Species of the Genera *Ceramium* and *Campylaephora*, Especially Those of Northern Japan

By

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This article and those preceding it (1950, 1954), are a series of studies of the *Ceramium* complex of Japan. A portion of the taxonomic results, the structure and reproduction of the genera *Ceramium* and *Campylaephora*, and the taxonomic characteristics of the genera, subgenera, and species were discussed in the previous reports. Determination and description of the species of the genera concerned, especially those from northern Japan are described in the present paper.

The majority of the material for the present study was collected by the writer from 1943 to 1949, but it also includes investigation of specimens in the Herbaria of the Faculties of Science (SAP) and Agriculture (SAPA), Hokkaido University, and the YENDO Herbarium of the University of Tokyo (TI).

The YENDO Herbarium of the University of Tokyo has a great many valuable specimens of these genera. About one hundred sheets of these specimens were used. YENDO described two new species, *Ceramium kondoi* and *Cer. sugiyamai* (in Herb.). The late Professor K. OKAMURA applied himself to the problems of *Ceramium* in Japan at various times throughout his career. OKAMURA, whose investigations of *Ceramium* were based primarily upon the material in the YENDO Herbarium, recorded six new species, three of which are listed in "Herbarium" and one in "Manuscript". In 1934, he reported his preliminary revision of the Japanese *Ceramium* at a meeting of the Japanese Society of Scientific Fisheries. His valuable studies were unfortunately curtailed by his death in the following year, and with the exception of a brief copy of the lecture given at that meeting, and the notes written on the specimen sheets, no records were found. The three other new species of *Ceramium*,*Cer. mucronatum* SEGI, *Cer. equisetoides* NAKAMURA, and *Cer. aduncum* NAKAMURA have been observed in the waters investigated.

Previous records of *Ceramium* in Japan include the following species: *Cer. miniatum* (HEYDRICH, 1894), *Cer. paniculatum* (OKAMURA, 1896), *Cer. japonicum* (OKAMURA, 1896), *Cer. clavulatum* (OKAMURA, 1901), *Cer. gracillimum* (OKAMURA, 1902), *Cer. tenuissimum* (OKAMURA, 1902), *Cer. rubrum* (OKAMURA, 1902), *Cer. boydenii* (GEPP, 1904), *Cer. hamatum* (YENDO, 1911), *Cer. circinatum* (YENDO, 1917), *Cer. pedicellatum* (YENDO, 1918), *Cer. secundatum* (YENDO, 1918), *Cer. rubrum* f. *fasciculatum* (YENDO, 1918), *Cer. rubrum* f. *corymbifera* (YENDO, 1918), *Cer. kondoi*

(YENDO, 1920), *Cer. sugiyamai* (YENDO, in Herb.), *Cer. nitens* (YENDO, in Herb.), *Cer. tenerrimum* (OKAMURA, 1921), *Cer. hypnaeoides* (OKAMURA, 1927), *Cer. crassum* (OKAMURA, 1930), *Cer. boreale* (OKAMURA, in Herb.), *Cer. cymosum* (OKAMURA, in Herb.), *Cer. ochotensis* (OKAMURA, in Herb.), *Cer. pumilum* (OKAMURA, in Mscr.), *Cer. mucronatum* (SEGI, 1944), *Cer. cimbricum* (TOKIDA, 1948), *Cer. equisetoides* (NAKAMURA, 1950), *Cer. aduncum* (NAKAMURA, 1950), *Cer. codii* (NAKAMURA, 1954), and *Cer. fimbriatum* (NAKAMURA, 1954). With the exception of *Cer. miniatum*, their present status is discussed in the present work. The list given below embraces all of the species determined by the writer with reference to synonyms from previous records of the Japanese *Ceramium*.

Genus *Ceramium* ROTH

Subgenus *Hormoceras* (KÜTZING) NAKAMURA

1. *Cer. codii* (RICHARDS) G. MAZOYER.
   Syn. *Cer. mucronatum* SEGI.
2. *Cer. cimbricum* H. PETERSEN.
3. *Cer. fastigiatum* HARVEY.
   Syn. ? *Cer. tenuissimum* YAMADA (non J. AGARDH).
4. *Cer. nakamurai* DAWSON.
   Syn. *Cer. equisetoides* NAKAMURA (non DAWSON).
5. *Cer. tenerrimum* (MARTENS) OKAMURA.
   Syn. *Cer. gracillimun* OKAMURA (non GRIFFITHS and HARVEY).
6. *Cer. gracillimum* GRIFFITHS and HARVEY.
7. *Cer. aduncum* NAKAMURA.
   Syn. *Cer. circinatum* YENDO (non J. AGARDH).
8. *Cer. tenuissimum* (LYNGBYE) J. AGARDH.
9. *Cer. fimbriatum* SETCHELL and GARDNER.
10. *Cer. paniculatum* OKAMURA.
11. *Cer. ciliatum* (ELLIS) DUCLUZEAU.

Subgenus *Euceramium* DE TONI

12. *Cer. japonicum* OKAMURA.
13. *Cer. kondoi* YENDO.
    Syn. *Cer. rubrum* OKAMURA (non C. AGARDH), in part.
    " *Cer. rubrum* f. *fasciculatum* YENDO (non J. AGARDH).
    " *Cer. rubrum* f. *corymbifera* YENDO (non J. AGARDH).
    " *Cer. pedicellatum* YENDO (non J. AGARDH).
    " *Cer. ochotensis* OKAMURA.

14. *Cer. boydenii* GEPP.
    Syn. *Cer. rubrum* OKAMURA (non C. AGARDH), in part.
    " *Cer. sugiyamai* YENDO in Herb.

Genus *Campylaephora* J. AGARDH

15. *Camp. crassa* (OKAMURA) NAKAMURA.
    Syn. *Cer. crassum* OKAMURA.
    " *Cer. cymosum* OKAMURA.
    " *Cer. boreale* OKAMURA.
    " *Cer. secundatum* YENDO (non LYNGBYE).
    " *Cer. nitens* YENDO (non J. AGARDH).
16. *Camp. hypnaeoides* J. AGARDH.
    Syn. *Cer. hypnaeoides* (J. AGARDH) OKAMURA.
    " *Cer. hamatum* COTTON.
    " ? *Cer. pumilum* OKAMURA in Mscr.

The writer wishes to express his gratitude to Prof. Y. YAMADA for his kind guidance during the course of these investigations and for the use of his collection of *Ceramium* from Japan, America, and Europe and to Prof. J. TOKIDA for the use of a great number of the valuable specimens in his own collection and those in the Herbarium of the Faculty of Agriculture of Hokkaido University. The writer also wishes to thank Prof. M. HONDA for the use of the library and the YENDO Herbarium of the University of Tokyo.

Criteria for Distinguishing Genera and Species

In the Ceramiaceae, the mode of cortication of the frond is one of the most significant criteria in determining genus. As the writer has previously described (1950, 1954), frond cortex and base structure are of great value in delimiting the genera *Ceramium* and *Campylaephora*. In *Ceramium*, there are no rhizoidal cells in the cortex and the frond-base is composed of a cluster of rhizoids, In *Campylaephora*, there are rhizoidal cells in the cortex and the frond-base is composed of rhizoidal cells, which form a distinct conical disc.

The arrangement of species in the subg. *Hormoceras* is based primarily upon mode of ramification, details of the microscopic structure of the corticating band, and the disposition of the tetrasporangia. The presence or absence of gland cells or spines is one of the most useful criteria in separating species. The structure of the frond-apex is also of some diagnostic value.

In the subg. *Euceramium*, the mode of ramification of the main branch and the gross structure of the cortex are the most distinctive characteristics in determination of the species. The details of the microscopic structure of the cortex,

as well as the variance in the entire ramification are of no consequence, however, in grouping the forms into species. They may be useful to a limited degree in distinguishing formae.

Determination of species of the genus *Campylaephora* is based primarily upon whether ramification of the main branch occurs in the same plane or is multidirectional, and upon the presence or absence of the sickle-shaped portions of the frond which are invariable concomitants of multidirectional branching. As in the subg. *Euceramium*, variance in the entire ramification and details of the microscopic structure of the cortex, may also be useful in delimiting the formae.

Description of the Genera and Species

Ceramium ROTH

Cat. Bot., 1797, p. 146, Pl. 8, Fig. 1.

Plants epiphytic or saxicolous, small tufted, filiform, repeatedly branched; fronds composed of a monosiphonous central axis and cortex; cortication now entirely interrupted, forming a distinct band at each node, now partially or completely continuous; articulations pellucid or scarcely visible; frond-bases composed of a cluster of rhizoids, given off from the lowermost portion of the frond; ramification pseudodichotomous, dichotomous, trichotomous or tetrachotomous, often subpinnate; reproduction by tetraspores and carpospores, rarely paraspores; tetrasporangia erumpent or immersed in cortex, whorled around nodes or scattered; spermatangia forming sessile patches on upper branches, produced one to three from each outermost cortical cell; procarps borne on the abaxial side of upper portion of branchlets, bearing one carpogonial branch on each supporting-cell; cystocarps globular, consisting of one to four gonimolobes, surrounded by 3–6 involucral ramuli.

Type species: *Ceramium virgatum* ROTH
[=*Ceramium rubrum* (HUDSON) AGARDH]

There is much confusion with regard to the generic name *Ceramium*. A full analysis of early concepts of *Ceramium* has been given by SILVA (1952) and DIXON (1960). SILVA has proposed that *Ceramium* ROTH (1797) should be conserved against *Ceramion* ADANSON (1763). ROTH referred six species to the genus *Ceramium* and one of these, *Cer. virgatum* ROTH, is but a single species of the genus as now delimited. SILVA has also proposed this species, *Cer. virgatum* ROTH (1797, p. 148, Pl. 8, Fig. 1), as the lectotype species and his proposals have now been accepted (LANJOUW, 1956, p. 206).

According to SILVA, BONNEMAISON (1822) was the first author to clearly distinguish *Ceramium* from *Polysiphonia*, placing species of the former genus in his

Dictiderma, for which *Conferva rubra* HUDSON [=*Ceramium rubrum* (HUDSON) AGARDH] was designated as the type species.

KÜTZING (1841, 1847, 1849) made a revision of the genus *Ceramium* and proposed that the genus should be divided into nine smaller genera, *Hormoceras*, *Gongroceras*, *Echinoceras*, *Acanthoceras*, *Chaetoceras*, *Trichoceras*, *Celeceras*, *Pteroceras*, and *Centroceras*. As the writer has previously commented (1954), with the exception of *Centroceras*, KÜTZING'S genera are inadequately established. The genus *Ceramothamion* RICHARDS (1901) was rightly merged with the genus *Ceramium* by MAZOYER (1938). Another new genus, *Ceramiella* was established by BOERGESEN (1953) for *Ceramium huysmansii* WEBER VAN BOSSE, but this hat not been generally approved.

Key to the Subgenera

1. Cortication interrupted, forming a zonate band at each node throughout the entire frond . . . . . Subg. *Hormoceras*
2. Cortication continuous throughout the entire frond. . . . Subg. *Euceramium*

Subgenus ***Hormoceras*** (KÜTZING) NAKAMURA

New *Ceramiums* and *Campylaephoras* from Japn, 1950, p. 155.

Articulations pellucid; central axes surrounded by coloured cellules, forming a distinct corticating band at each node; ramification pseudodichotomous or dichotomous; tetrasporangia erumpent or somewhat immersed in cortex at nodes; cystocarps consisting of 2–4 gonimolobes.

Type species: *Ceramium diaphanum* (ROTH) HARVEY.

Key to the Species

1. Frond smooth
   2. Gland cells absent
      3. Tetrasporangia erumpent, often slightly bracteate; frond-apices straight
         4. Edge of the apex serrate; corticating bands 20–26 μ high, with 1–2 (rarely 3) transverse cell-rows; fronds sometimes creeping . . . . *Cer. codii*
         4. Edge of the apex even
            5. Corticating bands usually 20–60 μ high, with 1–3 (usually 2) transverse cell-rows; fronds sometimes creeping . . . . . *Cer. cimbricum*
            5. Corticating bands 80–130 μ high, with 2–5 (usually 3) transverse cell-rows; fronds perfectly fastigiate . . . . . *Cer. fastigiatum*
      3. Tetrasporangia immersed
         6. Frond-apices straight; edge of the apex even; corticating bands usually 20–108 μ high, with 5–8 transverse cell-rows, tetrasporiferous bands much

swollen and confluent, slightly separating at the centre of internodes . . . . . *Cer. nakamurai*

6. Frond-apices rolled inwards; outer edge of the apex dentate; corticating bands 50–80 μ high, with 3–4 transverse cell-rows, cells in upper border of bands smaller than those in lower . . . . . *Cer. tenerrimum*

2. Gland cells present

7. Tetrasporangia erumpent, seriated on the adaxial side of branches, often verticillated

8. Frond-apices slightly incurved; edge of the apex serrate; lower end of each corticating band somewhat narrower and with a 1–2 series of transversely elongated cells . . . . . *Cer. gracillimum*

8. Frond-apices strongly rolled inwards; outer edge of the apex dentate; corticating bands 50–130 μ high, with 2–5 transverse cell-rows . . . . . *Cer. aduncum*

7. Tetrasporangia prominent, usually bracteate, seriated on the abaxial side of branches; frond-apices slightly incurved or strongly rolled inwards; outer edge of the apex dentate; corticating bands 60–180 μ high, with 4–6 transverse cell-rows . . . . . *Cer. tenuissimum*

1. Frond armed

9. Thumb-like processes seriated on the abaxial side of branches; gland cells absent; lower end of each corticating band somewhat narrower and with a 1–2 series of transversely elongated cells . . . . . *Cer. fimbriatum*

9. Subulate spines present

10. Spines seriated on the abaxial side of branches; gland cells absent; corticating bands 50–70 μ high, with 3–4 transverse cell-rows . . . . . *Cer. paniculatum*

10. Spines whorled around each node of the frond; gland cells present; corticating bands 90–100 μ high, with 5–8 transverse cell-rows . . . . . *Cer. ciliatum*

Ceramium codii (RICHARDS) G. MAZOYER

Pl. I, 1; Fig. 1.

Ceram. Afr. Nord, 1938, p. 324; Id., Céram. Médit. 1940, p. 285, Figs. 59 a, 105; FELDMANN-MAZOYER, *Ceramium*, in BOERGESEN's Mar. Alg. Mauritius, 1952, p. 40; DIXON, *Cer. codii*, 1958, pp. 14–16, Fig. 1.

Ceramium mucronatum SEGI, Mar. Alg. Ise Bay I, 1944, p. 33, Fig. 1.

Ceramothamnion codii RICHARDS, New Rhodophy. Alg. 1901, pp. 254–265, Pls. 21–22; DE TONI, Syll. Alg. IV, 1903, p. 1354; Id., l. c. VI, 1924, p. 522.

Ceramothamnion adriaticum SCHILLER, S. M. S. Najade, 1912, p. 90; SCHUSSNIG, Bemerk.

Ceramoth. adriaticum, 1914, pp. 85-93.

Jap. name: Togari-igisu (SEGI).

Hab.: Wagu, Sima Prov (T. SEGI).

Distr.: Atlantic, Baltic, Adriatic, and Mediterranean Seas, West Indies.

Plants 3-7 mm. high, 40-70 μ thick, fine capillary, densely caespitose, forming a fringe along the host frond; basal portions of the frond somewhat creeping on the substratum, issuing erect filaments upwards and rhizoids downwards from the nodes; basal rhizoids simple or branched, 20-40 μ thick, 500-600 μ long, penetrating among tissues of the host, ending in a blunt apex; supporting-rhizoids absent; the entire ramification sparse; ramification pseudodichotomous; axils rather acute; frond-apices almost straight, with serrate outlines near the apices; articulations pellucid, 1-2 times as long as diameter in basal portions of the frond, 2-3 (-8) times in middle portions, becoming shorter above; nodes usually prominent, coated with coloured cellules, forming a distinct band; corticating bands less developed throughout the frond, consisting of 1-2 (rarely 3) transverse cell-rows, 24-26 μ high, 50-60 μ broad in basal portions of the frond, 20 μ high, 40-50 μ broad in middle portions, 20 μ high, 30-40 μ broad in upper portions; central axial cells pen shaped, acute at their apices, truncated at their bases, 30-40 μ broad, 110-160 μ long, longest in middle portions of the frond, becoming shorter above and below; gland cells absent; chromatophores parietal laminate in both cortical and central axial cells; hyaline unicellular hairs scarce; tetrasporangia seriated usually in a single longitudinal row on abaxial side, often on both sides of branches, apparently erumpent, somewhat bracteate, enclosed with thick pericarp, spherical in shape, about 35 μ in diameter exclusive of pericarp 4-6 μ thick, divided triangularly; spermatangia forming sessile patches on each node of upper branches, produced from cortical cells primarily on the adaxial side of branchlets and gradually spread over the entire area of corticating bands, borne usually 1-3 on each cortical cell, elliptical, whitish, about 4 μ by 6 μ; cystocarps consisting of 1-2 globular gonimolobes, subterminal on upper branches, provided with 2-3 involucral ramuli; carpospores numerous, somewhat oblong, 14-18 μ by 18-22 μ; colour light pinkish red; substance soft and flaccid, adhering to paper in drying.

This minute (<1 cm.) plant grows on *Codium divaricatum*, spreading all over the host frond. A plant from Wagu, Sima Prov. was first described by SEGI (1944) as *Cer. mucronatum*. Comparison of the original specimen of *Cer. mucronatum* with the specimen of *Cer. codii* (in P. B. A., no. 845, under the name of *Ceramothamnion codii* RICHARDS) shows that both are quite identical, although the former is more slender.

According to SEGI (1944, p. 33), the most distinguishing characteristics of *Cer. mucronatum* are the shape of the central axial cell and the configuration of the

corticating band. The pen-shaped feature of the central cells pointed out by SEGI, however, is not sufficiently invariable to warrent its use in determining species, and it is obscure especially when the specimens are dried. In addition, the corticating band is not always composed of a single horizontal row of irregular cells

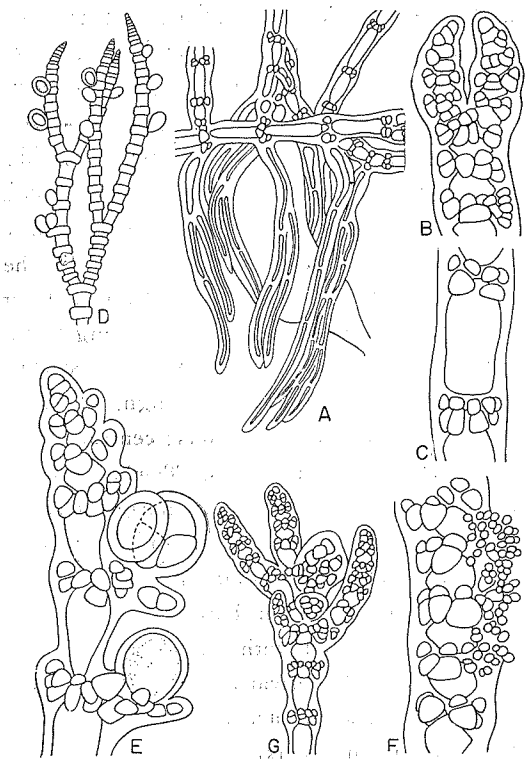

Fig. 1. *Ceramium codii* (RICHARDS) G. MAZOYER
A. Basal portion of a plant. × 77. B. Frond-apex. × 250. C. Portion of a frond with two corticating bands. × 300. D. Tetrasporic plant showing an arrangement of tetrasporangia. × 50. E. Tetrasporangia. × 250. F. Portion of a frond bearing spermatangia. × 300. G. Cystocarp. × 50.

as was described and illustrated by SEGI. It more commonly consists of two (rarely three) horizontal rows of cells (Fig. 1, B, C). Measurements of the height (H), breadth (B) of corticating bands, and length of articulations (L) of a frond are as follows:

	H	B	L
1st degree from the forcipe	12 μ	28 μ	12 μ
2nd " " " "	20	38	46
3rd " " " "	20	40	70

	H	B	L
4th " " " "	20	40	90
5th " " " "	20	45	140
6th " " " "	26	56	160
Near the frond-base	26	56	140

Ceramium cimbricum H. PETERSEN

Pl. I, 2; Figs. 2-3.

in ROSENVINGE's Mar Alg. Denmark, 1923-24, p. 378, Figs. 318-319; TOKIDA, New or Little Known Mar. Alg., 3, 1948, p. 100, Figs. 10-28; Id., Mar. Alg. S. Saghalien, 1954, p, 202; IWAMOTO, Mar. Alg. Saroma, 1960, p. 39, Pl. VII.

Jap. name: Matsubara-igisu (TOKIDA).

Hab.: Akkesi, Kusiro Prov., Muroran, Iburi Prov., Saroma Lake, Kitami Prov. (K. IWAMOTO), Hokkaido; Kaiba-tô, Tôbuti Lake, Saghalien (J. TOKIDA).

Distr.: Limfjord, Denmark.

Plants 1-3 cm. high, capillary, growing on various algae or on shells, upright portions of the frond partly decumbent; creeping basal portions of the frond, emitting 1-3 rhizoids from each node; basal rhizoids usually simple, ending in a blunt apex or expanding into a small conical disc at the tip, usually composed of 2-3 cells, about 25 μ thick, various in length; supporting-rhizoids arisen from nodes of erect frond, tangling with fronds; the entire ramification somewhat irregular, usually sparse; ramification pseudodichotomous; lower axils patent, upper axils very acute; frond-apices always straight, usually unequal in length at the forcipe; outer edge of the apex even; articulations pellucid, 1-1$\frac{1}{2}$ times as long as diameter in basal portions of the frond, 1$\frac{1}{2}$-3 (-7) times as long in middle portions, becoming shorter upwards; nodes not prominent, coated with coloured cellules, forming a distinct band; corticating bands very narrow, consisting of 1-3 (usually 2) transverse cell-rows, 20-60 μ (mostly 35-45 μ) high, 50-110 μ (mostly 85-90 μ) broad, decreasing in both height and breadth upwards; cortical cells more or less angular, 25-30 μ high, 25-35 μ broad, upper and lower sides of cortical cells in the lower edge of corticating band often parallel; axial cells cylindrical, becoming shorter and narrower upwards; gland cells absent; chromatophores numerous, parietal laminate in cortical cells, filiform in axial cells; hyaline hairs scarce; tetrasporangia usually seriated in longitudinal rows on the adaxial side of upper portion of the frond, sometimes more or less whorled around nodes, apparently erumpent, roundish in shape with thick pericarp, 30-55 μ by 50-60 μ exclusive of pericarp 6-10 μ thick, divided triangularly; spermatangia forming sessile patches on each node of upper branches, produced primarily from cortical cells on the adaxial side of branchlets and gradually spread over the entire area of corticating bands, borne usually 1-3 on each cortical

cell, elliptical, whitish, about 4 μ by 6 μ; cystocarps consisting of 2–4 globular gonimolobes, lateral on upper branches, provided with 3–4 involucral ramuli; involucres usually 1–1$\frac{1}{2}$ times as long as nucleus of cystocarp; carpospores numerous, somewhat oblong, 24–42 μ by 40–60 μ; colour light pinkish red; substance soft and flaccid, adhering to paper not so closely in drying.

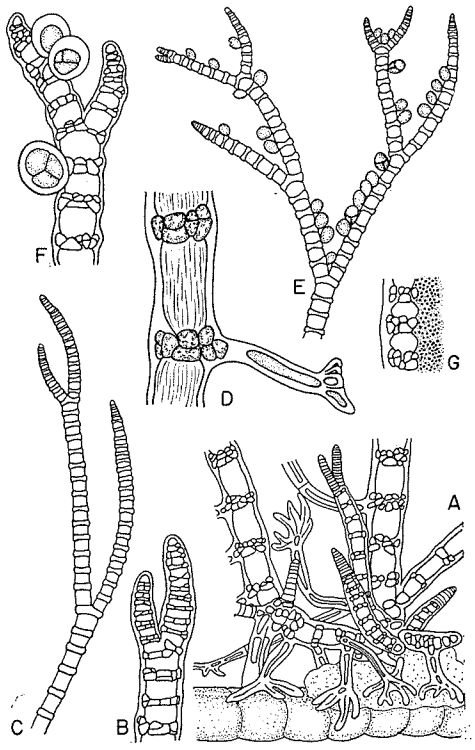

Fig. 2. *Ceramium cimbricum* H. PETERSEN

A. Basal portion of a frond. × 40. B. Frond-apex with an unequal forcipe. × 100. C. Upper part of a plant showing a pseudo-dichotomous branching. × ca. 28. D. Portion of a frond with a supporting-rhizoid. The filiform or parietal laminate chromatophores are shown in axial or cortical cells respectively. × 100. E. Tetrasporic plant showing an arrangement of tetrasporangia. × 28. F. Erumpent and triangularly divided tetrasporangia. × 100. G. Portion of a frond bearing spermatangia. × 300.

This plant reaches a height of 3 cm. and may be found between tide marks at high tide growing on *Bryozoa*, *Balanus* or on various algae. It is more or less tangled and partly decumbent, creeping on the substratum. The frond usually emits one to three rhizoids from each node. There are many of these rhizoids in

the basal portion of the frond (Fig. 2, A). They frequently issue from nodes on the upper branches, but rarely from the uppermost branchlets.

The writer's specimen agrees quite well with the description and illustration of *Ceramium cimbricum* given by PETERSEN. Prof. J. TOKIDA kindly sent the writer a specimen from the Tôbuti Lake, Saghalien, which he had determined to be *Cer. cimbricum*, and which is quite similar to the writer's specimen. All of the Danish plants described by PETERSEN were sterile, but some of the plants from Muroran and Saghalien have many tetrasporangia. These tetrasporangia are apparently erumpent and are arranged in rows on the adaxial side of the upper branches (Fig. 2, E–F). They are occasionally in whorls around the nodes. They are divided triangularly and no irregular divisions were observed in the material examined. A sexual plant was obtained from specimens collected by K. IWAMOTO in the Saroma Lake, Kitami Prov., Hokkaido. The procarp occurs close to the frond-apex on the abaxial side of the branchlets (Fig. 3, A–B). A carpogonial branch consists of three cells. Not infrequently, cystocarps and tetrasporangia are borne on one and the same frond, however, the former is far less frequent than the latter. In the basal portion of the plant, there are many fragmentary older fronds, giving off young erect fronds. From this, it is clear that vegetative propagation is not infrequent in this species. This species may be distinguished from the closely allied species, *Cer. fastigiatum*, by habit, by the pseudodichotomous branch with a frequently unequal forcipe and by the very narrow corticating band.

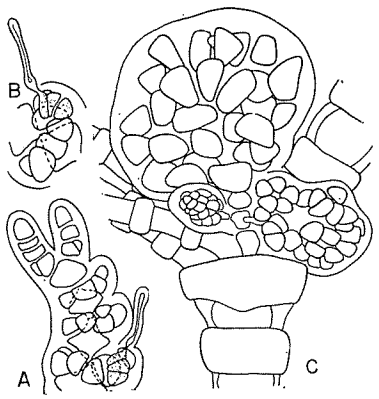

Fig. 3. *Ceramium cimbricum* H. PETERSEN
A. Frond-apex bearing a carpogonial branch. × 300.
B. Carpogonial branch. × 300.
C. Cystocarp. × 100.

Ceramium fastigiatum HARVEY

Pl. I, 3; Fig. 4.

in HOOKER's Lond. Journ. Bot Vol. III, p. 303; WYATT, Alg. Danm. No. 86; HARVEY, Man. Brit. Mar. Alg. 1st ed., 1840, p. 99; Ibid., 2nd ed., 1849, p. 164; Id., Phyc. Brit. Vol. 3, 1846-51, Pl. 225; J. AGARDH, Sp. II, 1851, p. 119; Id., Epicr., 1876, p. 96; ARDISSONE, Phyc. Medit. I, 1883, p. 109; FARLOW, Mar. Alg. New. Eng., 1881, p. 137; HAUCK, Meeresalgen, 1885, p. 105; DE TONI, Syll. Alg. IV, 1903, p. 1448; Id., l.c., VI, 1924, p. 506; NEWTON, Handb. Brit. Seaweed, 1931, p. 397; BOERGESEN, Mar. Alg. Dan. W. Ind., 1918, p. 241, Fig. 231; TAYLOR, Mar. Alg. N. E., N. Amer., 1937, p. 333, Pls. 47-51; Id. Pac. Mar.

Alg., 1945, p. 271; DAWSON, Mar. Fl. Costa Rica and Nicaragua, 1962, p. 387.

f. *flaccida* H. PETERSEN in BOERGESEN's Mar. Alg. Dan. W. Ind., II, 1918, p. 241, Fig. 231.

Gongroceras fastigiatum (HARVEY) KÜTZING, Phyc. germ., 1845, p. 291; Id., Sp., 1849, p. 678; Id., Tab. Phyc. XIII, 1863, t. 79, f. a–c.

? *Ceramium tenuissimum* YAMADA (non LYNGBYE), Mar. Alg. Mutsu Bay, II, 1928, p. 530, Fig. 23; OKAMURA, Nippon Kaisôsi, 1936, p. 738.

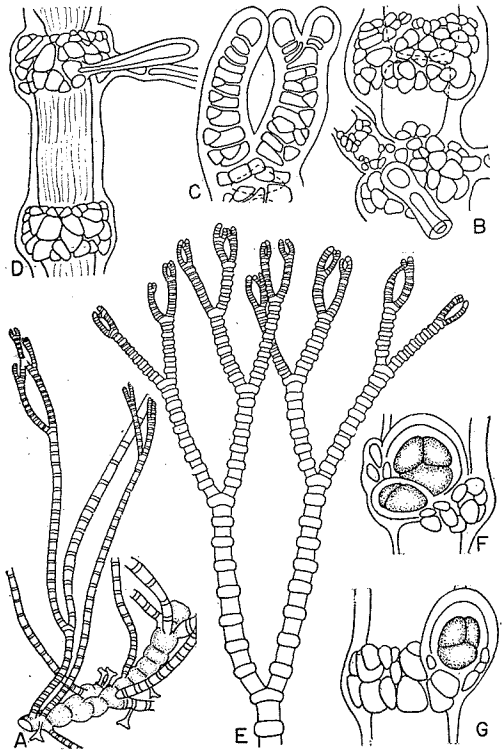

Fig. 4. *Ceramium fastigiatum* HARVEY

A. Fragmentary older frond, issuing several new erect fronds. × 15. B. Portion of a fragmentary older frond. × 100. C. Frond-apex, showing the development of corticating bands. × 250. D. Corticating bands with supporting-rhizoids. × 375. E. Upper portion of a plant, showing a regularly dichotomous branching. × ca. 28. F–G. Tetrasporangia. × 350.

Jap. name: Hime-igisu (n. n.).

Hab.: Muroran Harbour, Iburi Prov., Hakodate Harbour, Osima Prov. (T. INABA), Hokkaido; Asamusi, Mutu Prov. (S. INOH).

Distr.: England, Mediterranean Sea, East Coast of N. America, Pacific Central America, Danish West Indies.

Plants 3–5 cm. high, capillary, growing on *Zostera* or on rocks; basal portions of the frond more or less creeping on the substratum with rhizoids; basal rhizoids arising 1–3 from each node, 1–4 celled, about 25 μ thick, expanding into a small conical disc at the tip or ending in a blunt apex; conical attachment discs irregularly lobed; supporting-rhizoids arising 1–3 from each node on the entire frond, especially more frequent in middle portion of the frond; the entire ramification perfectly fastigiate, forming regular circular fans when displayed on paper; branches dichotomous, regularly forking from base to apex, usually bare of lateral branchlets, but sometimes with a few short, simple or forked branchlets; lower axils patent, upper axils acute; frond-apices usually emarginate, straight or slightly incurved, sometimes more or less hooked, but not rolled inwards; edge of the apex even; articulations pellucid, 3–4 (–6) times as long as diameter in lower portions of the frond, gradually becoming shorter and narrower upwards, the uppermost articulations very short and densely coloured; nodes somewhat prominent, coated with coloured cellules, forming a distinct band; corticating bands consisting of (2–) 3 (–4) transverse cell-rows, 80–130 μ high, 45–70 μ broad in lower portions of the frond, 130–140 μ high, 70–85 μ broad in middle portions, becoming shorter and narrower upwards; cortical cells compactly arranged, somewhat angular, those in both borders (usually in upper border) of corticating bands smaller than those in median part of the band, smaller cells 15–20 μ, larger cells 30–35 μ in transverse diameter; axial cells cylindrical, becoming shorter and narrower upwards; gland cells absent; chromatophores numerous, parietal laminate in cortical cells, filiform in axial cells; hairs scarce; tetrasporangia arranged in a longitudinal row on the adaxial side of branches, usually erumpent, often slightly bracteate, divided triangularly, 26–38 μ by 30–40 μ exclusive of pericarp; spermatangia unknown; cystocarps sessile near the frond-apex, with a few short involucral ramuli; colour carmine; substance flaccid adhering closely to paper in drying.

This plant grows on *Zostera* in calm sandy seas, in association with *Ulva*, and *Sphacelaria*, etc. The plant is erect, forming a dense tuft 3–4 cm. high, but the lowermost part of the frond creeps on the substratum. One to three supporting-rhizoids which are entangled with the frond, issue from each node. A fragmentary older frond may commonly be found in the basal portion of the plant, issuing many erect fronds from its nodes. This fragmentary frond is clearly distinguishable by its greatly swollen articulation in its median portion and by its darker red colour (Fig. 4, A–B). This peculiar frond is apparently a survival from the foregoing year, and it appears, therefore, that vegetative propagation commonly occurs in this species as in the *Cer. cimbricum*.

This plant agrees well with HARVERY's description and illustration of *Ceramium fastigiatum*. The writer, however, did not find any sexual plants. One of the most

distinctive characteristics of this species is a perfectly fastigiate habit, which produces regular circular fans when the specimens are displayed on paper (Pl. I, 3).

Ceramium nakamurai DAWSON

Mar. Fl. San Benedicto, 1954, p. 6; Id., Costa Rican Alg., 1957, p. 21; Id., Benthic Alg., 1961, p. 440.

Ceramium equisetoides NAKAMURA (non DAWSON), New *Ceramiums* and *Campylaephoras*, 1950, p. 157, Figs. 1, 2a.

Jap. name: Tukusi-igisu (n. n.).

Hab.: Garanbi, Formosa (T. TANAKA).

Distr.: Golfo de Nicoya, Costa Rica.

Plants 5–10 mm. high, growing on *Gracilaria* sp.; frond-bases creeping on the substratum, emitting several rhizoids from each node; basal rhizoids usually simple, ending in a blunt apex or expanding into a conical disc at the tip, usually composed of 2–3 cells, about 20–35 μ thick, various in length; supporting rhizoids comparatively numerous; the entire ramification usually sparse; ramification pseudodichotomous; lower axils patent, upper axils very acute; frond-apices straight, usually not forcipated, often emarginated; edge of the apex even; articulations pellucid, 1–1$\frac{1}{2}$ times as long as diameter in the middle portion of branches between bifurcations, becoming shorter towards both ends, coated with coloured cellules, forming a distinct band; nodes in tetrasporiferous fronds much swollen, but not prominent in sterile fronds; corticating bands consisting of 5–8 transverse cell-rows, usually 15–96 μ high, 80–130 μ broad, in the tetrasporiferous frond 100–110 μ high, 200–250 μ broad; cortical cells more or less angular, nearly uniform in size, but slightly larger and longer in median part of the band, measuring $8\times8\,\mu$, $8\times18\,\mu$, $10\times18\,\mu$, $12\times14\,\mu$, $12\times18\,\mu$, $12\times22\,\mu$; axial cells cylindrical; gland cells absent; chromatophores parietal laminate in cortical cells, filiform in axial cells; hyaline unicellular hairs not observed; tetrasporangia immersed in cortex, slightly protruding from cortical cells on the upper border of the corticating band, disposed in a single whorl, ellipsoidal in shape, 20–35 μ by 35–55 μ, exclusive of pericarp 4–5 μ thick, divided triangularly or irregularly cruciately; spermatangia and cystocarps unknown; colour pinkish red; substance flaccid, adhering to paper closely in drying.

The writer (1950) gave a new name, *Ceramium equisetoides* to this plant, which should be replaced by the neonym, *Ceramium nakamurai* proposed by DAWSON (1954), since *Ceramium equisetoides* DAWSON (1944) is an earlier homonym.

This minute plant was found on *Gracilaria* sp., associating with *Cer. gracillimum* and *Centroceras clavulatum*. The tetrasporangia develop in a whorl around the nodes, especially on the last few dichotomies of the frond. The tetrasporiferous

branch is greatly swollen at the nodes and almost entirely corticated, separating slightly at the centre of the internodes and resembling the sporiferous shoots of *Equisetum*. The frond-apex is always straight and elongated, and rarely emarginated. These are the most distinguishing characteristics of this species.

This plant is most closely related to *Cer. equisetoides* DAWSON (1944) and *Cer. vagabunde* DAWSON (1957). Examination of the specimens of *Cer. equisetoides* kindly sent to me by Dr. DAWSON, shows that the branching in his specimens is clearly less regularly dichotomous. In DAWSON's specimens, the tetrasporangia are primarily on simple short branches, while in the writer's specimens, they are usually on the last few dichotomies of the frond. In addition, according to DAWSON (1957), in *Cer. vagabunde* the ramification is not dichotomous as in *Cer. equisetoides* and *Cer. nakamurai*. Accordingly, it seems best to regard these three species as a distinct entity, pending further study.

Ceramium tenerrimum (MARTENS) OKAMURA

Pl. I, 4; Fig. 5.

Icon. Jap. Alg. IV, 1921, p. 112, Pl. 179, Fig. 1–7; DE TONI, Syll. Alg. VI, 1924, p. 515; OKAMURA, Nippon Kaisôsi, 1936, p. 736; MAZOYER, Presence C. T. nord-africaines, 1937, p. 610; Id., Ceram. Villefrance, 1939, p. 12; *Ceramium* Méditerr., 1940, p. 289, Figs. 107, 106; LEVRING, Meeresalg. Adriat. Meer, Sizilien, Neapel, 1942, p. 10.

Hormoceras tenerrimum MARTENS, Tange Preuss. Exped. Ost-Asien, 1866, p. 146, t. VIII. Fig. 2 (Type Loc. Nagasaki, IV, 1861, SCHOTTMÜLLER).

Hormoceras flaccidum SURINGAR (non HARVEY), Alg. Jap. Mus. Bot. Lugd.-Bat., 1870, p. 28, Tab. XIII.

Ceramium gracillimum OKAMURA (non GRIFFITHS and HARVEY), Nippon Sôrui-meii, 1st ed. 1902, p. 83, 2nd. ed., 1916, p. 97; Id., Alg. Jap. Exsic. fasc. I, n. 28; DE TONI, Syll. Alg. IV, 1903, p. 1483 (partim).

Jap. name: Ke-igisu (OKAMURA).

Hab.: Setana, Nagatoyo (Y. YAMADA), Osima Prov. Hokkaido; Same, Horotuki, Mutu Prov. (TI); Kominato, Amatura, Nemoto (T. MURAOKA), Sunosaki and Katuyama (TI), Bôsyu; Enosima, Sagami Prov.; Susaki (S. SEGAWA), Simoda (YENDO Herb.), Kinuura (TI), Kainohama, Ôno, and Hinaga, (S. ARASAKI), Mikawa Prov,; Gôza, Sima Prov. (YENDO Herb.); Kusimoto, Seto, Wakanoura (TI), Kii Prov,; Kôbe, Settu Prov. (TI); Onomiti, Bingo Prov,; Ujina, Aki Prov. (OKAMURA Herb.); Kita-nada, Iyo Prov. (OKAMURA Herb.); Mugi, Awa Prov. (OKAMURA Herb.); Tosa Prov. (OKAMURA Herb.); Usuki, Bungo Prov. (OKAMURA Herb.); Kagosima, Satuma Prov. (OKAMURA Herb.); Amakusa, Higo Prov. (T. TANAKA); Nomozaki (T. TANAKA), Nagasaki (TI), Karatu (OKAMURA Herb.), Hizen Prov.; Hagi, Nagato Prov. (OKAMURA Herb.); Nagahasi, Etizen Prov.; Sado, Kaifu-ura, Etigo Prov. (TI); Hukaura, Mutu Prov. (YENDO Herb.); Huzan, Korea (TI).

Distr.: Mediterranean Sea.

Plants 2–6 cm. high, 60–150 μ thick, very flaccid, forming a globular mass,

capillary, growing on *Sargassum* or *Corallina*; basal portions of the frond somewhat creeping on the substratum with rhizoids; basal rhizoids arising numerously from nodes of lower portion of the frond, simple or distantly branched, ending in

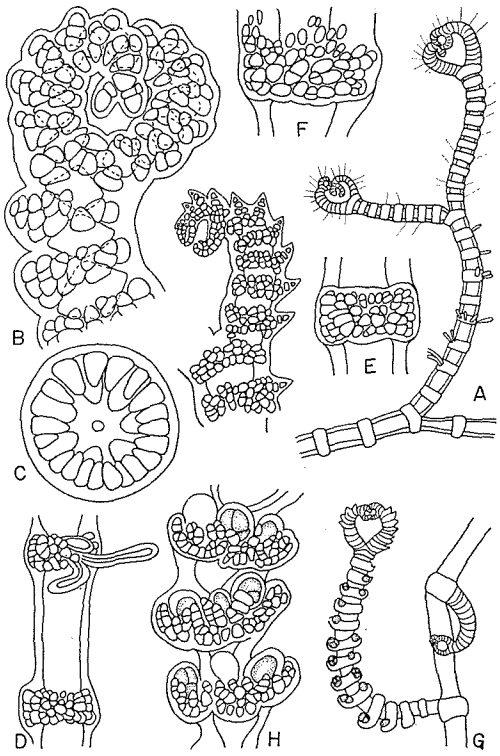

Fig. 5. *Ceramium tenerrimum* (MARTENS) OKAMURA

A. Portion of a frond with numerous supporting-rhizoids. × ca. 28. B. Frond-apex strongly rolled inwards, with dentate outer edges. × 250. C. Transverse section of a corticating band. × 250. D. Corticating bands with supporting-rhizoids. ×100. E. Corticating band, showing an arrangement of cortical cells. × 100. F.Corticating band being decurrent by upward proliferations. × 100. G. Tetrasporiferous branchlet. × ca. 28. H. Portion of a frond, showing a whorled arrangement of tetrasporangia being somewhat prominent and bracteate by cortical cells. × 100. I. Apex of a tetrasporiferous branchlet with short spines on the outer edges. ×250.

a blunt apex or expanding into a small conical disc at the tip; supporting-rhizoids numerous on the entire frond; the entire ramification deliquescently dichotomo-fastigiate; branches distantly dichotomous in lower portions of the frond, gradually

becoming closer upwards, sometimes emitting short lateral branchlets from nodes; axils patent; frond-apices forcipated, strongly rolled inwards; outer edge of the apex dentate; articulations pellucid, 4–5 (–10) times as long as diameter, gradually becoming shorter above; nodes usually not prominent, but somewhat prominent in lower portion of the frond, coated with minute coloured cells, usually forming a distinct band; corticating bands narrow, consisting of 3–4 transverse cell-rows, often becoming decurrent by slightly upward proliferations, 70–80 μ high, 130–150 μ broad in lower portions of the frond, 50–70 μ high, 100–130 μ broad in middle portions, 30–50 μ high, 60–100 μ broad in upper portions; cortical cells somewhat angular, those in the upper end of the corticating band far smaller than those in the lower end, 14–20 (–22) μ in transverse diameter; gland cells absent; chromatophores numerous, parietal laminate in cortical cells, filiform in axial cells; hyaline hairs numerous; tetrasporangia borne on lateral branchlets, arranged in a whorl around nodes, somewhat prominent, bracteate by cortical cells, enclosed with thick pericarp, roundish, divided triangularly or somewhat cruciately, 30–42 μ by 38–42 μ exclusive of pericarp 10 μ thick; sexual plants unknown; colour light pinkish red, often almost colourless; substance soft and very flaccid, adhering closely to paper in drying.

This plant grows on *Sargassum thunbergii* or *Corallina* in the intertidal belt along both coasts of Japan, reaching a height of 6 cm. It is very flaccid and deliquescently dichotomo-fastigiate, forming a globular mass. The frond-apex is rolled inwards very strongly and its outer edge is dentate (Fig. 5, B). The corticating band is usually composed of many small cells, and sometimes of a few large cells. The band is usually clear-cut on both borders (Fig. 5, E), but often shows slightly upward proliferations as is shown in Fig. 5, F. The cortical cell in the upper end of the corticating band is far smaller than the one in the lower end. This is one of the most distinctive characteristics of this species.

No sexual plants have been found, although tetrasporic plants are occasionally obtained. The tetrasporangia are always borne on the lateral branchlets in the specimens examined. They are somewhat prominent, but bracteate, and arranged in a whorl on each node of the lateral branchlets (Fig. 5, G–H). The tetrasporiferous branchlet has short (usually the length of two cells) spines at the outer edge of the apex (Fig. 5, G, I). These spines, however, are never found in other parts of the frond.

According to the OKAMURA's original description and illustration, the articulation is 5–10 times as long as diameter. In the writer's specimens, however, it is less than 5 times as long (usually 2–4 times). In addition, OKAMURA does not fully describe the tetrasporic characteristic, but the specimens at hand agree well with OKAMURA's specimens in all other respects.

Ceramium gracillimum (KÜTZING) GRIFFITHS and HARVEY

Pl. I, 5-6; Fig. 6.

Phyc. Brit., 1846-51, Pl. 206; Id., Man. Brit. Mar. Alg. ed. 2, 1849, p. 163; J. AGARDH, Sp. Alg. II, 1851, p. 118; DE TONI, Syll. Alg. IV, 1903, p. 1483; Ibid. VI, 1924, p. 515; NEWTON, Handb. Brit. Seaw., 1931, p., 396, LEVRING, Meeresalg. Adriat. Meer, Sizilien, Neapel, 1942, p. 11; DAWSON, Mar. Alg. Calif., 1944, p. 319; FELDMANN-MAZOYER, *Ceramium* Maurice, in BOERGESEN's, Mar. Alg. Mauritius, Add. IV, 1952, pp. 42-43, Fig. 21; DAWSON, Mar. Plants Nha Trang, 1954, p. 448, Fig. 55 e, f; Id., Mar. Alg. S. Marshalls, 1956, p. 53; Id., Mar. Alg. Eniwetok, 1957, p. 122; Id., Costa Rican Alg., 1957 p. 21; JOLY, Fl. Mar. Santos, 1957, p. 147, Pl. XVIII, Figs. 2, 2a; DAWSON, Mar. Alg., 1958 Cruise, 1959, p. 30; Id., Mar. Alg. El Salvador, 1961, p. 418; Id., Benthic Alg., 1961, p. 440; Id., Mar. Red Alg. Pac. Mexico, 1962, p. 57. Pl. 20, Figs. 2-3; Id., Mar. Fl. Costa Rica, Nicaragua, 1962, p. 387.

Hormoceras gracillimum KÜTZING, in Linn. Vol. 15, 1841, p. 733; Id., Phyc. gen., 1843, p. 378; Id., Phyc. germ., 1845, p. 290; Id., Sp. Alg., 1849, p. 675.

Ceramium flaccidum HARVEY in Herb.

Ceramium gracillimum (KÜTZING) GRIFFITHS and HARVEY

var. *byssoideum* (HARVEY) G. MAZOYER, Cérm. Afr. Nord, 1938, p. 323; Feldmann-Mazoyer, Céram. Villefr. 1939, p. 8; Id., Céram. Médit. 1940, p. 293, Fig. 109.

Ceramium byssoideum HARVEY, Ner. Bor. Amer., 1853, p. 218; HOWE, in BRITTON, Flora of Bermuda, 1918, p. 351.

Ceramium transversale COLLINS and HERVEY, Bermuda, 1917, p. 145, Pl. 5, Figs. 29-31; BOERGESEN, Mar. Alg. Ostenfeld, 1924, p. 14; Id., Mar. Alg. Dan. W. Ind., II, 1918, p. 243; Id., Mar. Alg. Canary, 1930, p. 505; Id., Mar. Alg. Ceylon, 1936, p. 91; Id., Contri. S. Indian Mar. Alg. III, 1938, p. 299; H. PETERSEN, Alg. in Report Dan. Oceanogr. Exped. 1908-1910, Vol. II, p. 14, Figs. 5-7; DE TONI, Syll. Alg. VI, 1924, p. 505; SETCHELL and GARDNER, Mar. Alg. Revillagigedo, 1930, p. 170, Pl. 7, Figs. 23-24; BOERGESEN, Mar. Alg. Mauritius, 1945, p. 9.

Jap. name: Hai-igisu (SEGI in Mscr.).

Hab.: Utumi, Owari Prov. (T. SEGI); Kii Prov. (OKAMURA Herb.); Naha, Ryukyu Il.; Kitikaitô, Kontei, Dairi, Hukkikaku (J. TOKIDA), Garanbi, Dairi (T. TANAKA), Santenkaku (OKAMURA Herb.), Formosa.

Distr.: England, West Indies, Canary Islands, Mediterranean Sea, Indian Ocean, Pacific Coast of Central America.

Plants 1-5 mm. high, densely caespitose, creeping on other algae or rocks; basal prostrate filaments branched sparingly and irregularly, issuing erect filaments upwards and rhizoids downwards from the nodes; basal rhizoids colourless, unicellular, 15-30 μ thick, 200-400 μ long, ending in a blunt apex or expanding into a small conical disc at the tip; supporting-rhizoids few; the entire ramification sparse; ramification pseudodichotomous or dichotomous; main branches divided every five or ten articulations by alternate branches, shooting forth lesser sorts of branches; axils acute; frond-apices emarginated, often unequally forcipated, slightly

incurved with serrate outlines near the apices; articulations pellucid, $1\frac{1}{2}$–8 times as long as diameter in basal portions of the frond, $1\frac{1}{2}$–2 times as long in middle portions, becoming shorter upwards; nodes usually prominent, coated with coloured cellules, forming a distinct band; corticating bands sharply marked off from interstices, consisting of 3–6 (usually 5) transverse cell-rows, 40–85 μ high, 50–140 μ broad

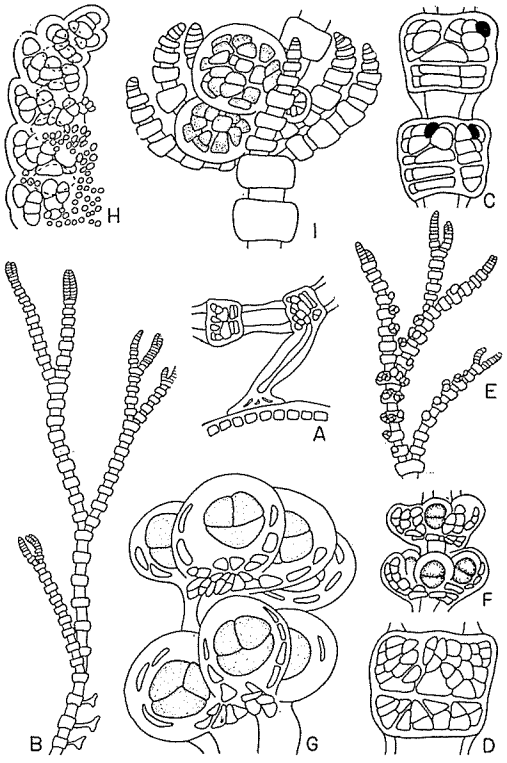

Fig. 6. *Ceramium gracillimum* GRIFFITHS and HARVEY

A. Basal attachment-rhizoid. × 100. B. Portion of a plant. × 40. C. Two corticating bands with gland cells. × 250. D. Corticating band, showing an arrangement of cortical cells. × 250. E. Tetrasporic frond. × ca. 28. F. Tetrasporangia whorled around nodes. × 100. G. Tetrasporangia. × 250. H. Frond-apex with spermatangia. × 250. I. Cystocarp. × 100.

in lower portions of the frond, 40–50 μ high, 46–60 μ broad in middle portions, 10–30 μ high, 25–45 μ broad in upper portions; lower border of corticating bands somewhat narrower than upper border, having a 1–2 series of transversely elongated cells (about 6 μ pby 25 μ), assing around axial cells; upper border of corticating bands composed of 2–3 series of irregularly arranged, roundish cells (smallest cells

6 μ by 8 μ, largest ones 15 μ by 25 μ); central axial cells cylindrical, 20–22 μ broad, 50–90 (–350) μ long, becoming shorter and narrower above; gland cells lenticular, 6 μ by 8 μ; chromatophores numerous, parietal laminate in cortical cells, filiform in axial cells; hairs hyaline unicellular; tetrasporangia arranged in longitudinal rows, borne usually one, occasionally two on each node, often whorled around nodes, protruding from cortical layer, bracteate, bracts within pericarp, spherical in shape, 30–50 μ in diameter exclusive of pericarp 8–10 μ thick, divided triangularly; spermatangia forming sessile patches, covering the entire area of corticating bands, produced primarily on the adaxial side of upper branches, ellipsoid in shape, 4 μ by 6 μ; cystocarps borne laterally on branches and branchlets, consisting of 1–3 globular gonimolobes, surrounded by usually seven involucral ramuli; involucres about 1–1$\frac{1}{2}$ times as long as nucleus of cystocarp; carpospores numerous, somewhat angular, 18–24 μ by 20–28 μ; colour pinkish red; substance flaccid, adhering closely to paper in drying.

This plant is found in the southern part of Japan, the Ryukyu Islands and Formosa. It grows on rocks or *Ulva*, *Gelidium*, *Corallina*, *Laurencia*, *Phyllospadix*, and *Zostera*, etc. in the months from April to June, creeping on the substratum. The plant is especially characterized by transversely elongated cells in the lower border of the corticating bands (Fig. 6, C). Other distinguishing features of this plant are the serrate outline near the frond-apex and large tetraspore in comparison with the frond (Fig. 6, G, H).

The specimens examined may be separated into two forms; one is more slender and decumbent than the other. This more slender form agrees quite well with *Cer. transversale* COLLINS and HERVEY which was merged by MAZOYER (1940, p. 293) with *Cer. gracillimum* as var. *byssoideum*. The Japanese name, Hai-igisu is the manuscript name given by SEGI, the discoverer of *Cer. transversale* in Japan.

Ceramium aduncum NAKAMURA

Pl. II, 1–2.

Ceramium circinatum YENDO (non J. AGARDH), Alg. New to Japan VI, 1917, p. 92.

Ceramium clarionensis DAWSON (non SETCHELL and GARDNER), Rev. Ceram., N. Amer., 1950, pp. 134–137, Pl. 4, Fig. 29; Id., Mar. Plants Nha Trang, 1954, p. 448, Fig. 55 k; Id., Mar. Alg. S. Marshalls, 1956, p. 54; Id., Mar. Alg. Eniwetok, 1957, p. 119; Id., Benthic Alg., 1961, p. 440; Id. Mar. Red Alg. Pac. Mexico, 1962, p. 53, Pl. 18, Fig. 5–6; Id., Galapagos Alg., 1963, p. 12.

Type: No. 6, Herb. Imper. Museum in the YENDO Herb. of the University of Tokyo, collected by K. SAIDA, March, 1893, at Gôza, Sima Prov.

Jap. name: Maki-igisu (OKAMURA in Herb.).

Hab.: Hukuyama, Esasi, Osyoro, Hokkaido; Nomozaki, Hizen Prov (T. TANAKA); Birô-jima, Ôsumi Prov.; Tosa Prov. (OKAMURA Herb.); Gôza, Sima Prov. (YENDO Herb.); Ôsima, Izu Prov.; Onahama, Iwaki Prov. (OKAMURA Herb.); Garanbi, Formosa (T. TANAKA).

Distr.: Pacific Coast of Central America.

Plants 1–2 cm. high, capillary, growing on *Corallina* or *Sargassum*; basal portions of the frond creeping on the substratum, emitting 1–2 rhizoids from each node; basal rhizoids usually composed of 2–3 cells, about 20–50 μ thick, various in length, ending in a blunt apex or expanding into a conical disc at the tip; supporting rhizoids few; the entire ramification sparse; ramification regularly dichotomous; lower axils patent, upper ones comparatively acute; frond-apices usually strongly rolled inwards; outer edge of the apex dentate; articulations usually 1–1$\frac{1}{2}$ times as long as diameter, decreasing in length upwards; nodes slightly prominent, densely coated with minute coloured cells, forming a distinct band, but slightly separating from each other especially on upper branches; corticating bands consisting of several rows of irregularly arranged cells; cortical cells roundish or somewhat angular, measuring $6\times6\,\mu$, $8\times8\,\mu$, $10\times10\,\mu$, $12\times14\,\mu$; axial cells cylindrical, becoming shorter and narrower towards the frond-apices; gland cells usually numerous especially in younger portions of the frond, often scarce; chromatophores parietal laminate in cortical cells, filiform in axial cells; hyaline hairs numerous, sometimes scarce; tetrasporangia usually seriated in one or two longitudinal rows on the adaxial side of branches, often somewhat whorled around nodes especially in lower portion of the frond, apparently not bracteate, roundish with thick pericarp, 40–50 μ in diameter exclusive of pericarp 8 μ thick, divided triangularly; spermatangia forming sessile patches on each node of upper branches, produced primarily from cortical cells on the adaxial side of branchlets and gradually spread over the entire area of corticating bands, usually borne 1–3 on each outermost cortical cell, elliptical, whitish, about $4\times6\,\mu$; cystocarps consisting of 2–4 globular gonimolobes, subterminal or terminal on upper branches, provided with 3–4 involucral ramuli; involucres usually 1–1$\frac{1}{2}$ times as long as nucleus of cystocarp; carpospores numerous, somewhat oblong, 28–40 μ by 40–50 μ; colour dark red; substance flaccid, adhering to paper closely in drying.

This plant is widely distributed in the waters investigated, from Hokkaido to Formosa, growing in the intertidal belt on *Corallina* or *Sargassum*. The corticating bands are usually well separated from one another, showing a median, irregular row of large cells with two to three layers of outer, smaller cells. Each corticating band has a great many gland cells which are deeply stained with erythrosin. The frond-apex is forcipated and rolled strongly inwards, and the outer edge of the apex is dentate. The tetrasporangium is clearly erumpent and usually arranged in one to three or more longitudinal rows on the adaxial side of the branches, often somewhat whorled around the nodes in the lower portion of the frond. These

are the most distinguishing characteristics of this species.

The writer (August, 1950) established a new species, *Cer. aduncum* for this plant and suggested that it might be identical with SETCHELL and GARDNER's plant from Guadalupe Island. The plant from Guadalupe Island was recorded by SETCHELL and GARDNER (1930, p. 173) as a new species without giving the plant any name, since the specimens were few and sterile. In the same paper (p. 170), another new species, *Cer. clarionensis* was described on the basis of material from Clarion Island. Judging from the original description and illustration, the tetrasporic characteristics given by SETCHELL and GARDNER for *Cer. clarionensis* are quite different from those of the writer's specimen. However, DAWSON (December, 1950) pointed out that the plants from Guadalupe and Clarion were identical, and that the tetrasporic characteristics of *Cer. clarionensis* were not clearly represented in SETCHELL and GARDNER's original description and illustration. He comments that "The tetrasporangia are not as fully developed in numbers on the type as in some of the new material, but those present show a much more clearly emergent, projecting character than is indicated by the SETCHELL and GARDNER illustration. Furthermore, the occurrence of bracteate filaments associated with the tetrasporangia are neither of regular nor conspicuous occurrence in the type material reexamined. Such filaments within the tetrasporangial wall are not ordinarily present in the other collections now at hand".

In fact, examination of the specimen of *Cer. clarionensis* determined by DAWSON, shows that DAWSON's specimen agrees quite well with the writer's specimen. DAWSON, however, has no comment on the holotype specimen, on the basis of which *Cer. clarionensis* is described and illustrated by SETCHELL and GARDNER. Thus the possibility that the material used by SETCHELL and GARDNER consisted of two or more entirely discordant elements, has not been completely excluded. It, therefore, seems logical to retain the name of *Cer. aduncum* for the writer's plant, pending further study of the holotype specimen of *Cer. clarionensis*.

Ceramium tenuissimum J. AGARDH

Pl. II, 3-4; Fig. 7.

Sp. Alg. II, 1851, p. 120; Id., Epicr., 1876, p. 94; FARLOW, Mar. Alg. New England, 1881, p. 138; HAUCK, Meeresalgen, 1885, p. 104; PHILLIPS, Develop. Cystocarp in Rhodymeniales, 1897, p. 361, Pl. 18, Fig. 19; DE TONI, Syll. Alg., IV, 1903, p. 1450; Id., l. c. VI, 1924, p. 506; OKAMURA, Nippon Sôrui-meii, 1st ed., 1902, p. 81, 2nd ed., 1916, p. 97; KYLIN, Stud. Algenf. Schwed. Westküste, 1907, p. 174; H. PETERSEN, Dan. Alt. Slag. *Ceramium*, 1908, p. 54 Pl. I, Fig. 1; Id., *Ceramium*-Studies I-II, 1911, p. 97; Id., *Ceramium* in ROSENVINGE's Mar. Alg. Denmark, 1923-24, p. 376, Fig. 314; Id., Oversigt nordvest. Kattegat *Ceramium*-Arter, 1929, p. 394; COLLINS and HERVEY, Alg. Bermuda, 1917, p. 143; WEBER VAN BOSSE, Alg. Siboga,

III, 1923, p. 333; LAKOWITZ, Algenf. Ostsee, 1929, p. 361, Fig. 482; MAZOYER, Céram. Medit. 1940, p. 229, Figs. 113–114. LEVRING, Meeresalg. Adriat. Meer, Sizilien, Neapel, 1942, p. 11; Kylin, Rhodophy. Schwed. Westküste, 1944, p. 65.

Ceramium diaphanum var. *tenuissimum* LYNGBYE, Tent. Hydr. Dan., 1819, p. 120, Pl. 37, B 4.

Gongroceras tenuissimum (LYNGBYE) KÜTZING, Ueber *Ceramium* Ag., Linnaea. XV, 1841, p. 736; Id., Phyc. germ., 1845, p. 281; Id., Sp. Alg., 1849, p. 680.

Ceramium nodosum HARVEY, Phyc. Brit. I, 1846–1851, Pl. 90.

Ceramium diaphanum, rigid variety, "WYATT, Alg. Danm. no. 217".

Ceramium rigidulum GRIFFITHS and HARVEY in Herb. *Gongroceras nodiferum* KÜTZING, Sp. Alg., 1849, p. 678; ? *Hormoceras nodosum* KÜTZING, in Linnaea, XV, p. 732; Id., Sp. Alg. 1849, p. 674.

Jap name: Kinuito-igisu (OKAMURA).

Hab.: Nou, Etigo Prov.; Amabarasi, Ettyu Prov.; Okinosima, Kii Prov.; Wagu, Sima Prov.; Enosima, Misaki (Y. YAMADA), Zusi (T. TANAKA), Sagami Prov.; Sira-hama, Bôsyu (OKAMURA Herb.).

Distr.: Baltic, North Atlantic, Mediterranean Sea, West Indies, Tasmania, Celebes.

Plants 0.5–5.0 cm. high, capillary, often partly decumbent; basal creeping portions of the frond, emitting 1–3 rhizoids from each node; basal rhizoids usually composed of 2–3 cells, 15–50 μ thick, various in length, ending in a blunt apex or expanding into a conical disc at the tip; supporting-rhizoids numerous; the entire ramification fastigiate; ramification regularly dichotomous; branches densely branched in a regularly dichotomous manner, often furnished with short branchlets in upper portions especially in fertile plants; axils very patent, often divaricate, sometimes more or less acute; frond-apices usually incurved or rolled inwards, often somewhat straight; outer edge of the apex sometimes dentate, sometimes even; articulations pellucid, usually 1–3 (–6) times as long as broad, becoming shorter upwards; nodes not prominent, excepting tetrasporiferous branches, coated with coloured cellules, forming a distinct band; corticating bands consisting of 3–6 transverse cell-rows, 60–108 μ high, 60–180 μ broad, decreasing in both height and breadth upwards; cortical cells somewhat angular, measuring $8\times9\,\mu$, $8\times12\,\mu$, $10\times16\,\mu$, $14\times12\,\mu$, $14\times16\,\mu$, $19\times16\,\mu$, $26\times30\,\mu$; axial cells cylindrical, becoming shorter and narrower upwards; gland cells numerous, often scarce; chromatophores parietal laminate in cortical cells, filiform in axial cells; tetrasporangia borne one to four on each node, when singly at a node, seriated longitudinally on the abaxial side of branches, usually bracteate, often about half of a sporangium projecting beyond the cortex, ovoid in shape, 40–60 μ by 48–80 μ, exclusive of pericarp 4–6 μ thick, divided triangularly or cruciately; spermatangia forming sessile patches over the entire area of corticating bands, produced primarily from cortical cells on the adaxial side of upper branches, ellipsoid in shape, about 4 μ by 6 μ; cystocarps

borne terminally on branchlets or laterally on branches, consisting of 1–3 gonimolobes, surrounded by 3–5 involucral ramuli; involucres 1–1½ times as long as nucleus of cystocarp; carpospores numerous, somewhat oblong, 22–30 μ by 30–35 μ; colour dark pinkish red; substance somewhat rigid, adhering to paper not so closely in drying.

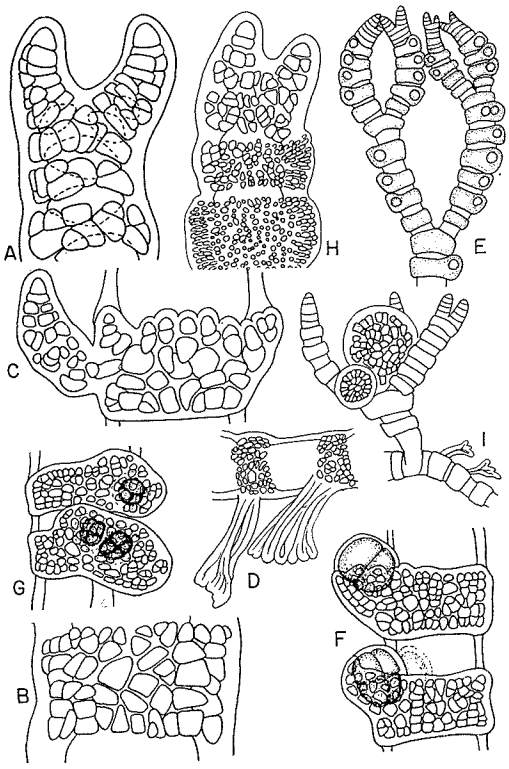

Fig. 7. *Ceramium tenuissimum* (LYNGBYE) J. AGARDH
A. Frond-apex. × 250. B. Corticating band, showing an arrangement of cortical cells. × 250. C. Corticating band with upward proliferations and an adventive branchlet. × 250. D. Portion of a frond with supporting-rhizoids. × 100. E. Portion of a frond, showing an arrangement of tetrasporangia. × ca. 28. F–G. Tetrasporangia. × 100. H. Frond-apex, bearing spermatangia. × 250. I. Cystocarp. × 40.

This plant is found growing on various algae. Some specimens are relatively large and erect, reaching a height of 5 cm. Some are minute and somewhat decumbent. The plant is characterized by extruding tetrasporangia seriated longitudinally on the abaxial side of the branches.

Ceramium tenuissimum is one of the most widespread species of *Ceramium*

and there is much confusion with regard to a specific concept. J. AGARDH (1851, p. 116) established *Cer. tenuissimum*, distinguishing it from its most nearly related species, *Cer. fastigiatum*" primarily by tetrasporic characteristics. H. E. PETERSEN (1908 p. 54) emphasized that, in addition to the tetraspores, the outstanding characteristics of *Cer. tenuissimum* are the denticulate outline of the incurved frond-apex and the presence of gland cells. G. MAZOYER (1940, p. 300), however, commented that the characteristics reported by PETERSEN, were of no specific value in this species and the writer supports this view.

A typical specimen of *Cer. tenuissimum in sensu meo* is shown in Fig. 7 and Pl. II, 4. This is the only specimen of *Cer. tenuissimum* in the OKAMURA Herb. of Hokkaido University and consists of one half a specimen sheet. On the back of the envelope enclosing this specimen is written in ink, in OKAMURA's hand "*Ceram. tenuissimum* det. YENDO, From Nô Fish. Inst". OKAMURA, as well as YENDO, must therefore, have considered it a reliable specimen of *Cer. tenuissimum*. OKAMURA listed this species in his "Nippon Sôrui Meii" and "Nippon Kaisôsi", but he did not enumerate it in his key to the Japanese species of *Ceramium* (1934, unpublished). Accordingly, it seems that he assigned this species with uncertainty to the coast of Japan. In addition to OKAMURA, Professor YAMADA reported this species from Mutu Bay. Judging from his description and illustration, however, YAMADA's plant seems to be quite different from *Cer. tenuissimum* by virtue of its clearly projecting tetrasporangia. It should probably be referred to *Cer. fastigiatum* or to *Cer. aduncum*.

In the YENDO Herb. and the OKAMURA Herb., almost all of the specimens belonging to the *Cer. tenuissimum* assemblage, remain undetermined. As far as the writer could determine, some of the specimens agree well with *Cer. fastigiatum* and most of them are identical with *Cer. tenuissimum* in habit and in disposition of tetrasporangia. Most of these specimens, however, have tetrasporangia which are divided not only triangularly but also cruciately. Therefore, some of the material, especially the creeping forms, are most closely related to *Cer. cruciatum*.

Ceramium fimbriatum SETCHELL and GARDNER

Fig. 8.

New Mar. Alg. Gulf of Calif., 1924, p. 777, Pl. 26, Figs. 43-44; Id., Report Algae, 1937, p. 88, Pl. 7, Fig. 18; DAWSON, Mar. Alg. Calif., 1944, p. 317; Id., Rev. Cerm. N. Amer., 1950, p. 123; Id., Mar. Plants Nha Trang, 1954, p. 446, Fig. 55a; Id., Mar. Alg. S. Marshalls, 1956, p. 53; Id., Mar. Alg. 1958 Cruise, Calif., 1959, p. 30; SEGAWA and KAMURA, Mar. Fl. Ryukyu, 1960, p. 57; DAWSON, Benthic Alg., 1961, p. 440; Id., Galapagos Alg., 1963, p. 12.

Jap. name: Husa-tuki-igisu (n. n.).

Hab.: Arasidomari, Izu Prov. (S. SEGAWA); Oryuzako, Hyuga Prov. (M. KUROGI); Oki-

nawajima (S. KAMURA).

Distr.: Baja California, Gulf of California, Marshall Ils., Viet Nam.

Plants ca. 5 mm. high, 70–140 μ thick, small tufted, capillary, growing on various algae; basal portions of the frond creeping on the substratum with rhizoids; basal rhizoids given arise numerously from nodes of lower portion of the frond, simple, expanding into a conical disc at the tip or ending in a blunt apex, usually 1–2 celled, 15–30 μ thick; supporting-rhizoids scarce; the entire ramification somewhat paniculate; ramification subdichotomo-alternately decompound, usually occurring in

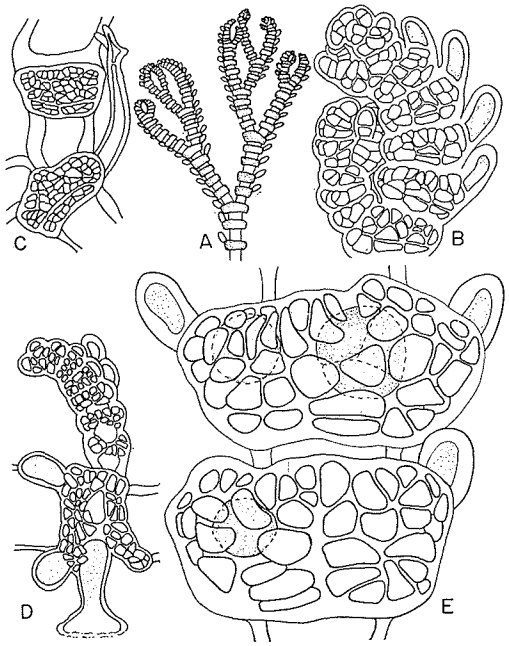

Fig. 8. *Ceramium fimbriatum* SETCHELL and GARDNER

A. Habit sketch, showing method of branching and an arrangement of thumb-like processes. × ca. 28. B. Frond-apex with thumb-like processes. × 250. C. Lower portion of a frond. × 100. D. Corticating band with an adventive branchlet and an attachment-rhizoid. × 100. E. Tetrasporangia. × 200.

the same plane; main branches divided mostly every four articulations (often five or six) by alternate branches, shooting forth lesser sorts of branches; branches and branchlets divided in the same manner; branches short, length of branches subequal, often becoming shorter above, furnished with short similarly arranged branchlets; axils comparatively acute; frond-apices often unequally forcipated, slightly incurved; outer edge of the apex dentate; articulations pellucid, 1–2½ times

as long as diameter, becoming shorter upwards; nodes coated with coloured cellules, forming a distinct band; corticating bands narrow, consisting of 3–5 transverse cell-rows, 70–80 μ high, 140–150 μ broad in basal portions of the frond, 50–60 μ high, 100–140 μ broad in middle portions, 12–14 μ high, 38–70 μ broad in upper portions; lower end of each corticating band somewhat narrower than upper end, having a 1–2 series of transversely elongated cells, passing around axial cells; cortical cells in both upper and lower borders (especially in upper border) smaller than those in median portion of the bands, smaller cells 6–8 μ by 8–10 μ, largest ones about 20 μ by 25 μ, somewhat angular in shape; axial cells cylindrical, becoming shorter and narrower upwards; gland cells absent; chromatophores numerous, parietal laminate in cortical cells, filiform in axial cells; thumb-like unicellular processes longitudinally seriated on the abaxial side of each node almost all over the frond, 25–35 μ broad, 50–55 μ long, somewhat lighter coloured; hyaline unicellular hairs scarce; tetrasporangia whorled around nodes in a single row, protruding, bracteate, bracts within the sporangial wall, spherical in shape, 55–65 μ in diameter, exclusive of pericarp 4–6 μ thick, divided triangularly; spermatangia and cystocarps unknown; colour light pinkish red; substance soft and flaccid, adhering to paper in drying.

This minute plant grows on *Ulva*, *Sargassum*, *Liagora* and *Galaxaura* in the intertidal belt. The specimens collected by S. SEGAWA in November 1934 at Arasi-domari, Izu Prov., and by M. KUROGI in March 1948 at Oryuzako, Hyuga Prov. are altogether sterile, but the specimen from Okinawajima gathered by S. KAMURA in Feburary 1958 has tetrasporangia.

This plant agrees quite well with the description and illustration of *Ceramium fimbriatum* given by SETCHELL and GARDNER. It is easily distinguished from any other species of *Ceramium*, by the thumb-like unicellular processes seriated over almost the entire frond, especially on the abaxial side of each node. This outstanding characteristic is described by SETCHELL and GARDNER as "the presence of a single row of thicker, short, unseptate hairs". These structures, however, seem to correspond to the spines in certain species of *Ceramium*. The microscopic structure of corticating bands are also characteristic as in *Cer. gracillimum* (Fig. 8, B, C).

The writer wishes to express his indebtedness to Drs. S. SEGAWA and M. KUROGI for sending the collections and drawings of this plant.

Ceramium paniculatum OKAMURA

Pl. II, 5; Figs. 9–10.

Contr. Knowl. Mar. Alg. Jap. II, 1896, p. 36, Pl. 3, Figs. 22–23; Id., Nippon Sôrui-meii, 1st ed., 1902, p. 83, 2nd ed., 1916, p. 98; Id., Alg. Jap. Exsic. no. 2; Id., Icon. Jap. Alg. IV, 1921, p. 114, Pl. 179, Figs. 8–16; Id., Mar. Alg. Mutsu Bay I, 1927, p. 14; YAMADA, Mar.

Alg. Mutsu Bay II, 1928, p. 529; OKAMURA, Nippon Kaisôsi, 1936, p. 737; DE TONI, Syll. Alg. IV, 1903, p. 1488; Id., l. c. VI, 1924, p. 518; DAWSON, Mar. Alg. Calif., 1944, p. 319; Id., Rev. Ceram. N. Amer., 1950, p. 122; Id., Mar. Alg. 1958 Cruise Calif., 1959, p. 30; Id., Benthic Alg., 1961, p. 441; Id., Mar. Red. Alg. Pac. Mexico, 1962, p. 61, Pl. 23, Figs. 5–7.

Jap. name: Hari-igisu (OKAMURA).

Hab.: Todohokke and Hukusima (YENDO Herb.), Hukuyama, Setana, Nagatoyo, Osima Prov.; Osyoro, Siribesi Prov.; Ôma and Bentenjima (Y. YAMADA), Horozuki, Asamusi, and Simohuro (YENDO Herb.), Mutu Prov.; Watanoha (OKAMURA Herb.), Syôbuta (YENDO Herb.), Rikuzen Prov.; Onahama, Iwaki Prov. (OKAMURA Herb.); Hiraiso, Hitati Prov. (OKAMURA Herb.); Inubôzaki, Simohusa Prov. (OKAMURA Herb.); Ôhara (Y. YAMADA), Kominato (OKAMURA Herb.), Kazusa Prov.; Enosima, Sagami Prov.; Hatijôjima, Ogasawara Ils. (OKAMURA Herb.); Susaki, Izu Prov. (S. SEGAWA); Kajiga, Sima Prov. (OKAMURA Herb.); Murotozaki, Simizu, Kasiwajima, Tosa Prov. (OKAMURA Herb.); Ajirowan, Inaba Prov. (YENDO Herb.); Obama, Wakasa Prov. (OKAMURA Herb.); Mikuni, Etizen Prov. (OKAMURA Herb.); Nô, Etigo Prov. (OKAMURA Herb.); Kosagawa, Ugo Prov. (T. MURAOKA); Kasyo-tô, Formosa (OKAMURA Herb.).

Distr.: Baja California, Gulf of California.

Plants 3–5 cm, high, 130–200 μ thick, densely tufted, forming a subglobose mass, capillary, growing on *Corallina*, *Rhodomela* or on *Mytilus*; basal portions of the frond creeping on the substratum with rhizoids; basal rhizoids arising numerously from nodes of lower portions of the frond, simple or distantly branched, ending in a blunt apex or expanding into a small conical disc at the tip, usually 2–5 celled, 25–36 μ thick; supporting-rhizoids scarce; the entire ramification paniculate; ramification subdichotomo-alternately decompound, usually occurring in the same plane; main branches divided every four articulations by alternate branches, shooting forth lesser sorts of branches; branches and branchlets divided in the same manner; branches patent, often almost horizontal, length of branches mostly subequal, often becoming shorter above, furnished with short similarly arranged branchlets; axils patent; frond-apices often unequally forcipated, slightly incurved; outer edge of the apex dentate; articulations pellucid, a little shorter than diameter in basal portions of the frond, $1\frac{1}{2}$–$2\frac{1}{2}$ times as long as diameter in middle portions, becoming shorter above; nodes somewhat prominent in upper portions of the frond, but not as above in the remaining portions, coated with coloured cellules, forming a distinct band; corticating bands narrow, consisting of 3–5 transverse rows of cells, 50–70 μ high, 120–150 μ broad in basal portions of the frond, 50–60 μ high, 130–180 μ broad in middle portions, 25–50 μ high, 100–150 μ broad in upper portions; cortical cells in upper and lower borders (especially in upper border) smaller than those in median portion of the bands, smaller cells 6–8 μ by 8–10 μ, largest ones about 25 μ by 30 μ, somewhat angular; axial cells cylindrical, becoming shorter and narrower above; gland cells absent; chromatophores numerous, parietal laminate in cortical cells,

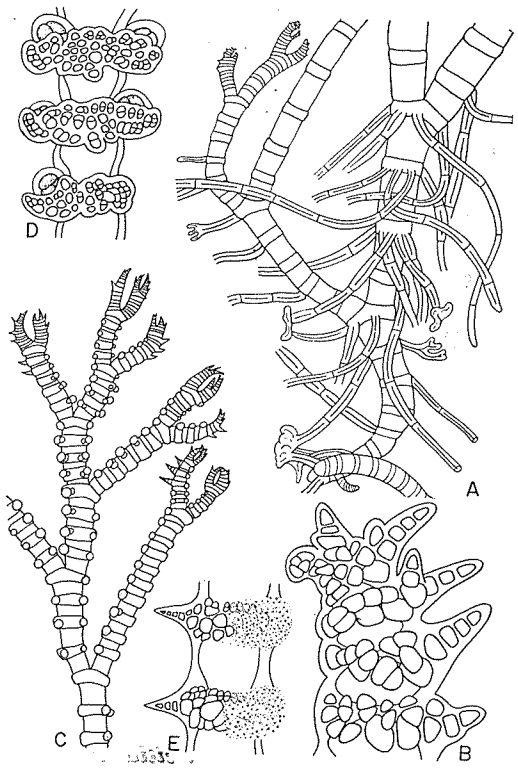

Fig. 9. *Ceramium paniculatum* OKAMURA

A. Basal portion of a frond. × 40. B. Frond-apex with spines on its outer edge. × 250. C. Tetrasporic plant, showing an arrangement of tetrasporangia. × ca. 28. D. Portion of a frond with somewhat immersed tetrasporangia. × 100. E. Spermatangia. × 100.

filiform in axial cells; subulate, 2–4 celled spines longitudinally seriated on the abaxial side of each node of upper branchlet; hyaline unicellular hairs sparse; tetrasporangia whorled around nodes of branchlets in a single row or often seriated in a longitudinal row on the adaxial side of branchlets, bracteate by cortical cells, slightly bulging out from cortical layer, enclosed with thick pericarp, roundish, 34–40 μ by 38–50 μ exclusive of pericarp 10 μ thick, divided triangularly, often somewhat cruciately; spermatangia forming sessile patches on each node of upper branches, produced primarily from cortical cells of the adaxial side of branchlets and gradually spread over the entire area of corticating bands, borne 1–3 on each cortical cell, elliptical, about 4 μ by 6 μ; cystocarps consisting of 2–4 gonimolobes, lateral on upper branches with 4–5 involucral ramuli; involucres two times or more as long as nucleus of cystocarp; carpospores numerous, somewhat oblong,

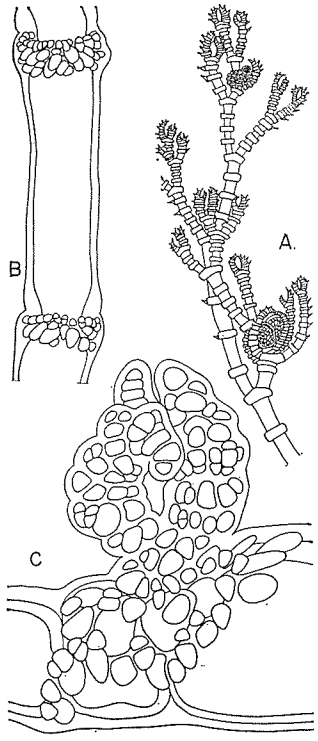

Fig. 10. *Ceramium paniculatum* OKAMURA

A. Cystocarpic plant. × 28.
B. Corticating bands in lower portion of a frond. × 150.
C. Corticating band with secondary adventive branchlet. × 250.

16–24 μ by 22–30 μ; colour light pinkish red; substance soft and flaccid, adhering to paper in drying.

This plant reaches a height of 5 cm. and commonly grows on *Corallina*. It is found from summer to autumn between tide marks near high tide on both coasts of Japan. The writer's specimen agrees quite well with OKAMURA's authentic specimen of *Ceramium paniculatum*. This species is clearly distinguished from its closely related species by regular paniculated ramification and by the presence of short coloured spines.

The male, female, and tetrasporic plants are commonly found, although the male is usually far smaller than the other two. It is not rare to find fully developed spermatangia even in specimens only 5 mm high. A secondary adventive branchlet is often observed, especially in the lower portion of the frond. It issues from the cortical cells as is shown in Fig. 10, C.

Ceramium ciliatum (ELLIS) DUCLUZEAU

Pl. II, 6; Fig. 11.

Ess., 1805, p. 64; LYNGBYE, Hyd. Dan., 1819, Pl. 121, t. 37; HARVEY, Man. ed. 1, 1841, p. 100, ibid. ed. 2, 1849, p. 166; Id., in HOOKER's Br. Fl. II, 1830–1841, p. 336; Id., Phyc. Brit., 1846–1851, Pl. 139; AGARDH, Sp. Alg. II, 1828, p. 153; J. AGARDH, Medit., 1842, p. 81; Id., Advers., 1844, p. 26; Id., Sp. Alg. II, 1851, p. 133; Id., Epicr., 1876, p. 103; Id., Anal. Alg. II, 1894, p. 35; ARDISSONE, Phyc. Medit. I, 1883, Pl. 7; HAUCK, Meeresalgen, 1885, p. 110; DE TONI, Syll. Alg. IV, 1903, p. 1473; BOERGESEN, Mar. Alg. Canary, 1930, p. 65, Fig. 24; NEWTON, Handb. Brit. Seaw., 1931, p. 402; MAZOYER, Céram. Afri. Nord, 1938, p. 322; Id., Ceram. Medit., 1940, p. 322, Fig. 122; LEVRING, Meereasl g. Adriat. Meer, Sizilien, Neapel, 1942, p. 11; DIXON, *Ceramium*, 1960, p. 369.

Conferva ciliata ELLIS, in Philos. Transact. 57, p. 426, t. 18 f. h; DILLWYN, Conf., 1805, t. 53; ENGLER, Bot., 1790–1814, t. 2428.

Conferva pilosa ROTH, Cat. Bot. II, 1800, t. 5, f. 2.

Boryna ciliata BONNEMAISON, Hydroph. Céramiées, 1828, p. 57.

Echinoceras ciliatum KÜTZING, in Linn. XV, 1841, p. 736; Id., Sp., 1849, p. 680; Id., Tab. Phyc. XII, 1862, t. 86, f. a–c.

Echinoceras hirsutum KÜTZING, in Linn. XV, 1841, p. 737; Id., Sp., 1849, p. 681; Id., Tab. Phyc. XII, 1862, t. 86, f. d-e; J. AG., Sp. II., 1851, p. 135.

Echinoceras armatum KÜTZING, in Bot. Zeit., 1847, p. 34; Id., Sp., 1849, p. 681; Id., Tab. Phyc. XII, 1862, t. 87, f. a-c; J. AG., Sp. II, 1851, p. 145.

Echinoceras imbricatum KÜTZING, in Linn. XV, 1841, p. 737; Id., Sp., 1849, p. 681; Id., Tab. Phyc. XII, 1862, t. 87, f. d-f; J. AG., Sp. II, 1851, p. 145.

Echinoceras julaceum KÜTZING, in Linn. XV, 1841, p. 737; Id., Sp., 1849, p. 681; Id., Tab. Phyc. XII, 1862, t. 88, f. a-f (incl. var. *villosa*); J. AG., II, 1851, p. 145.

Echinoceras diaphanum KÜTZING, in Linn. XV, 1841, p. 737; Id., Sp., 1849, p. 681; Id., Tab. Phyc. XII, 1862, t. 89, f. a-c; J. AG., Sp. II, 1851, p. 145.

Echinoceras hystrix KÜTZING, in Linn. XV, 1841, p. 738; Id., Sp., 1849, p. 681; Id., Tab. Phyc. XII, 1862, t. 89, f. d-f.

Ceramium venetum ZANARDINI, Not. Cell. Mar. Ven., 1847, n. 139.

Echinoceras horridum KÜTZING, Sp., 1849, p. 681; Id., Tab. Phyc. XII, 1862, t. 90, f. e-g.

Echinoceras tenellum KÜTZING, Sp., 1849, p. 681; Id., Tab. Phyc. XII, 1862, t. 90, f. e-g.

Echinoceras spinulosum KÜTZING, in Linn. XV, 1841, p. 738; Id., Sp., 1849, p. 682; Id., Tab. Phyc. XII, 1862, t. 91, f. a-d; J. AG., Sp. II, 1851, p. 135.

Echinoceras distans KÜTZING, Tab. Phyc. XII, 1862, p. 28, t. 91, f. e-g.

Echinoceras secundatum KÜTZING, in Bot. Zeit., 1847, p. 34; Id., Sp., 1849, p. 682; Id., Tab. Phyc. XII, 1862, t. 92, f. a-d; J. AG., Sp. II, 1851, p. 146.

Echinoceras patens KÜTZING, Tab. Phyc. XII, 1862, t. 92, f. e-g (spinis validissimis).

Echinoceras pellucidum KÜTZING, in Linn. XV, 1841, p. 738; Id., Sp., 1849, p. 682; Id., Tab. Phyc. XII, 1862, t. 92, f. a-c; J. AG., Sp. II, 1851, p. 146.

Echinoceras puberulum KÜTZING, in Linn. XV, 1841, p. 739; Id., Sp., 1849, p. 682; Id., Tab. Phyc. XII, 1862, t. 93, f. d-f; J. AG., Sp., 1851, p. 146 (non *Ceramium puberulum* SONDERS).

Echinoceras ramulosum KÜTZING, Sp., 1849, p. 683; Id., Tab. Phyc. XII, 1862, t. 94, f. a-c.

Ceramium ramulosum MENEGHINI, in Giorn. Bot. Ital., 1844, p. 185; J. AG., Sp. II, 1851, p. 143.

Echinoceras nudiusculum KÜTZING, in Linn. XV, 1841, p. 739; Id., Sp., 1849, p. 682; Id., Tab. Phyc. XII, 1862, t. 94, f. d-f; J. AG., Sp. II, 1851, p. 146.

Echinoceras hamulatum KÜTZIMG, in Bot. Zeit., 1847, p. 739; Id., Sp., 1849, p. 682; J. AG., Sp. II, 1851, p. 146.

Ceramium giganteum MENEGHINI, in Giorn. Bot. Ital., 1844, p. 185; J. AG., Sp. II, 1851, p. 144.

Echinoceras giganteum KÜTZING, Sp., 1849, p. 683.

Ceramium uniforme MENEGHINI, in Giorn. Bot. Ital., 1844, p. 184; J. AG., Sp. II, 1851, p. 143.

Echinoceras uniforme KÜTZING, Sp., 1849, p. 682.

Ceramium tumidulum MENEGHINI, in Giorn. Bot. Ital., 1844, p. 184; J. AG., Sp. II, 1851, p. 143.

Echinoceras tumidulum KÜTZING, Sp., 1849, p. 683.

Ceramium cristatum MENEGHINI, in Giorn. Bot. Ital., 1844, p. 185; J. AG., Sp. II, 1851, p. 143.

Echinoceras cristatum KÜTZING, Sp., 1849, p. 638.

Ceramium forcipatum TITIUS in Mscr.

Echinoceras subspinosum KÜTZING, in HOHENACKER Alg. n. 440.

Ceramium robustum J. AGARDH, Anal. Alg. II, 1894, p. 35 (formas mediterraneas amplectens).

Jap. name: Tuno-igisu (n. n.).

Hab.: Garanbi, Formosa (T. TANAKA).

Distr.: Faeroe Ils. to Canary Ils, Mediterranean Sea.

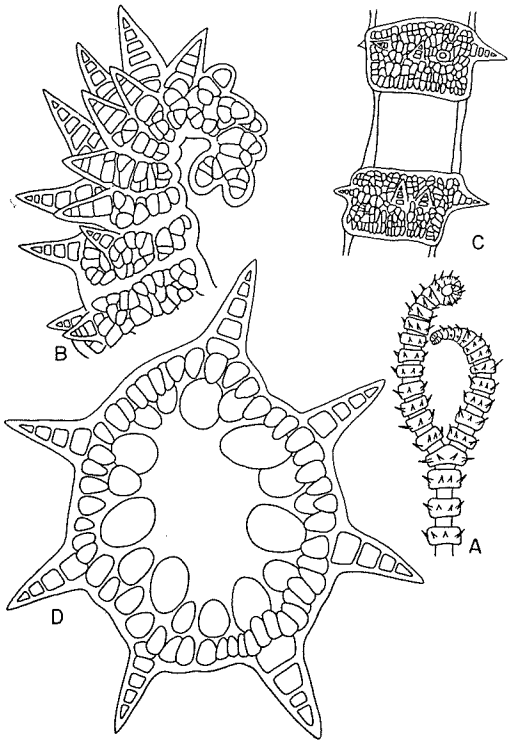

Fig. 11. *Ceramium ciliatum* (ELLIS) DUCLUZEAU

A. Upper part of a plant. × ca. 28. B. Frond-apex with spines. × 250. C. Portion of a frond, showing an arrangement of cortical cells and spines. × 100. D. Transverse section of a corticating band with seven whorled spines. × 250.

Plants 3–15 cm. high, 100–150 μ thick, small tufted, growing on rocks or *Corallina*; basal portions of the frond creeping on the substratum with rhizoids; basal rhizoids given arise from nodes of lower portions of the frond, simple, ending in

a blunt apex or expanding into a concial disc at the tip; branches repeatedly dichotomous, somewhat sparse, sometimes bearing fastigiate lateral branchlets; axils rather patent; frond-apices strongly rolled inwards; outer edge of the apex dentate; articulations pellucid, 3–4 times as long as diameter in lower portions of the frond, becoming shorter and narrower upwards; nodes coated with coloured cellules, forming a distinct band; corticating bands consisting of 5–8 transverse rows of cells, arranged rather in longitudinal chains, 90–100 μ high, 100–150 μ broad in middle portions of the frond; cortical cells nearly equal in size, 6 μ by 12 μ, 12 μ by 17 μ, 7 μ by 18 μ, somewhat angular or elongated; axial cells cylindrical, becoming shorter and narrower upwards; gland cells absent; chromatophores parietal laminate in cortical cells, filiform in axial cells; subulate spines whorled around each node in a single transverse row, composed of 3–5 (–8) cells, 40–50 μ long, about 20 μ thick in the lowest cell; tetrasporangia arranged in a whorl around nodes, alternating with spines, divided triangularly; spermatangia unknown; cystocarps roundish, lateral, nearly sessile, usually accompanied by 3–4 involucral branchlets; colour purplish red; substance rigid, not adhering to paper in drying.

This plant was growing on *Corallina* and was collected by T. TANAKA at Garanbi, Formosa. It is characterized by the spines which arm the nodes. The number of spines corresponds to the number of pericentral cells, usually seven, and they are arranged in whorls around the nodes.

This plant agrees well with the original description and illustration of *Ceramium ciliatum*. It is distinguished from its closely related species, *Cer. echinotum* by the structure of the spines. In *Cer. ciliatum*, the spine is composed of 3–5 (–8) cells and in *Cer. echinotum* it is unicellular. According to G. MAZOYER, *Cer. ciliatum* may be divided into two varieties by the structure of the spines. In var. *typicum* the spine is composed of three cells, and in var. *robustum*, of five to eight cells. In the material examined the spine was composed of three to five (usually four) cells, and therefore, it belongs to the var. *robustum*.

Subgenus ***Euceramium*** DE TONI

Syll. Alg. IV, 1903, p. 1445; NAKAMURA, New *Ceramiums* and *Campylaephoras*, 1950, p. 156.

Articulations scarcely visible; central axes monosiphonous, surrounded by a continuous cortex; ramification dichotomous, trichotomous or tetrachotomous; tetrasporangia whorled around nodes or scattered, immersed in cortex; cystocarps consisting of a single globular gonimolobe and rudimentary one.

Type species: *Ceramium virgatum* ROTH [=*Ceramium rubrum* (HUDSON) AGARDH.]

Key to the Species

1. Tetrasporangia arranged in a 1–2 series on the abaxial side of upper branches or on proliferous branchlets; ramification always dichotomous; 3–7 proliferous branchlets arising in whorls around nodes of the frond . . . . *Cer. boydenii*
1. Tetrasporangia whorled around nodes of the frond or scattered
   2. Ramification more or less pinnato-decompound; branchlets arising on all sides of branches . . . . . *Cer. japonicum*
   2. Ramification dichotomous or trichotomous, often tetrachotomous; at each axil a branchlet arising in alternate directions . . . . . *Cer. kondoi*

Ceramium japonicum OKAMURA

Pl. III; Figs. 12–13.

Contr. Knowl. Mar. Alg. Jap. II, 1896, p. 38, Pl. 3, Figs. 24–28; Id., Icon. Jap. Alg. 3, 1914, p. 91, pl. 124, Figs. 14–22; Id., Nippon Sôrui-meii, 1st ed., 1902, p. 92; Ibid., 2nd ed., 1916, p. 1001; Id., Mar. Alg. Mutsu Bay I, 1927, p. 14; Id., Nippon Kaisôsi, 1936, p. 742; DE TONI, Syll. Alg. IV, 1903, p. 1459; Id., l. c. VI, 1924, p. 508; NAGAI, Mar. Alg. Kurile II, 1941, p. 251; YAMADA and TANAKA, Mar. Alg. Akkesi, 1944, p. 74; NAKAMURA, Str. Repr. *Cer.* and *Camp.* 1954, pp. 15–62, Figs. 1 (13–18), 6 (4), 9 (3), 13 (4), 15 (1); TOKIDA, Mar. Alg. S. Saghalien, 1954, p. 203.

Jap. name: Hane-igisu (OKAMURA).

Hab.: Akkesi, Kusiro Prov.; Horoizumi, Samani, Hidaka Prov.; Muroran, Rebun, Iburi Prov.; Osatube, Hakodate, Kamaya, Hukuyama, Esasi, Setana, Osima Prov.; Osyoro, Otaru, Siribesi Prov.; Masike, Tomamai, Haboro, Tesio, Tesio Prov.; Risiri Il., Wakkanai, Sôya, Kitami-esasi, Abasiri, Kitami Prov.; Simoburo, Mutu Prov. (S. INOH); Enosima, Sagami Prov.; Susaki, Izu Prov.; Iragosaki, Mikawa Prov. (K. INAGAKI); Maizuru, Tango Prov.; Kunasiri, Kuriles (M. NAGAI); Hiroti, Nobori, Saghalien (J. TOKIDA).

Plants 3–11 cm. high, small tufted, growing on various algae; frond-bases composed of a cluster of rhizoids; basal rhizoids issued numerously from the lowermost part of the primary frond and from basal secondary branchlets, consisting of 3–5 (–7) elongated cells, 15–35 μ thick, often distantly branched, mostly expanding into a small conical disc at the tip or ending in a blunt apex; supporting-rhizoids absent; ramification somewhat irregularly and divaricately pinnato-decompound, branches and branchlets occurring on all sides of the frond; main branches usually simple, tending to form percurrent axes, clothed with numerous branches and branchlets especially in upper portions of the frond; in sterile or tetrasporic plants, branches elongated, alternate, often subsecund, the entire ramification assuming a pinnato-corymbose outline when displayed on paper; in cystocarpic plants, branches comparatively short, branched in a subcorymbose manner, densely clothed with short, subulate, somewhat fasciculate branchlets, the entire ramification assuming a densely subcorymbose

appearance; branches and branchlets slightly constricted at the base, tapering towards the apex; frond-apices always straight, not forcipated, abruptly attenuated; axils patent; nodes neither constricted nor prominent; articulations opaque, densely corticated throughout, 400–900 μ broad, subequal in length and breadth in middle portions of the frond, 1/2–1/3 times as long as broad in lower portions of the frond and in branchlets; axial cells cylindrical, slightly shorter than diameter in

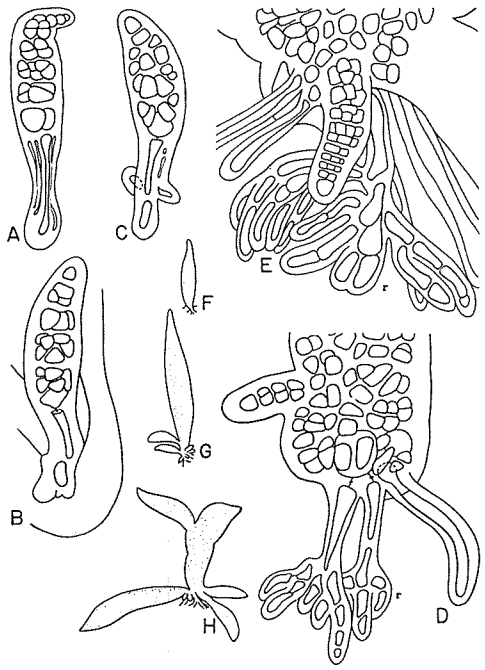

Fig. 12. *Ceramium japonicum* OKAMURA

A–E. A series of various stages in the development of the frond-base. × 250. r. Basal attachment-rhizoid. F–H. Plantlets, showing the method of the primary branching. × ca. 13.

middle portions of the frond, gradually decreassing in length and breadth towards apex and base; cortices composed of pericentral cells, inner cortical cells, and outer cortical cells; pericentral cells arising from axial cells in a whorl, globular in shape, usually seven in number in upper portions of the frond; inner cortical cells given off from pericentral cells, somewhat larger, roundish, often slightly elongated; in surface view, outer cortical cells densely arranged with a somewhat parenchymatous order, giving a reticulate appearance, uni- or bistratose, angular in shape, measuring $6\times6\,\mu$, $9\times18\,\mu$, $14\times20\,\mu$, $15\times18\,\mu$, rarely more than $20\,\mu$ in length and breadth;

chromatophores parietal laminate in outer cortical cells, filiform in inner cortical or axial cells; hairs hyaline, unicellular, about 5 μ thick, 100–200 μ long; tetrasporangia mostly roundish, immersed in cortical layer, disposed primarily in a whorl around nodes of upper branches, finally scattered all over the frond, enclosed with thick pericarp, divided usually triangularly, more often cruciately, 36–42 μ by 40–52 μ

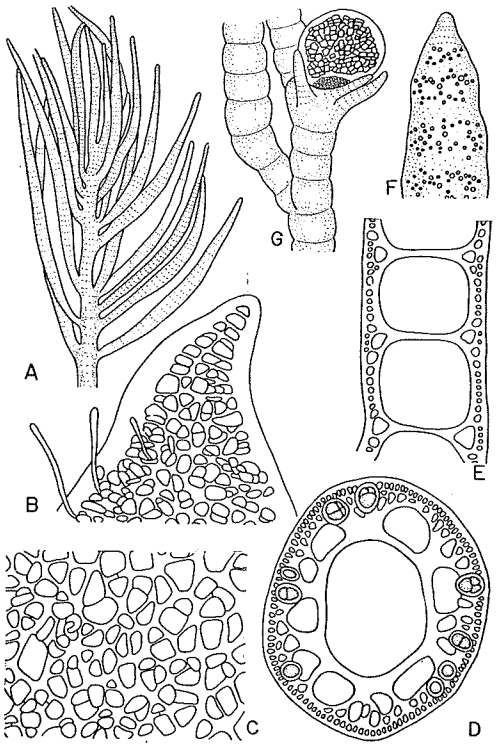

Fig. 13. *Ceramium japonicum* OKAMURA

A. Tetrasporic plant, showing a pinnate branching. × 3. B. Frond-apex. × 250. C. Surface view of the cortex, showing an arrangement of cortical cells. × 250. D. Transverse section of a tetrasporic frond. × 55. E. Longitudinal section of a frond. × ca. 37. F. Frond-apex, showing an arrangement of tetrasporangia. × 15. G. Cystocarp with a single large globular gonimolobe and a rudimentary one. × ca. 37.

exclusive of pericarp 5–6 μ thick; male plant unknown; cystocarps lateral, sessile on branchlets, terminal or subterminal on proliferous branchlets, single or often two seriated longitudinally along the same side of longer branchlets, provided with 5–7 involucral ramli; involucres slightly longer than nucleus of cystocarp, mostly 100–250 μ broad, 300–700 μ long; carpospores numerous, oblong, ovoid, ellipsoid,

20–30 μ by 32–54 μ; colour blood-red or purplish-red; substance soft cartilaginous and tough, adhering to paper in drying.

This plant grows on *Sargassum thunbergii*, *Rhodomela larix* and on various other algae, between tide marks near high tide. It is found along both coasts of northern Japan in the months from May to October. It is small tufted, reaching a height of 10 cm. or more. The basal portion of the frond usually creeps on the host for a short distance with many rhizoids, presenting a disc like appearance. The frond-base, however, does not constitute of a true disc, but a cluster of rhizoids (Fig. 12, D–E). There were no rhizoids arising from the upper erect frond (supporting-rhizoids) in the material examined, except from the injured portion of the erect frond.

The frond-apex is densely corticated throughout, and abruptly attenuated to a single row of apical cells (Fig. 13, B). It is always straight and never forcipated, even in the youngest part of the frond. The tetrasporic plant branches somewhat pinnately, especially in the upper portion of the frond, and has elongated branches on all sides, which show a tendency to become alternate or subsecund. Consequently, when displayed on paper, it assumes a pinnato-corymbose outline. The cytocarpic plant branches similarly, but the branch is not as long as that of the tetrasporic plant, and has many short, subulate, somewhat fasciculate branchlets. It has, therefore, a dense, subcorymbose appearance. In addition, the cystocarpic plant is usually smaller than the tetrasporic plant. This plant is clearly distinguishable by these characteristics, especially by its mode of ramification.

Ceramium kondoi YENDO

Pls. IV–VI, IX, 1; Fig. 14.

Nov. Alg. Jap. Decas I-III, 1920, p. 9; DE TONI, Syll. Alg. VI, 1924, p. 511; OKAMURA, Nippon-Kaisôsi, 1936, p. 736; NAGAI, Mar. Alg. Kurile II, 1841, p. 214; YAMADA and TANAKA, Mar. Alg. Akkesi, 1944, p. 74; NAKAMURA, New Ceram., Camp., 1950, pp. 160–165, Figs. 4-5; Id., Str. Repr. Cer. Camp., 1954, pp. 15–62, Fig. 4 (1–5), 6 (1–4), 7, 8 (1), 10; TOKIDA, Mar. Alg. S. Saghalien, 1954, pp. 202–203; IWAMOTO, Mar. Alg. Saroma, 1960, p. 39. Pl. VIII, A, B.

Ceramium pedicellatum YENDO (non J. AGARDH), Alg. New Jap. VI, 1917, p. 93.

Ceramium rubrum YENDO (non AGARDH), Kaisan-Syokubutugaku, 1911, p. 680, Fig. 193; OKAMURA, Nippon Sôrui-meii, 1st ed., 1902, p. 82; Id., Igisu no wamei, 1914, p. 233; Id., Nippon Sôrui-meii, 2nd., 1911, p. 99; Id., Nippon Kaisôsi, 1936, p. 738.

Ceramium rubrum f. *fasciculatum* YENDO (non J. AGARDH), Alg New Jap. VIII, 1918, p. 79.

Ceramium rubrum f. *corymbiferum* YENDO (non J. AGARDH), l. c. p. 80.

Ceramium ochotensis OKAMURA in Herb., the YENDO Herb. T. I.

Jap. name: Igisu (OKAMURA).

Hab.: Both coasts of Honsyu; Hokkaido; Kuriles; Saghalien.

Plants very vigorous, usually 10–30 cm., often 50 cm. high, densely tufted, often

forming a large globular mass, entangled with supporting-rhizoids, growing on rocks on various algae; frond-bases composed of a cluster of rhizoids; basal rhizoids issued from the lowermost portion of the primary frond and from basal secondary branchlets, consisting of several elongated cells, 20–35 μ thick, often distantly branched, usually expanding into a conical disc at the tip or ending in a blunt apex; supporting-rhizoids given off as outgrowths from cortical cells in any part of the erect frond; the entire ramification densely subcorymboso-fastigiate when displayed on paper; ramification tetrachotomous, trichotomous, or dichotomous; branches and branchlets occurring on all sides of the frond; main axes short, giving off main branches; main branches long, usually trichotomous, often dichotomous, at each axil bearing a branchlet in alternate directions especially in upper portions of the frond; proliferous branchlets very numerous, arising on all sides of branches, but often scarce; frond-apices usually forcipated, incurved, often somewhat straight; outer edge of the apex even; lower axils patent, upper axils acute; nodes constricted, excepting in the uppermost portion of the frond; internodes usually constricted in their median portions, assuming a doliform appearance; articulations opaque, densely corticated throughout, decreasing in length and breadth from base to apex of the frond, 1–2 mm. broad, $1\frac{1}{2}$–2 times as long as broad in lower portions of the frond, 150–180μ broad, about $\frac{1}{2}$ times as long in the penultimate bifurcations; axial cells cylindrical, $1\frac{1}{2}$–2 times as long as broad, decreasing in size upwards; cortices composed of pericentral cells, inner cortical cells, and outer cortical cells; pericentral cells globular, (6–) 7 (–10) in number, arising from axial cells in a whorl; inner cortical cells about 30 μ broad, often elongated along the long axis of the frond, reaching 720 μ in length; in surface view, outer cortical cells densely arranged somewhat longitudinally, but in the uppermost portions of the frond showing a reticulate appearance, more dense at nodal

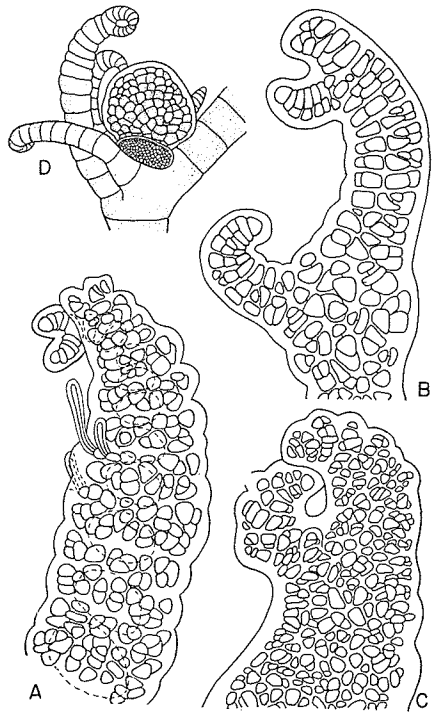

Fig. 14. *Ceramium kondoi* YENDO
A–C. Frond-apices. × 250. A. f. *ambiguum* NAKAMURA. B. f. *abbreviatum* NAKAMURA. C. f. *typicum* NAKAMURA. D. Cystocarp with a single large globular gonimolobe and a rudimentary one.

or internodal constrictions, consisting of uni- or bistratose, somewhat roundish in shape, meauring $8\times6\,\mu$, $8\times14\,\mu$, $8\times24\,\mu$, $12\times10\,\mu$, rarely more than $20\,\mu$ in length and breadth; chromatophores parietal laminate in outer cortical cells, filiform in inner cortical or axial cells; hairs hyaline, unicellular; tetrasporangia roundish, immersed in cortex, disposed verticillately, in middle portions of the frond somewhat scattered, provided with thick pericarp, divided usually triangularly, often cruciately, measuring 48–50 μ in diameter, exclusive of pericarp 5 μ thick; spermatangia forming sessile patches on upper branches, produced primarily from cortical cells on the adaxial side of branchlets, afterwards spreading over the entire area of branches and branchlets, usually borne two on each outermost cortical cell, elliptical in shape, 4 μ by 6 μ; cystocarps lateral, sessile on branches and branchlets, subterminal or terminal on proliferous branchlets, single or seriated, provided with 4–5 involucral ramuli; involucres usually shorter than nucleus of cystocarp, 60–100 μ broad, 140–660 μ long; carpospores numerous, ovoid or ellipsoid, 30–42 μ by 44–74 μ; colour dark red; substance soft cartilaginous and tough, adhering to paper closely or not so closely in drying.

This plant grows on rocks or on various algae in the intertidal belt, forming a large tuft 30 cm. or more in height. The general appearance of the plant varies considerably, sometimes with many proliferous branchlets (Pl. VI, 2) and sometimes with almost none (Pl. VI, 1), and the frond-apex is either markedly forcipated (Pl. IX, 1) or almost straight (Pl. V). Nevertheless, it is altogether characterized by having branchlets at each axil of branches in alternate directions, especially in the upper portion of the frond. This is one of the most distinctive characteristics, by which *Cer. kondoi* emended by the writer may be distinguished from its closely related species, *Cer. rubrum*, as is explained in detail in previous papers (1950, 1954).

The main branch usually branches dichotomously, trichotomously, or often tetrachotomously. The four formae described below may be distinguished by modes of ramification and by the structure of the cortex.

Key to the Formae

1. Cortices thin, axes appear to be banded; main branches usually dichotomous, rarely trichotomous . . . . . f. *ambiguum*
1. Cortices thick, axes not appear to be banded
   2. Main branches dichotomous, tending to form percurrent axes; branches abbreviated, sparsely branched in a somewhat alternate manner, arising on all sides of upper portion of the frond . . . . . f. *abbreviatum*
   2. Main branches usually dichotomous, often trichotomous; plants vigorous, more than 10 cm. high; branches repeatedly dichotomous in a somewhat

regularly corymboso-fasciculate manner . . . . . f. *typicum*

2. Main branches usually trichotomous, often tetrachotomous; plants very vigorous, often forming a large globular mass . . . . . f. *trichotomum*

f. ***typicum*** NAKAMURA

Pl. VI, 1.

New *Ceramiums* and *Campylaephoras*, 1950, p. 163.

Hab.: Rausu (T. TANAKA), Nemuro (K. YENDO), Nemuro Prov.; Kusiro (YENDO Herb.), Akkesi, Kusiro Prov.; Hiroo, Tokati Prov.; Horoizumi (Y. YAMADA), Samani, Hidaka Prov.; Muroran, Rebun, Iburi Prov.; Osatube, Todohokke (YENDO Herb.), Hakodate (T. MORITAKE), Kamaya, Hukuyama, Esasi, Setana, Osima Prov.; Osyoro, Otaru, Hariusu (YENDO Herb.), Siribesi Prov.; Kabuka, Rebun Il, Saroma Lake (K. IWAMOTO), Saruru, Abasiri (T. MURAOKA), Kitami Prov.; Ôma (T. KANDA), Nonai, Asamusi, Mutu Prov.; Hasigami, Syôbuta, Rikuzen Prov. (YENDO Herb.); Taitô-misaki, Kazusa Prov. (YENDO Herb.); Ôsima, Izu Prov. (Y. YAMADA); Ebima, Mikawa Prov. (S. ARASAKI); Okinosima, Bingo Prov. (I. TAKI); Maizuru. Tango Prov.; Kosagawa, Konoura (T. KANDA), Ugo Prov.; Etorohu (YENDO Herb.), Kunasiri (M. NAGAI), Sikotan (S. KAWABATA), Kuriles; Tokoro, Yôman, Kitasiretokosaki, Robben Il., Kasiho, Sakaehama, Nobori, Siranusi, Hisitoma, Tomarioru, Hota, Kaibatô, Saghalien (J. TOKIDA).

Plants vigorous, usually 10–30 cm. high; main axes evident; main branches usually dichotomous, rarely trichotomous, at each axil always bearing a branchlet in alternate directions; branches repeatedly dichotomous, regulary corymboso-facsiculate especially in upper portions of the frond; cortices comparatively thin; tetrasporangia whorled around nodes in a somewhat regular order.

This forma is most commonly distributed along both coasts of northern Japan. The main branch usually branches dichotomously and always bears a branchlet at each axil in alternating directions.

f. ***ambiguum*** NAKAMURA

Pl. V, 1–2.

New *Ceramiums* and *Campylaephoras*, 1950, p. 164.

Hab.: Akkesi, Kusiro Prov.; Nemuro, Nemuro Prov. (YENDO Herb.); Maizuru, Tango Prov.; Tirie, Saghalien (J. TOKIIDA).

Type: No. 25849, SAP.

Plants small tufted, 10–30 cm. high; main axes evident; main branches dichotomous, at each axil always bearing a branchlet in alternate directions; branches repeatedly dichotomous, showing a tendency to become alternate; cortices very thin, the axes appearing to be banded; tetrasporangia, at least in upper branches, arranged

in a single transverse row around nodes.

This forma is found at Akkesi and Nemuro, Hokkaido. The type locality is Akkesi, Kusiro Prov., Hokkaido. The most distinguishing characteristic of this forma is that in a surface view, the cortex is so thin that the axis appears to be banded as is shown in Fig. 14, A. In this respect, this forma is closer to *Cer. rubrum* than to *Cer. kondoi.* It is, however, clearly characterized by a branchlet at each axil on the branches, and it appears, therefore, to be intermediate between *Cer. rubrum* and *Cer. kondoi.*

f. ***abbreviatum*** NAKAMURA

Pl. IV, 4; V, 3-4.

New *Ceramiums* and *Campylaephoras*, 1950, p. 164.

Type: No. 25847, SAP.

Hab.: Akkesi, Kusiro Prov.; Cape Inubô, Simohusa Prov. (YENDO Herb.).

Plants dwarf, 5–10 cm. high; main axes markedly evident; main branches tending to form percurrent axes, bearing abbreviated branchlets verticillately in upper portion of the main branch; branches markedly abbreviated, less branched in a somewhat alternate manner; cortices thick; tetrasporangia scattered even in upper branchlets.

This forma is found at Akkesi, thriving in shallow waters, facing the surf. It has a percurrent axis with abbreviated branches on all sides, especially in its upper portion. There are often a few, somewhat alternating branches, giving it a corymbose appearance.

This forma is identical with *Cer. rubrum* f. *corymbifera* YENDO (non J. AGARDH) from Cape Inubô, Simohusa Prov., pacific coast of Honsyu (Pl. IV, 4). As is desciribed above, this forma does not have the "trichotomous ramification", which distinguishes *Cer. kondoi,* but it is closer to *Cer. kondoi* than to *Cer. rubrum* in its cortical structure and in many other respects, and appears to be an abbreviated, dwarf form of *Cer. kondoi.*

f. ***trichotomum*** NAKAMURA

Pl. VI, 2.

New *Ceramiums* and *Campylaephoras*, 1950, p. 164.

Hab.: Akkesi, Kusiro Prov.; Rakuma, Tôbuti, Honto, Saghalien (J. TOKIDA).

Plants very vigorous, 20–50 cm. high, densely tufted or glomerated, tangled with supporting-rhizoids; main axes evident; main branches usually trichotomous, often tetrachotomous, at each axil always bearing a branchelt in alternate directions; branches elongated, densely dichotomous; cortices very thick; tetrasporangia ar-

ranged in disturbed rings around nodes.

This forma is found washed ashore from the Akkesi Lake. It is glomerated in a large mass, tangled with supporting-rhizoids. The main branch usually branches trichotomously, often tetrachotomously. It may be clearly distinguished from other formae by its peculiar habit and by the ramification of its primary branch.

Ceramium boydenii GEPP

Pls. VII, VIII, 1; Figs. 15–16.

Chinese Mar. Alg., 1904, p. 164, Pl. 406, Figs. 1–3; OKAMURA, Icon. Jap. Alg. I, 1909, p. 248, Pl. 50; YENDO, Kaisan-Syokubutugaku, 1911, p. 686, Fig. 195; OKAMURA, Igisu no wamei, 1914, p. 253; Id., Nippon Sôrui-meii, ed. 2, 1916, p. 99; DE TONI, Syll. Alg. VI, 1924, p. 514; OKAMURA, Nippon Kaisôsi, 1936, p. 739, Fig. 353; Id., Mutsu Bay I, 1927, p. 14.

Ceramium rubrum OKAMURA (non AGARDH), Nippon Sôrui-meii, ed. 1, 1902, p. 82,
Ceramium sugiyamai YENDO in Herb. (Note No. 66).

Jap. name: Amikusa (OKAMURA).

Hab.: Hakodate, Osima Prov. (YENDO Herb.); Ôma (YENDO Herb.), Moriyama (Y. SAKAI), Mutu Prov.; Syôbuta and Kinkazan (YENDO Herb.), Otomo and Onagawa (SAP.), Rikuzen Prov.; Bôsyu (YENDO Herb.); Kamakura (YENDO Herb.); Enosima, Sagami Prov.; Kakizaki, Izu Prov. (YENDO Herb.); Tanabe, Kii Prov. (SAP.); Bungonada (I. TAKI); Ujina, Aki Prov. (SAP.); Amakusa, Higo Prov. (T. TANAKA); Nomozaki, Hizen Prov. (T. TANAKA); Yunotu, Iwami Prov. (SAP.); Usagi, Izumo Prov. (SAP.); Maizuru, Tango Prov.; Sibagaki, Teraya, Noto Prov. (SAP.); Sado (SAP.), Nô (YENDO Herb.), Etigo Prov.; Tobisima (SAP.), Kosagawa (T. MURAOKA), Konoura (T. KANDA), Ugo Prov.; Hukaura, Mutu Prov.

Distr.: China, Korea.

Plants 5–20 cm. high, 0.3–1.5 mm. thick, epiphytic on *Sargassum*, etc., usually forming a large mass of laxly interwoven filaments; frond-bases composed of a conical disc, surrounded by a cluster of rhizoids; basal conical disc minute, composed of rhizoidal cells descending from the lowermost segment of the frond; basal rhizoids issued numerously from the lowermost part of the primary axis and from nodes of prostrate fronds, consisting of three to five elongated cells, 15–30 μ thick, often distantly branched, usually expanding into a small conical disc at the tip or ending in a blunt apex; supporting-rhizoids very numerous, tangled with the fronds; ramification regularly dichotomous in young plants, becoming intricate as it grows; main branches patent dichotomous, set with lateral proliferous branchlets; proliferous branchlets very numerous, especially on main branches in older plants, whorled around nodes, 3–7 ramuli at a node, simple, or once or twice forked; frond-apices forcipated and incurved in young plants, not forcipated and slightly incurved in older plants; axils very patent in lower portions of the frond, acute in upper

portions; nodes neither constricted nor prominent in upper portions of the frond, but constricted in lower portions; internodal constrictions usually occur in lower portions of the frond; articulations opaque, corticated throughout, about 1 mm. broad in older fronds, mostly $1\frac{1}{2}$–2 times as long as broad, subequal or slightly shorter in upper portions of the frond; axial cells cylindrical, thick-walled, about 350 μ broad, 1–2 times as long as broad in middle portions of the frond; cortices relatively thin, about 80 μ thick in the frond of 500 μ breadth, gradually becoming thinner upwards, consisting of pericentral cells, inner cortical cells, and outer cortical cells; pericentral cells globular, usually 7 in number, arising from axial cells in a whorl; inner cortical cells usually unistratose, somewhat larger globular; outer cortical cells issued from inner cortical cells, usually unistratose, rarely bistratose, in surface view, compactly arranged without any regular order, angular in shape at nodal or internodal constrictions, elongated in the remaining part of the frond, 8×8 μ, 8×10 μ, 10×20 μ in size; chromatophores parietal laminate in outer cortical cells, filiform in inner cortical or axial cells; hyaline unicellular hairs not observed; tetrasporangia immersed in cortex of upper branches or proliferous branchlets, arranged sometimes in a 1–2 series along the abaxial side of branchlets, sometimes in globose heads without any regular order especially in older plants, divided triangularly, or cruciately, measuring 50–60 μ×60–70 μ exclusive of pericarp 5–6 μ thick; sexual plants usually less than 1 cm. high; spermatangia forming sessile patches covering the entire frond, produced primarily on the adaxial side of branches, ellipsoid in shape, about 4 μ by 6 μ; cystocarps terminal or subterminal, provided with 5–6 involucral ramuli; involucres relatively short; carpospores numerous, ovoid to ellipsoid, 26–45 μ by 30–50 μ; colour crimson red to dark red; substance membranaceous in younger plants, more cartilagenous in older plants, not adhering to paper in drying.

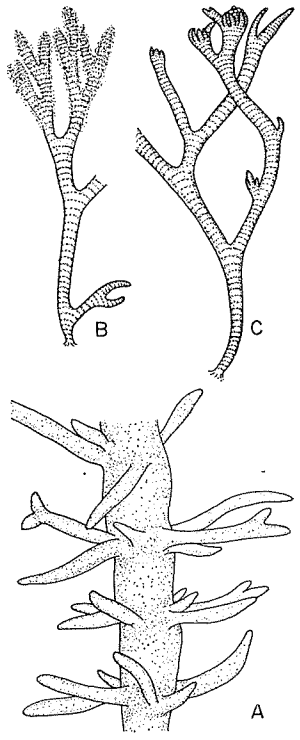

Fig. 15. *Ceramium boydenii* GEPP
A. Portion of a frond with whorled proliferous branchlets. × 15. B. Male plant, bearing spermatangia. × 15. C. Female plant, bearing cystocarps. × 15.

This plant grows commonly on *Sargassum* in the intertidal belt. It is widely distributed along both coasts of Japan and is utilized in mixtures of "Kanten-

material". The plant usually forms a large mass of laxly interwoven filaments closely connected by supporting-rhizoids which grow out at the intersections (Fig. 16, B). When young, the plant branches in a regularly dichotomous manner, but as it grows, it becomes tangled. As has been previously described, the cortex is very thin and there are many internal rhizoids in the cortex (1954, p. 27, Fig. 8, 2–3).

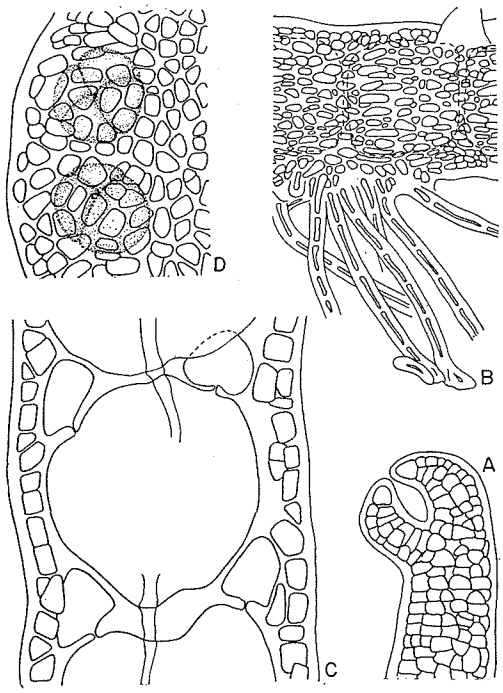

Fig. 16. *Ceramium boydenii* GEPP

A. Frond-apex. × 250. B. Portion of a frond with supporting-rhizoids. × 77. C. Longitudinal section of a frond. × 250. D. Surface view of a tetrasporiferous frond. × 250.

No male or female plants have previously been recorded, but the writer did collect a number of sexual plants from Maizuru and Enosima in early May. Although they are less than 1 cm. high, they are all fertile (Pl. VIII, 1). The branching is sparse, and more or less regularly dichotomous. The tetrasporangia are arranged in a 1–2 series along the abaxial side of the upper branches, or on the proliferous branchlets. This characteristic arrangement of tetrasporangia is apparently initiated by the formation of the sporangium, as has been previously described (1954, p. 36, Fig. 16). Another outstanding characteristic of this species is the structure of the frond base, which is composed of a minute conical disc surrounded by a cluster

of rhizoids (l. c. p. 24, Fig. 4, 6–10). In this respect, this species links two genera *Ceramium* and *Campylaephora*. It seems best, however, to retain it in the genus *Ceramium*, pending further study.

Campylaephora J. AGARDH

Sp. Alg., II, 1851, p. 149; Schmitz and Hauptfleisch, Rhodophyceae, ENGLER und PRANTL Pflanzenf., 1897, pp. 485, 502; NAKAMURA, New *Ceramiums* and *Campylaephoras*, 1950, p. 165, Figs. 6–7; Id., Str. Repr. *Ceramium* and *Campylaephora*, 1954, pp. 15–62.

Plants always epiphytic, usually solitary, filiform, repeatedly branched; fronds composed of a monosiphonous central axis and cortex; cortication completly continuous, composed of pericentral cells, inner cortical cells, elongated rhizoidal cells, and outer cortical cells; articulations invisible; frond-bases forming a conical disc of 1–2 mm. diameter, composed of rhizoidal cells; ramification dichotomous; reproduction by tetraspores and carpospores; tetrasporangia immersed in cortex, whorled around nodes or scattered; spermatangia forming sessile patches on upper branches, produced one to three from each outermost cortical cell; procarps borne on the abaxial side of upper portions of branchlets, bearing one carpogonial branch on each supporting-cell; cystocarps globular, consisting of one gonimolobe, surrounded by 4–9 involucral ramuli.

Type species: *Campylaephora hypnaeoides* J. AGARDH

The generic diagonosis of *Campylaephora* was emended by the writer (1950, p. 165). The genus includes two species, *Camp. crassa* and *Camp. hypnaeoides*.

Key to the Species

1. Sickle-shaped portions of the frond absent; ramification usually occurs in the same plane . . . . . *Camp. crassa*
1. Sickle-shaped portions of the frond present; ramification multidirectional . . . . . *Camp. hypnaeoides*

Campylaephora crassa (OKAMURA) NAKAMURA

Pls. IX, 2–4, X-XII; Fig. 17–18.

New *Ceramiums* and *Campylaephoras*, 1950, pp. 166–170, Figs. 6–7; Id., Str. and Repr. *Cer.* and *Camp.* pp. 15–62, Figs. 2, 3 (3–4), 9 (2), 11, 12, 13, (3, 6), 15 (2–4), 17 (6), 20; TOKIDA, Mar. Alg. S. Saghalien, 1954, p. 204.

Ceramium crassum OKAMURA, Icon. Jap. Alg. VI, 1930, p. 26, Pl. 269, Figs. 1–10; Id., Nippon Kaisôsi, p. 740; SEGAWA, Mar. Alg. Susaki, Prov. Izu, III, 1938, p. 152.

Ceramium secundatum YENDO (non LYNGBYE), Alg. New Jap. VIII, 1918, p. 79.

Ceramium cymosum OKAMURA in Herb.

Ceramium boreale OKAMURA in Herb.
Ceramium nitens YENDO (non J. AGARDH) in Herb.

Jap. name: Huto-igisu (OKAMURA),

Hab.: Both coasts of northern Honsyu from Kii Prov. and Etigo Prov.; Hokkaido; Saghalien.

Plants usually solitary, 3–30 cm. high, always epiphytic, growing on various algae; the entire ramification considerably variable, sometimes cymose or corymbose, sometimes somewhat decompound-paniculate with prominent main branches, sometimes sparse subcorymbose or pinnato-decompound when displayed on paper; frond-bases composed of a distinct conical disc, giving off one erect main axis; basal discs 1–2 mm. in diameter, with more or less irregular margin, consisting of rhizoidal cells; ramification usually divaricate, sometimes regularly, sometimes irregularly dichotomous, often alternate, occurring usually in the same plane; main axes short, emitting divaricately two main branches, often set with one or more short secondary branches quite near the frond-base; main branches divaricate, usually regularly dichotomous, often somewhat alternate; branches repeatedly branched in the same manner, sometimes naked, sometimes set with lateral proliferous branchlets; proliferous branchlets simple, or once or twice or more forked, secundly seriated or irregularly inserted, usually scarce, often numerous especially along the main branches, occurring on all sides of the frond; frond-apices usually straight or slightly incurved, often rather outcurved especially in male plants, but emarginated or strongly rolled inwards in young plants; axils very patent, especially in lower portions of the frond, often gradually becoming somewhat narrower upwards; nodes sometimes neither constricted nor prominent, sometimes slightly constricted; articulations opaque, corticated throughout, usually 600–1000 μ broad in the main branches, often reaching up to 2mm. breadth, 1–1½ times as long as broad, gradually becoming narrower and shorter toward apex and base; axial cells cylindrical, thick-walled, 3/4–1½ times as long as broad, becoming shorter and narrower upwards; cortices thick, about 250 μ thick in the frond of 800 μ breadth, becoming thinner upwards, consisting of four kinds of cells: pericentral, inner cortical, elongated rhizoidal, and outer cortical cells; pericentral cells globular, usually 7 in number, arising from axial cells in a whorl; inner cortical cells somewhat irregular in shape, given off from pericentral cells; rhizoidal cells elongated, usually 4–5 μ broad or more, various in length, richly developed in inner cortical layer near the frond-base, becoming scarce upwards, none in the uppermost portion of the frond; outer cortical cells issued from inner cortical cells, usually unistratose, often bistratose, in surface view, arranged with a somewhat regular order in two or three cell groups, now angular, now somewhat gloubular in shape, 5–10 μ by 6–20 μ in size; chromatophores parietal laminate in outer cortical cells, discoid in inner cortical

cells, filiform in axial cells; hyaline unicellular hairs very numerous, covering the entire frond, about 4 μ broad, 100–450 μ long; tetrasporangia roundish, immersed in cortical layers, arranged in a whorl around nodes with somewhat regular order in upper branches, but becoming irregular downwards, enclosed with thick pericarp, divided usually triangularly, often somewhat cruciately, about 72–96 μ by 84–120 μ exclusive of pericarp 8–10 μ thick; spermatangia forming sessile patches on upper

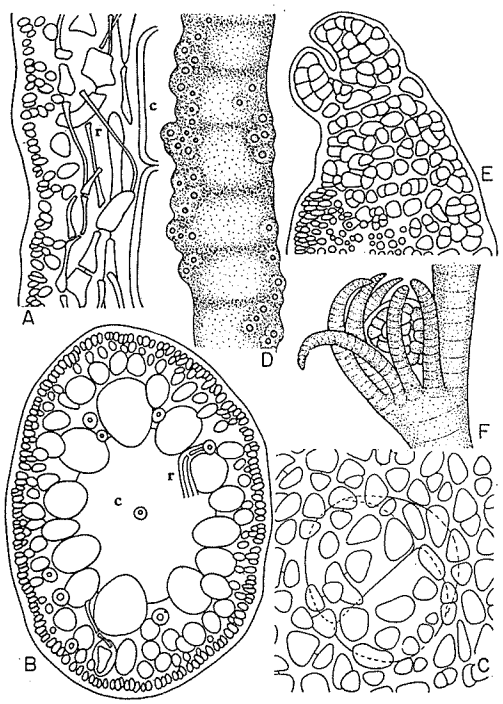

Fig. 17. *Campylaephora crassa* (OKAMURA) NAKAMURA f. *typica* NAKAMURA

A. Portion of longitudinal section of a frond; r. rhizoidal cells; c. central axial cells. × 100. B. Transverse section of a frond. × 77. C. Surface view of a tetrasporiferous frond. × 250. D. Portion of a tetrasporic frond. × 15. E. Frond-apex bearing spermatangia. × 250. F. Cystocarp. × 40.

branches, produced primarily on the adaxial side of branches, gradually spreading over the entire area, borne terminally 1–2 on each outermost cortical cells, elliptical in shape, 4 μ by 6 μ; cystocarps roundich, berry-like, with thick pericarp, provided with 4–9 involucral ramuli; involucres slightly incurved, simple, 1–1½ times as long as nucleus of cystocarp, about 84–140 μ broad, 400–960 μ long; carpospores numerous, oblong or somewhat angular, 36–70 μ by 40–90 μ; colour varying from dark

red to yellowish; substance somewhat cartilaginous, adhering to paper closely or often not so closely in drying.

The plant is always epiphytic on various algae growing in the intertidal belt from early spring to late autumn. Although fairly uncommon, it is distributed in the northern part of Honsyu, Hokkaido, and Saghalien. A single erect frond is given off from a basal conical disc. The main axis is short and stem-like. It branches in a patent dichotomous manner. Ramification usually occurs in the same plane. Every segment has short, usually secund, often irregularly inserted proliferous branchlets, which may be simple or once or twice or many times forked (corymboso-fasciculate branchlets). Some of the proliferations may develop into normal branches. The central axis is formed of thick-walled, large diameter cells. The cortex is so thick that the axis is invisible in the surface view. The development of the rhizoidal cell in the cortex varies. The outer cortical cell is arranged in 3–5 cell groups, in somewhat parenchymatous order. As cortication advances, the arrangement of cortical cells loosens in no fixed order.

The specimens obtained may be separated into four formae, primarily by ramification mode and cortical structure.

Key to the Formae

1. Cortices thin, with poorly developed rhizoidal cells; tetrasporangia whorled around nodes; ramification patent dichotomous . . . . . f. *cymosa*
1. Cortices thick, with richly developed rhizoidal cells; tetrasporangia rather scattered
   2. Proliferous branchlets secundly seriated on the adaxial side of branches
      3. Corymboso-fasciculate branchlets absent; main branches usually 7–8 times bifurcated; branches distantly branched . . . . . f. *typica*
      3. Corymboso-fasciculate branchlets scarce; main branches usually 10–12 times bifurcated; in tetrasporic plants branches elongated, distantly branched; in sexual plants fronds more slender and often curled . . . . . f. *elongata*
   2. Proliferous branchlets occur on all sides of branches; corymboso-fasciculate branchlets usually numerous; main branches usually 10–12 times bifurcated, always evident, tending to form percurrent axes; branches somewhat alternately branched . . . . . f. *borealis*

f. ***typica*** NAKAMURA

Pl. X, 1–2.

New *Ceramiums* and *Campylaephoras*, 1950, pp. 167–168.

Ceramium crassum OKAMURA

Ceramium secundatum YENDO (non LYNGBYE) in part.

Type Locality: Enosima, Sagami Prov.

Hab.: Enosima, Sagami Prov.; Ôhara, Kazusa Prov. (Y. YAMADA); Tyôsi, Simohusa Prov. (OKAMURA Herb.); Syôbuta, Matusima, Rikuzen Prov. (YENDO Herb.); Ôsima, Sirahama, Susaki Izu Prov. (S. SEGAWA); Susami, Kii Prov. (Herb. Seto Biol. Station).

Plants 4–12 cm. high, patently branched in a regular dichotomous manner; proliferous branchlets secundly seriated on the adaxial side of branches; corymboso-fasciculate branchlets absent; main branches usually 7–8 times, distantly bifurcated; cortices thick, with rhizoidal cells developed richly throughout the entire frond; outer cortical cells somewhat angular, arranged in a somewhat parenchymatous order; tetrasporangia usually scattered.

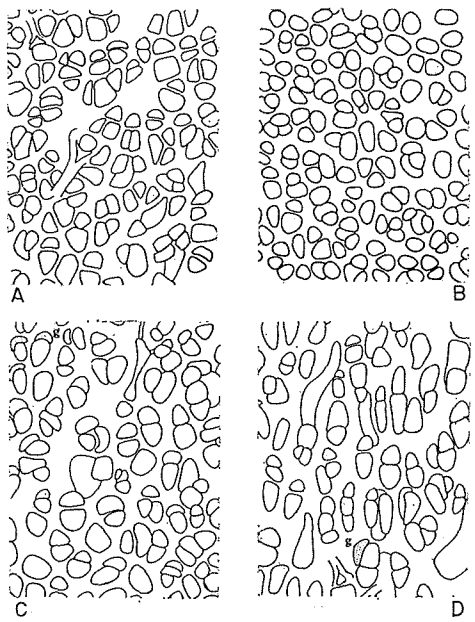

Fig. 18. *Campylaephora crassa* (OKAMURA) NAKAMURA
A–D. Surface view of the cortex in the middle portion of a frond. ×250; g, lenticular cell. A. f. *cymosa* NAKAMURA. B. f. *typica* NAKAMURA. C. f. *borealis* NAKAMURA. D. f. *elongata* NAKAMURA.

This forma is shown in Pl. X, 1–2. The plant is a deep red colour and somewhat cartilaginous, and does not adhere closely to the paper when drying. It branches distantly and dichotomously, assuming a flabellate outline. There are usually a few proliferous branchlets, sometimes almost none. They are always secundly seriated, primarily on the adaxial side of the branches and forkd simply, or one or two times. This is one of the most distinguishing characteristics of the

present forma. In this respect, it is closely related to f. *cymosa*, but may be distinguished from f. *cymosa* by the thickness of the cortex and the arrangement of the tetrasporangia.

f. ***cymosa*** (OKAMURA) NAKAMURA

Pl. X, 3-4.

New *Ceramiums* and *Campylaephoras*, 1950, pp. 168-169, Fig. 7.

Ceramium secundatum YENDO (non LYNGBYE) in part.

Ceramium cymosum OKAMURA in Herb. in part.

Ceramium nitens YENDO (non J. AGARDH) in Herb.

Hab.: Muroran, Iburi Prov.; Osatube, Osima Prov.; Osyoro, Siribesi Prov.; Tomamae, Haboro, Tesio Prov.; Kutugata, Senpôsi, Risiri Il., Esantomari, Kitami Prov. (J. TOKIDA); Syôbuta, Matusima, Takayama, Rikuzen Prov.; Mituhama, Iyo Prov. (YENDO Herb.); Hiroti. Rakuma, Saghalien (J. TOKIDA).

Plants 3-10 cm. high, patently branched in a regular dichotomous manner; proliferous branchlets secundly seriated on the adaxial side of branches; corymboso-fasciculate branchlets absent; main branches bifurcated usually 7-8 times, now distantly, now densely; cortices thin, with rhizoidal cells developed poorly only near the frond-base; outer cortical cells angular, compactly arranged in a parenchymatous order; tetrasporangia whorled around nodes.

In the waters investigated, this forma usually grows on *Phyllospadix* during late summer and autumn. It is a light red colour and somewhat membranaceous, and does not adhere closely to the paper when drying. Ramification of this forma is markedly divaricated. The branching varies from distant (Pl. X, 4) to dense (Pl. X, 3) in a regular dichotomous manner. The most distinguishing characteristics of this forma are a very thin cortex with a poorly developed rhizoidal cell, and tetrasporangia arranged in a single transverse row which is whorled around the node.

f. ***elongata*** NAKAMURA

Pl. XI.

New *Ceramiums* and *Campylaephoras*, 1950, pp. 169-170.

Ceramium secundatum YENDO (non LYNGBYE) in part.

Hab.: Kitami-esasi, Kitami Prov.; Nou, Etigo Prov. (YENDO Herb.); Kosagawa, Ugo Prov. (T. MURAOKA); Zeni, Hiroti, Saghalien (J. TOKIDA).

Tetrasporic plants 10-20 cm. high, branched in a distantly dichotomous manner, often in an alternate or somewhat pinnate manner, almost destitute of proliferous branchlets; both sexual plants 5-15 cm. high, more slender, branched in a somewhat regularly dichotomous manner, furnished with mostly secund proliferous branchlets; corymboso-fasciculate branchlets scarce; main branches bifurcated 10-12 times;

cortices thick, with rhizoidal cells developed richly throughout the frond; outer cortical cells somewhat loosely arranged at least in lower portions of the frond, somewhat roundish in shape; tetrasporangia rather scattered.

This forma is found in Kitami-esasi, Hokkaido, Kosagawa, Ugo Prov., and Nou, Etigo Prov., growing on *Phyllospadix* and *Sargassum*. The plant is a deep red colour and the young or tetrasporic plants are very flaccid to the touch. The older sexual plants are somewhat harsh and do not adhere as closely to the paper when drying as do the younger ones.

The tetrasporic plant branches in a distant, rather irregular dichotomous manner, and when it is displayed on paper, it assumes a sparse subcorymbose or somewhat pinnato-decompound outline (Pl. XI. 1). The sexual plant is more slender than the tetrasporic one. When young, the sexual plant is regularly corymbose and its frond-apex is rolled markedly inwards. As the plant grows, the branching gradually becomes irregular and the frond-apex straightens.

The most distinguishing characteristic of this forma is that the tetrasporic plant differs greatly from the sexual plant in general appearance. In the tetrasporic plant, the branch is elongated, and the arrangement of the outer cortical cells is comparatively loose.

f. ***borealis*** (OKAMURA) NAKAMURA

Pl. XII.

New *Ceramiums* and *Campylaephoras*, 1950, p. 170.

Ceramium boreale OKAMURA in Herb.

Hab.: Muroran, Iburi Prov.; Osatube, Hakodate, Osima Prov.; Osyoro, Siribesi Prov.; Tomamai, Haboro, Tesio Prov.; Kutugata, Senpôsi, Risiri, Il. (J. TOKIDA); Kabuka, Rebun Il. (YENDO Herb.); Honto, Saghalien (J. TOKIDA).

Plants 5–25 cm. high, branched usually irregular dichotomously, often alternately; proliferous branchlets irregularly inserted on all sides of branches; corymboso-fasciculate branchlets usually numerous; main branches always prominent, tending to form percurrent axes, densely bifurcated usually 10–12 times; cortices thick, with rhizoidal cells developed richly throughout the frond; outer cortical cells arranged in two or three cell groups with somewhat regular order; tetrasporangia usually scattered.

This forma is widely distributed in Hokkaido, growing on various algae. The plant is deep red, varying to pinkish red in colour, and is somewhat flaccid to the touch, adhering closely to the paper when drying. The general appearance of this forma varies considerably, but it is always characterized by a prominent main branch which tends to form a percurrent axis. The branching is somewhat irregularly dichotomous or alternate. Every segment usually has irregularly

inserted, proliferous branchlets on all sides of the branches. Some of the proliferations may develop into normal branches, assuming a corymboso-fasciculate appearance. There are usually many of these corymboso-fasciculate branchlets along the main branch, and this is one of the most distinguishing characteristics of this forma.

Campylaephora hypnaeoides J. AGARDH

Pls. XIII-XIV; Fig. 19.

Sp. II, 1851, p. 150; Id., Epicr., 1876, p. 108; SURINGAR Alg. Jap., 1870, p. 28, t. XIV, Figs. 1-4; DE TONI, Phyc. Jap. Nov., 1895, p. 36; Id., Syll. Alg. IV, 1903, p. 1503; Id., l. c. VI, 1924, p. 526; OKAMURA, Alg. Jap. Exc. No. 80; Id., Nippon Sôrui-meii, 1st ed., 1902 p. 83, 2nd ed., 1916, p. 100; YENDO, Kaisan-Syokubutugaku, 1911, p. 689, Fig. 197; OKAMURA, Icon. Jap. Alg. II, 1910, p. 99, Pl. 79, Figs. 1-13; Id., Propagation of *Campylaephora hypnaeoides*, 1922, p. 45; SINOVA, Mar. Alg. Commander Is., 1940, p. 124; NAKAMURA, New *Ceram. Camp.*, 1950, pp. 170-171, Fig. b, f; Id., Str. Repr., *Cer. Camp.*, 1954, pp. 15-62, Fig. 9 (1), 17 (5).

Ceramium hypnaeoides (J. AGARDH) OKAMURA, On *Campylaephora hypnaeoides*, 1927, p. 365, Figs. A, B, 1-12; Id., Mar. Alg. Mutsu Bay I, 1927, p. 14; Id., Nippon Kaisôsi, 1936, p. 740, Fig. 354; SEGAWA, Mar. Alg. Susaki, Prov. Idzu, 1935, p. 87; KAWABATA, List Mar., Alg. Shikotan, 1936, p. 210; NAGAI, Mar. Alg. Kurile II, 1941, p. 213; YAMADA and TANAKA, Mar. Alg. Akkesi 1944, p. 74.

Ceramium rubrum (HUDSON) AGARDH var. *firmum* AGARDH, Sp. II, 1828, p. 149.

Ceramium hamatum COTTON, Mar. Alg. Korea, 1906, p. 370; YENDO, Kaisan-Syokubutugaku, 1911, p. 687, Fig. 196; DE TONI, Syll. Alg. VI, 1924, p. 512.

? *Ceramium pumilum* OKAMURA in Mscr.

Jap. name: Egonori (OKAMURA).

Hab.: Both coasts of Honsyu; Hokkaido; Kuriles; Saghalien.

Distr.: Korea; China.

Plants solitary, growing on *Sargassum* or *Laminaria*, 3-20 cm. or more high, primarily erect, afterwards becoming entangled into a large mass with sickle-shaped portions of the frond; ramification regularly dichotomous, occurring in all directions; frond-bases composed of a distinct conical disc, giving off one erect main axis; basal discs 2.0-2.5 mm. in diameter with more or less irregular margin, consisting of rhizoidal cells; main axes usually very short, stem like, divaricately branched successively for a short distance in all directions; main branches ordinally repeatedly branched in a regularly dichotomous manner, bifurcated 10-15 times; branches patent, usually clothed with lateral branchlets, very often naked in older individuals, falling off lesser branches; proliferous branchlets usually numerous, sometimes, simple, sometimes forked or repeatedly dichotomous; terminal portions of branches swollen up behind the apex in sickle-shape; sickle-shaped portions of

the frond very numerous in tetrasporic plants, but scarce in sexual plants, commonly carrying forked branchlets on their apices and outer sides, usually becoming naked in older plants; frond-apices usually forcipated, rolled inwards, sometimes slightly incurved, sometimes straight especially in older plants; lower axils very patent, often distantly divaricated in older plants, becoming gradually narrower upwards, upper axils acute; nodes usually somewhat constricted, often swollen up; articulations opaque, thickly corticated throughout, about 1 mm. broad in older plants,

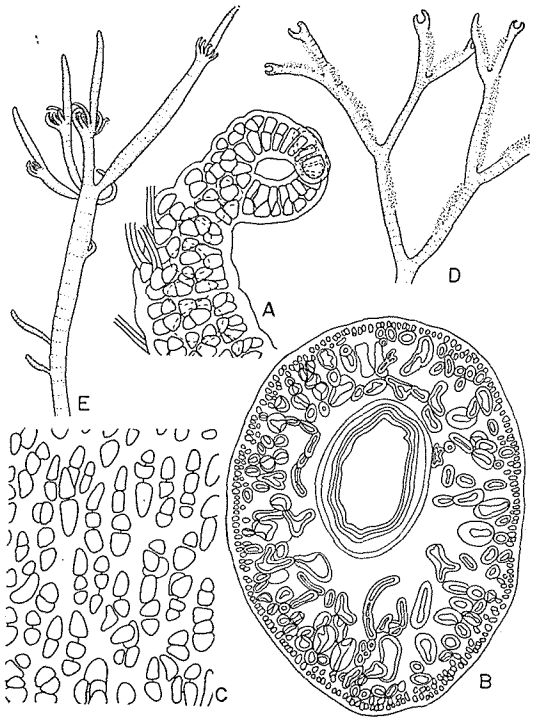

Fig. 19. *Campylaephora hypnaeoides* J. AGARDH
A. Frond-apex. × 250. B. Transverse section of the basal portion of a frond. × ca. 53. C. Surface view of the cortex in the middle portion of a frond. × 250. D. Male plant of f. *hamata* NAKAMURA E. Female plant of f. *hamata* NAKAMURA.

mostly $1\frac{1}{2}$–2 times as long as broad, subequal or slightly shorter in upper portions of the frond and near the frond-base; axial cells cylindrical, thick-walled, 300–500 μ broad in middle portions of the frond, 1–2 times as long as broad; cortices very thick, about 200 μ thick in the frond of 720 μ breadth, gradually becoming thinner upwards, consisting of pericentral, inner cortical, elongated rhizoidal, and outer cortical cells; pericentral cells globular, usually 7 in number, arising from axial

cells in a whorl; inner cortical cells somewhat irregular in shape, given off from pericentral cells; rhizoidal cells in the cortex numerous, 5–10 μ thick, various in length, well developed throughout the entire frond, but becoming scarce upwards, finally destitute of them in the uppermost portions of the frond; outer cortical cells issued from inner cortical cells, unistratose or bistratose, in surface view, somewhat loosely arranged in two or three cell-rows at least in lower portions of the frond, somewhat roundish in shape, 8–10 μ broad, 10–12 μ long; chromatophores parietal laminate in outer cortical cells, discoid in inner cortical cells, filiform in axial cells; hyaline unicellular hairs numerous, covering the entire frond, 4–5 μ thick, 180–200 μ long; tetrasporangia roundish, immersed in cortical layers, scattered all over the frond, enclosed with thick pericarp, divided usually triangularly, often irregularly cruciately, measuring 72–84 μ by 80–84 μ, exclusive of pericarp 5–6 μ thick; spermatangia forming sessile patches on upper branches, produced primarily on the adaxial side of branches, gradually spread over the entire area of branches, borne terminally, usually 2 on each outermost cortical cells, elliptical, 4 μ by 6 μ; cystocarps roundish, lateral on branches or terminal on proliferous branchlets, provided with 4–6 involucral ramuli; involucres slender, somewhat strongly incurved, about $1\frac{1}{2}$–2 times as long as nucleus of cytocarp; carpospores numerous, oblong, somewhat angular, 60–65 μ broad, 85–130 μ long; colour varying from dark red to yellowish; substance membranaceous in younger fronds or in plants from calm seas, more cartilaginous in older fronds or in plants from rough seas, the former somewhat flaccid, the latter somewhat harsh to the touch, adhering to paper not so closely, or not at all in drying.

This plant grows on *Sargassum* and *Laminaria*, never on rocks. It is one of the most widely distributed species on both coasts of Japan, but the writer has not as yet observed it on the coast of the Okhotsk Sea. The general appearance of the plant varies greatly, but it is clearly charcterized by the sickle-shaped portion of the frond.

When young, the plant usually branches in a regularly dichotomous manner (Pl. XIV, 1), but as it grows, the branching becomes irregular and profusedly entangled with the sickle-shaped portions of the frond (Pl. XIV, 2). The frond-base consists of a distinct conical disc from which a single frond stands erect. The main axis is short and stem like. Two main branches are given off divaricately, and subsequently, two main branches in the opposite plane. Ramification of the main branch thus occurs in all directions, and this is one of the most distinguishing characteristics of this species. When young, the frond is slender and membranaceous, but as it grows it becomes robust and cartilaginous. In addition, plants from the Japan Sea coast are generally more robust and cartilaginous than those from the pacific coast. The frond is thickly corticated throughout the entire frond

which is usually constricted at the nodes, and often at the centre of the internodes.

The tetrasporic plant is very common, but both male and female plants are rare. Occasionally tetrasporangia and cystocarps are produced in the same frond, but in such cases there are usually fewer cystocarps than tetrasporangia, indicating that the cystocarps are borne on the tetrasporic plant. Plants of both sexes are often far smaller than the tetrasporic plants, as is shown in Pl. XIII, 6–7. They are less than 5 cm. high and usually do not have sickle-shaped portions of the frond. The minute specimen shown in Pl. XIII, 6 was collected by the writer at Muroran in June. This plant agrees well with a typical specimen of *Camp. hypnaeoides*, except for its minute habit and the absence of sickle-shaped portions in the frond. Many similar specimens have been collected by the writer at Osyoro, Hokkaido and Maizuru, Tango Prov. and by S. ARASAKI at Morozaki, Mikawa Prov., and I. UMEZAKI at Maizuru. These specimens are less than 2 cm. high and are all fertile, but, as far as the writer could examine, there were no tetrasporic plants. It seems safe therefore, to regard them as a dwarf sexual form of this species.

Two formae are distinguished primarily by habit and ramification. One of them is the f. *typica* shown in Pls. XIII, 6–7, XIV, the other is f. *hamata*, illustrated in Pl. XIII, 1–5.

Key to the Formae

1. Fronds vigorous, usually forming a large entangled mass, growing on *Sargassum* in rough seas; ramification comparatively sparse, more or less irregularly dichotomous . . . . . f. *typica*
1. Fronds slender, assuming an elegant arbuscular appearance, growing on *Laminaria* in calm seas; ramification dense, regularly dichotomous . . . . . f. *hamata*

f. ***typica*** NAKAMURA

Pls. XIII, 6–7, XIV.

New *Ceramiums* and *Campylaephoras*, 1950, p. 171.

Hab.: Hanasaki, Nemuro Prov. (J. TOKIDA); Kiritappu (J. TOKIDA), Akkesi, Kusiro, Kusiro Prov.; Samani, Hidaka Prov.; Muroran, Iburi Prov.; Osatube, Hakodate, Esasi, Okusiri-tô (K. INAGAKI), Hukusima and Hukuyama (YENDO Herb.), Osima Prov.; Suttu, Iwanai, Osyoro, Siribesi Prov.; Masike, Haboro, Tomamae, Tesio Prov.; Wakkanai, Kitami Prov.; Ôma, Natutomarisaki, Mutu Prov. (Y. YAMADA); Syôbuta, Rikuzen Prov. (YENDO Herb.); Enosima, Sagami Prov.; Simoda (YENDO Herb), Susaki (S. SEGAWA), Izu Prov.; Morozaki, Ebima, Mikawa Prov. (S. ARASAKI); Nakiri, Sima Prov. (YENDO Herb.), Bingo Nada (I. TAKI); Hizen Prov. (YENDO Herb.); Hinomisaki, Izumo Prov.; Maizuru, Tango Prov.; Wazima, Noto Prov. (T. MURAOKA); Nô, Kaifu-ura, Etigo Prov. (YENDO Herb.); Kosagawa, Ugo Prov.;

Hukaura (T. KANDA), Ajigasawa and Tappizaki (YENDO Herb.), Mutu Prov.; Etorohu (OKAMURA Herb.); Sikotan (S. KAWABATA), Kunasiri (M. NAGAI), Kuriles; Tirie, Airoppu, Rakuma, Ôdomari, Nobori, Tisiya, Saghalien (J. TOKIDA).

Plants vigorous, usually more than 20 cm. high and more than 1 mm. in diameter, commonly entangled, growing usually on *Sargassum*, rarely on *Laminaria* in rough seas; ramification more or less irregularly dichotomous, more often alternate; sickle-shaped portions of the frond always present in both sexual and asexual plants.

Plants growing on *Laminaria* are more regularly dichotomous in branching than those growing on *Sargassum*. They are widely distributed along almost the entire coast of Japan, and are usually used as the raw material of "Kanten" or seaweed jelly. The best quality of this marketable seaweed is obtained in Hekura Islets, Prov. Noto.

f. ***hamata*** (COTTON) NAKAMURA

New *Ceramiums* and *Campylaephoras*, 1950, p. 171.

Ceramium hamatum COTTON

Hab.: Osyoro, Siribesi Prov.; Haboro, Tesio Prov.

Distr.: Korea.

Plants slender, 3–15 cm. high, less than 1 mm. in diameter, forming an elegant arbuscular feature, growing on *Laminaria* in calm seas; ramification regularly dichotomous, occurring densely in all directions, tetrasporic or the oldest sexual plants somewhat intricated irregularly; sickle-shaped portions of the frond usually absent in both sexual plants; cortices thinner than f. *typica*.

This plant is found in calm seas at Osyoro, Siribesi Prov., Hokkaido, growing on *Laminaria*. It may easily be distinguished from f. *typica* by its slender and elegant arbuscular appearance. The sexual plant is usually about 5 cm. high and generally does not have sickle-shaped portions in the frond (Pl. XIII, 1, 3), exept for the oldest plants, which are shown in Pl. XIII, 2, 4. The tetrasporic plant, however, is commonly entangled with these sickle-shaped portions of the frond, although less so than the f. *typica* (Pl. XIII, 5). The cortex is far thinner in this forma than in f. *typica*.

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PLATE I

1. *Ceramium codii* (RICHARDS) G. MAZOYER

Epiphytic on *Codium divaricatum*.
No. 25860, SAP. × 7/5.

2. *Ceramium cimbricum* H. PETERSEN

No. 25864, SAP. ×1.

3. *Ceramium fastigiatum* HARVEY

No. 25862, SAP. × 3/2.

4. *Ceramium tenerrimum* (MARTENS) OKAMURA

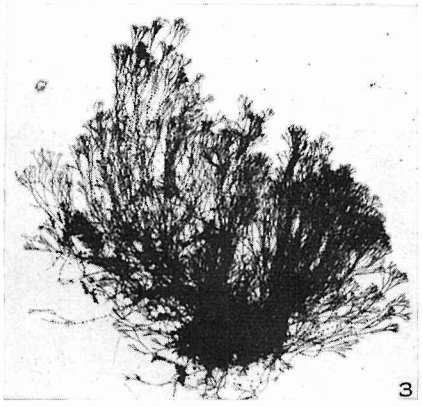
No. 25861, SAP. × 1/2.

5. *Ceramium gracillimum* GRIFFITHS and HARVEY

No. 25854, SAP. × 6/5.

6. *Ceramium gracillimum* GRIFFITHS and HARVEY

Epiphytic on *Phyllospadix*.
No. 25855, SAP. × 3/5.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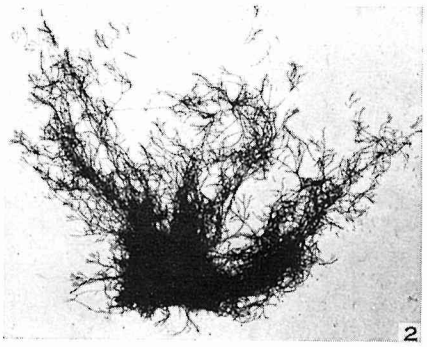
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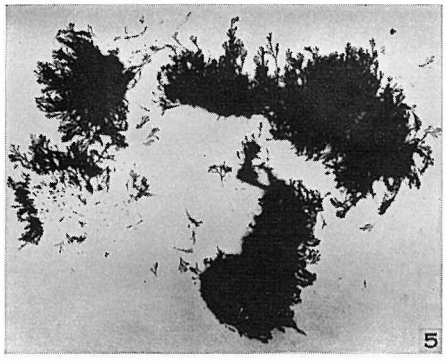
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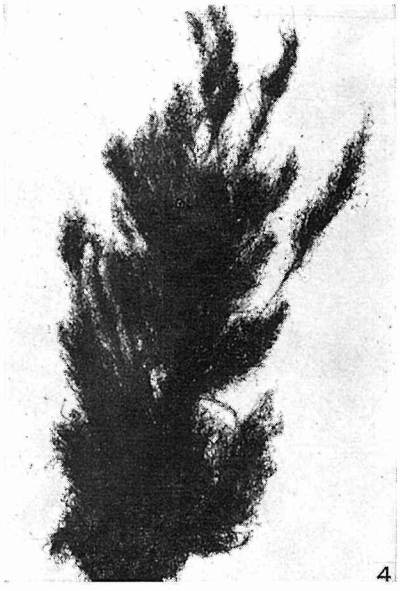
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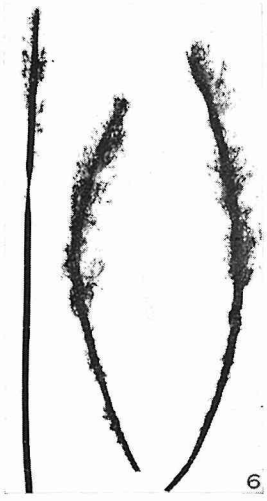
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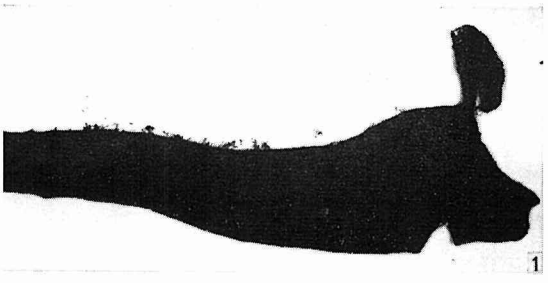
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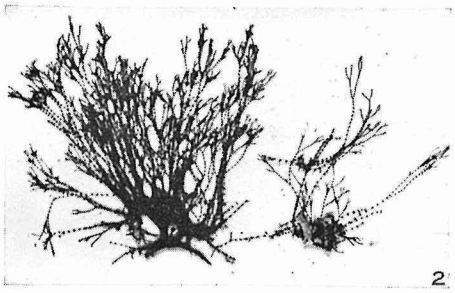
PLATE II

Ceramium aduncum NAKAMURA

1. Tetrasporic plant.
2. Cystocarpic plant. No. 25858, SAP. × ca. 2.

Ceramium tenuissimum (LYNGBYE) J. AGARDH

3. No. 25852, SAP. × 6/5.
4. Half a sheet of specimen determined by K. YENDO. No. 25853, SAP. × 6/5.
5. *Ceramium paniculatum* OKAMURA
   No. 25856, SAP. × 1.
6. *Ceramium ciliatum* (ELLIS) DUCLUZEAU.
   No. 25859, SAP. × 12/5.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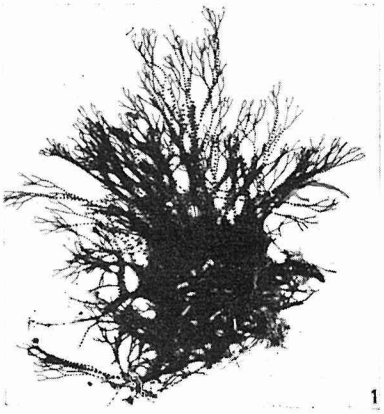
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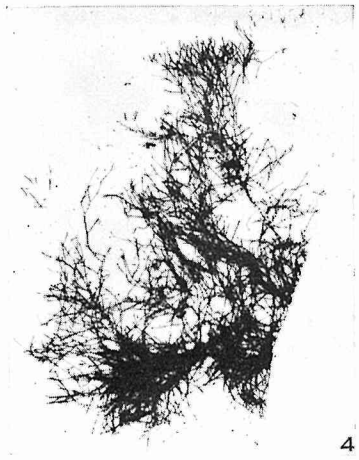
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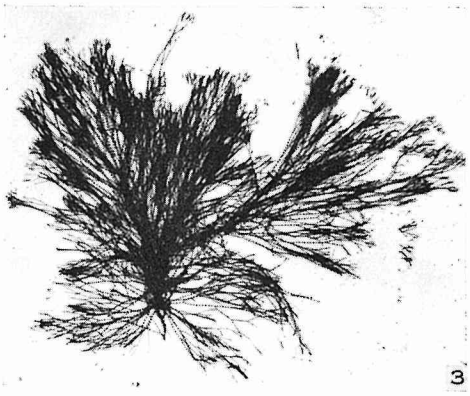
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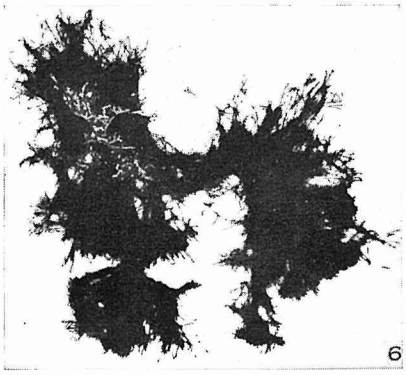
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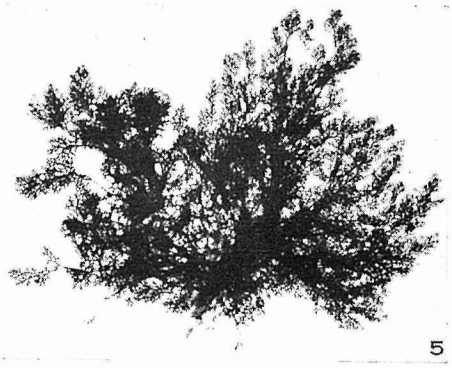
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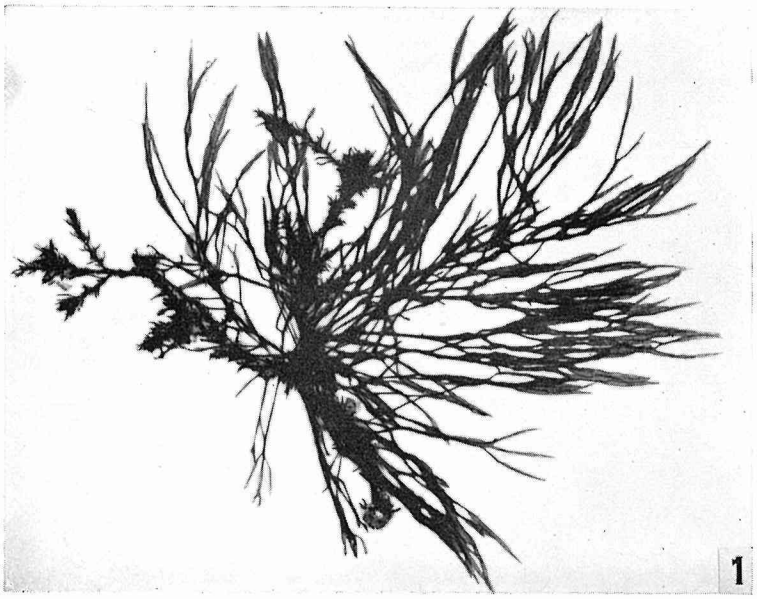
PLATE III

Ceramium japonicum OKAMURA

1. Tetrasporic plant. 2. Cystocarpic plant.
No. 25850, SAP. × 1.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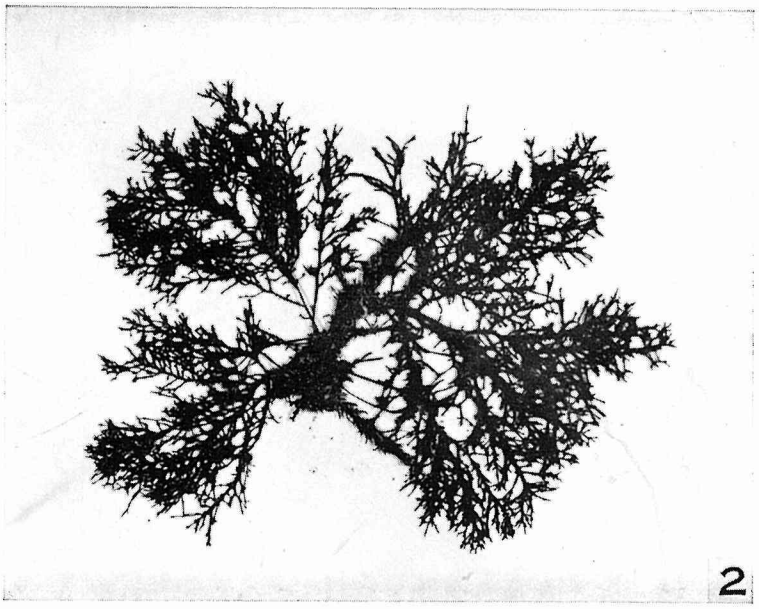
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PLATE IV

1–2. *Ceramium kondoi* YENDO

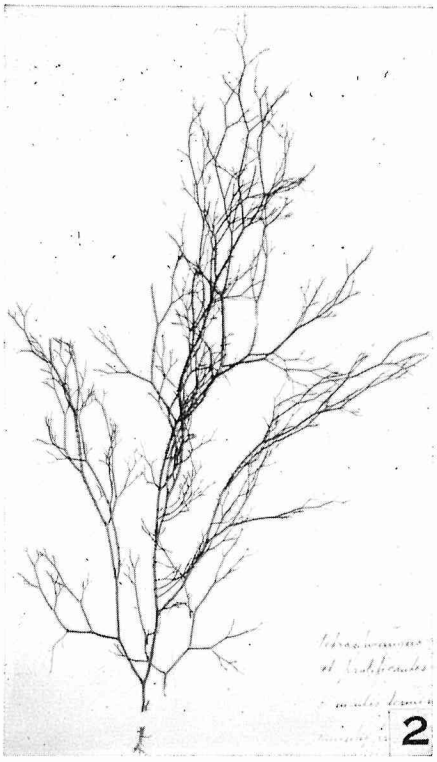
1. The type specimen. Cystocarpic plant. Loc. Hariusu, Siribesi Prov.; June 29, 1905. Leg. K. KONDO. 2. Tetrasporic plant. Loc. Kabuka, Rebun Il.; July 1910. Leg. K. YENDO. YENDO Herb. TI. × 1/2.

3. *Ceramium pedicellatum* YENDO (non J. AGARDH)

Cystocarpic plant. The trichotomous branching is seen on the left hand. Loc. Kabuka, Rebun Il.; July 1910. Leg. K. YENDO. YENDO Herb. TI. × 5/8.

4. *Ceramium rubrum* f. *corymbiferum* YENDO (non J. AGARGH)

Loc. Cape Inubô, Simohusa Prov.; July 1906. YENDO Herb. TI. × 5/8.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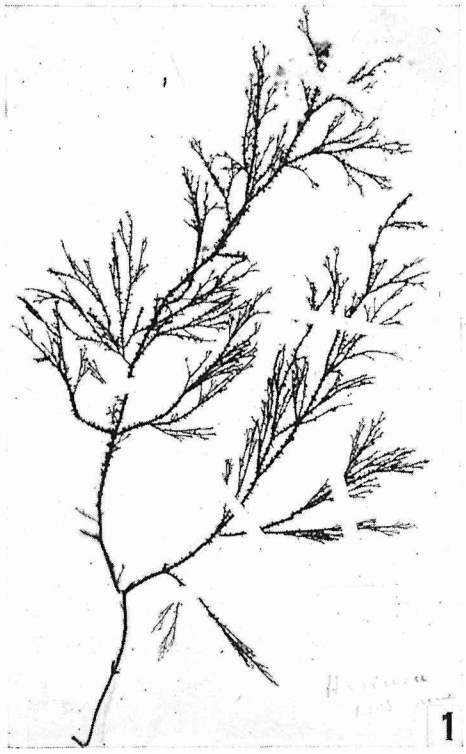
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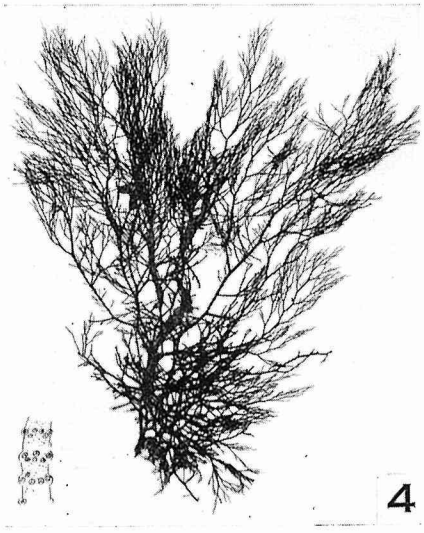
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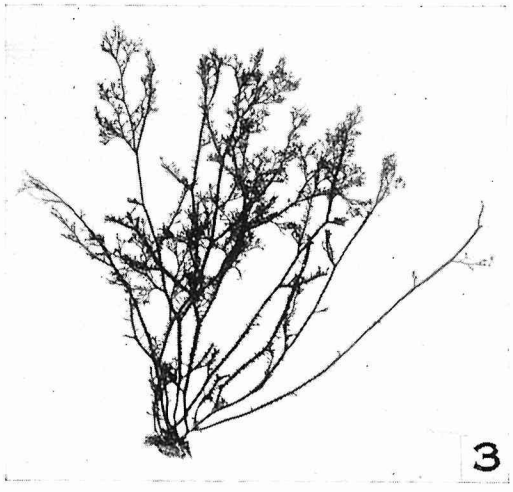

3

PLATE V

Ceramium kondoi YENDO.

1. f. *ambiguum* NAKAMURA

Tetrasporic plant. No. 25849, SAP. × 1/2.

2. f. *ambiguum* NAKAMURA

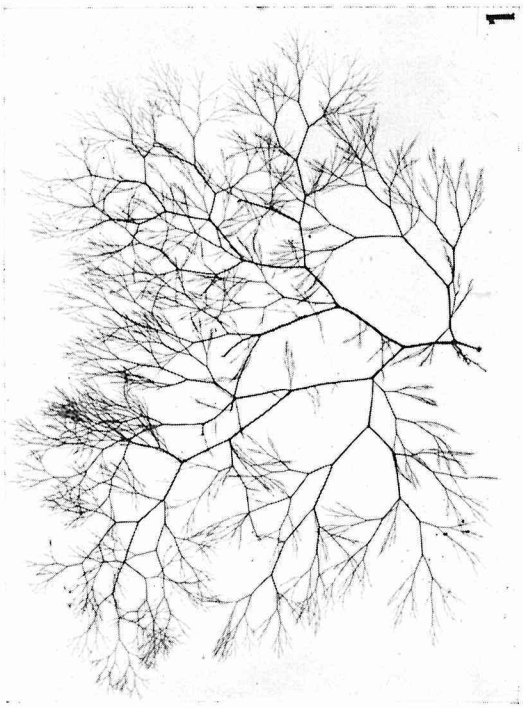
Cystocarpic plant. No. 25849, SAP. × 1/2.

3. f. *abbreviatum* NAKAMURA

Tetrasporic plant. No. 25847, SAP. × 1.

4. f. *abbreviatum* NAKAMURA

Cystocarpic plant. No. 25847, SAP. × 1.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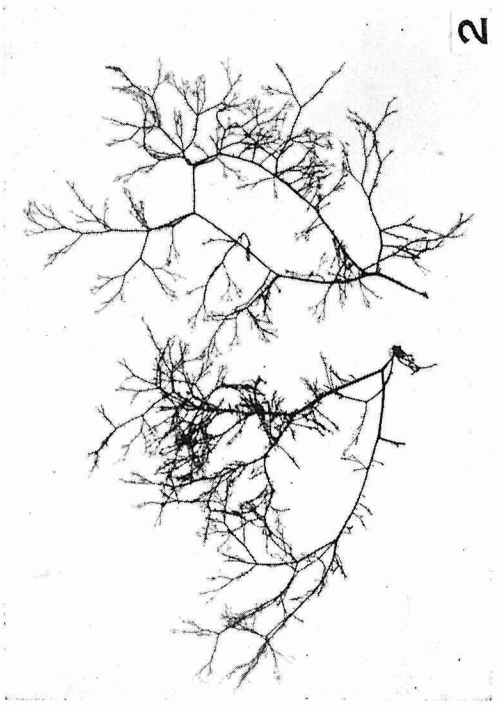
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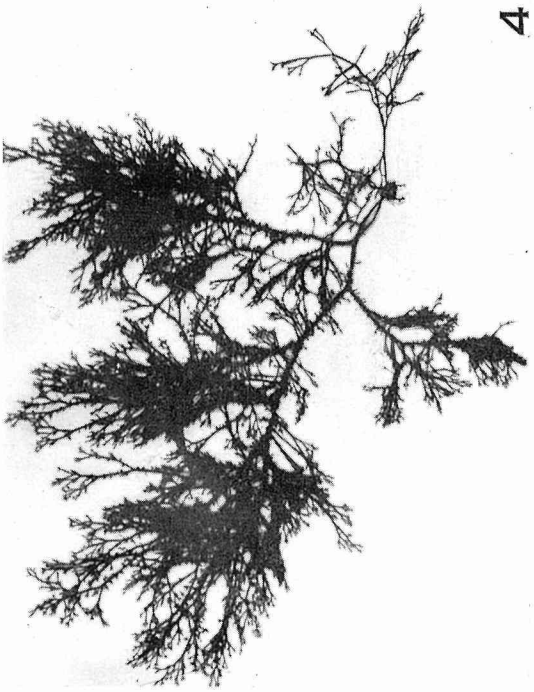
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PLATE VI

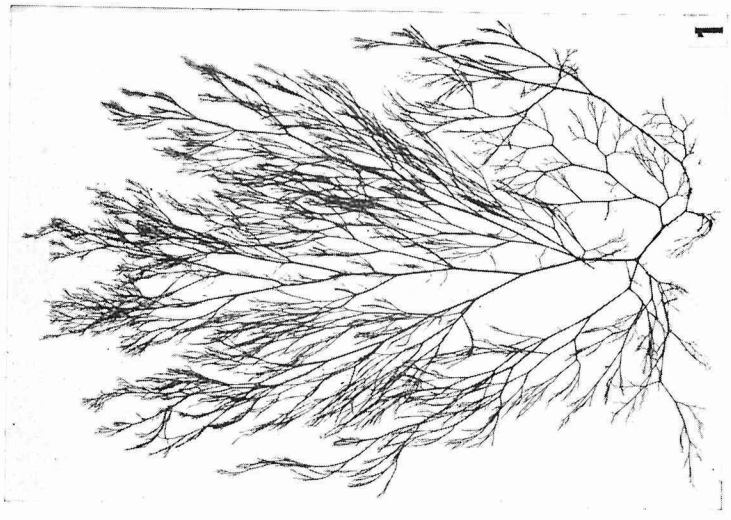
Ceramium kondoi YENDO

1. f. *typicum* NAKAMURA

Tetrasporic plant. No. 25845, SAP. × 2/5.

2. f. *trichotomum* NAKAMURA

No. 25804, SAP. × 2/5.



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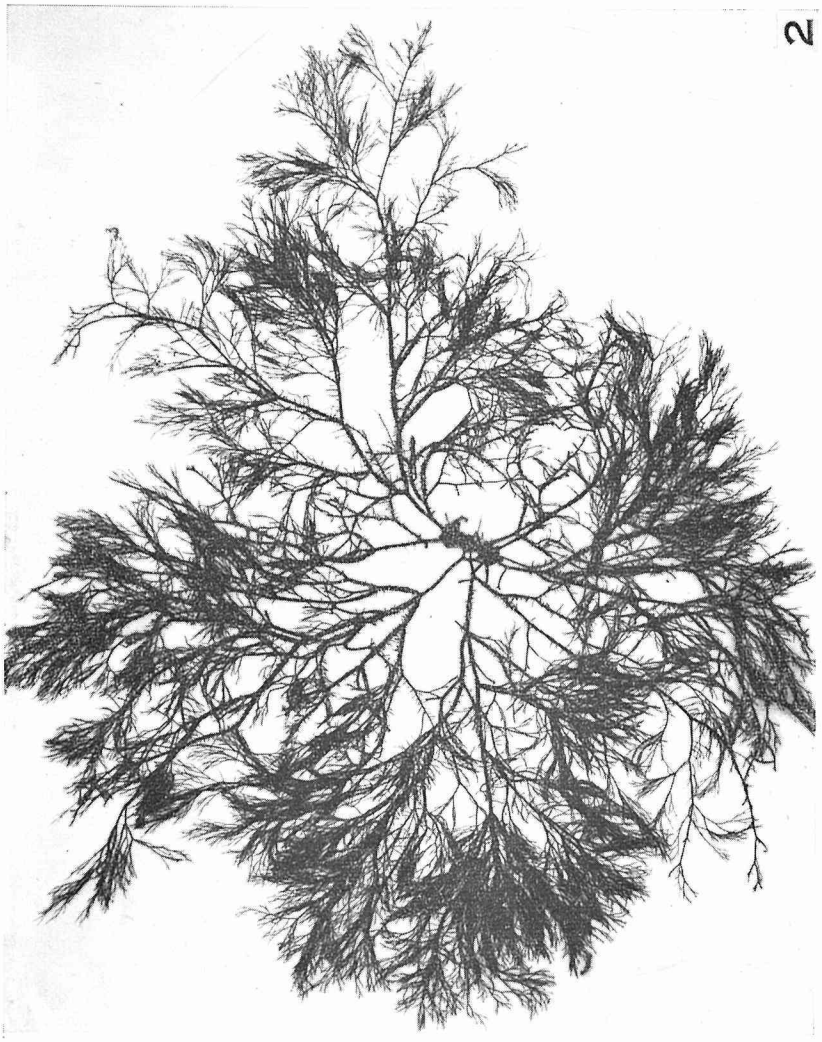


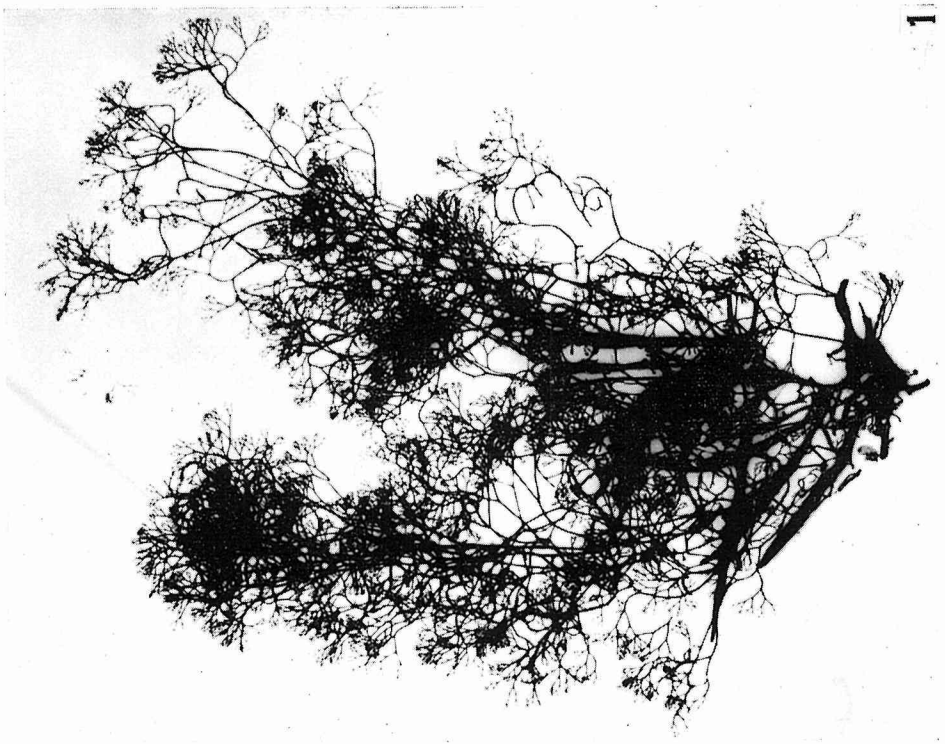
2

PLATE VII

Ceramium boydenii GEPP

1. Young plant epiphytic on *Sargassum* sp. No. 25807, SAP. × 4/5.

2. Tetrasporic plant. No. 25844, SAP. × 2/3.



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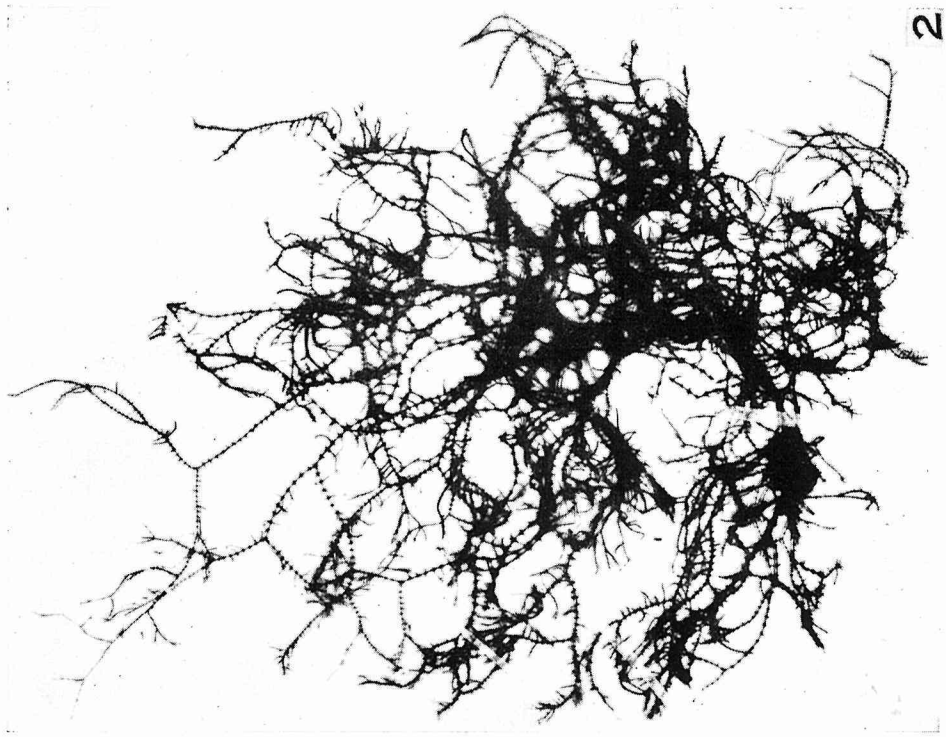


2

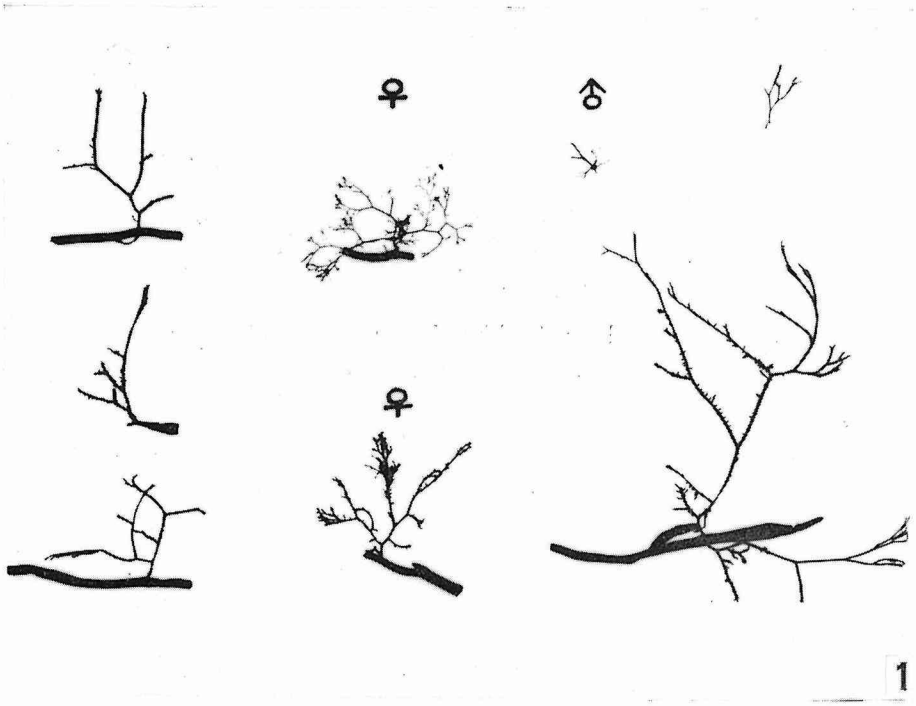
PLATE VIII

1. *Ceramium boydenii* GEPP

Dwarf forms of the plant. No. 25816, SAP. × 9/7.

2. *Campylaephora crassa* (OKAMURA) NAKAMURA
f. *typica* NAKAMURA

Dwarf forms of the plant. No. 25817, SAP. × 5/4.



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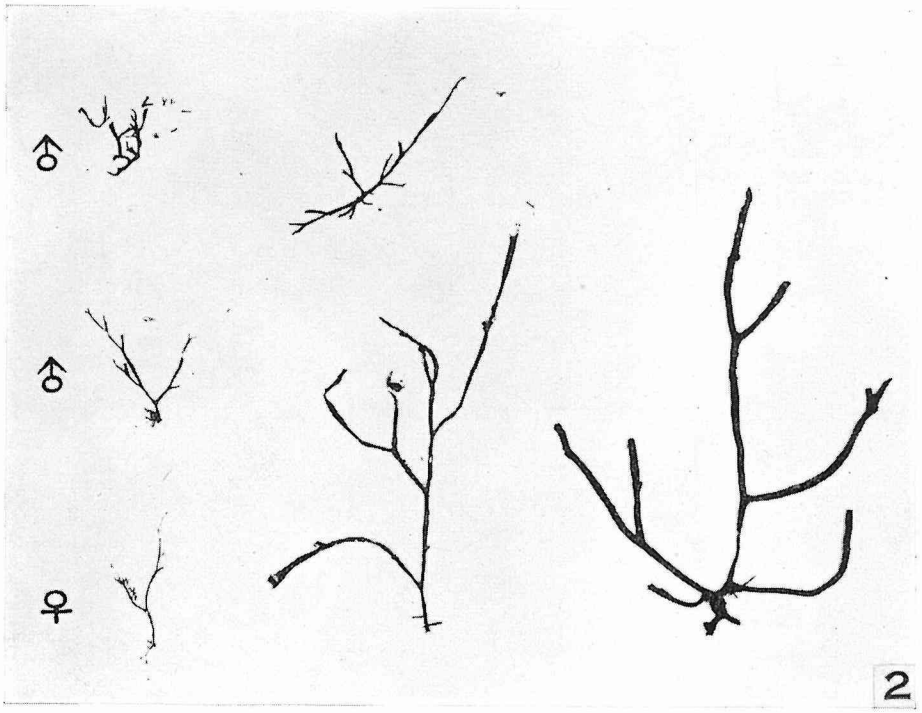
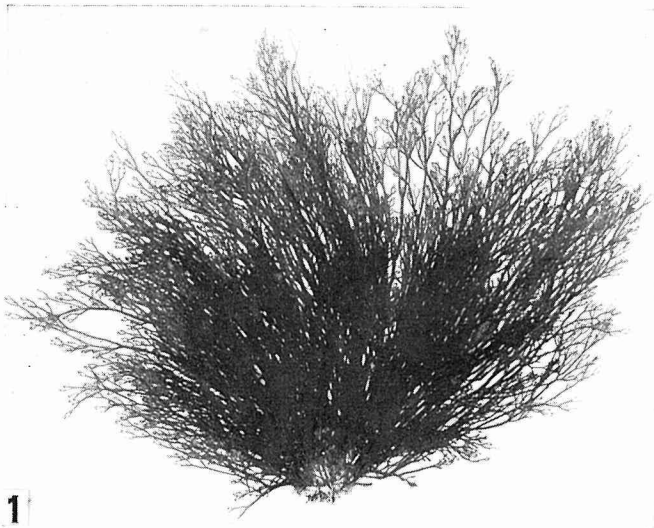


2

PLATE IX

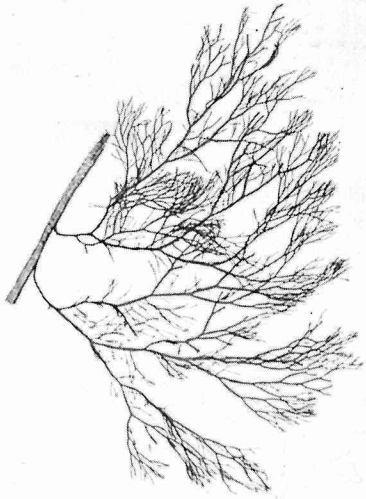
1. Specimen determined by YENDO as *Ceramium rubrum* f. *fasciculatum* J. AGARDH and described by OKAMURA as *Ceramium ochotensis* n. sp. YENDO Herb. TI. × 3/5.
2. Specimen determined by YENDO as *Ceramium secundatum* LYNGBYE. Loc. Syôbuta, Rikuzen Prov.; July 1915. Leg. Mrs. WAINWRIGHT, YENDO Herb. TI. × 1.
3. Original specimen of *Ceramium boreale* OKAMURA. No. 25813 (15336), SAP. × 1/2.
4. Specimen determined by YENDO as *Ceramium secundatum* LYNGBYE, YENDO Herb. TI. × 3/5.



1

4 (No.224)

2



15336

3 Ceramium boreale Okam. sp. nov.

PLATE X

Campylaephora crassa (OKAMURA) NAKAMURA
f. *typica* NAKAMURA

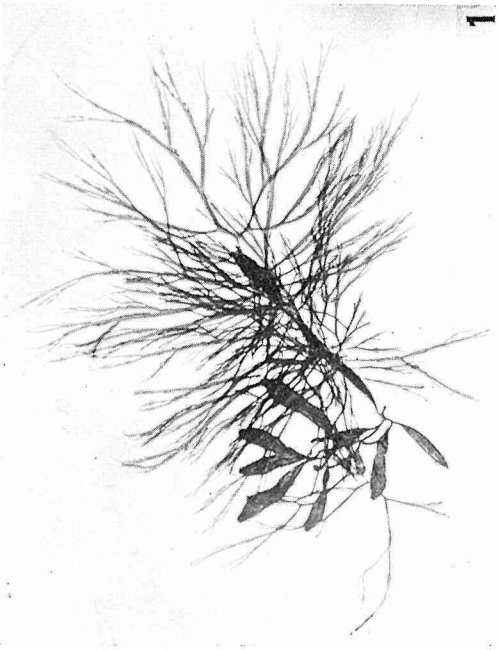
1. Tetrasporic plant. No. 8058, SAP. ×1/2.

2. Cystocarpic plant. TI. × 3/5.

Campylaephora crassa (OKAMURA) NAKAMURA
f. *cymosa* NAKAMURA

3. One tetrasporic plant and two cystocarpic ones growing on *Phyllospadix*. No. 25843, SAP. ×1/2.

4. Tetrasporic plant. No. 25843, SAP. × 5/8.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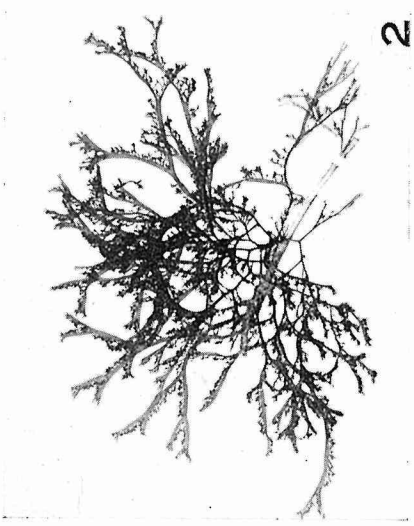
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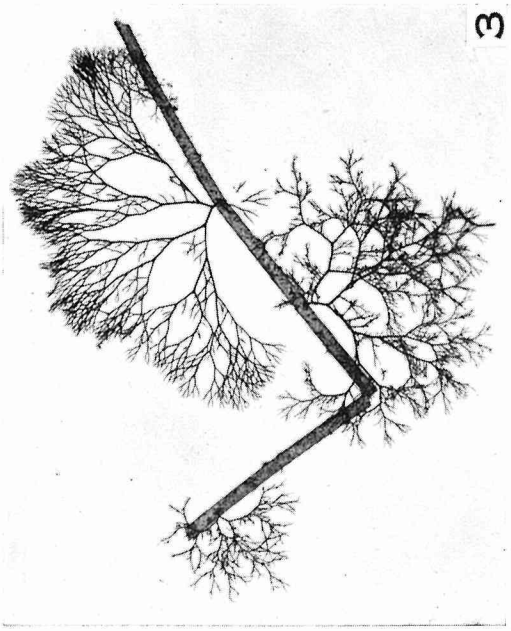
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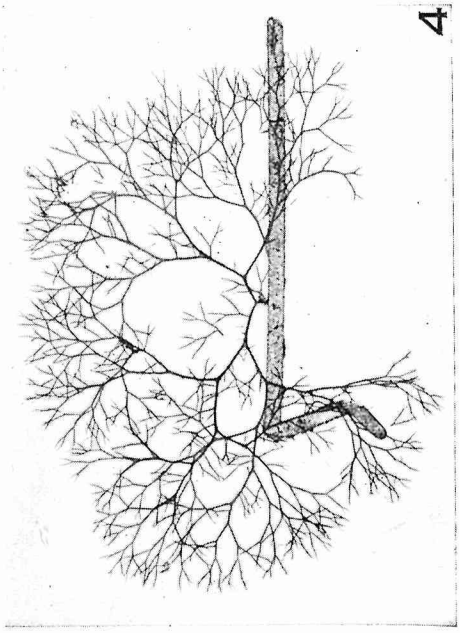
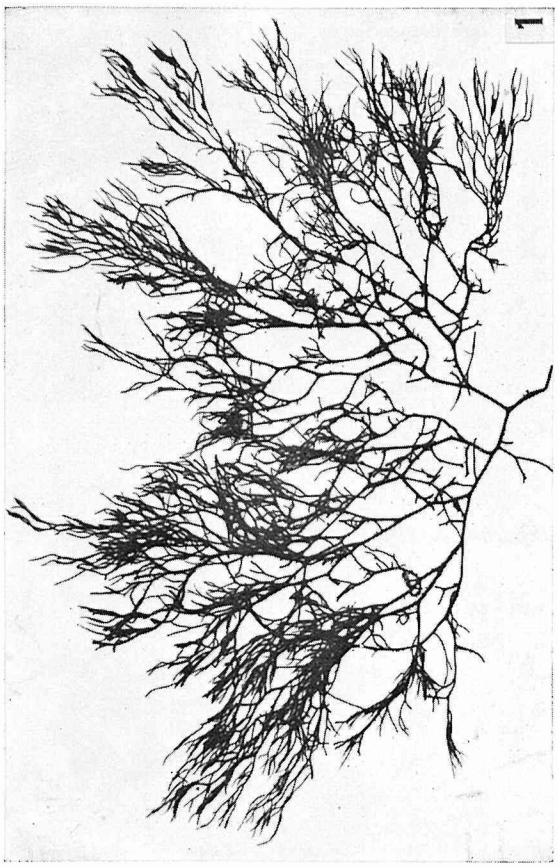

4

PLATE XI

Campylaephora crassa (OKAMURA) NAKAMURA
f. *elongata* NAKAMURA

1. Tetrasporic plant. No. 25795, SAP. × 1/3.
2. Male plant. No. 25828, SAP. × 3/5.
3. Female plant. No. 25796, SAP. × ca. 3/5.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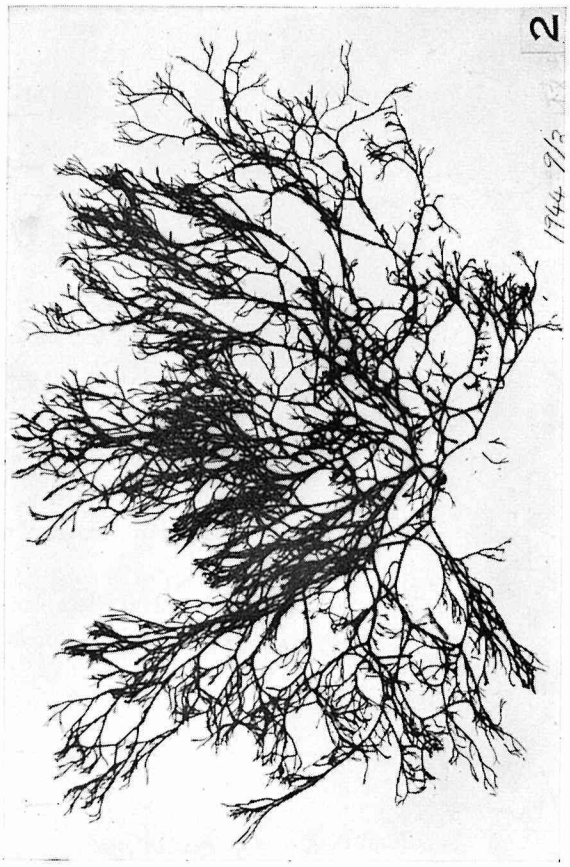
2
1944 9/5

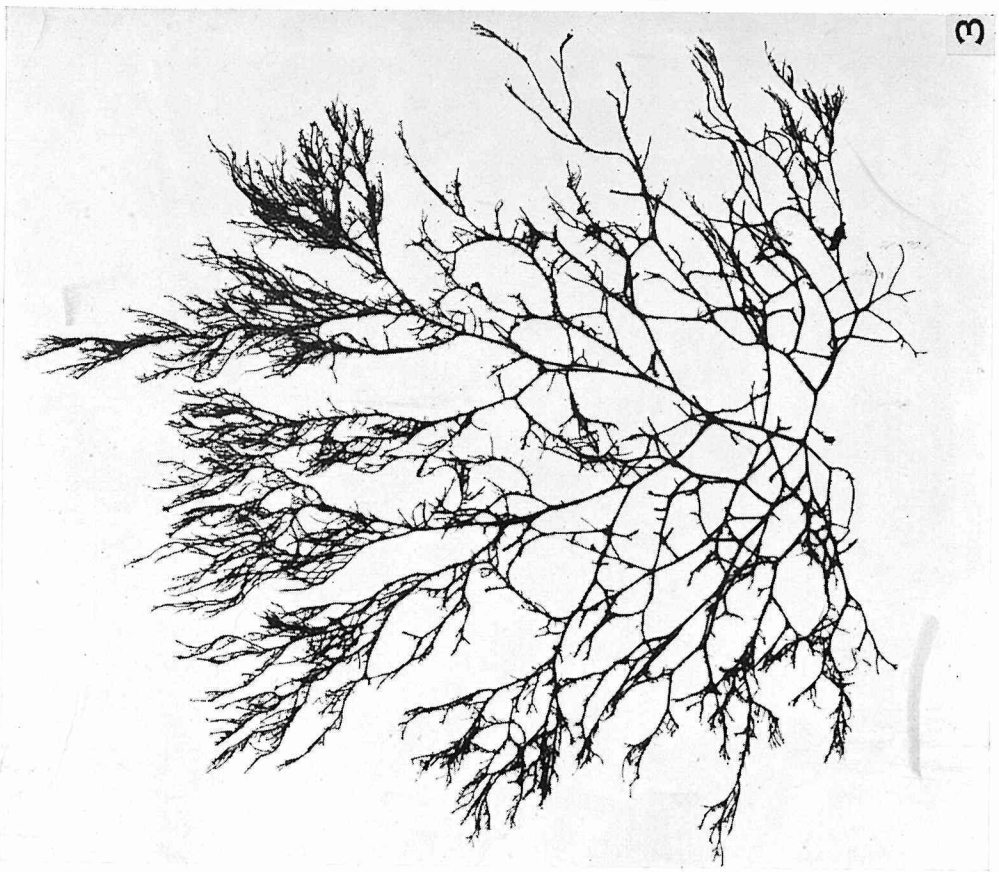
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PLATE XII

Campylaephora crassa (OKAMURA) NAKAMURA
f. *borealis* NAKAMURA

1. Tetrasporic plant (approaching to f. *cymosa* NAKAMURA). No. 25838, SAP. × 4/5.
2. Cystocarpic plant (approaching to f. *cymosa* NAKAMURA). No. 25837, SAP. × 3/5.
3. Tetrasporic plant growing on *Rhodomela* No. 25832, SAP. × 2/5.
4. Tetrasporic plant (left hand) and cystocarpic one (right hand) growing on *Rhodomela*. No. 25833, SAP. × 2/5.

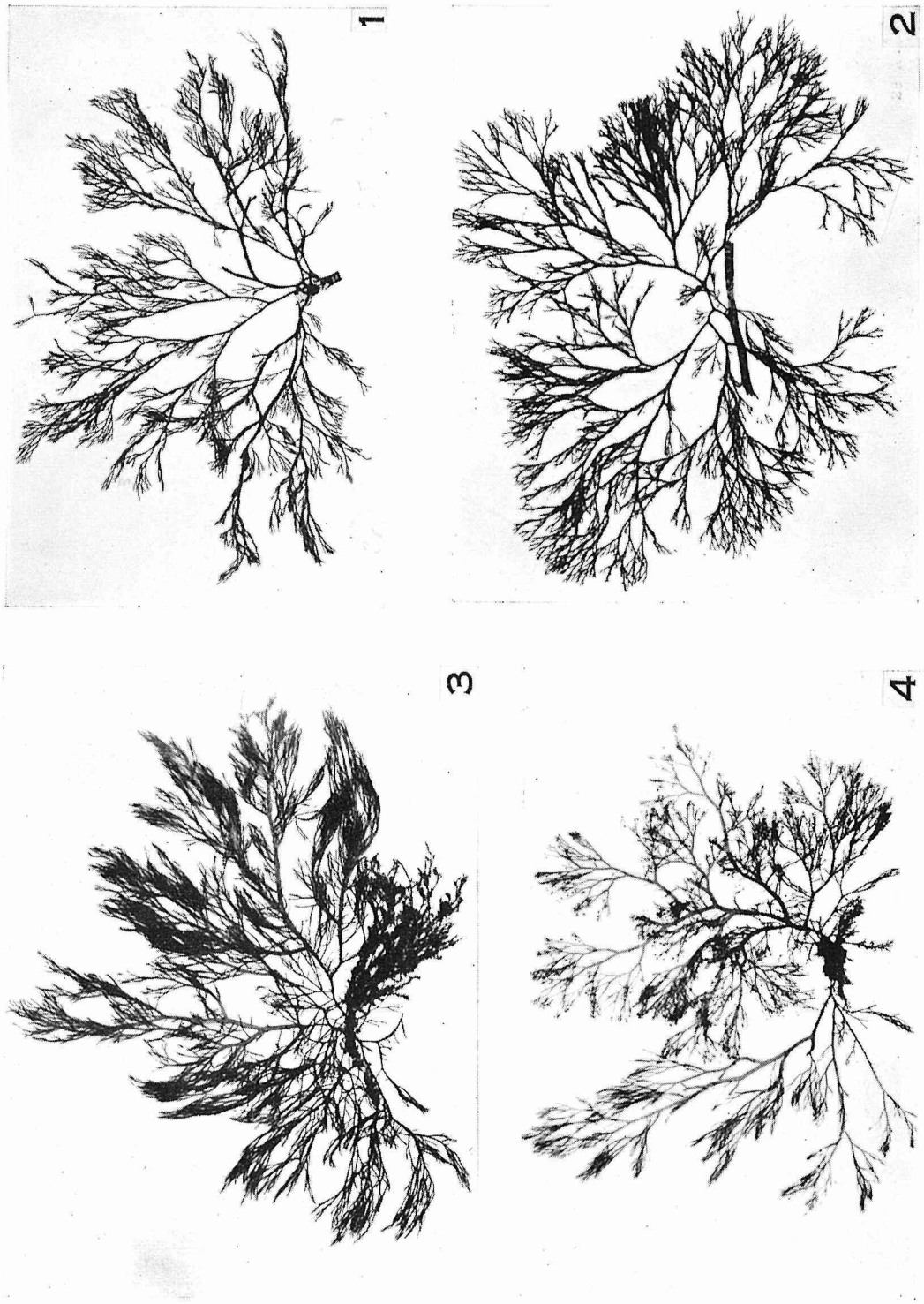

1
2
3
4

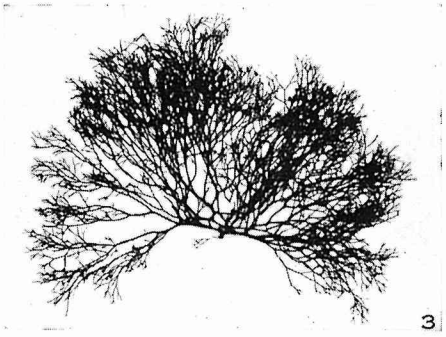
PLATE XIII

1–5. *Campylaephora hypnaeoides* J. AGARDH
f. *hamata* NAKAMURA

1. Male plant. No. 25823, SAP. × 6/5.
2. Older male plant. No. 25823, SAP. × 4/5.
3. Female plant. No. 25823, SAP. × 6/5.
4. Older female plant. No. 25823, SAP. × 3/5.
5. Tetrasporic plant. No. 25822, SAP. × 1/2.

6–7. *Campylaephora hypnaeoides* J. AGARDH
f. *typica* NAKAMURA

6 Dwarf cystocarpic plant. No. 25818, SAP. × 3/2.
7. Cystocarpic plant. No. 25803, SAP. × ca 1.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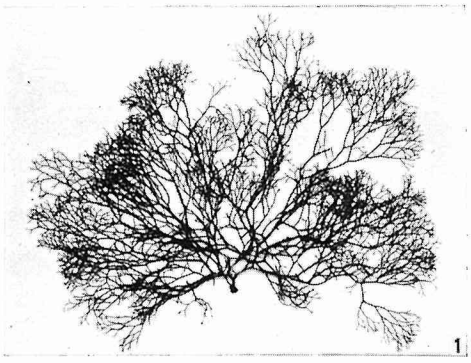
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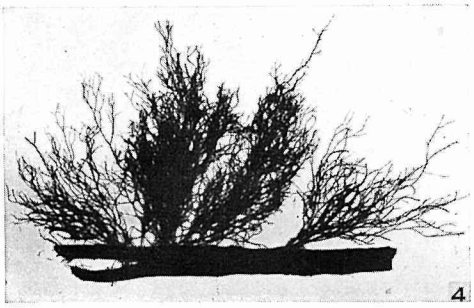
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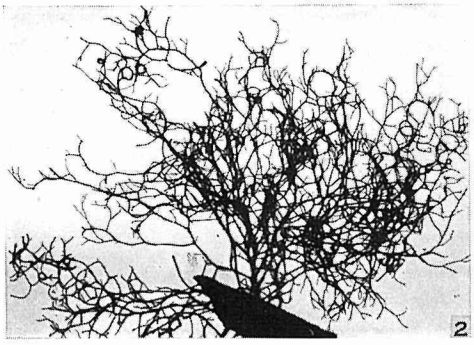
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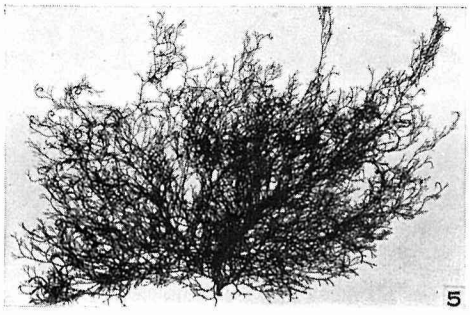
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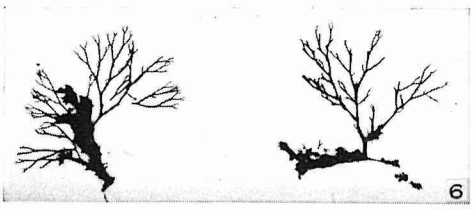
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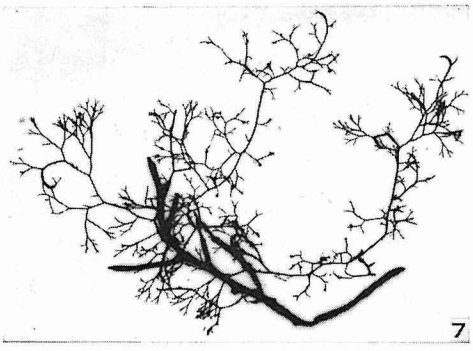
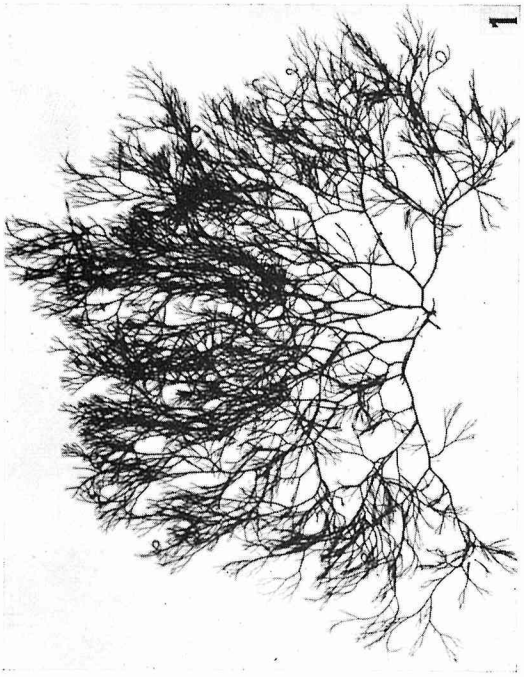

7

PLATE XIV

Campylaephora hypnaeoides J. AGARDH f. *typica* NAKAMURA

1. Young plant growing on *Laminaria*. × 1/2.
2 Older Japan Sea form. No. 25819, SAP. × 1/2.
3. Cystocarpic plant. No. 24530, SAP. × 1/2.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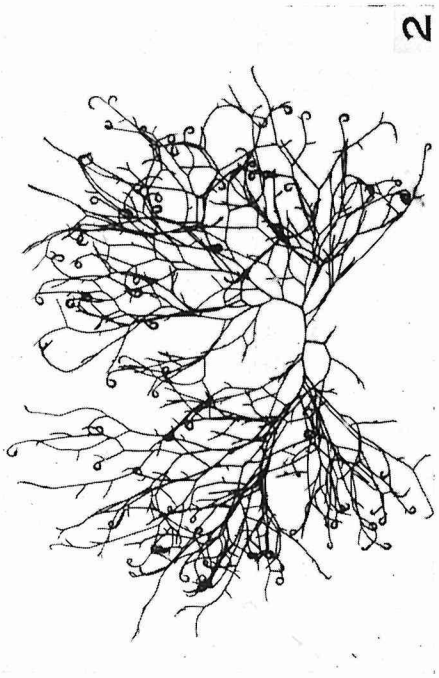
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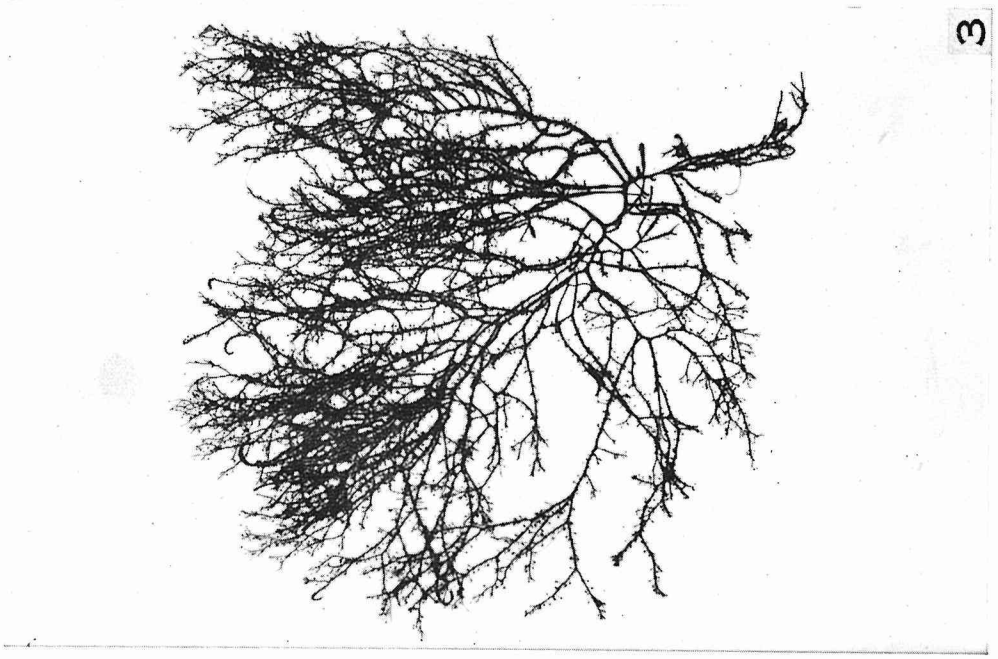
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