The Species of *Cladophora* from Japan and its Vicinity

By

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I. Introduction

The genus *Cladophora*, one of the great genera in algae consisting of 229 species (including *Spongomorpha*; DE-TONI, Syll. alg. I, 1, 1889) is widely distributed in both fresh and salt waters all over the world. Identification of the species of the genus, accordingly, is very difficult, because of the paucity of definite characters and their variations by enviromental factors. In spite of these difficulties, systematic studies of *Cladophora* in Japan were made chiefly by K. YENDO and Y. YAMADA to some extent. Since then no one, however, has attempted to study this troublesome genus and almost nothing has been published except for some floral work by Japanese phycologists.

For many years the writer has been studying the Japanese species of *Cladophora* under the guidance of Prof. Y. YAMADA, in the Botanical Institute, Faculty of Science, Hokkaido University. Efforts were made to collect fresh materials from as many localities as possible. Attempts were also made to study specimens preserved in formaline solution except when only dried specimens were available. On the other hand, specimens made available in various ways were quite helpful for the systematic study. In studying this genus the morphological characteristics, especially the rhizoids which had not been remarked by any authors, branching mode, length of the branch- or branchlet-top-portions, and dimension or shape of the segments were used for the description. In the present monographic paper, 30 species, including 5 new species, and 2 new forms are arranged in a new intrageneric system. Beside these, there are some species remaining to be studied when more materials can be obtained.

In this account, the following abbreviations are used:

HAHF ····· Herb. of Allan Hancock Foundation, U. S. A.

HFH ····· Herb. of Faculty of Fisheries, Hokkaido University at Hakodate.

SAPA ····· Herb. of Biological Institute, Faculty of Agriculture, Hokkaido University.

TI ····· Herb. of Botanical Institute, Faculty of Science, University of Tokyo.

Before going further the writer wishes to tender his thanks to several persons for their help in his work. First of all, the writer wishes to express his sincerest thanks to his teacher, Prof. Y. YAMADA, under whose guidance the present work has been carried out. Prof. Y. YAMADA also kindly made available all of the specimens he had gathered during many years from all over the world, and read this manuscript. Cordial thanks are expressed to the late Dr. T. KANDA who aroused the writer's great interest in phycology. Moreover, cordial thanks are due to Prof. J. TOKIDA, Faculty of Fisheries of our University, Prof. H. HIROSE, Kobe University, and Prof. S. UEDA, Tokyo University of Fisheries. Further thanks should be expressed to Dr. J. TH. KOSTER for her kindly loan of a number of valuable specimens in the Rijksherbarium at Leiden and for her valuable suggestions. Gratitude is also expressed to Prof. H. HARA University of Tokyo, who gave the writer a chance to examine YENDO's herbarium; also to Dr. YALE E. DAWSON, Allan Hancock Foundation for Biological Research, U. S. A., for the loan of abundant specimens of *Cladophora*. And also for all gentlemen who helped the writer in various ways in the course of this study.

All type specimens concerned are preserved in SAP (Herb. of Botanical Institute, Faculty of Science, Hokkaido Univ., at Sapporo).

II. Taxonomic characteristics

1. Colour of the frond

In the various species of *Cladophora*, the colour of the frond varies from whitish yellow to dark blackish green. These colour-variations seem to remain constant for the species, at least within narrow limits sufficient for aid in specific distinction. All the species of the genus are arranged in the colour of the dried frond fundamentally in the following ranks; (1) whitish yellow e. g. *Cl. albida* (HUDS.) KUETZ., (2) whitish green e. g. *Cl. opaca* SAKAI, *Cl. gracilis* (GRIFF.) KUETZ., (3) yellowish green e. g. *Cl. rudolphiana* (AG.) HARV., *Cl. uncinella* HARV., (4) rich or grass green···many species, (5) dull green e. g. *Cl. rupestris* f. *submarina* FOSLIE, (6) blackish green e. g. *Cl. rugulosa* MART. In ordinary cases, the colour of the fresh materials is nearly preserved in drying. The darker coloured species in living state, in some cases, become lighter in colour when dried. Namely the frond of *Cl. wrightiana* HARV. is rich or dark verdigris when living, after drying, however, it loses its original colour, and becomes brownish green. The upper portion of the frond of *Cl. opaca* bleaches in the sun, and its glaucous green colour becomes partially yellowish green.

The gloss of the frond seems to be peculiar to certain species. The glossy species, *Cl. stimpsoni* HARV. and *Cl. gracilis* KUETZ., retain the gloss in drying.

And, glossy species tend to have delicate texture and lighter colour. However, many species of the genus are lustreless. ARDISSONE (1886) divided *Eucladophora* into 6 groups chiefly by the characters given by KÜTZING and by the colour of the fronds, and many phycologists followed this example. As a distinctive character for segregation of the sections, the colour does not seem to be sufficient but is a useful character for specific distinction.

2. Attaching organ

Many species of *Cladophora* attach to some substrata for their entire life, except for those belonging to the subgenus *Aegagropila* and certain other species. The attaching organ found on the fronds of the genus is the rhizoid and in the case of one species, *Cl. patentiramea*, a hapteron-like organ. This alga is peculiar in the genus because of its attaching organ, and appears to belong to the genus *Boodlea*. According to REINBOLD (1813), BØRGESEN, (1940), and the writer's observation, however, segregative cell-divisions and opposite branchlets which are generic characters of *Boodlea* were not observed. And in spite of the presence of the hapteron-like organ, the writer recognizes the alga as a member of the genus *Cladophora*.

BRAND (1904) has treated the rhizoid, tendril, helicoid, cirroid, etc. as equal ranking. According to the writer's opinion the rhizoid of the genus is the attaching organ or reinforcement of the fronds, and is uniseriate, uni- or multisegmented, and slenderer than the rhizoid-mother segment. In the developmental aspect, they are divided into two types, primary rhizoids and adventitious ones. These rhizoids are often confused in mature algae (e.g. *Cl. rugulosa*). The primary rhizoids originate from zoospores or zygotes, and in the later stages of the growth they are observed only in the frond-base. Except for the species of the subgenus *Aegagropila*, almost all species of *Cladophora* are primarily and often permanently attached to some substrata by means of them. They may sometimes creep as stolonids, and give rise to new upright filaments, or their tips may divide into a number of short segments which have dense chromatophores. In *Cl. ohkuboana* HOLMES, a peculiar species, a well developed primary rhizoid forms a discoid (Fig. 2, E). Even in the same species, the primary rhizoids may be septate or non-septate in particular cases or individuals. And both primary and adventitious rhizoids diverge irregularly.

The adventitious rhizoids, on the other hand, originate secondarily from every portions of the fronds. Consequently in the early stages they are not observed. As an exceptional case, in the early stages of development of *Cl. wrightiana* HARV., many adventitious rhizoids descend from lower segments of the fronds, just as in the adult fronds of *Cl. rugulosa* MARTENS. In the species of the subgenus *Aegagropila*, however, they come from branch-apices, and also from the lower portion of

the frond. By means of these organs the plants attach themselves to the substratum, and hold together. This is one of the causes of ball-formation of the alga.

If new individuals of the subgenus *Aegagropila* originate from swarmers (NISHIMURA and KANNO, 1927, pp. 432–438), primary rhizoid could be present in the early stage at least. However, one can not observe the primary rhizoid but only the adventitious ones. In 1958–'60, the writer and S. ENOMOTO have collected *Cl. minima* var. *crassa* SAKAI in Lake Akan, which was attached to stones by means of adventitious rhizoids (SAKAI and ENOMOTO, 1960, pp. 117–123).

On the other hand, some species of the subgenus *Cladophora* have only primary rhizoids at the frond-base, but in many species of it the adventitious rhizoids are observed together with the primary rhizoids. The adventitious rhizoids of the genus, as a rule, descend from the branch-base segment (rhizoid-mother segment), and generally septum-formation is observed between branch-base and rhizoid initial. Furthermore, they are slenderer than branch-base segments, and may be septate or non-septate. These characters of the rhizoids remind the writer of *Spongomorpha*, while the frond of the genus *Spongomorpha* sends down more rhizoids than that of *Cladophora*. In the highly developed species (e. g. *Cl. rugulosa*), adventitious rhizoids descend from branch-base segments as in some other species of *Cladophora*, but they have no septum between branch-base segment and rhizoid intitial. The basal portion of the species reminds the writer of *Ficus wightiana* WALL under a microscope. Moreover, almost all species have extracuticular adventitious rhizoids, and the writer could not observe complete intracuticular rhizoid in this study. But, in a few cases, e. g. *Cl. opaca*, initial portions of the rhizoids seem to be intracuticular. On the other hand, the lateral membrane of the branch fuses basally with that of the next segment of the axis. On the basis of this fact the intracuticular portion of the rhizoid-initial appears to be of basal fusion of the membrane.

3. Ramification

The fundamental type of the branching of *Cladophora* is believed to be lateral. The branching, however, among the species of the genus falls under some other types···dichotomous, trichotomous, polychotomous, opposite, unilateral or secund. The branches nearly always arise from the upper end of the mother-segment, just beneath a septum. At first, branch initial forms a wide angle with the axis, the septum cutting off the branch being generally placed approximately perpendicular to those in the axis. Before long, however, by localised surface-growth of the lateral membrane of the mother-segment beneath the branch, the latter becomes upwardly displaced (evection), and lies on the same level as the continuation of the main axis. Owing to the evection and basal fusion of the branch with the axis the branching appears to be dichotomous. In many species of *Cladophora*, it is not

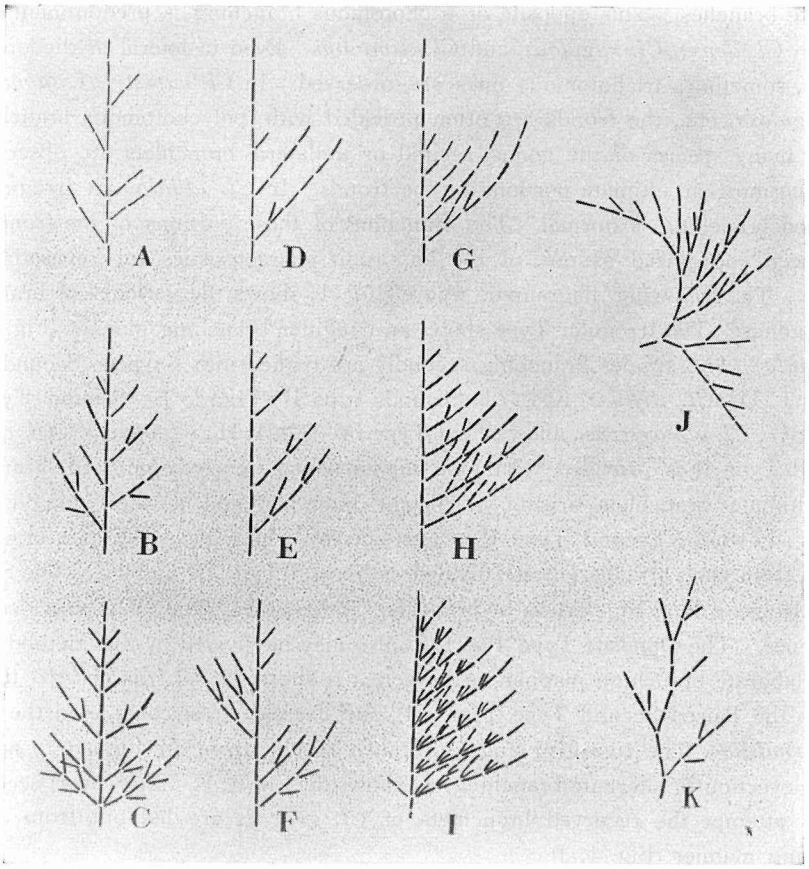

Fig. 1. Diagram of branching types

A. Irregular type	B. Alternate type	C. Opposite type
D. Secund type I	E. Secund type II	F. Alternately secund type
G. Secund type III	H. Secund type IV	
I. Paired type	J. Evectioned type	K. Zigzag type

an easy matter to distinguish a nude basal portion which has no branch as a main axis. Moreover, even in the uppermost portion of *Cl. densa* the main axis is scarcely distinguishable under a microscope (Fig. 3, A).

In younger portions of the fronds and the loose-evectioned species of the genus, one can recognize the branching as lateral, unilateral, or alternate. On the other hand, in the normal-evectioned species one can not help recognizing the branching as "dichotomous" in a narrow field of vision of the microscope. In *Cl. valonioides* SONDER, however, clear dichotomy is observed in some successive fields of vision. The trichotomous branching is not so uncommon and is produced by

opposite branches. This opposite or trichotomous branching is predominant in *Cl. sibogae*, *Cl. densa*, *Cl. rugulosa*, and *Cl. stimpsoni*. Even in lateral or dichotomous species, sometimes trichotomous ones are observed. In *Cl. rupestris* f. *submarina*, *Cl. rugulosa*, etc., the fronds are often provided with polychotomous branches.

In many species of the genus, secund or unilateral branchlets are observed in the uppermost or ultimate portions of the fronds. In *Cl. albida*, an irregular or scattered branching is normal. The branching of these portions of the fronds has long been recognized as one of the important characteristics for separating the species. The following diagramatic figure (Fig. 1) shows the varieties of branching in the genus. The Irregular Type shows an irregular branching manner (Fig. 1, A; *Cl. albida*). The species branching secundly are typfied into 4 types···Secund Type I (Fig. 1, D; *Cl. diffusa* KUETZ.), Secund Type II (Fig. 1, E), Secund Type III (Fig. 1, G; *Cl. glaucescens*), and Secund Type IV (Fig. 1, H; *Cl. opaca*). *Cl. diffusa* (Secund Type I) is provided with long top-portioned (many segmented) branchlets and ultimate branchlets arising at distant intervals, and a short top-portioned type is shown in Secund Type II. The species which have ultimate branchlets arising from each articulation are divided as Secund Type III and IV. The Secund Type III has a long top-portion of branchlet, and Secund Type IV is provided with short ones. The Opposite Type (Fig. 1, C) also may be divided by this method. The most elaborate branching manner in the genus is shown in *Cl. fascicularis* (Fig. 8). This is the Paired Secund Type (Fig. 1, I), and has clear fascicules as in the genus *Draparnaldia*. The zigzag or angular branch results from an attempt to add the fact of evection to alternate branching, as shown in Fig. 1, K. Moreover, according to this attempt the recurved branchlets of *Cl. gracilis* are led out from secund branching manner (Fig. 1, J).

In the subgenus *Aegagropila* the fundamental branching manner is also lateral. In abundant species of the subgenus, however, an irregular branching manner is dominant, but in the uppermost portion one observes a unilateral or secund tendency. The evection is loose, and insertion of the branch is subterminal in the subgenus. In these cases one often observes the pushed-forward septa. These loose evections, subterminal insertion of the branch, and pushed-forward septum characterize the subgenus.

4. Segment

The essential shape of the segments of *Cladophora* is cylindrical, but is often barrel-shape owing to constriction of the articulations. And also club-shaped segments are observed in certain species of the genus (*Cl. rupestris*). The shape of the segments is a remarkable character for specific distinction of fresh-water *Aegagropila*. For example, F. BRAND (1906) has distinguished in *Euaegagropila*

BRAND two groups chiefly by club-shaped or nearly cylindrical segments of main branches. And he cited the species having club-shaped segments as *Aeg. linnaeii*, *Aeg. martensii*, and *Aeg. holsatica*.

Moreover, the shape of the segments is concerned with relative segment-length. It varies from square to very long cylinders in optical sections. And the value of the relative segment-length is (1–) 2–10 (–20) or more times as long as the diameter. The relative segment-lengths vary in value ordinally according to the order of branching represented. The basal or lowermost segments are usually longer than those of other portions of fronds, and are especially prominent (reaching 20–30 times as long as diam.) in some species, *Cl. wrightiana* HARV., *Cl. japonica* YAM., *Cl. patula* SAKAI, and *Cl. fastigiata* HARV. There are no basal segments which are shorter than those of other portions of fronds. In *Cl. fascicularis* (MERT.) KUETZ., relative segment-lengths shows almost the same value ((1–) 2–4 times as long as diam.), in spite of different width and the order of branching. The value, "2–5 times as diam." is the ordinal case of the genus, but in all the portions of the frond of *Cl. patentiramea* the segments show the greatest value, reaching 30 times.

The articulations of the species of *Cladophora* have three taxonomic characters ……smooth, constricted, and swollen. In many species of the genus, *Cl. albida* (HUDS.) KUETZ., *Cl. opaca* SAKAI, and *Cl. rudolphiana* (AG.) HARV., smooth or slightly constricted articulations are observed in all the portions of the fronds. As a rule, the constricted articulations appear in upper portions of the fronds, but in lower portions of the fronds articulations are swollen (e. g. *Cl. densa* HARV.). In certain species of the subgenus *Aegagropila*, however, they have smooth articulations in upper portions and constricted articulations in lower portions of the fronds. Except for one species, no special structure of articulation could be observed. While in the peculiar species, *Cl. wrightiana*, trabeculars or portoplasmic protuberances are observed (Fig. 34, C, D) in almost all articulations of the fronds (CHIHARA, 1960; SAKAI, 1960).

In the two species concerned, the annular constrictions are observed in basal segments (*Cl. wrightiana* HARV.) and in lower segments (*Cl. rugulosa* MARTENS) of the fronds. BØRGESEN (1912–'14, 1925) and FELDMANN (1938) attached importance to these annular constrictions of *Siphonocladus* and *Apjohnia* as an important character of Siphonocladales. On the other hand, in the specimens of *Cl. densa* HARV. and *Cl. fastigiata* HARV. the writer observed annular striations in basal segments. These annular striations are recognized in certain species of *Spongomorpha*, Sp. *saxatilis* (RUPR.) COLLINS.

The dimensions of the segments vary from 15 μ (ultimate portion of *Cl. albida* KUETZ.) to more than 1,000 μ (lower portion of *Cl. ohkuboana* HOLM. and *Cl. japonica* YAM.) in diameter. In ordinary cases the diameter of the segments

decreases from the lowermost portion to the uppermost portion of the fronds, while on the contrary, increased diameter towards the apex is recognized in some species of the genus (e. g. *Cl. arenaria* SAKAI). On the other hand, special attention should be paid to the fact that many species of the genus *Spongomorpha* have an increased diameter towards the apices. Now, if one takes the value of the diameter of the lowermost portion of the frond of the species as a denominator and takes that of the uppermost portion as a numerator, one can show the gradient of certain species. According to this method, the species of *Cladophora* can be divided into three classes, reverse, little, and great gradients. The reverse gradient species is represented by *Cl. arenaria* SAKAI. And for example, *Cl. rudolphiana* (1/6), *Cl. gracilis* (1/7), *Cl. fascicularis* (1/6) show great values of the gradient, and *Cl. rugulosa* (1/2) shows small values of the gradient.

Moreover, the segments of the fronds of the genus have thick stratified lateral membranes consisting of an inner cellulose zone, a median pectic zone, and an outer chitinous zone. The above mentioned annular constrictions and striations are also due to the structure of the membrane. The lateral membrane is more pronounced in the basal segments and those of main branches. The thickest membrane of the species concerned is recognized in *Cl. densa* HARV. whose membrane is 50–80 μ in thickness, and it is 1/3 times as thick as the diameter of the segment. In many species, ordinary, lateral membranes are 3–8 μ in thickness and 1/6–1/10 times as thick as the diameter of the segment. The thick membrane is observed in thick species and rigid species. *Cl. rugulosa* MARTENS, the thick and rigid species, has 14–17 μ thick membranes in the main branches, but it is 1/23–1/10 times as thick as the diameter. On the other hand, however, *Cl. albida*, the slender and soft species, has a thick stratified membrane (1/5–1/4 times). In *Cl. fastigiata* HARV. the segments have thick membranes in the lowermost portions (17–20 μ in diam., 1/10 times as thick) but have very thin membranes in the uppermost portions of the fronds.

In *Cl. fuliginosa* KUETZ. (Fig. 43), the peculiar species of the endophytic fungus, *Blodgettia borneti* WRIGHT, is always observed on the inner side of the lateral membrane. And HARVEY (1858) erected the new genus *Blodgettia* based on the alga and the fungus.

Reference will be made to other characters of the segments in the following chapter, "Generic limitation between *Clodophora* and *Spongomorpha*".

III. Inter- or intrageneric divisions of the genus

1. Generic limitation between *Cladophora* and *Spongomorpha*

Nowadays, *Spongomorpha* is separated from *Cladophora* as an independent genus by the following characteristics: (1) spongy habit, (2) special branches, (3) intercalary cell-division, (4) larger and longer terminal segments than the segments below, and decending rhizoids. But, these characteristics are variable. For example, *Sp. breviarticulata* SAKAI has no spongy habit consisting of only straight branches and terminal segments shorter than below. Moreover, the intercalary cell-division is not peculiar but apical cell-division is often observed. According to NICOLAI and PRESTON (1954), physical differentiation in X-ray diagrams of cell-wall structure between *Cladophora* and *Spongomorpha* is explained. In addition to these characteristics, the writer notes hereinafter the peculiar or noteworthy characteristics of the genus *Spongomorpha*, which distinguish it from the genus *Cladophora*.

(1) Special branch

In the genus *Cladophora* the fronds consist of only homogeneous branches. The fronds of *Spongomorpha*, on the other hand, are composed of various kinds of special branches. COLLINS (1909, p. 357) notes concerning it, "The special branches give this genus a higher rank than that of *Cladophora*". In a majority of the species, recurved branches occur often in the middle and lower portions of the fronds (*Sp. mertensii*, *Sp. spiralis*, etc.). But, in some species (*Sp. breviarticulata*, *Sp. duriuscula* v. *tenuis*, etc.) only normal straight branches are observed.

In the fronds of *Sp. heterocladia*, "sterile branches or rami steriles" have been observed by the writer (1954, p. 78, fig. 6, A). They occur on the upper portions of the fronds, which have longer and larger cells, obtuse tip cells, thin cell-membranes, light chromatophores, and normal septa (not rim-shaped). SETCHELL and GARDNER (1920, p. 220) noted concerning *Spongomorpha* "terminal segments frequently larger and longer than the segments below", in the description of generic characters. Their description seems to suggest the existence of the intercalary cell-division or the sterile branches. All vegetative segments of the recurved or spinous branches, with the exception of apical segments and rhizoids, have the ability to become sporangia by themselves. The segments of sterile branches, however, do not form sporangium. And the sterile branches adhere closely to paper when they are dried.

(2) Septum

KJELLMAN (1893) and TOKIDA (1932) illustrated the remarkable septa in certain species of *Spongomorpha*-complex, and KJELLMAN denoted them in the explanation of the figures as "Tvärvägg och väggflrtjockning". According to these figures and

to the writer's observations (1954), the septa show apparent swelling at the edge, like a rim. And the writer (id., p. 73, Fig. 1, E, etc.) proposed the name "rim-shaped septa" in all species of the genus.

A progression of the rim-shaped septa from a plain degree to elaborate is observed in various species of the genus *Spongomorpha*. The species having elaborate rim-shaped septa, *Sp. breviarticulata*, was shown in the writer's account (id., p. 72, fig. 1, E). In this species the remarkable septa are observed in all portions of the fronds, even in rhizoids. The normal rim-shaped septa are observed in the middle or the lower portions of the fronds of certain species, but neither in the upper portions (or sterile branches) nor rhizoids of *Sp. duriuscula* (id., p. 75, fig. 4, D), *Sp. duriuscula* v. *cartilaginea* (dried specimen, leg. Y. YAMADA, loc. Kurile Isl.), *Sp. heterocladia* (id., p. 76, fig. 6, E, F), *Sp. saxatilis* (id., p. 76, fig. 5, D–F), and *Sp. hystrix* (dried specimen, leg. M. NAGAI, loc. Kurile Isl.). On the other hand, more simple rim-shaped septa are observed in such species as *Sp. lanosa* (dried specimen) only in the middle portions of the fronds, and are recognized more clearly by staining (BOEHMER's haematoxylin), but are shown in only lower portions of the fronds, in the case of *Sp. spiralis* (id., p. 81, fig. 7, D). In *Sp. arcta* (herb. LENORMAND, Cherbourg; herb. KÜTZING, Brest: both preserved in Rijksherbarium at Leiden), simple rim-shaped septa are observed only in the lower portions of the fronds. *Sp. arcta* v. *centralis* (as *Cladophora*, Phyc. Bor.-Amer., no. 721) has the remarkable septa in the middle and lower portions of the fronds.

Not having observed any remarkable septum in *Cladophora* and *Aegagropila*, the writer concluded that the rim-shaped septa are to be recognized as one characteristic which rigidly places the *Spongomorpha* separately from the other related genera.

(3) Orifice of sporangium

Many phycologists who illustrated the *Spongomorpha*-complex have shown the circular orifices of the sporangia. According to the writer's observations, the circular orifices are recognized in all species of *Spongomorpha* collected from Hokkaido and Kurile Islands, and are also illustrated in the writer's account (l. c.). Moreover, the lids which are attached to the upper end of the orifices are frequently observed in *Sp. heterocladia* (id., fig. 6, F), but rarely in *Sp. breviarticulata*. This phenomenon indicates that the orifice opens by the lid. In the species of the genus *Cladophora*, on the other hand, orifices are formed as a result of an irregular crack on the lateral membrane. This is one of the distinguishable characters which segregate *Spongomorpha* from *Cladophora*.

Here the relation between *Spongomorpha* and *Acrosiphonia* may be touched.

The genus *Spongomorpha* was created by KÜTZING (1843, p. 283) based upon

Conferva uncialis and *C. congregata*, the synonyms of *Sp. lanosa* (ROTH) KUETZ. On the other hand, in 1846, the genus *Acrosiphonia* was established by J. G. AGARDH based upon *Conferva lanosa*, *C. arcta*, and *C. membranacea*.

F. SCHMITZ (1882), in his cytological studies, clarified the nuclear number in the cells of *Cladophora* (*Acrosiphonia*) *arcta* which has many nuclei in each cell (segment). Subsequently, it was elucidated by WILLE (1884) that *Spongomorpha lanosa* has only one nucleus in each cell. On the basis of these facts, WILLE (1890, p. 117) rigidly segregated the two genera one from the other.

Recently, this very important criterion was revised by PRINTZ (1927) and KYLIN (1949), they are distinguished as follows:

1. *Spongomorpha*, whose cells contain one or a few nuclei.
2. *Acrosiphonia*, whose cells contain many nuclei.

And, KYLIN (l. c.) writes on the *Spongomorpha* in his "Bestimmungstabelle", „Wie Acrosiphonia, aber Zweigbüschel kürzer und dichter; oft mehr als einen Kern in jeder Zelle". As mentioned above, the definite criterion for separation of these two genera is still obscure. On the other hand, the cells of some species distributed by KYLIN, WILLE, and PRINTZ, under the genus *Spongomorpha*, *Sp. lanosa*, *Sp. pallida*, etc., have smaller diameters and less cell-content than the ones in the other species of the *Spongomorpha- Acrosiphonia* complex. In a species of *Rhizoclonium* belonging to the Cladophoraceae, F. PETERSCHILKA (1924) observed uninucleate cells in the slender portion of the frond, and multinucleate ones in the thicker portion of the filament. These observations seem to show that the number of nuclei may be related to the volume of the cell-content. From this fact, to take the number of the nucleus as the most important criterion for generic separation seems to be doubtful. On the other hand, all morphological characteristics (e. g. structure of septum, orifice of sporangium, rhizoid, branching manner, etc.) of the species distributed under the genera *Spongomorpha* and *Acrosiphonia* are about the same. Moreover, *Spongomorpha* KUETZING (1843) has priority to *Acrosiphonia* J. AGARDH (1846). Therefore, *Acrosiphonia* is to be recognized as a synonym of *Spongomorpha*.

2. Intrageneric division of the genus *Cladophora*

As a result of the argument in the preceding chapter, only *Aegagropila* remains as a subject of discussion. According to the generic key given by PRINTZ (1927, p. 275), *Aegagropila* was characterized as "Thallus von mehreren ursprunglich getrennten Individuen gebildet" and "Keine Schwärmerbildung", and *Cladophora* was separated from it by the characters, "Thallus von einem ursprunglich festsitzenden Individuum ausgehend".

There is no fact to deny that many fronds of *Aegagropila* form floating globular masses and irregularly shaped masses. In Lake Akan, however, wide areas

were found (Y. YAMADA et al., 1958–'60) where the fronds of *Cl. sauteri* grow in lawn-like habit, and limited areas were found covered by globular masses. On the other hand, in a cultural condition without water current, lake-balls lose their globular shape, and they change into a lawn-like habit. These lawn-like aggregations, however, form beautiful globular aggregations under the cultural condition with water current. According to these facts, the lawn-like habit seems to be the normal form of this alga.

The above mentioned characteristics given in Chapter III, are summarized in the following table:

characters / genera	hooked branch	septum	shape of orifice	evection	rhizoid
Cladohora	—	normal	indefinite	normal	primary prim. & advent.
Aegagropila	—	normal	?	loose	adventitious
Spongomorpha	±	rim-shaped	circular	looser	prim. & advent.

By the characteristics shown in the Table and of the cell-wall structure studied by NICOLAI and PRESTON (1952), *Spongomorpha* differs from *Cladophora* and *Aegagropila*. And the latter two genera have the same cell-wall structure and nearly the same natures. Accordingly, the writer recognize the genus *Aegagropila* as a subgenus of the genus *Cladophora* which will be divided as follows:

Genus *Cladophora* KUETZING (1843)
Subgenus *Cladophora*
Sect. *Japonicae* SAKAI
Sect. *Opacae* SAKAI
Sect. *Rugulosae* SAKAI
Subgenus *Aegagropila* (1849)

IV. Keys to the taxa

Key to the subgenera

1. Species erect; rhizoids primary, sometimes with adventious ones descending from lowermost portions of fronds; insertion and evection normal . . . . . Subgen. *Cladophora*
1. Species pulvinate; rhizoids adventitious, descending from some portions of fronds; insertion and evection loose . . . . . Subgen. *Aegagropila*

Key to the species of the subgen. *Cladophora*

1. Fronds having only primary rhizoids (Sect. *Japonicae*) 3

1. Frodds having primary rhizoids and adventitious ones 2
   2. Lower segments even (Sect. *Opacae*) 13
   2. Lower segments provided with annular constrictions (Sect. *Rugulosae*) 23
3. Main branches more than 200 μ in diam 4
3. Main branches less than 200 μ in diam. 8
   4. Branchlets alternate or somewhat secund 5
   4. Branchlets clearly secund 7
5. Rhisoids compact fibrous disc-shape; branchlets few . . *Cl. ohkuboana* HOLMES
5. Rhizoids not so compact as above; branchlets dense, fasciculate 6
   6. Basal segments with annular striations; branchlets 60–130 μ in diam . . . . . *Cl. densa* HARV.
   6. Basal segments even; branchlets 150–300 μ in diam. . . . . *Cl. japonica* YAM.
7. Branchlets 210–380 μ in diam., solitary . . . . . *Cl. patula* SAKAI
7. Branchlets 40–160 μ in diam., paired . . . . *Cl. fascicularis* (MERT.) KUETZ.
   8. Branchlets irregular or alternate 9
   8. Branchlets secund 10
9. Fronds froming loose tufts; branchlets few, short, (35–) 40–70 μ in diam. . . . . *Cl. oligoclada* HARV.
9. Fronds entangled masses; branchlets dense, 15–35 μ in diam. . . . . *Cl. albida* (HUDS.) KUETZ.
   10. Fronds not gelatinous . . . . . *Cl. gracilis* (GRIFF.) KUETZ.
   10. Fronds gelatinous 11
11. Branches dichotomous, (10–) 15–25 (–40) μ in diam. . . . . *Cl. speciosa* SAKAI
11. Branches di- trichotomous 12
   12. Apex of branches acute . . . . . *Cl. rudolphiana* (AG.) HARV.
   12. Apex of branches obtuse . . . . . *Cl. crystallina* (ROTH) KUETZ.
13. Fresh-water species 14
13. Marine species 15
   14. Fronds floating; segments of primary branches 45–60 (–100) μ in diam. . . . . *Cl. crispata* (ROTH) KUETZ.
   14. Fronds attaching; segments of primary branches 80–100 (–150) μ in diam. . . . . *Cl. glomerata* KUETZ.
15. Fronds less than 1 mm in height . . . . . *Cl. conchopheria* SAKAI
15. Fronds more than 1 cm in height 16
   16. Main branches more than 100 μ in diam. 17
   16. Main branches less than 100 μ in diam. 20
17. Fronds soft and gelatinous . . . . . *Cl. stimpsoni* HARV.
17. Fronds rigid 18
   18. Branchlets composed of long cylindrical segments, 8–15 times as long as diam. . . . . *Cl. fastigiata* HARV.
   18. Branchlets composed of nearly barrel-shaped segments, 2–4 times as long as diam. 19

19. Adventitious rhizoids descending even from upper portions of fronds . . . . . *Cl. aokii* YAM.
19. Adventitious rhizoids descending from lowermost portions of fronds . . . . . *Cl. rupestris* f. *submarina* FOSLIE
20. Fronds soft, short, less than about 2 cm 21
20. Fronds somewhat rigid, longer than above 22
21. Branchlets irregular, soritary, not hooked, 15–30 μ in diam. . . . . *Cl. pusilla* SAKAI
21. Branchlets secund, often paired, hooked, 35–70 μ in diam. . . . . *Cl. uncinella* HARV.
22. Branchlets secund; diameter decreased upwards . . . *Cl. opaca* SAKAI
22. Branchlets irregular; diameter increased upwards . . *Cl. arenaria* SAKAI
23. Fronds growing at high tide mark; main branches 170–320 μ in diam. . . . . *Cl. rugulosa* MARTENS
23. Fronds growing in deeper waters; main branches reaching 800 μ in diam. . . . . *Cl. wrightiana* HARV.

Key to the species of the subgen. *Aegagropila*

1. Fresh-water species 2
1. Marine species 3
2. Segments cylindrical . . . . . *Cl. sauteri* (NEES) KUETZ.
2. Segments clavate or barrel-shaped . . . . *Cl. minima* (OKADA) SAKAI
3. Fronds soft; main branches less than 120 μ in diam. 4
3. Fronds rigid; main branches more than 140 μ in diam. 5
4. Branch-top portions short, composed of short segments, 3–6 times as long as diam. . . . . *Cl. socialis* KUETZ.
4. Branch-top portions long, composed of long segments, 4–10 (–30) times as long as diam. . . . . *Cl. patentiramea* (MONT.) KUETZ.
5. Branchlets secund . . . . . *Cl. fuliginosa* KUETZ.
5. Branchlets opposite . . . . . *Cl. sibogae* REINBOLD

V. Descriptions and notes of taxa

Subgenus ***Cladophora***, emend. SAKAI

Species erect; rhizoids primary, sometimes with adventitious ones, descending from lower portions of fronds; insertion and evection normal.

Speciebus erectis; rhizoideis principalibus, nonnumquam etiam adventibus, descendentibus ex partibus inferioribus frondium; insertionibus evectionibusque normalibus.

Sect. ***Japonicae*** SAKAI, sect. nov.

Species provided with only primary rhizoids; without annular constriction in

basal portions of fronds.

Speciebus solum rhizoideis principalibus ornatis; nullo ruguloso-annulato in partibus basalibus frondium.

Cladophora ohkuboana HOLMES

Pl. I, 2; Fig. 2

New mar. alg. Jap., 1895, p. 249, pl. 10, fig. 1; OKAMURA, Nippon sorui meii, 1902, p. 239; Id., Icon. Jap. alg., vol. 7, no. 5, 1934, p. 42 and 47, pl. 325, figs. 1–2; Id., Nippon kaiso shi, 1936, p. 52.

Jap. name: Kata-shiogusa.

Hab.: Shichirigahama, Kanagawa Pref. (Apr., K. OKAMURA; May, 1941, Y. YAMADA); Shimoda (May, 1953, M. CHIHARA), Cape Omaezaki (Apr., 1944, T. SEGI), Shizuoka Pref.; Tanegashima Isl. (Aug., 1959, Y. SAKAI and S. ENOMOTO).

Fronds on rocks, vigorous, bushy, but not dense, 15–22 cm high, deep green, rigid; rhizoids primary, descending from frond-bases, forming compact fibrous discs; primary branches distinct, 2–3 cm or more log, erect, 750–900 μ in diam., with thick lateral membranes, 100–110 μ thick, about 1/8–1/7 times as thick as diam.; branches dichotomous or sometimes trichotomous, forming acute axils, very long, slender downwards, with smooth or slightly swollen articulations, 400–1000 μ in diam., composed of segments 4–6 (–10) times as long as diam., with lateral membrane 1/20–1/10 times as thick as diam.; branchlets few, alternate, forming acute axils, very long, 400–1000 μ in diam., composed of segments 3–6 times as long as diam., ending in blunt or sometimes acute apices; insertion and evection normal.

This is the thickest species of *Clodophola* from Japan, and seems to be a resident of deep water. The specimens at hand were collected often being cast ashore. The present species is characterized by its wide diameter, few branchlets, and disc-shaped fibrous rhizoids. According to the descriptions and the writer's observations of the Japanese species of the genus, the thick species which have nearly 1 mm in diameter are *Cl. wrightiana*, *Cl. japonica*, and *Cl. ohkuboana* among which the last one is the only species which has disc-shaped fibrous rhizoids (Fig. 2, E, F). OKAMURA (1934) described the segments as follows; not or slightly constricted at dissepiment,···ending in blunt apices. The writer observed, however slightly swollen articulations, and sometimes somewhat acute apices with blunt ones (Fig. 2, D). In many cases, *Contarinia okamurai* SEGAWA is often epiphytic on the basal portions of the fronds (Fig. 2, C, F).

OKAMURA (1934) has pointed out that the "present plant allied on the one had to *Cl. wrightiana* HARV. and on the other hand to *Cl. japonica* YAMADA". From the former species it differs in having no annular ring at the base and no abventitious rhizoids, few branchlets, and from the latter species in having wider diameter of the branchlets, fewer branchlets, and in the structure of the rhizoids.

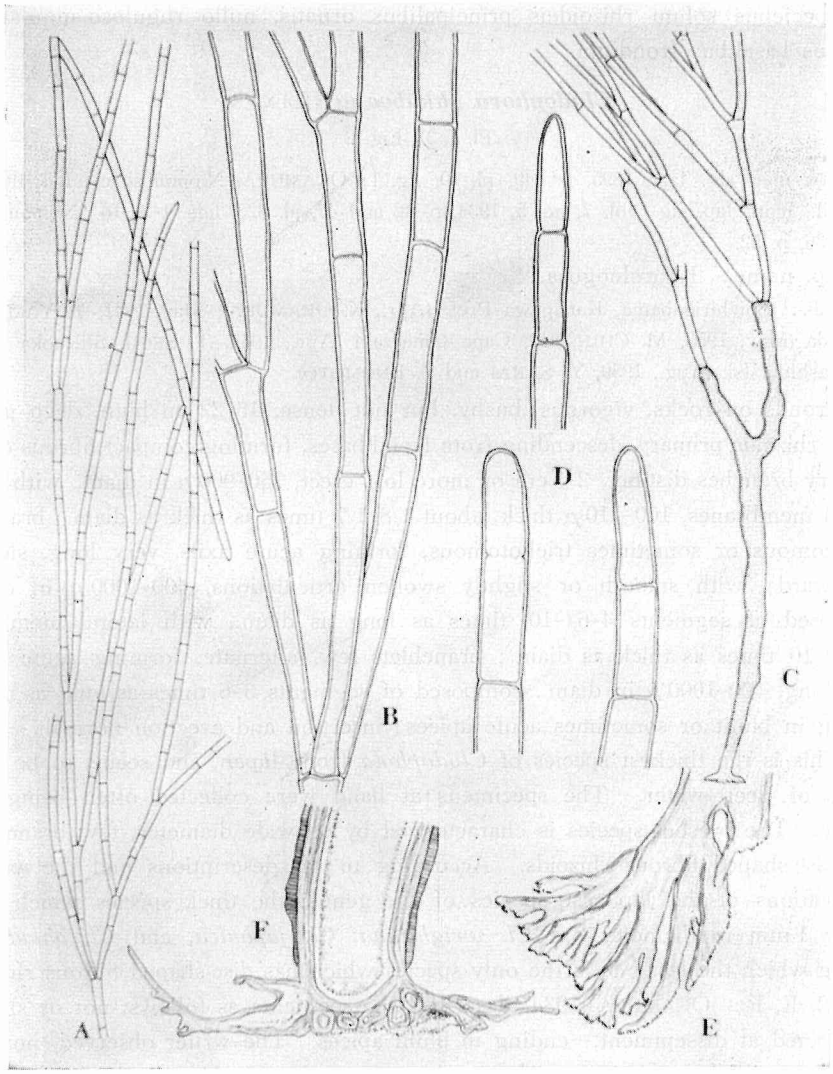

Fig. 2. *Cl. ohkuboana* HOLMES

A. Upper portion of frond, showing branching manner × 1.4.
B. Middle portion × 8.5. C. Basal portion epiphyted by *Contarinia okamurai* SEGAWA (dotted portion) × 1.8.
D. Ends of branchlets, showing subacute, obtuse and somewhat truncate apices × 8.5. E. A portion of rhizoid × 20.
F. Longitudina section of rhizoid × 20.

Cladophora densa HARVEY

Pl. II, 2; Figs. 3-4

Charact. new alg., 1859, p. 333; KJELLMAN, Mar. Chlorophyc. Jap. 1897, p. 26, figs. 1-6; DE-TONI, Phyc. Jap. nov., 1895, p. 60; OKAMURA; Nippon sorui meii, 1916, p. 241; Id., Nippon kaiso shi, 1936, p. 59; YAMADA, Mutsu Bay, II, 1928, p. 499, fig. 2; HARVEY, in DAWSON's HARVEY's Jap. alg., 1959, p. 28.

Jap. name: Asamidori-shiogusa.

Hab.; Muroran (Aug., 1890, K. MIYABE, SAPA; June, 1947, July, 1949, Y. SAKAI), Okushiri Isl. (July, 1943, Y. HASEGAWA), Matsumae (June, 1890, S. NOZAWA, SAPA), Bikuni (May, 1952, E. OHTAKE), Hakodate (Moritake; July, 1953, Y. SAKAI), Cape Shirakami-misaki (Aug., 1954, Y. SAKAI), Hokkaido; Asamushi (July, 1927, S. INOH), Oma (Y. YAMADA; Aug., 1943, S. INOH), Shimofuro (Aug., 1940, S. INOH), Aomori Pref.; Kesen-numa (May, 1936, G. TOBA), Hirota (June, 1954, S. KAWASHIMA), Miyako (Aug., 1951, Id.), Ofunato (May, 1951, Id.), Kuji Bay (July, 1952, Id.), Kamaishi (Aug., 1951, Y. YAMADA and S. KAWASHIMA), Nakano (July, 1951, S. KAWASHIMA), Iwate Pref.; Amatsu, Chiba Pref. (Aug., 1931, A. HIROHASHI); Shibagaki, Ishikawa Pref. (Aug., 1938, M. KUMAZAWA); Otsu, Ibaragi Pref. (July, 1903, K. OKAMURA): Ago Bay, Mie Pref. (Apr., 1955, J. KOJÔ); Onsentsu, Shimane Pref. (S. TAKAGI).

Fronds hanging down from rocks in elittoral zone, often forming hemispherical tuftus, about 5–20 cm high, caespitose, very rigid, full green; rhizoids primary, descending from frond-bases, sometimes well developed, septate by a few septa, dividing dichotomously, 35–110 μ in diam., with thin lateral membranes; primary branches erect, provided with swollen articulations, with thick lateral membranes, about 1/3 times as thick as diam., with annular striations downwards, 150–280 μ in diam., composed of segments 7–13 (–20) times as long as diam.; branches di- trichotomous or sometimes polychotomous, straight, forming somewhat acute axils, provided with swollen or slightly constricted articulations, 130–160 μ in diam., with lateral membranes about 1/4–1/5 times as thick as diam.; branchelts somewhat secund, arising from each articulation forming acute axils, straight, short (1–3 segmented), provided with slightly constricted articulations, 60–130 μ in diam., ending in obtuse or nearly acute apices, composed of segments 4–7 times as long as diam.; fruiting segments forming in branchlets, provided with subterminal or terminal orifices; reproductive cells in segments spherical, 13–15 μ in diam.; insertion and evection normal, sometimes irregular.

This is the rigidest and coarsest species of *Cladophora* from Hokkaido. In the elittoral zone, this alga attaches here and there, and hangs down from sheltered parts of rocks. It, however, grows sometimes on ear-shells, and is deep green in colour in living state, but becomes yellowish green in drying. The habit of the alga shows usually a hemispherical outline.

On the branching manner, HARVEY (l. c.) and KJELLMAN (l. c.) described it as "dichotoma", but the latter (Tab. 5, fig. 1) illustrated trichotomous branches. And

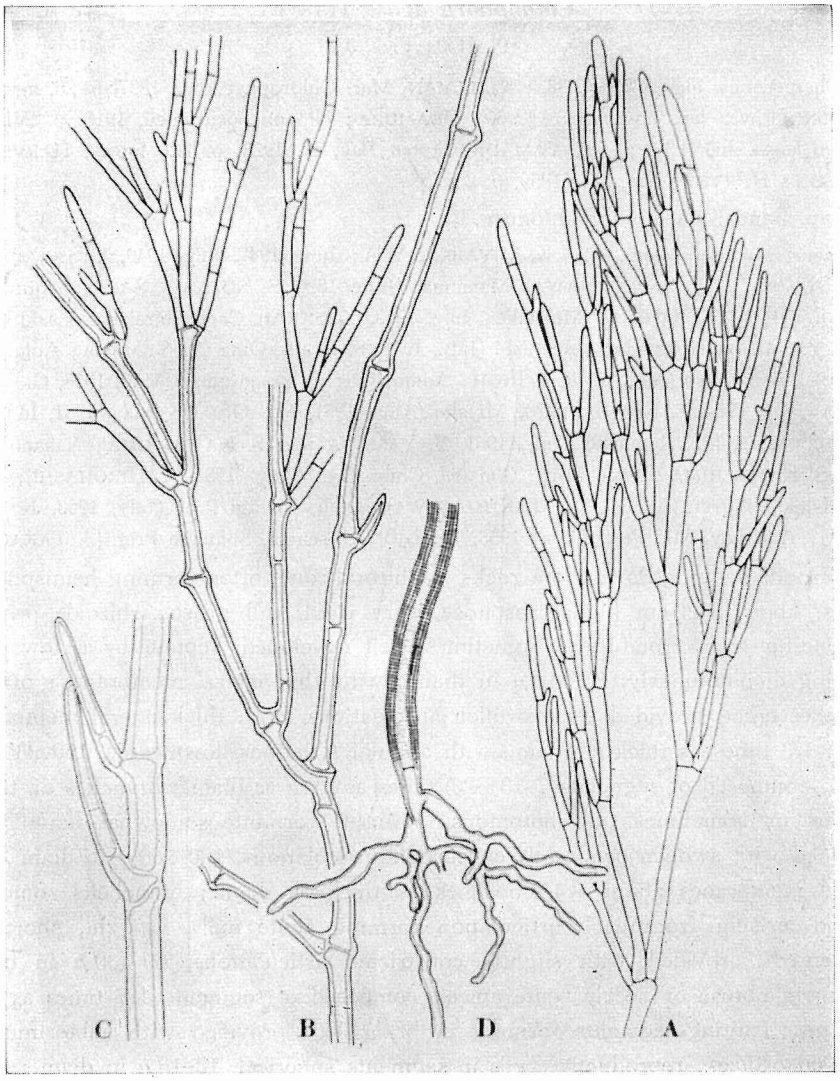

Fig. 3. *Cl. densa* HARVEY

A. Upper portion of frond × 13. B. Middle portion, showing branching manner and side insertion of branches × 1.6.
C. "Halb zurückgeruckete Scheidewand" × 20.
D. Frond base, showing annular striations and rhizoid. × 20.

they wrote "ad genicula constrictis". The writer observed constricted articulations in upper portions of the fronds, but in the middle and lower portions, he often recognized many swollen articulations (Fig. 3, B).

According to the description of primary branches given by HARVEY as "longissimis" and by KJELLMAN as "stipes utgöres af en åtminstone 7 mm lång cell", the above diagnosis of the dimension of primary branches is adequate. On the other hand, however, the relative segment-length of the branchlets of the species vary from 2–3 times (Ago Bay specimen) to 14–20 times as long as diameter (Ôtsu specimen). The diameter of the segments of the primary branches are written as "360 μ och annu" by KJELLMAN (l. c.), but the writer could not observe such a part of the specimens collected from all parts of Japan.

Cl. densa strongly resembles *Cl. graminea* COLLINS in growing belt, habit, height, colour, rigidity, rhizoids, branching manner, dimensions of the segments, and presence of the annular striations in lower segments. In comparison with the

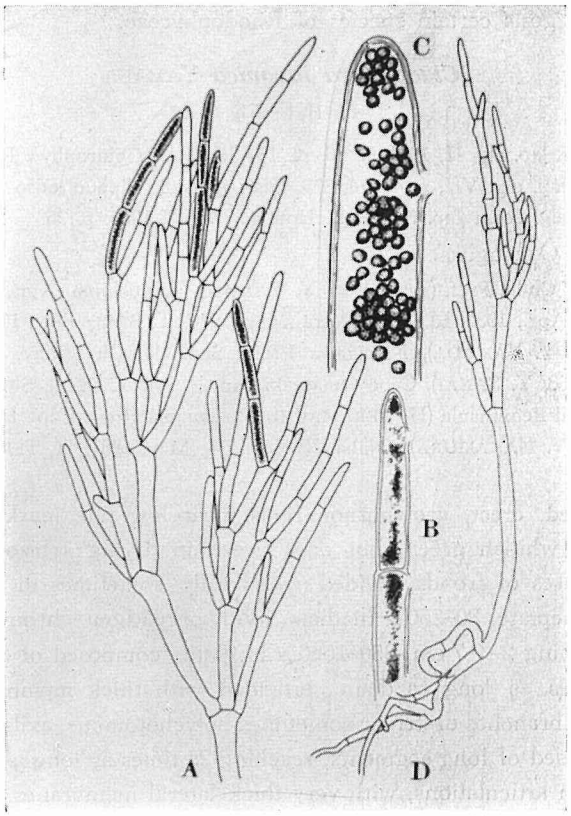

Fig. 4. *Cl. densa* HARVEY

A. Upper portion, provided with fertile segments × 16.
B, C. Fertle segments B. × 39, C × 130.
D. Young plant × 8.

Japanese specimens of *Cl. densa* and the American *Cl. graminea* (HAHF, no. 55927, Pacific Grove, det. N. L. GARDNER; Phyc. Bor.-Amer., no. 1960, as *Cl. erecta* COLLINS) this resemblance is clear. There are, however, some different characteristics between them. That is to say, *Cl. densa* has many swollen articulations in the lower portions of the fronds, but *Cl. graminea* has slightly constricted articulations, and the latter has a wider diameter (about 500 μ but SMITH (1943, p. 59) described as "300 μ" on the specimens from Monterey Peninsula). According to the above mentioned characteristics, the writer feels it desirable to recognize *Cl. graminea* as a variety of *Cl. densa*.

On the other hand, *Cl. densa* (ROTH) KUETZ. (Phyc. Germ., 1845, p. 209) is a quite different one from the species described by HARVEY. ROTH's description (Cat. bot. II, 1800, p. 179, as *Geramium densum*), "capsulis lateralibus sessilibus subglobosis", suggests certain species of Rhodophyceae.

Cladophora japonica YAMADA

Pl. II, 1; Fig. 5

Notes on some Jap. alg. II, 1931, p. 65, pl. 16; Id., Mar. Chlorophyc. Ryûkyû, 1934, p. 45; OKAMURA, Icon. Jap. alg. VII, p. 48, pl. 325, figs. 4–7; Id., Nippon kaiso shi, 1936, p. 52, fig. 26; IKOMA, Mar. alg. coast Jap. Sea in S. Honshû, Jap. I, 1956, p. 25.

Jap. name: Ô-shiogusa.

Hab.: Ohara, Chiba Pref. (June, 1925, Y. YAMADA); Enoshima (Apr., 1929, Y. YAMADA; March, 1931, Id.; Apr., 1932, Id.), Kamakura (May, 1944, T. SEGI; Feb., 1947, Id.), Shichirigahama (May, 1941, Y. YAMADA), Kanagawa Pref.; Shizuoka City (May, 1955, T. SAWADA), Shimoda (Apr., 1958, Y. SAKAI), Cape Omaezaki (Apr., 1944, T. SEGI), Shizuoka Pref.; Wagu (Apr., 1944, Id.), Kii Penninsula (H. TERAMACHI), Wakayama Pref.; Cape Hinomisaki, Shimane Pref. (Aug., 1942, Y. NAKAMURA); Naha, Ryukyu Isl. (May, 1931, H. TERAMACHI; 1932, Y. YAMADA).

Fronds tufted, erect, growing on rocks near low tide mark, large, attaining 20 cm or more, whitish green, but dark green in drying; rhizoids primary, descending from bases of fronds, divided irregulardly, sometimes di- polychotomously, septate or non septate, 80–250 μ in diam., with or without chromatophores; stems long, often reaching 2–4–7 cm, 350–1000 μ in diam., composed of (1–) 2–4 segments, reaching 20 times as long as diam., provided with thick membranes, 40–50 μ in thickness; main branches di- tri- or sometimes polychotomous, axils acute, 350–650 μ in diam., composed of long segments, reaching 25 times as long as diam., 500–850 μ in diam., swollen articulations, with very thick lateral membranes, about 40–80 μ in thickness; branches and branchlets di- trichotomous, axils acute, 200–380 μ in diam., composed of segments 3–5 (–10) times as long as diam., straight, upper ends of segments sometimes swollen, but slightly constricted at articulations; ultimate branchlets arising from every two to three articulation, alternate, sometimes secund,

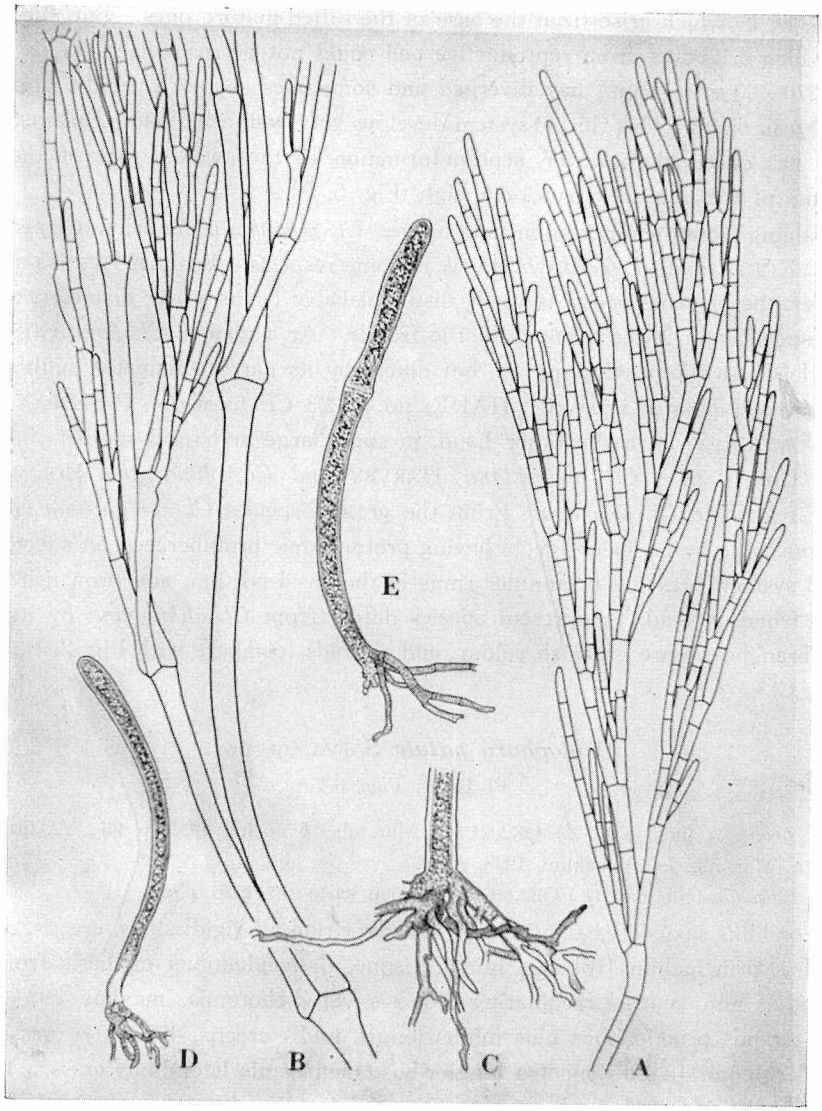

Fig. 5. *Cl. japonica* YAMADA

A. Uppermost portion of frond × 8.5 B. Middle portion × 8.5.
C. Rhizoid × 13. D. Very young plants × 8.5.

axils acute, straight, not so long, ending in obtuse or sometimes subacute apices, with smooth articulations, 150–300 μ in diam., composed of segments 2–5 times as long as diam.; insertion and evection normal.

In Shimoda specimens, the writer observed one or two segmented young algae

(Fig. 5, D, E) which arise from the base of the tufted mature ones. But, the young alga which originates from reproductive cell could not be recognized. This young alga (270–460 μ in diam.) has diverged and sometimes septate rhizoids which are 80–200 μ in diam. This rhizoid-system develops very well as in mature plants. The writer has observed, oowever, septum-formation at the swollen part of the erect filaments of the alga of baout 1 cm high (Fig. 5, E).

Judging from the descriptions and figures, *Cl. japonica* is similar to *Cl. pellucida* (HUDS.) KUETZ. and *Cl. feredayii* HARV. in some respects. From KÜTZING's species, however, the present species is easily distinguishable by its wider diameter, narrow axils especially in lower portions of the fronds. At a glance, *Cl. feredayii* stands most closely to the present species, but differs by its narrow diameter, high degree evection, and pointed apex (Cf. HAHF, no. 49203 *Cl. feredayii*, Pt. Elliot, leg. et det. WOMERSLEY). On the other hand, in some large and rigid species of *Cladophora* from Japan, *Cl. wrightiana* HARVEY and *Cl. ohkuboana* HOLMES are closely related to *Cl. japonica*. From the present species *Cl. wrightiana* is easily distinguishable by its special septa having protoplasmic protuberaces, an adventitious rhizoid system, presense of annular rings in the basal portion, and brownish colour of the fronds. And, the present species differs from *Cl. ohkuboana* by its more dense branches, more greenish colour, and rhizoids (compare with Fig. 2, E, F and Fig. 5, C).

Cladophora patula SAKAI, sp. nov.

Pl. III, 2; Figs. 6–7

Cl. prolifera (non KUETZ.) OKAMURA, Mar. alg. Kôtôsho, 1931, p. 96; YAMADA and TANAKA, Mar. alg. Isl. Yonakuni, 1938, p. 58.

Cl. pellucida (non KUETZ.) OKAMURA, Nippon kaiso shi, 1936, p. 53.

Frondibus saxicolis, ca. 2–5 cm altis, luteo-viridibus, rigidissimis, erectis, densis; rhizoideis principalibus robustis numerosisque, descendentibus ex basis frondium, plerumque non septis, irregulariter ramosis vel dichotomis, maxime 190 (–250) μ crassis; ramis principalibus plus minus longis, nudis erectis, 450–750 μ crassis, cellulis plerumque 15-plo diametro longioribus, membranis lateralibus crassis, 1/8–1/6 (–1/5)-plo diametro crassioribus compositis; ramis (di-) tri- polychotomis, divaricatis patulisve in partibus inferioribus frondium, plerumque rectis, articulis levigatis, autem inferne crescentibus, 380–450 μ crassis, segmentis 6–8-plo diametro longioribus, membranis lateralibus (ca. 42 μ crassis) ca. 1/12-plo diametro crassioribus; ramulis et ramulis ultimis secundis, nonnumquam 2 (–3) ramulis emittentibus ex articulis omnibus, axilis acutis, partibus apicibus ramorum et ramulis 2–4 segmentis, 210–380 μ crassis, articulis levigatis, longitudine variabilis, plerumque ca. 2–6 (–10)-plo diametro longioribus, apicibus obtusis; insertionis evectionibusque normalis.

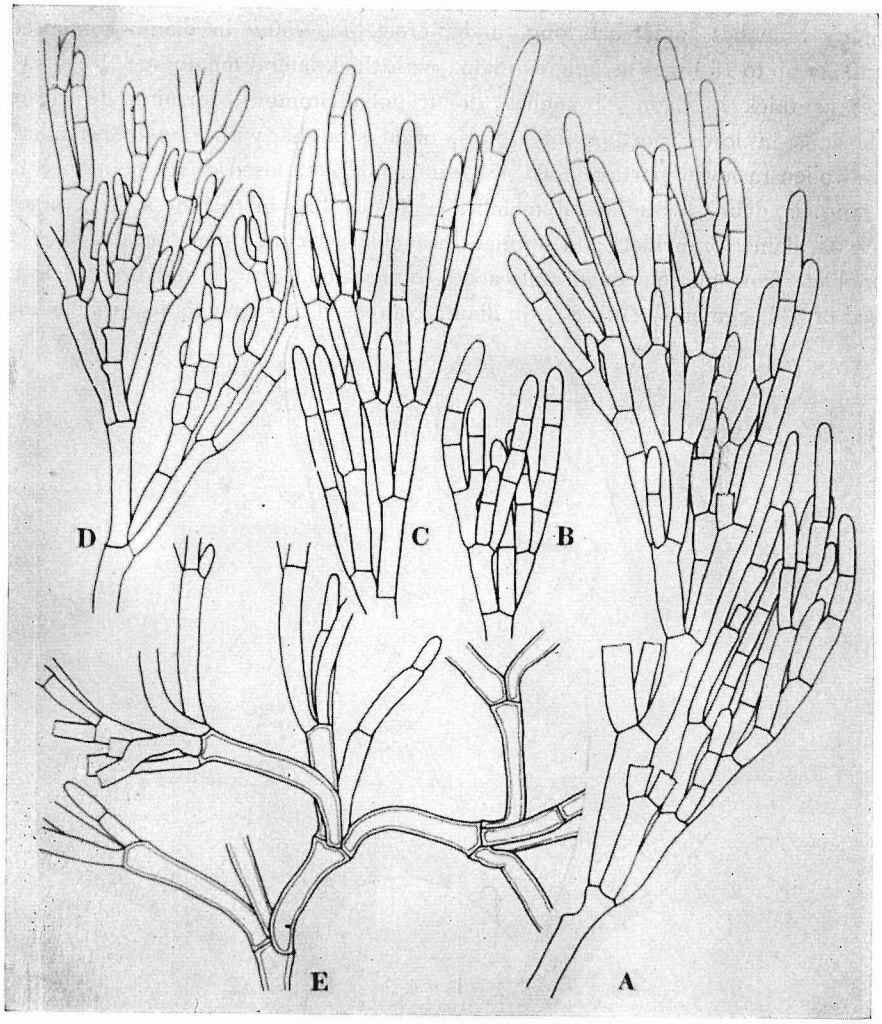

Fig. 6. *Cl. patula* SAKAI

A–C. Upper portions of frond provided with short segments (B) and long segments (C) × 13.
D. Middle portion of frond × 8.5.
E. Lower portion, showing divaricate branches × 8.5.

Jap. name: Minami-shiogusa (nov.).

Type loc.: Yonakuni Isl. (Apr. 1935, T. TANAKA).

Hab.: Kôtôsho, Formosa (T. SEGAWA).

Fronds on rocks, about 2–5 cm high, yellowish green, very rigid, erect, dense; rhizoids primary, robust and abundant, descending from frond-bases, often non septate, branching irregular or dichotomous, reaching 190 (–250) μ in diam.;

primary branches somewhat long, nude, erect, 450–750 μ in diam., composed of segments up to 15 times as long as diam., with thick lateral membrane, 1/8–1/6 (–1/5) times as thick as diam.; branches (di-) tri-polychotomous, forming divaricate or wide axils in lower portions of fronds, often straight, with smooth articulations, but swollen in lower portions, 380–450 μ in diam., composed of segments 6–8 times as long as diam., with lateral membrane (about 42 μ in thickness) 1/12 times as thick as diam.; branchlets and ultimate branchlets secund, sometimes arising 2 (–3) branchlets from all segments, axils acute, branch-top portions and branchlets composed of 2–4 segments, 210–380 μ in diam., composed of segments in variable length,

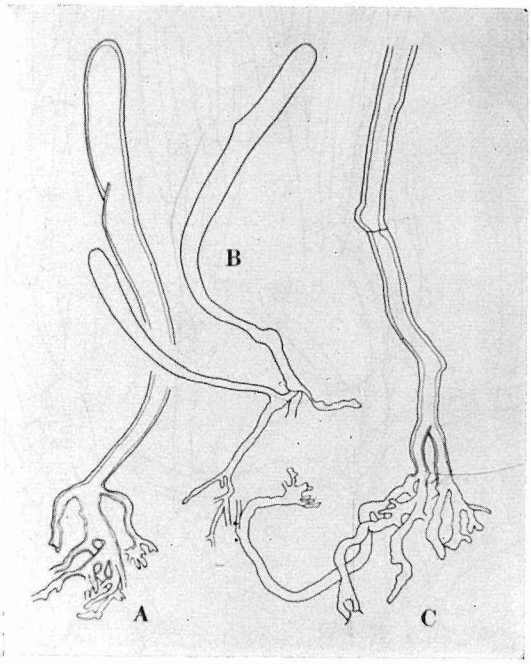

Fig. 7. *Cl. patula* SAKAI
A, B. Younger plants × 13. C. Rhizoid × 8.5.

about 2–6 (–10) times as long as diam., ending in obtuse apices; insertion and evection normal.

The frond of the present species forms hemispherical tuft, is yellowish or grey green, and has rigid texture in drying. The rhizoids of specimens at hand are only primary ones (Fig. 7, C), and may issue new upright sprosses (Fig. 7, A, B). Branches of lower portions of the fronds are divaricate, cuneate at the bases, and sometimes polychotomous (Fig. 6, E). At the uppermost portions, a secund manner is pronounced (Fig. 6, A–D).

This new species resembles *Cl. prolifera* (ROTH) KUETZ. and *Cl. pellucida* (HUDS.) KUETZ., but differs from the former by its lighter colour, divaricate branches, smooth lateral membrane, and by having no adventitious rhizoid. OKAMURA (1936) described the rhizoid of the present species as "desceding intramatrically from lower portion of stem" (in Japanese). But, the writer cannot observe the descending adventitious rhizoids in his specimen (leg. T. SEGAWA, from Kôtôsho). On the other hand, the new species is distinguishable from *Cl. pellucida* in having lighter colour, divaricate branches, wider diameter, shorter stems, and secund branchlets.

Cladophora fascicularis (MERT.) KUETZING

Pl. IV, 1; Fig. 8

Phyc. gener., 1843, p. 268; Id., Sp. alg., 1849, p. 393; Id., Tab. phyc. III, 1853, pl. 90, fig. 2; DE-TONI, Syll. alg. I, 1889, p. 316; VICKERS, Phyc. Barbad., 1908, pl. XIII, p. 18; HOWE, Mar. alg. Peru, 1914, p. 34; Id., Bahama fl., 1920, p. 601; COLLINS et HERVEY, Alg. Bermuda, 1917, p. 46; COLLINS, Green alg. N. Amer., 1909, p. 345; BØRGESEN, Canary Isl. I, 1925, p. 61; TAYLOR. Mar. alg. Florida, 1928, p. 62; Id., Caribbean Mar. alg. Allan Hancock Exped. 1939, 1942, p. 25; Id., Mar. alg. east. tropic., 1960, p. 91, pl. 3, fig. 3; SLOOTWEG, Netherland's Mar. Cladophora sp., 1948, p. 279, fig. 4; CHAPMAN, Mar. alg. New Zealand, 1956, p. 447, fig. 98.

Confeava fascicularis MERTENS, in C. AGARDH, Syst. alg., 1824, p. 114; MONTAGNE, Voy. l'Amer. merid. par d'Orbigny, Bot. 18, pl. 7, fig. 1; ZANARDINI, Plant. in Mari Rubro fucusque collect., 1858, p. 88.

Cl, mauritiana KUETZING, Sp. alg., 1849, p. 399; DE-TONI, Syll. alg., 1889, p. 328 (fide BØRGESEN, Some Mar. alg. Maurit., I, 1940, p. 34).

Cl, utriculosa (non KUETZ.) YENDO, Note on alg., II, 1914, p. 265, fide spec.

Jap. name: Fusa-shiogusa (nov.).

Hab.: Nagatoyo, Hokkaido (Aug., 1941, Y. YAMADA); Oma (Sept. 1917, L. ROSENBAUM, TI; Aug., 1847, S. MIKAMI), Cape Tappi (Sept., 1917, L. ROSENBAUM, TI), Asamushi (Aug., 1916, T. TOMOMICHI, TI; Aug., 1940, S. INOH), Cape Natsudomarizaki (Y. YAMADA), Sai (Aug., 1955, S. KAWASHIMA), Fukaura (Nov., 1956, Id.), Same (Sept., 1908, N. TAKAHASHI, TI), Aomori Pref.; Nagahama (June, 1949, E. UMEZAKI), Takahama (July, 1950, Id.), Koiso June, 1950, Id.), Fukui Pref.; Shibagaki, Ishikawa Pref. (Aug., 1938, M. KUMAZAWA); Miyazu (July, 1931, A. HIROHASHI), Onsentsu (S. TAKAGI), Cape Hinomisaki (Aug., 1942, Y. NAKAMURA), Shimane Pref.; Uchinomi, Kagawa Pref. (Apr., 1938, T. SEGI).

Fronds on rocks or on other algae, 10–20 cm high, grass- or yellowish green, having dense fasciculate branchlets; rhizoids primary, descending from frond-bases, septate, devided irregularly, with rich or sometimes thin chromatophores, 75–85 μ in diam., composed of segments 1–5 times as long as diam.; primary branches or stems erect, brancing di- trichotmously, sometimes with swollen articulations, clearly fused branch-bases, 230–250 μ in diam., with thick and lamellated lateral membrane, composed of segments 10–20 times as long as diam., provided with sparse fascicules

downwards, but dense upwards; branches di- tri- polychotomous (sometimes 6), generally straight, 140–250 μ in diam., composed of segments 2–4 times as long as diam., with thin lateral membrane; penultimate and ultimate branchlets forming dense fascicules; penultimate branchlets issuing from branches, di- polychotomous, forming somewhat acute axils, 60–160 μ in diam., composed of segments 2–4 times as long as diam., ending in obtuse apices, branchlet-top portions (1–) 2–3 segmented; ultimate branchlets issuing from each segment of penultimate ones, paired, forming obtuse axils, 40–120 μ in diam., composed of segments 2–4 times as long as diam., 1–4 segmented, sometimes with pinnate branchlets; insertion and evection normal.

At first this species was described from the West Indies, and now it is reported from almost everywhere in tropical seas. In the temperate seas the alga is reported by SLOOTWEG (l. c.) from the Netherlands. In the present alga, dense fasciculate branches and suddenly reduced dimension of branchlets are the characteristics making it distinguishable from the other species of Japanes *Cladophora*.

The fasciculate branchlets of this species are often incurved. And, minimum diameter of the segments of branchlets varies from 40 μ to 70 μ, depending on individuals or on localities. The characteristic fascicules are already visible in younger stages. The young branches having 150–250 μ in diam. in about a 5 cm high plant have unilateral small fascicules arising from each articulation and from every 2–3 articulations (Fig. 8, D). These young fascicules have also incurved branchlet-top portions (Koiso specimens). The segments of ramuli, in typical form, are 4–6 times as long as the diameter.

In Japan, the present species is epiphytic on *Coccophora langsdorfii* or on *Sargassum* sp., and also saxicolous. MERTENS (l. c.) has not described the habitat of *Conferva fascicularis*. KÜTZING (1843) who recognized at first the alga as a species of the genus *Cladophora* described it as "parasitica", but he did not describe its habitat in his latter papers. After him, TAYLOR (1942) noted that the alga is epiphytic. In VICKERS' Phyc. arbadensis (l. c.), there is no description on it, but the specimen distributed in Phyc. Bor.-Amer., no. 1472 a (leg. et det. VICKERS) seems to the writer epiphyctic on other alga.

This species is related to some species haveing fasciculate branchlets, *Cl. dalmatica* KUETZ., *Cl. utriculosa* KUETZ., and *Cl. monumentaris* BOERG.

According to the description and the figure given by HAMEL (Quelp. *Cladophora* des cotes Franc., 1928, p. 49, fig. 10), *Cl. dalmatica* forms the fasciculate branchlets and incurved ultimate ramuli. Judging from his figure, paired ultimate branchlets forming fascicules arise from the same articulations is the some direction. In the specimen collected from Algaerie (HAHF, no. leg. et det. J. FELDMANN), usually one ultimate branchlet arises from each articulation, but the writer observed a rarely paired ultimate branchlet arising from it. In spite of these

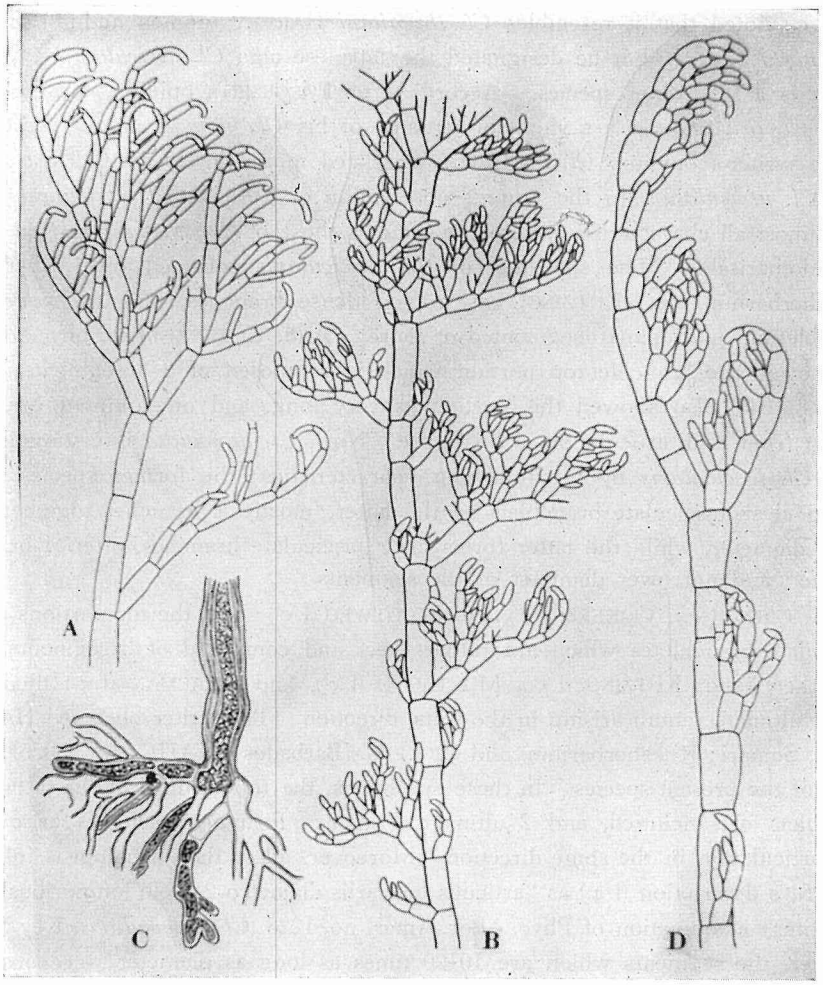

Fig. 8. *Cl. fascicularis* (MERT.) KUETZING
A. Uppermost portion of frond × 16.
B. Middle portion × 16. C. Rhizoid × 33.
D. Uppermost portion of a young frond × 20.

resemblances, *Cl. fascicularis* is distinguishable from *Cl. dalmatica* by its dense fasciculate branchlets, thicker diameter, and shorter segmet-length.

Cl. monumentaris BOERG. (List Mar. alg. Bombay, 1935, p. 26, pl. 4, fig. 12) also resembles this species, but differs from this species in having shorter fasciculate branchlets, not so pectinately arranged ramuli, and thicker branchlets.

On the other hand, *Cl. utriculosa* relates with *Cl. fascicularis* KG., and the alga colle cted in Japan is called as *Cl. utriculosa*, since K. YENDO had identified it.

He (l. c.) noted that it resembles *Cl. thwaitesii* HARVEY (nomen nudum) and *Cl. fasciculata* KUETZ., but he designated the Japanese alga *Cl. utriculosa*. *Cl. fasciculata* is a freshwater species. According to BØRGESEN's opinion, on the other hand, *Cl. thwaitesii* is a s ynonymous name of his *Cl. monumentaris*. According to the writer's opinion, *Cl. thwaitesii* is related more closely to *Cl. fascicularis* than *Cl. utriculosa*. In the writer's observation of YENDO's *Cl. utriculosa* (Sept., TI), almost all characteristics were the same as those of YAMADA's specimen (Cape Natsudomarisaki). The specimen of *Cl. fascicularis* collected from Cherbourg (Rijksherbarium, det. KÜTZING) has not so dense branches, and has very long branchlet-top portions (10 segmented or more). And, KÜTZING (Tab. phyc. III, fig. 94) showed the branchlet-top portion which is composed of 2–3 segments. SLOOTWEG (1948) also showed this portion as very long, and one ultimate branchlet arising from each articulation is his figure. Now, *Cl. utriculosa* is distinguishable from *Cl. fascicularis* by the following characteristics: the former species forms not so clear fasciculate branchlets as the latter, mostly 2 branches together, and wider diameter, while the latter forms clear fasciculate branches, often 4 or more together, and norrower diameter of the segments.

KÜTZING (l. c.), VICKERS (l. c.), and SLOOTWEG (l. c.) show the top-portions of the fasciculate branchletes which are rather erect and composed of 3 segments. On the other hand, KÜTZING (l. c.), MONTAGNE (l. c.), and CHAPMAN (l. c.) illustrated paired ultimate ramuli arising in the some direction. The writer observed HAUCK's (Scara, Somari; Rijksherbarium) and VICKERS' (Barbados; HAHF, no. 56025) specimens of the present species. In these specimens, the top-portions of the fasciculate branchlets are incurved, and 2 ultimate branches forming fascicules arise from each articulation in the some direction. Moreover, all of the phycologists followed KÜTZING's description (l. c.) as "articulis primariis diametro 2–4-plo longioribus". In the writer's examination of Phyc. Bor.-Amer. no. 1228 (*Cl. fascicularis*, Key West), however, the segments which are 10–20 times as long as diameter were observed in the basal portion of the primary branches. In this case too, branches show numerical values near 4–6 times as long as the diameter.

CROUAN (in MAZÉ et SCHRAMM's Algues de la Guadeloupe, 1870–'77, p. 58–59) placed *Cl. fascicularis* KUETZING on an equal footing with *Cl. fascicularis* MERTENS, and listed new forms, f. *denudata* CRN. and f. *glomerata* CRN. without diagnosis and figure. But the writer cannot form an opinion on it, before studying these specimens.

According to the description and figure of *Cl. zostericola* (non GROUAN) MARTENS (Preus. Exped. Ost-Asien, Tange, 1866, p. 112, pl. I, fig. 3), it seems to relate closely to *Cl. fascicularis*. The writer had, however, no opportunity to examine an authentic specimen of *Cl. zostericola*, so cannot decide whether

MARTENS' species is a synonym of *Cl. fascicularis* or not.

Cladophora oligoclada HARVEY

Pl. III, 1; Fig. 9

Charact. new alg., 1859, p. 333; Id., in DAWSON's HARVEY's Jap. alg., 1959, p. 28; DE-TONI, Phyc. Jap. nov., 1895, p. 60; OKAMURA, Nippon sorui meii, 1902, p. 241; Id., Nippon Kaiso shi, 1936, p. 60.

Jap. name: Saida-shiogusa (nov.).

Hab.: Ryûkyû (?).

Frond about 10 cm high, dull green, delicate, penicilliform; rhizoids primary, rarely septate, irregularly divided, 15–65 μ in diam., with or without chromatophores; primary branches 70–115 μ in diam., composed sometimes of long segments, reaching 10 times as long as diam., with stratified lateral membrane, 1/7–1/10 times as thick as diam.; branches few, straight or flexuose, dichotomous or alternate, forming acute axils, 60–75 μ in diam., with smooth articulations, composed of short segments, 2–3 (–4) times as long as diam., and of thin lateral membrane, top-portions consisting of up to 30 segments, ending in obtuse apices; branchlets few, arising from distant segments of branches, forming acute axils, alternate or sometimes secnud, short, (1–) 3–10 segmented, smooth or slightly constricted articulations, (35–) 40–70 μ in diam., composed of short segments, 1–3 (–4) times as long as diam., ending in obtuse apices; insertion and evection normal.

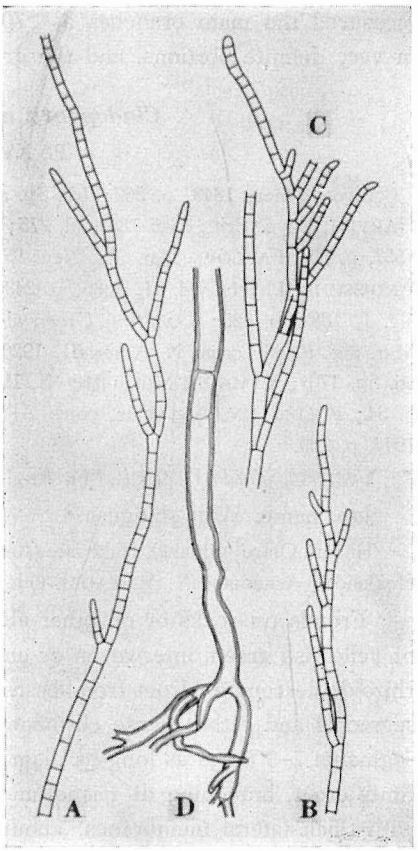

Fig. 9. *Cl. oligoclada* HARRVEY
A, B. Upper portions of a frond × 28.
C. Younger portion × 28.
D. rhizoid × 33.

The above diagnosis and the figures are based on a specimen preserved in TI, and on the label reading "Herb. W. G. FARLOW···*Cladophora oligoclada*" designated without locality, date, collector, or identifier. The present specimen agrees well with HARVEY's original description and the dimension given by OKAMURA (l. c.). Accordingly, this seems to be a specimen originating from WRIGHT's original collection from "Loo Choo".

This species is characterized by its softness, few and short branchlets arising

at distant intervals, short segments, and nearly smooth articulations. HARVEY's description says "ramuli secundis brevissimis unicellulosis; articulis ramorum diametro 4-9-plo longioribus". The specimen at hand, however, has (1-)3-10 segmented branchlets (Fig. 9, A-C) and shorter segments (2-3(-4) times). Moreover, the branching manner of the specimen is generally alternate, but in younger portions or in rare cases the writer can observe secund manner (Fig. 9, C). OKAMURA measured the main branches as "70-100 μ", but the widest portions are observed in very definite portions, and the gradient of the diameter is small.

Cladophora albida (HUDS.) KUETZING

Pl. XVII 1,; Figs. 10-11

Phyc. gener. 1843, p. 267; Id., Sp. alg., 1849, p. 400; Id., Tab. phyc. IV, 1854, pl. 15; HARVEY, Phyc. Brit., 1846-1851, pl. 275; Id., MANUAL, 1849, p. 203; Id., Ner. Bor.-Amer. III, 1857, p. 80; FARLOW, Mar. alg. New Engl., 1880, p. 51; HAUCK, Meeresalgen, 1885, p. 458; ARDISSONE, Phyec. Md. II, 1886, p. 243; DE-TONI, Fl. alg. Venezia, 1888, p. 167; Id., Syll. alg. I, 1889, p. 325; COLLINS, Green alg. N. Amer., 1909, p. 336; SETCHELL and Gardner, Mar. alg. Pacific coast N. Amer. II, 1920, p. 218; HAMEL, Cladophora cotes Franc., 1928, p. 66, fig. 17 b; YAMADA, Mutsu Bay II, 1928, p. 498, fig. 1; OKAMURA, Nippon kaiso shi, 1936, p. 54; FELDMANN, Alg. mar. cotes Alberes, 1937, p. 206; DAWSON, Mar. alg. Gulf Calif., 1944, p. 209.

Conferva albida HUDSON, "Fl. Angl., 1732, p. 597".

Jap. name: Wata-shiogusa.

Hab.: Otaru (Ohtake), Hakodate (June, 1950, Y. SAKAI), Ranshima (Aug., 1949, Y. SAKAI), Hokkaido; Asamushi (Y. YAMADA), Odomari (July, 1948, Y. SAKAI), Aomori Pref.

Fronds on rocks or on other algae in tidal pools, reaching 60 cm high, whitish or yellowish green, interwoven or entangled, very delicate and soft, not gelationous; rhizoids descending from frond-bases, dividing dichotomously, septate, with rounded segments and rather dense chromatophores, about 50-60 μ in diam., composed of segments 1-3 times as long as diam.; main filaments flexuose or bent, short, sometimes erect, branching di- trichotomous, forming very wide axils, 40-65 μ in diam., with thick lateral membranes, about 1/5-1/4 times as thick as diam., composed of cylindrical segments, 3-6 times as long as diam.; branches bent or nearly so, dense, di- trichotomous, about 20-45 μ in diam., forming wide axils, composed of cylindrical segments, 3-6 times as long as diam., sometimes with 1-2 segmented branchlets; branchlets irregularly branched, sometimes unilateral or opposite, forming wide axils but acute upwards, bent, ending in obtuse apices, 15-35 μ in diam., composed of segments 3-6 times as long as diam.; ultimate branchlets irregular, somewhat pectinate, arising from each 2-4 segment, or from each segment, 13-20 μ in diam., (1-)4-7(-12) segmented, 2-5 times as long as diam., with thin lateral membranes, 1/10-1/8 times as thick as diam.; evection normal, with

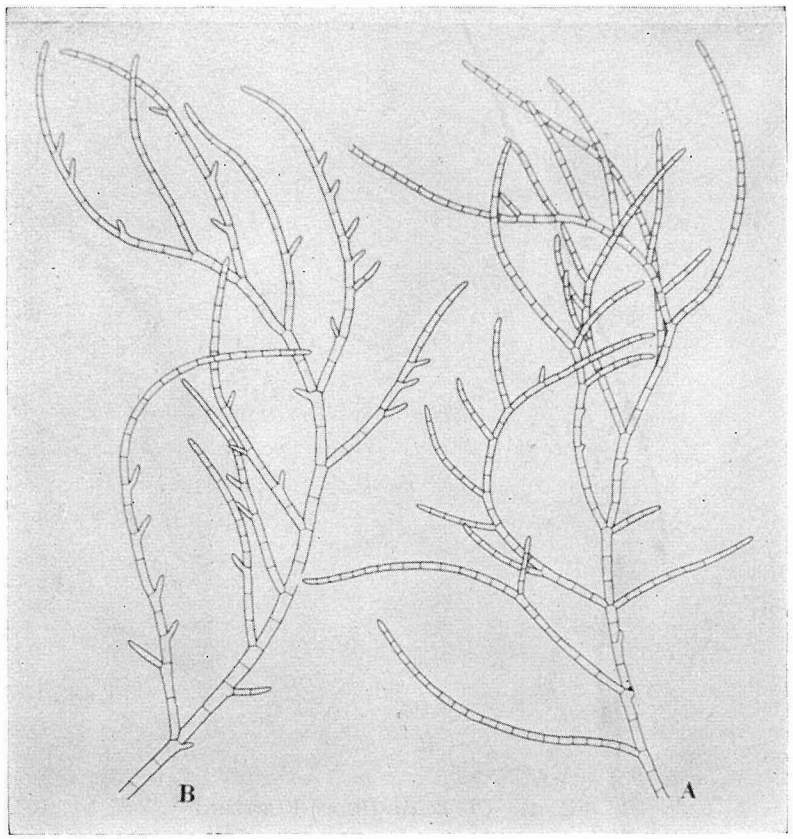

Fig. 10. *Cl. albida* (HUDS.) KUETZING

A, B. Upper portions of fronds, provided with long branchlets (A) and with short ones × 40.

basal fusion of segments in middle or lower portions; fruiting segments forming in uppermost portions of fronds, 25–35 μ in diam., with constricted articulations, provided with one orifice on each upper end of it.

The present species grows on rocks, *Mytilus* sp., or on the coralline algae in tide-pools, forming dense cotton-like tufts of whitish colour, and is one of the slenderest *Cladophora* in Japan. The rhizoids of the alga are simple, consisting of spherical segments. Moreover, the septa which separate each other at the articulations can be observed, especially in the fruiting portions. That is to say, each segment is not jointed at a common septum, but has an articulation-cavity.

KÜTZING (1849), FARLOW (1880), COLLINS (1909), and SETCHELL and GARDNER (1920) described *Cl. albida* (HUDS.) KUETZ. which has 30 μ in diam. in the main

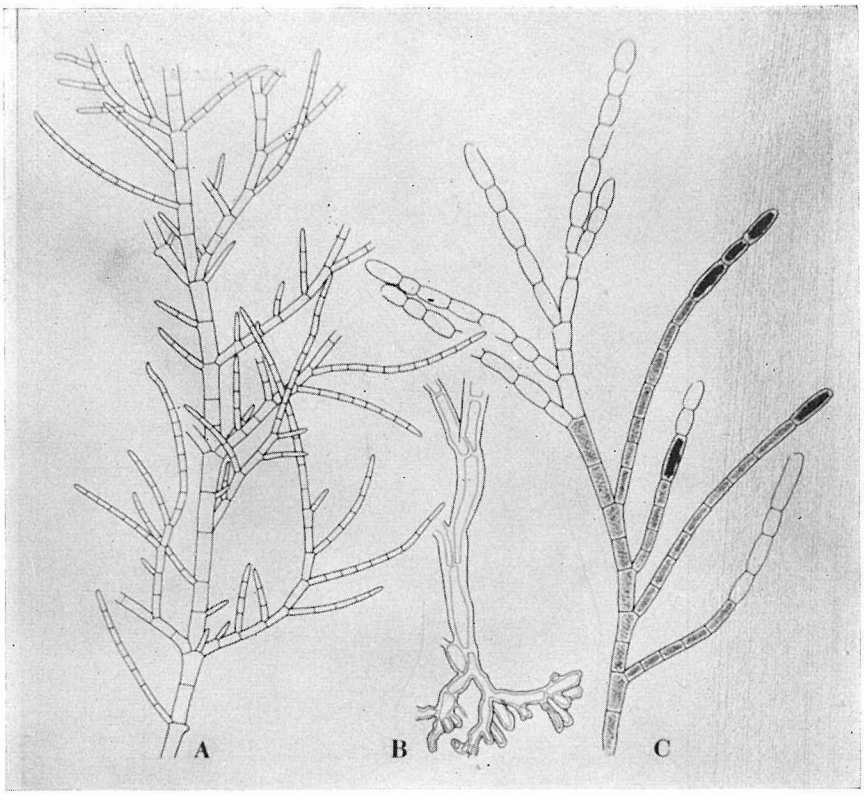

Fig. 11. *Cl. albida* (HUDS.) KUETZING
A. Middle portion of a frond × 33. B. Rhizoid × 33.
C. Upper portion of a frond, showing fetile segments × 64.

branches. On the other hand, HAUCK, (1885), ARDISSONE (1886), and DE-TONI (1889) had described a species which had 60 μ in diam. in the main filaments, and they recognized *Cl. chlorothrix* KUETZ. and *Cl. tenuis* KUETZ. as synonyms of the present species. Recently, SLOOTWEG (The Netherland's *Cladophora* species, 1948), after the examination of the authentic specimens of *Cl. albida*, *Cl. chlorothrix*, and *Cl. tenuis*, wrote that "both *Cl. chlorothrix* and *Cl. tenuis* differ from *Cl. albida* by their very long branches, which bear only very few ultimate ramuli with a smaller diameter than these branches and a smaller relative cell-length (length times breadth").

Moreover, HAUCK (l. c.), ARDISSONE (l. c.), and DE-TONI (l. c.) added some synonymous species, *Cl. ramellosa* KUETZ., *Cl. reticulata* KUETZ., *Cl. gracillima* KUETZ., and *Cl. refracta* KUETZ. etc. *Cl. refracta*, however, is generally recognized as one of the independent species of the genus or a variety of *Cl. albida* in the present

time. If the writer excepts *Cl. refracta*, *Cl. chlorothrix*, and *Cl. tenuis* from the synonyms of *Cl. albida*, he cannot recognize the diameter of main filaments given by HAUCK, ARDISSONE, and DE-TONI. However, the writer cannot identify the Japanese specimens as *Cl. chlorothrix* which has "very long branches which bear only very few ultimate ramuli with a smaller diameter than these branches and smaller relative cell-length" (SLOOTWEG, 1948, p. 275). With the exception of the dimension of main filaments, the Japanese species agrees very well with the descriptions, figures, and the specimen identified by KÜTZING (Rijksherbarium). The writer, however, cannot help identify the Japanese specimens with this species, before having an oppotunity to examine the authentic specimens of these synonymous species.

Cladophora gracilis (GRIFF.) KUETZING

Pl. VI, 1; Fig. 12

Phyc. Germ., 1845, p. 215; Id., Sp. alg., 1849, p. 403; Id., Tab. phyc. IV, 1854, pl. 23; HARVEY, Manual, 1849, p. 202; Id., Ner. Bor.-Amer. III, 1875, p. 81; FARLOW, Mar. Alg. New Engl., 1880, p. 55; KJELLMAN, Alg. Arctic Sea, 1883, p. 308; HAUCK, Meeresalgen, 1885, p. 457; ARDISSONE, Phyc. Med. II, 1886, p. 237; DE-TONI, Fl. alg. Venezia, III, 1888, p. 165; Id., Syll. alg. I, 1889, p. 322; FOSLIE, Mar. alg. Norway, 1890, p. 316; HARIOT, List alg. mar. Yokosuka, 1891, p. 214; COLLINS, New Engl. mar. Cladophora, 1902, p. 121; Id., Green alg. N. Amer., 1909, p. 342; SETCHELL and GARDNER, Mar. alg. Pacific coast N. Amer. II, 1920, p. 216; HAMEL, Quelq. Cladophora cotes Franc., 1928, p. 63, fig. 16 A; LAKOWITZ, Algenfl. Ostsee, 1929, p. 159, fig. 223; OKAMURA, Nipoon kaiso shi, 1936, p. 58, fig. 28; SLOOTWEG, Netherland's mar. Cladophora sp., 1948, p. 277, fig. 5; WOMERSLEY, Crit. surv. mar. alg. New Zealand, 1956, p. 454, fig. 110.

Conferva gracilis GRIFFITHS, in "Wyatt, Alg. Dann., no. 97".

Jap. name: Nayo-shiogusa (nov.).

Hab.: Haneda, Tokyo (March, 1958, A. Miura).

Fronds 7–15 cm high, light green, erect or flexuose, somewhat rigid, but delicate; rhizoids primary, descending from frond-bases, sometimes septate, 30–60 μ in diam., composed of long segments; main filaments straight or flexuose, dichotomous, or sometimes trichotomous, forming acute axils, 140–160 (–170) μ in diam., composed of short segments, 3–5 (–10) times as long as diam., provided with thin lateral membrane, 1/15–1/10 times as thick as diam., slightly constricted at dissepiment; branches straight or curved, dichotomous or sometimes opposite, arising from acute axils, 130–150 μ in diam., composed of short segmets, 2–4 times as long as diam., with slightly constricted articulations; branchlets alternate or unilateral, straight or curved, forming acute axils, 70–130 μ in diam., composed of segments 2–4 times as long as diam., with very long top-portions, about 6–16 segmented, ending in obtuse apices; ultimate branchlets secund or pectinate, arising from every

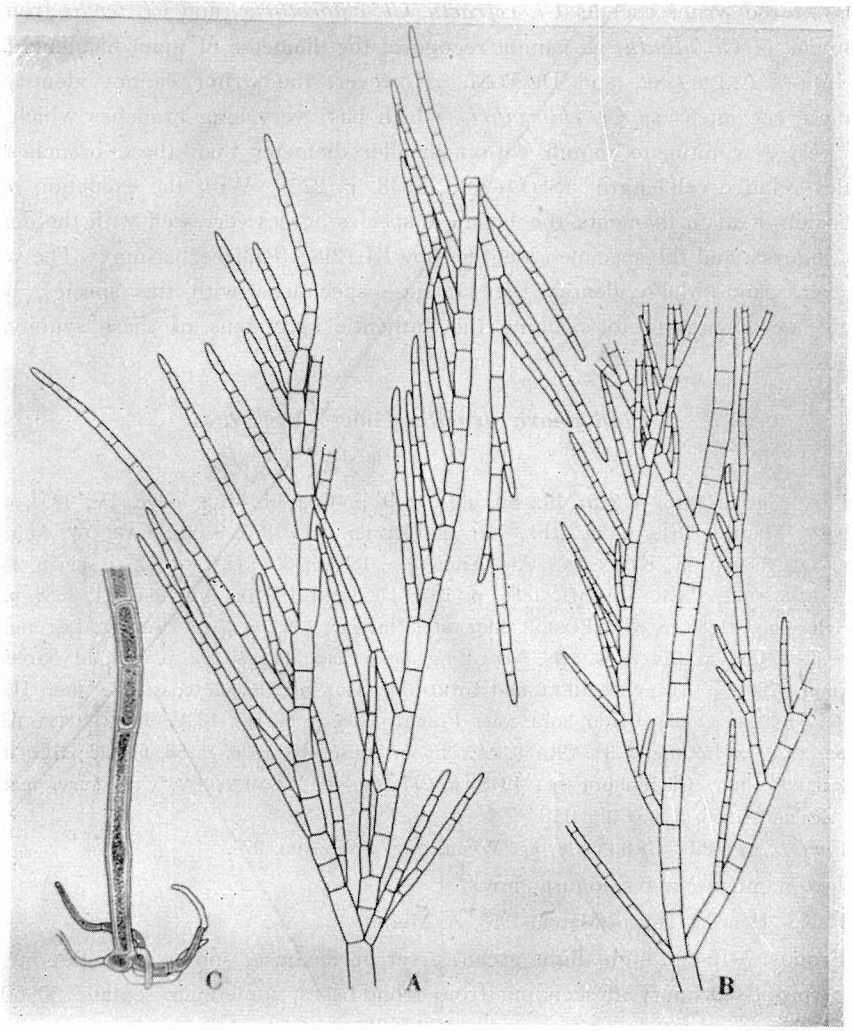

Fig. 12. *Cl. gracilis* (GRIFF.) KUETZING
A. Upper portion of a frond × 27.
B. Middle portion × 16. C. Rhizoid × 28.

segment or from every 2–3 segment, forming somewhat acute axils, straight, long, 30–60 μ in diam., (1–) 4–10 segmented, 2–4 times as long as diam; evection and insertion normal.

The present species was listed at first from Yokosuka (Pref. Kanagawa) by HARIOT (l. c.) based on the collection of SAVATIER. The specimens at hand are collected from Haneda, Tokyo Bay, near Yokosuka. It is coarser than *Cl. albida*,

and does not so closely adhere to paper in drying. This species is characterized by its delicate texture, flexuose branches, pectinate and long branchlets, almost the same value of relative segment-length in all portions of the fronds, and slightly constricted at dissepiments.

According to the description and figure of *Cl. stimpsoni* HARV., the present species is very closely related to it. The present species is, however, distinguishable from *Cl. stimpsoni* by its not gelationous texture, short segments, and more obtuse apices than that of *Cl. stimpsoni*.

Cladophora speciosa SAKAI, sp. nov.

Pl. V, 2; Figs. 13–14

Frondibus in conchis saxibusque, dense fruticosis, 8–15 cm altis, subflavo- vel pallidi-viridibus, mollibus et mucosis; rhizoideis primariis descendentibus ex basis frondium, septatis, irregulariter ramosis, 15–60 μ crassis, segmentis irregulariter formatis ornatis, cum chromatophoris densis; ramis principalibus rectis, nonnumquam flexuosis, dichotomis, emittentibus ex axilis obtusis, articulis levigatis vel leviter crescentibus, ca. 50–80 (–110) μ crassis, segmentis brevioribus quam in his partium alium frondium ornatis, 2.5–10-plo diametro longioribus, membranis lateralibus crassis, ca. 12 μ, 1/10–1/5-plo diametro crassioribus; ramis lateralibus vel rarius oppositis, clare rectis et longis, axilis obtusis vel acutiusculis, ca. 35–60 μ crassis, segmentis elongatis, 6–10-plo diametro longioribus, membranis lateralibus ca. 1/10-plo diametro crassioribus; ramulis et ramulis ultimis secundis vel alternate secundis, clare rectis, emittentibus ex axilis acutiusculis, longissimis, consistentibus ca. 20 vel ultra segmentibus, articulis leviter constrictis, (10–) 15–25 (–40) μ crassis, segmentis elongatis ornatis, (5–) 6–10 (–15)-plo diametro longioribus; insertione ramoroum normali, sine connatis in basis ramorum.

Jap. name: Miyabi-shiogusa (nov.),

Type. loc.: Muroran, Hokkaido (Aug., 1951, Y. SAKAI).

Fronds on shells and stones, 8–15 cm high, yellowish or light green in colour, soft and gelationous, densely bushy; rhizoids primary, descending from frond-bases, septate, irregularly divided, 15–60 μ diameter, composed of irregularly shaped segments, with dense chromatophores; primary branches straight, sometimes flexuose, dichotomous, arising from rounded axils, articulations smooth or somewhat swollen, about 50–80 (–110) μ in diameter, composed of rather short segments than that of other portions of the frond, 2.5–10 times as long as diameter, with rather thick lateral membranes, about 12 μ, 1/10–1/5 times as thick as diameter; branches lateral, rarely opposite, very straight and long, axils obtuse or somewhat acute, about 35–60 μ in diameter, composed of very long segments, 6–10 times as long as diameter, with thin lateral membranes, about 1/10 times as thick as diameter; branchlets and

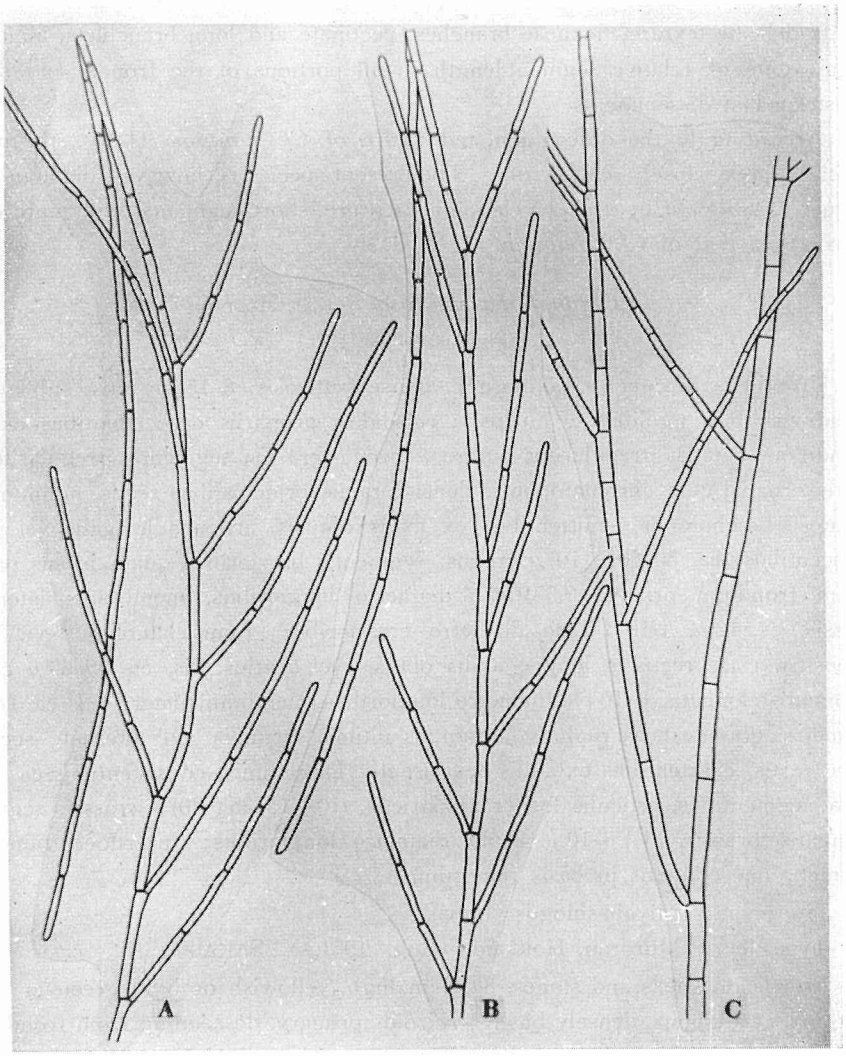

Fig. 13. *Cl. speciosa* SAKAI

A, B. Upper portions of fronds × 64.
C. Middle portion of a frond × 39.

ultimate branchelts secund or alternately secund, very straight, arising from rather acute axils, very long, consisting of about 20 or more segments, ending in obtuse apices, with slightly constricted articulations, (10–) 15–25 (–40) μ in diameter, composed of very long segments, (5–) 6–10 (–15) times as long as diameter; insertion of branches normal, without basal fusion.

This new species is collected from a 6 m depth on dead shalls of *Pecten yezoensis* (Jap. name, "Hotategai") and stones and the specimens are in fruiting stage. The fruiting segments have the same diameter as branches and branchlets, thin lateral membranes, and one orifice at the upper lateral side of the segments. In rare or abnormal (?) cases, the orifices are observed in the middle portions of the segments (Fig. 14, A). It is conspicuous that the septa of the fertile segments are much clearer than that of vegetative portions. On the other hand, in the lowermost portions, segments are cut by non-definite septa, and also are cut off by cytoplasm itself (Fig. 14, D, E). In some cases, the writer observed middle insertion of branches, "vorgerückte Scheidewand", and "zurückgerückte Scheidewand" in the lower por tions of the fronds (Fig. 14, D).

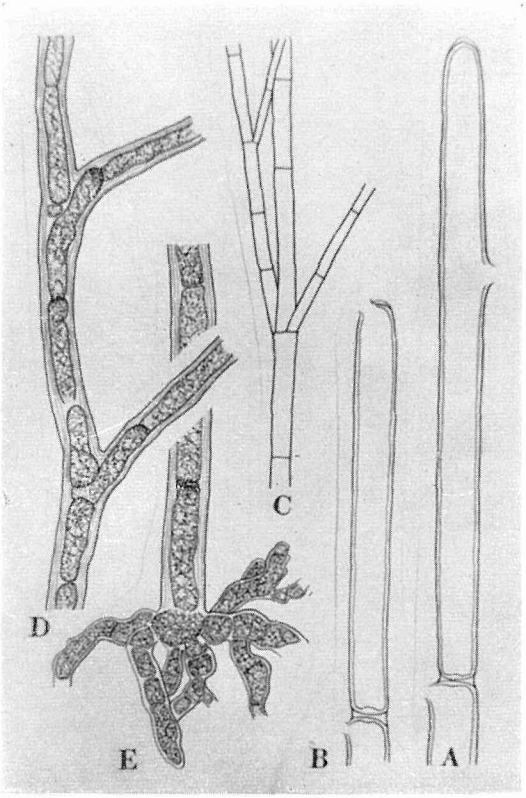

Fig. 14. *Cl. speciosa* SAKAI

A, B. Empty fertile segments showing orifices × 380. C. Middle portion showing rare branching manner × 39.
D. Branch insertion × 39. E. Rhizoid × 64.

The new species is related to *Cl. rudolphiana* and *Cl. crystallina* in many respects, but differs from the former species by its dichotomous branches, narrower diameter of branchlets, obtuse apices, and thicker lateral membranes of main branches. On the lateral membranes, certain phycologists noted it as "crassiusculis donatis" (DE-TONI, Syll. alg. I, 1889, p. 321). According to the writer's observation of loco-type specimen (Herb. KÜTZING, Rijksherbarium), however, it is thinner than that of the present new species. Moreover, the Muroran specimens differ from *Cl. crystallina* by a narrower diameter of main filaments, dichotomous branches, and very long branch-top portions. On the other hand, the new species is very close to *Cl. fertilis* ASKENASY (Ueber einige australische Meeresalgen, 1894, p. 4, pl. I, figs. 4, 5). In the figure (microphotograph) and diagnosis given by him, he described it as "ramis oppositis vel ad 3–4

verticillatis; plures rami repetito ramosi, fasciculosi, breviores". The writer observed opposite or trichotomous branches rarely or abnormally, and very long and straight branches in the present species. In these points, *Cl. speciosaa* differs from *Cl. fertilis*.

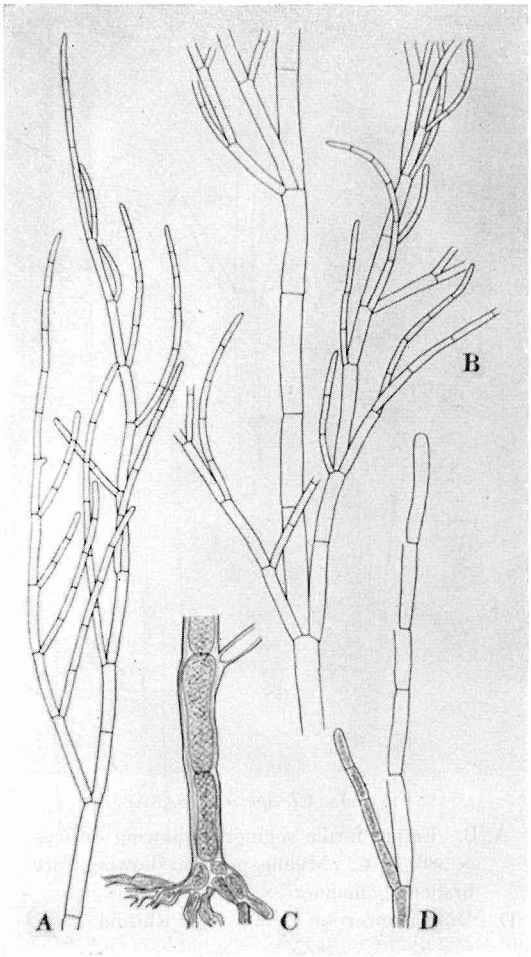

Fig. 15. *Cl. rudolphiana* (AG.) HARVEY f. *rudolphiana*

A. Upper portion of frond × 33.
B. Middle portion × 33. C. Rhizoid × 33.
D. Empty fertile segments with orifices and vegetative segments × 64.

Cladophora rudolphiana
(AG.) HARVEY
Pl. V, 1; IV, 2; Figs. 15-16

Phyc. Brit., 1846-'51, pl. 86.
Conferva rudolphiana AG., "Flora, 1827, p. 636".

Fronds growing on rocks, loosely tufted, often forming free floating entangled masses, reaching 15 cm high, flexuose or straight, very soft and delicate, of gelationouse texture, silky gloss, yellowish or full green in colour; rhizoids primary, descending from frond-bases, somewhat simple, divided irregulary, with dense chromatophores, 20–50 μ in diam.; main braches straight or flexuose, di- trichotomous, sometimes polychotomous, forming somewhat wide axils, composed of cylindrical segments, reaching 125 μ in diam., 3–12 times as long as diam., with thin lateral membranes; branches straight or flexuose, di- trichotomous, forming obtuse or acute axils, composed of cylindrical segments, 30–50–100 μ in diam., 3–7–12 times as long as diam., with smooth articulations; branchlets and ultimate branchlets stright or curved, secund or alternately secund, arising from acute or obtuse axils, composed of up to 30 segments, (15–) 20–30 μ in diam., 3–7–12 times as long as diam., with

sooth or slightly constricted articulations, with acute or obtuse apices; insertion normal.

This species is characteriszed by its softness, gelatinous texture, trichotomous branching in branches etc.

Key to the forms

1. Segments of main branches 100–125 μ in diam., (3–) 7–12 more time as long as diam. . . . . f. *rudolphiana*
1. Segments of main branches 40–60 μ in diam., 3–5 times as long as diam . . . . . f. *brevisegmentea*

f. ***rudolphiana***

Pl. V, 1; Fig. 15

Cladophora rudolphiana (AG.) HARVEY, Phyc. Brit., 1846–'51, pl. 86; Id., Manual, 1849, p. 203; Id., Phyc. Bor.-Amer. III, 1857, p. 80; KÜTZING, Sp. alg., 1849, p. 404; Id., Tab. phyc. IV, 1854, pl. 26, fig. 2; FARLOW, Alg. New Engl., 1880, p. 54; HAUCK, Meeresalg., 1885, p. 457; ARDISSONE, Phyc. Med., II, 1886, p. 237; DE-TONI, Syll. alg. I, 1889, p. 321; COLLINS, Mar. Cladophora New Engl., 1902, p. 120; Id., Green alg. N. Amer., 1909, p. 336; SCHIFFNER, Stud. Alg. adrait. Meer., 1915, p. 180; SETCHELL and GARDNER, Mar. alg. Pacific coast N. Amer., 1920, p. 217; HAMEL, Quelq. Cladophora cotes Franc., 1928, p. 54, fig. 12 A; NEWTON, Brit. seaweeds, 1931, p. 86; OKAMURA, Nippon kaiso shi, 1936, p. 54; FELDMANN, Alg. mar. cotes Alberes, 1937, p. 205; TAYLOR, Mar. alg. northeast. N. Amer., 1937, p. 87, pl. 5, figs. 3–4, pl. 6, fig. 2; DAWSON, Mar. alg. Gulf Calif., 1944, p. 209,

Conferva rudolphiana AG., "Flora, 1827, p. 636„.

Jap. name: Tamari-shiogusa.

Hab.: Ofunato Bay, Iwate Pref. (May, 1951, S. KAWASHIMA),

Fronds whitish green, forming entangled masses, about 3–10 cm high; primary branches 100–125 μ in diam., composed of long cylindrical segments, (3–) 7–12 or more times as long as diam.; branches not so long, flexuose; branchlets secund, 18–40 μ in diam., composed of very long segments, 8–12 times as long as diam., 6–10 segmented, ending in obtuse apices.

Our specimens were collected from were collected from shallow pools as floating masses, but have rhizoids (Fig. 15, C).

According to the descriptions given by the above mentioned authors on the present species (form), two different dimensions of the primary branches are recognized. One of them is "20–60 (–80) μ" given by KÜTZING (1849), Newton, and American phycologists; and the other is "up to 150 μ" given by almost all European phycologists and OKAMURA. KÜTZING's specimens (loc. Triest, Herb. KÜTZING, HAHF, no. 56794) has the slender diameter. On the other hand, HARVEY (1846–'51 described the apices as "attenuated", but TAYLOR (1937) figured nearly clavate apices.

According to the above mentioned facts, *Cl. rudolphiana* seems to be a very variable species. And, our specimens have the wider diameter given by KÜTZING and others, and have nearly obtuse apices.

The specimens at hand are related with *Cl. crystallina*, *Cl. speciosa*. in many respects, but differ from the former species by the branching manner of the branchlets, shorter segment-length, etc. Moreover, the present specimens are distinguishable from *Cl. speciosa* by their trichotomous branches, short branchlets, and thin lateral membranes.

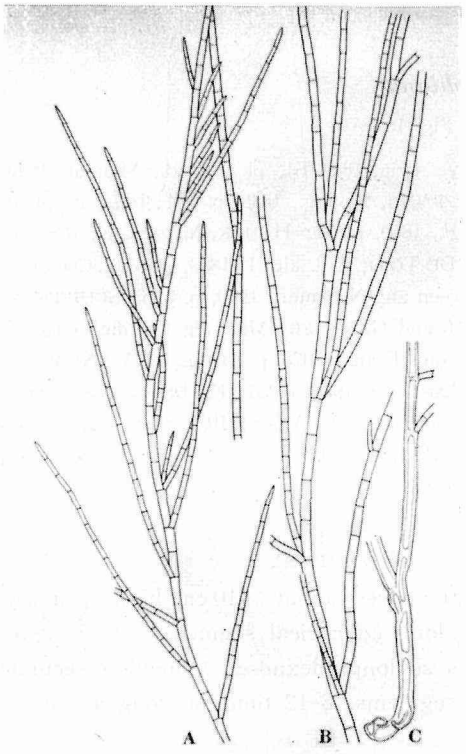

Fig. 16, *Cl. rudolphiana* (Ag.) HARVEY f. *brevisegmentea* SAKAI

A. Upper portion of frond × 23.
B. Middle portion × 23.
C. Rhizoid × 23.

f. ***brevisegmentea*** SAKAI, f. nov.

Pl. IV, 2; Fig. 16

Frondibus viridibus, erectis, ca. 5–15 cm altis; rhizoideis primariis simplicibus; ramis principalibus 40–60 μ creassis, segmentis brevioribus quam in typo, 4–6-plo diametro longioribus; ramis rectis, elongatis, ad 30 segmentis; ramulis secundis vel alternato-secundis, 15–30 μ in diam., segmentis 3–6-plo diametro longioribus, apicibus acutis.

Jap. name: Ao-tamari-shiogusa (nov.).

Hab: Takahama, Kyoto Pref. (Aug., 1960, I. UMEZAKI).

Fronds green in colour, erect, about 5–15 cm high; rhizoids primary, simple; main branches 40–60 μ in diam., composed of shorter segments than that of the type, 4–6 times as long as diam.; branches straight, elongate, composed of 30 segments; branchlets secund or alternately secund, 15–30 μ in diam., composed of segmets 3–6 times as long as diam., ending in acute apices.

This alga is very beautifully green in colour, and has very simple primary rhizoids (Fig. 16, C).

The specimens at hand are identical with *Cl. rudolphiana* itself except for its grass green colour and short segments. Their widths of all the portions of the

frounds and the acute apices coincide with the description given by KÜTZING, NEWTON and American phycologists.

The present new form resembles *Cl. crystallina*, *Cl. stimposni* and *Cl. speciosa*. It differs, however, from the first species in having acute apices, short segments, and very long branchlets; from *Cl. stimpsoni* by its rhizoid-system and dimension. Moreover, the present alga is distinguishable from *Cl. speciosa* by its trichotomous branching, short segments, and grass green colour.

Cladophora crystallina (ROTH) KUETZING

Pl. XVII, 3; Figs. 17–18

Phyc. gen., 1843, p. 267; Id., Sp. alg., 1849, p. 401; Id., Tab. phyc., IV, 1854, pl. 19; ARDISSONE, Phyc. Med. II, 1886, p. 235; DE-TONI, Fl. alg. Venezia, III, 1888, p. 163; Id., Syll. alg. I, 1889, p. 318; HOWE, in Britton and Millspaugh's Bahama fl., 1920, p. 601; COLLINS and HERVEY, Alg. Bermuda, 1917, p. 46; MIGULA, Meeresalg. etc, 1922, p. 54; COLLINS, Green alg. N. Amer., 1928, p. 342; HAMEL, Quelq. Cladophora cotes Franc., 1928, p. 54, fig. 12 B; SLOOTWEG, Netherland's mar. Cladophora sp., 1948, p. 279, fig. 8.

Conferva crystallina ROTH, Cat. bot. I, 1797, p. 196.

Jap. Name: Kuristaru-shiogusa (nov.).

Hab.: Kussharo-ônuma Marsh, Hokkaido (June and Aug., 1947, Y. SAKAI); new to Japan.

Fronds growing on shells, loosely tufted, 10–25 cm high, flexuose, very soft and delicate, of gelatinous texture, silky gloss, yellowish or whitish green in colour; rhizoids primary, descending from frond-bases, somewhat simple, septate, divided chiefly dichotomously, with dense chromatophores, 20–50 μ in diam.; main branches straight or flexuose, di- trichotomous, or rarely polychotomous, forming wide axils, 130–150 μ in diam., composed of long cylindrical segments, (2–) 4–6 times as long as diam., with somewhat thick lateral membranes, provided often with short branchlets; branches straight or flexuose, di- tri- or rarely polychotomous, forming obtuse axils, 45–90 (–130) μ in diam., composed of somewhat long segments, 5–10 times as long as diam., with smooth articulttions; branchlets straight or somewhat flexuose, secund or alternately secund, arising solitarily or sometimes pairy from each segment, forming acute or obtuse axils, 25–45 μ in diam., composed of (1–) 4–8 (–10) segments, 7–10 (–13) times as long as diam., with smooth or slightly constricted articulations, ending in obtuse or acute apices; insertion normal.

The present species grows on shells (*Corbicula* sp., Japanese name, "Shijimi") living in muddy bottoms of the brackish-water lake. The writer collected the alga twice at the points about 30–40 cm deep. The specimens sollected in June are young, but the ones in August are mature. The segments of the younger form of this species are 20–30 μ in diameter and 8–10 times as long as diameter at branchlets, 35–50 μ and 12–18 times at branches, and 50–70 μ and 3–5 (–8) times at

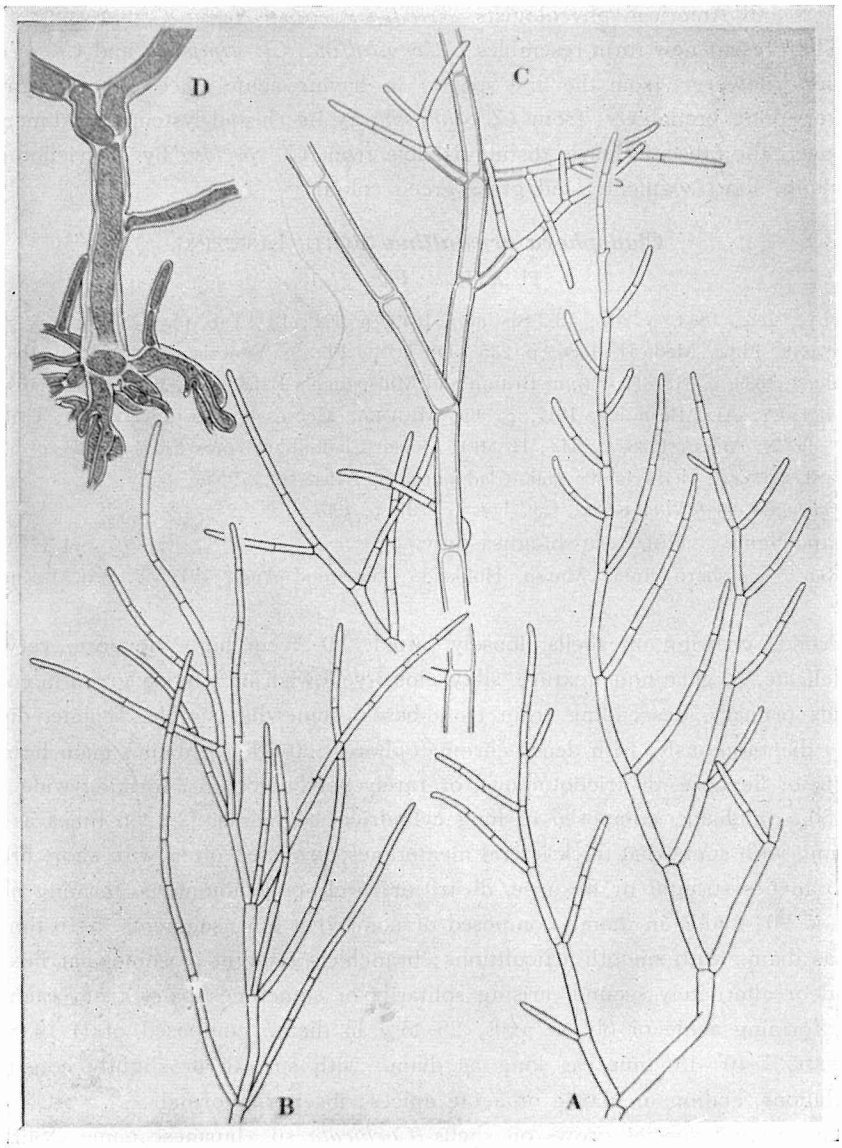

Fig. 17. *Cl. crystallina* (ROTH) KUETZING

A, B. Upper portions of fronds, showing branching manner × 28.
C. Middle portion × 28.
D. Frond-base, with two young plantlets arizing from rhizoid × 39.

main branches. Moreover, paired branchlets could scarcely be observed, and simple or dichotomously divided rhizoids could be recognized (Figs. 17, B; 18, B). In mature specimens, on the other hand, long top-segments reaching 13 times as long as the diameter, and young up-right sprosses arising from rhizoids which are provided with dense chromatophores were observed (Fig. 17, D).

The present species is related very closely with *Cl. rudolphiana* on one hand, and with *Cl. sericea* on the other by their softness, gelatinous texture, and dimension of the fronds. The present species is distinguishable from the former species by its clearly pectinated branchlets and short branchlet-top portions. According to KÜTZING's figure (l. c.) and the specimen of *Cl. crystallina* (Rijksherbarium), paired branchlets arise from every segment in pectinate manner. In the specimens at hand, however, paired branchlets are fewer than KÜTZING's specimen, but they are arranged in a clear pectinate or alternately pectinate manner. Moreover, the present species is different from *Cl. sericea* (HUDS.) KUETZ. in its longer segments, smooth articulations, and denser branching.

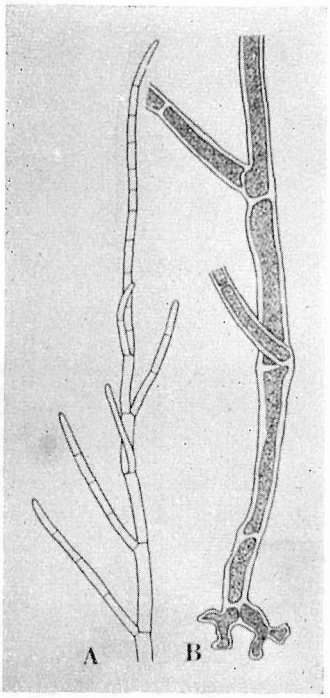

Fig. 18. *Cl. crystallina* (ROTH) KUETZING

A. Uppermost portion of a young plant, showing branch manner and short segmrnts × 28.

B. Frond base of the same plant, showing simple rhizoid × 33.

Sect. ***Opacae*** SAKAI, sect. nov.

Speciebus rhizoideis principalibus adventibusque ornatis; nullo rugloso-annulato in partibus inferioribus frondium.

Species provided with primary and adventitious rhizoids; without annular constriction in basal portions of fronds.

Cladophora crispata (ROTH) KUETZING

Pls. VI, 2; XVI 3; Figs. 19, 20

Phyc. gen., 1843, p. 264; Id., Sp. alg., 1846, p. 407; RABENHORST, Fl. Europ. alg., 1868, p. 336; COOKE, Brit. freshw. alg., 1882-'84, p. 143, pl. 55, fig. 3; DE-TONI, Syll. alg., I, 1889, p. 291; BRAND, Ueber. Cl. crispata u. Sekt. Aegagropila, 1906, p. 242; HEERING, in Pascher's Süssw.-Fl. Deutschl., 7. Chlorophyc., IV, 1921, p. 40; TIFFANY and BRITTON, Alg. Illinois, 1951, p. 45, fig. 92; PRESCOTT, Alg. West. Great Lake Area, 1951, p. 135, pl. 19, figs. 9-11.

Conferva crsipata ROTH, Cat. bot., I, 1797, p. 178.

Jap. name: Uki-shiogusa (nov.).

Hab.: Lake Akan (Aug, 1958 and Oct., 1959, Y. YAMADA et al.), Lake Konuma (July, 1924, H. HIROSE), Hokkaido.

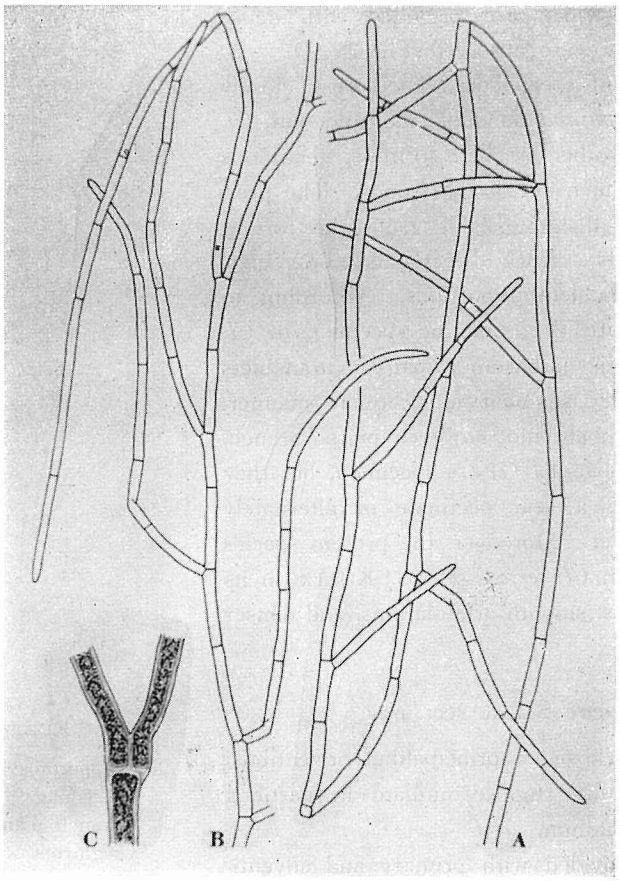

Fig. 19. *Cl. crispata* KUETZING
A, B. Upper portions of fronds × 33.
C. Branch base × 64.

Fronds growing on substrata in younger stages, but free floating in latter stages, reaching 30 cm in length, yellowish green, soft and delicate, forming dense masses; rhizoids appeared in younger stages, primary, or sometimes with adventitious intracuticular rhizoids, septate, divided dichotomously, 20–30 μ in diam., provided with dense chromatophores; primary branches not clear, straight of flexuose, loosely dichotomous, with smooth articulations, forming wide axils, 45–60 (–100) μ

in diam., composed of long segments, (6–) 8–15 (–20) times as long as diam., provided with somewhat thick lateral membranes, 1/8–1/4 times as thick as diam.; branches laxly dichotomous, straigh or flexuose, very long, arising from wide axils and from connated branch-base segments, 30–50 μ in diam., provided with segments 7–10 times as long as diam., with thin lateral membrane; branchlets and ultimate branchlets secund or alternately secund, straight, arising from wide axils and from distant intervals, (15–) 30–45 μ in diam., composed of segments 6–14 times as long as diam.,

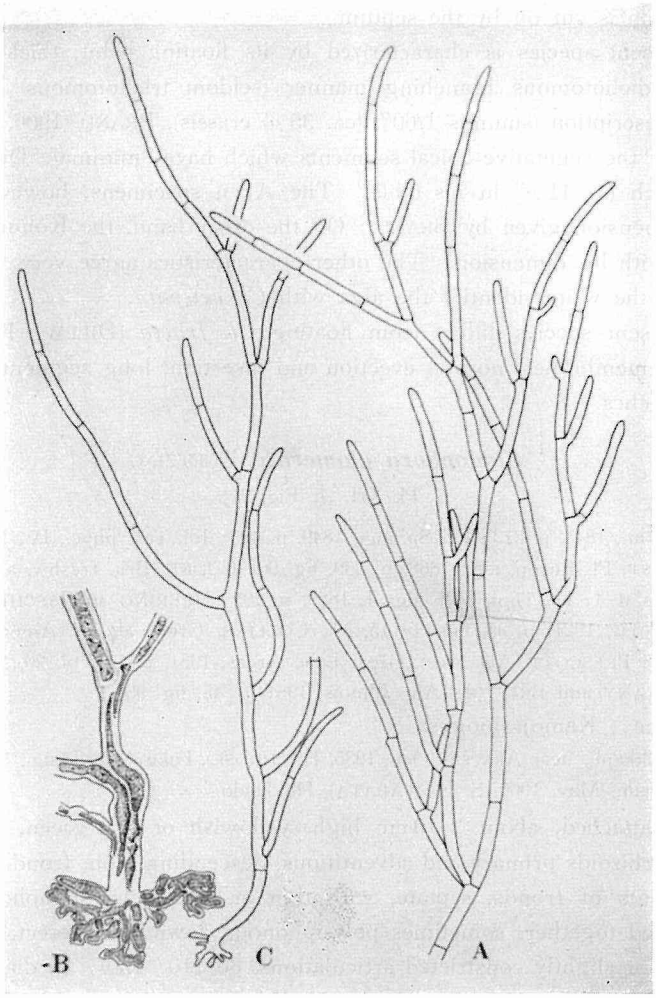

Fig. 20. *Cl. crispata* KUETZING

A. Upper portion of a frond × 33.
B. Frond base × 33. C. A small plant × 64.

ending in long and obtuse apices; insertion and evection normal.

The writer observed the young fronds of the present species attaching to withered culms of *Phragmites communis* TRIN. in Lake Akan (Pl. 14; Fig. 20, B, C). The description of the attaching fronds is as follows: Fronds 0.4–2 cm high, yellowish green, delicate, attached by septate rhizoids; branches alternately secund or scattered, erect or curved, arising from obtuse or rounded axils, provided with long segments, 7–10 (–20) times as long as diam., ending in obtuse apices. In these fronds, as shown in Fig. 20, C, the branch is sent off from middle portion of the segment which is cut off by the septum.

The present species is characterized by its floating habit, thick lateral membrane, and dichotomous branching manner (seldom trichotomous). In spite of KÜTZING's description (summis 1/60‴ (ca. 35 μ) crassis), BRAND (1906, p. 259) gives dimension of the vegetative apical segments which have "minimale Dicke meist ca. 20, doch auch bis 11 μ" in his table. The Akan specimens, however, are wider than the dimension given by BRAND. On the other hand, the Konuma specimens agree well with his dimension. The other characteristics agree very well with this species, and the writer identify the alga with *Cl. crispata*.

The present species differs from floating *Cl. fracta* (DILLW.) KUETZ. by its thick lateral membranes, normal evection and insertion, long segments, and nearly straight branches.

Cladophora glomerata KUETZING

Pl. XII, 2; Fig. 21

Phyc. Germ., 1845, p. 212; Id., Sp. alg., 1849, p. 405; Id., Tab. phyc., IV, 1854, pl. 33, fig. 1; RABENHORST, Fl. Europ. alg., 1868, p. 339, fig. 96; COOKE, Brit. freshw. alg., 1882–'84, p. 143, pl. 56, figs. 1–4; DE-Toni, Syll. alg., I, 1889, p. 295; HEERING, in PASCHER's Süssw.-Fl., 7, Chlorophyc. IV, 1921, p. 35, figs. 14–15, 39; COLLINS, Green alg. N. Amer., 1928, p. 350, pl. 13, fig. 124; PRESCOTT, Alg. west. Great Lake Areas, 1951, p. 138, pl. 20, figs. 8–9, pl. 21, figs. 1–2; TIFFANY and BRITTON, Alg. Illinois, 1951, p. 45, fig. 93.

Jap. name: Kamoji-shiogusa

Hab.: Aikkapu, near Akkeshi (Oct., 1935, H. HIROSE), Lake Akan (Aug., 1958, S. SAKAI), Katsurazawa Dam (May, 1960, S. KAWABATA), Hokkaido.

Fronds attached, about 2–10 cm high, yellowish or full green, soft, forming dense tufts; rhizoids primary and adventitious, descending from frond-bases or from lower segments of fronds, septate, with thin or dense chromatophores; primary branches fused together, sometimes polysiphonous downwards, erect, dichotomous, with smooth or slightly constricted articulations, 80–110 (–150) μ in diam., composed of segmentes (2–) 3–6 (–10 or more) times as long as diam., with thick stratified lateral membranes, 12–25 μ thick, 1/5–1/3 times as thick as diam.; branches di-trichotomous, erect, with slightly constricted articulations, 60–100 μ in diam., com-

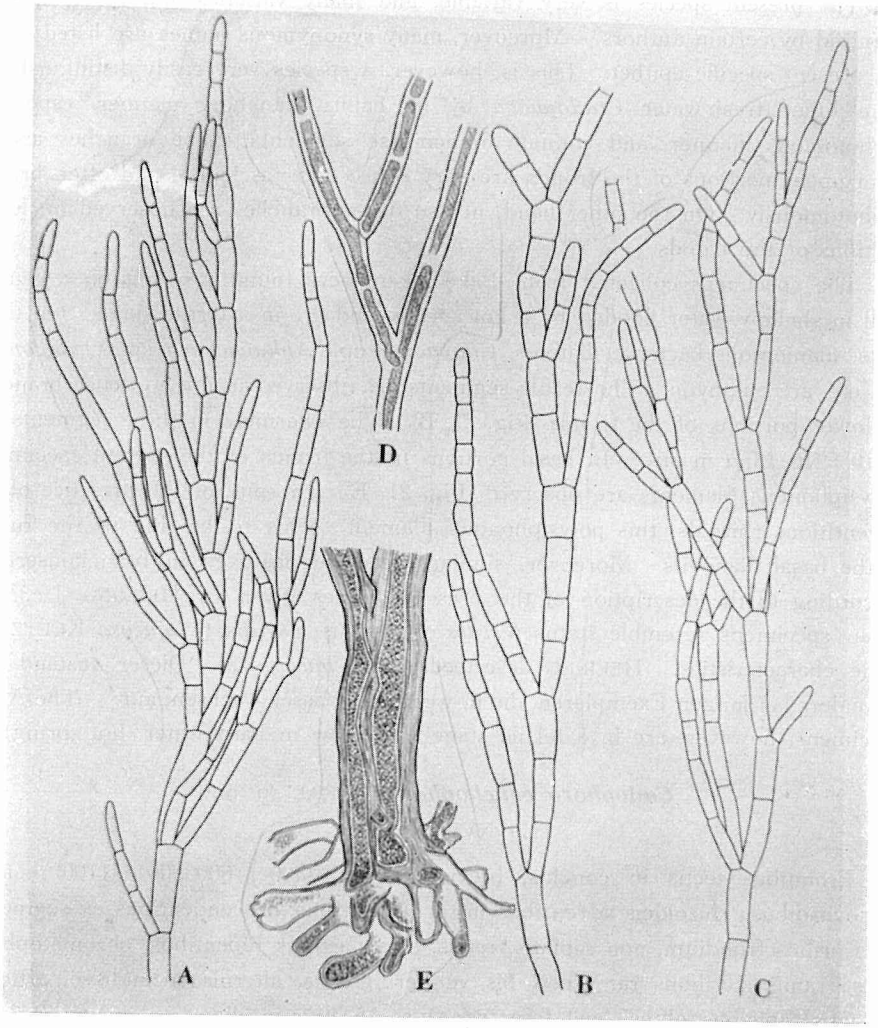

Fig. 21. *Cl. glomerata* KUETZING

A, B, C. Upper portions of fronds × 33. D. Middle portion, showing side insertion of branch × 33. E. Rhizoid × 64.

posed of segments 2–4 (–6) times as long as diam., with thin lateral membranes, 5–12 μ thick, 1/20–1/12 times as thick as diam.; branchlets and ultimate branchlets alternate or opposite downwards, secund upwards, arising from each or distant articulation, erect, short (2–4 segmented) or long top-portions, (35–) 40–80 μ in diam., composed of segments 2–4 (–6) times long as diam., ending in obtuse apices; insertion and evection generally normal, often connated at branch-bases.

The present species is very variable, and many varieties and forms are recognized by certain authors. Moreover, many synonymous names are listed under the present specific epithet. This is, however, a species very easily distinguishable from other fresh-water *Cladophora* by its habit, branching manner, especially trichotomous manner, and connate branch-base segments. The branches arising from upper portions of the fronds are very dense, like fascicules, and often branch trichotomously. On the other hand, not so dense branches are observed on lower portions of the fronds.

The specimens collected from Lake Akan were found growing on a cement wall in shallow water flooded by a hot spring, and are in a fertile stage. On these tufts, filamentous bacteria, diatoms, *Characium* sp., *Aphanochaete* sp., *Oedogonium* sp., etc. are epiphytic. The fertile segments are observed in not so dense branches of lower portions of the fronds (Fig. 21, B). The swarmers in these segments are (7–10)×(10–13) μ in size. In basal portions of the fronds of the present specimens, polysiphonous filaments are observed (Fig. 21, E). In spite of the presence of the abventitious rhizoids, this polysiphonous filament seems to be due to the fusion of the basal filaments. Moreover, similar facts are observed in branch-insertion. According to the description of the present species given by HEERING (l. c.), the Akan specimens resemble status *fertiles* and status *mucosis* (f. *mucosa* KUETZ.) in some characteristics. HEERING described status *musosis* as "Dieser Zustand tritt besonders bei jungen Exemplaren, die in weichem Wasser wachsen, auf." The Akan specimens, however, are in a fertile stage and grow in hard water (hot spring).

Cadophora conchopheria SAKAI, sp. nov.

Pl. XVI, 2; Fig. 22

Frondibus tectis in conchis, brevissibus, ca. (400–) 600–900 (–1100) μ altis, fuscoviridibus; rhizoideis adventibus intracuticularibus, descendentibus ex segmentis inferioribus frondium, non septatis, rectis, sine partibus repentibus, chromatophoris laxis; ramis sterilibus ramurosis bis vel ter, erectis, alternis secundisve, articulis levigatis, apicibus obtusis vel fere truncatis, 15–40 μ in diam. segmentis 3–6 (–9)-plo diametro longioribus; segmentibus fructiferis sursum maturientibus, doliiformibus vel sphaericiis, 35–50 μ diam., 1–2-plo diametro longioribus; membranis lateralibus crassis plicatostriatis, sursum 1/7–1/5-plo, deorsum 1/5–1/3-plo diametro crassioribus.

Jap. name: Kaigoromo (nov.).

Type loc.: Nagahama, near Maizuru City, Kyoto Pref. (May, 1949, I. UMEZAKI).

Hab.: Eramachi, Hokkaido (Sept., 1957, Y. HASEGAWA); Shimoda, Shizuoka Pref. (April, 1960, M. CHIHARA).

Fronds growing on shells, very short, about (400–) 600–900 (–1100) μ high, full

green in colour; rhizoids adventitious, intracuticular, descending from lower segments of fronds, non septate, straight, without creeping portion, having thin chromatophores; vegetative branches branching twice or rarely thrice, erect, alternate or secund, with smooth articulations, 15–40 μ in diam., composed of segments 3–6(–9) times as long as diam., ending in obtuse or nearly truncate apices; fruiting segments barrel-shape to spherical, ripening upwards, 35–50 μ in diam., composed of segments 1–2 times as long as diam.; lateral membranes thick-stratified, 1/7–1/5 times as thick as diam. upwards, 1/5–1/3 times downwards.

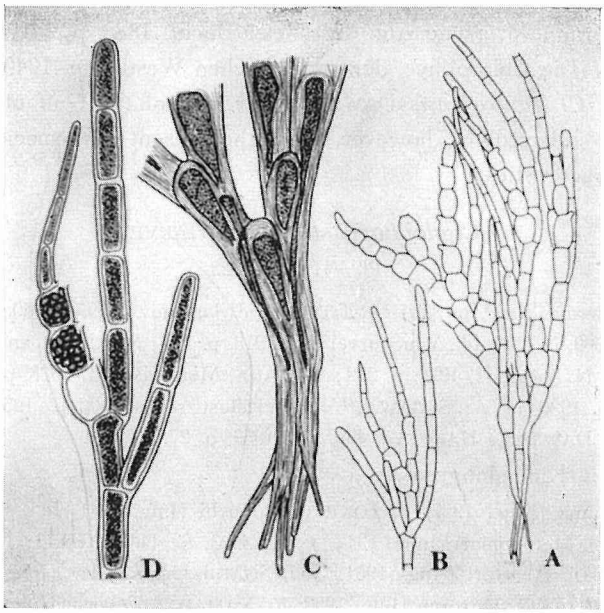

Fig. 22. *Cl. conchopheria* SAKAI

A. A plant × 56. B. A portion of a plant × 56.
C. Base of a plant, showing thick stratified membrane and rhizoid × 20. D. Fertile segments × 20.

This is a unique species, and is only found on shells of *Turbo* (*Lunella*) *coronatum* GMELIN (Japanese name, "Sugai"), beautifully green in colour, velvety, and is characterized by the following features:

(1). minute species less than 1 mm high; the smallness and colour of the species suggest some species of Cyanophyceae.

(2). intracuticular adventitious rhizoids; the writer had never seen a quite intracuticular adventitious rhizoid in the Japanese species, but in this species they descend intracuticularly from lower segments of the fronds (Fig. 22, C).

(3). fruiting segments; in the ordinary species of the genus, the segments mature

from the top downwards. In this species, however, they mature ordinarily from the bottom upwards. On the contrary, reproductive cells are formed from the top downwards in the Shimoda specimens. In the former cases, upper segments become thorn-like, as in many species of Chaetophoraceae. The liberation pore of swarmers is formed on the bill-like projection (Fig. 22, D).

(4). swarmers; about $18\times5\,\mu$ in size, and larger and more oblong than that of ordinary species of the genus (Fig. 22, D).

Minute speceis already known to the world are *Cl. caspia* GRUN. ("Alg. u. Diat. aus den Kaspischen Meere, 1878, p. 99"; 3–4 mm high), *Cl. pygmaea* REINKE ("Einige neue braune u. grüne Alg. der Kieler Bucht, 1888, p. 241"; 0.5–1 mm), *Cl. tuberosa* KYLIN (Die Chlorophyc. der schwedischen Westküste, 1949, p. 58, Fig. 59; 1–1.5 mm), and *Cl. tiburonensis* DAWSON (Mar. alg. of the Gulf of Calif. 1944, p. 211; 3–4 mm). They differ, however, from the present new species by the above mentioned characteristics.

Cladophora stimpsoni HARVEY

Pl. VII ; Fig. 23

Charact. new alg., 1859, p. 333; DE-TONI, Phyc. Jap. nov., 1895, p. 60; COLLINS, Green alg. N. Amer., 1909, p. 338; Id., Vancourver Isl., 1913, p. 104; SETCHELL and GARDNER, Mar. alg. Pacific coast N. Amer. II, 1920, p. 219; YAMADA, Mutsu Bay II, 1928, p. 501; OKAMURA, Nippon kaiso shi, 1936, p. 54; SEGAWA, Coloured illust. seaweeds Jap., 1956, p. 10, pl. 5, fig. 47; HARVEY, in DAWSON's HARVEY's Jap. alg. 1959, p. 27.

Jap. name: Kinu-shiogusa.

Hab.: Rakuma (Aug., 1927, J. TOKIDA), Tôbuchi (July, 1941, Id.), Kaibatô Isl. (Aug., 1933, MORIMOTO), Motodomari (June, 1942, J. TOKIDA), Saghalien, HFH; Lake Saroma (July, 1947, K. IWAMOTO), Abashiri (Aug., 1951, K. INAGAKI), Oshoro Bay (June, 1832, Id.), Otaru (June, 1954, E. OHTAKE), Muroran (July, 1933, Y. YAMADA), Tôbetsu (July, 1936, J. TOKIDA, HFH), Hakodate (May, 1903, K. YENDO), Hokkaido; Asamushi, Aomori Pref. (Y. YAMADA; May, 1944, T. SEGI); Yonezaki (June, 1954, and May, 1951, S. KAWASHIMA), Iwate Pref.; Onagawa, Miyagi Pref. (June, 1942, S. INOH).

Fronds on rocks or on other algae, caespitose, 15–30 cm high, yellowish or full green, delicate, silky gloss, of gelatinous texture; rhizoids primary and adventitious, dividing irregularly, composed of many segments, about 20–60 (–80) μ in diam., 2–4 times in end-segments, 4–10 (–20) times as long as diam. in other segments; adventitious ones intracuticular in upper half of them, the latter extracuticular; stems not distinguishable; main branches di- trichotomous, sometimes polychotomous, straight, about 120–160 μ in diam., composed of rather long segments, about 3.5–7 times as long as diam., with rather thick lateral membranes; branches di- trichotomous, straight, forming acute axils with smooth or slightly constricted articulations, rather long top-portions, 3–4 segmented, acute or subacute apices,

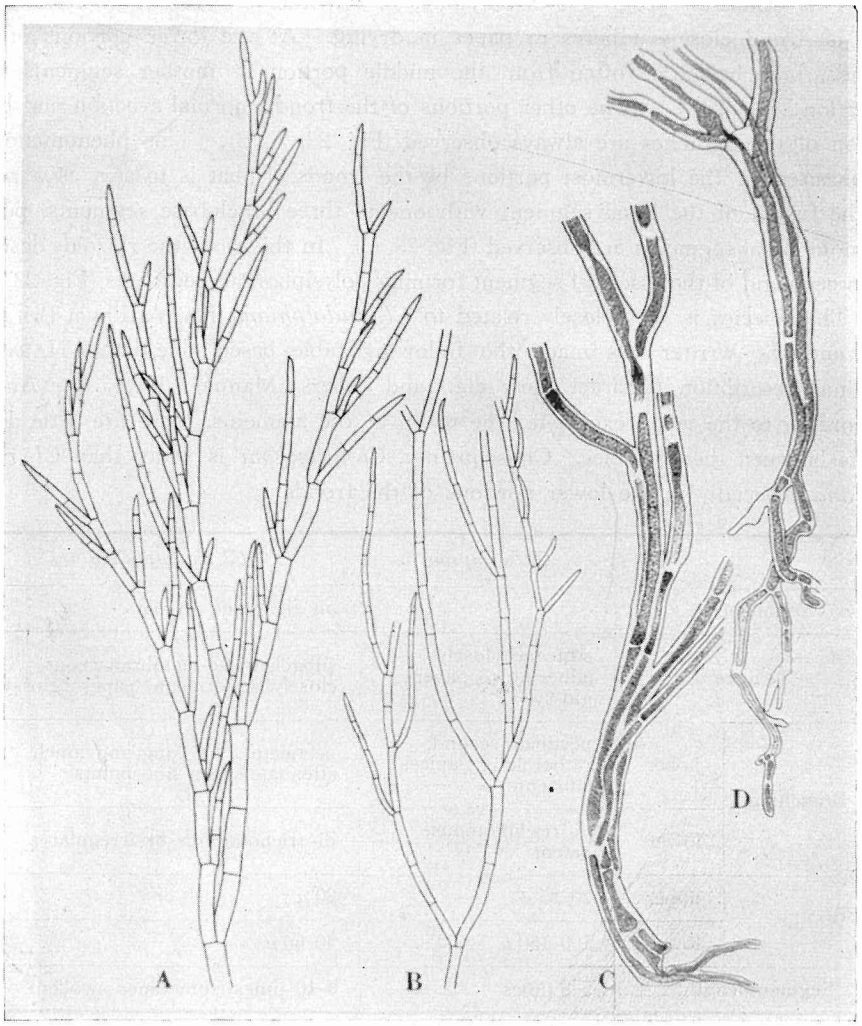

Fig. 23. *Cl. stimpsoni* HARVEY

A. Upper portion of a frond × 20. B. Middle portion × 13.
C. Lower portion of a frond, showing polysiphonous segments × 28.
D. Frond-base showing rhizoid and bisiphonous portion × 28.

95–115 μ in diam., composed of segments 3–6.5 times as long as diam.; branchlets and ultimate branchlets alternately secund, secund, or sometimes opposite, straight, forming acute axils, arising from every smooth or slightly constricted articulation, 2–8 segmented, 30–60 μ in diam., composed of segments 4–10 times as long as diam., ending in obtuse apices; insertion and evection normal.

This beautiful species grows on stones or on other algae in the elittoral zone, and its frond closely adheres to paper in drying. At the lower portions of the fronds, branches arise often from the middle portion of mother segments (side insertion) (Fig. 23, C). The other portions of the fronds, normal evection and basal fusion of the branches are always observed (Fig. 23, A, B). This phenomenon is emphasized in the lowermost portions of the fronds. That is to say, as a result of the fusion of the basal segment with one to three brach-base segments, polysiphonous basal segments are observed (Fig. 23, C). In this case, the rhizoids descend from each end of the essential segment forming polysiphonous segments (Fig. 23, C).

This species is very closely related to *Cl. rudolphiana* HARV. (Phyc. Brit., pl., 86), and the wrriter has made the following table based chiefly on HARVEY's original description (Charact. new alg.) and others (Manual; Phyc. Bor.-Amer.). According to the table, except for the width of the filaments, there are little differences between these species. Consequently, *Cl. stimpsoni* is wider than *Cl. rudolphiana* especially in the lower portions of the fronds.

		Cl. stimpsoni	*Cl. rudolphiana*
Habitat			on algae and stones
Texture		soft and closely adhering to paper; glossy	subgelatinoso-membranaceous, closely adhering to paper; glossy
Branching	upper	pectinato-secund, rather long; apices subacute	pectinate, very long and much attenuated to a fine points
	lower	di- trichotomous, patent	di- trichotomous or irregular
Width*	upper	20–25 μ	20 μ
	lower	100–150 μ	40–60 μ
Segment-length		5–8 times	6–10 times (sometimes swollen)

* Adopted from COLLINS (Green alg. N. Amer.) who described these two species in the same paper.

Cladophora fastigiata HARVEY

Pl. I, 1; Fig. 24

Charact. new alg., 1859, p. 333; DE-TONI, Phyc. Jap. nov., 1895, p. 60; YAMADA, Mar. Chlorophyc. Ryukyu, 1934, p. 43; OKAMURA, Nippon kaiso shi, 1936, p. 57; HARVEY, in DAWSON's HARVEY's Jap. alg., 1959, p. 28; SEGAWA and KAMURA, Mar. fl. Ryukyu Isls., 1960, p. 8.

Jap. name: Chabo-shiogusa.

Hab.: Naha (May, 1932, Y. YAMADA), Mabuni (Apr., 1957, S. KAMURA), Ryukyu Isls.; Takarazima Isl. Tokara Isls. (May, 1953, E. OGATA).

Fronds on rocks, small, 1.5–3 cm high, dark green, very rigid, not so caespitose, flabelliform; rhizoids primary and adventitious, few, descending from frond-bases and lower segments of fronds, usually non septate, dividing di- trichotomously,

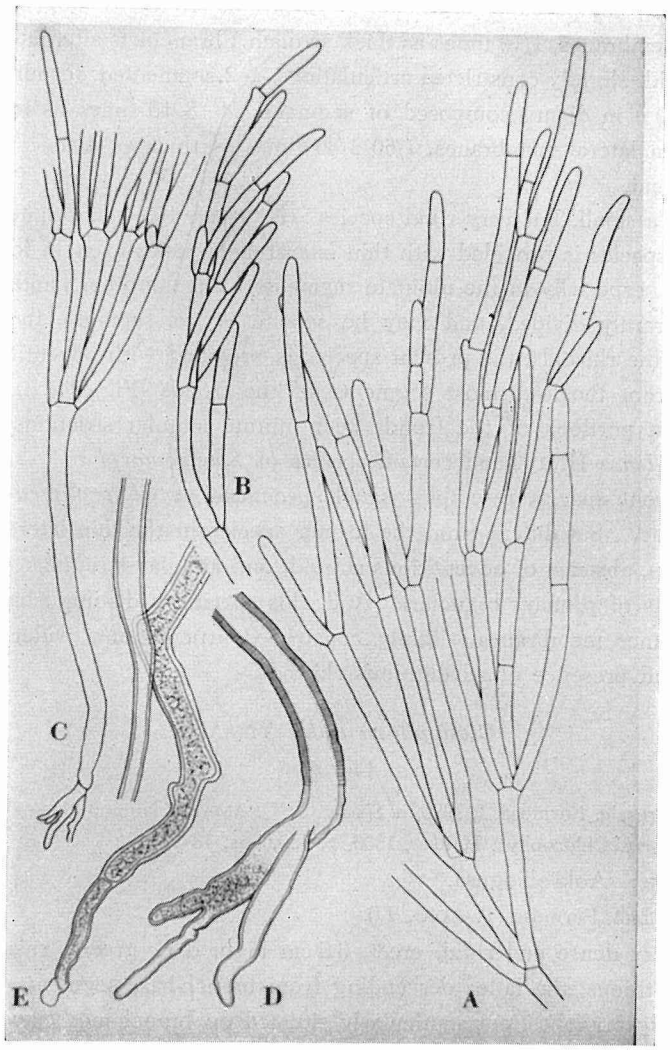

Fig. 24. *Cl. fastigiata* HARVEY

A, B. Upper portions of fronds × 13. C. Basal portion, provided with primary rhizoid × 13. D. basal portion, showing annular striations and rhizoid × 20. E. An adventitious rhizoid × 20.

45–125 μ in diam., with or without chromatophores; primary branches distinguishable, long, erect, nearly nude, with annular striations near base, (140–) 230–265 μ in diam., composed of segments reaching 25 times as long as diam., with thick and stratified lateral membranes, 1/10–1/8 times as thick as diam.; branches tri- polychotomous, erect, with slightly constricted articulations, forming acute axils, 160–225 μ in diam., composed of segments (4–) 8–25 (–30) times as long as diam., with thin lateral membranes, 1/10 times as thick as diam.; branchlets alternate or opposite, few, erect, with slightly constricted articulations, 1–2 segmented, forming very acute axils, 160–230 μ in diam., composed of segments (4–) 8–15 times as long as diam., with very thin lateral membranes, 1/60–1/30 times as thick as diam.; insertion and evection normal.

This is "a small, but very rigid species" (HARVEY, 1959). In spite of the rigid texture, this species is provided with thin lateral membranes even in lower portions of the fronds, especially in the ultimate segments. On the other hand, the rhizoids are simple, rarely divided, and may be septate or non-septate. In spite of the simplicity of the rhizoids, the present species is provided with adventitious rhizoids descending from the lowermost segments of the fronds (Fig. 24, E). Moreover, the lowermost portions of the fronds bear minute annular striations (Fig. 24, D) just like *Cl. densa* HARV. and certain species of *Spongomorpha*.

The present species resembles small specimens of *Cl. prolifera* KUETZ. and *Cl. densa* HARV., but differs from the former species in the thin lateral membrane, long segments, absence of adventitious rhizoid, and annular striations of the lowermost segments of primary branches. And, this species is distinguishable from *Cl. densa* in thinner membranes, slightly constricted articulations, wider diameter of branchlets, and presence of adventitious rhizoids.

Cladophora aokii YAMADA

Fig. 25

Stud. Meeresalg. Formosa, I, 1925, p. 85, fig. 3; OKAMARA, Nippon kaiso shi, 1936, p. 56; TSENG, Stud. mar. Chlorophyc. Hainan, 1936, p. 150, figs. 13–14.

Jap. name: Aoki-shiogusa.

Hab.: Byôbitô, Formosa (T. AOKI, TI).

Frond very dense and rigid, erect, 3.5 cm high, dark green; rhizoids primary (?) and adventitious, the latter descending from branch-base segments, non septate, seldom slightly branches, extracuticularly situated on branch-mother segments, 25–60 μ in diam., very long, with simple ends; main branches reaching 240 μ (or more) in diam., with constricted articulations, composed of short segments, about (1–) 2–4 (–6) times as long as diam., provided with thin lateral membranes; branches fasciculate, di- trichotomous, forming very acute axils, reaching 240 μ in diam., composed

of short segments; branchlets opposite or sometimes secund, forming acute axils, 75–170 μ in diam., composed of segments (1–) 2–4 times as long as diam., with constricted articulations, ending often in short segments (nearly one time) and rounded apices; insertion and evection normal; or somewhat loose.

The above diagnosis depends chiefly on the type specimen (TI) and the orginal description.

The present species seems to be a rare alga, and is quite a unique one. It is characterized by its trichotomous branches forming acute axils and abundant rhizoids. In many cases, ultimate segments of branchlets are shorter than other segments (Fig. 25, A). The characteristic abventitious rhizoids descend from branch- or branchlet-base segments of almost all portions of the frond even from the upper portion (Fig. 25, B). In all cases, no septum is formed between rhizoid-mother segments (=branch-base segments) and rhizoids. This manner or rhizoid-formation remined the writer of a species belonging to sect. *Rugulosae*. Moreover, abundant rhizoids descending even from the upper portion of ihe frond of this species is similar to those of some species beloning to the subgenus *Aegagropila*. In the type specimen, however, there is no annular constriction, and insertion of branches and evection are in normal manner. The present species may belong to sect. *Opacae*, though the writer could not be convinced of the presence of primary rhizoids. But the erect habit suggests the presence of it.

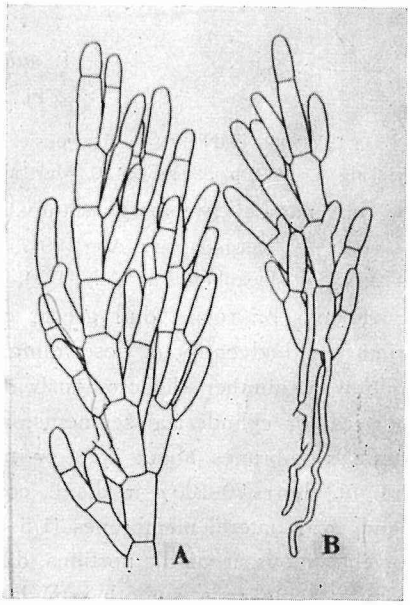

Fig. 25. *Cl. aokii* YAMADA
A, B. Upper most portions of a frond, showing branching manner and adventitious rhizoids × 28.

The present species resembles *Cl. sibogae* RBD. in its opposite branches and abundant adventitious rhizoids. But, it differs from *Cl. sibogae* by its habit, narrower axils, and properties of the rhizoid. The rhizoids of *Cl. sibogae* are septate, and are provided with hapteron-like ends. In the case of the present species, rhizoids are non-septate, and have simple rhizoid-ends. According to these characters *Cl. aokii* is clearly distinguishable from *Cl. sibogae*.

TSENG (l. c.) reported the present species from Hainan, China. The segments of his specimens are wider and larger than the type specimen. And he noted that

"The formation of the above described rhizoids seems to be favored by the presence of mud and foreign substances".

Cladophora rupestris (L.) KUETZING

f. ***rupestris***

Cl. rupestris (L.) KUETZ., Phyc. gen., 1843, p. 270.
Conferva rubestris LINNAEUS, "Syst. natur. II, 1765, p. 721".
Hab.: Unknown from Japanese coasts.

f. ***submarina*** FOSLIE

Pl. XII, 1; Fig. 26

in "WITTR. et NORDST., Alg. exsicc., no. 619, et in Bot. Notiser, 1884, p. 125"; DE-TONI, Syll. alg. I, 1889, p. 329; FOSLIE, Mar. alg. Norway, 1890, p. 135.

Jap. name: Iwa-shiogusa (nov.).

Hab.: Menashidomari (Aug,. 1947, Y. SAKAI), Shirikishinai (July, 1954, Id.; S. KAWABATA), Cape shickubi-misaki (July, 1954, Y. SAKAI), Hokkaido.

Fronds on rocks, dull green, caespitose, erect, 7–20 cm high, rigid; rhizoids primary and adventitious, descending from frond-bases and lower portions of fronds, but few in number, dichotomously divided, septate, 40–50 μ in diam., composed of spherical or cylinderical segments, reaching 10 times as long as diam., with thin lateral membranes about 1/10 or more times as thick as diam.; main branches straight, short, 70–100 μ in diam., composed of segments 2–4 (–20) times as long as diam., with lateral membranes (1/5–) 1/6–1/8 times as thick as diam.; branches di-polychotomous in middle portions, di- tichotomous in upper portions, rather straight, forming acute axils, smooth articulations, 50–75 μ in diam., composed of segments 2–4 times as long as diam., with lateral membranes about 1/10 times as thick as diam.; branchlets lateral or sometimes opposite, long, straight or somewhat curved, forming acute axils, 40–60 μ in diam., slightly or not constricted articulations, composed of segments 2–4 times as long as diam., with thin lateral membranes; fertile segments forming at upper portions of fronds, clavate, with clearly constricted articulations, wider than branchlets, reaching 120 μ in diam., 1–2 times as long as diam.; insertion and evection normal.

The present alga grows on rocks, and has rigid texture and is dull green in colour. The Shirikishinai and Shiokubi specimens grew on rocks at the mouth of a small stream. The vegetative segments of branchlets are cylindrical, but fertile segments are clavate and in curved rows (Fig. 26, A). And, the septa of this alga are separate from the other and form cavities.

The writer has had no opportunity to read the original description or to see any specimen, but could observe the specimen named *Cl. rupestris* f. *submarina*

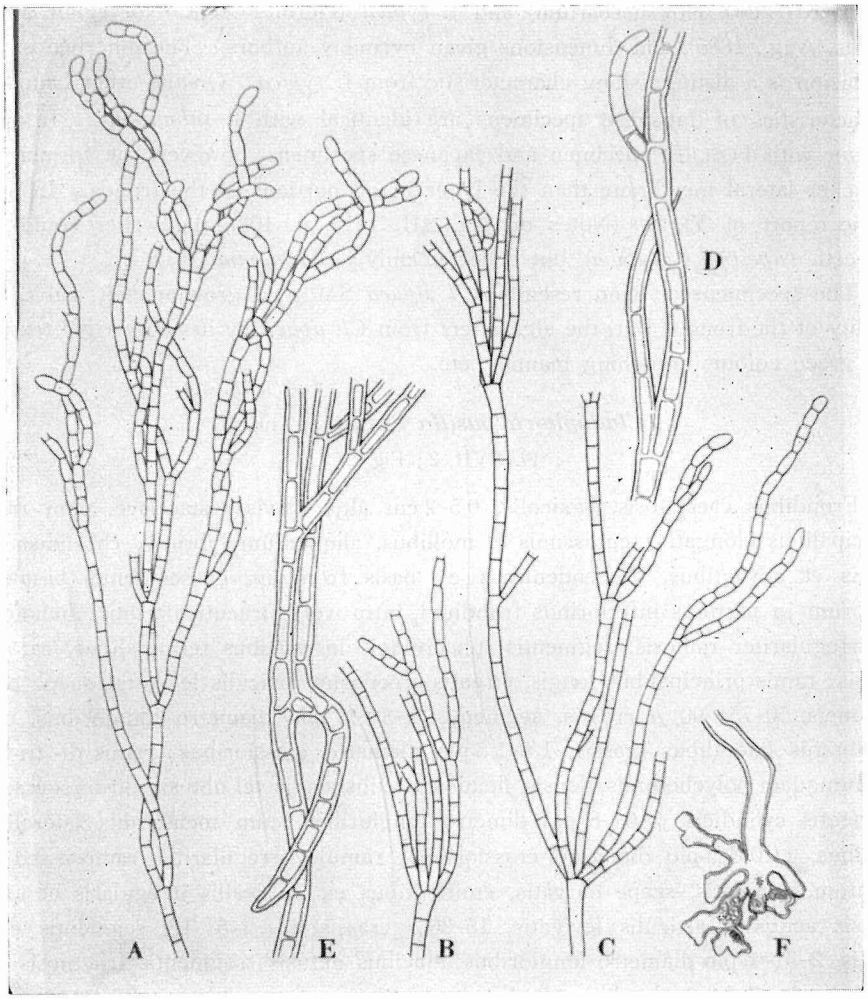

Fig. 26. *Cl. rupestris* KUETZING f. *submarina* FOSLIE

A. Upper portion of a frond in fertile stage × 28.
B, C. Middle portions × 28. D. Lower portion, showing connate at the branch base × 39. E. Adventitious rhizoid × 39.
F. Primary rhizoid × 64.

FOSLIE (Herb. FOSLIE, Norvegian austr., Svinor, Aug., 1885) in the Herbarium of the Tokyo Univ. of Fisheries. It is about 5 cm in length, and the dimensions of the segments of it are as follows: in the branchlets 40–60 μ in diam., and (2–) 3–4 times as long as diam.; in branches reaching 85 μ in diam., and 3–5 (–9) times as long as diam. Moreover, it is slenderer than the specimens named *Cl. rupestris*

(Herb. KÜTZING, Rijksherbarium) and f. *typica* (Herb. FOSLIE, Norvegian austr., Svinor, Aug., 1885), and dimensions given by many authors. The differnce of the dimension is a distinguishing characteristic from f. *typica*. On the other hand, the characteristics of Japanese specimens are identical with f. *submarina*. In comparison with FOSLIE's specimen and Japanese specimens, however, the former has a thicker lateral membrane than the latter in all portions of the fronds. In spite of the report of YENDO (Notes on alg., III, 1915, p. 103), the writer could not coll ectf. *rupestris* (=*typica*), but collected only f. *submarina*.

The specimens at hand resemble *Cl. opaca* SAKAI in growing belt, habit, and rigidity of the frond. But, the alga dffers from *Cl. opaca* by its more rigid texture, dull green colour, branching manner, etc.

Cladophora pusilla SAKAI, sp. nov.

Pl. XVII, 2; Fig. 27

Frondibus caespitosis, saxicolis, 0.5–2 cm altis, flavis testaceisve, cum ramis principalibus elongatis, tenuissimis et mollibus, aliquantum lubricis; rhizoideis primariis et adventibus, descendentibus ex basis frondium et segmentis basalibus ramorum in partibus inferioribus frondium, intra- vel extracuticularibus, dichotome vel irregulariter ramosis, segmentis sphaeroideis in partibus terminalibus, ca. 40 μ crassis; ramis principalibus longis, virgatis erectisque, articulis levigatis, saepe polysiphoneis, 50–75 (–90) μ crassis, segmentis 2–3 (–17)-plo diametro longioribus, cum membranis lateralibus crassis, 1/6–1/5-plo diametro crassioribus; ramis di- tri- vel nonnumquam polychotomis, densis, flexuosis, axilis acutis vel obtusis, 30–55 μ crassis, segmentis cylindicis, 3–6 (–8)-plo dimetro longioribus, cum membranis lateralibus tenuibus, 1/10–1/9-plo diametro crassioribus; ramulis irregulariter ramosis,sed aliquantum pectinatis, saepe curvatis, emittentibus ex intervallis irregularis et axilis obtusis acutisve, articulis levigatis, 15–30 μ crassis, (1–) 4–8 (–15) segmentis compositis, 2–3 (–4)-plo diametro longioribus, apicibus obtusis; segmentis fructuosis 20–40 μ crassis, 2–3 (–4)-plo diametro longioribus, articulis constrictis, formantibus in partibus superioribus frondium.

Jap. name: Ko-shiogusa (nov.).

Type loc.: Asari, Hokkaido (Aug., 1947, Y. SAKAI).

Fronds saxicolous, caespitose, 0.5–2 cm high, yellow or strow colour, provided with long stems, very slender and soft, somewhat gelationous; rhizoids primary and adventitious, descending from frond-bases and from branch-base segments of lower portions of fronds, intra- or extracuticular, dividing dichotomously or irregularly, ending often in small rounded segments, about 40 μ in diam.; primary branches long, virgate and erect, with smooth articulations, often polysiphonous by means of intracuticular rhizoids, 50–75 (–90) μ in diam., composed of segments 2–3 (–17)

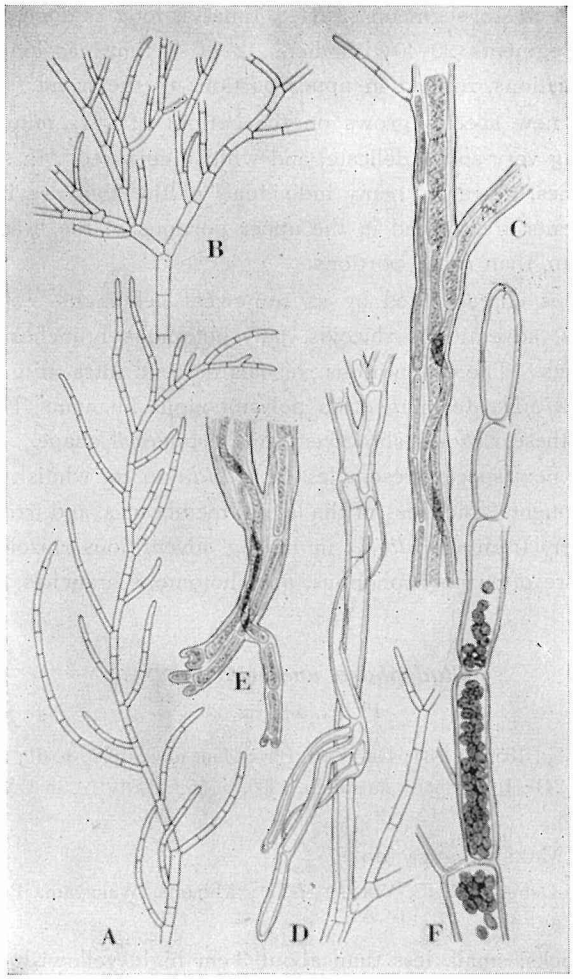

Fig. 27. *Cl. pusilla* SAKAI

A. Upper portion of a frond, showing branching manner × 28.
B. Middle portion × 28, C. Intramatrical rhizoids of lower portion of frond × 33. D. Extramatrical rhizoid × 33.
E. Base of a young plant × 33. F. Fertile segments × 200.

times as long as diam., with thick lateral membranes, 1/6–1/5 times as thick as diam.; branches di- tri- or sometimes polychotomous, dense, flexuose, forming acute or obtuse axils, 30–55 μ in diam., composed of cylindrical segments, 3–6 (–8) times as long as diam., with lateral membranes 1/10–1/9 times as thick as diam.; branchlets branching irregularly, but nearly pectinate, often curved, arising at irregular intervals and obtuse or acute axils, with smooth articulations, 15–30 μ in diam.,

composed of (1–) 4–8 (–15) segments, 3–6 (–8) times as long as diam., ending in obtuse apices; fruiting segments 20–40 μ in diam., 2–3 (–4) times as long as diam., with constricted articulations, formed in upper portions of the frond.

The present new species grows on the bottom of very minute tide pools of breakwaters, being very small, delicate, and whitish coloured. In spite of the smallness of the species, however, many individuals of the alga are in a fertile stage. The fertile segments are formed in the upper portions of the branchlets, and they have darker colour than other portions.

This species is characterized by its somewhat gelatinous texture, rather long primary branches, adventitious rhizoids, polychotomous branches, and irregularly arranged branchlets. The adventitious rhizoids descend intra- (Fig. 27, C) or extracuticularly (Fig. 27, D), forming often polysiphonous filaments (Fig. 27, C). The end-segments of these rhizoids show very small spherical shape.

The present new species resembles *Cl. albida* in its whitish colour, softness, dimensions of segments, thickness of the lateral membranes, and irregular branchlets. It differs, however, from *Cl. albida* in having adventitious rhizoids, long primary branches which are often polysiphonous, polychotomous branches, and smallness of the fronds.

Cladophora uncinella HARVEY

Pl. XI, 1; Fig. 28

Charact. new alg., 1859, p. 334; DE-TONI, Phyc. Jap. nov., 1895, p. 61; OKAMURA, Nippon sorui meii, 1902, p. 241; Id., Nippon kaiso shi, 1936, p. 55; HARVEY, in DAWSON's HARVEY's Jap. alg., 1959, p. 28.

Jap. name: Maki-shiogusa (nov.).

Hab.: Amami-Oshima Isl. (C. WRIGHT; TI); Mihama, Wakayama Pref. (Feb., 1960, T. YAMAMOTO).

Fronds on rocks, small, less than about 3 cm high, yellowish green in drying, dense pluvinate and subfastigiate; rhizoids primary and adventitious, descending from frond-bases and lower portions of the frond, septate, irregularly divided, 20–40 μ in diam.; main branches short, composed of long segments, reaching 15 times as long as diam., 40–100 μ in diam., with somewhat thick lateral membranes, 1/10–1/5 times as thick as diam.; branches trichotomous or sometimes di- or polychotomous, forming obtuse or acute axils, angularly bent, 100–140 μ in diam., composed of segments 6–8 times as long as diam., with thin lateral membranes; branchlets dense, trichotomous, forming somewhat acute or obtuse axils, angularly bent, 60–110 μ in diam., composed of segments 5–8 times as long as diam., provided with incurved top-portions consisting of (1–) 2 (–4) segments, ending in obtuse apices, with constricted articulations; ultimate branchlets secund, solitary or in pairs, arsing

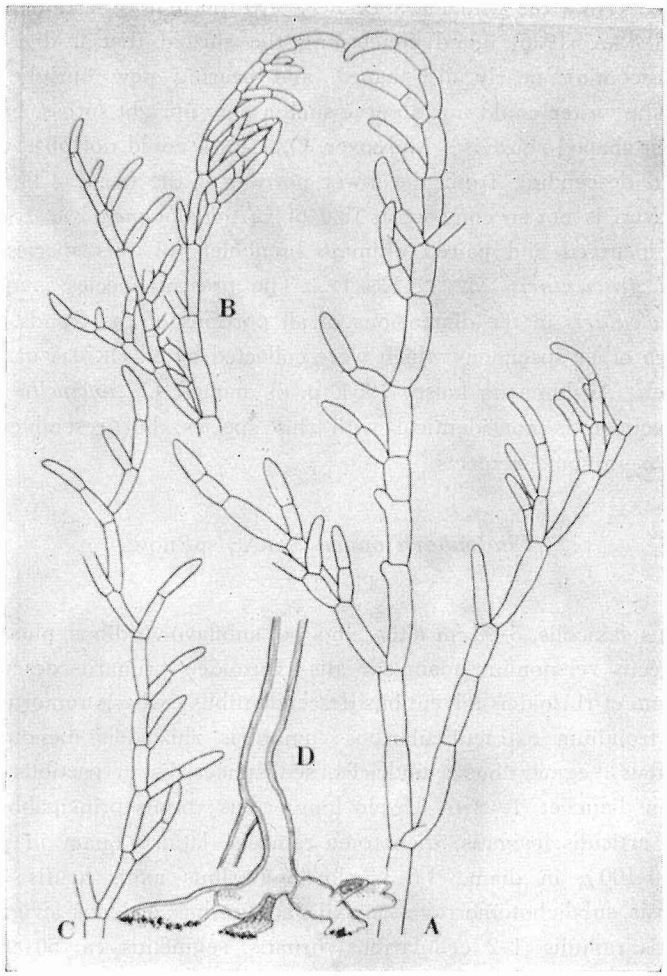

Fig. 28. *Cl. uncinella* HARVEY

A –C. Upper portions of a frond, A, B. × 93. C. × 39.
D. Rhizoid × 130.

from each articulation and somewhat acute axils, hooked, with constricted articulations, 35–70 μ in diam., composed of segments 3–6 times as long as diam., ending in obtuse or acute apices; insertion and evection normal, but seldom irregular.

The specimen (TI) distributed under the title of "North Pacific Exploring Expedition under Captain JOHN ROGERS" commingles with small species of *Entermorpha*. HARVEY (1859) described the colour as "laetevirens", but the above mentioned specimen and the Mihama specimens are yellowish green or nearly straw colour

in dried state. And, the Mihama specimens are the first collection from Honshû, Japan. OKAMURA (1936) noted concerning the rhizoid that it divides from the frond-base, becoming nearly disc-shaped, and bearing new upright sprosses (in Japanese). The writer could not observe such a new upright spross, but recognized the nearly disc-shaped rhizoids. Moreover, OKAMURA could not observe the adventitious rhizoid descending from the lower portion of the frond. The disc-shaped rhizoid, however, is not so compact as that of *Cl. ohkuboana* HOLMES. Under the microscope, incurved and paired ultimate branchlets of this species remind the writer of *Cl. fascicularis* (MERT.) KUETZ. The present species is quite different from *Cl. fascicularis* in the dimensions of all portions of the fronds.

There are other specimens which were collected by Y. OKADA in Aoshima Isl., Miyazaki Pref. (Aoshima no kaiso, 1954, p. 6), named *Cl. uncinella* HARV. The Aoshima specimen is not identical with this species, but resembles *Cl. scitula* (SUHR) KUETZ. in some respects.

Cladophora opaca SAKAI, sp. nov.

Pl. XI, 2

Frondibus saxicolis, 5–20 cm altis, albo- vel subflavo-viridibus, plus minus densis et rigidis, erectis vel nonnumquam curvatis; rhizoideis primariis descendintibus ex basis frondium, et rhizoideis adventibus descendentibus ex basis ramorum in partibus inferioribus frondium extracuticularibus; ambobus rhizoideis dichotome ramosis, multicellularibus, segmentibus cylindriciis, sed sphaericiis in partibus terminalibus, ca. 30–60 μ in diam. et (1–) 3–6 (–15)-plo longioribus; ramis principalibus erectis vel subflexuosis, articulis levigatis, dichotome ramosis, latioris quam in partibus allis, segmentis 80–100 μ in diam., 1.5–3.5-plo longioribus axilis acutis; ramis rectis vel subflexuosis, subdichotome ramosis, axilis acutioribus, articulis levigatis, nonnumquam pinnatis ramulis (1–2 cellularibus) ornatis, segmentis ca. 50–80 μ in diam., 2–4-plo longioribus; ramulis numerosis, alternatis vel unilateralibus, nonnumquam oppositis, axilis acutissimis, rectis, saepe aliquantum incurvatis, apicibus obtusis; ramulis ultimis emittentibus ex articulis omnibus ramulorum, pectinatis, 2–5 segmentis, 35–45 μ in diam., 2–5.5-plo longioribus; insertionis ramorum et evectionis normalib us in partibus superioribus mediisque, sed lateris in partibus inferioribus frondium. sporangiis ignotis.

Cl. glaucescens (non HARVEY) YENDO, Note on alg. V, 1916, p. 248; YAMADA, Mutsu Bay II, 1929, p. 501, fig. 3; OKAMURA, Nippon kaiso shi, 1936, p. 55; YAMADA and TANAKA, Shiretoko hantô, 1944, p. 176.

Jap. name: Tsuyanashi-shiogusa.

Type locality: Kamome-jima, Esashi, Hokkaido.

Hab.: Utoro, Shiretoko Peninsula (Sept., 1943, Y. YAMADA), Harutachi, Hidaka (Aug., 1953, Id.), Muroran (July, 1934), Hakodate (May, 1903, K. YENDO, HFH.; July, 1947, Y. SAKAI), Osatsube (July, 1938, Y. YAMADA and Y. NAKAMURA), Kamaya (Apr., 1940, Y. YAMADA et al.), Esashi (Apr., 1948, Y. SAKAI), Suttu (Apr., 1940, Y. YAMADA,) Okushiri Isl. (July, 1943, Y. HASEGAWA; July, 1934, K. INAGAKI), Shioya (July, 1940, Y. YAMADA and Y. NAKAMURA), Osyoro (June, 1931, K. INAGAKI), Hokkaido; Asamushi, Aomori Pref. (Y. YAMADA; July, 1927, S. INOH): Fudai (July, 1952, S. KAWASHIMA), Ofunato (May, 1951, Id.), Nakano (July, 1951, Id.), Yonezaki (June, 1954, Id.) Iwate Pref.; Onagawa, Miyagi Pref. (June, 1942, S. INOH).

Fronds on rocks, 5–20 cm high, whitish or yellowish green somewhat dense and rigid, erect or somewhat curved; primary rhizoids descending from frond-bases, and adventitious ones dencending from branch-bases in lowermost portions fronds, extracuticularly; both rhizoids dividing dichotomously, septate, composed of cylindrical, but spherical segments in terminal portions, (1–) 3–6 (–15) times as long as diam., about 30–60 μ in diam.; main branches erect or somewhat flexuose, with smooth articulations, dichotomous, 80–100 μ in diam., composed of cylindrical segments, 1.5–3.5 times as long as diam., forming acute axils; branches stright or somewhat flexuose, dichotomous, forming acute axils, with smooth articulations, 50–80 μ in diam., composed of segments 2–4 times as long as diam., sometimes provided with short branchlets (1–2 segmented); branchelets dense, alternate or unilateral, sometimes opposite, forming more acute axils, straight, often somewhat incurved, ending in obtuse apices; ultimate branchlets arising from every articulation of branchlets, pectinate, 2–5 segmented, composed of segments 2–5 times as long as diam., 35–45 μ in diam.; insertion and evection normal, but lateral in lower portions.

The present species grows on rocks in the tidal zone, and is common on the shores of Hokkaido and Northern Honshû of Japan. The individuals growing in the upper part of the tidal zone are shorter and denser than those growing in the lower part of the zone. In the dense form the frond has pectinate ultimate branchlets which are ornamented with short ramuli. In the Hakodate specimens ultimate branchlets of upper portions of the fronds are longer (composed of 10 segments) than those of the lower portions which are composed of 2–4 segments. The present species, however, is characterized by its glaucous green colour without gloss, rather of rigid texture, pectinate branchlets issuing from every segment, rather short branch-top portions (commonly 2–4, rarely reaching 10 segments), acute axilis, and obtuse apices. The primary rhizoids spread or creep on rocks like stolonids in the shape. The adventitious rhizoids, on the other hand, descend generally from branch-base segments of lowermost portions of the fronds, and at the beginning they often descend intracuticularly but in the later stage they descend extracuticularly. The writer has not been able to observe, however, any rhizoids which "traverse downwards through cell-rooms" (YENDO, l. c.).

On the other hand, *Cl. opaca* is more closely related to *Cl. flexuosa* (GRIFF.)

HARV. than to *Cl. glaucescens*. But, the species is more rigid than the specimens of *Cl. flexuosa* (Herb. G. THURET, Cherbourg, France, det. ED. BORNET; Phyc. Bor.-Amer., no. 2239, Montery, U. S. A., det. GARDNER), and slightly softer than *Cl. rupestris* f. *submarina* FOSLIE. Moreover, the species has a slender diameter of the main filaments and a greater value of relative segment-length of the branchlets of *Cl. flexuosa*.

Cladophora arenaria SAKAI, sp. nov.

Pl. XVI, 1; Figs. 29-30

Frondibus in saxibus tectis arenis, viridibus vel nonnumquam fusco-viridibus, ca. 3–9 cm altis, aliquantum rigidis, sursum dense ramosis; rhizoideis principalibus adventibusque, descendentibus ex basis frondium et ex segmentis basis ramorum inferiorum frondium ca. 35–50 μ crassis, segmentis minute spheroideis in partibus terminalibus; ramis principalibus erectis vel curvatis, longis, nonnumquam nudis, tenuioribus quam in partibus aliis frondium, 40–60 (–80) μ crassis, cum articulis levigatis et membranis crassis, 1/7–1/5-plo diametro crassioribus, segmentis aliquantum orciformibus, 2–5-plo diametro longioribus, nonnumquam bi- vel polysiphoniis; ramis dichotomis vel raro trichotomis, axilis obtusis formantibus, plerumque curvatis vel angulatis, cum articulis levigatis, saepe crassioribus quam in partibus aliis frondium, 50–60 (–80) μ crassis, segmentis brevioribus, 2–3-plo diametro longioribus, apicibus obtusis; ramulis pectinatis, sed saepe irregulariter ramosis, (1–) 3–5 segmentis, 40–50 μ crassis, formis segmentum irregularibus, (1–) 2–3 (–5)-plo longioribus, axilis obtusis vel acutis formantibus, cum membranis lateralibus tenuibus, 1/10–1/8-plo diametro crassioribus; insertionibus irregularibus.

Jap. name: Suna-shiogusa (nov.).

Type loc.: Hakodate, Hokkaido (Aug., 1947, Y. SAKAI).

Hab.: Hakodate (Apr., 1954, Id.), Muroran (Sept., 1947, Id.), Hokkaido.

Fronds on sand-covered rocks, green or sometimes brownish green, about 3–9 cm high, somewhat rigid, dense upwards; rhizoids primary and adventitious, descending from frond-bases and from branch-bases segments of lower portions of fronds, about 35–50 μ in diam., septate, composed of small spherical segments in terminal portions; main branches erect or curved, long, sometimes nude, narrower than other portions of fronds, 40–60 (–80) μ in diam., with smooth articulations and thick stratified lateral membranes 1/7–1/5 times as thick as diam., composed of sometimes barrel-shaped segments, 2–5 times as long as diam., sometimes bi- or polysiphonous; branches dichotomous or seldom trichotomous, forming obtuse axils, generally curved or angular, with smooth articulations, often wider than other portions, 50–60 (–80) μ in diam., composed of short segments, 2–3 times as long as diam.; branchlets pectinate, but often irregularly arranged, (1–) 3–5 segmented,

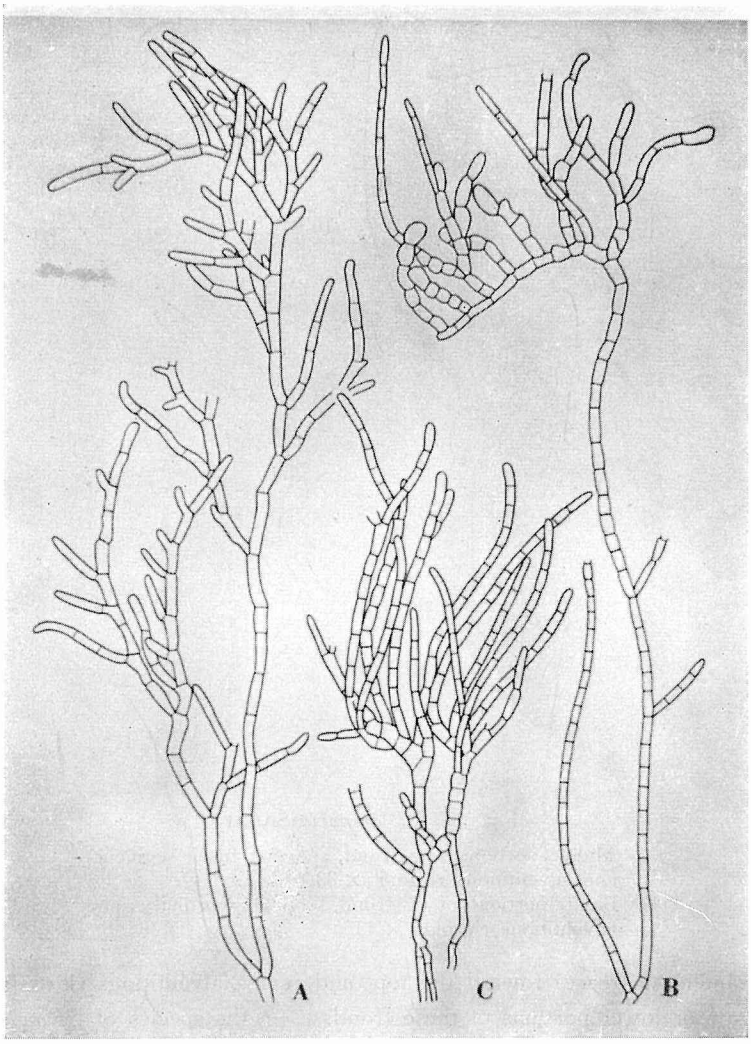

Fig. 29. *Cl. arenaria* SAKAI

A. Uppermost portion of a frond growing on rock × 21.
B, C. Uppermost portions of fronds growing in sand × 21.

40–50 μ in diam., composed of irregularly shaped segments, (1–) 2–3 (–5) times as long as diam., forming obtuse or acute axils, with thin lateral membranes 1/10–1/8 times as thick as diam., ending in obtuse apices; insertion irregular.

This species is characterized by its smallness, darker colour, somewhat rigid texture, and dense branches toward the top. Moreover, in many cases, the diameter

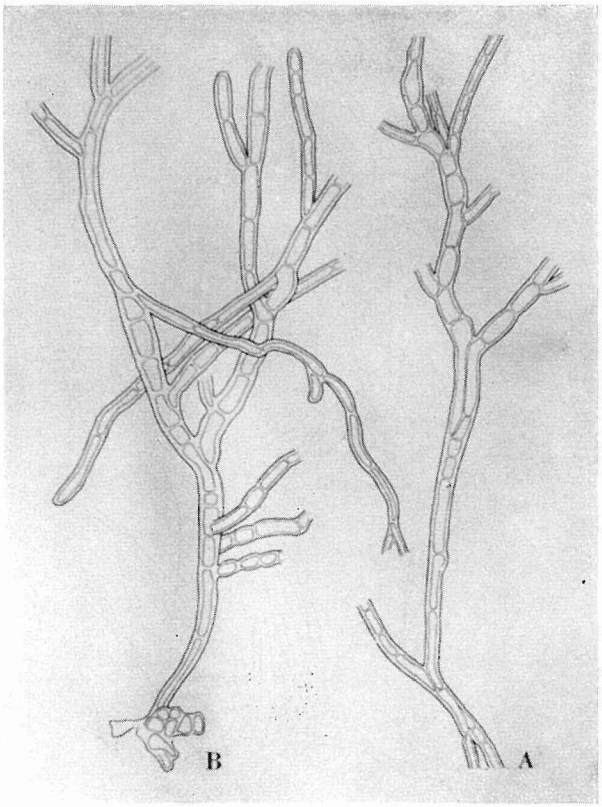

Fig. 30. *Cl. arenaria* SAKAI

A. Middle portions of a frond, showing fused segments and adventitious rhizoid × 33.
B. Basal portion of a frond, showing primary and adventitious rhizoids × 43

of the branches increases toward the top, and many adventitious rhizoids descend from middle or lower portions of these fronds as in the species of *Spongomorpha*.

The present species is very variable, and some interesting morphological features are visible. That is to say, the shape of the segments, the number of adventitious rhizoids, density of branches, several methods of insertions of branches, and ring-formed segments (SCHORR, 1938) are observed. Moreover, the polysiphonous (generally bisiphonous) filaments are often recognized partially in lower portions of the fronds (Fig. 30, A). The specimens growing on rocks which are covered by thick sand have short total length, nude primary branches, dense branches and increase in diameter upwards (Fig. 29, B). On the other hand, however, the specimens growing on rocks which are covered by thin layer of sand have long total

length, general branching manner, and decrease in diameter upwards (Fig., 29, A).

The present new species is closely related with *Cl. bertolonii* v. *corymbifera* (KUETZ.) ARDISSONE in following characteristics: "rigidula, obscure viridis, ramis omnibus basi concretis, erectis, ⋯; articulis omnibus ex membrana crassa cartilaginea formatis, primariis vel confluentibus, obsoletis" (KÜTZING, Sp. alg., 1849, p. 397; as *Cl. corymbifera* KUETZ.). In this species, however, increased diameter towards the apices, longer segments, dense branches towards the top, etc. are characteristics distinguishable from KÜTZING's species. From *Cl. opaca* SAKAI, the alga is distinguishable in having darker colour, narrower diameter, rather irregular branching manner, etc.

Sect. ***Rugulosae*** SAKAI, sect. nov.

Sepeciebus rhizoideis principalibus adventibusque ornatis; ruguloso-annulatis in partibus inferioribus frondium ornatis.

Species provided with primary and adventitious rhizoids; with annular constrictions in basal portions of fronds.

Cladophora rugulosa MARTENS

Pl. XV, 1; Figs. 31-32

Tange v. preuss. Exped. Ost-Asien, 1866, p. 112, pl. II, fig. 3; DE-TONI, Syll. alg. I, 1889, p. 306; Id., Phyc. Jap. nov., 1895, p. 59; KJELLMAN, Chlorophyc. fr. Jap., 1897, p. 26; OKAMURA, Icon. Jap. alg., vol. II, no. 6, 1910, pl. 80, figs. 1-7, p. 103; Id., Nippon kaiso shi, 1936, p. 51, fig. 25; PAPENFUSS, Notes S. African mar. alg. II, 1943, p. 79.

Apjohnia rugulosa (MART.) G. MURRAY, On new sp. Caulerpa, 1891, p. 209, pl. 52, fig. 5.

Jap. name: Kuro-shiogusa.

Hab.: Cape Omaezaki, Shizuoka Pref. (Apr., 1944, T. SEGI); Cape Iragosaki, Aichi Pref. (K. INAGAKI); Shirahama, Wakayama Pref. (June, 1951, T. YAMAMOTO).

Fronds on rocks or on shells at high tide level, about 3-8 cm high, erect, blackish or brownish in colour, cartilagineous, forming dense tufts; primary rhizoids descending from frond-bases, non-septate or rarely septate, divided irregularly, 60-125 μ in diam., very long, reaching 1 cm, with or without chromatophores; adventitious ones descending from branch-base segments of lower or middle portions of fronds, or from any portions, non-septate, at first intracuticular, but almost all portions and lower portions extracuticular, provided with annular constrictions; primary branches more or less elongate, sometimes more than 1 cm long, often one segmented, erect, provided with many adventitious rhizoids, with annular constrictions, 170-320 μ in diam., with thick stratified lateral membranes, 14-17 μ thick; branches whorled, sometimes 7-9 in lower portions, but mostly 2-3 upwards, arising from every articulation, erect-fastigate, forming acute axils, composed of nearly club-shaped segments, 7 (upwards)-17 (downwards) times as long as diam., 240-280 μ

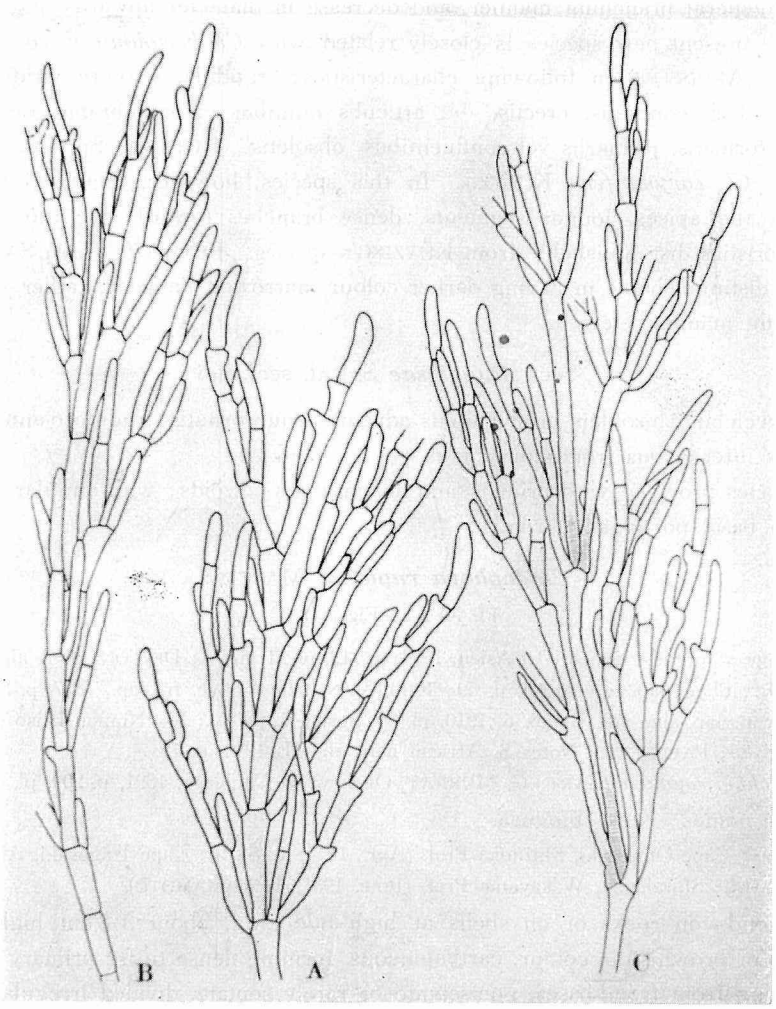

Fig. 31. *Cl. rugulosa* MARTENS

A, B. Uppermost portions of a frond A × 16, B × 13.
C. Lower portion of a frond, showing branching manner and annular constrictions × 13.

in diam., with rather thin lateral membranes, about 10 μ thick; branchlets and ultimate branchlets opposite or secund, arising from each articulation and acute axils, top-portions consisting of 1–2 segments, ending in blunt or subacute apices, 125–200 μ in diam., composed of cylindrical segments, 4–7 (–10) times as long as diam., evection loose, but insertion of branches not subterminal.

The present alga grows at high tide level in the southern parts of Japan, and

the adventitious rhizoids descend from the middle and lower portions of the fronds. Though adventitious ones are often observed in the genus *Spongomorpha*, in *Cl. rugulosa* there is no septum between rhizoid-mother segments (branch-base segments) and rhizoids (Fig. 32). That is to say, the appearance of abventitious rhizoids is due only to prolongation of the branch-base segments. One of the other char acteristics of the alga is the presence of the annular constrictions in the lower portions of the fronds. In the middle portions of the alga, however, annular constrictions are observed in lower portions of the segments (Fig. 31, C). From the standpoint of the portions bearing the annular constrictions, the present alga is more elaborate than *Cl. wrightiana* HARV. which has annular constrictions only in the lowermost segments.

No adventitious rhizoid is described or illustrated by MARTENS (l. c.) and MURRAY (l. c.). They illustrated, however, the fibrous rhizoids descending from frond-bases (primary ones). According to OKAMURA's figures and to the specimens at hand, as noted above, they are very obvious. On the branching manner, MARTENS (l. c.) described it as "filis dichotomis, remellis terminalibus fasciculatis, erectis, obtusis", but in his figures based on the specimen of Yokohama, Japan, trichotomous or opposite (Tab. II, fig. 3) and whorled branches (Id., fig. 3 b) are shown. Moreover, OKAMURA (l. c.) described the branches as "alternate manner and often 3–5 (sometimes 7–9 in lower portion, but mostly 2–3 upwards)".

PAPENFUSS (l. c.) indicated Port Natal of South Africa as the type locality of this species.

The present species resembles *Cl. pro-*

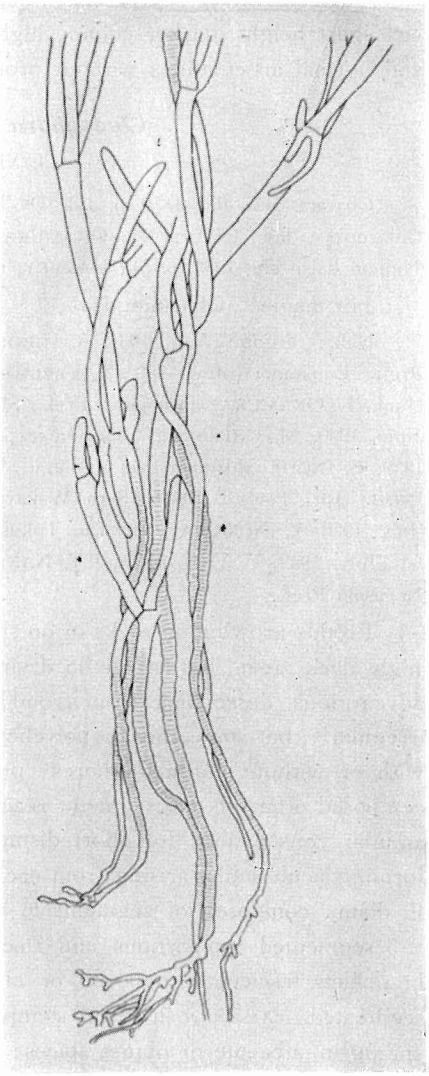

Fig. 32. *Cl. rugulosa* MARTENS
Frond base, showing many adventitious rhizoids, and annular constrictions × 13.

lifera KUETZ. as pointed out by PAPENFUSS. He noted that "In *C. rugulosa* the cells are considerable longer, the annular constrictions in the cells more pronounced, the main axis more prominent, and the whorls of short and longer branches more obvious" than *Cl. prolifera*. And it is related with *Cl. wrightiana* HARV. in vigorous habit and presence of annular constrictions. The present species, however, has short height, darker colour, high growing belt, abundant descending rhizoids, and normal articulations without protoplasmic protuberances.

Cladophora wrightiana HARVEY

Pl. XIV; Figs. 33-34

Charact. new alg., 1859, p. 333; DE-TONI, Phyc. Jap. nov., 1895, p. 60; KJELLMAN, Mar. Chlorophyc. Jap., 1897. p. 26; OKAMURA, Illustr. mar. alg. Jap. I, 6, 1902, p. 89, pl. 29; Id., Nippon kaiso shi, 1936, p. 51; HARVEY, in DAWSON'S HARVEY'S Jap. alg., 1959, p. 27.

Jap. name: Cha-shiogusa.

Hab.: Futomi (Aug., 1931, A. HIROHASHI), Kominato (Aug., 1960, S. ENOMOTO), Chiba Pref.; Enoshima (May, 1953, Y. YAMADA), Misaki (Aug., 1932, MACLENDON, TI), Moroiso (June, K. OKAMURA), Kanagawa Pref.; Shimoda (May, 1941, S. INOH; Apr., 1958, Y. SAKAI; June, 1960, M. CHIHARA), Cape Omaezaki (July, 1930, U. KIMOTO), Shikinezima Isl. (Aug., 1939, S. INOH), Shizuoka Pref.; Wagu, Mie Pref. (Apr., 1931, K. INAGAKI; June, 1942, S. INOH; Apr., 1944, T. SEGI); Seto, Wakayama Pref. (Apr., 1942, S. INOH); Ikata, Ehime Pref. (July, 1956, Y. NOMURA); Hiwasa, Tokushima Pref. (Feb., 1957, E. OHTAKE); Katsura-jima Isl. (July, 1942, Y. YAMADA and Y. NAKAMURA), Shûgen-jima Isl. (Id.), Fukue-jima Isl. (Id.), Nagasaki Pref.

Fronds growing on rocks or on shells, forming tufts, erect and filiform, 20–40 cm high, dark green, but brown in drying, very rigid and harsh; rhizoids primary and adventitious, descending from frond-bases and lower segments of fronds, dividing irregularly, but sometimes di- polychotomously, non-septate, (40–) 100–420 μ in diam., with or without chromatophores; primary branches erect, more or less elongate, composed often of one segment, reaching 4 cm in length, 500–800 μ in diam., with annular constrictions for short distances; branches opposite or whorled, straight, forming acute axils, arising from each articulation (sometimes each two), 400–650 μ in diam., composed of segments (6–) 10–15 times as long as diam., provided with 2–5 segmented top-portions and thick lateral membranes; branchlets or ultimate branchlets fasciculate, opposite or alternate, forming very acute axils, short, 1–2 segmented, 300–500 μ in diam., composed of segments 5–12 times as long as diam., ending in subacute or obtuse apices; each articulation (excepted 1–3 segments from apices) provided with protoplasmic protuberances, short, descending from lower end of segments, surrounded upper end of just beneath segment; insertion and evection normal.

The present species is distributed in warm seas around Japan, but is quite

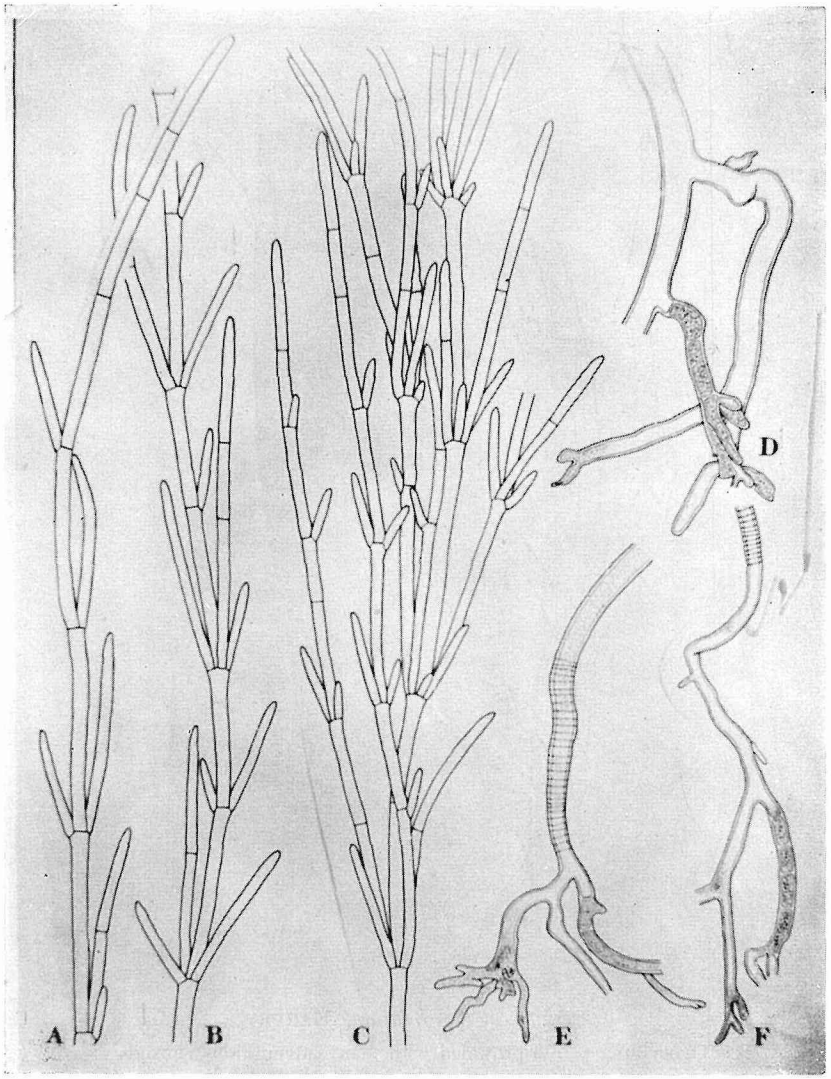

Fig. 33. *Cl. wrightiana* HARVEY

A, B. Uppermost portions of a frond × 3.5. C. Middle portion, showing branching manner × 3.5 D. Adventitious rhizoids × 13.
E, F. Rhizoid system, and annular constrictions. × 8.5.

a unique species. OKAMURA (1902) described the habitat as "extending from low tide to the depth of 15–18 fathoms".

This species have annular constrictions in lower portions of the fronds just like *Cl. rugulora* (Fig. 33, E, F). In younger stages (Fig. 34, A, B), as pointed out

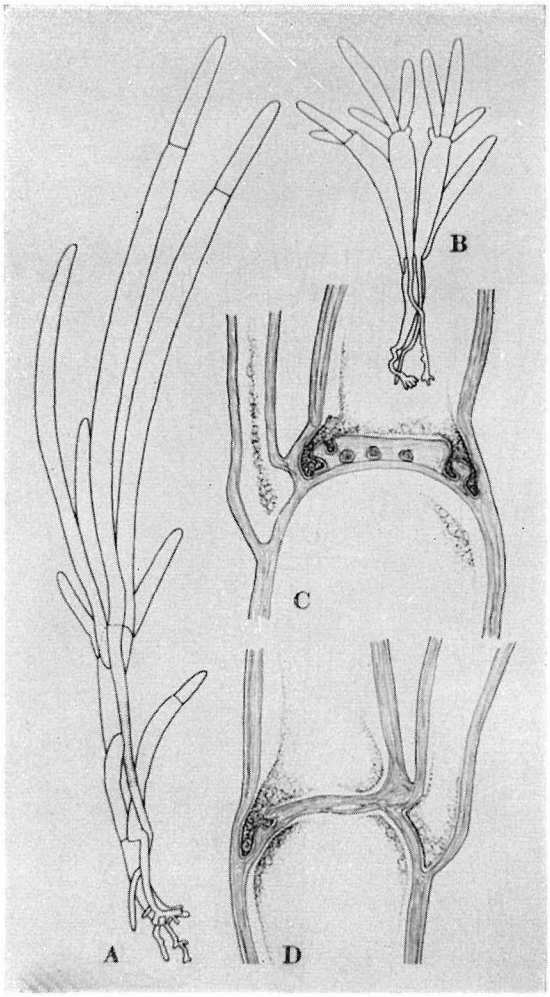

Fig. 34. *Cl. wrightiana* HARVEY

A, B. Two young plants provided with many adventitious rhizoids × 8.5.
C, D. Longitudinal sections through articulations showing protoplasmic protuberances. Peripheral portion (C) and median portion (D) × 39.

by CHIHARA (Stud. life-history green alg. (10). On *Cl. wrightiana*, 1960, pp. 1–11, fig. 2), many adventitious rhizoids descend from each basal end of branch-base segments as in the adult specimens of *Cl. rugulosa*. In the latter stages, however, the adventitious rhizoids decending from branch-base segments disappear. On the contrary, they descend only from frond-base segments. These young specimens are collected from Shimoda, the type locality, by M. CHIHARA, at June 11, 1960.

Moreover, the greatest peculiarity of this species is a special structure of articulations (CHIHARA, l. c.; SAKAI, Struct. articulations of *Cl. wrightiana*, 1960, pp. 1–4). The articulations of the fronds have 4–10, short, non-septate, intracuticular protoplasmisc protuberances. They descend from the lower end of the segment, and surround the upper end of the part just beneath the segment (Fig. 34, C, D), and are observed in well-developed conditions in the segments of the branch-insertions. This is the only species belonging to the genus *Cladophora* having the outstanding articulations.

The present species differs from *Cl. japonica* YAMADA by its short fasciculate branchlets, presence of the adventitious rhizoids and of the special articulations, and annular constrictions of the lowermost portions of the fronds.

Subgenus ***Aegagropila*** KUETZING, emend. SAKAI

Speciebus pulvinatis; rhizoideis adventibus, descendentibus ex partibus omnibus frondium; insertionibus evectionibusque laxis.

Species pulvinate; rhizoids adventitious, descending from all portions of fronds, insertion and evection loose.

Cladophora sauteri (NEES) KUETZING

Sp. alg., 1849, p. 414.

Fronds forming matted tufts, irregularly shaped or globular aggregations, reaching 25 cm in diam., with or without a pebble in aggregations; individual filaments 0.5–3.5 cm long, grass green, rigid or somewhat soft, branching dense; rhizoids only adventitious, descending chiefly from branch-base segments, or from any portions of fronds, intertwined with others, composed of septate, smooth articulations, dividing simply or sometimes irregularly, 15–50 μ in diam., composed of elongate segments, reaching 100 times as long as diam.; branches alternate, sometimes opposite, erect, arising from acute or obtuse axils, with smooth or slightly constricted articulations, 45–80 (–100) μ in diam., composed of cylindrical or sometimes slightly clavate segments (3–) 6–9 (–16) times as long as diam., with thin lateral membranes, 3–5 μ in thickness; branchlets or ultimate branchlets subsecund, often alternate, arising from acute or obtuse axils, top-portions consisting of (1–) 6–9 segments, provided with cylindrical segments, but slightly swollen in apical segments, 40–80 μ in diam., 3–12 times as long as diam.; insertion of branches subterminal, or sometimes lateral.

In Japan and its vicinity, this species is distinguished by its cylindrical segments from other fresh-water species of the subgenus *Aegagropila*, and the writer recognized three forms of this species.

Key to the forms

1. Axils of individual filaments very wide, reaching right angles; segments very long, (4–)7–20(–26) times as long as diam. . . . . f. *kannoi* (TOKIDA) SAKAI
1. Axils of individual filaments acute or obtuse; segments not so long, (3–)6–12(–17) times as long as diam. 2
   2. Ball-shaped aggregations with a pebble in centre, 1–3 layered; individual filaments somewhat soft . . . . . f. *kurilensis* (NAGAI) SAKAI
   2. Ball-shaped aggregations having no pebble, homogeneous layer; individual filaments somewhat rigid . . . . . f. *sauteri*

f. ***sauteri***

Pl. VIII, 2; Fig. 35

Cladophora sauteri (NEES) KUETZING, Sp. alg., 1849, p. 414; DE-TONI, Syll. alg. I, 1889, p. 342; BRAND, Cladophora-Aegagropilen des Süsswassers, 1902, p. 65.

Aegagropila sauteri (NEES) KUETZING, Phyc. gen., 1843, p. 273; Id., Phyc. Germ., 1845, p. 219; Id., Tab. phyc. IV, 1854, pl. 61; HEERING, in PASCHER's Süssw.-Fl. Deutschl., Heft 7, Chlorophyc. IV, 1921, p. 57; KANNO, Stud. *Aegagropila* Jap., 1934, p. 225; SAKAI, Marimo no keitai, 1952, pp. 57–66; KOSTER, Groene wierballen in Nederlandse plassen, 1959, p. 181, figs. 1, 3.

Cl. aegagropila f. *sauteri* RABENHORST, Fl. Europ. alg., 1868, p. 244.

Jap. name: Marimo.

Hab.: Lake Akan (Oct., 1894, Kôriyama, SAPA; Aug., 1951, Y. SAKAI; Aug., 1958, Oct., 1959, and Aug., 1960, Y. YAMADA et al.), Lake Tôro (Aug., 1948, H. HIROSE; June, 1960, E. OHTAKE), Lake Shirarutori (Dec., 1958), Hokkaido.

Globular aggregations reaching 25 cm in diam.; individual filaments somewhat rigid; rhizoids rather few, 20–50 μ in diam.; branches 40–80(–100) μ in diam., composed of somewhat long segments, 6–9 times as long as diam.; branchlets composed of cylindrical segments, (3–)9–12 times as long as diam., 40–85 μ in diam.

In 1924, this beautiful species of Lake Akan was designated as one of the special natural monuments of Japan. The ball-shaped aggregations are commonly 3–5 cm in diameter, but there are also greater globular aggregations (more than 10 cm in diam.) having hollow cavities in their centres. In many of the aggregations, individual filaments are arranged in radial orientation from their centres.

In other cases, in the egg-shaped and oblong aggregations, individual filaments are arranged in an irregular manner. Moreover, the irregularly arranged filaments sometimes cover the surfaces of the radial aggregations, forming double layered balls. These ball-shaped aggregations, however, occupy narrower areas than that of the lawn-like matted tufts in Lake Akan. The lawn-like aggregations are collected from deeper areas (more than 3 m in depth), and grow fully (reaching 3.5 cm

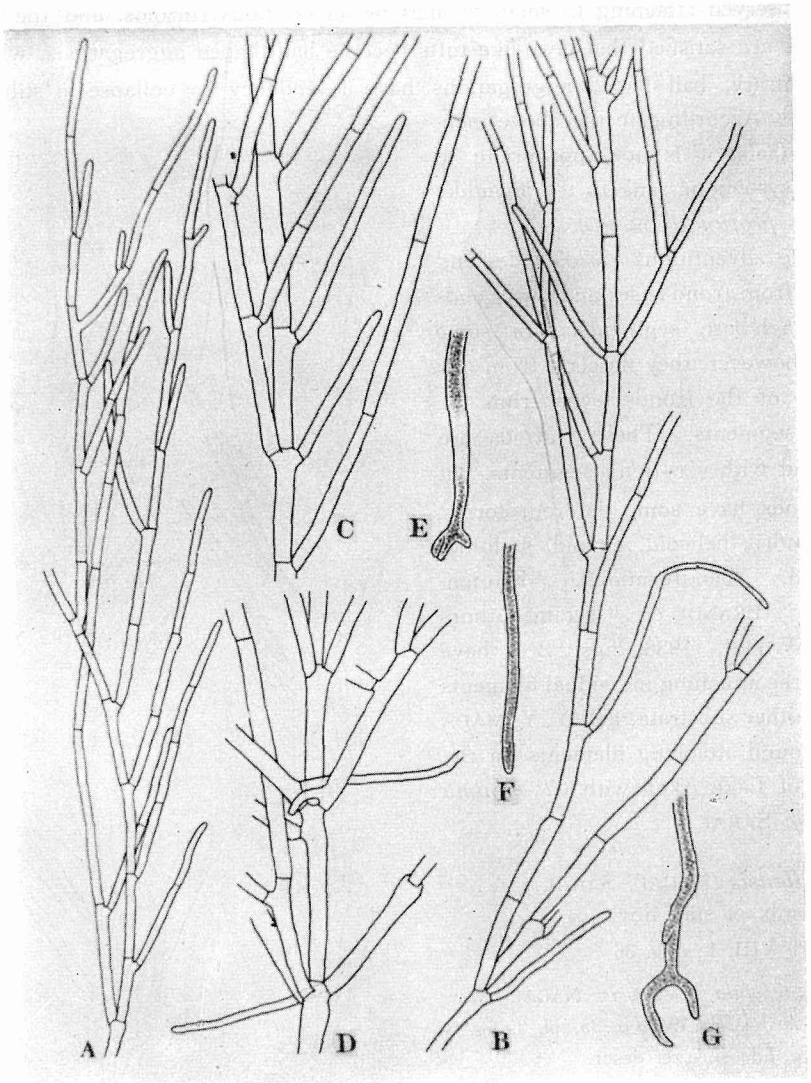

Fig. 35. *Cl. sauteri* KUETZING f. *sauteri*

A. Upper portion of a frond × 28. B, C. Middle portions, showing branching manner and neutral branch (B). B × 28, C × 34.
D. Lower portion, showing rhizoids × 39. E, F, G. Ends of rhizoids × 6,4.

in length) on the muddy bottom of the lake.

On the other hand, under the direction of Prof. Y. YAMADA, many lawn-like tufts and one ball-shaped aggregation are being observed in laboratory cultures which are given water current by magnetic stirrers. In this experiment, filaments

were observed attaching to small pebbles by adventitious rhizoids, and the experimenters are satisfied that lawn-like tufts become ball-shaped aggregations, while on the contrary, ball-shaped aggregations have a tendency to collapse in still water culture. According to the above mentioned facts, it is not appropriate to give a systematic rank to the lawn-like tufts (f. *profunda* BRAND).

The adventitious rhizoids descend chiefly from frond-bases and lower ends of branch-base segments. In some cases, however, they descend from any portion of the fronds, even from the apical segments. These rhizoids are provided with very long segments, but their ends have some different forms, e. g. tendril, helicoid, cirroid, stolonid, dermoid, "handförming", "Knotenbuscher" (BRAND), etc. Certain authors (e. g. WAERN, 1938, figs. 2–4) have shown the attaching individual filaments on the other substrata, and Y. YAMADA et al. found attaching filaments on the stones of Lake Akan with *Cl. minima* f. *crassa* SAKAI.

f. ***kurilensis*** (NAGAI), SAKAI, comb. et stat. nov.

Pl. VIII, 1; Fig. 36

Aegagropila kurilensis NAGAI, Mar. alg. Kurile Isls. I, 1940, p. 35, pl. 3, fig. 5. *pro parte, fide spec. et descr.*

Aeg. sauteri var. *yamanakaensis* OKADA, On a new var. of Aeg. sauteri etc., 1957, pp. 1–4, figs. 1–3, fide spec. et descr.

Aeg. sauteri var. *borgeana* (non NORDST.) KANNO, Stud. Aeg. Jap., 1934, p. 225, figs. 3–4, pro parte, fide spec.; OKADA, Stud. on ball-form. of Aeg. in Etorofu Isl., 1938, pp. 791–798, figs. 1–4, fide spec. et descr.

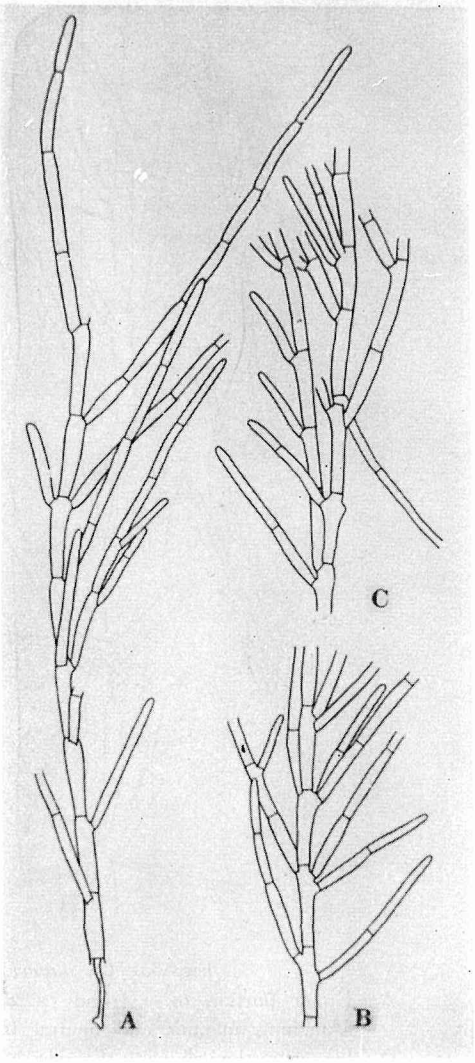

Fig. 36. *Cl. sauteri* KUETZING f. *kurilensis* (NAGAI) SAKAI

A. A plant with rhizoid × 33.
B, C. Middle portions of a frond, showing branching manaer and rhizoid × 33.

Jap name: Fuji-marimo.

Hab.: Lake Naibo, Etorofu Isl., Kuriles (July, 1934, M. NAGAI, SAPA; Aug., 1938, Y. OKADA); Lake Yamanaka, Shizuoka Pref. (Apr., 1957, SUGIURA).

Ball-shaped aggregations 1–3 cm in diam., compact or hollow, 1–3 layered, provided often with one pebble in centre; individual filaments somewhat soft; branches 45–80 μ in diam., composed of segments 6–10 (–14) times as long as diam.; branchlets 40–70 μ in diam.

According to OKADA (1938), there are three types of globular aggregations in the specimens collected from Lake Naibo: the first type shows a one-layered ball, which is at first a compact small aggregation, but develops a hollow cavity in greater aggregation (1.5–4 cm in diam.) without any pebble; the second type is a one to three layered ball with a pebble in the centre, having one layer and no cavity in small ball, and becoming concentric with 2–3 layers and a hollow cavity; the third type is a compact aggregation composed of irregularly (non radial) arranged individual filaments. On the other hand, the specimens of Lake Yamanaka are related to the juvenile stage of the second type, and to the third type of the Kurile specimens.

In spite of the description of the segments given by NAGAI as "subcylindricis" and "36–60 μ in diam.", the type specimen (SAPA) has cylindrical segments which are 50–80 μ in diam. and 3–9 times as long as diam. in branches, and 35–65 μ and 6–10 times in branchlets, and has rarely somewhat clavate segments. Except for the minimum dimension of branchlets of the fronds, the Kurile specimens are closely related to the Yamanaka specimens. Moreover, the double layered aggregation (Kurile specimens) are due to the ecological factors (cf. note on *Cl. sauteri* f. *sauteri*). According to these facts and the writer's opinion, the specimens from the Kuriles and Lake Yamanaka are to be included in one and the same taxon. On the other hand, the branching manner of individual filaments, shape and dimension of the segments are similar to *Cl. sauteri*, and the writer recognized the alga as one of the forms of the species. Upon observing the Chimikkepu specimen named *Aeg. kurilensis* by NAGAI (SAPA), the writer affirmed his description, "6–16 diametro longioribus". The Chimikkepu specimen has very wide axils (reaching a right angle) and very long cylindrical segments (reaching 25 times as long as diam.). According to these characteristics, this specimen is to be considered as another from of the present species.

f. ***kannoi*** (TOKIDA) SAKAI, comb. et stat. nov.

Pl. IX, 2; Fig. 37

Aegagropila kannoi TOKIDA, Mar. alg. southern Saghalien, 1954, p. 47, pl. III, figs. 1–4.

Aeg. kurilensis NAGAI, Mar. alg. Kurile Isls. I, 1940, p. 35, pl. 3, fig. 5, pro parte, fide spec. et descr.

Aeg. sauteri var. *borgeana* (non NORDST.) KANNO, Stud. Aeg. Jap., 1934, p. 225, figs. 3–4, pro parte.

Aeg. lagerheimii (non NORDST.) KANNO, Id., p. 225; OKAMURA, Nippon kaiso shi, 1936, p. 49.

Jap. name: Karafuto-marimo.

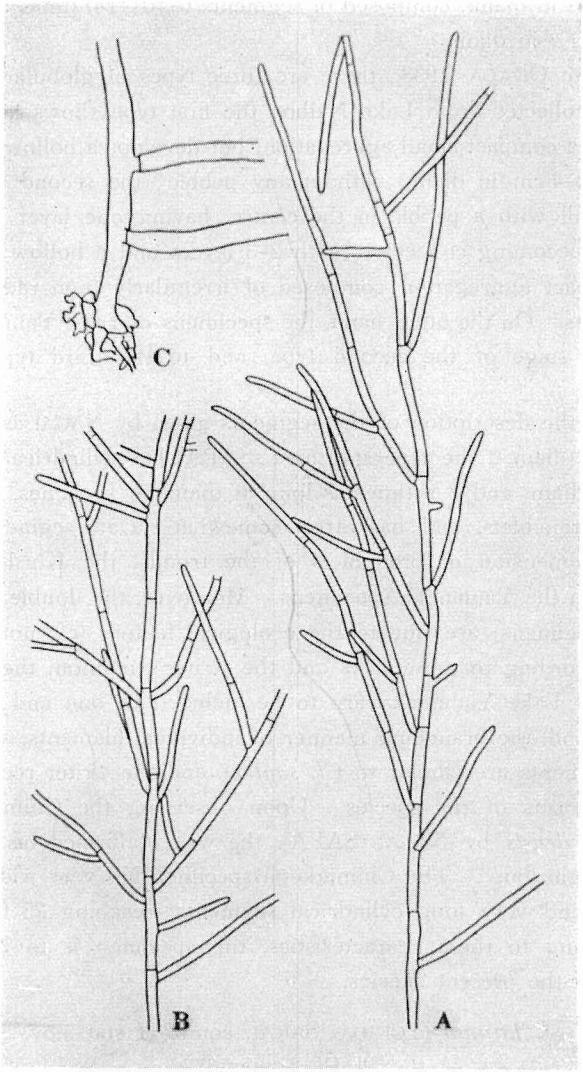

Fig. 37. *Cl. sauteri* KUETZING f. *kannoi* (TOKIDA) SAKAI
A. Upper portion of a frond × 28.
B. Lower portion × 28. C. Rhizoid × 64.

Hab.: Chimikkepu Marsh, Hokkaido (Aug., 1937, MATSUDA, SAPA).

Ball-shaped aggregations up to 5 cm in diam., solid; individual filaments flexuos; axils very wide especially downwards, reaching right angles; segments very long, (4–) 7–20 (–26) times as long as diam.; insertion subterminal, sometimes lateral, without matrical projection.

Ball-shaped aggregations of this alga collected from Chimikkepu Marsh are soild, and about 1–3 cm in diameter composed of lax entangled filaments. The writer could not observe the Saghalien specimen, but the Chimikkepu specimens are closely related to the description and figures of *Aeg. kannoi* TOKIDA. The segments of the Chimikkepu specimens have greater relative segment-length (4–) 7–20 (–26) times as long as diam. TOKIDA gives the value "5–20 times" to them, but in this specimen the writer observed sometimes longer segments especially in apical segments, reaching 26 times. The present form has very wide axils up to a right angle. These characteristics distinguish this form from other forms of this species.

The alga identified as *Aeg. kannoi* has characteristics similar to *Cl. sauteri* except for the length of the segments and wide axils. From the standpoint of these facts, it is by no means an independent species, but is to be recognized as a form of the species. On the other hand, KANNO (l. c.) has referred the Chimikkepu specimens with Kurile specimens to *Aeg. sauteri* var. *borgeana* NORDST. (SAPA). After him, NAGAI (1940) named both specimens as *Aeg. kurilensis*, but the former specimens are different from Kurile ones, and are referred to this form. Moreover, *Aeg. lagerheimii* NORDST. is different from this alga by its "vorgeruckte Schedewand", dimension of segments, etc.

In the Chimikkepu specimens, the writer could not observe segments which are "nonnulis terminalibus et intercalaribus raro inflatis ad 90–180 μ crassis" (TOKIDA, l. c.).

Cladophora minima (OKADA) SAKAI, comb. nov.

Aegagropilma minima OKADA, On new var. of Aeg. sauteri found in Lake Yamanaka, 1957, p. 4.

Fronds forming tufts attaching to stones, or free floating flattened or oblong aggregations, 1–1.5 (–3) cm in diam., compact, arranged in radial manner; individual filaments small, 0.5–1.0 cm long, grass green, somewhat rigid, densely branched; rhizoids adventitious, sometimes abundant, descending chiefly from branch-base segments, or from any portion of fronds, sepate, with smooth articulations, (15–) 20–55 μ in diam., composed of segments (7–) 10–25 times as long as diam.; branches opposite or lateral, erect, arising from acute axils, composed of clavate segments, 70–150 (–240) μ in diam., 2–4 (–6) times as long as diam., provided with rather thick lateral membranes, 3–6 (–10) μ in thickness; branchlets and ultimate branchlets sub-

secund, arising from acute axils, top-potions consisting of (1–) 6–8 segments, provided often with cylindrical segments, but sometimes dilated towards apices, or often clavate, (35–) 50–90 μ in diam., 2–8 (–13) times as long as diam.; insertion of branches subterminal or sometimes lateral.

The present species is characterized by small ball-shaped aggregations and clavate segments of the fronds. The rigidity of this species owes to thick lateral membranes, and it reaches 10 μ in thickness.

Key to the forms

1. Segments of branches 70–120 μ in diam.; free floating aggregations . . . . . f. *minima*
1. Segments of branches (65–) 100–170 (–240) μ in diam.; attaching to stones . . . . . f. *crassa* SAKAI

f. ***minima***

Pl. IX, 1; figs. 38, 39

Aegagropila minima, OKADA, On new var. of Aeg. sauteri found in Lake Yamanaka, 1957, p. 4.

Aeg. sauteri var. *minima* OKADA, in KOBAYASHI and OKADA's On new var. of Aeg. sauteri found in Honshu of Jap., 1953, pp. 99–103, figs. 1–4, fide spec. et descr.

Jap. name: Hime-marimo.

Hab.: Sakyonuma Marsh, Aomori Pref. (1951, S. NAKAJIMA; 1952, Y. KOBAYASHI).

Fronds forming free floating, flatten or oblong ball-shaped aggregations, composed of radial individual filaments; branches composed of segments 70–120 μ in diam.; branchlets and ultimate branchlets composed of cylindrical segments, but sometime dilated towards apices, (35–) 60–90 μ in diam.

The rhizoids are rarely observed in many aggregations, but are observed abundantly in some other aggregations, and they descend from lower ends or middle portions of branch-base segments or other segments (Fig. 38). In these cases, rhizoid-initial appears as a projection of the segment, then, it is cut off by the septum when it grows longer than about 6 times as long as diameter.

The present alga resembles *Cl. martensii* MENEGH. in some respects, but differs from it by dilated apical segments, wider diameter, and subterminal insertion of branches. Moreover, *Cl. minima* is distinguishable from *Cl. linnaei* KUEZING by its "Ausgesprochen subterminal Insertion häufig, Septa oft provekt" (BRAND, 1902, p. 61), and dimension of segments.

The Kussharo-konuma specimens (Fig. 39) collected by H. HIROSE (SAKAI, Marimo no keitai, 1952, fig. 5 as *Aeg. sauteri*) agree with this form in many respects. In some cases, however, they have clavate segments even in apical portions

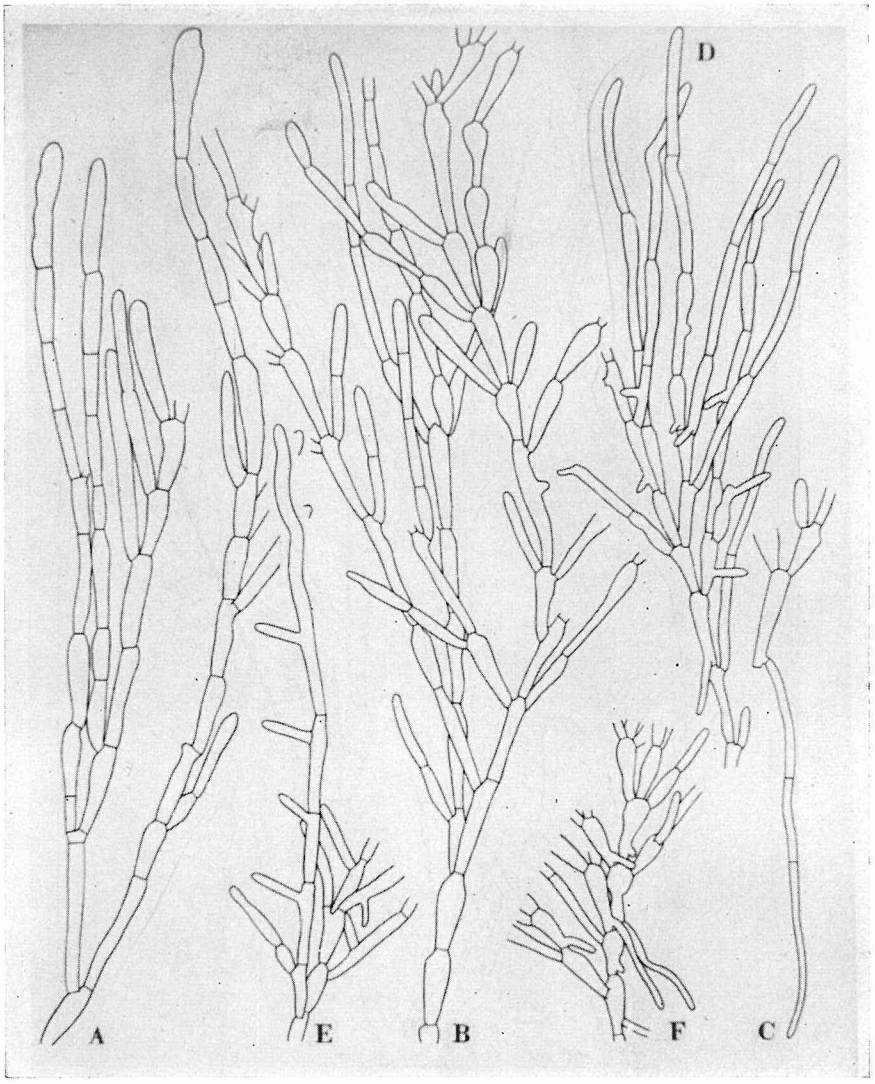

Fig. 38. *Cl. minima* (OKADA) SAKAI f. *minima*
A, D, E. Upper portions of fronds, showing dilated apices (A) and many rhizoid initials (D) × 33. B. Middle portion × 33.
C, F. Lower portion, showing rhizoids and their initials × 33.

(Fig. 39). Almost all individual filaments of this alga have many segments which have 1–4 globular calosities in these segment-cavities (Fig. 39, D). These calosities are comprised of 3 layers; the outer layer of the calosity originates from the inner layer of the lateral membrane, and the median and inner layers of them originate

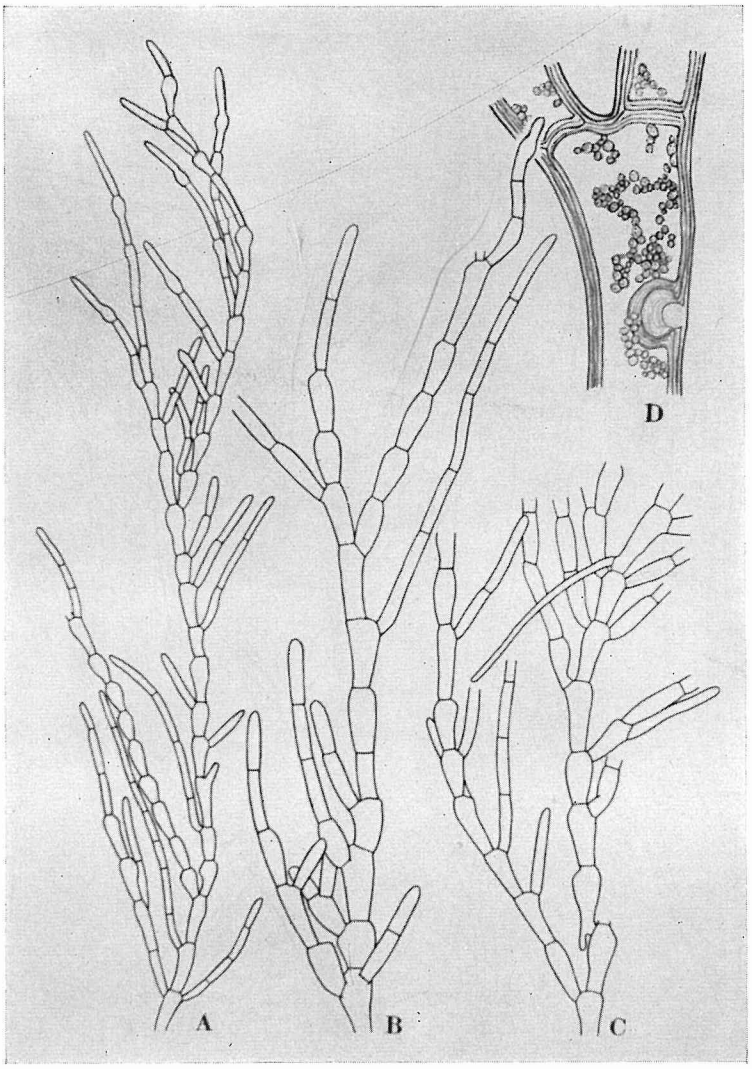

Fig. 39. *Cl. minima* (OKADA) SAKAI f. *minima*
A, B. Upper portions of fronds × A, 23, B, × 33.
C. Lower portion × 33.
D. A portion of segment, showing calosity × 33.

from the median and inner layers of the lateral membrane respectively. But the inner layer is not stratified but minutely punctate. These calosities are observed not only is inflated portions but also in non inflated portions. Accordingly, inflated portions are not related with presence or absence of them. They may be supposed

to be calosities attached by some parasitic fungus, but on the other hand, they seem to be a fundamental character of the alga as in the mechanical structure of *Caulerpa*. If the presence of the calosities is the fundamental nature of the Kussharo-konuma specimens, the alga will be recognized as a new form of *Cl. minima*. But a positive decision cannot be reached, because of the paucity of the material.

f. ***crassa*** SAKAI, f. nov.

Pl. X, 1; Fig. 40

Frondibus saxicolis; segmentis ramorum crassioribus quam in typo, (65–) 100–170 (–240) μ in partibus inferioribus frondium; segmentis ramulorum et ramulorum ultimum cylindricis, 45–80 μ in diam.

Jap. name: Futo-hime-marimo (nov.).

Type loc.: Lake Akan, Hokkaido (Nov., 1959; Aug. 1960, Y. YAMADA et al.).

Fronds on rocks; segments of branches wider than the type, (65–) 100–170 (–240) μ

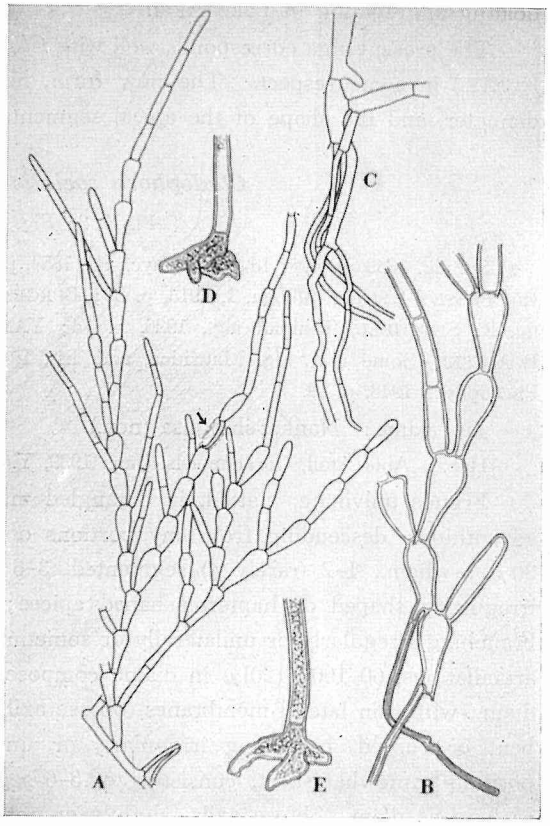

Fig. 40. *Cl. minima* (OKADA) SAKAI f. *crassa* SAKAI

A. Upper portion of a frond, showing branching manner and rejuvenescens × 22.
B. Lower portion × 39.
C. Lowermost portion × 26.
D, E. Ends of rhizoids × 30.

in lower portions of fronds; segments of branchlets and ultimate branchlets cylindrical, 45–80 μ in diam.

This alga was collected by a mud-sampler or grab for limnology from about 2–5 (–10) m deep points of Lake Akan. The individual filaments of this alga attach to small stones (SAKAI and ENOMOTO, Attaching organ of a spc. *Aeg.* growing on small stones, 1960, pp. 117–123, figs. 1–3) together with *Cl. sauteri* f. *sauteri* by adventitious rhizoids. When the writer met with the alga at first, he thought it to be one of the forms of *Cl. sauteri*, because only *Cl. sauteri* had been described from this lake. BRAND (1902) divided the fresh-water species of the subgenus *Aegagropila* into two groups; the one having clavate segments in main branches (incl. *Cl. linnaei*, *Cl. martensii*, *Cl. profunda*, and *Cl. holsatica*), the other having only cylindrical segments (incl. *Cl. armeniaca* and *Cl. sauteri*). According to his opinion, the present alga is quite different from *Cl. sauteri* in having clavate segments, more rigid texture, wider diameter, and short filament-length. YAMADA et al. have collected only attaching alga, but it cannot be said that there is no free floating aggregation in Lake Akan.

The present alga corresponds well with *Cl. holsatica* KUETZING (*Cl. froelichiana* KUETZ.) in some respect. The new form, however, differs from it in its wider diameter, and the shape of the apical segments.

Cladophora socialis KUETZING

Pl. X, 2; Fig. 41

Sp. alg. 1849, p. 416; Id., Tab. phyc., IV, 1854, p. 15, pl. 71, fig. 1; REINBOLD, in WABER van BOSSE's List alg. Siboga, 1, 1913, p. 82; BØRGESEN, Mar. alg., Easter Isl., 1924, p. 249, fig. 2; SETCHELL, Tahitian alg., 1926, p. 74; YAMADA, List mar. alg. Ant, 1944, p. 33; BØRGESEN, Some mar. alg. Mauritius, add. list, I, 1946, p. 28; Id., Add. list Chlorophyc. Phaeophyc., 1948, p. 19.

Jap. name: Nankai-shiogusa (nov.).

Hab.: Ants Atoll, Coraline Isls. (Jan., 1939, Y. YAMADA).

Fronds pulvinate, matted, in entangled masses, dark green, delicate; rhizoids adventitious, descending from any portions of fronds, long or short, narrow, 15–30 μ in diam., 1–2 (rarely 4) segmented, 3–6 times as long as diam., ending in irregularly shaped or hapteron-shaped apices; primary branches curved or bent, branching irregularly or unilaterally or sometimes opposite, with slightly constricted articulations, 60–100 (–120) μ in diam., composed of segments 3–6 times as long as diam., with thin lateral membranes, obtuse axils; branches or branchlets irregularly bent or curved, branching irregularly or unilaterally, branch- and branchlet-top portions somewhat short, consisting of 3–6 segments, 40–70 μ in diam., 3–6 times as long as diam., obtuse axils, slightly or not constricted articulations; chromato-

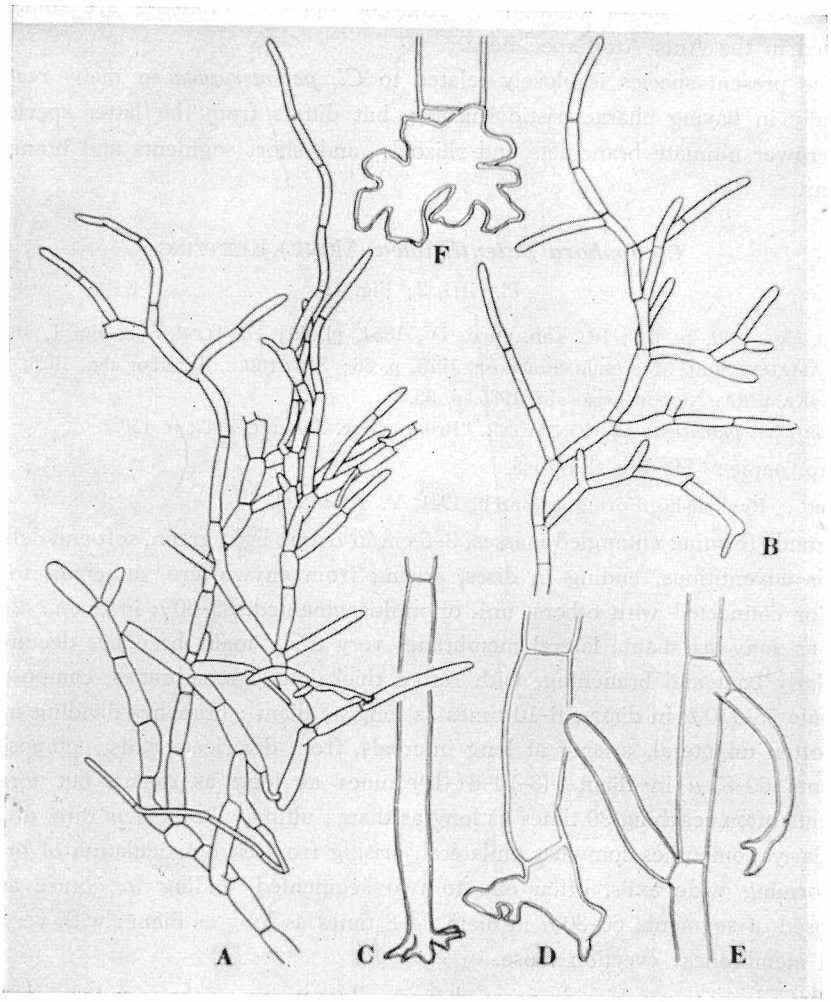

Fig. 41. *Cl. socialis* KUETZING

A. A part of tuft × 27. B. Upper portion of a frond × 27.
C, D, E, F. Ends of a frond C × 130, D × 200, E × 64, F × 200.

phores lax in all portions of fronds; insertion and evection loose.

The rhizoids of Ants Atoll specimens are generally one-segmented which divided irregularly (Fig. 41, C–F). BØRGESEN (1924), however, shows many-segmented rhizoids. On the branching manner of the species, KÜTZING (l. c.) described it as "trichomatibus pluries et laxe dichotomis ···", but opposite branches are shown in his Tab. phyc. (l. c.) and he noted in his explanation of the figures that "quirlförmige oder opponierte Verästelugen". BØRGESEN (1924) described the branching manner

of the species as "subdichotomous". And the opposite branches are sometimes observed in the Ants Atoll specimens.

The present species is closely related to *Cl. patentiramea* in many respects, especially in having characteristic rhizoids, but differs from the latter species by its narrower ultimate branchlets and rhizoids, and short segments and branch-top portions.

Cladophora patentiramea (MONT.) KUETZING

Pl. XIII, 2; Fig. 42

Sp. alg., 1849, p. 416; Id., Tab. phyc. IV, 1854, pl. 69; DE-TONI, Syll. alg. I, 1889, p. 346; YAMADA, Stud. Meeresalg. Formosa, 1925, p. 86; SETCHELL, Tahitian alg., 1926, p. 74, pl. 9; OKAMURA, Nippon kaiso shi, 1936, p. 55.

Conferva patentiramea MONTAGNE, "Prodr. phyc. Antarct. 1842, p. 15".

Jap. name: Hosoba-shiogusa.

Hab.: Ryukyusho, Formosa (March, 1941, Y. YAMADA).

Fronds forming entangled masses, 3–5 cm in diam., light green, soft and delicate; rhizoids adventitious, ending in discs, arising from anywhwere, attaching to substrate or connected with others, uni- or multisegmented, 35–60 μ in diam., (2–) 4–8 times as long as diam., lateral membranes very thin; main branches decumbent, irregularly bent and branching, with rather thick lateral membranes, composed of segments 75–110 μ in diam., 6–10 times as long as diam.; branches dividing irregularly, often unilateral, arising at long intervals, from divaricate axils, composed of segments 60–85 μ in diam., (3–) 4–8 (–10) times as long as diam., but terminal segments often reaching 30 times as long as diam.; ultimate branchlets rare, dividing irregularly, sometimes somwhat unilateral, arising from each articulation of branchlets, forming wide axils, often one to two segmented, ending in obtuse apices, composed of segments 60–80 μ in diam., 4–8 times as long as diam., with very thin lateral membranes; evection loose.

The adventitious rhizoids descend from all portions of the fronds, and attach to substrata, or are connected mutually with other filaments. The species of the rhizoids are discoid, and are similar to hapteron of some species of *Boodlea*. Moreover, dense intricate masses of the alga seems to the writer to be *Boodlea*. MURRAY (1890, p. 245) described the genus *Boodlea* as "inter se per tenacula adhaerentibus composita". The original type of the branching manner of the genus is opposite, and the base of ultimate branchlets have no septum with branchlet-mother segments. Furthermore, the origin of the branches of *Boodlea* is originally due to the segregative cell-division. In this species, however, the writer could not observe it.

The hapteron may be defined by the following characteristics: (1) it appears

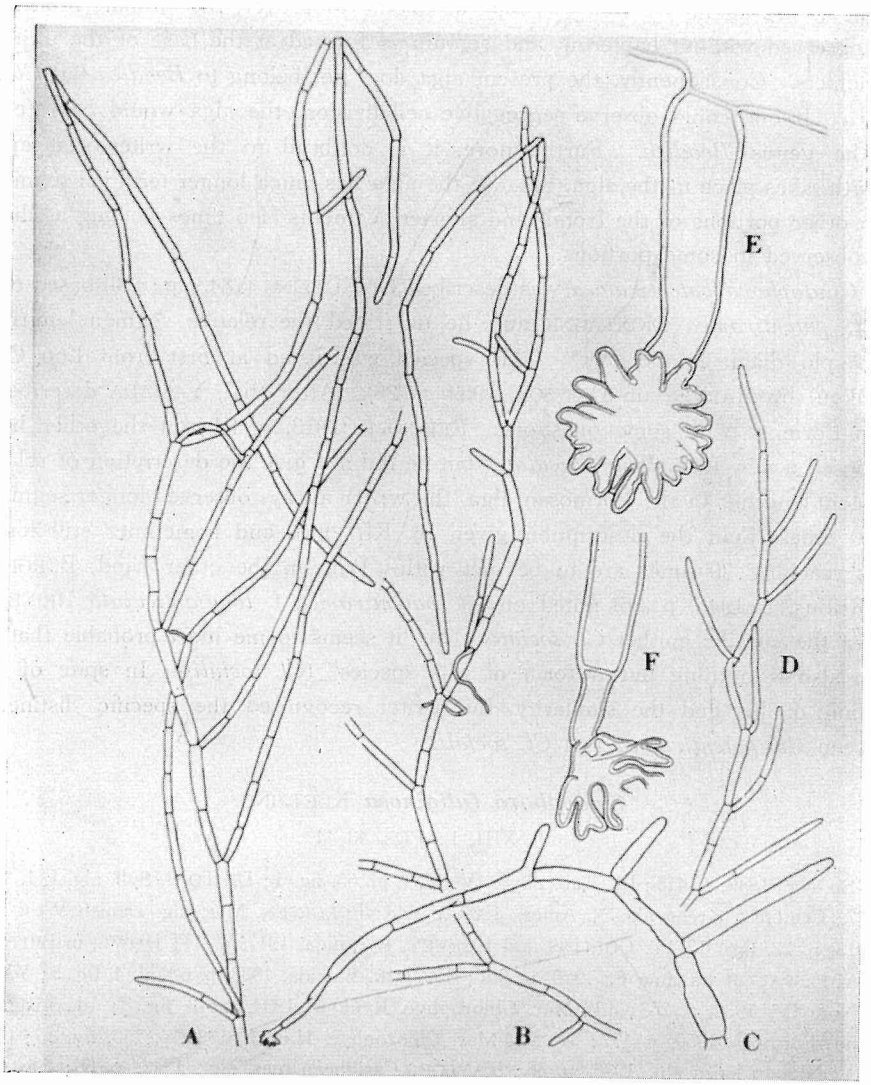

Fig. 42. *Cl. patentiramea* (MONT.) KUETZING
A, B. Upper portions of fronds, provided with adventitious rhizoids × 16. C. Tip of a frond having rhizoid × 33. D. Uppermost portion × 13. E, F. Ends of rhizoids × 200.

in all portions of the fronds, (2) it appears especially at the ends of ultimate branchlets, (3) it is unicellular without peduncle, and (4) its diameter is less than its length. In the present alga, the apices of the uni- or multisegmented rhizoids which grow in any portion of the frond are of hapteron-like shape, and the apical

segments are about 4–6 times as long as diam. Moreover, the ultimate branchlets are observed without hapteron, and septum is formed at the base of the ultimate branchlets. Consequently, the present alga does not belong to *Boodlea* but *Cladophora*. If one could observe segregative cell-division, the alga would be referred to the genus *Boodlea*. Furthermore, it is doubtful to the writer that apical growth takes place in the alga, because the alga has much longer terminal segments than other portions of the frond, and shorter segments (4–5 times as long as diam.) are observed in some portions.

Cladophora patentiramea was described by KÜTZING (1843, p. 416) based upon *Conf. patentiramea* MONTAGNE and he described the relative segment-length as "4–6- plo diam. longioribus". This species was listed at first from Loo Choo (Ryûkyû) by HARVEY (in DAWSON, 1959, p. 28). After that, YAMADA described it from Formosa with some questions. REINBOLD (1913, p. 84), on the other hand, proposed a new form *longiarticulata*, but he did not give the description of relative segment-length. In the Formosan alga, the writer always observed longer segments (4–10 times) than the description given by KÜTZING, and sometimes still longer ones reaching 30 times are to be met with. But, on the other hand, BØRGESEN (Mauritius, I, 1946, p. 26) noted on *Cl. patentiramea* f. *longiarticulata* REINBOLD under the specific epithet *Cl. socialis* that "it seems to me most probable that his form also is nothing but a form of this species" (*Cl. socialis*). In spite of this opinion of his and the similarity, the writer recognized the specific distinction between *Cl. patentiramea* and *Cl. socialis*.

Cladophora fuliginosa KUETZING

Pl. XIII, 1; Figs. 43–44

Sp. alg., 1849, p. 415; Id., Tab. phyc. IV, 1854, pl. 65, fig. 1; DE-TONI, Syll. alg. I, 1, 1889, p. 347; COLLINS, Green alg. N. Amer., 1909, p. 348; BØRGESEN, Mar. alg. Danish West Ind., 1, 1913, p. 22, figs. 13–14; COLLINS and HERVEY, Bermuda, 1917, p. 44; HOWE, in BRITTON and MILLSPAUGH Bahama fl., 1920, p. 601; TAYLOR, Florida, 1938, p. 62, pl. 4, fig. 5; YAMADA, Note IV, 1932, p. 268; Id., Mar. Chlorophyc. Ryûkyû, 1934, p. 43, fig. 8; Id., List Ryûkyûsho, Formosa, 1950, p. 177; TSENG, Mar. Chlorophyc. Hainan, 1936, p. 153, fig. 15; OKAMURA, Nippon kaiso shi, 1936, p. 56; TAYLOR, Caribbean mar. alg., 1942, p. 56; SEGAWA and OKAMURA, Mar. fl. Ryûkyû Isl., 1960, p. 8.

Blodgettia confervoides HARVEY, Ner. Bor.-Amer., 3, 1858, p. 48, pl. 45 C, pro parte.

Jap. name: Kabi-shiogusa.

Hab.: Hachijo Isl. (June, 1956, M. CHIHARA); Naha, Ryûkyû Isl. (May, 1932, Y. YAMADA); Ryûkyûsho (March, 1941, Id.), Kaikô (March, 1924, Id.), Formosa.

Fronds on rocks (?), tufted and prostrate, 2–3 cm high, grass green, rigid and stiff; rhizoids adventitious, descending from any portion of fronds, ending in irregularly divided segments, with or without chromatophores, 190–200 μ in diam.;

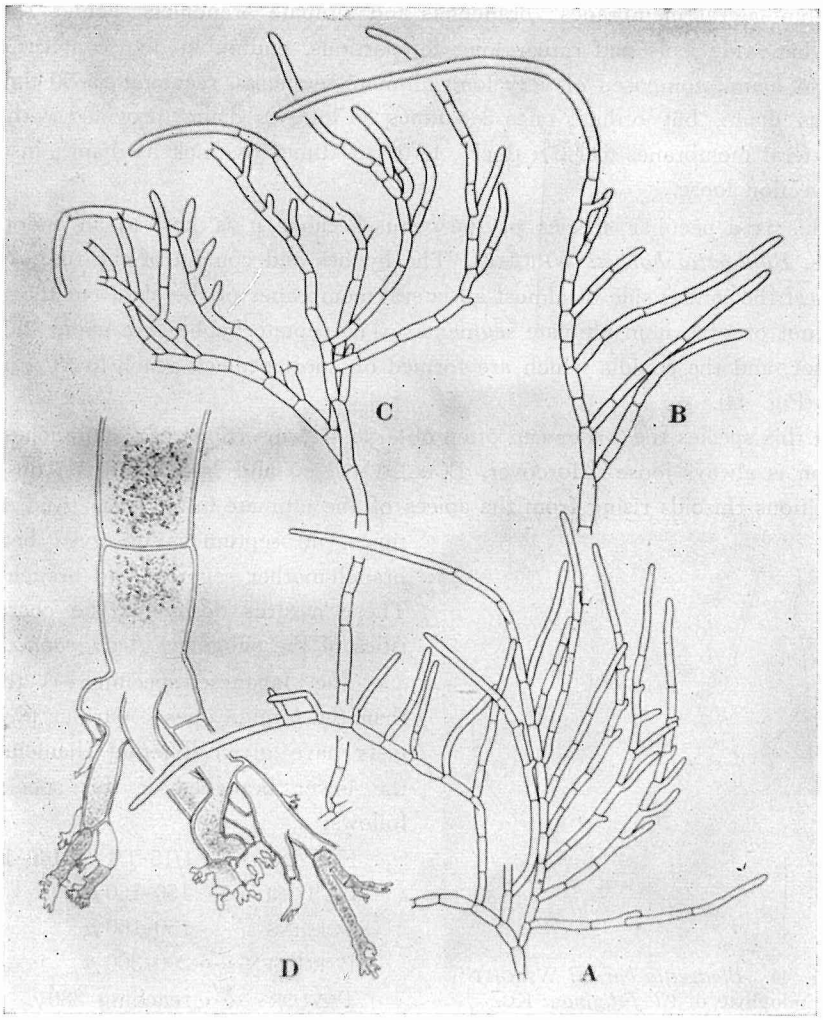

Fig. 43. *Cl. fuliginosa* KUETZING

A, B, C. Upper portions of fronds. A × 27. B, C × 41.
D. Rhizoid × 39.

primary branches sometimes distinguishable, straight or curved, branching dichotomous or lateral, with smooth or sometimes slightly constricted articulations, 270–520 μ in diam., composed of segments 3–6 times as long as diam., with very thin lateral membranes (ca. 7–8 μ), 1/30–1/70 times as thick as diam.; branches unilateral, erect, with slightly constricted or smooth articulations, forming somewhat wide axils, 360–440 μ in diam., composed of segments 3–6 times as long as diam., with

very thin lateral membranes; branchlets and ultimate branchlets secund, forming somewhat wide axils and rather long top-portions, ending in obtuse apices, 350–400 μ in diam., composed of very long ultimate segments, reaching 25–30 times as long as diam., but ordinal ones 3–6 times as long as diam., provided with very thin lateral membranes (ca. 5 μ thick), 1/70–1/80 times as thick as diam.; insertion and evection loose.

This is a peculiar species of the genus because it is host to an endophytic fungus, *Blodgettia borneti* WRIGHT. The hyphes and conidia of the fungus (Fig. 44) infest the innner side of almost all lateral membranes of the alga, but the writer could not observe it in ultimate segments. The septate hyphes are about 2–3 μ in diameter, and the conidia which are formed on short pedicels reach to 21 μ in diameter (Fig. 44).

In this species the writer can often observe side insertions of the branches, and evection is always loose. Moreover, BØRGESEN (l. c.) and YAMADA (l. c.) observed adventitious rhizoids rising from the apices of the ultimate branchlets. And, sometimes, no septum is observed between branch-mother segment and branch-base. These natures designate the characteristics of the subgenus *Aegagropila*.

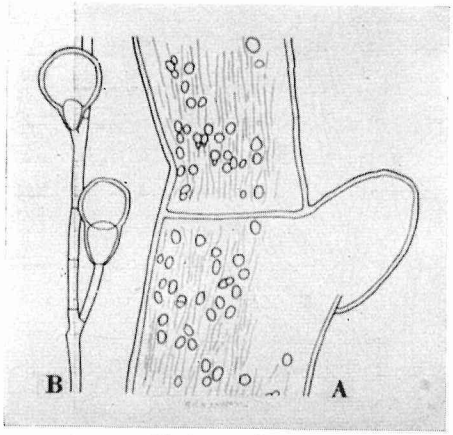

Fig. 44. *Blodgettia borneti* WRIGHT
Endophyte of *Cl. fuliginosa* KG.
A×64. B×375.

The Japanese specimen is thicker than the foreign ones. Various phycologists have given different diameters to the lower branches of this species as follows;

KÜTZING ····· 1/15–1/14‴ (140–150 μ)
DE-TONI ····· 150–160 μ
COLLINS ····· 150–160 μ
BØRGESEN····· 200–300 μ
TAYLOR ····· reaching 380 μ
HOWE ····· 150–320 μ

COLLINS (l. c.), on the other hand, noted on the species, "The hyphae of the fungus may possibly occur in connection with some other species of *Cladophora*, but in all specimens observed the host agrees fairly well with the description of *C. fuliginosa*". In spite of COLLINS' note, if the writer attaches great importance to the wider diameter than that of the original description, this alga agrees better with *Cl. montagnei* than *Cl. fuliginosa*. However, according to the writer's observation on the specimen of *Blodgettia confervoides* HARV. (Alg. Exsic. Amer. Bor., loc. Key West, leg. F. W. HOOPER, SAPA), the Japanese specimens agree better with this specimen in diameter, branching manner, and other characters.

Cladophora sibogae REINBOLD

Pl. XV, 2; Fig. 45

Einige neue Chlorophyc. ind. Ozean, 1905, p. 146; Id., in WEBER van BOSSE's List alg. Siboga, I, 1913, p. 81, fig. 19; OKAMURA, Mar. alg. Kôtôsho, 1931, p. 96; Id., Nippon kaisô shi, 1936, p. 56; YAMADA, Mar. Chlorophyc. Ryûkyû, 1936, p. 54; YAMADA and TANAKA, Mar. alg. Yonakuni, 1938, p. 57; YAMADA, List mar. alg. Ryûkyûsho, Formosa, I, 1950, p. 177; SEGAWA and KAMURA, Mar. fl. Ryûkyû Isls., 1960, p. 8.

Jap. name: Nedashi-shiogusa.

Hab.: Naha (May, 1933, Y. YAMADA), Gushichan (Jan., 1958, S. KAMURA), Komesu (Mar., 1959, Id.), Yonakuni Isl. (Apr., 1935, T. TANAKA), Ryûkyû Isls.; Takarashima Isl., Tokara Isls. (May, 1953, E. OGATA); Ryûkyûsho (Mar., 1941, Y. YAMADA), Kôtôsho Isl. (K. SEGAWA), Formosa; Korôru Isl. (Dec., 1938, T. KANDA).

Fronds forming dense cushions on rocks, about 1 cm high, dark green, rigid; rhizoids adventitious, descending from branch-base segments, or from any portion of fronds, septate, attaching to substrata and hold together, 25–50 μ in diam., composed of segments 4–10 (–20) times as long as diam., ending in discoids or hapteron-like structures; main branches undistinguishable; branches di- or sometimes trichotomous, straight, forming somewhat wide axils, 140–185 μ in diam., composed of segments 5–8 times as long as diam., with very thin lateral membranes, about 3 μ thick; branchlets opposite or sometimes whorled, forming acute or obtuse axils, arising from every articulation of branches, with slightly constricted articulations, composed of segments 80–150 μ in diam., 3–5 times as long as diam., ending in small segments; ultimate branchlets opposite or secund, short, 1–3 segmented, 2–4 times as long as diam., 70–120 μ in diam., arising from every articulation and acute axils, with slightly consticted articulations, ending in obtuse apices; insertion and evection loose.

The present alga forms pulvinate dense cushions, and has dark green colour and rigid texture. The rhizoids of this species are peculiar, descending adventitiously from branch-base segments and any portion of the fronds (Fig. 45). These adventitious rhizoids are more slender than their mother-segments (Fig. 45, C, D). And they mostly grow downwards serving to attach the fronds to the substrata, but they may also attach themselves to other filaments in the tufts (Fig. 45, B). Their ends form discoidal or hapteron-like structures, but sometimes they are formed in the lateral portions of the rhizoids (Fig. 45, C).

The leading branching manner of this species is opposite, but the opposite branches grow in unequal length. And the writer observed the secund branching manner in ultimate branchlets, the younger portions. In the Naha specimen, the writer observed rejuvenescens (Fig. 45, D) as in certain species of subgenus *Aegagropila*.

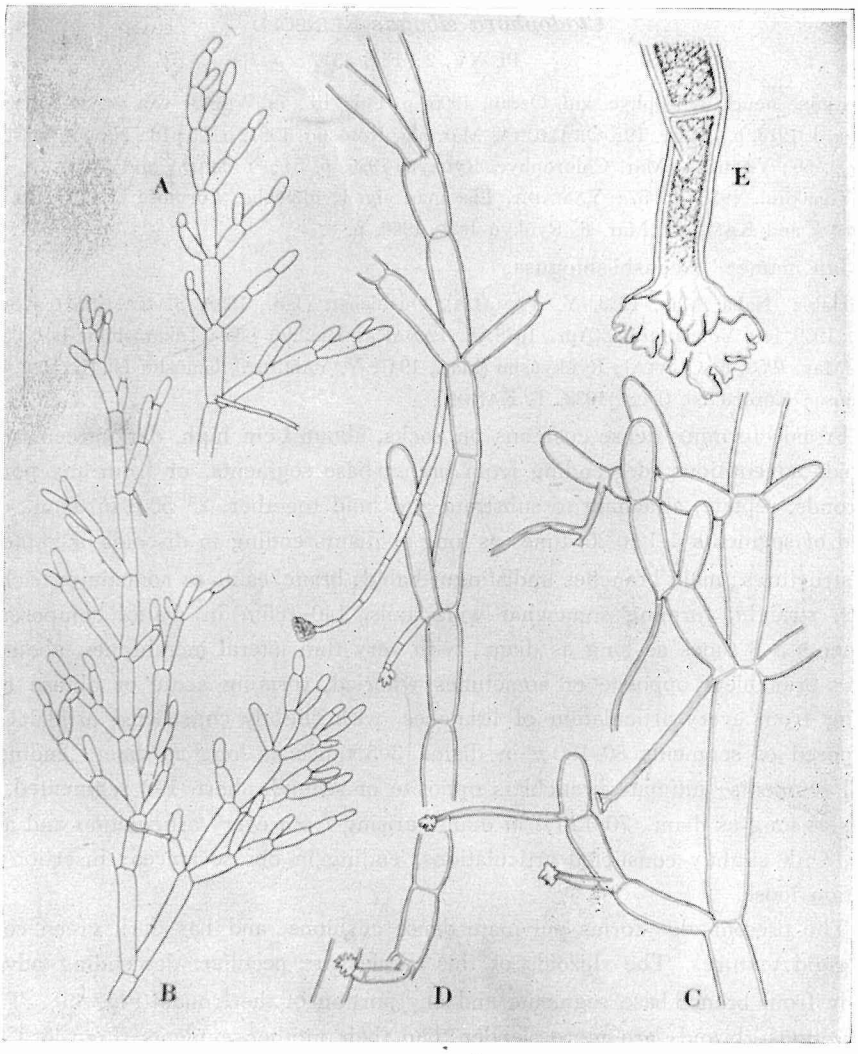

Fig. 45. *Cl. sibogae* REINBOLD

A, B. Upper portions of fronds, showing branching manner and adventitious rhizoids × 16. C, D. Lower portions of fronds × 33. E. End of rhizoid × 200.

As pointed out by YAMADA (1934), the present specimens have thicker diameter than the specimens of REINBOLD. REINBOLD has given the diameters, as 40–60 μ for the branchlets, and 120–150 μ for the main branches. The writer measured the diameter of the ultimate branchlets of the specimens at hand as 70–120 μ and 80–150 μ in the branches. In all respects, except for the dimension of ultimate branchlets,

the Japanese alga agrees very well with the description and figure given by REINBOLD.

On the other hand, this species resembles *Cl. boodleoides* BOERGESEN (Mar. alg. Canary Isl., I, 1925, p. 56, figs. 19–22), but differs from his species by its rhizoids, branching manner, etc.

VII. Uncertain or not collected species

1. *Cl. arbuscula* KJELLMAN

   Mar. Chlorophyc. Jap., 1897, p. 27, pl. 5, figs. 7–14.

   .Hab.: Nagasaki.

YENDO (Notes on alg., II, 1914, p. 266) noted that this species "is very likely referrable to" *Cl. utriculosa* KUETZ.

2. *Cl. divergens* KJELLMAN

   Id., p. 29, pl. 6, figs. 1–7.

   Hab.: Hakodate, on *Chaetomorpha moniligera.*

3. *Cl. glaucescens* (GRIFF.) HARV. ? var. japonnica HARVEY

   in DAWSON's HARVEY's Jap. alg., 1959, p. 28; YENDO, Notes on alg., V, 1916, p. 248.

   Hab.: Hakodate Bay, on Sargassa.

   It may be *Cl. opaca* SAKAI.

4. *Cl. insignis* (AG.) KUETZ. f. *fluviatilis* KUETZING

   Sp. alg., 1849, p. 406; SURINGAR, Alg. Jap., 1870, p. 20.

   Hab.: Japan, fresh-water species.

5. *Cl. montagnei* var. *radicans* YAMADA

   Stud. Meeresalg. Formosa, I, 1925, p. 87, fig. 4.

   Hab.: Garanbi, Formosa.

   The writer could not observe the detailed characteristics of the species, because the type specimen (TI) is not restored to its living state.

6. *Cl. polaris* HARVEY

   Charact. new alg., 1859, p. 334.

   Hab.: Simavina Bay.

HARVEY 1959, p. 28 noted on the alga that "This much resembles the young state of *Cl. arcta*" (*Spongomorpha arcta*).

7. *Cl. scitula* (SUHR) KUETZING

   Sp. alg., 1849, p. 399; HEYDRICH, Beitr. Algenfl. v. Ost-Asien, 1894, p. 273.

   Hab.: Formosa.

8. *Cl. tomentosa* SURINGAR

Alg. Jap., 1870, p. 20, pl. 5.

Hab.: Japan, fresh-water species.

9. *Cl. zelleri* MARTENS

Tange v. Ost-Asien, 1866, p. 111.

Hab.: Yokohama, fresh-water species.

10. *Cl. zostericola* MARTENS

l. c., p. 112.

Hab.: Yokohama, on *Zostera marina*.

It belongs to *Cl. fascicularis*.

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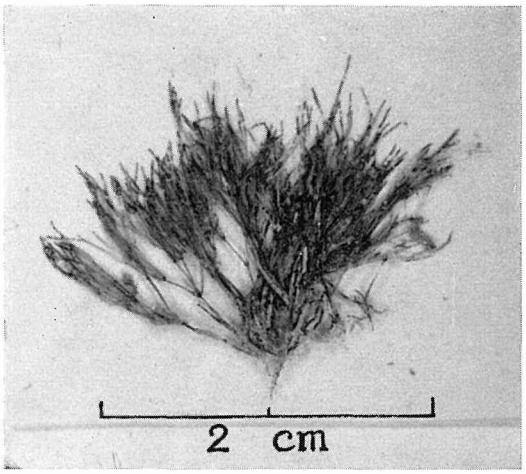
PLATE I

1. *Cl. fastigiata* HARV.

Naha, Okinawa Isl. Ryukyu.
May 1932. Leg. Y. YAMADA

2. *Cl. ohkuboana* HOLMES

Shichirigahama, Kanagawa Pref.
May 11, 1941. Leg. Y. YAMADA



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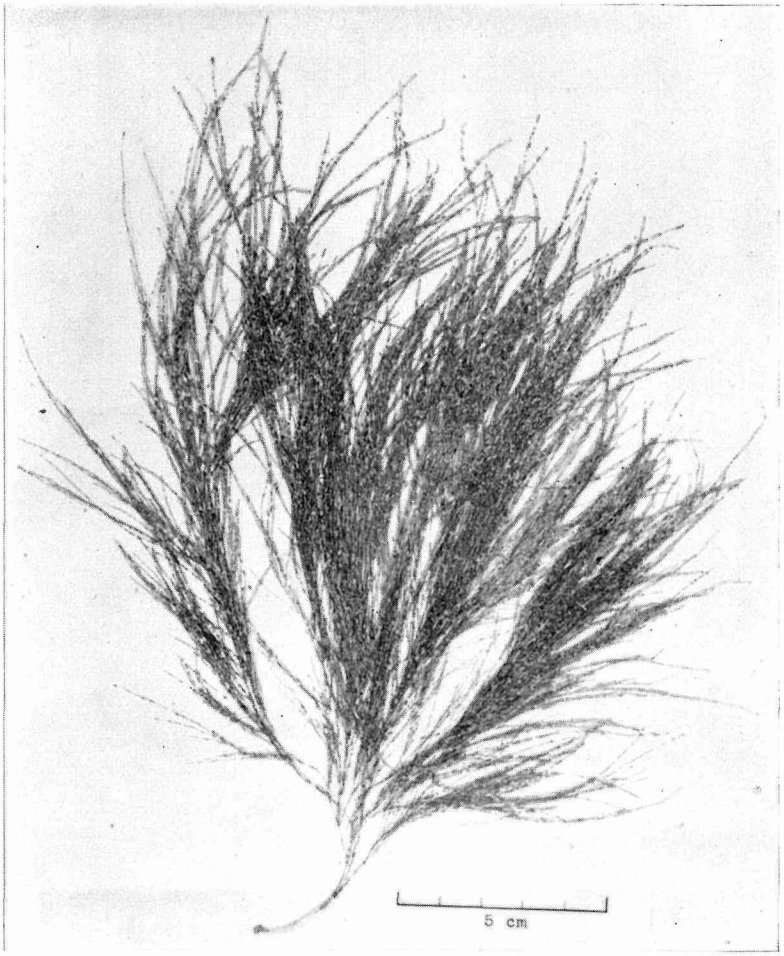

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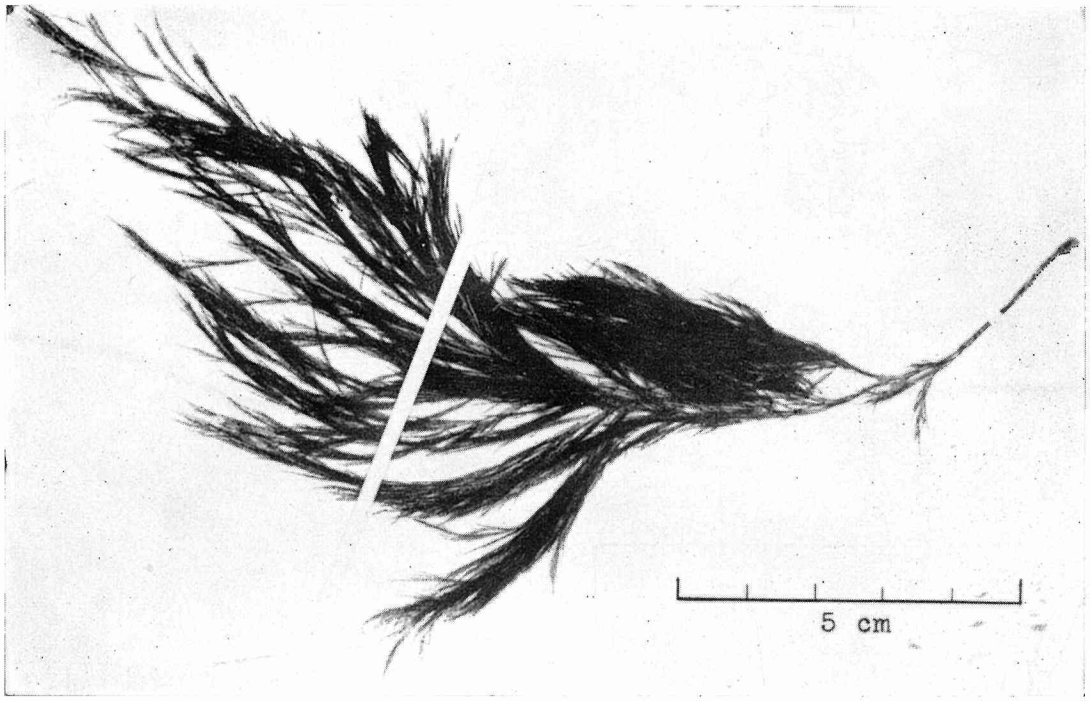
PLATE II

1. *Cl. japonica* YAMADA

Shizuoka, Shizuoka Pref.
May 4, 1955. Leg. T. SAWADA

2. *Cl. densa* HARV.

Cape Shirakami, Hokkaido
July 26, 1957. Leg. Y. SAKAI



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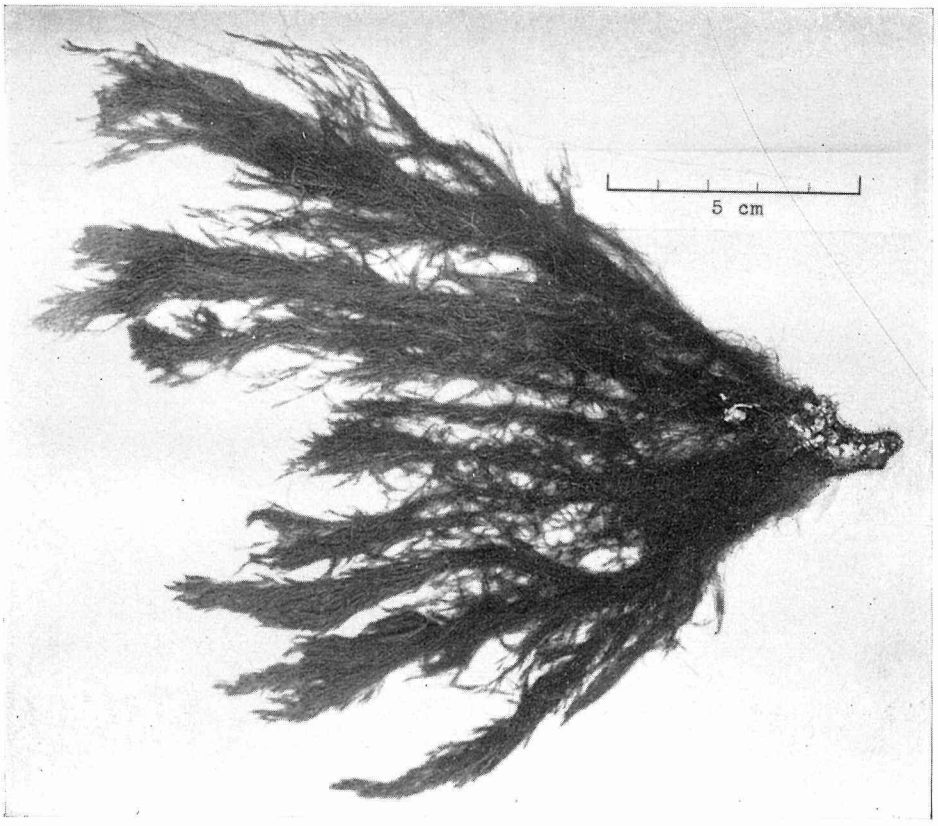

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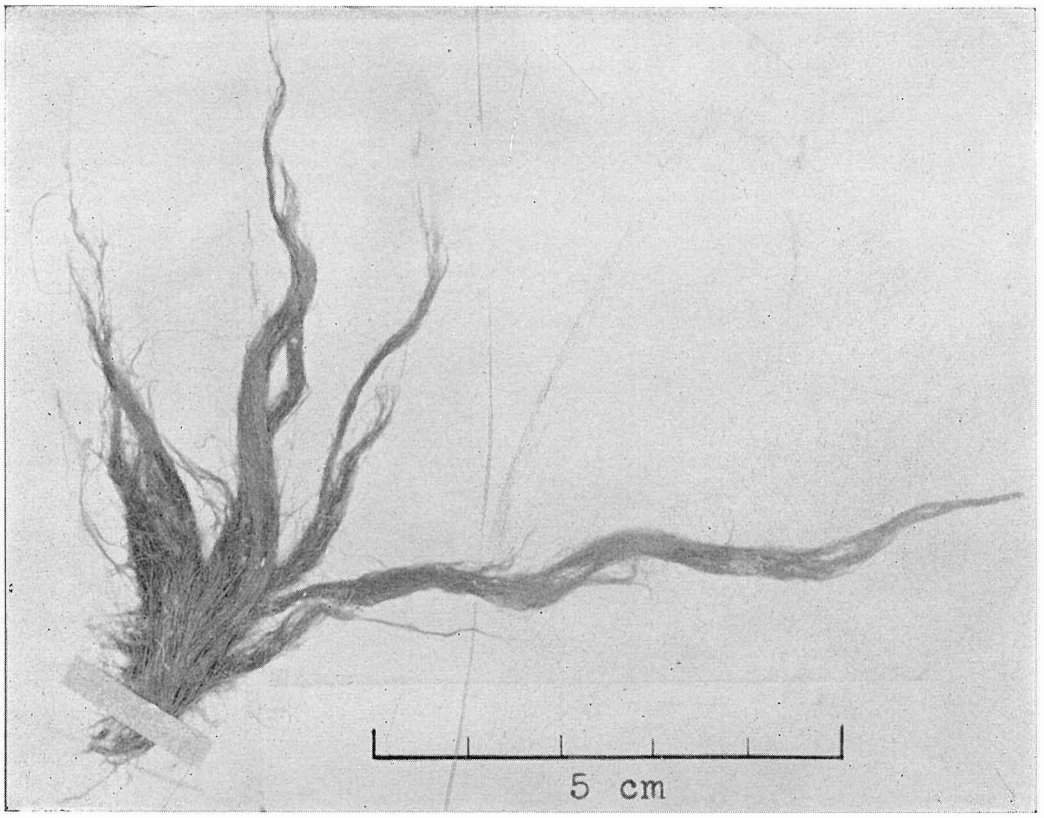
PLATE III

1. *Cl. oligoclada* HARV.

Herb. W. G. FARLOW (TI)

2. *Cl. patula* SAKAI

The type specimen
Yonakuni Isl., Ryukyu.
April 15, 1935. Leg. T. TANAKA



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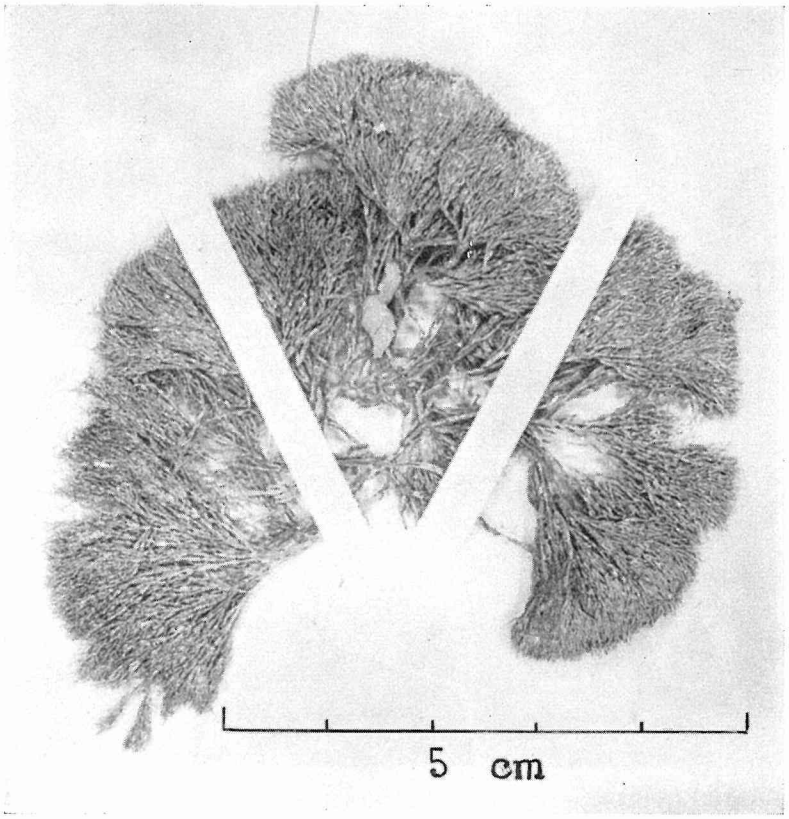

2

PLATE IV

1. *Cl. fascicularis* (MERT.) KUETZ.

Takahama, Fukui Pref.
July 8, 1950. Leg. I. UMEZAKI

2. *Cl. rudolphiana* HARV.
f. *brevisegmentea* SAKAI

The type specimen
Takahama, Fukui Pref.
July 18, 1960. Leg. I. UMEZAKI

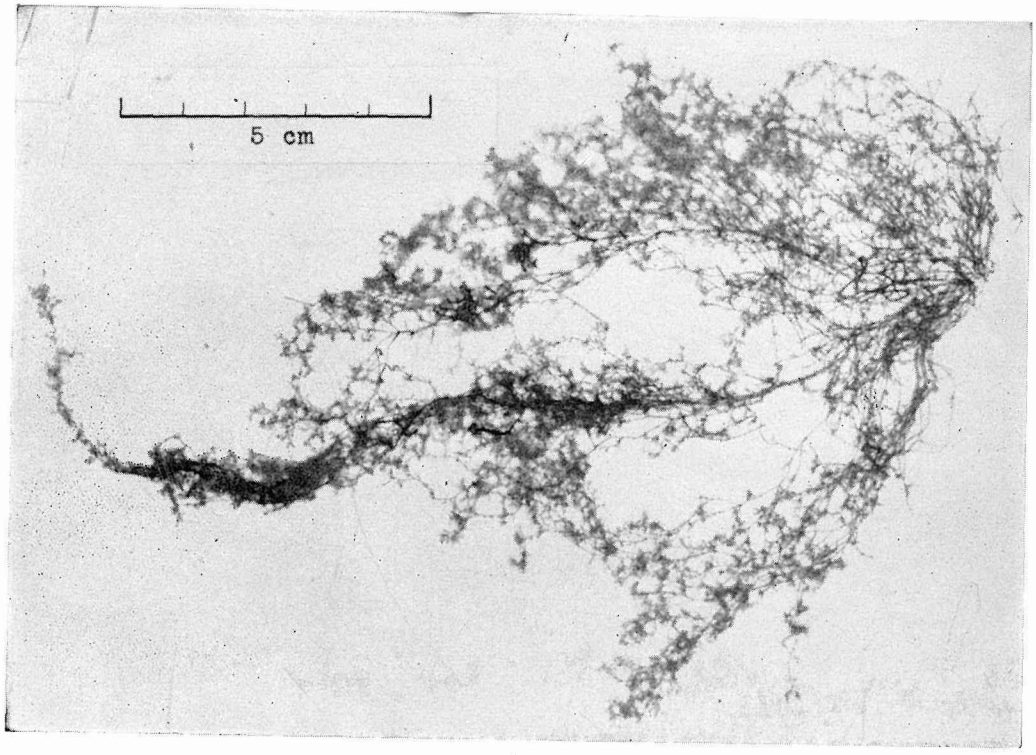

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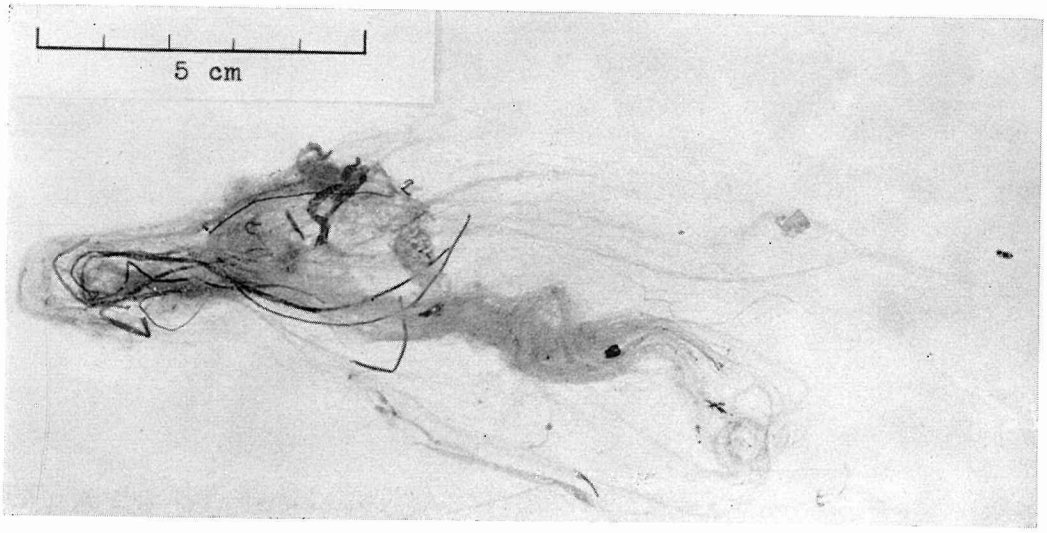
PLATE V

1. *Cl. rudolphiana* (AG.) HARV.
f. *rudolphiana*

Ofunato Bay, Iwate Pref.
May 19, 1951. Leg. S. KAWASHIMA

2. *Cl. speciosa* SAKAI

The type specimen
Muroran, Hokkaido
Aug. 24, 1951. Leg. Y. SAKAI



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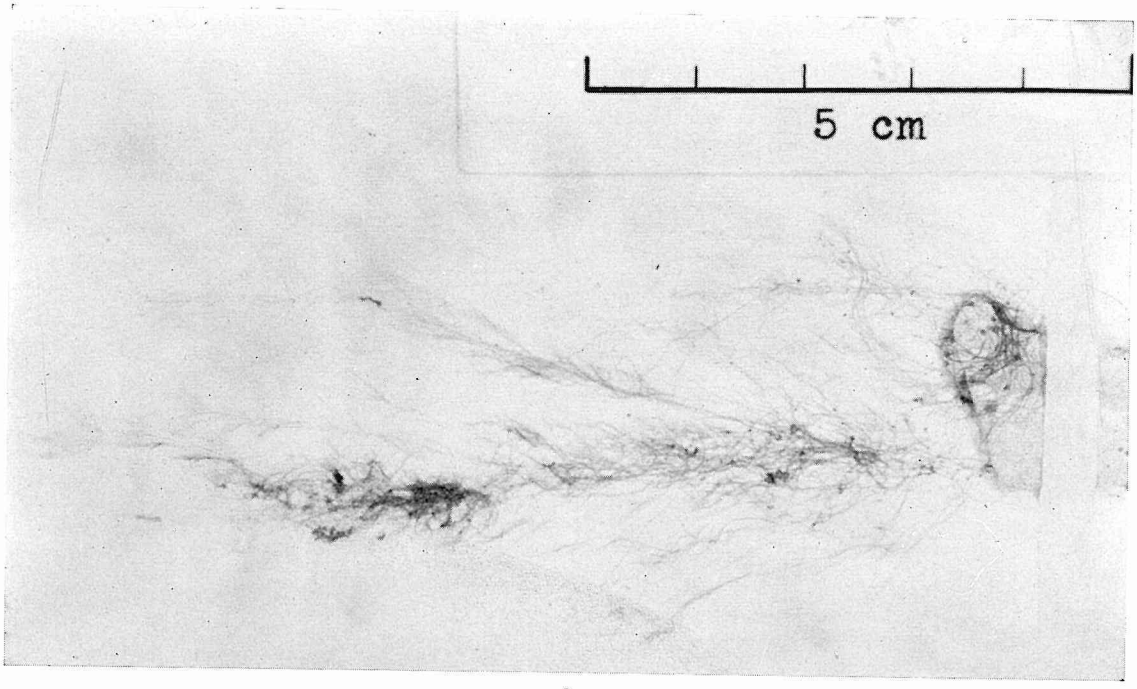


2

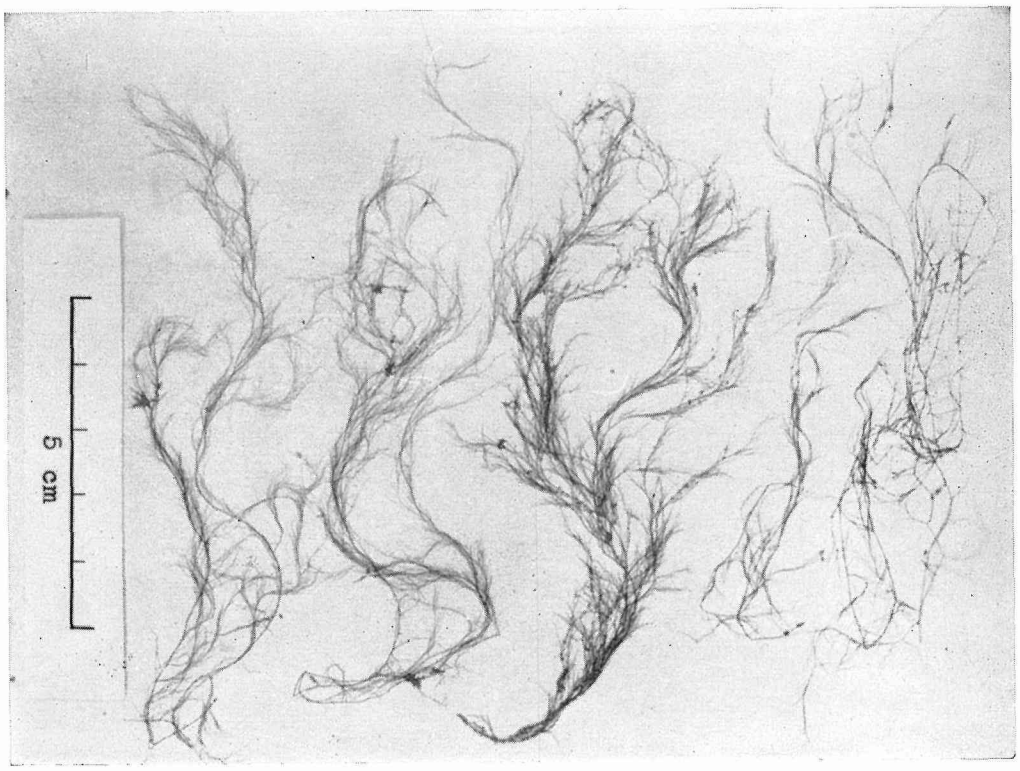
PLATE VI

1. *Cl. gracilis* (GRIFF.) KUETZ.

Haneda, Tokyo
March 31, 1958. Leg. A. MIURA

2. *Cl. crispata* (ROTH) KUETZ.

Lake Akan, Hokkaido
August 24, 1957. Leg. Y. YAMADA



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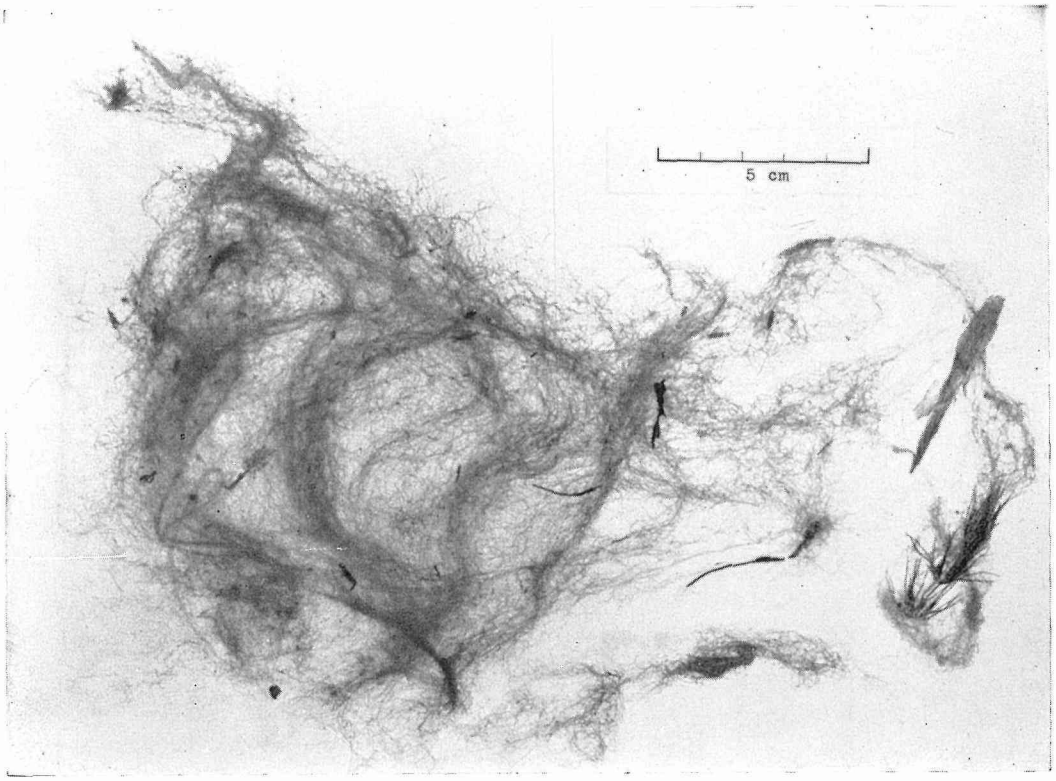

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PLATE VII

Cl. stimpsoni HARV.

Asamushi, Aomori Pref.

Leg. Y. YAMADA

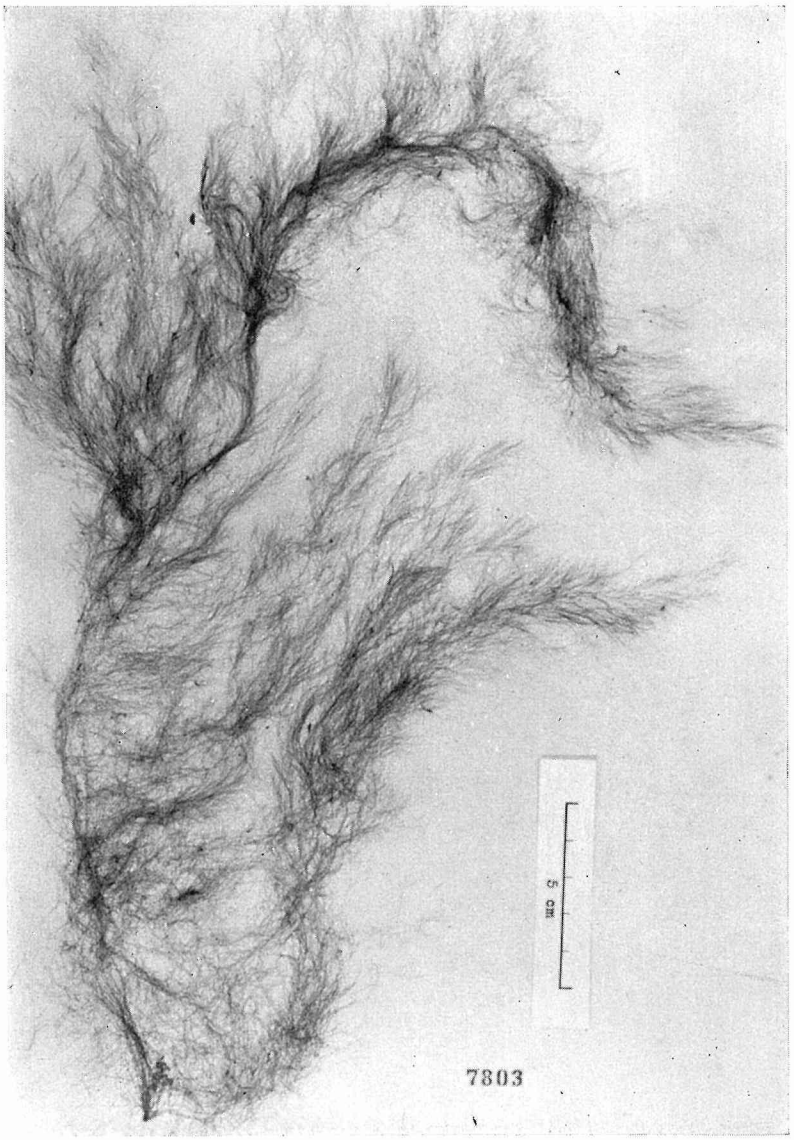

5 cm
7803

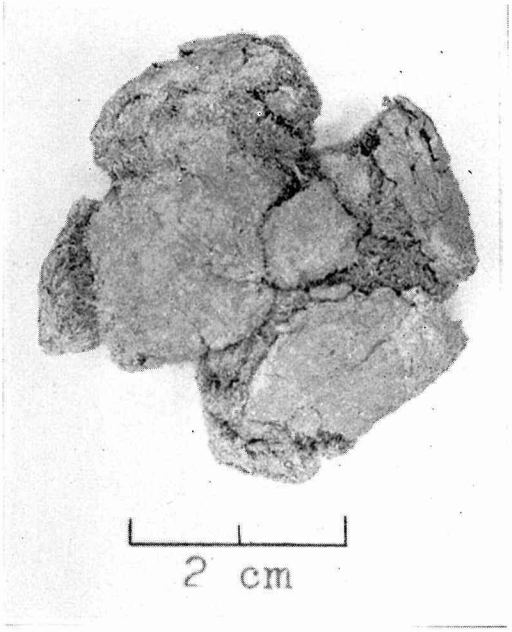
PLATE VIII

1. *Cl. sauteri* KUETZ.
f. *kurilensis* (NAGAI) SAKAI

Lake Naibo, Etorofu Isl.
July 19, 1934. Leg. M. NAGAI (SAPA)

2. *Cl. sauteri* KUETZ.
f. *sauteri*

Lake Akan, Hokkaido
August, 1952. Leg. Y. SAKAI



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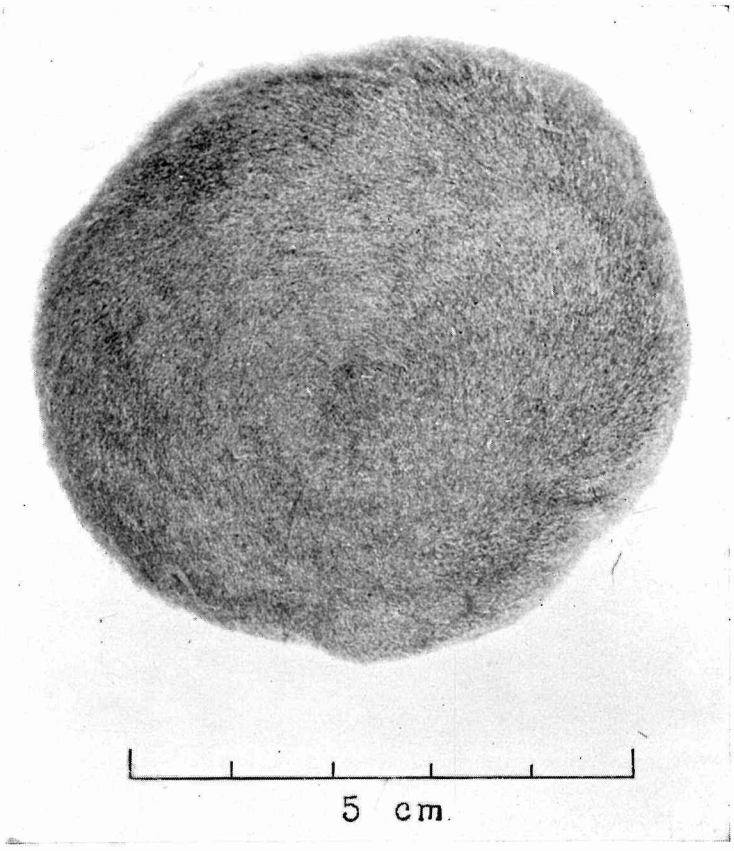

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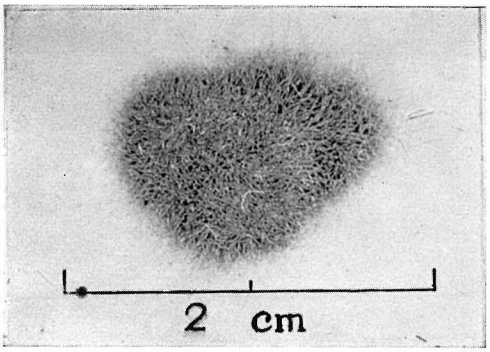
PLATE IX

1. *Cl. minima* (OKADA) SAKAI
f. *minima*

Sakyo-numa, Aomori Pref.
Dec., 1952. Leg. Y. KOBAYASHI

2. *Cl. sauteri* KUETZ.
f. *kannoi* (TOKIDA) SAKAI

Marsh Chimikkepu, Hokkaido
Aug., 1937. Leg. T. MATSUDA (SAPA)



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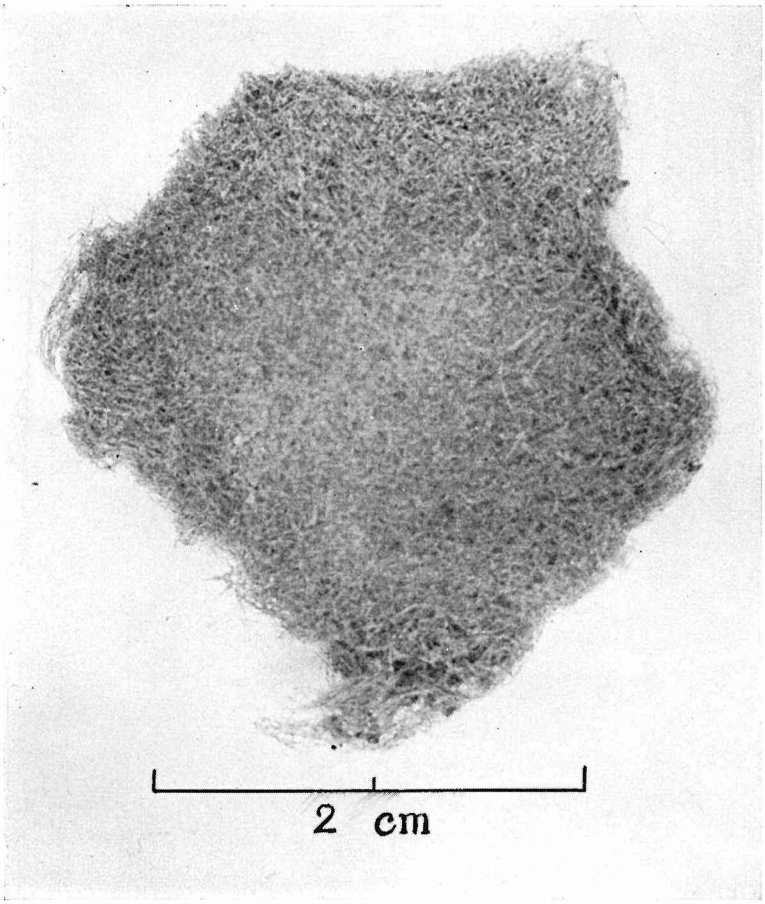

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PLATE X

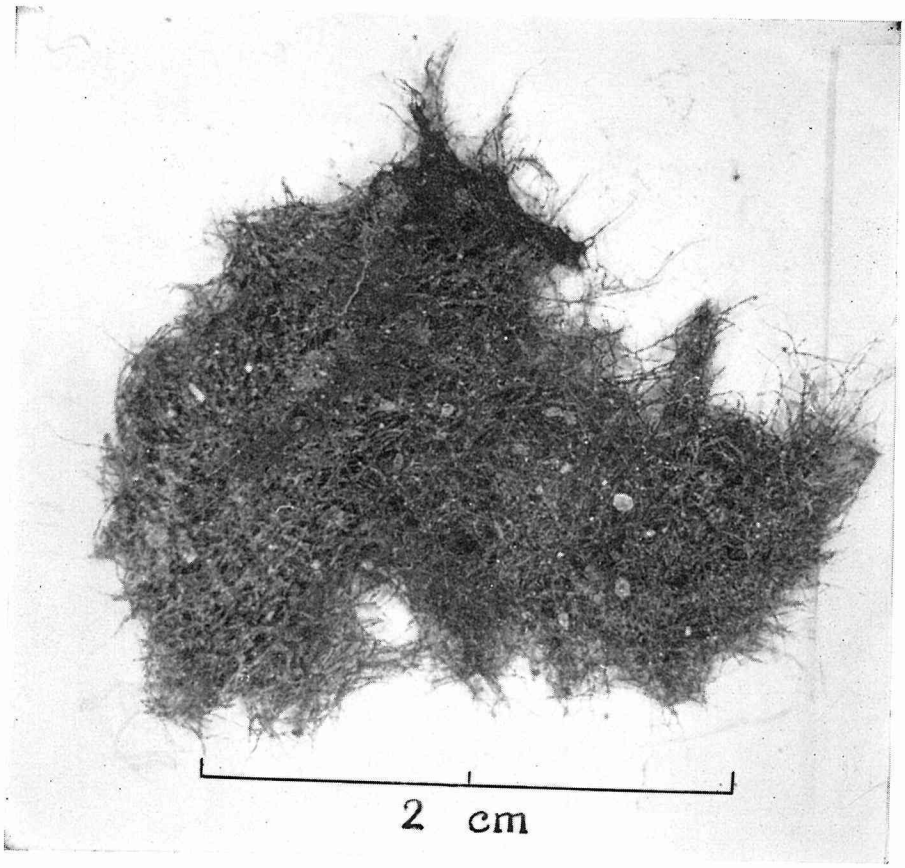
1. *Cl. ninima* f. *crassa* SAKAI

The type specimen
Lake Akan, Hokkaido
Oct., 1939. Leg. Y. YAMADA et al.

2. *Cl. socialis* KUETZ.

Ants Atoll, Ponape Isl., Caroline Isls.
Jan., 1939. Leg. Y. YAMADA

1



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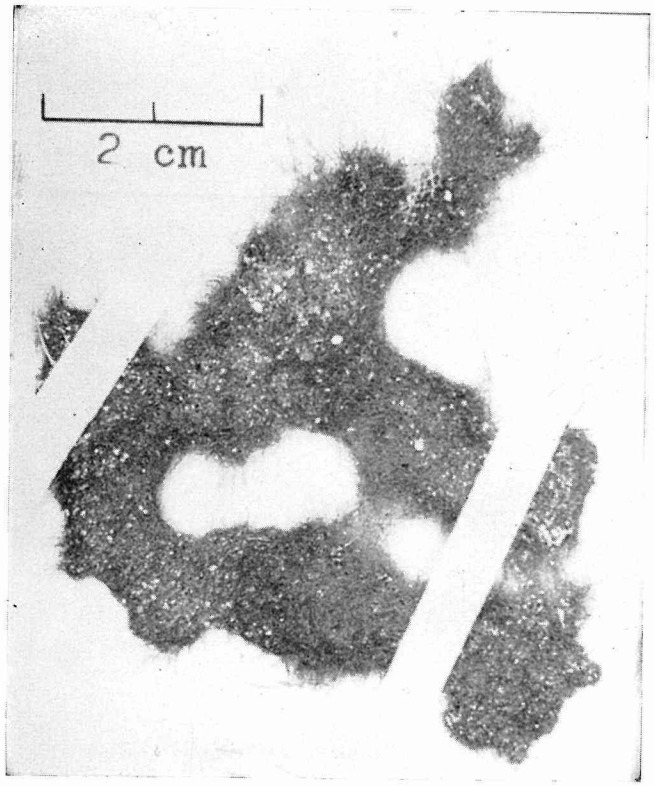


PLATE XI

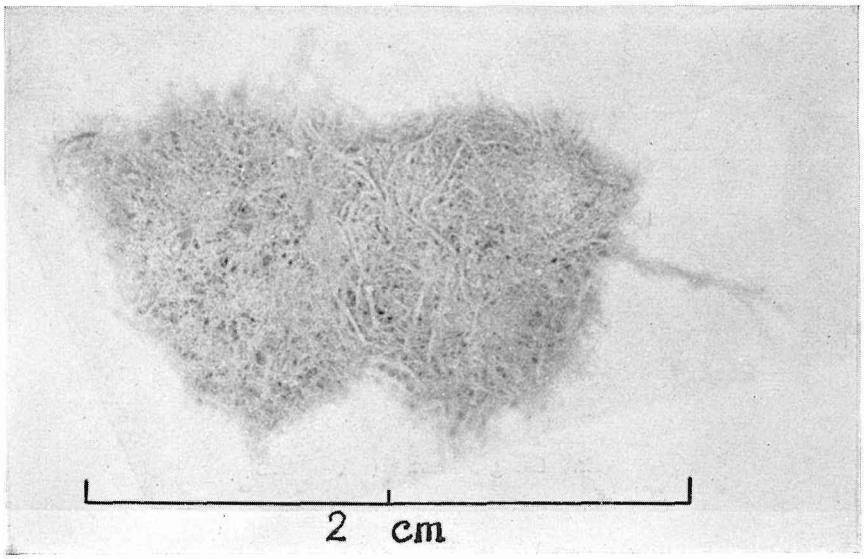
1. *Cl. uncinella* HARV.

Japan Leg. C. WRIGHT (TI)

2. *Cl. opaca* SAKAI

Esashi, Hokkaido

Apr., 13, 1948. Leg. Y. SAKAI



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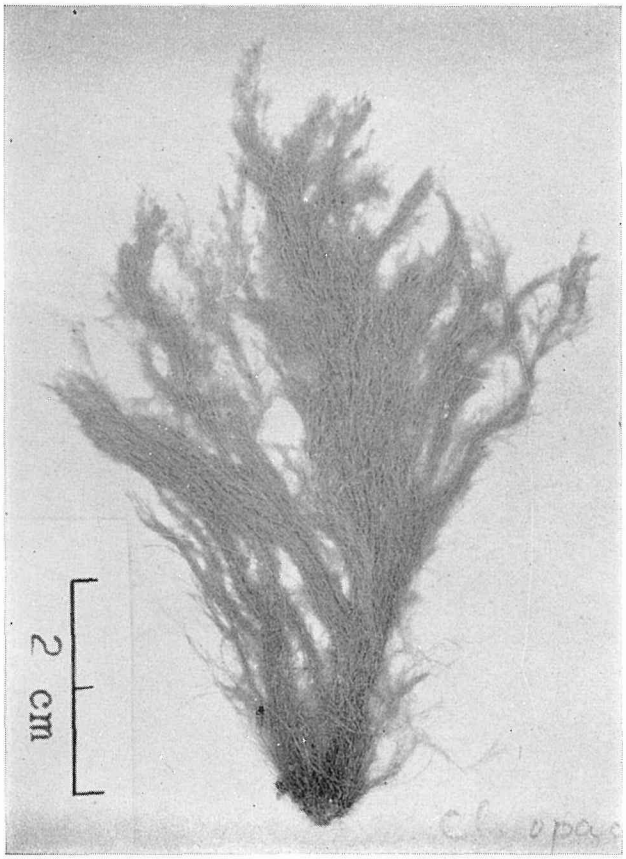

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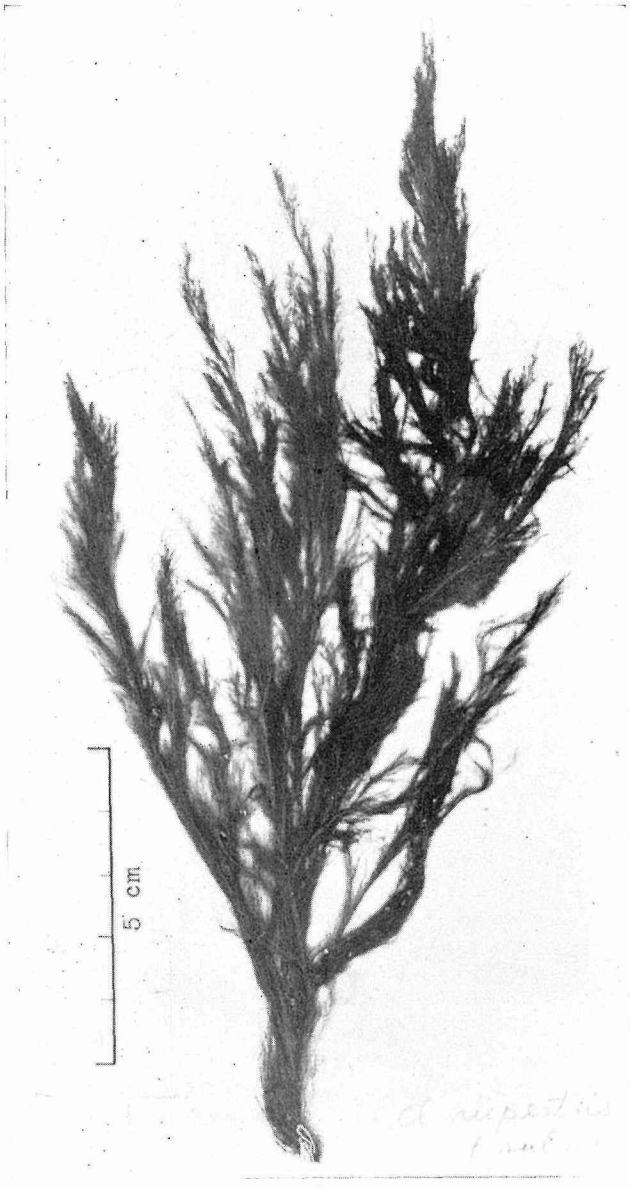
PLATE XII

1. *Cl. rupestris* KUETZ.
   f. *submarina* FOSLIE

Cape Shiokubi, Hokkaido
July 21, 1947. Leg. Y. SAKAI

2. *Cl. glomerata* (L.) KUETZ.

Lake Akan, Hokkaido
August 12, 1958. Leg. Y. SAKAI



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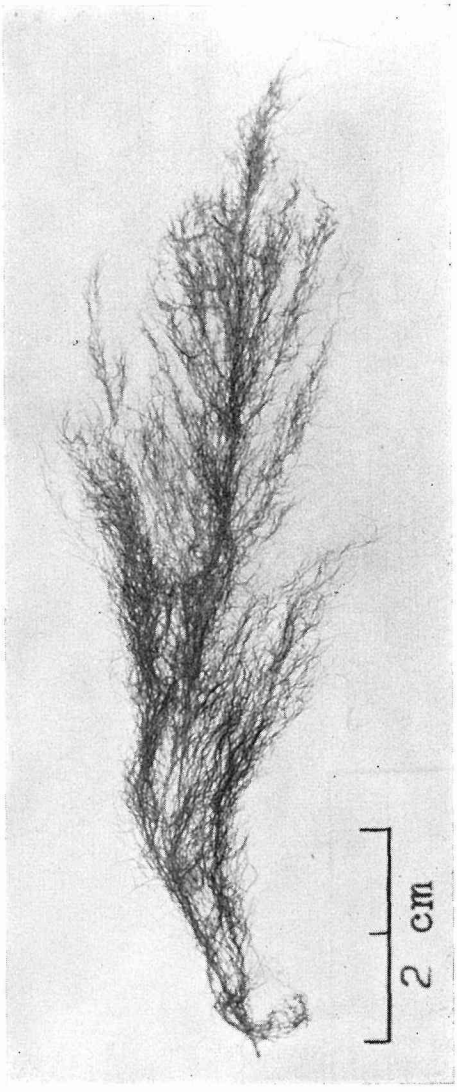

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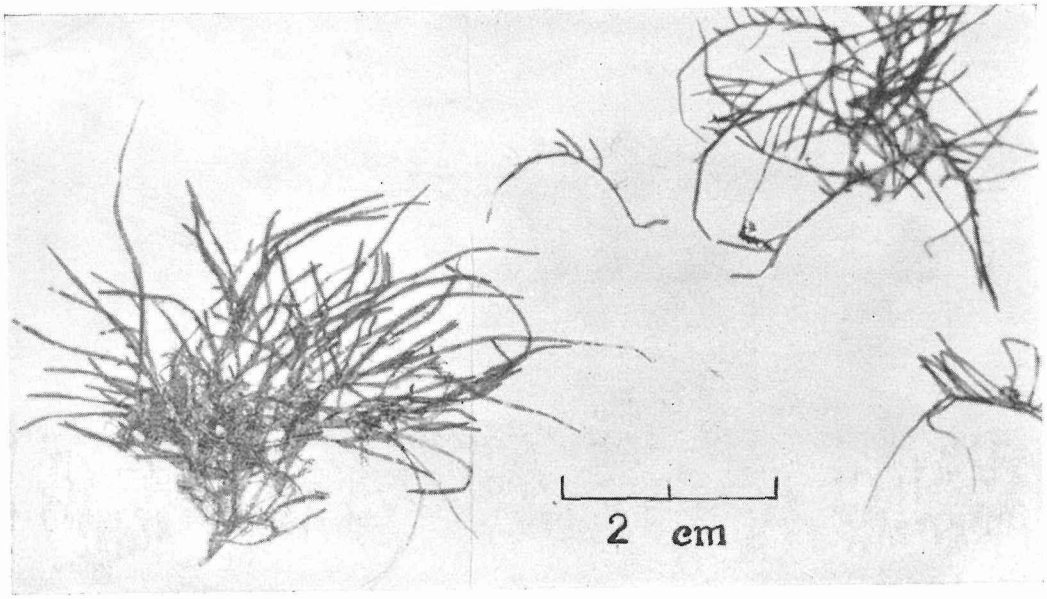
PLATE XIII

1. *Cl. fuliginosa* KUETZ.

Ryukyusho, Formosa
March, 1941. Leg. Y. YAMADA

2. *Cl. patentiramea* KUETZ.

Ryukyusho, Formosa
March, 1941. Leg. Y. YAMADA



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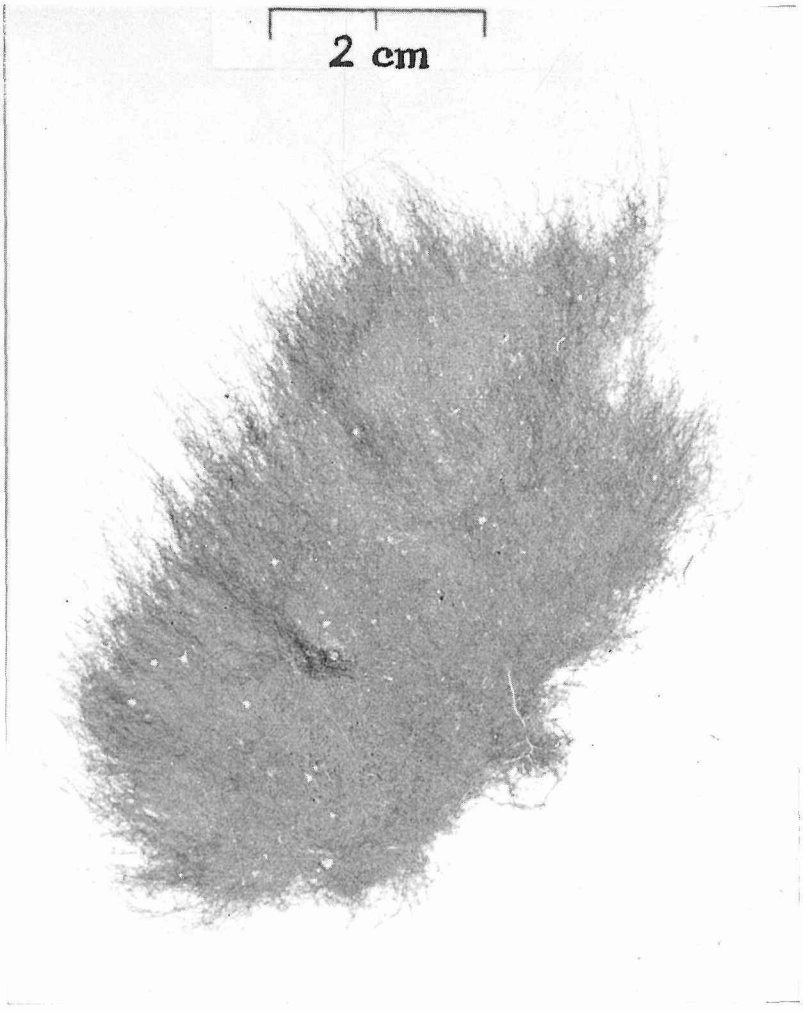

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PLATE XIV

Cl. wrightiana HARV.

Shimoda, Shizuoka Pref.
April 7, 1958. Leg. Y. SAKAI

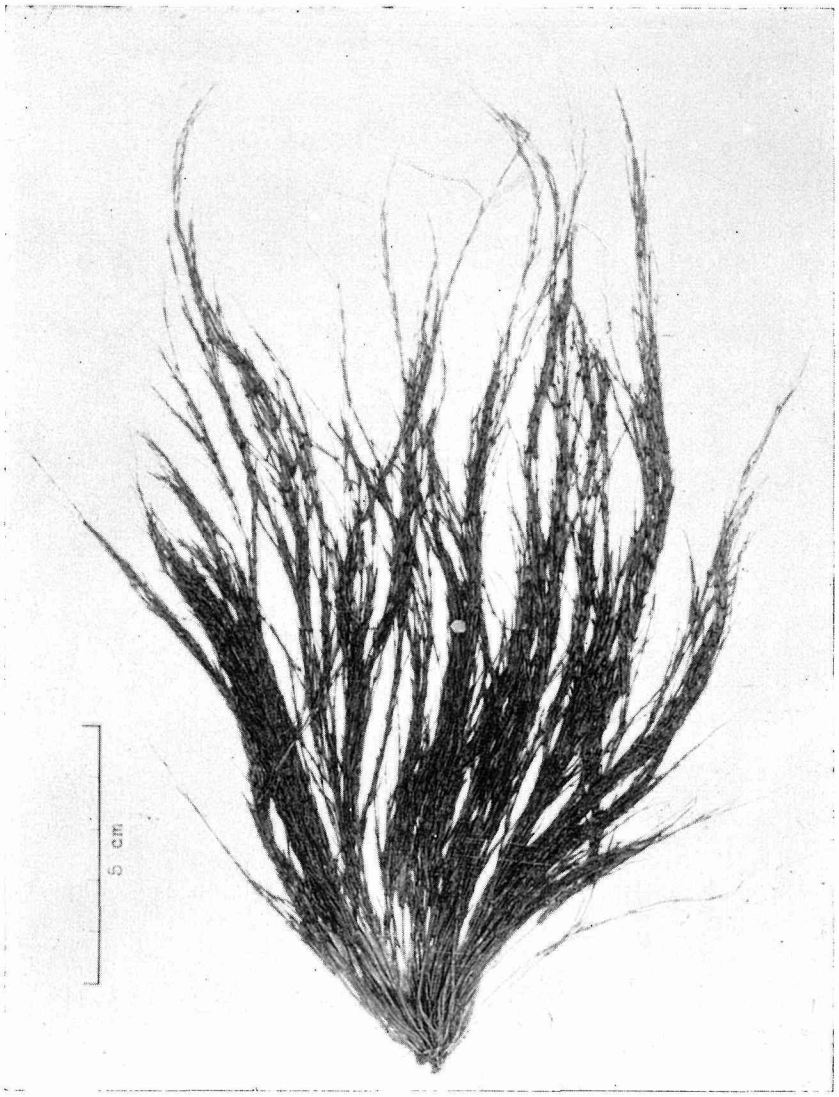

5 cm

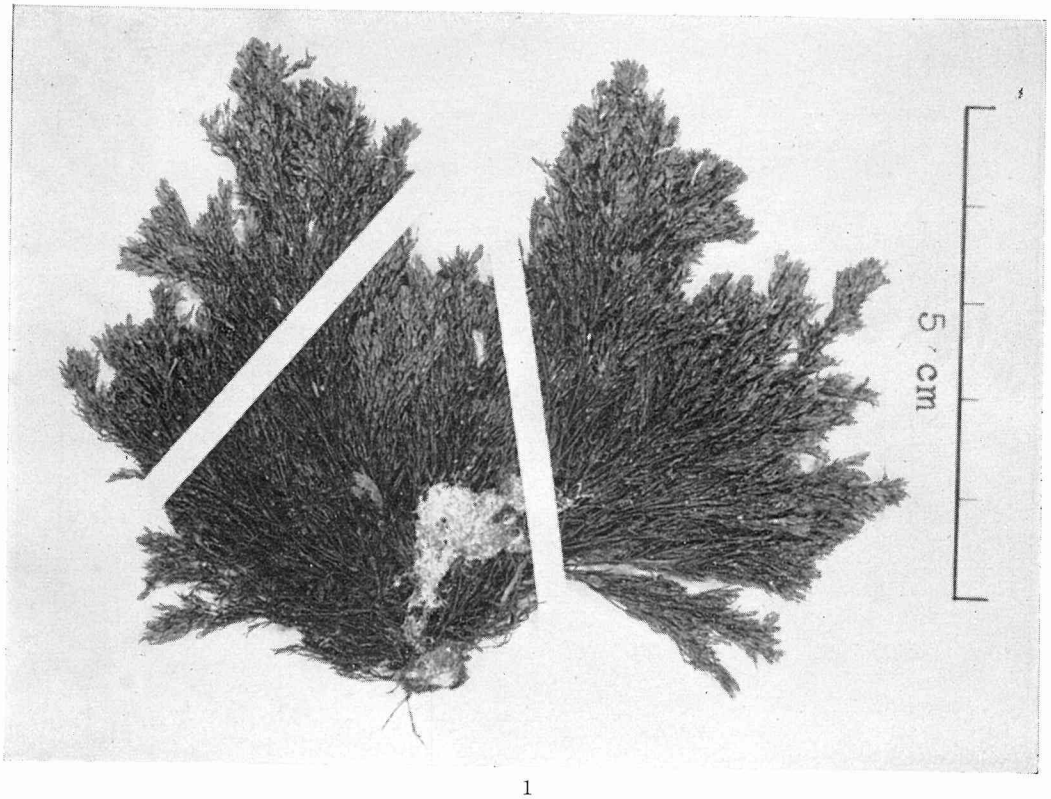
PLATE XV

1. *Cl. rugulosa* MARTENS

Cape Iragosaki, Aichi Pref.
Leg. K. INAGAKI

2. *Cl. sibogae* REINBOLD.

Gushichan, Okinawa Isl., Ryukyu.
Jan. 19, 1958. Leg. S. KAMURA



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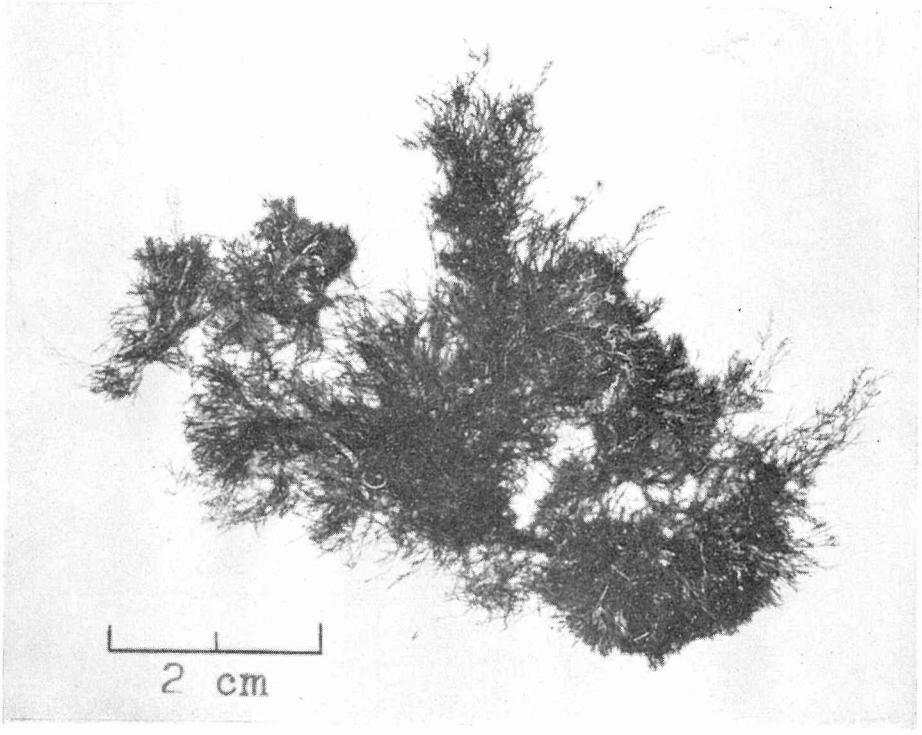

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PLATE XVI

1. *Cl. arenaria* SAKAI

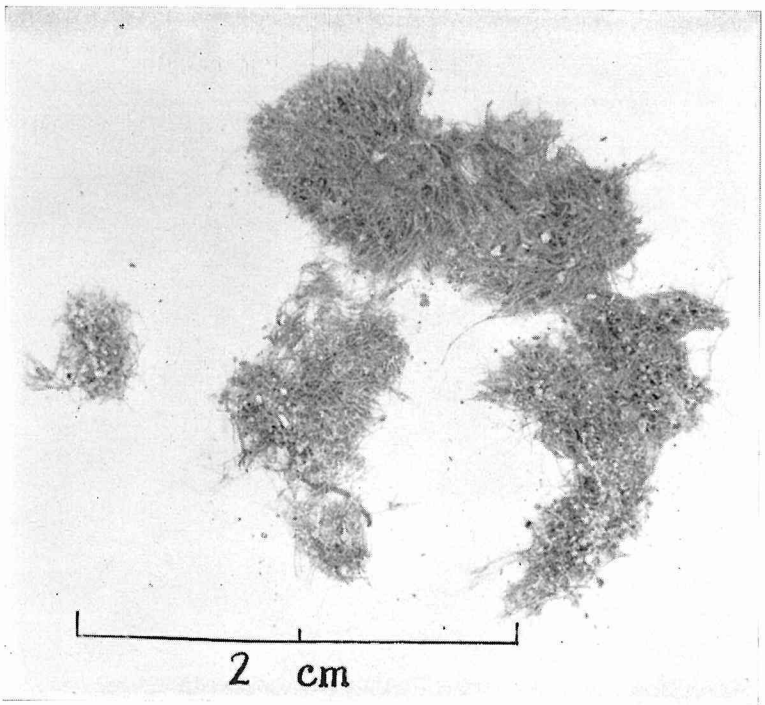
The type specimen
Hakodate, Hokkaido
Apr. 1, 1954. Leg. Y. SAKAI

2. *Cl. conchopheria* SAKAI

The type specimen
Nagahama, Maizuru, Kyoto Pref.
May 12, 1949. Leg. I. UMEZAKI

3. *Cl. crispata* (ROTH) KUETZ.

Attaching filaments
Lake Akan, Hokkaido
Aug. 12, 1958. Leg. Y. SAKAI



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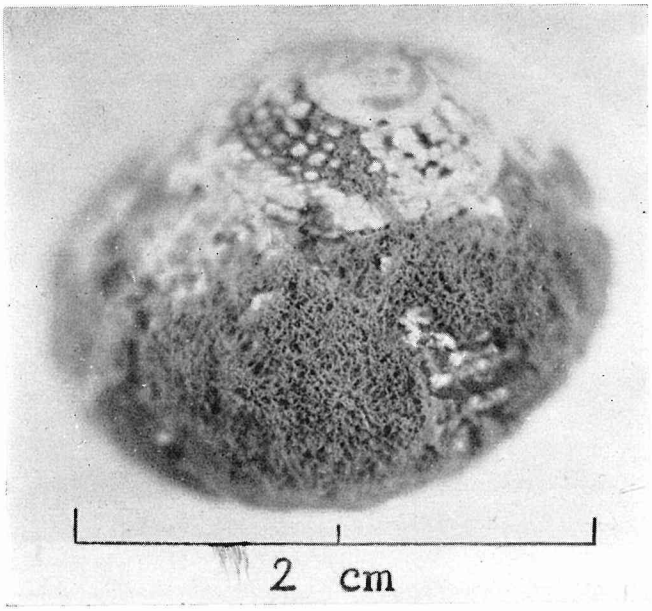

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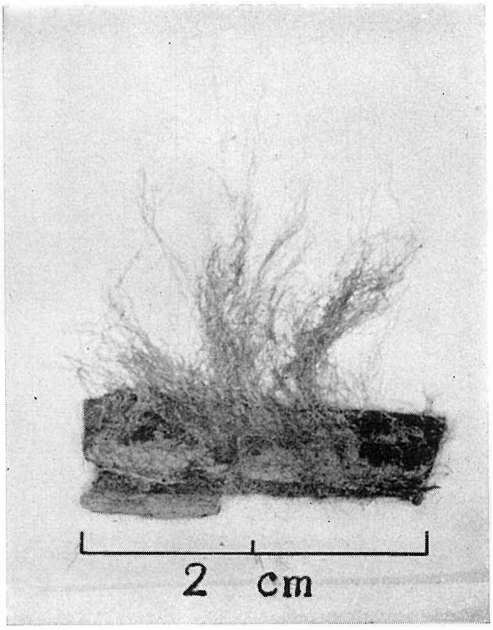


3

PLATE XVII

1. *Cl. albida* (HUDS.) KUETZ.

Hakodate, Hokkaido
June 2, 1950. Leg. Y. SAKAI

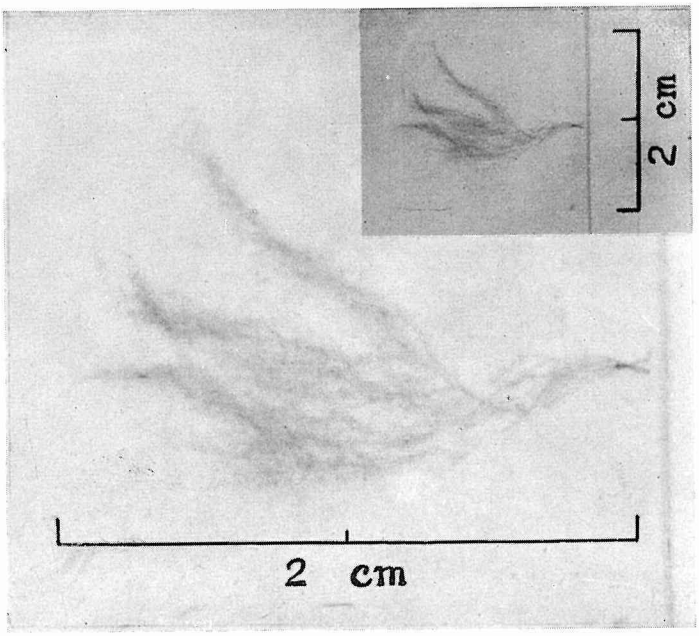
2. *Cl. pusilla* SAKAI

The type specimen
Asari, Hokkaido
August 8, 1947. Leg. Y. SAKAI

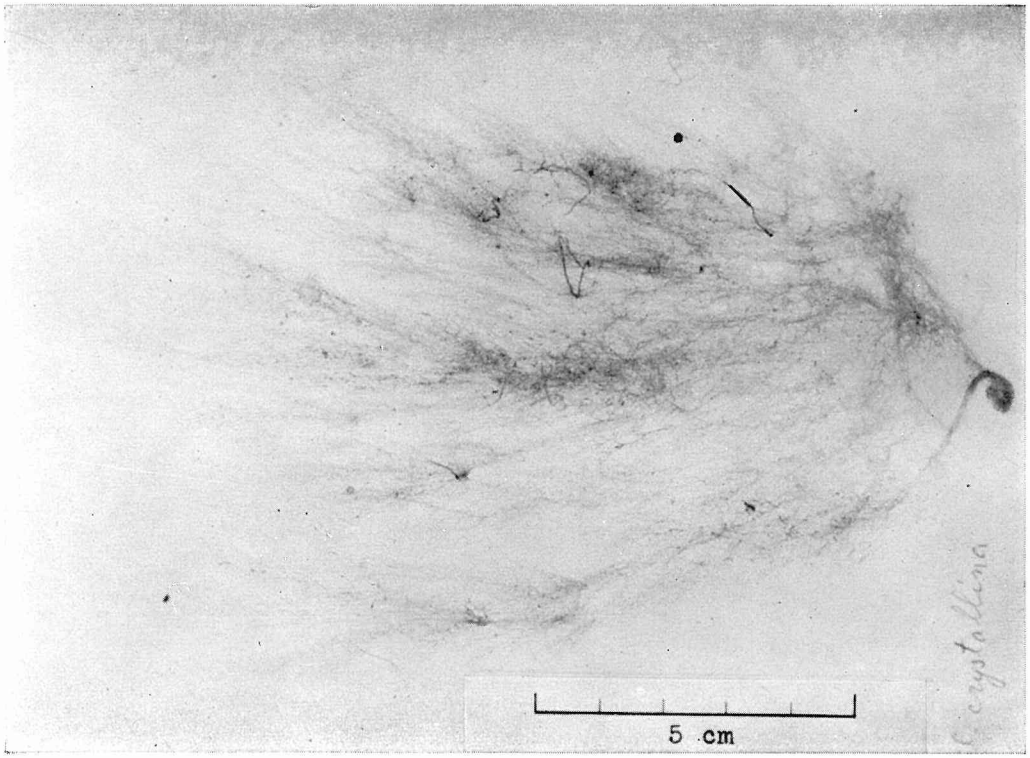
3. *Cl. crystallina* (ROTH) KUETZ.

Lake Kussyaro-Onuma, Hokkaido
July 33, 1951. Leg. Y. SAKAI

1



2



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