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New Records of Marine Algae from Korea I

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Three species of marine algae, two browns and one red were newly reported from the eastern and the southern coast of Korea including Cheju Island. Their vegetative and reproductive structures were described. *Colpomenia phaeodactyla* Wynne et J.N. Norris (Scytosiphonaceae, Phaeophyceae) commonly occurred in middle to lower intertidal zone of southern coast. Plants consisted of clusters of elongated and hollow sacs arising from an adherent colpomenioid base. Plurilocular sporangia were multiseriate, forming dense, extensive sori over the erect sacs. *Cutleria adspersa* (Mertens ex Roth) De Notaris (Cutleriaceae, Phaeophyceae) was collected from subtidal region of Cheju Island. It was characterized by broadly fan-shaped habits with golden brown colour and hair-fringed margins, attached by rhizoids along undersurface. *Halarachnion latissimum* Okamura (Furcellariaceae, Rhodophyceae) was found adrift from several areas of southern coast. Plants were brownish red, filmy and delicate, membranaceous roundish fronds. Cystocarps were globular and formed under the cortical layer. Tetrasporangia were oblong and zonately divided.

Key Words: *Colpomenia phaeodactyla, Cutleria adspersa, Halarachnion latissimum*

INTRODUCTION

Since Lee and Kang (1986) had enumerated 620 species including blue-green algae from the coasts of Korea, many species were added through monographic and floristic works. Recently, Lee and Kang (2001) arranged 753 species excluding blue-green algae with nomenclatural accounts based on these works. Meanwhile, many other species have been identified from various works and supplimented to the marine algal flora of Korea.

With the recent intensive surveys on the coastal and island environments, numerous members of marine algae, which have not been reported up to present, have been explored. Moreover, the surveys from the intertidal to subtidal region have been enabling to add further more information on the distribution of other new algal groups to the flora of Korea.

Among them, three species of brown and red algae, *Colpomenia phaeodactyla* Wynne et J.N. Norris, *Cutleria adspersa* (Mertens ex Roth) De Notaris and *Halarachnion latissimum* Okamura found from the eastern and the southern coast including Cheju Island were described in present study. The vegetative and the reproductive structures of these species have been studied.

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MATERIAL AND METHODS

Plants were collected from intertidal to subtidal zones on the eastern to the southern coast including Cheju Island. Collections were fixed with 5% formalin seawater solution in the field. The preserved materials were sectioned and stained with methylene blue for light microscopy. Observation and photomicrography were conducted using an Olympus BX50 microscope with PM10 photography system. Specimens examined in present study were deposited in the herbarium of Division of Life Science, Gyeongsang National University (GSNU).

RESULTS AND DISCUSSION

***Colpomenia phaeodactyla* Wynne et J.N. Norris 1976: 5, figs 4, 5, 11c**

(Fig. 1A-1I)

Korean name: 대롱불레기말 (신칭)

Type locality: Playa Estacion, Puerto Penasco, Sonora,

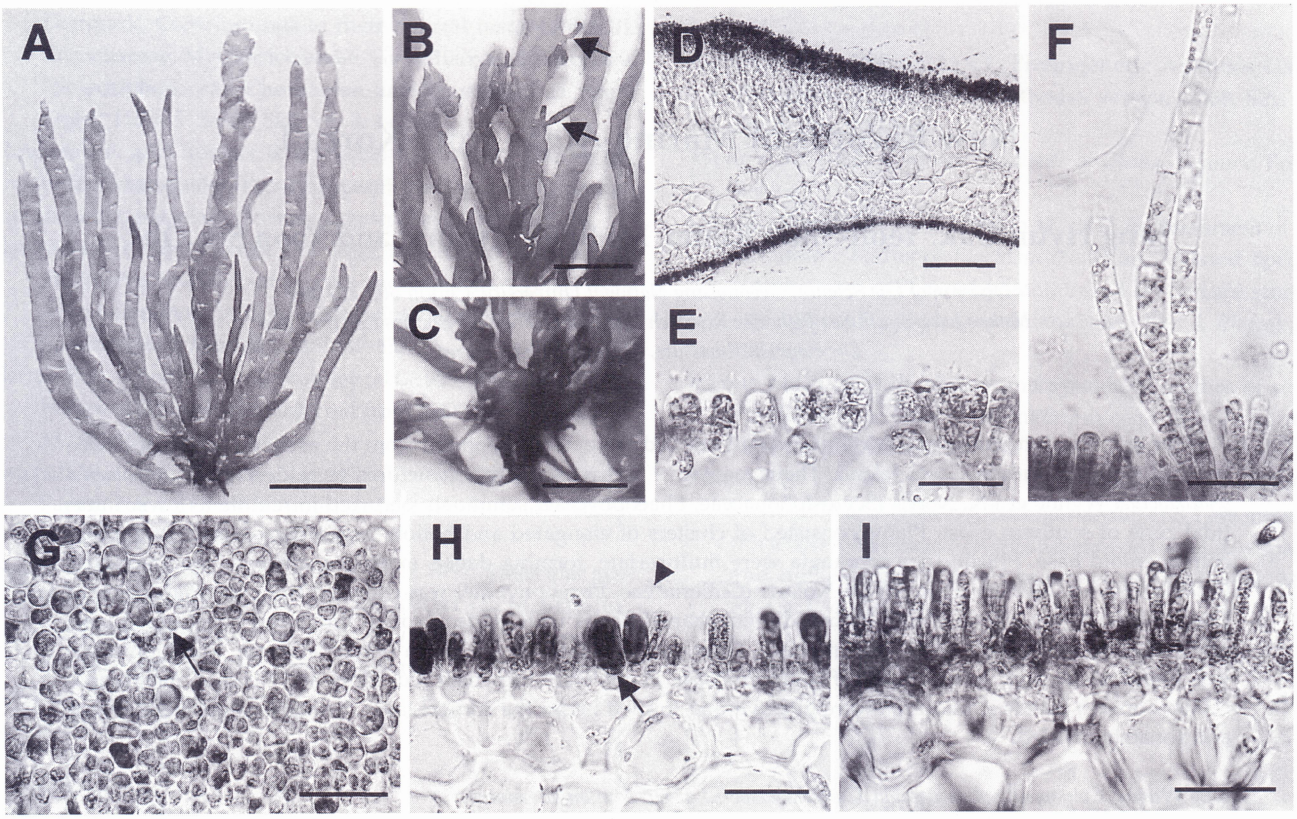

Fig. 1. *Colpomenia phaeodactyla* Wynne et J.N. Norris.
A. Plant from Sangjokam, Goseong. B. Erect sacs with adventitious branches (arrows). C. Colpomenioid base. D. Cross section of base. E. Cortex of base. F. Tufts of hair cells. G. Cortical cells and ascocysts in surface view. H. Ascocysts (arrow) and cuticle (arrowhead) in cross section. I. Plurilocular sporangia (Scales A: 5 cm, B: 2 cm, C: 1 cm, D: 500 μm, E, H: 20 μm, F, I: 30 μm, G: 50 μm).

Gulf of Californica, Mexico

Distribution: Northern Gulf of California, Pacific Baja California, Mexico, Costa Rica (Wynne and Norris 1976), Chile (Santelices 1989; Santelices and Hoffmann 1997) and central Japan (Yoshida *et al.* 2000) and Korea (present study).

Specimens examined: Sangjokam, Goseong, Gyeongnam, 14 II 2002 (J.H. Oak), Sachon, Namhaedo, Gyeongnam, 16 III 2001 (Y.S. Oh), Geumodo, Yeosu, 8 III 2001 (Y.S. Oh), Jindo, Jeonnam, 18 II 2000; 25 II 2001 (Y.S. Oh and M.S. Hwang).

Plants commonly occurred in middle to lower intertidal zone and tidal pools of southern coast. Thalli were dark brown, consisted of clusters of elongated and hollow sacs (Fig. 1A), 15-25 cm long and 0.5-1.5 cm broad, arising from an adherent colpomenioid base, 0.8-1.5 cm in diameter and 800 μm thick (Fig. 1C). Cortical layer of the base was 1-2 cells thick and cortical cells were cuboidal, 10-13 μm long and 10-15 μm broad. Medullary cells were elongated, 75-125 μm long and 25-45 μm broad in longitudinal section (Fig. 1D-E). The sacs were 5-15 from a single base, tapered toward the base and apex, 100-160 μm thick. They were occasionally undulated or contorted and produced adventitious branches (Fig. 1B). Cortical layer was 1-2 cortical cells thick with a cuticle outside. The cortical cells were cuboidal, 10-15 μm in diameter (Fig. 1G). Medullae consisted of 3-4 layers of spherical to subspherical cells with 20-75 μm in cross section, elongated cells with 60-140 μm long and 25-90 μm broad in longitudinal section. Ascocysts were globular in surface, ovoid to obovoid in cross section, 20-25 μm long and 10-15 μm broad (Fig. 1H). Hairs were tufts, colorless, consisting of elongated cells with 30-45 μm long and 10 μm broad (Fig. 1F). Plurilocular sporangia were biseriate, 30-45 μm long, forming dense, extensive sori lacking a cuticle over the erect sacs (Fig. 1I). Unilocular sporangia were not found.

Colpomenia phaeodactyla grew on rocks covered with muddy sands in middle to lower intertidal zone along the southern coast. In the field, however, the apparent cylindrical sacs of *C. phaedactyla* could be misidentified as enlarged forms of *Scytosiphon lomentaria* (Lyngbye)

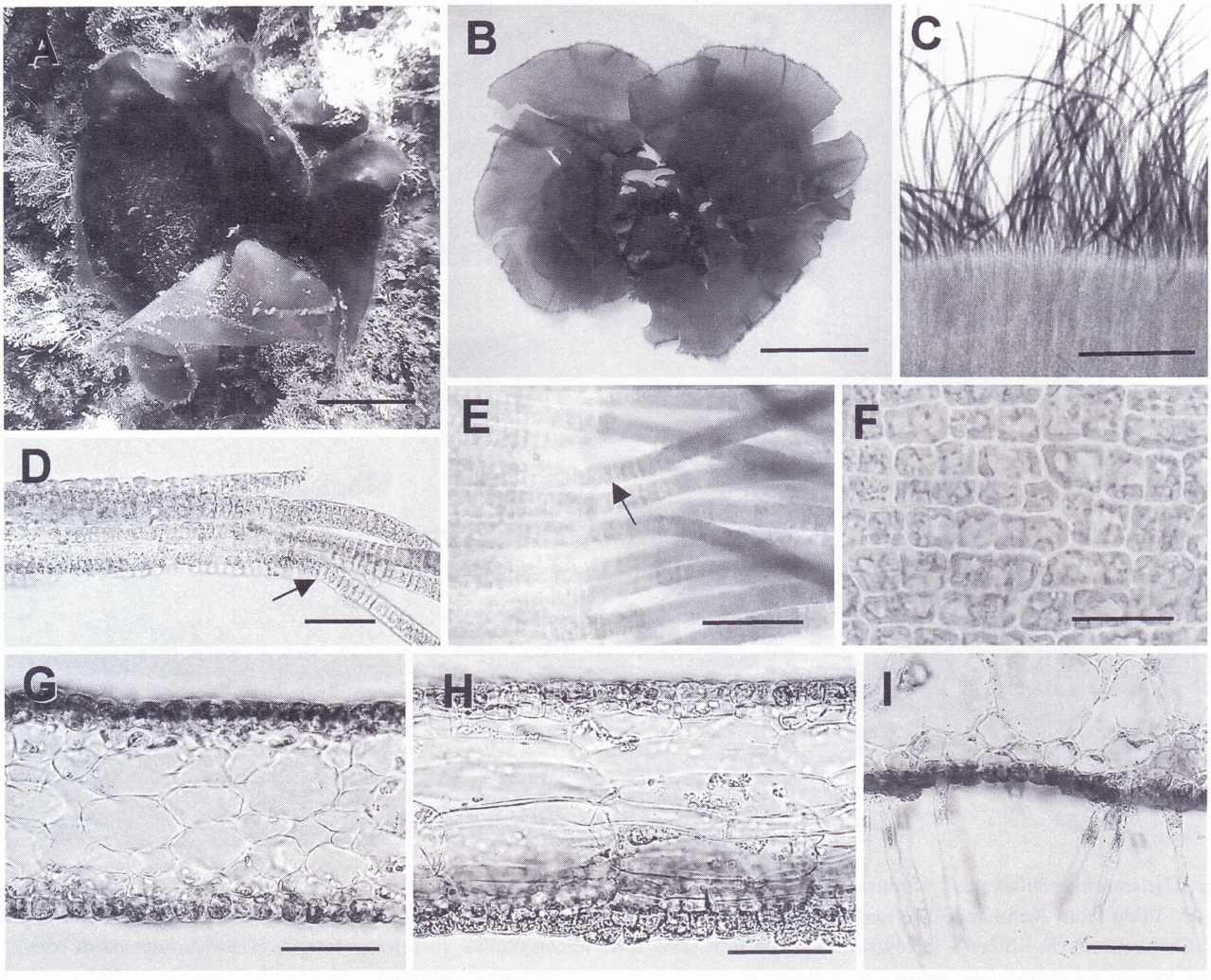

Fig. 2. *Cutleria adspersa* (Mertens ex Roth) De Notaris.
A. Plant growing on rocks mixed with corallines in subtial zone. B. Plant with fan-shaped habit. C. Hair-fringed margins. D. Trichothallic filaments with meristems (arrow) in cross section. E. Trichothallic meristems (arrow) in surface view. F. Rectangular cortical cells. G. Subspherical medullary cells in cross section. H. Elongated rectangular medullary cells in longitudinal section. I. Rhizoids from undersurface (Scales A: 2 cm, B: 3 cm, C: 500 μm, D, E: 50 μm, F: 20 μm, G-I: 50 μm).

Link or elongated forms of *Colpomenia bullosa* (Sauders) Yamada. *C. phaeodactyla* was distinguished from *C. bullosa* by having the delicate feature of the sacs and its clustered aspect from common basal system (Wynne and Norris 1976). The soft and delicate texture was due to thinner sacs with the range of 100-160 μm, compared to *C. bullosa* with 120-230 μm in thickness.

The general features of the plants were in good accordance with the original description given by Wynne and Norris (1976). However, the plants of our collections formed occasionally undulated or contorted sacs and produced adventitious branches in contrast to the morphological feature of the type with a smooth and entire habit.

Colpomenia phaeodactyla was reported from the southeastern Pacific, including the Gulf of California, Costa Rica and Chile, while *C. bullosa* usually occurred at the pacific coast of North America (Wynne and Norris 1976; Santelices 1989). In the northwestern Pacific, *C. bullosa* occurred in the northern part of Japan (Yoshida *et al.* 2000) and *C. phaeodactyla* was mostly restricted in the southern to central part as currently observed in the distribution of the plants in Korea.

***Cutleria adspersa* (Mertens ex Roth) De Notaris 1842: 10**

(Fig. 2A-2I)

Korean name: 겹부채채찍말 (신칭)

Type locality: Cadiz, Spain

Distribution: Northeast Atlantic (Feldmann and

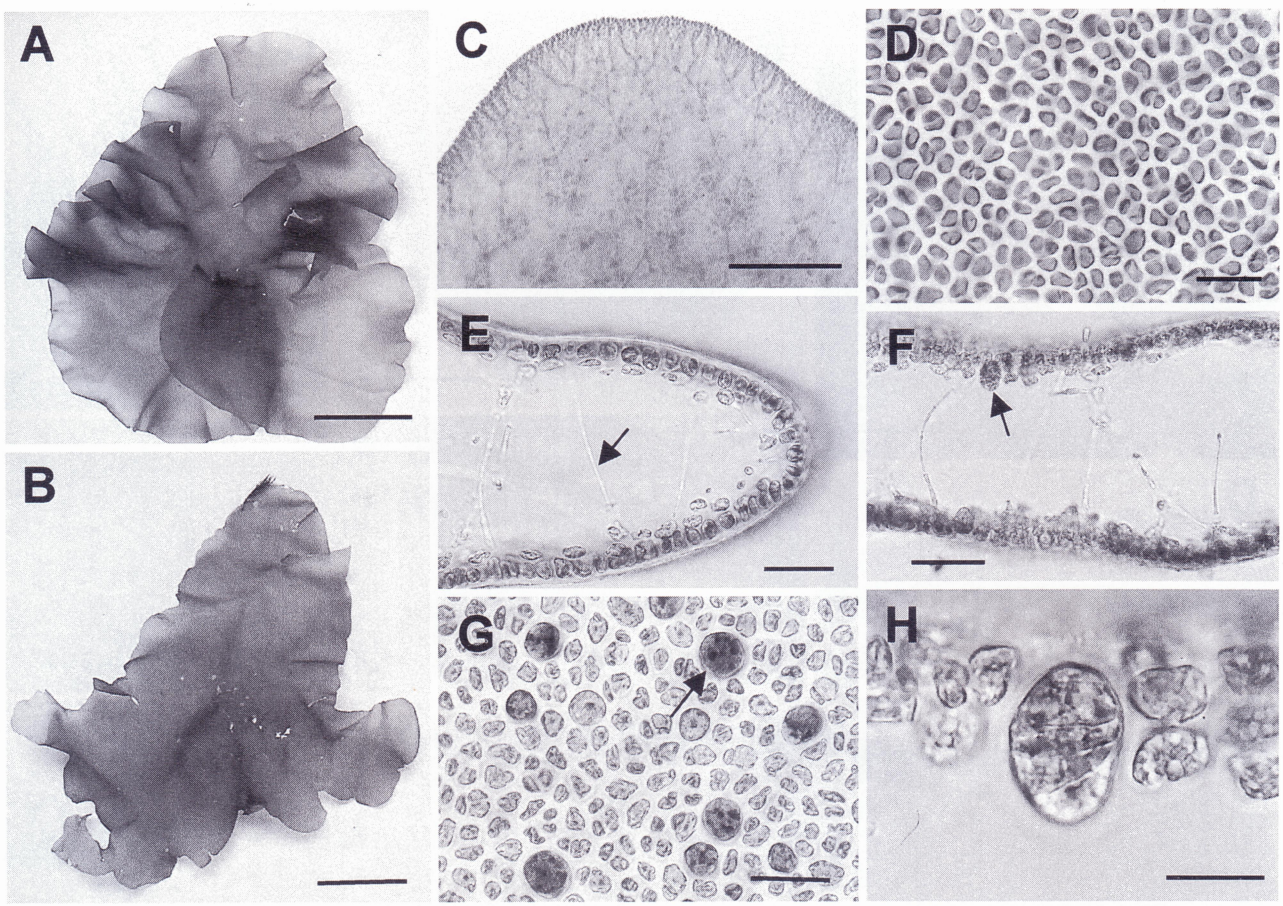

Fig. 3. *Halarachnion latissimum* Okamura.
A. Plant from Namhaedo (Tetrasporophyte). B. Plant from Namhaedo (Carposporophyte). C. Apex showing axial cells. D. Cortical cells. E. Rhizoids (arrow) from subcortical cells transversing thallus. F. Tetrasporangia (arrow) immersed in cortex. G. Globular tetrasporangia (arrow) in surface view. H. Elliptical tetrasporangia divided zonately (Scales A: 3 cm, B: 2 cm, C: 500 μm, D, G: 30 μm, E, F: 50 μm, H: 20 μm).

Magne 1964), Mediterranean (Ribera *et al.* 1992), Australia (Phillips 1997), Japan (Yoshida *et al.* 2000) and Korea (present study)

Specimens examined: Seongsanpo, Cheju Island, 10 III 2001; 25 III 2002 (Y.S. Oh).

Plants grew on rocks in the subtidal zone of Cheju Island (Fig. 2A). Thalli were up to 4 cm high, golden brown coloured, fan-shaped upright habits with hair-fringed margins (Fig. 2B, C). Rhizoids arose from epidermal cells along lower surface of prostrate portion (Fig. 2I). Thalli showed marginal trichothallic growth from the basal meristem of tufts of uniseriate apical filaments at the edges (Fig. 2D, E). The filaments were 20-25 mm in diameter. Fronds were polystichous, 100-120 μm thick. Cortices were phaeoplastic, 1-2 cells thick, and upper cortical cells were rectangular, 7-15 μm long and 5-10 μm broad (Fig. 2F). Medulla was 5-7 cells thick and medullary cells were colorless, subspherical and 15-40 μm in cross section (Fig. 2G), elongated rectangular, 70-95 μm long and 18-25 μm broad in longitudinal section (Fig. 2H). Sporangia were not found.

In Korea, only one species in the genus *Cutleria*, *C. cylindrica* was commonly recorded in the eastern and the southern coast, whereas three species, including *C. adspersa* and *C. multifida*, were widely distributed in Japan (Kitayama *et al.* 1992; Sasaki *et al.* 1987; Yoshida *et al.* 2000). In present study, *C. adspersa* was firstly found from the subtidal area of Seongsanpo, Cheju Island. It grew on rocks covered with coralline algae, such as *Amphiroa* spp. and *Marginisporum* spp. and shaded by *Sargassum* forest in 5-10 m deep bottom.

The genus *Cutleria* showed a heteromorphic life history. An erect bladed gametophyte alternated with a small encrusting sporophyte, which was once called *Aglaozonia* by culture studies (Falkenberg 1879; Kuckuck 1899; Yamanouchi 1912). Sporophytes and fertile thalli were

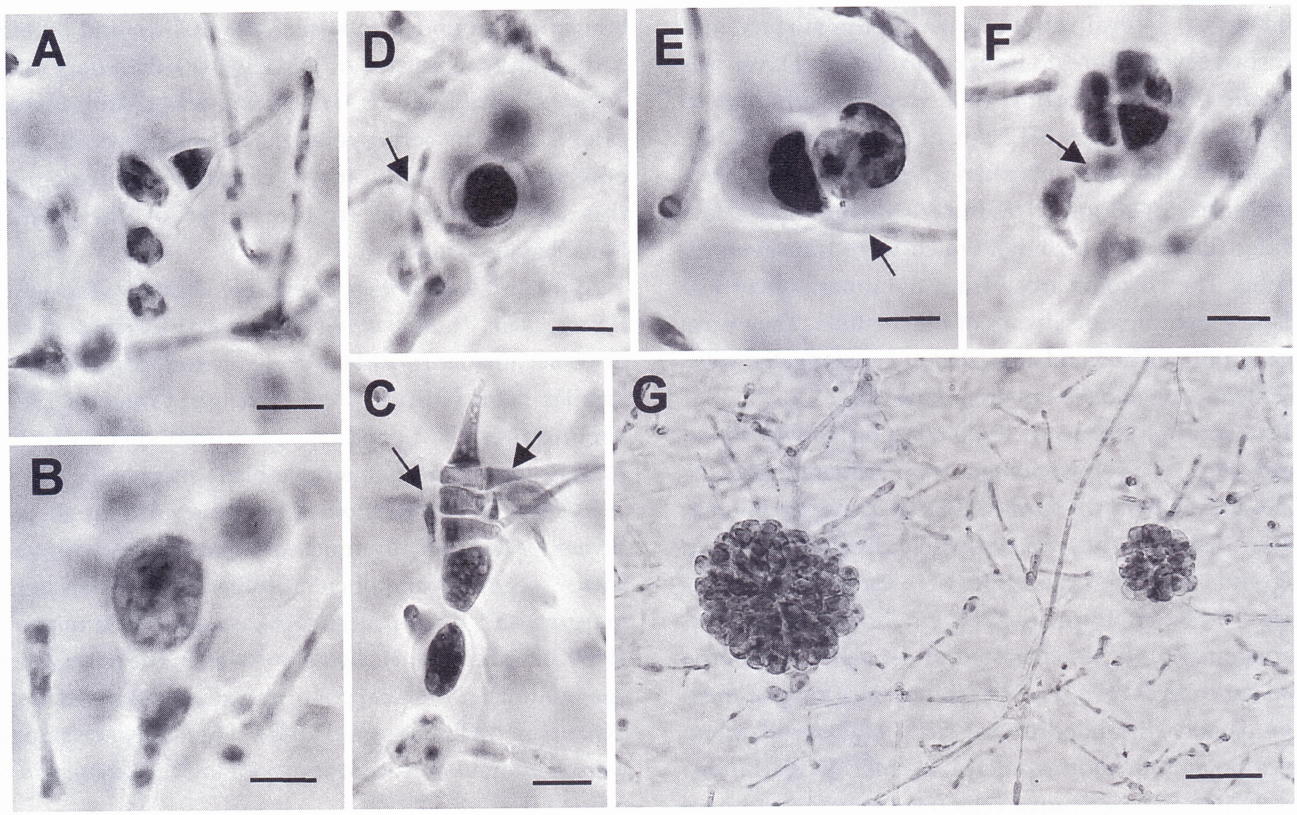

Fig. 4. *Halarachnion latissimum* Okamura.
A. Carpogonial branch. B. Auxiliary cell. C. Connecting filaments (arrows) from carpogonial derivative cells. D. Gonimoblast initial and connecting filament (arrow). E, F. Gonimoblast development and connecting filaments (arrows). G. Globular cystocarps immersed under the cortical layer (Scales A-F: 10 μm, G: 50 μm).

not found in present study.

Cutleria adspersa was similar to *C. mollis* and *C. hancockii* in having broadly fan-shaped blades developed from marginal zones of the thallus. *Cutleria mollis* known in Australia appeared more erect habit with soft and thinner blade than *C. adspersa* (Allender and Kraft 1983). However, *C. adspersa* was fairly similar to *C. mollis* in size and thickness of the thalli; the former observed in present study was 4 cm long and 100-120 μm thick, while the latter 5 cm long and 95-125 μm thick (Allender and Kraft 1983).

C. hancockii commonly occurred in the northern coast of the Gulf of California (Dawson 1944). It was distinguished from *C. adspersa* in having light coloured small and loosely anchored sporophyte as well as the middle to lower intertidal habitat (Dawson 1944). However, there were little differences in morphological features from the fan-shaped gametophytes of the two species (Dawson 1944). In addition, *C. hancockii* was occasionally collected from the subtidal area and showed much more morphological variation than the original description (Riosmena-Rodriguez *et al.* 2001). We could not compare the features of sporophytes of the two species, because sporophytes of *C. adspersa* were not available in present study. Therefore these three species should be investigated to confirm their specific delimitations in detail.

***Halarachnion latissimum* Okamura 1933: 9, pl. 306**
(Figs 3A-4G)

Korean name: 매끈곱단이 (신칭)

Type locality: Enoshima, Japan

Distribution: Japan (Okamura 1933; Yoshida *et al.* 2000) and Korea (present study)

Specimens examined: Pogyo, Goseong, Gyeongnam, 7 II 2002 (J.H. Oak and Y.-S. Keum); Mibeob, Namhaedo, Gyeongnam, 14 III 2002 (Y.-S. Keum); Yeonampo, Pohangshi, 17 III 2002 (Y.S. Oh).

Thalli were brownish red, delicately membranaceous, roundish, cuneate or subcordate with entire margin (Fig. 3A-B), arising from a small basal disc, 0.7-2 mm in diameter. They were up to 20 cm long, 15 cm broad and 100-200 μm thick, and oftenly undulate to lobed in mature. Thalli were multiaxial, initiated by several apical cells, forming subterminal cells (Fig. 3C). The subterminal

cells cut off lateral initials towards the surface and branched several times to form cortex. Cortical layer was 1-3 cells thick and cortical cells were subspherical to polygonal in surface, 8-12 μm in diameter (Fig. 3D). Subcortical cells were subspherical to stellate with elongated arms, 13-18 μm in diameter. Medulla has a few slender filaments (rhizoids), which were transeversely located. The rhizoids arose from the inner subcortical cells to grow transversely out of the medulla. They were usually unbranched and consisted of 3-5 elongated cells, 55-150 μm long and 4-5 μm broad (Fig. 3E).

Tetrasporophytes were 15-20 cm long and 13-15 cm broad (Fig. 3A). Tetrasporangia were scattered over the frond and globular in surface (Fig. 3G), elliptic in cross section (Fig. 3F). They were zonately divided, 28-34 μm long and 18-22 μm broad (Fig. 3H). Carposporophytes were 10-15 cm long and 10 cm broad (Fig. 3B). Carpogonial branches consisted of 3-4 cells were borne from subcortical cells (Fig. 4A). Intercalary cells of them were usually distended to one side. After fertilization, the carpogonium and the intercalary cells divided transversely into two derivative cells (Fig. 4C). The carpogonial derivative cells produced 1-2 connecting filaments. The second connecting filament was cut off from each derivative cell opposite to the first (Fig. 4C). The connecting filaments were septate and branched. Auxiliary cells arisen from the subcortical cells produced 3-4 lateral branches with small cortical cells. They were round to broadly obovate, 20-28 μm long and 13-20 μm broad (Fig. 4B). After fusion between the connecting filament and the auxiliary cell, the auxiliary cell initiated a hemispherical lobe that developed gonimoblast initial (Fig. 4D-E). The gonimoblast initials were divided and developed into gonimoblasts (Fig. 4F). The gonimoblasts grew inwards in the thallus. Cystocarps were globular, 200-350 μm in diameter and densely scattered over the whole frond and immersed under the cortical layer (Fig. 4G). Spermatangia were not found.

Plants adrift were collected from the beaches of the eastern and the southern coasts. Most of them were found at the sheltered area with sandy and rocky substrata. Matured plants attached to pebbles oftenly occurred at the shallow tidal pools in lower intertidal zone.

Halarachnion latissimum was characterized by filmy, delicate membranous habit and zonately divided tetrasporangia. These features were similar to *Schizymenia dubyi* (Chauvin) J. Agardh commonly occurred in Korea, but *H. latissimum* showed more membranaceous, rounded to subcordate thallus, and thinner cortical layers consisted of 1-2 cells thick than those of *S. dubyi*. Additionally, *H. latissimum* was distinguished from *S. dubyi* by carposporangia showing inward development. In this study, it was remarkable to recognise this species as the first member of the family Furcellariaceae in Korea.

At present two more species were known in the genus *Halarachnion: H. ligulatum* (Woodward) Kützing and *H. parvum* Yamada. *H. parvum* endemic to Japan showed a smaller habit with ca. 1 cm in height (Yamada 1941). Among them *H. ligulatum*, a subtidal species in the Atlantic, was similar in simple blade morphology to *H. latissimum*. *H. ligulatum* was distinguished from *H. latissimum* by occasionally much-divided thallus with very narrow segments and oftenly proliferous branches at the margins and the surfaces (Knauss and Hommersand 1989). In addition, *H. ligulatum* was monoecious with spermatangia and carposporangia on same thallus (Knauss and Hommersand 1989), whereas spermatangia were not found on carposporic plants of *H. latissimum* in present study.

Halarachnion ligulatum showed a heteromorphic life history in which tetrasporophyte formed discoid crust corresponding to *Cruoria rosea* (Crouan frat.) Crouan frat. (Boillot 1965; Kornmann and Sahling 1977; Maggs 1983). However, we could collect cystocarpic and tetrasporic plants with erect and membranaceous habit of *H. latissimum*. It agreed well with the report that *H. latissimum* has an isomorphic life history (Okamura 1933). The discrepancies in the life history between *H. ligulatum* and *H. latissimum* led to question their relationship and suggested that two species could be separated at the generic level. As the genera in the family Furcellariaceae showed both heteromorphic and isomorphic life history, the further study needs to confirm their relationships.

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