

## ***Gregarinidra* (Bryozoa: Gymnolaemata: Flustridae) of Korea**

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### **ABSTRACT**

Two species belonging to the genus *Gregarinidra* Barroso, 1949 (Bryozoa: Gymnolaemata: Flustridae) were first found in this study from Korean waters. *Gregarinidra furcula* n. sp. is new to science, and *G. incrustans* (Silén, 1941) is newly added to the Korean fauna. Species belonging to this genus are primarily distinguished by two characteristics: interzooidal avicularia and marginal spines. The pitchforked spines clearly distinguish *G. furcula* n. sp. from the other *Gregarinidra* species, and *G. incrustans* shows the difference by having blunt spines and short-triangular avicularia. *Gregarinidra incrustans* was known to be distributed only in Japan until this species was reported from the South Sea, Korea, in the present study. This study provides descriptions of two species with detailed illustrations by scanning electron microscopy, distributional data, and a taxonomic key to the Korean *Gregarinidra* species. With the addition of two species reported herein, four Korean *Gregarinidra* are recorded: *G. corbula* Seo, 1996, *G. furcula* new species, *G. incrustans* (Silén, 1941), and *G. serrata* (MacGillivray, 1869). Finally, *Gregarinidra* totals 10 species worldwide.

**Keywords:** Bryozoa, *Gregarinidra*, new species, Korea, taxonomic key

### **INTRODUCTION**

The genus *Gregarinidra* Barroso, 1949 is one of 17 genera in the family Flustridae Lamouroux, 1821, known as a highly heterogeneous family of simple and weakly calcified anascan cheilostomes (Schwaha, 2020). The species of *Gregarinidra* show asymmetrical interzooidal avicularia with elongated, pointed rostra and mandibles and distinguished shapes of marginal spines. To date, nine species of *Gregarinidra* have been recorded worldwide: *G. corbula* in Korea (Seo, 1996; Seo and Kil, 2019), *G. gregaria* in the Adriatic Sea (Heller, 1867; Novosel et al., 2019), *G. inarmata* in Australia, New Zealand (Hincks, 1881; Gordon et al., 2009; Cook et al., 2018), and China (Liu and Liu, 2008), *G. incrustans* in Japan (Silén, 1941; Hirose, 2010), *G. rhizophora* in Japan, India and W Pacific (Ortmann, 1890; Thormely, 1907; Hirose, 2010), *G. serrata* in Australia (MacGillivray, 1869; Cook et al., 2018), New Zealand (Gordon, 1984), Japan (Hirose, 2010), and Korea (Chae et al., 2016), and *G. spinuligera* in South Africa and W Indian (Boonzaaier-Davids et al., 2020), *G. variabilis* in

Chile (Moayno, 1974), and *G. vegae* in Japan (Silén, 1941).

As mentioned above, two of nine *Gregarinidra*, *G. corbula* and *G. serrata*, have been recorded only from Jeju waters in the southern part of the Korean seas. Since *G. corbula* was first reported from Jeju waters (Biyangdo) by Seo (1996), it is still known to be an endemic species. Afterward, *G. serrata* was added from Jeju waters (Seogwipo) (Chae et al., 2016). Furthermore, *G. inarmata*, *G. incrustans*, *G. rhizophora*, and *G. vegae*, which occurred in Japan or China, are not found in Korean seas yet. These four species are expected to be distributed in Korean waters, too. Thus, this study aims to clarify the diversity and provide a taxonomic key to the Korean *Gregarinidra*.

### **MATERIALS AND METHODS**

The specimens were collected from three southern coastal localities in Korea National Park from 2018 to 2021. Additional specimens were examined in the MBRBK (Marine

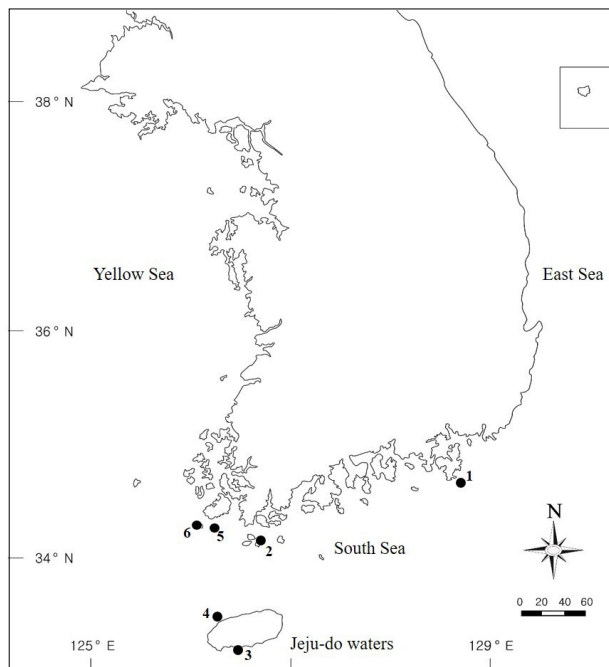
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**Table 1.** Sampling localities of *Gregarinidra* specimens in South Korean waters

Locality	Coordinates	Date	Depth (m)	Remark
1. Angyeongseom Island, Geoje, South Sea	34°41'00.5"N, 128°46'33.4"E	11 Nov 2016	15–30	MBRBK
2. Soan Island (Soando), South Sea	34°13'49.79"N, 126°38'54.96"E	1 Sep 2021	33	Korea National Park
3. Geomeunyeo (underwater cave), Jeju waters	33°14'19.2"N, 126°34'31.20"E	7 Jan 2011	15–30	MBRBK
4. Biyangdo Island, Jeju waters	–	6 Feb 1986	100	MBRBK
5. Hajo Island (Hajodo), South Sea	35°34'00.00"N, 127°33'20"E	11 Feb 2020	21	Korea National Park
6. Tanhangyeo, Jindo Island, South Sea	33°27'15.53"N, 128°26'04.45"E	16 Apr 2018	1–2	Korea National Park



**Fig. 1.** A map showing the collecting localities of *Gregarinidra* specimens used in this study. Numbers refer to the localities shown in Table 1.

Bryozoans Resources Bank of Korea), Woosuk University, Korea. All specimens were obtained from rocks in the subtidal zone by SCUBA diving, and they were preserved in 95% ethyl alcohol or air-dried. For identification, the external features of the zooid were observed under a stereomicroscope (Stemi SV6; Carl Zeiss, Germany), and bleached parts of specimens with hot aqueous sodium hypochlorite, washed, gold coated

(MCM-100; SEC, Korea) were observed with a scanning electron microscope (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). Sampling localities of the specimens mentioned in this study are given in Table 1 and Fig. 1.

## SYSTEMATIC ACCOUNTS

Phylum Bryozoa Ehrenberg, 1831  
 Class Gymnolaemata Allman, 1856  
 Order Cheilostomatida Busk, 1852a  
 Family Flustridae Lamouroux, 1821  
 Genus *Gregarinidra* Barroso, 1949

### 1. *Gregarinidra corbula* Seo, 1996 (Fig. 4)

*Gregarinidra corbula* Seo, 1996: 46; 2005: 323; 2010: 37; Seo and Kil, 2019: 72.

**Previous record.** Biyangdo Island, 6 Feb 1986, 100 m depth.

**Substratum.** Unknown.

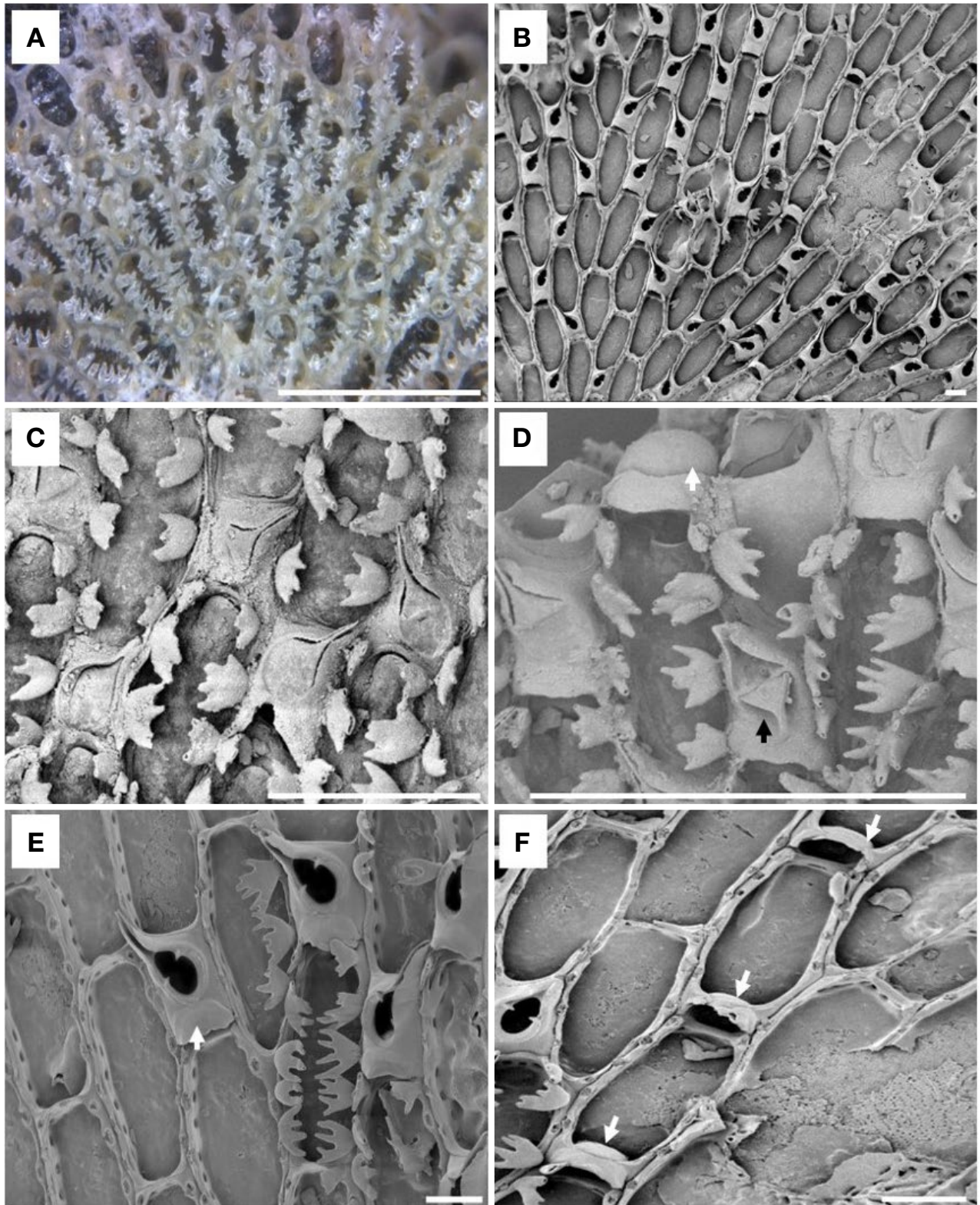
**Remarks.** This species has yet to be added to Korean waters or other seas since it was reported as a new species in Korea. Thus, specimens collected from Biyangdo Island, Jeju waters, in 1996 were photographed to compare four Korean species of *Gregarinidra*.

**Distribution.** Korea (Jeju waters).

### <sup>1</sup>\*2. *Gregarinidra furcula* new species (Fig. 2)

**Etymology.** Latin ‘*furca*’, pitchfork, fork, alluding to the

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



**Fig. 2.** *Gregarinidra furcula* n. sp. A, Light micrograph of colony, showing well-developed marginal spines, unbleached; B, Zooidal arrangement, bleached; C, Detailed zooids with operculum, marginal spines, and avicularia, unbleached; D, Cap-shaped ovicells (white arrow) and mandible of avicularium (black arrow), unbleached; E, Zooids with marginal spines, avicularia, and ovicell immersed in avicularium (white arrow), bleached; F, Ovicells (white arrows), bleached. Scale bars: A=1 mm, B, E, F=0.1 mm, C=0.3 mm, D=0.5 mm.

pitchfork-shaped spine.

**Material examined.** Korea: Jeollanam-do: Jindo-gun, off islets SW of Hajo Island (Hajodo), 34.2303°N, 125.9039°E, 11 Feb 2020 by SCUBA diving from 21 m in depth, MABIK IV00173455: Holotype and Paratype, Wando-gun, N of Soan Island (Soando), 34.2305°N, 126.6486°E, 1 Sep 2021 by SCUBA diving from 33 m in depth.

**Substratum.** Rock.

**Description.** Colony encrusting, radiating, unilaminar, multi-serial, delicate. Autozooids arranged vertically in irregular series, elliptical or rectangular, wider than long, 0.27–0.35 (0.32 ± 0.02) mm long, 0.11–0.15 (0.12 ± 0.01) mm wide. No cryptocyst and gymnocyst. Opesia elliptical or rectangular, often with straight proximal margin, almost as long as zooids, 0.28–0.34 (0.31 ± 0.02) mm long, 0.09–0.12 (0.11 ± 0.01) mm wide. Operculum semicircular or rectangular, 0.03–0.04 (0.03 ± 0.005) mm long, 0.05–0.06 (0.06 ± 0.005) mm wide, with a pair of pitchfork-shaped upward spines on lateral sides. Spines along mural rim, 4–6 pairs, pitchfork-shaped, bifurcate to trifurcate as fingers outstretched; usually first pairs on sides of operculum upright; rest spines bending over arching opesia inwards, but not meeting in midline. Avicularium interzooidal, distal to many zooids, positioned on a square cystid, 0.10–0.15 (0.12 ± 0.01) mm long, 0.08–0.12 (0.10 ± 0.01) mm wide, directed obliquely distolaterally; rostrum acute-triangular with sharp tip, mandible acute-triangular and hooked, no crossbar, just angular pivots; opesial cryptocyst narrow, descending, smooth. Ovicell small, cap-shaped, wider than long, 0.02–0.03 (0.02 ± 0.005) mm long, 0.08–0.09 (0.08 ± 0.005) mm wide, occurring beneath proximal end of distal zooid or immersed in avicularium. Distal transverse wall with two or three uniporous. Later wall with about seven uniporous. Ancestrula not seen.

**Remarks.** *Gregarinidra furcula* n. sp. is easily distinguished from all nine species belonging to the genus *Gregarinidra* by having 4–6 pairs of pitchfork-shaped spines. The serrated or bifurcated spines are shown in both *G. serrata* and *G. incrustans*. Whereas *G. serrata* (MacGillivray, 1869), described from Australia, has 8–10 pairs of spines, including bifurcated or trifurcated first two pairs and the rest with 2–3 small and slightly raised spikes, and elongated triangular avicularia, *G. furcula* new species has 4–6 pairs of spines, much less than *G. serrata* and short-triangular avicularia. *G. incrustans* (Silén, 1941), described from Japan, has 3–5 pairs of spines, including the 3rd and 5th pairs with 2–3 forks, and similar short-triangular avicularia to new species. *G. corbula*, an endemic to Korean waters, differs from *G. furcula* n. sp. in having smooth and elongated triangular spines (Fig. 4).

**Distribution.** Korea (South Sea).

### <sup>1</sup>\*3. *Gregarinidra incrustans* (Silén, 1941) (Fig. 3)

*Spiralaria incrustans* Silén, 1941: 59.

*Hippoflustra incrustans* Moyano, 1972: 86; Mawatari and Mawatari, 1979: 33.

*Gregarinidra incrustans*: Hirose, 2010: 42.

**Material examined.** Korea: Jeollanam-do: Jindo-gun, Jodo Island, Tanhangyeo, 16 Apr 2018, MABIK IV00173456.

**Substratum.** Rock.

**Description.** Colony encrusting, unilaminar, multiseriate, delicate. Autozooids arranged vertically, elliptical or rectangular, 0.27–0.44 (0.32 ± 0.04) mm long, 0.11–0.17 (0.14 ± 0.01) mm wide, occasionally tapering or pyriform. No cryptocyst and gymnocyst. Around mural rim, 3–5 pairs of short and blunt spines, arching over opesia but not meeting in midline, usually first pair of spines more upright, with some spines ending into 2–3 forks. Opesia elliptical or rectangular, often with straight proximal margin. Operculum rectangles with rounded corners. Avicularium interzooidal, short-triangular on square chamber, 0.10–0.14 (0.12 ± 0.01) mm long, 0.11–0.13 (0.12 ± 0.001) mm wide, directed obliquely, extending between distal zooids, crossbar incomplete; rostrum acute-triangular with sharp tip, mandible small and acute-triangular. Ovicell small, cap-shaped, not as wide as autozooid, occurring beneath proximal end of distal zooid or immersed in avicularium, 0.05 mm long, 0.07 mm wide. Distal transverse wall with three to four single pores. About 10 single pores in lateral wall present.

**Remarks.** *Gregarinidra incrustans* is distinguished from both *G. corbula* and *G. serrata*, which have previously been reported from Korea (Seo, 1996; Chae et al., 2016) by having blunt spines and short-triangular avicularia. Most of the morphological features, i.e., the shape of opesia and avicularia, immersed ovicell, and absence of cryptocyst and gymnocyst, are identical to the descriptions in Silén (1941), Mawatari and Mawatari (1979), and Hirose (2010). However, the spines illustrated by Silén (1941) and Mawatari and Mawatari (1979) are forked in the 3rd and 5th pairs, whereas Hirose's spines are not forked. In our specimens, some spines forked, too.

Since *Gregarinidra incrustans* was described from a depth of 100–135 m in Japanese waters (Silén, 1941; Mawatari and Mawatari, 1979), this is the first and only occurrence outside Japanese seas.

**Distribution.** Korea (South Sea) and Japan.

### 4. *Gregarinidra serrata* (MacGillivray, 1869) (Fig. 4)

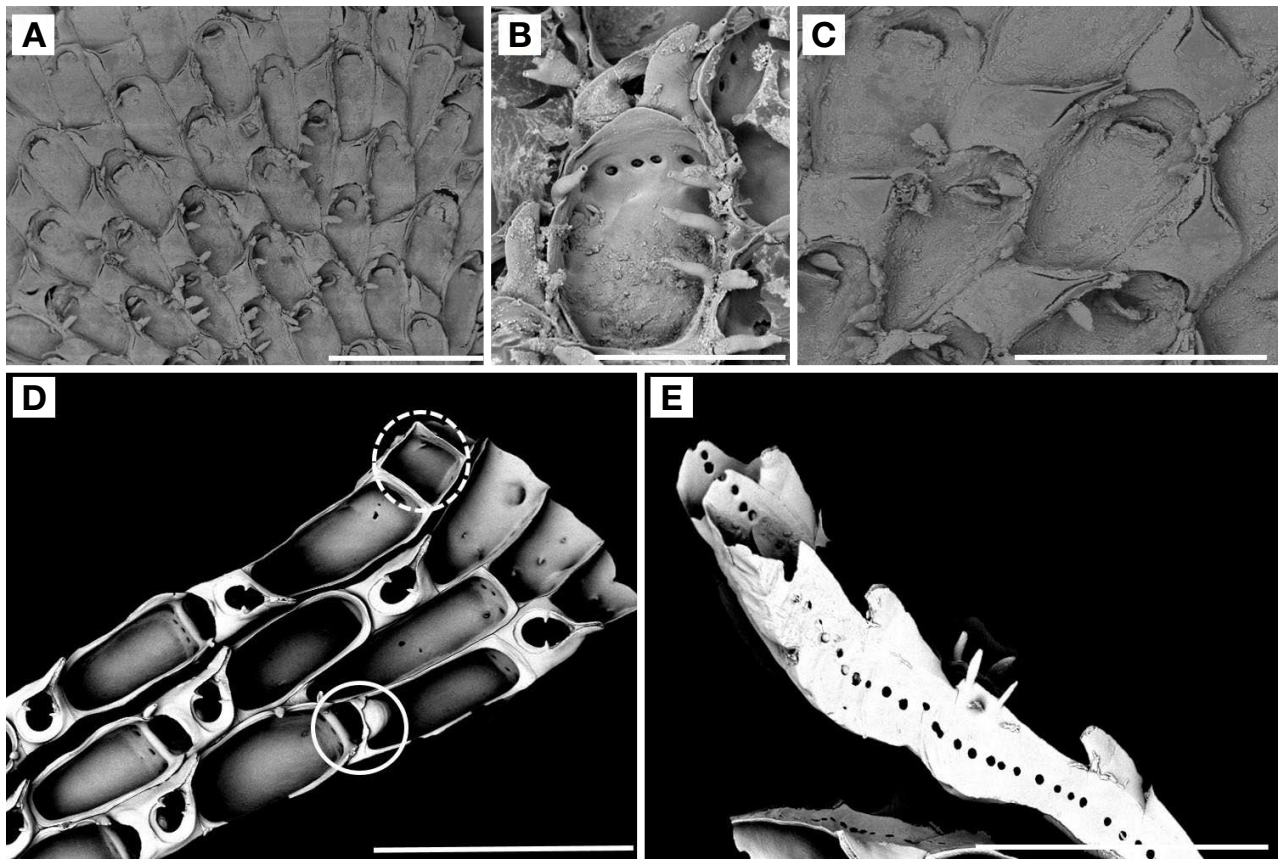
*Membranipora serrata* MacGillivray, 1869: 131.

*Spiralaia spinuligera*: Okada and Mawatari, 1936: 53.

*Spiralaia serrata*: Silén, 1941: 57; Mawatari, 1952: 272;

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





**Fig. 3.** *Gregarinidra incrustans* (Silén, 1941). A, Zooidal arrangement, unbleached; B, Detailed blunt marginal spines and four single pores of distal transverse wall, unbleached; C, Detailed avicularium and operculum, unbleached; D, Square avicularium chamber (dotted circle) and cap-shaped ovicells (circle), bleached; E, Lateral wall showing 10 single pores, bleached. Scale bars: A, D, E=0.5 mm, B=0.2 mm, C=0.3 mm.

1965: 599.

*Hippoflustra serrata*: Moyano, 1972: 86; Mawatari and Mawatari, 1979: 35.

*Gregarinidra serrata*: Gordon, 1984: 25; 1986: 28; Hirose, 2010: 43; Chae et al., 2016: 554; Seo and Kil, 2019: 74.

**Material examined.** Korea: Jeju-do: Seogwipo-si, Geomeunyeo (underwater cave), 7 Jan 2011, by SCUBA diving from 15–30 m in depth; Gyeongsangnam-do: Geoje-si, Angyeongseom Island, 11 Nov 2016, by SCUBA diving from 15–30 m depth, Min BS.

**Substratum.** Gastropod shells, rocks, and sponges.

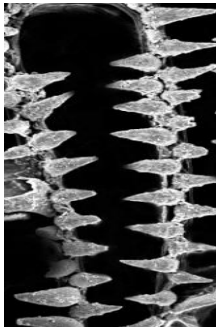
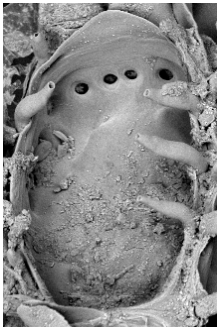

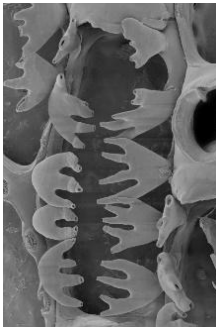
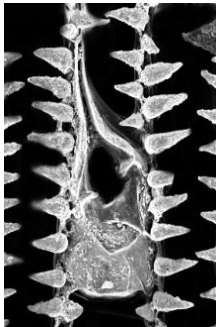

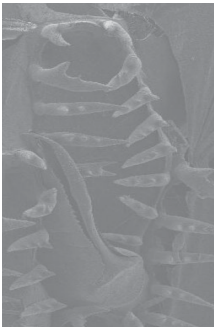
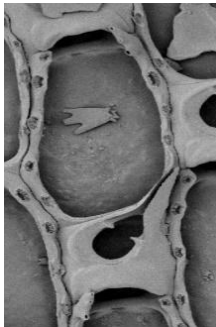
**Remarks.** This species occurred in the South Sea in this study since it was first reported from the underwater cave, Jeju-do waters, in 2011 (Chae et al., 2016).

**Distribution.** Korea (South Sea and Jeju-do waters), Japan, southern Australia, and New Zealand (Hauraki Gulf, Auckland Harbours, Foveaux Strait, Kermadec area).

## RESULTS AND DISCUSSION

Two species belonging to the genus *Gregarinidra* Barroso, 1949 (Bryozoa: Gymnolaemata: Flustridae) were first found in this study from Korean waters. *G. furcula* n. sp. is new to science, and *G. incrustans* (Silén, 1941) is newly added to the Korean fauna. With the addition of two species reported herein, four Korean *Gregarinidra* are recorded: *G. corbula*, *G. furcula* n. sp., *G. incrustans*, and *G. serrata*. Furthermore, the Korean *Gregarinidra*, which used to be distributed only in Jeju-do waters, are newly found in the South Sea for the first time. Finally, *Gregarinidra* came to be 10 species worldwide.

The colonial growth form of type species *Membranipora gregaria* Heller, 1867 of the genus *Gregarinidra* was known to be encrusting (Cook et al., 2018). However, Cook et al. (2018) noted that *Gregarinidra* in Australia mainly produces erect fronds from an encrusting base. Four Korean *Gregarinidra* species show both erect and encrusting forms in colonial growth. *Gregarinidra corbula* shows an erect colony, and the

	<i>G. corbula</i>	<i>G. incrustans</i>	<i>G. serrata</i>	<i>G. furcula</i> n. sp.
Spines				
	Not forked	Some forked	Forked	Forked
Interzoooidal avicularium				
	Long triangular	Short triangular	Elongated triangular	Short triangular
Distribution	Korea	Korea, Japan	Korea, Japan, Australia, New Zealand	Korea

**Fig. 4.** Comparison of *Gregarinidra furcula* n. sp. with its three congeneric species in Korea in two key characters and distributional records.

other three species, *G. furcula* n. sp., *G. incrustans*, and *G. serrata*, are encrusting the substratum.

Fig. 4 shows the differences between the four species of *Gregarinidra* from Korea in terms of spines, interzoooidal avicularium, and distribution. As shown in a taxonomic key below, all species have interzoooidal vicarious avicularium discriminated by the shape of avicularia. And spines are remarkably varied in those numbers and shapes. Concerning the distribution of 10 species, including four Korean species, each shows quite an endemism zoogeographically. Both *G. corbula* and *G. furcula* are endemic to Korea, and *G. incrustans* and *G. vegae* are found only in Korea and Japan. On the other hand, *G. gregarinidra*, *G. spinuligera*, and *G. variabilis* are only known to the Adriatic Sea, South Africa, and Chile, respectively. The remaining three species, *G. inarmata*, *G. serrata*, and *G. rhizophora*, are distributed in the Pacific only, including Japan or China, Australia, and New Zealand. Additionally, four Korean *Gregarinidra* species in this study occur only in the South and Jeju waters in the warm temperate to sub-

tropical seas. Considering the above facts, it seems clear that *Gregarinidra* species are somewhat endemic in their distributional pattern.

*Gregarinidra inarmata*, *G. rhizophora*, and *G. vegae* have not been found in Korean seas yet, even though they have been recorded in Japan and China (Silén, 1941; Liu and Liu, 2008; Hirose, 2010). The authors expect to find these three species in the Korean waters shortly.

**Key to the Korean species of the genus *Gregarinidra***

- 1. 10–15 pairs of spines, all not forked..... *G. corbula*
- Spines less than 10 pairs, some forked or not..... 2
- 2. All spines blunt, some forked or not..... *G. incrustans*
- All spines pointed, some spines forked..... 3
- 3. Avicularium elongated triangular and some spines forked..... *G. serrata*
- Avicularium short triangular and spines pitchfork-shaped..... *G. furcula* n. sp.

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## CONFLICTS OF INTEREST

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

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