

A New Record and Redescription of *Zygophylax* (Hydrozoa: Leptothecata: Zygophylacidae) from Korea

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ABSTRACT

A taxonomic examination of *Zygophylax* species collected from the subtidal zone of Seongsan Ilchulbong in the east of Jeju Island and a reexamination of the voucher specimens previously described as *Z. biarmata* were conducted. Through this study, the species previously reported as *Z. biarmata* in Korea was redescribed as *Z. pacifica*, and the specimens from Seongsan Ilchulbong were confirmed to be *Z. biarmata*. *Zygophylax biarmata* has two nematothecae on the apophysis of the hydrotheca, a clear distinction between the apophysis and the pedicel of the hydrotheca, and much smaller hydrothecae, whereas *Z. pacifica* has a single nematotheca on the apophysis of the hydrotheca, no distinction between the apophysis and the pedicel of the hydrotheca, and much larger hydrothecae. As a result of this study, a total of two species belonging to genus *Zygophylax* have been reported in the hydrozoan fauna of Korea to date.

Keywords: unrecorded hydroid, *Zygophylax biarmata*, *Zygophylax pacifica*, Korean fauna, taxonomy

INTRODUCTION

The genus *Zygophylax* Quelch, 1885 belonging to the family Zygophylacidae Quelch, 1885 was established with the type-species *Zygophylax profunda* Quelch, 1885. A total of three genera (*Abietinella* Levinsen, 1913; *Cryptolaria* Busk, 1857; *Zygophylax* Quelch, 1885), containing a total of 65 valid species, have been reported in the family Zygophylacidae. Among the genera, *Abietinella* is a monotypic genus, while *Cryptolaria* and *Zygophylax* include 6 and 58 species, respectively (Schuchert, 2023). In Korea, only two species, *Cryptolaria pectinata* (Allman, 1888) and *Zygophylax biarmata* Billard, 1905, have been reported.

The family Zygophylacidae has long been classified by previous taxonomists, including Korean researchers, into the subfamily Zygophylacinae within the family Lafoeidae Hincks, 1868 along with Lafoeinae (Rho and Chang, 1974; Gravier-Bonnet, 1979; Rees and Vervoort, 1987; Hirohito, 1995; Vervoort and Watson, 2003; Park, 2010). However, molecular phylogenetic studies based on 16S rRNA sequences revealed that Lafoeidae is not monophyletic but also polyphyletic, indicating the recovery of the family Zygophylacidae (Moura et al., 2012). An extensive molecular

phylogenetic study using 16S, 18S, and 28S rRNA sequences from 56 species of Leptothecata, including 14 species of the genus *Zygophylax*, revealed that Zygophylacidae is monophyletic and closely clustered to Plumularioidea McCrady, 1859 rather than Lafoeidae. Therefore, in this study, the genus *Zygophylax* was classified into Zygophylacidae according to the recently accepted classification system (Schuchert, 2023).

Since the genus *Zygophylax* was first reported in a study on hydrozoan specimens collected from the deep sea (over 915 m) around the Cape Verde Islands in the North Atlantic Ocean (Quelch, 1885), most species around the world have been mainly reported in the deep sea (Hirohito, 1995; Vervoort and Watson, 2003; Gu et al., 2022). *Zygophylax biarmata*, the only species reported in Korea, was first reported in 1905 using specimens collected in 1882 from depths of 112–411 m in the Bay of Biscay and off Cape Spartel in the North Atlantic through the Travailleur expedition (Billard, 1905; Rees and Vervoort, 1987). The species was collected in and around the Strait of Gibraltar, connecting the Atlantic Ocean to the Mediterranean Sea, from depths of 135–580 m (Ramil and Vervoort, 1992). In Japan, it was recorded in Sagami Bay and Bonin Island and was collected at a

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depth of 60–100 m in Sagami Bay (Yamada, 1959; Hirohito, 1995). In Korea, it was first reported by Rho and Chang (1974) as a single specimen collected in the waters of Seogwipo, Jeju Island, without recording the depth.

Colonies with anastomosed branches were collected, and a taxonomic study was conducted through a survey of subtidal hydrozoan fauna around Seongsan Ilchulbong. The specimens were identified as *Zygophylax biarmata*, which had already been added to the Korean fauna. However, due to differences from the previous description (Rho and Chang, 1974), a taxonomic reexamination of the voucher *Z. biarmata* specimen reported in Korea was conducted. As a result, *Z. biarmata* and *Z. pacifica* Stechow, 1920 were added to the hydrozoan fauna of Korea.

MATERIALS AND METHODS

In 2019, specimens were collected through scuba diving at a depth of 12 m to 13 m in the subtidal zone of Seongsan Ilchulbong, Jeju Island. After collection, images of the living colonies were taken with a digital camera (TG-6; Olympus, Tokyo, Japan) to record their morphological (color, shape, and size of colonies) data before fixation. After that, specimens were transferred into a plastic container with seawater and anesthetized with menthol powder for 4 h. After removing the menthol powder with distilled water, the colonies were fixed with 99% ethanol (v/v) for further morphological examination.

For identification, detailed morphological characteristics, such as the dimension of the stems, hydrocladia, hydrothecae, and nematothecae, were examined under a stereomicroscope (SteREO Discovery. V8; Carl Zeiss, Jena, Germany). All photographic images were captured in detail using a CMOS sensor microscope digital camera (KCS-2000SS; Korea Lab Tech, Seongnam, Korea). Measurements of the dimensions of each part were calculated with an image analyzer (OptiView; Korea Lab Tech). Hydrothecae, nematothecae, and hydrocladia were cut into small pieces and washed briefly by ultrasonic cleaning (GT-X1; Guangdong GT ultrasonic, Shenzhen, China) to obtain images by scanning electron microscopy (SEM). The washed samples were air-dried for about two days. Then, the samples were coated with gold and photographed with a Mini-SEM (SNE 3200M; SEC Co. Ltd., Suwon, Korea) at the Marine Bryozoans Resources Bank of Korea (MBRBK).

Specimens of *Zygophylax biarmata* were deposited separately in the National Marine Biodiversity Institute of Korea, Seocheon (MABIK CN00081414) and Marine Biodiversity and Conservation Laboratory at Woosuk University, Jincheon (MBCL19CnHyE064). The voucher specimen (EWNHMHY69) of *Z. pacifica* was stored in the Natural History Museum of Ewha Womans University.

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SYSTEMATIC ACCOUNTS

Phylum Cnidaria Hatschek, 1888
 Class Hydrozoa Owen, 1843
 Subclass Hydroidolina Collins, 2000
 Order Leptothecata Cornelius, 1992
¹*Family Zygophylacidae Quelch, 1885
 Genus *Zygophylax* Quelch, 1885

Key to species of the genus *Zygophylax* from Korea

- Two nematothecae on apophysis of hydrotheca, one longer *Z. biarmata*
 – One nematotheca on apophysis of hydrotheca ... *Z. pacifica*

Zygophylax biarmata Billard, 1905 (Table 1, Figs. 1, 2)

Zygophylax biarmata Billard, 1905: 97, fig. 2; Yamada, 1959: 47; Rees and Vervoort, 1987: 70; Ramil and Vervoort, 1992: 59–65, figs. 11e–h, 12a–i, 13e, f; Hirohito, 1995: 138–140, fig. 41, pl. 8, fig. C; Gu et al., 2022: 63–66, fig. 7.

Material examined. Korea: many broken colonies, Jeju-do, Seogwipo-si, Seongsan-eup, Seongsan Ilchulbong (33°27'15"N, 126°56'24"E), 6 May 2019, Hwang SJ, Jeong SC, Kim CH, 12–13 m. Specimens were collected by scuba diving.

Description. Colonies up to 50 mm in height. Stems polysiphonic, branched in one plane, dichotomously divided into stems and hydrocladia (Fig. 1A, B, D). Hydrocladia polysiphonic or monosiphonic toward end, dichotomously branched at angles of 86–94°, resulting anastomosis (Fig. 1C); distal hydrocladia very slightly geniculate. Nodes and internodes on stems and hydrocladia absent (Fig. 1E). One axillary hydrotheca located upwards at point of division of hydrocladia; two or more hydrothecae between successive branching points (Fig. 1B, C). Hydrothecae tubular narrowing at proximally with short pedicles, rim of upper opening slightly everted, with sometimes multiple growth stripes (annulation) along margins (Figs. 1F, 2A). Hydrothecae raised alternately left and right from apophysis of monosiphonic tubule (Fig. 1E), appear to rise from several sides in polysiphonic parts; forming angles of 62–73° to hydrocladia. Apophyses somewhat wide and swollen, clearly distinguishable from pedicles (Figs. 1F, 2). Hydrothecal di-

Korean name: ¹*두관절히드라과 (신칭)

Table 1. Comparison of detailed measurements of *Zygophylax biarmata* between original description, previous documents, and this study, size in μm

Characters	<i>Zygophylax biarmata</i>			
	Billard, 1905 (Original description)	Ramil & Vervoort, 1992 (Billard's type)	Hirohito, 1995	This study
Stems				
Length (mm)	20–50	–	70	27–50
Hydrocladia				
Distance between two successive hydrothecae on opposite side	–	355–510	–	395–440
Distance between two successive hydrothecae on same side	–	–	–	701–771
Hydrothecae				
Length of hydrothecae without renovations (diaphragm–first stripe)	–	275–335	–	293–322
Length of hydrothecae (diaphragm–aperture)	–	–	320–350	322–352
Diameter of aperture	–	120–140	120–150	141–152
Nematothecae				
Length with renovations	–	100–105	40–50	87–100
Diameter of aperture	–	40–45	30–40	43–46
Gonophore (coppinia)				
Length	–	–	1,600–12,800	–
Width	–	–	–	–

apophysis thick, adcauline wall somewhat convex, abcauline wall straight. Hydrothecae 322–352 μm in length (from diaphragm to aperture), 141–152 μm in diameter of aperture. Distance between two successive hydrothecae on opposite side approximately 395–440 μm . Two nematothecae, one rising from each side of apophyses of hydrothecae, one longer, tubular shaped with short pedicels, easily eliminated, but presence confirmed with remaining a hole as a trace in position of detaching, lengths of 87–100 μm (Figs. 1F, 2). Sometimes, nematothecae on stems and hydrocladia. Gonothecae absent. Comparison of detailed measurements among original description, previous records, and Korean materials in Table 1.

Color. When alive, entire colonies are light brown with a beige tone, and stems appear somewhat dark due to sediment, etc., attaching to them (Fig. 1A). All colors fade in alcohol. The stems and hydrocladia take on a somewhat yellow-brown color, and distal hydrocladia, hydrothecae, and nematothecae become opaque white color.

Ecology and habitat. The colonies live in the subtidal zone in shallow water (depth of 12–13 m) compared to the habitat depth of species discovered to date. Some colonies attach to the Bryozoa, *Caberea hataii* Okada, 1929. It has many anastomosed stems and branches, so various organisms, such as diatoms and *Barentsia* sp., attach to the colonies (Figs. 1C, 2A).

Distribution. Pacific Ocean: Korea (Jejudo), Japan (Bonin

Island, Sagami Bay); Atlantic Ocean (Spain, Morocco, Strait of Gibraltar, Gulf of Cadiz); Indian Ocean (South Africa).

Remarks. *Zygophylax biarmata* was first reported by Billard (1905) as a species with a pedicel distinct from the apophysis and two nematothecae of different lengths on the apophysis. Additionally, the stem and hydrocladia of the colony are multi-tubed, or the terminal hydrocladia are single-tubed. Billard (1905) reported that this species was similar to *Z. profunda* in that it has two nematothecae but differs in that *Z. profunda*'s nematothecae are very long, about half the length of the hydrothecae (Quelch, 1885). Our materials are identical to original description of *Z. biarmata* in this respect. In addition, Gu et al. (2022) described the branching angles of *Z. biarmata* as 60° to 90°, and our materials also have the same obtuse branching angles of 86–94°. Rho and Chang (1974) first reported *Z. biarmata* in Korean waters from one specimen collected in Seogwipo. However, this specimen appears to be a different species (newly described as *Z. pacifica* in this study) as it has a much larger hydrotheca than *Z. biarmata* and one nematotheca on the apophysis. This was also described by Ramil and Vervoort (1992).

¹**Zygophylax pacifica* Stechow, 1920 (Table 2, Fig. 3)

Zygophylax biarmata: Stechow, 1913: 114–115, fig. 88; Rho and Chang, 1974: 139, pl. 4, figs. 1–3; Rho, 1977: 255–256, pl. 74; Park, 2010: 43, fig. 21.

Zygophylax pacifica Stechow, 1920: 11; Yamada, 1959: 48;

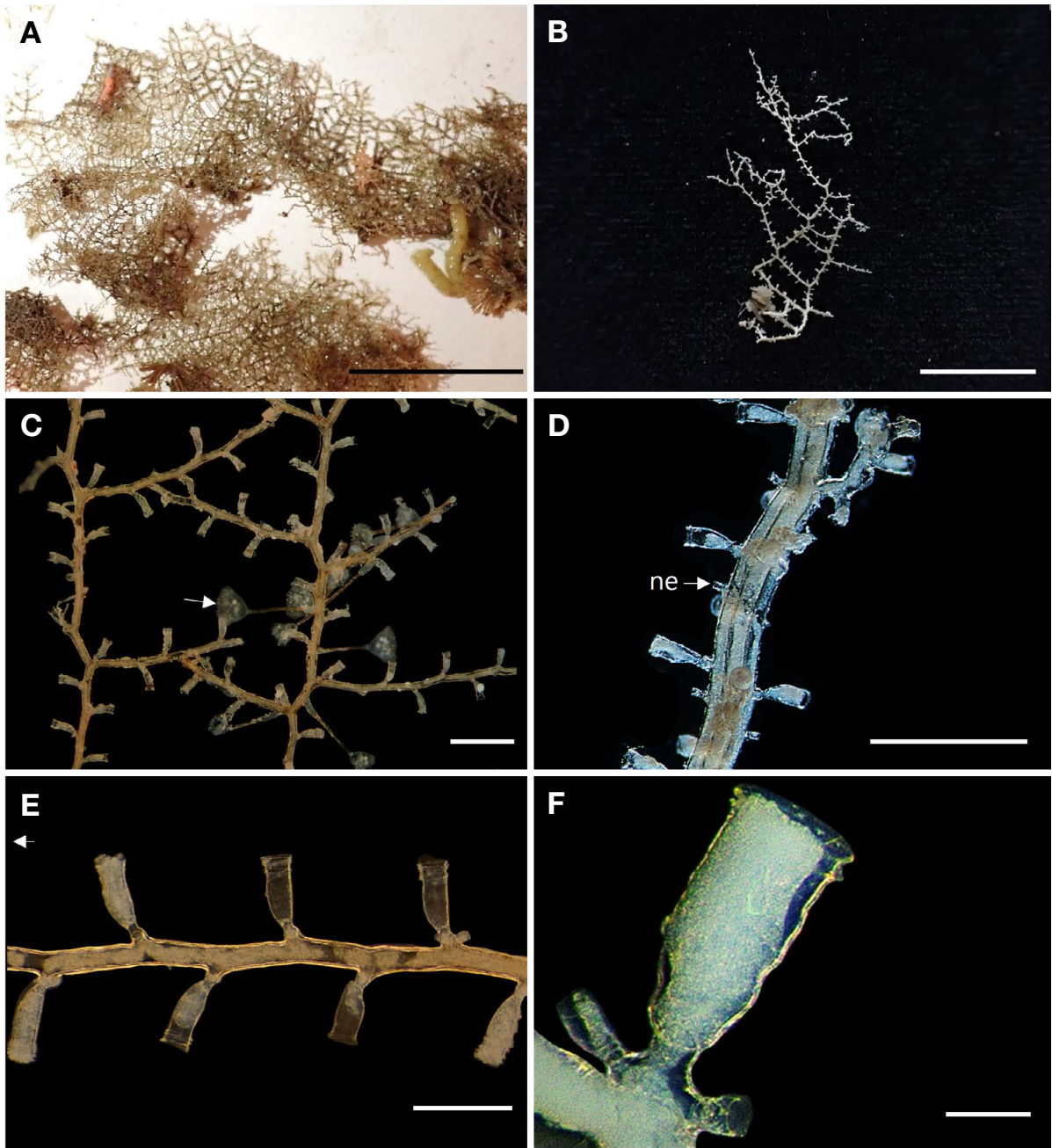


Fig. 1. Stereo microscope images of *Zygophylax biarmata*. A, Living colonies before fixed in alcohol; B, Broken colony branched in one plane; C, Anastomosed hydrocladia with attached Entoprocta, *Barentsia* sp. (arrow); D, Polysiphonic stem with hydrothecae and nematothecae; E, Monosiphonic hydrocladium with alternately positioned hydrothecae (arrow indicate distal direction of colony); F, Hydrotheca with two nematothecae on apophysis. ne, nematotheca. Scale bars: A = 5 cm, B = 1 cm, C, D = 1 mm, E = 500 μ m, F = 100 μ m.

Hirohito, 1995: 142–144, fig. 43e, f, pl. 9, fig. B; Gu et al., 2022: 72–74, fig. 15.

Material examined. Korea: 7 colonies, Jeju-do, Seogwipo, 12 Dec 1969, Rho BJ. Specimens were collected by a gill net.

Description. Colonies up to 43 mm in height. Stems polysiphonic, branch alternately on left and right sides in one plane (Fig. 3A, C). Hydrocladia polysiphonic or monosiphonic toward end, pinnately branched at angles of 53–76° to stems. Nodes and internodes absent (Fig. 3B, D). One axillar hydrotheca facing hydrocladium at an angle of approx-

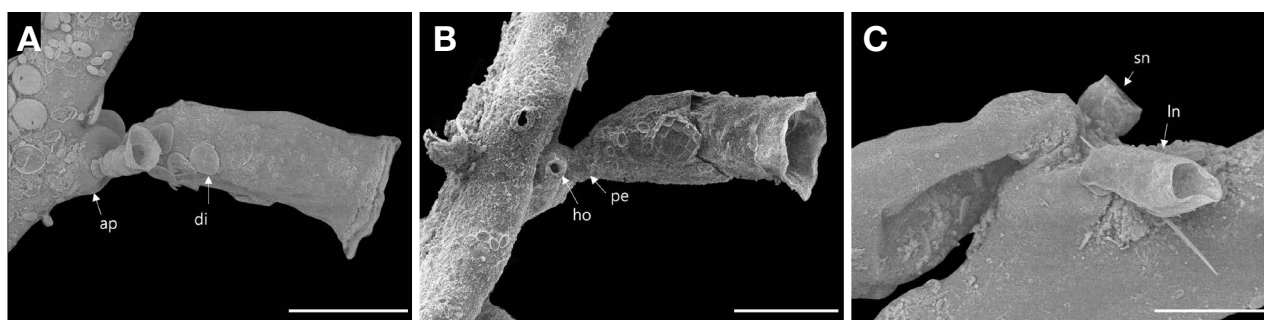


Fig. 2. Scanning electron microscope images of *Zygophylax biarmata*. A, Hydrotheca with nematotheca; B, Trace hole of nematotheca on apophysis; C, Two nematothecae on apophysis. ap, apophysis; di, diatom; ho, hole; ln, longer nematotheca; pe, pedicel; sn, shorter nematotheca. Scale bars: A, B= 100 μ m, C= 50 μ m.

Table 2. Comparison of detailed measurements of *Zygophylax pacifica* between original description, previous documents, and this study, size in μ m

Characters	<i>Zygophylax pacifica</i>			
	Stechow, 1920 (Original description)	Hirohito, 1995	Gu et al., 2022 (Syntype)	This study
Stems				
Length (mm)	-	-	36	20-43
Width	-	-	-	-
Maximal diameter	-	-	1,330	-
Distance between two successive hydrocladia of a pair	-	-	500-670	577-710
Distance between two successive hydrocladia on same side	-	-	2,830-3,170	2,738-2,942
Hydrocladia				
Length of internode	-	-	-	-
Distance between two successive hydrothecae	-	-	440-560	411-524
Hydrothecae				
Pedicel length (insertion-diaphragm)	-	-	130-220	132-157
Diameter of pedicel	-	-	100-130	95-106
Length of hydrothecae without renovations (diaphragm-first stripe)	560	-	-	410-465
Length of hydrothecae (diaphragm-aperture)	-	522-587	600-700	425-529
Diameter of diaphragm	-	-	130-150	110-131
Diameter of aperture	260	196-261	270-330	220-259
Nematothecae				
Length	80-110	-	100-130	117-118
Diameter of aperture	-	-	50	49-56
Gonothecae				
Length	-	1,150-1,200	-	-
Maximal width	-	350-550	-	-
Diameter of distal aperture	-	-	-	-

imately 32°; 1 hydrothecae between successive hydrocladia on same side (Fig. 3B). Hydrothecae tubular narrowing at proximally with indistinct pedicels from apophyses, raised alternately left and right from apophyses, forming angles of 45-56° to hydrocladia (Fig. 3B). Hydrothecal adcauline wall somewhat convex, abcauline wall straight; sometimes 2 to 4 growth stripes (annulation) along margins of hydroth-

ecae; overall shape of hydrothecae very similar to *Z. biarmata*, but length (from diaphragm to aperture) and diameter of aperture much longer at 425-529 μ m and 220-259 μ m, respectively. Only one tubular nematotheca rising from apophysis of hydrotheca between hydrotheca and hydrocladium (Fig. 3D), lengths of 117-118 μ m. Gonothecae absent.

Comparison of detailed measurements among original de-

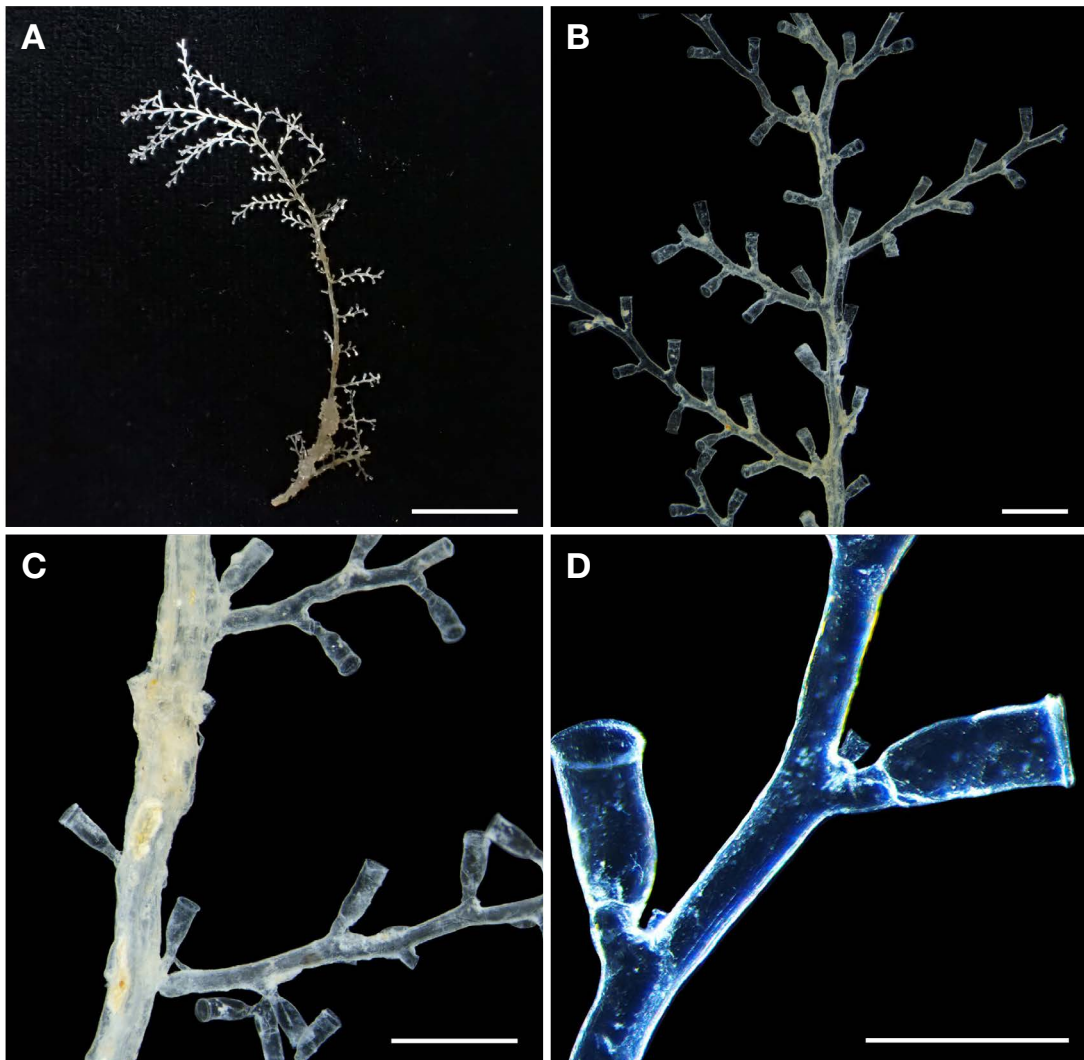


Fig. 3. Stereo microscope images of *Zygophylax pacifica*. A, Pinnately branched colony; B, Monosiphonic hydrocladia branching from stem; C, Polysiphonic basal part of stem; D, Hydrothecae with one nematotheca rising from apophysis between hydrotheca and hydrocladium. Scale bars: A=1 cm, B, C=1 mm, D=500 μ m.

scription, previous records, and Korean material in Table 2.

Color. Colonies preserved in alcohol entire colonies are somewhat yellow-brown color, and distal hydrocladia, hydrothecae, and nematothecae become opaque white color (Fig. 3A).

Distribution. Pacific Ocean: Korea (Jejudo), Japan (Sagami Bay), Philippines.

Remarks. This species was first described by Stechow (1913) as *Z. biarmata* using material collected at a depth of 250 m in Sagami Bay. However, Stechow (1920) later reported that that specimen was a new species, *Z. pacifica*. In Korea, specimen collected with a gill net off the coast of Seogwipo, Jejudo Island, were reported as *Z. biarmata* by Rho and Chang (1974). However, a reexamination of the

specimen confirmed that the species described as *Z. biarmata* is *Z. pacifica* due to the features of a single nematotheca at the apophysis of the hydrotheca, an unclear distinction between the pedicel of the hydrotheca and apophysis, rather narrow branching angles of 45–56°, and a much larger hydrotheca.

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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. All remaining authors have declared no conflicts of interest.

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