The Korean Journal of Phycology
Volume 7(2): 257-268, 1992

Notes on Marine Algae from Korea (IV)

In Kyu Lee, Mi Sook Hwang and Yoon Sik Oh

Department of Biology, Seoul National University, Seoul 151-742, Korea

韓國産 海藻類에 대한 註解 (IV)

李仁圭 · 黃美淑 · 吳潤植

(서울大學校 自然科學大學 生物學科)

Five marine algal species, *Turbinaria ornata* (Turner) J. Agardh of brown, *Stylonema cornu-cervi* Reinsch, *Acrothamnion preissii* (Sonder) Wollaston, *Herposiphonia plumula* (J. Agardh) Hollenberg and *Pterosiphonia pennata* (C. Agardh) Falkenberg of reds were newly introduced to Korean flora. They were collected from rocky intertidal zone and from deep hard bottom. All these plants were found at the southern coast, especially Cheju Island and its vicinities. The morphological characteristics of the plants were described.

Key Words: *Turbinaria ornata, Stylonema cornu-cervi, Acrothamnion preissii, Herposiphonia plumula, Pterosiphonia pennata*

INTRODUCTION

Since Lee and Kang (1986) listed up the Korean marine algae, many species have newly been introduced due to surveys currently performed on algae growing in intertidal areas as well as deep hard bottoms along the coasts of Korea. Five species among them, one brown and four red algae, were found at the southern coast and the taxonomic examinations were given to them including detailed descriptions and drawings. Materials examined in the study were preserved in the herbarium of Seoul National University (SNU).

Turbinaria ornata (Turner) J. Agardh 1848

(Figs 1, 2A - F)

Fucus turbinatus Linnaeus *β ornatus* Turner 1808

Sargassum turbinatum C. Agardh 1824

Korean name: 왕관잎모자반 (nom. nov.)

Plants 5-10 cm long, erect with axes, branched once or twice, epilithic with stoloniferous holdfast, light brown in color. Main axes subcylindrical, 1-2 mm in diameter, slightly geniculate at stalk base of blade. Blades racemose, 1-2 cm long with obtuse-ridged stalks, obpyramidal in lateral view, obovate to rarely obconic in surface view, dentate in margin, concaved forming large vesicle at center, crowned with erect teeth along submarginal portion. Receptacles racemose, cylindrical, irregularly branched, 0.5-1 cm long, 0.5-1 mm broad at conceptacular branches, developed from basal portion of blades. Conceptacles unisexual, scattered ostiolate at surface, 170-350 μm in diameter. Oogonia sessile, ovoid, 140-160 μm long, 80-110 μm broad.

Type locality: not specified

Collections examined: Pyongdae, Chejudo, northern small cove in pebbly intertidal zone, beach drift (*Oh, Y.S.*, 3 X 1990)

Distribution: Korea, Japan, Polynesia, Viet-Nam,

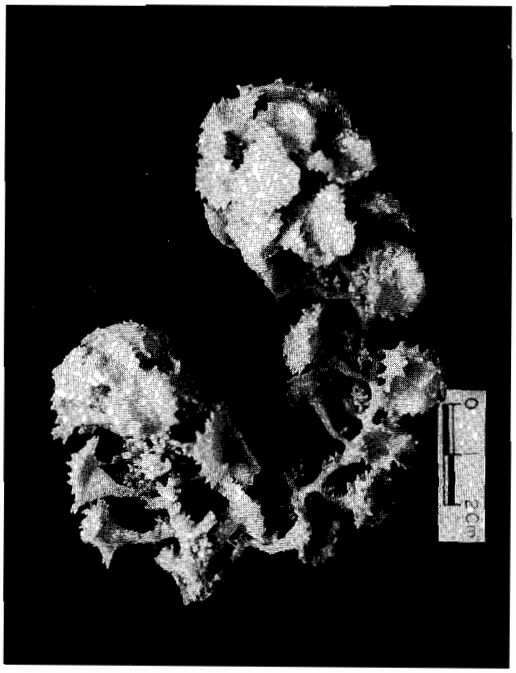

Fig. 1. *Turbinaria ornata* (Turner) J. Agardh.

Malay Archipelago, Indo-Pacific Ocean

This is the first report to occur Eusargassum in Korean waters. The genus *Turbinaria* Lamouroux (Sargassaceae) are very common in tropical and subtropical coasts (Taylor, 1963, 1966). The plants were easily confused in species identification, though they have long been known as common members of tropical algal flora. The brief description of the type could not cover the morphological variability among the species (Taylor, 1963).

Turner (1808) recognized a variety, *β ornatus* in *Fucus turbinatus* Linnaeus (1753), which was consequently elevated to species by J. Agardh (1848). *Turbinaria ornata* was a widespread and especially common species in Indo-Pacific coasts, growing on rocky substratum in the upper subtidal zone (Taylor, 1963; Lüning, 1990). It has been identified on the basis of the leaf morphology without any accounts on reproductive structures. Taylor (1963), reviewing the genus *Turbinaria* from Indo-Pacific areas, recognized three variational lines in this species based on vesicles and marginal structures of the blade: f. *ecoronata,* f. *evasiculosa* and f. *hainanensis.*

Two plants were collected at a sandy beach by a cast ashore, which were attached on a pebble in fresh state (Fig. 1). According to the distributional records (Okamura, 1936; Taylor, 1963, 1966; Pham-Hoang, 1969; Silva *et al.,* 1987), it was very doubtful to occur in Cheju Island. From this, two possibilities could be assumed; one was a transport of the plants from the southern area by Kuroshio Current and the other was its natural habitation in the coast as the northern limit. Considering their features when collected, the latter was more confident. Further investigation of its distribution in Korean waters will be followed.

Our plants (5-10 cm) are somewhat dwarf compared with the typical ones (30 cm) (Taylor, 1963) and East Asian plants (10-20 cm) (Okamura, 1936; Pham-Hoang, 1969; Egerod, 1974). The last author fortunately had an oppertunity to collect this species from intertidal zone of Amamioshima, Japan and compared with Korean plants. The morphology of both plants accorded well with each other except only for their size.

The blades were racemosely borne on the subcylindrical main axes with obpyramidal vesicles (Figs 1, 2B). They were obovately expanded with dentate margin and also prominently crowned with erect teeth on the broader side around the central vesicular surface (Fig. 2D). The young plants were often devoid of the crown. As the plants grew older, the teeth became more prominent on the leaf surfaces (Taylor, 1963).

The receptacles were clustered on the basal portion of the blade stalks and branched racemosely (Fig. 2A). Every receptacular branch developed 5-6 ostiolate female conceptacles (Fig. 2E, F). Several cryptostomata were found rarely in addition. Two to three oogonia were borne in each conceptacle with paraphyses (Fig. 2E, F).

Stylonema cornu-cervi Reinsch 1875

(Fig. 3A-C)

Goniotrichum dichotomum Berthold 1882

Goniotrichum cornu-cervi (Reinsch) Hauck 1885

Korean name: 쇠뿔마디털 (nom. nov.)

Plants erect, epiphytic, sparsely to irregularly branched, 0.2-0.7 mm long, uniseriate at base and apices, multiseriate at middle portion with irregularly arranged cells, bluish red in color. Branches 30-60 μm broad with mucilaginous matrix, tapering

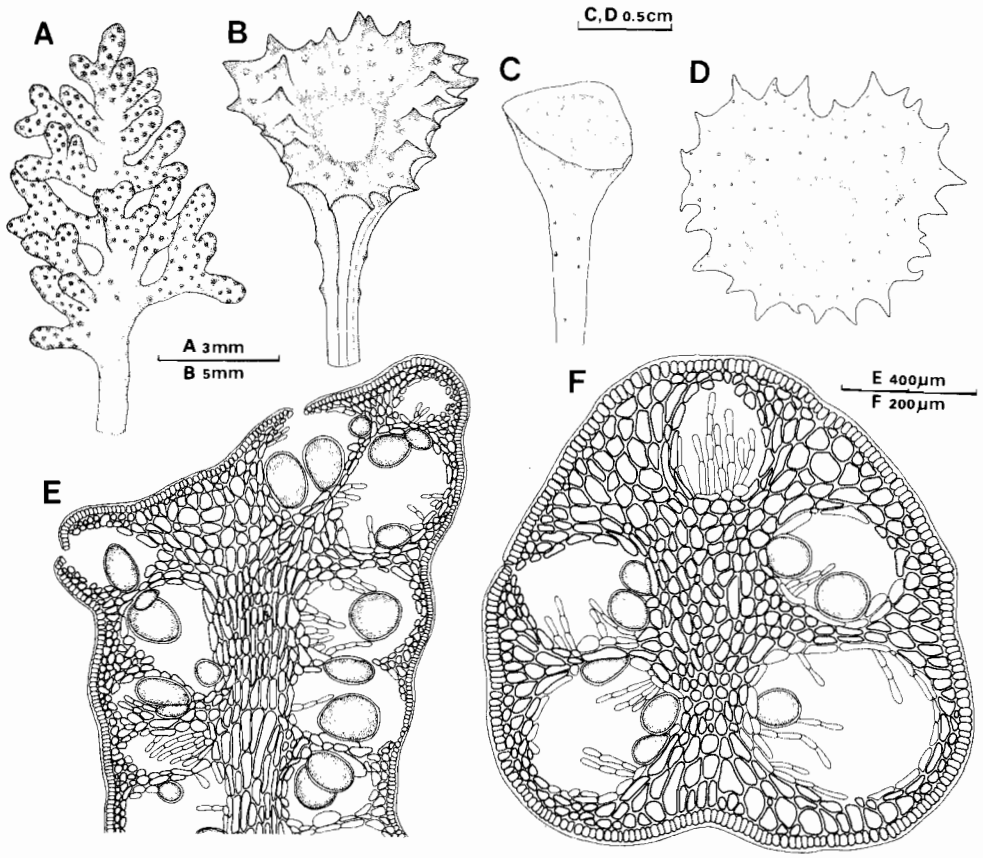

Fig. 2. *Turbinaria ornata* (Turner) J. Agardh.
A. Receptacular branches; B. Leaf with dentate margin; C. Air bladder in cross section; D. Outline of leaf; E. Receptacle in longitudinal section; F. Conceptacles in cross section.

toward base and apices. Cells ovate to oblong, 5-10 μm broad, containing stellate chloroplast with pyrenoids. Reproductive cells not observed.

Type locality: Adriatic Sea

Collections examined: Yeosodo, South Sea, southern rocky slope of 10 m depth (*Jae, J.K.*, 21 VIII 1988)

Distribution: Korea, Japan, Australia, northern Europe, Mediterranean Sea and Pacific coast of North America

The genus *Stylonema* Reinsch (1875) were commonly epiphytic on other algae, marine seed plants and rarely epizoic on invertebrates (Garbary *et al.*, 1980). Only one species, *S. alsidii* (as *Goniotrichum alsidii* (Zanardini) Howe), has been listed in the Korean algal flora (Lee and Kang, 1986), although *S. cornu-cervi* (as *Goniotrichum cornu-cervi*) has once been recorded to occur without description (Song, 1984).

The nomenclatural assessment has been given to the genus *Goniotrichum* Kützing (1843) and *Erythrotrichia* Areschoug (1850) in taxonomic relationships (J. Agardh, 1883; Drew, 1956; Drew and Ross, 1965; Garbary *et al.*, 1980). Originally two genera were established on the basis of *Conferva ceramicola* Lyngbye (1819) and have been regarded as nomenclatural synonyms (J. Agardh, 1883; Drew and Ross, 1965). It was found, however, that Kützing's material of *Goniotrichum* was not congeneric with the type of Lyngbye (1819), and the genus *Goniotrichum* was rejected because two generic names were nomenclatural synonyms (*cf.* Wynne, 1985). Recently, Wynne (1985) has reassigned the genus *Stylonema* Reinsch

(1875), which belonged traditionally to the genus *Goniotrichum* Kützing (1843) and included three species placed formerly in *Goniotrichum; S. alsidii* (Zanardini) Drew, *S. cornu-cervi* Reinsch, and *S. subcoryleum* (Dangeard) Wynne (see Wynne, 1985 in detailed nomenclatural treatments).

The plants from southern coast of Korea were very tiny and rarely branched, and commonly epiphytic on *Sphacelaria* spp. growing in deep hard bottom of the rocky slope (Fig. 3A), while the Japanese plants found on *Hypnea, Spermothamnion, Callophyllis* and *Polysiphonia* (Tanaka, 1952). Branching manner and the cell shape including chloroplast morphology of the plants from Korea agreed in general with Japanese and Californian plants (Tanaka, 1944, 1952; Abbott and Hollenberg, 1976). Simple thallus in young stage became branched dichotomously as it grew older (Fig. 3B,C). This also agreed best with the young thallus morphology described by Tanaka (1944). Basal cells were specifically enlarged in two times of the upper cells (Fig. 3A), while apical cells were a little larger than those of middle multiseriate cells of the thallus (Fig. 3C).

Korean plants were closely similar in gross morphology to Japanese and Californian than to European plants (Hamel, 1924; Tanaka, 1944, 1952; Abbott and Hollenberg, 1976). Our plants also differed from Canadian plants in having strictly dichotomous and slenderly uniseriate branches except for the basal cell morphology and multiseriate middle portion (Garbary *et al.*, 1980).

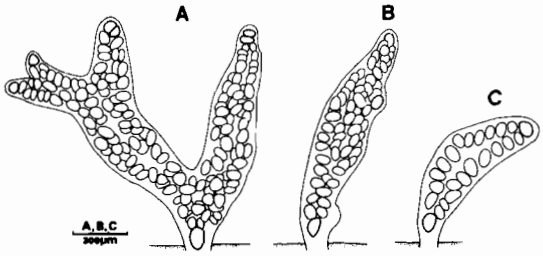

Fig. 3. *Stylonema cornu-cervi* Reinsch.
A. Habit of mature plant; B. Young plant with branch initial; C. Juvenile plant.

***Acrothamnion preissii* (Sonder) Wollaston 1968**

(Fig. 4A - E)

Callithamnion preissii Sonder 1845

Callithamnion pulchellum Harvey 1855

Acrothamnion pulchellum (Harvey) J. Agardh 1892

Antithamnion preissii De Toni 1903

Korean name: 끝동비단깃풀 (nom. nov.)

Plants 5-10 mm long, caespitose, sparsely bipinnately branched, partly prostrate, epiphytic, pinkish red in color. Main axes straight, provided with long indeterminate and short determinate branches. Rhizoids multicellular, elongate with digitate tips, arising from basal cells of axes. Axial cells cylindrical, single rowed, 90-160 μm long, 30-60 μm broad, 3 times as long as broad. Indeterminate branches straight, bearing two major and one minor whorl-branchlets on each axial cell, composed of 40-170 μm long, 20-60 μm broad cells, tapering slightly upwards. Major whorl-branchlets opposite, straight to adaxially curved, composed of 7-9 cells of 15-30 μm width, producing terminal unbranched branchlets oppositely in every segment. Minor branchlets straight or adaxially curved, 5-6 celled, providing with 3-10 celled terminal branchlets, 7-15 μm broad, subacute in apices. Short determinate branches dwarf, developed 1-2 from same basal cells with rhizoids. Gland cells terminal on cells of all branches and branchlets, transversely elliptical, 22-24 μm long, 16-20 μm broad. Reproductive structures not observed.

Type locality: Rottnest Island, West Australia

Collections examined: Gwantaldo of Cheju Island, southern rocky slope of 10-15 μm depth (*Jae, J.K.*, 9 VIII 1988)

Distribution: Korea, Japan, Australia and Indian Ocean

The genus *Acrothamnion* J. Agardh (1892) was separated from *Callithamnion* Lyngbye (1819) based on the description of *Callithamnion pulchellum* by Harvey(1855); the former bore cruciate tetrasporangia at the base of whorl-branches, while the latter had tetrahedral ones at the determinate branches (Wollaston, 1968, 1977). The morphological similarities of *Acrothamnion* and related taxa brought about issues on its generic position in Ceramiaceae, *viz.*, Spermothamnieae by De Toni (1924), Crouanieae by Kylin (1956), and Antithamnieae by Hommersand (1963). Wollaston (1968) subsequently maintained Hommersand's classification and mentioned that the genus was closely related to *Antithamnion* and *Ballia* in their

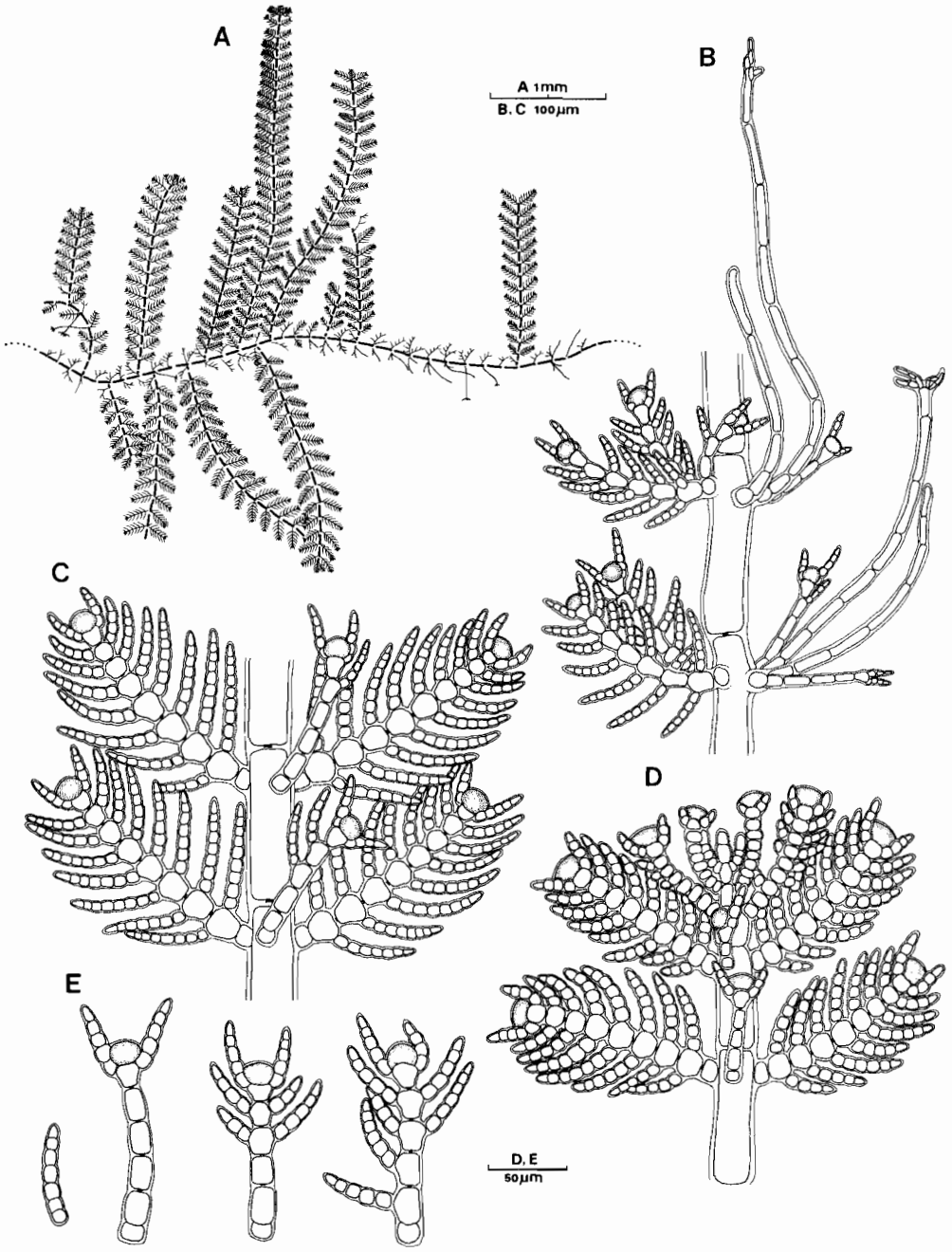

Fig. 4. *Acrothamnion preissii* (Sonder) Wollaston.

A. Habit of thallus; B. Prostrate axis with short lateral branchlets and rhizoids; C. Whorl-branchlets with apical gland cells; D. Apical portion of indeterminate branches; E. Ultimate minor branchlets.

Table 1. Morphological characteristics of *Acrothamnion preissii* (Sonder) Wollaston among three local populations

Characters \ Localities	Korea	Japan	Australia
Thallus habit	partly prostrate	prostrate	prostrate
length (mm)	5-10	15-20	15
Main axes length (μm)	90-160	200	120-190
diameter (μm)	30-60	50	40-60
Branches length (μm)	40-170	—	380-580
diameter (μm)	20-60	—	125-190
Whorl-brachlets No.	7-9	9-12	—
diameter (μm)	15-30	—	—
Terminal branchlets No.	3-10	5-8	—
diameter (μm)	7-15	—	—
Gland cells length (μm)	22-24	20	25
breadth (μm)	16-19	15	18
Rhizoids	digitate	digitate	digitate
Sources	This study	Itono (1970)	Wollaston (1968)

branching pattern of two opposite branchlets, small basal cells and some reproductive structures, but differed from the latter two in bearing gland cells on terminal position of the whorl-branchlets. She concluded that the above characteristics were very consistent and distinct. *Acrothamnion preissii* was combined by Wollaston (1968) with *Callithamnion preissii* Sonder (1845), including *Callithamnion pulchellum* Harvey as a synonym. In Japan *Acrothamnion pulchellum* (Harvey) J. Agardh *sensu* Yendo was early described based on *C. pulchellum* (Yendo, 1916; Yamada, 1928; Tokida and Inaba, 1950). However, Yamada and Inagaki (1935) investigated this plant carefully and concluded it was a new species, *Antithamnion nipponicum,* of which treatment was accepted later by Itono (1970).

The plants from Korea were collected at rocky hard bottom of 10-15 μm depth, and caespitosely grew on *Cladophora wrightiana* and Bryozoa, while Japanese plants mainly grew on *Beckerella subcostatum* (Tokida and Inaba, 1950; Itono, 1970). They crept on other plants with digitate rhizoids from basal cells at every node of main axes (Fig. 4A). One or more rhizoids developed from a single basal cell and elongated to form a digitate tip (Fig. 4B). Minor whorl-branchlets were also borne on the same basal cells originated from the rhizoid (Fig. 4B). The indeterminate branches, replaced by determinate whorl-branchlet, were borne in irregular mode from main axes (Fig. 4A). No secondary growth system of indeterminate branch were observed. Gland cells were transversely elliptical with light orange-colour in fresh state and showed consistency in their size (Fig. 4C, E).

Tetrasporangia as well as sexual reproductive structures were not observed in our materials in spite of the same seasonality as Japanese plants described by Itono (1970). Unique features of tetrasporangial development were also well-described by Itono (1970), and whole reproductive structures by Wollaston (1968, 1977).

The collection locality was situated on the northern vicinity of Cheju Island. The local branch of Kuroshio Current passes through the island westwardly and runs together with eastward branch near Tsushima Island to stream away to the Japan Sea (Cho and Choe, 1988). The situation allows warm water species to form their habitat. The morphological characteristics of our plants in general agreed with the Japanese and the Australian plants except for their sizes (Table 1). However, more solid information on the species from Korea requires to examine further reproductive and vegetative structures.

***Herposiphonia plumula* (J. Agardh) Hollenberg 1970** (Fig. 5A - I)

Polysiphonia plumula J. Agardh 1885

Herposiphonia rigida Gardner 1927

Herposiphonia subdisticha Dawson 1944

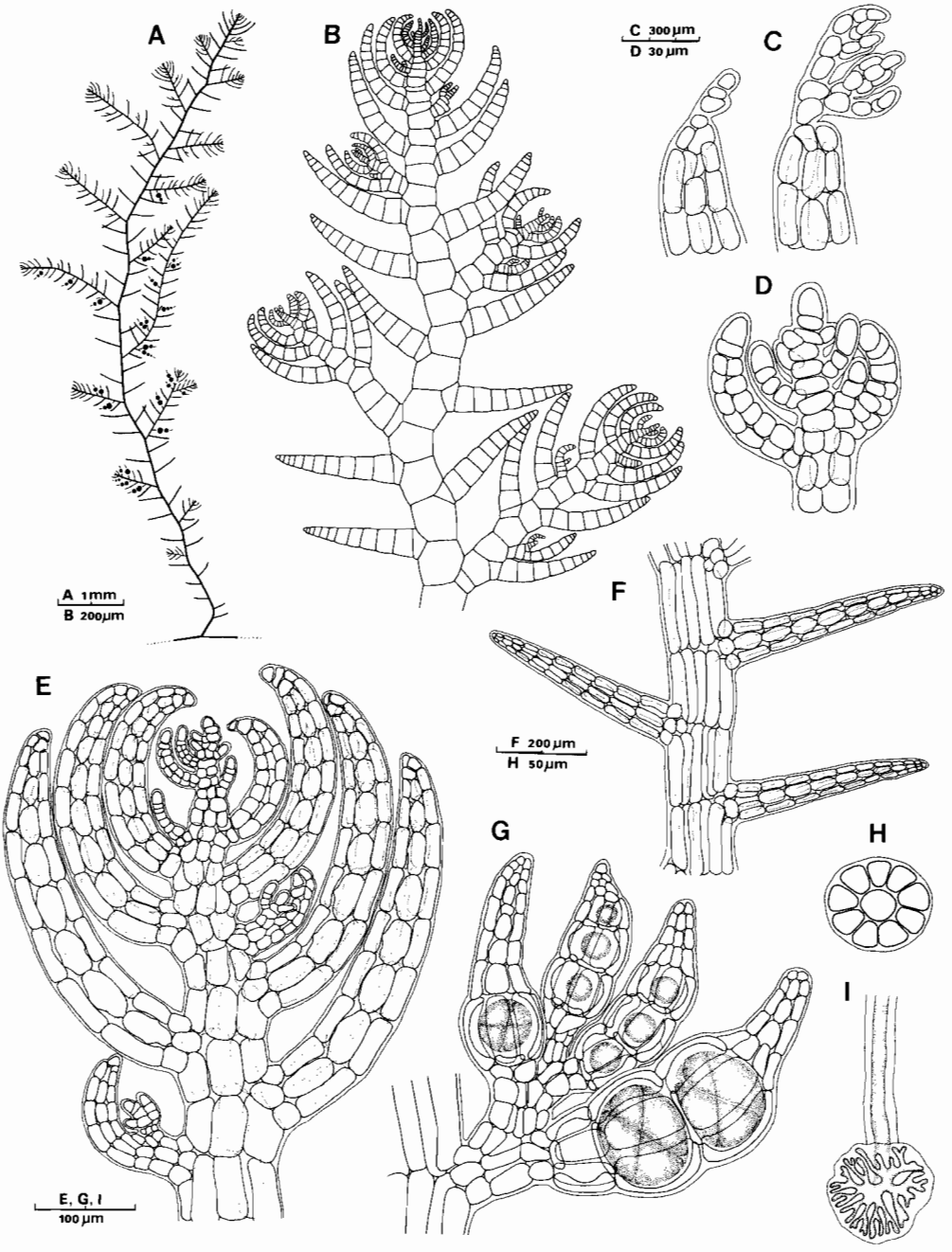

Fig. 5. *Herposiphonia plumula* (J. Agardh) Hollenberg.

A. Habit of thallus with tetrasporangia; B. Branching pattern of main axis; C. Trichoblasts; D. Apex of indeterminate branch; E. Formation of indeterminate branches and determinate branchlets; F. Determinate branchlets in alternate arrangement; G. Tetrasporangia in determinate branchlets; H. Branch in cross section; I. Unicellular rhizoid with digitate base.

Korean name: 엇깃꼴거미줄 (nom. nov.)

Plants epiphytic, repent, 1-2 cm high, strictly distichous at every nodes, brownish red in color. Rhizoids single-celled, digitate at tip, 20-60 μm in diameter, from upper portion of branches and branchlets. Main axes straight, 150-200 μm broad, bearing indeterminate branches or determinate branches at every nodes. Indeterminate branches replacing by determinate branches at every fourth segment alternately, provided with adaxially curved branchlets, similar in branching pattern to main axes. Determinate branches 7-11 segmented, three borne between successively alternate indeterminate branches, straight at middle to lower portion, curved adaxially at upper portion of axes, broad at bases, tapering towards apices. Branches and branchlets in cross section consist of axial and periaxial cells. Periaxial cells up to 7-12. Trichoblasts at tip of branchlets and stichidia, pectinately branched. Tetrasporangia obliquely cruciate, ovoid to ellipsoidal, 70-100 μm in diameter, borne on second segments of branchlets in indeterminate branches.

Type locality: Santa Barbara, California

Collections examined: Gwantaldo of Cheju Island, southern rocky slope of 5-10 μm depth (*Jae, J.K.*, 9 VIII 1988)

Distribution: Korea, Japan and Pacific coast of North America

The genus *Herposiphonia* Nägeli (1846) characterized by its dorsiventral organization was composed of small epiphytes favouring the warmer waters. It was majorly distributed downwards to the Tropic of Cancer (Silva *et al.*, 1987; Yoshida *et al.*, 1990). Five species have been recorded in Korea (Lee and Kang, 1986), and *H. fissidentoides* (Holmes) Okamura and *H. tenella* (C. Agardh) Nägeli epiphytic usually on other algae were commonly collected.

Falkenberg (1901) first examined J. Agardh's type of *Polysiphonia plumula* and considered it as *Herposiphonia* species but no nomenclatural treatment. Hollenberg (1970) later examined broadly the herbarium specimens related to this species, and made a new combination with *Herposiphonia*, including *H. rigida* Gardner (1927) and *H. subdisticha* Dawson (1944) as synonyms.

The plants at hand were collected on *Corallina officinalis* from the rocky slope in 5-10 m depth. Basically, they were repent with digitate rhizoids issuing from the main axes, and later became caespitose with erect branches (Fig. 5A). Digitate rhizoids developed from the upper portion of indeterminate branches (Fig. 5I). The habit of our plants was very similar to the picture described by Hollenberg (1970). The erect branches bore indeterminate branches in strict distichous manner giving intervals of every three determinate branchlets (Fig. 5B, F). The number of periaxial cells in main axes is 7-12 in our plants (Fig. 5H). Trichoblasts, which was not mentioned by Abbott and Hollenberg (1976) frequently occurred on the apices of determinate branches (Fig. 5C). Two or three tetrasporangia usually were borne on a determinate branchlet in middle portion of indeterminate branches, and divided to obliquely cruciate manner (Fig. 5G). Other reproductive structures were not observed in our materials.

Herposiphonia subdisticha Okamura (1899) was often confused with *H. plumula* (J. Agardh) Hollenberg owing to their indeterminate branches (Hollenberg, 1970). The former, however, bore irregular branches in contrast to regularly strict distichous branches with intervals of successively alternative three determinate branches in the latter.

***Pterosiphonia pennata* (C. Agardh) Falkenberg 1901** (Figs 6A-F, 7A-E)

Hutchinsia pennata C. Agardh 1824

Pterosiphonia californica Kylin 1941

Korean name: 나래붉은깃 (nom. nov.)

Plants erect from creeping branches with unicellular digitate rhizoids cut off from pericentral cells, caespitose, 1-3 cm long, epilithic or epiphytic, densely tufted with branches, ecorticate, dark brownish red in color. Main axes cylindrical, 250-280 μm broad in lower portion, slightly compressed, 110-330 μm broad in middle to upper portion. Branches alternately pinnate or partly bipinnate with subacute apices, borne at intervals of two segments, connate with axes every segment. Branchlets more or less cylindrical, slightly outcurved in upper portion, rarely inward in lower portion, 0.2- 0.7 mm long, 64-100 μm broad, borne at intervals of two segments. Axes and branches in cross section consisting of axial and periaxial cells. Periaxial cells 7-

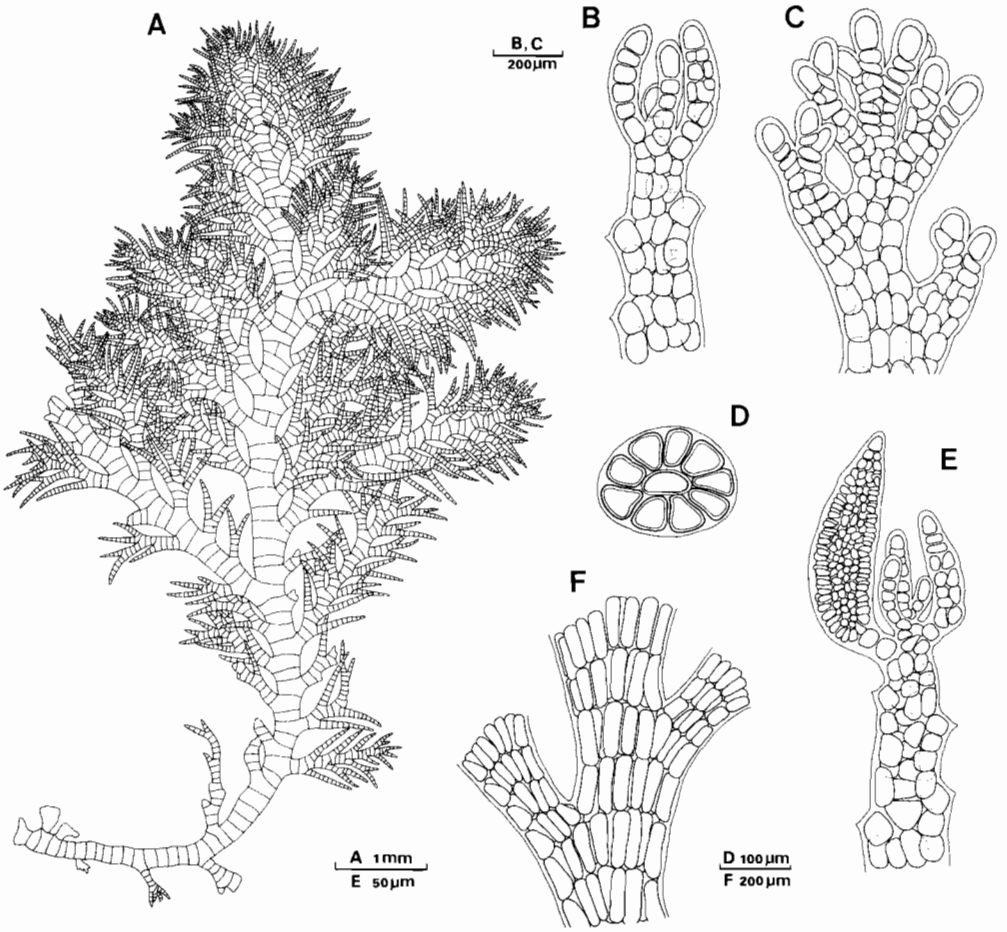

Fig. 6. *Herposiphonia plumula* (J. Agardh) Hollenberg.
A. Habit of thallus; B.E. Spermatangial branchlets, B being young; C. Apical portion of main axis; D. Main axis in cross section; F. Connate fusion of branches and main axes.

11. Trichoblasts present. Spermatangial stichidia several, distichous, adaxial on short branchlets.

Type locality: Mediterranean Sea

Collections examined: Dadaepo cove, Pusan, lower rocky intertidal zone (*Oh, Y.S.*, 25 XI 1991)

Distribution: Korea, Japan, Europe and Mediterranean Sea

The genus *Pterosiphonia* was originally proposed as *nomen nudum* by Falkenberg (*in* Schmitz, 1889), and described later by him with *P. cloiophylla* (C. Agardh) Falkenberg (*in* Schmitz and Falkenberg, 1897) based on *Rhodomela cloiophylla* C. Agardh (1822). Falkenberg (1901) included 10 species in it, previously belonged to *Polysiphonia* and *Rytiphlaea. Pterosiphonia* is distinguished from the other related genera on the basis of its erect and alternately distichous branches with congenital fusion of one branch to another but never extending over more than two internodes (Fritsch, 1945; Hommersand, 1963).

This species was originally described by Roth (1800) as *Ceramium pennatum* intermixed with *Sphacelaria* based on materials from Mertens collected at warmer areas of the Mediterranean to Atlantic Sea. C. Agardh (1824) assessed it as *Hutchinsia pennata* and later gave it a full description. *Pterosiphonia pennata* was collected at the rocky intertidal zone of the sheltered area. It grew on crustose coralline algae intermingled with other species such as *Gelidium* spp. and *Corallina* spp.

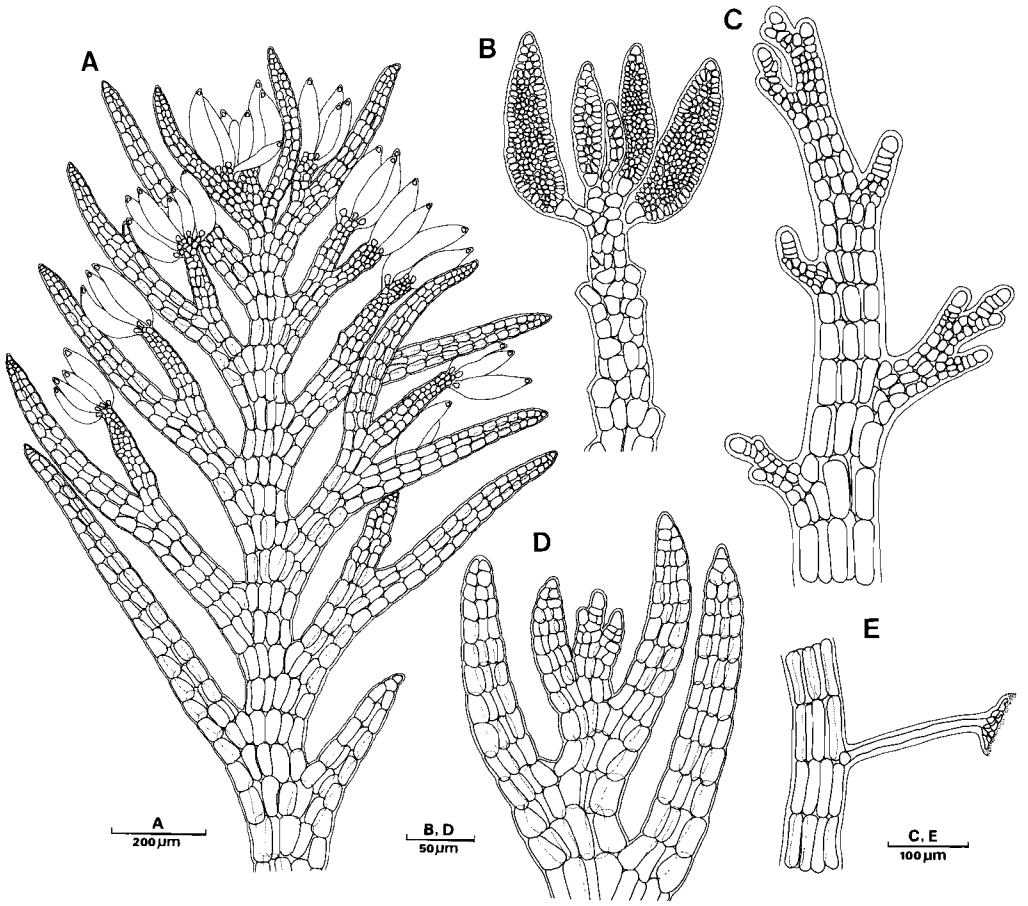

Fig. 7. *Pterosiphonia pennata* (C. Agardh) Falkenberg.
A.B. Spermatangial branches, B showing mature branches; C. Dwarf branches in lower portion of main axis; D. Branching pattern in sterile plant; E. Unicelluar rhizoid with digitate base.

Erect branches developed connate lateral branches alternately in every two segments (Fig. 6A). Rhizoids were borne at the nodal portion of segment in main axes with unicelullar digitate tip (Fig. 7E).

With some extent of differences in dimension, branching pattern of our plants shows a proper feature of the species and close relationships to Japanese and Californian plants (Okamura, 1908, 1936; Abbott and Hollenberg, 1976). The plants at hand had connate branches and develop branchlets in distichous and connate manner (Figs 6F, 7A), which became key characters distinguishing the genus from other related genera (Choi, 1986). The number of periaxial cells usually were 9 (Fig. 6D), but more cells with two axial cells can be observed in congenital portion of the branches, as described by Okamura (1908).

Spermatangia were formed spirally on fertile branches, which were produced abaxially at subaxillary portion of the branches (Figs 6E, 7B). The fertile branches were composed of monosiphonous or polysiphonous, and develop to mature spermatangial branchlets with a single-celled stalk (Fig. 6B). Mature spermatangia usually fell down from basal part of branchlets, persisted two to five (Fig. 7B). Other reproductive structures were not observed. Several authors commented on the similarity of *Pterosiphonia* and *Symphyocladia*. Okamura (1923) described *Symphyocladia pennata* based on *Pterosiphonia parasitica* (*non* Falkenberg) *sensu* Yendo under the characteristics of apical connate. Choi (1986) pointed out, describing the genus

Symphyocladia from Korea, that the connate fusion of the branches showed too variable to assign the delimitation of the both genera adopting indoor culture. Further intensive examination on the generic delimitation will be followed.

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(Accepted September 16, 1992)