

A Taxonomic Reappraisal of *Ceramium fastigiatum* Harvey (Rhodophyta, Ceramiaceae)

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紅藻 *Ceramium fastigiatum* Harvey의 分類學的 再檢討

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ABSTRACT

Because *Ceramium fastigiatum* Harvey (1834) is a later homonym of *C. fastigiatum* Roth (1806), a quite different plant from the former, it becomes illegitimate and must be rejected under the Article 64 of International Code of Botanical Nomenclature. For this reason, we suggest to give a new name, *Ceramium fastigiramosum* Boo et Lee, to the former species, keeping the original specific epithet '*fastigiatum*'. The morphology of vegetative and reproductive structures is re-examined. The life history is confirmed as a *Polysiphonia*-type in laboratory culture.

INTRODUCTION

Ceramium fastigiatum Harvey, reported from England and the Mediterranean Sea (Harvey, 1934; Ardissonne, 1871), occurs commonly in Korea and Japan (Nakamura, 1965; Kang, 1966). Morphology and reproduction were observed by many investigators (J. Agardh, 1851; Ardissonne, 1871; De Toni, 1903, 1924; Nakamura, 1965). The laboratory culture was carried out recently by Yabu *et al.* (1981). They confirmed the chromosome number of the species as $n=28$ and $2n=ca. 56$.

This work was carried out as a part of monographic study on Korean Ceramieae. The morphological characters of vegetative structure, the developmental anatomy of reproductive organs and the life history in laboratory culture were reinvestigated, specially dealing with the taxonomic account.

MATERIALS AND METHODS

Materials were collected along the coasts of Korea since 1980 (Fig. 1). Description

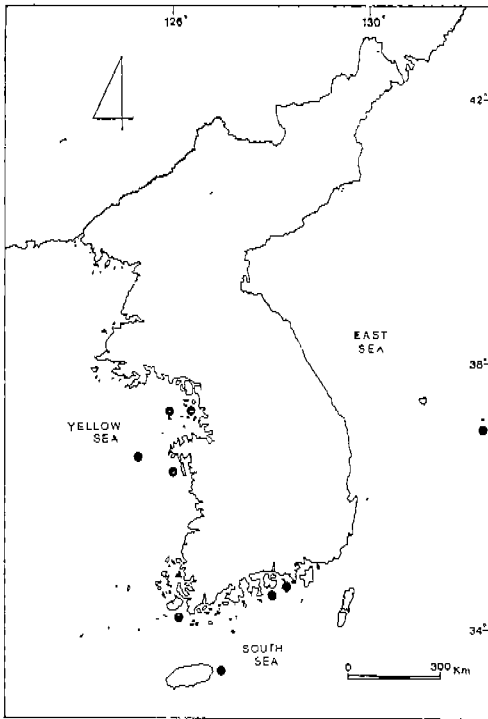


Fig. 1. Geographical distribution of *Ceramium fastigiatum* Boo et Lee along the coasts of Korea.

and illustration were based on materials preserved in 5% formalin sea water.

Two populations of Seongsanpo, Cheju Island ($33^{\circ} 28'N$, $126^{\circ} 56'E$) on 20 August, 1982 and Bangpo, Anmyundo ($36^{\circ} 31'N$, $126^{\circ} 20'E$) on 4 April, 1984 were used for laboratory culture. Both were tetrasporophytes and 20~30 mm high. Methods for unialgal culture were described in Boo and Lee (1983).

RESULTS AND DISCUSSION

Habitat and phenology. *Ceramium fastigiatum* Harvey was collected at several sites in Korea (Fig. 1). The plants grew solitarily and gregariously on rock, or were epiphytic on other macroalgae. They inhabited in the lower littoral zone sheltered from light and drying.

In the south coast, both the carposporophytes and tetrasporophytes were collected in January and February at Yeosu and Samchunpo, and tetrasporophytes in August at Hazodo and Seongsanpo. In the west coast, the male plants were found in March at Deokjeokdo, tetrasporophytes in April at Bangpo, and both the tetrasporophytes and carposporophytes in July and August at Deokjeokdo. In the east coast, the tetrasporophytes were collected in August and September at Dogdo. In addition, Kang (1966) collected several vegetative plants epiphytic on *Gracilaria textorii* and *Gelidium* spp. at Wando and Yokchido in the south coast. Lee (1980) and Lee and Lee (1981) reported tetrasporophytes and carposporophytes at Deokjeokdo.

Considering the above observations, this species occurs commonly in the west and south coasts of Korea through all seasons, whereas in the east it is not common except for Dogdo where the marine algal flora is more proximate to Cheju Island than the other places in the east coast (Lee and Boo, 1981). The perennial plants observed by Nakamura (1965) in Hokkaido, Japan were not found in Korea.

Vegetative thallus. The morphology of *Ceramium fastigiatum* has been described and illustrated by several investigators (Harvey, 1834; Kützing, 1841, 1862~1863 as *Gongroceras fastigiatum*; J. Agardh, 1851; Ardissonne, 1871; De Toni, 1904, 1924; Nakamura, 1954, 1965; Yabu *et al.*, 1981). Our plants agreed well with Harvey and Nakamura in

diagnostic characters. The following observations were based on the plants collected in January at Yeosu.

The plants consist of densely tufted erect fronds and prostrating axes anchored by filamentous rhizoids on the substratum. They are flaccid, bright rose-red, and adhere tightly to paper in drying. Mature plants are 30~50 mm high and branched in several times dichotomously to form a fan-shape in external appearance.

Rhizoids arise one to three from periaxial cells at dorsal side of each node. Rhizoids attached on substratum are usually 1~2 celled, ending with a multicellular pad (Fig. 3H), whereas those free from the substratum are often 3~6 celled with a blunt apex. Branched rhizoids mentioned by Nakamura (1965) are not found in our plants.

Main axis consists of axial cells and cortical nodes. The axial cells are cylindrical, 200~230 μm high and 70~80 μm broad at the central cell of the seventh branch from apex, making L/B be 3~4 : 1. They are divided acro-basipetally to produce five periaxial cells alternately in a ring. The sequence of their formation accords well with that of other species in *Ceramium* (Hommersand, 1963; Itono, 1977). It has been accepted as an important taxonomic character of the genus (Dixon, 1960; Hommersand, 1963; Womersley,

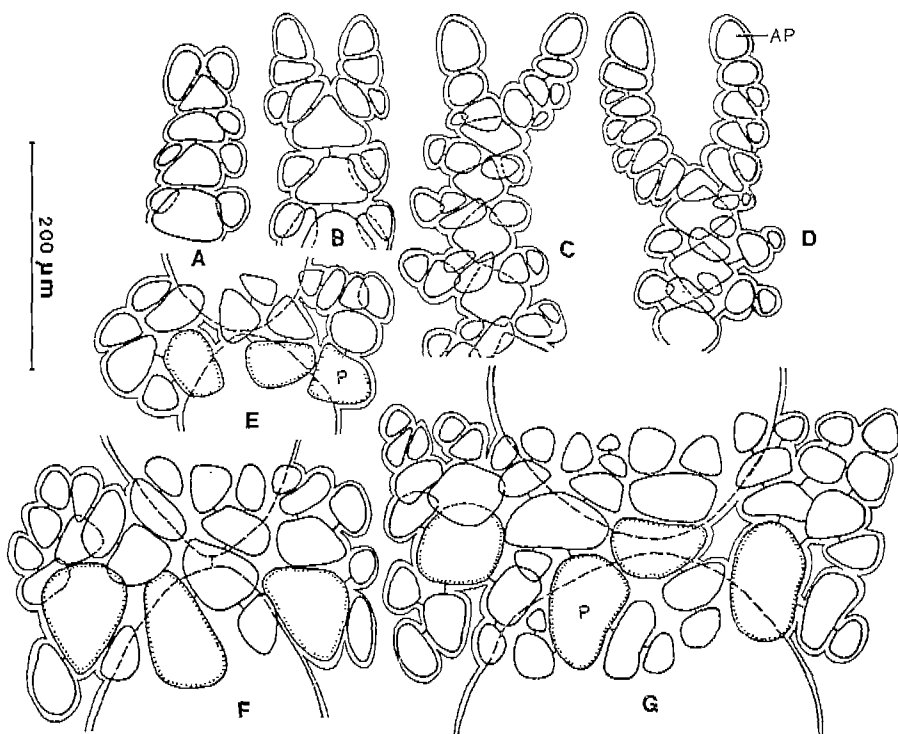


Fig. 2. *Ceramium fastigiatum* Boo et Lee nom. nov. A-D. Development of pseudodichotomous branches. E-F, Development of cortical node (AP, apical cell; P, periaxial cell).

1978).

The first periaxial cell elongates acro-basipetally and divides obliquely to produce four to five primary cortical cells. Each primary cortical cell also elongates and divides once or more times to produce secondary and tertiary cortical cells (Figs. 3A-I). The other periaxial cells also produce cortical cells in a same sequence as the first, so that the periaxial cells and cortical cells join together to form a cortical node in a ring (Figs. 2E-G). Mature cortical node consists of 5~6 cells in row and $95\sim 100\ \mu\text{m} \times 45\sim 50\ \mu\text{m}$, whereas the internode is $170\sim 175\ \mu\text{m}$ in height. The cytoplasmic strands observed in upper axial cells disappear from mid- to lower portion of the plant. The linear rhodoplasts are numerous, arranged in parallel along axial cells.

Apices are emarginated and straight or slightly incurved, but not hooked as in *Ceramium aduncum* (Nakamura, 1965; Suh and Lee, 1984).

Apical cell divides obliquely to produce branch initials in a dichotomous manner at every (4)~8~(10) cortical node. The apical cell elongates adaxially to divide the adaxial branch initial, whereas the subapical cell elongates abaxially to divide the abaxial branch initial. The abaxial branch grows more slowly than the adaxial branch, but later they become same in height, showing a level-topped and subcomplanate form (Figs. 2A-D), as mentioned by Harvey (1834).

Adventitious branches arise rarely on the periaxial cells. They are short and simple.

Male gametophyte. Spermatangia, not reported previously (Harvey, 1834; Nakamura,

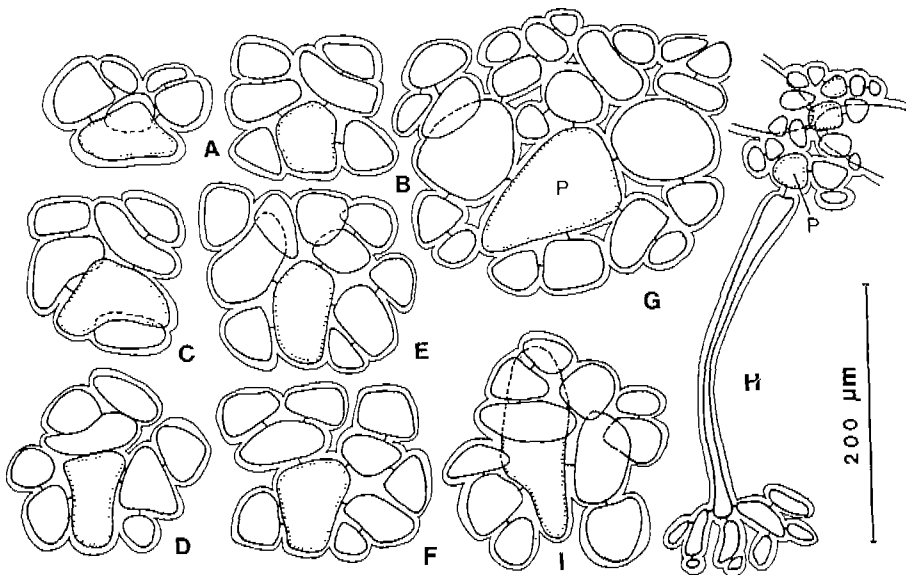


Fig. 3. *Ceramium fastigiramosum* Boo et Lec nom. nov. A-H, Development of cortical cells. I, Digitate rhizoid from periaxial cell (P, periaxial cell).

1965), arise on the cortical cells. They are first produced on adaxial side of cortical nodes and gradually on all surfaces. Cortical cells lose the pigments and divide into the spermatangial mother cells, which produce 1~3 subterminal spermatangia respectively (Fig. 4A). Spermatangia are elliptical and $3\sim4\ \mu\text{m} \times 4\sim5\ \mu\text{m}$ in size. Male plants become 10~20 mm high. Yabu *et al.* (1981) reported 24~26 chromosomes in spermatangia of the cultured male plant.

Female gametophyte. Carpogonial branches occur always near the apex on abaxial side of the branches. The periaxial cell becomes the supporting cell and produces a four celled carpogonial branch. The trichogyne is comparatively long and narrow. It swells a little above the carpogonium.

After fertilization, the supporting cell produces an auxiliary cell and coalescences to the axial cell, forming a large fusion cell (Fig. 4B). The auxiliary cell cuts off a gonimoblast initials (Fig. 4C). The mature cystocarp is sessile and subterminal (Fig. 4D). It becomes $440\sim445\ \mu\text{m} \times 460\sim470\ \mu\text{m}$ and is surrounded by 5~6 involucrel branches (Nakamura, 1965), which arise from periaxial cells so that the number usually accords with

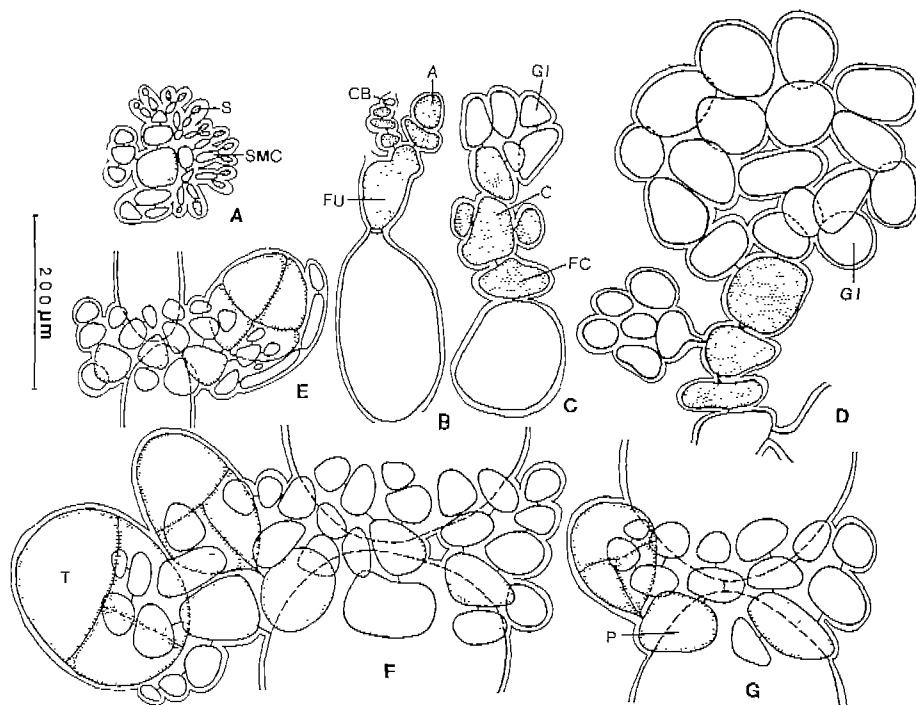


Fig. 4. *Ceramium fastigiatum* Boo et Lee nom. nov. A; Development of spermatangia. B; Auxiliary and foot cell after fertilization. C; Young cystocarp. D; Mature cystocarp. E-G. Development of tetrasporangia with involucrel cells (A, auxiliary cell; C, central cell; CB, carpogonial branch; FC, foot cell; FU, fusion cell; GI, gonimoblast initial; P, periaxial cell; S, spermatangium; SMC, spermatangial mother cell; T, tetrasporangium).

that of periaxial cells.

Tetrasporophyte. Tetrasporangium arises from the periaxial cell in upper cortical nodes. It is erumpent and often slightly bracteate by cortical cells (Fig. 4E). Tetrasporangia are $30\sim 40\ \mu\text{m} \times 35\sim 45\ \mu\text{m}$ in size and divided in irregular cruciate manner (Figs. 4E-G), in contrast to tetrahedral ones reported by Nakamura (1965). Harvey (1834), however, did not describe them in the original paper.

Laboratory culture. Unialgal culture was obtained from Seongsanpo and Bangpo isolates with excised tetrasporic branches. The Bangpo isolates produce tetraspores normally, which germinate into bipolar sporelings within one day. The sporeling becomes 8~10 celled in three to five days. The branches arise in 10~14 days. Spermatangia are observed in three weeks after germination. Carpogonial branches are observed on female gametophytes in five to six weeks, while the mature cystocarps are in eight weeks. Released carpospores germinate into the tetrasporophytes, which produce tetrasporangia in 8~10 weeks. Therefore, a *Polysiphonia*-type of life history is completed in four months as mentioned by Yabu *et al.* (1981). Isolates from Seongsanpo, however, show vegetative growth alone in the laboratory.

The taxonomic characters in culture are basically similar to those of the field plants. However, the cortical node in culture becomes 2~3 celled in row in contrast to 5~6 celled rows of the field plants. Therefore, the row of cortical cells, which was regarded as an important taxonomic character of *Ceramium* by Nakamura (1965), seems to be variable according to environmental conditions (Womersley, 1978; Suh and Lee, 1984). Womersley (1978) mentioned that the row of cortical cells was probably dependent on the space available around the node.

Taxonomic account. *Ceramium fastigiatum* Harvey is characteristic in following features. The plants are erect, produce branches regularly in dichotomous and level-topped manner on a same plane (Harvey, 1834), and bear tetrasporangia arranged adaxially (Nakamura, 1965; Boo, 1985).

Harvey (1834), first describing this species, considered it as a variety of *Ceramium diaphanum* (Roth) Harvey. However, by a request of Mrs. Griffiths he separated this from the latter species, and gave a new name, *C. fastigiatum*. He distinguished this from *C. diaphanum* by regularly dichotomous and level-topped branches. On the other hand, Kützing (1841), dividing *Ceramium* into five genera, transferred this to his new genus *Gongroceras*, but J. Agardh (1851) kept this in *Ceramium sensu lato*. J. Agardh's treatment of this species was accepted thereafter by many investigators (Ardissone, 1871; De Toni, 1903, 1924; Børgesen, 1918; Dawson, 1962; Nakamura, 1954, 1965; Kang, 1966; Lee, 1980; Lee and Lee, 1981; Lee and Boo, 1981).

However, *C. fastigiatum* Harvey (Harvey, 1834) is a later homonym of *C. fastigiatum* Roth (1806), a quite different plant from the former species. Therefore, the former name becomes illegitimate and must be rejected under the Article 64 of International Code

of Botanical Nomenclature (Stafleu, 1972). For this reason we suggest to give a new name to this species, keeping the original specific epithet "*fastigiatum*", as follows:

Ceramium fastigiramosum Boo et Lee nom. nov.

[Basionym: *Ceramium fastigiatum* Harvey (1834, p.303) non Roth (1806, p.175)]

摘 要

紅藻植物 비단풀목에 속하는 *Ceramium fastigiatum* Harvey (1834)는 *Ceramium fastigiatum* Roth (1806)의 later homonym이므로 국제식물명명규약 제 64조에 따라 그 적법성이 인정되지 않는다. 따라서 본 식물은 Harvey의 종소명을 근거로 하여 *Ceramium fastigiramosum* Boo et Lee nom. nov.로改名한다. 아울러 본 종의 영양체와 배우체 및 파포자체의 생식기 형태가 재검토되었고 응성생식기의 구조는 처음으로 도해되었다. 실내배양을 통한 生活史는 홍조류 비단풀목의 전형적인 *Polysiphonia*형이었다.

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