, detail. D. basal surface, detail. E. ooeciostome and gonozooid, detail. F. stout rooting processes. Scale bars: A, B, E = 1 mm; C = 50 μm; D = 500 μm.

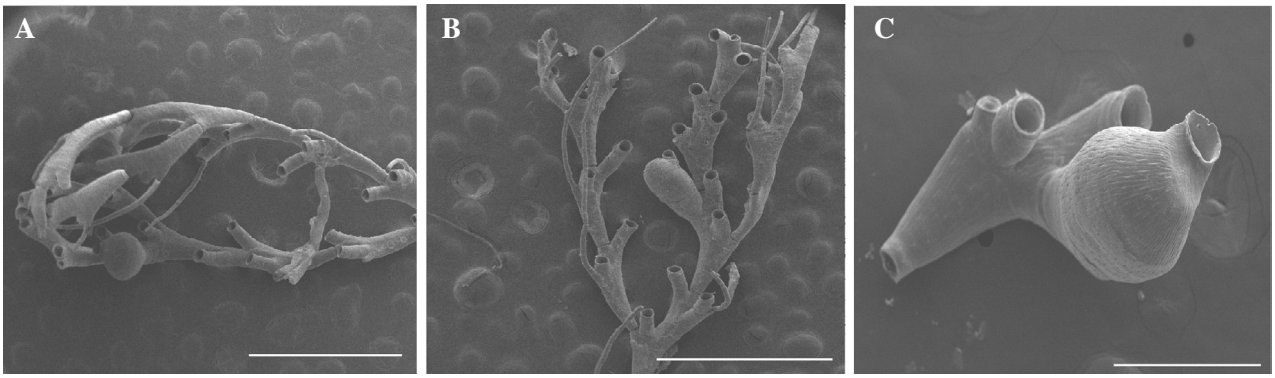

Fig. 3. *Bicrisia erecta* Mawatari & Mawatari, 1973. A. colony. B. internodes, spine and position of gonozooid. C. erect gonozooid and ooeciostome, detail. Scale bars: A, B = 1 mm; C = 300 μm.

cific Ocean so far, not from any temperate sea or the Pacific Ocean. It is likely that the species was imported from the tropical sea or the taxonomic study on the cyclostomatous bryozoans from the North Pacific Ocean is not enough. Further succeeding study on cyclostomes seems to need.

Distribution. Korea (South Sea), Sri Lanka, Australia and East Africa.

Family Crisiidae Johnston, 1838
Genus *Bicrisia* d'Orbigny, 1853

3. *Bicrisia erecta* Mawatari & Mawatari, 1973 (Fig. 3)

Bicrisia erecta Mawatari & Mawatari, 1973: 99, fig. 7.

Material examined. NIBRIV0000833743, Sangchujado Island, Seogwipo, 13 Nov. 2009 by SCUBA diving from 20 m in depth.

Substratum. Other bryozoan (*Crisia eburneodenticulata* Smitt, 1875).

Description. Colony small, delicate, slender, bushy mass encircled, internally curved (Fig. 3A). Each branch composed of two to four internodes. Internodes short, 537-667 μm long, zigzag lines of alternately situated by usually two to three zooids (Fig. 3B): consisting of two zooids usually give rise single new internode, while others of three zooids giving rise two internodes laterally. Fertile internode comprising two to three zooids. Zooids turned forward, elongate peristome, 126-205 μm long at internode base, slit-shaped pseudopores 7-13 μm, long whip-like spine from near distal end. Orifice circular, 45-69 μm diameter. Gonozooid placed second zooid in fertile internode, erect bottle-like, slit-shaped pseudopores, faint concentric stria (Fig. 3C). Ooeciostome short, bent, near distal end, no pseudopores (Fig. 3C).

Remarks. This genus is reported from Korea for the first time. Six recent species of *Bicrisia* have been recognized: *Bicrisia abyssicola* Kluge, 1962, *B. biciliata* (MacGillivray, 1869), *B. edwardsiana* (d'Orbigny, 1841), *B. erecta* Mawatari & Mawatari, 1973, *B. gibraltarensis* Harmelin, 1990 and *B. robertsonae* Soule, Soule & Chaney, 1995. Mawatari & Mawatari (1973) described a new species by number of zooids in the fertile internode and the erect positon of gonozooid with tubular peristome from Hokkaido Island in Japan. The placement of the gonozooid in its internode, its shape in general, and the nature of its opening in particular, provide valuable species-specific characters (Hayward & Ryland, 1985). The characteristic of this species is the erect positon of gonozooid and additionally the Korean specimen have small slit-shaped pseudopores on the surface of the zooids and gonozooids.

Distribution. Korea (Jeju Island) and Japan.

Genus *Crisia* Lamouroux, 1812

4. *Crisia spissus* n.sp. (Fig. 4)

Material examined. Holotype (NIBRIV0000833744) and Paratype (NIBRIV0000833745), Daegueulbido Island, Tongyeong, 25 Jun 2013.

Etymology. The species name is derived from '*spissus*' Latin, compact, packed, dense, referring to the shape of colony.

Substratum. No data.

Description. Colony erect, very dense, white (Fig. 4A). Internodes very short, incurving, narrowing proximally, slightly wide, 873-2,000 μm long × 132-261 μm wide, 8-15 zooids alternately disposed to left and right (Fig. 4B). Fertile internodes comprising 8-14 zooids (Fig. 4C). New internodes ramified immediately above 1-2nd zooid. Sometimes trifurcation, two new internodes arising alternately to left and right at 1-2nd zooid (Fig. 4AB). Autozooids tubular, like short tube with sharp lateral, disposed alternately on either side, fused with each other proximally, 19-40 μm long × 54-68 μm wide, di-

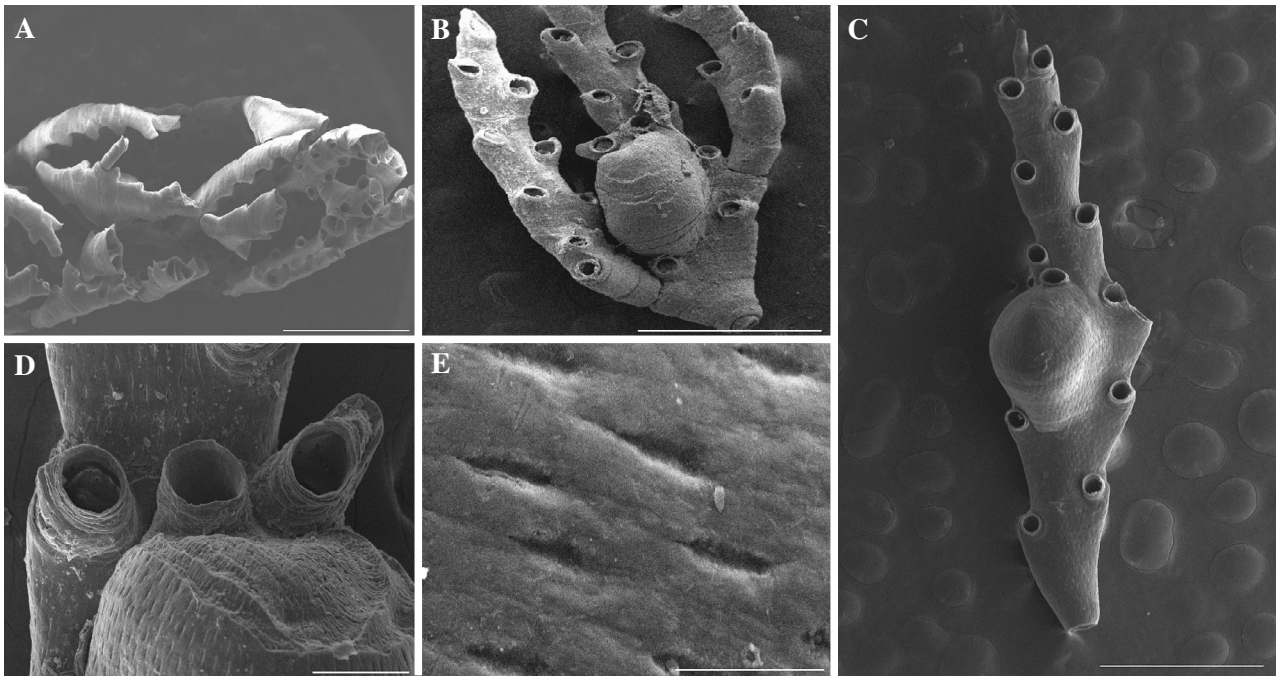

Fig. 4. *Crisia spissus* n. sp.. A. several branches. B. gonozooid and trifurcation barnches. C. fertile internode. D. ooeciostome on gonozooid, detail. E. silt-shaped pseudopores of gonozooid, detail. Scale bars: A = 1 mm; B, C = 500 μm; D = 100 μm; E = 20 μm.

rected slightly outwards and upwards, wrinkles near distal ends, aperture circular. Gonozooid globular-shaped, small, 373-457 μm long × 315-367 μm wide, occupying position of third to fourth zooid; ooeciostome well developed, wrinkles, ooeciopore circular 62-75 μm in diameter × 32-37 μm long (Fig. 4D). Surface covered by slit-shaped pseudopores, 9-11 μm (Fig. 4E).

Remarks. *Crisia spissus* n. sp. is characterized by its densely colonies, 8-15 zooids per internode (8-15 on the sterile and 8-14 on the fertile), wrinkly ooeciosomes on small gonozooid and slit-shaped pseudopores on surface.

So far one species of *Crisia* have been recorded from Korea: *C. eburneodenticulata* Smitt ms in Busk, 1875. *Crisia spissus* n. sp. differs from *C. eburneodenticulata* which has 18-20 zooids per internode (mostly 11-13), shorter ooeciosomes.

According to Hayward & Ryland (1985), the gonozooids of Crisiidae show three different shapes, clavate (club-shaped), pyriform (pear-shaped) or subglobular. *Crisia globosa* Mawatari & Mawatari, 1973 and *Crisia constans* Kluge, 1946 seem to be the most similar species to *Crisia spissus* n. sp. with their globose (subglobose) shaped gonozooids. However, in terms of number of zooids per internode, *Crisia globosa* Mawatari & Mawatari, 1973 has 6-10 on the sterile and 10-12 on the fertile, and *Crisia constans* Kluge, 1946 5-11, whereas new species has 8-14 zooids (Ryland, 1967). In addition, two species has no slit-shaped pseudopores on surface of gonozooid.

Distribution. Korea (South Sea).

Discussion

Four additional species to the Korean bryozoans fauna, *Bicrisia erecta*, *Nevianopora pulcherrima*, *Tubulipora similis* and *Crisia spissus* n. sp., were found in the present study. Of which, *Bicrisia erecta*, *Nevianopora pulcherrima* and *Tubulipora similis* are newly added to the Korean cyclostomatous fauna, and *Crisia spissus* n. sp. is new to science. The Korean cyclostomatous bryozoans come to be 9 species, 7 genera, 5 families in consequence of the present study.

The taxonomy of cyclostomatous bryozoans is poorly understood at all hierarchical levels. While contemporary bryozoological research has tended to focus on the more diverse and character-rich cheilostomes, cyclostomes have been relatively neglected (Taylor & Gordon, 2001), and Korea had also the same tendency. The Cyclostomata have a number of highly distinctive features which renders them difficult to compare with any common, simple representative of one of the other three groups (Hayward & Ryland, 1985). Three features of importance of cyclostomes are pseudopores, gonozooids and ooeciostomes. Pseudopores of this type occur only

in the Cyclostomata and impart the speckled appearance characteristic of most cyclostome zooids. In particular, pseudopores, typically less than 10 mm in diameter, provide an additional source of information in these character-poor bryozoans (Taylor and Zatoń, 2008). The structure of the brood chamber and its ooeciostome are very useful taxonomic characteristics and reference to these will usually allow rapid identification. The brood chambers of many species are highly modified zooids, termed gonozooids. Colonies lacking gonozooids may be difficult, or even impossible, to identify with certainty (Hayward & Ryland, 1985). However, gonozooids and ooeciostomes are uncommon in many species.

Four species in this study are identified based on three features, its pseudopore, gonozooids and ooeciostomes, and fortunately, our materials from the collection of Woosuk University and MBRBK had all three. Further taxonomic studies using these materials deposited at Woosuk University will undoubtedly increase the diversity of the Korean cyclostomatous bryozoans.

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