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Distributional spread and DNA barcoding of invasive species, *Thalamoporella californica* (Levinsen, 1909) (Bryozoa, Cheilostomatida, Thalamoporellidae) in Korean waters

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Thalamoporella californica (Levinsen, 1909) is an invasive bryozoan species first found on ropes at the Tongyeong Yacht Marina in 2020. It was subsequently found in Geojedo Island (Beopdong-ri and Gujora Harbor), Tongyeong Yacht Marina, Hansando Island in the South Sea, and Yangpo Yacht Marina in the East Sea. This suggests that the distribution of *T. californica* has gradually expanded from its initial detection in Korean waters. We also analyzed the DNA barcode region of the mitochondrial cytochrome *c* oxidase subunit I (*COI*) of *T. californica*. The intra-specific *COI* sequence variation of *T. californica* collected from three different localities in this study ranged from 0.002 to 0.014. *T. californica* and *T. lioticha* were separated by a genetic distance of 0.328−0.338. The present study provides *COI* sequences that can be utilized in molecular research on *T. californica* and the genus *Thalamoporella* and basic information to eDNA-based methods for quick identification of marine invasive species.

Keywords: Bryozoa, *COI*, distribution, DNA barcode, fouling, Korean waters, *Thalamoporella californica*

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Introduction

The invasion of exotic marine species is an escalating global concern as it poses a significant threat to biodiversity and the economy (Bax *et al*., 2001). This issue is further compounded by the unpredictability of the damage caused by these non-native marine species (Bax *et al*., 2001). Marine exotic species that are highly tolerant to environmental changes and capable of rapid growth by attaching to artificial structures, particularly in ports and harbors, have a high potential to become invasive (Gordon and Mawatari, 1992; Almeida *et al*., 2015). For example, a bryozoan, *Membraniporopsis tubigera* (Osburn, 1940), was reported to block fishing nets in New Zealand in 2001 (Gordon *et al*., 2006). Subsequently, mass bloom events were observed at Cassino Beach, Brazil, and La Coronilla Beach, Uruguay, in 2003, where the species covered up to 2 km of the beach (Gappa *et al*., 2010). In Korean waters, *Bantariella bocki* (Silén, 1942), first invaded the black corals on Munseom in Jejudo Island in 2005 (Moon and Song, 2007; Seo *et al*., 2009) since this species was described from Bonin Islands in Japan (Silén, 1942). In response to this invasion, Moon and Song (2007) proposed the removal method of *B. bocki* to conserve black corals in Jeju waters. Five species of *Bugula neritina* (Linnaeus, 1758), *Bugulina californica* (Robertson, 1905), *Celleporaria brunnea* (Hincks, 1884), *Schizoporella unicornis* (Johnston, 1847) and *Tricellaria occidentalis* (Trask, 1857) have been known as newly introduced bryozoans of Korea (Shin *et al*., 2013). Three of *Jellyella tuberculata* (Bosc, 1802), *T. occidentalis* and *Watersipora subtorquata* (d'Orbigny, 1852) were legally designated as harmful bryozoans in Korea in 2019 (Park *et al*., 2020). The technique to rapidly identify these marine invasive species and monitor

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their introduction to Korean waters and distributional dispersion was suggested through molecular methods. *Bugulina californica* and *Bugula neritina* were detected by environmental DNA assay with simple sampling seawater (Kim *et al*., 2018; 2021). Following the early detection of marine invasive species through DNA monitoring, we expect to see the development of technologies to eliminate disturbing and harmful species from the marine ecosystem shortly. For this reason, DNA barcoding is essential for quick identification of marine invasive species.

The cheilostome genus *Thalamoporella* Hincks, 1887 contains 50 species, with the largest diversity among the five genera in the family Thalamoporellidae Levinsen, 1902 worldwide (Bock, 2025). Three *Thalamoporella* species have been reported to inhabit Korea: *T. californica*, *T. lioticha*, and *T. sibogae* (Chae *et al*., 2022). Among them, *T. californica* was first found on rope hanging at the Tongyeong Yacht Marina in 2020 (Chae *et al*., 2022). Afterward, the authors monitored this species to investigate its distributional spread to different localities and whether it attached to algae instead of fouling the artificial substrata. In 2021, this species was found only in the same locality where it was first reported and exclusively on artificial substrata, such as ropes (Chae *et al*., 2022).

The accurate morphological identification of species is central to biodiversity research, but several technical challenges exist (Padial *et al*., 2010; Twyforwd *et al*., 2024). Significant efforts are being made to obtain genetic data from various species for identification, and DNA barcoding is a method used to distinguish species by sequencing standardized DNA regions (Hebert *et al*., 2003; Hebert and Gregory, 2005). Currently, integrative taxonomy has been proposed to catalogue the biodiversity of the planet with an integrative and evolutionary framework by morphologists and molecular biologists (Padial *et al*., 2010). In Britain and Ireland, DNA barcoding for the Darwin Tree of Life Project (DToL), aiming to sequence and assemble high-quality reference genomes for all eukaryotic species, was developed and implemented (Twyforwd *et al*., 2024). Unfortunately, there is a lack of DNA barcoding studies on bryozoans (Taylor and Waeschenbach, 2015). In this study, we present the cytochrome *c* oxidase subunit I (*COI*) sequence as a barcode marker for the molecular identification of *T. californica* for the first time.

Materials and Methods

The colonies of *Thalamoporella californica* were collected from five localities in Korea (Table 1). The colonies from Hansando Island were attached to algae [*Codium fragile* (Suringar) Hariot, 1889] and 20–30 mm sized stone, while the others were found hanging on ropes in harbors and yacht marinas and fouling on nets at the fish farm. All were collected using hand and forceps. After separating them to prevent contamination with other organisms, the samples were preserved in 99.99% ethyl alcohol. For species identification, the external features of the zooids were observed under a stereomicroscope (Stemi SV6, Carl Zeiss, Germany). Parts of the specimens were bleached with hot aqueous sodium hypochlorite (10–25%), washed, and gold coated (MCM-100, SEC, Korea) before being examined with a scanning electron microscope (SNE-3200M Mini-SEM, SEC, Korea) set to an accelerating voltage of 15 kV. Measurements were made using Image J on SEM images of the zooids. Voucher specimens were deposited at Woosuk University (MBRBK-9828, MBRBK-9827, MBRBK-9826, MBRBK-9825, MBRBK-9824, MBRBK-9823).

Table 1. Information on sampling localities of *T. californica* in Korea in this study.

Locality	Coordinates	Date	Substratum
Tongyeong Yacht Marina	34°49′42″N, 128°26′05″E	14 Oct 2020 20 Oct 2021 4 Jul 2022 13 Oct 2022 26 Jul 2023 25 Oct 2023 3 Jul 2024 5, 16 Oct 2024	Rope
Hansando Island	34°47′04″N, 128°29′32″E	3 Sep 2024	*Codium fragile* (Suringar), Stone
Beopdong-ri at Geojedo Island	34°48′46″N, 128°31′20″E	22 Aug 2022	Fishing net
Gujora Harbor	34°49′56″N, 128°42′10″E	26 Jul 2023 25 Oct 2023 3 Jul 2024 5, 16 Oct 2024	Rope
Yangpo Yacht Marina	35°52′40″N, 129°31′10″E	27 Jul 2023 26 Oct 2023 4 Jul 2024 17 Oct 2024	Rope

The genomic DNA of *T. californica* was extracted following the manufacturer's protocol using a DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany). The *COI* sequences of *T. californica* were amplified using LCO 1490 and HCO 2198 primers (Folmer *et al*., 1994), and the sequence length of all specimens was 658 bp throughout this study. A total of six sequences were deposited in GenBank under the accession numbers PQ454604 and PQ454605 (Tongyeong Yacht Marina), PQ454606 and PQ454607 (Hansando Island) and PQ454608 and PQ454609 (Yangpo Yacht Marina). Geneious Prime v2021.2.2 (Biomatters, Auckland, New Zealand) was used to compare the sequen-

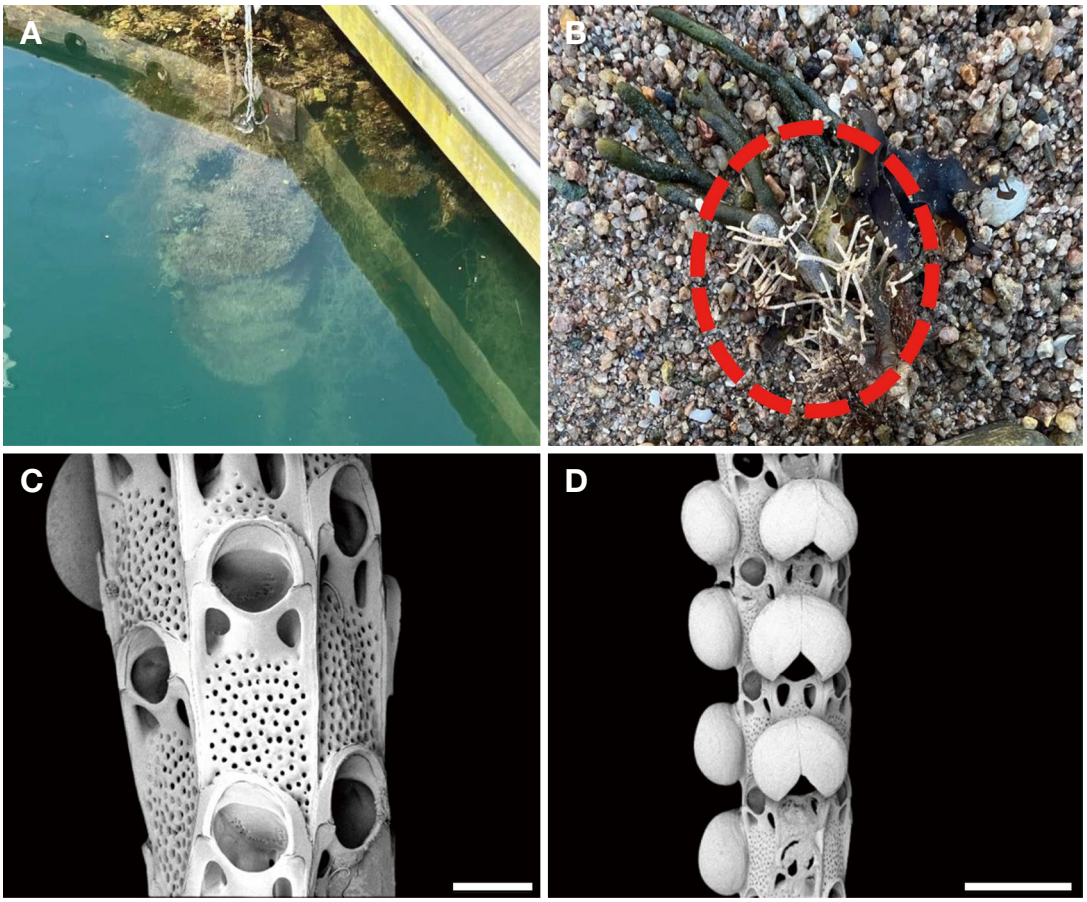


Fig. 1. *Thalamoporella californica*. A. Colony fouled the ropes at Tongyeong Yacht Marina; B. Colony attached to algae at Hansando Island; C. Detailed autozooid showing orifice, a pair of opesiules and porous frontal wall; D. Ovicell typical in thalamoporellids. Scale bars: C, D = 300 μm.

ces with *T. lioticha* (Ortmann, 1890) and *Steginoporella magnifica* Harmer, 1900, belonging to the same superfamily. *T. lioticha* is the only *Thalamoporella* species with *COI* sequences registered in NCBI (473 bp), and *S. magnifica* is known to be the closest to the genus *Thalamoporella*. The sequence of *Heteropora alaskensis* Borg, 1933, which belongs to a different class, was used as the outgroup. The sequences for *T. lioticha* from Korea, *S. magnifica* from New Zealand (612 bp), and *H. alaskensis* from San Juan Island (U.S.A.) (658 bp) were obtained from NCBI with the accession numbers HQ896191.1, JF950435.1, and MH242798.1, respectively, and they were referenced for comparison with *T. californica*. The intra- and intergenetic distance of *T. californica* were calculated using the Kimura-2-parameter (K2P) model with the software MEGA X (Kumar *et al*., 2018).

Results and Discussion

Class Gymnolaemata Allman, 1856
Order Cheilostomatida Busk, 1852
Suborder Thalamoporellina Ostrovsky, 2013
Superfamily Thalamoporelloidea Levinsen, 1902
Family Thalamoporellidae Levinsen, 1902
Genus *Thalamoporella* Hincks, 1887

***Thalamoporella californica* (Levinsen, 1909)**
New Korean name: 캘리포니아안방이끼벌레
(cal-li-po-ni-a-an-bang-i-kki-beol-le)

Materials examined. See Table 1 for Information on sampling localities, dates and substrata in which *T. californica* was collected in Korea. All materials were collected from waters shallower than 5 m deep.

Diagnosis. Colony light beige (Fig. 1A, B), erect, dichotomously branching. Zooids elongated, rectangular or oval, 0.38–0.56 mm long (0.45 ± 0.07 mm), 0.19–0.30 mm wide (0.24 ± 0.05 mm). Orifice subcircular, 0.12–0.18 mm long (0.14 ± 0.01 mm), 0.12–0.16 mm wide (0.14 ± 0.01 mm). Pair of opesiules with different sizes. Cryptocyst flat with densely distributed small perforations (Fig. 1C). Ovicells very large, ectoecium, symmetrical along central groove, 0.39–0.45 mm wide (0.43 ± 0.04 mm) (Fig. 1D).

Distribution. Korea (South Sea, East Sea), East Pacific (Monterey Bay to southern California, Colombia, Galapagos Islands).

Remarks on the distribution expansion of *T. californica* in Korea. *Thalamoporella californica* is regarded as an invasive species in Korea, with its primary distribution in the eastern Pacific (Chae *et al*., 2022). Since this species was first found in Korea on artificial substrata, such as ropes hanging at the Tongyeong Yacht Marina in 2020, the volume of colonies was found to be doubled only in the same locality the following year (Chae *et al*., 2022). *T. californica* has been consistently monitored in the eight harbors and ports of Incheon, Dangjin, Bieung, Nokdong, Gujora, Ulsan, Donghae and Sokcho, and five yacht marinas of Mokpo, Soho, Tongyeong, Busan and Yangpo from 2020 to 2024 (Table 2). The monitoring of *T. californica* resulted in Table 3. As shown in Table 3, *T. californica* has occurred continuously from Tongyeong Yacht Marina since 2020, and its presence was confirmed in Gujora Harbor and Yangpo Yacht Marina in 2023 and 2024. In addition to the monitored localities, *T. californica* was found fouling the fishing net of the fish farm in Beopdong-ri at Geojedo Island, in 2022, causing damage to the fish farming industry (Table 1). It is noteworthy that this species attached to the algae [*Codiun fragile* (Suringar) Hariot, 1889)] and stone in Hansando Is. was additionally found in 2024 (Table 1). This situation confirmed the occurrence of *T. californica* in additional localities beyond its first found site, suggesting that its distribution within Korean waters may be expanding. Regarding the substratum, *T. californica*, is originally known to be encrusted to *Macrocystis* holdfasts from the intertidal to 15 m deep in the eastern Pacific (Soule *et al*., 1999). However, this species was reported on only ropes in Korean waters (Chae *et al*., 2022) and additionally found on natural substrata, such as algae and stone, in 2024 in Korean waters, too. It is necessary to consistently monitor to which substratum this species is attached to consistently.

Remarks on the DNA barcoding of *T. californica* and other species. We obtained six new partial *COI* sequences from *T. californica* collected from three localities (Hansando Is., Tongyeong and Yangpo Yacht Marinas) in Korean waters and calculated genetic distances within and between species for evaluating DNA barcoding resolution of *COI*. Because *Thalamoporella lioticha* was GenBank's only available congeneric species, *Steginoporella magnifica*, belonging to the same superfamily, was included in this study to enhance the accuracy of species identification using its *COI*. Additionally, we included the outgroup *Heteropora alaskensis* according to the preceding analysis (Knight *et al*., 2011; Lee *et al*., 2011; Leray and Paulay, 2018). The *COI* gene of each species for the genetic comparison turned out to be 658 bp in length and then was

Table 2. Monitored localities of Korean harbors, ports and yacht marinas.

No.	Locality	Coordinates
1	Incheon Port	37°25′41″N, 126°37′01″E
2	Dangjin Port	36°59′48″N, 126°47′40″E
3	Bieung Harbor	35°56′14″N, 126°31′45″E
4	Mokpo Yacht Marina	34°47′01″N, 126°23′18″E
5	Nokdong Harbor	34°42′20″N, 127°11′50″E
6	Soho Yacht Marina	34°44′14″N, 127°39′02″E
7	Tongyeong Yacht Marina	34°49′42″N, 128°26′05″E
8	Gujoro Harbor	34°49′56″N, 128°42′10″E
9	Busan Yacht Marina	35°09′29″N, 129°08′43″E
10	Ulsan Harbor	35°29′02″N, 129°25′47″E
11	Yangpo Yacht Marina	35°52′40″N, 129°31′10″E
12	Donghae Port	37°29′28″N, 129°07′29″E
13	Sokcho Port	38°12′39″N, 128°35′47″E

Table 3. Occurrence of *T. californica* in monitored localities from 2020 to 2024.

Date	Locality													Data source
	1	2	3	4	5	6	7	8	9	10	11	12	13	
27–31 Jul 2020							○							Chae *et al*., 2022
12–16 Oct 2020							○							This study
7, 19–23 Jul 2021							○							Chae *et al*., 2022
18–22 Oct 2021							○							This study
2–6 Jul 2022							○							This study
11–15 Oct 2022							○							This study
24–28 Jul 2023							○	○			○			This study
23–28 Oct 2023							○	○			○			This study
1–5 Jul 2024							○	○			○			This study
5, 14–18 Oct 2024							○	○			○			This study

※ Information on locality numbers is indicated in Table 2.

Table 4. Genetic distance (K2P) based on 417 bp of *COI* sequences in *Thalamoporella californica* and three bryozoans.

No.	Species	Accession No.	1	2	3	4	5	6	Data source
1	*Thalamoporella californica*	PQ454604							This study
2	*Thalamoporella californica*	PQ454605	0.003						This study
3	*Thalamoporella californica*	PQ454606	0.005	0.008					This study
4	*Thalamoporella californica*	PQ454607	0.006	0.009	0.002				This study
5	*Thalamoporella californica*	PQ454608	0.006	0.003	0.011	0.012			This study
6	*Thalamoporella californica*	PQ454609	0.008	0.005	0.012	0.014	0.002		This study
7	*Thalamoporella lioticha*	HQ896191.1	0.328	0.331	0.328	0.328	0.335	0.338	Lee *et al*., 2011
8	*Steginoporella magnifica*	JF950435.1	0.331	0.336	0.329	0.331	0.339	0.342	Knight *et al*., 2011
9	*Heteropora alaskensis*	MH242798.1	0.457	0.451	0.454	0.457	0.451	0.454	Leray and Paulay, 2018

aligned into 417 bp. The intra-specific variations in *T. californica* were 0.2−1.4%, and the genetic differences of *T. californica* compared to three other bryozoans are as follows: 32.8−33.8% with *T. lioticha* within the same genus, 32.9−34.2% with *S. magnifica* within the same superfamily, and 45.1−45.7% with *H. alaskensis* from a different class (Table 4). In this study, the K2P model was used for genetic sequence analysis, focusing on simple species identification rather than phylogenetic relationship analysis. The sequence differences in the *COI* gene region indicate that *T. californica* from three different localities belong to the same species. This study does not provide a clear understanding of where *T. californica* was first introduced or how it spread. For more accurate information on how *T. californica* invaded Korean waters from a single location and spread in distribution, it is necessary to verify using microsatellite analysis (Mackie *et al*., 2012).

As a result of this study, *T. californica*, a member of the genus *Thalamoporella*, has been added to GenBank, where previously only *T. lioticha* was registered. The longer 658 bp *COI* sequence of *T. californica* compared to the 473 bp sequence of *T. lioticha*, which was already deposited in GenBank, is likely to provide better species discrimination. By providing DNA barcoding data of *T. californica* along with its ecological photographs and information in this study, these features can be utilized to facilitate the distinction of *T. californica* from other congeners.

Conflicts of Interest

The authors of this paper have no affiliation with any interests and are solely responsible for the paper.

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References

Almeida, A.C., F.B. Souza, D.P. Gordon and L.M. Vieira. 2015. The non-indigenous bryozoan *Triphyllozoon* (Cheilostomata: Phidoloporidae) in the Atlantic: morphology and dispersion on the Brazilian coast. Zoologia (Curitiba) 32(66): 476-484.

Bax, N., J.T. Carlton, A. Mathews-Amos, R.L. Haedrich, F.G. Howarth, J.E. Purcell, A. Rieser and A. Gray. 2001. The control of biological invasions in the world's oceans. Conservation Biology 15(5):1234-1246.

Bock, P. 2025. World List of Bryozoa. Thalamoporellidae Levinsen, 1902 [Available from: https://www.marinespecies.org/aphia.php?p=taxdetails&id=196093/, accessed 9 Jan 2025].

Chae, H.S., H.J. Yang, B.S. Min, G.W. Noh, D.H. Lee and J.E. Seo. 2022. Three newly recorded species of Korean fouling bryozoans. Journal of Species Research 11(3):180-187.

Folmer, O., M. Black, W. Hoeh, R. Lutz and R. Vrijenhoek. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294-299.

Gappa, J.L., A. Carranza, N.M. Gianuca and F. Scarabino. 2010. *Membraniporopsis tubigera*, an invasive bryozoan in sandy beaches of southern Brazil and Uruguay. Biological Invasions 12:977-982.

Gordon, D.P. and S.F. Mawatari. 1992. Atlas of marine-fouling Bryozoa of New-Zealand harbors and harbours. Miscellaneous Publication New Zealand Oceanographic Institute 107(1992):1-52.

Gordon, D.P., L.V. Ramalho and P.D. Taylor. 2006. An unreported invasive bryozoan that can affect livelihoods *Mem-*

braniporopsis tubigera in New Zealand and Brazil. Bulletin of Marine Science 78(2):331-342.

Hebert, P.D. and T.R. Gregory. 2005. The promise of DNA barcoding for taxonomy. Systematic Biology 54(5):852-859.

Hebert, P.D., A. Cywinska, S.L. Ball and J.R. DeWaard. 2003. Biological identifications through DNA barcodes. Proceedings of the Royal Society of London. Series B: Biological Sciences 270(1512):313-321.

Kim, P., D. Kim, T.J. Yoon and S. Shin. 2018. Early detection of marine invasive species, *Bugula neritina* (Bryozoa: Cheilostomatida), using species-specific primers and environmental DNA analysis in Korea. Marine Environmental Research 139: 1-10.

Kim, P., T.-J. Yoon and S. Shin. 2021. Monthly eDNA monitoring of an invasive bryozoan, *Bugulina californica*, in seawater using species-specific marker. Animals 11(7):1966.

Knight, S., D.P. Gordon and S.D. Lavery. 2011. A multi-locus analysis of phylogenetic relationships within cheilostome bryozoans supports multiple origins of ascophoran frontal shields. Molecular Phylogenetics and Evolution 61(2):351-362.

Kumar, S., G. Stecher, M. Li, C. Knyaz and K. Tamura. 2018. MEGA X: molecular evolutionary genetics analysis across computing platforms. Molecular Biology and Evolution 35(6):1547-1549.

Lee, H.J., Y.S. Kwan, S.R. Kong, B.S. Min, J.E. Seo and Y.J. Won. 2011. DNA barcode examination of Bryozoa (Class: Gymnolaemata) in Korean seawater. Animal Systematics, Evolution and Diversity 27(2):159-163.

Leray, M. and G. Paulay. 2018. Marine invertebrates of the San Juan Islands in the Pacific Northwest. Naos Laboratories, Smithsonian Tropical Research Institute, Luis F. Clement, Tupper BLODG. #401, Panama City, Panama 0843-03092, Panama [Available from: https://www.ncbi.nlm.nih.gov/nuccore/MH242798.1/, accessed 20 Apr 2018].

Mackie, J.A., J.A. Darling and J.B. Geller. 2012. Ecology of cryptic invasions: latitudinal segregation among *Watersipora* (Bryozoa) species. Scientific Reharbors 2(1):871.

Moon, H.W. and J.I. Song. 2007. Impact of bryozoan, *Bantariella* sp., on black corals at Munseom in Jejudo Island. Korean Journal of Environmental Biology 25(2):139-148.

Padial, J.M., A. Miralles, I. De la Riva and M. Vences. 2010. The integrative future of taxonomy. Frontiers in Zoology 7: 1-14.

Park, J.Y., J.H Chae, S. Shin, H.J. Lee and M.J. Lee. 2020. Marine ecosystem disturbing and harmful organisms in Korea. Ministry of Oceans and Fisheries and Marine Ecosystem Disturbing and Harmful Organisms Project Team, Korea.

Seo, J.E., S.J. Suh and B.S. Min. 2009. First record of *Bantariella bocki* (Bryozoa: Ctenostomata) from Korean waters. Korean Journal of Systematic Zoology 25(1):133-136.

Shin, S., J.H. Park, J.S. Lee, I.H. Kim, J.E. Seo, H.S. Kim, G.S. Min and S.H. Kim. 2013. Marine Introduced Benthos of Korea. Min. Ocean. Fish., Korea.

Silén, L. 1942. Carnosa and Stolonifera (Bryozoa) collected by Prof. Dr. Sixten Bock's Expedition to Japan and the Bonin Islands 1914. Arkiv för Zoologi 34A(8):1-33.

Soule, D.F., J.D. Soule and H.W. Chaney. 1999. New species of *Thalamoporella* (Bryozoa) with acute or subacute avicularium mandibles and review of known species worldwide (No. 4). Irene McCulloch Foundation Monograph Series, Number 4, pp. 1-57.

Taylor, P.D. and A. Waeschenbach. 2015. Phylogeny and diversification of bryozoans. Paleontology 58(4):585-599.

Twyford, A.D., J. Beasley, I. Barnes, H. Allen, F. Azzopardi, D. Bell, M.L. Blaxter, G. Broad, L.C. Dominguez, D. Choonea, L. Crowley, P. Cuber, M. Cunliffe, A. Dombrowski, B. Douglas, L.L. Forrest, E. Gaya, C. Greeves, C. Griffin, J. Harley, M.L. Hart, P.W.H. Holland, P.M. Hollingsworth, I. Januszczak, A. Jones, P. Kersey, E. Kilias, M.K.N. Lawniczak, O.T. Lewis, S. Mian, A. Minotto, R. Misra, P.O. Mulhair, L.P. Conceicoa, B.W. Price, S. Salatino, F. Shaw, O. Sivell, L. Sivess, R. Uhl, K. Woof and Darwin Tree of Life Consortium. 2024. A DNA barcoding framework for taxonomic verification in the Darwin Tree of Life Project. Wellcome Open Research 9(339):9-339 [https://wellcomeopenresearch.org/articles/9-339/, assessed 25 June 2024].

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