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Two Korean Species of *Centroceras* Kützing (Ceramiaceae, Rhodophyta)

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韓國產 紅藻 *Centroceras*屬 二種

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ABSTRACT

Two Korean species of *Centroceras* Kützing, Ceramiaceae was investigated taxonomically. *C. clavulatum* (Ag.) Montagne collected at several sites along the coast of Korea was characterized by regular dichotomous branches with whorl spines at every node, whereas *C. distichum* Okamura collected at Soando in the southern coast was by alternate branches with gland cells around nodes. Biogeographic data show that Korea is almost northern limit in distribution of the former species.

INTRODUCTION

Centroceras is characterized by its pseudodichotomous branches, rectangular cortical cells arranged longitudinally on axis and branches, and spermatangia originated from anterior end of the periaxial cells (Kützing, 1841; Feldmann-Mazoyer, 1940; Hommersand, 1963; Gallagher and Humm, 1983). It is closely related to *Ceramium* in structure of tetrasporophyte and female gametophyte (Hommersand, 1963).

The genus was established by Kützing (1841) based on the character of cortical cells in shape and arrangement. He included six species in it. Soon after Montagne (1846) added one more species, *C. clavulatum* which had been known as *Ceramium clavulatum* C. Ag. (1822). However, J. Agardh (1851) reduced all the Kützing's species to synonymy of *Centroceras clavulatum* (Ag.) Montagne. Therefore, Kylin (1956) lectotypified the genus with *C. clavulatum* (Ag.) Montagne.

Feldmann-Mazoyer (1940) pointed out that *Centroceras* differed from *Ceramium* by quadrate cortical cells and a greater number of periaxial cells. Hommersand (1963) mentioned that two genera were separated by the spermatangial origin e.g., *Centroceras*

produced spermatangia directly from the periaxial cells, whereas *Ceramium* produced them from the cortical cells. Gallagher and Humm (1983) reported that even though the spermatangial origin might be a distinguishable feature of *Centroceras*, the taxonomic status of the genus was in doubt because spermatangia were known only in two among nine species described.

In Korea, *Centroceras clavulatum* and *C. distichum* have been recorded in floristic lists (Kang, 1966; Kim and Lee, 1981; Lee and Boo, 1982). The morphological and anatomical characters as well as geographic distribution of the both species are investigated in this paper.

MATERIALS AND METHODS

Field populations of *C. clavulatum* were investigated during 1981 and 1984 from the coasts of Korea. They were epiphytic or epilithic. Tetrasporangiate and vegetative plants were up to 3~5cm high. *C. distichum* was collected on August 1982 at Soando-island in the south-eastern coast. The plants were epiphytic on melobesioidean algae and up to 2 cm high in tetrasporophytes.

Living plants of *C. clavulatum* from Songjung in the eastern coast were collected on April, 1983 for laboratory culture. They were vegetative in 3 cm height. Methods for unialgal culture were described in Boo and Lee (1985).

Descriptions and illustrations were based on materials preserved in 5% formalin-sea water. Specimens examined were preserved in the Herbarium, Kangreung National University.

RESULTS AND DISCUSSION

***Centroceras clavulatum* (C. Agardh) Montagne** (Figs. 1~6)

Basionym : *Ceramium clavulatum* C. Agardh (1822) p. 2.

Korean Name : 가시비단풀

Materials : *East coast:* Dockdo (Oct. 1981), Ulreungdo (Oct. 1981), Bugyung (Jul. 1984), Gampo (Feb. 1983; Jul. 1984), Songjung (Feb. 1983; Apr. 1983; Dec. 1983). *South coast:* Yeosudo (Aug. 1982), Maando (Aug. 1982), Soando (Aug. 1982). *West coast:* Gyeokpo (Dec. 1983; Aug. 1984). *Cheju Isl.:* Sungsan (Jul. 1981; Jan. 1984), Bubwhan (Jan. 1984), Gosan (Jul. 1981).

Description. Plants bright red, up to 5 cm high, tufted, epiphytic to epilithic; filaments erect to creeping on substratum; rhizoids from periaxial cells, rarely from cortical cells, 2~3 celled, ending with multicellular pad; branches from apical cells, regular in every six to eight node, pseudodichotomous to sometimes tri- or tetrachotomous; axis cylindrical, 50~60 μm×680~820 μm, 10-12:1 in L/B, producing periaxial cells in ring; periaxial cells fourteen, spherical to irregular in shape, each cutting off three cortical initials

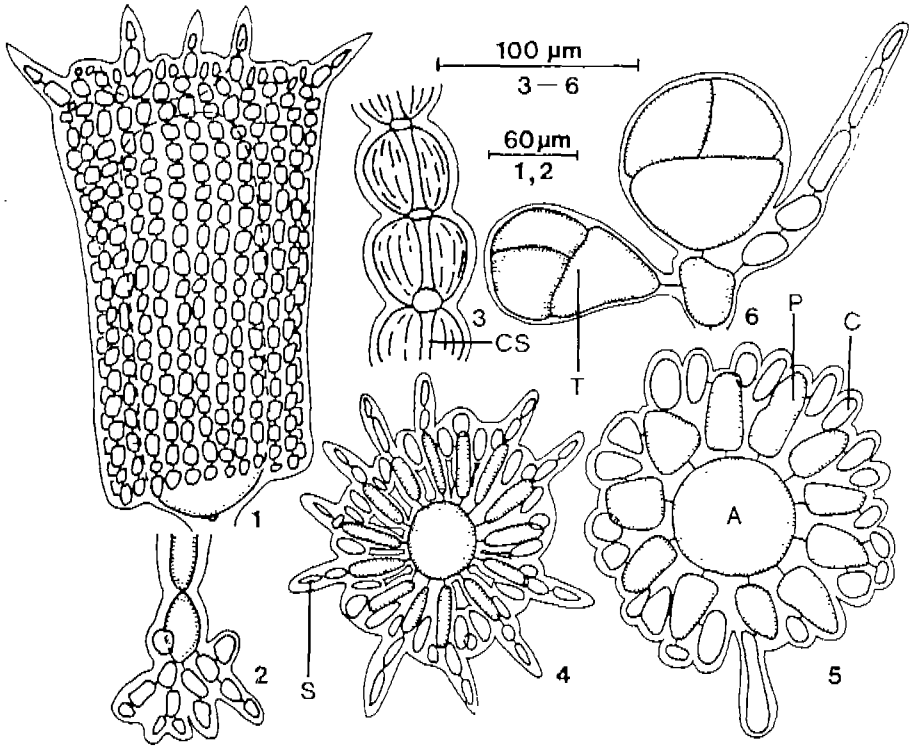


Fig. 1-6. *Centroceras clavulatum* (C. Ag.) Montagne.
Fig. 1. Cortical node with spines in whorl (squashed). Fig. 2. Rhizoid with multicellular pad. Fig. 3. Cytoplasmic strand intercrossed among axial cells. Fig. 4. Transverse view of axis showing 14 periaxial cells with spines in field plants. Fig. 5. Transverse view of axis showing 11 periaxial cells and young spine in culture plants. Fig. 6. Development of tetrasporangia (A : axial cell, C : cortical cell, CS : cytoplasmic strand, P : periaxial cell, S : spine, T : tetrasporangium).

acro-basipetally; cortical initials divided acropetally once or more, basipetally 20 times or more; cortical cells rectangular, arranged regularly in longitudinal rows of 20~24 cells, 30~35 μm×70~75 μm; cytoplasmic strand linear, intercrossing among axial cells in upper portion of thallus; proliferations short, originated from periaxial cells abaxially; spines acuminate, 2~3 celled from periaxial cells, whorled, eleven around node in maximum; tetrasporangia oblong, originated from periaxial cells abaxially, later whorled, enclosed by several cortical cells, 40~45 μm×45~50 μm, divided tetrahedrally; sexual reproductive organs not observed.

Habitat : Epiphytic on *Sargassum thunbergii* and other macroalgae, or epilithic on rocks in intertidal zone.

Laboratory Culture. Unialgal culture from Songjung isolates was obtained with excised apical tips of vegetative thallus. The isolates grew well vegetatively in 15 months. They grew up to 6 cm height and branched regularly in divaricate manner without any adven-

titious branches observed in field materials. Spines in cortical node occurred in lower frequency than in field plants, but they were never completely absent (Gallagher and Humm, 1983). The number of periaxial cells was eleven in contrast to fourteen of field plants (Fig. 5).

Taxonomic account. *Centroceras clavulatum* is characterized by its filamentous thallus, regular pseudodichotomous branches with whorl spines in every node (Feldmann-Mazoyer, 1940; Hommersand, 1963). It distributes from tropical to temperate zones and is highly variable in shape.

The species, first described by Agardh (1822) as *Ceramium clavulatum*, was removed to *Centroceras* by Montagne (1846) on the basis of rectangular cortical cells arranged regularly in longitudinal rows. According to Hommersand (1963), the plants from South China Sea produced spermatangia from the periaxial cells, which were regarded as a distinguishable character of the genus (Egerod, 1971; Itono, 1977; Gallagher and Humm, 1983).

Our plants agree basically well to the previous descriptions (Feldmann-Mazoyer, 1940; Hommersand, 1963; Itono, 1977). However, the number of periaxial cells, which can be an important character delimiting species in Ceramieae (Womersley, 1978), appears to be eleven in culture and fourteen in field plants. They were reported as fourteen in field from Japan and South China Sea (Hommersand, 1963; Itono, 1977), Gallagher and Humm (1983) mentioned that the number of periaxial cells could be ten to fourteen according to plants, but they did not vary due to habitat.

Spines occur both in field and culture plants. They may depend in part upon environmental conditions, as mentioned by Gallagher and Humm (1983). Cytoplasmic strand not mentioned previously occurs among axial cells in upper part of thallus. It occurs in most species belonging to Ceramieae (Boo and Lee, unpublished data).

Tetrasporangia occur at abaxial side of branches in a whorl around node. They arise on main branches in plants from Dokdo and Cheju Isl., but on short adventitious branches as stichidia in plants from Maando and Gyeokpo.

Feldmann-Mazoyer (1940) reported that this species from Mediterranean Sea propagated only vegetatively, and from Algerie by tetrasporangia and sexual organs. Hommersand (1963) mentioned tetrasporophytes, gametophytes and carposporophytes from Malaya, whereas Børgesen (1917, 1953) and Itono (1977) only the tetrasporophytes from West Indies and southern Japan, respectively. Van den Hoek (1982) suggested that the formation of tetrasporangia or gametangia needed higher temperature than the vegetative growth needed. In Korea only the tetrasporophytes are observed both in winter and summer, and gametophytes are not found yet. According to Dixon (1965, 1970), tetrasporophytes occurred farther to the north than gametophytes, while vegetative plants only at the extreme northern limit of distribution. Druehl (1981) pointed out that the diploid stage of red algae had a broader environmental tolerance than the haploid. Considering these discussion, Korea seems almost the northern limit in distribution of the species.

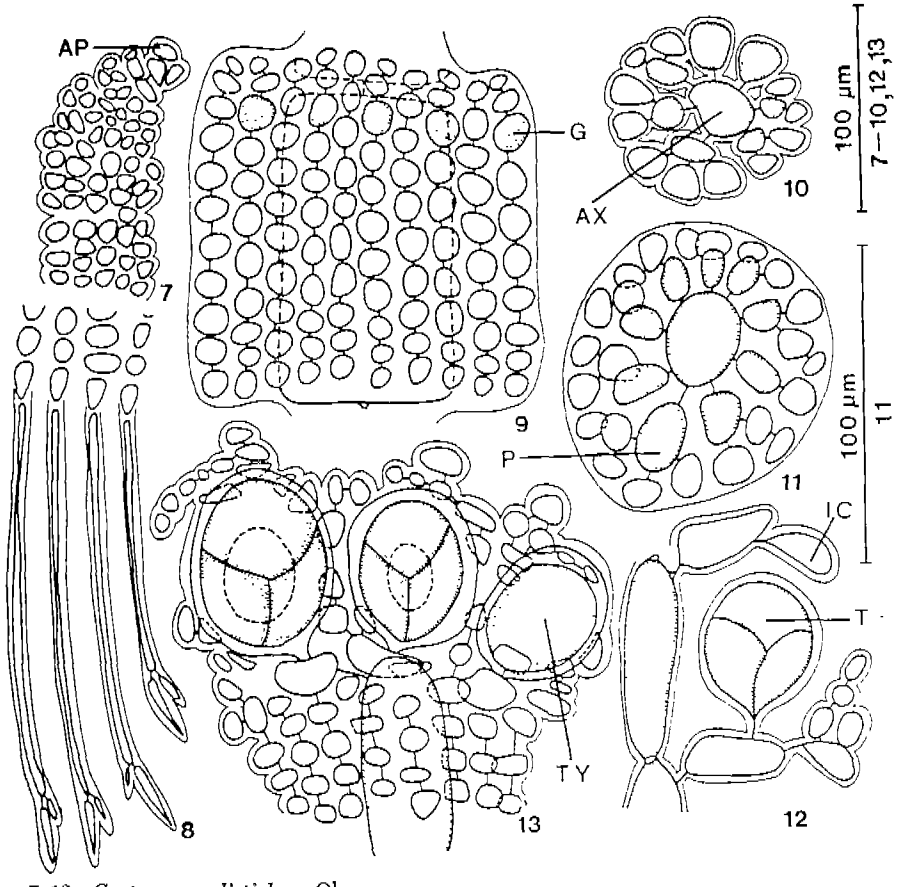
Van den Hoek (1982) suggested that the northern distributional boundary of *C. clavula-*

tum approximates 20°C summer isotherm along the eastern shores in the Pacific and Atlantic. In the eastern coast of Korea the plants occur up to Jukbyun and Ulreungdo (Fig. 14), where the mean temperature is above 20°C in summer, or above 10°C in winter (Fig. 15), while in the western coast they occur up to Eochungdo (Fig. 14), where the mean temperature is above 20°C during three months in summer, or above 4°C during one month in winter (Fig. 15).

***Centroceras distichum* Okamura** (Figs. 7~13)

Korean Name : 눈가시비단풀(nom. nov.)

Materials : *South coast:* Soando-isl. (Aug. 1982).



Figs. 7-13. *Centroceras distichum* Okamura.
Fig. 7. Actively dividing apex. Fig. 8. Digitate rhizoids arising on cortical cells. Fig. 9. Cortical node with gland cells in whorl (squashed). Fig. 10. Transverse view of development of axis showing seven periaxial cells. Fig. 11. Transverse view of nine periaxial and cortical cells. Fig. 12. Longitudinal view of tetrasporangium with involucral cells. Fig. 13. Surface view of tetrasporangia in whorl (squashed). (AP:apex, AX: axial cell, G: gland cell, IC: involucral cells, P: periaxial cell, T: tetrasporangium, TY: young tetrasporangium).

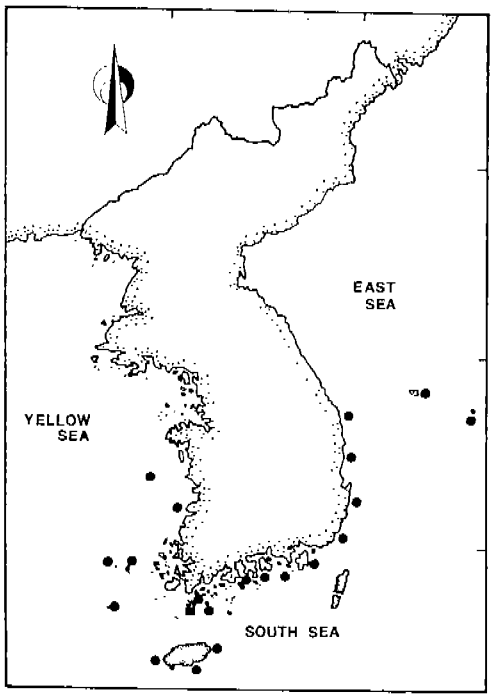


Fig. 14. Geographical distribution of *Centroceras clavulatum* (circle) and *C. distichum* (quadrate) in the coasts of Korea. Additional data from Kang (1966) and Kim & Lee (1981).

Description. Plants yellowish red, up to 2 cm high, epiphytic, prostrate to decumbent; rhizoids single celled from cortical cells, numerous, ending with multicellular pad; branches from apical cells, pseudodichotomous, complanate, alternate regularly in every four node; axis patent, composed of axial, periaxial and cortical cells, 170~180 μm in diam.; axial cells cylindrical, 2~4 times as long as broad, producing periaxial cells in ring; periaxial cells globular to irregular in shape, 8~9 in every node, each cutting off three cortical initials acro-basipetally; cortical initials irregular in shape, divided once or more acropetally, five or more basipetally; cortical cells quadrate, regular in 10~12 celled longitudinal rows, 6~10 μm × 10~12 μm, covering entire surface of branches; gland cells spherical, whorled in every two cortical filaments in upper portion of each node, 8~9 μm × 10~

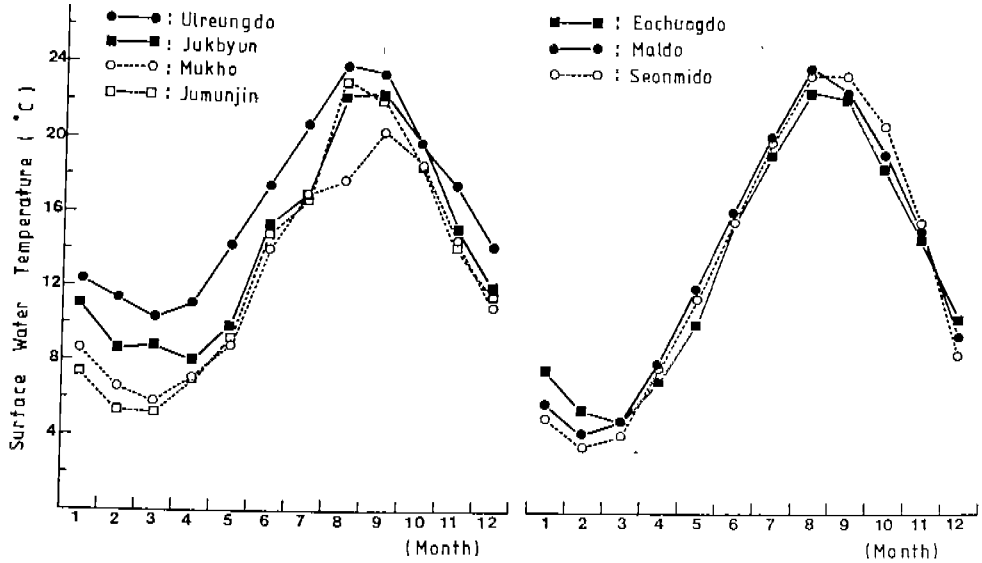


Fig. 15. Monthly variation of mean sea water temperature at surface in representative sites of the east coast (left) and the west coast (right). Data from "Annual report of oceanographic observations, 1983. Vol. 23. Korea (1984)."

12 μm; tetrasporangia oblong, originated from periaxial cells abaxially, whorled later, immersed, surrounded by rosette of cortical cells, divided tetrahedrally, 45~50 μm×55~60 μm; sexual reproductive organs not observed.

Habitat : Epiphytic on melobesioidean algae in upper subtidal zone.

Taxonomic account. *Centroceras distichum* is characterized by its complanate thallus, regular alternate branches with gland cells whorled at every node (Okamura, 1936; Itono, 1977). It distributes in Korea and Japan (Itono, 1977; Lee and Boo, 1982).

This species was first described by Okamura (1934) with two small fragments of thalli collected in deep water at Wagu, Japan. He noticed that the plants had alternate branches and spineless cortical nodes. However, Tanaka (1950) collected spined plants from southern Japan, and Itono (1977) observed both the spined and spineless plants from southern Japan.

Our plants have 8~9 periaxial cells, in contrast to 10~12 of Japanese plants (Itono, 1977). Spines are not observed. Gland cells occur in regular arrangement at every two cortical filaments, as seen in Japanese plants (Itono, 1977). Gland cells and alternate branches can be characteristic of this species. Tetrasporangia first occur in abaxial side of branches and later whorl around node, as seen in *C. clavulatum* from Korea.

摘 要

韓國産 紅藻 *Centroceras*屬 植物 2種에 대하여 分類學的 識別形質을 검토하고 그 分布를 考察하였다. *C. clavulatum* (Ag.) Montagne는 가지가 규칙적으로 叉狀分岐하며, 마디에 가시가 輪生하는 것이 特徵이다. 韓國은 本種의 分布北限界地域이라 간주되는데, 東海岸에서는 冬季 最低平均水溫이 10°C 以上인 곳, 西海岸에서는 4°C 以上인 곳까지 分布한다. *C. distichum* Okamura는 가지가 互生하고 마디에 腺細胞가 輪生하는 것이 特異하다.

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