ASED http://e-ASED.org
Animal Systematics, Evolution and Diversity

Anim. Syst. Evol. Divers. Vol. 41, No. 1: 75-82, January 2025
https://doi.org/10.5635/ASED.2025.41.1.038

A New Record of Sand Anemone, *Paracondylactis sinensis* (Anthozoa: Hexacorallia: Actiniaria: Actiniidae), from Korea

Sung-Jin Hwang[1,2,*]

[1]Department of Life Science, Woosuk University, Jincheon 27841, Korea
[2]Cnidaria Bioresources Bank of Korea, Jincheon 27841, Korea

ABSTRACT

Since 2020, specimens of the *Paracondylactis* species, which primarily inhabit soft sediments such as sandy mudflats, have been collected from the intertidal zones of Korea's western coast (Boryeong and Byeonsan) by digging through the sand with a shovel. These specimens have smooth, very elongated, and cylindrical bodies. The juvenile sea anemones attached to floating bamboo sticks, Chinese-made snack bags, and water bottles were found in 2024 near the rocky shoreline of the western part of Jeju Island. It is thought that this species is native to Korea from China, which is its type locality. By comparing mitochondrial COX3 sequences with those of relative species and analyzing its external morphology and cnidae, this unrecorded species has been identified to be *Paracondylactis sinensis*. With 96 tentacles, *P. sinensis* differs morphologically from the recorded species, *P. hertwigi*, which has 48. It is also easily distinguishable from the latter by body color.

Keywords: burrowing sea anemone, *Paracondylactis sinensis*, sandy mud flat, taxonomy, COX3

INTRODUCTION

The genus *Paracondylactis* Carlgren, 1934 belonging to the largest family, Actiniidae, of Actiniaria currently has three species—*Paracondylactis hertwigi* (Wassilieff, 1908), *P. sinensis* Carlgren, 1934, and *P. singaporensis* (England, 1987)—worldwide (Rodríguez et al., 2024). Among them, *P. hertwigi* has been reported in Korea (Song, 1984). *Paracondylactis* is widely distributed in the Indian Ocean (India and Pakistan), the Indo-Pacific Ocean (Andaman Island, the East China Sea, and Singapore), and the western Pacific Ocean (Korea and Japan) (Carlgren, 1934; Song, 1984; England, 1987; Fautin et al., 2015; Gul and Häussermann, 2017; Choudhury and Sivaperuman, 2023). They live primarily in tropical and subtropical regions of these oceans, but have also been found in temperate regions, typically living in burrows in soft sediments, such as mud sand, in the intertidal to shallow subtidal zones (Song, 1984; Mitra and Pattanayak, 2010; Fautin and Tan, 2016). In certain countries, such as China, *P. sinensis* is consumed as food (Li et al., 2023). *Paracondylactis* is characterized by having smooth, very elongated, and cylindrical bodies which are wide distally and narrow toward the base, and it usually extends tentacles over muddy sand during the night (Carlgren, 1934).

A species morphologically distinct from *P. hertwigi* previously reported in Korean waters was discovered during surveys conducted in the sandy intertidal zones of the western coast of Korea, encompassing Boryeong and Byeonsan, beginning in 2020. In August 2024, small sea anemones identical to those found on the west coast were collected from the rocky coast of Jeju Island, attached to floating bamboo sticks, plastic bottles, and snack bags. Through taxonomic and genetic analyses with related species, a previously unreported species, *Paracondylactis sinensis*, was identified and described herein with its photographs of external features and cnidae. A total of two *Paracondylactis* species have been described from Korean anthozoan fauna as a result of this study.

MATERIALS AND METHODS

Since 2020, specimens of the *Paracondylactis* species have

*To whom correspondence should be addressed
Tel: 82-43-531-2892, Fax: 82-43-531-2862
E-mail: buteo2@woosuk.ac.kr, buteo2@gmail.com

eISSN 2234-8190

been collected from the intertidal zones of the Yellow Sea (Boryeong and Byeonsan) by digging through the sand with a shovel, as it mainly occurs on sandy mudflats. In 2024, small sea anemones attached to floating bamboo sticks, plastic bottles, and snack bags were collected at the rocky shoreline of the western part of Jeju Island. Photographs of live anemones attaching to substrata or burrowing in the sand were taken using a digital camera (Tough TG-5; Olympus Digital Solution Corporation, Tokyo, Japan) in order to record their ecological features and morphological characteristics. The specimens were anesthetized with menthol powder for approximately four to six hours after collection. They were then preserved in 99% alcohol (v/v) for molecular analysis and in 5% neutral buffered formalin (v/v) for morphological examinations. Of the total of 15 specimens, three (MABIK CN00081558–CN00081560) were deposited at the National Marine Biodiversity Institute of Korea in Seocheon. The remaining specimens were stored separately at the Marine Biodiversity and Conservation Laboratory at Woosuk University in Jincheon and the Cnidaria Bioresources Bank of Korea, respectively.

To identify the sea anemones, a stereomicroscope (SteREO Discovery. V8; Carl Zeiss, Jena, Germany) was used to observe their detailed morphological characteristics, including the length and size of each body part, the number of tentacles, and their color pattern. A light microscope (Axio Lab.A1; Carl Zeiss) was also used to examine the types of cnidae found in the tissues of each sea anemone part. A CMOS sensor microscope digital camera (KCS-2000SS; Korea Lab Tech, Seongnam, Korea) was used to take every detailed photographs. An image analyzer (OptiView; Korea Lab Tech) was used to measure the size of the cnidae.

Using mitochondrial COX3 sequences, molecular identification was carried out to estimate the genetic distances between related *Paracondylactis* species, such as *P. hertwigi* and *P. singaporensis*, and identical species collected from China and Singapore. Following the manufacturer's protocol, total DNA was extracted from an ethanol-preserved specimen using a DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany). Partial COX3 sequences were amplified using primer sets (COIIIF and COIIIR), which have been applied to molecular phylogenetic studies of actiniarians (Geller and Walton, 2001; Glon et al., 2021). In 50 μL reactions, amplification was performed using a MiniAmp thermal cycler (Thermo Fisher Scientific Inc., Waltham, MA, USA) and the TaKaRa Ex Taq (Takara Bio Inc., Kusatsu, Japan). The PCR conditions were 10 min at 94°C, 35 cycles of 94°C for 30 s, annealing at 47°C for 40 s, and extension at 72°C, with a final extension step at 72°C for 10 min.

Neighbor-Joining (NJ) tree was built using the Molecular Evolutionary Genetics Analysis (MEGA) software version 11, and genetic distance analysis was performed using the Kimura 2-parameter model (Tamura et al., 2021). All 10 COX3 sequences from *Paracondylactis* (including all three valid species) and the outgroup *Entacmaea quadricolor* (Leuckart in Rüppell & Leuckart, 1828) were assessed. Five of these sequences were from the present study, while the others were obtained from GenBank. In NJ tree, the accession numbers for each sequence were positioned next to the names of the species.

SYSTEMATIC ACCOUNTS

Phylum Cnidaria Hatschek, 1888
Class Hexacorallia Haeckel, 1896
Order Actiniaria Hertwig, 1882
Family Actiniidae Rafinesque, 1815
Genus *Paracondylactis* Carlgren, 1934

Key to species of the genus *Paracondylactis*

1. Tentacles 48 in number ····· 2
− Tentacles 96 in number ····· *P. sinensis*
2. Without verrucae on the distalmost column ····· *P. hertwigi*
− With verrucae on the distalmost column ····· *P. singaporensis*

[1]**Paracondylactis sinensis* Carlgren, 1934 (Tables 1, 2, Figs. 1–4)

Paracondylactis sinensis Carlgren, 1934: 26–28, fig. 15; Den Hartog and Vennam, 1993: 625–631, figs. 40, 41; Fautin et al., 2015: 50–51, figs. 6, 7; Gul and Häussermann, 2017: 250, fig. 4; Choudhury and Sivaperuman, 2023: 123, fig. 1.
Paracondylactis dawydoffi Carlgren, 1943: 27–28, figs. 17, 18.
Paracondylactis davydoffi Carlgren, 1949: 55 [misspelling].
Paracondylactis indicus Parulekar, 1968: 143, 145, pl. 2 fig. 10; Mitra and Pattanayak, 2010: 78–79, fig. A.
Paracondylactis sagarensis; Parulekar, 1990: 223, 226.

Material examined. Korea: 4 individuals, Chungcheongnam-do: Boryeong-si, Ungcheon-eup, Doksan Beach (36°13′20″N, 126°31′40″E), 16 Nov 2020, Lee SJ, Lee KH, Hwang SJ, intertidal zone; 2 individuals, Jeonbuk-do: Buan-gun, Byeonsan-myeon, Norumok-gil, Gosapo Beach (35°39′40″N, 126°30′15″E), 15 Sep 2023, Lee SH, Bae JK, intertidal zone; 1 individual, Gyeokpo-ro, Haseom Island (35°39′20″N, 126°29′26″E), 16 Sep 2023, Lee SH, Bae JK, intertidal zone; 8 individuals, Jeju-do: Seogwipo-si, Andeok-myeon, Gam-

Korean name: [1]*다촉수측해변말미잘 (신칭)

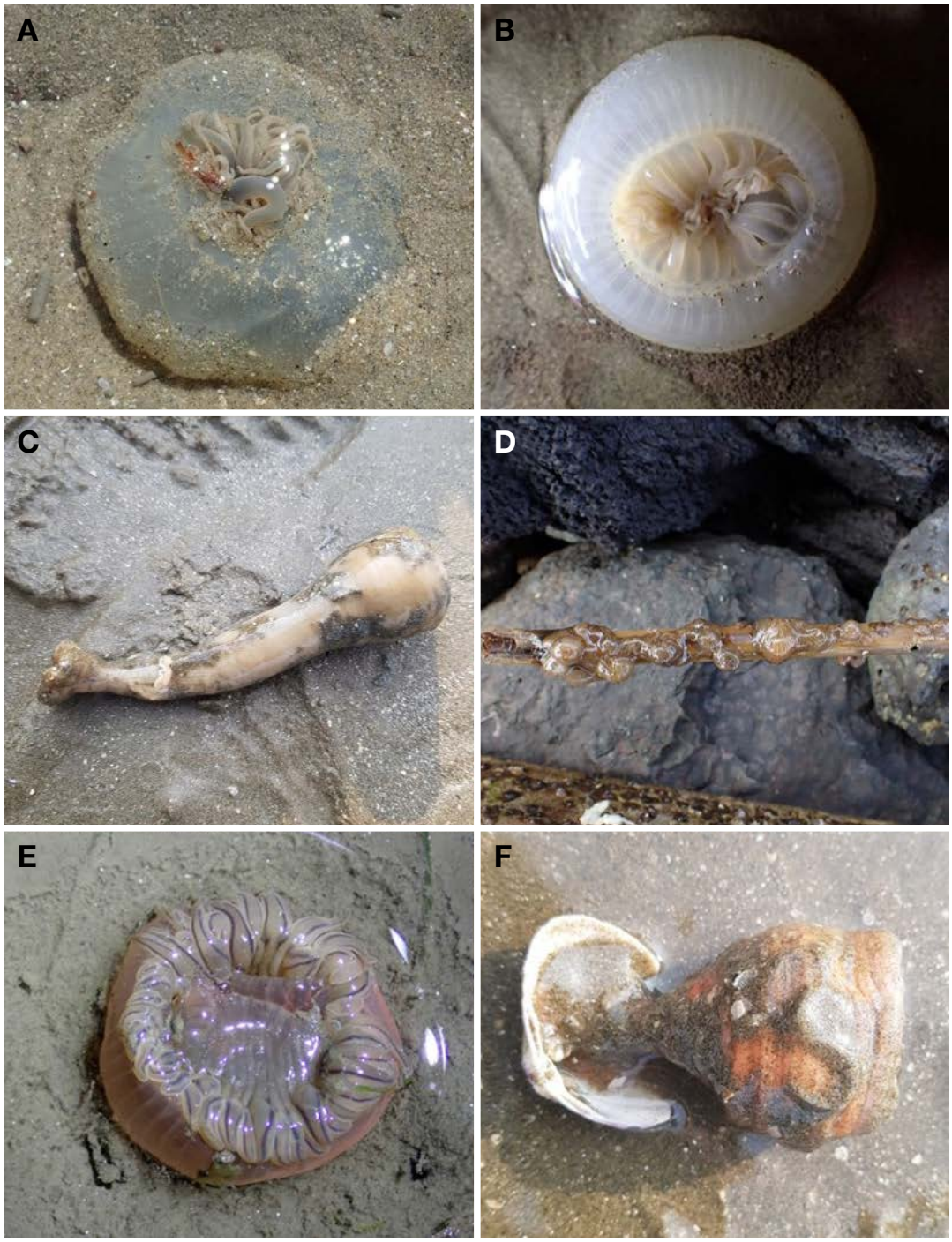

Fig. 1. Living *Paracondylactis* species. *P. sinensis*: A, B, Sea anemones burrowing in sandy mud flat at night; C, Shrunken sea anemone collected at Doksan Beach; D, Small sea anemones attached to floating bamboo stick; *P. hertwigi*; E, Sea anemone burrowing in mud flat; F, Shrunken orange colored sea anemone attached to shell.

san-ri, Baksugijeong Beach (33°14′05″N, 126°21′30″E), 3 Aug 2024, Lee SJ, Yu HJ, Lim MK, Kim SH, Hwang SJ, intertidal zone.

Description. Column smooth, long, cylindrical, highly extensible, significantly tapering toward base; 48 pseudospherules at margin (Figs. 1C, 2A–C). Oral disc flat, sometimes pharynx protruding slightly outside mouth, mouth with two siphonoglyphs; considerably wider than pedal disc in adults (Figs.

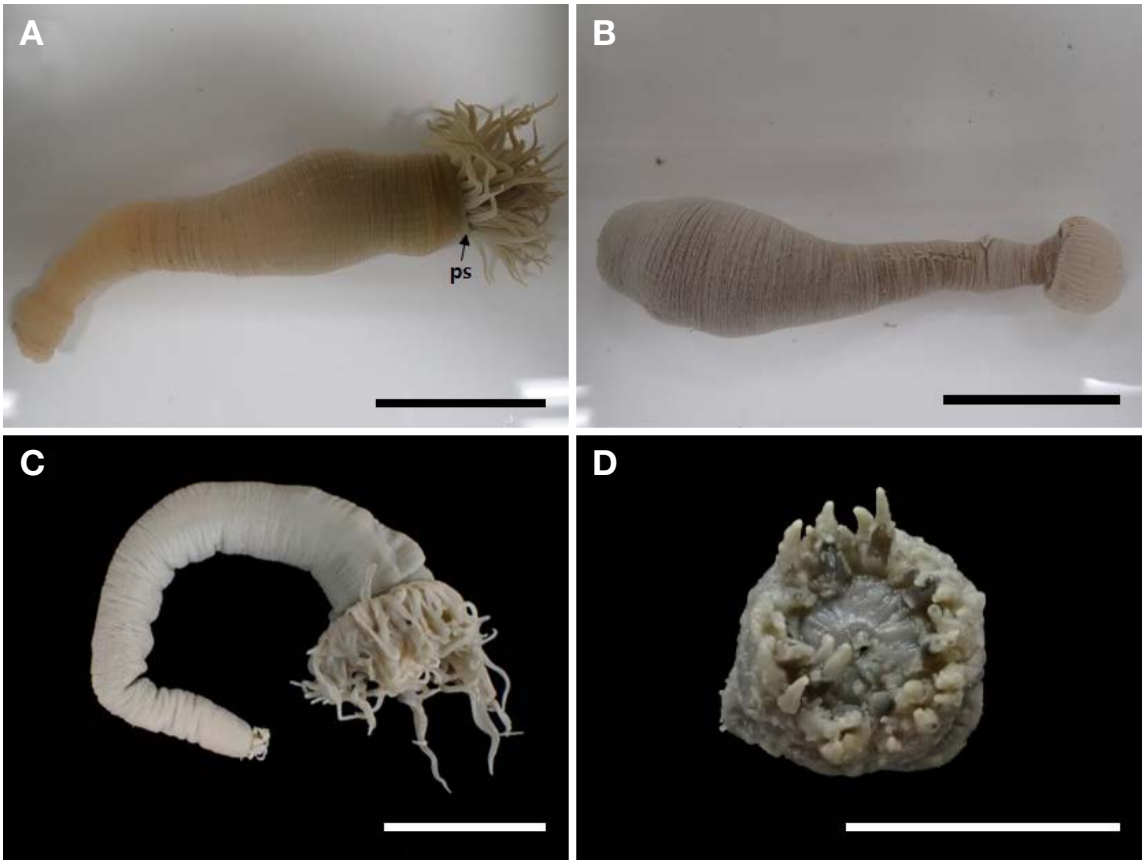

Fig. 2. Specimens of *Paracondylactis sinensis*. A, Expanded sea anemone showing pseudospherules (arrow) at margin of column before fixation; B, Shrunken sea anemone with a bulging pedal disc; C, Well-relaxed and fixed specimen; D, Fixed small specimen. ps, pseudospherules. Scale bars: A–C = 5 cm, D = 1 cm.

1C, 2A). Tentacles plump at base, tapered toward tips and pointed; large adult individuals (over 60 mm in height) with up to 96 in number arranged in five cycles, inner (14–85 mm long) longer than outer (9–32 mm); small young individuals (less than 6 mm in height) with 24–36, inner (3–4 mm long) longer than outer (1–4 mm) (Fig. 2A, C, D). Pedal disc small, usually not attached to hard substrate, sometimes swells (Figs. 1C, 2B).

Size: large adult individuals up to 182 mm high from oral disc to pedal disc, oral disc 19–35 mm in diameter, column 29–51 mm wide in upper part and 9–19 mm wide in narrow part, pedal disc 10–25 mm; small young individuals less than 6 mm high, oral disc 5–7 mm in diameter, column 4–9 mm in diameter, pedal disc 5–10 mm.

Cnidom: spirocysts, basitrichs, microbasic b-mastigophores, microbasic p-mastigophores (Fig. 3). Distribution and detailed measurements of cnidae in Table 1.

Color. When alive, the oral disc and tentacles are fairly transparent, yellowish or slightly pinkish, and the body is tan brown to dusty blue in hue (Figs. 1A–C, 2A).

Ecology and habitat. This species of burrowing sea anemones primarily inhabits the sandy mud flats of the intertidal zones along the western coast in Korea (Fig. 1A–C). The sea anemones expand their tentacles mainly at night, but occasionally during the day. Young sea anemones, on the other hand, seem to migrate by adhering to floating matters like bamboo sticks and plastic bottles (Fig. 1D). It is assumed that this species was introduced to Korea from China, its type locality, especially since the juveniles collected in Jeju were discovered attached to Chinese snack bags and water bottles.

Distribution. Western Pacific Ocean: Korea (Byeonsan, Boryeong, and Jeju); Indo-Pacific Ocean (Andaman Island, the East China Sea, and Singapore): Indian Ocean (India and Pakistan).

Remarks. Carlgren originally described *Paracondylactis sinensis* in 1934 using specimens collected in China, including the Yangtze River basin, and widely observed from the Indian to the western Pacific Oceans. Our specimens align with the original description of *P. sinensis* on the basis of external characteristics. However, our specimens' cnidae data were com-

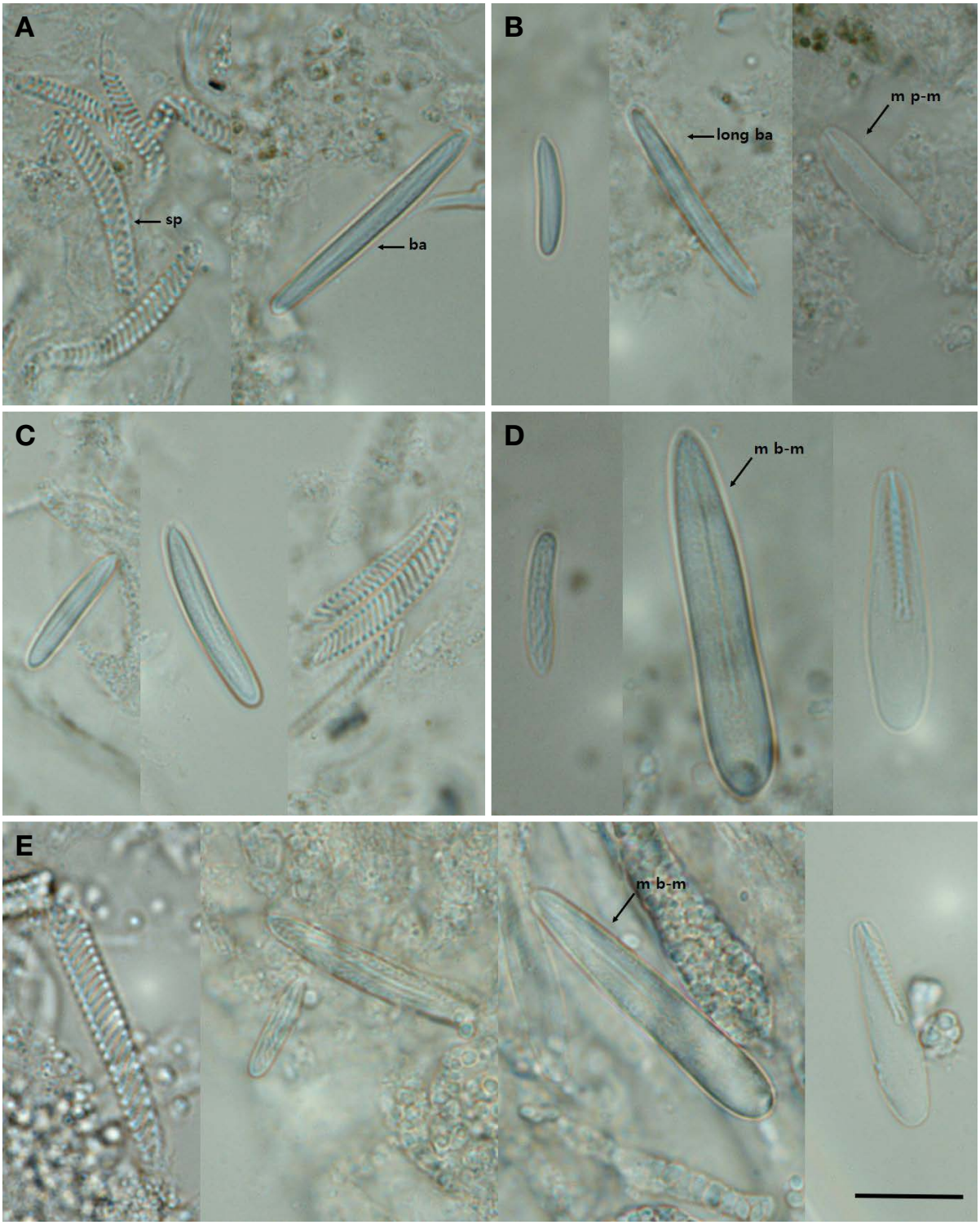

Fig. 3. Cnidae of *Paracondylactis sinensis*. A, Tentacle; B, Pseudospherule; C, Column; D, Mesenterial filament; E, Actinopharynx. ba, basitrich; m b-m, microbasic b-mastigophore; m p-m, microbasic p-mastigophore; sp, spirocyst. Scale bar: A–E = 10 μm.

pared with those of Den Hartog and Vennam (1993) because the original description did not adequately describe the different types of cnidae. Despite some variation in cnidae type, the cnidae data from our specimens generally indicate cnidae

Table 1. Comparison of size of cnidae of *Paracondylactis sinensis*, size in μm

Tissue and cnidae	Den Hartog and Vennam, 1993 (number of cnidae)	This study (mean, number of cnidae)
Tentacles		
Spirocysts	17.0–40.0×2.2–4.0 (many)	15.5–40.4×2.4–3.6 (25.0×3.0, 68)
Basitrichs	23.4–36.9×2.3–2.7 (70)	15.5–33.0×2.1–3.3 (26.3×2.6, 77)
Microbasic p-mastigophores	14.4–20.7×3.6–5.6 (40)	Not observed
Pseudospherules		
Basitrichs	11.7–15.8×2.3–2.7 (40)	8.7–24.7×1.8–2.7 (13.6×2.3, 46)
Microbasic p-mastigophores	17.1×5.0 (1)	18.0–18.4×4.9–5.3 (18.2×5.1, 2)
Column		
Spirocysts	9.0–12.0×2.0 (rare)	18.9–32.0×2.5–3.9 (24.6×3.2, 9)
Basitrichs	11.7–20.7×2.3–2.7 (90)	13.3–29.0×2.2–3.7 (18.4×2.9, 42)
Microbasic p-mastigophores	16.7–21.6×4.5–5.9 (30)	Not observed
Actinopharynx		
Spirocysts	Not observed	29.1–31.1×3.4–3.8 (30.1×3.6, 2)
Basitrichs	20.7–27.9×3.2–3.6 (50)	11.4–29.7×2.4–4.4 (22.9×3.6, 52)
Microbasic b-mastigophores	Not observed	31.9–37.7×5.8–6.9 (34.9×6.3, 25)
Microbasic p-mastigophores	17.1–26.1×4.5–5.9 (27)	20.3–25.3×4.8–6.0 (22.9×5.2, 25)
Mesenterial filaments		
Basitrichs	9.9–13.5×2.0–2.7 (40)	11.6–25.6×2.2–3.0 (15.8×2.6, 11)
Microbasic b-mastigophores	23.9–36.9×4.1–6.1 (60)	33.1–40.5×5.5–6.8 (36.0×6.1, 20)
Microbasic p-mastigophores	16.2–26.1×3.2–5.9 (70)	17.4–25.7×4.8–6.3 (23.4×5.4, 20)

Table 2. Genetic distances within and between species of the genus *Paracondylactis* and *Entacmaea quadricolor* (outgroup) based on partial COX3 DNA in 630 bp length

Species (No. of sequences)	Within species of *Paracondylactis* (mean±SD)	Among species of *Paracondylactis* (min.–max.)	Between *P. sinensis* (mean±SD)	GenBank accession No.
P. hertwigi (1)	n/c	0.011–0.023	0.023±0.006	PQ799252[a]
P. sinensis (6)	0.001±0.001	0.021–0.023	–	PQ799248–PQ799251[a] OQ363537 OP903146
P. singaporensis (2)	0.000±0.000	0.011–0.021	0.021±0.006	OQ363529 OQ363539
Entacmaea quadricolor (1)	n/c	0.044–0.051	0.044±0.009	OQ363532

n/c, not calculated.
[a]The sequences obtained in this study are indicated.

type and size comparable to those of *P. sinensis* (Table 1). In the field, *P. sinensis* can be easily identified from the recorded species, *P. hertwigi*, based on body color (Fig. 1E, F). Also, it is distinguishable morphologically from the latter, which has 48 tentacles, in that it has 96 tentacles (Carlgren, 1934; Song, 1984). *P. singaporensis*, which has only been documented from Singapore, differs from *P. sinensis* in that it has 48 tentacles and verrucae on the distalmost column (Fautin and Tan, 2016).

DNA barcoding. The partial sequences (630 bp) of COX3 from *Paracondylactis* species and one outgroup (*Entacmaea quadricolor*) were used to analyze genetic distances between and within species. The intra- and inter-specific genetic distances of the *Paracondylactis* species are shown in Table 2. With the exception of the species for which only one sequence was available in GenBank, intraspecific genetic distances were extremely low, with 0.1% in *P. sinensis* and 0.0% in *P. singaporensis*. On the other hand, the range of 1.1% to 2.3% for the interspecific genetic distances between *Paracondylactis* species were comparatively large. Furthermore, com-

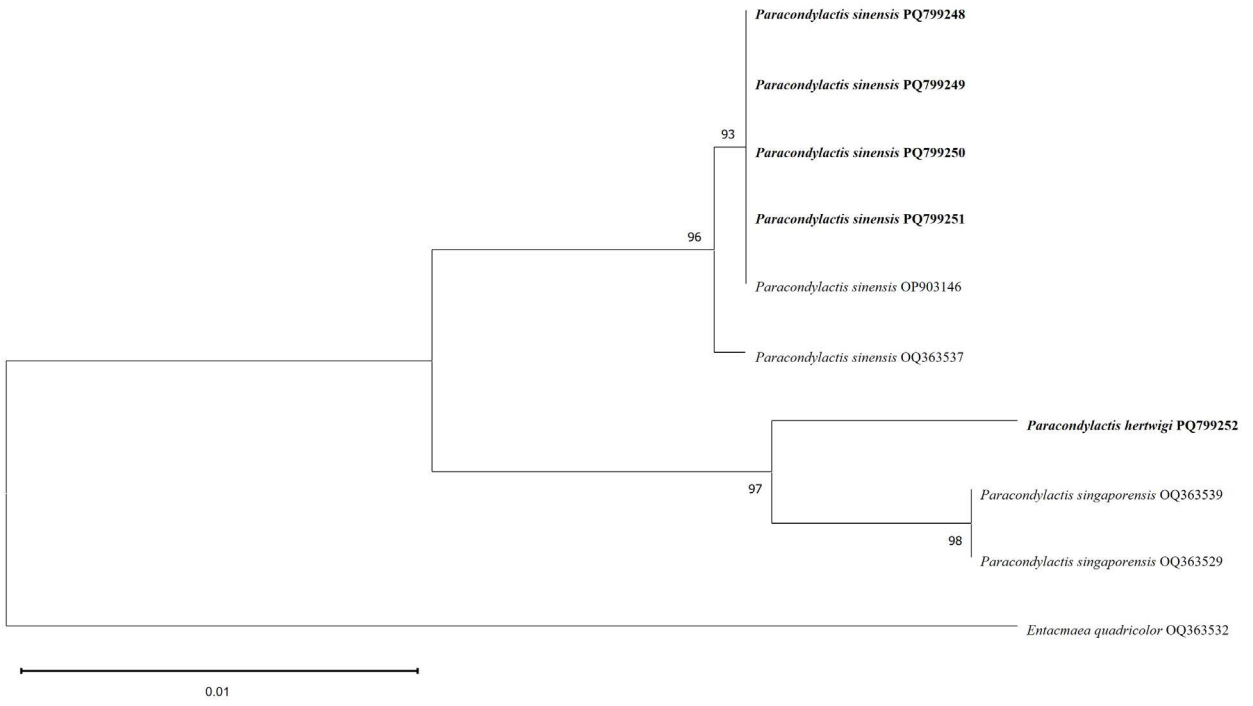

Fig. 4. Neighbor-Joining tree constructed from COX3 sequences of *Paracondylactis sinensis* and related species. Numbers at the nodes indicate the percentage occurrences among 1,000 bootstrap values. GenBank accession numbers are given next to the species name, and newly sequenced species in this study are bolded.

pared to the outgroup *Entacmaea quadricolor*, the *Paracondylactis* species showed genetic differences of 4.4–5.1%. The interspecific genetic distance of the *Paracondylactis* COX3 gene is approximately ten times greater than its intraspecific genetic distance, and it is two to five times smaller than that of other Actiniidae genus. The COX3 gene thus appears to be a powerful barcode region for distinguishing Actiniarian species, as demonstrated by previous studies (Rodríguez et al., 2014; Frazão et al., 2020). The NJ tree based on partial COX3 sequences indicates evidence that *Paracondylactis sinensis* collected from Korea belongs to the same clade as *Paracondylactis sinensis* published from China (type locality) and Singapore (Fig. 4). Furthermore, it turned out that there was a clear distinction between the three species of *Paracondylactis*: *P. hertwigi*, *P. sinensis*, and *P. singaporensis*. *Paracondylactis sinensis* was found to be somewhat different from the other two species, with genetic distances of 2.3% and 2.1%, respectively, approximately twice as great as the 1.1% genetic difference between these two species.

ORCID

Sung-Jin Hwang: https://orcid.org/0000-0002-1259-6775

CONFLICTS OF INTEREST

Sung-Jin Hwang, a contributing editor of the Animal Systematics, Evolution and Diversity, was not involved in the editorial evaluation or decision to publish this article.

ACKNOWLEDGMENTS

This work was supported by the management of Marine Fishery Bio-resources Center (2024) funded by the National Marine Biodiversity Institute of Korea (MABIK).

REFERENCES

Carlgren O, 1934. Zur Revision der Actiniarien. Arkiv für Zoologi, 26A:1-36.

Carlgren O, 1943. East-Asiatic Corallimorpharia and Actiniaria. Kungliga Svenska Vetenskapsakademiens Handlingar, Serie 3, 20:1-43.

Carlgren O, 1949. A survey of the Ptychodactiaria, Corallimorpharia and Actiniaria. Kungliga Svenska Vetenskapsakademiens Handlingar, Series 4, 1:1-121.

Choudhury S, Sivaperuman C, 2023. New record of sea anemones (Actiniaria: Actiniidae) from Andaman and Nicobar Is-

lands. Journal of the Marine Biological Association of India, 65:122-128. https://doi.org/10.6024/jmbai.2023.65.2.2305-20

Den Hartog JC, Vennam J, 1993. Some Actiniaria (Cnidaria: Anthozoa) from the west coast of India. Zoologische Mededelingen, 67:601-637.

England KW, 1987. Certain Actiniaria (Cnidaria, Anthozoa) from the Red Sea and tropical Indo-Pacific Ocean. Bulletin of the British Museum of Natural History (Zoology), 53:205-292.

Fautin DG, Tan R, 2016. Sea anemones (Cnidaria: Actiniaria) of Singapore: redescriptions of *Paracondylactis singaporensis* (England, 1987) and *P. hertwigi* (Wassilieff, 1908). Raffles Bulletin of Zoology, 34:170-177.

Fautin, DG, Tan R, Yap N, Liang W, Hee TS, Crowther A, Goodwill R, Sanpanich K, Chieh TY, 2015. Sea anemones (Cnidaria: Actiniaria) of Singapore: shallow-water species known also from the Indian subcontinent. Raffles Bulletin of Zoology, 31:44-59.

Frazão B, Froufe E, Fernandes A, Barreiro A, Vasconcelos V, Antunes A, 2020. Genetic records of intertidal sea anemones from Portugal. Regional Studies in Marine Science, 34:101067. https://doi.org/10.1016/j.rsma.2020.101067

Geller JB, Walton ED, 2001. Breaking up and getting together: evolution of symbiosis and cloning by fission in sea anemones (genus *Anthopleura*). Evolution, 55:1781-1794. https://doi.org/10.1111/j.0014-3820.2001.tb00827.x

Glon H, Quattrini A, Rodríguez E, Titus BM, Daly M, 2021. Comparison of sequence-capture and ddRAD approaches in resolving species and populations in hexacorallian anthozoans. Molecular Phylogenetics and Evolution, 163:107233. https://doi.org/10.1016/j.ympev.2021.107233

Gul S, Häussermann V, 2017. First records of sea anemones (Cnidaria: Actiniaria) from the coast of Pakistan (northern Arabian Sea). International Journal of Biology and Biotechnology, 14:247-252.

Li J, Li Y, Xie T, Feng J, Yang X, Zhan Z, 2023. The complete mitochondrial genome of an economic sea anemone (*Paracondylactis sinensis*) in the East China Sea. Mitochondrial DNA Part B, 8:977-980. https://doi.org/10.1080/23802359.2023.2254464

Mitra S, Pattanayak JG, 2010. First record of two species of sea anemones *Edwardsia jonesii* and *Paracondylactis indicus* from Karnataka, India. Records of the Zoological Survey of India, 110:77-79. https://doi.org/10.26515/rzsi/v110/i4/2010/158923

Parulekar AH, 1968. Sea anemones (Actiniaria) of Bombay. Journal of the Bombay Natural History Society, 65:138-147.

Parulekar AH, 1990. Actinarian sea anemone fauna of India. In: Marine biofouling and power plants (Eds., Nair KVK, Venugopalan VP). Bhabha Atomic Research Centre, Bombay, pp. 218-228.

Rodríguez E, Barbeitos MS, Brugler MR, Crowley LM, Grajales A, Gusmão L, Haussermann V, Reft A, Daly M, 2014. Hidden among sea anemones: the first comprehensive phylogenetic reconstruction of the order Actiniaria (Cnidaria, Anthozoa, Hexacorallia) reveals a novel group of hexacorals. PLoS ONE, 9:e96998.

Rodríguez E, Fautin D, Daly M, 2024. World List of Actiniaria. Actiniidae Rafinesque, 1815 [Internet]. World Register of Marine Species, Accessed 22 Dec 2024, <https://marinespecies.org/aphia.php?p=taxdetails&id=267675>.

Song JI, 1984. A systematic study on the Korean Anthozoa 8. Actiniaria (Hexacorallia). Journal of Korean Research Institute for Better Living, 34:69-88.

Tamura K, Stecher G, Kumar S, 2021. MEGA11: molecular evolutionary genetics analysis version 11. Molecular Biology and Evolution, 38:3022-3027.

Received December 24, 2024
Revised December 26, 2024
Accepted December 26, 2024