

Taxonomy of Ascidians from Geojedo Island in Korea

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ABSTRACT

This study was made as a part of the benthic fauna of Geojedo Island. The material was obtained from 17 localities (Fig. 1) along the coastal sea of Geojedo Island and its adjacent waters during the years 1995-1998. This paper includes 38 species from a limited area of the southern part of Korea and includes 13 previously known species by Rho (1975-1991). Of these *Didemnum (D.) pardum*, *Symplegma oecania*, and *Styela coriacea*, are new to the Korean fauna, and 22 species are newly added to the fauna of Geojedo Island. We provided taxonomic notes and brief notes on the ascidian fauna, and the biogeographical distribution of Geojedo island. Its ascidian fauna are characterized by a high percentage of 18 (47.4%) warm-water species and the extreme scarcity of eight (21.1%) boreal-water forms. This result may be attributable to the fact that Geojedo Island and its adjacent waters are located under the influence of the warm Kuroshio Current.

Key words: Taxonomy, Ascidians, Geojedo Island, Korea

INTRODUCTION

Geojedo Island (34°40' -35°04' N, 128°27' -128°45' E) is located in the southern part of Korea, and faces a long calm inlet with shallow sand-muddy bottom of its western side. In the inlet there are many floats for culturing the pearl oysters, to which a large number of ascidians are attached. On the other hand, rocky or gravel shores facing the open sea are also not far from the collection areas. During recent years it has been affected by designation as a special economic area with rapidly growing industry and tourism, and also influenced by the warm Kuroshio Current.

The ascidian fauna of Korean waters has been intensively studied by Rho (1971, 1975, 1995),

Rho and Huh (1984), Rho and Lee (1989, 1991), Rho *et al.*, (1996). The studies of the Korean ascidians, however, have been made on the specimens collected from rather restricted localities. Though Geojedo Island is the second largest island in Korea, its ascidian fauna so far was relatively poorly known. Rho (1975-1991) reported 13 ascidian species, of which 10 species were recorded from Changsungpo and Yundol Island, two from Chisepo and two from Kujora.

MATERIALS AND METHODS

All the specimens were made by quantitative sampling method from depths ranging from the intertidal zone to a maximum depths of 30 meters. The specimens were collected from 17 localities along the coastal sea of Geojedo Island and its adjacent waters during from February 1995 to January 1998 (Fig.1). They were preserved in 5% neutral formalin after narcotization with menthol and kept in the solution for a day, which is composed of that 1% chromic acid and 50% acetic acid are in the ratio 1: 10. And then they were transferred in 1% chromic acid solution for softening the tunics.

Among the 38 examined species, nine species are arranged to synonyms and other three of new to the Korean species are described and illustrated.

The identification was done on the basis of the external and internal morphological characters, which were proposed by Van Name (1945), Kott (1985) and Nishikawa (1990, 1991) and the pattern of biogeographical distribution followed after that used by Nishikawa (1992). The specimens examined here were deposited in Department of Biological Science, Ewha Womans University.

SYSTEMATIC ACCOUNTS

Taxonomic notes

Family Polyclinidae Milne Edwards, 1842 만두멍게 과

1. *Aplidium pliciferum* (Redikorzev, 1927) 만두멍게

Amaroucium pliciferum Redikorzev, 1927, p. 387, figs. 9-10.

Amaroucium pliciferum: Tokioka, 1953, p. 183, pl. 6, figs. 1-10; pl. 7, fig. 1; Rho, 1966, p. 211, pl.1, figs. 1-5.

Aplidium pliciferum: Kott, 1963, p. 106, fig. 20.

For other synonyms and reference; see Nishikawa, 1990, p. 94.

Material examined. 2 colonies, Isudo I., 12 Feb. 1995 (scuba); 10 colonies, Gudo I., 6 Feb. 1996 (scuba); 5 colonies, Isudo I., 7 Feb. 1996 (scuba); 5 colonies, Heungnam, 30 Jan. 1997 (scuba); 1 colony, Heungnam, 6-8 m depths, 3 July 1997 (scuba); 1 colony, Yanghwa, 4 July 1997 (scuba); 4 colonies, Heungnam, 7 m depths, 13 Jan. 1998 (scuba); 3 colonies, Sagog, 8-10 m depths, 14 Jan. 1998 (scuba); 1 colony, Haksan, 14 Jan. 1998 (scuba)

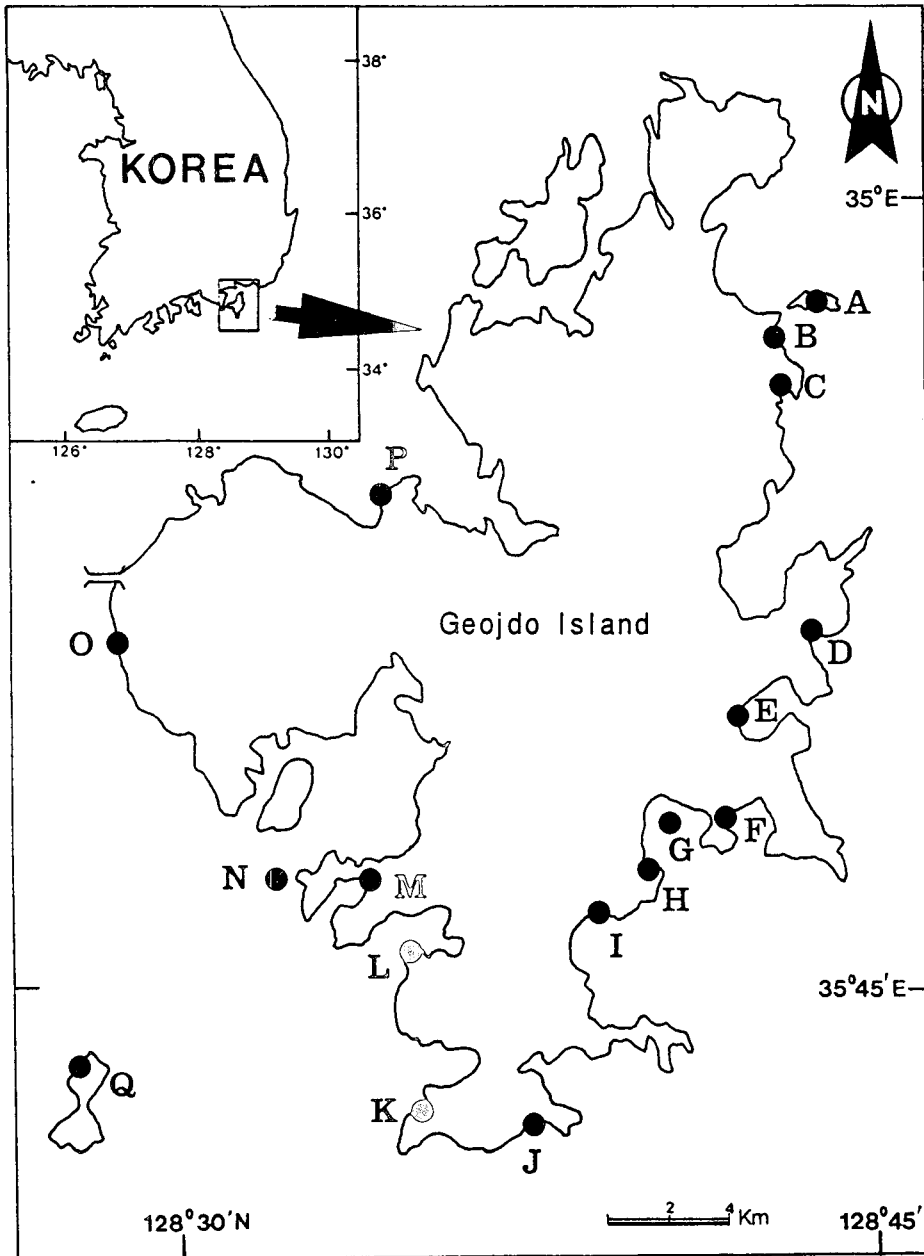


Fig. 1. Map showing the sampling sites. A, Isudo Island; B, Heungnam; C, Oepo; D, Jangseungpo; E, Chisepo; F, Kujora; G, Yundol Island; H, Yanghwa; I, Susan; J, Yeocha; K, Daepo; L, Ssanggeun; M, Gabae; N, Gudo Island; O, Haksan; P, Sagog; Q, Bijindo Island.

Family Didemnidae Verrill, 1871 흰덩이멍게 과

*2. *Didemnum (D.) pardum* Tokioka, 1962 짝패흰덩이멍게 (신칭) (Fig. 2 A-E)

Didemnum (Didemnum) pardum Tokioka, 1962, p. 266, text fig. 4.

Didemnum (Didemnum) pardum : Nishikawa, 1990, p. 103, fig. 5B-D.

Material examined. 2 colonies, Isudo I., 25 July 1995 (scuba); 10 colonies, Oepo, 7 July 1996 (scuba); 2 colonies, Ssanggeun, 7 July 1996 (scuba); 5 colonies, Yeocha, 9 July 1996 (scuba); 6 colonies, Yanghwa, 8-10 m depths, 4 July 1997 (scuba).

Description. Colonies shape variable, growth extensive, depending on substrate, often cylindrical over worm tubes, not over 1 mm to 2.5 mm thick; preserved pale pinkish white; Lacuna very spacious in thoracic zone, sometimes down to abdominal or rarely further hypozoidal zone; Spicules crowded at surface over zooids and around cloacal apertures, and *moseleyi*-type, 20 to 40 μm in diameter in surface layer, but rather various size in the rest, 12 to 50 μm in diameter, rays short, conical, blunted at the tip, about 7 to 9 or most frequently 8 to 9 rays on equatorial plane and

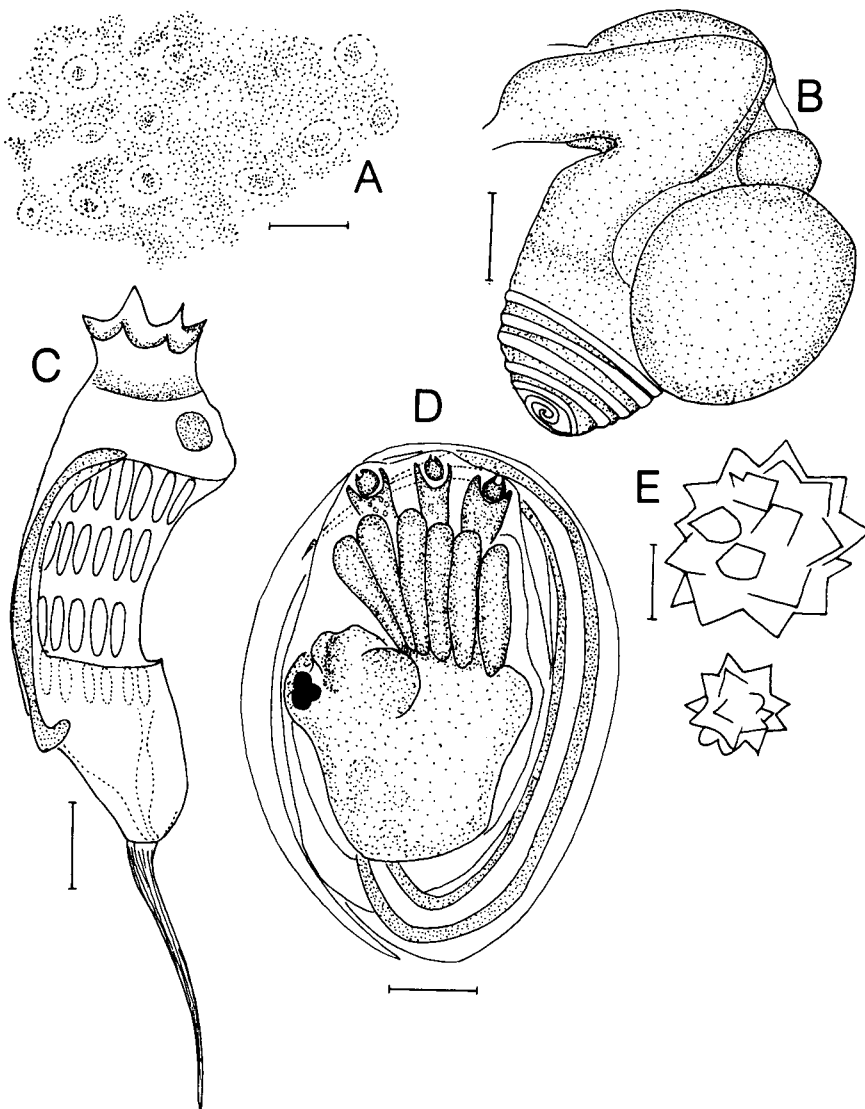


Fig. 2. *Didemnum (D.) pardum* Tokioka, 1962. A, Part of a colony; B, Left side of abdomen; C, Left side of thorax; D, Larva from right side; E, spicules; (Scale bars: A = 0.5 mm, B-D = 0.1 mm, E = 0.001 mm).

distance between zooids 400 μm .

Zooid length to 1mm (thorax 550 to 900 μm , abdomen 300 to 900 μm long); color preserved opaque white; short branchial siphon with six blunt lobes distinctly, atrial aperture wide and lacking languet; branchial sac with four rows about six stigma in each row; small thoracic organs observed; retractile muscle various size, length to 700 μm ; anus opens on third stigmata row.

Ovary contains single ovum, 280 to 350 μm in diameter, situated right side of testis. Testis follicle single, 6-7 times vas deferens coils. Larva oval, length without tail 450 to 550 μm , three adhesive disks, six pairs lateral ampullae.

Remarks. This species are quite similar to *Didemnum (D.) pardum* (see Tokioka, 1962 and Nishikawa, 1990), collected from Japanese waters, the test surface of which is usually flat encrusting, the dense and usually even distribution of *moseleyi*-type spicules, and the thoracic organ situated near the posteroventral corner of atrial aperture. But the Korean specimens are somewhat distinguished from it by the size of spicules, the distance between zooids and the number of vas deferens coils. This species is the first described in Korean waters.

Distribution. Korea (South Sea), Japan (Hokkaido, Mutsu Bay, Sagami Bay).

Family Rhodosomatidae Kott, 1992 안장멍게 과

3. *Chelyosoma siboja* Oka, 1906 거북등안장멍게

Chelyosoma siboja Oka, 1906, p. 51.

Chelyosoma dofleini: Rho, 1971, p. 112; 1975, p. 113.

Chelyosoma siboga: Nishikawa 1984, p. 150; 1991, p. 67, fig. 20.

Material examined. 5 individuals, Gudo I., 6 Feb. 1996 (scuba); 6 inds., Ssanggeun, 7, 8 July 1996 (scuba); 4 inds., Oepo, 7 July 1996 (scuba); 4 inds., Heungnam, 30 Jan. 1997 (scuba); 3 inds., Heungnam, 6-8 m depths, 3 July 1997 (scuba); 2 inds., Heungnam, 7m depths, 13 Jan. 1998 (scuba).

Family Styelidae Sluiter, 1895 미더덕 과

*4. *Symplegma oceania* Tokioka, 1961 오세안구멍미더덕 (신칭) (Fig. 3 A-F)

Symplegma oceania Tokioka, 1961, p. 114, fig. 7.

Symplegma oceania: Kott, 1981, p. 199; Kott and Goodbody, 1980, p. 531; Kott, 1985, p. 257, fig. 126.

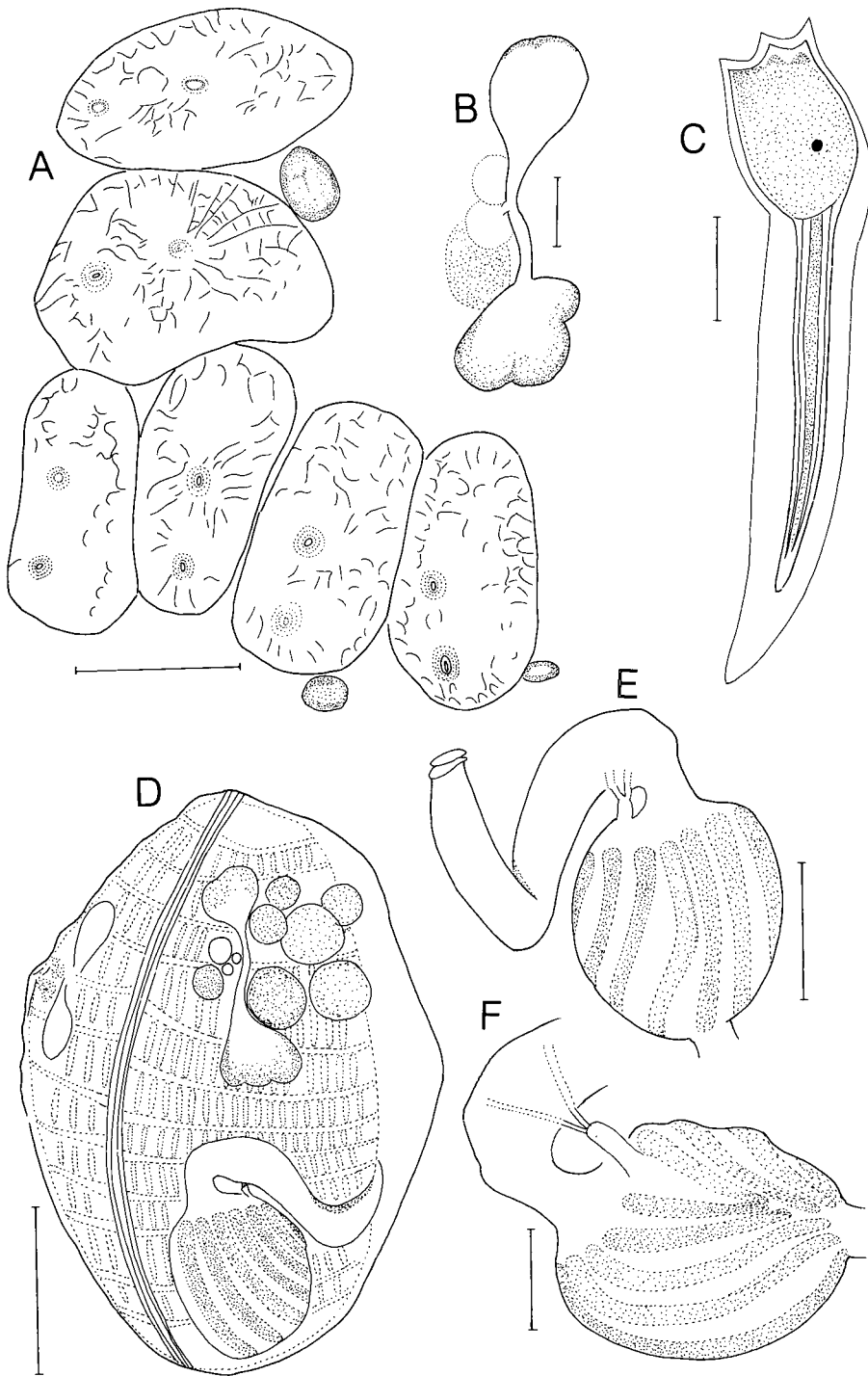
Symplegma viridae: Van Name, 1945, p. 232, fig. 139.

Symplegma sp. aff. *viride*: Tokioka and Nishikawa, 1975, p. 334, fig. 21.

Material examined. 6 colonies, Isudo I., 6 m depths, 12 Feb. 1995 (scuba); 1 colony, Yeocha, 7 July 1996 (scuba); 6 colonies, Ssanggeun, 7-8 July 1996 (scuba); 1 colony, Isudo I., 7 Feb. 1996 (scuba); 9 colonies, Yanghwa, 8-10 m depths, 4 July 1997(scuba); 2 colonies, Heungnam, 7 m depths, 13 Jan. 1998.

Description. The colony covered with *Styela clava*, shells or encrusting tubes of a polychaetous annelid, and up to 3 mm thick. Test thin but very tough nearly transparent and colorless.

Zooids, up to 3 mm long and 2 mm width, compressed dorsoventrally, lie obliquely on their postero-ventral surface, with both sessile apertures on the dorsal surface, branchial aperture subterminal and atrial at about the middle of the body. Tentacles 10, longer and smaller ones



Figs. 3. *Symplegma oecania* Tokioka, 1961. A, Part of a colony; B, A gonad, showing elongated sperm duct; C, Larva from left side; D, Zooid from ventral side; E-F, Right and left side of alimentary canal. (Scale bars: A = 2 mm, B, E = 0.5 mm, C = 0.03 mm, D = 1mm, F = 0.3 mm).

alternating. Ciliated groove an oval slit elongated. Four inner longitudinal vessels, and 11-13 rows of branchial stigmata, with 21-27 stigmata in a row and arranged as D. 4-6 : 3-5 : 4 : 4-5 : 6-7 V., on the right side, and second row of branchial stigmata on each side never reaches mid-dorsal line. Stomach, globular in outline, short, wide with 13-14 plications, pyloric caecum curved only slightly, one or two vessels running along outer margin of caecum. Gut, short loop at posterior end of right side and anus turns up onto dorsal side, which opens at 6-7 stigmatal row, bilobed margin.

Gonads well developed, rounded ovary, up to eight eggs, on both side of anterior part of body wall, testes composed of two testicular lobes with 2-5 lobules, contains 2-4 tadpole larvae as well as matured ova in a zooid collected from Ssanggeun.

In preserved larvae, yellowish orange, 2-4 mm in whole length, and trunk attains 0.5 mm long, three conical processes arranged in a triangle, and seen several elongated ampullae.

Remarks. The most of characters of our specimens are very similar to the type specimen from Melanesia, the Western Pacific (see Tokioka, 1961), however our specimens differ in that *Symplegma oceania* (see Tokioka, 1961) has 13-14 rows of branchial stigmata, with 23-29 stigmata in a row, only eight tentacles and slightly curved caecum.

The general morphology of our specimen is the same as that of *S. oceania* (see Kott and Goodbody, 1980), but the Hong Kong species have only 11 stomach plications and 11 rows of branchial stigmata, not our specimen's 13-14 and 11-13 rows. The other similar species, the lectotype and paralectotype of *S. reptans* (Oka, 1927) sensu Nishikawa, 1991 collected from Tateyama by Oka, given by Nishikawa (1991) is similarities to *S. oceania* (see Tokioka, 1961) in it's form of the pyloric coecum, but *S. oceania* (see Tokioka, 1961) is distinguished from it by the number of stigmatal rows (8-9), stigmata in a row (20) and stomach plications (8-9).

Distribution. Korea (South Sea), Hong Kong (Bluff Island, S-W., East Nine Pins), China, Thailand, Piliphine, Melanesia, Fiji, Australia, Indian Ocean, Sri Lanka, Polynésie.

5. *Cnemidocarpa clara* (Hartmeyer, 1906) 긴위멍게

Styela clava Hartmeyer, 1906, p. 13, fig. 7.

Styela macrogastra: Oka, 1935, p. 450, figs. 20-21.

Cnemidocarpa macrogastra: Tokioka, 1953, p. 260, pl. 59, figs. 1-7; 1967, p. 183, fig. 77; Rho, 1971, p. 118, pl. 4, figs. 2-5; 1975, p. 138.

Cnemidocarpa clara: Redikorzev, 1941, p. 191, fig. 15; Nishikawa, 1991, p. 99, fig. 25.

Material examined. 1 ind., Oepo, 7 July 1996 (scuba); 1 ind., Daepo, 29 Jan. 1997 (scuba); 5 inds., Yanghwa, 8-10 m depths, 4 July 1997 (scuba); 2 inds., Sagog, 8-10 m depth, 14 Jan. 1998 (scuba); 1 ind., Heungnam, 13 Jan. 1998 (scuba).

6. *Cnemidocarpa irene* (Hartmeyer, 1906) 유두멍게

Styela irene Hartmeyer, 1906, p. 7, fig. 4.

Styela esther Hartmeyer, 1906, p. 8; Oka, 1935, p. 445, figs. 15.

Cnemidocarpa areolata: Tokioka, 1950, p. 145, fig. 20; 1953, p. 254, pl. 54, figs. 1-9, pl. 58, figs. 5-8; 1967, p. 181, fig. 76; Rho, 1971, p. 117, pl. 5, figs. 1-7; 1975, p. 136; Nishikawa, 1980, p. 99, tab. 1; Kott, 1985, p. 122, figs. 50 b, c, 53.

Cnemidocarpa irene: Nishikawa, 1991, p. 96.

Material examined. 1 ind., Isudo I., 25 July 1995 (scuba); 1 ind., Isudo I., 6 m depths, 7 Feb. 1996 (scuba); 1 ind., Yeocha, 9 July 1996 (scuba); 1 ind., Ssanggeun, 8 July 1996 (scuba).

7. *Metandrocarpa Kudo* Rho and Cole, 1998 구도짜구슬미더덕

Metandrocarpa Kudo Rho and Cole was submitted to the Bulletin of Marine Science (in press).

Material examined. 10 colonies, Mipo (Pusan), covered with seaweeds, 10 December 1981 (scuba); 2 colonies, Ssanggeun, 8 July 1996 (scuba); 1 colony, Bijindo I., covered with Gastropoda, *Ocinebrellus oduneus*, 30m depths, 9 July 1996 (scuba)

Remarks. This colony in life is cherry-red, a colony consist of bulbous or dome-shaped zooids, and 4 to just over 6 mm in diameter. The general morphology of the Mipo, Ssanggeun and Bijindo Island specimens are the same as that of the Gudo Island (Geojedo Island) species, and *Metandrocarpa kudo* (see Rho and Cole, 1998) is distinguished from present specimens by its laterally compressed of the body (table 1).

8. *Styela tokiokai* Nishikawa, 1991 세줄멍게

Styela tokiokai Nishikawa, 1991, p.125.

Styela esther: Tokioka, 1953, p. 266, pl. 60, figs. 5-11; Rho, 1971, p. 119; 1975, p. 140; Nishikawa and Tokioka, 1975, p. 222.

Material examined. 1 ind., Isudo I., 12 Feb. 1995 (scuba); 2 inds., Gudo I., 6 Feb. 1996 (scuba); 1 ind., Isudo I., 7 Feb. 1996 (scuba); 14 inds., Ssanggeun, 7-8 July 1996 (scuba); 2 inds., Yeocha, 9 July 1996 (scuba); 2 inds., Susan, 29 Jan. 1997 (scuba); 1 ind., Yanghwa, 8-10 m depths, 4 July 1997 (scuba); 4 inds., Heungnam, 7m depths, 13 Jan. 1998 (scuba).

***9. *Styela coriacea* (Alder and Hancock, 1848)** 가죽주머니미더덕 (신칭) (Fig. 4 A-F)

Cynthia coriacea Alder and Hancock, 1848, p. 196.

Styela coriacea: Hartmeyer, 1923, p. 220, fig. 15; Van Name, 1945, p. 285, fig. 179F, 181-183; Berrill, 1950, p. 182, fig. 56b, 58; Årnback-Christie-Linde, 1952, p. 26; Millar, 1952, p. 24, 1966, p. 65, fig. 41; 1970, p. 55, fig. 36; Tokioka, 1967, p. 195, fig. 85; Monniot, 1969, p. 169, fig. 4-5; Nishikawa, 1984, p. 151; 1991, p. 115, fig. 30.

Material examined. 1 ind., Isudo I., 8 m depths, 25 July 1995 (scuba).

Description. Specimens 20 mm length, 17 mm width, 9 mm in depth, rather tall, compressed laterally with four lobed aperture, attached by broad expended base; test tough, commonly spread out; specimen dirty pinkish yellow, contract in preserved state.

Musculature of mantle developed on dorsal and ventral; tentacles 29, filiforms, arranged alternating in sizes; dorsal lamina membranous; ciliated groove C-shaped with open toward left; branchial sac with four folds; inner longitudinal vessels quite close, seperated by width of one, two, or three stigmata, arranged as follows:

L.D. 1 (13) 2 (11) 2 (14) 3 (11) 2 V.

R.D. 1 (13) 2 (16) 3 (9) 2 (6) 2 V.

One or two thinner vessels inserted between thicker ones, 5-6 or 6 stigmata in a mesh, 10 along endostyle; parastigmata present; stomach elongated, ovoid, with 16 plications, without pyloric coecum; intestinal loop large, deep, closed intestine, rectum S-shaped curve; anus with 10 lobes.

Table 1. Characters on *Metandrocarpa kudoii* from Korean waters.

Locality and date	Zoid from	Length, with & height of zooids (mm)		Internal longitudinal vessels	Rows of stigmata	Gonads		Tentacles	No. of stomach plications	Larva (μ m)	Substratum
		length	width			height	length				
Mipo, Dec. 81	dorsoventrally depressed	3-4	2.8-3	1.8-2.8	7	13-14 or 15	4	5	18-19	trunk; 1,000 notochord; 1,000-1,500 tail fin: 1,800-2,000 width: 800	sea weeds, tube of annelids
							7	10			
Gudo I., Feb. 96 (paratype)	laterally compressed	4.5-6	2.5-4.5	2.5-3	7-8	14-15	8	5	10-20	18-20	Rock, <i>Styela clava</i>
							5	6			
Ssanggeun, JUL. 96	dorsoventrally depressed	5-6.5	3-4	1.8-2	7-8	14	5	5	16-20	19-20	other ascidian, mollusca's shell
							4	5			
Bijindo I., Jul. 96	dorsoventrally depressed	4-6	3-4	2-3.5	7-8	14	4	5	12	14	Gastropoda; <i>Ocinebrellus oduncus</i>
							7	8			
							5	6			
							4	4			
							4	4			
							4	6			
							7	7			
							7	10			
							5	5			
							4	5			
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							4	5			
							7	8			
							5	8			
							7	7			

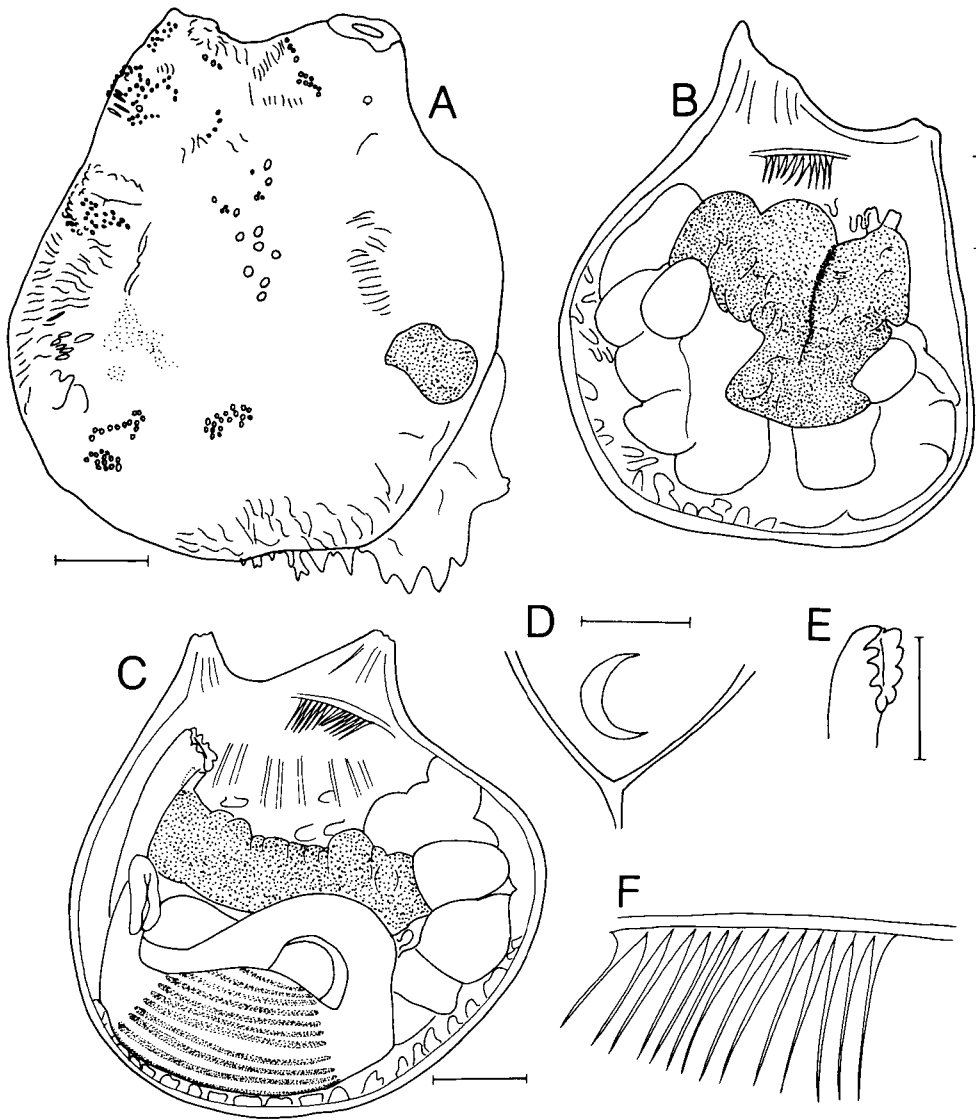


Fig. 4. *Styela coreace* (Alder et Hancock, 1948). A, Entire animal; B, Right inner side of mantle body; C, Left inner side of mantle body; D, Ciliated groove; E, Rim of anus; F, Tentacles. (Scale bars: A-C = 3 mm, D, E = 0.3 mm, F = 1 mm).

Gonads developed, one on each side, very voluminous, strongly curved; ovary yellow, situated along ventral branch of second intestinal loop, sosage-shaped; massive testicular follicles milky white, along ovary on both and especially ventral sides, double U-shaped on right side, ducts of testes follow ovary, uniting to common duct ending beside oviduct.

This species is the first described from Korean waters.

Remarks. This species is the most closely related to *Goniocarpa coriacea* given by Huntsman, 1912 from the coast of Massachusetts Bay, which may be identical with *G. coriacea*, have larger stomach with numerous longitudinal plications and forming the intestinal loop, and also in many respects this species resembles *S. coriacea* from Japanese waters (see Tokioka, 1967), but the

Japanese species differs in that our species has only 29 tentacles and 5-6 stigmata in a mesh.

Distribution. Korea (South Sea), Japan (South Sakhalin, Hokkaido, Mutsu Bay, Oga Peninsula, Toyama Bay, off Oka islands, Arctic to Northern boreal temperature waters in both hemisphere, Bay of Biscay.

10. *Pyura sacciformis* (Drasche, 1884) 미끈이멍게

Cynthia sacciformis Drasche, 1884, p. 376, pl. 5, figs. 2-3.

Cynthia sanderi Traustedt and Weltner, 1894, p. 11, tab. 11, figs. 1-3.

Halocynthia sanderi: Hartmeyer, 1906, p. 4.

Pyura aspera: Tokioka, 1949a, p. 10, pl. 4, figs. 6-8.

Pyura masuii: Tokioka, 1949b, p. 57, text-fig. 21.

Pyura sanderi: Tokioka, 1953, p. 275, pl. 67, figs. 1-9, pl. 68, figs. 1-2; Rho, 1971, p. 122, pl. 8, figs. 1-4; 1975, p. 144.

Pyura sacciformis: Kott, 1981, p. 203, fig. 34c; 1985, p. 321; Nishikawa, 1991, p. 131.

Material examined. 6 inds., Isudo I., 6-7m depths, 12 Feb. 1995 (scuba); 7 inds., Isudo I., 2-7m depths, 25 July 1995 (scuba); 4 inds., Isudo I., 7 Feb. 1996 (scuba); 9 inds., Gudo I., 6 Feb. 1996 (scuba); 7 inds., Ssanggeun, 7-8 July 1996 (scuba); 6 inds., Oepo, 7 July 1996 (scuba); 2 inds., Daepo, 29 Jan. 1997 (scuba); 3 inds., Susan, 29 Jan. 1997 (scuba); 5 inds., Heuhngnam, 30 Jan. 1997 (scuba); 4 inds., Yanghwa, 8-10m depths, 4 July 1997 (scuba); 11 inds., Heungnam, 8-10m depths, 3 July 1997 (scuba); 1 ind., Heungnam, 7m depths, 13 Jan. 1998 (scuba).

11. *Halocynthia hispida* (Herdman, 1881) 개멍게 (신칭)

Cynthia hispida Herdman, 1881, p. 61.

Halocynthia igaboja Oka, 1906, p. 45.

Halocynthia ritteri Oka, 1906, p. 43.

Halocynthia igaboja: Van Name, 1945, p. 362.

Halocynthia hilgendorfi f. *igaboja*: Tokioka, 1959, p. 233, pl. 17., figs. 38; Rho, 1975, p. 151, pl. 11, figs. 1-5.

Halocynthia hilgendorfi f. *ritteri*: Tokioka, 1959, p. 233, pl. 17, figs. 43, pl. 18, figs. 44; Rho, 1971, p. 129, pl. 13, figs. 1-5; 1975, p. 150.

Halocynthia hispida: Kott, 1968, p. 77, text-fig. 1; Nishikawa, 1991, p. 145.

Material examined. 14 inds., Isudo I., 4-6m depths, 12 Feb. 1995 (scuba); 19 inds., Isudo I., 5-8m depths, 25 July 1995 (scuba); 9 inds., Isudo I., 5-7m depths, 7 Feb. 1996 (scuba); 5 inds., Gudo I., 6 Feb. 1996 (scuba); 32 inds., Ssanggeun, 7-8 July 1996 (scuba); 4 inds., Yeocha, 9 July 1996 (scuba); 2 inds., Daepo, 9 July 1996 (scuba); 31 inds., Oepo, 7 July 1996 (scuba); 7 inds., Yeocha, 9 July 1996 (scuba); 2 inds., Daepo, 29 Jan. 1997 (scuba); 5 inds., Susan, 29 Jan. 1997 (scuba); 7 inds., Heungnam, 30 Jan. 1997 (scuba); 16 inds., Yanghwa, 10m depths, 4 July 1997 (scuba); 1 ind., Heungnam, 6-8m depths, 3 July 1997 (scuba); 1 ind., Heungnam, 7 m depths, 13 Jan. 1998 (scuba).

12. *Mogula tectiformis* Nishikawa, 1991 미끈가죽빛멍게

Mogula tectiformis Nishikawa, 1991, p. 160, fig. 39.

Mogula calvata Sluiter, 1904, p. 116.

Mogula calcata: Kott, 1964, p. 144; 1985, p. 369, figs. 184; Miller, 1975, p. 322, fig. 101; Rho, 1991, p. 206, fig. 5.

Material examined. 2 inds., Ssanggeun, 8 July 1996 (scuba); 3 inds., Yeocha, 9 July 1996 (scuba).

Collection made by the present survey

1. Isudo Island

Rocky shore and Subtidal zone, by Scuba divers, 1989, 1995 to 1996, 2-8 m depths: *Aplidium pliciferum* Redikorzev, *Didemnum (Didemnum) moseleyi* (Herdman), *D. (D.) pardum* Tokioka, *D. (Polysyncraton) aspiculatum* Tokioka, *Diplosoma macdonaldi* Herdman, *Ascidia sydneyensis* Stimpson, *Rhodossoma turcicum* Savigny, *Chelyosoma siboja* Oka, *Botryllus tuberatus* Ritter et Forsyth, *Symplegma oceanica* Tokioka, *Cnemidocarpa clara* (Hartmeyer), *C. fertilis* Hartmeyer, *C. irene* (Hartmeyer), *Styela tokiokai* Nishikawa, *S. coriacea* (Alder and Hancock), *S. clava* Herdman, *Pyura sacciformis* (Drasch), *Boltenia echinata* (Linnaeus), *Halocynthia roretzi* (Drasch) and *H. hispida* (Herdman).

2. Heungnam

Rocky shore and Subtidal zone (muddy bottom), by Scuba divers, Jan. 1997 to Jan. 1998, 6-8 m depths: *Aplidium pliciferum* Redikorzev, *Didemnum (D.) moseleyi* (Herdman), *D. (P.) aspiculatum* Tokioka, *Diplosoma macdonaldi* Herdman, *Ciona intestinalis* (Linnaeus), *Ascidia sydneyensis* Stimpson, *Chelyosoma siboja* Oka, *Botryllus tuberatus* Ritter et Forsyth, *Symplegma oceanica* Tokioka, *Cnemidocarpa clara* (Hartmeyer), *Styela plicata* (Lesueur), *Styela tokiokai* Nishikawa, *S. clava* Herdman, *Pyura sacciformis* (Drasche), *Halocynthia roretzi* (Drasche) and *H. hispida* (Herdman).

3. Oepo

Fishing net, 7 July 1996, 30 m depths: *Didemnum (D.) moseleyi* (Herdman), *D. (D.) pardum* Tokioka, *Diplosoma macdonaldi* Herdman, *Ciona intestinalis* (Linnaeus), *Ascidia sydneyensis* Stimpson, *A. gemmata* Sluiter, *Chelyosoma siboja* Oka, *Cnemidocarpa clara* (Hartmeyer), *Styela clava* Herdman, *Pyura sacciformis* (Drasche), *Herdmania mirabilis* (Drasche), *Boltenia echinata iburi* (Oka), *Halocynthia roretzi* (Drasche) and *H. hispida* (Herdman).

4. Changseungpo

Fishing net, on 17 July 1970: *Halocynthia hispida* (Herdman).

5. Chisepo

Rocky shore and Gravel shore, 9 July 1977: *Dendrodoa aggregata* Rathke and *Styela clava* Herdman.

6. Kujora

Rocky and Gravel shores, 21 July 1970: *Styela tokiokai* Nishikawa, *Pyura vittata* (Stimpson) and *Boltenia echinata iburi* (Oka).

7. Yundol Island

Rocky shore, 3 July 1973 and 19 July 1989, 0-3 m depths: *Aplidium pliciferum* Redikorzev, *D. (D.) moseleyi* (Herdman), *D. (D.) candidum* Savigny, *Botryllus tuberatus* Savigny, *B. violaceus* Oka, *Pyura vittata* (Stimpson), *P. sacciformis* (Drasche), *Boltenia echinata iburi* (Oka), *Halocynthia roretzi* (Drasche) and *H. hispida* (Herdman).

8. Yanghwa

Rocky shore and Subtidal zone, 4 July 1997, 8-10 m depths: *Aplidium pliciferum* Redkorzev, *D. (D.) moseleyi* (Herdman), *D. (D.) pardum* Tokioka, *Diplosoma macdonaldi* (Herdman), *Ciona intestinalis* (Linnaeus), *Ascidia sydneyensis* Stimpson, *A. zara* Oka, *Rhodosoma turcicum* (Savigny), *Botryllus tuberatus* Ritter et Forsyth, *Symplegma oecania* Tokioka, *Cnemidocarpa clara* (Hartmeyer), *C. fertilis* (Hartmeyer), *Styela tokiokai* Nishikawa, *S. clava* Herdman, *Pyura sacciformis* (Drasche), *P. lepidoderma* Tokioka, *Halocynthia roretzi* (Drasche) and *H. hispida* (Herdman).

9. Susan

Rocky shore and Subtidal zone, 29 Jan. 1997, 10 m depths: *Ascidia sydneyensis* Stimpson, *A. gemmata* Sluiter, *Botryllus tuberatus* Ritter et Forsyth, *Styela tokiokai* Nishikawa, *S. clava* Herdman, *Pyura vittata* (Stimpson), *P. sacciformis* (Drasche), *Halocynthia aurantium* (Pallas), *H. roretzi* (Drasche) and *H. hispida* (Herdman).

10. Yeocha

Fishing net, July 1996 to Jan. 1997, 30 m depths: *Didemnum (D.) moseleyi* (Herdman), *D. (D.) candidum* Savigny, *D. (D.) pardum* Tokioka, *Trididemnum savignii* (Herdman), *Ciona intestinalis* (Linnaeus), *Botryllus tuberatus* Ritter et Forsyth, *Symplegma oecania* Tokioka, *Cnemidocarpa irene* (Hartmeyer), *Styela tokiokai* Nishikawa, *S. clava* Herdman, *Pyura vittata* (Stimpson), *P. sacciformis* (Drasche), *Herdmania mirabilis* (Drasche), *Boltenia echinata iburi* (Oka), *Halocynthia roretzi* (Drasche), *H. hispida* (Herdman) and *Mogula tectiformis* Nishikawa.

11. Daepo

Fishing net, July 1996 to Jan. 1997, 5 m, 30 m depths: *Didemnum (D.) moseleyi* (Herdman), *Ciona intestinalis* (Linnaeus), *Ascidia sydneyensis* Stimpson, *Botrylloides violaceus* Oka, *Dendrodoa aggregata* (Rathke), *Cnemidocarpa clara* (Hartmeyer), *Styela plicata* (Lesueur), *S. clava* Herdman, *Pyura sacciformis* (Drasche), *Halocynthia roretzi* (Drasche) and *H. hispida* (Herdman).

12. Ssanggeun

Fishing net, 7 July 1997, 30 m depths: *Didemnum (D.) moseleyi* (Herdman), *D. (D.) candidum* Savigny, *D. (D.) pardum* Tokioka, *Trididemnum savigny* (Herdman), *Pseudodistoma antinboja* Tokioka, *Ciona intestinalis* (Linnaeus), *Ascidia sydneyensis* Stimpson, *Rhodosoma turcicum* (Savigny), *Chelyosoma sibaja* Oka, *Botryllus tuberatus* Ritter and Forsyth, *Symplegma oecania* Tokioka, *Polyzoa pacifica* Tokioka, *Dendrodoa aggregata* (Rathke), *Metandrocarpa kudoi* Rho and Cole, *Cnemidocarpa irene* (Hartmeyer), *Styela tokiokai* Nishikawa, *Pyura sacciformis* (Drasche), *Herdmania mirabilis* (Drasch), *Boltenia echinata iburi* (Oka), *Halocynthia roretzi* (Drasche), *H. hispida* (Herdman) and *Molgula tectiformis* Nishikawa.

13. Gabae

The Korean Marine Biological Laboratory, on sea weeds, July 1996 to July 1997: *Ciona intestinalis* (Linnaeus).

14. Gudo Island

Rocky intertidal and Subtidal zones, 6 Feb. 1996, 0-30 m depths: *Aplidium pliciferum* Redkorzev, *Didemnum (D.) moseleyi* (Herdman), *D. (P.) aspiculatum* Tokioka, *Trididemnum savigny* (Herdman), *Diplosoma macdonaldi* Herdman, *Ciona intestinalis* (Linnaeus), *Ascidia sydneyensis* Stimpson, *A. zara* Oka, *Rhodosoma turcicum* (Savigny), *Chelyosoma sibaja* Oka,

Table 2. Ascidians recorded from Geojedo Island and its adjacent waters.

Species	Locality																	Total Locality	Depth range (m)	Substratum or Bottom	Biogeographical distribution**													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17																	
Polyclinidae																																		
<i>Aplidium pliciferum</i>																		+(7)+(10)	+(2)	+(1)			7	0-10	rock	WP								
Didemnidae																																		
<i>Didemnum</i> (D.) <i>moseleyi</i>																		+(10)	+(1)	+(9)	+(8)	+(12)	+(9)	+(5)			9	0-28	sea weeds, rock	IWP				
<i>D. (D.) candidum</i>																		+(2)	+(3)	+(10)	+(2)	+(4)				3	30	sea weeds	WP					
* <i>D. (D.) pardum</i>																		+(2)	+(6)	+(5)	+(2)					5	8-10	worm tubes	KJ					
<i>D. (P.) aspiculatum</i>																		+(2)	+(2)		+(1)					4	8-10	sea weeds	IWP					
<i>Trididemnum saignii</i>																		+(3)	+(1)	+(1)	+(2)	+(7)	+(2)	+(3)		3	30	sea weeds	IWA					
<i>Diplosoma macdonaldi</i>																		+(3)	+(1)	+(1)	+(2)	+(7)	+(3)	+(1)		6	3-10	sea weeds, other ascidian	IPT					
Pseudodistomidae																																		
<i>Pseudodistoma antinboja</i>																						+(3)				1	30	other ascidian	IKJ					
Cionidae																																		
<i>Ciona intestinalis</i>																		+(4)	+(30)	+(1)	+(7)	+(14)	+(1)	+(27)	+(2)	+(3)	9	8-30	sea weeds, shell, rock, other ascidian	COS				
Ascididae																																		
<i>Ascidia sydneyensis</i>																		+(5)	+(11)	+(3)	+(12)	+(14)	+(9)	+(9)	+(6)	9	6-30	rock, other ascidian	PT					
<i>A. gemmata</i>																		+(5)		+(3)						2	10	sea weeds, other ascidian	WP					
<i>A. zara</i>																			+(1)		+(1)		+(17)			3	8-10	rock, other ascidian	KJ					
Corellidae																																		
<i>Rhodosoma turcicum</i>																		+(1)		+(2)		+(3)	+(2)			4	8-30	other ascidian	PT					
<i>Chelyosoma siboja</i>																		+(37)	+(9)	+(4)	+(6)	+(5)				5	6-30	other ascidian	WP					
Botryllidae																																		
<i>Botryllus tuberatus</i>																		+(3)	+(2)	+(4)	+(11)	+(1)	+(4)	+(12)	+(2)	7	6-30	sea weeds	PT					
<i>B. magnicoecus</i>																										1	8-10	shells, sea weeds	IWP					
<i>Botrylloides violaceus</i>																			+(2)		+(7)					2	5	worm tubes	SKJ					
Styelidae																																		
* <i>Symplegma oceanica</i>																		+(7)	+(2)	+(9)	+(1)	+(6)				5	7-30	sea weeds, worm tubes, shells, other ascidian	IWP					
<i>Polyzoa pacifica</i>																																		
																						+(3)				1	30	other ascidian	KJ					

Table 2. Ascidians recorded from Geojedo Island and it's adjacent waters.

Species	Locality																	Total Locality	Depth range (m)	Substratum or Bottom	Biogeographical distribution**
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17				
<i>Dendrodoa aggregata</i>																		3	5-30	rock, shell	A, NA
<i>Metandroarpa kudoi</i>																		3	29-30	rock, sea weeds, other ascidian	K
<i>Cnemidocarpa clara</i>																		6	7-10	other ascidian	AP
<i>C. fertilis</i>																		2	5-10	other ascidian	KJ
<i>C. irene</i>																		3	30	other ascidian	IWP
<i>Styela plicata</i>																		3	10	rock, other ascidian	IWP
<i>S. tokiokai</i>																		8	6-30	other ascidian	KJ
* <i>S. coriacea</i>																		1	8	other ascidian	ANA
<i>S. clara</i>																		10	0-10	rock, other ascidian	OB
Pyuridae																					
<i>Pyura vittata</i>																		6	0-10.	rock	SKJ
<i>P. saciformis</i>																		10	2-30	other ascidian	KJ
<i>P. lepidoderma</i>																		1	10	other ascidian	WP
<i>Herdmani mirabilis</i>																		4	8-30	rock, gravel	AP
<i>Boltenia echinata</i>																		1	5-8	other ascidian	ANA
<i>B. echinata iburi</i>																		5	10-30	other ascidian	AP
<i>Halocynthia aurantium</i>																		1	10	other ascidian	OB
<i>H. roretzi</i>																		10	6-30	rock, other ascidian	SKJ
<i>H. hispida</i>																		11	4-30	rock, other ascidian	IWP
Molgulidae																					
<i>Molgula tectiformis</i>																		2	30	other ascidian	WP
Total 38 Species	20	16	14	1	2	3	10	18	10	17	11	22	117	2	11	1	1,294				
	(251)	(136)	(124)	(4)	(7)	(10)	(25)	(92)	(40)	(66)	(77)	(138)	(27)	(88)	(67)	(141)	(1)				

+ : present; () : Number of specimens; * : new to Korea.

**The biogeographic distribution codes used stand for as follows; WP, West-Pacific; IWP, Indo-West Pacific; IWA, Indo-West Atlantic and tropical-warm temperature Atlantic; PT, pan-Tropical; K, Korean; SKJ, Chinese-Korean-Japanese; KJ, Korean-Japanese; AP, amphipacific; ANA, Arctic-North Atlantic; OB, Okhotsk-Bering; COS, Cosmopolitan.

Table 3. The number of ascidian species according to the biogeographical distribution in the Geojedo Island and Chundo Island (Onsan Bay, Rho *et al.*, 1996).

Biogeographical distribution Localities and species	Warm water				East Asia endemic			Boreal water			Cosm- opolitan	Total
	WP	IWP	IWA	PT	SKJ	K	KJ	AP	ANA	OB	COS	
Geojedo Island species	5	8	1	4	3	1	7	3	3	2	1	38
Subtotal (percentage)	18 (47.4%)				11 (26.3%)			8 (21.1%)			1 (2.7%)	100%
Chundo Island species	2	2	1	2	2	0	2	1	1	1	1	15
Subtotal (percentage)	7 (47%)				4 (26%)			3 (20%)			1 (7%)	100%

Metandrocarpa kudo Rho and Cole, *Styela tokiokai* Nishikawa, *Styela clava* Herdman, *Pyura vittata* (Stimpson), *P. sacciformis* (Drsche), *Halocynthia roretzi* (Drsche) and *H. hispida* (Herdman).

15. Haksan

Rocky-Muddy shore and Gravel intertidal zone, 14 Jan. 1998, 0-1 m depths: *Aplidium pliciferum* Redikorzev and *Pyura vittata* (Stimpson).

16. Sagog

Subtidal zone of Muddy bottom, 14 Jan. 1998, 8-10 m depths: *Aplidium pliciferum* Redikorzev, *Didemnum (P.) aspiculatum* Tokioka, *Diplosoma macdonaldi* Herdman, *Ciona intestinalis* (Linnaeus), *Ascidia sydneyensis* Stimpson, *A. zara* Oka, *Botryllus magnicoecus* (Hartmeyer), *Cnemidocarpa clara* (Hartmeyer), *Styela plicata* (Lesueur), *S. clava* Herdman and *Herdmania mirabilis* (Drasche)

17. Bijindo Island

Fishing net, 9 July 1996, 30 m depths: *Metandrocarpa kudo* Rho and Cole.

RESULTS

This study on the classification and the distribution of Geojedo Island and its adjacent waters ascidians was conducted by collecting a total of 1,294 specimens from 17 localities during the period from 1995 to 1998. The results are given in Table 2, together with the previous records by Rho.

A total 1,294 specimens of ascidians were classified into 38 species (subspecies), 22 genera, 10 families and two orders. Among the above 38 species, 13 species were previously reported by Rho (1975-1991) for the first time, the remaining 22 are new to the fauna of Geojedo Island and its adjacent waters and the following three species were found to be new to Korea: *Didemnum (D.) pardum* Tokkioka, *Symplegma oceania* Tokioka and *Styela coriacea* (Alder and Hancock).

As shown in the Table 2, the largest number of species (22) was found in the locality of Ssanggeun and nextly, 20 species were found on Isudo Island. *Styela clava*, *Pyura sacciformis*, *Halocynthia roretzi* and *H. hispida* were collected from more than 10 localities and the other species were collected from less than nine. In the case of *Styela plicata*, the largest number of specimens (86 individuals) collected and other cases are *Halocynthia roretzi* (76 inds.), *Pyura vittata* (66 inds.), *Styela clava* (47 inds.) and *Halocynthia hispida* (47 inds.) in order of number of specimens. This

means that they are widely and commonly distributed in Geojedo Island and its adjacent waters.

From the standpoint of biogeographical distribution, the 38 species of ascidians reported from Geojedo Island and its adjacent waters are all shallow-water (littoral and sublittoral) species, and these amount to about half of numbers of previously reported Korean ascidians.

Table 3 shows the biogeographical distribution and the ascidian species in the Geojedo Island and Chundo Island (Onsan Bay) already reported by Rho et al., in 1996. As shown on this table, the ascidian fauna of Geojedo Island and its adjacent waters consist of 18 (47.4%) warm water species, 11 (26.3%) east Asia endemic ones, eight (21.2%) boreal water ones and one (2.6%) cosmopolitan ones and Chundo Island of seven (47%) warm water species, four (26%) east Asia endemic ones, three (20%) boreal water ones and one (7%) cosmopolitan species.

The ascidian fauna from both island indicated in common high percentage of warm water species and the extreme scarcity a boreal water forms. It may be attributable to the fact that the both island are directly washed by the warm Kuroshio Current and the water temperature is high.

ACKNOWLEDGEMENT

This study is supported partially by the academic research fund of Ministry of Education, Republic of Korea (BSRI-94-97-4421) and also is supported partially by the academic research fund of Korea Racing Association (1998). We are deeply grateful to Dr. J. Chang of the Korean Marine Biological Laboratory at Gabae and the Scuba divers of the BSRI-94-97-4421 for their help in the specimens collection. We are indebted as well to Dr. I.S. Seo of Ecosystem Conservation Division, Ministry of Environment, for her help in preparing the figures and cordial thanks should be extended to Ms H.R. Cha of the Department of Biological Science, Ewha Womans University, for her help in preparing the manuscript.

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RECEIVED: 7 August 1998

ACCEPTED: 20 August 1998

한국 거제도 해초류의 분류

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요 약

본 연구는 1995년 2월부터 1998년 1월까지 거제도 (巨濟島)의 12개 지역과 비진도 (比珍島)에서 채집된 재료들을 동정·분류하였고, 이미 채집지가 밝혀진 4개 지역을 포함하여 모두 17개 지역에서 이루어졌다. 연구의 결과 2목 10과 22속 38종이 밝혀졌고, 이 중 13종은 거제도 기지종이고, 3종, *Didenum* (*D.*) *pardum*, *Symplegma oceanica*와 *Styela coriacea*는 한국 미기록종이었으며, 그 외 22종은 거제도에서는 처음으로 밝혀지는 종들이다. 거제도 해초류의 생물지리학적 분포를 보면, 38종 모두는 우리나라 천해종이며, 지금까지 밝혀진 한국 해초류의 반에 해당하는 종이다. 이들 중 18종 (47.4%)은 열대수성종, 11종 (26.3%)은 온대수성종, 8종 (21.1%)은 냉수성종, 1종 (2.7%)은 광포종이었다. 이들을 오수지역인 춘도 (온산만)의 해초류상과 비교하면 15종의 해초류중 7종 (47%)은 열대수성종, 4종 (26%)은 온대수성종, 3종 (20%)은 냉수성종, 1종 (7%)은 광포종이었다 (see Rho *et al.*, 1996). 두 지역에 나타난 해초류의 구성을 보면 각 지역에서 전체 종 수의 반에 해당하는 종이 열대수성종이었고 극히 적은 수의 종이 냉수성종이었으며, 1/3 이상의 종이 온대수성종이었고, 그리고 각각 1종이 광포종으로 나타났다. 이러한 사실은 두 지역 모두가 우리나라 남단에 위치하여 북한 한류의 영향보다 흑조난류의 영향을 크게 받는다는 사실과 부합한다. 거제도는 종수에 있어서나 개체 (군체) 수에 있어 춘도와 비교하여 2배가 넘게 나타났다. 이러한 사실은 거제도에서 채집 지역 수가 많았고 또한 이 지역은 청정해역으로서 아직은 보존이 잘 되고 있다는 사실과 일치한다.