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Crisiidae (Bryozoa: Cyclostomata) of Korea

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In the family Crisiidae (Bryozoa: Cyclostomata), 90 species have been recognized worldwide in seven genera: *Bicrisia* d'Orbigny, 1853, *Crisia* Lamouroux, 1812, *Crisidia* Milne Edwards, 1838, *Crisiella* Borg, 1924, *Crisiona* Canu & Bassler, 1928, *Filicrisia* d'Orbigny, 1853 and *Unicrisia* d'Orbigny, 1853. Four species in Crisiidae are described from 11 localities from 2008 to 2014, resulting in two new distributional records and two new species in Korea. The new additions to the fauna are: *Crisia cuneata* Maplestone, 1905, *C. elongata* Milne Edwards, 1838, *C. jejuensis* n. sp. and *Filicrisia cygnus* n. sp. A total of seven Korean crisiids with the addition of four species reported herein are recorded and distributed in three genera: *Bicrisia*, *Crisia* and *Filicrisia*. Accordingly, the Korean cyclostomatous bryozoans come to be 12 species, in eight genera, and five families. All of Korean *Crisia eburneodenticulata* specimens needed to be reexamined, thus this species is tentatively deleted from the Korean bryozoan fauna.

Keywords: *Bicrisia*, Bryozoa, *Crisia*, Crisiidae, Cyclostomata, *Filicrisia*

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Introduction

The family Crisiidae Johnston, 1838 consists of approximately 90 species and seven genera worldwide; however, only three species, *Bicrisia erecta* Mawatari & Mawatari, 1973, *Crisia eburneodenticulata* Smitt ms in Busk, 1875, and *Crisia spissus* Chae, Kil, Zágoršek & Seo, 2018, have been reported from Korea so far. Furthermore, two of these species, *Bicrisia erecta* and *Crisia spissus* were not reported from Korea until 2018.

The erect and fragile bushy colonies of crisiid bryozoans have been analyzed in detail by many scientists over the last 100 years (Silén, 1977). For the precise characterization of crisiid species, it is important to ascertain not only the number of zooids comprising the internodes, but the astogenetic sequence of internodes and the manner of branching (Hayward & Ryland, 1985). The authors exclusively used the morphological characters, such as shape of colony, number of autozooids, shape of pseudopores and gonozooids with ooeciopore for identifying Crisiidae herein.

This study aims to clarify the diversity of the Korean crisiids with description of two new species and redescription of two unrecorded species from Korean waters through scanning electron microscope (SEM) illustrations.

Materials and Methods

These crisiid bryozoans were found in the collection (MBRBK) of Woosuk University in Jincheon. All specimens were collected from nine localities from 2008−2013 and have been preserved in 95% ethanol. Specimens prepared for examination by SEM were bleached with hot aqueous sodium hypochlorite, washed, and gold coated, prior to examination using a SEC Co. Ltd SNE-3200M Mini-SEM. The information of sampling localities in this

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

Locality	Coordinates	Date	Depth
Daegueulbido Island, South Sea	34°34′46.49″N, 128°32′54.38″E	25 Jun. 2013	5–15 m
Eoyudo Island, South Sea	34°39′31.66″N, 128°34′24.47″E	23 Jul. 2013	35 m
Geomdeungyeo, Gadongseom Is., South Sea	34°36′36.98″N, 128°16′26.00″E	1 Nov. 2012	15–30 m
Hongdo Island (Geomundo Is.), South Sea	34°32′3.85″N, 128°14′42.15″E	25 Apr. 2013	15–30 m
Jodo Island, East Sea	33°27′15.53″N, 126°56′37.04″E	4 May 2010	8–13 m
Marado Island, Jeju Island	36°6′38.52″N, 126°15′59.52″E	14 Nov. 2010	15–30 m
Munseom Island, Jeju Island	33°13′38.18″N, 126°34′50″E	19 Apr. 2012	19 m
Sangchujado Island, Jeju Island	33°57′15.03″N, 126°19′18.09″E	13 Nov. 2009	20 m
Uido Island, Yellow Sea	34°36′20.16″N, 125°49′41.87″E	16 Oct. 2008	0 m

paper are given in Table 1.

Results

As a result of the present study, seven species and three genera of the Korean crisiid bryozoans were identified.

The asterisks (*) indicate the species that are newly added to the Korean bryozoan fauna.

The asterisks (**) indicate the species that are new to science.

Phylum Bryozoa Ehrenberg, 1831
Class Stenolaemata Borg, 1926
Order Cyclostomata Busk, 1852
Family Crisiidae Johnston, 1838
Genus *Bicrisia* d'Orbigny, 1853

1. *Bicrisia erecta* Mawatari & Mawatari, 1973

Bicrisia erecta Mawatari & Mawatari, 1973: 99; Chae *et al*., 2018: 351.

Material examined. Uido Island, Sinan, 16 Oct. 2008; Sangchujado Island, Seogwipo, 13 Nov. 2009.
Substratum. Other bryozoan.
Remarks. The Yellow Sea is newly added to the distribution of this species in addition to Jeju Island (Chae *et al*., 2018).
Distribution. Korea (Yellow Sea and Jeju Island) and Japan.

Genus *Crisia* Lamouroux, 1812

2. *Crisia spissus* Chae, Kil, Zágoršek & Seo, 2018

Crisia spissus Chae *et al*., 2018: 351.

Material examined. Daegueulbido Island, Tongyeong, 25 Jun. 2013; Jodo Island, Yangyang, 4 May 2010.
Substratum. Stone and tunicates.
Remarks. The East Sea is newly added to the distribution of this species in addition to the South Sea (Chae *et al*., 2018).
Distribution. Korea (South and East Seas).

***3. *Crisia cuneata* Maplestone, 1905 (Fig. 1)**

Crisia cuneata Maplestone, 1905: 390; Harmer, 1915: Okada, 1917:336; 103; Brood, 1976: 282; Gordon, 2016: 605.

Material examined. MBRBK 1946, Munseom Island, Seogwipo, 9 Apr. 2012; Eoyudo Island, Tongyeong, 23 Jul. 2013.
Substratum. Corals and stones.
Description. Colony branched, erect. Internodes long, narrow, its margin strongly serrate by protruding zooids, consisting of approximately 8–15 zooids (Fig. 1A). Fertile internodes 1,112–1,874 μm long × 112–115 μm wide, consisting of 15–24 zooids (Fig. 1B). Autozooids long tubular, concentric striated, 73–98 μm long, disposed alternately on either side, directed slightly outwards and upwards. Aperture circular, inner margin dentate, approximately 53–60 μm in diameter (Fig. 1C). Gonozooid remarkably prominent, located distally in internode, conical or rugby ball-shaped by flattened distally (Fig. 1B, E). Ooeciopore conspicuous tube-shaped, slightly curved, circular, less than autozooidal aperture (Fig. 1E). Surface stratified, uneven by sunken pseudopores (Fig. 1D).
Remarks. This species is characterized by having remarkably prominent gonozooid and strongly serrated marginal edge by protruding zooids, compared with the other *Crisia*. Harmer (1915) described and illustrated the gonozooid from Japanese specimens which shows its remarkably prominent and distal extremity being in the form of a cylinder terminated by a rounded or conical end, the elongated being at right angles to the surface of the branch. Korean *Crisia cuneata* had the same gonozooid as one of the Japanese specimens. The dentate inner

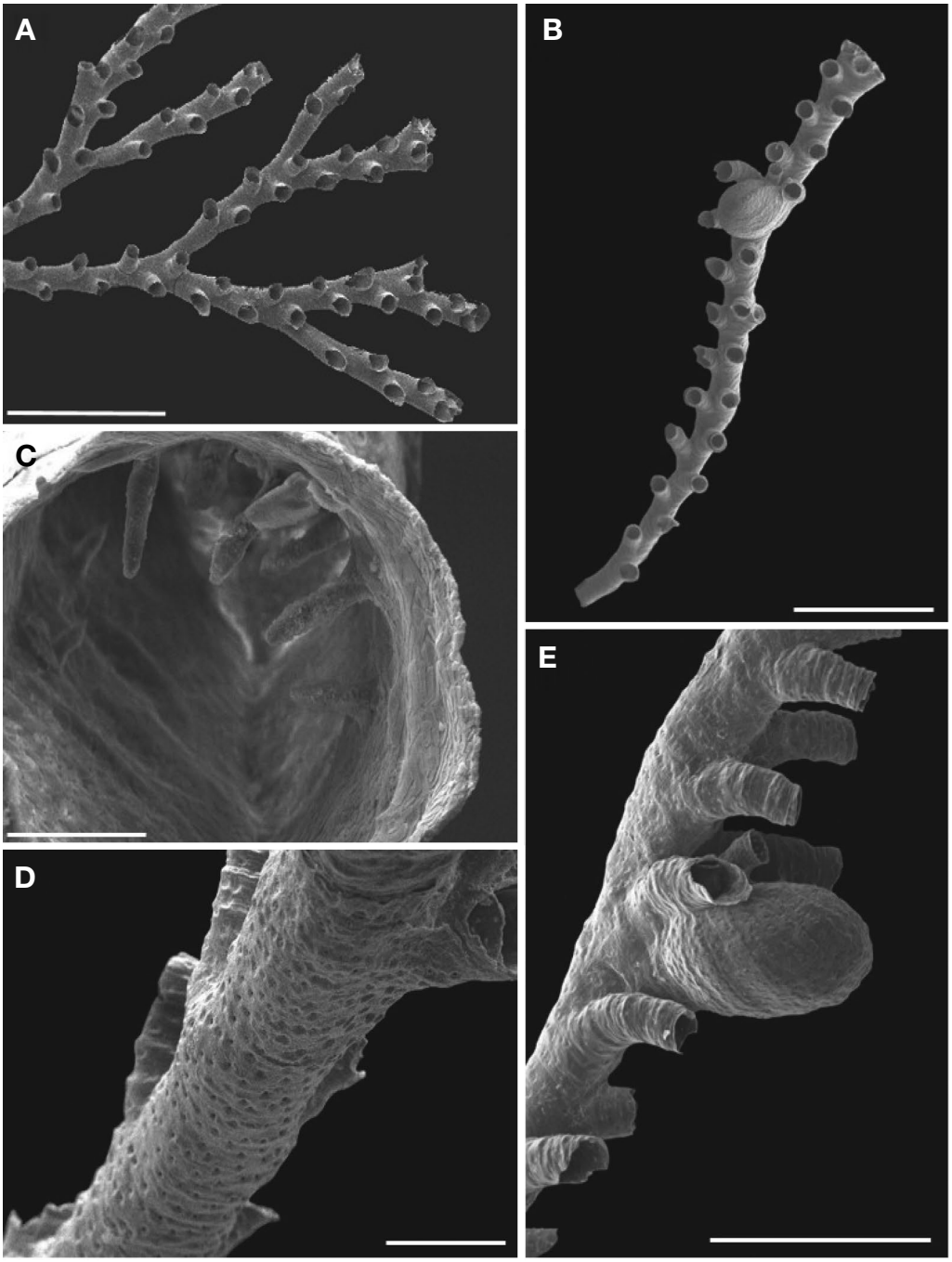

Fig. 1. *Crisia cuneata* Maplestone, 1905. A, zooidal arrangement in several branches; B, dentate inner margin of aperture in detail; C, gonozooid and ooeciopore; D, pseudopores on surface; E, gonozooid, detail. Scale bars: A = 1 mm; B = 500 μm; C, D = 100 μm; E = 300 μm.

margin of the aperture is shown with SEM for the first time in this paper.

Distribution. Korea (South Sea and Jeju Island), West Pacific (China, Indonesia, Japan), Mediterranean, Red Sea and Coast of East Africa.

***4. *Crisia elongata* Milne Edwards, 1838 (Fig. 2)**

Crisia elongata Milne Edwards, 1838: 203; Busk, 1875: 5; Harmer, 1915: 96; Brood, 1976: 282.

Material examined. NIBRIV0000836444, Geomdeungyeo (Gadongseom Island), 1 Nov. 2012.

Substratum. Unknown.

Description. Colony erect, thin and bend slightly for-

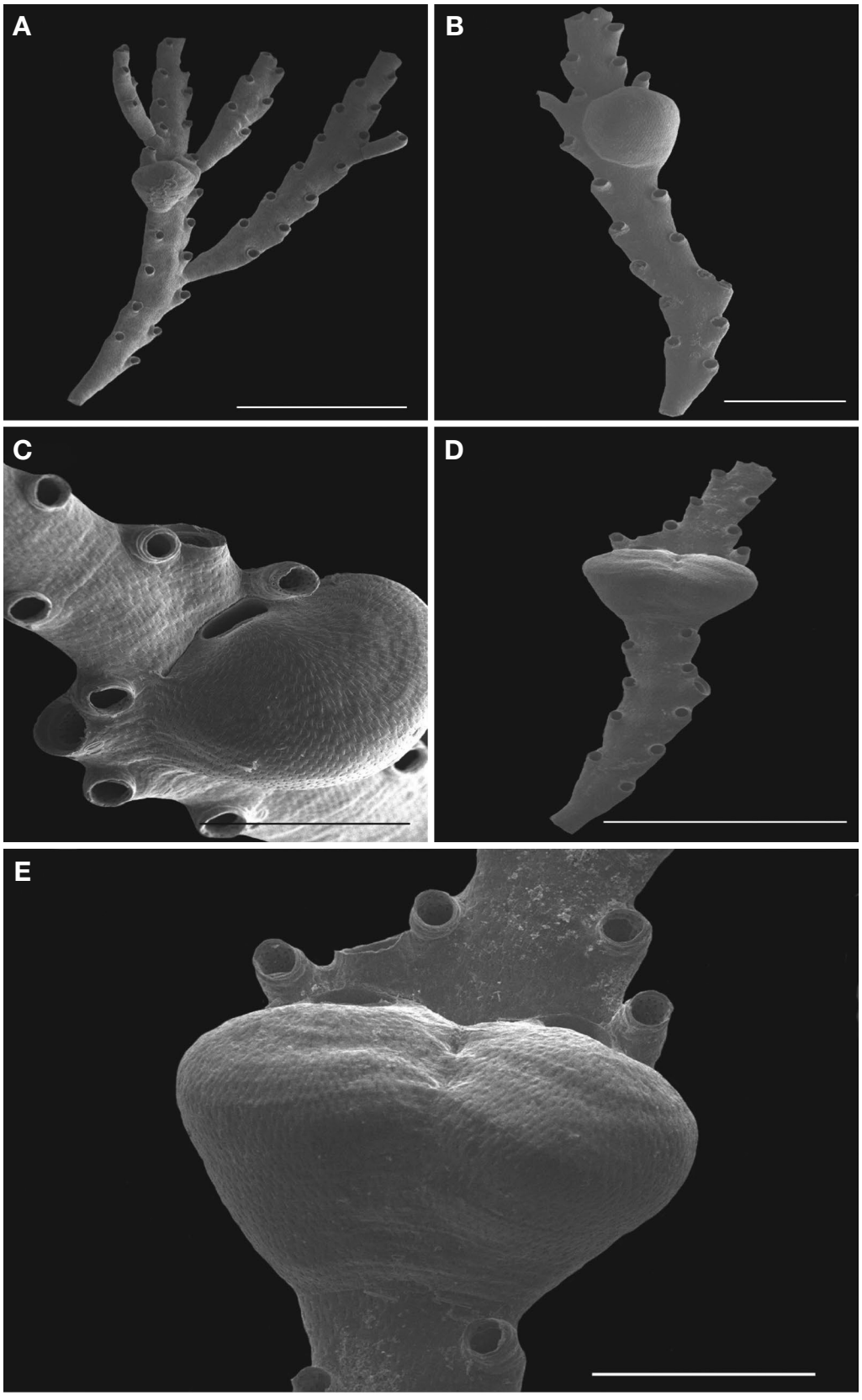

Fig. 2. *Crisia elongata* Milne Edwards, 1838. A, colony; B, an internode; C, gonozooid and ooecipore; D, an internode with twin gonozooids; E, twin gonozooids, detail. Scale bars: A, D = 1 mm; B = 500 μm; C, E = 300 μm.

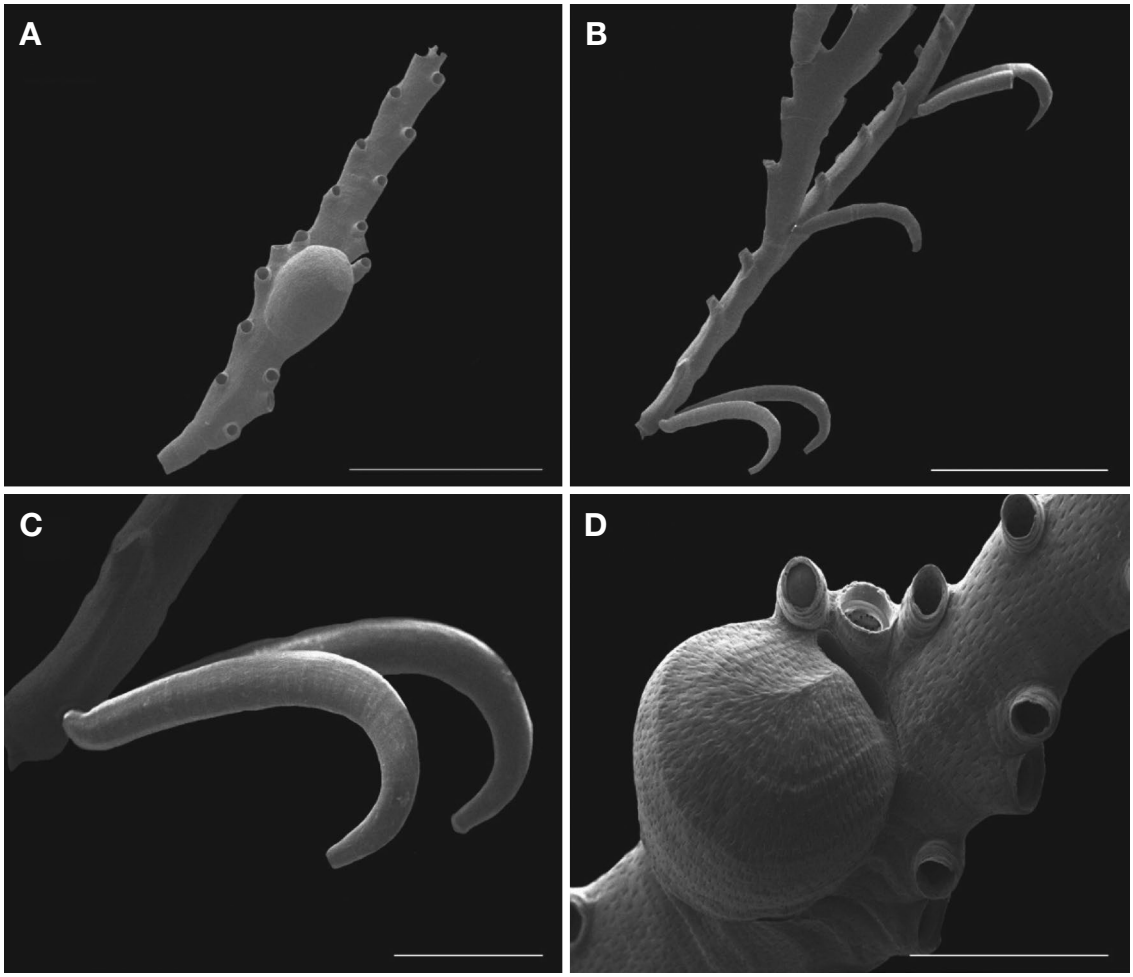

Fig. 3. *Crisia jejuensis* n. sp. A, an internode; B, position of hook; C, hooks, detail; D, gonozooid and ooeciopore, detail. Scale bars: A, B = 1 mm; C, D = 300 μm.

ward. Internode slightly wide and flat, narrowing proximally. One internode consisting of 12−24 zooids, alternately disposed to left and right, 2,667−3,625 μm long × 86−353 μm width (Fig. 2A). Autozooids tubular, fused each other proximally, 127−232 μm long × 56−67 μm wide. Aperture circular, approximately 58−72 μm in diameter, with peristome facing frontally (Fig. 2B). Gonozooids triangular round, expanded distally, located in 5th−11th zooid, 363−404 μm long × 414−457 μm wide, sometimes twined. Ooeciopore flat rounded rectangular, 33−37 μm long × 88−114 μm wide. Surface covered by slit-shaped pseudopores (Fig. 2B, C).

Remarks. This species is characterized by flat ooeciopore and twin gonozooids. Remarkably, the twin-gonozooids, mentioned by Harmer (1915) as "in a single case I have found twin-ovicells", were observed, in this study (Fig. 2D).

Crisia pseudosolena (Marcus, 1937) and *C. ficulnea* Buge, 1979 seem to be the most similar species to *C. elongata* in having flat ooeciopore; however, *C. elongata* differs from *C. pseudosolena* which has pear-shaped gonozooids and *C. ficulnea* with less in number: 9−13 zooids per internode than *C. elongata*.

Distribution. Korea (South Sea) and widespread.

****5. *Crisia jejuensis* n. sp. (Fig. 3)**

Material examined. More than 30 colonies, Holotype: MBRBK 1947, Marado Is., Jeju Island, 14 Nov. 2010. Paratype: same data as holotype.

Etymology. Alluding to the provenance of the species on the south coast of Jeju Island.

Substratum. Sponges and seaweeds.

Description. Colony erect, thin and bend slightly forward. Internode slightly wide and flat, arrowing proximally (1,671−2,105 μm long) with hooked spine (pair in most) (Fig. 3A−C). One internode consisting of 14−24 zooids (14−16 in most), alternately disposed to left

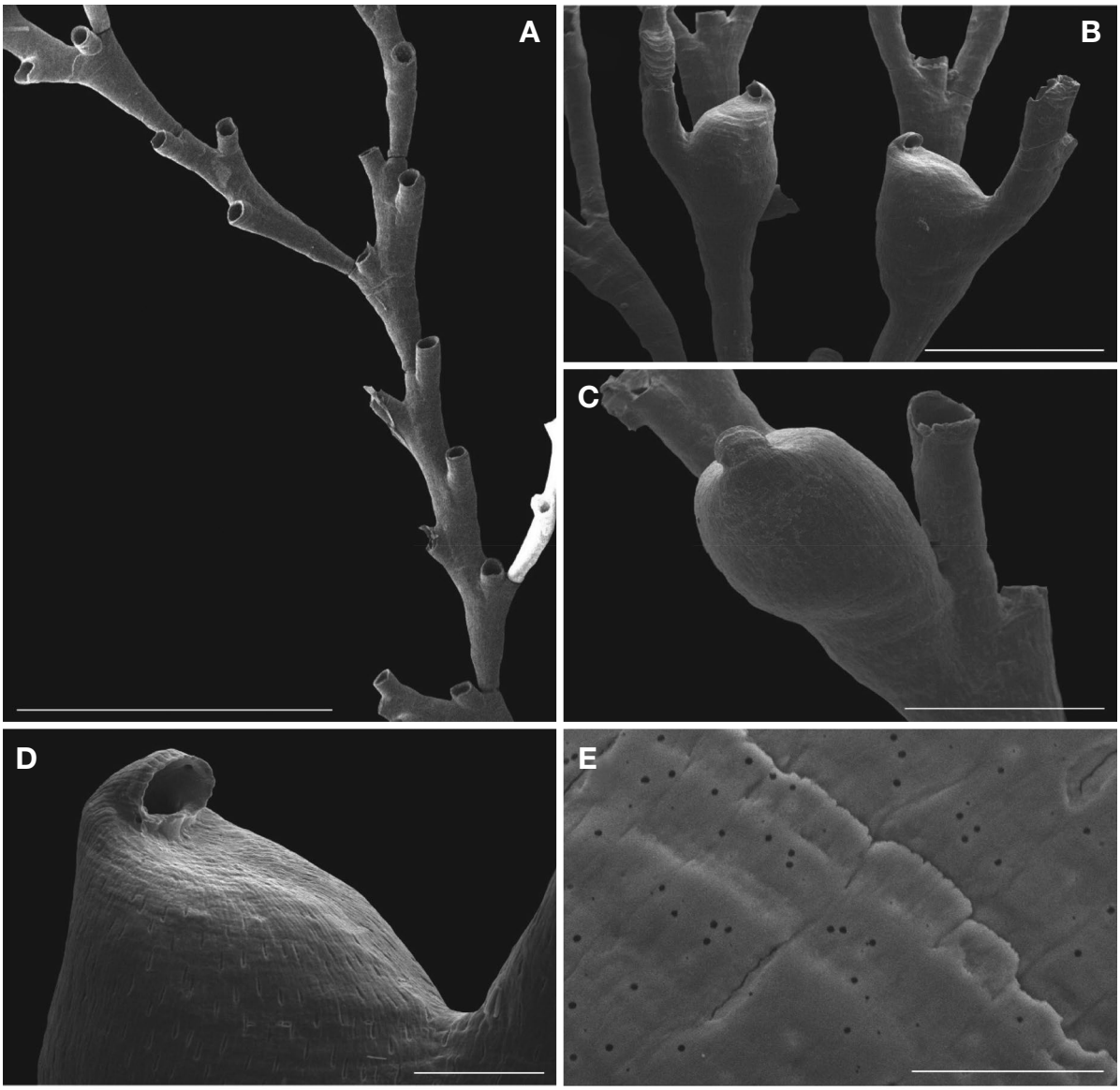

Fig. 4. *Filicrisia cygnus* n. sp. A, internode and zooid; B, gonozooid; C, ooeciopore on gonozooid in detail; D, top view of gonozooid showing ooeciopore; E, pseudopores and layer, detail. Scale bars: A = 1 mm; B = 500 μm; C = 300 μm; D = 100 μm; E = 20 μm.

and right. Autozooids tubular, like short tube by fused each other proximally, 57–63 μm long × 50–76 μm wide, protruding like short tube with sharp lateral processes (Fig. 3B). Joints black. Ramified at 6–12th zooid (6–10th in most). Gonozooids elongate oval to elliptical, 873–2,000 μm long × 132–261 μm wide, occupying position of 5–10th zooid. Ooeciopore flat rounded rectanglular, 22–39 μm long × 127–148 μm wide (Fig. 3D). Surface covered by slit-shaped pseudopores.

Remarks. This new species is easily distinguished from the other species belonging to *Crisia* Lamouroux, 1812 in having a pair of hooked spines at the proximal end of internode and flat ooeciopore.

Two Korean species of *Crisia*, *C. eburneodenticulata* Smitt ms in Busk, 1875 and *C. spissus* Chae, Kil, Zágoršek and Seo, 2018 that have no hook-shaped spines, are different from the new species. Also, *Crisia pseudosolena* (Marcus, 1937), *C. ficulnea* Buge, 1979 and *C. elongata* seem to be the most similar species to *C. jejuensis* n. sp. with these flat ooeciopores, but *C. jejuensis* n. sp. differ from *C. pseudosolena*, *C. ficulnea* Buge, 1979 and *C. elongata* which has no hooked spines. By all means, not all *Crisia* is absent of spines; for example, *Crisia aculeata* Hassall, 1841 has a slender spine instead of a hooked spine; however, most species indeed do not have spines. *Crisia jejuensis*'s hooked spines are certainly very

unique.
Distribution. Korea (Jeju Island).

Genus *Filicrisia* d'Orbigny, 1853

****6. *Filicrisia cygnus* n. sp. (Fig. 4)**

Material examined. Holotype: NIBRIV 0000836441, Jodo Island, Yangyang, 4 May 2010. Paratype: Hongdo Island beside Geomundo Island, South Sea, 25 April 2013.
Etymology. Latin, *cygnus*, alluding to gonozooid shape resemblance to the swan.
Substratum. Sponges and stones.
Description. Colonies erect, delicate, branched with many internodes. Internodes short, 457−766 μm long, 1−5 zooids (3 in most), alternately disposed to left and right (Fig. 4A). Fertile internodes comprising 3−5 zooids (Fig. 4B). Autozooids tubular, straight or weakly curved, 68−89 μm wide at distal end, up to 211−239 μm wide at bifurcation. Apertures circular, 52−74 μm diameter. Gonozooid attached to zooid, conspicuously inflated, expanded distal end, over 69 degrees from zooid, slightly oblique at top (Fig. 4B, C). Ooeciopore short, oval, wider than long, 41−49 μm long × 57−63 wide μm, located dorsally on opposite side or laterally of zooid, curved towards zooid but vertically when viewed from front, shallow longitudinal grooves, directly outward with wave shape at end (Fig. 4C, D). Surface of both zooids and gonozooids covered by circular (0.4−0.7 μm diameter) and slit-shaped (11−15 μm long) pseudopores (Fig. 4E), looked layered. Spines absent.
Remark. *Filicrisia* d'Orbigny, 1853 is a relatively little-known genus, and four recent species have been recognized: *Filicrisia allooeciata* Liu in Liu, Yin and Ma, 2001, *F. franciscana (*Robertson, 1910), *F. geniculata (*Milne Edward, 1838) and *F. smitti (*Kluge, 1946) worldwide.

Filicrisia cygnus n. sp. is characterized by its 1−5 zooids per internode (3 in most), short zooid and internode, oval-shaped ooeciopore which completely curve towards the zooid at the frontal margin of gonozooid and two shaped (circle and slit) pseudopores with sometimes layers on the surface. *Filicrisia allooeciata* Liu in Liu, Yin and Ma, 2001 is differentiated from this new species by sprung gonozooid from zooid and fertile internode composing of a single gonozooid. Two species, *F. geniculata (*Milne Edward, 1838) and *F. smitti (*Kluge, 1946), have the ooeciopore located close to the zooid at the dorsal of gonozooid, which is different from the *Filicrisia cygnus* n. sp. The ooeciopore shape, curved from the frontal dorsally, is very similar to *F. franciscana (*Robertson, 1910), but *Filicrisia cygnus* n. sp. differs from *F. franciscana* as the latter has erect ooeciopore with curve and a flat top of gonozooid. In Soule *et al.* (1995), Fig. 38 shows the same characters as the *Filicrisia cygnus* n. sp., i.e., ooeciopore position with curved backwards, gonozooid shaped; however, whereas Plate 121C shows erect ooeciopore with longer than wide and sharped-up and down when looking down on top of gonozooid, the ooeciopore is different in that "it bends from the frontal dorsally or is erect". The ooeciopore of *Filicrisia cygnus* n. sp. is not erected. The surface layer of this new species is a very distinguished characteristic of the genus *Filicrisia*. The genus *Filicrisia* d'Orbigny, 1853 is reported from Korea for the first time.
Distribution. Korea (East and South Seas).

Conclusions and Discussion

Recently, Liu *et al.* (2019) reported 15 species belonging to 11 genera, of Cyclostome bryozoans from the South Yellow Sea, China, and noted that they considered the differences in the position, shape and size of the ooeciopore as well as the protoecium structures as important features to distinguish different species. Even quite small crisiid colonies can often be identified on the basis of number of zooids per internode, position and form of the basis rami, joint colour, presence or absence of spines, and meristic data (Hayward & Ryland, 1985). The identification of crisiids was based on its characteristics, such as pseudopore and gonozooid with ooeciopore in this study. As mentioned in Chae *et al.* (2018), fortunately, our materials from the collection of Woosuk University and MBRBK had all these characteristics.

Crisia eburnodenticulata has been only *Crisia* until 2018. However, Liu *et al.* (2019) noted that *Crisia eburneodenticulata* is highly probable and that this species is absent from the western Pacific. All Korean *Crisia eburneodenticulata* specimens needed to be reexamined, thus this species is tentatively deleted from the Korean bryozoan fauna.

As results of the present study, *Crisia elongata* and *C. cuneata* are newly added to the Korean fauna, and *Crisia jejuensis* n. sp. and *Filicrisia cygnus* n. sp. are new to science. With the addition of four species reported herein, a total of six Korean crisiids are recorded and distributed in three genera: *Bicrisia*, *Crisia* and *Filicrisia*. Furthermore, the genus *Filicrisia* is new to the Korean bryozoans fauna based on this study. Eight cyclostome species have been recorded from Korea up to now (Seo, 2005; Zágoršek *et al.*, 2017; Chae *et al.*, 2018). Accordingly, the Korean cyclostomatous bryozoans come to be 12 species, including the aforementioned four species, eight genera and five families. They are as follows: *Tubulipora similis* Liu in Liu, Yin & Ma, 2001, *T. pulchra* MacGillivray, 1885, *Nevianipora pulcherrima* (Kirkpatrick, 1890), *Bicrisia erecta* Mawatari & Mawatari, 1973, *Crisia cu-*

neata Maplestone, 1905, *C. elongata* Milne Edwards, 1838, *C. jejuensis* n. sp., *C. spissus* Chae, Kil, Zágoršek & Seo, 2018, *Filicrisia cygnus* n. sp., *Hornera jeongsangi* Zágoršek, Chae, Min, Yang & Seo, 2017, *Disporella novaehollandiae (*d'Orbigny, 1853) and *Patinella radiata (*Audouin, 1826).

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