The occurrence of two non-indigenous Conopeum (Bryozoa: Cheilostomata) species in the coastal waters of South Korea

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Abstract

Bryozoans are major fouling organisms and include some of the most invasive marine species globally. Hull fouling of transoceanic vessels is a major vector of non-indigenous bryozoans. One genus known to be important in this regard is Conopeum, but its occurrence in the coastal waters of South Korea has yet to be established. We sorted bryozoan samples from the collection of Park et al. (2017) and carried out surveys for marine organisms in 2013 and 2019–2020 in coastal waters of South Korea. We found two non-indigenous bryozoans: Conopeum reticulum (Linnaeus, 1767) and C. seurati (Canu, 1928). These two species and a third in the genus, C. hexagonum Seo, 1996, have distinctive morphologies and distributions along environmental gradients of the sampling sites. Gymnocyst and cryptocyst development and spine presence were used to identify each species morphologically. According to the salinity and turbidity of the sites, the inhabiting species appeared differently. The two non-indigenous species occurred in association with other sessile organisms such as oysters, mussels, and serpulid polychaetes. In particular, C. reticulum was associated with an invasive species of the Mediterranean mussel (Mytilus galloprovincialis Lamarck, 1819) and C. seurati was associated with the serpulid polychaetes Hydrodoides ezoensis Okuda, 1934 and Ficopomatus enigmaticus (Fauvel, 1923), as well as with the mytilid bivalve Xenostrobus securis (Lamarck, 1819), and the Pacific oyster Crassostrea gigas (Thunberg, 1793). Conopeum seurati and H. ezoensis completely encrusted all surfaces in artificial canal docks seemingly negatively affecting richness of native species.

Key words: Conopeum reticulum, Conopeum seurati, non-indigenous species, biofouling, euryhaline species

Introduction

Bryozoans are among the most important fouling organisms and some species have significant ecological and physical effects on estuarine and coastal habitats worldwide. They are colonial, mostly sessile aquatic suspension feeding invertebrates represented by approximately 6,000 living (Bock and Gordon 2013, 2020) and 15,000 fossil species (Gordon 2009).
Bryozoans foul various man-made structures, such as ship hulls, pipes, concrete structures, and plastic buoys, in addition to natural substrata, such as rocks and shells (Ryland 1970; Salta et al. 2009; Cook et al. 2018). Significantly, they can attach to the hulls of transoceanic vessels and various marine debris that drift across oceans, or to aquatic organisms being imported and exported, spreading to other regions as invasive aliens (Carlton 1987; Kaluza et al. 2010; Carlton et al. 2018; Gordon 2018). This can lead to the introduction of non-indigenous bryozoan species that can adversely affect biodiversity and species richness in natural ecosystems and fisheries (Carlton and Geller 1993; Molnar et al. 2008; Katsanevakis et al. 2014; McCuller and Carlton 2018), and even harm native ecosystems when and where they become invasive (Lodge et al. 2006).

Six non-indigenous bryozoan species have been reported in Korean waters (Je et al. 1988; Shin et al. 2013): *Amathia verticillata* (delle Chiaje, 1822) (previously reported as *Zoobotryon verticillatum*), *Bugulina californica* (Robertson, 1905) (previously reported as *Bugula californica*), *Bugula neritina* (Linnaeus, 1758), *Celleporaria brunnea* (Hincks, 1884), *Schizoporella unicornis* (Johnston in Wood, 1844), and *Tricellaria occidentalis* (Trask, 1857). In addition, further ten non-indigenous bryozoan species (*Amathia distans* Busk, 1886, *Bowerbankia gracilis* Leidy, 1855 complex, *Bugula flabellata* (Thompson in Gray, 1848), *Bugula stolonifera* (Ryland, 1960), *Conopeum seurati* (Canu, 1928), *Cryptosula pallasiana* (Moll, 1803), *Arbopercula tenella* (Hincks, 1880), *Escharoides excavata* (MacGillivray, 1860), *Membraniporopsis tubigera* (Osburn, 1940) and *Watersipora subtorquata* (d’Orbigny, 1852)) have been reported in marine ecoregions adjacent to Korean waters – i.e., the Yellow Sea, the East China Sea, and the East Sea (Sea of Japan) (Zvyagintsev et al. 2011; Lee II and Reusser 2012; Lutaenko et al. 2013).

The genus *Conopeum* Gray, 1848 includes twenty species worldwide (Bock and Gordon 2020), of which seven have been reported in Northeast Asia (Figure 1). Of these, *C. hexagonum* Seo, 1996 has been recorded in South Korea (Seo 1996, 2005), *C. nakano sum* Grischenko, Dick & Mawatari, 2007 in Japan [reported as *C. reticulum* by Mawatari (1956) and recognised as a new species by Grischenko et al. (2007)], and *C. seurati* (Canu, 1928) in the Russian Far East (Kubanin 1975; Zvyagintsev 2003; Zvyagintsev et al. 2011). The species *C. eriophorum* Lamouroux, 1816, *C. loki* Almeida, Souza & Vieira, 2017, and *C. reticulum* Linnaeus, 1767 have been reported from China (Li 1988; Liu et al. 2001; Liu and Liu 2008; Gordon 2016; Almeida et al. 2017). A further putative species listed by Liu and Liu (2008) from China, following a never published manuscript by Liu and Ristedt (Tilbrook 2011; Almeida et al. 2017).

To date, no systematic survey of *Conopeum* has been made in Korean waters despite the ease of its introduced via hull fouling. Examination of samples from previous and new surveys in South Korean waters allowed us
to find two non-indigenous species belonging to the genus *Conopeum*, *C. reticulum* and *C. seurati* whose ecological requirements and distribution in Korean waters are discussed.

**Materials and methods**

Bryozoan species were sorted from fouling samples which were collected by Park from June 2010 to March 2013 and where ports of trading and fishing on the Korean coast (see Park et al. 2017). Additional surveys were performed in Songdo Newtown, Incheon, in 2013 and at coastal waters of the Yellow Sea, in 2019 and 2020 in South Korea (Figure 2; Table S1).

We obtained GPS positions of survey sites using GPS receiver (Montana® 650TK, Garmin, US) or GPS digital camera (WG-4 GPS, Ricoh, Japan). The samples were collected from a variety of hard substrates such as quay walls, floating docks, vessel hulls, columns, tires, ropes, and buoys. The fouling communities were scraped from the substrates using chisels using knives and collected using nets (0.5 mm mesh size) from areas of 10 cm × 10 cm. For additional surveys, the coverage of each bryozoan species by site was examined and categorized as either low (< 10%), intermediate (10–70%) or high (> 70%). We recorded the substratum type and conditions for each site from which each specimen was collected. Collected samples were photographed and then preserved with 10% seawater formalin or 70% ethanol. The preserved samples were taken to a laboratory and sorted into phyla and classes (Park et al. 2017).
Sorted bryozoans were identified to species level using a stereo microscope (M205C, Leica, Germany) and scanning electron microscope (SEM; SU3500, Hitachi, Japan). Specimens prepared for SEM examination were bleached for at least two hours in 2% sodium hypochlorite solution until the membrane and impurities were dissolved. The specimens were then washed in distilled water for 30 seconds to remove any residue and dried for 100 minutes in a critical point dryer (EM CPD300, Leica, Germany). Dried samples were coated in gold at 15V for 120 seconds using an ion sputter coater (MC1000, Hitachi, Japan) (Min et al. 2017). Global distributions of the two species found were inserted on a map of the marine ecoregions (Spalding et al. 2007). Information about environmental factors in collecting sites were acquired from MEIS (2020).

**Results**

The general morphological characters of the genus *Conopeum* appear closest to the family Membraniporidae, but a lack of twinned ancestrulae suggests it is related to the family Electridae (Winston and Hayward 2012; Gordon 2016). Two species of *Conopeum* found from the rapid survey in South Korean waters are identified and described herein.
Two non-indigenous bryozoan in South Korean Waters

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**Figure 3.** *Conopeum reticulum*. A: Zooids with a few broken distal spines (scale bar = 500 μm). B: Zooid with distal and lateral spines (scale bar = 300 μm). C: Periancestral zooids with wide proximal gymnocyst and the “arrow” show the septulum buttressed in the terminal wall (scale bar = 500 μm). D: Distal septulum (scale bar = 100 μm). E: Lateral septulum (scale bar = 50 μm). F: Colony with triangular kenozooids. Photomicrographs by C. Yu.

**Systematic account**

Phylum Bryozoa Ehrenberg, 1831  
Class Gymnolaemata Allman, 1856  
Order Cheilostomatida Busk, 1852  
Family Electridae Stach, 1937  
Genus *Conopeum* Gray, 1848

Type species: *Millepora reticulum* Linnaeus, 1767

**Conopeum reticulum** (Linnaeus, 1767)  
(Figures 3, 5A)  
(New Korean Name: Se-mang-i-ki-beol-le)

*Millepora reticulum* Linnaeus 1767: 1284.  
*Millepora reticulum*: Esper 1791: 205, Millep. Tab. 11, Figs. 1–2.  
*Membranipora lacroixii*: Hincks 1880: 129, pl. 17, figs. 5–8.  
*Membranipora lacroixi*: Robertson 1908: 261, pl. 14, fig. 5.  
*Conopeum reticulum*: Harmer 1926: 211, pl. 13, fig. 12; Osburn 1950: 31, pl. 2, fig. 11; Ryland 1965: 30, fig. 13; Prenant and Bobin 1966: 124, fig. 32; Menon and Nair 1975: 13, fig. 21; Ryland and Hayward 1977: 60, fig. 20; Lichtschein de Bastida and Bastida 1980: 379, figs. 3, 14, 15, 16; Zabala and Maluquer 1988: 76, fig. 65; Hayward and Ryland 1998: 120, figs. 23, 24A, B; Faasse and De Blauwe 2004: 32, figs 41–43; Abdel-Salam and Ramadan 2008: 6, fig. 2; Cook et al. 2018: 84; López-Gappa and Liuzzi 2018: 1163, fig. 3A.
Type locality: uncertain, maybe the Atlantic coast of Europe (Hayward and Ryland 1998).

Material examined: Gomso Port, Buan (35°35′7.69″N; 126°36′21.54″E), 25 March 2019 (MABIK IV00169684, 169687, 169688), on oyster shell; Gosapo Beach, Buan (35°39′51.27″N; 126°30′35.55″E), 26 March 2019 (MABIK IV00169689), on wood debris; Garyeokdo Port, Buan (35°43′35.43″N; 126°31′46.03″E), 26 March 2019 (MABIK IV00169685), on mussel shell; Gyeokpo Port, Buan (35°37′21.68″N; 126°28′8.85″E) 15 June 2020 (MABIK IV00169691), on mussel shell.

Description: Colony encrusting, unilaminar, forming sheet-like crusts. Autozooids thin and delicate, rectangular or hexagonal, longer than wide. Cryptocyst granular, wide proximally. Gymnocyst smooth and wide, especially proximally. Kenozooids triangular, located at distal angle of autozooid. One pair of spines located on distal gymnocystal corners. Two or three pairs of gymnocystal spines can occur laterally. Septulum multiporous, round, wider in the distal wall than in the lateral walls. Ovicells and avicularia absent.

Remarks: Triangular kenozooids were not observed in the peri-ancestrular zone and in small colonies, likely because they develop in large adult colonies as suggested by Cook (1964) and Grischenco et al. (2007). Periancestrial zooids have a gymnocyst wider than normal zooids and shorter spines. The lateral spines were arched over the front similarly other records (Figure 3B; Prenant and Bobin 1966; Lichtschein de Bastida an Bastida 1980). A septulum buttressed in the terminal wall was observed (Figure 3C), unlike other records only in the peri-ancestrular zone (Hayward and Ryland 1998; López-Gappa and Liuzzi 2018). This species is similar to C. loki, with distal and lateral spines, as reported for specimens from China (Almeida et al. 2017). However, C. loki has distal communication pores in a single row in spite of the multiporous mural septula present in C. reticulum. Furthermore, C. reticulum lacks the falciform cryptocystal plate that is typical of C. loki (Almeida et al. 2017).

Conopeum reticulum was collected in ports and beaches near to tidal mud flats with freshwater input. Samples, except for those found on the beach, were collected at depths of 1–2 m. In the ports, it occurred in association with bivalves. A few colonies were less than 5 cm in size whereas those found in Gyeokpo Port, were 10 cm in size and often encrusting mussel shells.

Conopeum seurati (Canu, 1928)

(Figures 4, 5B)

(Neoporean Name: Jan-ga-si-se-mang-i-ki-beol-le)

Nitscheina seurati Canu 1928: 263, pl. 30, figs. 3–6.

Conopeum seurati: Bobin and Prenant 1962: 381, figs. 2–3; Prenant and Bobin 1966: 127, figs. 33–34; Ryland and Hayward 1977: 62, fig. 21; Winston 1982: 117, figs. 31, 43; Poluzzi and Sabelli 1985: 265, figs. 1, 5, 8; Gordon and Kawatari 1992: 17, pls. 2A–C, 4A; Gugel 1997: 107, figs. 1–2; Hayward and Ryland 1998: 124, figs. 24C, D, 25; O'Dea and Okamura 1999: 583, fig. 2; Faasse and De Blauwe 2004: 33, fig. 46; Gontar 2013: 362, fig. 1; López-Gappa and Liuzzi 2018: 1162, figs. 2D, E; Gordon et al. 2020: 955, figs. 3–4.
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Figure 4. Conopeum seurati. A: Autozooids and a kenozooid, arrowed (scale bar = 500 μm). B: A distal spine and distal septulum (scale bar = 100 μm). C: Distal septulum and lateral septula (scale bar = 100 μm). D: Proximal septulum (scale bar = 100 μm). E: Acicular spinules on lateral wall (scale bar = 50 μm). F: Colony on a carbonate tube of the serpulid polychaete Hydroides ezoensis found in the manmade Songdo New City Central Canal. Photomicrographs by C. Yu and photo by J.-S. Hong.

Type locality: Estuary of Qued Bezirk, Tunisia, Mediterranean Sea.

Material examined: Gunsan Port, Gunsan (35°58′35.48″N; 126°37′22.14″E), 23 Feb 2012 (NIBRIV0000813656), on mussel shell; Songdo, Incheon (37°23′26.00″N; 126°38′35.94″E), 5 March 2013 (MABIK IV00165958, 169683), on wood panel, plastic floating dock, and calcareous polychaete tube; Gungpyeong Port, Hwaseong (37°7′3.56″N; 126°40′48.74″E), 25 September 2019 (MABIK IV00169686), on oyster shell collected from fishing boat hull.

Description: Colony encrusting, unilaminar, pale-brown in color. Autozooids hexagonal or rectangular in shape. Gymnocyst absent. Cryptocyst uniformly narrow, deeply sloping from the zooidal rim and flat peripherally, but granular and raised around the opesium. Two spines on the distal margin of the gymnocyst, often singly or frequently absent. Kenozooid infrequent, dwarfed. Septulum multiporous, round on lateral wall, variably shaped on distal and proximal walls. Acicular spinules on interior lateral walls around septula (Figure 4E). Tiny pores on basal walls (Figure 4C, D) Ovicells and avicularia absent. Ancestrula not observed.

Remarks: The cryptocyst of C. seurati is surrounded by narrow furrow (Figure 4B; Gordon et al. 2020), but C. hexagonum and C. reticulum are absent.
The kenozooid of *C. seurati* may occur at zooid arrangement disrupted (Hayward and Ryland 1998), but specimen we observed has kenozooids adventitious without disrupted likewise Gordon et al. (2020).

*Conopeum seurati* was collected from artificial estuarine structures with other sessile organisms, such as serpulid polychaetes, mussels, oysters and one other bryozoan, *Cryptosula pallasiana*. Samples were collected at depths of 1~2 m, and 0~3 m in the canal. The colonies were dominant in Incheon and Pohang with very large colonies encrusting nearly completely all available substrata, while in Gunsan, Mokpo and Hwaseong few colonies were observed, each less than 10 square cm in size.

**Discussion**

*Species diversity in Korean waters*

Besides the two *Conopeum* species here reported, a further species, *Conopeum hexagonum*, is known from Korean waters, each showing distinctive, morphological characters. *Conopeum hexagonum* lacks gymnocyst, kenozooids and spines (Seo 1996, 2005) but has an extensive tuberculated cryptocyst
Table 1. Morphological and ecological characters of three *Conopeum* species from South Korea.

| Species       | Gymnocyst         | Cryptocyst                      | Spines                                                     | Kenozooid                  | Salinity (PSU) | Tolerance of turbidity | Substrata         |
|---------------|-------------------|--------------------------------|------------------------------------------------------------|----------------------------|----------------|------------------------|------------------|
| *C. hexagonum*| Absent            | Developed, granular and subdenticulate | Absent                                                      | Absent                     | 34.5           | Unknown                | Fishing net      |
| *C. reticulum*| Present or reduced. Smooth. Wider at periancesticular | Developed, granular            | A Pair on distal corner and two or three pairs on lateral wall | Triangular, located on old zooids on distal sometimes | 30–32          | Low (maybe)            | Bivalve shell, wood |
| *C. seurati*  | Absent            | Thin, granular                  | A pair or single on distal margin rarely                   | Elongated or dwarfed, infrequently | 20–31          | High                   | Shell, polychaete tubes, wood |

that distinguish it from *C. seurati*. *Conopeum reticulum* has a proximal cryptocyst that is comparably wider and a septulum in the terminal wall that is larger relative to that of *C. seurati*. These two species also differ for the zooidal spines with *Conopeum reticulum* having lateral spines besides the pair of disto-lateral spines, and *C. seurati* lacking lateral spines and only occasionally showing single or paired oral spines (López-Gappa and Liuzzi 2018; Table 1; Figures 3, 4). Furthermore, adult colonies of *C. reticulum* have triangular kenozooids on the distal margin of autozooids (Figure 3F), whereas *C. seurati* has infrequently small kenozooids (Figure 4A).

**Ecological distribution**

The habitats of the three species of *Conopeum* reported from Korean waters differ slightly for their salinity (Table 1). *Conopeum hexagonum* was found in habitats with seawater salinities of 34.5 PSU, *C. reticulum* at 30–32 PSU, while *C. seurati* was associated with estuarine waters at 20 PSU. *Conopeum hexagonum* occurred offshore under relatively stable salinity conditions in the eastern part of the East China Sea, while *C. seurati* was found in large river mouth such as Geum River (20–30 PSU), Han River, Yeongsan River (25–31 PSU), and Hyeongsan River (26–30 PSU; Kim et al. 2008) with seasonal variations in freshwater inflow (Rho et al. 2012; MEIS 2020). *Conopeum* species seem well adapted to waters with low salinity and salinity variations and is likely that salinity is an important factor in determining the distribution of *Conopeum* species (Ryland 1970; Poluzzi and Sabelli 1985; Seo 1996; Tyler-Walters and Ballerstedt 2005).

Tyler-Walters (2015) reported tolerance of *C. reticulum* to turbid waters on rocks of the Tamar Estuary, England. Consistently, this species was found close to a tidal mud flat in Gomso Bay in South Korea where the turbidity is fairly high (max 500 mg/L) due to nearby riverine inflow and strong tidal currents in this macrotidal setting (Lee 2010; Rho et al. 2012). In contrast, the ports on the west coast of Korea, where *C. seurati* was collected, were less turbid than Gomso Bay (20–50, max 100 mg/L; MEIS 2020), suggesting that this species is less tolerant to turbidity.
**Historical distribution**

The original distribution of *Conopeum reticulum* is uncertain (Hayward and Ryland 1998) because Linnaeus (1767) did not record the type locality of his species. *Conopeum reticulum* has been reported from the Mediterranean (Esper 1791; Gmelin 1791), East Indian Sea (Esper 1791), the British isles (Gray 1848; Hincks 1880), Australia (Haswell 1880), Florida (Osburn 1914) and the Pacific coasts of North America (Robertson 1908; O'Donoghue and O'Donghue 1923). Harmer (1926) listed records from the Mediterranean and Europe to North America and Asia. Prenant and Bobin (1966) reported that *C. reticulum* is less widespread than *C. seurati* in the Mediterranean and Zabala and Maluquer (1988) suggested that *C. reticulum* was imported with commercial mussels from Atlantic coasts to the Mediterranean.

The distribution of *Conopeum seurati* is incompletely known, due to its taxonomic confusion with other species such as *C. reticulum* and *Einhornia crustulenta* (Pallas, 1766) (Prenant and Bobin 1966; Hayward and Ryland 1998). Although the type locality of *Conopeum seurati* is the estuary of Tunisia, Mediterranean (Canu 1928), it is widespread in shallow, low salinity waters from the North African, Mediterranean to North Sea regions (Prenant and Bobin 1966).

Both species are known to occur from the North Sea and Atlantic coasts of Europe to North and South America, Africa, and Oceania (Winston 1977; Lee II and Reusser 2012; Gordon 2018; López-Gappa and Liuzzi 2018; Table S2 with its references provided in Appendix 1). First records from East Asia are relatively recent as *C. seurati* was reported from the coast of the Russian Far East only in the 1970s (Kubanin 1975; Zvyagintsev 2003; Zvyagintsev et al. 2011) and *C. reticulum* from the east coast of China in Yellow Sea in the 1980s (Li 1988).

**Introducing vectors**

*Conopeum reticulum* and *C. seurati* are considered as non-indigenous fouling organisms in several regions of the world, with ship’s hulls and aquaculture as possible main vectors (Ryland 1965, 1970; Hayward and Ryland 1998; Naylor et al. 2001; Zvyagintsev 2003; Lee II and Reusser 2012). With increasing global cargo ship movements (Kaluza et al. 2010), they will likely spread further (Carlton and Geller 1993; Drake and Lodge 2007). Due to the recent economic development of South Korea and other Northeast Asian countries, the rapid growth of marine traffic between different regions plays a crucial role in the spread of invasive species through hull fouling (Ducruet et al. 2010; Kaluza et al. 2010). Sites, such as Incheon, Gunsan, Mokpo and Pohang, where we collected *C. seurati* are international trading port or nearby. Since 2010, about 200,000 ships moved between Korean ports and NE Asian ports every year (KOSIS 2020).
Aquaculture shells, such as *Mytilus galloprovincialis* Lamarck, 1819 and *Crassostrea gigas* (Thunberg, 1793), also favoured introducing and settling of *Conopeum* species. *Conopeum reticulum* was seemingly introduced into the Mediterranean by mussel import (Zabala and Maluquer 1988), and both *C. reticulum* and *C. seurati* occurred on oysters and mussels (Hayward and Ryland 1998). However, *C. gigas* is a native species in NE Asia (Fofonoff et al. 2018) whereas *M. galloprovincialis* was introduced by transoceanic vessels hull fouling since the World War II, not by aquaculture import (Lee et al. 2010). In sampling sites, *Conopeum* species encrusted shells of these two aquaculture species. Aquaculture seems not to be a main introducing pathway for *Conopeum* species in Korean seawaters, but may enhance settlement providing substrata for these species.

**Co-occurrences with other sessile species**

*C. reticulum* and *C. seurati* were occurred with the mussel and oyster above. In addition, *C. seurati* was found on serpulid polychaete tubes – i.e., *Hydroides ezoensis* Okuda, 1934 and *Ficopomatus enigmaticus* (Fauvel, 1923), and on molluscan shells – i.e., the mytilid bivalve *Xenostrobus securis* (Lamarck, 1819). The co-occurrence with serpulid *H. ezoensis* is first reported in this study, and *F. enigmaticus* also represented a favorite substratum in Italy (Poluzzi and Sabelli 1985), New Zealand (Read and Gordon 1991) and Argentina (López-Gappa and Liuzzi 2018). The mytilid *X. securis* co-occurred with *C. seurati* in New Zealand (Gordon and Mawatari 1992).

It is worth noting that both species show a certain fidelity for the hosting organism in wide and widely separated world regions, and that organisms acting as substrata are also known as invasive alien taxa in South Korean waters and in wide areas (Lee II and Reusser 2012; GISD 2020).

**Ecological impact**

In the recently developed city of Songdo, the bryozoan *C. seurati* and serpulid polychaete *H. ezoensis*, thrive on the concrete substratum in the central artificial canal which receives inflowing water from the adjacent sea through filtering systems. Non-indigenous species are generally opportunistic and can recruit and rapidly colonize new areas (Dunstan and Johnson 2004; Lagos et al. 2017). On artificial substrata, they also tend to grow faster than native species (Tyrrell and Byers 2007; Lagos et al. 2017). Since the canal was only completed in 2009, *C. seurati* and *H. ezoensis* may have settled first or grew more rapidly than other species (Poluzzi and Sabelli 1985; Thorp et al. 1987) to dominate the assemblage colonizing the artificial substratum.

It is yet uncertain if *C. reticulum* affects native coastal ecosystems given the small colonies observed. However, *C. seurati* with *H. ezoensis* seemingly affect negatively the richness of native species in artificial
habitat, as there were no other species found where these two species encrusted all surfaces. Further research is needed to accurately evaluate the quantitative impact of these non-indigenous bryozoans on South Korean marine ecosystems.

Conclusions

Two non-indigenous bryozoan species, *C. reticulum* and *C. seurati*, are here reported for the first time from South Korean waters. The two species are distinguished by morphology and slightly different environmental requirements. Both species represent non-indigenous species in the area and we assume that the main vector for their introduction would have been international shipping. Providing valuable shell substrata, aquaculture seemingly enhances their settlement, but does not represent a major vector for introduction. Both *C. reticulum* and *C. seurati* were found associated with other sessile invertebrate species. In particular, *C. seurati* was associated with invasive serpulid polychaetes.

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Supplementary material
The following supplementary material is available for this article:
Table S1. Occurrences of Conopeum reticulum and C. seurati in the South Korea.
Table S2. References for the construction of the distribution maps of Conopeum reticulum and C. seurati against the marine ecoregion suggested by Spalding et al. (2007).
Appendix 1. References for Table S2.
This material is available as part of online article from:
http://www.reabic.net/aquaticinvasions/2021/Supplements/AI_2021_Yu_etal_SupplementaryMaterial.xlsx