A Systematic Study of the Order Chordariales from Japan and its Vicinity

By

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I. Introduction

Since 1950 the present writer has been studying systematically the Japanese species of the Order Chordariales under the guidance of Prof. YUKIO YAMADA, in the Institute of Algological Research, Faculty of Science, Hokkaido University. In treating this Order, use is made of the inner characters, especially the growing point, the central axis of the frond, the medullary layer and the assimilating filaments, as well as the outer characters.

Here, the writer wishes to express his hearty thanks to his teacher, Prof. Y. YAMADA, for kind guidance during the course of this work. The writer is also very thankful to Dr. Y. NAKAMURA for valuable suggestions regarding his study. Sincere thanks are also due to Dr. E. YALE DAWSON in the Allan Hancock Foundation, University of Southern California for the use of valuable material of the Order Chordariales gathered from many parts in America. Thanks are also due to Dr. J. TOKIDA in the Faculty of Fisheries, Hokkaido University, Dr. M. ARAZAKI in the Fisheries Institute, Faculty of Agriculture, Tokyo University, and all gentlemen in the Botanical Institute, Faculty of Science, Hokkaido University, and in other institutes, who sent the writer their valuable specimens. To Mr. Y. SAEKI, Mr. K. KATSUKI in the Muroran Technical College and Mr. K. AKINO, the writer offers his sincere thanks for photographing the plates. The writer also records his indebtedness to the Ministry of Education for financial aid for pursuing the present investigation.

II. Some taxonomic remarks on the morphological details of Chordariales

1. External shape

In *Leathesiaceae* the frond of *Petrospogium* is flat on rocks and stones, its surface making folds, and is 2.5–5 cm or sometimes up to 10 cm in diam. The frond of the members of *Leathesia* sect. *Leathesia* is hemispherical or globular when solitary, 2 mm to 3 cm or more in diam., and when grouping, it spreads

generally to some extent, while the frond of the species belonging to *Leathesia* sect. *Primariae* is much smaller, spherical, hemispherical or rarely pulvinate, 1–2 mm in diam., and epiphytic on other algae.

In *Chordariales* except *Leathesiaceae* the fronds are erect or entangled on the substrata in a certain species (*Nemacystus decipiens* (SUR.) KUCK.), generally cylindrical or somewhat compressed (*Chordaria flagelliformis* (MULL.) AG. f. *chordaeformis* KJELLM.), 3–5 cm (*Heterosaundersella hattoriana* TOKIDA)—80 cm or longer (*Chordaria flagelliformis* (MULL.) AG. f. *chordaeformis* KJELLM.), usually 20–30 cm in length; in *Leathesiaceae* they are spreading 0.5–1.0 mm (*Leathesia yezoensis* INAGAKI, *L. monilicellulata* TAKAMATSU, etc.) to 15 cm in diam. (*L. saxicola* TAKAMATSU).

The cylindrical fronds are 1 mm (*Nemacystus decipiens* (SUR.) KUCK., *Acrothrix pacifica* OKAMURA et YAMADA, etc.) to 3–5 mm thick (*Tinocladia crassa* (SUR.) KYLIN, *Saundersella simplex* (SAUND.) KYLIN) although they are very variable among the different species and even different individuals of the same species.

When the fronds are dried, they become shrunken and narrower in breadth than when fresh, for the inner tissues of the fronds are not so dense.

The fronds in living stage are also classified by the sense of touch as follows:

The fronds are generally gelatinous, slippery, soft or somewhat hard. The fronds of *Eudesme virescens* (CARM.) J. AG., *Acrothrix pacifica* OKAMURA et YAMADA, *Nemacystus decipiens* (SUR.) KUCK., *Tinocladia crassa* (SUR.) KYLIN, etc. are remarkably lubricous and slippery. The frond of *Saundersella simplex* (SAUND.) KYLIN as well as *Heterosaundersella hattoriana* TOKIDA is also very lubricous, although in *Saundersella saxicola* (OKAMURA et YAMADA) INAGAKI and *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. the fronds are herbaceous and elastic. The fronds of *Chordaria flagelliformis* (MULL.) AG. and *Sphaerotrichia divaricata* (AG.) KYLIN are lubricous and cartilaginous, but somewhat hard, especially those of *Pseudochorda* and *Chordaria flagelliformis* (Mull.) AG. f. *chordaeformis* KJELLM. are harder than the fronds of the above two. The fronds of the species of *Leathesiaceae* are always very lubricous and carnose, but in *Petrospongium* the adult frond is very often leather-like. The soft fronds of *Chordariales* are easily to be disorganized when they are taken out from sea water.

The difference by the sense of touch for the surface of the frond is certainly one of the characteristics for the classification, but at least such a characteristic is conceptual at the present time.

2. Branching

The frond is not ramified or irregularly branched, but in the latter case the

branching is comparatively simple, and in the same species branching is variable. In the Genus *Saundersella* the fronds of all well-known species are simple. The fronds of *Sauvageaugloia ikomae* (NARITA) INAGAKI and *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI are usually simple, but often provided with a few branches, and then one can very often find a few sparse branches on the frond of *Chordaria flagelliformis* (MUELL.) AG. f. *chordaeformis* KJELLM. which is distinguishable from f. *ramusculifera* KJELLM. provided with scattered, short, simple branches. In *Heterochordaria abietina* (RUPR.) S. et G. a single main branch is provided with many short or sometimes considerably long branchlets. The fronds from certain localities (Muroran, Nemuro-Bentenjima, etc.) become simple leaving only the main stems, the branchlets falling off in summer (after June) and sometimes on the main stem unremarkable knobs are scattered as the traces of the branchlets. Of course, in these localities, there are many fronds whose main stems are not provided with such branchlets from the early stage of their development. In some species with branched fronds the central axes are distinctive, but in other ones they are not so. The central axes are found on the fronds of *Chordaria flagelliformis* (MUELL.) AG., *Heterochordaria abietina* (RUPR.) S. et G., *Chordaria gracilis* S. et G., *Papenfussiella kuromo* (YENDO) INAGAKI, etc.

In *Sphaerotrichia divaricata* (AG.) KYLIN, *Eudesme virescens* (CARM.) J. AG., *Tinocladia crassa* (SUR.) KYLIN, etc., the fronds are provided with a more or less traceable percurrent axis or sometimes irregular dichotomous main axes. The fronds of the latter two species are very often irregularly branched so that the main axes and the branchlets are not distinguishable from each other. The fronds of *Chordariales* in the adult stage are generally erect and do not creep or grow prostrate on the frond of the host. However, in the juvenile stage of certain species, for instance, *Heterosaundersella hattoriana* TOKIDA, *Sphaerotrichia divaricata* (AG.) KYLIN, *Papenfussiella kuromo* (YENDO) INAGAKI, etc. prostrate fronds are apparent surrounding the juvenile erect fronds, but when the juvenile erect fronds were elongated or in late spring to summer these prostrate fronds cannot be found, for the latter are already fallen off from the host. The solitary frond of *Leathesia* is generally globose or hemispherical, though it is more or less irregular in shape, but the fronds grow grouping with each other, they are very irregular in shape.

3. Base

The primary base is microscopic in size, spreading marginally or mostly irregularly in different diretions by means of creeping rhizoids issued from the marginal cells. It usually develops into a single cell-layer, however, in *Heterochordariaceae* it grows into several layers of cells. The prostrate filaments arising directly from the primary base and the rhizoidal filaments descending from the

basal cells of the assimilating filaments in the basal portion of the erect frond, in spite of presence of a monosiphonous or polysiphonous central axis which is occurring from the primary base, construct generally a secondary base. The secondary base develops gradually into the adult discoid base. In *Heterosaundersella* the adult base is constructed from the primary base without the descending rhizoidal filaments as is above mentioned. In the base of *Heterochordariaceae* the primary base also develops into the secondary ones without such descending rhizoidal filaments from the basal cells of the assimilating filaments or prostrate assimilating ones, and then the secondary base becomes widespread, branching profusely or somewhat dichotomously. The branches of the perennial base become horizontal thalli piling up one after another.

In the adult fronds of *Chordariales* except *Heterochordariaceae* and *Leathesiaceae* the primary bases are quite invisible. The basal central axes of the adult fronds also are indistinct, for the rhizoidal filaments are entangling with each other in the subcortex and cortex.

The bases of *Heterochordaria* and *Pseudochorda* are composed of much more conspicuously parenchymatous cells than in any other genus of *Chordariales*. But the base of *Pseudochorda* seems to us to show an intermediate form between *Heterochordariaceae* and *Chordariaceae*, for the base of *Pseudochorda* consists of many descending filaments from the lower portion of the erect frond.

4. Central axis

The mode of the growth of the central axis is sympodial or monopodial and it develops mono-polysiphonously or at first monosiphonously and afterwards polysiphonously. Thus, the mode of the growth and the growing point are observed in the very juvenile stage of the development of the frond. One can no longer observe the standard structure of the central axis in the juvenile portion remaining on the adult frond, for the appearance of the central axis in the juvenile stage is quite different from the remaining juvenile portion on the adult branch. The standard mode of the central axis or the growing point can generally be observed in the frond which is 1 mm to 2 cm long or less. It is most probable that many growing modes of the apices and the central axes described by KYLIN and KUCKUCK were observed in the above-mentioned juvenile stage, though they apparently did not state these facts. In the early stage, the central axis gives rise to branches upwards or downwards and to many incomplete assimilating filaments from its middle and superior portions. Through self-branching of the primary central axis the permanent polyseriate central axis is contructed and it gives rise to many complete assimilating filaments. In the adult frond, even its apical portion consists of thicker polysiphonous medullary filaments than in the juvenile one; therefore,

one cannot observe the true stage of the standard central axis shown by KYLIN and by KUCKUCK. In the adult frond one can recognize neither distinction between the monosiphone and polysiphone of the standard central axis nor that between mono- and sympodial growths. In *Sphaerotrithia*, *Nemacystus* and *Acrothrix* the central axes are monosiphonous, growing monopodially upwards, whilst in *Saundersella* and *Heterosaundersella* they are polysiphonous, growing monopodially. In *Chordaria* (*Ch. gracilis* S. et G.) the central axis is monosiphonous only in the juvenile stage, soon becoming polysiphonous as a result of branching of the primary axis. The fronds of *Tinocladia*, *Sauvageaugloia*, *Eudesme* and *Cladosiphon* always grow sympodially with polysiphonous central axes. So far as the present writer has observed, the standard central axis and the growing point can be recognized only in the very juvenile stage of the frond.

5. Growing point

KUCKUCK (1929) used the differences of the growing points of the fronds for distinguishing the genera or the species of *Chordariales*, though this characteristic was not standardized by him. KYLIN (1940) described the apical portions of the fronds in this Order and made evidently standardized distinction by the appearences of the growing points in various genera or species, but he did not state the growing point of *Leathesiaceae*. The present writer thinks that the frond of *Leathesiaceae* grows marginally by means of branching of the peripheral filaments outwards. According to the present writer's observation, the figures of the growing points of *Chordariales* presented by KYLIN and KUCKUCK have been drawn from the most juvenile fronds. In fact, in the later juvenile frond, the appearance of the growing point is already different from that of the above-mentioned most juvenile stage, and after the growing season such standard growing point is not found. In summer the apical growth continues, but no longer is the so-called "growing point" by KYLIN visible, and the internal structure in the apical portion develops into the adult stage. Therefore, there is a remarkable difference among apical structures in each growing stage of one individual and of the same species. After that season one can very often find late-growing juvenile fronds and also sometimes late-growing portions on the adult frond. In this late-growing portion the apical structure is different from the above-mentioned most juvenile frond and rather similar to the apical portion of the adult frond. In the adult fronds of different genera or species, the internal structures become similar to each other and then no exact distinction can be recognized between different genera and species. So, the observation of the growing points of the most juvenile frond is indispensable for establishing the generic or the specific classification. Such a most juvenile frond is found mostly in spring or rarely in summer. The frond found

in summer is already the adult, though it may seem to be smaller in size and younger in stage. The writer cannot find any useful growing point from the summer frond. The apical portion of the adult branch of each species consists of a bundle of cylindrical cells which are longitudinally arranged in the medula, and assimilating filaments in the periphery, which were transformed gradually from the terminal portion of the primary growing point.

6. Medullary layer

The medullary layer originates from the erect filaments developed from the primary base spreading on the substratum. The cells of these young erect filaments divide upward and downward to form the medullary layer of the adult frond elongating longitudinally. The filaments divided from the basal cells of the young or often the primary assimilating filaments also grow partially into the medullary layer. The medullary layer usually consists of a bundle of many cylindrical cells which are arranged longitudinally and straightly, though in the basal portion of the frond these medullary cells are rhizoidal and very often entangling with each other, for instance, in *Sphaerotrichia*, *Saundersella*, *Tinocladia*, etc. So, the primary erect filaments are not conspicuous in the above-mentioned basal portion. In *Leathesia* sect. *Primariae* of *Leathesiaceae* the medullary cells are cylindrical being comparatively regularly di-trichotomous towards the periphery; on the contrary, ni *Leathesia* sect. *Leathesia* the medullary cells are irregularly reticulated becoming gradually roundish or oblong towards the periphery. In *Petrospongium* the medullary layer is composed of rhizoidal and cylindrical cells which are entangling with each other, although there are outer medullary ones which are cylindrical or oblong in shape and trichotomous regularly towards the periphery. But in *Petrospongium* one can barely distinguish the subcortical layer composed of 2 or 3 cell-layers in the periphery, whose ultimate cells are giving rise to the assimilating filament. In *Chordariales* except *Leathesiaceae* the medullary layer of the adult frond consists of broad or slender filaments, or in a certain species both of these are mixed. The filaments are composed of cylindrical, spindle-shaped or elliptical cells and are unbranched or very often branched. The medullary cells of *Nemacystus*, *Sphaerotrichia*, etc. are often long spindle-shaped, especially as was shown by KYLIN (1940) in *Sauvageauglcia* these cells are remarkably elongated; on the contrary, the medullary ones of *Eudesme* and *Tinocladia* are broad or slender and evidently cylindrical giving rise horizontally to the subcortical cells. In *Leathesia* sect. *Leathesia*, *Heterochordaria*, etc. the central portion of the medullary layer is hollow except in the juvenile stage, for the central filaments are stretched outwards in spite of there being no lateral division of them. In the adult fronds of *Acrothrix* (described by KUCKUCK 1929),

Sauvageaugloia (shown by KYLIN 1940), etc. the central portion also becomes incompletely hollow and these hollow places are considerably different from those of *Heterochordaria* and *Leathesia*. The central portions of the medullary layers in *Chordaria*, *Sphaerotrichia* and *Pseudochorda*, etc. are not so distinctly hollow as *Acrothrix* and *Sauvageaugloia*, etc. as is oberved by the present writer.

7. Subcortical layer

The subcortical layer develops between the medullary and the cortical layers, and these cells scarcely contain similar chromatophores to those in the coloured layer of the cortical cells, in which thick contents are crowded. From these outermost, that is, ultimate cells of the subcortical layer assimilating filaments are arising tuft-like in general. The ultimate cells also very often serve as the basal cells of the assimilating filaments. In the genera *Tinocladia*, *Eudesme*, *Myriogloia*, etc. the subcortical layer is composed of cells dividing patently and repeatedly and it changes into a cortical layer consisting of smaller cells outwards. The cortical cells contain crowded chromatophores, so the cortical layer is remarkably more concentrated than the subcortical ones. In the genera *Saundersella* and *Heterosaunderesella* the subcortex consists of reticularly divided cells and somewhat roundish ones outwards. In the genera *Sauvageaugloia*, *Papenfussiella*, *Chordaria*, *Sphaerotrichia*, etc. the endogenous cells become gradually smaller in size towards the periphery, so no remarkable distinction between the subcortex and the medullary layer is easily recognized. In *Leathesiaceae* one cannot distinctly recognize such a tissue to be regarded as the subcortex, for in any portion of the inner tissue the construction mode is similar except for the fact that several cell-layers of the periphery consist of smaller cells than in the inner portion.

8. Cortical layer

The cortical layer consists of assimilating filaments, hairs, and uni- and plurilocular sporangia. The assimilating filaments are usually clavate, filamentous, unbranched or branched (for instance, *Petrospongium rugorum* (OKAM). S. et G., *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI, etc.) arising from their basal cells which are ultimate cells of the medullary or subcortical layer. The assimilating filaments of *Tinocladia*, *Eudesme*, *Myriogloia* and *Petrospongium*, etc, are generally different from the subcortical cells, for the former contains dense contents, while the latter are destitute of them. But the assimilating filaments are usually equal in shape and size to each other, although partially variable. But in *Haplogloia*, *Papenfussiella* there are long and short assimilating filaments. The cortical layer is mostly imbedded in gelatinous substance except the long assimilating filaments. Such filaments are very long and free from gelatinous substance.

These long assimilating filaments can be easily observed on the fronds of *Haplogloia*, *Myriogloia* and *Papenfussiella*. The shape of the assimilating filament, especially that of its terminal cell is the important one of many systematic characteristics of *Chordariales*, though it is widely variable in one and the same individual or the same species. The terminal cells in *Saundersella*, *Heterosaundersella*, *Sphaerotrichia* and *Chordaria* are considerablly larger than in any other species, and also distinct from the other cells which construct the assimilating filaments. In *Nemacystus*, *Acrothrix* (as described by KUCKUCK, 1929), *Papenfussiella* (as described by KYLIN, 1940) *Sauvageaugloia*, *Cladosiphon* (described as *Castagnea* by KUCKUCK, 1929) and *Haplogloia* (as described by LEVRING, 1939) the terminal cells are not much larger than any other ones. The terminal cells of these genera are usually obtuse, sometimes acute (*Haplogloia*). The constrictions at the joints of the assimilating filaments are very remarkable in *Leathesia crassipilosa* TAKAMATSU, *L. japonica* INAGAKI, *Sauvageaugloia ikomae* (NARITA) INAGAKI, *Tinocladia crassa* (SUR.) KYLIN, *Heterosaundersella hattoriana* TOKIDA, etc., but the constrictions are very often changeable, as they are strong or slight in the different portions of one and the same individual. In *Leathesia japonica* INAGAKI, *L. crassipilosa* TAKAMATSU the assimilating filaments ramify secundly in the superior portions.

9. Hairs

Hairs interspersed on the frond of *Chordariales* are called "typische Phaeophyceenhaare" by KYLIN. (Phaeophyc. Chordar. 1940). They consist of uniseriate cylindrical cells and are colourless except those in the lower portions which are growing intercalarily containing dense contents. As is seen on the fronds of *Papenfussiella*, *Myriogloia* and *Haplogloia*, etc. the long assimilating filaments are hair-like, not hyaline, but they contain dense contents like the general assimilating filaments (short assimilating filaments in these genera). Both these hairs and the long assimilating filaments are not imbedded in gelatinous substance. The hairs are 1–2 mm long, 10 μ or broader, but very often broad or slender, variable within the same species or in the different portions of one individual. In *Sphaerotrichia divaricata* (AG.) KYLIN, *Leathesia japonica* INAGAKI, *Chordaria flagelliformis* (MUELL.) AG. the hairs are scattering solitary or somewhat tufted on the peripheral cells or the basal ones of the assimilating filaments. In *Eudesme virescens* (CARM.) J. AG., *Tinocladia crassa* (SUR.) KYLIN, *Saundersella simplex* (SAUND.) KYLIN, etc. the hairs issue from the basal cells of the assimilating filaments, but in many species of *Leathesia*, as Dr. TAKAMATSU shows (1939), the hairs develop from deeply inserted medullary cells. He used the breadth of the hair in the distinction among the Leathesian species, but the present writer thinks

that the hair is widely variarble in breadth in the same species. The hairs of certain species, for instance, *Nemacystus decipiens* (SUR.) KUCK., *Acrothrix pacifica* OKAM. et YAMADA, etc., are often directly developed from the basal cells spreading on the host, but such hairs on the basal cells fall off from the host, early in the growing season. The hairs in the adult frond are very often more meagre than in the young ones on account of their falling.

10. Unilocular sporangia

The unilocular sporangia are generally elliptical, oviform or oblong in shape, about $40 \times 80\,\mu$ in size, with some exceptions; namely, in *Leathesia yezoensis* INAGAKI they are lineari-oblong or ovato-lanceolate. The sporangia usually are borne on the peripheral (ultimate) cells (the basal cells of the assimilating filaments) of the medullary or the subcortical layer, solitary or tufted on the ultimate cells, sessile or pedicellate with a single cell or more, connecting at the bottoms, or a little lateral walls and rarely connecting at the lateral walls (*Petrospongium rugosum* (OKAM.) S. et G.). The sporangia are usually observed in the peripheries of the mature fronds, but in some species they are already grown on the very juvenile fronds. In *Leathesia yezoensis* INAGAKI and *Leathesia japonica* INAGAKI the sporangia develop directly on the basal cells of the fronds or on the basal ones of the assimilating filaments on the medullary layer consisting of a few cell-layers in the very juvenile frond. The unilocular sporangia are generally developed on the same position as the assimilating filaments as is seen in *Leathesia*, *Sphaerotrichia*, *Acrothrix*, *Chordaria* and *Tinocladia*. In *Nemacystus*, *Sphaerotrichia*, etc. the sporangia are also developed on the basal cells of the assimilating filaments as on the branches of them. In *Myriogloia* the sporangia are solitary or in tufts, borne on the different portions of the assimilating filaments, but some of them seem to be developed from the same position as the assimilating filament. Such sporangia are easily observed in *Sphaerotrichia divaricata* (AG.) KYLIN, *Chordaria flagelliformis* (MUELL.) AG., *Saundersella simplex*, (SAUND.) KYLIN, *S. saxicola* (OKAM. et YAMADA) INAGAKI, *Heterosaundersella hattoriana* TOKIDA, *Eudesme virescens* (CARM.) J. AG., *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI, *Leathesia difformis* (L.) Aresch., *Petrospongium rugosum* (OKAM.) SETCH. et GARDN., etc. In *Nemacystus decipiens* (SUR.) KUCK., *Leathesia difformis* (L.) ARESCH., *L. crassipilosa* TAKAMATSU, *L. monilicellulata* TAKAMATSU, etc., unilocular and plurilocular sporangia are borne on one and the same individual. In *Leathesia sphaerocephala* YAMADA the unilocular sporangia are often visible in the peripheries of the pretty young frond.

11. Plurilocular sporangia

The plurilocular sporangia are greatly variable in shape, being generally trans-

formed from the middle and the upper portions of the assimilating filaments except in certain species. The sporangia in the Genus *Pseudochorda* are fusiform in shape and are borne on the segments of the lower portions of the assimilating filaments, and they develop independently on the assimilating ones, not being transformed from the latter. In *Leathesia* sect. *Leathesia* the sporangia are mostly slender or cylindrical arising tuft-like on the peripheral cells of the medullary layer and on the basal cells of the assimilating filaments at the same position as the assimilating ones or the branchlets from them. But in *Leathesia* sect. *Primariae* the sporangia are rather variable in shape. The sporangia in *Leathesia sadoensis* INAGAKI are broadly fusiform with undulate surface, while in *L. monilicellulata* TAKAMATSU they are long fusiform or cylindrical developing at the same position as the assimilating filaments; in *L. primaria* TAKAMATSU the sporangia are evidently transformed from the upper portions of the assimilating filaments. The sporangia of *Nemacystus decipiens* (SUR.) KUCK. are arising tuft-like from the lower portions of the assimilating filaments with 1–2-celled pedicels. In *Heterochordaria abietina* (RUPR.) S. et G. and *Haplogloia kurilensis* INAGAKI, etc. the sporangia are transformed from the assimilating filaments. The sporangia of *Heterosaundersella hattoriana* TOKIDA develop on the basal cells of the assimilating filaments of the juvenile frond, on the prostrate filaments or on the rhizoidal base of the frond and they are occupying the same position as the assimilating filaments; they are provided with 1–2-celled pedicels. The ramified sporangia transformed from the upper portions of the assimilating filaments are observed in *Sauvageaugloia* and various species of *Cladosiphon* described by KUCKUCK (1929) and by KYLIN (1940). As described by KUCKUCK (1929), KYLIN (1940), in *Cladosiphon contortus* (THUR.) KYLIN the sporangia are transformed from the apical branchlets of the assimilating filaments.

III. Descriptions of the genera and species

Fam. **Leathesiaceae**

SETCHELL and GARDNER, Mar. Alg. Pacif. Coast. N. Amer., III, 1925, p. 507; OKAMURA, Nippon Kaisoshi, 1936, p. 185; *Corynophloeaceae*, in OLTMANNS, Morph. Biol. Alg., ed. 2, II, 1922, p. 23; KUCKUCK, Monogr. Phaeosp., 1929, p. 35.

Petrospongium NAEGELI.

NAEGELI, in KÜTZING, Tab. Phyc., vol. 8, 1858, p. 2, pl. 3, fig. II; SETCHELL and GARDNER, *Melanophyceae*, 1925, p. 508; OKAMURA, Nippon Kaisoshi, 1936, p. 186.

Frond solid, gelatinous, carnose adhering to the substratum by means of rhizoids, afterwards becoming spongy or hollow in the central portion, more or less circular in shape, flat or wrinkled, composed of four layers: (1) basal or

central layer of the frond consisting of one, or of a few stromatic layer of entangled cylindrical or rhizoidal cells, the cells giving rise to (2) dense rhizoidal layer adhering to the substratum; (3) subcortical cells di-trichotomously divided upwards without connecting laterally with each other becoming reticular, decumbent below, curving to erect above, elongated, cylindrical or somewhat swollen, giving rise to rhizoidal filaments; (4) assimilating filaments of cortex 8–10 cells long, linear, simple or sparsely divided terminating in obtuse cells; hairs hyaline, arising from the basal cells of the assimilating filaments, the outer cells of the subcortex and transformed from the terminal cells of the assimilating filaments; unilocular sporangia long ellipsoidal, oblong or decidedly irregular in form, in mature stage attached laterally with one- or two-celled short pedicels or sessile on the basal cells of the assimilating filaments or on the outer cells of the subcortex; plurilocular sporangia unknown.

Petrospongium rugosum
(OKAMURA) SETCHELL et GARDNER
(Figs. 1–3)

SETCH. and GARDN., Phyc. Cont., VII, 1924, p. 12; Id., *Melanophyceae*, Mar. Alg. Pacif. Coast Nor. Amer. III, 1925, p. 509, pl. 39, figs. 42, 43; YAMADA, Sci. Rep. (Biol.,) Tohoku Imp. Univ., Vol. 3, 1927, p. 514; OKAMURA, Alg. Seto-Kanayama, Journ. Jap. Bot. Vol. 10, 1934, p. 155; Id., Nippon Kaisoshi, 1936, p. 186, Fig. 96, 1–3; *Cylindrocarpus rugosa* OKAM., Icon. Jap. Alg., Vol. I, 1909, p. 20, pl. 5, Figs. 1–6; Id., Alg. Jap. Exsic., II, No. 88; Id., Contents of the Alg. Jap. Exsic. II (Bot. Mag. Tokyo, Vol. XVII, 1903) p. 131; Id., Nippon Sorui Meii, 1916. p. 159.

Japanese name: Shiwa-no-kawa.

Locality: Hebi-ura and Asamushi, Mutsu Prov.; Miyato-jima, (Y. NAKAMURA) Rikuzen Prov.; Miyazaki and Fukue-Gulf, Mikawa Prov.; Toyohama, Owari Prov.;

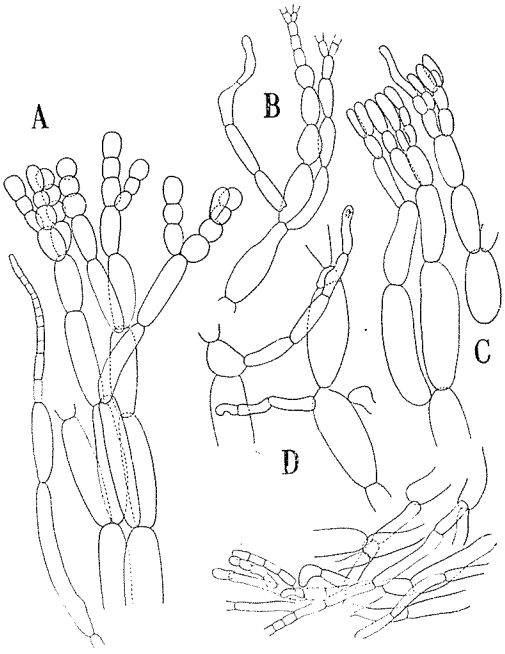


Fig. 1.
Petrospongium rugosum (OKAM.) SETCH. et GARDN.
A, C Younger assimilating filaments and subcortical cells × 110 (Miya-jima, Aki Prov., 5–III, 1954)
B Rhizoidal filament issued from a subcortical cell × 110 (Ditto.)
D Rhizoidal filaments issued from inner subcortical cells × 110 (Ditto.)

Wagu (Y. YAMADA) and Hama-jima, Shima Prov.; Miya-jima, Aki Prov.; Nada, Tosa Prov. (Y. YAMADA).

Growing on rocks and stones between the two tide marks, rather near the upper tide mark.

Frond solid, adhering to the substratum with its under-surface by means of rhizoids when young, afterwards becoming somewhat spongy or hollow in the central portion expanding on the substratum, more or less irregularly circular in outline, flat, deeply thrown up into wrinkles or folds; in the adult stage detached from the substratum, carnose, very lubricous, glossy, 1–5 cm in diam., sometimes attaining 7–8 cm, rarely up to 10 cm (cf. OKAMURA), 0.5–2 mm thick, composed of four remarkably distinct tissues: (1) central portion (innermost portion) consisting of one or a few stromatic layers of entangled cylindrical or rhizoidal cells decumbent below; (2) rhizoidal layer adhering to the substratum; (3) subcortical cells dichotomously or trichotomously divided upwards neither connecting laterally with each other nor becoming reticular, erect to curving from these central cells or decumbent below, elongated, cylindrical or swollen, in juvenile stage 30–40 μ thick, 50–80 μ long, but when adult up to 150 μ long, 40 μ thick, giving rise to rhizoidal filaments, the filaments more abundant in the inner portion of the subcortex, but in the outer portion very often elongated; (4) assimilating filaments 5–8 μ thick, 8–10 cells long, linear, simple or sparsely divided fastigiate, slightly torulose, remarkably deep coloured, terminating in obtuse cells; hairs hyaline, up to 7 μ thick, arising from the basal cells of the assimilating filaments and the outer subcortical cells, sometimes transformed from the terminal cells of the assimilating filaments; unilocular sporangia long ellipsoidal, oblong or decidedly irregular in form, 20–30 $\mu \times$ 50–120 μ in size, at first terminating in short

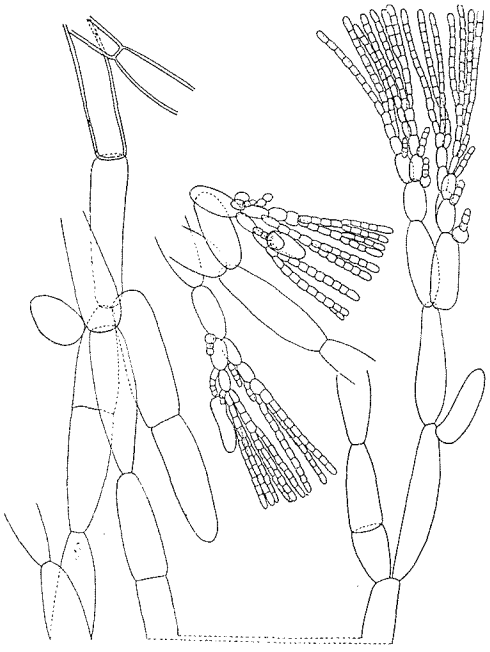


Fig. 2.

Petrospongium rugosum (OKAM.) SETCH. et GARDN.

Inner tissue provided with unilocular sporangia × 110 (Miya-jima, Aki Prov., 5-III, 1954)

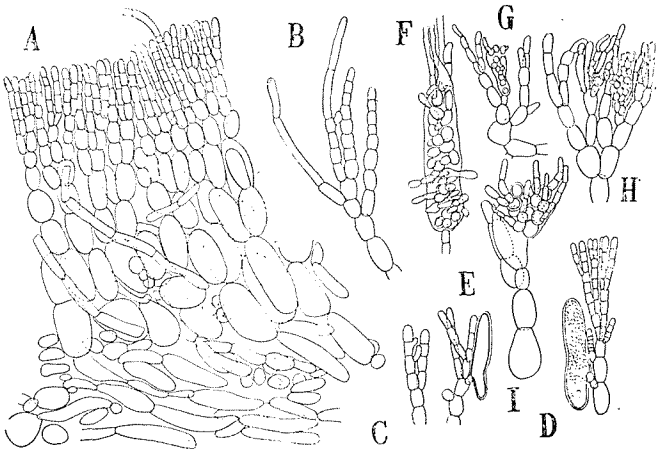


Fig. 3. *Petrospongium rugosum* (OKAM.) SETCH. et GARDN.

A Vertical section of a younger frond × 110 (Kai-ga-hama, Mikawa Prov. 6-III, 1939. Collected by M. ARAZAKI)

B Cortical and hair-shaped filaments × 110 (Miya-jima), Aki Prov. 5-III, 1954)

C Upper portion of a juvenile assimilating filament × 130 (Ditto.)

D Unilocular sporangium × 110 (Miya-jima, Aki Prov. 5-III, 1954)

E Unilocular sporangia × 110 (Sagawa, Tosa Prov. Collected by Y. YAMADA)

F Mature unilocular sporangia issuing rhizoids × 200 (Ditto.)

G, H, I Mature unilocular sporangia issuing rhizoids × 110 (Ditto.)

assimilating filaments consisting of 1–2 cells, afterwards elongating downwards, in maturity as if attached laterally with one or two celled short pedicels or sessile on the basal cells of the assimilating filaments or the outer cells of the subcortex; plurilocular sporangia unknown; frond dark brown, becoming blackish and not adhering to paper when dried.

The fronds are very variable in outline; some of them expand widely on the substratum or become confluent with each other, and the surface is nearly smooth, or deeply or slightly wrinkled. The subcortical cells divide di-trichotomously and patently upwards, but they do not construct such a reticular tissue as in *Leathesia*.

The unilocular sporangia are borne on the same location as the general assimilating filaments, which arise from the outer or the outermost subcortical cells.

Thus, the present alga is widely variable in character according to the habitat, but the writer considers the specimens at hand as the only one species following SETCHELL and GARDNER. The specimens from the above-mentioned localities are very similar to the American ones preserved in the herbarium of the Allan Hancock

Foundation which were collected from different localities; also they agree with Dr. OKAMURA's description.

Leathesia GRAY

GRAY, Nat. Ar. Brit. Pl., vol. 1, 1821, p. 301; SETCH. and GARDN., Mar. Alg. Pacif. Coast N. Amer., 1925, part III, *Melanophyceae*, p. 510; OKAM., Nippon Kaisoshi, 1936, p. 187; TAKAMATSU, Spec. of *Leathesia* from Northeastern Honshu, Japan (Saito Ho-on Kai Museum, Research Bulletin, No. 17, 1939, p. 1).

Frond epiphytic on different algae or growing on different substrata with rhizoidal base consisting of a single cell-layer in general, large or small in size, solitary or gregarious, globose, hemispherical or pulvinate, solid or hollow, carnose, lubricous; medullary layer consisting of radially di-trichotomously divided cells, the cells comparatively large, colourless, thin-walled longly cylindrical or elliptical becoming gradually slender towards the base, and smaller towards the peripheral portion; assimilating filaments tufted from peripheral cells being set in firm or fragile mucous matrix, composed of a short series of small, colour-bearing cells; hairs hyaline, colourless, uniseriate with cylindrical cells, growing intercalarily in the lower portions; unilocular sporangia elliptical or oviform and plurilocular sporangia cylindrical, uniseriate or rarely bi- or tri-seriate, both kinds of sporangia produced on the basal cells of the assimilating filaments or the peripheral cells of the medullary layer, developed mostly in one and the same individual.

Frond grows intercalarily by means of cell-divisions of juvenile assimilating filaments.

As to number of the species of the genus *Leathesia* in Japan, in 1916 Dr. OKAMURA reported *Leathesia difformis* (L.) ARESCH. which is very commonly distributed along the coasts of many foreign countries. Afterwards in the year 1916, *L. umbellata* MENEGH. was added by Dr. YENDO and in 1932 *L. sphaerocephala* YAMADA was reported by Dr. YAMADA as a new species from this country. During the years 1934–1938, Dr. TAKAMATSU, as a result of a detailed investigation of the present genus from Northeastern part of Japan Proper, newly added ten species, in which 8 new species were included; many microscopical species of the genus were discovered.

Since 1950 the present writer has been studying *Leathesia* with other species of *Chordariales* and examined many different specimens of this Genus from various localities, and of course from the coasts investigated by Dr. TAKAMATSU. After having studied this Genus basing his work on the above-mentioned material and the cotype specimens sent by Dr. TAKAMATSU, the present writer proposes the classification of the genus as follows.

The Genera *Corynophlaea*, *Corynephora* and *Leathesia*, have been treated as

Leathesia by SETCHELL and GARDNER, as among them no fundamental distinctions are recognized.

KÜTZING transferred the type species of his genus *Corynophlaea*, *C. baltica* to his genus *Corynephora* in Tabulae Phycologicae (1858, pl. II), but according to SETCHELL and GARDNER (1925), the frond of KÜTZING's genus is also hollow and differs in no fundamental characters from *Leathesia*. The main distinction between *Corynophlaea* and *Leathesia* is the solidity or hollowness of the adult frond, though the juvenile frond of *Leathesia* is solid like *Corynophlaea*. SETCHELL and GARDNER, who have discussed in detail the structural relation of these genera, concluded that it seems to them best to combine the two genera and to call under the oldest name "*Leathesia*". Dr. TAKAMATSU also follows their conclusion.

Many results of experimental studies concerning the development of *Leathesia* carried out by OKAMURA (1907), OLTMANNS (1922), DAMMANN (1930) and KYLIN (1933), support the fact that no difference is recognizable between the two genera except in solidity and hollowness.

The present writer has studied the mode of development of the frond concerning those characters and found that the distinction is already observable in the juvenile frond.

In the species belonging to the hollow-type of the genus the medullary cells are patently divided and loosely arranged; the frond is already hollow in early stage, for the cylindrical medullary cells are spread, becoming irregular with the development of the frond. The hollowness of the frond develops sooner or later in different ages, and the medullary layer separates from the base of the frond. The medullary layer of the microscopical type of *Leathesia* is provided with regular-shaped cells in both juvenile and adult stages, so far as the writer has observed. So, it seems to the present writer best to divide the genus into 2 sections on the basis of the arrangement of the medullary cells and the aspect of the medullary layer.

Leathesia sect. *Leathesia*, sect. nov.

Frond hollow; medullary layer reticulated with irregular polygonal cells.

Leathesia difformis (L.) ARESCH.

ARESCHOUG, Phyc. Scand., I, 1846, p. 154; LE JOLIS, List. Alg. Mar. Cherboug., 1863, p. 84; GOBI, Brauntange, 1874, p. 17; KJELLM., Alg. Arctic Sea, 1885, p. 252; FARLOW, Mar. Alg. New Engl., 1882, p. 82, pl. V, fig. I; HAUCK., Meeresalg. Deut. u. Oesterr., 1884, p. 355; REINKE, Alg. West-Ostsee, deut. Anth., 1889, p. 76; FOSLIE, Contr. Knowl. Mar. Alg. Norway, 1890, p. 91; GRAN, Alg. Veg. Tronbergfjord, 1882, p. 26; KUCKUCK, Bemerk. Mar. Alg. Veg. Helgoland, 1894,

Vol. I, p. 248; JÖNSSON, Mar. Alg. Iceland, II, *Phaeophyc.* 1903, p. 171; GEPP, Chinese Mar. Alg., Jour. Bot. 1904, Vol. 17, p. 162; BÖRGESEN, Mar. Alg., Bot. Faeroes, 1903; LAKOWITZ, Algfl. Danz. Bucht., 1907, p. 43, fig. 33; KYLIN, Algfl. Norweg. W. Küste 1910, p. 21; COLLINS, Mar. Alg., Vancouver, 1913, No. I, p. 108; SKOTTSBERG, Bot. Eregeb. Schwed. Exp. Patagonen etc., Mar. Alg. *Phaeophyc.* p. 26, 1912; SETCHELL and GARDNER, Mar. Alg. Pacif. Coast N. Amer., Part III, 1925, Vol. 8, p. 511, pls. 41, 43; PRINZ., Alg. Veg. Trondhjemfjordes, 1926, No. 5, p. 177; LAKOWITZ, Alg. fl. Gesam. Ostsee, 1929, p. 267, fig. 370; KNIGHT, Max Alg. 1931, p. 71; OKAMURA, Nipp. Sorui Meii, (2nd ed., in Jap.) 1916, p. 159; Id., Icon. Jap. Alg., 1909, Vol. I, p. 80, pl. 18; Id., Notes Alg. Setokanayama, Journ. Jap. Alg. 1934, Vol. 10, No. 3, p. 155; Id., Nippon Kaisoshi, 1936, p. 187; TAKAMATSU, Spec. of *Leathesia* Northeast Honshu, 1939, p. 15, pl. III, fig. 3, Text-fig. 10; TOKIDA, Mar. Alg. S. Saghalien, 1954, p. 88.

Frond epiphytic on different algae or saxicolous by means of a disc giving rise to rhizoids, solitary or gregarious, spherical or globose with irregular lobes in age, wrinkled on the surface, very variable in size and shape, solid when young, in adult stage hollow, very fragile, lubricous, solitary frond 2–30 mm in diam. gregarious one attaining 50–60 mm; medullary cells colourless, in the basal portion long cylindrical, thin walled, generally dichotomously divided, in the middle portion larger than the other portions, di-trichotomously divided, in adult stage irregularly angular, slightly or deeply forked, very often cylindrical or twisted, becoming smaller towards the peripheral portion, elliptical, oblong, globose or ovate; assimilating filaments unbranched, variable in shape, arising from peripheral cells of the medullary layer by twos to fives, comparatively long, clavate, composed of 3–6 cells, 50–125 μ long, the cells cylindrical, cuboid, elliptical except apical cell, provided with a few chromatophores in each cell, cells 15–30 μ long, 4–6 μ broad or less; apical cells globose, ellipsoid or ovoidal, remarkably larger than the other ones, 12–20 μ long, 10–12 μ broad with crowded chromatophores; hairs hyaline, colourless, uniseriate, cells cylindrical, 50–80 μ long, about 10 μ broad, growing intercalarily at the basal portion, solitary or in tuft on the peripheral cells; unilocular sporangia borne on the basal cells of the assimilating filaments or the outer cells of the medullary layer, sessile, ellipsoidal, ovoidal, 30–50 $\mu \times$ 10–18 μ in size; plurilocular sporangia cylindrical, straight, sessile or pedicellate, 30–50 μ long, 5 μ broad, tufted borne on the basal cells of the assimilating filaments or the outermost cells of the medullary layer with 6–12 uniseriate loculi; both kinds of sporangia produced in one and the same individual; colour light or deep brown.

f. ***difformis*** (Figs. 4-6 Pl. I)

Japanese name: Nebarimo.

Locality: Okujiri (on rocks), Oshima Prov.; Oshoro (On *Rhodomela larix* THURN.) C. AG. Shiribeshi Prov.; Asamushi (On *Sargassum thunbergii* KUNTZ.), Mutsu Prov.; Kisagata (On *Laurencia* sp.), Uzen Prov.; Toyoma (On *Sargassum thunbergii* KUNTZ., *Corallina pilulifera* P. et R.), Iwaki Prov.; Himi (On *Sargassum patens* C. AG., *Sarg. piluliferum* AG.), Etchu Prov.; Ehima (on stones), Mikawa Prov.; Ohno (On *Gracilaria confervoides* (L.) GREV., Owari Prov.

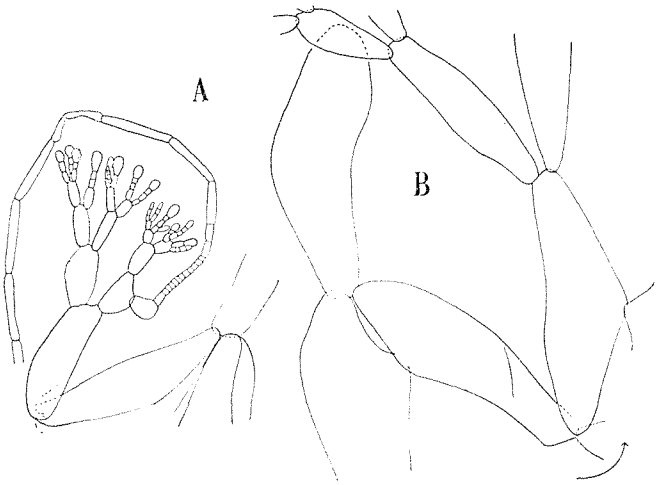


Fig. 4. *Leathesia difformis* (L.) ARESCH. f. *difformis*
A Cortical layer × 110 (Asamushi, Mutsu Prov. 24-V, 1952)
B Medullary cells × 110 (Ditto.)

Widely distributed along the Pacific and the Japan Sea coasts. Growing between the tide marks.

Frond provided with assimilating filaments 5-6 μ broad.

The present alga is the most general type from our coast and agrees with *Leathesia difformis* (L.) ARESCH. described by Dr. OKAMURA, Dr. TAKAMATSU and others.

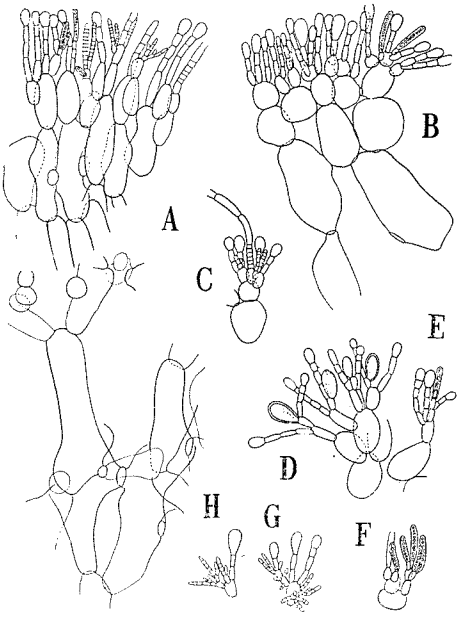


Fig. 5. *Leathesia difformis* (L.) ARESCH. f. *difformis*

A Portion of medullary and cortical layers with plurilocular sporangia × 110 (Toyoma, Iwaki Prov., 27-V, 1953)

B Portion of a cortical layer with plurilocular sporangia × 110 (Ditto.)

C A hair × 110 (Ditto.)

D Unilocular sporangia × 110 (Ditto.)

E, F, G, H Plurilocular sporangia × 110 (Ditto.)

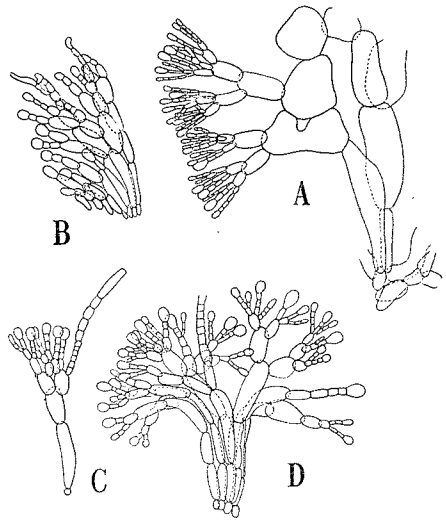


Fig. 6. *Leathesia difformis* (L.) ARESCH. f. *globosa* INAGAKI

A Medullary and cortical layers × 110 (Sai, Mutsu Prov., 27-V, 1952)

B, C, D Medullary and cortical layers of juvenile fronds × 110 (Ditto.)

f. ***globosa*** (TAKAMATSU) INAGAKI, comb. nov. (Fig. 7 Pl. II)

Leathesia globosa TAKAMATSU, Spec. *Leathesia* Northeast Honshu, 1939, p. 12, pl. III, Fig. Text-fig. 8.

Japanese name:

Locality: Utoro (On *Grateloupia divaricata* OKAM.,) Kitami, Prov.; Sai (On *Sargassum piluliferum* AG.), Mutsu Prov.; Hanabuchi (On *Sargassum thunbergii* KUNTZ.), Rikuzen Prov.

Epiphytic on different algae between the tide marks.

Frond provided with slender assimilating filaments 4 μ or less broad.

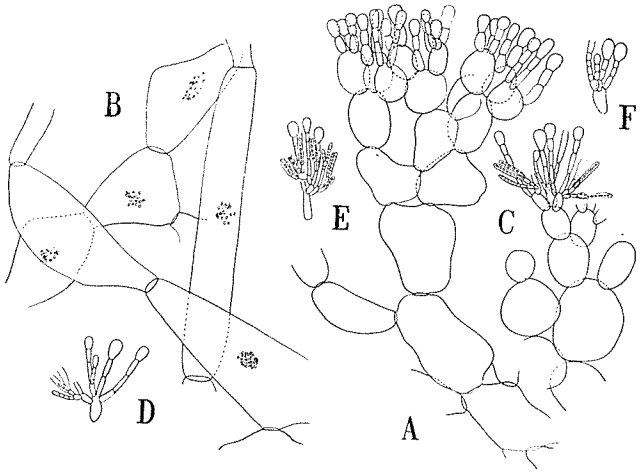


Fig. 7. *Leathesia difformis* (L.) ARESCH. f. *globosa* INAGAKI

A Medullary and cortical layers × 110 (Utoro, Kitami Prov. 14-VIII, 195)
B Medullary cells × 110 (Ditto.)
C, D, E Plurilocular sporangia × 110 (Ditto.)
F Assimilating filaments × 110 (Ditto.)

The assimilating filaments are slenderer than those of the typical form. *Leathesia globosa* TAKAMATSU may be recognized as one form of *Leathesia difformis* (L.) ARESCH. on account of presence of slender assimilating filaments provided with comparatively larger apical cells.

The specimens of *Leathesia globosa* TAKAMATSU sent to Dr. YAMADA by Dr. TAKAMATSU, do not agree with Dr. TAKAMATSU's description.

Leathesia saxicola TAKAMATSU (Figs. 8, 9)

Spec. *Leathesia* Northeast. Honshu, Japan, 1939, p. 17, pl. IV, Fig. 1, Text-fig. 11; *L. granulosa* TAKAM., 1939, p. 14, pl. IV, Fig. 2, 3 Text-fig. 9.

Japanese name: Iwa-nebarimo (nom. nov.).

Locality: Toyoma, Ena, Nakanosaku and Yotsukura (M. TAKAMATSU), Iwaki Prov.; Iwasaki, Mutsu Prov.; Kisagata and Tsubaki (M. TAKAMATSU), Nezugasaki and Tobishima (M. TAKAMATSU), Uzen Prov.; Sado, Tatsha, Sado Prov. Growing on *Sargassum piluliferum* AG. and rocks between the tide marks or below the low tide mark.

Frond in juvenile stage solid, in mature stage becoming hollow, very lubricous, carnose, firm, solitary or grouped, spherical, subglobose or slightly flattened, on the surface slightly lobed, attaining 1–15 cm in diam.; cells in medullary layer as the

basal portion long-cylindrical, dichotomously divided, in the middle portion ditrichotomously divided, angular, ellipsoidal, deeply furcate, variable in shape, spherical or elliptical becoming gradually smaller towards the peripheral portion; assimilating filaments rather short, somewhat thick, clavate, consisting of 2–4 oblong cells, slightly moniliform or not so, 20–40 μ long, 8–10 μ broad excepting apical cells, but in juvenile stage 10 μ or broader; apical cells enlarged spherically or obovately enlarged, 15–20 μ long, 10 μ or broader containing dense chromatophores;

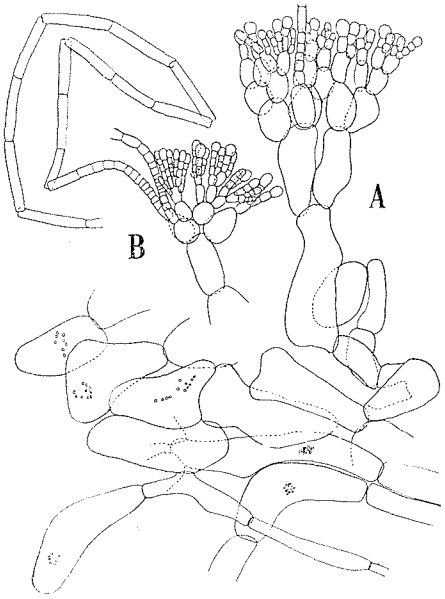


Fig. 8. *Leathesia saxicola* TAKAMATSU
A Portion of cortical and medullary layers × 110 (Kannon-zaki, Asamushi, Mutsu Prov. 25-V, 1952)
B Assimilating filaments and hairs × 110

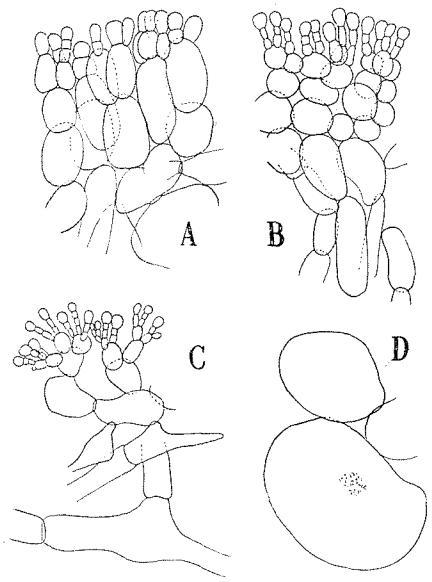


Fig. 9. *Leathesia saxicola* TAKAMATSU
A, B, C Young portions of a frond × 110 (Tatsha, Sado Prov. 23-V, 1954)
D Medullary cells × 110

basal cells of assimilating filaments sometimes smaller than the other ones, oblong or slightly elliptical, 8–12 μ long, 4–7 μ broad; hairs hyaline, colourless, arising on ultimate medullary cells growing intercalarily in the basal portions; unilocular sporangia sessile, borne on the ultimate medullary cells or the basal cells of the assimilating filaments, obovate or elliptical, 24–30 $\mu \times$ 4–6 μ in size; plurilocular sporangia cylindrical, 20–30 μ long, 4–6 μ broad, sessile or pedicellate, with 6–7 loculi, arising from the ultimate medullary cells or the basal cells of the assimilating filaments; both sorts of sporangia developed in one individual; colour brownish

or light brown, adhering to paper when dried.

Though Dr. TAKAMATSU's specimens are sterile, *Leathesia granulosa* TAKAMATSU coincides with *L. saxicola* TAKAMATSU. The present writer examined the structures of the specimens of both species sent by the author, but between the two species no difference was found.

The frond of the present species consists of angular and forked cells in the medullary layer; however, roundish or elliptical cells are also visible in the peripheral portion.

Leathesia difformoides TAKAMATSU (Figs. 10-12)

Spec. *Leathesia* Northeast. Honshu, 1939, p. 6, pl. I, Fig. 3, Text-fig. 4.

Japanese name:

Locality: Muroran, Iburi Prov. (On *Rhodomela larix* (TURN.) C. AG.); Asamushi and Sai (On *Sargassum micracanthum* (KÜTZ.) YENDO), Mutsu Prov.; Nezu-ga-saki (On *Sargassum patens* C. AG.) and Kisagata (On *Sargassum piluliferum* AG.), Uzen Prov.; Takahama (On *Sargassum piluliferum* AG.), Wakasa Prov.; Moroyose (On *Sargassum tortile* AG. and *Sarg. thunbergii* KUNTZ.), Tanba Prov.

Epiphytic on different algae between the tide marks or below the low tide mark.

Frond epiphytic on different algae by means of rhizoidal base, in juvenile stage solid, in age becoming hollow, globose, solitary or sometimes grouped, 0.5–1.5 mm or attaining 10 mm in diam., lubricous, fragile; medullary cells colourless, di-trichotomously divided, in the basal portion elliptical or cylindrical, in the middle and peripheral portions irregularly angular, roundish or broadly elliptical, variable in shape, becoming

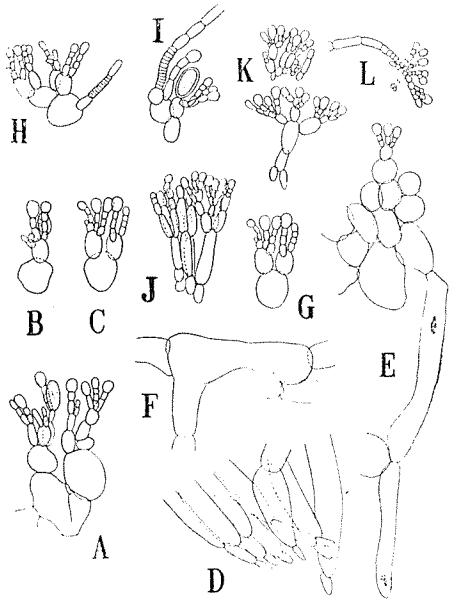


Fig. 10. *Leathesia difformoides* TAKAMATSU

A, B Unilocular sporangia × 110 (from TAKAMATSU's specimens)
C Assimilating filaments × 110 (Ditto.)
D Basal portion × 110 (Ditto.)
E Medullary and cortical layers × 110 (Ditto.)
F Medullary cell × 110 (Ditto.)
G, H Assimilating filaments and a hair × 110 (Ditto.)
I An unilocular sporangium and a hair × 110 (Ditto.)
J, K, L Portions of juvenile fronds × 110 (Ditto.)

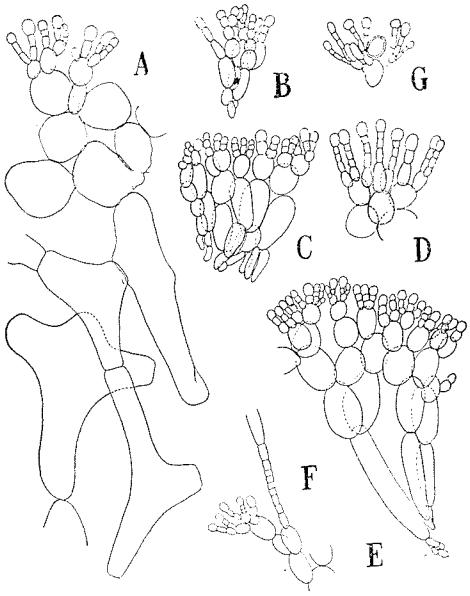


Fig. 11. *Leathesia difformoides* TAKAMATSU

A Younger portion of a frond × 110 (Nezu-ga-seki, Uzen Prov. 4-IV, 1952)

B, C, E Medullary and cortical layers of young fronds × 110 (Ditto.)

D Assimilating filaments ×110 (Ditto.)

G Unilocular sporangia ×110 (Ditto.)

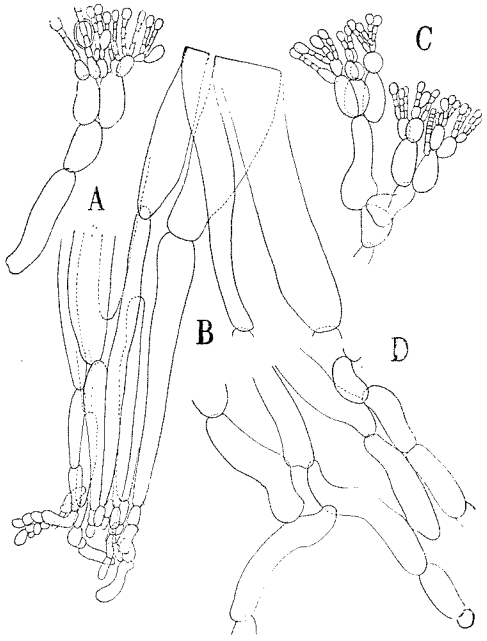


Fig. 12. *Leathesia difformoides* TAKAMATSU

A Unilocular sporangia × 110 (Moroyose, Tajima Prov. 10-V, 1953)

B Medullary and basal portions ×110 (Ditto.)

C Cortical layer × 110 (*Leathesia globosa* TAKAMATSU named by the author)

D Medullary layer × 110 (Ditto.)

smaller towards the peripheral portion; assimilating filaments arising from peripheral celles of the medullary layer, clavate, 2-5 celled, 30-50 μ long, 5-8 μ broad, cells cylindrical or oblong excepting apical cell; apical cells 10-15 μ high, sometimes attaining 20 μ, 8-12 μ broad, globose, ovoidal, comparatively larger than the other cells, with crowded chromatophores; hairs hyaline, colourless, arising from the peripheral cells of the medullary layer, growing intercalarily in the basal portion; unilocular sporangia sessile, borne on the ultimate cells or the basal cells of the assimilating filaments, ovate or ellipsoid, 20-35 $\mu \times$ 15-20 μ in size; plurilocular sporangia unknown; colour brownish.

The present writer himself examined TAKAMATSU's specimen, but he did not observe such characters as those described by Dr. TAKAMATSU. According to TAKAMATSU's description the frond is solid, small in size and in such small frond

the unilocular sporangia already are developed, but these characteristics are often found in other Leathesian species. According to the present writer's observation, the medullary layer of TAKAMATSU's specimen at first is solid becoming gradually hollow like the other species and provided with irregularly shaped cells, but not composed of sphericalor elliptical cells as TAKAMATSU stated. It is also visible in other species that the unilocular sporangia are mostly attached by means of the more or less lateral-basal walls on the ultimate medullary cells or on the basal cells of the assimilating filaments. The specimens of *L. difformoides* TAKAMATSU and *L. globosa* TAKAM. (treated as a form of *L. difformis* by the present writer) which were collected by Dr. TAKAMATSU, show similar characteristics, though the peripheral medullary cells of the former species are nearly spherical or sometimes elliptical, but in the latter ones elliptical. The present writer believes that *L. difformoides* is one species having very strong resemblance to *L. globosa*, judging from the authentic specimens of both species which were sent to Dr. YAMADA by Dr. TAKAMATSU.

Leathesia sect. *Primariae*, sect. nov.

Frond solid; medullary cells cylindrical or elliptical.

Leathesia primaria TAKAMATSU

(Fig. 13)

Spec. *Leathesia* from Northeast. Honshu, Jap., 1939, p. 5, pl. I, fig. 2, Text-fig. 3.

Japanese name: Ito-nebarimo (nom. nov.).

Locality: Tsubaki, Ugo Prov. (M. TAKAMATSU). Epiphytic on the thallus of *Cystophyllum sisymbrioides* J. AG. below the low tide mark.

Frond epiphytic on other algae by means of rhizoids composed of irregularly shaped cells, solid, lubricous, somewhat fragile, solitary, spherical, 1–3 mm in diam., or gregarious; medullary cells with 1–3 chromatophores, colourless, slenderly cylindrical or somewhat filamentous in juvenile frond, longest in the middle portion, becoming gradually shorter towards

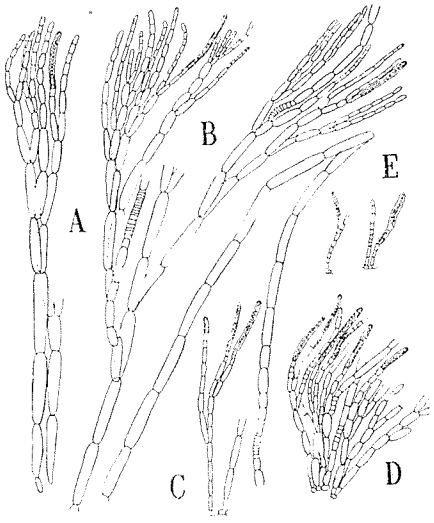


Fig. 13. *Leathesia primaria* TAKAMATSU

A, B Cortical and medullary portions with assimilating filaments, plurilocular sporangia and a hair × 110 (Collected by M. TAKAMATSU)

C, D Somewhat younger portions with plurilocular sporangia × 110 (Ditto.)

E Juvenile filaments with plurilocular sporangia ×110 (Ditto.)

the cortex of the basal portion, usually dichotomously branched, rather unbranched in the lower portion, thick-walled or not so, 70–90 μ long, about 10 μ broad in the middle portion; assimilating filaments filiform, straight, including several chromatophores, gradually narrower and smaller upwards, consisting of 5–8 or more cells, terminating obtuse cells; terminal cells almost similar in size to the other assimilating cells; cells constructing assimilating filaments cylindrical, oblong or long elliptical, measuring 80–110 μ in length, 4–6 μ in breadth; hairs hyaline, solitary, issuing from the neighbouring portion or the deeply inserted portion of the medullary layer, sometimes developed from the basal portion, consisting of cylindrical cells measuring 70–110 μ in length, about 10 μ in diam.; plurilocular sporangia filiform, arising from the assimilating filaments, sessile or pedicellate with 1–2 cells, including gametes in 1–2 rows, very often arising from the middle and upper portions of the assimilating filaments, shorter than the assimilating filaments or not so; unilocular sporangia unknown; frond yellowish brown, adhering to paper when dried.

Some of the medullary cells of the juvenile frond, whose assimilating filaments are already transformed into plurilocular sporangia, smaller than the adult, 10 μ long, 5 μ broad, but other ones are 20–30 μ long, 5 μ broad.

Leathesia sadoensis INAGAKI, sp. nov. (Figs. 14, 15)

Japanese name: Okesa-nebarimo (nom. nov.).

Locality: Tatsha Gulf, Island Sado, Sado Prov.

Growing on *Sargassum piluliferum* C. AG. below the low tide mark.

Frond epiphytic on other algae (*Sargassum piluliferum* C. AG.) with short rhizoids arising from basal cells, solitary, spherical or hemispherical, 1–2mm in diam. or gregarious, variable in size and shape, lubricous, soild, somewhat fragile; medullary cells cylindrical or oblong, those of the middle portion 60–100 $\mu \times 50\ \mu$, but towards the outer portion becoming gradually smaller and oviform or elliptical in shape, dividing patently and repeatedly 4–6 times, dichotomous in the lower portion and trichotomous in the middle or outer portion; outermost cells of the medullary layer ellipsoidal or roundish in shape, 20–30 $\mu \times 30$–45 μ in size, generally variable; assimilating filaments with 4–6 chromatophores, in the upper portion 3–4 or more in tuft on the outermost cells of the medullary layer clavate, 60 μ–100 μ long, up to 10 μ thick, unbranched, 4–6 celled with large terminal cells, the cells spherical, ovoidal, sometimes elliptical with thick walls, 20–25 $\mu \times 30$–35 μ in size; cells of assimilating filaments twice as long as the diam., but in the upper ones as long as broad; cells of the growing point intercalarily segmented in their lower portions, such assimilating filaments very often 8-celled; hairs hyaline, arising solitary from the peripheral cells of the medullary layer, 15 μ in diam., growing intercalarily in the lower portion; apical point provided with a single hair or the

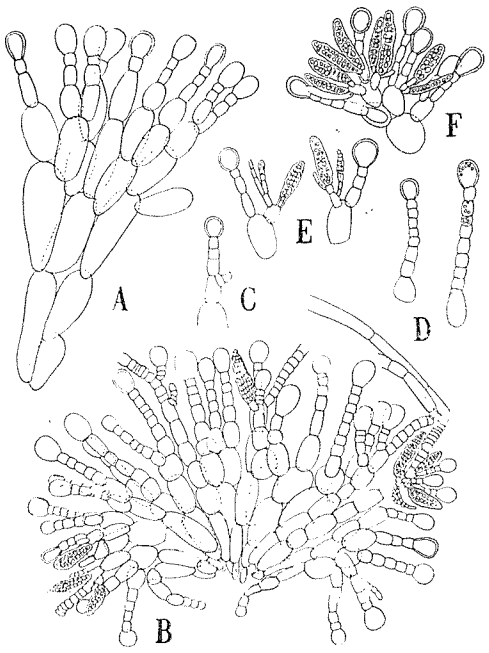


Fig. 14. *Leathesia sadoensis* INAGAKI

A Portion of juvenile cortical and medullary layers × 110 (Tatsha, Sado Prov. 23-V, 1954)

B Vertical section of a juvenile frond showing growing points at the peripheral portion ×110 (Ditto.)

C, D Assimilating filaments at growing points × 110 (Ditto.)

E, F Juvenile and mature plurilocular sporangia × 110 (Ditto.)

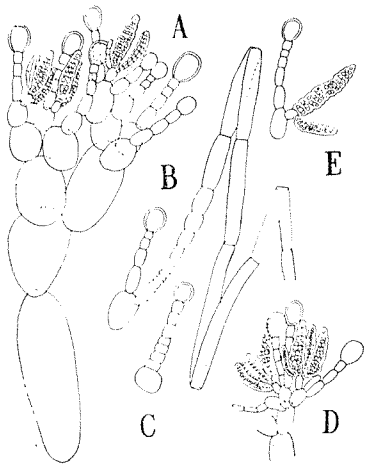


Fig. 15. *Leathesia sadoensis* INAGAKI

A Portion of medullary and cortical layers with plurilocular sporangia × 110 (Tatsha, Sado Prov. 23-V, 1954)

B An assimilating filament and a hair × 110 (Ditto.)

C Growing point elongated from an ultimate cell of the medullary layer × 110 (Ditto.)

D, E Plurilocular sporangia ×110 (Ditto.)

above-mentioned assimilating filaments; plurilocular sporangia single, lanceolate or fusiform, tuft-like to number of 2–4, borne on the outermost cells of the medullary layer, pedicellate with 1–2 cells, slightly curved, repandous in surface, 40–70 $\mu \times$ 15–20 μ in size in adult, but in younger portion 20–30 μ in size or more; unilocular sporangia unknown; frond brownish, adhering to paper in drying.

The present species resembles the juvenile frond of the other Leathesian members in external appearance; it is epiphytic on the host mixing with the other Leathesian members. The assimilating filaments of the present alga are closely related to those of *Leathesia sphaerocephala* YAMADA in the shape of the terminal

cell, but those of the former are distinctly broader and larger than the latter. The plurilocular sporangia of the present species, however, though they are unknown in *Leathesia sphaerocephala* YAMADA, are remarkably larger with gametes in 1–4 rows than those in the already known species of *Leathesia*, and also different in shape from the latter.

Leathesia monilicellulata TAKAMATSU (Figs. 16-19)

Spec. *Leathesia* Northeast. Honshu, Japan, 1939, p. 11, pl. III, fig. I, Text-fig. 7.

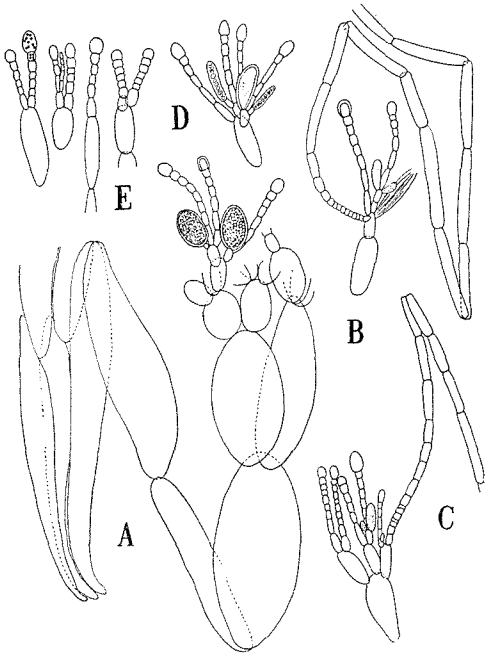


Fig. 16. *Leathesia monilicellulata* TAKAMATSU

A Portion of medullary and cortical layers with unilocular sporangia ×110 (Tatsha, Sado Prov. 23–V, 1954)

B Unilocular sporangia and a hair × 110 (Ditto.)

C Unilocular sporangia and a hair ×110 (Kesa-iso-hama, Rikuzen Prov. 1–V, 1953)

D An unilocular sporangium and plurilocular sporangia × 110 (Ditto.)

E Assimilating filaments × 110 (Ditto.)

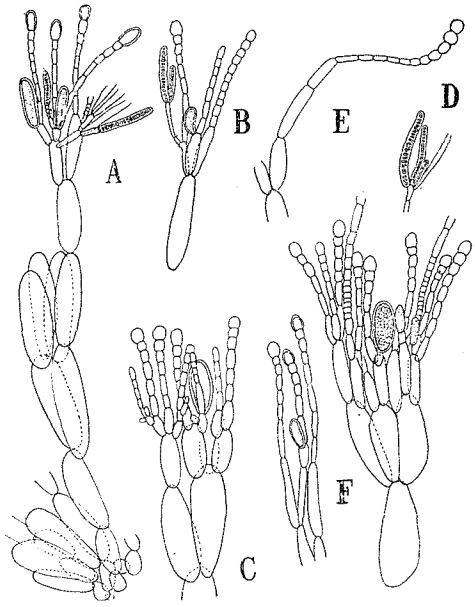


Fig. 17. *Leathesia monilicellulata* TAKAMATSU

A, B Unilocular and plurilocular sporangia × 110 (Hebi-ura, Mutsu Prov. 26–IV, 1952)

C Unilocular sporangia × 110 Tatsha, Sado Prov. 23–V, 1954)

D Plurilocular sporangia × 110 (Ditto.)

E Elongated assimilating filament × 110 (Ditto.)

F Unilocular sporangia borne on the basal cells of the assimilating filaments × 110 (Tatsha, Sado Prov. 23–V, 1954)

Japanese name: Nankin-nebarimo (nom. nov..)

Locality: Asamushi (epiphytic on *Sargassum confusum* AG. and *S. piluliferum* AG.), Miumaya (*S. piluliferum* AG.), Fukaura (*S. kjellmanianum* YENDO), Hebi-ura (*S. confusum* AG.), Mutsu Prov.; Tatsha (*S. patens* C. AG., *S. piluliferum* AG. and *S. toritile* C. AG.), Sado Prov.; Hariusu (*S. confusum* AG. and *S. kjellmanianum* YENDO), Ishikari Prov.; Muroran (*S. confusum* AG.), Iburi Prov. Growing below the low tide mark.

Frond epiphytic on the thallus of *Sargassum* by means of uniseriate rhizoids, spheroidal, subspheroidal or somewhat elliptical, 1–4 mm in diam. in solitary ones, often gregarious in broad area, solid, lubricous, fragile; cells of rhizoids elliptical, oblong, variable in shape, nearly colourless; cells of medullary layer colourless, with a few chromatophores, long elliptical, broadly elliptical, largest in the middle portion, smaller or narrower towards the basal or the peripheral portion, 100 $\mu \times$ 30–40 μ in size in the basal portion, 20 $\mu \times$ 30–40 μ in the peripheral ones, 50 $\mu \times$ 150–180 $\mu \times$ 230 μ in size in the middle portion, repeatedly 2–4 times, patently, usually trichotomously or very often dichotomously divided; assimilating filaments rather long, unbranched, composed of 5–9 cells becoming slightly broader towards the terminal portion, clavate, straight, moniliform or sometimes scarsely curved, very variable in shape, containing 3–6 or more discoidal chromatophores in each cell; the cell long cylindrical, oblong ellipsoidal in the basal or the lower portion, becoming gradually broadly elliptical or roundish towards the terminal portion; terminal cells elliptical, oviform, spherical, variable in shape, 15–20 $\mu \times$ 10– μ in size, very often larger than the other cells of the assimilating filaments, containing 8–10 or

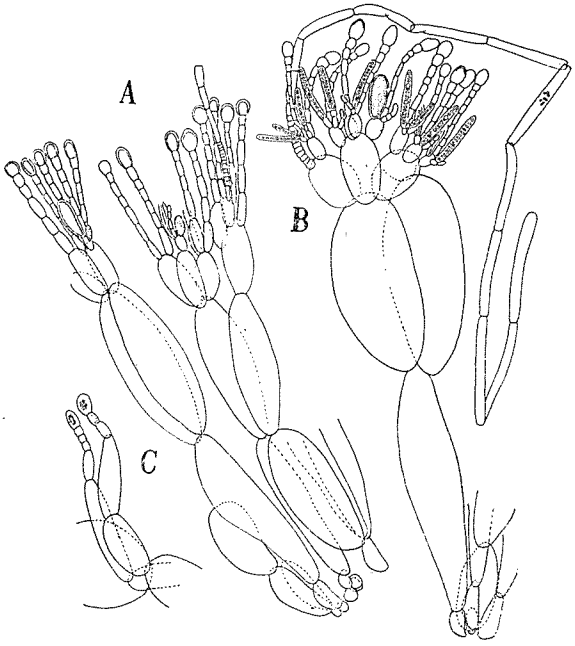


Fig. 18. *Leathesia monilicellulata* TAKAMATSU

A Portion of medullary and cortical layers × 110 (Asamushi, Mutsu Prov. 24–V, 1952)

B Unilocular and plurilocular sporangia, a hair × 110 (Kesa-iso-hama, Rikuzen Prov. 1–V, 1953)

C Younger assimilating filaments × 110 (Ditto.)

more discoidal chromatophores; hairs hyaline, colourless, 6–10 μ broad arising solitarily from the basal cells of the assimilating filaments, growing intercalarily in the lower portion, composed of cylindrical cells, the cells 50–80 μ long, 8–10 μ broad; unilocular sporangia borne on basal cells or peripheral cells of the medullary layer solitary or two to three together, sessile or pedicellate with 1 cell, elliptical, ovoidal, about 50 $\mu \times 30\ \mu$ in size; plurilocular sporangia borne on peripheral cells of the medullary layer, sessile or pedicellate with 1–2 cells, straight, cylindrical, 50–60 μ long, 60–70 μ broad, containing 10–20 gametes; both kinds of sporangia found in different individulals, or in one or the same individual; frond deep brown.

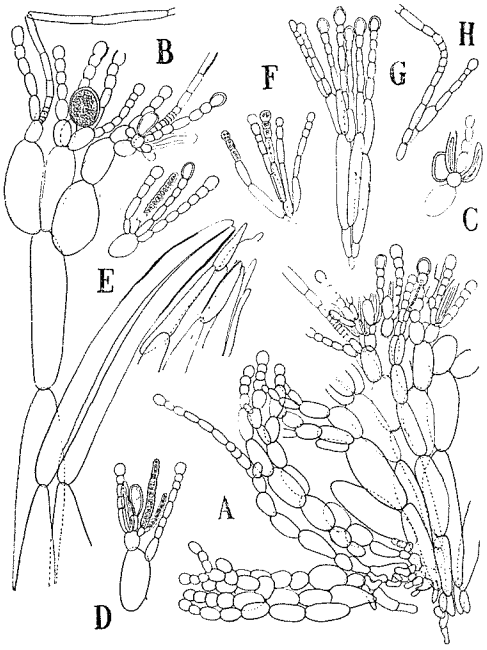


Fig. 19. *Leathesia monilicellulata* TAKAMATSU

A Juvenile portion with unilocular and plurilocular sporangia × 110 (Asamushi, Mutsu Prov. 24-V, 1952)

B, C Comparatively young portions provided with unilocular sporangia ×110 (Ditto.)

D Cortical layer with unilocular and plurilocular sporangia × 110 (Ditto.)

E Plurilocular sporangium ×110 (Ditto.)

F, G, H Portions of younger sterile tissues × 110 (Hariusu, Shiribeshi Prov. 10-IV, 1954)

The present species is very variable in structure of the frond as described above, especially in the shape of the assimilating filaments and their terminal cells as well as the medullary cells. The shape of the assimilating filaments as in TAKAMATSU's figure is very rare. The present writer has collected some specimens similar to Dr. TAKAMATSU's typical form only from a tidal pool near the Asamushi Marine Laboratory, but he has not found such a form amongst the specimens collected by Dr. TAKAMATSU. In Dr. TAKAMATSU's description the assimilating filaments are reported to be distinctly moniliform and the terminal cells are not so enlarged, and also in his specimens as well as the present writer's ones the assimilating filaments are not moniliform except 2–3 cells of the terminal portions which are provided with terminal cells of different shapes. The walls of the enlarged terminal cells of the assimilating filaments are sometimes thickened or sometimes not so, according to the difference of the localities, and also in the same individual the grade

of the thickening varies. The medullary cells in Dr. TAKAMATSU's description are 85–121 μ long, 27–36 μ broad in the middle portion, but those of his actual specimens and the present writer's ones which were collected from various localities, are attaining 150–230 $\mu \times$ 50–180 μ in size.

The present alga is not closely related to *Leathesia yezoensis*, *L. umbellata* and *Corynophlaea crispa* at all, but rather resembles *L. sphaerocephala* in structure.

Leathesia sphaerocephala YAMADA (Figs. 20–23)

Not. Some Japan. Alg. IV, Journ. Facult. Sci., Hokk. Imp. Univ., Ser. V, Vol. II, No. 2, 1932, p. 269, Fig. 2, a–b, Text-fig. 2; OKAM., Nippon Kaisoshi, 1936, p. 188; TOKIDA, Mar. Alg. S. Saghalein, 1954, p. 87.

Japanese name: Hime-nebarimo.

Locality: Saruru and Utoro, Kitami Prov.; Akkeshi, Kushiro Prov.; Muroran, Iburi Prov. Growing epiphytically on the thallus of *Cystophyllum hakodatense* YENDO below the low tide mark.

Frond epiphytic on other algae by means of rhizoidal base consisting of uniseriate layer of irregularly divided cells, lubricous, fragile, solid, spherical or hemispherical, solitary, 1–3 mm or more in diam. or usually gregarious, overspreading on the thallus of the host with rugged surface; medullary layer consisting of densely and 2–6 times repeatedly ditrichotomously divided cells, the cells nearly colourless, long cylindrical, very often oblong or broadly ellipsoidal, generally variable in shape and size, but usually largest in the middle portion, 50–70 $\mu \times$ 250–320 μ or 90 $\mu \times$ 200 μ in size, becoming gradually narrower or long cylindrical towards the lower portion, 100–200 $\mu \times$ 15–30 μ in size and towards the peripheral portion smaller or elliptical, oviform, 20–30 $\mu \times$ 15–20 μ to 25 $\mu \times$ 40 μ in size; as-

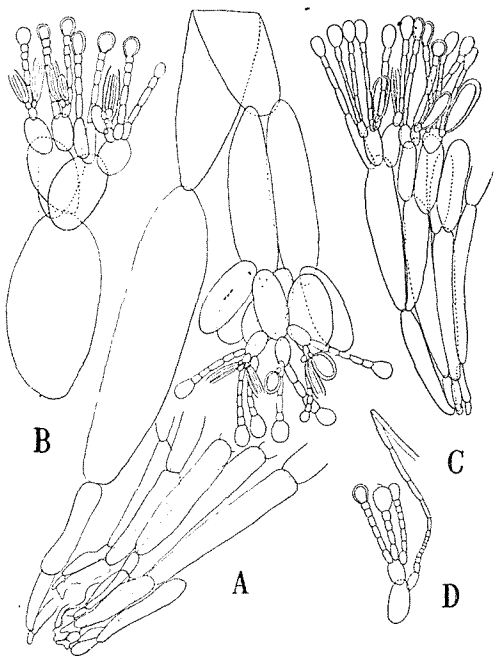


Fig. 20. *Leathesia sphaerocephala* YAMADA

A, B, C Medullary layers provided with unilocular sporangia × 110 (Akkeshi, Kushiro Prov. 23-VIII, 1956)

D Assimilating filaments and a hair × 110 (Ditto.)

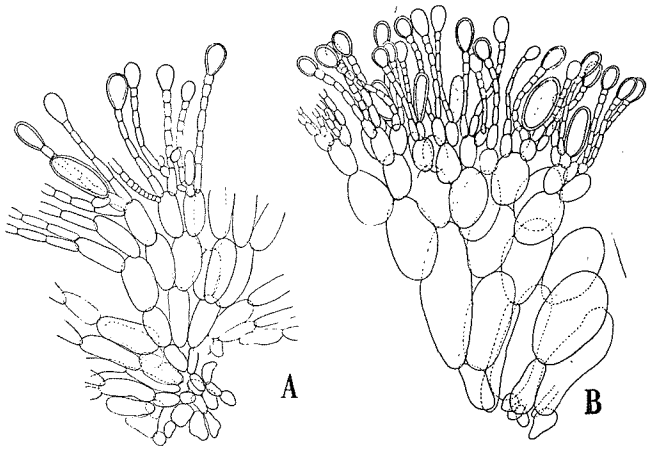


Fig. 21. *Leathesia sphaerocephala* YAMADA

A Basal, medullary, and cortical portions with unilocular sporangia and a hair × 110 (Motomari, Muroran, Iburi Prov. 19–VIII, 1955)

B Basal, medullary, and cortical layers with unilocular sporangia × 110 (Motomari, Muroran, Iburi Prov. 6–VII, 1954)

similating filaments arising from the outermost cells of the medullary layer by twos and threes or more, rather long, clavate, erect, composed of 5–9 cells or rarely more, 80–130 μ long or more, 4–5 μ broad in the middle portion, 5–8 μ in the basal or the upper cells, the lower cells twice as long as broad containing several chromatophores, becoming slightly thicker towards the upper portion, ending in extraordinarily large cells, the cells ovoidal, ellipsoidal, elliptical, sometimes roundish, variable in shape, thick-walled, 20–30 $\mu \times$ 15–20 μ in size, containing several chromatophores; 2–3 superior cells constricted at dissepiments in general; hairs colourless, hyaline, solitary, issuing from the outermost cells of the medullary layer, growing intercalarily in the lower portion, consisting of uniseriate cylindrical cells, the cells 40–50 μ long, 6–8 μ broad; unilocular sporangia borne on the basal cells of the assimilating filaments or the outermost cells of the medullary layer, tufted by twos and threes or more, sessile or pedicellate; plurilocular sporangia unknown; frond dark brown, adhering to paper in drying.

As mentioned above, the medullary cells of the present alga are remarkably variable in shape and size. In specimens collected from Akkeshi and Muroran, the medullary cells are broadly elliptical, but the writer very often observed narrower elliptical or cylindrical ones in specimens from the different localities of Hokkaido. The cells of the assimilating filaments are moniliform, generally as long

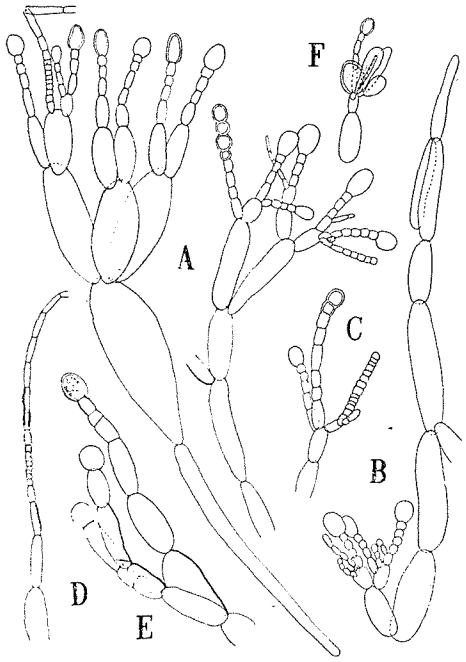


Fig. 22. *Leathesia sphaerocephala* YAMADA
A, B, C Medullary portions and a cortical one with a growing point in comparatively young fronds × 110 (Motomari, Muroran, Iburi Prov. 6-VII, 1954)
D A hair × 110 Motomari, Muroran, Iburi Prov. 6-VII, 1954)
E Younger portions of medullary and cortical layers × 110 (Ditto.)
F Unilocular sporangia ×110 (Ditto.)

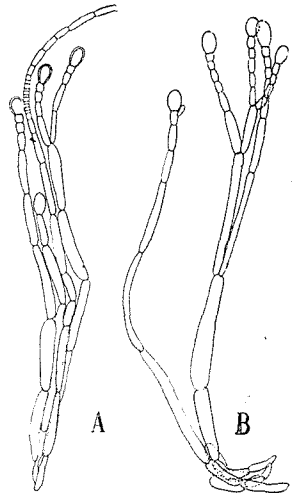


Fig. 23. *Leathesia sphaerocephala* YAMADA
A, B Portions of younger tissues ×110 (Motomari, Muroran, Iburi Prov. 6-VII, 1954)

as broad above, elongated or often twice as long as below, but in the lower portion not constricted at dissepiments. The present species is already provided with unilocular sporangia in the juvenile frond or the smaller frond. The specimens of the present species from different localities of Hokkaido resemble *Leathesia pulvinata* TAKAMATSU from Northeastern Honshu which is epiphytic on the frond of *Cystophyllum sisymbrioides* J. AG.

Leathesia pulvinata TAKAMATSU (Figs. 24, 25)

Spec. *Leathesia* Northeast. Honshu, Japan, 1939, p. 3, pl. 1, fig. 1, Text-fig. 2.

Japanese name: Hina-nebarimo (nom. nov.).

Locality: Sai, Mutsu Prov.; Kisagata, Uzen Prov.; Hanabuchi, Matsushima Gulf, Rikuzen Prov.; Tatsha, Sado Prov.; Himi, Ettchu Prov.; Kato, Wakasa Prov. Growing epiphytically on the fronds of *Cystophyllum hakodatense* YENDO, *Sargassum tortile* AG., *S. patens* C. AG., etc. below the low tide mark.

Frond epiphytic on other algae by means of rhizoidal base composed of uni-

seriate layer of irregularly divided cells, lubricous, fragile, solid, when solitary pulvinate, or spreading long-pulvinately though usually gregarious on the thallus of the host; medullary layer consisting of 2–5 times or more repeatedly densely divided cells, cells nearly colourless, longly cylindrical or oviform, very often narrowly elliptical, generally variable in shape and size, but usually largest and longest in the middle portion, 200–250 $\mu \times$ 30–50 μ in size becoming gradually narrowly cylindrical or elliptical above, in the lower portion 15–20 $\mu \times$ 100–150 μ in size, in the peripheral ones 20–30 $\mu \times$ 100–150 μ; assimilating filaments arising from the ultimate cells of the medullary layer, rather long, clavate, erect, composed of 5–7 cells or rarely 8, 80–150 μ long, 3–4 μ broad in the middle portion, 4–5 μ or more in the basal, or the upper one, not strongly constricted at dissepiments in the upper portion, the lower cells 2–4 times as long as broad, ending in extraordinarily large

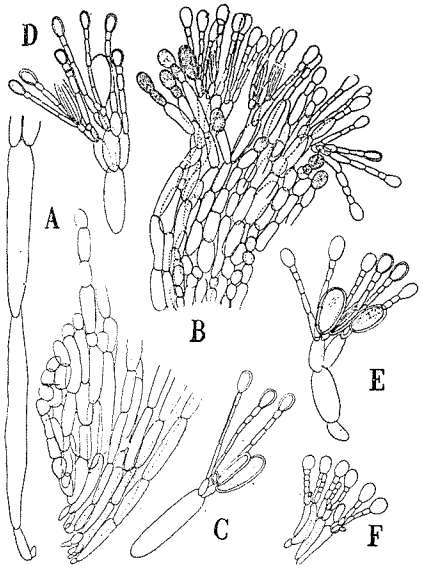


Fig. 24. *Leathesia pulvinata* TAKAMATSU

A Lower portion of a frond ×110 (Kisagata, Uzen Prov. 4–VI, 1952)
B Basal portion of a frond with unilocular sporangia × 110 (Ditto.)
C, D Unilocular sporangia × 110 (Ditto.)
E, F Inner tissues of small individuals with unilocular sporangia ×110 (Himi, Etchû Prov. 25–V, 1954)

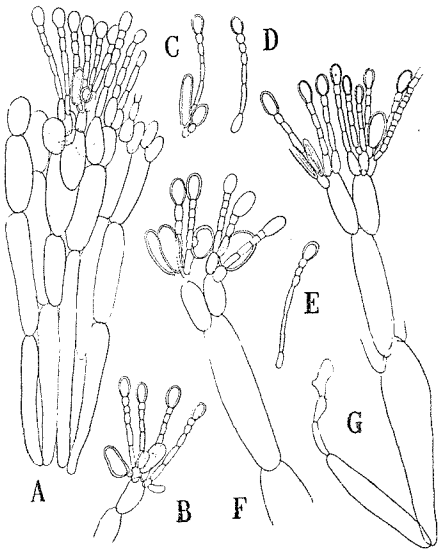


Fig. 25. *Leathesia pulvinata* TAKAMATSU

A Vertical section of a frond × 110 (Kato, Wakasa Prov. 12–V, 1953)
B, C Unilocular sporangia ×110 (Ditto.)
D, E Assimilating filaments ×110 (Ditto.)
F Unilocular sporangia borne on the basal cells of assimilating filaments × 110 (Matsushima-Bay, Rikuzen Prov. VII, 1953)
G Portion of a tissue provided with unilocular sporangia and a hair × 110 (Sai-Mutsu Prov. 27–V, 1952)

cells, the cells ovoidal, elliptical, variable in shape, thick-walled, 15–20 $\mu \times$ 20–30 μ in size, containing several chromatophores; hairs colourless, hyaline, solitary issued from the ultimate cells of the medullary layer, growing intercalarily in the lower portion, consisting of uniseriate cylindrical cells, the cells 40–50 μ long, 6–8 μ broad; unilocular sporangia borne on the basal cells of the assimilating filaments or the peripheral cells of the medullary layer, tufted in small groups, sessile or pedicellate with one cell; plurilocular sporangia unknown; frond dark brown adhering to paper when dried.

As Dr. TAKAMATSU stated in describing the histological structure, the present alga is very closely related to *Leathesia sphaerocephala* YAMADA, but the former differs from the latter in the following points. In the present alga the solitary frond is pulvinate in shape and not spherical or hemispherical as in *Leathesia sphaerocephala* YAMADA. The medullary cells of the present species are long cylindrical, narrowly elliptical, different to YAMADA's species, whose medullary cells are very often broadly elliptical, oblong and generally broader than those of TAKAMATSU's species. Of course somewhat oblong or elliptical medullary cells can also be observed in the present species. The assimilating filaments in TAKAMATSU's species are often provided with slender, long cylindrical cells in the lower portion and very often terminate in the elliptical or ovoidal large cells, but in YAMADA's species the lower cells of the assimilating filaments are not so slender and very often terminate in roundish large cells. In the adult fronds both species are distinguishable in the above-mentioned points, but in the juvenile ones these distinctions cannot be easily recognized.

Leathesia yezoensis INAGAKI, sp. nov. (Figs. 26, 27)

Leathesia umbellata YENDO (non MENEGH.), Not. Alg. New Jap., Bot. Mag. Tokyo Vol. XXX, 1916. p. 250; *Leathesia umbellata* TAKAMATSU (non MENEGH.), Spec. *Leathesia* Northeast. Honshu, Japan, 1939, p. 8, pl. I, fig. 4, Text-fig. 5; *Leathesia umbellata* TOKIDA (non MENEGH.), Mar. Alg. S. Saghalien, 1954, p. 86, pl. IX, Figs. 1–2.

Japanese name: Kotsubu-nebarimo.

Locality: Isatomai, Rikuzen Prov.; Tappi, Mutsu Prov.; Hariusu, Shiribeshi Prov. Epiphytic on the thallus of *Sargassum kjellmanianum* YENDO below the low tide mark.

Frond epiphytic on other algae by means of a single cell-layered rhizoidal base, attached over a broad area, hemispherical or somewhat pulvinate, sometimes gregarious, solid, lubricous, fragile 1–2 mm in diam. in solitary frond; cells of rhizoid variable in shape, oblong or elliptical, irregularly divided; cells of medullary layer oblong, somewhat cylindrical, long elliptical, irregular in shape, in the middle

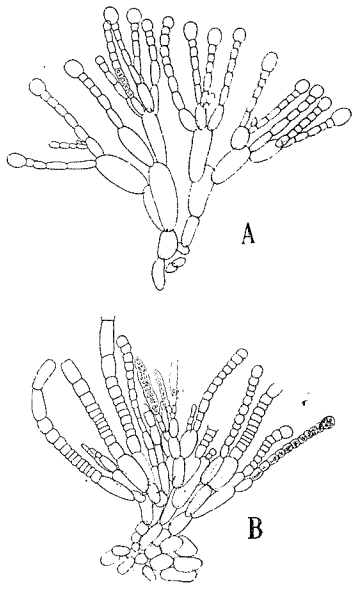


Fig. 26. *Leathesia yezoensis* INAGAKI

A, B Portions of medullary and cortical layers provided with hairs and plurilocular sporangia ×110 (Hariusu, Shiribeshi Prov. 10-VI, 1954)

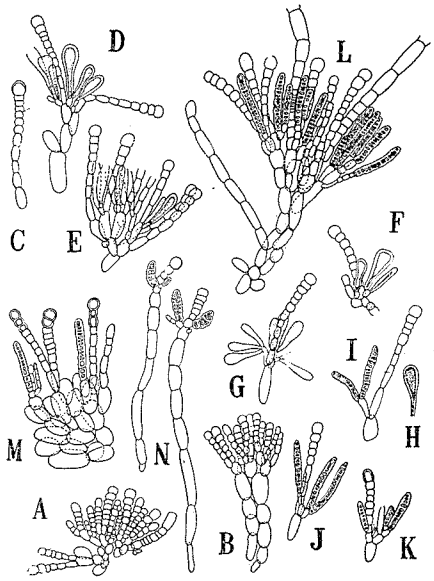


Fig. 27. *Leathesia yezoensis* INAGAKI

A, B Juvenile fronds ×110 (Hariusu, Shiribeshi Prov., 10-VI, 1954)
C Assimilating filament in growing stage ×110 (Ditto.)
D, E, F, G, H Unilocular sporangia ×110 (Ditto.)
I, J, K, L, M Plurilocular sporangia ×110 (Ditto.)
N Growing points and plurilocular sporangia in different shape ×110 (Ditto.)

portion largest, 15×50 μ–30×80 μ in size, gradually smaller towards the lower and cortical portions, almost colourless containing a few chromatophores, usually patently dichotomously or trichotomously divided, not densely congested; assimilating filaments solitary or tufted by twos and threes on the outermost cells of the medullary layer, rather elongate-clavate, straight or slightly curved on the upper portion, gradually broader upwards, 100 μ or more long, 6–11 celled, cells oblong, cuboid, very often half as long as broad with several chromatophores except in the cylindrical basal cells; apical cells spherical or elliptical, sometimes larger than any other cells in the juvenile frond, provided with thickened wall; hairs colourless, hyline, comparatively broader, composing of cylindrical cells, 30-50 μ long, 15 μ broad, growing intercalarily in the lower portion, arising solitarily from the larger medullary cells; unilocular sporangia borne on the basal cells of the

assimilating filaments or the outermost cells of the medullary layer furnished with 1–2 celled petioles, long ovoidal, 35–60 μ long, 10–20 μ broad; plurilocular sporangia long cylindrical, arising from the outermost medullary cells or the basal cells of the assimilating filaments, 60–80 μ long, about 10 μ broad, sessile or pedicellate with 1–2 cells, containing 9–17 gametes in 1–3 rows; both kinds of sporangia developed in different individuals; frond brownish, adhering to the paper in drying.

The present alga is different from the European species, *L. umbellata* MENEGH. in the following points. The medullary layer of the former are not provided with elliptical or roundish cells as the latter, and also the assimilating filaments and the plurilocular sporangia are longer. On account of these differences the present writer recognizes Japanese specimens as a new species, though Dr. TAKAMATSU has identified this alga without any hesitation with *Leathesia umbellata* following the late Dr. K. YENDO.

Leathesia crassipilosa TAKAMATSU (Figs. 28, 29)

Spec. *Leathesia* Northeast. Honshu, Japan, 1939, p. 9, pl. II, fig. 1–2, Text-fig. 6.

Japanese name: Edauchi-nebarimo (nom. nov.)

Locality: Tappi, Shiriya and Kita-kanagasawa, Mutsu Prov.; Iwaisaki, Rikuzen Prov. Epiphytic on *Sargassum piluliferum* AG. below the low tide mark.

Frond epiphytic on other algae, with one cell-layered rhizoidal base spreading over a broad area, hemispherical or slightly pulvinate, solitary, 0.5–2.0 mm in diam or often gregarious, solid, lubricous, fragile; medullary layer rather loose, composed of dichothomously or trichotomously, repeatedly 2–4 times divided cells; the cells colourless, cylindrical, long ellipsoidal, oviform, generally

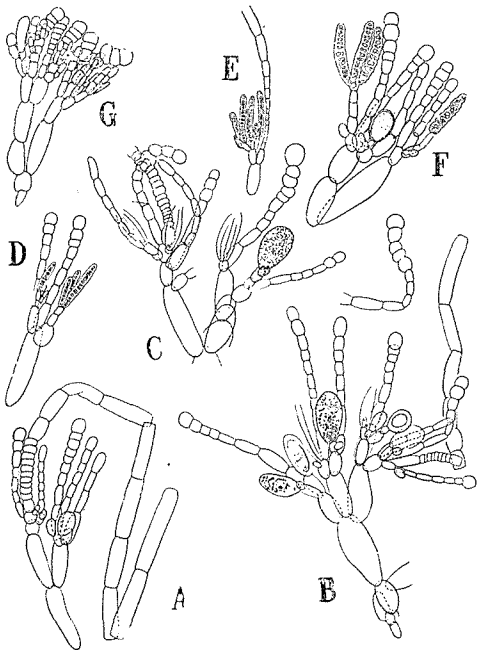


Fig. 23. *Leathesia crassipilosa* TAKAMATSU

A, B, C Cortical layers with second assimilating filaments, hairs and unilocular sporangia × 110 (Collected by TAKAMATSU)

D, E Plurilocular sporangia × 110 (Ditto.)

F Unilocular and plurilocular sporangia borne on the same individual × 110 (Ditto.)

G Portion of a juvenile tissue ×110 (Ditto.)

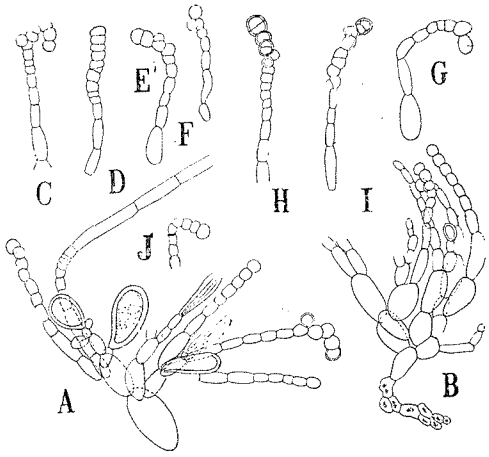


Fig. 29. *Leathesia crassipilosa* TAKAMATSU

A Portion of a cortical layer, a hair and unilocular sporangia × 110 (Suetsugu, Rikuzen Prov., 26-VI, 1953)
B Basal, medullary and cortical portions with a young unilocular sporangium × 110 (Ditto.)
C, D, E, F, G, J Secund assimilating filaments × 110 (Ditto.)
H, I Assimilating filaments in growing stages × 110 (Ditto.)

largest in the middle portion, 70–100 μ long, 20–25 μ broad, becoming shorter and narrower outwards, clavate, in the outer portion oviform or ellipsoid; assimilating filaments remarkably moniliform, gradually broader towards the apex, very often curved and sometimes secundly branched on the terminal portion, 100–200 μ long, composed of 6–11 cells or more in branched assimilating filaments; cells of assimilating filaments variable in shape, 20–30 μ long, 10 μ broad, elongate-cylindrical in the lower portion or in the terminal ones, globose, cuboid, ellipsoid, 10–15 μ long, 10–18 μ broad, provided with 10 or more chromatophores in each cell; terminal cells globose, hemispherical or broadly lanceolate, variable in shape, with thickened wall on the upper side, 10–15 μ long, 10–18 μ broad; hairs hyaline, colourless, solitary, 10–15 μ broad, arising from the outermost cells of the medullary layer, growing intercalarily in the lower portion; unilocular sporangia arising from the basal cells of the assimilating filaments, sessile or tuft-like with one-celled petioles on the outermost cells of the medullary layer, broadly ellipsoidal, oviform, 20–25 μ × 40–55 μ in size; plurilocular sporangia usually borne on the basal cells of the assimilating filaments, sessile or pedicellate with 1–2 cells, cylindrical, fusiform, 50–70 μ long, containing 11–20 gametes in 1 or sometimes 3 rows; unilocular and plurilocular sporangia developed in different individuals or in one and the same individual; frond deep brownish in colour.

The present alga is related closely to *Leathesia yezoensis* INAGAKI, though there is the following difference between both species. In the present species the assimilating filaments are moniliform and in the terminal portion secundly branched; also the medullary layer is several times repeatedly divided. Moreover, the present species is rather more closely related in structure to *Leathesia yezoensis* INAGAKI than to *Leathesia monilicellulata* TAKAMATSU.

Leathesia japonica INAGAKI, sp. nov. (Fig. 30)

Japanese name: Kogome-nebarimo (nom. nov.)

Locality: Suetsugu, Rikuzen Prov. (*Sargassum confusum*) AG.) Hebi-ura, Mutsu Prov. (*Sargassum miyabei* YENDO ?); Kato, Wakasa Prov. (*Sargassum thunbergii* (MERT.) O. KUNTZE.). Epiphytic on the thallus of *Sargassum* below the low tide mark.

Frond epiphytic, with rhizoidal base consisting of a uniseriate layer of variably shaped cells, usually hemispherical or pulvinate, solid, lubricous, solitary, about 0.5–1.0 mm in diam. or rarely gregarious; medullary layer composed of cells divided 1–4 times, not densely congested, cells in the basal portion almost colourless, roundish or elliptical, 10–15μ in diam., the second or the third cells from the base largest, longly cylindrical or elliptical 90–110μ long, 20–30μ broad, superior cells than those ones becoming gradually smaller towards the peripheral portion, 20$\mu \times$ 40μ in size; medullary cells usually dichotomously or rarely trichotomously divided; each peripheral cells giving rise to assimilating filaments by twos and threes; assimilating filaments clavate, very variable in length, almost straight, remarkably moniliform in the upper portion, rarely branched in the terminal portion, in adult stage comparatively long, generally 80–200μ long, composed of 10–15 cells, but in juvenile or smaller frond rather short, down to 70μ long, provided with 5–7 cells, cells in the middle or lower portion cylindrical or often slender, 20–25μ long, 5–6μ broad, in the upper portion oblong or roundish with terminal cells, cells globose or elliptical, as long as the other ones, containing 7–8 chromatophores in each cell, but very often more enlarged than the other ones containing 4 or more chromatophores; hairs hyaline, solitary, arising from the peripheral cells of the medullary layer, growing intercalarily in

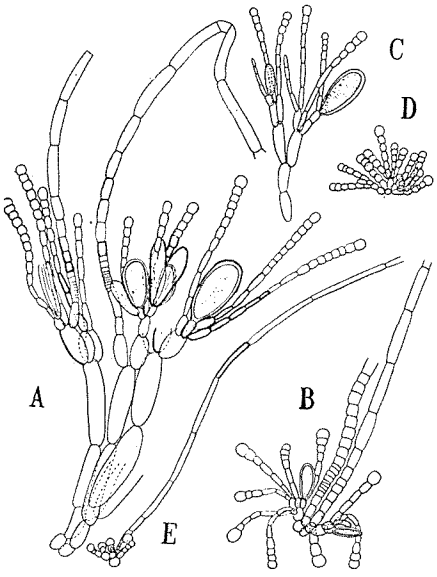


Fig. 30. *Leathesia japonica* INAGAKI

A Portion of an inner tissue with unilocular sporangia and hairs ×110 (Hebi-ura, Mutsu Prov. 26–V, 1952)

B, C Portions of juvenile inner tissues with unilocular sporangia and hairs (in C) ×110 (Ditto.)

D Portion of a juvenile frond ×110 (Ditto.)

E Assimilating filaments and a hair arising from a basal cell in juvenile stage ×110 (Ditto.)

the lower portion, composed of uniseriate cylindrical cells 50–100 μ long; unilocular sporangia borne on the basal cells of the assimilating filaments, sessile, long oviform, elliptical, 40–80 $\mu \times$ 20–40 μ in size; plurilocular sporangia unknown; frond brownish in colour.

The frond of the present alga consists of a thin layer of the medullary cells, especially in the juvenile or the smaller frond almost always of 1–2 layers of small roundish or elliptical cells, giving rise to assimilating filaments and then hairs or unilocular sporangia from the basal cells of the assimilating filaments.

This alga is rather closely related to *Elachista* in structure; the medullary cells are arranged loosely and are irregularly divided, being different from other species of *Leathesia*. The assimilating filaments which are peculiar in shape are held together in a hemispherical mass by the surrounding jelly. There are not so long assimilating filaments in the present alga as in *Elachista*. So far as the author has observed, this species is provided with unilocular sporangia already in small microscopic stage of the frond.

Fam. **Chordariaceae**

REICHENBACH, Conspectus Regn. Veg., 1828, p. 25 (in part); OKAMURA, Nippon Kaisoshi, 1936, p. 190; KYLIN, Phaeoyphyceenord. *Chordar.*, 1940, p. 5; *Chordarieae*, AGARDH, Syst. Alg., 1824, p. XXVI (in part); HARVEY, Ner. Bot. Amer., I, 1852, p. 121 (in part); *Myriogloiaceae*, KUCKUCK, in OLTMANNS, Morph. und Biol. der Algen, ed. 2, Vol. 2, 1922, p. 19 (by implication); *Myriogloeaceae* OLTMANNS, loc. cit.; *Mesogloeaceae*, KUCKUCK, Monogr. *Phaeosp.* 1929, p. 46; *Myriogloeaceae*, KUCKUCK, Monogr. *Phaeosp.*, 1929, p. 62; *Myriocladiaceae*, KUCKUCK, 1929, p. 63; *Aegiraceae*, SETCHELL et GARDNER, *Melanophyc.*, 1925, p. 543; *Heterochordariaceae*, SETCHELL et GARDNER, *Melanophyc*, 1925, p. 549; Id., Phyc. Cont., VII, 1924, p. 6; OKAMURA, Nippon Kaisoshi, 1936, p. 199.

Myriogloia KUCK. 1929.

KUCKUCK, Monogr., 1929, p. 63; KYLIN, Phaeophyceenord. *Chordariales*, 1940, p. 10.

Central axis monopodial, polysiphonous, composed of many longitudinal filaments, but somewhat loosely arranged arising from the primary base; base small, constructed directly from the primary base without descending rhizoids from the lower portion of the erect frond; medullary layer composed of a bundle of many slender filaments divided here and there without remarkable connections with one another; the difference between subcortex and cortex evident; subcortical filaments very loosely arranged issuing horizontally from the medullary layer, repeatedly divaricated; assimilating filaments hair-like, very long, unbranched, not included in gelatinous substance, containing dense contents in the upper portion; hyaline

hairs lacking; unilocular sporangia ellipsoid, oviform, solitary or tufted, sessile or petiolate with 1–2 cells on the basal and lower portions of the assimilating filaments; plurilocular sporangia, judging from KYLIN and KUCKUCK's descriptions, transformed from the upper portion of the assimilating filaments.

Myriogloia simplex (SEGAWA et OHTA) INAGAKI, comb. nov. (Figs. 31–34)

Tinocladia simplex SEGAWA et OHTA mscr., SEGAWA and OHTA, Notes on some seaweeds of Hakata Bay (The Science Bulletin, Faculty of Agriculture, Kyushu University, Vol. 13, 1–4, 1951).

Japanese name: Kitsune-no-wo.

Locality: Na-jima and Myoken-jima, Chikuzen Prov. Growing on rocky places.

Frond often caespitose, very lubricous, gelatinous, simple or sparsely branched into short or long branches, 8–15 cm high, long clavate, gradually thicker upwards tapering immediately at the base, 5–13 mm thick in the middle or lower portion; central axis polysiphonous, composed of many filaments arising from the primary base without descending rhizoidal filaments from the lower portion of the frond so as to form the secondary base; medullary filaments very slender terminating as elongated hairs, here and there divided, becoming a bundle of filaments about 350 μ in diam.; medullary cells about 50–100 μ long, 10–18 μ thick; base discoid, small in comparison with the frond, giving rise to creeping filaments from the margin and then unbranched assimilating filaments, the creeping ones irregulary divided; subcortical layer very thick; the difference between subcortex and cortex evident; subcortex about 0.4–4 mm thick, composed of very loosely arranged filamentous cells issuing horizontally from the central axis and dividing generally patently, but in the lower portion of the frond scattering on one side of the main axis, the filamentous cells 15–20 μ in diam.,

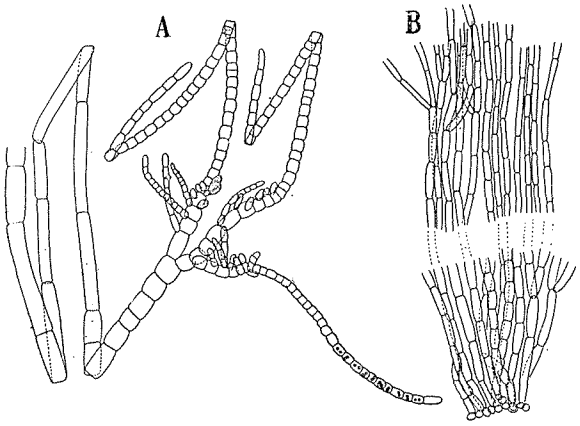


Fig. 31. *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI

A Growing point × 130 (Na-jima, Hakata, Chikuzen Prov., 4–II, 1951. Collected by SEGAWA and OHTA)

B Central axis in the lower portion of the frond arising on the primary base × 110 (Ditto.)

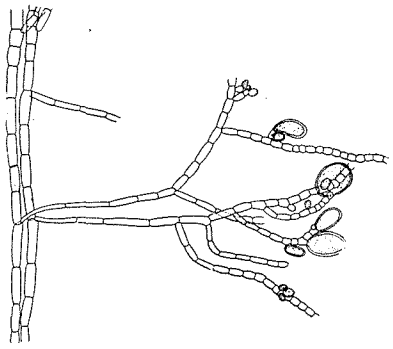


Fig. 32. *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI

Unilocular sporangia borne on assimilating filaments × 70 (Na-jima, Hakata, Chikuzen Prov., 4-II, 1951. Collected by SEGAWA and OHTA)

30–50 μ long or 100–120 μ in the portion neighbouring the cortex and the lower portion of the frond; each segment of the filamentous ones not constricted by cell-wall; assimilating filaments hair-like, 1–2 mm long, uniseriate with cylindrical cells, unbranched, not included in gelatinous substance, growing intercalarily in the lower portion, terminating blunt cells constricted at dissepiments in the lower and middle portions, but in the upper ones not so; cells of assimilating filaments in the middle portion 15–20 μ long, as long as broad, gradually longer upwards attaining 30–40 μ, in the apical portion tapering to breadth of 7–10 μ; unilocular sporangia ellipsoid, oviform, 40–100 μ × 25–60 μ in size, solitary or tufted, sessile or petiolate with 1–2 cells on the basal or lower portion of the assimilating filament; plurilocular sporangia unknown; hyaline hair lacking; frond brown in colour, adhering to paper when dried.

The present species was referred to *Tinocladia* by SEGAWA and OHTA, from which it differs in the following points.

In contrast to the genus *Tinocladia* the present alga has no hair which is characteristic in the frond of *Phaeophyceae*, but it is provided with very long assimilating filaments. The unilocular sporangia of the present species are sessile or petiolate on the basal or lower portion of the assimilating filament; however, in the genus *Tinocladia* they grow on the base of the assimilating filament.

The present alga resembles *Myriogloia abreviata* KYLIN collected by Papenfuss from Sea Point and Mouille Point near Cape Town, from which it differs in the following points. While every segment of the assimilating filaments of KYLIN's species is not constricted and the medullary layer attains 4–6 mm thickness, in the present species every segment of the assimilating filaments is evidently constricted on their lower and middle portions, and the medullary layer is merely about 350 μ thick. The assimilating filaments of the present alga are 1–2 mm long, but in KYLIN's specimens their length is 1 mm.

The writer has easily found that the unilocular sporangia of the present alga are sessile or petiolate with 1–2 cells; however, in the other species they are sessile. All specimens were sent him by Dr. S. SAGAWA.

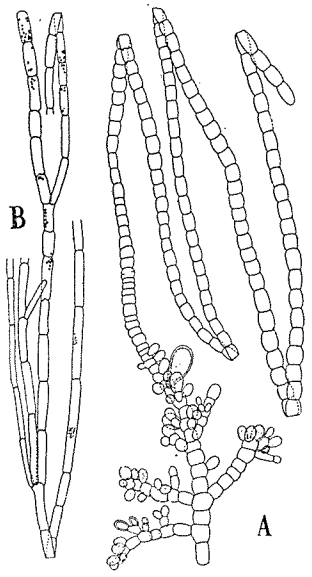


Fig. 33. *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI

A Long assimilating filament and many unilocular sporangia ×110 (Na-jima, Hakata, Chikuzen Prov., 4-II, 1951)

B Central filaments ×110 (Ditto.)

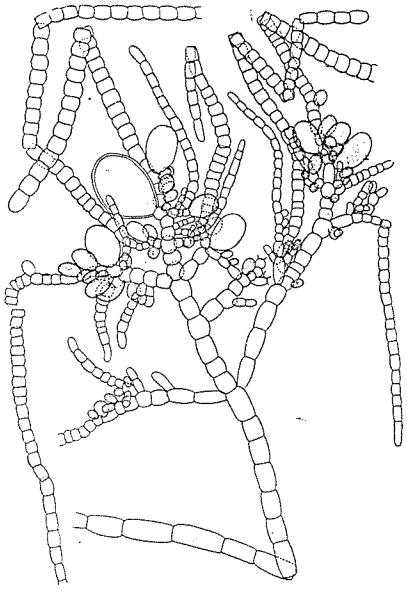


Fig. 34. *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI

Long and short assimilating filaments, subcortical cells and unilocular sporangia ×110 Na-jima, Hakata, Chikuzen Prov., 4-II, 1951. Collected by SEGAWA and OHTA)

Papenfussiella KYLIN 1940

KYLIN, Phaeophyceenord. *Chordariales*, 1940, p. 17.

Frond dimorphic with short assimilating filaments arising from the primary rhizoidal base and erect main stem; central axis in juvenile stage composed of a bundle of several filaments or sometimes a single filament, monopodial, polysiphonous, in adult stage composed of a bundle of many filaments lying lengthwisely, somewhat loosely arranged, in the inner portion, the filaments variable in diam.; slender rhizoidal filaments in the medullary layer present or not; boundary between medulla and cortex distinct; repeatedly divaricate subcortical cells lacking; assimilating layer consisting of one or two kinds of filaments, long and short ones tapering towards the apices; long assimilating filaments hair-like, containing dense contents, free from gelatinous substance; hyaline hairs lacking; unilocular sporangia ellipsoid or ovate, sessile on the first basal cells or pedicellate on the basal cells of the short assimilating filaments; plurilocular sporangia unknown.

Papenfussiella kuromo (YENDO) INAGAKI, comb. nov.

Myriocladia kuromo YENDO, Nov. Alg. Japan., 1-3, 1920, p. 1 (B.M.T. Vol. XXXIV); OKAMURA, Nippon-Kaisoshi, 1936, p. 204, Fig. 108; KYLIN, Phaeophyceenord. *Chord.*, 1940, p. 10; ARAZAKI, On the life-history of the *Acrothrix pacifica*, *Myriocladia kuromo* and *Petrospongium*, Seibutu Vol. III, No. 3-4, 1948, p. 98, Fig. 3.

Locality: Comparatively widely distributed along the Pacific and the Japan sea coasts.

Frond erect, single or caespitose arising from small discoid base, solid, cord-shaped, subcartilaginous, slimy, provided with a main stem or more usually branching patently in all directions without a main stem; main branches 10-30 cm long, 1-2 mm sometimes 3 mm in diam., slightly narrower towards the apices, branches sparse or luxuriant, irregulary alternately or laterally divided in 1-4 orders; central axis at first generally composed of a bundle of several filaments, but sometimes in the active growing point consisting of only a single filament, each apical filament elongated to an assimilating hair at the apex of the young branch; on the old ones the assimilating hairs gradually short; apical assimilating hairs olive or greenish brown, 1 mm long or more, 20 μ thick in the thickest portion, consisting of a single row of cells, the assimilating hairs growing intercalarily at the growing point; afterwards central axis composed of a bundle of cylindrical cells becoming to a medullary layer, the cells longitudinally arranged with considerable density in the outer part of the medullary layer, but in the inner part rather loosely: subcortical layer absent between medullary layer and cortical ones: assimilating filaments consisting of two forms, the long ones not imbedded in gelatinous substance, elongated like hairs, about 1-2 mm long, somewhat thicker in the middle portion, but in age very often filling off; the short ones imbedded in gelatinous substance, considerably shorter than the former, composed of 6-10 or more cells, about 50-100 μ long, club-shaped, very often curved, densely covering surface of the medullary layer; typical phaeophyceae-hair absent; rhizoidal cells and cylindrical ones issuing from basal cells of primary assimilating filaments in the apical portion, developing into medullary cells descending along the central axis; primary assimilating filaments growing gradually to long assimilating filaments composed of about 22-28 cells, giving rise to short assimilating filaments in the lower portion of them; unilocular sporangia ellipsoid, ovate, 20 $\mu \times 40\ \mu$, sessile on the first basal cells or pedicellate on the basal cells of the short assimilating filaments, sometimes found in their middle and lower portions; plurilocular sporangia unknown; colour brownish olive, greenish brown or dark brown; frond adhering to paper when dried.

The present alga was described as *Myriocladia kuromo* by YENDO, but it ought to be referred to the genus *Papenfussiella* because of the tissue and the growing

point as mentioned above. In the frond of *Myriocladia* long phaeophycean hairs are present, and there is only one kind of assimilating filaments, not imbedded in gelatinous substance. The medullary layer is composed of dense filamentous cells. But the frond of *Papenfussiella* has no phaeophyceae-hair and the assimilating filaments are distinguished into two kinds, short and long ones. The short assimilating filaments are enclosed in gelatinous substance, but the long ones are not. The medullary cells of *Papenfussiella* are arranged densely in the outer portion and loosely in the inner portion. The present genus also resembles the genus *Myriogloia* in that the apex of the frond takes the form of a tuft of the long assimilating filaments in general. However, the present species seems to belong to *Haplogloia andersonii* (FARL.) KYLIN in respect to its single central axis in the active apical point, but it belongs neither to *Myriogloia* nor to *Haplogloia* as proven by the following characteristics. In the genus *Myriogloia* the central axis consists of a bundle of many filaments and the subcortical layer consisting of filamentous cells which are divided repeatedly and radiately is apparently present. In the genus *Haplogloia* the monosiphonous central axis is always present. On the contrary, in the genus *Papenfussiella* one cannot find at all such intermediate layer and monosiphonous central axis, except in the active apical portion of the frond. The terminal cell of the assimilating filament of *Haplogloia andersonii* (FARL.) KYLIN is swollen, but in the genus *Papenfussiella* it is not so.

The following three forms are separable.

f. ***kuromo*** (Figs. 35–39 Pl. III)

Japanese name: Kuromo.

Locality: Ohkamiko-ura (J. NIKAI), Awa Prov.; Arashima (M. HIRAYAMA), Ishikagami (K. YENDO), Wagu and Suga-shima, Shima Prov.; Iragozaki, Ikawazu and Ehima, Mikawa Prov.; Asahi-mura (M. ARAZAKI), Owari Prov.; Inubo-zaki (K. YENDO) Shimofusa Prov.; Maizuru (UMEZAKI) Tango Prov.; Nanawo (M.YAMAMOTO), Noto Prov.; Himi (K. OHSHIMA), Etchu Prov.; Noh (K. YENDO), Echigo Prov.; Shiranuka (K. YENDO), Mutsu Prov.; Oshoro (K. YENDO), Hariusu (N. TAZAWA), Shiribeshi Prov.

Growing on rocks or epiphytic on *Eisenia bicyclis* (KJELLM.) SETCHELL, *Gymnogongrus flabelliformis* HARV. and other algae between the two tide marks or below the low tide mark in the open sea.

Main stem about 2–3 mm in diam., in 1–2 orders sparsely branched.

The branching of the frond is polymorphous in different manners, according to locality and season.

f. ***gracilis*** INAGAKI, f. nov.

Japanese name: Hoso-kuromo (nom. nov.)

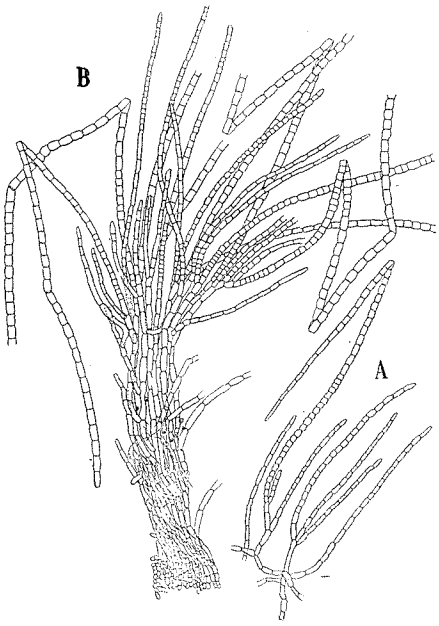


Fig. 35. *Papenfussiella kuromo* (YENDO) INAGAKI f. *kuromo*

A Assimilating filaments arising from creeping rhizoids of the primary base × 90 (Himi, Etchû Prov., 19-III, 1953)

B Growing portion of the juvenile erect frond on the primary base × 90 (Ditto.)

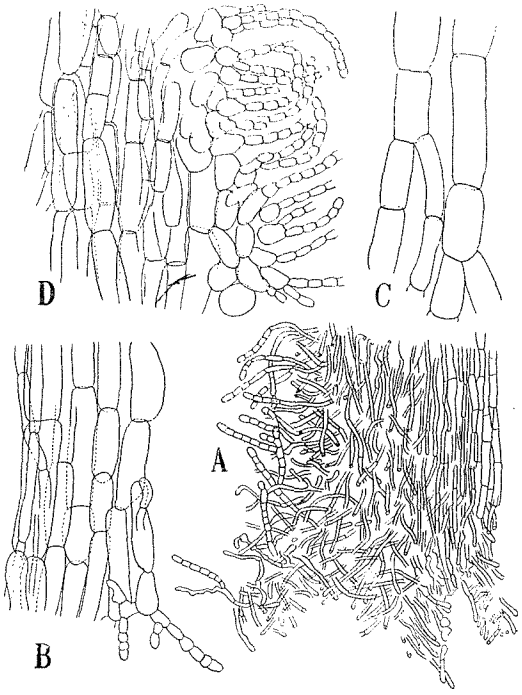
Fig. 36. *Papenfussiella kuromo* (YENDO) INAGAKI f. *kuromo*

A Half portion of the secondary base composed of entangled filaments and slender assimilating filaments × 70 (Wakasa-Bay, Wakasa Prov., 10-VI, 1950)

B Lower portion of a medullary layer composed of cylindrical cells which are sometimes dichotomously divided, and assimilating filaments arising from this layer × 160 (Shinmaiko, Owari Prov.)

C Dichotomously divided central filaments × 160 (Irago-zaki, Mikawa Prov., 10-III, 1938)

D Portion of a vertical section of a frond, whose surface densely covered with short assimilating filaments × 130 (Ditto.)



Locality: Toyohama, Ohno and Asahi-mura, Owari Prov.

Growing on rocks in calm waters.

Main stem about 1 mm in diam., in 2–3 orders sparsely or somewhat densely branched.

The branches and the branchlets are 0.5 mm or less in diam. and slender.

f. ***densa*** INAGAKI, f. nov.

Japanese name: Fusa-kuromo (nom. nov.)

Locality: Toyohama, Owari Prov.

Growing on rocky places in shallow waters.

Main branches of the frond about 1 mm in diam., in 3–4 orders densely or patently branched.

The present forma is very different from the other ones in branching; also a percurrent main axis is not visible.

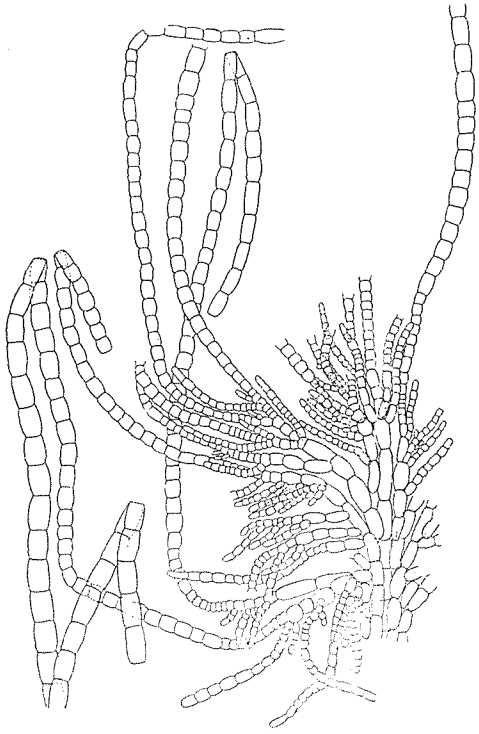


Fig. 37. *Papenfussiella kuromo* (YENDO) INAGAKI f. *kuromo*
Growing point of the apex of a juvenile frond × 140 (Shinmaiko, Owari Prov., 24-II, 1938)

Development of the frond.

The primary rhizoidal base consists of an irregular single cell-layer and in its cells some chromatophores are included. Many entangled filaments arise from the primary base, and from their apices issue abundant primary assimilating filaments which are simple or branching sparsely. Some of these primary assimilating filaments become a bundle of primary central axes by their own apical growth, and the apex of each assimilating filament develops into a primary apical assimilating hair which grows intercalarily in its lower portion. Afterwards the other general primary assimilating filaments fall off from the substratum or one part of the secondary base of the frond.

The central axis of the frond consists of several filaments, each of which is composed of a single cell-row. Afterwards, the apex of each central filament becomes a hair which has chromatophores like a usual assimilating filament. The apical assimilating hair is gradually elongated to a length of 1 mm or more and

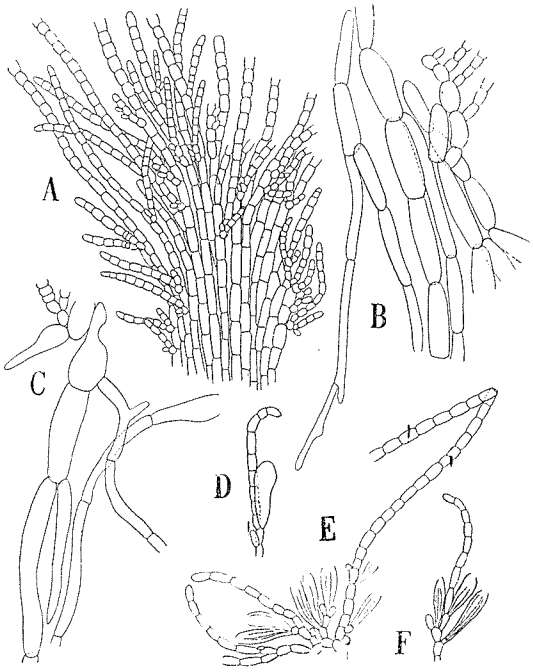


Fig. 38. *Papenfussiella kuromo* (YENDO) INAGAKI f. *kuromo*

A Apical portion of a adult frond × 130 Shin-maiko, Owari Prov., 24-III, 1938)

B Rhizoidal filaments descending from medullary cells × 160 (Ditto.)

C Rhizoidal filaments descending from medullary cells in the lower portion of a frond × 160 (Irago-zaki, Mikawa Prov., 25-III, 1947)

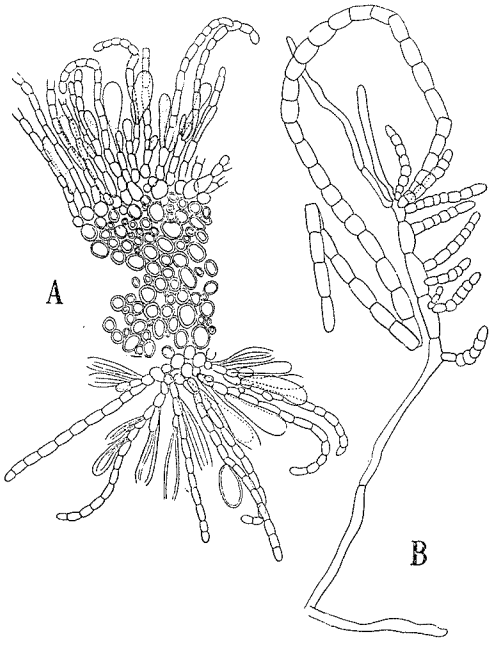
D Unilocular sporangia bore on the basal cell of a short assimilating filament × 90 Wakasa Bay, Wakasa Prov., 10-IV, 1950)

E, F Sessile or one-celled petiolate empty unilocular sporangia borne on the basal cells or the lower portion of short or long assimilating filaments × 90 (Ditto.

Fig. 39. *Papenfussiella kuromo* (YENDO) INAGAKI f. *kuromo*

A Cross section of a frond provided with unilocular sporangia × 90 (Wakasa-Bay, Wakasa Prov., 10-IV, 1950)

B Assimilating filaments, a hair and descending filaments arising in the lower portion of a frond × 160 (Irago-zaki, Mikawa Prov., 25-III, 1947)



a thickness of about 20 μ growing intercalarily in the lower portion, and becomes a true primary assimilating hair. The cells of the apical hair are 15–20 $\mu \times$ 15–20 μ, cubic in the middle and lower portions, but in the upper portion they are 10–15 $\mu \times$ 20–25 μ, cylindrical and becoming gradually narrower towards the apex. The assimilating filament and the secondary apical assimilating hair occurring on the primary apical assimilating hair resemble each other. In the old stage these apical assimilating hairs gradually become central axes elongating themselves slowly, so one is at a loss how to distinguish them from the primary central axes. In this stage the apical portion of the frond looks like an apex of *Myriogloia*. But in the active apex of the juvenile frond of the present alga the central axis is monosiphonous just as in the apical portion of *Haplogloia andersonii* (FARL.) LEVR. One cannot find any external differentiation between the primary apical assimilating hairs and the secondary ones which have already constructed the medullary layer by their elongation and branching. The primary assimilating filaments newly develop on the secondary apical assimilating hair and the long assimilating filaments are again arising from the primary assimilating filaments. The short assimilating filaments develop on the bases of the primary assimilating ones and the neighbouring parts of the bases. Both kinds of assimilating filaments project like comb-teeth from the outsides of the central filament. Cells borne on the basal cells of the primary assimilating filaments and the secondary apical assimilating hair, are elongate downwards along the primary central axes. These cells are rhizoidal or cylindrical and dividing obliquely downwards from the medullary cells which are cylindrical or filamentous. As a result of repetitions of such an action the elongated cells gradually compose the medullary layer. The medullary cells customerily give rise to cylindrical cells in the upper portion, but in the lower portion filamentous or cylindrical ones. The filamentous cells of the medullary layer are found entangling abundantly in the lower and the basal portions of the frond, but the cylindrical cells are only found in the inner portion except in the outer portion which consists of the entangled filamentous cells. The secondary discoid base is almost entirely composed of these entangled filamentous cells arising from the basal cells of the assimilating filaments or the cylindrical medullary cells. At the base of the adult frond we cannot yet find the primary base. Filaments of a single cell-row also are often found arising here and there from the medullary cells. The medullary layer being composed of many cell-rows arranging longitudinally, is compact in the outer portion, but in the inner portions rather loose. The medullary cells tend to separate easily longitudinally. The filamentous cells do not arise from the basal cells of the assimilating filaments whose growth is already finished. As it were, in the middle or the upper portion the cylindrical cells and the filamentous ones of the medullary layer are various in thickness,

so one cannot find the differentiation in shape between the two sorts of cells. The frond grows monopodially and the secondary apical assimilating hairs apparently grow like a writing brush, however, the frond consists of a bundle of many central axes just as in *Myriogloia*. In the adult the primary apical assimilating hair becomes short, so it is difficult to differentiate it from the secondary apical assimilating hair. The unilocular sporangia are sessile or petiolate and usually are borne on the basal cells of the assimilating filaments, sometimes on branchlets of the lower portion of the assimilating ones.

Haplogloia LEVR. 1939.

LEVRING, Gattungen *Myriogl.* und *Haplogloia*, 1939, p. 48; KYLIN, Phaeophyceenord. *Chordariales*, 1940, p. 21.

Central axis composed in early stage of a single filament in apical portion, later of a bundle of longitudinally arranged filaments, the filaments variable in breadth, sometimes slender ones being intermixed, arranged loosely with one another in the inner medulla, but in the outer medulla somewhat dense; medullary layer hollow in its central portion; repeatedly divaricated subcortex lacking; assimilating filaments distinctive with two forms, the long assimilating filaments very long, hair-like, arising from the subcortical cells, the short ones clavate, several cells long with obtuse terminal cells; unilocular sporangia ovoidal, sessile on the basal cells or the first basal cells of the short assimilating filaments; plurilocular sporangia transformed from each cell of the short assimilating filaments.

Haplogloia kurilensis INAGAKI, sp. nov. (Figs. 40, 41)

Japanese name: Iwa-mozuku (nom. nov.)

Locality: South Uwashiru, Kuriles (Aug. 12, 1935, M. NAGAI.) Endemic.

Growing on rocks.

Frond lubricous, caespitose on discoid (?) base, unbranched, simple, 10–20 cm high or more, about 2–2.5 mm in diam., hollow in the central portion of the medullary layer; the distinction between assimilating filaments and central axis evidently recognized; in the outer portion of the central axis the cells cylindrical, cells in subcortex and cortex more densely arranged than in the medullary layer; subcortical cells oblong, 60–80 μ long, 30 μ broad, constructing the subcortical portion with 2–4 layer; cortical cells cubic, 20–40 μ in diam., constructing the cortical portion with 1–3 layers; cells of median tissue generally thick-walled, but filamentous cells in the inner portion of the medullary layer and the cortical one thin-walled; central portion composed of several layers of cylindrical and filamentous cells becoming almost hollow, cells 100–150 μ long or more, 3–6 times as long as the breadth, lengthwisely arranged, including some discoid chromatophores; assimilating filaments

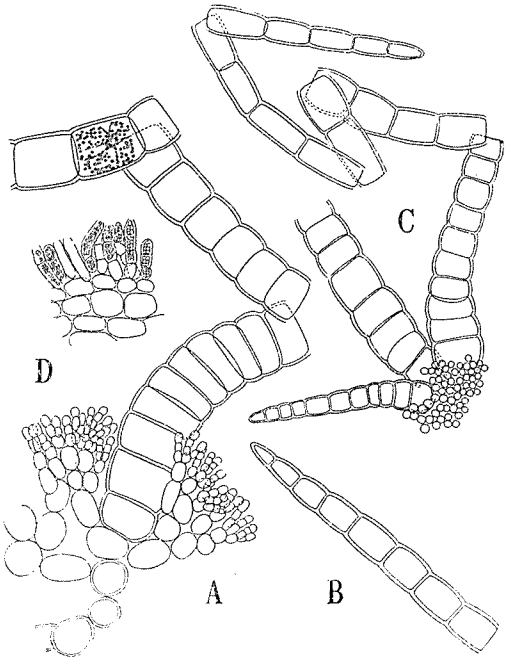
Fig. 40. *Haplogloia kurilensis* INAGAKI

A Cross section of a frond × 110 (Uwashiru, Kurile, 12-VIII, 1935. Collected by M. NAGAI)

B Apical portion of a long assimilating filament × 110 (Ditto.)

C Long assimilating filaments × 110 (Ditto.)

D Plurilocular sporangia transformed from cells of short assimilating filaments ×110 (Ditto.)



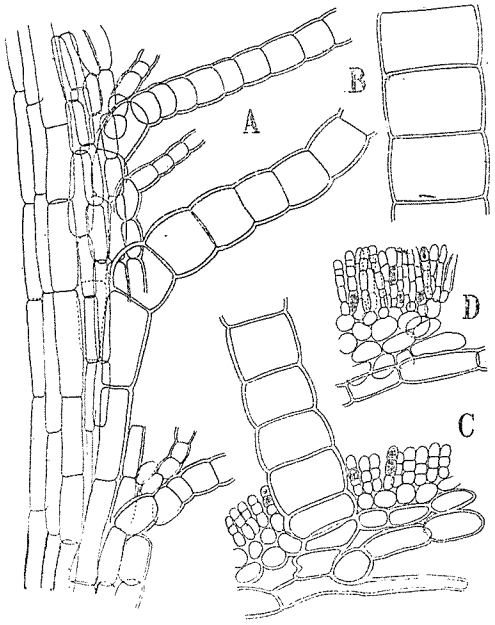


Fig. 41. *Haplogloia kurilensis* INAGAKI

A Longitudinal section through the peripheral portion × 110 (Uwashiru, Kurile, 12-VIII, 1935. Collected by M. NAGAI)

B Portion of a long assimilating filament × 110 (Ditto.)

C Long and short assimilating filaments, and plurilocular sporangia × 110 (Ditto.)

D Plurilocular sporangia × 110 (Ditto.)

distinguishable in two forms of short and long ones; the short assimilating filaments clavate, arising on the surface cells, 2–4 cells long, up to 30–50 μ high, 10 μ broad or more, with obtuse terminal cells; the long assimilating filaments hair-like, arising from subcortical or deeper cells, thick-walled, about 3 mm long, 30–60 μ broad, growing intercalarily in the lower portion, tapering towards the upper portion with somewhat pointed terminal cells; plurilocular sporangia changing from contents in each cell of short assimilating filaments at maturity; unilocular sporangia and hairs unknown; frond yellowish brown.

This interesting alga collected by Dr. M. NAGAI is so far found only in the Kuriles. It reminds one at a glance of *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI, from which it entirely differs in median tissue, assimilating filaments, etc. The frond is provided with many long assimilating filaments arising from subcortical or deeper cells and is densely covered with many short assimilating ones. It also possesses filamentous cells in the medullary layer. There is an evident differentiation between the median tissue and the assimilating filaments. From these points it is easily recognized that the present species belong to the genus *Haplogloia*, however the writer could not observe the apical portion of the frond from the present specimens. The present writer would record that the specimens were sent to him by Dr. TOKIDA.

Cladosiphon KÜTZ. 1843.

KÜTZING, in LINNAEA, 17, 1843, p. 96; Id., Phyc. gener., 1843, p. 329.

Secondary base composed of the basal portion of the primary central axis and rhizoidal filaments descending from the central axis; central axis sympodial, polysiphonous, composed of cylindrical or elongated cells, lengthwisely, loosely, more or less parenchymatously arranged, in its inner portion very often hollow; subcortical layer very thin consisting of 1–3 cell-layers; assimilating filaments simple or provided with a few branches near the basal portion of them, slightly curved in the superior portion; all of the tissues excepting hairs imbedded in gelatinous substance; hyaline hairs present; unilocular sporangia elliptico-obovate, borne on the basis of the assimilating filaments; plurilocular sporangia changing from the upper segments of the assimilating filaments.

Cladosiphon okamuranus TOKIDA (Figs. 42–44)

Phyc. Obs., V, 1942, pp. 87, 89, Fig. 4,; *Eudesme virescens* (non J. AG). OKAMURA, Icon, Jap. Alg., I, 4, 1907, pl. 77, Figs. 11–15 p. 78; Id., Nippon-Kaisoshi, 1936, p. 192, Fig. 99.

Japanese name: Okinawa-mozuku.

Locality: Nago (M. ARAZAKI) and Kerama (TAMAKI), Ryukyu: Sokari (I. NIIMURA),

Koniya (I. UMEZAKI), Amami-Ohshima, Ohsumi Prov.

Growing on rocks.

Frond erect, caespitose from a small discoid base, cylindrical, solid or somewhat hollow, lubricous, 20–25 cm high, 1–1.5 mm thick, moderately, irregularly alternately branched 1–4 times on all sides; branchlets variable in length with blunted apices; secondary base composed of the basal portion of central axis arising from the primary base and rhizoidal filaments descending from the cells of the central axis; medullary layer consisting of cylindrical or elongated cells lengthwisely, uniseriately and loosely arranged, cells variable in size, 20–150 μ long or more, 20–50 μ thick, generally in the outer portion narrower and smaller, on the contrary in the inner ones thicker and larger; cells of subcortical layer in the middle or upper portion of the frond cuboid or somewhat elongated, giving rise directly to assimilating filaments or after dividing divaricately 1–2 times to the same assimilating filaments; cells in the basal portion cylindrical, divaricate 2–3 times transforming gradually into the assimilating filaments; assimilating filaments of the cortical layer in the middle or upper portion of the frond 150–250 μ high, 5–20 cells long, uniseriate, constricted at dissepiments, curved in the apical portion, but in the lower portion 200–250 μ high, 10–15 celled, the lower cells cylindrical, 7–8 μ in diam., the upper cells swollen, about 10 μ in diam., nearly as long as the diameter; terminal cells ellipsoid, similar to the other ones in size; hairs hyaline, 8–10 μ thick, uniseriate with cylindrical cells covered with basal sheaths, the sheath also covering the basal portion of the apical hair; unilocular sporangia and plurilocular sporangia borne on one and the same individual; unilocular sporangia borne on the base of the assimilating filaments, elliptico-obovate, 30 × 60 μ in size; plurilocular sporangia transformed from the upper segments of the assimilating filaments, seriate, at maturity with unilateral openings;

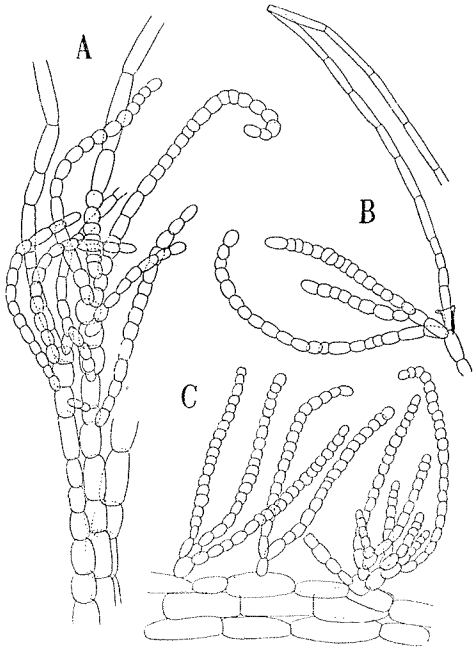


Fig. 42. *Cladesiphon okamuranus* TOKIDA
A Growing point with hairs × 130 (Kerama, Riukyu Islands. Collected by GORÔ TAMASHIRO)
B Assimilating filaments and a hair with sheath at the base × 130 (Ditto.)
C Longitudinal section × 130 (Nago, Riukiu Islands., 21–V, 1935)

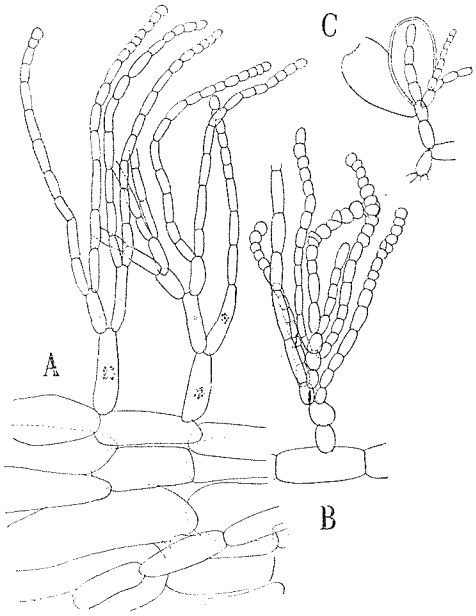


Fig. 43. *Cladosiphon okamuranus* TOKIDA

A Longitudinal section of a frond × 130 (Nago, Riukiu Islands., 21-V, 1935)
B Assimilating filaments and a hair × 130 (Ditto.)
C Unilocular sporangia × 130 (Ditto.)

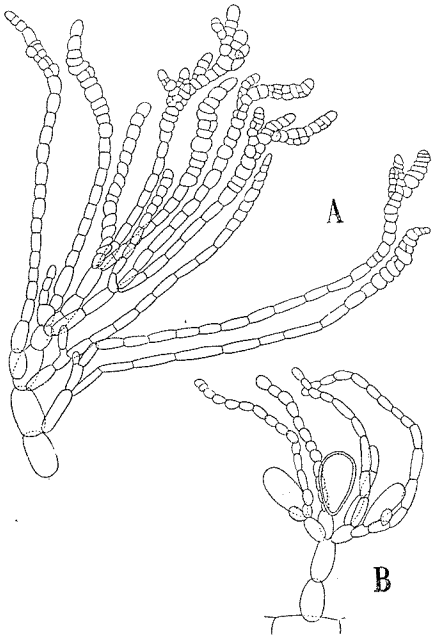


Fig. 44. *Cladosiphon okamuranus* TOKIDA

A Plurilocular sporangia × 130 (Kerama, Riukiu Islands. Collected by GORÔ TAMASHIRO)
B Unilocular sporangia × 130 (Nago, Riukiu Islands., 21-V, 1935)

frond brownish in colour, closely adhering to paper when dried.

The present writer has studied the specimens collected by Dr. ARAZAKI, Dr. OKAMURA's specimens lent to him by Dr. YAMADA and some specimens sent to him from Messrs. UMEZAKI and NIIMURA; they all coincide with Dr. TOKIDA's specimens.

Eudesme J. AG. 1880.

J. AGARDH, Till Alg. Syst. 4, 1880, p. 29; OKAMURA, Nippon-Kaisoshi, 1936, p. 191; KYLIN, Phaeophyceenord. *Chordar.*, 1940, p. 31.

Secondary base composed of the basal portion of erect primary central axis constructed with a bundle of several filaments and rhizoidal filaments descending from the basal portion of these central filaments; central axis polysiphonous, sympodial, growing trichothallic consisting of lengthwise arranged filaments, the filaments variable in thickness and separable from each other, but transversally not

so; subcortical cells growing horizontally from the central axis, di-trichotomously divided forming somewhat reticular arrangement; assimilating filaments developed on the outer portion of the subcortical layer, unbranched containing crowded chromatophores; hyaline hairs arising from growing point or bases of the cortical filaments; unilocular sporangia sessile or petiolate on the cortical filaments.

Eudesme virescens (CARM.) J. AG. (Figs. 45-47 Pl. IV)

Till Alg. Syst. 4, 1880, p. 31; KJELLM., Handbok.: Skandinaviens hafsalgflora, 1890, p. 40; KUCK., Morph. *Phaeospor.*, 1929, p. 47; KYLIN, Entwickl. *Phaeoph*, 1933, p. 56; PARKE, Contrib. knowl. Mesogl. and associ. fam. 1933, p. 15; KYLIN, Phaeophyceenord., *Chordar.*, 1940, p. 31, Tab. 5, Fig. 13; Id. *Phaeoph.* Schwed. Westk., 1947, p. 56, Fig. 48; *Eudesme virescens* SAUND., Alg. Harriman Exp., 1901, p. 423; SETCH. and GARDN., Alg. N. W. Amer., 1903, p. 249; *Mesogloia virescens* CARM., in Hokk., 1833, p. 387; ARESCH., 1847, p. 151 (373); HARV., phyc. brit., Tab. 82; HARV., Ner. bor amer., Tab. 9; *Mesogloia zosterae* KÜTZ., Tab. phyc, 8, Tab. 5; *Mesogloia affinis* BERK., Gleanings brit. alg., p. 43, tab. 16; *Aegira virescens* (CARM.) SETCH. et GARDN., Phyc. Cont., VII, 1924, p. 11; Id. *Melanoph.*, 1925, p. 547, pl. 42, Figs. 59, 60; TOKIDA, Mar. Alg. S. SAGHALIEN, 1954, p. 88, pl. IX, Figs. 4–7; XIII, Fig. E.

Japanese name: Nise-futomozuku, Yezo-mozuku,

Locality: Toyohama, Owari Prov. (K. INAGAKI); Muroran, Iburi Prov. (Y. NAKAMURA, K. INAGAKI); Akkeshi, Kushiro Prov.; Nemuro, Nemuro Prov. (K. INAGAKI, Y. NAKAMURA); Shikotan Island, Southern Kuriles (S. KAWABATA).

Growing on rocks and stones, sometimes on other algae (*Phyllospadix*, etc.) below the low tide mark.

Frond solitary or caespitose, erect on discoid base, 10–20 cm high or more, 2–5 mm thick, solid, imbedded in gelatinous substance, slimy, very lubricous, remarkably soft, provided with a main axis, growing sympodially and trichothallicaly, branched alternately 1–3 times on all sides; branches and branchlets patent, dense or sparse in various manner, gradually narrower towards the blunt apex; medullary layer composed of a bundle of many length-wisely parallely arranged cell-rows, cell-rows very loosely bound together, easily separable from each other; the cells cylindrical $50\times70\,\mu$–$20\times150\,\mu$ in dimension, thick or slender, generally variable in dimension; assimilating filaments produced from the outer filaments of the medullary layer at right angles branching gradually repeatedly forming subcortex and cortex; subcortical filaments patently bifurcate, trifurcate or multifurcate, divergently branched terminating in cortical filaments; subcortical cells containing scarcely chromatophores, cylindrical, $20\times80\,\mu$–$15\times50\,\mu$ in dimension, however-variable in general, usually narrower in the outer portion of the frond than in the

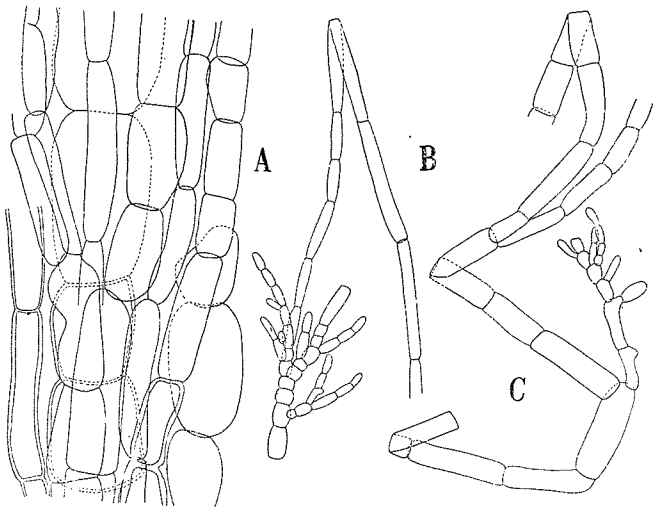


Fig. 45. *Eudesme virescens* (CARM.) J. AG.

A Portion of the central axis × 130 (Denshin-hama, Muroran, Iburi Prov., 3-IV, 1951)

B Growing point × 130 (Toyohama, Owari Prov., 28-II, 1948)

C Young branch arising from the central axis × 130 (Ditto.)

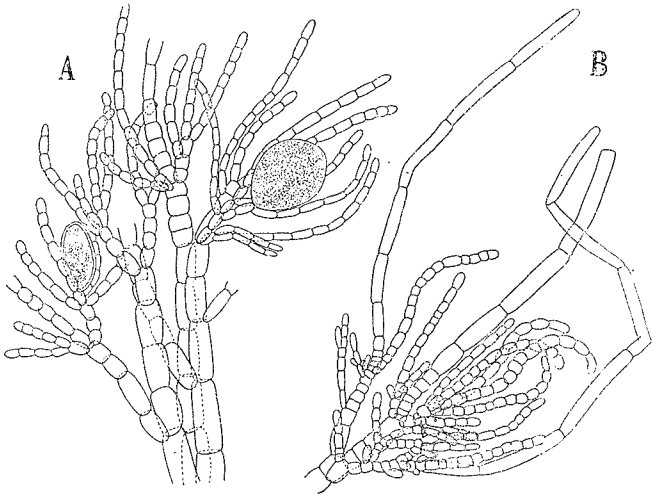


Fig. 46. *Eudesme virescens* (CARM.) J. AG.

A Apical portion provided with unilocular sporangia × 130 (Denshin-hama, Muroran, Iburi Prov., 3-IV, 1951)

B Growing points with hairs × 130 (Ditto.)

inner portion; cortical filaments unbranched, tapering towards the apices or in the apical portion moniliform, curving in the upper portion, crowned with unswollen terminal cells bearing resemblance to the other cortical ones, their apices somewhat acute in the basal portion of the frond, however, in general blunt; cortical cells containing chromatophores more than subcortical ones, but some of the cortical filaments slender, elongated into a hair, containing very few chromatophores; secondary discoid base composed of rhizoids descending from medullary cells in the basal portion of the frond; incomplete assimilating filaments terminating acutely, arising from basal cells of descending rhizoids; hairs hyaline, generally about 100 μ long, sometimes in apex 1 mm, 10 μ in diam., consisting of a single row of cylindrical cells, arising from growing points of central axes or bases of cortical filaments; unilocular sporangia ellipsoid, oviform, 50–90 μ, sessile or petiolate on cortical filaments; frond greenish brown or light brown in colour, adhering to paper when dried.

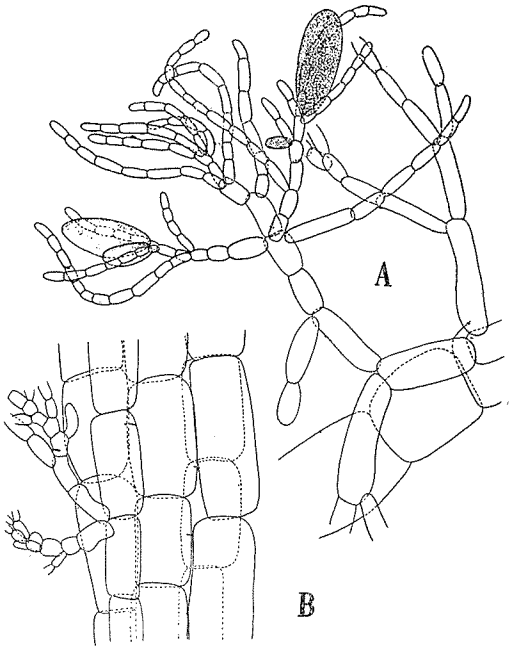


Fig. 47. *Eudesme virescens* (CARM.) J. AG.

A Unilocular sporangia borne on the basal and lowest cells of assimilating filaments, and a portion of subcortex × 130 (Denshin-hama, Muroran, Iburi Prov., 3-IV, 1951)

B Portion of a medullary layer and young branches arising from the medullary cells ×130 (Toyohama, Owari Prov., 28-II, 1948)

Development of the frond.

The primary base is mostly one cell-layered spreading over a small area, giving rise to an erect central axis. The axis is composed of lengthwise arranged one to several rows of filaments, thickened by means of lateral-branching. Each filament of the central axis grows sympodially. The secondary base is constructed of the primary base and many rhizoids descending from the medullary cells in the basal portion of the frond. The assimilating filaments issuing from the basal portion are incomplete in shape, but the assimilating ones divided from the subcortex in the superior portion of the frond are regular containing densely chromatophores. The juvenile frond grows

trichothallicaly at its apex, but in age very often the apex turns into an uniseriate cell-row.

Sauvageaugloia HAMEL 1939.

HAMEL, *Phéophyc.* France. S. XXXVII; KYLIN, Phaeophyceenord. *Chordar.*, 1940, p. 32.

Central axis almost hollow except the young or the apical portion; medullary layer composed of loosely, lengthwise arranged cells, cells extremely elongated, 20 times as long as broad; subcortical cells remarkably smaller than the medullary cells, very often creeping rhizoidally on the medullary layer or the inner subcortical layer emitting assimilating filaments tufted on subcortical cells or above-mentioned creeping cells; boundary between cortex and subcortex evident; assimilating filaments simple or divided one time; plurilocular sporangia transformed from the upper portion of the assimilating filament.

Sauvageaugloia ikomae (NARITA) INAGAKI (Fig. 48)

INAGAKI, Contrib. Knowl. *Chordar.* Jap. I, 1954, p. 13, Fig. 10; *Castagnea ikomae* NARITA, Two new mar. alg. Japan Sea, 1936 (Bot. Mag. Tokyo, Vol. 50, No. 596), p. 385, Figs. 1–2.

Japanese name: Kuro-mozuku.

Locality: Oh-haneo, Inaba Prov. Growing on stones below the low tide mark.

Frond cylindrical, 40–50 cm long, 2–4 mm in diam. caespitose, erect on a small

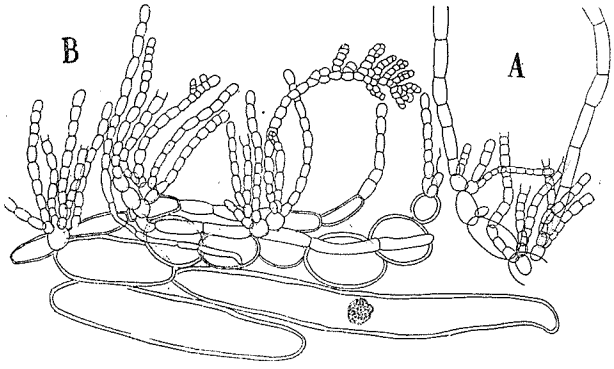


Fig. 48. *Sauvageaugloia ikomae* (NARITA) INAGAKI

A Apical portion of a frond in age × 160 (Oh-haneo, Inaba Prov., 12–VIII, 1930)

B Longitudinal section of a frond with plurilocular sporangia × 130 (Ditto.)

disc, gelatinous or gelatinoso-coriaceous, simple or sometimes irregularly dichotomously branched, obtuse at the apex, slightly tapering downwards; inner medullary layer hollow in the middle portion, composed of cells extremely elongated longitudinally, cells 25–50 μ thick, 200–300 μ long, loosely arranged; outer medullary layer composed of ovate or spherical cells, cells 40–70 μ long, 30–40 μ thick; walls of medullary cells thick as being also subcortical ones; subcortical cells somewhat smaller, spherical, ovate or elongated, very often transformed into rhizoidal filaments creeping on the medullary layer; central axis composed of many sympodial central filaments; assimilating filaments simple, erect or slightly curved, constricted at the joints in the apical portion, but scarcely so in the lower portion, arising tuft-like or dichotomously from the cortical cells, composed of 7–13, sometimes 19 cells, cells 10–15 μ long, 6–9 μ in diam., arranged in a single row; hairs colourless, very long, consisting of many cylindrical cells, arising from the basal cells of the assimilating filaments; unilocular sporangia unknown; plurilocular sporangia subpinnately branched, transformed from the upper cells of the assimilating filaments; colour brown; frond adhering to paper in drying.

The present alga is very closely related to *Cladosiphon filum* (HARV.) KYLIN, from which it differs in the shorter cells of the assimilating filaments and the subpinnate plurilocular sporangia.

Tinocladia KYLIN 1940

KYLIN, Phaeophyceenord. *Chordar.* 1940, p. 33.

Frond imbedded in gelatinous substance excepting hairs, dimorphic, distinguishable with unbranched or scarcely branched, uniseriate filaments surrounding erect main axis and erect portion; secondary base consisting of irregularly prostrate primary base and entangled rhizoidal filaments descended from primary erect central filaments; central axis polysiphonous, sympodial, composed of lengthwise arranged filaments, filaments thick or slender, variable in diameter, giving rise to repeatedly divided, slender subcortical cells; assimilating filaments developed on the ultimate portion of the subcortical layer, unbranched or sparsely branched, filiform, imbedded in gelatinous substance; hairs hyaline, arising from the basal cells of the assimilating filaments; unilocular sporangia elliptical, borne on the basal cells of the assimilating filaments; plurilocular sporangia unknown.

Tinocladia crassa (SURINGAR) KYLIN (Figs. 49, 50, Pl. V)

Phaeophyceenord. *Chordar.*, 1940, p. 34, Figs. 17, 18; *Mesogloia crassa* SUR., Illustr. alg. jap., 1872, p. 85, Tab. 10–12; OKAM., Icon. jap. alg. I, 1907, p. 89, Tab. 20, Figs. 1–9; *Eudesme crassa* (SUR.) OKAM., Nippon Kaisoshi, 1936, p. 193, Tab. 100, Figs. 1–5; SEGAWA, Mar. alg. Susaki, 1935, p. 65; INAGAKI, Contrib. Knowl.

Chordar. Japan, I, 1954, p. 3, Figs. 4, a–d, Fig. 5, a, b.

Japanese name: Futo-mozuku.

Locality: Misaki and Enoshima, Sagami Prov.; Toyohama, Onizaki, Ohno, and Asahi-mura, Owari Prov.; Iragozaki and Miyazaki, Mikawa Prov.; Hama-jima, Shima Prov.; Kushimoto, Kii Prov.; Kobe, Settsu Prov.; Miya-jima, Aki Prov.; Amakusa, Hizen Prov. Along the Pacific coast from Iwaki Prov. to the southern part of Honshu, and also from Shikoku and Kyushu. Growing on rocks and stones between the tide marks.

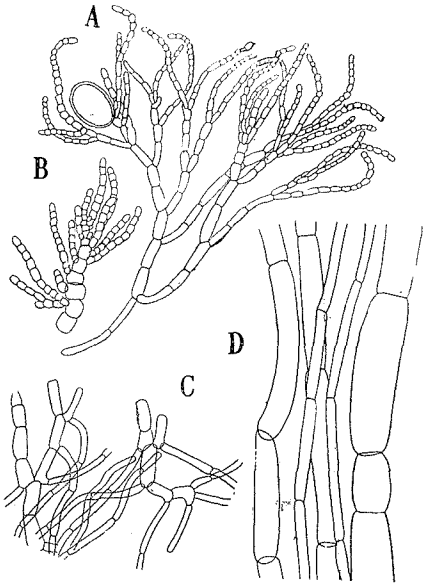


Fig. 49. *Tinocladia crassa* (SUR.) KYLIN

A Assimilating filaments and an unilocular sporangium ×90 (Miyazaki, Mikawa Prov. IV, 1950)
B Growing point ×200 (Toyohama, Owari Prov. II, 1949)
C Portion of a subcortical layer ×90 (Miyazaki, Mikawa Prov. IV, 1950)
D Medullary cells ×130 (Toyohama, Owari Prov. II, 1948)

Frond solid, columnar, gelatinous, very lubricous, arising from a small disc with an evident principal axis, 10–30 cm long, 1–3 mm in diam., gradually tapering upwards, irregularly alternately branched in all directions, sometimes, however, provided with a few main branches, when the main branches become longer, the principal axis indistinct; branches scattered or dense, simple, patent, very often provided with sparse branchlets; branches and branchlets more or less tapering to the ends, obtuse at apices; central axis consisting of many central filaments, braided with thinner rhizoidal filaments 100–180 μ long, 10 μ broad; some apical cells of central filaments growing intercalarily, sending out young hairs and assimilating filaments; subcortical layer developed between medullary layer and cortical ones of assimilating filaments, consisting of filaments repeatedly patently or somewhat dichotomously branched; cells of central filaments cylindrical, elongated, 100–180 μ long, 20–40 μ broad; assimilating filaments in the marginal portion of the frond entirely imbedded in gelatinous substance, simple or sparsely branched, more or less curved on the terminal portion, composed of cylindrical cells in upper portion of swollen cells; in lower portion and hairs almost colourless, slender, arising from the bases of the assimilating filaments; unilocular sporangia elliptical, about $70 \times 50\,\mu$, borne on the basal cells of the assimilating

filaments; plurilocular sporangia unknown; colour yellowish brown, very often dark in age; frond adhering firmly to paper in drying.

The genus *Tinocladia* differs from the genera *Mesogloia* and *Eudesme* in the following points.

Tinocladia has a sympodial central axis and an evident subcortex, whose cells are radiately arranged between the central axis and the exact assimilating filaments, but in the genus *Mesogloia* the central axis develops monopodially and such a subcortex is not found. In the genus *Eudesme* the subcortex is indistinct and the filaments of the medullary axis are easily longitudinally separated from each other.

The present alga differs from *Tinocladia australis* (HARV.) KYLIN in its richer branching and in having narrower branches.

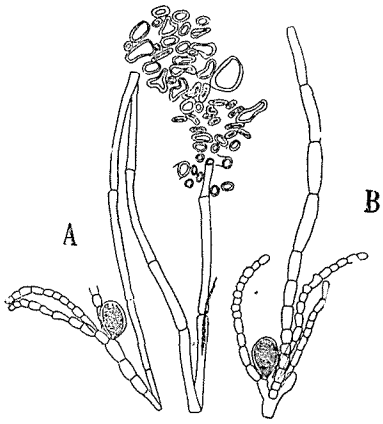


Fig. 50. *Tinocladia crassa* (SUR.) KYLIN

A Cross section of a frond with an unilocular sporangium × 130 (Irago-zaki, Mikawa Prov. VIII, 1931)

B Assimilating filaments, a hair and an unilocular sporangium ×130 (Miyazaki, Mikawa Prov.)

Sphaerotrichia KYLIN 1940

KYLIN, Phaeophyceenord. *Chordariales*, 1940, p. 38.

Frond dimorphic, distinguishable by erect or prostrate monosiphonous, unbranched filaments on irregular roundish primary base and erect branching filaments; secondary base composed of prostrate primary base and descending rhizoidal filaments from primary central axis; central axis monopodial, monosiphonous, intercalarily transversally segmented in the apex provided with a single to several enlarged, moniliform cells; branching occurring below the intercalarily growing portion; adult central portion solid or incompletely hollow; medullary cells lengthwise, parencymatously arranged, but not so clearly from subcortical layer composed of densely aggregated short cells; subcortical layer and assimilating filaments distinguishable; each assimilating filament 4–6 cells long, terminating with a single enlarged cell; hairs hyaline arising from the ultimate cells of the subcortical layer or from the basal cells of the assimilating filaments; unilocular sporangia borne on the basal cells of the assimilating filaments; plurilocular sporangia unknown.

Sphaerotrichia divaricata (AGARDH) KYLIN

Phaeophyceenord. *Chordariales*, 1940, p. 38, Fig. 20, c, d; *Chordaria divaricata* J. AG. in HARV., Phyc. brit., Vol. 1 1851, p. 53, Tab. 17; *Mesogloia divaricata* (AG.) KÜTZ., Tab. Phyc., Vol. 8, 1858, Tab. 8; KYLIN, Phaeophyceen Schwed. Westk., 1947, p. 58, Figs. B, C; INAGAKI, Contrib. Knowl. *Chordar.* Japan, I, 1954, p. 9.

Frond solitary or tufted, arising from a scutate disc, 5–30 cm high, filiform, somewhat cartilaginous, gelatinous, slippery, hollow, irregularly divaricately, laterally or alternately 1–4 times branched in all directions, provided with a traceable principal axis or divided into a few main branches without a principal axis, sometimes flexuous; branches 0.5–1 mm thick or more, generally thinner in the upper portion of the frond, standing off in the lower portion; upper branches very often spread, especially in younger stage quite densely provided with very short branchlets or rarely elongated ones; ultimate ramuli 1–2 cm long; subcortex composed of 2–3 layers of short irregular cells in younger portion, but in older portion composed of 4–8 layers; medullary layer almost tubular, consisting of large longitudinally elongated parenchymatous cells outside, constructed through the activity of monopodial central filaments; walls of the medullary cells generally thickened; intercalarily transversal division occurring in the apical portion of the central axis; growing point composed of a single or several large and spherical cells; assimilating filaments simple, comparatively short, consisting of 4–6 cells entirely enclosed in gelatinous substance; lower cells cylindrical, 6–8 μ thick, two times longer than the diam; terminal cells almost spherical or pyriform, 20–25 μ broad; hairs colourless, very long, abundant in the younger portion, but in age falling off. unilocular sporangia borne on the bases of the assimilating filaments, sessile, ovate or pyriform, 120–140 μ long, 25–35 μ broad; plurilocular sporangia unknown; colour brown or light brown, changeable to darkish brown when dried; frond adhering to paper when dried.

The present species answers very well to a sketch of the type specimen of GEPP's *Chordaria firma* once made by Dr. YAMADA at the British Museum and also to sketches of the sections of the frond of the type specimen kindly made by Miss L. M. NEWTON and Miss F. L. B. BROWNE of the same Museum. Thus the writer was able to compare histologically the Japanese specimens with GEPP's type specimen and he recognized that the latter is the same as *Sphaerotrichia divaricata* (AG.) KYLIN and also as *Chordaria firma* GEPP from our country identified by Dr. OKAMURA.

The present writer also has examined OKAMURA's dried specimens (*Chordaria cladosiphon* KUETZ. and *Chordaria firma* GEPP identified by Dr. OKAMURA). Although the writer could not find the apical portion described by KYLIN among these materials, he could recognize that these specimens coincided with many

specimens of the present species collected from different localities in our country. Dr. TOKIDA states in his publication that *S. japonica* KYLIN is different from *S. divaricata* (AG.) KYLIN in the shape of the apical portion and that in the former "the lower part of the projecting portion of the central filament composed of narrow cylindrical cells is barely detectable for a few cells long" Such aspects are observed in the apical portion of the frond in later spring or summer, and in the very young frond in early spring as the present writer stated in the paragraph "growing point", such apical portion as described by KYLIN can be found, and in small frond attaining barely 1–2 mm height a single enlarged apical cell and normal central cylindrical cells are observed. In later spring and summer the central filament of the apical portion is narrower than in early spring and already such an apical portion is transforming to a general assimilating filament, as it were, an intermediate form in the midst of the development of the apex.

From these reasons the Japanese species seems to be referable to *S. divaricata* (AG.) KYLIN.

The present alga is exceedingly variable both in habit and substance, being soft or hard according to the localities. Here the writer proposes to distinguish 4 forms of this species as follows:

f. ***divaricata***

(Figs. 51–53 (A–E), 54 except C, Pls. VI–XV)

Sphaerotrichia divaricata (AG.) KYLIN f. *typica* INAGAKI, Contrib. Knowl. *Chordar.* Japan I, 1954, p. 11. Fig 8, a–e; Fig. 9, a–e; *Sphaerotrichia divaricata* (AGARDH) KYLIN, Phaeophyceenord. *Chordar.*, 1940, p. 38, Fig 20, c, d; *Chordaria cladosiphon* OKAMURA (non KÜTZING), Icon. Jap. Alg., Vol. III, 1915, p. 188, pl. 144, Figs. 1, 2, 4; pl. 145, Figs. 10–14 (in part); *Sphaerotrichia japonica* KYLIN, Phaeophyceenord. *Chordar.*, 1940 p. 38; Id., Phaeophyceen

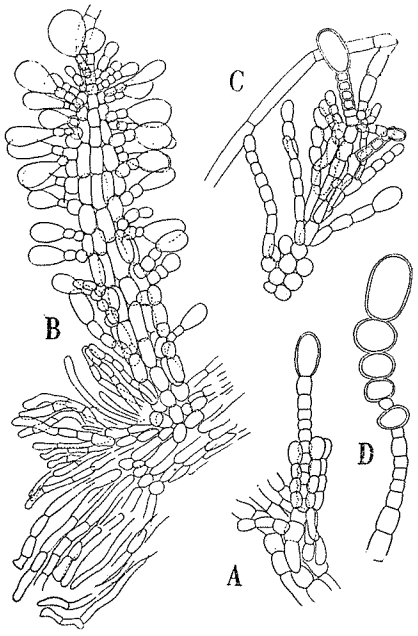


Fig. 51. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*

A Growing point on the basal portion of a adult frond × 200 (Etomo, Muroran, Iburi Prov. VII, 1951, Y. NAKAMURA)

B Half portion of the secondary base and a growing point of the juvenile frond arising from the base × 160 (Ditto.)

C Juvenile frond arising from the primary base and its growing point × 200 (Ditto.)

D Growing point (Ditto.)

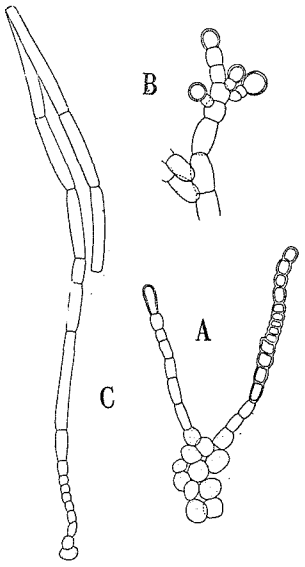


Fig. 52. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*

A Primary central axes arising from the primary base ×200 (Etomo, Muroran, Iburi Prov. VII, 1951)

B Growing point of a juvenile frond ×200 (Ditto.)

C A hair on the primary base ×200 (Ditto.)

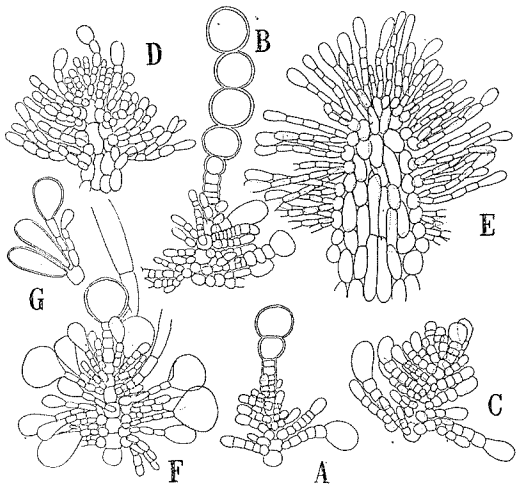


Fig. 53. *Sphaerotrichia divaricata* (AG.) KYLIN

A, B, C, D, E f. *divaricata*. Series of development of growing points and apical portions ×200 (Muroran, Iburi Prov. VII, 1951)

F f. *chordarioides* (YAMADA) INAGAKI. Growing point ×160 (Utoro, Kitami Prov. IX, 1943)

G f. *gracilis* (YAMADA) INAGAKI. Unilocular sporangia ×160 (Ditto.)

schwed. Westk., 1947, p. 58, Fig. B, D; *Chordaria firma* GEPP, Chinese Mar. Alg., Journ. Bot. Vol. 42, 1904, p. 162, Tab. 460, Figs. 7, 8; OKAMURA, Icon. Jap. Alg., Vol. III, 1915, p. 183, pl. 143, Figs. 1–9, p. 145, Figs. 1–9.

Japanese name: Ishi-mozuku (Kusa-mozuku).

Locality: Tsushima Prov.; Higo Prov.; Igami, Nagato Prov.; Garo, Inaba Prov.; Ochi-gun, Dôgo Prov.; Fukue, Mikawa Prov.; Toyohama and Himaka-jima, Owari Prov.; Wa-jima, Noto Prov.; Suezaki and Motoyoshi, Rikuchu Prov.; Nou, Awau-jima and Teradomari, Echigo Prov.; Iwai-zaki, Rikuzen Prov.; Ohma, Ishizaki and Fukaura, Mutsu Prov.; Okushiri and Hakodate, Oshima Prov.; Muroran, Iburi Prov.; Cape Soya, Kabuka and Utoro, Kitami Prov.; Oshoro, Shiwoya, Yoichi, Tomari and Otaru, Shiribeshi Prov.; Tomari (Kunashiri). Growing on stones or epiphytic on *Sargassum confusum* C. AG., and *Rhodomela larix* (TURN.) C. AG. below the low tide mark.

Frond about 20 cm high, 1–1.5 mm, very often 2–3 mm in diam. in the thickest

portion, provided with an evident principal axis or divided into a few main branches, rather densely, 3 times or rarely 4 times branched; ultimate branchlets 1–2 cm long or more, falling off in age.

f. ***epiphytica*** INAGAKI
(Figs. 55, 56 Pls. XVI, XVII)

INAGAKI, Contrib. Knowl. *Chordar*. Japan I, 1954, p. 12; *Spherotrichia japonica* KYLIN, Phaeophyceenord. *Chordar* 1940, p. 38; *Chordaria cladosiphon* OKAM. (non KÜTZ.), Icon. Jap. Alg. Vol. III, 1951, p. 188, pl. 144, Fig., 3 (in part).

Japanese name: Yase-mozuku.

Locality: Tomari and Shiwoya, Shiribeshi Prov.; Lake Saroma, Kitami Prov. Epiphytic on *Rhodomela subfusca* (WOODW.) C. AG., *Sargassum confusum* C. AG. and *Phyllospadix scouleri* HOOK. in shallow waters below the low tide mark.

Frond epiphytic, 5–15 cm long, filiform, slender, sometimes exceedingly slender, 2–3 times branched, provided with an evident principal axis, comparatively densely giving rise to short branchlets; branchlets 1–10 mm long.

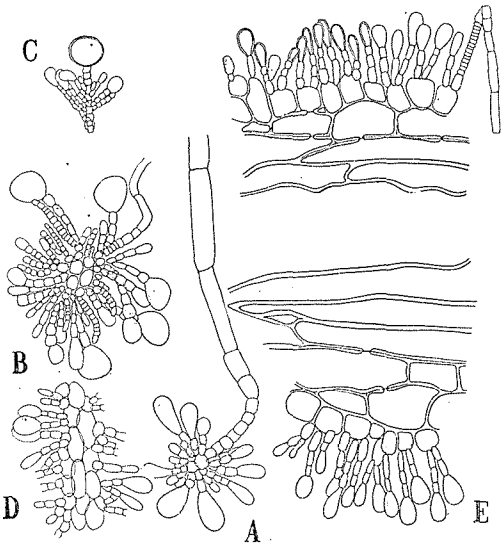


Fig. 54. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*

(C f. *chordarioides* (YAMADA) INAGAKI)

A Cross section of a branchlet in the apical portion ×130 Yoichi, Shiribeshi Prov., 28-VII, 1951)
B Cross section of a branchlet in the upper portion ×130 (Etomo, Muroran, Iburi Prov., 7-VII, 1951)
C Growing point of an adult frond ×110 (Utoro, Kitami Prov., 15-IX, 1943. Y. YAMADA)
D Longitudinal section of a branchlet in the upper portion ×110 (Yoichi, Shiribeshi Prov., 28-VII, 1951)
E Longitudinal section of a frond with unilocular sporangia in the middle portion ×90 (Oshoro, Shiribeshi Prov., 1-VIII, 1949. M. KUROGI)

f. ***chordarioides*** (YAMADA) INAGAKI (Figs. 53 (F), 54 (C). Pl. XVIII)

INAGAKI, Contrib. Knowl. *Chordar*. Japan I, 1954, p. 13, Fig. 8, f; *Sphaerotrichia chordarioides* YAMADA, Alg. report Shiretoko Peninsula, Kitami Prov., 1944, p. 167 (in Japanese).

Japanese name: Nise-nagamatsumo.

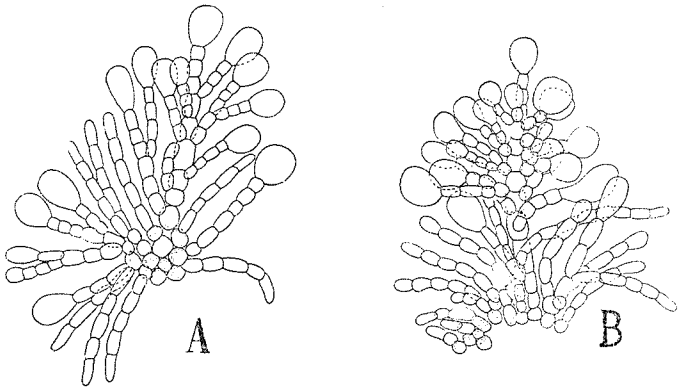


Fig. 55. *Sphaerotrichia divaricata* (AG.) KYLIN f. *epiphytica* INAGAKI

A, B Juvenile fronds arising from the primary bases and those growing points ×200 (Oshoro, Shiribeshi Prov., 11-VI, 1952)

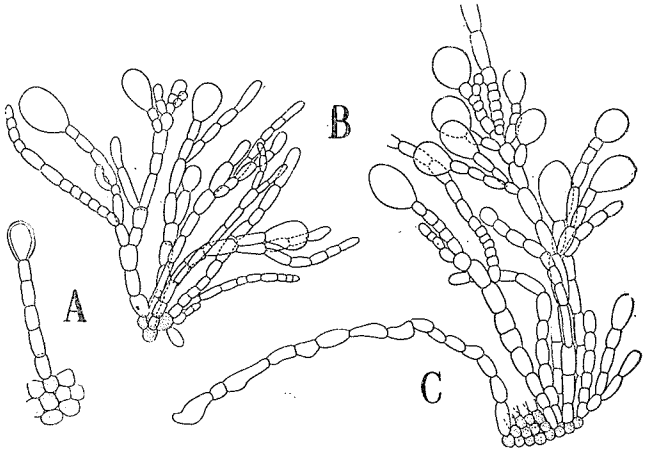


Fig. 56. *Sphaerotrichia divaricata* (AG.) KYLIN f. *epiphytica* INAGAKI

A, B, C Juvenile fronds arising from the primary bases and those growing points ×200 (Oshoro, Shiribeshi Prov., 11-VI, 1952)

Locality: Utoro, Kitami Prov. Growing on stones below the low tide mark to the depth of about a fathom.

Frond cylindrical, 20–30 cm high, 1–2 mm in diam. with an evident principal axis, 1–2 times sparsely branched; branches about 10 cm long.

f. ***gracilis*** (YAMADA) INAGAKI (Fig. 53 (G). Pl. XIX)

INAGAKI, Contrib. Knowl. *Chordar.* Japan I, 1954, p. 13, Fig. 8, g; *Sphaerotrichia chordarioides* YAMADA var. *gracilis* YAMADA, Alg. Report Shiretoko Peninsula, Kitami Prov. 1944, p. 167 (in Japanese).

Japanese name: Hosoba-no-nisenagamatsumo.

Locality: Cape Shiretoko, Kitami Prov. Growing on stones below the low tide mark to the depth of 2 fathoms.

Frond filiform, about 20 cm high, 0.5 mm in diam., with an evident principal axis, somewhat densely, 1–2 times branched; branches very slender, 5–10 cm long.

Development of the frond.

The primary base of the frond is irregulary roundish elliptical, about 150–300 μ in diam. consisting of a single layer of cells and giving rise to rhizoidal cells which branch somewhat divaricately from the margin. The fronds are dimorphic, some prostrate, while others are erect. Many filaments arise gregariously from the cells of the primary base. Each filament is composed of 10–15 cylindrical or cubic cells, simple or sparsely branched in the basal portion, growing intercalarily in the middle portion. Apical cells of the central axis are elongated, or enlarged, roundish or elliptical, 1–5 seriated being evidently distinguishable from the other cells of the filament. Each cell of the filament bears several brownish chromatophores which are discoid in shape. The writer was also able to find colourless hairs arising directly from the cells of the primary base. Such hair also apparently grows intercalarily in the lower portion. Some assimilating filaments arising from the cells of the primary base gradually develop into the central axis which gives rise to laterally or obliquely short branches from each cell, but the other unbranched ones do not develop any more and become prostrate on the substratum. Each basal cell of the short branches gives rise to rhizoidal filaments or cylindrical cells which are descending along the primary central axis. The rhizoidal filaments and the cylindrical cells become the medullary layer with a primary central axis, so that the medullary layer consists of both of these sorts of cells in the lower portion of the frond. The above-mentioned basal cells also give rise to primary assimilating filaments upwards or obliquely. Some branches arising from the lower portion of each primary assimilating filament make some part of the medullary layer, and others from the middle or the upper portion give rise to new branches. The filaments arise abundantly from the subbasal cells of the assimilating filaments below and also from the medullary cells or the basal ones of the secondary assimilating filaments. The filaments cover the primary base entangling with each other and form the secondary true discoidal base. Therefore, in the basal portion of the frond the outer layer consists almost entirely of many entangling filaments

except the inner layer which is composed merely of a few straight rows of cylindrical cells.

The assimilating filaments in the basal portion of the frond are generally irregular in shape, but regular in the other portion. The regular assimilating filaments arise on the outside of the above-mentioned medullary layer which consists mainly of the cylindrical cells, but they are composed of 2-3 cells possessing already large terminal cells in the younger stage. The terminal cell is spherical or ellipsoid. The apex of the young frond grows intercalarily possessing a large apical cell, but on the contrary, in certain cases the apical cells are small and in shape resembling other cells of the frond. Hairs are found on the upper portion of the frond. The basal cells of the young assimilating filaments and the medullary cells on the outside of the medullary layer divide repeatedly downwards, so that the medullary layer becomes thickened by degrees. The writer could not find the one and only one central axis in the adult frond except in the apical portion. Unbranched filaments being gregarious on the base and its neighbouring portion of the frond are prostrate on the substratum. Chromatophores are discoid and 10 pieces or more of them are found in a terminal cell of the assimilating filament.

Chordaria AG. 1817

AGARDH, Syn. Alg. Scand. 1817, p. 12; SETCH. and GARDN., 1925, p. 570; KYLIN, Phaerophyceenord. *Chordar*. 1940, p. 39.

Central axis at first singular, afterwards soon polysiphonous consisting of filaments branched from the primary central filament up and downwards, monopodial, with discoid base composed parenchymatously of irregularly prostrate primary base and unbranched assimilating filaments arising from the primary base; apex polysiphonous; central portion consisting of parenchymatous elongated cells and slender rhizoidal filaments, in the adult frond incompletely hollow; assimilating filaments simple, several cells long, terminating in slightly enlarged cells; unilocular sporangia ovoidal, borne on the basal cells of the assimilating filaments; plurilocular sporangia unknown.

Chordaria flagelliformis (MUELL.) AG.

Syn. Alg. Scand. 1817, p. 12, pl. XII; *Fucus flagelliformis* MUELLER, Flor. Dan., 1771, pl. 650; OKAM., Icon. Jap. Alg., Vol. II, p. 140, pl. 90, figs. 1-6; SETCH. and GARDN., Mar. Alg. Pacif. Coast N. Amer., *Melanoph.*, Part. III, 1925, p. 572; YAMADA, List Mar. Alg. Urupu Isl, 1934, p. 14; OKAM., Nippon Kaisoshi, 1936, p. 196, pl. 103; KYLIN, Phaeophyceenord. *Chordar*. 1940, p. 40, Fig. 21, A, B.

Frond solitary or caespitose, erect from a small disc, cylindrical, or some-

times compressed, lubricous, somewhat cartilaginous, solid, 20–60 cm long or more, 1–2 mm thick, branching densely or scattered 1–2 times, irregularly alternately on all sides of a percurrent main stem, in some individuals simple or sparsely branched; branches and branchlets tapering towards obtuse apices; medullary layer consisting of thickened membranous cylindrical cells about 300–600 μ long or more, 30–50 μ thick, in age mixed with spindle-shaped, narrower or rhizoidal cells 50 μ long, 10–20 μ thick; medullary cells variable in shape, dividing here and there; subcortical layer composed of oblong or roundish, more or less loosely arranged cells in longitudinal section, giving rise to assimilating filaments from the surface cells; the subcortical cells 20 μ in diam., smaller than the inner subcortical ones, 50 μ in diam., forming several layers in the adult; assimilating filaments simple, clavate, 4–6 celled with terminal cells; terminal cells slightly swollen, nearly spherical, or very often clavate, somewhat larger than other assimilating cells or similar in size to the latter; hairs hyaline, up to 5 μ broad, slender, simple consisting of single rows of cylindrical cells, arising from the basal cells of the assimilating filaments, containing chromatophores in cells of the basal portion and growing intermediately in the same portion; chromatophores discoid, 15–20 μ in diam., containing about 3–7 pieces in each cell of the assimilating filaments; unilocular sporangia about 20–40 μ long, ovoid to pyriform, borne on the basal cells of the assimilating filaments; plurilocular sporangia unknown; colour dark brown, black when dried; frond not adhering closely to paper in drying.

The following 3 forms are found in our waters.

f. ***flagelliformis*** (Fig. 57)

Chordaria flagelliformis (MUELL) AG. f. *typica* KJELLM., Om Spets. Thall., II, 1877 a, p. 28; Reinke. Atlas, 1889, pl. 39, Figs. 1–7; SETCH. and GARDN., Alg. N. W. Amer., 1903, p. 250; Id., Mar. Alg. Pac. Coast N. Amer., Part III, *Melanophyc.*, pp. 572–573, pl. 39, Fig. 44; YAMADA and TANAKA, Mar. Alg. Akkeshi Mar. Biol. Stat., 1944, p. 58; TOKIDA, Mar. Alg. S. Saghlien, 1954, p. 91.

Japanese name: Naga-matsumo.

Locality: Muroran, Iburi Prov.; Akkeshi, Kushiro Prov.; Abashiri and Utoro, Kitami Prov.

Growing on rocks and stones between the tide marks and below the low tide mark.

Frond 20–40 cm high, much branched on all sides with a percurrent main axis; branches 1–2 mm broad, irregulerly alternate 1–2 times; assimilating filaments 4–6 cells long, clavate with terminal cells slightly swollen or not.

f. ***ramusculifera*** KJELLM.

Om Spets. Thall., II, 1877 a, ps. 29, 30, pl. I, Figs. 10–12; SETCH. and GARDN.,

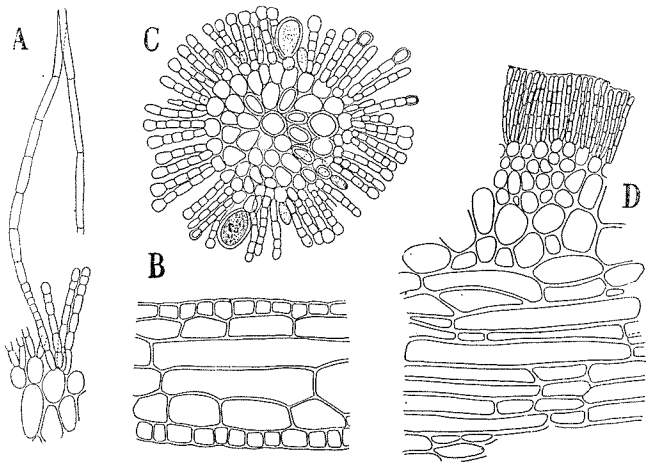


Fig. 57. *Chordaria flagelliformis* (MUELL) AG.
f. *flagelliformis*

A Assimilating filaments and a hair ×130 (Daikoku-jima, Akkeshi, Kushiro Prov., 25-VIII, 1953)

Chordaria flagelliformis (MUELL) AG.
f. *chordaeformis* KJELLM.

B Vertical section of a juvenile frond ×130 (Akkeshi, Kushiro Prov., 14-VII, 1952)

C Cross section of a frond provided with unilocular sporangia borne on the basal cells of the assimilating filaments ×130 (Aikapp-misaki, Akkeshi, Kushiro Prov., 14-VII, 1952)

D Vertical section of a adult frond ×70 (Akkeshi, Kushiro Prov., 6-IX, 1940)

Alg. N. Amer., Part III, *Melanoph.*, 1925, p. 537.

Japanese name: Mabara-nagamatsumo (nom. nov.)

Locality: Abashiri, Kitami Prov.

Growing on rocks below the low tide mark.

Frond cylindrical, 20–30 cm high or more, 1–1.5 mm broad, with almost simple branches scattered nearly perpendicularly on the main stem; assimilating filaments about 6 cells long, clavate with terminal cells slightly swollen; unilocular sporangia $20 \times 40\,\mu$ in size, ovoid, pyriform.

f. ***chordaeformis*** KJELLM. (Fig. 58)

Om Spets. Thall., II, 1877 a, ps. 28, 29, pl. I, figs. 13–15; SETCH. and GARDN., Alg. N. W. Amer., 1903, p. 251; Id. Mar. Alg. Pacif. Coast N. Amer., Part III, *Melanoph.*, 1925, p. 573; OKAMURA, Nippon-Kaisoshi, 1936, p. 196; NAGAI, Mar.

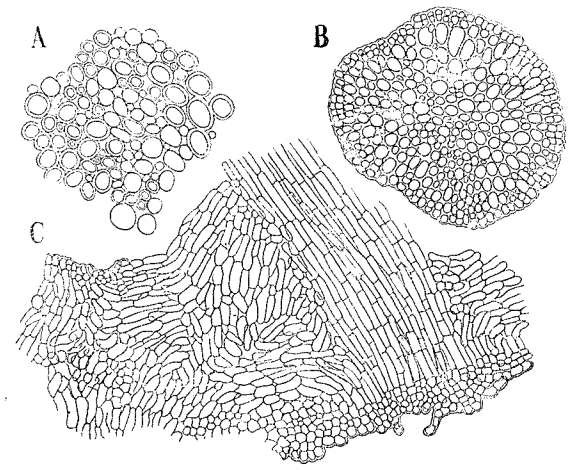


Fig. 58. *Chordaria flagelliformis* (MUELL) AG.
f. *chordaeformis* KJELLM.

A Cross section through the medullary layer × 130
(Akkeshi, Kushiro Prov., 14-VII, 1952)
B Cross section of a juvenile frond × 110
(Akkeshi, Kushiro Prov., 14-VII, 1952)
C Vertical section through the basal portion composed of descending rhizoids × 110 (Ditto.)

Alg. Kurile Isl. 1, 1940, p. 46; YAMADA, and TANAKA, Mar. Alg. Akkeshi Mar. Biol. Stat., 1944, p. 58; TOKIDA, Mar. Alg. S. Saghalien, 1954, p. 92.

Japanese name: Himo-nagamatsumo.

Locality: Akkeshi, Kushiro Prov.; Utoro, Kitami Prov.

Growing on rocks and stones between the tide marks.

Frond cylindrical, simple or sparsely branched, 60 cm high, 1–2 mm broad, cord-shaped; assimilating filaments 4–6 cells long, clavate, with terminal cells slightly swollen; unilocular sporangia $20 \times 40\,\mu$ in size, ovoid or pyriform.

The secondary base of the frond of the present form consists of many rhizoidal filaments which descend obliquely downwards and are packed densely with one another. The rhizoidal filaments arise from the primary base and soon after become prostrate on the primary ones and then form the secondary base with the above-mentioned descending rhizoidal filaments.

In the juvenile frond the medullary layer is composed of cylindrical cells only., and the cortical cells are oblong or cubic, but it is not filamentous as in the adult. Such cortical cells develop into assimilating filaments by division of their cells. The apex generally consists of a bundle or many cylindrical cells,

but judging from the structure of the very juvenile branch, it may be supposed that the apex may be monosiphonous at the beginning of the development.

Chordaria gracilis SETCHELL et GARDNER (Figs. 59, 60, Pl. XX)

Mar. Alg. Pacif. Coast N. Amer. part III, *Melanoph.* 1925, p. 573, pl. 84; YAMADA, Mar. Alg. Urupu, Mid. Kuriles 1935, p. 13, pl. III.

Japanese name: Hoso-Matsumo.

Locality: Akkeshi, Kushiro Prov.; Urupp (YAMADA) and Shikotan (KAWABATA), Kuriles.

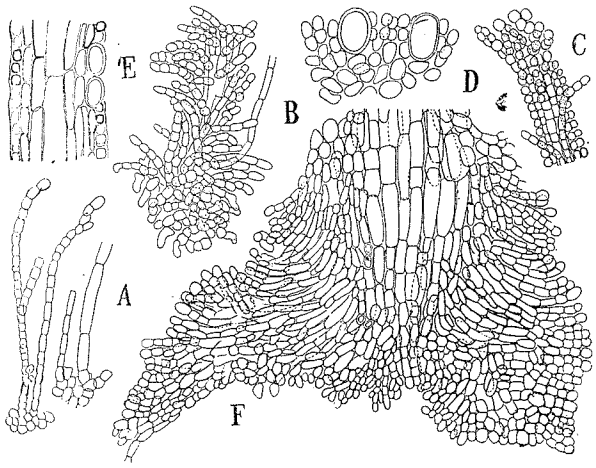


Fig. 59. *Chordaria gracilis* SETCH. et GARDN.

A Growing points of an erect frond arising from the primary base × 130 (Akkeshi, Kushiro Prov., 9-VI, 1952)

B Prostrate filaments covering the primary base and forming the secondary base × 130 (Ditto.)

C Apical portion of a juvenile frond × 130 (Ditto.)

D, E Unilocular sporangia × 130 (Urup-island, Kurile. S. KAWABATA)

F Longitudinal section through the basal portion showing descending rhizoidal filaments forming the secondary base × 110 (Aikapp-misaki, Akkeshi, Kushiro Prov., 14-VII, 1952)

Growing on rocks, stones or in tidal pools between the tide marks.

Frond 8–30 cm high, 0.5–1 mm in diam. with a single percurrent axis, solitary or tufty, arising from a scutate disc, gelatinous, slippery, solid, irregularly alternately branched 2–3 times on all sides of the main stem, but in the lower portion lacking branches; branches 2–4 cm long, patent standing almost at right angles to the main stem; branchlets 0.5–1 cm long at wide angles like the branches; branches and branchlets more or less twisted; assimilating filaments 40–50 μ long, arising

on the outermost cells of the medullary layer, clavate, generally composed of 2–3 cells, but in the adult very often of 3–4 cells respectively provided with a terminal cell swollen or not so; hairs hyaline, 5–10 μ in diam., very long consisting of a single row of cylindrical cells arising from the basal cells of the assimilating filaments or on the primary base and very often found on the neighbouring portion of the growing point; medullary cells cylindrical with thickened membranes, 35–150 μ long or more, 20–30 μ or rarely 10 μ in diam., but cells of 1–2 layers in the outermost portion of the medullary layer oblong or ellipsoid; in the older portion of the medullary layer slender cells sparingly mixed among cylindrical cells very often shrinking, therefore many spaces found among those cylindrical ones; chromatophores ellipsoid, 3–4.5 μ in diam. several pieces found in each cell of the assimilating filament, especially in the terminal cell 7–8 pieces; unilocular sporangia oviform, 30×50 μ in size, borne on the basal cells of the assimilating filaments; plurilocular sporangia unknown; frond light or dark brown in colour, adhering to paper when dried.

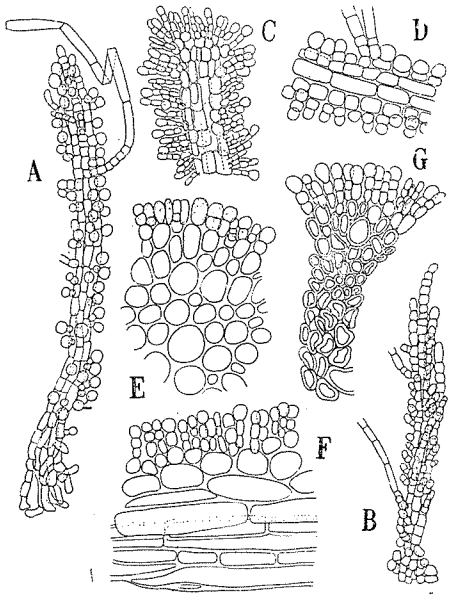


Fig. 60. *Chordaria gracilis* SETCH. et GARDN.

A, B Juvenile fronds arising from the primary bases ×130 (Akkeshi, Kushiro Prov., 9-VI, 1952)
C Apical portion of a frond ×110
D Longitudinal section through the lower portion of a juvenile frond ×200 (Ditto.)
E Cross section of a frond ×130 (Ditto.)
F Longitudinal section of a frond ×130 (Ditto.)
G Cross section of a adult frond showing thickning cell-walls in the medullary layer ×130 (Urup, Kurile. Y. YAMADA)

Dr. YAMADA referred some specimens collected by himself in the Kuriles and at Akkeshi, Kushiro Prov. and S. KAWABATA's specimens from Urup Island in the Middle Kuriles to the present species. The writer also holds the same opinion regarding the present specimens as Dr. YAMADA does, after having made comparison with some fragments of the type specimen (No. 8836, Allan H. F.) kindly loaned from the herbarium of the Allan Hancock Foundation by Dr. Y. DAWSON. This type specimen was collected by SETCHELL on the western coast of Amaknak Island, Unalaska, Alaska in 1899.

Development of the frond.

The primary base of the frond consists of a single layer of cells which divide irregularly or somewhat dichotomously extending towards the margin. Erect filaments are 100–200 μ long, tufted, arising from the drimary base and consist of a single row of short cylindrical cells, whose membranes are sometimes thickened. Some of the upper cells of the filaments give rise to new branches which divide obliquely upwards. The terminal cell of the filament is frequently ellipsoid in side view and slightly larger than the others. The filaments divided from some of the erect filaments develop into primary assimilating filaments and a medullary layer giving rise to branches at times, but from the other filaments such development does not occur. The latter erect filament becomes the primary assimilating filament arising from the primary base, afterwards it does not give rise to branches. Unbranched assimilating filaments gradually become prostrate on the substratum and become one part of the secondary base. The above-mentioned branching erect filaments become the medullary layer showing an apical growth and lateral branches of the filaments also become the medullary layer growing parallelly along the first main axis. So that, the main axis is found only at the apex of the young frond in general. The medullary cells make the medullary layer develop dividing only obliquely upwards.

Secondary assimilating filaments arise from the outermost cells of the medullary layer. The apex in a young bud looks like a hair-pen just as in the apical portion of the juvenile frond. The apex of the old frond consists of many rows of medullary cells, so that the writer cannot find any distinction about the structure of the medullary layer at the apex between the present species and *Chordaria flagelliformis* (MÜLL) AG. Buds consisting of 2–3 rows of cells, arise very often from the upper portion of the juvenile frond, and the central axis composed of a single cell-row is scarcely visible at its apex. The secondary base is composed of many rhizoidal filaments which descended from the medullary cells and the basal cells of the assimilating filaments in the lower portion of the frond with the above-mentioned unbranched assimilating ones. The descending rhizoids in the basal portion of the frond associate densely with each other dividing somewhat dichotomously, so that the discoid basal cells of the adult arrange parenchymatously; the surface of the base consists of a single row of 3–4 cubic cells, whose 1–2 upper cells are rich in their contents. The assimilating filaments in the young bud are scattered, but in the adult branch they are very dense. A hair is hyaline, unbranched, being composed of a single row of cylindrical cells, growing intercalarily in the lower portion and it arises from the primary base, the basal cell of the assimilating filament or very often from a neighbouring cell of the growing point of the frond. The medullary cells in longitudinal section are cylindrical, 50–200 μ

long, 10–20 μ in diam., sometimes 25 μ with thickened membranes, but in the outer portion of the medullary layer oblong and in cross section roundish or somewhat ellipsoid being arranged radially. The assimilating filament consists of 1–2 cubic cells in the young bud and its terminal cell is moderately swollen, spherical or ovate, and larger than the others. In the adult the assimilating filament is clavate being 3 cells long, but the terminal cell is not always swollen. Chromatophores are ellipsoid, 3–4.5 μ in diam., several pieces of them being reckoned in each cell of the assimilating filaments, especially in the terminal cell 7–8 pieces. Young hairs are very often found mixed with the assimilating filaments. They are hyaline, slender and meagre in their contents. Plurilocular sporangia are unknown.

Saundersella KYLIN 1940

KYLIN, Phaeophyceenord. *Chordariales*, 1940, p. 41; TOKIDA, Mar. Alg. S. Saghalien, 1954, p. 94.

Frond simple, filiform or cylindrical attached by means of a small disc with a short pedicel on other algae; secondary base composed of primary rhizoidal base, entangled rhizoids descending from the subcortical cells and the basal cells of the assimilating filaments, incomplete assimilating filaments surrounding the basal portion of the main axis and entangling rhizoids arising from these filaments; central axis monopodial, polysiphonously developed, some of them intercalarily grown below the apex; medullary layer solid in juvenile stage, in age becoming hollow, provided with central axis consisting of longitudinally, loosely arranged cylindrical or oblong cells and mixed with entangled rhizoids in the basal portion; central filaments variable in diam.; subcortical cells very loosely reticularly arranged, becoming smaller roundish basal cells of assimilating filaments; assimilating filaments clavate, simple, several cells long, terminating in enlarged cells, cells oviform or oval, thick-walled; hairs hyaline, uniseriate arising from the basal cells of the assimilating filaments; unilocular sporangia ellipsoid or oviform, borne on the basal cells of the assimilating filaments or the ultimate cells of the subcortical cells: plurilocular sporangia unknown.

Saundersella simplex (SAUNDERS) KYLIN (Figs. 61–63, Pl. XXI)

Paeophyceenord. *Chordar*. 1940, p. 42, Fig. 21, E; *Mesogloia simplex* SAUND., Alg. Harr. Exp., 1901, p. 423, tab. 50, Figs. 3, 4; SETCH. and GARDN., Alg. N. W. Amer., 1903, p. 250; *Gobia simplex* SETCH. and GARDN., Phycol. contrib. 7, 1894, p. 12; Id., Mar. Alg. *Melanophyc*., 1929, p. 2, pl. 251, Figs. 8, 9; TOIKDA, Mar. Alg. S. Saghalien, 1954, p. 95.

Japanese name: Gobia, Motsuki-chasohmen.

Locality: Yuhbu, Saruru, Esashi (M. KUROGI), Menashitomari (M. KUROGI),

Abashiri, Utoro (K. INAGAKI), Rausu and Shiretoko (Y. YAMADA), Kitami Prov.; Nemuro (S. AKIYAMA) and Rausu (T. TANAKA, Y. HASEGAWA), Nemuro Prov.; Akkeshi (S. Funabashi, K. INAGAKI), Kushiro Prov.; Sokobetsu, Kunashiri Isl. (M. NAGAI), Southern Kuriles. Epiphytic on *Chordaria flagelliformis* and *Chord. flagel.* f. *chordaeformis* between the tide marks.

Frond epiphytic on other algae, attached by a small disc with a short pedicel, lubricous, filiform or cylindrical, often decidedly clavate, simple, up to 5–20 cm high, 2–5 mm in diam., solid in the juvenile stage, afterwards becoming hollow, arcuate, blunt; secondary base composed of primary rhizoidal base, entangled rhizoids descending from subcortical cells and basal cells of assimilating filaments, incomplete assimilating filaments surrounding the basal portion of the main axis and entangling rhizoids grown out from these incomplete assimilating filaments; medullary layer composed of entangling rhizoidal filaments in the basal, in the middle and in the upper portions; medullary cells cylindrical, filamentous,

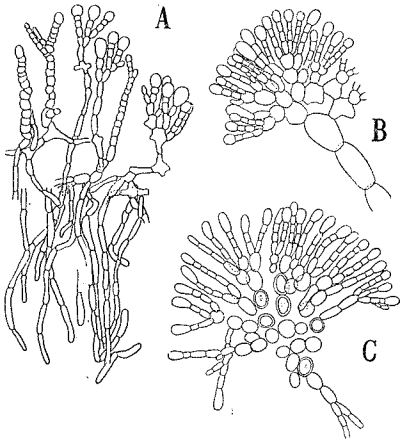


Fig. 61. *Saundersella simplex* (SAUND.) KYLIN

A Portion of a base composed of rhizoidal filaments ×110 (Utoro, Kitami Prov., 15-VIII, 1951)
B Apical portion of a adult frond × 110 (Akkeshi, Kushiro Prov., 8-VIII, 1952)
C Cross section of a juvenile frond × 110 (Ditto.)

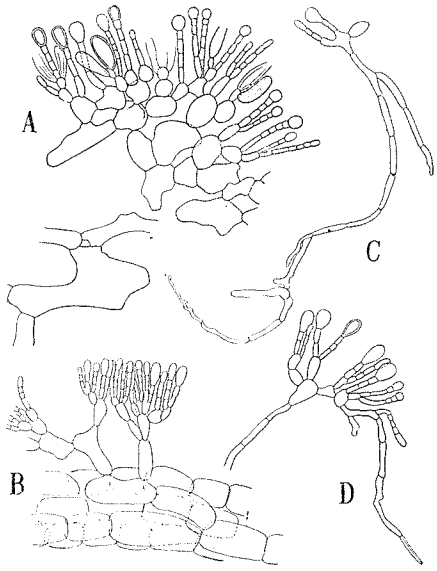


Fig. 62. *Saundersella simplex* (SAUND.) KYLIN

A Cross section of a frond provided with unilocular sporangia × 110 (Utoro, Kitami Prov., 15-VIII, 1951)
B Vertical section through the lower portion of a juvenile frond × 110 (Aikappu-misaki, Akkeshi, Kushiro Prov., 8-VIII, 1952)
C, D Rhizoidal filaments descending from subcortical cells in the basal portions of fronds ×110 (Rausu, Nemuro Prov., 15-VII, 1936)

50–130 μ long, 10–40 μ in diam., straight, longitudinally loosely arranged, anastomosing freely, colourless, but in the lower portion slender, rhizoidal, entangled with each other, similar rhizoidal filaments descending from subcortical cells, the cells irregularly polygonal, up to 50–80 μ in diam., loosely reticularly arranged becoming smaller basal cells of assimilating filaments in the outermost subcortex; cells roundish or elliptical, about 20–30 × 20 μ in size; assimilating filaments deeply coloured, clavate, simple, 3–5 cells long, not much constricted at each segment, provided with terminal cells larger than the other cells, oviform or oval, thick-walled; hairs hyaline, slender, grown out from the basal cells of the assimilating filaments, deeply coloured in the basal portion, growing intermediately; unilocular sporangia ellipsoid or oviform, 30 × 60 μ in size, borne on the basal cells of the assimilating filaments or directly on the ultimate subcortical cells; plurilocular sporangia unknown; frond browinsh, adhering to paper when dried.

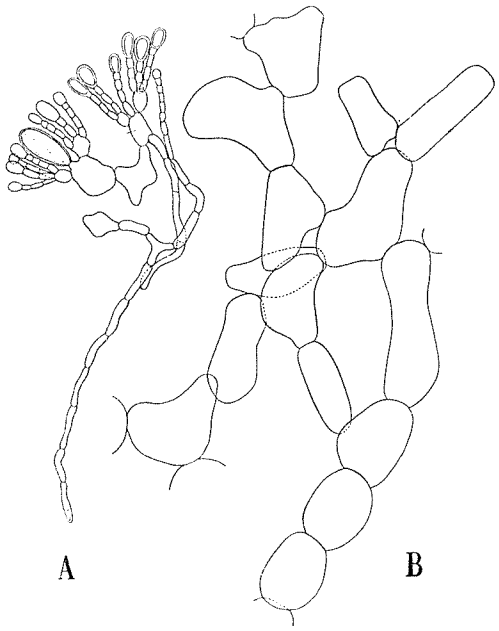


Fig. 63. *Saundersella simplex* (SAUND.) KYLIN

A Unilocular sporangium and rhizoidal filaments descending from subcortical cells × 110 (Akkeshi, Kushiro Prov., 8-VIII, 1952)

B Outer medullary layer × 110 (Ditto.

The present alga is very variable in outer appearance according to the locality.

Saundersella saxicola (OKAMURA et YAMADA) INAGAKI, comb. nov. (Fig. 64)

Gobia saxicola OKAMURA et YAMADA, in YAMADA, Mar. Alg. of Mutsu Bay and Adjacent Waters, II, Fig. 9, a, b, Sci. Rep. of Tohoku Imp. Univ. IV Ser., Vol. III, 1928, p. 502; OKAMURA, Nippon-Kaisoshi, 1936, p. 203.

Japanese name: Ishitsuki-gobia.

Locality: Oma, Gomi-jima, Asadokoro (Y. YAMADA), Sai, Benten-jima, Tappi, Horotsuki and Utetsu (Y. TAKAMATSU), Mutsu Prov.; Obama (NONAKA), Wakasa Prov.

Growing on rocks and stones between the tide marks, sometimes together

with *Gloiopeltis furcata.*

Frond caespitose attached by a small discoid base, somewhat herbaceous, elastic, filiform, simple, about 15 cm high, 0.3 cm in diam., hollow excepting the base and the apical portions, often twisted, tapering to a blunt apex; base composed of rhizoidal filaments descending from medullary and subcortical cells, filaments 10 μ thick consisting of cubic cells in general, dichotomous; medullary layer of the solid portion composed of a loose bundle of many straight filaments growing erect from the primary base, medullary cylindrical cells 30–40 μ long, 7–14 μ thick and filaments longitudinally arranged, connecting with adjacent ones here and there; subcortical cells irregularly polygonal, about $10 \times 20 \mu$ in size, anastomosing freely, loosely reticulately arranged; assimilating filaments deeply coloured, unbranched, straight, perpendicular to the main axis, 2–4 cells or sometimes 5 cells long, terminating in pyriform cells, terminal cells 15–25 μ long, 10–15 μ in diam.; hairs hyaline, uniseriate with cylindrical cells, about 5–7 μ thick, arising from the basal cells of the assimilating filaments or the outermost cells of the subcortex, growing intermediately in the lower portion; unilocular sporangia obovate or elliptical, 30–35 μ long, 18–20 μ broad, sessile or petiolate with 1–2 cells borne on the basal cells of the assimilating filaments; frond brownish in colour, slightly adhering to paper in drying.

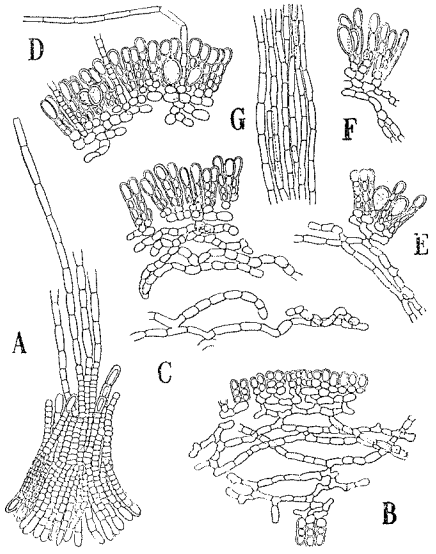


Fig. 64. *Saundersella saxicola* (OKAMURA et YAMADA) INAGAKI

A Portion of the secondary base and some central filaments ×110 (Ohma-misaki, Mutsu Prov., Y. YAMADA)

B, C Vertical sections of fronds ×160 (Ditto.)

D, E, F Unilocular sporangia borne on the basal or the first basal cells of the assimilating filaments and hairs. ×110 (Ditto.)

G Central filaments in the medullary layer ×110 (Ditto.)

The cells of the tissue of the present alga are remarkably smaller in comparison with *Saundersella simplex*, but there are not any differences concerning the tissue of the frond and the unilocular sporangia between both species.

So, the writer referred the present alga to the genus *Gobia* in agreement with Dr. OKAMURA and YAMADA's opinions, and after KYLIN the writer named this species *Saundersella saxicola.*

Heterosaundersella TOKIDA, 1942

TOKIDA, Phyc. Observ. V, p. 84, Figs. 2, 3.

Frond caespitose, simple, unbranched, cylindrical, epiphytic on certain other algae by means of discoidal holdfast, dimorphic with prostrate filaments and erect axis; primary base irregularly divided, directly developing into secondary base without surrounding of descending rhizoidal filaments from the lower portion of the erect frond; prostrate filaments simple, more or less branched, constructing assimilating palisade layer, terminating with ovate or spherical cells; erect axis composed of a bundle or longitudinally arranged cylindrical cells, growing monopodially, dividing intercalarily below the apex, terminating with a single to several enlarged moniliform apical cells, polysiphonous in age; central filaments longitudinally separable from each other; subcortical cells irregularly polygonal, loosely arranged; assimilating filaments of the cortex clavate, 2–5 cells long, composed of 2–3 spherical cells in upper section and 2–3 cylindrical cells in lower section terminating with enlarged spherical cells deeper coloured than the other cells; hairs hyaline, slender, arising from the basal cells of the assimilating filaments, growing intercalarily in the deeper coloured basal portions; unilocular sporangia ellipsoid or obovate, borne on the basal cells of the assimilating filaments; plurilocular sporangia linear, simple or branched, transformed from branches of the prostrate filaments.

Heterosaundersella hattoriana TOKIDA (Figs. 65–67, Pl. XXII)

Phyc. Observ. V, p. 84, Figs. 2, 3, Transac, Sapporo Nat. Hist. Soci., 1942; *Gobia simplex* (non SETCH. et GARDN). TOKIDA, in Kenkyu-Syoroku, Hattori Hokokai, II, 1936, p. 250, No. 16; Id., Mar. Alg. S. Saghalien, p. 95, pl. XIII, Fig. D.

Japanese name: Karafuto-mozuku.

Locality: Yoman, Saghalien (TOKIDA, Aug. 1935); Isl. Shikotan, Kuriles (S. KAWABATA); Rausu, Benten-jima Nemuro Prov., Akkeshi, Kushiro Prov.

Epiphytic on *Heterochordaria abietina*, rarely on *Chordaria flagelliformis* f. *chordaeformis* between the tide marks.

Frond flaccid, epiphytic on certain other algae, generally caespitose or rarely simple attached by a small discoid holdfast, dimorphic with prostrate filaments and erect axis, cylindrical to compressed cylindrical, attaining 2–5 cm in height, 1–2.5 mm in breadth, tapering towards the base, terminating into blunt apex, giving rise to above-mentioned fronds from the base penetrating into the tissue of the host; prostrate frond consisting of a palisade layer of straight assimilating filaments over the surface of the host, simple or provided with a few irregular branches, giving rise to short assimilating filaments terminating in ovate or spherical

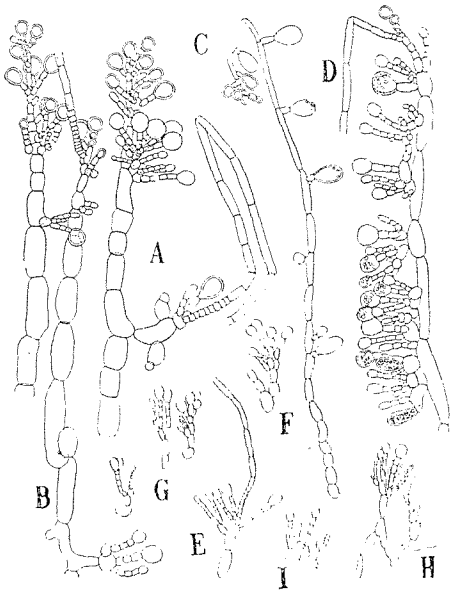


Fig. 65. *Heterosaundersella hattoriana* TOKIDA

A, B Central filaments and growing points in juvenile stages ×110 (Yôman, Saghalien. VIII, 1935. J. TOKIDA)

C Outer medullary filament in juvenile stage ×110 (Ditto.)

D Central filament, assimilating filaments, unilocular sporangia, a hair and a growing point in comparatively juvenile stage ×110 (Ditto.)

E Prostrate filaments and a hair arising from the primary base ×110 (Ditto.)

F Prostrate filaments ×110 (Ditto.)

G, H, I Plurilocular sporangia transformed from prostrate filaments on the primary bases. ×110 (Ditto.)

Fig. 66. *Heterosaundersella hattoriana* TOKIDA

A, B Unilocular sporangia ×110 (Yômon, Saghalien. VIII, J. TOKIDA)

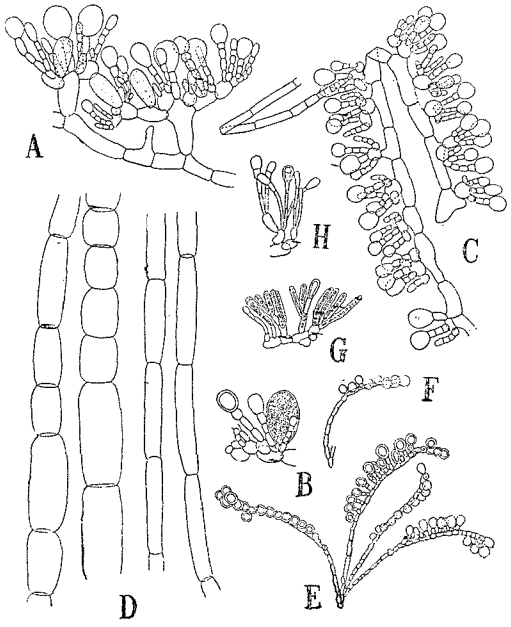
C Assimilating filaments in somewhat juvenile stage ×110 (Ditto.)

D Medullary filaments ×110 (Ditto.)

E, F Growing points and juvenile fronds arising from the primary bases ×110 (Ditto.)

G Plurilocular sporangia on prostrate filaments arising from the primary base ×110 (Shikotan-island, Kurile. VII, 1934, S. KAWABATA)

H Prostrate filaments ×110 (Ditto.)



cells; erect frond polysiphonous, growing monopodially, consisting of a bundle of free central filaments rarely branched, perpendicularly divided quite loosely in subcortex and cortex; central filaments longitudinally arranged with elongated cells 5 μ in diam. in the basal portion, 40 μ in diam. in the upper portion, 50–100 μ long; subcortical cells irregularly polygonal, somewhat smaller than the central cells; assimilating filaments of the prostrate frond arising from nearly the same level as those of the host, but projecting almost beyond the height of the assimilating filaments of the host, simple, more or less branched, 4–12 celled, 3–10 μ broad, 30–150 μ high with terminal cells, cells enlarged, spherical or ovate, with thickened cell-walls, containing abundant chromatophores; some of the apical cells on the juvenile central axis spherical forming moniliform cell-row, deeply coloured; assimilating filaments of cortex clavate, 2–5 cells long; 2–3 upper spherical cells moniliform, lower cells cylindrical; terminal cells enlarged, spherical or ovate, more deeply coloured than the other cells; hairs hyaline, 5–7 μ broad, but in the lower portion containing chromatophores and growing intercalarily, arising from the primary base or the basal cells of the cortical assimilating filaments; unilocular sporangia ellipsoid or obovate, 20–35 $\mu \times$ 40–65 μ in size, arising from the basal cells of the assimilating filaments; plurilocular sporangia linear, simple or branched, transformed from branches of the prostrate frond, with 5–12 uniseriate loculi, 5 μ broad, 50 μ long; frond brownish in colour, adhering to paper when dried.

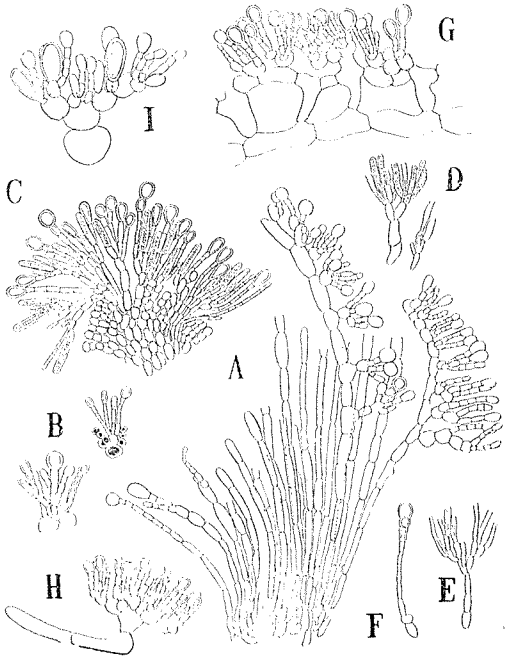


Fig. 67 *Heterosaundersella hattoriana* TOKIDA

A Medullary layer arising from the primary base of a juvenile frond not provided with descending filaments ×110 (Rausu, Nemuro Prov., 15–VII, 1936)

B assimilating filaments on the primary bases ×110 (Ditto.)

C, D, E Prostrate filaments with plurilocular sporangia ×110 (Ditto.)

F Elongated prostrate filament ×110 (Ditto.)

G, H Subcortical cells and assimilating filaments ×110 (Ditto.)

I Unilocular sporangia borne on the basal cells of the assimilating filaments ×110 (Ditto.)

In the erect frond of the present species there are no rhizoidal filaments descending from the subcortical cells, so the central axis consists only of a bundle of many cylindrical filaments.

As was described by Dr. TOKIDA, the prostrate fronds are provided with plurilocular sporangia arising from the same base as the erect frond, whose base penetrates inte the cortical or subcortical tissue of the host.

The present alga is generally caespitose, epiphytic on *Heterochordaria abietina* or *Chordaria flagelliformis* f. *chordaeformis*, while the frond of *Saundersella simplex* is usually solitary or somewhat caespitose and found only on the frond of *Chordaria flagelliformis*. The frond of the present species shows dimorphism, being different from the genus *Saundersella*. In the juvenile as well as in the adult frond of the genus *Saundersella* one may recognize many entangling rhizoidal filaments arising from the subcortical cells and so cylindrical central filaments become rather inconspicuous.

Because of the above-mentioned characteristics the writer agrees with Dr. TOKIDA's opinion that the present alga is different from *Saundersella simplex* SETCH. et GARDN.

Development of the frond.

The frond is epiphytic on *Heterochordaria abietina* or *Chordaria flagelliformis* f. *chordaeformis* by means of a primary base, whose cells are rhizoidal and irregularly divided, and in process of penetrating among the subcortical and cortical tissues of the host. Each prostrate frond covers the surface of the host and is 100–150 μ in height, terminating a large apical cell, and its upper cells are more deeply coloured than the lower ones. The cells of the primary base are roundish in its central portion, but towards the outer portion they become long. Some of the prostrate filaments construct the central axis of the erect frond, which consists of a bundle of slender filaments in the lower portion while in the outer portion short assimilating filaments are scattered. Some apical cells of the central filaments of the juvenile frond are deeply coloured and spherically enlarged, moniliform, giving rise to primary assimilating filaments. The central axis is polysiphonous and each cylindrical filament grows monopodially. The primary assimilating filaments which already have formed at the termini of the spherical cells, make several new assimilating ones dividing from their basal cells and after branching several times these assimilating ones develop into subcortical layer no longer possessing chromatophores. The outer central filaments give rise to subcortical and cortical layers, but these layers do not develop from the inner ones which consist of only cylindrical cells.

The plurilocular sporangia are borne on the branches of the prostrate frond

or rarely on the central filaments of the basal portion of the juvenile erect frond which will perhaps develop into adult frond in future. The unilocular sporangia and the hairs are borne on the basal cells of the assimilating filaments. The basal cells of the assimilating filaments are very variable in size and shape.

Heterochordaria SETCH. et GRADN. 1924

SETCH. and GARDN., 1924, Phycol. Contrib. 7, p. 6; Id., Mar. Alg. *Melanoph.*, 1925, p. 550; KYLIN, Phaeophyceenord. *Chordar.*, 1940, p. 42.

Frond simple or branched with an unbranched main stem and lateral branchlets; secondary base constructed of irregularly divided one cell-layered primary base spreading on substratum and assimilating cortical tissue developed from the primary base without filaments descending from the central axis or the basal cells of the assimilating filaments; central axis polysiphonously and monopodially developed with a polysiphonous growing point; medullary layer in juvenile stage solid, in age completely hollow, composed of cylindrical and filamentous cells, cells sometimes divided; assimilating filaments clavate, terminating in somewhat enlarged cells; hairs hyaline, uniseriate with cylindrical cells, found on juvenile frond; unilocular sporangia oviform to elliptical; plurilocular sporangia transformed from cells of the assimilating filaments; both kinds of sporangia developed on different individuals.

Though the basal structure of the present genus is different from that of other ones of Chordariaceas, at present the writer follows KYLIN (1940) and TOKIDA's (1954) opinions.

Heterochordaria abietina (RUPR.) SETCH. et GARDN.

Phyc. Cont. VII, 1924, p. 6; Mar. Alg. Pacif. Coast of North America, part III, *Melanoph.*, 1925, p. 550, pl. 36, Figs. 18, 19, pl. 91; YAMADA, Mar. Alg. N. Kuriles, 1934, p. 344; OKAM., Nippon Kaisoshi, 1936, p. 199, Fig. 104; KAWABATA, List Mar. Alg. Isl. Shikotan, 1936, p. 203; *Chordaria abietina* RUPRECHT, in FARLOW, List Mar. Alg. U. S., 1875, p. 375; J. AG., Till. Alg. Syst., 1880, p. 4, Tab. 74, Fig. 3 2 a–b; DE TONI, Phyc. Jap., 1895, p. 53, 1895 a, p. 434; SAUND., Alg. Harriman Exp., 1901, p. 424; OKAM., Nippon Sorui, Meii, ed. 1, 1902, p. 124, ed. 2, 1916, p. 160; Id., Icon. Jap. Alg., 11, 7, 1910, p. 122, pl. LXXXV, Figs. 8–15; SETCH. and GARDN., Alg. N. W. Amer., 1903, p. 251, pl. XVIII, Figs. 16, 17; SINOVA, Alg. Kamtschatika, 1932, p. 16. *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. f. *simplex* TOKIDA, Mar. Alg. S. Saghalien, 1954, p. 94.

Frond gregarious, simple, branched from a main stem, or entirely unbranched, cylindrical, often subcylindrical or slightly flattened, solid in the juvenile stage, but in the mature stage hollow, provided with at times slightly swollen, long or

short, simple, sometimes forked branchlets on all sides of the main stem, the stem giving rise to very small branchlets or rather small protuberances, or sometimes lacking these processes; base prostrate, somewhat divaricately or rather irregulary branched, piled up in several layers, extendible adhering closely on rock, composed of parenchymatous cells; main stem 5–40 cm long, 1–4 mm thick; lateral branchlets 0.5–6 cm long; branches and branchlets tapering gradually towards both ends; medullary layer composed of filamentous or cylindrical cells, solid in the basal portion, becoming hollow in its central portion upwards, cells cylindrical or filamentous, 30–80 mm long, here and there laterally connected; subcortex composed of 1–3 layers of cells, cells cuboidal or oblong, $1.5\mu \times 3\mu$–$2\mu \times 2\mu$ in diam; assimilating filaments clavate, 2–5 celled, 50–90 μ long, terminal cells much or slightly enlarged, pyriform to spherical; hairs hyaline, uniseriate with cylindrical cells, usually found in the juvenile frond, but in the mature falling off, growing intermediately in the basal portion; chromatophores concave; plurilocular sporangia arranged in 2 rows through the transformation of the cells of the assimilating filaments except the terminal cell; unilocular sporangia borne on the basal portion of the assimilating filament, oviform to elliptical, about $80 \times 30\mu$ in diam.; both kinds of sporangia found on main stem and lateral branchlets; frond herbaceous, greenish brown or dark olive brown, but in age reddish brown, faded black in the dried mature frond, adhering to paper in drying in juvenile stage, but not so in older stage.

By Dr. TOKIDA the unbranched form of *H. abietina* is distinguished from the branched typical form, but on the Hokkaido coast it is found not rarely that the fronds of these two forms come out of the same base. The present writer supposes, therefore, that the former is the same individual as the latter and that there is no difference between the two forms.

The present species is separable into the following two forms.

f. ***abietina*** (Figs. 68–71)

Japanese name: Matsumo, Matsubo, Gunji-matsumo (M. NAGAI), Himo-matsumo.

Locality: Oshoro, Shiribeshi Prov.; Muroran, Iburi Prov.; Akkeshi, Kushiro Prov.; Asamushi, Hebiura and Sai, Mutsu Prov. Widely distributed along the coasts of Hokkaido and the Kuriles.

Growing on rocks, stones or sea mussels, very often in tide pools between the tide marks.

Frond usually provided with many simple or someitmes bifurcated branchlets on a principal axis; principal axis sometimes lacking these branchlets.

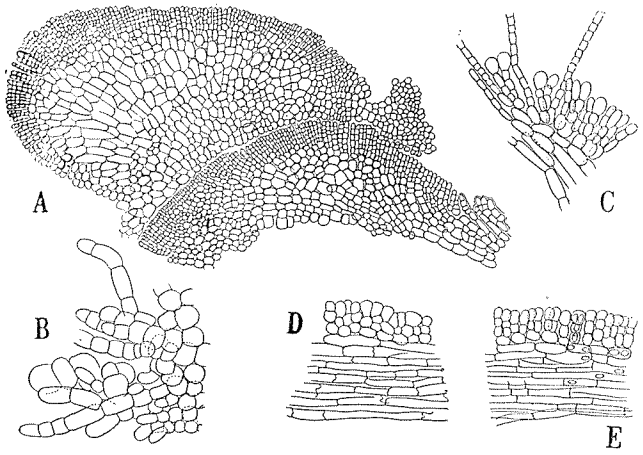


Fig. 68. *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. f. *abietina*

A Vertical section of the base ×70 (Muroran, Iburi Prov., 30-X, 1951)
B Rhizoids issued from the bases of a juvenile frond ×70 (Muroran, Iburi Prov., 20-II, 1952)
C Portion of a juvenile frond with hairs ×160 (Ditto.)
D, E Vertical sections of juvenile fronds ×160 (Ditto.)

Development of the frond.

The primary discoid base of the frond is made by means of the horizontal cell-division of the zygote or the zoospore becoming about 1 mm in diam.; the base also divides vertically and many cell-layers are formed. Such a disc develops gradually branching somewhat dichotomously and puts forth creeping rhizoids which pile on each other. On the other hand, from the primary disc arise some new fronds which are at first simple, but soon afterwards many short branchlets make appearance laterally. The lateral short branchlets usually arise abundantly on all sides of the main stem. Branchlets of some individuals grow to their maximum length very quickly though they are short, but the other ones do not grow fully, remaining short even in the adult. At the extremities the adult main stem is provided with only a few very short branchlets, or none at all. When the frond consists of a single main stem only, it seems as if it belongs to a different species. The writer often has found these variable forms on the Muroran coast (Jinya, Denshin-hama, Ponmoi, Motomari, etc.). The lateral branchlets of the frond from the Pacific coast of Hokkaido are attaining to a length of 2–3 cm or more, but the ones from the Japan Sea coast (Oshoro Bay) and Mutsu

Bay are shorter in comparison with branchlets of the fronds from the Pacific coast; they attain a lengh of 1–2 cm and develop unsufficiently in the adult. The fronds are usually 10–40 cm long or more, but some fronds from the Pacific coast washed by cold waters are larger than those from the Japan Sea coast washed by the warm current. The rhizoid of the frond from the Pacific coast is often extending more widely than those from the Japan Sea coast. The frond in shallow waters or in upper littoral zone is very often small in size. Plurilocular sporangia are borne on the lateral branchlets or the main stems. After gametes were emitted from the lateral branchlet, the latter appears white. The unilocular sporangia as well as the plurilocular sporangia are borne on the lateral branchlets or the main stems. After zoospores were emitted from the lateral branchlets, the latter does not seem white. These fertile fronds are widely variable in form, but the writer cannot make any distinction between them. In May and June, the fronds usually fall off from the base which remains adhering to rocks and gives rise to new fronds again in September or October.

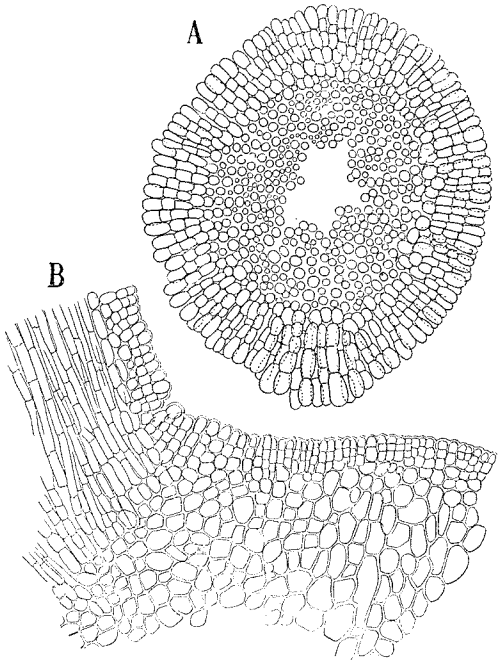


Fig. 69. *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. f. *abietina*

A Cross section through somewhat hollow medullary portion of a juvenile frond × 160 (Kujira-hama, Muroran, Iburi Prov., 22–III, 1952)

B Vertical section through the basal portion ×90 (Nirasu-iwa, Muroran, Iburi Prov., 22–III, 1952)

The medullary layer of the primary discoid base consists of parenchymatous cells which are irregularly polygonal. The membranes of the primary discoid base are thickened. Some rhizoidal filaments are found issuing from the marginal portion of the primary discoid base.

The cortex of the primary base consists of 2–3 layers of cubic cells and the cortical filaments divide very often cleary, so the cortex looks like a pavement. when the primary discoid base gives rise to the rhizoids, the parenchymatous cells in the dividing part are elongated parallelly to the dividing direction. At first the

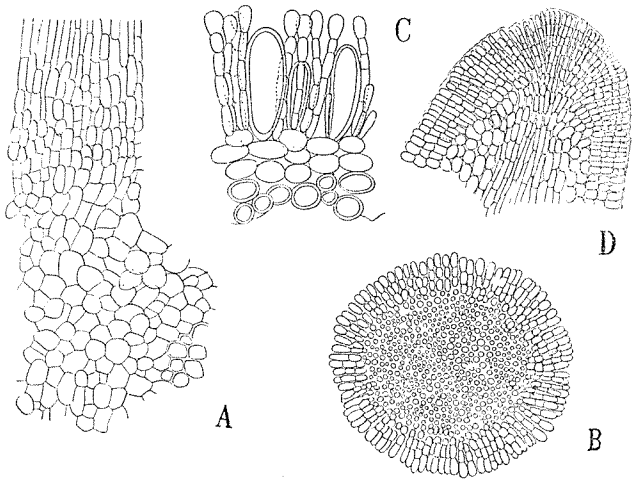


Fig. 70. *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. f. *abietina*

A Portion of the boundary between a base and an erect frond × 110 (Muroran, Iburi Prov., 22-III, 1952)

B Cross section of a juvenile frond, whose medulla in solid × 110 (Ditto.)

C Unilocular sporangia × 160 (Pon-moi, Muroran, Iburi Prov., 10-III, 1952)

D Growing point of a juvenile frond × 110 (Ditto.)

central axis of the main stem seems to consist of about several to 10 rows of cylindrical cells which are arranged longitudinally with one another arising from the primary disc. The medullary cells construct the medullary layer by a result of dividing obliquely upwards. In the intermidiate portion between the primary disc and the young stem, the medullary cells already are longitudinally elongated. The medullary cells at the apex divide patently outwards and make cortex and subcortex to develop with attendant extension of the medullary layer. It is found that the medullary cells divide obliquely upwards or downwards connecting very often partially with those of neighbouring cell-rows. The medullary cells in the apical portion of the adult are larger in size than those of the young frond. The writer cannot find any anatomical differences between apices of the fronds of the present alga and those of *Chordaria flagelliformis* (MUELL.) AG. except for the following point. In the present species, the primary base develops into the secondary ones by means of a division in itself and in the basal portion of the

frond the medullary cells give rise to the cortical and subcortical layers dividing obliquely upwards. The cortical and subcortical layers become also some part of the base. Thus, the secondary base is not composed of the rhizoidal filaments which descend from the medullary cells in the basal portion. On the contrary, in *Chordaria flagelliformis* (MUELL.) AG., etc. the secondary base of the frond is composed of the descending filaments from the medullary cells in the basal portion, and these filaments are densely connected with one another.

The subcortex consists of 1–3 layers of cuboid cells and their most external cells become basal cells of the assimilating filaments in the adult, but no differences in form are found among medullary cells, subcortical and cortical ones in the juvenile frond and the apical portion of the rhizoid. The assimilating filaments of the juvenile frond consist of 1–3 layers of cells separated from the medullary cells. The cortical cells divide longitudinally with the developments of the frond and the branches, and then the assimilating filaments attain 50–90 μ length and consist of 2–5 cells. The terminal cell of the assimilating filament is ovoid and enlarged. In the assimilating filament of the juvenile frond, the terminal cell is not yet enlarged, rather more or less longer and more slender than any other cells which are cuboid. Several basal cells of the mature assimilating filament are cuboid. The juvenile frond is solid (about 1 mm high) as well as the basal portion, but according to development of the frond the central portion of the medullary layer becomes hollow, for the medullary cells are pulled outwards. The hollowness of the frond is distinctly observable in the mature frond. The

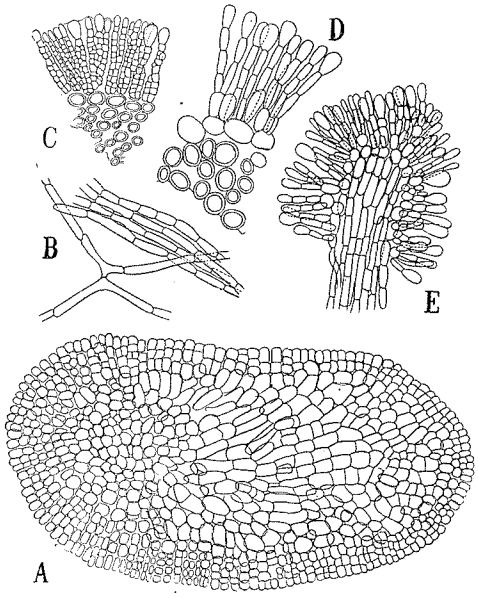


Fig. 71. *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. f. *abietina*

A Horizontal section through the base ×110 (Muroran, Iburi Prov., 22–III, 1952)
B Medullary filaments dividing often dichotomously ×160 (Kuzira-hama, Muroran, Iburi Prov., 22–III, 1952)
C Plurilocular sporangia ×160 (Muroran, Nirasu-Iwa, Iburi Prov., 1–IV, 1952)
D Portion of a frond provided with assimilating filaments and young unilocular sporangia ×160 (Muroran, Iburi Prov., 10–III, 1952)
E Vertical section through the apex of a juvenile frond ×160 (Ditto.)

medullary cells are 50–80 μ long or more, 10–20 μ thick, and the subcortical cells are 20–30 μ long, 20 μ thick.

f. ***gunjii*** (YENDO) INAGAKI, comb. nov. (Figs. 72, 73 Pl. XXIII)

Chordaria gunjii YENDO, Some New Alg. fr. Japan, 1913, p. 280, pl. XIII, Figs. 12–17; OKAM., Nippon Sorui Meii, ed. 2, p. 160; Id., Nippon-Kaisoshi, 1936, p. 199; *Heterochordaria gunjii* (YENDO) TOKIDA, Phyc. Obs., IV, 1938, p. 218; NAGAI, Mar. Alg. Kurile Isl., p. 49, pl. 11, Figs. 14, 15, pl. III, Fig. 8.

Japanese name: Gunjii-matsumo.

Locality: Shumushu Isl. (YENDO), Paramushiru Isl. (M. NAGAI), Northern Kuriles; Etorohu Isl. (M. NAGAI), Southern Kuriles.

Frond caespitose, cylindrical, simple on prostrate base, unbranched, provided with protuberances or not; bases divaricated, piled on each other.

YENDO has given a new name to the specimens from Shumushu Isl., Northern Kuriles, but SETCHELL and GARDNER considered YENDO's species with some doubt as a gametangial form of some species of Myelophycus.

OKAMURA has noted in his publication that in his judgment the present alga resembles *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. from the appearance of the gametangia and the small conical protuberances in YENDO's figure. YENDO's specimens were transferred to the genus Heterochordaria by TOKIDA on account of bearing zoosporangia and gametangia on macroscopic plants. NAGAI has referred his specimens tentatively to *Heterochordaria gunjii* (YENDO) TOKIDA, because the specimens from Kakumabetsu (Paramusiru Isl.) and Moyoro, Kamuikotan

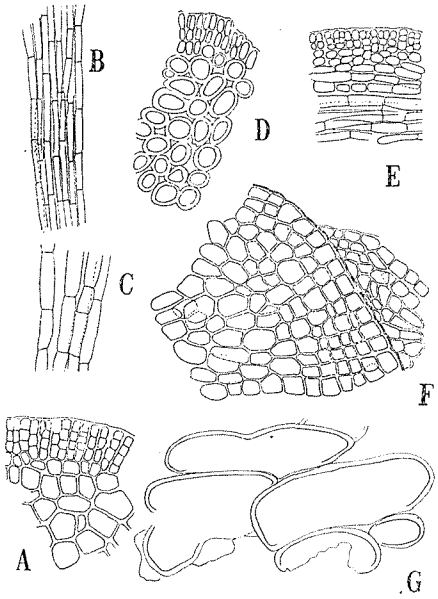


Fig. 72. *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. f. *gunjii* (TOKIDA) INAGAKI

A Cross section through the basal portion ×130 (Shumushu-island, Kurile. VII, 1903. K. YENDO)
B Slender central filaments in the medullary layer ×130 (Ditto.)
C Central filaments in the medullary layer ×130 (Ditto.)
D Cross section of a lower portion ×130 (Ditto.)
E Longitudinal section of an erect frond ×130 (Ditto.)
F Cross section of the base ×130 (Shumushu-island, Kuriles)
G Longitudinal section of the base piled with each other ×10 (Ditto.)

Etorofu Isl.) in his collection accord well with the original description and with the specimens determined by YENDO. TOKIDA in his studying of the marine algae of Southern Saghalien has placed the present alga in *Heterochordaria* from some characteristics.

After a histological investigation of YENDO's specimens preserved in the herbarium of the Botanical Departments of Tokyo University, the writer was able to assure himself of the following facts.

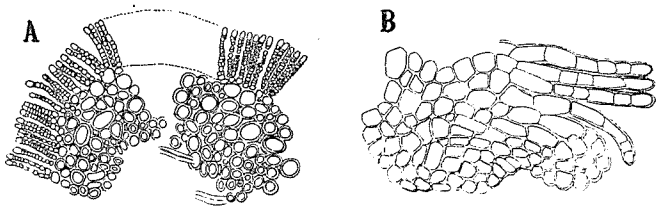


Fig. 73. *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. f. *gunjii* (TOKIDA) INAGAKI

A Plurilocular sporangia × 130 (Shumushu-island, Kuriles. VII, 1903. K. YENDO)
B Rhizoids issued from the marginal portion of the base × 130 (Ditto.)

The present alga must be identical with *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. judging from the inner structure and the basal portion of the frond as OKAMURA has suggested. Small protuberances are scattering on the frond, sometimes abundantly observable. Similar protuberances are very often found on the fronds from Jinya, Ponmoi, Motomari or Denshinhama near Muroran, though the fronds from Ponmoi and Motomari are remarkably shorter in length than those from Jinya. On the Muroran coast a main stem of the frond usually gives rise to thin branchlets and very small branchlets or rather protuberances and sometimes such a stem is not provided with accessory products.

Pseudochorda YAMADA, TOKIDA et INAGAKI, gen. nov.

Frond caespitose, arising from a confluent secondary base developing from the primary base, cylindrical, unbranched, evidently hollow, tapering gradually towards both ends, about 150 cm long, parenchymatously composed of cylindrical cells in the inner portion, especially near the central portion of the medullary layer with filamentous or hyphal cells, provided with clavate assimilating filaments gradually broadened above; unilocular sporangia oblong or clavate, borne to the number of 1–3 or more on the segment of the lowest cell of the assimilating filament; plurilocular sporangia and hairs unknown.

The present alga resembles *Chorda filum* (L.) LAMOUROUX in the outer appearances, and the genus *Chordaria* in the inner structure, but in differs from the latter species as follow:

Dr. TOKIDA has classified the present alga in the genus *Chordaria* with some hesitation. In the genus *Chordaria* the frond is provided with many hyaline hairs and unilocular sporangia which are ovoid or pyriform growing on the surface cells of the frond, from which the assimilating filaments arise. The central portion of the frond is evidently folid, even consisting of cylindrical and filamentous cells. But in the present alga such characters cannot be found as in the genus Chordaria.

In the present genus the frond lacks hairs, and the unilocular sporangia are elongated or clavate being borne usually on the segment of the lowest cell of the assimilating filament.

In the genus *Chordaria* the base is composed or rhizoidal filaments descending from the central filaments which in turn are arising from the primary base.

In the present genus the cells of the primary base develop into the confluent secondary base dividing themselves outwards, and the basal rhizoids merely arise from the under surface or the marginal portion of the base and then often surface cells of the base are ending rhizoidally. According to the character of the median tissue, the present genus bears some resemblance to the genus *Heterochordaria*, but the position of the unilocular sporangia shows that our alga does not belong to the latter genus.

Pseudochorda nagaii (TOKIDA) INAGAKI, comb. nov. (Figs. 74-76)

Chordaria nagaii TOKIDA, Phycolog. Observations IV, p. 213, Figs. 1-4, Transact. of the Sapporo Nat. His. Soci. Vol. XV, pt. 4, 1938; M NAGAI, Mar. Alg. of the Kurile Isl., 1940, p. 47; *Chordaria* sp., S. KAWABATA, A List of mar. alg. Isl. of Shikotan, Sc. Pap. of the Inst. of Algol. Res., Vol. 1, No. 2, 1936, p. 203, No. 20; TOKIDA, Taxon and Phytogeogr Stud. Mar. Alg. Saghalien (Prelim. Rept.), 1936 p. 250, No. 18; TOKIDA, Mar. Alg. S. Saghalien, 1954, p. 92.

Japanese name: Nise-tsurumo.

Locality: Shikotan Island, Kuriles (M. NAGAI and S. KAWABATA), Saghalien (J. TOKIDA), Daikoku-jima near Akkeshi, Kushiro Prov. (Y. YAMADA).

Growing on stones and pebbles below the low tide mark.

Frond cartilagenous, lubricous, caespitose arising from a base, cylindrical, evidently hollow except near the base, sometimes spirally twisted, unbranched, tapering gradually at both the ends, 150-165 cm long, 5 mm in diam., in maturity very often the upper portion is torn away leaving behind the lower portion; base confluent into discoid shape, solid, composed of longitudinally elongated parenchymatous cells; except cortex and outer portion of subcortex, cells more enlarged

in the inner portion of the subcortex than the outer portion, in the medullary layer becoming cylindrical; cell-walls thickened, especially in the neighbouring part of the undersurface remarkably shrunk; rhizoids irregulary divided, issuing from the marginal portion or the undersurface of the base; cortex of the base composed of unicellular layer; cells of the confluent portion of the base filled up with compact contents; medullary layer evidently hollow, but in the outer portion cells cylindrical running straight longitudinally, 150–250 μ long, 30 μ in diam. or cuboidal, in the inner portion cells slender, 15 μ in diam. or hyphal in form, sometimes enlarged at ends, here and there laterally connected with projections; subcortical cells cuboidal, vertically elongated, 50–100 μ long, 4–5 μ in diam.; median tissue parenchymatous, 7–10 cell-layered in mature frond, composed of remarkable thick-walled cells with scattered phaeoplasts; pits roundish, scattered on cell-walls; assimilating fiiaments of the cortex filamentous, clavate, 100–150 μ long, about 8 μ in diam., erect, 5–7 cells in a single row, gradually broadened above, slightly constricted or not at each segment, provided with enlarged terminal cells, cells globular or pyriform, 8–14 μ in diam., but in the juvenile or lower portion the assimilating filaments consisting of a single row of 1–3 cells; apical portion polysiphonous with monopodial growth; hair unvisible; unilocular sporangia elongated or clavate, 30–40 μ long, 7–10 μ wide, borne on the segment of the lowest cell of the assimilating filament or on a segment upper than the lowest cell

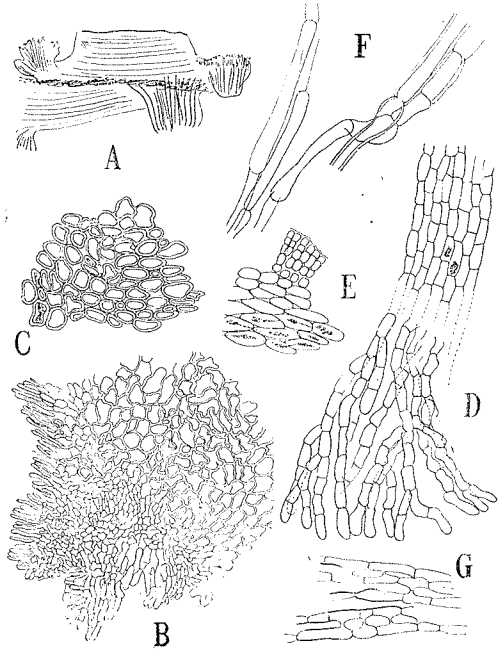


Fig. 74. *Pseudochorda nagaii* (TOKIDA) INAGAKI

A Vertical section of the base ×10 (Shikotan-island, Kuriles. VII, 1934. S. KAWABATA)
B Cross section of the confluent base ×110 (Ditto.)
C Showing thickened cell-walls in the base ×110 (Ditto.)
D Dichotomous rhizoids descending downwards × 130 (Ditto.)
E Vertical section through the lower portion of a frond ×110 (Ditto.)
F Hyphal cells in the medullary layer ×110 Ditto.
G Inner medullary cells in the basal portion ×130 (Ditto.)

being usually 1 in number, sometimes 2–3 or more successively from one and the same cell; plurilocular sporangia unknown; frond olive brown, subcoriaceous in drying, adhering well or not to paper when dried.

Fam. **Acrothrichaceae**

KUCKUCK, Monogr. Phaeosp., 1929, p. 65; OKAMURA, Nippon Kaisoshi, 1936, p. 205; KYLIN, Phaeophyceenord. *Chordar.*, 1940, p. 43.

Acrothrix KYLIN 1907

KYLIN, Algenfl. 1907, p. 93; Id., Phaeophyceenord. *Chordar.*, 1940, p. 45.

Frond irregularly branched, imbedded in gelatinous substance, secondary base consisting of a primary base and rhizoids descending from subbasal cells of the

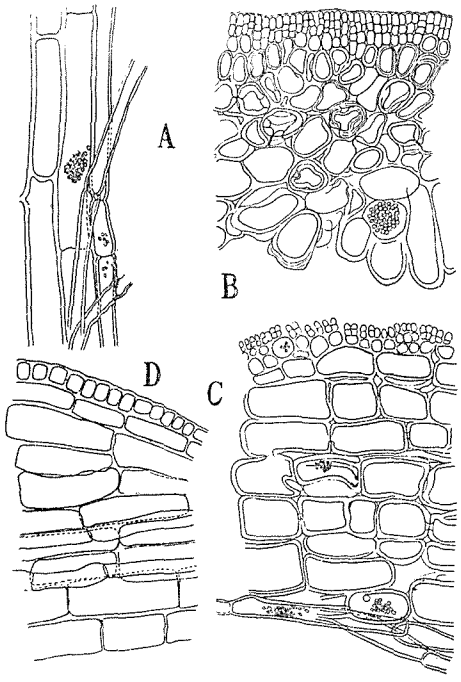


Fig. 75. *Pseudochorda nagaii* (TOKIDA) INAGAKI

A Hyphal cells in the medullary layer ×110 (Shikotan-island, Kuriles. VII, 1934. S. KAWABATA)
B, C Cross section through the lower portion ×110 (Ditto.)
D Longitudinal section through the upper portion ×130 (Ditto.)

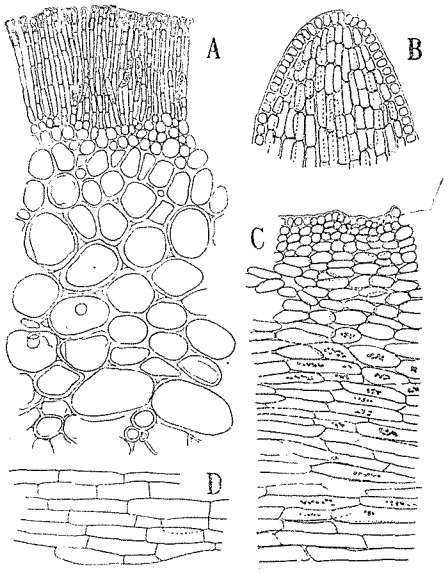


Fig. 76. *Pseudochorda nagaii* (TOKIDA) INAGAKI

A Cross section of a frond showing unilocular sporangia borne on the lower portions of assimilating filaments ×110 (Shikotan-island, Kuriles. VII, 1934. S. KAWABATA)
B Apex ×130 (Ditto.)
C Longitudinal section through the basal portion ×110 (Ditto.)
D Central axis in the basal portion ×130 (Ditto.)

primary assimilating filaments, terminal portions of descending rhizoids penetrating into cortex of the host; central axis growing trichothallically at the apex, solid in juvenile stage, in age incompletely hollow; medullary layer several loosely parenchymatous cell-layered, transforming indistinctly to subcortex; medullary layer and assimilating filaments distinguishable; assimilating filaments 2–8 cells long, unbranched, in somewhat upper portions; hairs hyaline, arising mostly from the subbasal cells (ultimate cells of the subcortex) of the assimilating filaments; unilocular sporangia sessile, borne on the basal cells of the assimilating filaments; plurilocular sporangia unknown.

Acrothrix pacifica OKAMURA et YAMADA

YAMADA, Notes on some japan. alg. III, 1932, p. 113, pl. 24, Text-fig. 2; KYLIN, Phaeophyceenord. *Chordar*, 1940, p. 45.; TOKIDA, Mar. Alg. S. Saghalien, 1954, p. 96, pl. XXIV, XXV; INAGAKI, Contrib. Knowl. Chordar. Japan, I, 1954, p. 6, Fig. 6, a-c.

Frond epiphytic, attaching to the host by means of a small disc, growing trichothallically at the apex, cylindrical or slightly compressed, gelatinous, slimy, very lubricous, solid in the upper portions of branches, hollow in the other portions, 8–20 cm. long, abont 0.5 mm in diam., attaining 1–1.5 mm in diam. in thick branch, usually irregularly alternately and repeatedly divaricately branched without a principal axis, very often densely provided with many short branchlets, or sometimes with an evident principal axis, but in some individuals the short branchlets somewhat scattered; central axis possessing a single central filament, growing intercalarily at the apex, transformed into a single hair, apical hair long, colourless, hyaline, always found in the young individuals, but in age disappearing; primary assimilating filaments 2–7 celled, arising below the dividing zone of the growing point, composed of several roundish or ellipsoid cells; medullary layer formed by the division of the central filament and of the basal cells of the primary assimilating filaments; subcortex composed of 2–4 cell-layers developing by the division of the subbasal cells of the primary assimilating filaments; secondary assimilating filaments generally unbranched, club-shaped, arising from the cortical cells, composed of 2–8 cells, 20–150 μ long, constricted at dissepiments, broadened towards the apices, generally somewhat curved; terminal cells of assimilating filaments ellipsoid, ovate or obovate, 10–20 $\mu \times$ 8–10 μ in size; upper cells of secondary assimilating filaments swollen; hairs arising from the subbasal cells of the primary assimilating filaments and the basal cells of the secondary assimilating filaments, colourless, very long, consisting of cylindrical cells, however in age falling off; unilocular sporangia ovate or pyriform, 30–50 $\mu \times$ 40–50 μ, sessile, borne on the basal cells of the secondary assimilating filaments; plurilocular sporangia unknown; colour yellow or yellowish brown; frond adhering to paper in drying.

f. ***pacifica*** (Figs. 77, 78, Pl. XXIV)

Japanese name: Nise-mozuku.

Locality: Abashiri and Utoro, Kitami Prov.; Muroran, Iburi Prov.; Oshoro, Shiribeshi Prov.; Ehima, Mikawa Prov.; Wagu, Shima Prov.; Iyo Prov. Epiphytic on *Chorda filum* LAMOUR. below the low tide mark.

Frond provided with dense branches without any evident principal axis; thick branches attaining 1 mm in diam.

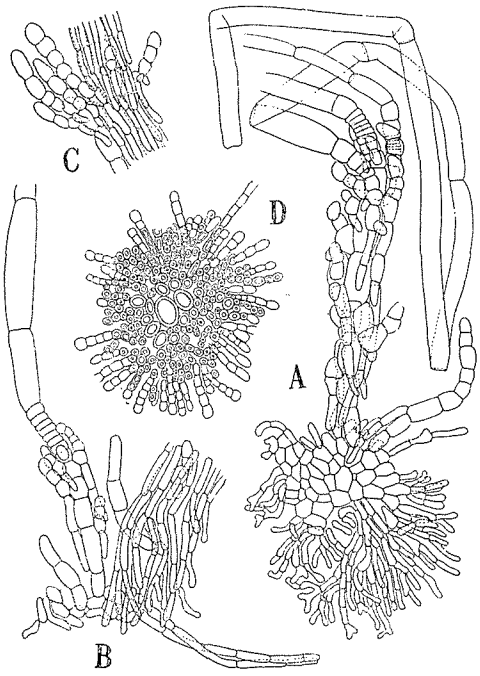


Fig. 77. *Acrothrix pacifica* OKAMURA et YAMADA f. *pacifica*

A Juvenile frond arising on the primary base ×200 (Sai, Mutsu Prov., 27-V, 1952)
B Juvenile frond arising on the primary base and a portion of descending filaments ×200 (Ditto.)
C Assimilating filaments on the basal portion of a frond ×130 (Ditto.)
D Cross section through the basal portion of a frond with a distinctive central axis ×110 (Abashiri, Kitami Prov., 12-VIII, 1951)

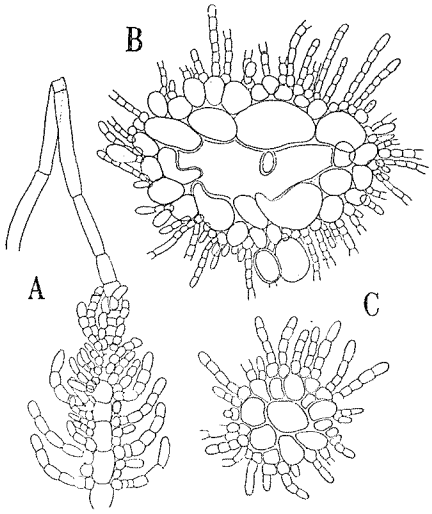


Fig. 78. *Acrothrix pacifica* OKAMURA et YAMADA f. *pacifica*

A Growing point ×200 (Oshoro, Shiribeshi Prov.)
B Cross section of a frond ×90 (Ditto.)
C Cross section of a juvenile frond ×90 (Ditto.)

f. ***crassa*** INAGAKI (Fig. 79)

INAGAKI, Contrib. Knowl. *Chordar.* Japan I, 1954, p. 9, Fig. 7, a-c.

Japanese name: Futo-nisemozuku.

Locality: Atsumi peninsula, Mikawa Prov. Growing on stones or epiphytic

on *Chorda filum* LAMX. below the low tide mark.

Frond 8–20 cm long, attaining 1–1.5 mm in diam. in main branches, 2–3 times irregularly alternately branched; principal axis very distinct; branches patent, provided with scattered branchlets.

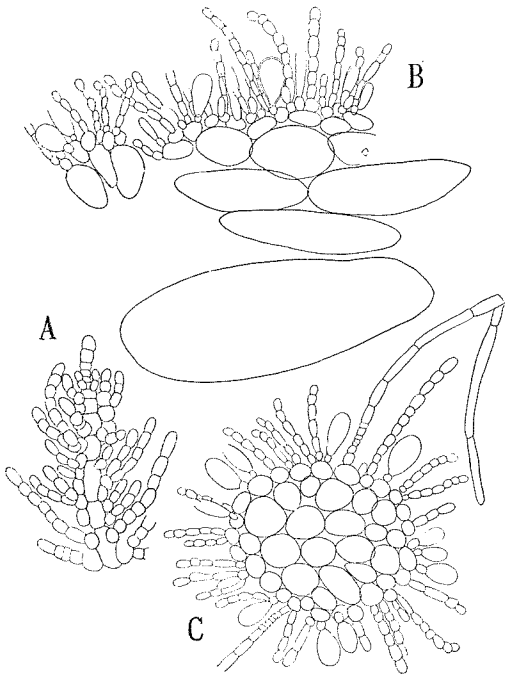


Fig. 79. *Acrothrix pacifica* OKAM. et YAMADA f. *crassa* INAGAKI

A Growing point in age ×200 (Oshoro, Shiribeshi Prov.)

B Longitudinal section of a frond with unilocular sporangia ×130 (Ehima, Mikawa Prov., 15-IV, 1940. M. ARAZAKI)

C Cross section of a frond with hairs and unilocular sporangia ×70 (Ditto.)

The present forma is usually epiphytic on *Chorda filum* LAMX., but sometimes it is found growing on stones.

The branching of this alga is irregularly alternate, sometimes divaricate and in the lower portion of the frond the branchlets are considerably scattered. The frond of this species is somewhat slimy to the touch, but the older frond often adheres slightly to paper in drying.

Development of the frond.

The primary base of the frond is roundish, 80–150 μ in diam., usually composed of a single layer of polygonal cells in the central portion and in the marginal portion composed of irregularly dichotomous rhizoidal cells which arise from the polygonal cells.

From the polygonal cells hairs and erect filaments are arising, the former are hyaline, about 5 μ in diam., the latter are composed of a single row of cylindrical cells which are cubic in shape and rich in their contents. But some apical cells of the erect filaments are poor in their contents or become apical hairs at the growing point in late stages.

Each cell of the erect filament gives rise to primary assimilating filaments in all directions. Such filaments are arising on their subbasal cells which have divided from the cells of the central axis and elongating upwards. Rhizoidal filaments arising from the subbasal cells of the primary assimilating filaments are

irregularly divided descending along the central axis in the basal portion of the frond and come gradually to form a secondary base of the frond penetrating into the cortex of the host. So that, the basal portion of the adult frond is covered densely with these rhizoidal filaments.

Instead of the above-mentioned rhizoidal filaments cylindrical cells descend from some of the subbasal cells of the primary assimilating filaments and form a medullary layer enclosing the central axis. The medullary cells in the lower portion of the frond divide again into rhizoidal filaments or cylindrical cells downwards. After the primary assimilating filament arises on its subbasal cell in general, an apical hair develops on the basal cell or the subbasal one of the primary assimilating filament and gives rise to many assimilating filaments growing intercalarily in the basal portion. The primary assimilating filaments arising from the central axis or on the basal portion of the young frond are usually rich in their contents, clavate in shape and considerably larger than other general assimilating filaments of the adult cortex. Every central axis grows monopodially and many branches, branchlets and assimilating filaments develop on the apical portion of the central axis being provided with apices in process of transformation into hyaline hairs. The hyaline hairs of the apex are visible on the growing points of the young frond, but in age they usually come to fall off. Chromatophores are discoid.

Fam. **Spermatochnaceae**

KUCKUCK, Monogr. Phaeosp., 1929, p. 67; OKAMURA, Nippon-Kaisoshi, 1936, p. 207.

Nemacystus DERB. et SOL. 1850

DERBES et SOLIER, 1850, Organ. reprod. des algus, p. 269; KYLIN, Phaeophyceenord. *Chordar.*, 1940, p. 46.

Frond dimorphic; unbranched monosiphonous filaments erect or prostrate on irregular rounded primary base and erect branched main stems, both the two types imbedded in gelatinous substance; central axis solid or somewhat incompletely hollow, growing monopodially with a single cell-row in the apical portion; secondary base composed of primary base and rhizoidal filaments descending from the basal cells of the assimilating filaments; medullary layer composed of loosely parenchymatously arranged cells sending out primary and secondary assimilating filaments from the peripheral cells; boundary between medulla and subcortex indistinct; primary and secondary assimilating filaments curving in the upper portion, imbedded in gelatinous substance, slightly swelling, filiform with unenlarged terminal cells; hairs hyaline arising from the basal cells or the branchlets of the assimi-

lating filaments, free from gelatinous substance; unilocular sporangia ellipsoid or obovate, sessile or pedicellate with one cell on the basal cells or the lower portion of the assimilating filaments; plurilocular sporangia filiform, tufted on the assimilating filaments; both types of sporangia borne on either different individuals, or on one and the same indiviual.

Nemacystus decipiens (SUR.) KUCKUCK (Figs. 80-83 Pl. XXV)

Fragm. einer Monogr. der Phaeosporeen, 1929, p. 68, Figs. 92–93; *Mesogloia*

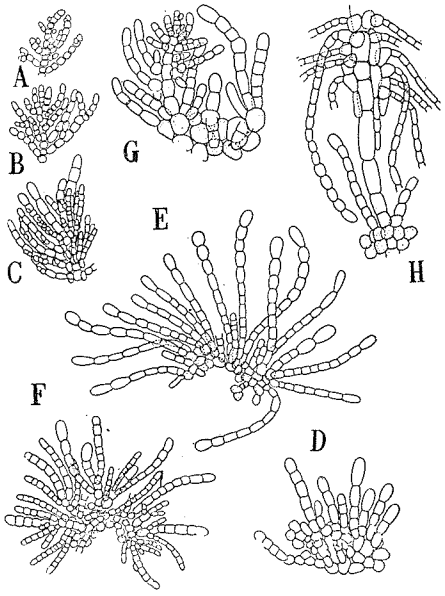


Fig. 80. *Nemacystus decipiens* (SUR.) KUCK.

A, B, C Series of developments of growing points A, B ×160 C ×90 (Morozaki, Owari Prov., 10-II, 1930)

D, E Juvenile prostrate filaments arising from the primary bases ×90 (Ohi, Owari Prov., 6-I, 1953)

F, G Growing points of the juvenile fronds arising from the primary bases F ×130, G ×200 (Ditto.)

H Descending filaments from the basal cells of the assimilating filaments ×130 (Ditto.)

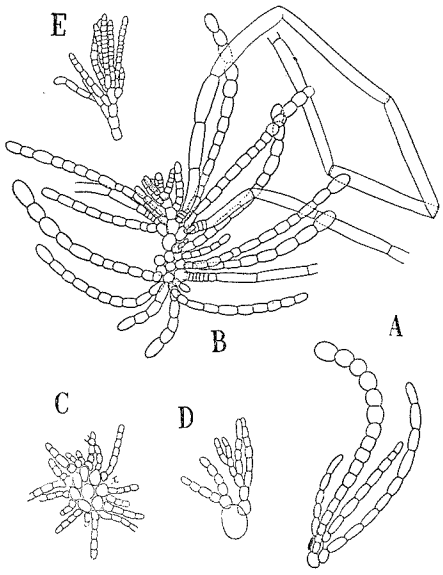


Fig. 81. *Nemacystus decipiens* (SUR.) KUCK.

A Prostrate filaments arising from the primary base ×130 (Ohi, Owari Prov., 6-I, 1953)

B Cross section through the juvenile portion of a frond with growing point ×130 (Ditto.)

C Cross section of a juvenile frond ×130 (Nanawo, Noto Prov., 3-IV, 1943, M. YAMAMOTO)

D Assimilating filaments ×130 Shino-jima, Owari Prov.)

E Assimilating filaments with plurilocular sporangia ×130 (Nanawo, Noto Prov., 3-IV, 1943, M. YAMAMOTO)

decipiens SUR., Illustr. des alg. de jap., Mus. bot. de Leyde. Tom I, 1872, p. 75, t. 25; DE TONI, Syll. Alg. III, 1895, p. 428; *Cladosiphon decipiens* OKAM., Algae japonicae exsicc. No. 87; Id., Icon. Jap. Alg. II, 1912, p. 136, Tab. 89; KYLIN, Phaeophyceenord. *Chordar*. 1940, p. 46; INAGAKI, Contrib. Knowl. *Chordar*. Japan, I, 1954, p. 2, Fig. 1, a-e, Fig. 2, a, b, Fig. 3, a-c.

Japanese name: Mozuku.

Locality: Enoshima, Sagami Prov.; Toyohama and Morozaki, Owari Prov.; Takeshima and Ikawazu, Mikawa Prov.; Hino-misaki, Izumo Prov.; Sado, Echigo Prov, etc. Widely distributed along the Pacific and the Japan Sea coasts of the middle and the southern parts of Honshu, also found along Shikoku and Kyushu coasts. Growing on the fronds of *Sargassum patens* C. AG., *S. piluliferum* C. AG., etc. below the low tide mark.

Frond generally growing on the fronds of several species of *Sargassum*, arising from small discoid base at first, 10–30 cm long, gelatinous, slimy, very lubricous, filiform, somewhat cord-shaped in older or main branches, in age branched several times alternately in various directions, provided with irregularly dichotomous branchlets, especially in younger stage with short, patent or inarching branchlets; branches about, 1 mm thick in the lower portion of the frond, gradually tapering upwards, usually scattered in the lower portion, but provided with branchlets considerably densely upwards; frond solid or more or less hollow, possessing oblong or elongated medullary cells, cells 100–180 μ, sometimes 1 mm long, 50–100 μ broad, somewhat loosely arranged; central axis monopodially developed, consisting of a single cell-row; longitudinal growth of the frond performed by the terminal cell of the central axis; rudimental assimilating filaments, formed from segment cells of the central filament, segment cells irregularly shaped, 10 μ in diam.; medullary layer and cortical one formed through stretching and dividing of the basal cells of the rudimental assimilating filaments, and also cortical layer formed from cell-rows separated from the subbasal cells of the rudimental assimilating filaments; cortical

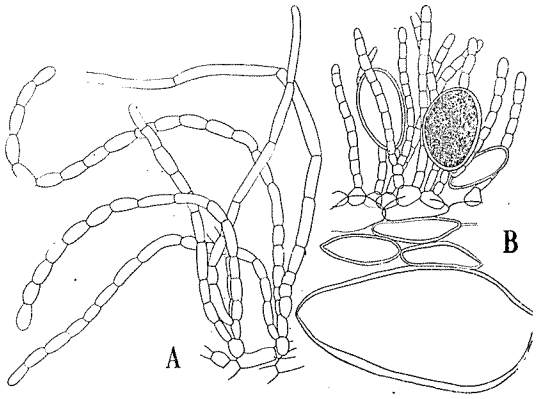


Fig. 82. *Nemacystus decipiens* (SUR.) KUCK.

A Assimilating filaments and a hair × 130 (Shino-jima, Owari Prov., 7–IV 1929)

B Longitudinal section of a frond with unilocular sporangia × 130 (Take-shima, Mikawa Prov., IV, 1941)

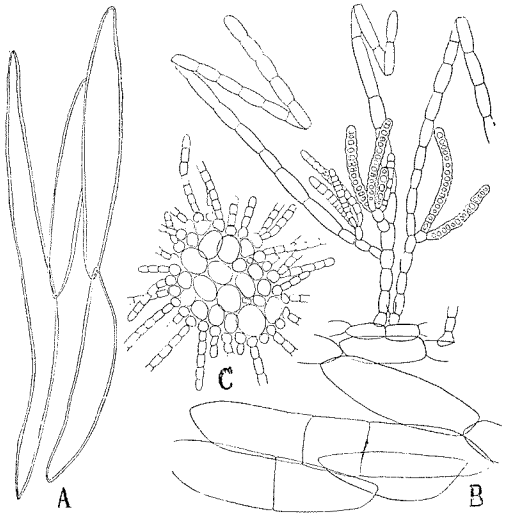


Fig. 83. *Nemacystus decipiens* (SUR.) KUCK.

A Medullary cells with thickened walls × 40 (Shino-jima, Mikawa Prov., 7-IV, 1929, T. SUZUKI)

B Longitudinal section of a frond with plurilocular sporangia × 120 (Takeshima, Mikawa Prov., IV, 1941)

C Cross section of a branch × 120 (Nanawo, Noto Prov., 3-IV, 1943, M. YAMAMOTO)

cells fully provided with secondary assimilating filaments and sporangia, so differentiation between the rudimental assimilating filaments and the secondary assimilating ones not found; secondary assimilating filaments simple or sparsely branched, filiform, 120–200 μ long, slightly curved upwards; consisting of about 9–21 cells, cells somewhat swelling in the upper portion; hairs colourless, up to 400 μ long, consisting of elongated cells, arising very abundantly from the basal cells or the branches of the assimilating filaments; unilocular sporangia ellipsoid or obovate, 80 μ long, 40–50 μ broad, sessile or with one-celled pedicels on the bases or the lower portions of the assimilating filaments; plurilocular sporangia filiform, gathering in tuft-like groups on the assimilating filaments, composed of one row of cells, transformed from the assimilating filaments; colour brown or light brown, very often becoming dark in age; frond firmly adhering to paper when dried.

Development of the frond.

The primary base of the frond is irregularly roundish, about 150 μ in diam. consisting of a single layer of cells which are round, elliptical, very often dichotomously divided, base gives rise to creeping rhizoidal filaments by means of, bifurcated divisions of the marginal cells.

The frond is dimorphic, partly erect or prostrate consisting of unbranched filaments, partly erect, but branched several times.

The unbranched filaments arise from the central part of the primary base in general or sometimes from creeping rhizoids, consisting of a single row of 8–12 cells or often 16 ones provided with spherical or elliptical terminal cells, that is, they are assimilating filaments on the primary base. The other erect filaments are somewhat broader than the unbranched ones, so that the former are different

in aspect from the latter. The erect filament grows into a primary central axis elongating monopodialy by means of apical growth and then gives rise to primary assimilating filaments in all directions from the basal portion or from each cell of the lower portion of the primary central axis. Basal cells of the primary assimilating filaments give rise to some secondary assimilating filaments and descending filaments along the primary central axis. The descending filaments are cylindrical and form a secondary central axis enclosing the primary central axis, but in the basal portion of the frond the descending filaments become irregularly rhizoidal except the central portion. The basal cells of the assimilating filaments divided from each cell of the central axis and of the descending cells form the medullary layer combining tightly perpendicularly and transversely to each other. The basal cells of the secondary assimilating filament are oblong, roundish or irregular in shape. Some of the primary assimilating filaments develop into branches becoming again central axes, and these central ones once again give rise to assimilating filaments or central axes. After branching repeatedly the frond comes to be provided densely with branches and branchlets. The assimilating filament is constricted remarkably moniliformously in the middle or upper portion.

At first a hyaline hair arises from the upper side of the basal cell of the primary assimilating filament of the apical portion of the central axis or the creeping cell of the primary base and also from the basal cell of the secondary assimilating filament. The descending filaments covering the surface of the central axis form a secondary discoid base and then come to cover the primary base, the creeping filaments and the unbranched filaments arising from the creeping filaments.

IV. Latin descriptions of new taxa

p. 101. *Leathesia* sect. *Leathesia* sect. nov.

Frons maturitate cava, ex cellulis medullaribus di-trichotome ramulosis, medio irregulariter longe cylindraceis, ellipsoideis vel angulatis, sursum gradatim minoribus, ultime ellipsoideis vel aliquantenus rotundiformibus ornata.

Typus: *Leathesia difformis* (L.) ARESCH. f. *difformis*.

Leathesia difformis (L.) ARESCH.

p. 103. f. *difformis*.

Frons paraphysibus 5–6 μ latis ornata.

p. 104. f. *globosa* (TAKAMATSU) INAGAKI, comb. nov.

Frons paraphysibus tenuibus 4 μ vel minus latis ornata.

p. 109. *Leathesia* sect. *primariae* INAGAKI, sect. nov.

Frons maturitate solida, ex cellulis medullaribus comparate regulariter di-trichotome ramulosis, medio longe cylindraceis, ellipsoideis, sursum gradatim minoribus, ultime ellipsoideis vel cylindraceis ornata.

Typus: *Leathesia primaria* TAKAMATSU.

p. 110. *Leathesia sadoensis* INAGAKI, sp. nov.

Frons epiphytica, solida, lubrica, irregulariter sphaeroidea vel hemisphaeroidea, 1–2 mm lata saepe gregaria in mensuram et formam variabilis, aliquantenus fragilis; cellulis medullaribus hyalinis comparate majoribus, cylindraceis, sursum sensim minoribus versus partes corticales et basales, obovoideis, ellipsoideis vel rotundiformibus in partibus exterioibus thalli, 30–45 μ altis, 20–30 μ latis, plerumque variabilibus, dichotome in partibus basalibus, trichotome ramulosis; paraphysibus comparate crassis, clavatis, 60–100 μ altis, 10 μ latis, 4–6 cellulatis, cellulis terminalibus magnis sphaeroideis vel ovoideis et muris crassis, fasciculatis ornatis; pilis hyalinis, 15 μ crassis, ex cellulis ultimis solitariis sparsis; sporangiis plurilocularibus fasciculate ex cellulis ultimis medullaribus oriundis, pedicellatis cum 1–2 cellulatis compositis, lanceolatis vel fusiformibus ornatis; sporangiis unilocularibus ignotis.

Typus: Tatsha, Ins. Sado (K. INAGAKI)-SAP.

p. 119. *Leathesia yezoensis* INAGAKI, sp. nov.

Frons epiphytica, solida, lubrica, irregulariter hemisphaerica vel ali-

quantenus pulvinata, gregaria, 1–2 mm lata, fragilis; cellulis rhizoideis variabilibus in formam, oblongis vel ellipsoideis, irregulariter ramosis; cellulis medullaribus oblongis vel longe ellipsoideis, aliquantenus cylindraceis, irregularibus in formam, 30–80 μ altis, 15–50 μ latis, majoribus in partibus mediis thalli, sursum deorsum minoribus, hyalinis, patenter dichotome vel trichotome ramosis; paraphysibus solitariis vel minute fasciculatis ex cellulis ultimis medulli, longe clavatis, rectis vel superioribus aliquantene curvatis, 6–11 cellulatis, ca 100 μ longis; cellulis paraphysium oblongis vel cuboideis, cellulis terminalibus saepe magnis, muris crassis, sphaeroideis vel ellipsoideis ornatis; pilis hyalinis, comparate brevioribus, cellulis cylindraceis 30–50 μ longis, 15 μ latis, ex cellulis medullaribus oriundis; sporangiis unilocularibus ex cellulis ultimis medullaribus oriundis, longe ovoideis, pedicellatis cum 1–2 cellulis, 35–60 μ longis, 10–20 μ brevibus; sporangiis plurilocularibus elongatis, cylindraceis ex cellulis ultimis medullaribus oriundis, 60–80 μ longis, ca 10 μ brevibus, sessilibus vel pedicellatis cum 1–2 cellulatis locellis 9–17, 1–2 seriatis; sporangiis unilocularibus et plurilocularibus plerumque in aliis individuis.

Typus: Hariusu, Ishikari Prov. (K. INAGAKI)-SAP.

p. 123. *Leathesia japonica* INAGAKI, sp. nov.

Frons epiphytica, saepius semisphaeroidea vel pulvinata, solida, lubrica, solitaria, ca 0.5–1.0 mm in diam., vel raro gregaria; rhizoideis basis uniseriate cellulis irregulariter divaricatis compositis, aliquantenus fragilis; cellulis medullaribus hyalinis, plerumque variabilibus in mensuram et formam, sphaeroideis, cylindraceis vel ellipsoideis, in medio majoribus, sursum minoribus, in periphere ellipsoideis vel sphaeroideis; paraphysibus clavatis, variabilibus in mensuram, 80–200 μ longis, 5–6 μ brevibus, cellulis paraphysium sursum sphaeroideis notabiliter moniliformibus, deorsum cylindraceis, cellulis terminalibus multo majoribus, globosis vel ellipsoideis, 10–18 μ latis ornatis; pilis hyalinis, solitariis, ex cellulis peripheralibus oriundis; sporangiis unilocularibus ex cellulis basalibus paraphysium oriundis, sessilibus, longe oviformis vel ellipsoideis, 40–80 μ longis, 20–40 μ latis; sporangiis plurilocularibus ignotis.

Typus: Suetsugu, Rikuzen Prov. (K. INAGAKI)-SAP.

p. 125. *Myriogloia simplex* (SEGAWA et OHTA) INAGAKI, comb. nov.

Frons saepe caespitosa, lubrica, gelatinosa, simplex, longe clavata vel vix ramis longis vel brevibus ornata, 8–15 cm alta, sursum gradatim crassiora, deorsum insigniter angusta; axe centrale ex filis multis composito,

cellulis medullaribus graciliscentis elongatis ad pilis ornata; cellulis subcorticalibus filamentosis laxe aut patenter divaricatis; filis assimilantibus piliformibus, 1–2 mm longis, uniceliatis; sporangiis, unilocularibus ellipsoideis vel oviformibus, 40–100 μ longis, 25–60 μ latis, sessilibus vel stipitatis, in cellulis basalis vel parte inferiora fili assimilanti insertis; sporangiis plurilocularibus adhuc ignotis.

Typus: Na-jima, Chikuzen Prov. (S. SEGAWA and K. OHTA) Lectotypus—SAP.

Papenfussiella kuromo (YENDO) INAGAKI, comb. nov.

p. 129. f. *kuromo.*

Axibus principalibus diametro ca 2–3 mm, semel vel bis ramosis, ramis sparsis ornatis.

Typus: Inubo-zaki, Shimofusa Prov. (K. YENDO)-TI.

p. 129. f. *gracilis* INAGAKI, f. nov.

Axibus principalibus diametro ca 1 mm, bis vel ter ramosis, ramis sparsis vel aliquantenus dentibus ornatis.

Typus: Toyohama, Owari Prov. (K. INAGAKI)-SAP.

p. 131. f. *densa* INAGAKI, f. nov.

Axibus principalibus diametro ca 1 mm, ter vel quater ramosis, ramis dentibus vel patentibus ornatis.

Typus: Toyohama, Owari Prov. (K. INAGAKI)-SAP.

p. 134. *Haplogloia kurilensis* INAGAKI, sp. nov.

Frons lubrica, caespitosa, simplex, 10–20 cm alta, ca. 2–2.5 mm crassa, cylindrica, cava; cellulis medullaribus cylindraceis in longitudinem ordinatis; cellulis subcorticalibus cuboideis; filis assimilantibus formarum binarum ornata; filis assimilantibus longis similis pilis 3 mm altis, ex cellulis subcorticalibus oriundis; filis assimilantibus brivibus clavatis, 30–50 μ altis, cellulis e binis ad quaternis compositis; sporangiis plurilocularicus ex cellulis filis assimilantibus oriundis; pilis et sporangiis uuilocullaribus ignotis.

Typus: South Uwashiru, Kuriles (M. NAGAI)-SAP.

p. 142. *Sauvageaugloia ikomae* (NARITA) INAGAKI.

Typus: Oh-haneo, Inaba Prov. (S. NARITA) Lectotypus—SAP.

Sphaerotrichia divaricata (AG.) KYLIN

p. 149. f. *epiphytica* INAGAKI.

Typus: Tomari, Shiribeshi Prov. (K. INAGAKI)-SAP.

p. 149. f. *chordarioides* (YAMADA) INAGAKI.

Typus: Utoro, Kitami Prov. (Y. YAMADA)-SAP.

p. 151. f. *gracilis* (YAMADA) INAGAKI.

Typus: Cape Shiretoko, Kitami Prov. (Y. YAMADA)-SAP.

Heterochordaria abietina (RUPR.) SETCH. et GARDN.

p. 168. f. *abietina.*

Axibus principalibus ramulis plurimis ornatis vel aliquando nudis.

p. 174. *Pseudochorda* YAMADA, TOKIDA et INAGAKI, gen. nov.

Frons caespitosa, cylindracea, simplicissima, praeter basin tubulosa, radice secundaria confluense discoideo parenchymato progresso baso principalo affixa, evidenter cava, utrimque attenuata, ca 150 cm alta; cellulis inferioribus frontis cylindraceis; cellulis centralibu ex filamentosis et hyphalis compositis; filis periphericis cylindraceis, erectis, simplitibus, clavatis; sporangiis unilocularibus clavatis vel oblongis in segmentis cellulis infinis filorum periphericorum evolutis; sporangiis plurilocularibus et pilis adhuc ignotis.

Typus: *Pseudochorda nagaii* (TOKIDA) INAGAKI, Syakotan, Shikotan Island, Kuriles (M. NAGAI)-Lectotypus.

Acrothrix pacifica OKAMURA et YAMADA

p. 179. f. *pacifica.*

Frons dense ramosa, axe principale evidentis nulla; ramis crassis 1 mm diametro.

p. 179. f. *crassa* INAGAKI.

Typus: Ikawazu, Mikawa Prov. (M. ARAZAKI)-SAP.

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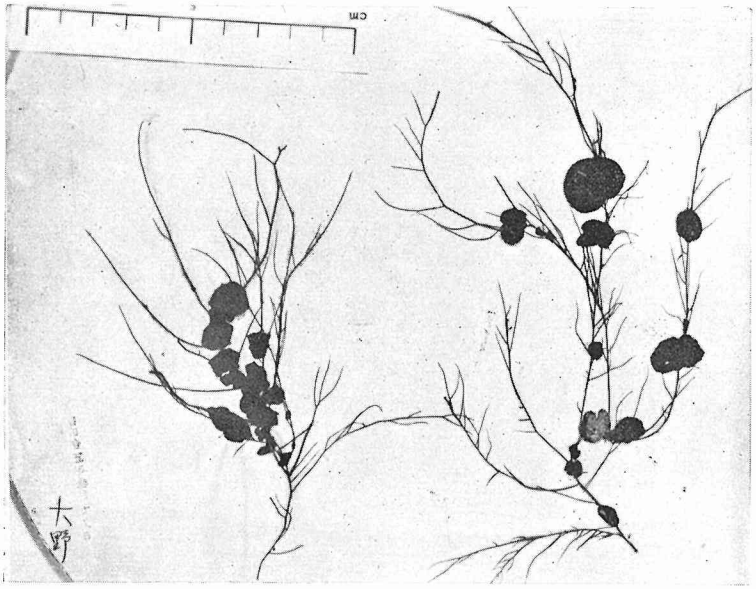
PLATE I

1. *Leathesia difformis* (L.) ARESCH. f. *difformis*
   Epiphytic on *Gracilaria verrucosa* (HUDSON) PAPENFUSS
   Ohno, Owari Prov.

2. *Leathesia difformis* (L.) ARESCH. f. *globosa* INAGAKI
   Epiphytic on *Rhodomela larix* (TURN.) C. AG., Abashiri,
   Kitami Prov.



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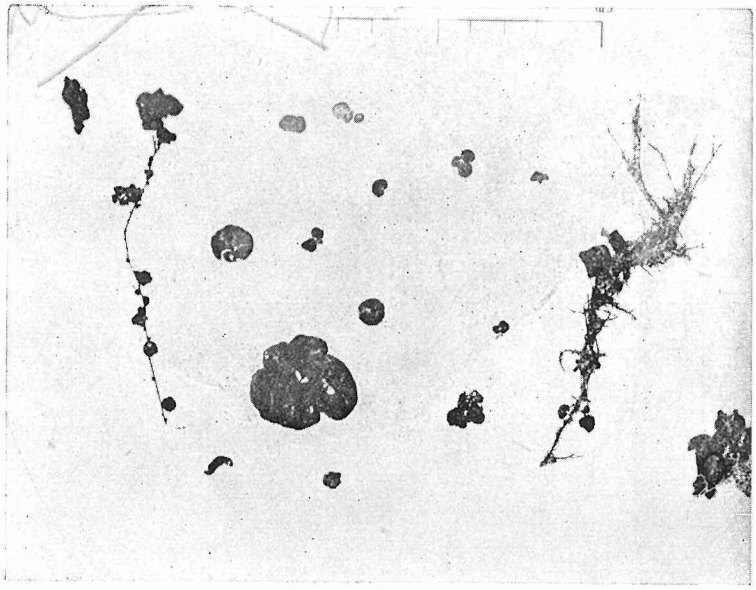

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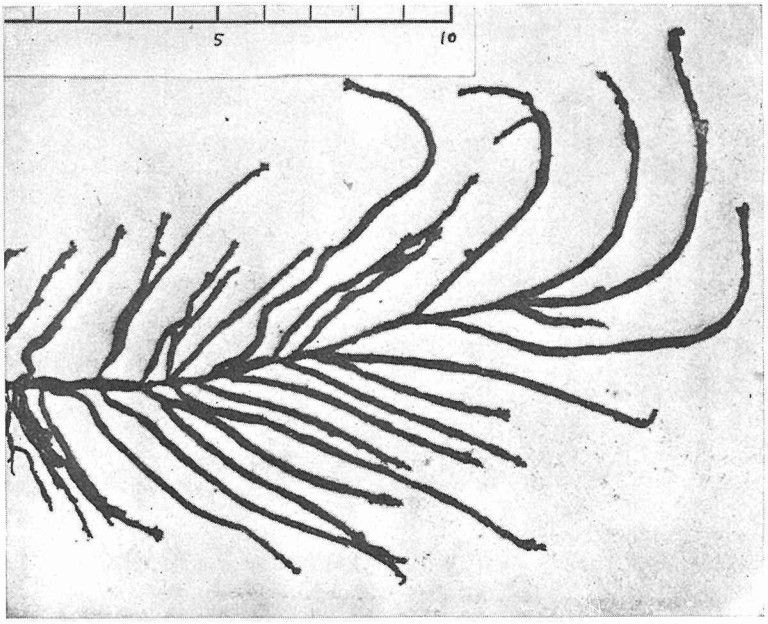
PLATE II

1. *Papenfussiella kuromo* (YENDO) INAGAKI f. *kuromo*
   YENDO's specimen, Oshoro. Shiribeshi Prov.

2. *Eudesme virescens* (CARM.) J. AG.
   Muroran, Iburi Prov.



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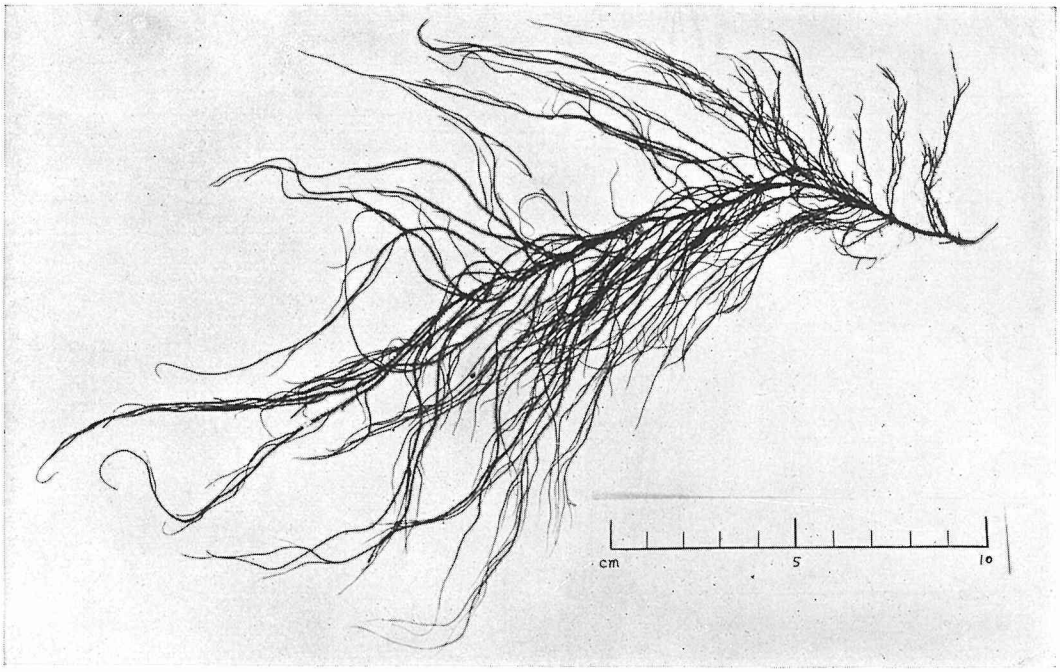

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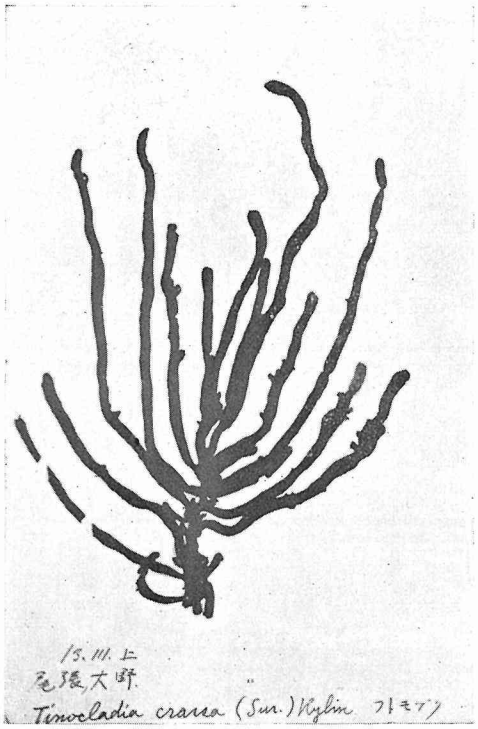
PLATE III

1. *Tinocladia crassa* (SUR.) KYLIN
   Ohno, Owari Prov.

2. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*
   Toyohama, Owari Prov.

3. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*
   Onagawa, Rikuzen Prov.



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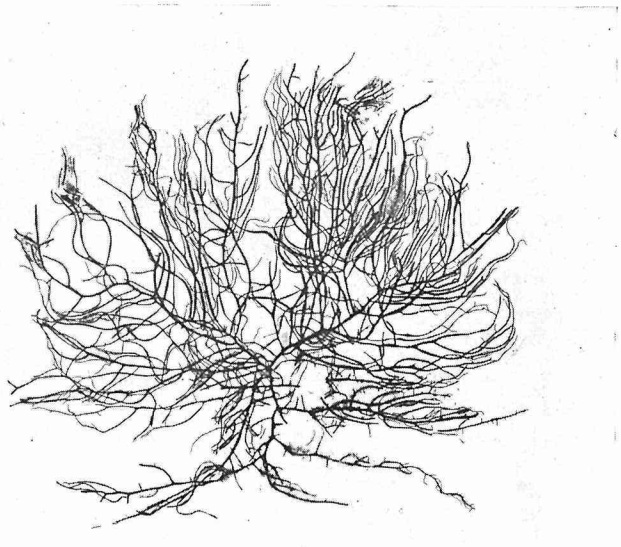

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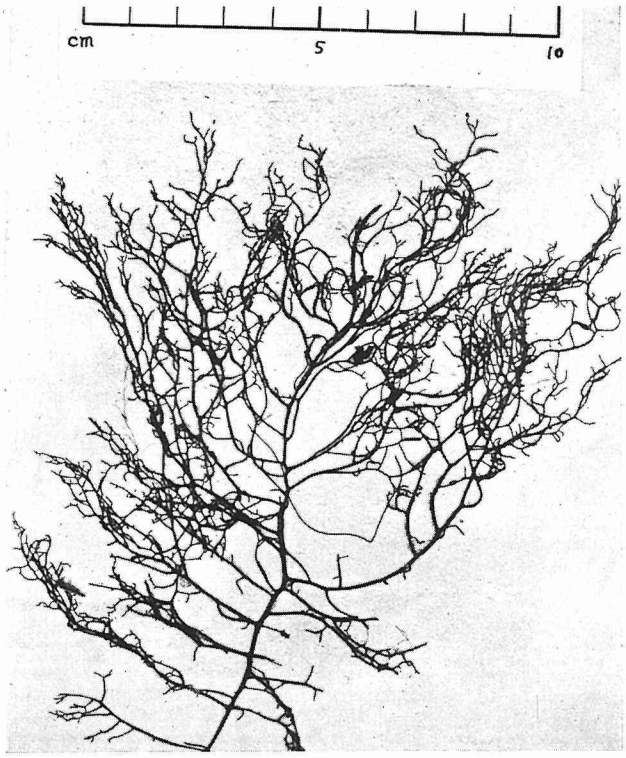

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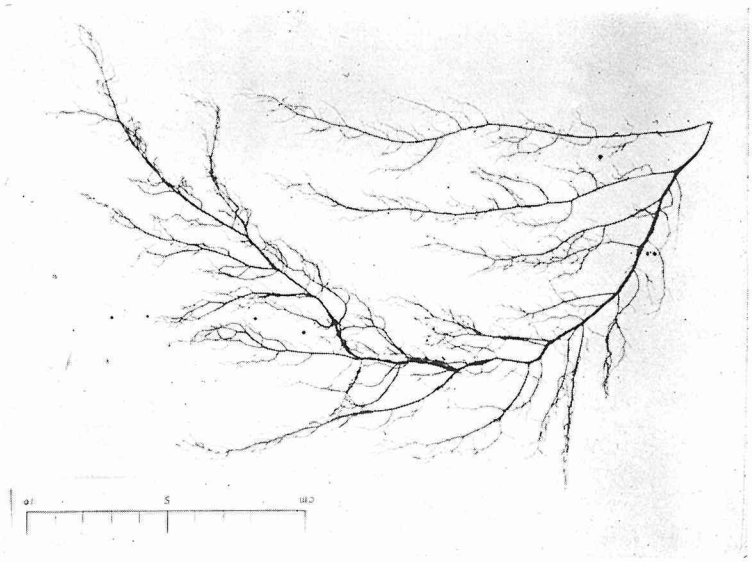
PLATE IV

1. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*
   Abashiri, Kitami Prov.

2. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*
   Utoro, Kitami Prov.

3. *Sphaeroirichia divaricata* (AG.) KYLIN f. *divaricata*
   Somewhat younger frond, Muroran, Iburi Prov.



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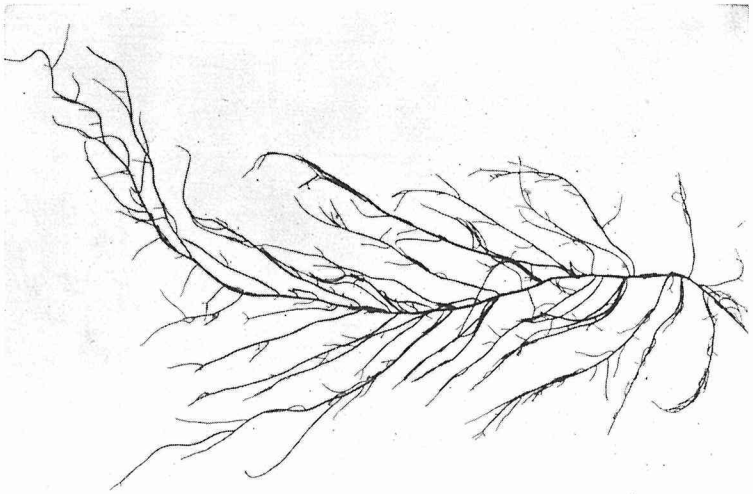

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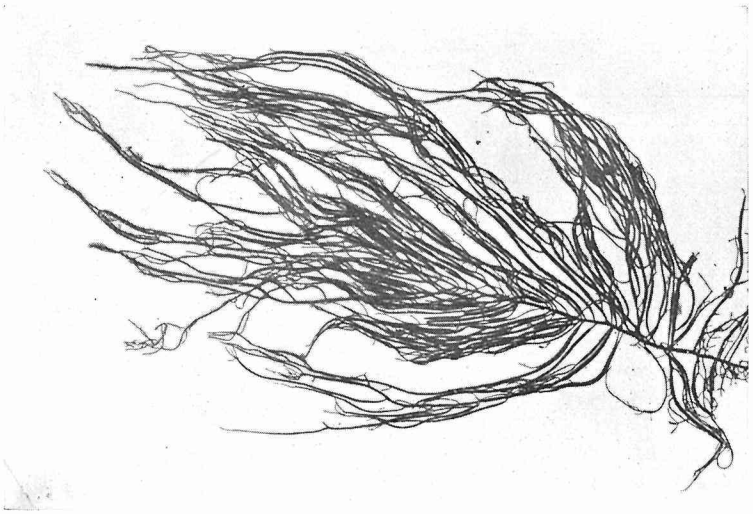

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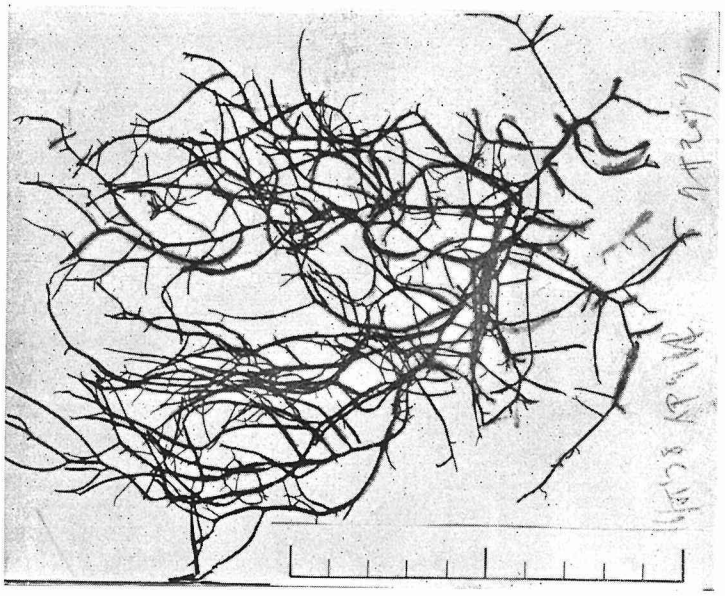
PLATE V

1. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata* YENDO's specimen, Motoyoshi.

2. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata* ARAZAKI's specimen, Ikawazu, Mikawa Prov.



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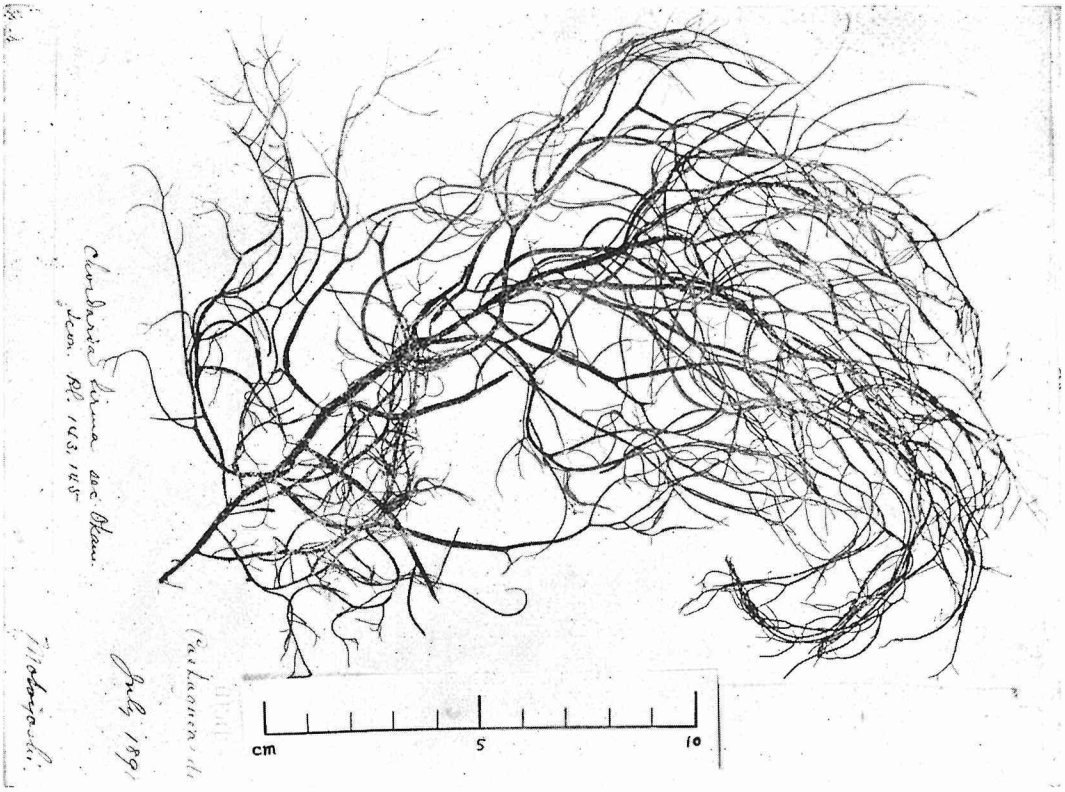

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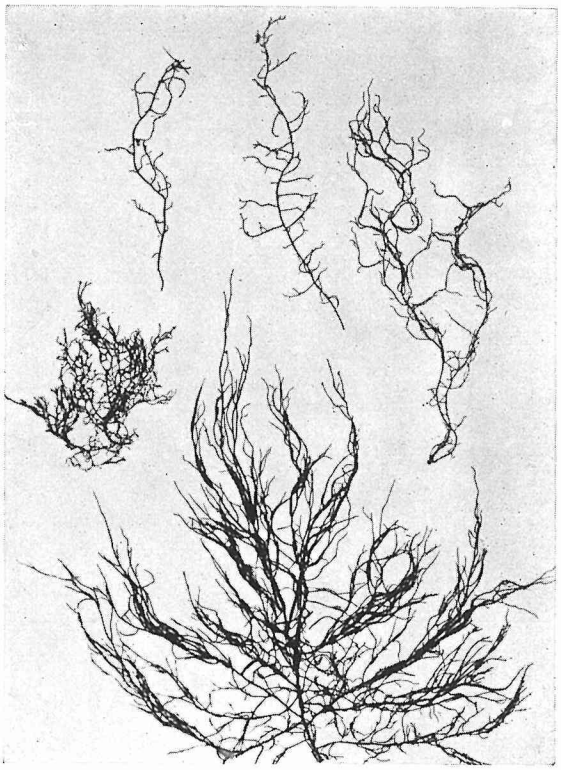
PLATE VI

1. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*
   Oshoro, Shiribeshi Prov.

2. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*
   YENDO's specimens, Awo-shima, Echigo Prov.

1



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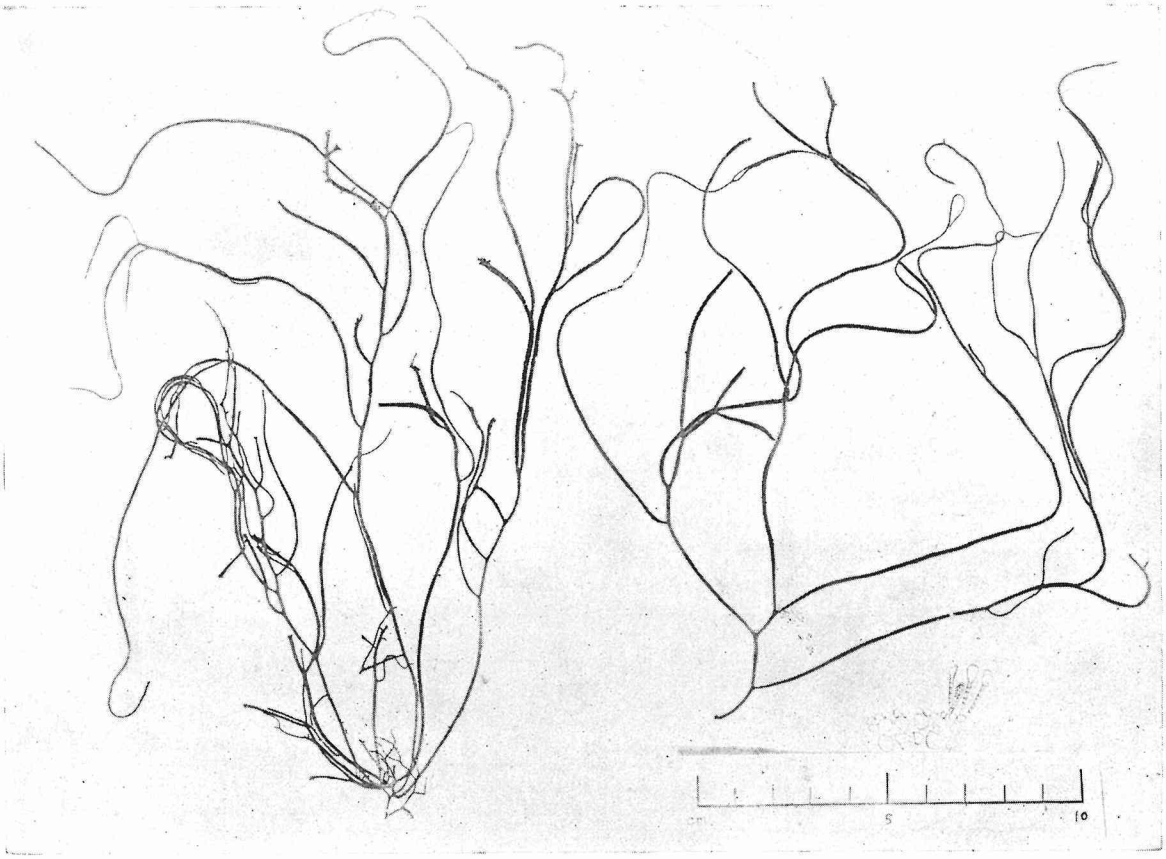
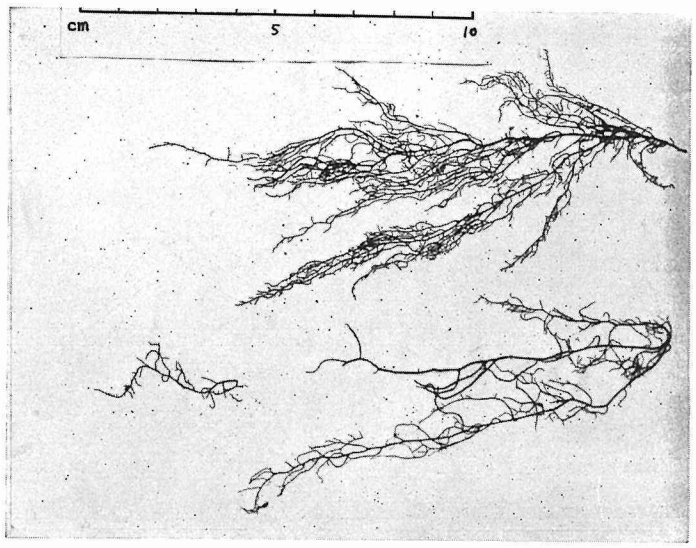


PLATE VII

1. *Sphaerotrichia divaricata* (AG.) KYLIN f. *divaricata*
   Sōya-misaki, Kitami Prov.

2. *Sphaerotrichia divaricata* (AG.) KYLIN f. *epiphytica* INAGAKI
   Epiphytic on *Rhodomela subfusca* (WOODW). C. AG., Sakazuki, Shiribeshi Prov.



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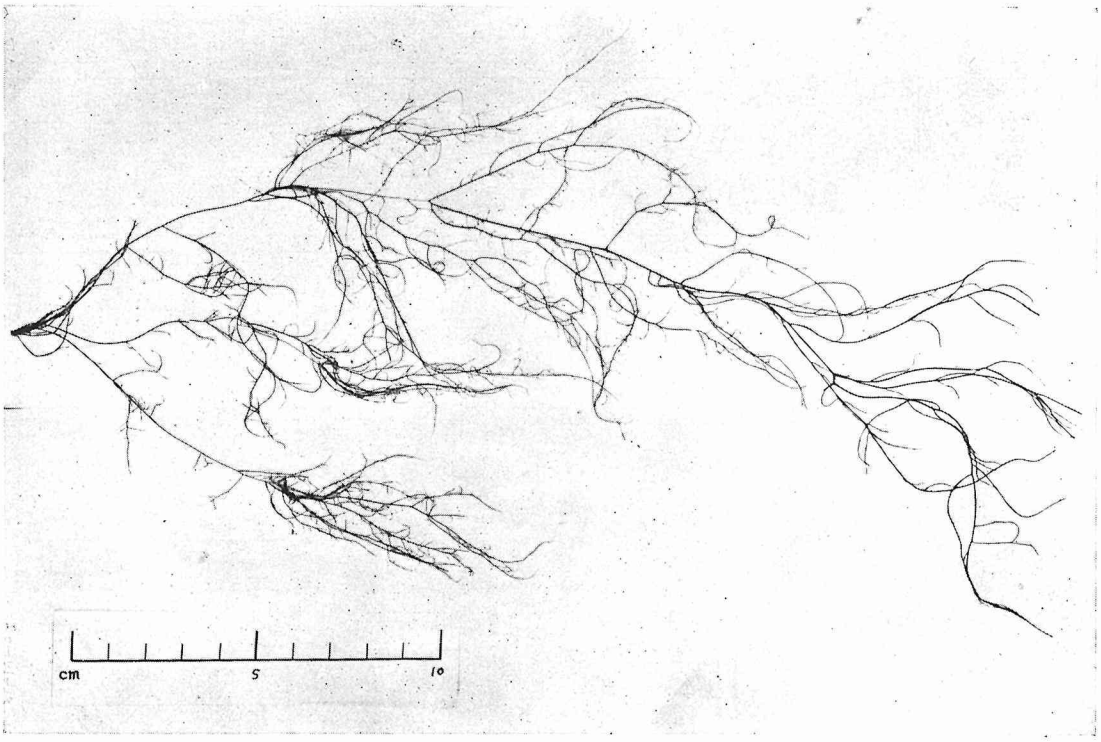

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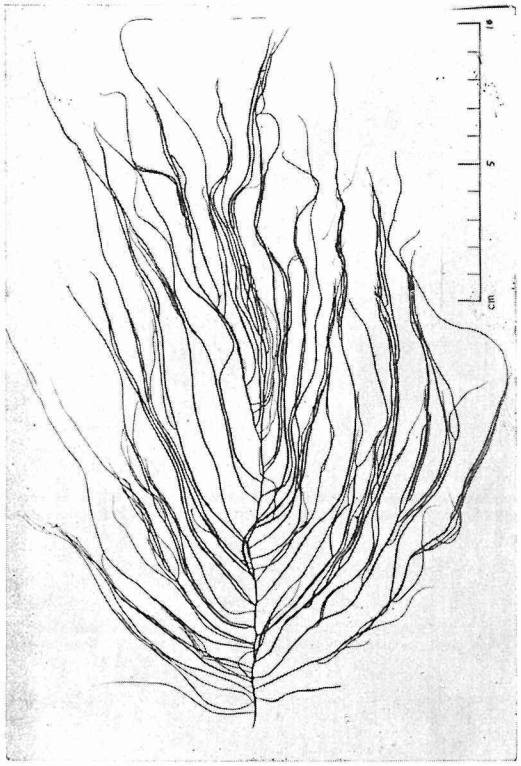
PLATE VIII

1. *Sphaerotrichia divaricata* (AG.) KYLIN f. *epiphytica* INAGAKI
   Epiphytic on *Rhodomela subfusca* (WOOD.) C. AG., Sakazuki, Shiribeshi Prov.

2. *Sphaerotrichia divaricata* (AG.) KYLIN f. *chordarioides* (YAMADA) INAGAKI
   Utoro, Kitami Prov.

3. *Sphaerotrichia divaricata* (AG.) KYLIN f. *gracilis* (YAMADA) INAGAKI
   Shiretoko-misaki, Kitami Prov.



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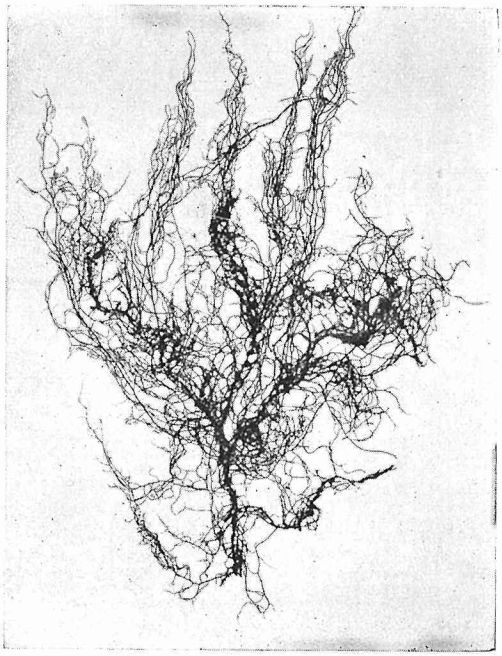

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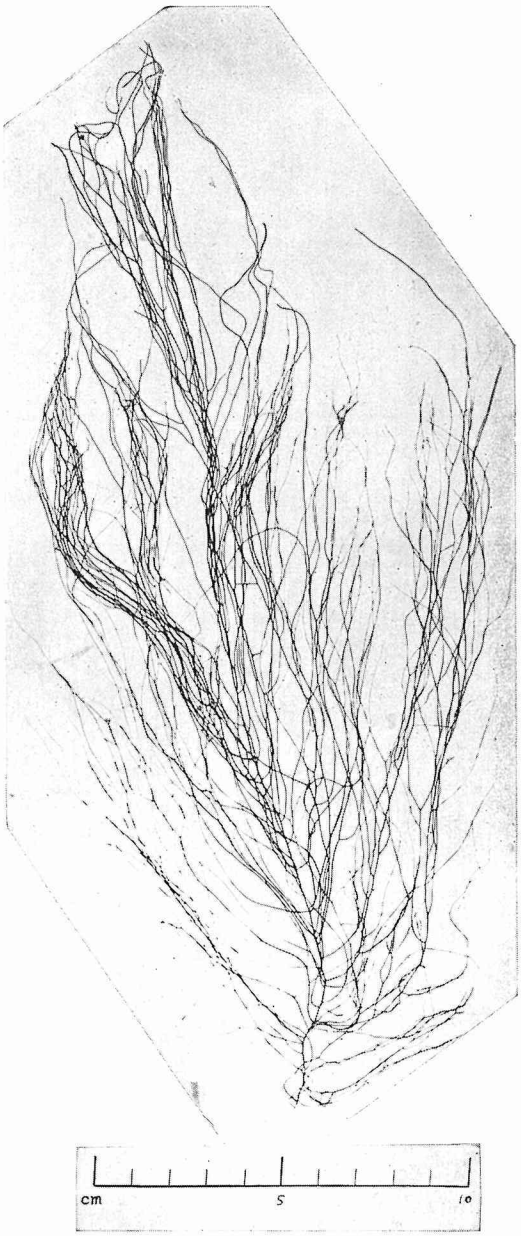
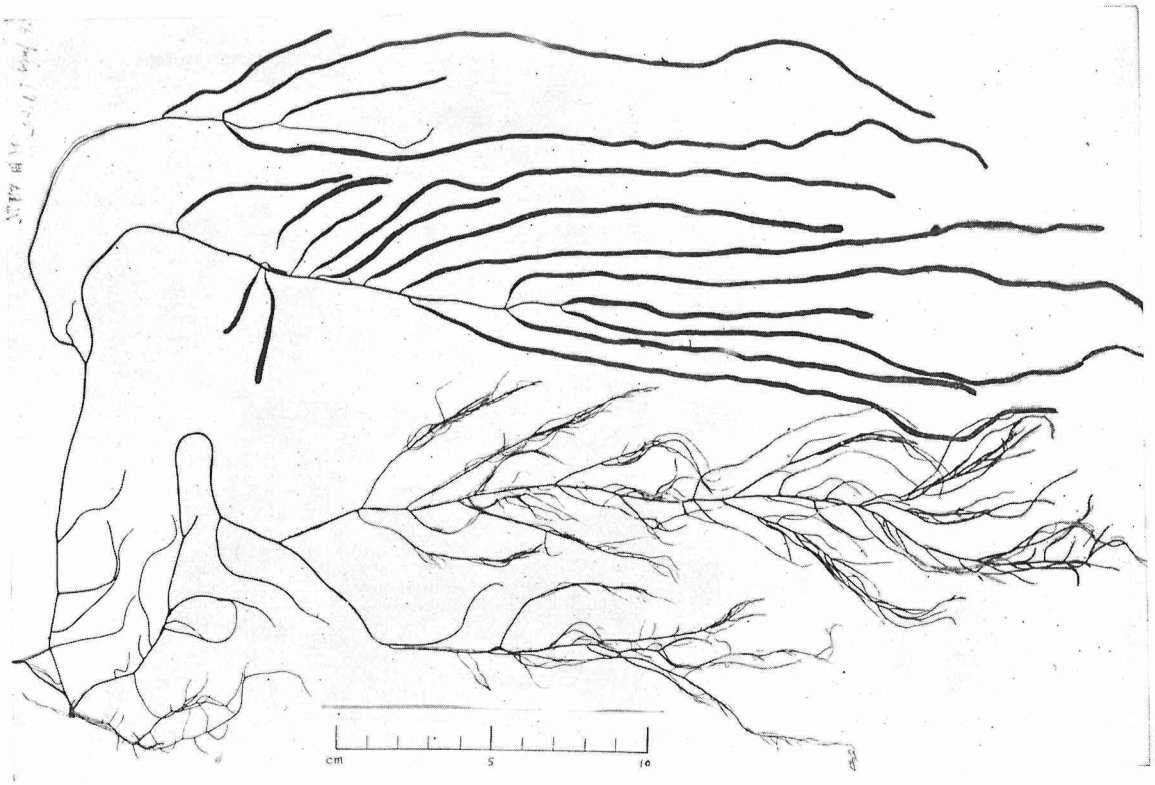


3

PLATE IX

1. *Chordaria gracilis* SETCH. et GARDN.
   YENDO's specimen, Shumushu Island, Kurile.

2. *Saundersella simplex* (SAUND.) KYLIN
   Epiphytic on *Chordaria fragelliformis* (MUELL.) AG., Yūbu, Kitami Prov.



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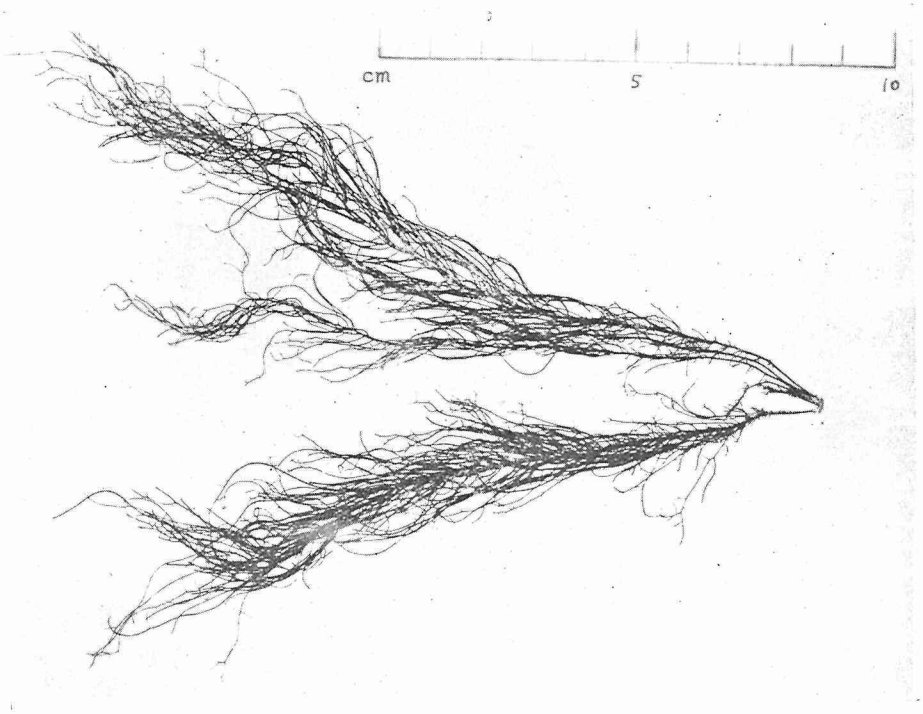

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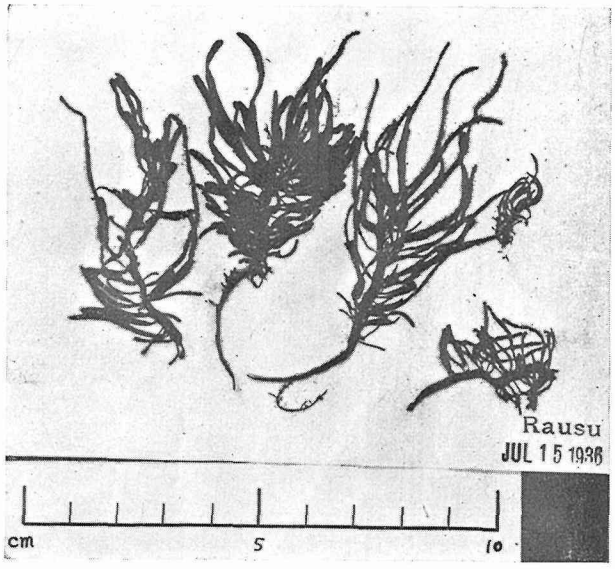
PLATE X

1. *Heterosaundersella hattoriana* TOKIDA

   Epiphytic on *Heterochordaria abietina* (RUPR.) SETCH. et GARDN., Rausu, Nemuro Prov.

2. *Heterochordaria abietina* (RUPR.) SETCH. et GARDN. f. *gunjii* (TOKIDA) INAGAKI

   YENDO's specimen, Shumushu Island, Kurile.



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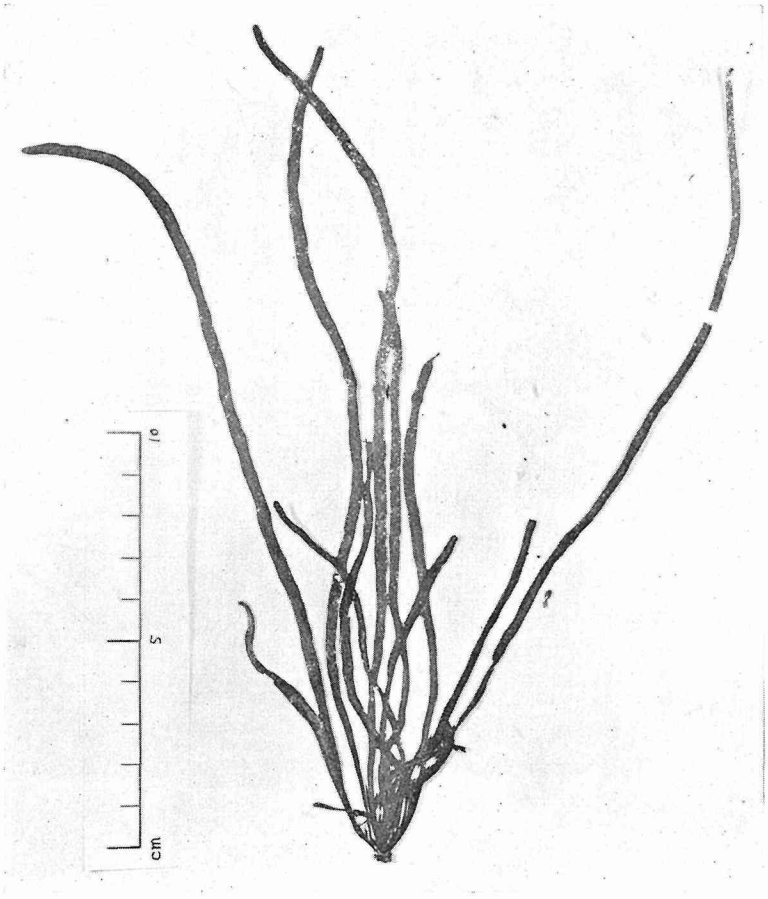

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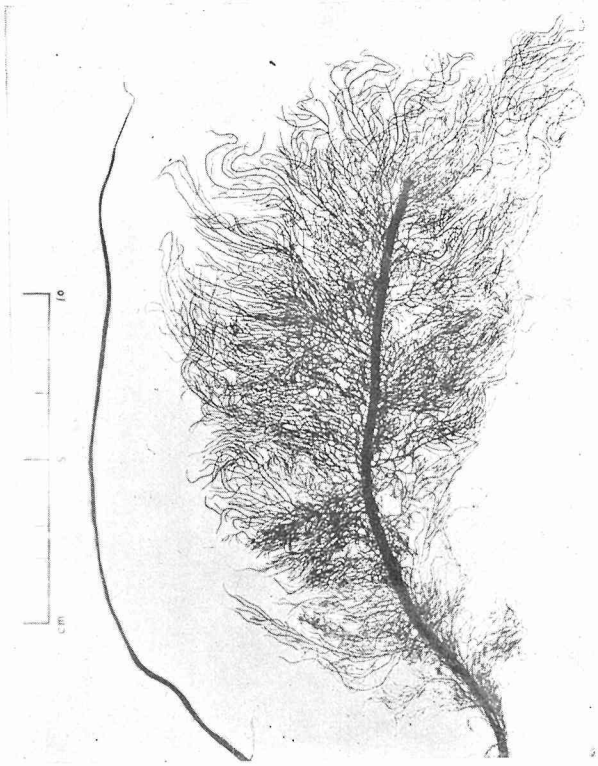
PLATE XI

1. *Acrothrix pacifica* OKAMURA et YAMADA f. *pacifica*
   Epiphytic on *Chorda filum* (L.) LAMOUR., Abashiri, Kitami Prov.

2. *Nemacystus decipiens* (SUR.) KUCK.
   Hama-jima, Shima Prov.



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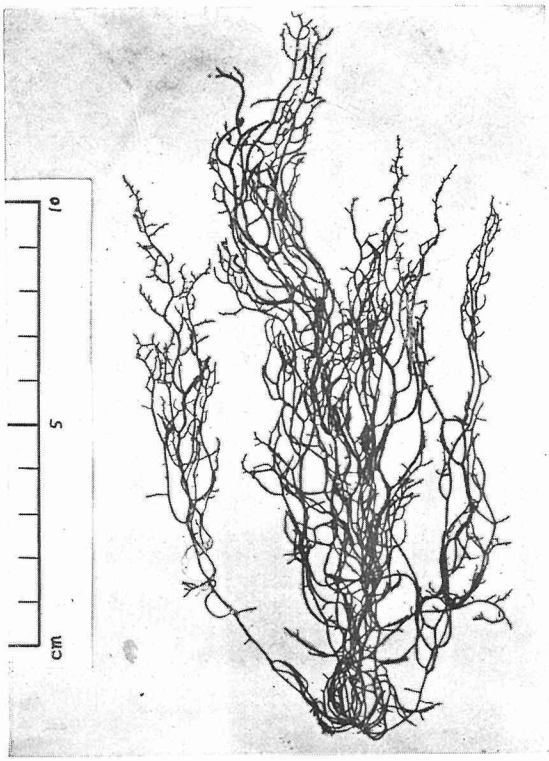

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