New Ceramiums and Campylaephoras from Japan

By

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A study on the genus *Ceramium* and its related genera of Japan, carried on by the writer since 1943, has revealed a number of emendations of the genera and species concerned. The present article deals with two species and seven formae new to science, and with one species and three formae newly combined. Moreover, a division of *Ceramium* into three subgenera and a revision of the generic diagnosis of *Campylaephora* are discussed in this paper. All the specimens, except those of the YENDO Herbarium of the Tokyo University, which are reported in the present paper are deposited in the Herbarium of the Faculty of Science, Hokkaido University.

Sincere thanks are expressed to Prof. Y. YAMADA for his kind guidance during the course of the present work and to Prof. J. TOKIDA for the use of a great number of valuable specimens in his own collections. Thanks are also due to Prof. M. HONDA for the use of the library and the YENDO Herbarium of the Faculty of Science, Tokyo University. The expense incurred in collecting a part of the material for the present study was covered by a grant of the Japan Society for the Promotion of Scientific Research.

Ceramium (ROTH) LYNGBYE

Tent. Hydr. Dan., 1918, p. 117.

1) Subgenus **Hormoceras** (KÜTZING) NAKAMURA comb. et emend. nov.

Hormoceras KÜTZ., Linnaea, 1841, vol. 15, p. 730, 732.
Gongroceras KÜTZ., l. c., p. 730, 735.
Echinoceras KÜTZ., l. c., p. 731, 736.
Acanthoceras KÜTZ., l. c., p. 731, 739.
Chaetoceras KÜTZ., Bot. Zeit., 1847, Vol. 5, p. 34.
Trichoceras KÜTZ., Sp. Alg., 1849, p. 680.
Celeceras KÜTZ., l. c., p. 683.
Euceramium DE TONI, Syll. Alg., IV, 1903, p. 1445, ex parte.

Articulis pellucidis; axibus centralibus monosiphoniis, ad genicula strato corticante zonatis et interstitiis nudis, instructis; ramificatione pseudodichotoma vel dichotoma; tetrasporangiis ad genicula erumpentibus aut aliquantum immersis; cystocarpiis 2–4 lobantibus.

Type species: *Ceramium diaphanum* (ROTH) HARVEY

2) Subgenus **Mesoceramium** NAKAMURA subg. nov.

Euceramium DE TONI Syll. Alg., IV, 1903, p. 1445, ex parte.

Articulis nunc pellucidis nunc haud pellucidis; axibus centralibus monosiphoniis, in partibus superioribus frondium ad genicula strato corticante zonatis et interstitiis nudis, instructis, in partibus inferioribus frondium per strato corticante continuato circumdatis; ramificatione dichotoma; tetrasporangiis ad genicula aliquantum immersis.

Type species: *Ceramium fruticulosum* (KÜTZING) J. AGARDH.

3) Subgenus **Euceramium** DE TONI, ex parte.

Syll. Alg., IV, 1903, p. 1445.

Ceramium KÜTZ., Linnaea, 1841, Vol. 15, p. 731.

Articulis haud pellucidis; axibus centralibus monosiphoniis, per strato corticante continuato circumdatis; ramificatione dichotoma aut trichotoma aut tetrachotoma; tetrasporangiis circa genicula verticillatis aut spargerentibus, inter cellulis corticantibus omnino immersis; cystocarpiis e uno gonimolobo globulari et gonimolobo inchoato compositis.

Type species: *Ceramium rubrum* (HUDSON) AGA DH.

The subgenus *Hormoceras* receives species whose axial cells are zonately corticated only around nodes, leaving hyaline interstices. The subgenus *Mesoceramium* embraces species whose axial cells in the upper part of the frond are zonately corticated only around nodes and those in the remaining part of the frond are completely corticated throughout. No species of this subgenus has as yet discovered in the investigated waters. The subgenus *Euceramium* is the same as the genus *Ceramium* emended by KÜTZING in 1841.

The three subgenera just considered seem to form a progressive sequence from such a primitive type as that of *Cer. Codii* (*Hormoceras*) through intermediate type (*Mesoceramium*) up to the ultimate development of *Cer. Kondoi* in *Euceramium*. The progression from *Hormoceras* to *Euceramium* through *Mesoceramium* seems normal and to afford legitimate argument for retaining these three groups as subgenera of one large polymorphic genus. Nevertheless the possibility suggesting generic cleavage among them should not be entirely excluded. The evidences in support of it are as follows:

In *Hormoceras* a cystocarp consists of two to four gonimolobes, while in *Euceramium* it constitutes a single large globular gonimolobe, usually accompanied by a rudimentary gonimolobe. According to the writer's observations, this distinction in the gross structure of the cystocarp is initiated by the first cell-division of the auxiliary cell to form the mother-cell of gonimoblast.

Other outstanding features which distinguish the two subgenera are: (1) In *Hormoceras* the tetrasporangia are initiated by pericentral cells, while in *Euceramium* they are formed from cortical cells in various orders as well as the pericentral cells. (2) In *Hormoceras* the ramification is pseudodichotomous or dichotomous, whereas in *Euceramium* it shows a progressive sequence from dichotomous to tetrachotomous through trichotomous.

Were the details of structure of reproductive organs definitely determined for all the species of *Ceramium*, it might possibly happen that lines of cleavage or adherence within the group could be found.

Ceramium equisetoides NAKAMURA spec. nov. Text-figs. 1; 2, a.

Frondibus minutis, 5–10 mm. altitudine, per rhizoideis affixis; partibus basalibus frondium repentibus, 1–3 rhizoideas ex eodem nodo frondis emittentibus; rhizoideis basalibus plerumque simplicibus, apicibus bulbosis aut in discum conicalem expansis, 2–3 cellularibus, 20–35 μ crassis; rhizoideis sustentantibus comparate numerosis; ramificatione pseudodichotoma; axillis inferioribus patentibus, superioribus valde acutis; apicibus frondium rectis, fere non forcipatis, saepe emarginatis; margine apicis aequo; articulis in partibus mediis filorum inter bifurcationes diametro 1–1½ plo longioribus, versus extrema ambo filorum sensim brevioribus, ad nodos solummodo corticatis, cingulum distinctum formantibus; nodis fructiferis valde tumidis, nodis aliis non tumidis; cingulis corticantibus plerumque 15–96 μ altis, 80–130 μ crassis, in frondibus fructiferis 100–110 μ altis, 200–250 μ crassis, 5–8 seriebus cellularum proxime isodiametricarum tametsi medio lente majorum longiorumque quam extremo; cellulis corticantibus plus minus angularibus, $8\times8\,\mu$, $8\times18\,\mu$, $12\times14\,\mu$, $12\times18\,\mu$, $12\times22\,\mu$ magnitudine; cellulis axialibus centralibus cylindricis; cellulis glandulinis nullis; chromatophoris in cellulis corticantibus parietalibus sparsis, in cellulis axialibus filiformibus, instructis; pilis unicellularibus hyalinis non observatis; tetrasporangiis verticillatis, immersis sed interdum leviter protrudentibus, ellipsoideis, $20–35\times35–55\,\mu$ magnitudine excepta pericarpia, triangule vel irregulariter cruciatim divisis; antheridiis et cystocarpiis nondum visis; colore rubro-puniceo; natura flaccida, cum siccantur ad papyrum solide adherentibus.

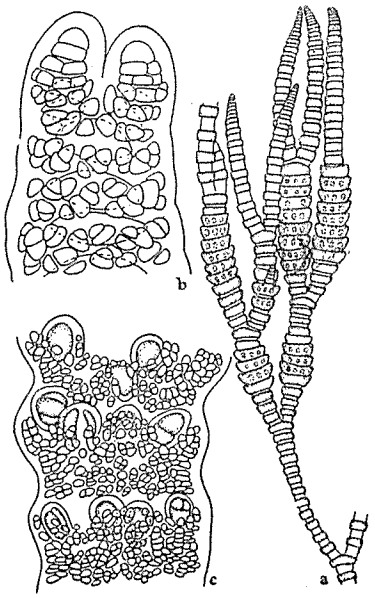

Fig. 1. *Ceramium equisetoides*: a, Part of a tetrasporic plant. ×15; b, Frond-apex. × 250; c, Part of a frond showing an arrangement of tetrasporangia. × 100.

Japanese name: *Tukusi-igisu* (n. n.).

Type Locality: Garanbi, Formosa (T. TANAKA).

The plant was found on other algae, associated with *Cer. gracillimum* and *Centroceras clavulatum*.

The tetrasporiferous branches are exceedingly swollen at their nodes and almost entirely corticated, slightly separated at the centre of the internodes (fig. 1, a, c). The

frond-apices are always straightly elongated and sometimes emarginated (fig. 1, b). These are the most distinguishing characters of this species.

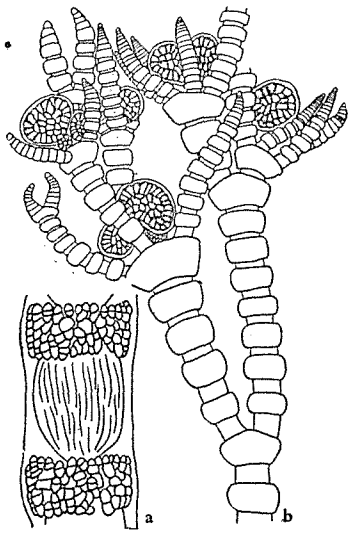

Fig. 2. a, *Ceramium equisetoides*: Part of a frond showing two corticating bands. × 100; b, *Ceramium aduncum*: Part of a cystocarpic plant. × 28.

This species belongs to J. AGARDH's Series 3, *Periclina*, in which the tetrasporangia develop in whorls at the nodes on the last few dichotomies of the frond.

The plant is most closely related to *Cer. Templetonii* SETCH. and GARDN. It, however, differs from *Cer. Templetonii* in the characters of the frond-apices and ramification, and in the swollen feature of tetrasporiferous branches.

Ceramium aduncum NAKAMURA spec. nov.
Text-figs. 2, b; 3.

Ceramium circinatum YENDO (non J. AGARDH), Notes on Alg. New to Japan VI, Bot. Mag. Tokyo, Vol. 31, 1917, p. 92.

Frondibus 1–2 cm. altitudine, capillaris, per rhizoideis affixis; partibus basalibus frondium plus minusve repentibus, 1–2 rhizoideas ex eodem nodo frondis emittentibus; rhizoideis basalibus plerumque simplicibus, apicibus bulbosis aut in discum conicalem expansis, 2–3-cellularibus, 20–50 μ crassis; rhizoideis sustentantibus paucis; ramificatione regulariter dichotoma; axillis inferioribus patentibus, superioribus comparate acutis; apicibus frondium forcipatis et valde incurvatis; margine exteriore apicis dentato; articulis diametro $1-1\frac{1}{2}$ plo longioribus, superne sensim brevioribus; nodis leviter prominentibus, dense corticatis; interstitiis pellucidis, in partibus superioribus frondium semper valde brevibus, inferne sensim longioribus sed plerumque brevioribus quam altitudine cingulorum corticantium; cingulis corticantibus seriebus nonnullis cellularum irregulariter positarum; cellulis corticantibus rotundatis aut plus minus angularibus, $6\times6\,\mu$, $8\times8\,\mu$, $10\times10\,\mu$, $10\times18\,\mu$, $12\times14\,\mu$ magnitudine; cellulis axialibus centralibus cylindricis, superne sensim brevioribus et attenuatis; cellulis glandulinis numerosis, saepe paucis; chromatophoris in cellulis corticantibus parietalibus sparsis, in cellulis axialibus filiformibus, instructis; pilis unicellularibus hyalinis nunc numerosis nunc paucis; tetrasporangiis erumpentibus in lateribus adaxialibus frondium, plerumque in 1–2 seriebus longitudinalibus formantibus, ebracteatis, 40–50 μ diam. excepta pericarpia, triangule divisis; antheridiis partes superiores frondis tegentibus; spermatangiis ellipsoideis, $4\times6\,\mu$ magnitudine, 1–3 spermatangias ex eadem cellula generatrice procreantibus; cystocarpiis 2 4 lobantibus, subterminalibus aut terminalibus, 3–4 ramellis involucrantibus; ramellis involucrantibus plerumque $1-1\frac{1}{2}$ plo longioribus quam diametro cystocarpi; car-

posporiis numerosis, plus minus oblongis, 28–40×40–50 μ magnitudine; colore ex rubro subnigero; natura flaccida, cum siccantur ad papyrum solide adherentibus.

Japanese name: *Maki-igisu* (OKAMURA in Herb.).

Type Locality: Goza, Sima Prov., (YENDO Herb., Tokyo Univ.).

This species is widely distributed in the investigated waters from Formosa to Hokkaido, growing on *Corallina* or *Sargassum* in the intertidal belt.

The corticating bands are in general clearly separated from each other, showing a median, irregular row of large cells, accompanied with two to three layers of outer smaller cells on each side (fig. 3, a, f).

Each corticating band is furnished with a number of gland cells which are deeply stained with erythrosin. The frond-apices are forcipated and strongly roll inwards. The outer edge of the apex is dentate.

The tetrasporangia are apparently erumpent. They are usually arranged in 1–3 or more longitudinal rows at the adaxial side of branches and often somewhat whorled around nodes in the lower portion of the frond.

This new species apparently belongs to J. AGARDH's Series *Ectoclina*, but judging from the structure of corticating band, it is rather referred to the *Ceramium diaphanum* assemblage. In the above mentioned characters, the plant is apparently different from any described species of *Ceramium*.

This plant was described by YENDO as *Cer. circinatum* in 1917 on the basis of the material collected by K. SAIDA at Goza, Sima Prov. An examination of the specimen shows that it is quite different from *Cer. circinatum* in the structure of corticating band and the disposition of tetrasporangia.

SETCHELL and GARDNER (1930) reported a new species of *Ceramium* from Guadalupe Island

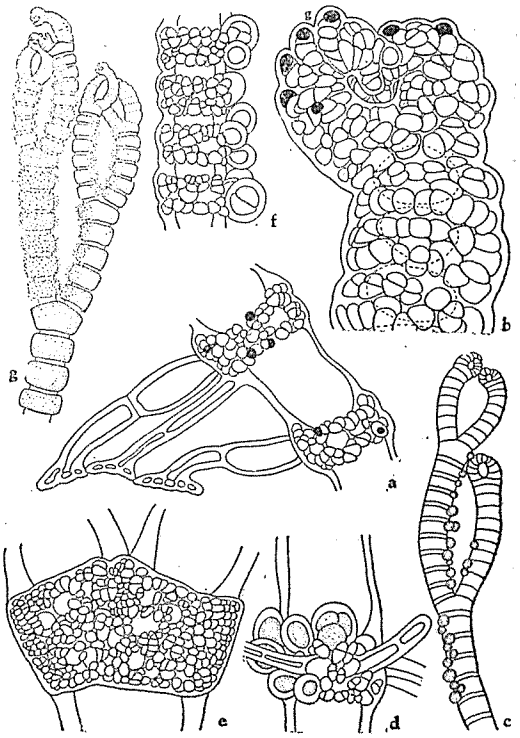

Fig. 3. *Ceramium aduncum*: a, Lower part of a frond issuing basal attachment-rhizoids. × 100; b, Frond-apex showing the dentate outer edge and gland cells (g). × 250; c, Part of a tetrasporic frond showing a seriated arrangement of tetrasporangia. × 28; d, Corticating band, bearing tetrasporangia and issuing supporting-rhizoids. × 100; e, Broader corticating band of a cystocarpic frond. × 100; f, Part of a tetrasporic frond. × 100; g, Upper part of a plant bearing antheridia. × 77.

without giving the plant any name, since the material is scanty and sterile. Judging from their description and figures, the writer's plant seems to be identical with it, especially since both plants have deeply coloured cells in the corticating band. These cells have been suspected by SETCHELL and GARDNER of being monospores or trichome structures, either young or of arrested development, but they appear to correspond to the writer's gland cells. If both the structures are the same, this new species may be identical with the plant from Guadalupe Island.

Ceramium Kondoi YENDO emend. NAKAMURA Text-figs. 4—5.

Novae Alg. Jap. Decas I–III, Bot. Mag. Tokyo, Vol. 34, 1920, p. 9 ; OKAMURA, *Cer. rubrum*-rui ni tuite, Bull. Jap. Soc. Sci. Fisheries, 3, 1935, p. 302 (Abstract in Japanese).

Ceramium rubrum OKAMURA (non AG.), ex parte, Nippon Sôrui-meii, 1st. ed. 1902, p. 82.

Ceramium pedicellatum YENDO (non J. AG.), Notes on Alg. New to Jap. VI, 1917, p. 93.

Ceramium rubrum YENDO (non AG.), Kaisan-Syokubutugaku, 1911, p. 680, fig. 193.

Ceramium rubrum f. *fasciculatum* YENDO (non J. AG.), Notes on Alg. New to Jap. VIII, 1918, p. 79.

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

Ceramium ochotense OKAMURA in Herb., YENDO Herbarium of the Tokyo University.

Japanese name : *Igisu.*

The present species is found growing on rocks or on various algae in the intertidal belt along both coasts of Honsyu, Hokkaido, Kuriles, and Saghalien. The plants are very vigorous, forming a large tuft. The main branches are usually dichotomous or trichotomous, often tetrachotomous. They send a branchlet at each axil in opposite directions by turns, especially in the upper portions of the frond (fig. 4). This fact had already been noticed by YENDO on *Cer. rubrum* f. *fasciculatum* YENDO (non J. AG.). Here the writer proposes to designate this character as "a trichotomous ramification occurs". This is one of the most distinguishing characters of *Cer. Kondoi* YENDO emended by the writer.

In general appearances the plants are very variable, the proliferous branchlets being sometimes almost absent, sometimes very numerous, and also the frond-apices markedly forcipated or almost straight. Nevertheless they are altogether characterized by the trichotomous ramification.

The present species is very closely related to *Ceramium rubrum* (HUDSON) AGARDH. After studying numerous specimens of *Cer. rubrum* from various places of the world, the writer has decided to identify all the materials at hand with *Cer. Kondoi*, distinguishing it from *Cer. rubrum* by the trichotomous ramification and thicker cortex.

Moreover, it was concluded that *Cer. rubrum* (non AGARDH), *Cer. rubrum* f. *fasciculatum* YENDO (*Cer. ochotense* OKAMURA), *Cer. rubrum* f. *corymbiferum* YENDO, and

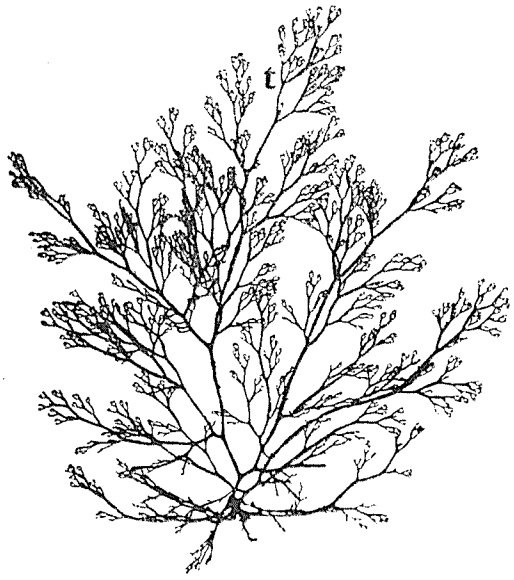

Fig. 4. *Ceramium Kondoi*: Specimen of a young plant showing the trichotomous frond-apices (t) which strongly roll inwards. Loc. Osyoro, Siribesi Prov., 11/II, 1932 (K. INAGAKI). × 7/8.

Cer. pedicellatum YENDO should be combined in one species as *Cer. Kondoi*, broadly extending its specific limit.

The evidence in support of this view follows.

When YENDO (1920, p. 9) established *Cer. Kondoi*, he distinguished it from *Cer. rubrum* by the possession of terminal cystocarps, by the abundance of spinous processes (proliferous branchlets) in the lower portions of the frond, and by the thicker cortex. According to the YENDO's original diagnosis, a striking distinction of *Cer. Kondoi* is the terminal cystocarp. The disposition of cystocarps of the present Japanese material is certainly more dominantly terminal than that of European *Cer. rubrum*. It is obvious, however, that this is an undependable character, since both terminal and lateral cystocarps are very commonly found in the same species of *Ceramium*.

Even though the characters relied upon by YENDO for segregation of *Cer. Kondoi* from *Cer. rubrum* are untenable, both so called Japanese and European *Cer. rubrum* are certainly dissimilar in habit. It was thus concluded by OKAMURA (1935, p. 302) that most of the Japanese materials concerned were rather to be referred to *Cer. Kondoi* than to *Cer. rubrum*. The writer agrees with OKAMURA on this view. According to the OKAMURA's key to the Japanese species of *Ceramium* (1934, unprinted), however, the characters whereby these two species are distinguished, lay in the fact that

in *Cer. Kondoi* the ramification is not so regularly dichotomous as in *Cer. rubrum*, and that the cortex of *Cer. Kondoi* is thicker than that of *Cer. rubrum*. These OKAMURA's methods of separation are not without fault, since the characters just considered are not sufficiently enough to warrant their use in determining species.

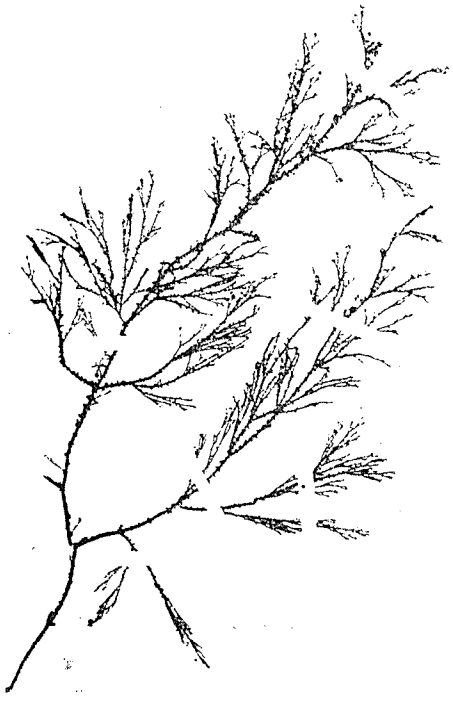

Fig. 5. *Ceramium Kondoi*: Type specimen of cystocarpic plant (Herb. YENDO, Tokyo University). Loc. Hariusu, Siribesi Prov., 29/VI, 1905 (K. KONDÔ). × ½.

The YENDO's original specimen of *Cer. Kondoi* kept in the YENDO Herb. of the Tokyo University consists of two sheets. One is a cystocarpic plant from Hariusu, Siribesi Prov., Hokkaido (fig. 5). Another is a tetrasporic plant from Kabuka, Rebun Island, Hokkaido. The former was collected by K. KONDÔ in the end of June, 1905 and the latter by YENDO in July, 1910. Judging from the general appearances and the date of collection, both specimens are apparently the oldest individuals. On the other hand, after a close examination of the writer's material in various stages in growth, it was found that the YENDO's original specimens were quite similar to the oldest individuals of the writer's plants.

Further, according to the writer's observations, *Cer. rubrum* f. *fasciculatum* YENDO which was given a new name *Cer. ochotense* as a distinct species by OKAMURA is a young or a hibernal form of *Cer. Kondoi*. *Cer. rubrum* f. *corymbiferum* YENDO is closely related to the writer's *Cer. Kondoi* f. *abbreviatum*, and *Cer. pedicellatum* YENDO is apparently a cystocarpic plant of *Cer. Kondoi*.

Furthermore, as to the specific limitation of *Cer. Kondoi*, there is an author's indication on the sheet of a specimen under the name *Cer. rubrum* which is kept in the YENDO Herb. of the Tokyo University. The specimen is labelled with YENDO's handwriting in ink as follows: "This form links f. *fasciculata* and f. *corymbifera*, and at the same time is showing a tendency to approach *Cer. Kondoi*. The forcipate apices are not so remarkable as in f. *fasciculata*, and the spinous processes in the lower parts of frond are not so conspicuous as in *Cer. Kondoi*. It is to be held as f. *corymbifera* showing a transitional stage between the Inuboi specimen noted under note No. 605 (Taisyô 6-nen 6-gatu 4-niti)". This specimen has been photographically reproduced

by YENDO in Kaisan-Syokubutugaku (1911, p. 683, fig. 193).

As has been mentioned in details, the establishment of *Cer. Kondoi* by YENDO is clearly not justifiable. At all events, *Cer. Kondoi*, *Cer. rubrum*, *Cer. rubrum* f. *fasciculatum*, *Cer. rubrum* f. *corymbiferum*, and *Cer. pedicellatum* which were recorded by YENDO are altogether characterized by the trichotomous ramification and thicker cortex. They accordingly are distinguished from so called European *Cer. rubrum* by these characters.

PETERSEN's (1911) pl. IV, figs. 23, 24 and pl. V. fig. 30, however, appear to agree with some specimens of *Cer. Kondoi*. Above all, YENDO's *Cer. rubrum* f. *fasciculatum* which is but the juvenile or hibernal form of *Cer. Kondoi* seems to be quite identical with PETERSEN's. If both the two are truly identical, the following PETERSEN's note is very significant: "The forma *fasciculata* type is perhaps rather to be considered as a species; at all events, it is nearer to a species than the other".

In fact, among fourty-odd sheets of specimens of *Cer. rubrum* from Europe and America, two specimens which are characterized by the trichotomous ramification were found by the writer. One is from St. Malo (MAZÉ, no. 4372, in YAMADA's collection). The other is from Gloucester, southern England and is one of the specimens of the FARLOW Herb. kept in the herbarium of the Faculty of Agriculture, Hokkaido University. In the writer's opinion, the above two specimens are to be rather considered as *Cer. Kondoi*.

On the other hand, the possibility that *Cer. Kondoi* is merged into *Cer. rubrum* should also not be entirely excluded, since the writer's *Cer. Kondoi* f. *ambiguum* appears to be an intermediate type between *Cer. rubrum* and *Cer. Kondoi*. Pending a further study concerning the authentic specimen of *Cer. rubrum*, however, it seems best to consider the present Japanese material as one species, *Cer. Kondoi*.

The four following formae are separable: f. *typicum*, f. *ambiguum*, f. *abbreviatum*, and f. *trichotomum*. These are segregated mainly by habit and the mode of ramification.

f. **typicum** NAKAMURA f. nov.

Frondibus validis, plerumque 10–30 cm. altitudine; axibus praecipuis perspicuis; ramis praecipuis plerumque dichotomis, raro trichotomis, ad eadem axillam unum ramulum, in directiones oppositas mutuo procreante, semper gerentibus; ramis saepenumero dichotomis, in parte superiore frondis plerumque regulariter corymboso-fasciculatis; corticibus comparate tenuibus; tetrasporangiis circa genicula verticillatis, in dispositione aliquantum regulari sitis.

Type Locality: Hariusu, Siribesi Prov., Hokkaido.

The most distinguishing character of this forma is in the fact that the main branches are usually dichotomous and always bear a branchlet at each axil in opposite directions by turns.

Cer. rubrum YENDO, *Cer. rubrum* f. *fasciculatum* YENDO, *Cer. rubrum* OKAMURA are included in the present forma.

f. **ambiguum** NAKAMURA f. nov.

Frondibus floccosis, 10–30 cm. altitudine; axibus praecipuis perspicuis; ramis praecipuis dichotomis, ad eadem axillam unum ramulum, in directiones oppositas mutuo procreante, semper gerentibus; ramis saepenumero dichotomis, alternare pertinentibus; corticibus tenuis, consequenter axibus centralibus a superficie zonatim conspicuis; tetrasporangiis saltem in parte superiore frondis, circa genicula in serie simplici transversali dispositis.

Type Locality: Akkesi, Kusiro Prov., Hokkaido.

The most distinguishing character of this forma lies in the fact that the cortices are so thin that the axes appear to be banded in the surface view. In this respect, this forma is rather nearer to *Cer. rubrum* than to *Cer. Kondoi*. It is, however, clearly characterized by the peculiar mode of the trichotomous ramification. Accordingly, the present forma appears to be an intermediate type between *Cer. rubrum* and *Cer. Kondoi*. The writer, however, proposes to regard it as one of the formae of *Cer. Kondoi* for the present.

f. **abbreviatum** NAKAMURA f. nov.

Frondibus pusillis, 5–10 cm. altitudine; axibus praecipuis valde perspicuis; ramis praecipuis axes percurrentes efficere pertinentibus, in parte superiore rami praecipui ramulos abbreviatos verticillater gerentibus; ramis valde abbreviatis, aliquantum alternis, parce ramosis; corticibus crassis; tetrasporangiis spargerentibus.

Type Locality: Akkesi, Kusiro Prov., Hokkaido.

The present forma thrives in shallow waters facing to the surfs. It has a percurrent axis which bears abbreviated branches on all sides of its upper portion. The branches often sparsely branch in the same plane in a somewhat alternate manner, taking a corymbose appearance.

This forma is identical with *Cer. rubrum* f. *corymbiferum* YENDO (non J. AG.) from Cape Inubô, Simohusa Prov., Pacific coast of Honsyu.

As shown in the above diagnosis, this forma is not sufficiently characterized by the trichotomous ramification whereby *Cer. Kondoi* is distinguished. Nevertheless, this is nearer to *Cer. Kondoi* than to *Cer. rubrum* in the structure of the frond and in many other respects. Consequently, the writer proposes to regard the present material as an abbreviated dwarf form of *Cer. Kondoi* for the present.

f. **trichotomum** NAKAMURA f. nov.

Frondibus validissimis, 20–50 cm. altitudine, dense floccosis vel glomeratis, connexis laxe per rhizoideis sustentantibus; axibus praecipuis perspicuis; ramis praecipuis plerumque trichotomis, saepe tetrachotomis, ad eadem axillam unum ramulum, in directiones oppositas mutuo procreante, semper gerentibus; ramis elongatis, dense dichotomis; corticibus crassioribus; tetrasporangiis circa genicula irregulariter spargerentibus.

Type Locality: Akkesi, Kusiro Prov., Hokkaido.

The present forma is found at Akkesi, washed ashore. It is glomerated in a large mass, entangling with supporting-rhizoids. In the Japanese species of the subgenus *Euceramium*, except in this forma, the writer never met with the supporting-rhizoids. It is easily distinguishable from the other formae by its peculiar habit and by the trichotomous or tetrachotomous ramification of the main branches.

Campylaephora J. AGARDH mutatis charact. NAKAMURA

Text-fig. 6.

J. AG., Sp. Alg., II, 1851, p. 149; SCHMITZ and HAUPTFLEISCH, Rhodophyceae, ENGLER und PRANTL Pflanzenf., 1897, pp. 485, 502.

Frondibus semper epiphyticis, plerumque solitariis, filiformibus, saepenumero ramosis, articulis haud pellucidis; axibus centralibus monosiphoniis, per zona pericentrali cellularum largarum et cellulis rhizoidalibus elongatis et strato extero cellularum parvarum circumdatis; basibus frondium e discis basalibus diametro 1–2 mm. et cellulis rhizoidalibus constitutis, constructis; ramificatione dichotoma; reproductione per tetrasporas et carposporas; tetrasporangiis circa genicula verticillatis aut spargerentibus, inter cellulis corticantibus omnino immersis; antheridiis super ramulos superiores pannis sessilibus formatis et 1–2 spermatangias ex eadem cellula generatrice procreantibus; procarpiis in facie externa apiceque ramulorum nascentibus atque uno ramulo carpogonici in eadem cellula sustentanti dispositis; cystocarpiis globularibus, haud lobantibus necnon 4–9 ramellis involucrantibus instructis.

Type species: *Campylaephora hypnaeoides* J. AGARDH

The genus *Campylaephora* was established by J. G. AGARDH in 1851 on the basis of the material collected by TILESIUS from Japan, which was described by C. A. AGARDH as *Ceramium rubrum* var. *firmum*. According to J. G. AGARDH, it was distinguished from *Ceramium* by a thicker cortex and crooked terminal portions of branches (sickle-shaped portions of the frond, fig. 6, f).

Later SCHMITZ and HAUPTFLEISCH (1897) distinguished *Campylaephora* from *Ceramium* by the occurrence of rhizoidal cells in the cortex. In 1927, however, OKAMURA stressed that the rhizoidal cells taken up by SCHMITZ and HAUPTFLEISCH were not true rhizoidal cells, but elongated, filamentous cortical cells, since they were not formed secondarily from cortical cells. On account of this, he remarked upon a close resembrance which *Campylaephora hypnaeoides* bears to species of *Ceramium*. Another significant fact supporting this view is what *Ceramium crassum* possesses the rhizoidal cells in the cortex as in *Camp. hypnaeoides* (OKAMURA, 1930). From this point of view, OKAMURA suggested that *Campylaephora* and *Ceramium* should be combined in one genus *Ceramium*, and his opinion has been accepted by the Japanese phycologists up to the present.

According to the writer's observations, however, it has been clarified that *Campylaephora* has so many and such clear points of difference that to sever it as a genus

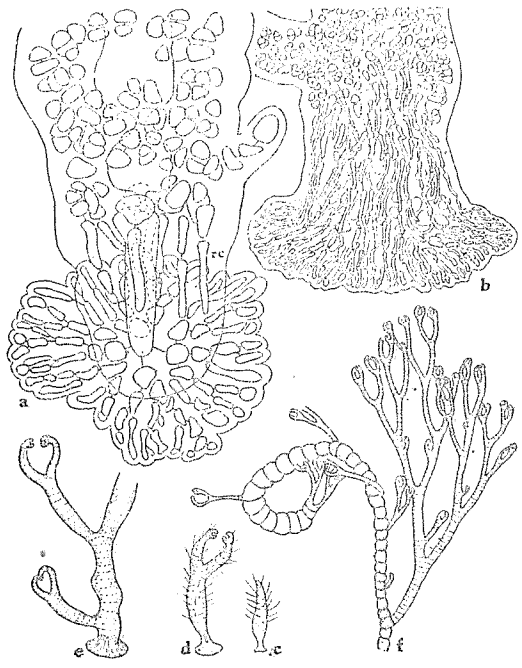

Fig. 6. a–e, *Campylaephora crassa*, f. *elongata*: a, Basal portion of a sporeling, giving off several elongated rhizoidal cells (re) primarily from cortical cells of the lowermost segment around axial cells. × 250; b, Frond-base of a young plant, forming a cortical disc composed of rhizoidal cells. × 100; c–e, Young plants, showing frond-base and method of the primary branching. ×15. f, *Campylaephora hypnaeoides*: Sickle shaped portion of the frond. × 3.

from *Ceramium* is properly desirable. The evidences in support of it are as follows: (1) The rhizoidal cells in the cortex are secondarily formed from cortical cells as shown in fig. 6, a. b. Therefore, they are not merely elongated cortical cells, but true rhizoidal cells. (2) In *Campylaephora* the frond-base forms a distinct conical disc composed of rhizoidal cells (fig. 6, b–e), while in *Ceramium* it consists of rhizoids (fig. 3, a). (3) In *Campylaephora* the sickle-shaped portions of the frond often occur, instead of the supporting-rhizoids in *Ceramium*. (4) The ramification of *Campylaephora* is always dichotomous, whereas that of *Ceramium* shows a progressive sequence from dichotomous to tetrachotomous through trichotomous. (5) The mean diameters of spores of *Campylaephora* are far larger than those of *Ceramium*.

By these methods of separation of the writer, the limit of the genus *Campylaephora* was materially altered, since the generic characters just considered were entirely different from those used by J. G. AGARDH. Consequently, *Ceramium crassum* OKAMURA must be transferred to *Campylaephora*, in spite of the lack of sickle-shaped portions of the frond. If the character concerned is omitted from the generic diagnosis of *Campylaephora*, this inconsistency is avoided.

Campylaephora crassa (OKAMURA) NAKAMURA comb. et emend. nov.

Ceramium crassum OKAMURA, Icon. Jap. Alg. VI, 1930, p. 26, pl. 269, figs. 1–10.
Ceramium secundatum YENDO (non LYNGBYE), Notes on Alg. New to Jap. VIII,

1918, Bot. Mag. Tokyo, Vol. 32, p. 79.

Ceramium cymosum OKAMURA in Herb. (Yendo Herb., Tokyo Univ.)

Ceramium boreale OKAMURA in Herb.

Japanese name: *Huto-igisa* (OKAMURA).

The plant is always epiphytic on various algae growing in the intertidal belt from early spring to late autumn. It is widely distributed along both coasts of northern Honsyu, Hokkaido, and Saghalien, though it is not so common.

Ceramium crassum was established by OKAMURA on the basis of the material from Tyôsi and Enosima, Pacific coast of the middle Honsyu. In consequence of the presence of rhizoidal cells in the cortex, *Ceramium crassum* was removed by the writer to the genus *Campylaephora*. Moreover, its specific boundary was largely extended by him, including *Cer. cymosum* OKAMURA, *Cer. boreale* OKAMURA, and *Cer. secundatum* YENDO (non LYNGBYE).

The name *Cer. cymosum* was given by OKAMURA to the specimens of YENDO's *Cer. secundatum* which are kept in the YENDO Herb. of the Tokyo University. It consists of nine sheets of specimens. One of them (Nou Fishery School, no. 272, b.) is apparently *Campylaephora hypnaeoides* J. AG. Three of them from Nou (Nou Fishery School, nos. 13, 274) quite agree with the writer's *Camp. crassa* f. *elongata*. The five remaining specimens (two specimens collected by A. YASUDA at Syôbuta, one collected by R. TUGE at Matusima, two collected by Miss WAINWRIGHT at Takayama, nos. 11, 12) are the writer's *Camp. crassa* f. *cymosa*.

According to the OKAMURA's key to the Japanese species of *Ceramium* (unprinted), *Cer. crassum* and *Cer. cymosum* are distinguished from each other by the entire ramification. In *Cer. crassum* it is flabellate and sparsely dichotomous, whereas in *Cer. cymosum* it is cymose and often strongly furcated. OKAMURA, however, separated *Cer. cymosum* from *Cer. crassum* with uncertainty. He has indicated that it might be synonymous as *Cer. crassum*. The writer agrees with OKAMURA on this view.

Cer. boreale is separable from both *Cer. crassum* and *Cer. cymosum* by the fact that the proliferous branchlets occur on all sides of branches, whereas in the latter two they are secundly seriated. A separation on this basis proposed by OKAMURA seems to be of no specific significance, since the intermediate types between the two are very commonly found.

After a close examination of the OKAMURA's original specimens, comparing with those of the writer's own collection, it was concluded that *Cer. crassum*, *Cer. cymosum* (*Cer. secundatum* YENDO), and *Cer. boreale* should be combined in one species as *Campylaephora crassa* (OKAMURA) NAKAMURA, reducing them to the rank of forma.

As a result of this, the four following formae are established: f. *typica*, f. *cymosa*, f. *elongata*, and f. *borealis*. These are separated mainly by the mode of ramification and the structure of cortication.

f. **typica** NAKAMURA f nov.

Frondibus 4-12 cm. altitudine, divaricate dichotomo-ramosis; ramulis proliferentibus

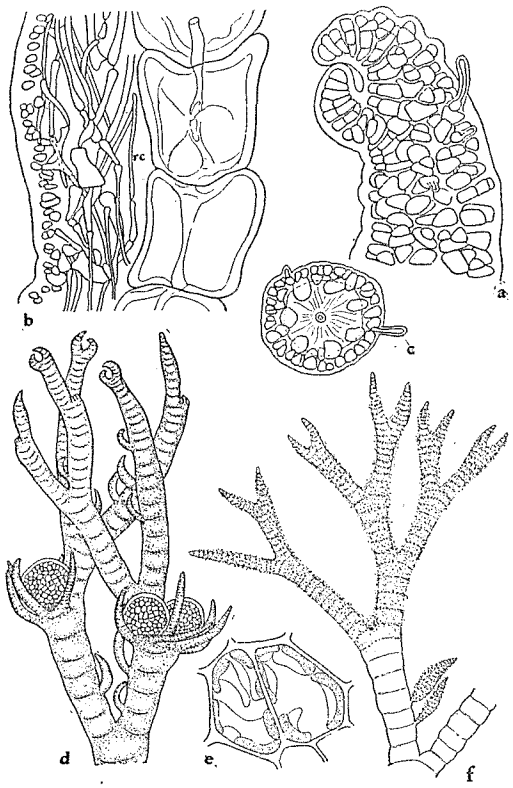

Fig. 7. *Campylaephora crassa*, f. *cymosa*: a, Frond-apex. × 250; b, Longitudinal section of a frond showing rhizoidal cells (rc) in the cortex. 100; c, Transverse section of upper portion of a frond showing seven pericentral cells around a central cell. × 100; d, Part of a cystocarpic frond. × 15; e, Outer cortical cells. The parietal laminate chromatophores are indicated. × 600; f, Part of a male plant showing an antheridial area. × 15.

ad faciem adaxialem ramorum serie secundata dispositis; ramulis corymboso-fasciculatis nullis; ramis praecipuis plerumque septies seu octies bifurcatis et pauce ramosis, sed non perspicuis; corticibus crassis, cellulis rhizoidalibus in corticibus frondium totarum bene crescerentibus; tetrasporangiis spargerentibus.

Type Locality: Enosima, Sagami Prov.

The plant is of deep red colour and somewhat cartilaginous, adhering to paper not so closely in drying. It distantly branches in a dichotomous manner, assuming a flabellate outline. The proliferous branchlets are usually scarce and sometimes distitute of them. They are always secundly seriated mainly on the adaxial side of branches and simple or 1–2 times forked without growing up to the corymboso-fasciculate branchlets. This is one of the most distinguishing characters of the present forma. In this respect, the present forma is closely related to f. *cymosa*. This, however, is distinguished from f. *cymosa* by its thicker cortex and the more scattered arrangement of tetrasporangia.

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

Ceramium cymosum OKAMURA in Herb., ex parte.

Frondibus 3–10cm. altitudine, divaricate dichotomo-ramosis; ramulis proliferentibus ad faciem adaxialem ramorum serie secundata dispositis; ramulis corymboso-fasciculatis nullis; ramis praecipuis plerumque septies seu octies bifurcatis et nunc parce nunc dense ramosis, sed non perspicuis; corticibus tenuis, cellulis rhizoidalibus in corticibus pauce crescerentibus; cellulis corticantibus exterioribus angularibus, in serie parenchymatas solide dispositis; tetrasporangiis circa genicula verticillatis.

Type Locality: Syôbuta, Matusima, Takayama, Rikuzen Prov. (YENDO Herb., Tokyo University).

The present forma usually grows on *Phyllospadix* in the season of late summer and autumn in Hokkaido. It is of light red colour and somewhat membranaceous, adhering to paper not so closely in drying.

The ramification of the present forma is markedly divaricated. It branches now distantly, now densely in a regular dichotomous manner. Some materials from the Japan Sea coast and those from Muroran growing on *Rhodomela* have a tendency to show somewhat alternate appearances, closely relating to f. *borealis*.

The most distinguishing characters of this forma lay in the fact that the cortex is very thin, the rhizoidal cells in the cortex are less developed, and the tetrasporangia are whorled in a single transverse row around nodes. Judging from these respects, it seems to be the most simple form of *Camp. crassa*, relating closely to a certain species of the genus *Ceramium*.

f. **elongata** NAKAMURA f. nov.

Frondibus in plantis asexualibus 10–20 cm. altitudine, plerumque dichotomo-ramosis, saepe alternato-ramosis aut aliquantum pinnato-ramosis, ramulis proliferentibus fere nullis; in plantis sexualibus 5–10 cm. altitudine, tenuoribus, aliquantum regulariter dichotomo-ramosis, ramulos proliferentes plerumque secundatim gerentibus; ramulis corymboso-fasciculatis paucis; ramis praecipuis, decies seu duodecies bifurcatis, sed plerumque non perspicuis; corticibus crassis, cellulis rhizoidalibus in corticibus frondium totarum bene crescerentibus; cellulis corticantibus exterioribus rotundatis, aliquantum laxe dispositis saltem super frondibus inferioribus; tetrasporangiis aliquantum spargerentibus.

Type Locality: Kitami-esasi, Kitami Prov.

The present forma is epiphytic on *Phyllospadix* or *Sargassum*. The plant is of deep red colour and is very flaccid to the touch in a young or a tetrasporic plant, but somewhat harsh to the touch in an older sexual one. The former adheres to paper closely, the latter not so closely in drying.

The tetrasporic plant branches in a distantly, rather irregularly dichotomous manner, or often in an alternate or a somewhat pinnate manner. It accordingly assumes a sparse subcorymose or a somewhat pinnato-decompound outline when displayed on paper. The branches are elongated.

The sexual plant is more slender than the tetrasporic one. When young, the sexual plant is regularly corymbose and its frond-apex strongly rolls inwards. The plant gradually becomes curled and irregular in branching as it grows, and more often much intricate in an older plant. At the same time, the frond-apices become almost straight.

The most distinguishing characters of this forma are in the fact that the tetrasporic plant is very different from the sexual one in general appearances, branches of the former are elongated, and an arrangement of outer cortical cells of the frond is

comparatively loose. Judging from these characters, the writer inclined at first sight to regard the present material as a distinct species. After a close examination of specimens in the YENDO Herb. from Nou, Etigo Prov. and those of T. MUKAOKA's collection from Kosagawa, Ugo Prov., however, he has arrived at a conclusion that this material is not sufficiently different to warrant removing it from *Campylaephora crassa* as a distinct species. Thus it seems best to consider the present material to be an ecological form of *Campyaephora crassa* on the coast which is washed by the Japan Sea current.

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

Ceramium boreale OKAMURA in Herb.

Frondibus 5–25 cm. altitudine, plerumque irregulariter dichotomo-ramosis, saepe alternato-ramosis; ramulis proliferentibus irregulariter undique procrescentibus; ramulis corymboso-fasciculatis plerumque numerosis; ramis praecipuis semper perspicuis et axes percurrentes efficere pertinentibus, fere decies seu duodecies bifurcatis, dense ramosis; corticibus crassis, cellulis rhizoidalibus in corticibus frondium totarum bene crescerentibus; cellulis corticantibus exterioribus aliquantum regulariter dispositis, necnon cellulis duabus vel tribus aggregatis confluentibus; tetrasporangiis plerumque spargerentibus.

Type Locality: Senpôsi, Risiri I., Hokkaido (J. TOKIDA).

The present forma is widely distributed in Hokkaido, growing on various algae. The plant is deep red, varying to pinkish red and is somewhat flaccid to the touch, adhering to paper closely in drying. A general appearance of the present forma is very variable, but it is always characterized by the evident main branches tending to form percurrent axes. It branches in a somewhat irregularly dichotomous or an alternate manner. Every segment is usually furnished with proliferous branchlets which irregularly occur on all sides of branches. Some of the proliferations may grow up to normal branches, taking a corymboso-fasciculate appearance. These corymboso-fasciculate branchlets are usually numerous along the main branches. This is one of the most distinguishing characters of the present forma.

Campylaephora hypnaeoides J. AGARDH Text-fig. 6, f.

Sp. Alg. II, 1851, p. 150.

Ceramium hypnaeoides (J. AG.) OKAMURA, On *Camp. hypnaeoides* J. AG., Bot. Mag. Tokyo, Vol. 41, 1927, p. 365, figs. A, B, 1–12.

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

Ceramium hamatum COTTON, Mar. Alg. from Corea, 1906, p. 370.

? Ceramium pumilum OKAMURA in mscr.

Japanese name: *Egonori* (OKAMURA).

This species is found growing on *Sargassum* and *Laminaria*, never on rocks. This is one of the most widely distributed species along both coasts of Japan.

The plant is so variable in general appearances that it is often not regarded as one species. It, however, is altogether characterized by the presence of sickle-shaped

portions of the frond and by the mode of branching, occurring in all directions.

Both female and male plants have not frequently been found, while tetrasporic ones very commonly found. Fortunately, a considerable specimens of both sexual plants were collected by the writer at Osyoro, Siribesi Prov. in August and at Maizuru, Tango Prov. in May. Almost all of them are far smaller than the tetrasporic plants.

Fertile cystocarpic plants which are less than 2 cm. high and epiphytic on *Cer. Kondoi*, were collected by the writer at Muroran in June. A number of specimens similar to them were collected by S. ARASAKI at Morozaki, Mikawa Prov. and by I. UMEZAKI at Maizuru, Tango Prov. These materials appear to agree with OKAMURA's *Cer. pumilum* in mscr. whose type specimen has not been found. In the writer's opinion, however, it seems safe to regard them as a dwarf sexual form of f. *typica* until a further study concerning the life history of the species concerned may be carried out.

Two formae are distinguished mainly by habit and ramification. One is f. *typica* and the other is f. *hamata*.

f. **typica** NAKAMURA f. nov.

Frondibus validis, plerumque ultra 20 cm. altitudine, ultra 1 mm. diamtero, communiter connexis laxe, super plerumque *Sargasso*, raro *Laminariis* in mare aspero; ramificatione aliquantum irregulariter dichotoma aut saepius alternata; apicibus incrassatis incurvis frondium semper praesentibus.

The plants growing on *Laminaria* are more regularly dichotomous in branching than those growing on *Sargassum*.

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

Ceramium hamatum COTTON, Mar. Alg. from Corea, 1906, p. 370.

Frondibus gacillibus, 3–15 cm. altitudine, intra 1 mm. diametro, eleganter arbuscularibus, super *Laminariis* in mare placido; ramificatione dense regulariter dichotoma, in plantis et sexualibus adultissimis et asexualibus aliquantum irregulariter intricatis; apicibus incrassatis incurvis frondium in planta sexuali fere nullis; corticibus tenuoribus quam f. *typica*.

Type Locality: Corea.

This forma is found on the Japan Sea coast of Hokkaido, growing on *Laminaria* in calm sea. This is easily distinguishable from f. *typica* by its slender and elegant arbuscular appearance. The sexual plants are commonly less than 5 cm. high. They are not furnished with the sickle-shaped portions of the frond. In the older sexual plants, however, these structures are not frequently found. The branches of the tetrasporic plants are usually entangled to one another with the sickle-shaped portions of the frond, though they are not so entangled as in f. *typica*. The cortex of the present forma is thinner than that of f. *typica*.

Since the cotype specimen of *Ceramium hamatum* in the YENDO Herb. of the Tokyo University is fragmentary, the writer could not closely prove its identity. As far as diagnosis shows, however, the present material is quite identical with *Cer. hamatum* COTTON.

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