

## Three New Records of Family Tubuliporidae (Bryozoa: Cyclostomata) from Korea

Hyun Sook Chae<sup>1</sup>, Bum Sik Min<sup>2</sup>, Ho Jin Yang<sup>3</sup>, Ji Eun Seo<sup>1,3,\*</sup>

<sup>1</sup>Department of Life Science, Woosuk University, Jincheon 27841, Korea

<sup>2</sup>Marine Research Center, National Park Research Institute, Korea National Park Service, Yeosu 59723, Korea

<sup>3</sup>Marine Bryozoans Resources Bank of Korea, Jincheon 27841, Korea

### ABSTRACT

This paper describes three cyclostomatous bryozoans belonging to the family Tubuliporidae Johnston, 1838 from Korean waters. It was carried out with the materials which were collected from three localities during the period from 2011 to 2017. As a result of the present study, three cyclostomatous bryozoans, *Exidmonea intercalata* Liu, Liu & Zágóršek, 2019, *Qingdaoella conaria* Liu, Liu & Zágóršek, 2019 and *Tubulipora perforata* Liu, Liu & Zágóršek, 2019 are newly added to the Korean bryozoan fauna. Furthermore, two genera, *Exidmonea* David, Mongereau & Pouyet, 1972 and *Qingdaoella* Liu, Liu & Zágóršek, 2019, are reported for the first time from Korea. These species were previously known only in Qingdao, China, which belongs to the temperate zone influenced by the Kuroshio Current. Descriptions and illustrations of the three cyclostomatous bryozoans using Scanning Electron Microscopy are provided in this study.

**Keywords:** cyclostomatous bryozoan, *Exidmonea*, *Tubulipora*, Tubuliporidae, *Qingdaoella*

### INTRODUCTION

Korean bryozoan taxonomists have tended to focus on the more diverse and rich cheilostomatous bryozoans, thus, little study was conducted on cyclostomes compared to cheilostomes. Until 2016, four species and three genera belonging to three families, Tubuliporidae Johnston, 1837, Crisiidae Johnston, 1838 and Lichenoporidae Smitt, 1867, have been reported in Korea. Chae et al. (2018) noted that further taxonomic studies will undoubtedly increase the diversity of the Korean cyclostomatous bryozoans. Taxonomic study on the family Crisiidae of Korea was done by Chae et al. (2020), and this study is focused on the family Tubuliporidae.

Bock and Gordon (2013) estimated that Tubuliporidae Johnston, 1838 contains 11 genera and 105 species. The representative genera of the family Tubuliporidae are *Tubulipora* Lamarck, 1816, *Idmidronea* Canu & Bassler, 1920 and *Exidmonea* David, Mongereau & Pouyet, 1972 (Cook et al., 2018). In Korea, four species belonging to the genus, *Tubulipora* have been recorded as follows: *T. continua* Ortmann, 1890, *T. flabellaris* (Fabricius, 1780), *T. pulchra* MacGillivray, 1885 and *T. similis* Liu in Liu, Yin & Ma, 2001. How-

ever, of these species, *T. continua* and *T. flabellaris* were reported for the first time in Korea by Rho and Kim (1981) and Rho and Chung (1975), and no further record is added since then. Currently, two species, *T. pulchra* and *T. similis*, of the family Tubuliporidae have been recognized in Korea.

This study aims to describe and illustrate three tubuliporid species from Korean waters.

### MATERIALS AND METHODS

All specimens were collected from three localities during the period from 2011 to 2017 and have been preserved in 95% ethanol. For the identification, the external features of zooid were observed under stereomicroscope and specimens in preparation for examination by scanning electron microscope (SEM) were bleached with hot aqueous sodium hypochlorite, washed, and gold coated, prior to examination using a SNE-3200M Mini-SEM (SEC Co. Ltd., Suwon, Korea) at 15 kV accelerating voltage. Sampling localities mentioned in this paper are given in Table 1.

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**\*To whom correspondence should be addressed**  
Tel: 82-43-531-2891, Fax: 82-43-531-2881  
E-mail: jeseo@woosuk.ac.kr

**Table 1.** Sampling localities of three species in Korea waters

Locality	Coordinates	Date	Depth
Geomdeungyeo, Gadongseom Island, South Sea	34°36'36.98"N, 128°16'26.00"E	1 Nov 2012	15–30 m
Biyangdo Island, Jeju Island	33°24'48.35"N, 126°14'19.73"E	24, 25 Sep 2011	30 m
Cheongpodaе, Yellow Sea	36°38'15.88"N, 126°17'56.73"E	26 May 2017	Intertidal

## SYSTEMATIC ACCOUNTS

Class Stenolaemata Borg, 1926

Order Cyclostomata Busk, 1852

Family Tubuliporidae Johnston, 1838

<sup>1</sup>\*Genus *Exidmonea* David, Mongereau & Pouyet, 1972

<sup>2</sup>\***1. *Exidmonea intercalata* Liu, Liu & Zágorsék, 2019 (Fig. 1)**

*Exidmonea intercalata* Liu, Liu & Zágorsék, 2019: 480.

**Material examined.** Korea: Gyeongsangnam-do: Tongyeong, Gadongseom Island, Geomdeungyeo, 2 Nov 2012, depth 15–30 m; MABIK IV00170947, Jeju Island: Biyangdo Island, 24 Sep 2011, depth 30 m.

**Substratum.** Sponge and ascidian.

**Description.** Colony erect rigid/delicate branching. Branches dichotomous, 477–594 µm wide, 1,314–1,146 µm wide at branch bifurcation, oval or rounded-rectangular in transverse section. Fascicles alternating on either side of branch, consisting of 2–6 autozooids, 6–8 autozooids at bifurcation and longitudinal spacing of fascicles 315–496 µm. Apertures oval to rounded rectangular, diameter approximately 82–109 µm. Gonozooid triangular, small and located frontally at branch bifurcation, with dense pseudopores; approximately 7–9 µm in diameter, sometimes teardrop-shaped. Ooeciostome oval, short, downwardly curved, swan-neck shaped with pseudopores, located on distal part of gonozooid, adjacent to autozooidal tube, hidden between bifurcating branches. Pseudopores at frontal surface partially occluded by spines, or no spines. Dorsal surface flat, with arcuate growth lines and circular pseudopores with irregular cracks; kenozooids absent.

**Remarks.** This species was first described by Liu et al. (2019) in Qingdao, China, in the South Yellow Sea. The characteristics of our specimens are identical to ones described by Liu et al. (2019). Both specimens have the downwardly curved and hidden swan-neck shaped ooeciostome. The gonozooid is located just below the bifurcation.

Additionally, in Korean specimens, the pseudopores cover-

ing the dorsal and gonozooidal surfaces are concave, closed and have irregular cracks at their center. In particular, the pseudopores on the gonozooid are teardrop-shaped.

**Distribution.** Korea (South Sea and Jeju Island) and China.

<sup>3</sup>\*Genus *Qingdaoella* Liu, Liu & Zágorsék, 2019

<sup>4</sup>\***2. *Qingdaoella conaria* Liu, Liu & Zágorsék, 2019 (Fig. 2)**

*Qingdaoella conaria* Liu, Liu & Zágorsék, 2019: 487.

**Material examined.** Korea: Chungcheongnam-do: Taean, Cheongpodaе, 26 May 2017, intertidal zone.

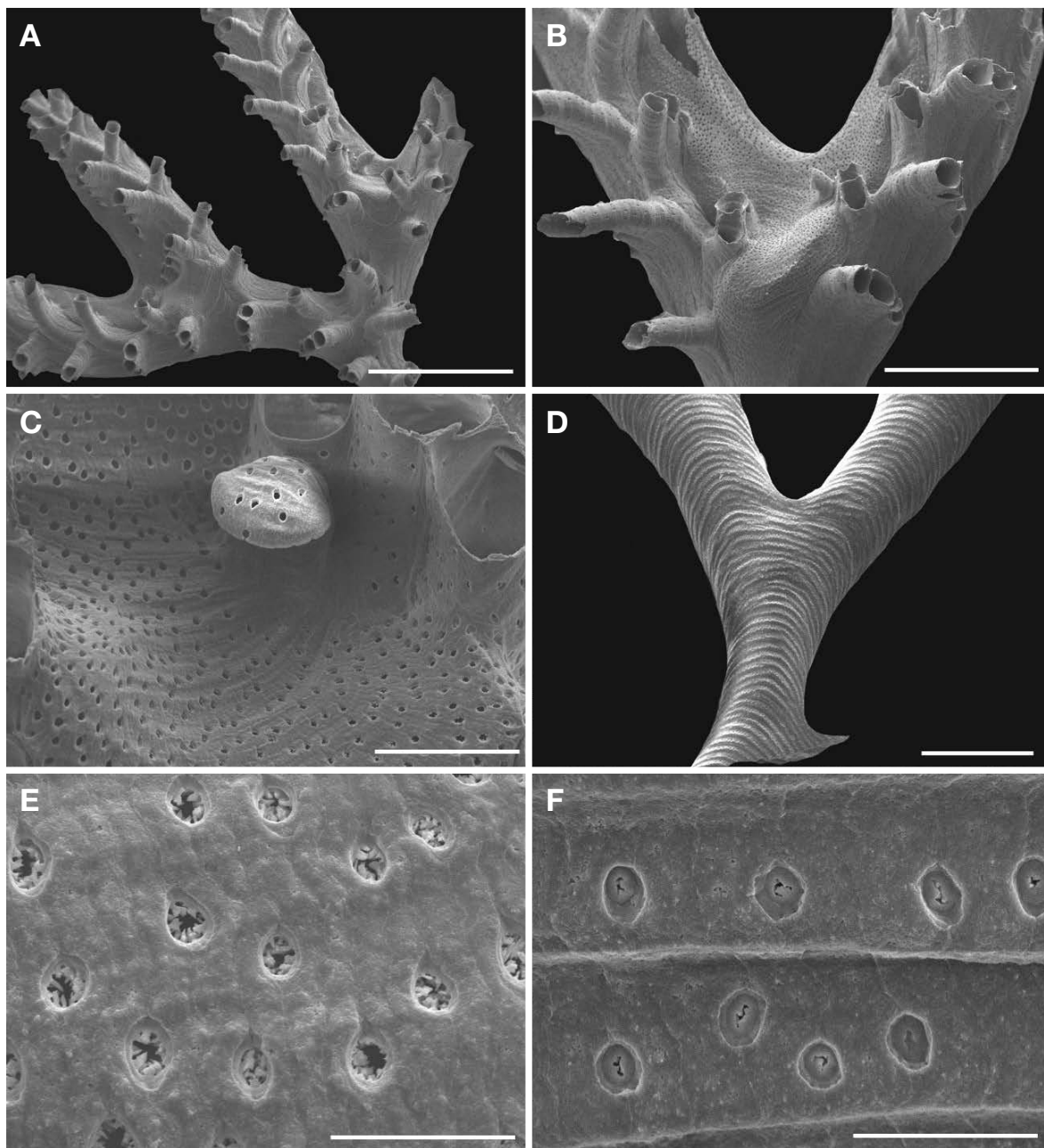
Substratum. Rock.

**Description.** Colony encrusting, lobate, oval to fan-shaped. Autozooids arranged in uniserial, rarely multiserial, radial rows. Apertures square to circular, 45–87 µm in diameter, independent, 2–6 autozooids joined together, forming radial fascicles; peristomes 79–237 µm long with pseudopores. Gonozooid expanded, frontal surface penetrated by numerous autozooidal peristomes, with pseudopores approximately 4–6 µm in diameter. Ooeciostome circular, short to moderately long, tubular/conical, obliquely frontal often parallel to autozooidal peristomes, approximately 58–74 µm long, approximately 27–29 µm wide at top and 48–51 µm wide at base. Protoecium circular, 81 µm in diameter, smooth margins, no pseudopores.

**Remarks.** Liu et al. (2019) established the genus *Qingdaoella*, for species resembling *Tubulipora*, but having a very stable characteristically long ooeciostome. Both genera *Qingdaoella* and *Tubulipora* have similar features such as an encrusting, lobate and circular-to-oval shaped colony, connate or free arranged autozooids diverging from protoecium and extended gonozooid and ooeciostome attached to or not an autozooidal peristome. However, they were divided into two different genera by the shape of ooeciostome. The ooeciostome of the *Qingdaoella* is longer, thinner, conical or tubular, whereas the ooeciostome of *Tubulipora* is short, tubular, compressed or flared.

There are three species belonging to the genus *Qingdao-*

Korean name: <sup>1</sup>\*매끈등이끼벌레속(신칭), <sup>2</sup>\*물한난구관이끼벌레(신칭), <sup>3</sup>\*긴난구관이끼벌레속(신칭), <sup>4</sup>\*원뿔관이끼벌레(신칭)



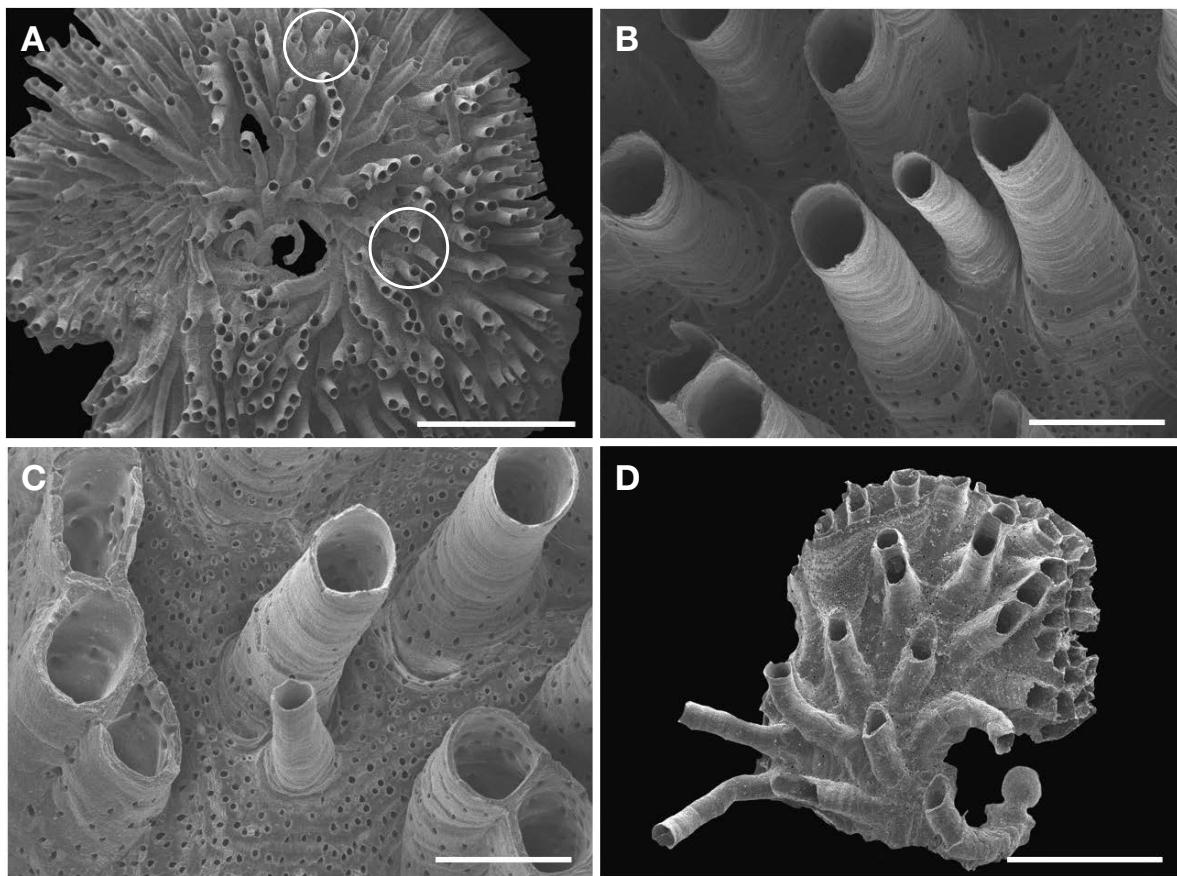
**Fig. 1.** *Exidmonea intercalata* Liu, Liu & Zágóršek, 2019. A, Zooidal arrangement in branches, B, Gonozooid below bifurcation; C, Oeciostome of gonozooid; D, Dorsal surface of colony; E, Pseudopores of frontal surface; F, Pseudopores of dorsal surface. Scale bars: A=1 mm, B, D=500 µm, C=100 µm, E, F=30 µm.

*ella-Q. conaria* and *Q. miaotiao* from China, and *Q. concinna* from Australia. *Qingdaoella conaria* is distinguished from the rest of *Qingdaoella* by having conical oeciostome, autozooidal peristomes arranged in independent or fascicles, protoecium with smooth margins and no pseudopores. According to Liu et al. (2019), the conical oeciostome of the Chinese specimen is about 40–100 µm long, 80–100 µm

wide at the base and 50–60 µm wide at the top. The top/base ratio of the oeciostome in width is larger in Korean specimens than Chinese ones.

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

Genus *Tubulipora* Lamarck, 1816



**Fig. 2.** *Qingdaoella conaria* Liu, Liu & Zágoršek, 2019. A, Zooidal arrangement and gonozooids in colony, white circles indicates gonozooid; B, Conical oeciostome parallel to autozooidal peristomes; C, Detailed conical oeciostome directed frontally; D, Young colony with protoecium. Scale bars: A=1 mm, B=100  $\mu$ m, C, D=300  $\mu$ m.

**<sup>1</sup>\*3. *Tubulipora perforata* Liu, Liu & Zágoršek, 2019 (Fig. 3)**

*Tubulipora perforata* Liu, Liu & Zágoršek, 2019: 478.

**Material examined.** Korea: Jeju Island: Biyangdo Island, 25 Sep 2011, depth 30 m.

**Substratum.** Unknown.

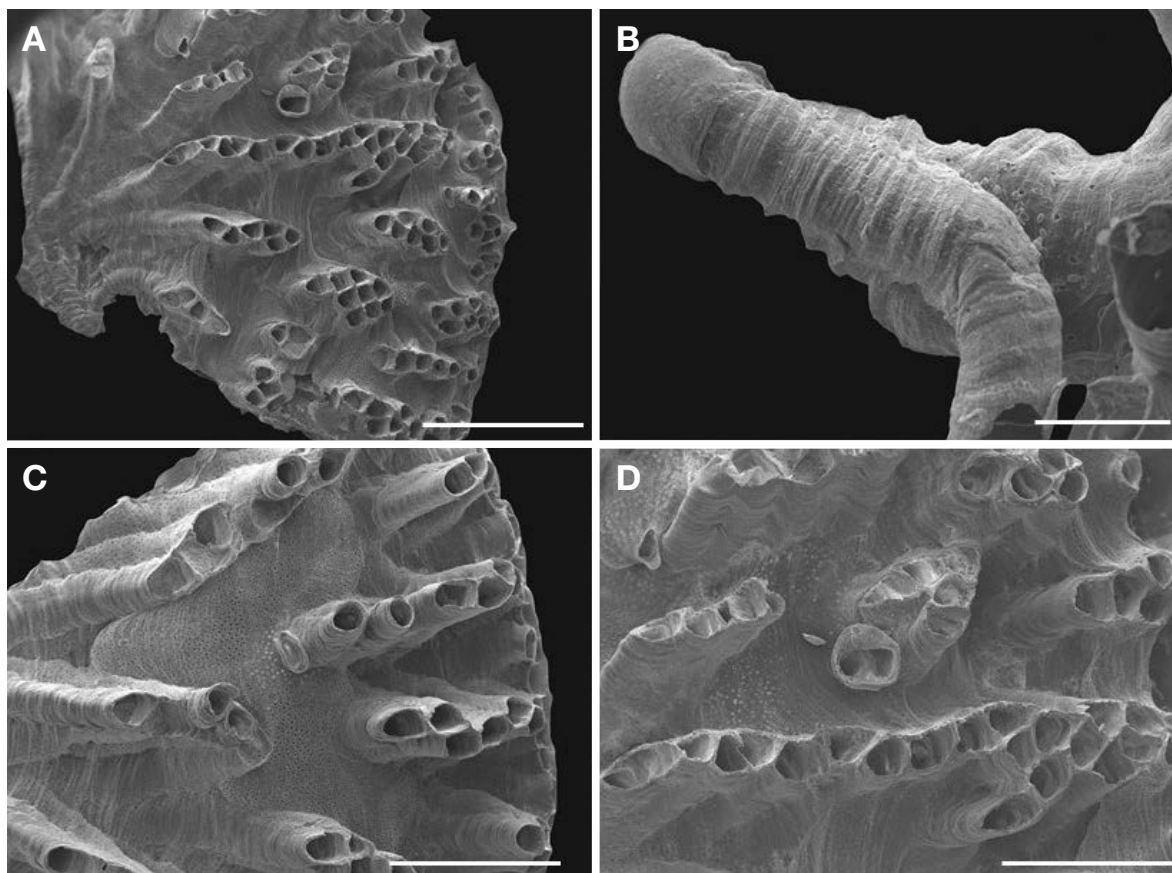
**Description.** Colony encrusting, lobate. Zooids arranged in uniserial, rarely multiserial, radial rows. Apertures rounded to square-shaped, general fascicles containing 2–10 autozooids, only one fascicle of 18. Peristomes long, slightly curved, with very small pseudopores. Budding margin 2–4 rows of autozooids overlapping margin, without basal lamina. Protoecium approximately 103  $\mu$ m in diameter and smooth margins. Gonozooid visible, triangular to quadrangle, spreading among zooidal rows and sometimes perforated by these peristomes, 1,246–1,450  $\mu$ m long, 816–910  $\mu$ m wide,

frontal wall inflated, with pseudopores numerous 7–14  $\mu$ m in diameter. Oeciostome elongated ovals with extended lips, adjacent to proximal part of succeeding fascicles.

**Remarks.** In our specimens, gonozooid could be somewhat variable in size and shape, but all the rest of the characteristics coincide exactly with the original description of Liu et al. (2019).

A large triangular gonozooid is mostly consistent with the description of Chinese specimens, but it is slightly rectangular shaped and somewhat wider than long in Korean specimens. In particular, fascicles with up to 18 zooidal apertures were observed in Korean *T. perforata*. Liu et al. (2019) regarded *T. pulchra* of Seo (2005) as a synonym of *T. perforata* based on large, almost triangular gonozooid with oval oeciopore attached to the succeeding autozooidal peristome. However, two Korean species of genus *Tubulipora*, *T. similis* Liu in Liu, Yin & Ma, 2001 and *T. pulchra* Mac-

Korean name: <sup>1</sup>\*구멍관이끼벌레 (신칭)



**Fig. 3.** *Tubulipora perforata* Liu, Liu & Zágoršek, 2019. A, Colony; B, Protoecium; C, Oeciostome on gonozooid; D, Oeciostome in detail. Scale bars: A=1 mm, B=100  $\mu$ m, C, D=500  $\mu$ m.

Gillivray, 1885, are different from this species in having no fascicles.

**Distribution.** Korea (Jeju Island) and China.

## RESULTS AND DISCUSSION

Due to lack of taxonomic study on Korean cyclostomes, only eight species are recorded so far, and they need to be reviewed. As a series of study on cyclostomes from Korean waters, all of the Korean crisiids known as *Crisia eburno-denticulata* until 2018 were synonymized into four different species by Chae et al. (2020). Of 11 genera and 105 species attributed to the Tubuliporidae Johnston (1838) by Bock and Gordon (2013), only one genus and two species, *T. pulchra* and *T. similis*, are currently recorded in Korea, excluding two species, *T. continua* and *T. flabellaris*, which have no more additional records since their first reports (Rho and Chung, 1975; Rho and Kim, 1981). The three principal genera included within the family are characterized by oligoserial

encrusting (*Tubulipora*) and erect branching (*Idmidronea* and *Exidmonea*) colonies (Cook et al., 2018). Colony growth pattern is one of the useful features for distinguishing the species. The Korean Tubuliporidae also show two different colony growth patterns, erect branching (*Exidmonea*) and encrusting (*Qingdaoella* and *Tubulipora*). With the addition of three species reported herein, a total of five Korean tubuliporids are recorded and distributed in three genera: *Tubulipora*, *Exidmonea*, and *Qingdaoella*. Furthermore, the genera *Exidmonea* and *Qingdaoella* are new to the Korean bryozoan fauna based on this study.

Three species of Tubuliporidae described here from Jeju Island, South Sea, and Yellow Sea were reported from the Qingdao, China (Liu et al., 2019). These localities (Jeju Island, South Sea, Yellow Sea, Qingdao) belong to the temperate zone and are affected by currents branching from the Kuroshio (Taiwan Warm Current, Tsushima Warm Current, Yellow Sea Warm Current). Moreover, Qingdao is located on the Chinese coast side of the Yellow Sea. It is known that the bryozoan fauna of Korea has affinities with faunas to the

west and south (in Chinese and warmer Indo-Pacific waters) (Min et al., 2017). It is probably not a coincidence that three species reported from China in 2019 are re-described in Korea. In addition, only *Qingdaoella conaria* was collected from the Yellow Sea, but *Exidmonea intercalata* and *Tubulipora perforata* are also expected to be from the Yellow Sea. Accordingly, the Korean cyclostomatous bryozoans have increased to 15 species, including the aforementioned three species, ten genera and five families. They are as follows: *Tubulipora similis* Liu in Liu, Yin & Ma, 2001, *T. perforata* Liu, Liu & Zágoršek, 2019, *T. pulchra* MacGillivray, 1885, *Exidmonea intercalata* Liu, Liu & Zágoršek, 2019, *Qingdaoella conaria* Liu, Liu & Zágoršek, 2019, *Neviani-pora pulcherrima* (Kirkpatrick, 1890), *Bicrisia erecta* Mawatari & Mawatari, 1973, *Crisia cuneata* Maplestone, 1905, *C. elongata* Milne Edwards, 1838, *C. jejuensis* Chae, Min, Zágoršek, Yang, Kil & Seo, 2020, *C. spissus* Chae, Kil, Zágoršek & Seo, 2018, *Filicrisia cygnus* Chae, Min, Zágoršek, Yang, Kil & Seo, 2020, *Hornera jeongsangi* Zágoršek, Chae, Min, Yang & Seo, 2017, *Disporella novaehollandiae* (d'Orbigny, 1853) and *Patinella radiata* (Audouin, 1826).

## ORCID

Hyun Sook Chae: <https://orcid.org/0000-0002-2702-9095>

Bum Sik Min: <https://orcid.org/0000-0003-4308-3734>

Ho Jin Yang: <https://orcid.org/0000-0003-4592-8542>

Ji Eun Seo: <https://orcid.org/0000-0001-5764-5457>

## CONFLICTS OF INTEREST

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

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