Aquatic Invasions (2021) Volume 16, Issue 2: 281–296

Research Article

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

Cheol Yu[1,2], Sungtae Kim[3,4], Jae-Sang Hong[3] and Keun-Hyung Choi[2,*]

[1]*Department of Taxonomy and Systematics, National Marine Biodiversity Institute of Korea (MABIK), Seocheon-gun, Chungcheongnam-do, 33662, Republic of Korea*

[2]*Department of Ocean Environmental Sciences, College of Natural Science, Chungnam National University, Daejeon, 34134, Republic of Korea*

[3]*Department of Ocean Sciences, College of Natural Science, Inha University, Incheon, 22212, Republic of Korea*

[4]*Korea Institute of Coastal Ecology, Inc., Gyeonggi, 14449, Republic of Korea*

Author e-mails: *yfe@mabik.re.kr (CY), stkim@coastkorea.com (SK), jshong@inha.ac.kr (JSH), keunhchoi@cnu.ac.kr (KHC)*

**Corresponding author*

Citation: Yu C, Kim S, Hong J-S, Choi K-H (2021) The occurrence of two non-indigenous *Conopeum* (Bryozoa: Cheilostomata) species in the coastal waters of South Korea. *Aquatic Invasions* 16(2): 281–296, https://doi.org/10.3391/ai.2021.16.2.05

Received: 7 April 2020

Accepted: 2 November 2020

Published: 22 December 2020

Handling editor: Leandro Vieira

Thematic editor: Charles Martin

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 *Hydroides 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. nakanosum* 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

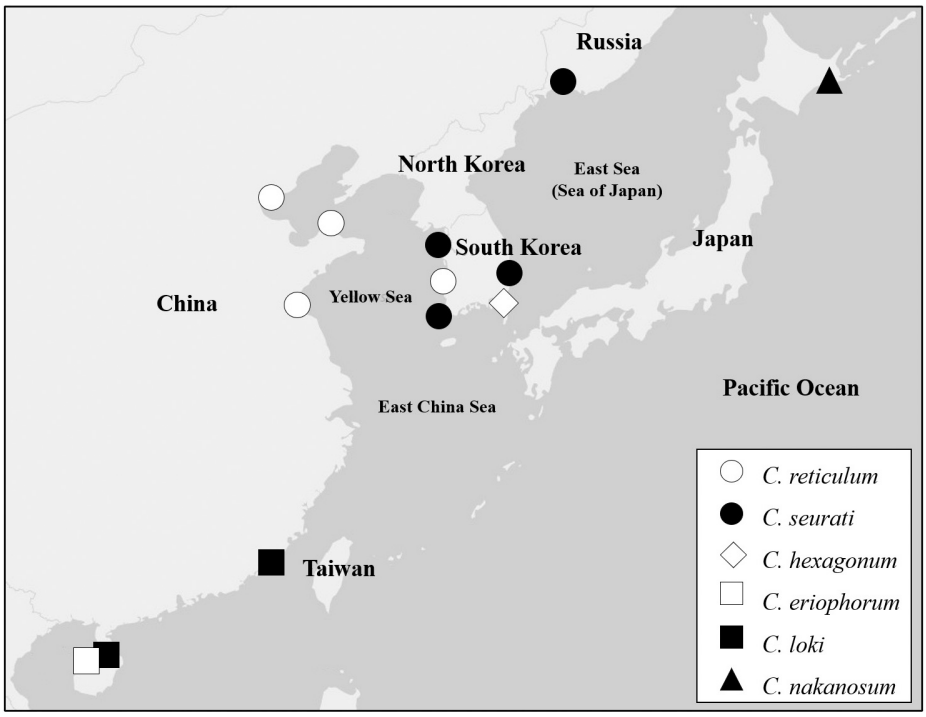

Figure 1. Distribution of *Conopeum* species in northeast Asia. *C. reticulum* and *C. seurati* are reported in Korean coastal waters from the present study. *C. reticulum*: Li 1988, this study. *C. seurati*: Kubanin 1975, Zvyagintsev 2003, Zvyagintsev et al. 2011; this study. *C. hexagonum*: Seo 1996, 2005. *C. eriophorum*: Liu and Liu 2008. *C. loki*: Liu et al. 2001, Liu and Liu 2008, Almeida et al. 2017. *C. nakanosum*: Mawatari 1956, Grischenko et al. 2007.

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 knifes 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).

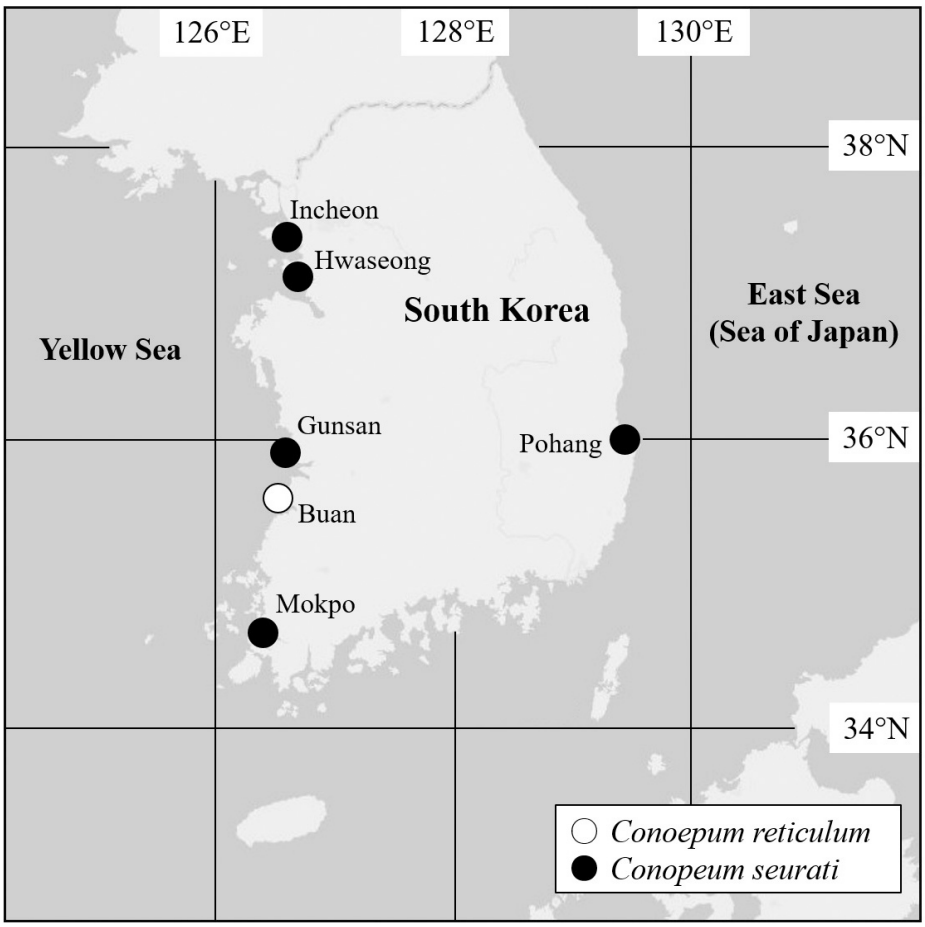

Figure 2. Collected sites (city name) of *Conopeum* species in South Korea (Republic of Korea).

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.

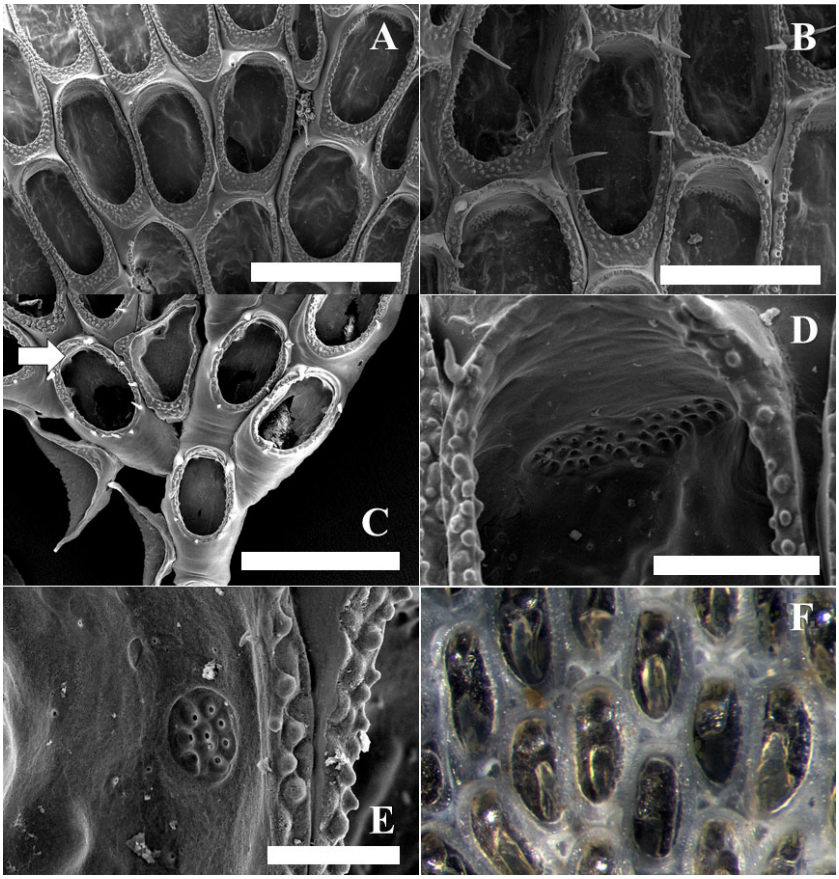

Figure 3. *Conopeum reticulum*. A: Zooids with a few broken distal spines (scale bar = 500 µm). B: Zooid with distal and lateral spines (scale bar = 300 µm). C: Periancestrular zooids with wide proximal gymnocyst and the "arrow" show the septulum buttressed in the terminal wall (scale bar = 500 µm). 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. 2L; 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 Grischenko et al. (2007). Periancestrular 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)

(New Korean 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 Mawatari 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.

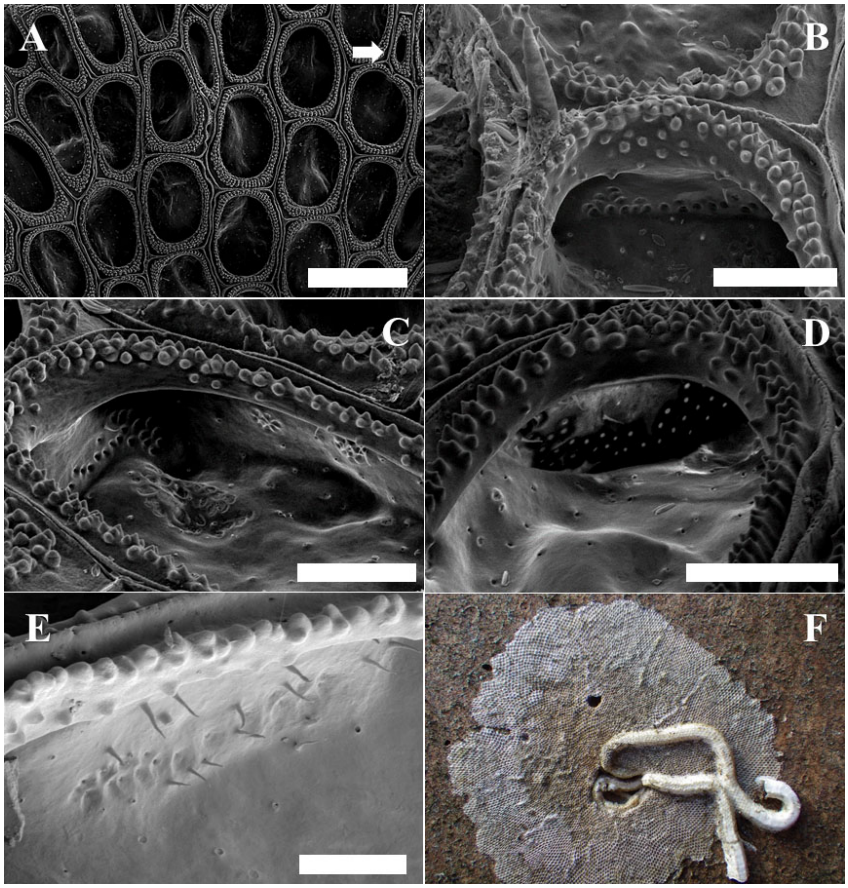

Figure 4. *Conopeum seurati*. A: Autozooids and a kenozooid, arrowed (scale bar = 500 μm). B: A distal spine and distal septulum (scale bar = 100 μm). C: Distal septulum and lateral septula (scale bar = 100 μm). D: Proximal septulum (scale bar = 100 μm). E: Acicular spinules on lateral wall (scale bar = 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.

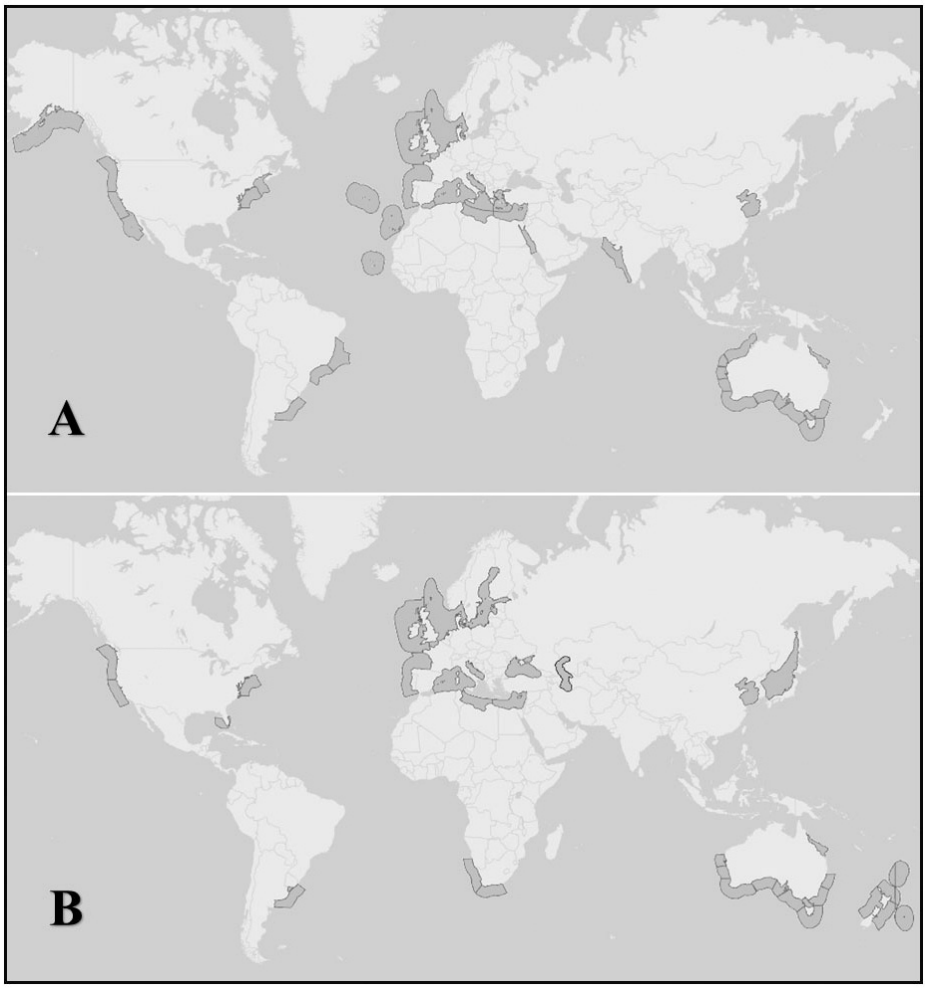

Figure 5. Global distribution of *Conopeum reticulum* (A) and *C. seurati* (B) based on marine ecoregion (Spalding et al. 2007).

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 periancestrular	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 Euryhaline	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* occured 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. galloprovinciallis* 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

Conopeum 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.

Acknowledgements

We thank Chae-Lin Lee, Seok-Hyeon Nam, Suk Hyun Kim, and So-Hyeok Woo for field survey assistance and sampling support, and Prof. Ji-Eun Seo and Ho-Jin Yang for providing Chinese bryozoan references and for guiding specimen treatment for SEM analyses. We are also especially grateful to reviewers and editor for careful reading and helpful comments on our manuscript.

Funding Declaration

This work was supported by grants from the National Institute of Biological Resources (NIBR) funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR No. 2014-02-001), and from the National Marine Biodiversity Institute of Korea (MABIK; 2020M00100, 2021M00100).

References

Abdel-Salam KM, Ramadan SE (2008) Fouling Bryozoa from some Alexandria harbours, EGYPT. (II) Encrusting species. *Mediterranean Marine Science* 9: 5–20, https://doi.org/10.12681/mms.129

Almeida ACS, Souza FBC, Vieira LM (2017) Malacostegine bryozoans (Bryozoa: Cheilostomata) from Bahia State, northeast Brazil: taxonomy and non-indigenous species. *Marine Biodiversity* 48: 1463–1488, https://doi.org/10.1007/s12526-017-0639-x

Allman GJ (1856) A monograph of the Freshwater Polyzoa, including all the known species, both British and Foreign. The Ray Society, London, 119 pp, https://doi.org/10.5962/bhl.title.9143

Bobin G, Prenant M (1962) Remarques sur quelques Alderinidae (Bryozoaires Chilostomes). *Cahiers de Biologie Marine* 3: 13–26

Bock PE, Gordon DP (2013) Phylum Bryozoa Ehrenberg, 1831. *Zootaxa* 3703: 67–74, https://doi.org/10.11646/zootaxa.3703.1.14

Bock PE, Gordon DP (2020) World List of Bryozoa. *Conopeum* Gray, 1848. World Register of Marine Species (WoRMS). http://www.marinespecies.org/aphia.php?p=taxdetails&id=110903 (accessed 20 February 2020)

Busk G (1852) An account of the Polyzoa, and sertularian zoophytes, collected in the Voyage of the Rattlesnake, on the coasts of Australia and the Louisiade Archipelago. In: MacGillivray J (ed), Narrative of the Voyage of the H.M.S. Rattlesnake Vol. 1. T. & W. Boone, London, pp 343–402

Busk G (1886) Report on the Polyzoa collected by H.M.S. Challenger during the years 1873-1876. Part 2. The Cyclostomata, Ctenostomata and Pedicellinea. *Report on the Scientific Results of the Voyage of the HMS "Challenger", Zoology* 17: 1–47

Canu F (1928) Trois nouveaux Bryzoaires d'eau douce. *Bulletin de la Société d'Histoire naturelle de l'Afrique du Nord* 19: 262–264

Carlton JT (1987) Patterns of transoceanic marine biological invasions in the Pacific Ocean. *Bulletin of Marine Science* 41(2): 452–465
Carlton JT, Geller JB (1993) Ecological Roulette: The Global Transport of Nonindigenous Marine Organisms. *Science* 261: 78–82, https://doi.org/10.1126/science.261.5117.78
Carlton JT, Chapman JW, Geller JB, Miller JA, Ruiz GM, Carlton DA, McCuller MI, Treneman NC, Steves BP, Breitenstein RA, Lewis R, Bilderback D, Bilderback D, Haga T, Harris LH (2018) Ecological and biological studies of ocean rafting: Japanese tsunami marine debris in north america and the hawaiian islands. *Aquatic Invasions* 13: 1–9, https://doi.org/10.3391/ai.2018.13.1.01
Cook PL (1964) The development of *Electra monostachys* (Busk) and *Conopeum reticulum* (Linnaeus), Polyzoa, Anasca. *Cahiers de Biologie Marine* 5: 391–397, https://doi.org/10.21411/CBM.A.B4F4C195
Cook PL, Gordon DP, Hayward PJ, Bock PE, Bone Y (2018) Introducing bryozoans. In: Cook PL, Bock PE, Gordon DP, Weaver HJ (eds), Australian Bryozoa Volume 1: Biology, Ecology and Natural History. 1st ed. CSIRO Publishing, Melbourne, pp 1–16, https://doi.org/10.1071/9781486306800
Delle Chiaje S (1822) Memorie sulla Storia e Notomia degli Animali senza Vertebre del Regno di Napoli. Fratelli Fernandes, Napoli, 109 pls, https://doi.org/10.5962/bhl.title.10021
D'Orbigny A (1852) Paléontologie française, Terrains Crétacés, V, Bryozoaires. Victor Masson, Paris, pp 185 bis–472
Drake JM, Lodge DM (2007) Hull fouling is a risk factor for intercontinental species exchange in aquatic ecosystems. *Aquatic Invasions* 2: 121–131, https://doi.org/10.3391/ai.2007.2.2.7
Ducruet C, Lee SW, Ng AKY (2010) Centrality and vulnerability in liner shipping networks: Revisiting the northeast asian port hierarchy. *Maritime Policy and Management* 37: 17–36, https://doi.org/10.1080/03088830903461175
Dunstan PK, Johnson CR (2004) Invasion rates increase with species richness in a marine epibenthic community by two mechanisms. *Oecologia* 138: 285–292, https://doi.org/10.1007/s00442-003-1400-7
Ehrenberg CG (1831) Symbolae Physicae, seu Icones et descriptiones Corporum Naturalium novorum aut minus cognitorum, quae ex itineribus per Libyam, Aegyptum, Nubiam, Dongalam, Syriam, Arabiam et Habessiniam. Studio annis 1820-25 redirerunt. Berolini, Berlin, Pars Zoologica, v.4. Animalis Evertebrata exclusis Insectis.
Esper EJC (1791) Die Pflanzenthiere in Abbildungen nach der Natur : mit Farben erleuchtet nebst Beschreibungen [Theilen 1]. Raspe, Nèurnberg, https://doi.org/10.5962/bhl.title.118730
Faasse M, De Blauwe H (2004) Faunistisch overzicht van de mariene mosdiertjes van Nederland (Bryozoa: Stenolaemata, Gymnolaemata). *Nederlandse Faunistische Mededelingen* 21: 17–54
Fauvel P (1923) Un nouveau serpulien d'eau saumatre *Merceriella* n.g., *enigmatica* n.sp. *Bulletin de la Sociét Zoologique de France* 47: 424–430
Fofonoff P, Ruiz G, Steves B, Simikanin C, Carlton JT (2018) National Exotic Marine and Estuarine Species Information System (NEMESIS). http://invasions.si.edu/nemesis/ (accessed 5 July 2020)
GISD (2020) Global Invasive Species Database (GISD). http://www.iucngisd.org/gisd/ (accessed 4 March 2020)
Gmelin JF (1791) Caroli a Linné, systema naturae. Tom. I. Pars VI
Gontar VI (2013) New Additions to the Fauna of Bryozoa Cheilostomata of the Black Sea. *Ecology and Safety* 8: 361–369
Gordon DP (2009) New bryozoan taxa from a new marine conservation area in New Zealand, with a checklist of Bryozoa from Greater Cook Strait. *Zootaxa* 60: 39–60, https://doi.org/10.11646/zootaxa.1987.1.2
Gordon DP (2016) Bryozoa of the South China Sea - an overview. *Raffles Bulletin of Zoology* 34: 604–618
Gordon DP (2018) Bryozoans and biosecurity. In: Cook PL, Bock PE, Gordon DP, Weaver HJ (eds), Australian Bryozoa Volume 1: Biology, Ecology and Natural History. 1st ed. CSIRO Publishing, Melbourne, pp 71–89
Gordon DP, Mawatari SF (1992) Atlas of Marine-fouling Bryozoa of New Zealand Ports and Harbours. *New Zealand Oceanographic Institute* 107: 1–52
Gordon DP, Sutherland JE, Perez BA, Waeschenbach A, Taylor PD, Martino E Di (2020) The bryozoan genus *Conopeum* (Electridae) in New Zealand, with description of a new species and discussion of the morphological and genetic characters of *Conopeum seurati* (Canu, 1928). *Journal of Natural History* 54: 947–970, https://doi.org/10.1080/00222933.2020.1771452
Gray JE (1848) List of the specimens of British animals in the collections of the British Museum. Part 1. Centrionae or radiated animals. Trustees of the British Museum, London
Grischenko AV, Dick MH, Mawatari SF (2007) Diversity and taxonomy of intertidal Bryozoa (Cheilostomata) at Akkeshi Bay, Hokkaido, Japan. *Journal of Natural History* 41: 1047–1161, https://doi.org/10.1080/00222930701391773

Gugel J (1997) The bryozoan *Conopeum seurati* (Canu, 1928) (Bryozoa, Cheilostomata, Anasca) in lake köyceğiz, Turkey. *Zoology in the Middle East* 15: 107–111, https://doi.org/10.1080/09397140.1997.10637745
Harmer SF (1926) Polyzoa from the Siboga-Expedition Part II Cheilostoma Anasca. *Siboga Expedition Reports* 28b: 183–501
Haswell SA (1880) On soem Polyzoa from the Queensland coast. *Proceedings of the Linnean Society of New South Wales* 5: 33–44, https://doi.org/10.1080/18324460.1912.10439228
Hayward PJ, Ryland JS (1998) Cheilostomatous Bryozoa. Part 1. Aeteoidea - Cribrilinoidea. Synopses of the British Fauna (New Series) 10. The Linnean Society of London; The Estuarine and Coastal Sciences Association, 366 pp
Hincks T (1880) A history of the British marine Polyzoa. Vol. 1. text. Van Voorst, London, https://doi.org/10.5962/bhl.title.31555
Hincks T (1884) Report on the Polyzoa of the Queen Charlotte Islands, 3. *Annals and Magazine of Natural History* 13: 49–58, https://doi.org/10.1080/00222938409459191
Je JG, Hong JS, Yi SK (1988) A study on the fouling organisms in pearl oyster culture grounds in the southern coast of Korea. *Ocean Research* 10(1): 85–105 [in Korean]
Kaluza P, Kölzsch A, Gastner MT, Blasius B (2010) The complex network of global cargo ship movements. *Journal of the Royal Society Interface* 7: 1093–1103, https://doi.org/10.1098/rsif.2009.0495
Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar M, Oztürk B, Grabowski M, Golani D, Cardoso A (2014) Impacts of Invasive Alien Marine Species on Ecosystem Services and Biodiversity: a pan-European Review. *Aquatic Invasions* 9: 391–423, https://doi.org/10.3391/ai.2014.9.4.01
Kim G, Ryu JW, Hwang DW (2008) Radium tracing of submarine groundwater discharge (SGD) and associated nutrient fluxes in a highly-permeable bed coastal zone, Korea. *Marine Chemistry* 109: 307–317, https://doi.org/10.1016/j.marchem.2007.07.002
KOSIS (2020) Korean Statistical Information Service (KOSIS). http://kosis.kr (accessed 15 July 2020)
Kubanin AA (1975) Bryozoans - Invader into Peter the Great Bay. Biology of the Shelf. Far East Center, USSR Academy of Sciences, Vladivostok, pp 89–90
Lagos ME, White CR, Marshall DJ (2017) Do invasive species live faster? Mass-specific metabolic rate depends on growth form and invasion status. *Functional Ecology* 31: 2080–2086, https://doi.org/10.1111/1365-2435.12913
Lamarck JBPA de M de (1819) Histoire naturelle des animaux sans vertèbres. Paris, 343 pp
Lamouroux M (1816) Histoire des Polypiers Coralligènes Flexibles, vulgairement nommés Zoophytes. F. Poisson, Caen, 559 pp, https://doi.org/10.5962/bhl.title.11172
Lee HJ (2010) Preliminary results on suspended sediment transport by tidal currents in Gomso Bay, Korea. *Ocean Science Journal* 45: 187–195, https://doi.org/10.1007/s12601-010-0017-0
Lee II H, Reusser D (2012) Atlas of Nonindigenous Marine and Estuarine Species in the North Pacific. Office of Research and Development, National Health and Environmental Effects Research Laboratory, EPA/600/R/12/631, 1915 pp
Lee J-S, Lee YS, Min D (2010) Introduced Molluscan species to Korea. *The Korean Journal of Malacology* 26(1): 45–49 [in Korean]
Leidy J (1855) Contributions towards a knowledge of the marine invertebrate fauna of the coasts of Rhode Island and New Jersey. *Journal of the Academy of Natural Sciences of Philadelphia* 3: 135–152
Li CY (1988) Bryozoan fouling along the coast of Huanghai and Bohai, China. *Acta Ecologica Sinica* 8(2): 170–175
Lichtschein de Bastida V, Bastida R (1980) Los briozoos de las comunidades incrustantes de puertos Argentinos. In: Aritio L (ed), Fifth International Congress on Marine Corrosion and Fouling. Barcelona, Spain, May 19-23, 1980, Gráficas Orbe, Madrid, Spain, pp 371–390
Linnaeus C (1758) Systemae naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differetiis, synonymis, locis. Laurentii Salvii, Holmiae, https://doi.org/10.5962/bhl.title.542
Linnaeus C (1767) Systemae naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differetiis, synonymis, locis Regnum Animale. Laurentii Salvii, Holmiae, https://doi.org/10.1017/CBO9781107415324.004
Liu X, Liu H (2008) Phylum Bryozoa. In: Liu R (ed), Checklist of Marine Biota of Chinese Seas. Science EP, Qingdao, pp 812–840
Liu X, Yin X, Ma J (2001) Biology of Marine-Fouling Bryozoans in the Coastal Waters of China. Science Press, Beijing, 860 pp
Lodge DM, Williams S, MacIsaac HJ, Hayes KR, Leung B, Reichard S, Mack RN, Moyle PB, Smith M, Andow DA, Carlton JT, McMichael A (2006) Biological invasions: Recommendations for U.S. policy and management. *Ecological Applications* 16: 2035–2054, https://doi.org/10.1890/1051-0761(2006)016[2035:BIRFUP]2.0.CO;2
López-Gappa J, Liuzzi MG (2018) Recent discovery of non-indigenous bryozoans in the fouling assemblage of Quequén Harbour (Argentina, Southwest Atlantic). *Marine Biodiversity* 48: 1159–1167, https://doi.org/10.1007/s12526-016-0561-7

Lutaenko KA, Furota T, Nakayama S, Shin S, Xu J (2013) Atlas of Marine Invasive Species in the NOWPAP Region. Northwest Pacific Action Plan Data and Information Network Regional Activity Center, 188 pp

MacGillivray PH (1860) Notes on the Cheilostomatous Polyzoa of Victoria and other parts of Australia. *Transactions of the Philosophical Society of Victoria* 4: 159–168

Mawatari S (1956) Cheilostomatous Bryozoa from the Kurile Islands and the neighbouring districts. *Pacific Science* 10: 113–135

McCuller MI, Carlton JT (2018) Transoceanic rafting of bryozoa (Cyclostomata, Cheilostomata, and Ctenostomata) across the north pacific ocean on Japanese tsunami marine debris. *Aquatic Invasions* 13: 137–162, https://doi.org/10.3391/ai.2018.13.1.11

MEIS (2020) Marine Environment Information System (MEIS). http://www.meis.go.kr/rest/main (accessed 15 July 2020)

Menon NR, Nair NB (1975) Indian species of Malacostega (Polyzoa, Ectoprocta). Journal of the Marine Biological Association of India 17(3): 553-579

Min BS, Seo JE, Grischenko A V., Lee SK, Gordon DP (2017) Systematics of some calloporid and lacernid Cheilostomata (Bryozoa) from coastal South Korean waters, with the description of new taxa. Zootaxa 4226: 471-486, doi: 10.11646/zootaxa.4226.4.2, https://doi.org/10.11646/zootaxa.4226.4.2

Moll JPC (1803) Eschara, ex zoophytorum, seu, phytozoorum ordine pulcherrimum ac notatu dignissimum genus, novis speciebus auctum, methodice descriptum et iconibus ad naturam delineatis illustratum. Camesiniana, Vindobonae, 70 pp

Molnar JL, Gamboa RL, Revenga C, Spalding MD (2008) Assessing the global threat of invasive species to marine biodiversity. *Frontiers in Ecology and the Environment* 6: 485–492, https://doi.org/10.1890/070064

Naylor RL, Williams SL, Strong DR (2001) Aquaculture - A gateway for exotic species. *Science* 294: 1655–1656, https://doi.org/10.1126/science.1064875

O'Dea A, Okamura B (1999) Influence of seasonal variation in temperature, salinity and food availability on module size and colony growth of the estuarine bryozoan *Conopeum seurati*. *Marine Biology* 135: 581–588, https://doi.org/10.1007/s002270050659

O'Donoghue CH, O'Donoghue E (1923) A preliminary list of Bryozoa (Polyzoa) from the Vancouver Island region. *Contributions to Canadian Biology and Fisheries New Series* 1: 143–201, https://doi.org/10.1139/f22-010

Okuda S (1934) Some tubicolous annelids from Hokkaido. *Journal of the Faculty of Science, Hokkaido University, Ser 6, Zoology* 3: 233–246

Osburn RC (1914) The Bryozoa of the Tortugas Islands, Florida. *Carnegie Institution of Washington Publication* 182: 183–222

Osburn RC (1940) Bryozoa of Porto Rico with a resume of West Indian Bryozoan fauna. *Scientific Survey of Porto Rico and the Virgin Islands* 16: 321–486

Osburn RC (1950) Bryozoa of the Pacific coast of America. Part 1, Cheilostomata-Anasca. *Allan Hancock Pacific Expeditions* 14: 1–269, https://doi.org/10.5962/bhl.title.6542

Pallas PS (1766) Elenchus zoophytorum sistens generum adumbrationes generaliores et speciarum cognitarum succintas descriptiones cum selectis auctorus synonymis. Petrum van Cleef, Hagae-Comitum, 451 pp, https://doi.org/10.5962/bhl.title.6595

Park C, Kim ST, Hong JS, Choi KH (2017) A rapid assessment survey of invasive species of macrobenthic invertebrates in Korean waters. *Ocean Science Journal* 52: 387–395, https://doi.org/10.1007/s12601-017-0024-5

Poluzzi A, Sabelli B (1985) Polymorphic zooids in deltaic species populations of *Conopeum seurati* (Canu, 1928) (Bryozoa, Cheilostomata). *Marine Ecology* 6: 265–284, https://doi.org/10.1111/j.1439-0485.1985.tb00326.x

Prenant M, Bobin G (1966) Bryozoaires, deuxieme partie. Chilostomes Anasca, Volume 68. Paris, 647 pp, https://doi.org/10.1038/158078b0

Read GB, Gordon DP (1991) Adventive occurrence of the fouling serpulid *Ficopomatus enigmaticus* (Polychaeta) in New Zealand. *New Zealand Journal of Marine and Freshwater Research* 25: 269–273, https://doi.org/10.1080/00288330.1991.9516478

Rho TK, Lee TS, Lee SR, Choi MS, Park C, Lee JH, Lee JY, Kim SS (2012) Reference Values and Water quality Assessment Based on the Regional Environmental Characteristics. *The Sea* 17: 45–58 [in Korean], https://doi.org/10.7850/jkso.2012.17.2.045

Robertson A (1905) Non-incrusting chilostomatous Bryozoa of the west coast of North America. *University of California Publications in Zoology* 2(5): 235–322

Robertson A (1908) The incrusting chilostomatous Bryozoa of the west coast of North America. *University of California Publications in Zoology* 4(5): 253–344

Ryland JS (1960) The British species of Bugula (Polyzoa). *Proceedings of the Zoological Society of London* 134: 65–104, https://doi.org/10.1111/j.1469-7998.1960.tb05919.x

Ryland JS (1965) Catalogue of main marine fouling organisms (found on ships coming into European Waters) Vol. 2: Polyzoa. OECD, Paris, 82 pp

Ryland JS (1970) Bryozoans. Hutchinson University Library, London, 175 pp, https://doi.org/10.1016/0020-7837(70)90058-0

Ryland JS, Hayward PJ (1977) British Anascan Bryozoans. The Linnean Society of London by Academic Press, London, 188 pp
Salta M, Chambers L, Wharton J, Wood R, Briand F, Blache Y, Stokes K, Toulon-var US, Garde L (2009) Marine fouling organisms and their use in antifouling bioassays. EUROCORR 2009, 26 pp
Seo JE (1996) Two new species of Membraniporoidea (Bryozoa: Cheilostomata) from Korea. *The Korean Journal of Systematic Zoology* 12(1): 45–51
Seo JE (2005) Illustrated Encyclopedia of Fauna and Flora of Korea, Vol. 40. Bryozoa. Ministry of Education and Human Resources, Seoul, 596 pp [in Korean]
Shin S, Park J, Lee J, Kim I, Seo J, Kim H, Min G, Kim S (2013) Marine Introduced Benthos of Korea. Ministry of Oceans and Fisheries, Sejong, 102 pp
Spalding MD, Fox HE, Allen GR, Davidson N, Ferdaña ZA, Finlayson M, Halpern BS, Jorge MA, Lombana A, Lourie SA, Martin KD, McManus E, Molnar J, Recchia CA, Robertson J (2007) Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. *BioScience* 57: 573–583, https://doi.org/10.1641/B570707
Stach LW (1937) [Lady Julia Percy Island. Reports of the McCoy society for field investigation and research.] 13. Bryozoa. *Proceedings of the Royal Society of Victoria New series* 49: 374–384
Thorp CH, Pyne S, West SA (1987) *Hydroides ezoensis* Okuda, a fouling serpulid new to british coastal waters. *Journal of Natural History* 21: 863–877, https://doi.org/10.1080/00222938700770521
Thunberg CP (1793) Tekning och Beskrifning på en stor Ostronsort ifrån Japan. *Kongliga Vetenskaps Academiens Nya Handlingar* 14: 140–142
Tilbrook KJ (2011) New genus for a unique species of Indo-West Pacific bryozoan. *Zootaxa* 67: 63–67, https://doi.org/10.11646/zootaxa.3134.1.4
Trask JB (1857) One some new microscopic organisms. *Proceedings of the California Academy of Sciences* 1: 110–115
Tyler-Walters H (2015) *Hartlaubella gelatinosa* and *Conopeum reticulum* on low salinity infralittoral mixed substrata. In: Tyler-Walters H, Hiscock K (eds), Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom, https://doi.org/10.17031/marlinhab.86.1
Tyler-Walters H, Ballerstedt S (2005) *Conopeum reticulum* An encrusting bryozoan. In: Tyler-Walters H, Hiscock K (eds), Marine Life Information Network: Biology and Sensitivity Key Information Reviews. [on-line]. Plymouth: Marine Biological Association of the United Kingdom, https://doi.org/10.17031/marlinsp.1582.1
Tyrrell MC, Byers JE (2007) Do artificial substrates favor nonindigenous fouling species over native species? *Journal of Experimental Marine Biology and Ecology* 342: 54–60, https://doi.org/10.1016/j.jembe.2006.10.014
Winston JE (1977) Distribution and Ecology of Estuarine Ectoprocts: A Critical Review. *Chesapeake Science* 18: 34–57, https://doi.org/10.2307/1350363
Winston JE (1982) Marine bryozoans (Ectoprocta) of the Indian River area (Florida). *Bulletin of the American Museum of Natural History* 173(2): 99–176
Winston JE, Hayward PJ (2012) The marine bryozoans of the northeast coast of the United States: Maine to Virginia. Virginia Museum of Natural History Memoir 11, Virginia Museum of Natural History, 180 pp
Wood SV (1844) Descriptive catalogue of the zoophytes of the Crag. *Annals and Magazine of Natural History* 13: 10–21, https://doi.org/10.1080/03745484409442561
Zabala M, Maluquer P (1988) Illustrated keys for the classification of Mediterranean Bryozoa. *Treballs del Museu de Zoologia, Barcelona* 4: 1–294
Zvyagintsev AY (2003) Introduction of species into the Northwestern Sea of Japan and the problem of marine fouling. *Russian Journal of Marine Biology* 29: 10–21, https://doi.org/10.1023/B:RUMB.0000011713.78917.e0
Zvyagintsev AY, Radashevsky VI, Ivin VV, Kashin IA, Gorodkov AN (2011) Nonindigenous species in the Far Eastern seas of Russia. *Russian Journal of Biological Invasions* 2: 164–182, https://doi.org/10.1134/S2075111711030210

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