

Taxonomy of *Cerianthus filiformis* (Ceriantharia, Anthozoa) and Its Phoronid Associate, *Phoronis australis* in Korea

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The tube anemone, *Cerianthus filiformis* Carlgren, was collected from nine localities in the Yellow Sea and the Korea Strait (the South Sea). Populations at different localities showed color variations in tentacles from pale brown to violet. This species is redescribed here because it shows the color variation and the association with the phoronid, *Phoronis australis*, which was newly recorded from Korean waters. The phoronid has black to purple tentacles shaded with the same color as the cerianthid's tube for mimicking.

Carlgren (1924), Nakamoto (1923), Hyman (1959) and Emig (1979) described that *Phoronis australis* with its own delicate chitinous tube was found commonly in the tube wall of cerianthids. However, this phoronid had not been detected in the previous faunal study of cerianthids in Korea until Song (1986) first recorded one species, *Cerianthus filiformis* from Jagyag-do and Hüg-san-do in the Yellow Sea. Thereafter there has been no faunal study including the geographical distribution of Cerianthids.

A faunal study on Korean cerianthids has been conducted recently, we are able to detect the color variation in tentacles of *C. filiformis* and its associate, *P. australis* in the tube walls.

In this paper, we report *P. australis* from Korea for the first time. In addition, we redescribe *C. filiformis* about color patterns in tentacles.

Materials and Methods

Specimens were collected from eight localities of the Yellow Sea and the Korea Strait (the South Sea) from 1996 to 1998, and a previous record of additional one locality is also included in this study (Song, 1986) (Fig. 1). Cerianthids buried in sandy mud were collected from the low intertidal zone by hand-picking, and from the subtidal zone by scuba diving. The detailed locality data and other information of materials are provided in Table 1. The specimens with tubes were preserved in 5% formalin after narcotization with menthol for the identification. Anatomical studies were conducted by routine histological procedures with the paraffin embedded tissue slices.

The commensal phoronids were taken out of all

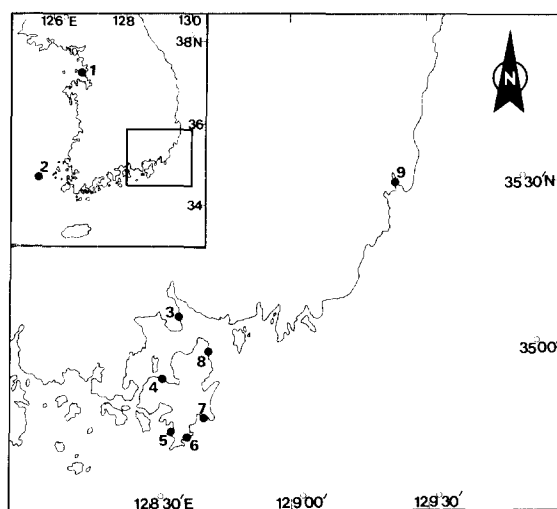


Fig. 1. Map showing the sampling sites of *Cerianthus filiformis* (see Table 1 for site number).

tube walls of cerianthids by dissecting under the stereomicroscope, and examined in detail by the histological studies. The specimens are deposited in the Department of Biological Science and the Natural History Museum, Ewha Womans University.

Systematic Accounts

Phylum Cnidaria Hatschek, 1888
Class Anthozoa Ehrenberg, 1834
Subclass Ceriantipatharia van Beneden, 1898
Order Ceriantharia Pirrier, 1893
Family Cerianthidae Milne-Edwards & Haime, 1851
Genus *Cerianthus* St. Delle Chiaje, 1832

Cerianthus filiformis Carlgren, 1924
(Fig. 2 A-E)

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Table 1. Locality data of *Cerianthus filiformis* and *Phoronis australis* sampled in Korea

Site no.	Locality	Date	Nt ¹	Nc ²	Nb ³	Np ⁴	Habitat
1	Jagyag-do	4 May 1996	1	6 (Ty2: 2 Ty4: 2 Ty5: 2) ⁵	0		Fine mud at low tide
		17 Oct 1997	3	3 (Ty2: 3)	0		
2	Hügsan-do	9 May 1985		1 (Ty2: 1)			Fine mud
3	Dökdong	6 July 1996	0	2 (Ty2: 2)	0		Coarse mud Dead shells Depth: 8-11m
		28 Jan 1997	2	0	0		
		2 July 1997	1	1 (Ty4: 1)	0		
		12 Jan 1998	4	1 (Ty3: 1)	2	4(1+3)	
4	Sagok	14 Jan 1998	14	3 (Ty1: 1 Ty2: 1 Ty3: 1)	3	4(1+1+2)	Fine mud Depth: 4-6m
5	Ssanggun	8 July 1996	3	3 (Ty1: 1 Ty2: 1 Ty4: 1)	1	1	Fine mud Depth: 5-10m
6	Susan	29 Jan 1997	14	4 (Ty2: 1 Ty3: 3)	8	51(2+3+4+7+8+9+9+9)	Mud Depth: 5-9m
7	Gujora	4 July 1997	1	0	0		Mud Depth: 4-8m
8	Hüngnam	30 Jan 1997	3	2 (Ty1: 1 Ty3: 1)	1		Muddy sand Depth: 6-8m
		3 July 1997	0	1 (Ty1: 1)	0	8	
		13 Jan 1998	2	2 (Ty1: 1 Ty4: 1)	0		
9	Ch'undo	1 Feb 1997	4	0	1		Coarse mud Dead shells Depth: 6-10m
		30 June 1997	0	1 (Ty4: 1)	0	2	

¹Total numbers of *C. filiformis*'s tubes, ²Numbers of *C. filiformis*, ³Numbers of *C. filiformis*'s tubes buried phoronids, ⁴Numbers of phoronids occurred in each tube of cerianthids, ⁵See Table 2 for color types.

Cerianthus filiformis Carlgren, 1924 (pp. 169-173);

Uchida, 1968 (p. 199); Song, 1986 (pp. 79-87).

Cerianthus misakiensis Nakamoto, 1923 (pp. 167-172).

Previous records in Korea: Jagyag-do, Hügsan-do (Song, 1986).

Material examined: 6 individuals, with larva, Jagyag-do, 4 May 1996 (Jl Song); 2 inds., Dökdong, 6 July 1996 (BSRI); 3 inds., Ssanggun, 8 July 1996 (BSRI); 2 tubes, Dökdong, 28 Jan. 1997 (BSRI); 4 inds., 14 tubes, Susan, 29 Jan. 1997 (BSRI); 2 inds., 3 tubes, Hüngnam, 30 Jan. 1997 (BSRI); 4 tubes, Ch'undo, 1 Feb. 1997 (BSRI); 1 ind., Ch'undo, 30 June 1997 (BSRI); 1 ind., 1 tube, Dökdong, 2 July 1997 (BSRI); 1 ind., Hungnam, 3 July 1997 (BSRI); 1 tube, Gujora, 4 July 1997 (BSRI); 3 inds., 3 tubes, Jagyag-do, 17 Oct. 1997 (Jl Song); 1 ind., 4 tubes, Dökdong, 12 Jan. 1998 (BSRI); 2 inds., 2 tubes, Hüngnam, 13 Jan. 1998 (BSRI); 3 inds., 14 tubes, Sagok, 14 Jan. 1998 (BSRI).

External features: Tube anemone with an elongated column and aboral end possessing a terminal pore about 1 mm in diameter. Its tube forming of hardened slimy secretion embedding shed cnidae, especially ptychocyst 40-60 x 11-16 µm and 64-92 x 40 µm.

Measurement (mm): Column, length 40-107 (86), width 6-15 (8); Marginal tentacles, length 8-22 (10), number 53-82 (79); Labial tentacles, length 4-10 (7), number 51-75 (69); Actinopharynx, length 6-16 (10); Aboral

end, length (15), width (12). (): Measurement of a complete individual from Jagyag-do on 4 May 1996.

Internal anatomy: Mesenteries of the 1st cycle 18-38 in number, reaching to aboral portion in relation to length of column. Three most dorsal couples, proto-septa present; directives (D) attached to siphonoglyph 3-5 mm long, 1st couple (P₂) to either side of them 38 mm long, 2nd couple (P₃) 9-11 mm long. Metasepta arranged in quartettes with different length; fertile 1st and 3rd septa in each quartette longer than sterile 2nd and 4th. Metaseptal length gradually decreasing from dorsal to ventral sides. In a complete individual from Jagyag-do on 4 May 1996, column 65 mm long, 1st metasepta (M₁) 60 mm, 3rd septa (m₁) 43 mm, 2nd septa (B₁) 8-9 mm, and 4th septa (b₁) 6-19 mm. All septa except for directives bearing filaments with cnidoglandular tracts 8-10 mm long. Longest and oldest metasepta (M₁) reaching 4-5 mm short to aboral end. Gonads were developed on odd-numbered metasepta present within individuals collected from Jagyag-do in April and May, and also larvae with ciliated surface was present within coelom. Samples were collected from Susan on end of January with small gonads within longer metasepta.

Coloration: Column shading was from pale brown to gray brown. Marginal and labial tentacles varied from pale brown to violet depending on individuals in each population (Table 2). Marginal tentacles tinged with

Table 2. Color types on *Cerianthus filiformis* in Korea

	Live specimen					Formalin-fixed specimen				
	Ty 1	Ty 2	Ty 3	Ty 4	Ty 5	Ty 1	Ty 2	Ty 3	Ty 4	Ty 5
Marginal tentacles	V ¹	B	V+B	B	V	V	B	V+B	B	V
Labial tentacles	V	B	V, B	V	B	V	B	V, B	V	B
Oral disc	V	B	V, B	V	B	V	RB	V, B	RB	B
Column										
upper part	B ²	RB	B	RB	RB	B	RB, GB ⁴	B	RB	GB
middle part	B	B	B	B	B	B	B	B	B	RB
lower part	RB ³	RB	B	RB	RB	RB	B	B	B	RB

¹Violet, ²pale brown, ³reddish brown, ⁴grayish brown.

pale brown were very common (Ty1+Ty4=14/27, 52%), with violet (Ty1+Ty5=7/27, 26%) were less, and with alternate arrangement of pale brown and violet (Ty3=6/27, 22%) were the least (Table 1).

Habitat: This species occurred in fine mud bottom of low intertidal zone on the western coast of Korea. It was also found in fine mud, coarse mud and muddy sand bottoms of 4-11 m deep on the southern coast, but it did not occur in the intertidal zone which is wide rocky or a shingle shoreline (Table 1). The anterior end was not retracted into the tube because of the lack of sphincter, but when disturbed, the oral end was swiftly drawn into the tube by strong thigmotactic. The tube wall of cerianthids formed of hardened slimy secretion may be divided into 5 layers (Emig et al., 1972), and it was found that *P. australis* builded its own chitinous tube and lived at the interstices of the tube wall layers.

Distribution: Korea (Yellow Sea and Korea Strait), Japan (Misaki-Kyushu).

Phylum Phoronida Hatschek, 1888
Family Phoronidae Lang, 1888
Genus *Phoronis* Wright, 1856

Phoronis australis Haswell, 1883
(Fig. 2 F-G, Figs. 3-4)

Phoronis australis Haswell, 1883 (pp. 606-608): Oka, 1897 (p. 148); Ikeda 1901 (p. 583); 1902 (pp. 115-118); 1903 (pp. 141-151); Ohuye 1942 (pp. 167-184); Hyman, 1959 (pp. 232, 247, 264, 267, 270); Emig, 1973 (pp. 346-247); 1977 (pp. 21-35); 1979 (pp. 5-14, 16, 22, 25, 47); 1985 (pp. 184-193); Emig and Roldan, 1992 (pp. 1-8); Emig et al., 1972 (pp. 304-315).

Phoronis buskii McIntosh, 1888 (pp. 1-27)

Material examined: 1 ind. in one of three (1/3) tubes, Ssanggun, 8 July 1996 (BSRI); 51 inds. in 8/14 tubes, Susan, 29 Jan. 1997 (BSRI); 8 inds. in 1/3 tubes, Hüngnam, 30 Jan. 1997 (BSRI); 2 inds. in 1/4 tubes, Ch'undo, 1 Feb. 1997 (BSRI); 4 inds. in 2/4 tubes, Dökdong, 12 Jan. 1998 (BSRI); 4 inds. in 3/14 tubes,

Sagok, 14 Jan. 1998 (BSRI).

External features: Column slender, cylindrical, colorless, and up to 42 mm long with 300-990 tentacles. Trunk uniform diameter except for posterior end bulb (ampulla). Tentacular crown demarcated from trunk by a slight groove. Tentacles basally fused about 1/4 of their total length, forming a membrane bordering mouth and buccal grooves, and continuous with lophophoral ridges. Mouth located midventrally between two lophophoral ridges, flattened dorsoventrally, and large crescentic aperture in shape. Lophophore spiral with 1.5 to 2.5 coils on each side. New tentacles, youngest and shortest ones, arising to each side in middle of inner row of tentacles.

Measurements (mm): Column, length 9.0-42, width 0.7-2.5; Lophophore, length 1.5-8, width 1.0-2.5; Ampulla, length 2.8-10, width 2.5-3.5.

Internal anatomy: Tentacles hollow, slender, ciliated extension of body wall, laterally flattened, hence oval in cross section. A plane passing through mouth and anus, bilateral symmetry at least anterior part. Nephridia with two funnels, anal large and oral small, descending branch lacking, and nephridiopores located on nephridial papilla on each side of anus at its level or above in group 3 (Emig, 1979). Giant nerve fibres two, one left and one right sides along site of attachment of lateral mesenteries.

Longitudinal muscle bundles of bushy type: (N=6), the general formula is

$$[50-60] \frac{17-22}{7-11} \left| \frac{16-21}{7-11} \right. \text{ and the mean formula is}$$

$$54 = \frac{19}{8} \left| \frac{18}{8} \right.$$

Coloration: Anterior body part and lophophore black to purple, from middle part towards posterior deep reddish or pink. In formalin, anterior part black and posterior milky white.

Habitat: This species has a remarkable habitat that its

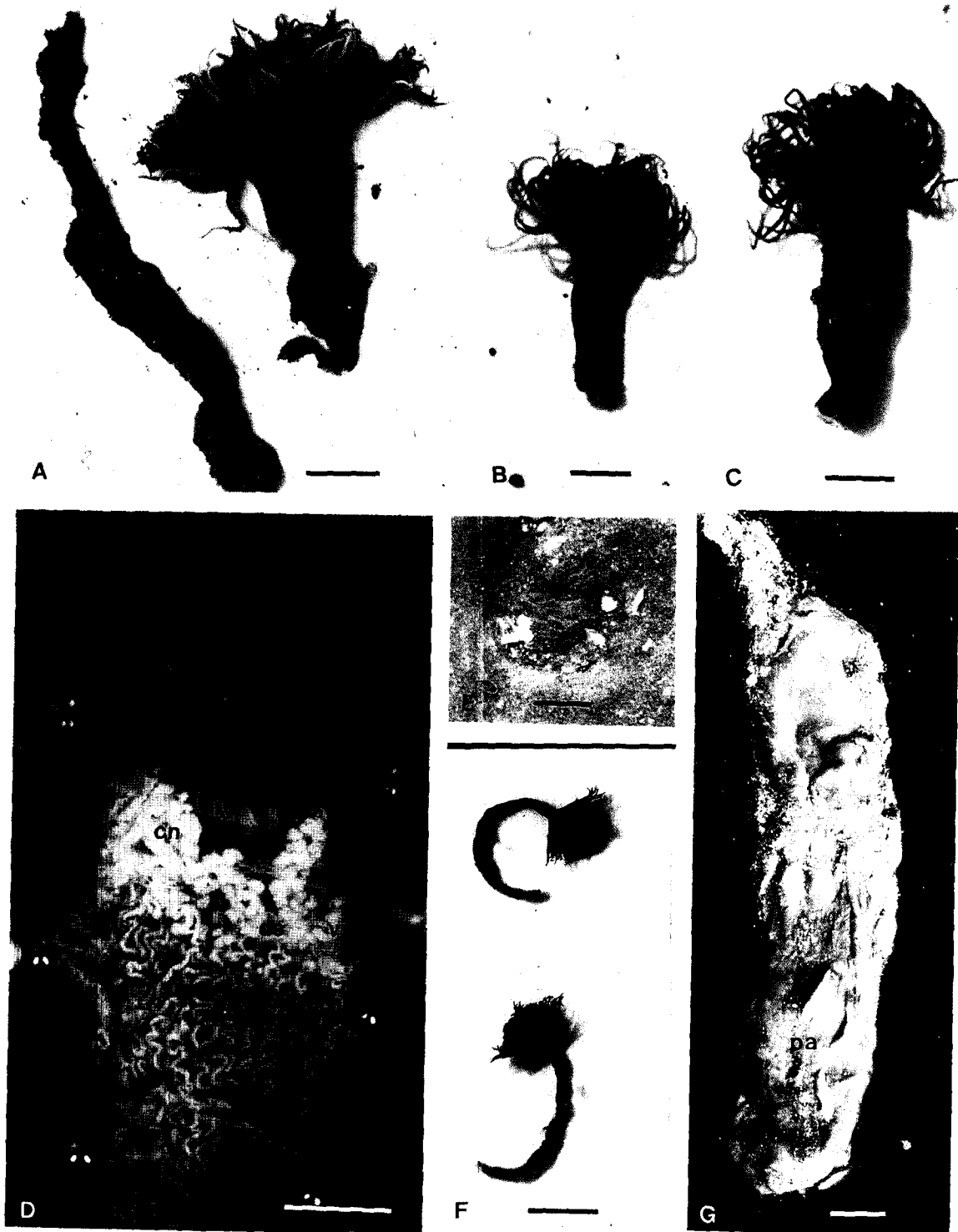


Fig. 2. Three color types of *Cerianthus filiformis*. A, Ty2 and a tube from Hungnam. B, Ty4 from Ssanggun. C, Ty1 from Ssanggun. D, Internal feature of *C. filiformis* from Jagyag-do. E, *C. filiformis* buried in sandy mud showing the tip of tube. F, Two shapes of *Phoronis australis*. G, Three specimens of *P. australis* embedded in the tube wall of *C. filiformis*. cn, cnidoglandular tract; di, directives; ds, dorsal side; lt, labial tentacles; me, odd numbered metasepta with gonads; mt, marginal tentacles; pa, *P. australis*; ph, pharynx; si, siphonoglyph; vs, ventral side. Scale bars=1 cm.

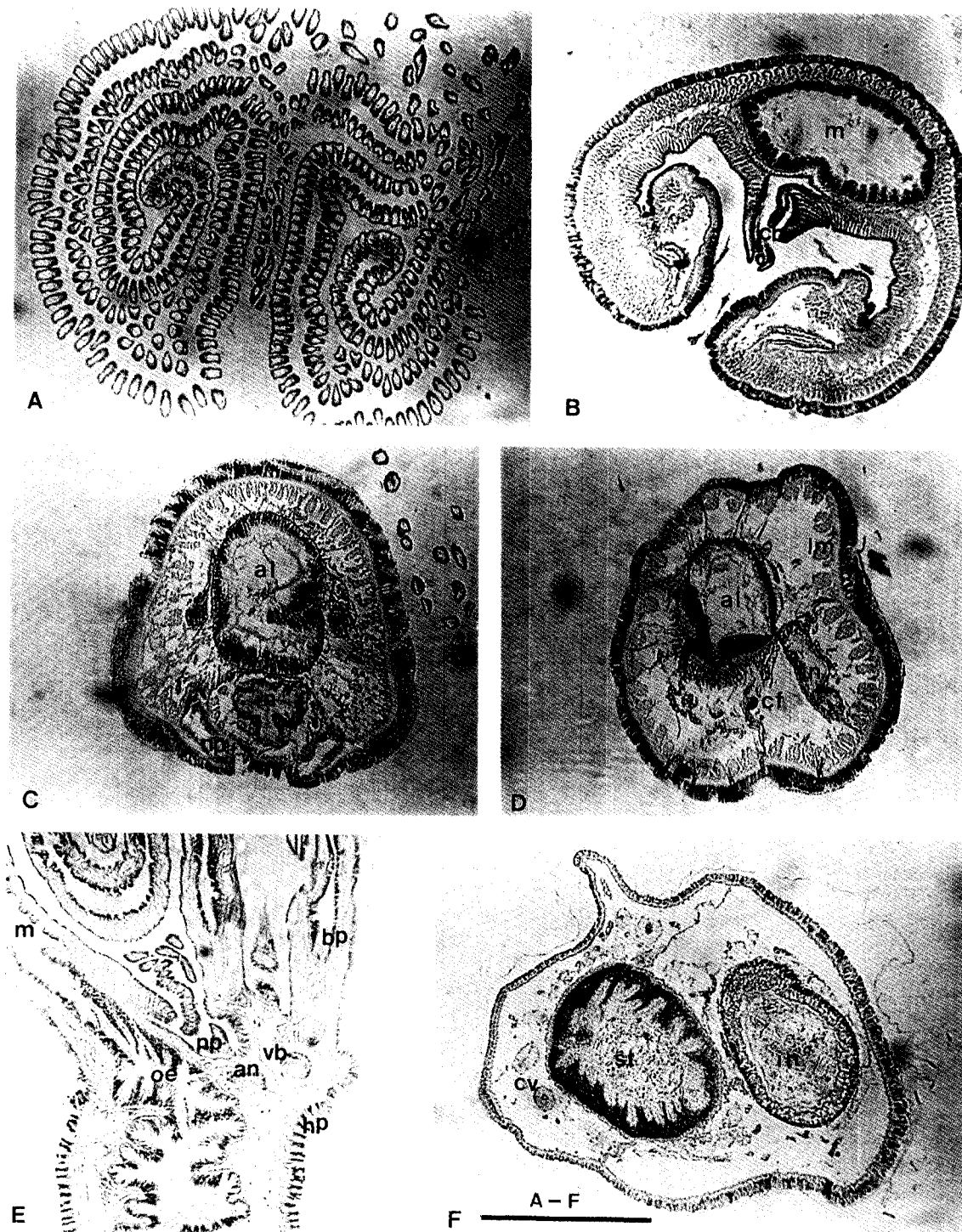


Fig. 3. Internal anatomy of *Phoronis australis*. A, Lophophore. B, Cross section of the base of branchial fans. C, Cross section of the anterior region below the level of anus. D, Cross section of the anterior region of body with longitudinal muscular bands. E, Longitudinal section through the base of branchial fans and the anterior region of body. F, Cross section of the posterior region showing the reproductive organs. an, anus; al, alimentary channel; bp, branchial plumes; cb, ciliated hypodermic organs; cf, peculiar ciliated folds; cv, capillary with vasoperitoneal tissue; hp, hypodermis; in, intestine; lm, longitudinal muscles; m, mouth; np, nephridia; oe, esophagus; st, stomach; vb, blood vessel. Scale bar=0.5mm.

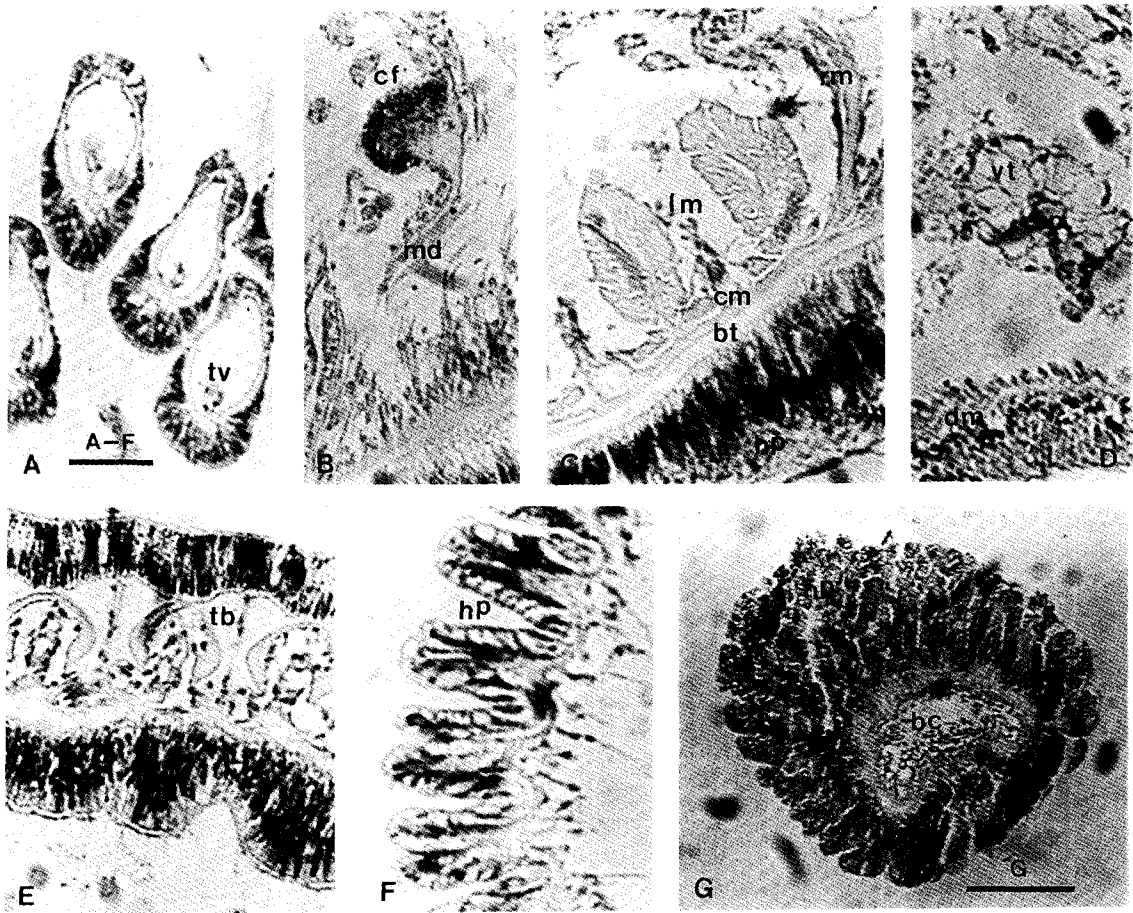


Fig. 4. Magnified view of portions of *Phoronis australis*. A, Cross section of branchial tentacles. B, Peculiar ciliated folds on the mesentery. C, Cross section of the body wall of anterior region. D, Cross section of the body wall towards the posterior end. E, Cross section of the base of branchial tentacles. F, Longitudinal section through the body wall. G, Cross section of the body wall towards the posterior end. bc, body cavity; bt, basement tissue. cf, peculiar ciliated folds; cm, circular muscle coat; cp, capillary coecum; dm, decussation of muscular layers; hp, hypoderm; lm, foliate of penniform arrangement of the longitudinal muscle; md, dorsal mesentery; rm, radiate mesentery; tb, base of tentacle; tv, tentacular vessel; vt, vasoperitoneal tissue. Scale bars=0.01 mm (A-F) and 0.5 mm (G).

delicate transparent tubes occupy interstices of tube wall of *C. filiformis*. This relationship indicates the commensals defined as an inquilinism on the basis of three relations, namely substrate, feeding and protection (Emig et al., 1972). Their transparent tubes were orange in color and made of chitin. Ampulla always burrows inner layer of tube wall of cerianthids, and lophophore projects externally. Seventy phoronids in total were collected from 16/53 tubes of cerianthids and they consisted of none in 9 tubes, 1 in 4 tubes, 2 in 3 tubes, 3 in 2 tubes, 4 in 1 tube, 7 in 1 tube, 8 in 2 tubes, and 9 in 3 tubes (Table 1). Most of them (69/70) occurred less than 10 individuals per a tube collected at 4-11 m deep of the Korea Strait in January and February.

Distribution: Korea (Yellow Sea and Korea Strait), Japan (Misaki and Kii Peninsula), China (Amoy and Qingdao), Philippines, Vietnam (Nhatrang Bay), Australia (Waterman Bay, South Port, Moreton Bay and Sydney),

India, Madagascar, Mozambique, Israel, Spain, Senegal and USA.

Discussion

Our results on the faunal study of Korean cerianthids revealed that *C. filiformis* lives in fine mud, coarse mud and muddy sand bottoms from low intertidal zone to 11 m deep at the western and southern coasts of Korea. The color of tentacles varied in each population. Marginal and labial tentacles were reported as light brown in the previous study (Song, 1986), but they showed pale brown to violet in each population, and a half of them were pale brown. The cerianthids generally develop their gonads from January, and breed in April and May in Korea. The tube walls of them consist of large cnidom, ptychocyst up to 92 x 40 μ m discharged from column.

The previous phylogenetic studies of Anthozoa reported that, according to the 18S rDNA sequence analyses,

Ceriantharia represented by *C. filiformis* and Antipatharia by *Antipathes lata* may not be closely related to each other. The former appeared as the most primitive within Anthozoa, and the latter seemed to be related to subclass Zoantharia (Song and Won, 1997).

P. australis defined as an inquilinism displays a unique association with cerianthid anemones, mainly of *Cerianthus*: *C. maua* from Madagascar (Emig, 1973; Emig et al., 1972) and *C. filiformis* from Japan (Uchida, 1968) and Korea in this work. Ikeda (1902) noticed that the phoronid has the same color as *Cerianthus*, a case of mimicry, but the tentacles of *P. australis* from Korea are black to purple, the same color as the cerianthid's tube. The phoronid has been widely recorded from the intertidal zone to 30 m deep of all ocean, but its distribution depends on the occurrence of cerianthids. Its density in Korea is lower (less than 10 individuals) than other records (up to 100 per a cerianthid tube) (Emig, 1979). Ikeda (1903) mentioned that some individuals with sexual organs were found to be developed in September, but such developed individuals were not found in the present study.

The past systematic studies of the phylum Phoronida consisting *P. australis* reported that the phoronids, as the sister class of the articulate brachiopod, are derived lophophorates and are also the protostome lineage closely related to mollusks and annelids (Halanych et al., 1995). However, several authors including Emig (1979, 1982) treated the phoronids as a class Phoronida within the phylum Lophophorata, and others regarded phoronids as a separate phylum Phoronida (Hyman, 1959; Brusca and Brusca, 1990; Kozloff, 1990; Pechenik, 1996).

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