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THE JAPANESE SOCIETY OF PHYCOLOGY

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本学会では日本植物学会第51回大会（鹿児島大学）の前日に，秋季シンポジウムおよび懇親会を下記のように開催しますのでご出席下さい。

日　　時：昭和61年10月６日（月）
16：00～18：00　シンポジウム
18：30～20：30　懇親会

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鹿児島大学水産学部　生協食堂

演題・演者：(1) 漸深帯海藻群落の植物社会学的研究
野澤洽治（鹿児島大学）・竹内　幹（ゼネラルフード ＫＫ）・新村　巌（鹿児島県水産試験場）
(2) 南日本におけるガラモ場造成に関する問題点
新村　巌（鹿児島県水産試験場）

座　　長：奥田武男（九州大学農学部）

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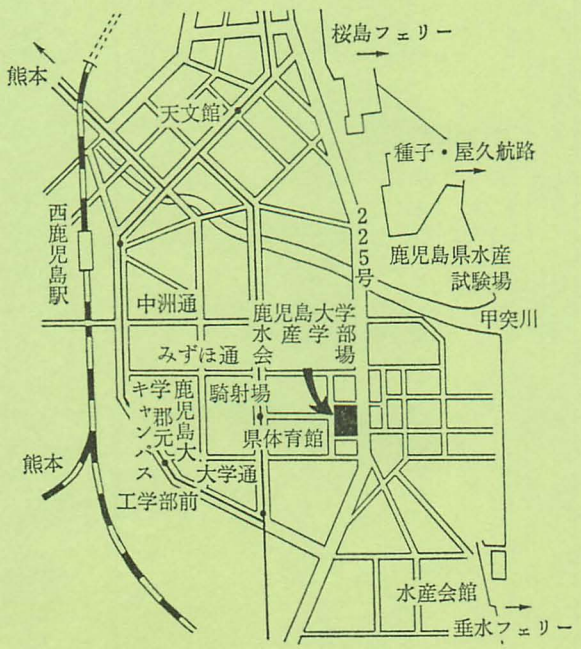
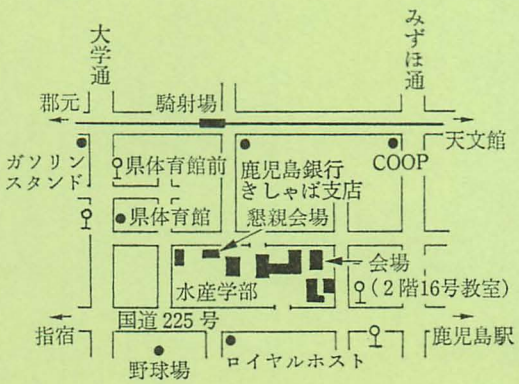


会場案内図



会場周辺案内図

Jap. J. Phycol. (Sôrui) 34: 69-73. June 20, 1986

Critical re-examination of sexual reproduction in *Tinocladia crassa*, *Nemacystus decipiens*, and *Sphaerotrichia divaricata* (Phaeophyceae, Chordariales)*

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PETERS, A.F. and MÜLLER, D.G. 1986. Critical re-examination of sexual reproduction in *Tinocladia crassa*, *Nemacystus decipiens*, and *Sphaerotrichia divaricata* (Phaeophyceae, Chordariales). Jap. J. Phycol. 34: 69-73.

Gametophytes of *Tinocladia crassa* and *Nemacystus decipiens* from Japan, and of *Sphaerotrichia divaricata* from the Pacific coast of Canada were studied in laboratory culture. All three species were dioecious, and sexual fusions occurred between isogametes. Settled female gametes were surrounded by numerous motile male gametes prior to plasmogamy indicating sex attraction. Planozygotes as reported by previous authors were not observed in any of the species.

Key Index Words: *Chordariales*; Nemacystus decipiens; *Phaephyceae*; *sexual reproduction*; Sphaerotrichia divaricata; Tinocladia crassa.

Introduction

The edible seaweeds *Tinocladia crassa* (SURINGAR) KYLIN, *Nemacystus decipiens* (SURINGAR) KUCKUCK, and *Sphaerotrichia divaricata* (AG.) KYLIN are placed in the order Chordariales (KYLIN 1940). Sexual reproduction has been documented recently in all three species (MIGITA and YOTSUI 1972, YOTSUI 1978, AJISAKA and UMEZAKI 1978). Reproduction of *Tinocladia* and *Nemacystus* has been studied in detail in connection with aquaculture (YOTSUI and MIGITA 1974, YOTSUI 1975 a, b, 1976, 1977, 1979 a, b 1980, 1982). In spite of these efforts, knowledge on sexual reproduction in the three species is still incomplete. In *Tinocladia* plasmogamy follows the common pattern of isogamous brown algae: a settled "female" cell fuses with a motile "male" gamete (Fig. 1B in YOTSUI 1978). In contrast, plasmogamy in *Nemacystus* (Fig. 3B in MIGITA and YOTSUI 1972) and *Sphaerotrichia* (Fig. 2DE in AJISAKA and UMEZAKI 1978) was reported to occur between motile gametes, resulting in planozygotes. Gametophytes of *Sphaerotrichia* from Japan were considered to be "sometimes monoecious" and "either isogamous or anisogamous" by AJISAKA and UMEZAKI (1978). *Tinocladia* and *Nemacystus* are both isogamous, but it is unkown whether their gametophytes are monoecious or dioecious.

Clonal gametophyte cultures of the three species were studied in detail in order to answer the questions pointed out above.

Materials and Methods

Gametophytes of *Tinocladia* and *Nemacystus* were obtained from unilocular sporangia on sporophytes collected at Nomozaki, Nagasaki, Japan in May 1984. Gametophyte cultures of *Sphaerotrichia* were initiated from mature sporophytes collected at Bamfield, British Columbia, Canada in August 1984. Unispores

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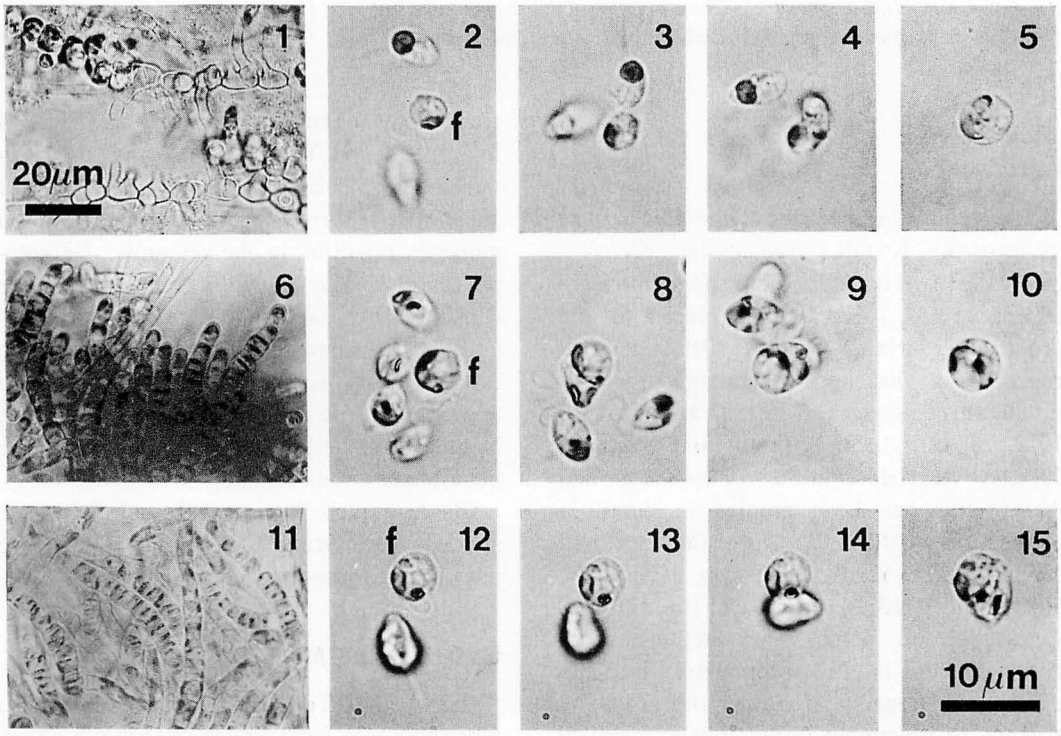
were allowed to settle on fragments of microscopic slides. Clonal cultures were established by isolation of single gametophyte germlings. The algae were cultivated in enriched sea-water (PROVASOLI-ES, after STARR 1978) under daylight-type fluorescent light. Vegetative growth occurred in 17°C with a short-day photoperiod (8 : 16) and a photon-flux density of 10 μmol $m^{-2} s^{-1}$. Gametogenesis was induced by transfer to fresh medium at a 14±2°C long-day photoperiod (16 : 8) and a photon-flux density of 35 μmol $m^{-2} s^{-1}$. Gametophytes of *Sphaerotrichia* were precultivated in 5°C, a long-day photoperiod and a photon-flux density of 5 μmol $m^{-2} s^{-2}$ for at least 8 days before induction of gametogenesis.

Behaviour of zoids was observed in hanging-drop preparations.

Results

In all three species gametophytes formed gametangia (Figs. 1, 6, 11) as described by various authors (MIGITA and YOTSUI 1972, YOTSUI 1978, AJISAKA and UMEZAKI 1978). Gamete release occurred in the morning. Gametes of *Tinocladia* were negatively, those of *Nemacystus* and *Sphaerotrichia* positively phototactic. In microscopic mounts consisting of one clone only, gametes settled without fusions.

In all three species, zygotes were only formed in hanging drops containing a mixture of gametes from compatible gametophyte clones. Fertilization begins after a female gamete has settled on a solid substrate and withdrawn its flagella. The tip of the



Figs. 1–5. *Tinocladia crassa*. 1. Plurilocular gametangia, consisting of 1 to 3 loculi ("paucilocular"), mostly released. 2–5. Sequence of gamete fusion. Figs. 6–10. *Nemacystus decipiens*. 6. Gametangia. 7–10. Sequence of gamete fusion. Figs. 11–15. *Sphaerotrichia divaricata*. 11. Gametangia 12–15. Sequence of gamete fusion. Figs. 1, 6, 11 : Same magnification. Figs. 2–4, 7–9, 12–14 taken at intervals of about ls, figs. 5, 10, 15 few minutes after plasmogamy. f=female gamete. Figs. 2–5, 7–10, 12–15 : Same magnification, hanging-drop preparations.

anterior flagellum of a male gamete attaches to the surface of the female cell. The bodies of the two cells touch and fuse. Subsequently the posterior flagellum of the male gamete is withdrawn. The zygote is usually irregular in shape, but rounds up within a few minutes. If male gametes are in excess, female cells are approached by several male gametes before a zygote is formed. Occasionally, two male gametes fuse with one female. Serial photomicrographs of gamete fusions in all three species are given in Figs. 2-5, 7-10, 12-15.

Female and male gametes are morphologically identical but physiologically different: (i) No interaction occurs if motile female gametes are combined with settled male gametes; (ii) Female gametes produce a conspicuous sweet fragrance not encountered in male cultures.

Sex distribution among the randomly isolated gametophyte clones was 2:2 in *Tinocladia*, 4 female: 3 male in *Nemacystus*, and 5 female: 6 male in *Sphaerotrichia*. No evidence for monoecism was found in this study.

Discussion

Our study shows that *Tinocladia crassa*, *Nemacystus decipiens*, and *Sphaerotrichia divaricata* are dioecious and isogamous. Plasmogamy takes place in the way described above which is known from brown algae since BERTHOLD's observations on *Ectocarpus siliculosus* (DILLW.) LYNGB. (1881). Sexual fusions between two motile gametes resembling plasmogamy in isogamous green algae have been reported and depicted by several authors for various species of brown algae (e. g. ARASAKI 1943a, b, 1948, LOISEAUX 1964, 1966, 1967, 1970), but have not been documented convincingly in any brown alga to date. In *Sphaerotrichia divaricata* (AJISAKA and UMEZAKI 1978) and *Acrothrix pacifica* OKAMURA et YAMADA (AJISAKA 1979) planozygotes have been reported recently. The photomicrographs in these papers can be more plausibly interpreted as showing unfused gametes that are separated by cell walls (Fig. 3E in AJISAKA and UMEZAKI 1978, Fig. 2J in AJISAKA 1979). From the corresponding descriptions in the text it remains uncertain whether genuine gamete fusions occurred. In *Nemacystus decipiens*, fusion of gametes was documented (Fig. 4C in MIGITA and YOTSUI 1972). In this photomicrograph, only one flagellum (presumably the hind flagellum of the male gamete) is visible during plasmogamy. The zygote does not possess any flagella. Thus, evidence for planogamy is not convincing in *Nemacystus*.

Some reports of planozygotes may be due to observation of swarmers with four flagella containing two chloroplasts and eyesports. There is no evidence that these "twins" originate from sexual fusions between gametes. In *Ectocarpus siliculosus* it was shown that such swarmers result from incomplete cell divisions in gametangia or sporangia (MÜLLER 1967, 1975). Actually, such "twin" zoids have not been observed in our study.

Some of our results on *Sphaerotrichia divaricata* from the Pacific coast of Canada differ from the fidings reported for Japanese plants as cited above (AJISAKA and UMEZAKI 1978). They also deviate from the indirect proof of anisogamy, monoecism, and planogamy in plants from Norway given by HYGEN (1934). Hygen did not observe copulations directly, and what he assumed to be male gametes lacking a chloroplast and bearing usually only one flagellum may have been a contaminant. These "male gametes" were not able to germinate apomictically and died, whereas unfused male gametes in our study developed to gametophytes or sporophytes (PETERS unpublished). I-KI-fixed "zygotes" with three flagella as reported by HYGEN do not prove existence of planozygotes convincingly. Since we doubt wether AJISAKA and UMEZAKI report true sexual fusions, their conclusions for anisogamy and monecism are not valid either. Occasionally encountered morphological evidence of anisogamy may

be due to variability in gamete size. Sexual differentiation is defined as anisogamous in cases where persistent differences of gamete size can be established. ARASAKI (1943a) studied the life histories of *Chordaria firma* E.S. GEPP and *Sphaerotrichia japonica* KYLIN, two taxa that were later included in *Sphaerotrichia divaricata* (INAGAKI 1958). ARASAKI described planogamy in both species, isogamy in *S. japonica*, and anisogamy in *C. firma*.

Although our isolates from a Canadian plant are dioecious and isogamous, the possibility that *Sphaerotrichia* is monecious and anisogamous in Japan cannot be excluded. Since sex distribution is important for artificial cultivation and breeding, a re-examination of Japanese *Sphaerotrichia* using clonal gametophyte cultures seems necessary.

Clustering of male gametes around females prior to plasmogamy, and odorous (i.e. volatile) substances produced by female gametes only, indicate sexual attraction. Pheromone systems have been demonstrated so far in several brown algae: *Adenocystis utricularis* (BORY) SKOTTSBERG, *Ascophyllum nodosum* (L.) LE JOLIS, *Chorda tomentosa* LYNGBYE, *Colpomenia peregrina* (SAUV.) HAMEL, *Cutleria multifida* (SMITH) GREV., *Desmarestia aculeata* (L.) LAMOUR., *D. viridis* (D.F. MÜLL.) LAMOUR., *Dictyosiphon foeniculaceus* (HUDS.) GREVILLE, *Dictyota dichotoma* (HUDS.) LAMOUR., *Ectocarpus siliculosus*, *Fucus serratus* L., *F. vesiculosus* L., *Hormosira banksii* (TURN.) DECAISNE, *Scytosiphon lomentaria* (LYNGB.) C. AG., *Sphacelaria rigidula* (KÜTZ.) PRUD'HOMME VAN REINE, some fucalean species from Australia and New Zealand, and several members of the Laminariales (MAIER and MÜLLER 1986).

Within the order Chordariales, only *Spermatochnus paradoxus* (ROTH.) KÜTZING has been examined in respect of gamete secretions so far (MÜLLER *et al.* 1981). Gamete suspensions of this species produced the unsaturated hydrocarbon finavarrene which is also known as sperm attractant of *Ascophyllum nodosum* (Fucales: MÜLLER *et al.* 1982). *Spermatochnus* is monoecious and no biological effect of the gamete secretion could be detected. Isolation of female gamete secretions of *Tinocladia*, *Nemacystus*, and *Sphaerotrichia* are presently attempted.

Acknowledgements

Thanks are due to Dr. Toshio YOTSUI for isolation of gametophye cultures of *Tinocladia* and *Nemacystus* and for reading the manuscript. The work was partly supported by travel grants of Newfoundland Institute for Cold Ocean Science and Deutsche Forschungsgemeinschaft.

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ピーターズ A.K.・ミューラー D.G.: フトモズク，モズク，イシモズク（褐藻類，ナガマツモ目）の有性生殖についての再調査

日本産フトモズク，モズクおよびカナダ大平洋産のイシモズクの配偶体を培養によって調べた。この3種はすべて雌雄異株で同形配偶子接合であったが，細胞質合体に先立ち着床した雌性配偶子のまわりには，性的誘引を思わせる雄性配偶子の集合が見られた。これらの種類では従来から報告のある遊走接合子は見当らなかった。

Jap. J. Phycol. (Sôrui) 34: 74-82. June 20, 1986

New records of marine algae from southern parts of Japan

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Department of Biology, Faculty of Science, Kagoshima University, Kagoshima 890 Japan

ITONO, H. 1986. New records of marine algae from southern parts of Japan. Jap. J. Phycol. 34: 74-82.

Rhipilia orientalis A. et E.S. GEPP, *Zellera tawallina* MARTENS and *Bostrychia calliptera* (MONTAGNE) MONTAGNE are reported from the southern Ryukyu Island and represent new records in Japan.

Key Index Words: Bostrychia calliptera; *Chlorophyta*; Claudea-*group*; Hypoglossum-*group*; Rhipilia orientalis; *Rhodophyta*; Zellera tawallina.

As further collections of marine benthic algae are made in the southern Ryukyu Islands, species which were not previously known from the past literatures (YAMADA and TANAKA 1938; SEGAWA and KAMURA 1960, TANAKA and ITONO 1972, AKATSUKA 1973, KAMURA 1977, OHBA and ARUGA 1982) are now being documented from these waters. This paper describes three species from the southern Ryukyu Islands and two of them, *Rhipilia orientalis* and *Zellera tawallina*, represent genera not previously known from Japan. The specimens are deposited in the Herbarium of the Kagoshima University, Department of Biology.

***Rhipilia orientalis* A. et E. S. GEPP** Siboga Exped. Monogr. **62**: 57. *f. 134-136*. 1911. (Fig. 1A-H)

Japanese name: Nise-hauchiwa.

Specimens examined: HI19851, collected by H. ITONO from Oogami island, May 26, 1984. The habitat of this species is on holes of the reef and the plants were found just below the low-tide level down to 4.5 m deep.

Distribution in literature: Borneo Bank, Fau Is. (GEPP and GEPP 1911); Bikini Atoll, Rongerik Atoll (TAYLOR 1950); Arno Atoll (DAWSON 1956); Eniwetok Atoll (DAWSON 1957); Truk Is. (TRONO 1968); Solomon Is. (WOMERSLEY and BAILEY 1970).

Remarks: Present southern Japanese specimens agree well with the original account (GEPP and GEPP 1911), but are rich green when alive and have a spongy texture which can hardly be described as translucent. In this respect the present specimens agree more closely to the description of TAYLOR (1950) based on the materials from the northern Marshall Islands.

The structure of thallus filaments (Fig. 1E) and the form of tenacula (Fig. 1 F-H) are in excellent agreement with the original descriptions and illustrations, and the differences in color and the texture of the blade in the present materials seem to contribute insufficient differences to preclude them from *Rhipilia orientalis*. *Rhipilia orientalis* varies considerably in its external features of thalli (Fig. 1A-D).

***Zellera tawallina* MARTENS** Bot. Th. Die Tange. 33, *Pl. 8, f. 3*. 1866. (Figs. 2A-B, 3A-B, 4A-E)

Japanese name: Beni-hauchiwa.

Specimens examined: HI19852, collected by H. ITOHO from Kabira, Ishigaki island, May 28, 1984. Growing on the submarine terrace in water about 5 m deep below low-tide level near the reef rim. A single collection of a

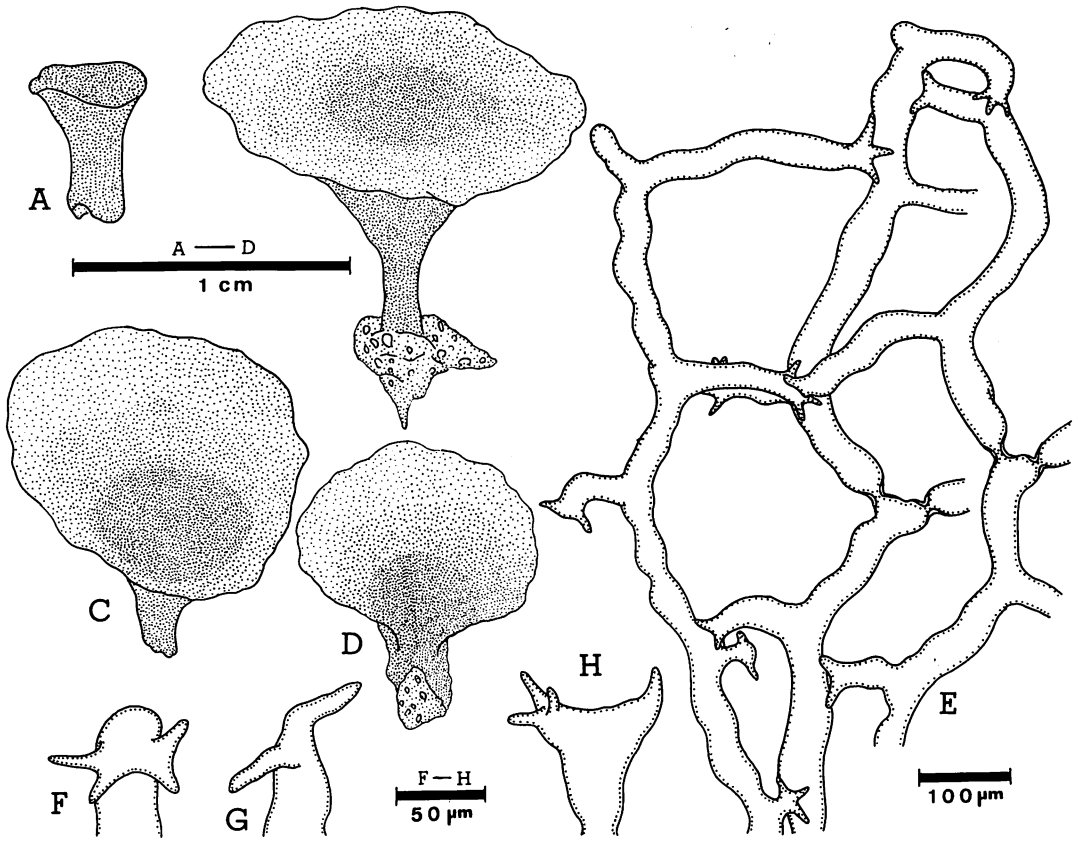


Fig. 1. *Rhipilia orientalis* A. et E. S. GEPP, A-D. habit of plants of both infundibuliform and flabellar types. E. vegetative filaments from the blade, showing the constrictions above the dichotomies and the hapteral connections of the lateral branches with other filaments. F-H. tenacula.

number of plants reveals that all plants are sterile.

Distsibution in literature: Tawalli Is. (MARTENS 1866), Waigeo Is. and Tiur Is. (WEBER VAN BOSSE 1923); Sulu Sea (WOMERSLEY 1965); Solomon Is. (WOMERSLEY and BAILEY 1970).

Remarks: The Claudea-group consist of two genera, *Zellera* and *Claudea*, (WYNNE 1983) and the major differences between these two genera are generally thought as follows (KYLIN 1956, WYNNE 1983): 1) In *Zellera* the fronds are the incomplete networks, while in *Claudea* they are complete; and 2) Branching of all orders of blade is abaxial in *Zellera*, whereas in *Claudea* it is adaxial. In plants habit (Fig. 2B), the present specimens agree well with *Claudea multifida* from the Philippines (CORDERO 1977, pl. 25-B) and *Claudea batanensis* from the Xisha Islands, China (ZHANG and XIA 1979, pl. I-8; XIA, XIA and ZHANG 1983, pl. 71, fig. 4). However, the structure of the frond in the present southern Japanese specimens is characterized by abaxial branching (Fig. 2 A-B) with the formation of nets by the blades of the fourth and fifth orders. Such characteristic is typical of the genus *Zellera*, and neither *Claudea multifida* nor *Claudea batanensis* agrees with the present southern Japanese species.

Up to now, two species of the genus *Zellera* have been described, *Zellera tawallina* (type of the genus) from the western tropical Pacific (MARTENS 1866) and *Zellera boekei* from the Atlantic (SLUITER 1908). The

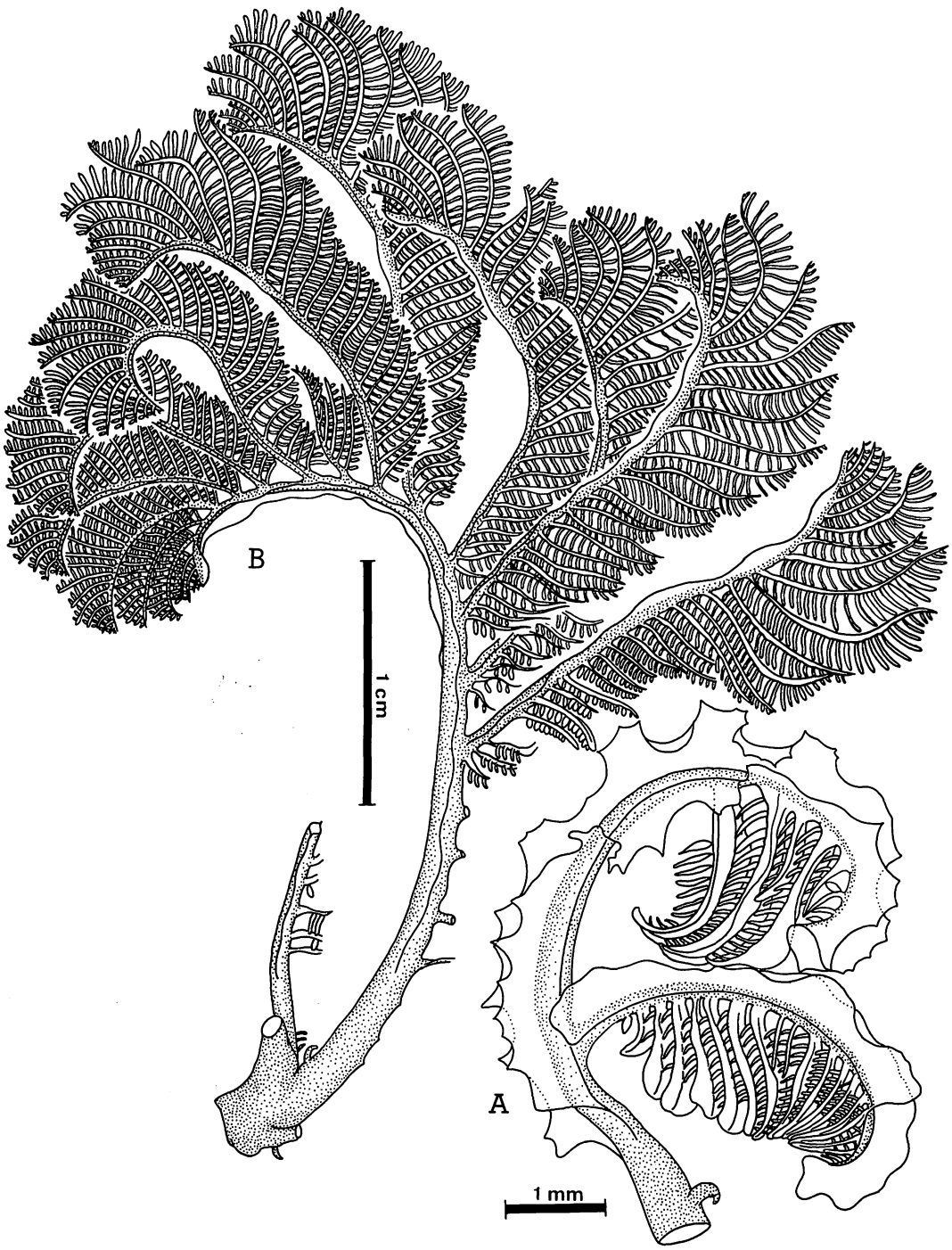


Fig. 2. *Zellera tawallina* MARTENS. A. frond of the young plants, showing the abaxial branching and undulate margin of blades. B. habit of the mature plant. Blades of the fifth order are not indicated.

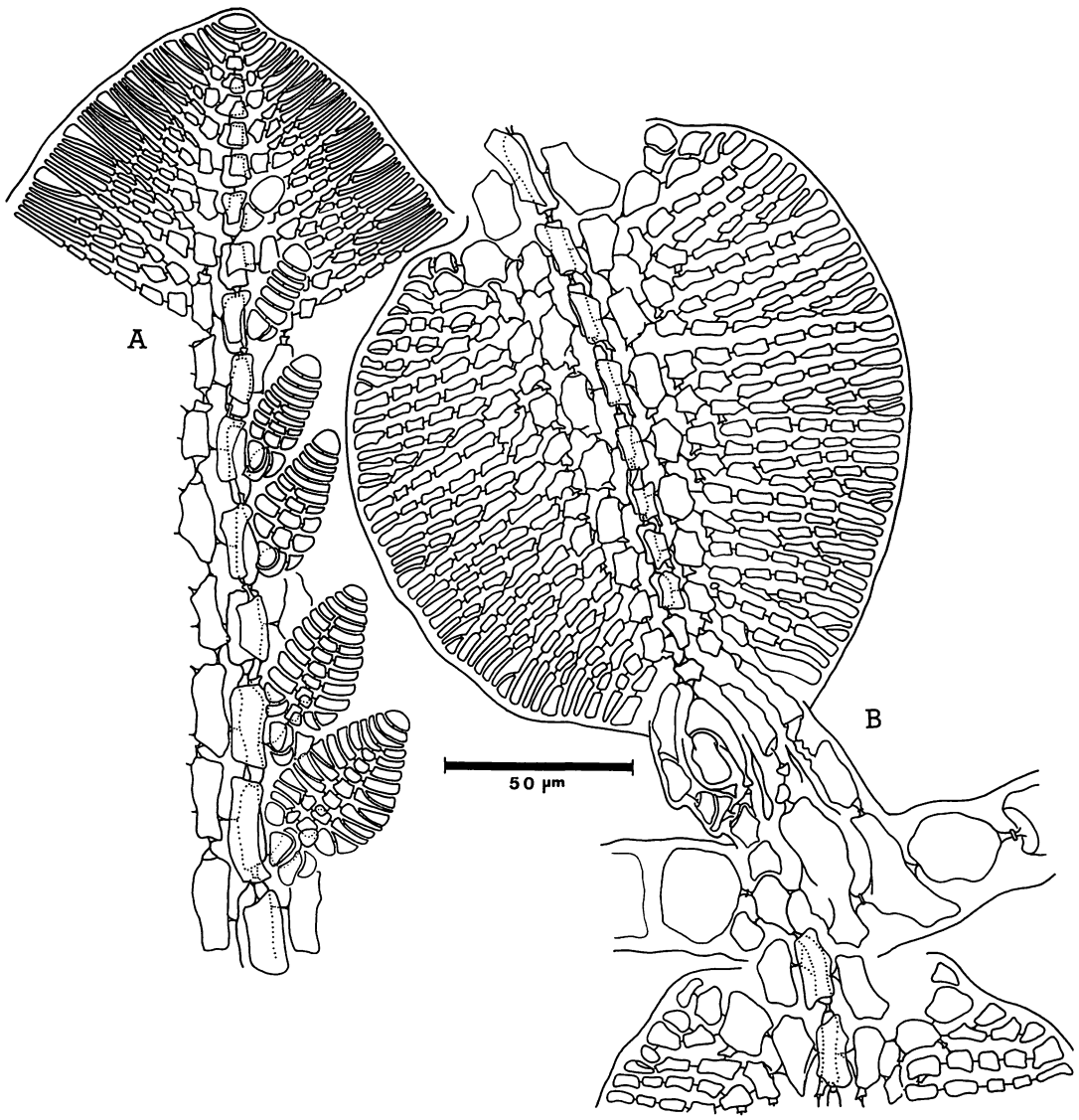


Fig. 3. *Zellera tawallina* MARTENS. A. mature blade with juvenile blades on abaxial side. B. surface view of a short blade, showing the elongation of distal cells and the union with the cells of an adjoining blade.

latter was considered to be synonymous with *Hypoglossum involuvens* by TAYLOR (1960). The present southern Japanese species agrees well with *Zellera tawallina* in all respects of its vegetative structures.

Present observation reveals that in the structures of blade *Zellera tawallina* provides some features in common with those that were observed by PAPENFUSS (1937) in *Claudea multifida* and *Vanvoorstia spectabilis*. *Zellera tawallina* agrees with *Claudea multifida* in the following features: 1) The lateral pericentral cells are formed earlier than transverse ones (Fig. 3A); 2) Blades are formed as a rule by successive segments (Fig. 3A); and 3) The interstices of the nets are four sided making always more or less rectangular meshes. The features which combine *Zellera tawallina* with *Vanvoorstia spectabilis* are as follows: 1) Blades are

formed by the characteristic abaxial branching (Fig. 2A-B); 2) One or more of the cells at the distal part of a short blade usually elongate and precede the apical cell in establishing connections with the cells of the adjoining blades (Fig. 3B); and 3) Basal segment of blade forms three pericentral cells, an abaxial and two lateral pericentral cells (Fig. 3A). These features, however, may not have so significant taxonomic im-

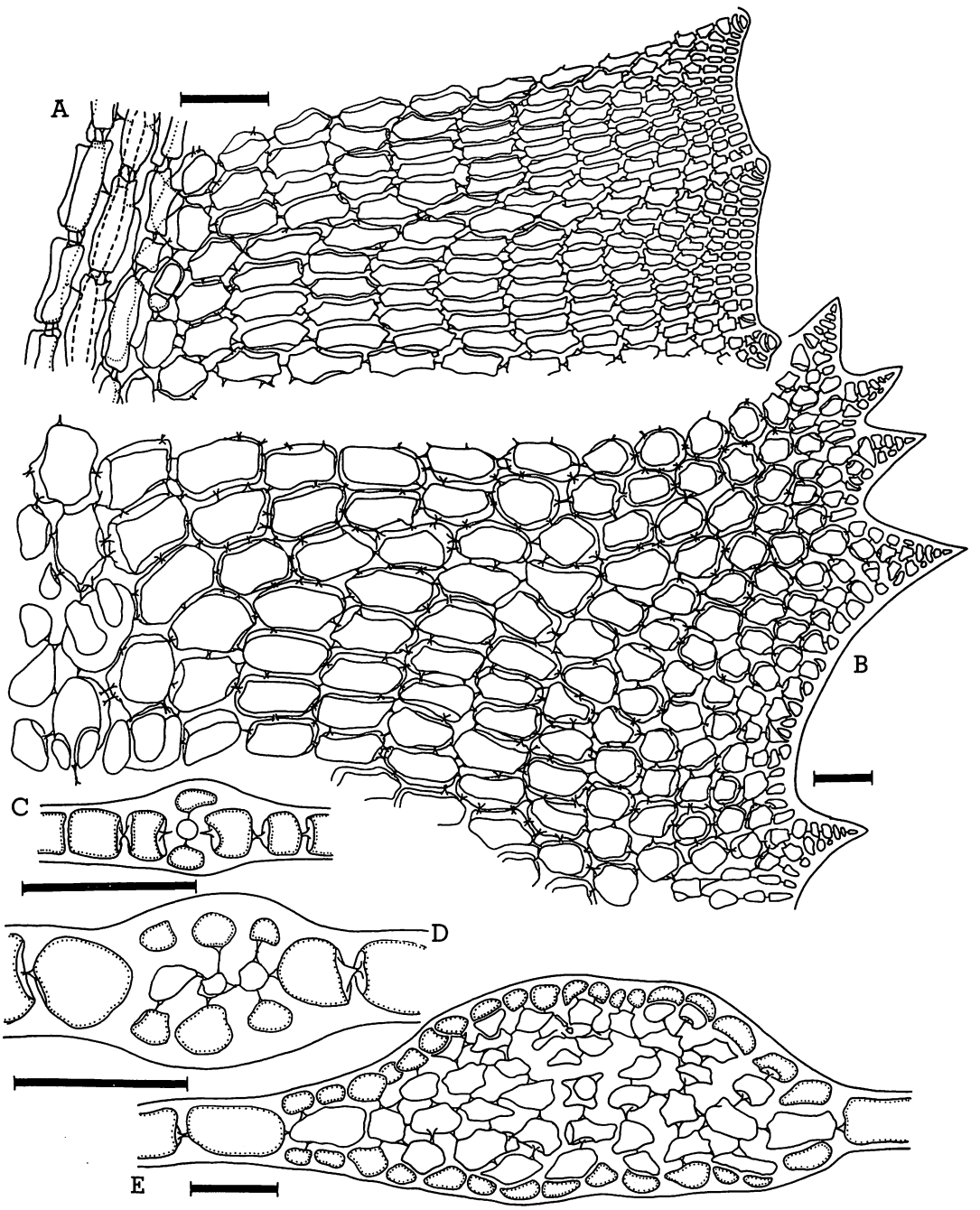
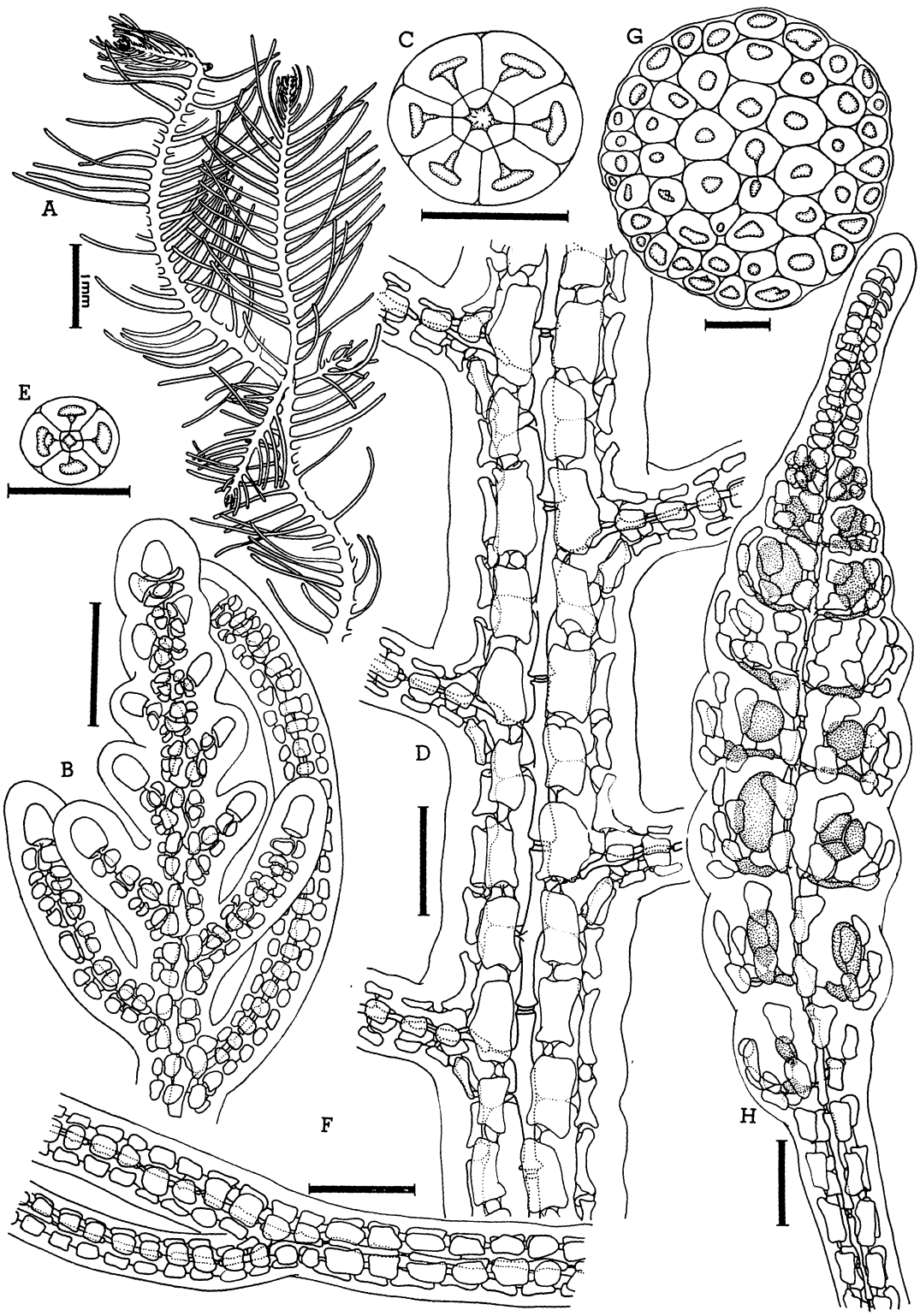


Fig. 4. *Zellera tawallina* MARTENS. A-B. parts of blades, showing the cell linneages. C-E. sectional view, showing cortication of mldrib regions of the blade. (Scale=50 μm).


A
1mm
B
C
D
E
F
G
H

plications in discussing the relationships of *Zellera* with *Claudea* or *Vanvoorstia*, and the features in the formation of blades and the development of tertiary cell rows seem to have much weight in the taxonomic argument about *Zellera tawallina*.

Unlike the structures of *Claudea multifida* and *Vanvoorstia spectabilis*, *Zellera tawallina* is distinct in the following features: 1) The primordium of the daughter blade is initiated as an outgrowth from the posterolateral side of a central cell and lies between abaxial and one of the lateral pericentral cells that elongates to the same length as the central cell (Fig. 3A); and 2) A number of tertiary cell rows, of which all apical cells reach the thallus margins, are produced (Figs. 3B, 4A-B), and some of these continue further development giving rise to irregular spinous projections resulting from short rows of fourth order cells (Fig. 4B). These features suggest that *Zellera* is closely related to the genera of the Hypoglossum-group more closely than to *Claudea* or *Vanvoorstia*. *Claudea* and *Vanvoorstia*, as well as *Zellera*, were formerly included under Claudea-group (KYLIN 1956), and now *Vanvoorstia* is excluded from this group representing a sole genus in the Vanvoorstia-group (WYNNE 1983). The results obtained from the present odservations on the vegetative structures of *Zellera tawallina* support the suggestion by WOMERSLEY (1965) that *Zellera* is closely related to the Hypoglossum-group. A study of further collections, especially those of tetrasporic and female plants of *Zellera tawallina*, would help in assessing its relationships.

Bostrychia calliptera (MONTAGNE) MONTAGNE KUETZING Sp. Alg. 839. 1849. (Fig. 5A-H)

Japanese name: Yaeyama-kokemodoki.
Specimens examined: HI19853, collected by H. ITONO from Fukido river, Ishigaki island, May 28, 1984. Growing on the prop-roots of rhizophoracean plants in shallow and sheltered situations, or forming dense mats on damp shaded rocks in the intertidal-zone near the river mouth.
Distribution in literature: French Guiana, Brazil (TAYLOR 1960); Florida (DAWES 1974); Venezuela, Ghana (POST 1936); Galapagos Is. (POST 1963); Panama, Colombia, Ecuador (TAYLOR 1945); Singapore, Sumatra, Newguinea (POST 1936).
Remarks: In habit, the present specimens agree well with the illustrations of *Bostrychia calliptera* by KUETZING (1864, pl. 19d-g) and by FALKENBERG (1901, pl. 11, figs. 26-29). Comparison with the description of TAYLOR (1960) of this species reveals that the southern Japanese specimens agree fairly well in their vegetative structures except some features such as the size of plants and the manner of the axial cortication. According to the TAYLOR's description (1960), the plants attain the height of 6-11 cm and the main axes become corticated by rhizoidal filaments. Our southern Japanese specimens, however, are generally slender and attain less than 2 cm high, and the axial cortication of the indeterminate axes is occasionally seen only in the basal parts of the axes. In the basal parts of the indeterminate axes, some of the pericentral cells and their first derivatives initiate rhizoidal cells from their posterior ends and these rhizoidal cells extend downwards on the surface of the pericentral cells in the segment below or even along the space between the central and pericentral cells, and the axes have usually slight cortication. In the most heavily corticated axis the cortex is two or three layers

Fig. 5. *Bostrychia calliptera* (MONTAGNE) MONTAGNE. A. habit of plant. B. dorsal surface of the tip of the of the main axis. C. transverse section of the main axis, showing six pericentral cells. D. dorsal surface of the main axis, showing arrangement of pericentral cells and the lateral branches. E. transverse section of the lateral branch, showing four pericentral cells. F. part of lateral branch, showing unusual branching. G. transverse section of basal part of the main axis, showing axial cortication. H. dorsal surface of the stichidium, showing the arrangement of tetrasporangia. (Scales in B-H=50 μm).

thick (Fig. 5G).

The structure, with the slight development of axial cortication by rhizoidal cells, is of distinctive morphology. However, in the development of the lateral branches in alternate distichous manner, the presence of six pericentral cells in the segment of indeterminate axes and four in the lateral branches, and the entire absence of monosiphonous branchs, they show the essential features of *Bostrychia calliptera*, though the thalli remain small. POST (1963) recognized fifteen species of *Bostrychia*, and as contrasted with all species with axial cortication, such axial cortication by rhizoidal filaments in *Bostrychia calliptera* is very distinctive. POST (1936) already recognized that specimens of *Bostrychia calliptera* from Indo-Pacific Oceans have smaller size of thalli and have a characteristic in which the axial cortication is suppressed in most cases. In agreement with the view of Post, it appears best to regard the southern Japanese species as a dwarf variant of *Bostrychia calliptera*.

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糸野　洋：南日本新産海産藻類について

沖縄県八重山諸島で採集した海産藻類のうち，南日本新産種として *Rhipilia orientalis* A. et E. S. GEPP ニセハウチワ（新称），*Zellera tawallina* MARTENS ベニハウチワ（新称）及び *Bostrychia calliptera* (MONTAGNE) MONTAGNE ヤエヤマコケモドキ（新称）の3種を報告した。これら3種のなかで，ニセハウチワ属 *Rhipilia* KUETZING (Udoteaceae, Chlorophyta) とベニハウチワ属 *Zellera* MARTENS (Delesseriaceae, Rhodophyta) の2属は我国の海藻フロラに新しく追加されるべき属である。(890 鹿児島市郡元1丁目21番35号，鹿児島大学理学部系統分類学研究室)

Jap. J. Phycol. (Sôuri) 34: 83-86. June 20, 1986

Scale bearing Chrysophyceae from the Panama Canal

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WUJEK, D.E. 1986. Scale bearing Chrysophyceae from the Panama Canal. Jap. J. Phycol. 34: 83-86.

Scale-bearing Chrysophyceae (Mallomonadaceae, Paraphysomonadaceae) from the Panama Canal have been examined using transmission and scanning electron microscopy. Eight species of the genera *Mallomonas*, *Paraphysomonas*, and *Spiniferomonas* are illustrated.

Key Index Words: *Chrysophyceae*; *Mallomonadaceae*; Mallomonas; *Panama Canal*; *Paraphysomonadceae*; Paraphysomonas; Spiniferomonas.

Several studies have been made on the phytoplankton of the Panama Canal (see PRESCOTT 1967 for literature review). In his photosynthetic activity study on the Panama Canal and its major tributary, Madden Lake, GLIWICZ (1976) included a list of phytoplankton differing slightly from that recorded by PRESCOTT (1936, 1951, 1955, 1967).

PRESCOTT (1955) does not list any species belonging to the Mallomonadaceae or Paraphysomonadaceae in his checklistof flagellated algae, but does mention *Mallomonas* and *Synura* in his Panama Canal algal ecology paper (PRESCOTT 1951). The 1951 paper is the only reference to this group of organisms occurring in the canal although no species are mentioned.

The purpose of this paper is to report the occurrence of eight taxa of scaled chrysophytes from the Panama Canal. Because electron microscopy is needed for identification of these siliceous scale-bearing organisms, all observations are by means of electron microscopy.

Materials and Methods

Phytoplankton samples were collected in Janaury, 1984 near the vicinity of Barro Colorado Island, Panama, with a plankton net (5 μm mesh), and were either unfixed or fixed with a few drops of Lugol's solution or 1% phosphate buffered osmium tetroxide. For transmission electron microscopy samples were placed on Formvar coated-carbon stabilized grids, air-dried and then examined with a Philips EM 300. Although no scanning micrographs are presented in this paper, samples were also examined with an AMR 1200 scanning electron microscope. Prior to examination these samples were air-dried on aluminum stubs and then sputtered with gold as previously described (WUJEK 1984a).

Observation and Discussion

Spiniferomonas bourrellyi TAKAHASHI Fig. 1

NICHOLLS (1981) recently synonymized *S. conica* with this species because of the difficulty in establishing characters to separate the two species. The past two years this species has been referred to as *Chromophysomonas bourrellyi* (TAKAHASHI) PREISIG and HIBBERD, but NICHOLLS (1985) has demonstrated the presence of a chloroplast reestablishing *Spiniferomonas* as a valid genus. This species has been found in many parts of the world (Asia, Europe, North America) and undoubtedly will prove to have even a

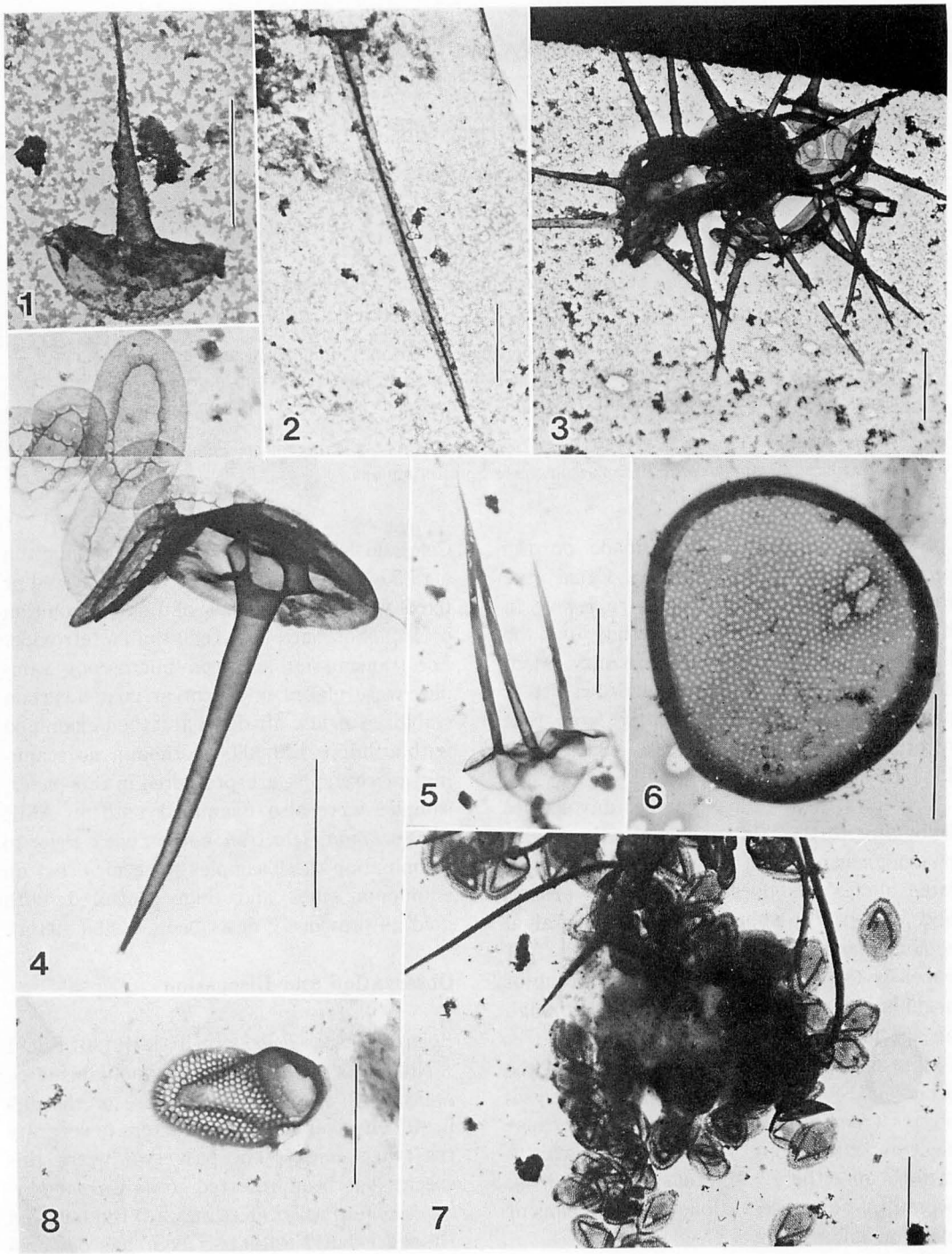

Fig. 1. *Spiriferomonas bourrellyi*, scale. Fig. 2. *S. trioralis*, scale. Figs. 3, 4. *S. enigmata*, whole cell; scales and bristle. Fig. 5. *Paraphysomonas imperforata*, scales. Fig. 6. *Mallomonas caudata*, scale. Fig. 7. *M. tonsurata*, scales. Fig. 8. *M. alpina*, scale. Bar=2 μm.

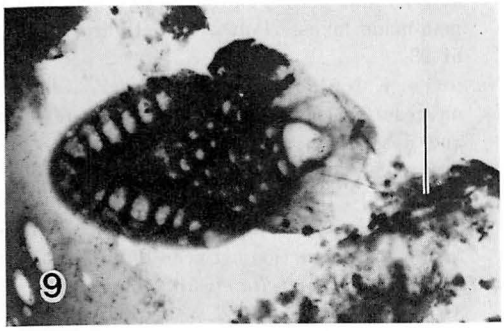

Fig. 9. *Mallomonas pseudocoronata*, scale. Bar=2 μm.

wider distribution.

Spiniferomonas trioralis TAKAHASHI Fig. 2

Easily recognized by its winged spine scale, this species is the most widely reported for the genus.

Spiniferomonas enigmata NICHOLLS Figs. 3, 4

This is the second report of this taxon. Described from Ontario, Canada, the specimens in my samples consistently possessed shorter shafts (4–6 μm) on the spine scales than those observed by NICHOLLS (1984) in his original description of the species which possessed shafts of much greater length (15–32 μm).

Paraphysomonas vestita (STOKES) de SAEDELER Fig. 5

This species is the most widely reported of its genus. It tolerates a wide range of salinities, temperatures and pH values. It has recently been reported from Costa Rica (WUJEK 1984b).

Mallomonas caudata IWANOFF emend. KRIEGER Fig. 6

First examined with the electron microscope by ASMUND (1955), it is a large species and is easily identified using light microscopy. It is widely distributed throughout the world.

Mallomonas tonsurata TEILING emend. KREIGER var. *tonsurata* Fig. 7

This is one of the most common *Mallomonas* species and occurs in many parts of the world. Easily confused with *M. alpina*, it is separated from it by the presence of a secondary layer on the base plate and a furcate bristle tip.

Mallomonas alpina RUTTNER in PASCHER Fig. 8

A common and widespread species, it is frequently treated as a variety of *M. tonsurata* owing to its lack of a secondary layer on the shield.

Mallomonas pseudocornata PRESCOTT Fig. 9

This species is one of the few *Mallomonas* species easily identified by cell or scale morphology with the light microscope. Known exclusively from North America, this is its most southern report. It has been reported from Canada and the northern United States and only recently was reported from south Florida (WUJEK, 1984a). DÜRRSCHMIDT (1980, 1982a, 1982b, 1983a, 1983b, 1983c) in her examination of South American Chrysophyceae did not observe this species.

Based on the species observed, the Chrysophycean flora of the Panama Canal does not deviate from what is found in the northern hemisphere. Although many species common in Europe or Japan were not found during this investigation, it must be considered that many areas within Panama still remain to be investigated. Surprisingly absent in this survey were taxa belonging to the genus *Synura*. In most every siliceous-scaled chrysophycean flora published to date, one or more species of this genus are reported.

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ビェック, D. E.: パナマ運河産の鱗片を有する黄藻綱について

パナマ運河産の鱗片を有する黄藻綱植物を TEM および SEM を用いて調べた。*Mallomonas*, *Paraphysomonas*, *Spiniferomonas* に属する 8 種について図示した。

Jap. J. Phycol. (Sôrui) 34 : 87-93. June 20, 1986

Observations on the valve structure of fresh water *Diploneis* (Bacillariophyceae), *D. oculata* (BRÉB.) CLEVE and *D. minuta* PETERSEN

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IDEI, M. and KOBAYASI, H. 1986. Observations on the valve structure of fresh water *Diploneis*, (Bacillariophyceae), *D. oculata* (BRÉB.) CL. and *D. minuta* PET. Jap. J. Phycol. 34 : 87-93.

Two *Diploneis* species with a sinuous slit on the exterior occlusion of the alveolus are identified on the basis of authentic specimens and examined using TEM and SEM. The alveolus of these species is occluded externally by a vola with a sinuous slit and internally by a hymen (a very thin perforated layer), bearing perforations in a hexagonal array. The cingulum is composed of two bands, one valvocopula, which is a broad open band, and a narrow pleura.

Key Index Words: *Diatoms*; Diploneis oculata; Diploneis minuta; *fine structure*; *sinuous slit*.

The fine structure of valves of the genus *Diploneis* has been mainly observed using transmission electron microscopy (TEM) (HELMCKE and KRIEGER 1962, GEISSLER *et al.* 1963, OKUNO 1964, 1970, GERMAIN 1979, 1981), although a few but noteworthy works have used scanning electron microscopy (SEM) (GERLOFF and HELMCKE 1975, SIMS and PADDOCK 1979, SCHOEMAN and ASHTON 1982).

Morphological characteristics useful for the taxonomy of the genus are more clearly visible with SEM, because almost all *Diploneis* valves have strongly silicified longitudinal canals and complex alveoli, the structure of which is hardly detectable by TEM.

The valve structure of *D. oculata* and *D. minuta* has already been examined with TEM by GERMAIN (1979, 1981). One of the peculiar features of these species, namely, the presence of a sinuous line on the alveolus, has been clarified, but whether the sinuous line is situated on the inner or outer side of the alveolus is still unclear. In this paper, further investigation using SEM makes clear a three-dimensional structure of the sinuous line and other features such as open valvocopula and pleura.

Materials and Methods

Specimens used for SEM observation of *Diploneis oculata* were collected from the following locations. 1) Bottom mud in Aoki-ko (Aoki Lake), Nagano Prefecture on 19 March 1974, K-3094. 2) Bottom mud in Yamanaka-ko (Yamanaka Lake), Yamanashi Prefecture on 22 Feb. 1984, K-1811. 3) Bottom mud in an irrigation pond without name near Ueda City, Nagano Prefecture in 5 May 1978, K-2924. 4) Bottom mud in an irrigation pond without name near Soma City, Fukushima Prefecture on 16 June 1984, K-1941.

The specimens of *D. minuta* were collected from moss on a rock beside Yōro Fall, Chiba Prefecture on 16 Dec. 1979, N-1006 (K-3172).

Methods of cleaning, washing, and preparing objects for light and electron microscopy are in KOBAYASI *et al.* (1985).

Results and Discussion

Diploneis oculata (BRÉB.) CLEVE (1894, p. 92). Figs 1-5, 9-20.

This species is found in various lakes and ponds in Japan, but the cells in each sample are usually very scarce. We found it in a considerable amount only in the sample collected from an irrigation pond near Sōma City, Fukushima Prefecture.

Valves of our specimens are 16-34 μm in length, 7-8 μ in width. Transapical striae number about 18 in 10 μm at the center and up to 20 in 10 μm at the poles. The valves are longer than those described for European specimens. CLEVE (1894) gave a length range of 15-20 μm, HUSTEDT (1930, 1937) and PATRICK & REIMER (1966) gave 10-20 μm and GERMAIN (1979) gave 8-12 μm. Our measurement of specimens from the following European collections showed a length range of 14-20 μm: V. Heurck Type Slide (No. 106, *Navicula oculata* Bréb. Bruxelles, Belgique) housed in the Naturhistorisches Museum, Wien (Fig. 1): Kützing collection in the British Museum (BM 18861) (Fig. 2); a collection from Lunzer Untersee, Austria (K-2090) (Fig. 3).

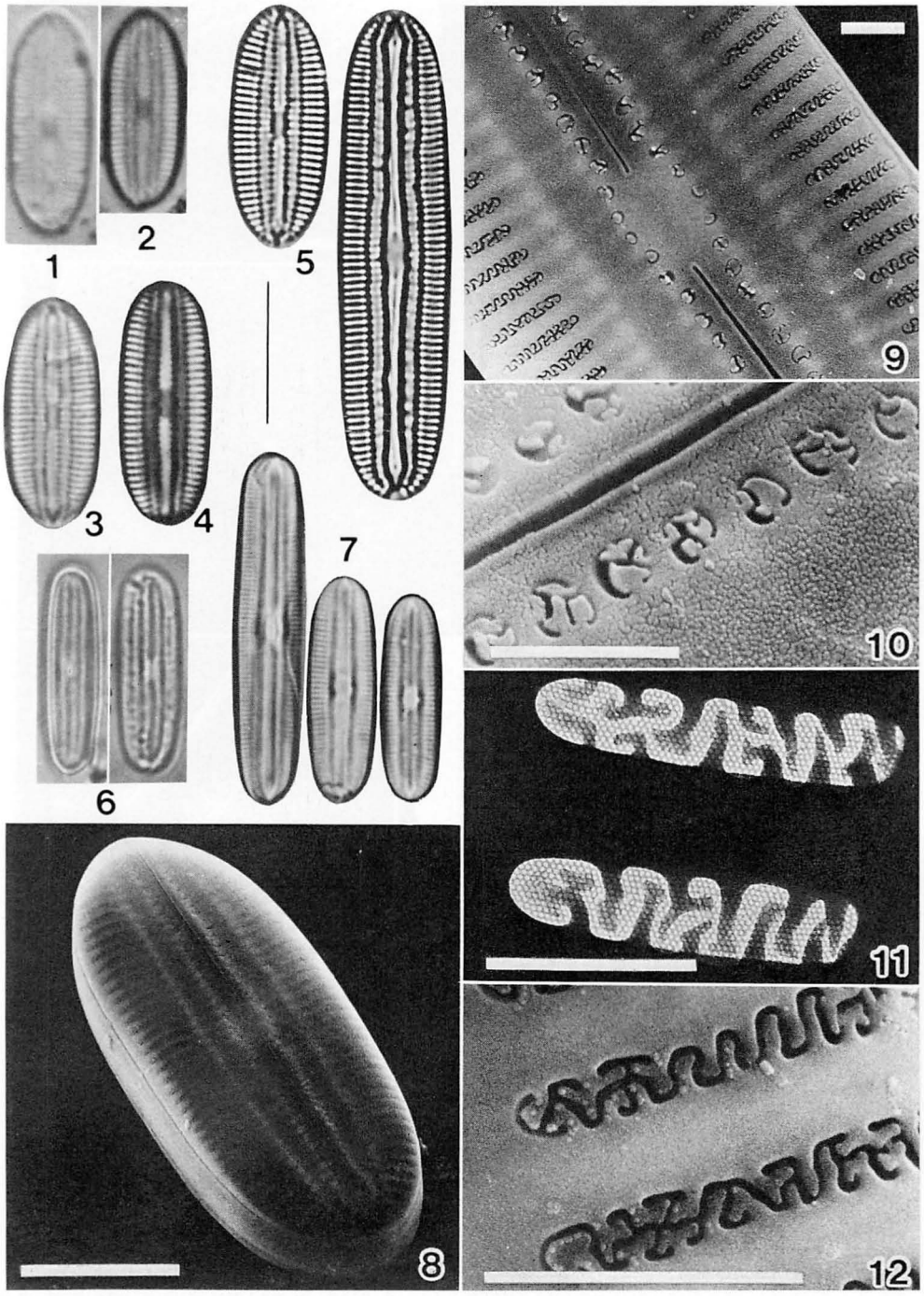
The striae of our specimens are coarser than those of European specimens, being 19 in 10 μm in Fig. 4 and 18 in 10 μm in Fig. 5. On the other hand, as seen in Figs 1-3, striae of the European specimens measure up to 22 in 10 μm. However, the fine structure of our specimens observed with SEM and TEM appeared to be identical with that of European specimens (GERMAIN 1979) and thus the Japanese specimens were identified as *D. oculata*.

In SEM, the valve face is almost flat and the mantle is relatively shallow (Fig. 8). Externally the raphe is a narrow slit. The proximal ends of the raphe branches are straight without forming a central pore. The distal ends are also straight and terminate some distance from the valve margin. Along both sides of the axial area, a longitudinal row of poroids extends the whole length of the valve. Each row expands slightly to the outside at the center and conspicuously at the terminal nodule (Figs 8, 9, 18 arrow). Each poroid penetrates obliquely the outer wall from the raphe side to the axial edge of the longitudinal canal lumen (Fig. 15 arrow). Those poroids that are arranged on either side of the central nodule are occluded by a single round flap (Fig. 9), while the remaining poroids are occluded externally by a vola and are uniformly larger (Fig. 10).

The internal fissures of the raphe are enclosed in a slightly raised rib lying between two prominent longitudinal canals, their proximal ends terminating up against a raised central nodule (Figs 15, 19; cf. SIMS and PADDOCK 1979, SCHOEMAN and ASHTON 1982). The costae run from the outer edges of the two longitudinal canals to the valve margin (Figs 13-15). The intercostal spaces consist of elongated alveoli (Figs 15, 17), each occluded externally by an elongated vola (Figs 9, 11, 12) and internally by a thin siliceous layer with perforations arranged in a hexagonal array (Figs 11, 15-17) (MANN 1981).

The area with volate occlusions occupies about half the valve width (Figs 8, 9, 18), but the alveoli extend beyond the occlusion

Plate 1. Figs 1-5. L.M. *Diploneis oculata* (BRÉB.) CL. bar=10 μm. Fig. 1. Kützing's Coll., BM 18861, Paris 1708. ×2,000. Fig. 2. Grunow's Coll., V.H. Type Slide No. 106, Bruxelles, Belgique. ×2,000. Fig. 3. Lunzer Untersee, Austria. K-2090. ×2,000. Fig. 4. A pond, Ueda City, Nagano Pref. K-2924. ×2,000. Fig. 5. A pond, Sōma City, Fukushima Pref. K-1941. ×2,000. Figs 6, 7. *Diploneis minuta* PET. bar=10 μm. Fig. 6. Isotype specimens. Hustedt's Coll., 04/59, moss, Eyvindará, Iceland,



Pet. 25. ×2,000. Fig. 7. On moss, Yōro Fall, Chiba Pref. N-1006. (=K-3172). ×2,000. Figs 8-12. *Diploneis oculata* (BRÉB.) CL. Fig. 8. Frustule from outside. A pond, Sōma City. SEM. ×4,500 (bar =5 μm). Fig. 9. Center enlarged, from outside. Aoki Lake Nagano Pref. K-3094. SEM. ×9,000 (bar =1 μm). Fig. 10. Axial row of poroids enlarged, from outside. Aoki Lake. SEM. ×27,000 (bar=1 μm). Fig. 11. Alveoli enlarged. A pond, Sōma City. TEM. ×60,000 (bar=0.5 μm). Fig. 12. Alveoli with a sinuous slit enlarged, from outside. A pond, Sōma City. SEM. ×45,000 (bar=1 μm).

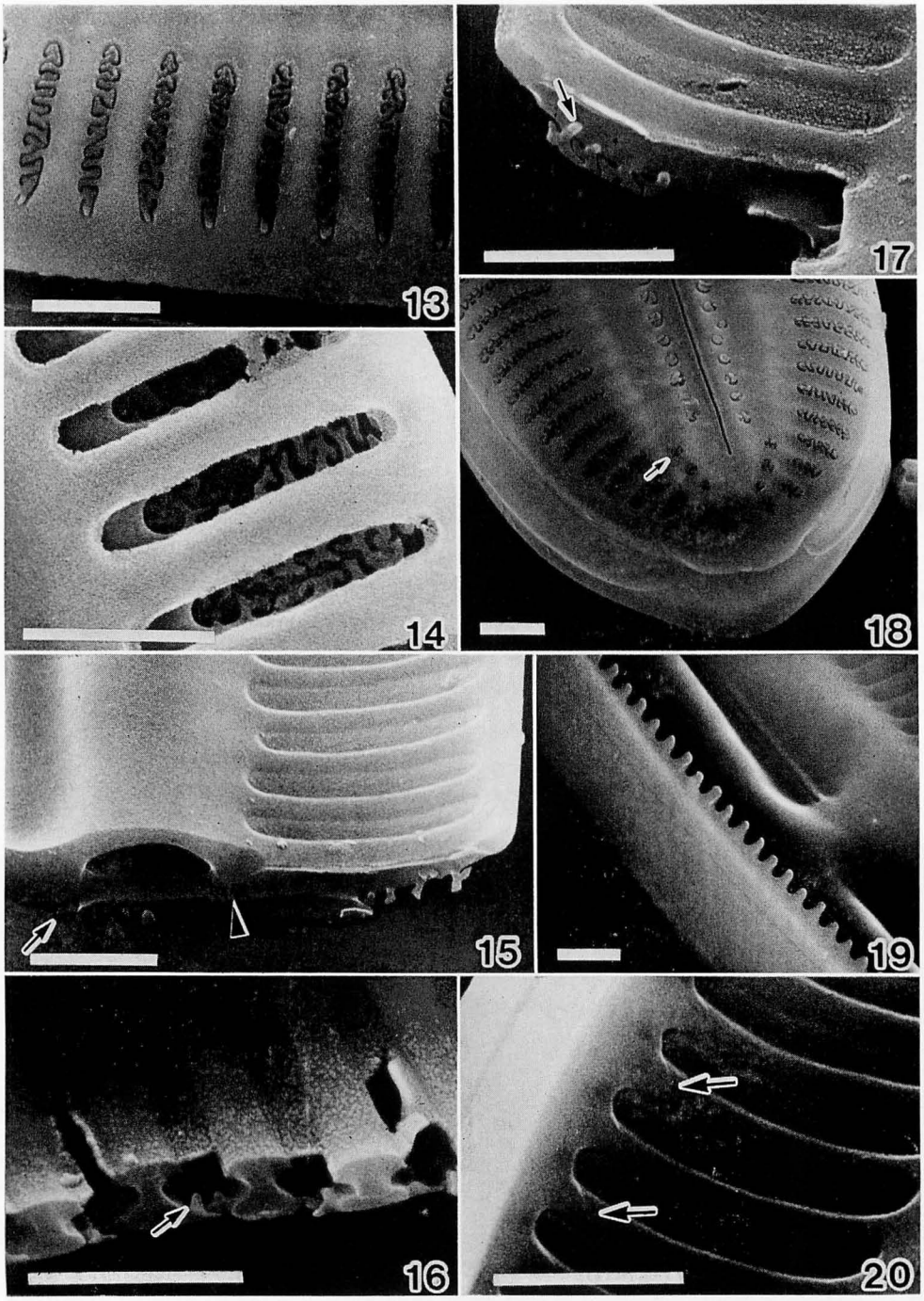


Plate 2. Figs 13-20. *Diploneis oculata* (BRÉB.) CL. A pond, Sōma City, Fukushima Pref. K-1941. SEM. Scale bar =1 μm. Fig. 13. Alveoli enlarged, from outside. ×18,000. Fig. 14. Alveoli enlarged, from inside. ×27,000. Fig. 15. Broken valve, valve center, from inside. ×18,000. Fig. 16. Cut ends of the transapical costae enlarged, contral valve, from inside. ×30,000. Fig. 17. Broken alveolus enlarged, from inside. ×27,000. Fig. 18. Valve pole enlarged, from outside. ×9,000. Fig. 19. Valvocopula without epivalve, enlarged, from outside. ×9,000. Fig. 20. Valve with valvocopula enlarged, from inside. ×27,000.

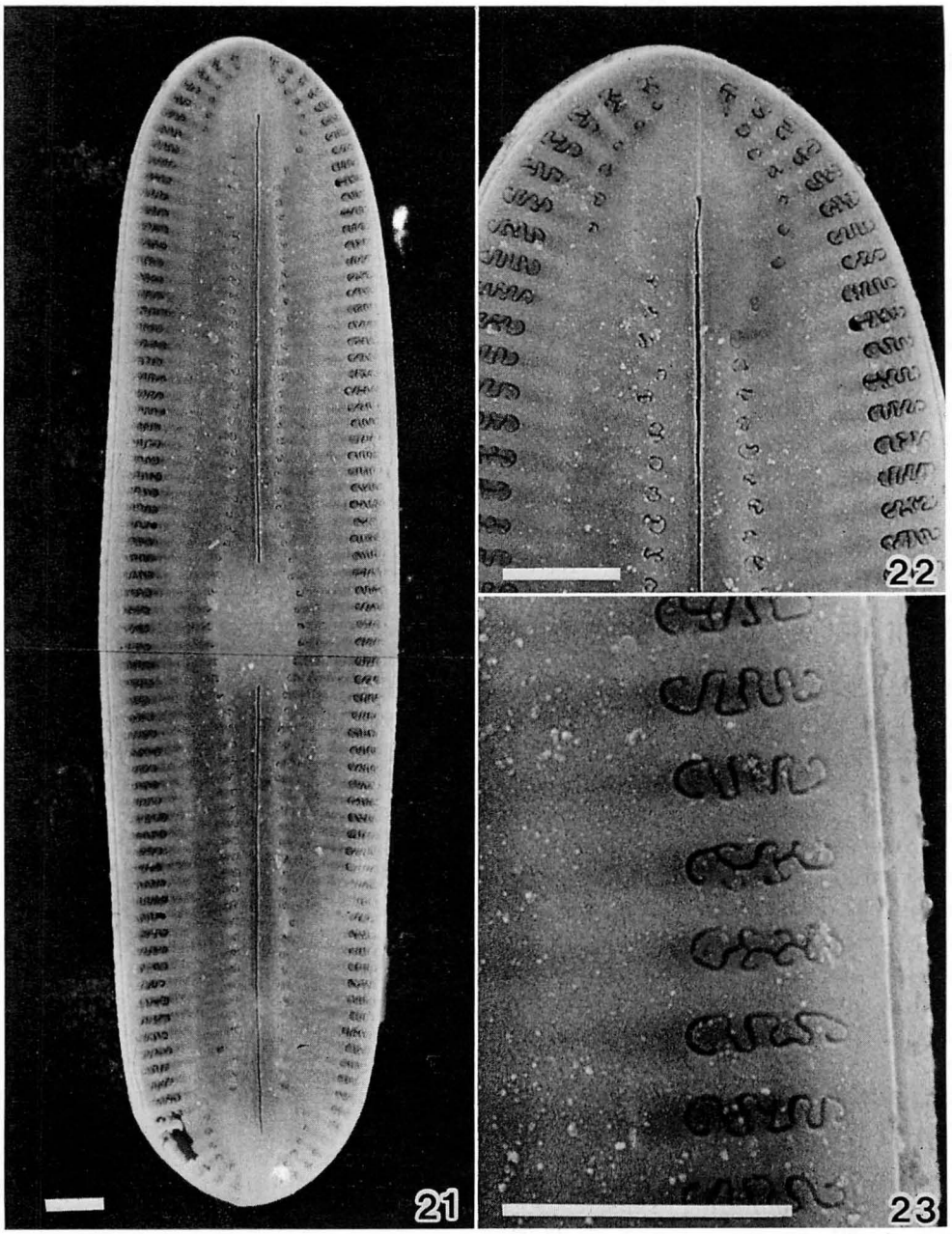


Plate 3. Figs 21-23. *Diploneis minuta* PET. On moss, Yōro Fall, Chiba Pref. N-1006 (=K-3172). SEM. Scale bar=1 μm. Fig. 21. Valve view, from outside. ×8,000. Fig. 22. Valve pole enlarged, from outside. ×16,000. Fig. 23. Alveoli enlarged, valve center from outside. ×40,000.

a short distance toward the axis (Figs 14, 15). Each alveolus opens laterally into the longitudinal canal through a tube-like opening (Fig. 15 arrow head) and opens externally through a sinuous slit with partial branching (Figs 11, 12). This structure was termed "sinuous line" by GERMAIN (1979).

The sinuous slit is formed as an interspace between variously shaped flaps extending from transapical costae. Each marginal flap is acutely elongate to the margin of the valve (Fig. 13). Internally, spine-like projections extend from each flap (Figs 16, 17 arrows). This feature seems to be peculiar to this species for it has hitherto appeared neither in the literature nor in our own observations.

Transapical costae are broader than alveoli in both inner and outer views (Figs 12, 14, 16) and are strongly constricted in the middle as clearly seen in the longitudinal section of the valve (Fig. 16).

The form of a cut end of a transapical costa seems to be an important taxonomic criterion, especially for this genus, although the fact has not been noticed by diatomists.

The cingulum is composed of two bands, one valvocopula and one pleura. The valvocopura is a broad open band (Fig. 18) with a smooth abvalvar edge and a serrated advalvar edge (Figs 18, 19) consisting of numerous small projections. Each projection lies on the internal surface of a transapical costa (Fig. 20). The pleura is a narrow open band except the broad mid-portion with a ligula which fits the opposing pole of the valve (Fig. 18).

Diploneis minuta PETERSEN
(1928, p. 381. fig. 6) Figs 6, 7, 21-23.

This species has only been found in a sample collected from moss on a wet rock in the spray zone of Yōro Fall, Chiba Prefecture. Valves observed are 11-25 μm in length, 4.5-5 μm in width. Valves of our specimens are longer than those of originally, described. It seems probable from PETERSEN's original description that he saw only one or two specimens, as the dimensions were given as 13 μm long and 4.4 μm broad. In 1937, HUSTEDT expanded the reported dimensions of this species to 13-18 μm long and 3.5-4 μm broad, presumably based on his reexamination of a slide prepared from the original material by the original author, for we have been able to see a slide No. 04/59 labeled "Iceland Eyvindará, Pet. 25" in the HUSTEDT Collection, Bremerhaven. This slide may be considered an isotype slide and the photomicrograph taken from this slide (Fig. 6) shows an isotype specimen. The striae density of our specimens is 28-32 in 10 μm, somewhat lower than that given for European specimens by HUSTEDT (1937) and GERMAIN (1979), namely, 32-35 in 10 μm. (Striae density was not given in the original description.)

Because of a scarcity of specimens in the sample, we could not get an adequate number of valves for a thorough SEM study. The fine structure that we were able to observe, however, is identical to that reported by GERMAIN (1979). The fine structure of *D. minuta* is similar basically to that of *D. oculata*. The valve face is almost flat and the raphe is a narrow straight slit externally. Both proximal and terminal endings are not dilated or curved (Figs 21, 22). The row of poroids bordering the axial area is almost straight and runs parallel to the longitudinal axis except the portions by the side of the central and terminal nodules (Figs 21, 22). The poroids are of a similar size and are occluded externally by mostly a round or reniform single flap.

The volate occlusion of the alveoli in *D. minuta* is relatively shorter than that of *D. oculata*, occupying only about one third of the valve width. On the other hand, the hyaline area between the axial row of poroids and the marginal row of occlusions of the alveoli is very broad, being about half of the valve width (Figs 21, 22). The sinuous slit on the volate occlusion is simple in shape. The slit is narrow and rarely branched (Fig. 23).

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出井雅彦*・小林　弘：淡水産デイプロナイス属（ケイソウ類），*D. oculata* (BRÉB.) CL. と *D. minuta* PET. の殻構造**

Grunow, Kützing, Hustedt のコレクション中の標本に基づいて同定した2種類のディプロナイス属ケイソウ，*D. oculata* と *D. minuta* を SEM と TEM を用い観察した。これらの種類の長胞はその外側を曲がりくねったスリットをもつ肉趾状師板によって閉ざされ，また，内側は六角整列をした小孔をもつ薄皮によって閉ざされていた。殻帯は幅の広い接殻帯片と幅の狭い連結帯片の2枚からなり，また，*D. oculata* の横走肋骨の断面は鼓状であった。(*305 茨城県新治郡桜村天王台 1-1-1 筑波大学生物科学系，**184 小金井市貫井北町 4-1-1 東京学芸大学生物学教室)

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Lipid and fatty acid composition in the red alga *Porphyra yezoensis*

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ARAKI, S., SAKURAI, T., OMATA, T., KAWAGUCHI, A. and MURATA, N. 1986. Lipid and fatty acid composition in the red alga *Porphyra yezoensis*. Jap. J. Phycol. 34: 94-100.

Lipids of *Porphyra yezoensis* thalli cultured at 13°C for 4 weeks were extracted with organic solvents. They were fractionated by column chromatography on DEAE-Sepharose CL-6B and on silicic acid and then separated by thin-layer chromatography. Monogalactosyl diacylglycerol, digalactosyl diacylglycerol, phosphatidylglycerol, sulfoquinovosyl diacylglycerol, phosphatidylcholine, phosphatidylethanolamine and triacylglycerol were identified as major lipid components.

Major fatty acid components of the lipid classes were palmitic and eicosapentaenoic acids, except for phosphatidylglycerol and phosphatidylethanolamine. Phosphatidylglycerol contained large proportions of *trans* ω13 hexadecenoic acid and a C_{20} monoenoic acid, and phosphatidylethanolamine contained C_{20} polyunsaturated acids which amounted to 85% of the total fatty acids. Both α- and γ-linolenic acids were detected. The γ-isomer was associated mainly with in phosphatidylcholine, phosphatidylethanolamine and triacylglycerol.

Key Index Words: *Fatty acid*; *lipid*; Porphyra yezoensis; *red alga*; *Rhodophyceae*.

The fatty acid composition of marine algae is remarkably different from that of higher plants in containing high levels of polyunsaturated fatty acids of 20 carbon atoms (POHL and ZURHEIDE 1979). In the red alga, *Porphyra*, eicosapentaenoic acid amounts to about 50% of total fatty acids (KAYAMA *et al.* 1983). Since this acid is one of the precursors of prostaglandins in animals (PIKE 1971), the lipids of the dried laver, "Hoshinori", which is a traditional foodstuff produced from *Porphyra* thalli in Japan, has high nutritional value.

There is, however, only limited information on the lipid and fatty acid composition of *Porphyra*. SATO (1971) separated the glycolipids from the thalli of *Porphyra tenera* and reported the occurrence of MGDG, DGDG and SQDG, and that the major fatty acids were palmitic and eicosapentaenoic acids. SAKAMOTO and ENOMOTO (1975,

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Abbreviations: MGDG, monogalactosyl diacylglycerol; DGDG, digalactosyl diacylglycerol; PG, phosphatidylglycerol; SQDG, sulfoquinovosyl diacylglycerol; PC, phosphatidylcholine; PE, phosphatidylethanolamine; PI, phosphatidylinositol; PS, phosphatidylserine; PA, phosphatidic acid; SPM, sphingomyelin; TG, triacylglycerol. In fatty acid shorthand such as 16:0, 20:5 etc, the colon separates figures denoting the number of carbon atoms and the number of double bonds respectively in the molecule. 16:1 *t*, *trans* ω13 hexadecenoic acid; 18:2ω6, linoleic acid; 18:3ω3, α-linolenic acid; 18:3ω6, γ-linolenic acid; 20:4ω6, arachidonic acid; 20:5ω3, eicosapentaenoic acid.

1976a, b) also studied the lipids from "Hoshi-nori". In contrast to the results of Sato, they found that the constituent sugars of the diglycosyldiacylglycerol were galactose and mannose, and that 16:0, 20:3 and 22:6 acids were the major fatty acids. ANDO and KANEDA (1968) examined the phospholipids from "Hoshi-nori" and identified PC, PE, PS, PI, PA and SPM. However, they described nothing on the fatty acid composition of these phospholipids. Moreover, they did not detect PG, which is widely distributed in photosynthetic plants (HARWOOD, 1980) and which has been reported to occur in *Porphyra yezoensis* by SAKAMOTO and ENOMOTO (1976b). It seems worthy of note to elucidate this apparent inconsistency, not only from the biological standpoint, but also for the development of the more rational methods of processing and storing the "Hoshi-nori".

In the present paper, we will describe the fatty acid composition of lipids extracted from cultured *Porphyra* thalli, and discuss their differences from the results of earlier workers.

Materials and Methods

Culture of Porphyra yezoensis. The germlings from conchospores were inoculated into a culture flask containing one litre of artificial seawater (SUTO's ASP 6 modified medium) and grown at 18°C, under aeration and with a light intensity of 10,000 lux. After three weeks, the thalli were transferred into a 10-litre flask, and grown for further 4 weeks at 13°C under the same light intensity, with weekly renewing of the medium. The thalli, which had grown up to 8-10 cm in length, were then harvested for lipid extraction. The culture was illuminated by a hallogen lamp (Toshiba), and the light regime was 10L-14D a day. The culture medium was maintained in a range of pH 8.0 to 8.5.

Extraction, Separation and Identification of Lipids. The lipids were extracted from the thalli with chloroform/methanol (1 : 2, v/v) according to the procedures of BLIGH and DYER (1959). The extract was concentrated under reduced pressure, dissolved in a small volume of chloroform/methanol (1 : 4, v/v), and then fractionated by the method of MURATA *et al.* (1982) as follows. The lipid solution was applied to a DEAE-Sepharose CL-6B column (50 mm×20 mm, internal diameter) and eluted with 100 ml of chloroform/methanol (1 : 4, v/v). This eluate (fraction A) was stored in a refrigerator until use. The column was then successively eluted with 100 ml of acetic acid (fraction 4) and chloroform/methanol (1 : 4, v/v) containing 0.2% (w/v) ammonium acetate (fraction 5).

The fraction A was concentrated under reduced pressure, and dissolved in a small volume of chloroform. It was then applied to a column (50 mm×20 mm, internal diameter) of silicic acid (Iatrobeads 6RS-8060), and was successively eluted with 25 ml of chloroform/acetone (4 : 1, v/v, fraction 1), 100 ml of acetone (fraction 2) and 50 ml of methanol (fraction 3).

The lipids in each fraction were further separated on precoated silica gel plates (Merk, 5721), using chloroform/methanol/water (70 : 21 : 3, v/v) as the developing solvent of TLC for fractions 1, 2 and 3 and chloroform/acetone/methanol/acetic acid/water (50 : 20 : 10 : 15 : 5, v/v) for fraction 4 and 5. The lipids separated on the plates were identified by comparing their Rf values with those of standard lipids from spinach leaves, and with visualizing reagents.

Analysis and Determination of the Fatty Acids and Sugars. The lipids separated on the TLC plate were located by a fluorescent dye, primuline. They were scraped off the TLC plate and treated with 5% hydrochloric acid in methanol at 90°C for 2 h. The resulting fatty acid methyl esters were extracted with *n*-hexane and analysed in a gasliquid chromatograph (Shimadzu GC-9A) equipped with a hydrogen flame ionization detector. The GLC column was a 2 m×3 mm glass column packed with 5% Thermon 3000 on Shimalite W, AW-DMCS (201D). Column temperature was 210°C and N_2 carrier gas

flow was 60 ml/min. Pentadecanoic acid was used as an internal standard.

The identification of individual fatty acids was carried out by gas chromatography-mass spectrometry; fatty acid methyl esters were applied to a glass column (2 m×2.6 mm) containing 5% Shinchrome E71 on Shimalite AW(80-100 mesh) and were chromatographed at 180°C with helium as a carrier gas at a flow rate of 30 ml/min. Mass spectra were taken every 3.0 sec with a GCMS-QP 1000 spectrometer (Shimadzu), with an electron-accelerating voltage of 70 eV and an ion source temperature of 250°C.

The sugar component of glycolipids were analysed as follows. Methylglycosides, recovered from the methanol phase after extracting the fatty acid methyl esters of glycolipids, were trimethylsilylated with a mixture of hexamethyldisilazane and trimethylchlorosilane in pyridine (SWEELEY and WALKER 1964). The trimethylsilylated sugars were analysed and identified by GLC using silicone SE-30 as a liquid phase at column temperature of 175°C. Mannitol was used as internal standard.

Results

The lipids extracted from *Porphyra* thalli were separated by the combined procedures of column and thin-layer chromatography. MGDG, DGDG, PG, SQDG, PC, PE and TG were identified as the major lipid classes (Table 1).

When the fraction 2 (glycolipid fraction) was developed on the TLC plate, double spots appeared close to the position equivalent to MGDG (Fig. 1). The Rf of the lower spot was the same as that of spinach MGDG. These spots were positive with the anthrone reagent (YAMAKAWA *et al.* 1960), suggesting that both are glycolipids. Then, in order to examine whether one of the two spots was caused by a glycolipid other than MGDG, the sugar moieties and fatty acid compositions of the lipids of the two spots were investigated.

Table 1. Lipid composition of *Porphyra yezoensis*.

Lipids	Molar %
MGDG	27.2
DGDG	24.5
PG	19.0
SQDG	10.6
PC	12.2
PE	3.2
TG	3.4

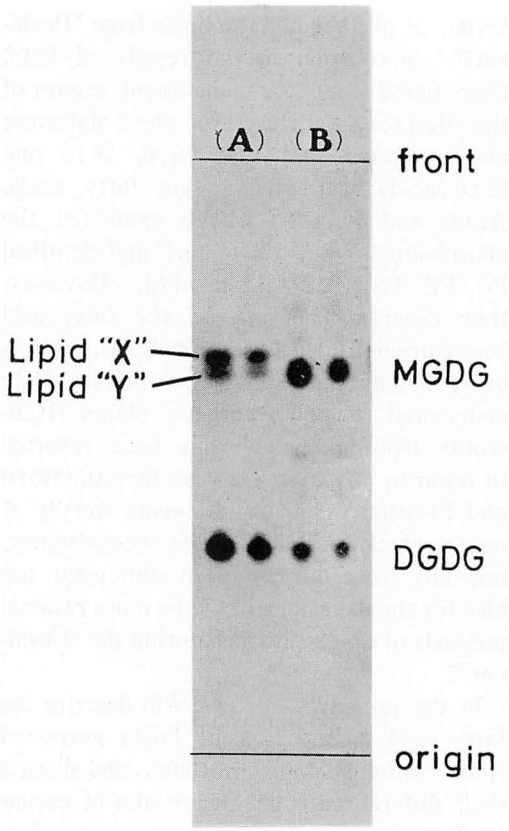

Fig. 1. TLC of fraction 2 from *Porphyra yezoensis* (A). Developmental solvent, chloroform/methanol/water (70 : 21 : 3, v/v); visualized reagent, anthron reagent. The glycolipids from spinach leaves are shown for comparison (B).

After TLC of fraction 2, the upper-spot (lipid "X") and the lower spot (lipid "Y") were separately scraped off from the plate, and their sugar and fatty acid compositions were analyzed. The results were shown in Table 2. The constituent ratio of sugar to

Table 2. Analysis of galactose and fatty acids of monoglycolipids and DGDG from *Porphyra yezoensis*.

	Lipid "X"	Lipid "Y"	DGDG
Galactose (nano mole)	69	63	430
Fatty acids (nano mole)	134	105	418
Galactose / Fatty acid	0.51	0.60	1.03

Table 3. Fatty acid composition of the kinds of monoglycolipids from *Porphyra yezoensis*.

	Molar %	
	Lipid "X"	Lipid "Y"
14 : 0	1	4
16 : 0	2	41
18 : 0	tr	2
18 : 1	1	8
18 : 2	tr	4
20 : 3	1	4
20 : 4	2	2
20 : 5	93	32

fatty acids in both lipids "X" and "Y" was close to 1 : 2, and the sugar component was only galactose. Thus, both lipids are identified as MGDG. However, in lipid "X" the 20 : 5 acid amounted to about 90% of total fatty acids, while in lipid "Y" both the 20 : 5 and 16 : 0 acids each comprised about 40% of the total (Table 3). The sugar component of DGDG was also analyzed and identified as galactose.

The fatty acid composition of the lipid classes from *Porphyra* thalli are shown in Table 4. The fatty acids comprised about 3% of the dry weight of the thalli, while the total lipid content of "Hoshi-nori" was reported to be 2% of dry weight (RESOURCES COUNCIL, 1982).

In agreement with the results of earlier workers (SATO 1971, KAYAMA *et al.* 1983), the major components of the total fatty acids were palmitic and eicosapentaenoic acids, but the content of C_{16} and C_{18} polyunsaturated

Table 4. Fatty acid composition of the lipids from *Porphyra yezoensis*.

	Molar %							
	Total	MGDG	DGDG	PG	SQDG	PC	PE	TG
14 : 0	0.4	1.2	0.1	0.1	0.1	—	0.5	0.4
16 : 0	25.6	12.8	38.1	30.8	49.6	9.5	1.5	13.1
16 : 1 t	2.9	—	0.0	15.1	0.0	—	0.4	0.0
18 : 0	0.7	—	—	0.6	—	1.0	0.8	
18 : 1	3.6	3.6	6.7	1.0	0.5	4.6	1.8	10.3
18 : 2	2.0	1.4	4.2	0.1	0.1	4.2	1.1	6.6
18 : 3ω6	0.6	0.6	0.05	0.0	0.0	3.0	2.1	1.3
18 : 3ω3	0.3	0.2	0.3	0.3	0.0	0.6	0.0	0.3
18 : 4	0.5	0.1	0.1	0.1	0.2	2.5	1.4	1.1
20 : 1	3.5	0.7	0.9	14.7	0.2	0.8	1.3	4.0
20 : 2	1.4	0.7	0.8	4.6	0.0	0.3	0.3	2.2
20 : 3	2.2	3.0	1.9	0.0	0.0	2.8	7.7	7.8
20 : 4ω6	2.4	1.8	0.6	1.0	0.7	5.5	15.9	11.0
20 : 5ω3	53.2	73.8	45.7	29.9	48.4	64.6	60.0	41.2
22 : 1	0.3	0.0	0.0	1.2	0.0	0.2	0.0	0.3
Unknown	0.6	0.2	0.5	0.6	0.5	0.3	5.0	0.7

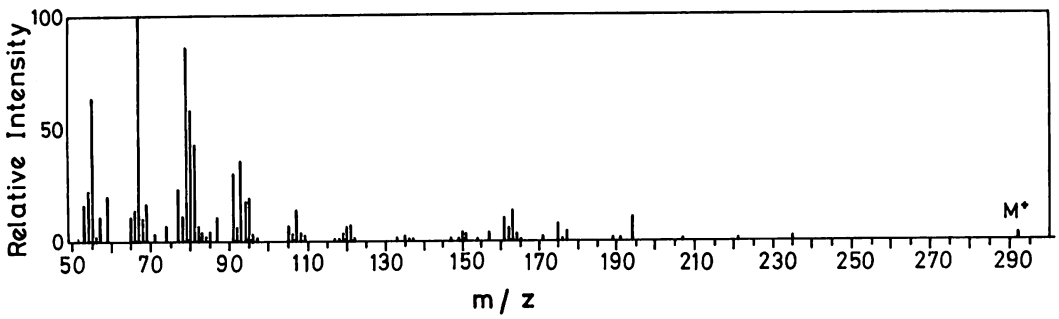

Fig. 2. Mass spectrum of methyl γ-linolenate from *Porphyra yezoensis*.

acids was relatively low.

The major fatty acid components of MGDG, DGDG and SQDG from *Porphyra* thalli were 16:0 and 20:5 which together comprised over 80% of the total fatty acids. On the other hand, PC and PE contained higher levels of C_{20} polyunsaturated fatty acids (20:3, 20:4 and 20:5) than the other lipids. PG differed from the other lipids in its high content of 16:1, 20:1 and 22:1 acids. A comparison of the retention time of the 16:1 acid from *Porphyra* PG with that of fish-oil (San omega), which contained only a *cis*-ω7-isomer, and that of spinach PG which contained only a *trans*-ω13-isomer suggested that the 16:1 acid of PG from *Porphyra* was identical with *trans*-ω13-16:1 acid of PG from spinach leaf.

γ-Linolenic acid, whose existence has not yet been reported in *Porphyra*, was also detected as a minor component. When the retention time of α- and γ-linolenate from *Porphyra* thalli was compared with that of the standard acids on two different GLC columns, Thermon 3000 and Shinchrome E 71, the values were completely consistent with those of the standards. Further, GC-MS spectra of both isomers from *Porphyra* also were identical with those of the standards (Fig. 2). These results lead us to conclude that the *Porphyra* thalli contain both α- and γ-linolenate. In *Porphyra*, the γ-isomer was found mainly in PC, PE and TG. However, MGDG and PC contained both isomers.

Discussion

In the present study we determined the major lipid and fatty acid compositions of the artificially grown *Porphyra* thalli, (see Tables 1 and 4). ANDO and KANEDA (1968) studied the phospholipids from commercial "Hoshi-nori", and reported the occurrence of PC, PE, PS, PI and PA. However, we could not detect the latter three components. Whether these lipids exist in *Porphyra* requires further studies, since they are only minor components of plant lipids (KATES 1970). In contrast to ANDO and KANEDA (1968) we found a significant content of PG, which is a constituent lipid of chloroplast thylakoids (HARWOOD 1980) and widely distributed in all the eukaryotic algae (JAMIESON and REID 1972).

TLC of the glycolipids from *P. yezoensis*, revealed a double spot close to the position equivalent to MGDG. SATO and MURATA (1982) demonstrated the occurrence of monoglucosyl diacylglycerol in the blue-green alga, *Anabaena variabilis*, and reported that the glucolipid migrated slightly faster than MGDG in TLC. On the other hand, SAKAMOTO and ENOMOTO (1976a) studied the glycolipids from the dried laver, "Hoshi-nori", and reported that mannose was one of the constituent sugars of glycolipids. The present study found that both components of the double spot contained only MGDG. However, the two components differed in fatty acid composition; while 20:5 comprised about 90% of the total fatty acid in the upper spot, both 20:5 and 16:0 acids amounted to

about 40% in the lower one. These results suggest that the upper component of MGDG consisted mainly of the molecular species 20:5/20:5, whereas the lower contained predominantly 20:5/16:0. Similar results were also obtained with MGDG from *Gracilaria verrucosa*, which contained a higher content of 20:4 than 20:5 acid (unpublished data).

Preliminary analyses of the total fatty acids of glycerolipids from another red alga, *G. verrucosa* also showed that γ-linolenate was more abundant than α-linolenate (data not shown). Most but not all red algae contained higher amounts of the α-isomer than the γ-isomer (POHL and ZURHEIDE 1979). However, further analyses are necessary before a general conclusion about the distribution of the linolenate isomers in lipids of the red algae can be drawn.

The red algae constitute a most primitive group of eukaryotic algae, and are systematically placed between the blue-green algae of prokaryotes and the cryptomonads of eukaryotes. Common and characteristic features of the three algal groups are the accessory pigments of photosynthesis, phycoerythrin and phycocyanin, and thylakoid ultrastructures that are much simpler than those of the other algal groups such as green and brown algae. However, as far as the lipid and fatty acid composition of the three groups are concerned, *Porphyra* is more closely related to the cryptomonads than to the blue-green algae since it contains as major phospholipids, PC and PE and *trans*-ω13-hexadecenoic acid as a major fatty acid of PG, all of which are lacking in the blue-green algae (KATES, 1970). However, the fatty acid composition of cryptomonads considerably differs from that of *Porphyra*. BEACH *et al.* (1970) showed that cryptomonads contain 18:3 and 18:4 acids as the major fatty acid components, whereas they are rather minor components in *Porphyra*. These authors further reported that 18:4 acid accounted for about 70% of the total fatty acids in MGDG and DGDG from *Cryptomonas* sp. WH.

In *Porphyridium cruentum*, the unicellular form of Bangiales in Rhodophyta, the total fatty acid composition is similar to *Porphyra* in that C_{18} unsaturated fatty acids are minor, and 16:0 and 20:5 acids are major components (NICHOLS and APPLEBY 1969). However, this alga contains a larger amount of 20:4 than 20:5 acid, especially in PC (NICHOLS and APPLEBY 1969). *Porphyra* is unique in having a particularly high content of 20:5 acid in all its lipid classes.

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荒木　繁*・桜井武麿*・小俣達男,1)・川口昭彦**・村田紀夫***：　スサビノリの脂質と脂肪酸組成**

室内培養で得られたスサビノリ藻体から，monogalactosyl diacylglycerol, digalactosyl diacylglycerol, phosphatidylglycerol, sulfoquinovosyl diacylglycerol, phosphatidylcholine, phosphatidylethanolamine, および triacylglycerol を分離した。それぞれの脂質クラスの脂肪酸組成を調べた結果，主な脂肪酸はパルミチン酸とエイコサペンタエン酸であったが，monogalactosyl diacylglycerol, phosphatidylcholine, phosphatidylethanolamine では炭素数 20 の高度不飽和脂肪酸の割合が高かった。また，いままでに *Porphyra* からは報告されていなかった *trans*-ω13-hexadecenoic acid が phosphatidylglycerol に，γ-リノレン酸が主として phosphatidylcholine と phosphatidylethanolamine に分布していることが明らかになった。(*143 東京都大田区大森東 5-4-6 山本海苔研究所，**153 目黒区駒場 3-8-1 東京大学教養学部，***444 岡崎市明大寺町西郷中 38 基礎生物学研究所，1)現勤務先 351-01 和光市広沢 2-1　理化学研究所太陽エネルギーグループ)

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Cross experiments of the color mutants in *Porphyra yezoensis* UEDA*

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Cross experiments have been achieved among the wild type, the red type mutant and the green type mutant in *Porphyra yezoensis*. Both the mutants were recessive to the wild type. The heterozygous conchocelis between the red type and the green type mutants was the wild type, indicating that the mutants complemented each other, and the yellow phenotype newly appeared as a result of recombination between the loci of the red and the green type mutants. Most of the F_1 thalli (92.9-99.5%) of the heterozygous conchocelis were sectorially variegated chimeral thalli composed of various combinations of color sectors which arose from meiotid segregation. Conchospores are assumed to be released during meiotic prophase to segregate haploid phenotype during their germination, and this leads to the formation of variegated chimeral thalli in *P. yezoensis*.

Key Index Words: *Chimeral thallus*; *color mutant*; *cross experiment*; Porphyra yezoensis.

In recent years red type mutant thalli or sectorially variegated chimeral thalli have been found in cultivated populations and laboratory cultures of *Porphyra yezoensis* UEDA (MIURA 1984). KOBARA *et al.* (1976) established the green type strain and ARUGA and MIURA (1984) characterized the red type and the green type strains of *P. yezoensis*. KIKUCHI *et al.* (1979) reported chemical nature of phycobilins of the color mutants of *P. yezoensis* from our laboratory. ARUGA and MIURA (1984) have made clear their characteristics by comparing *in vivo* absorption spectra. Comparative studies on the growth and photosynthesis of the mutants of *P. yezoensis* have been achieved (KATO and ARUGA 1984). As to other species of seaweeds, VAN DER MEER and his coworkers reported the genetic studies on the pigmentation mutants of *Gracilaria* (VAN DER MEER 1977, 1978, 1979a, b, 1980, VAN DER MEER and BIRD 1977, VAN DER MEER and TODD 1977) and a study of the life history of *Palmaria palmata* with a pigmentation mutant (VAN DER MEER and TODD 1980). However, there has been no genetical approach to *P. yezoensis*. Since the mutant strains are useful markers for genetic studies on *P. yezoensis*, crosses were performed for an initial study in this species. We report here the results of the crosses among the wild type and the mutants.

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Materials and Methods

The wild type strain (W, strain number U-51) was isolated from a cultivated population of *Porphyra yezoensis* at Ushigome,

Kisarazu City, Chiba Prefecture, in 1974 and the red type strain (R, F-6) was established from a red type mutant thallus isolated from a cultivated population of *P. yezoensis* at Shitazu, Futtsu City, Chiba Prefecture, in 1974. The green type strain (G, C-0 giant) was established by KOBARA *et al.* (1976). Laboratory cultures of thalli and conchocelis were carried out as described by KATO and ARUGA (1984). Crosses were performed by coculturing the marginal pieces of different phenotype thalli. When carposporangia were formed on the thallus piece, each piece was separated and cultured until carpospores were released. Carpospores collected from the crossed thallus piece were cultured in a petri dish and were separated one by one when they grew into a conchocelis colony 1 mm in diameter. Color types of the progeny thalli produced from the crossed conchocelis were determined with thalli 0.5–1.5 mm in length.

Results and Discussion

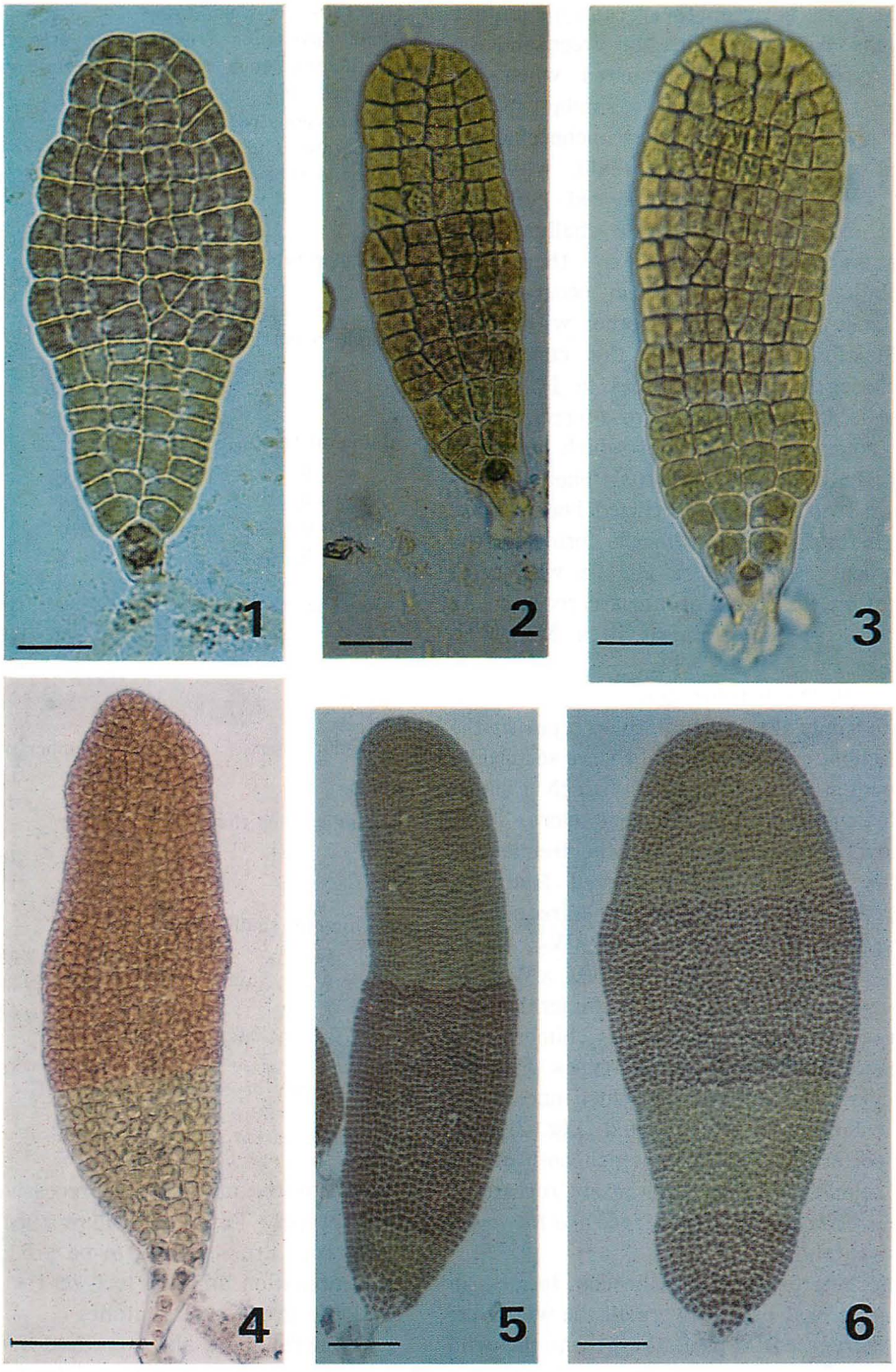
Crosses of the wild with the red and the green types

To characterize the mode of transmission of the mutants, the red type and the green type mutants were crossed with the wild type. In the cross experiments, we regarded the thallus from which carpospores were taken as female parent. Table 1 shows the results of these crosses. In the cross between the red type mutant and the wild type, F_1 conchocelis were of all the wild type when the wild type was female. Some conchocelis produced only the wild type thalli, while others produced both the wild and the red types in F_1 thallus phase. In the reciprocal cross, when the red type mutant was female, both the red and the wild type conchocelis occurred. The red type conchocelis produced only the red type thalli, while the wild one segregated the wild and the red types in F_1 thallus phase.

Table 1. Results of the reciprocal crosses of the wild with the red and the green type mutants of *Porphyra yezoensis*. W, wild type; R, red type; and G, green type. (* Female parent shown first.)

Cross*	F_1 conchocelis	F_1 thalli	Putative cross combination
W × R	W	W	W × W (self.)
	W	W, R (chimeral thalli)	W × R (cross.)
R × W	R	R	R × R (self.)
	W	W, R (chimeral thalli)	R × W (cross.)
G × W	G	G	G × G (self.)
	W	W, G (chimeral thalli)	G × W (cross.)

Figs. 1-6. Various types of sectorially variegated chimeral thalli which arose from heterozygous conchocelis in *Porphyra yezoensis*. Scale bar 30 μm in Figs. 1-3; 0.1 mm in Figs. 4-6. Fig. 1. A two-sectorial chimeral thallus composed of the green and the wild type sectors arisen from the heterozygote of the wild and the green types. Fig. 2. A three-sectorial chimeral thallus composed of the green and the wild type sectors arisen from the heterozygote of the wild and the green types. The green type sector is repeated. Fig. 3. A three-sectorial chimeral thallus composed of the yellow, the red and the green type sectors from the apex to the base of the thallus arisen from the heterozygote of the red and the green types. Fig. 4. A two-sectorial chimeral thallus composed of the red and the



green type sectors arisen from the heterozygote of the red and the green types. Fig. 5. A three-sectorial chimeral thallus composed of the green and the red type sectors arisen from the heterozygote of the red and the green types. The green type sector is repeated. Fig. 6. A four-sectorial chimeral thallus composed of the yellow, the wild, the green and the red type sectors from the apex to the base of the thallus arisen from the heterozygote of the red and the green types.

In the cross between the green type mutant and the wild type, both the green and the wild type conchocelis occurred when the green type was female. Similar to the prior cross, the green type conchocelis produced only the green type thalli, while the wild type conchocelis produced both the green and the wild types in F_1 thallus phase. As *P. yezoensis* is monoecious, there is a possibility of self-fertilization occurring in the cross experiments together with cross-fertilization. Therefore, the conchocelis which segregates color types in F_1 thallus phase is assumed to be a cross-fertilized heterozygote; the conchocelis which produced only thalli of the maternal phenotype is assumed to be a self-fertilized homozygote. The heterozygous conchocelis formed in the reciprocal crosses were all the wild type, indicating that the mutants are recessive to the wild type and inherit in a Mendelian manner.

Though the heterozygous conchocelis segregated only the parental color types in the F_1 thallus, most of the thalli were sectorially variegated chimeral thalli in which a single thallus was zoned into different colors. Table 2 shows the color types and the frequencies of the chimeral thalli occurred from the heterozygous conchocelis. The frequencies of the chimeral thalli were 97.4%($W_{(♀)} \times R_{(♂)}$), 94.3%($R_{(♀)} \times W_{(♂)}$) and 92.9%($G_{(♀)} \times W_{(♂)}$) in respective cross. Observed chimeral thalli were as follows: two-sectorial chimera consisted of two different color types (Fig. 1); three-sectorial chimera in which one of the two color types was repeated (Fig. 2); and four-sectorial chimera in which both of the two color types were alternately repeated.

Crosses between the red type and the green type mutants

The heterozygous conchocelis formed in the reciprocal crosses were all the wild type, and segregated the red, the green, the wild and the yellow phenotypes in F_1 thallus phase (Table 3). The red type mutant and the green type mutant are assumed to complement each other because the heterozygous conchocelis is the wild type in spite of the fact that the mutants are recessive to the wild type. Thus, the yellow type and the wild type are regarded to be produced by a recombination of the loci of the red type and the green type mutants.

Chimeral thalli also appeared from these heterozygous conchocelis. The frequencies of the chimeral fronds were 99.5% when the red type was female and 97.5% when the green type was female (Table 4). Chimeral thalli produced from the conchocelis

Table 2. Color types and frequency of the thalli developing from conchospores released by the heterozygous conchocelis from the cross of the red and the wild types (I), and by the heterozygous conchocelis from the cross of the green and wild types (II) in *Porphyra yezoensis*. W, wild type; R, red type; and G, green type.

(I)

Color types	Number of F_1 thalli	
	W×R*	R×W*
Single color thalli		
W	26	11
R	24	18
Chimeral thalli		
W+R	1019	338
W+R+W	280	77
R+W+R	316	61
W+R+W+R	2	0
Frequency of chimeral thalli	W×R*	97.4%
	R×W*	94.3%

(II)

Color types	Number of F_1 thalli	
	G×W*	
Single color thalli		
W	186	
G	114	
Chimeral thalli		
W+G	2584	
W+G+W	691	
G+W+G	637	
W+G+W+G	16	
Frequency of chimeral thalli	G×W*	92.9%

* Female parent shown first.

Table 3. Results of the reciprocal crosses between the red and the green type mutants of *Porphyra yezoensis*. W, wild type; R, red type; G, green type; and Y, yellow type. (* Female parent shown first.)

Cross*	F_1 conchocelis	F_1 thalli	Putative cross combination
R × G	—R	R	R × R (self.)
	—W	W, R, G, Y (chimeral thalli)	R × G (cross.)
G × R	—G	G	G × G (self.)
	—W	W, R, G, Y (chimeral thalli)	G × R (cross.)

consisted of various combinations of the four color types. Observed combinations were as follows: the two-color type chimera composed of two sectors and two color types (Fig. 4); the repeated two-color type chimera consisting of three sectors and two color types, one of which was repeated (Fig. 5); the three-color type chimera made up of three sectors and three color types (Fig. 3); and four-color type chimera made up of four sectors and four color types (Fig. 6). The number of chimeral sectors does not exceed four. Though all possible combinations of the four colors were observed among the two-, three- and four-color type chimeras, only two combinations of the red and the green types, or the yellow and the wild types (R+G+R, G+R+G, Y+W+Y, W+Y+W) were observed in the repeated two-color type chimeras.

Each color sector of the chimeral thalli of *P. yezoensis* is regarded as a haploid phenotype which arose from meiotic segregation. If meiosis has been completed in the conchosporangium (MIGITA 1967, KITO 1978), the conchospore which produces a chimeral thallus should contain two to four haploid nuclei similar to the mosaic in *Gracilaria* (VAN DER MEER 1977). However, *P. yezoensis* produces only uninucleate conchospores (MIGITA 1967, KITO 1978). Provided that the chimeral thalli should be produced from the uninucleate conchospores, then we can assume that the conchospores are released during meiotic prophase to segregate haploid

Table 4. Color types of the thalli developing from the conchospores released by the heterozygous conchocelis from the cross of the red and the green types in *Porphyra yezoensis*. W, wild type; G, green type; and Y, yellow type.

Color types	Number of F_1 thalli R × G*	G × R*
Single color thalli		
R	3	44
G	1	20
Y	1	19
W	2	22
Chimeral thalli		
R+G	401	1032
W+Y	138	340
R+Y	38	130
R+W	32	90
G+Y	12	46
G+W	33	120
R+G+R	92	265
G+R+G	61	311
Y+W+Y	24	73
W+Y+W	15	71
R+G+Y	140	394
R+G+W	137	413
R+Y+W	134	410
G+Y+W	138	386
R+G+Y+W	0	2
Frequency of chimeral thalli	R × G*	99.5%
	G × R*	97.5%

* Female parent shown first.

genotypes during their germination, and this leads to the formation of variegated chimeral thalli.

The chimeral thalli of *P. yezoensis* are interesting because they are haploid but have various phenotypes. The mechanism of the formation of chimeral thalli is furthe to be clarified for genetic analysis of the mutants and also for the discussion of meiosis in *P. yezoensis*.

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大目 優・国藤恭正・三浦昭雄： スサビノリの色素変異体の交雑実験

スサビノリ (*Porphyra yezoensis* UEDA) の赤色型および緑色型変異体を用いて変異型と野生型および赤色型と緑色型との交雑実験を行った。その結果，変異型は野生型に対して劣性形質であることがわかった。また，赤色型と緑色型との交雑の結果生じた異型接合型糸状体は野生型を示した。このことは，赤色型と緑色型の遺伝子は相補的に作用した遺伝子座が異なることを示す。さらに次代葉状体期に赤色型と緑色型のほかに黄色型と野生型を分離した。このことは，遺伝子間の組み換えの結果，新しく黄色型と野生型が生じたことを示している。また，色彩型に関する異型接合型糸状体から生じた 92.9-99.5%の葉状体は区分状斑入りキメラ葉状体であった。これらのキメラ葉状体の高頻度の出現は，スサビノリでは減数分裂が殻胞子の発芽時に起ることを示唆している。
(108 東京都港区港南 4-5-7 東京水産大学 藻類増殖学講座)

Jap. J. Phycol. (Sôuri) 34: 107-128. June 20, 1986

Studies on the freshwater Rhodophyta of Micronesia I. Six new species of *Batrachospermum* ROTH[1)]

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KUMANO, S. & BOWDEN-KERBY, W. A. 1985. Studies on the freshwater Rhodophyta of Micronesia I. Six new species of *Batrachospermum* ROTH. Jap. J. Phycol. 34: 107-128.

Six species of *Batrachospermum* ROTH (Rhodophyta, Nemalionales) from Micronesia are described as new species. *B. mahlacense* resembles *B. hirosei* KUMANO et RATNASABAPATHY (1982), but differs from the latter in the shape and size of whorls and axial cells. *B. doboense* resembles *B. tortuosum* KUMANO (1978), but differs from the latter in the number of cells per carpogonium-bearing branch, and the shape of whorls and trichogynes. *B. omodoense* resembles *B. mahlacense* but differs from the latter in the shape of wholrs and trichogynes, and the number of cells per fascicle and carpogonium-bearing branch. *B. tabagatenense* resembles *B. iriomotense* KUMANO (1982), but differs from the latter in the size of whorls, carpogonia and carposporangia. *B. nechochoense* resembles *B. tabagatenense* and *B. iriomotense*, but differs from *B. tabagatenense* in the size of trichogynes and from *B. iriomotense* in the size of whorls and carposporangia, and the shape of trichogynes. *B. faroense* resembles *B. doboense*, but differs from the latter in the number of cells per fascicle and the shape of whorls and trichogynes. A tentative key to the known taxa of the section *Contorta* is shown in the present study.

Key Index Words: Batrachospermum doboense, *sp. nov.*; Batrachospermum faroense, *sp. nov.*; Batrachospermum mahlacense, *sp. nov.*; Batrachospermum nechochoense, *sp. nov.*; Batrachospermum omobodoense, *sp. nov.*; Batrachospermum tabagatenesne, *sp. nov.*; *freshwater Rhodophyta*; *Micronesia*; *taxonomy*.

Although many phycologists studied the marine algae of Pacific islands, few investigations have been undertaken for the freshwater algal floras of these islands. Guam is the only Pacific island where some freshwater Rhodophyta taxa have been reported: *Audouinella* sp. by RAULERSON (1979), *Thorea gaudichaudii* by AGARDH (1824, 1828), and by SETO (1979), and *Bostrychia tenella* by KUMANO (1979). Palau, Western Caroline Islands, has the most extensive freshwater streams system in Micronesia. However, only four taxa of freshwater algae have been reported from Palau (BRIGHT, 1979). No freshwater Rhodophyta taxa have been reported from Palau and also from Truk, Eastern Caroline Islands. The present authors initiate a series of studies on the Micronesian freshwater Rhodophyta.

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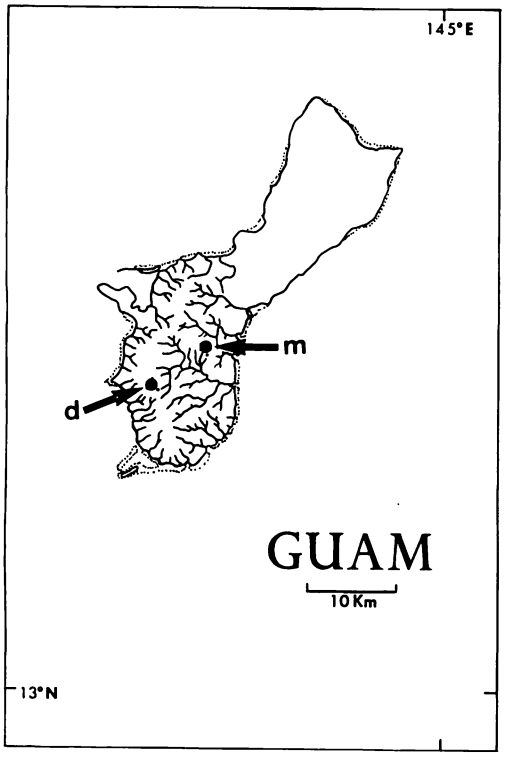
Topography and Collection Sites

All specimens examined in the present

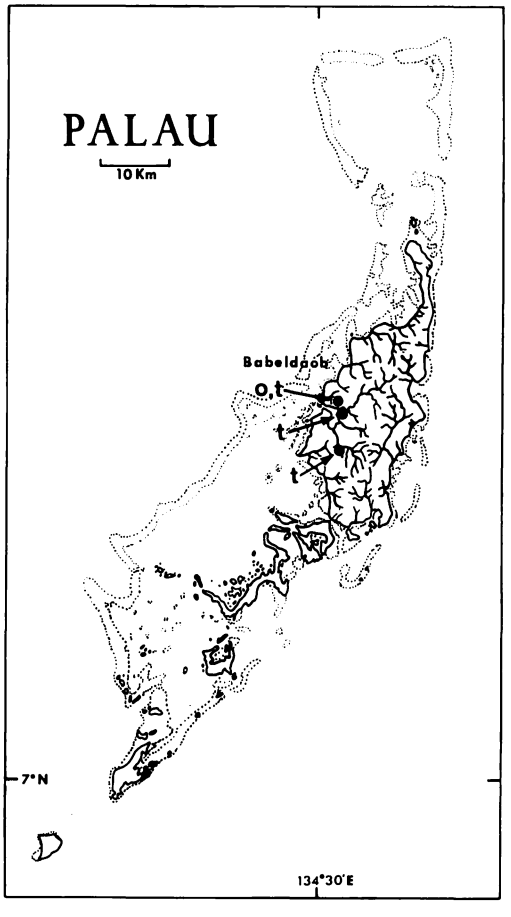
study were collected by W. Austin BOWDEN-KERBY from Guam, Mariana Islands, Palau, Western Caroline Islands, and Truk, Eastern Caroline Islands.

Guam (Map 1) is approximately 45 km long and 12 km wide. The northern half is composed of an elevated limestone plateau, while the southern half is mainly ancient volcanic origin. Guam's heavy tropical rainfall, on an average almost 2,000 mm/year, is absorbed by the limestone areas, but it runs off in the southern volcanic areas, forming several well-developed drainage systems. A smaller limestone cap overlaies at the high elevation in the southern half as well, and though it absorbs all rainfall, it releases the water as numerous perennial springs at lower elevation where the water meets impervious volcanic rock. The freshwater Rhodophyta were found at twelve locations on southern Guam, all in such springs or spring-fed headstreams; *Audouinella* sp. at nine sites, *Thorea gaudicahudii* at four sites and the two species of *Batrachospermum*, *B. mahlacense* and *B. doboense*, described here at one site each, associated with *Thorea gaudichaudii*.

Babeldaob Island of Palau (Map 2) is the largest land mass of volcanic origin in Micronesia, 43 km long and 15 km wide. Babeldaob is dominated by gently rolling hills, reaching an elevation of about 60 m in several localities. Grass- and fernlands dominate the upper ridges, while dense tropical forest covers the valleys. Palau lacks the limestone cap as in the southern Guam and therefore has fewer perennial springs. It has about 3,300 mm of rainfall per year, and streams are therefore very



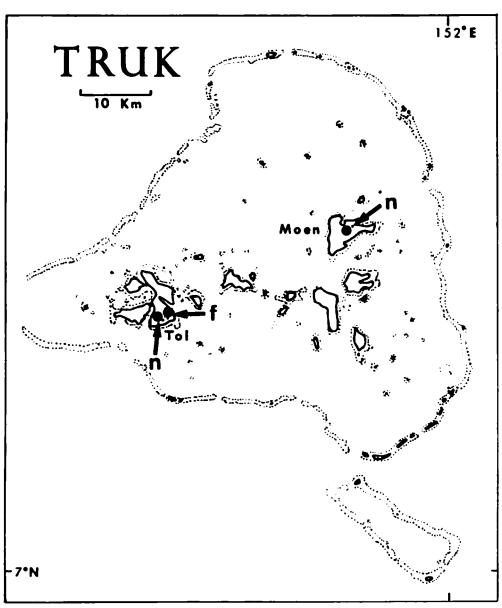
Map. 1. Site locations on Guam. (m: *B. mahlacense*, d: *B. doboense*)



Map. 2. Site locations on Palau (o: *B. omobodoense*, t: *B. tabagatenense*)

numerous. All three sites, where *Batrachospermum omobodoense* and *B. tabagatenense* were found in Palau, receive a few hours of direct sunlight each day, being lightly shaded for the remainder. This contrasts with those heavily shaded most other streams. These three sites are also lotic, having a slight current originating from seeps or springs.

Truk (Map 3) is composed of a large coral atoll of many low, sandy islands surrounding several mountainous volcanic islands located at the centre of the lagoon. Tol and Moen are the largest and highest ones among sixteen volcanic islands. Both are about 8 km in length, and up to 4 km in width. Tol is mainly occupied by the highest mountain in Truk, which is 443 m in height and forms a large plateau steeply ascending from the shore. Perennial streams are absent at the higher elevations, but the base of this volcanic mass is fringed by numerous perennial and intermittent springs and associated streams and rivulets. These streams have a hard substratum of dense volcanic rock or cobbles. Moen Island rises steeply to 373 m in height from a flat, swampy coastal plain. Like Tol, Moen is fringed by numerous springs which arise near the base of the volcanic mass. The water from these springs flows as streams or rivulets into coastal swamps or into mangrove-lined bays. The largest stream in Truk, called Wichen, is found on Moen and it flows at the rate of about 1 m^3/min. in a well-developed valley. It is rarely more than 2-3 m wide and 3-20 cm deep.



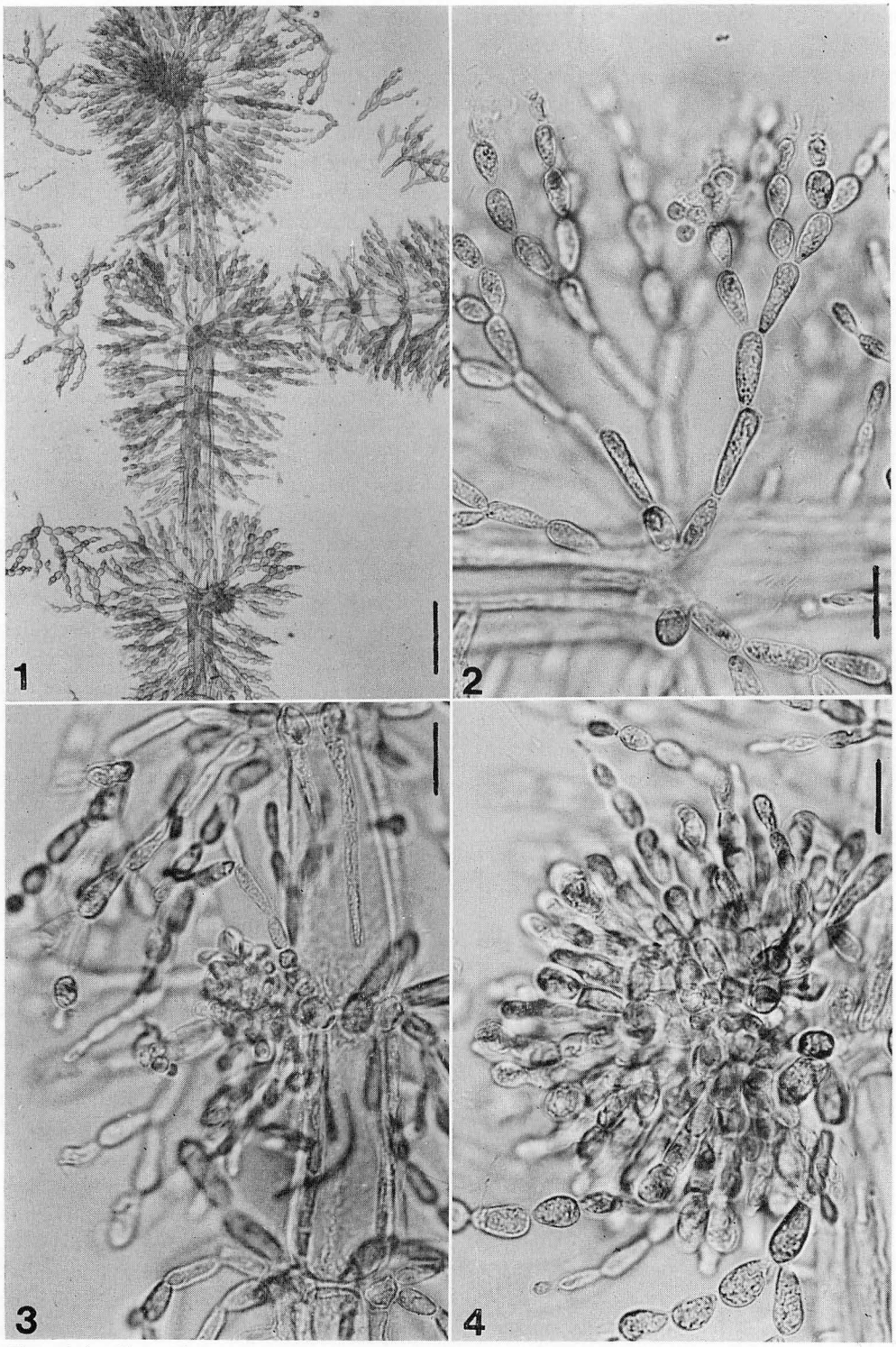
Map. 3. Site locations on Truk. (n: *B. nechochoense*, f: *B. faroense*)

Descriptions of the Species

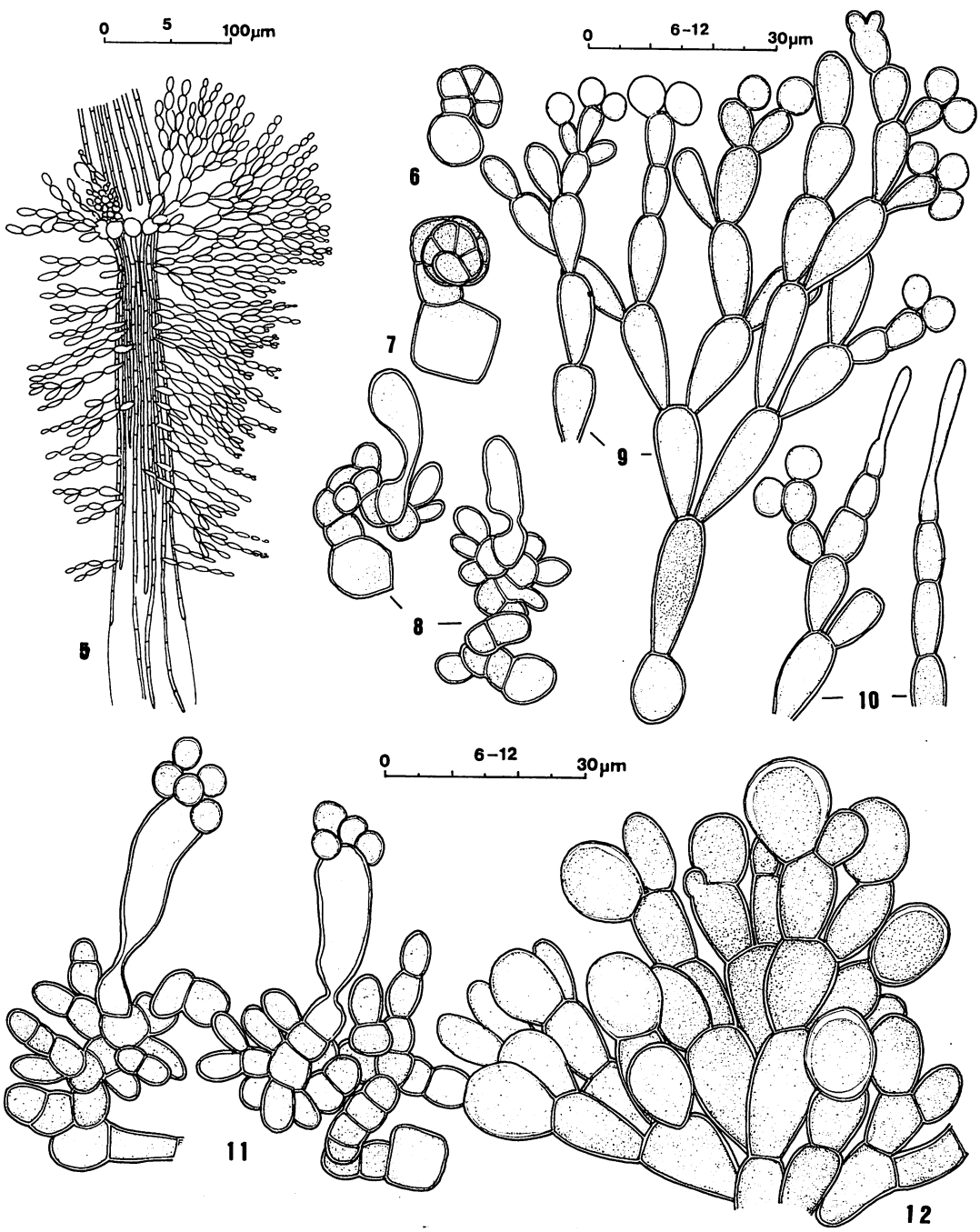
1. *Batrachospermum mahlacense* KUMANO et BOWDEN-KERBY, sp. nov. (Figs. 1-4, 5-12)

Frons monoica, ca. 6 cm alta, 250-400 μm crassa, abundanter irregulariterque ramosa, modice mucosa, glauca. Cellulae axiales cylindricae, 30-60 μm crassae, 200-400 μm ongae. Verticilli pyriformes. Ramuli primarii dichotome ramificantes, ex 7-9 cellulis constantes; cellulae fasciculorum ellipticae; pili plus minusve breves. Fila corticales bene evoluta. Ramuli secundarii numerosi, non vel dichotome ramificantes, ex 6-7 cellulis constantes, totum internodium obtegentes. Spermatangia globosa, 4-6 μm diametro, in ramulis primariis et secundariis terminalia vel lateralia. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, ex cellulis 5-15 doliiformibus constantes, valde tortuosi; carpogonium 25-40 μm longum, basi 4-5 μm crassum, apice 7-8 μm crassum; trichogyne ellipsoidea vel urnformes, plus minusve distincte pedicellata. Bracteae numerosi et breves. Gonimoblasti singuli vel duo, globosi vel semiglobosi, 140-170 μm crassi, 80-160 μm alti, in centro verticilli inserti. Carposporangia obovoidea, 7-12 μm crassa, 12-14 μm longa.

Fronds monoecious, ca. 6 cm high, 250-400 μm wide, abundantly and irregularly branched, moderately mucilaginous, dark greyish green. Axial cells cylindrical, 30-60 μm wide, 200-400 μm long. Whorls pear-shaped. Primary branchlets dichotomously branched, consisting of 7-9 cell-stories; cells of fascicles ellipsoidal; hairs more or less short. Cortical filaments well-developed.



Figs. 1-4. *Batrachospermum mahlacense* KUMANO et BOWDEN-KERBY, sp. nov. 1. A part of thallus showing pear-shaped whorls; 2. Spermatangia; 3. A part of whorls showing a carpogonium-bearing branch with a fertilized trichogyne; 4. A gonimoblast. (Scale bar; 100 μm for Fig. 1; 20 μm for Figs. 2-4).



Figs. 5-12. *Batrachospermum mahlacense* KUMANO et BOWDEN-KERBY, sp. nov. 5. A part of thallus showing axial cells, primary branchlets, cortical filaments, secondary branchlets and a carpogonium-bearing branch; 6-7. Coiled carpogonium-bearing branches at very early stages in development; 8. Early stages in development of coiled carpogonium-bearing branches with young carpogonia; 9. Spermatangia; 10. Hairs; 11. Fertilized carpogonia with spermatia; 12. Carposporangia terminal on gonimoblast filaments.

Secondary branchlets numerous, consisting of 6-7 cell-stories, non or dichotomously branched, covering all the internodes. Spermatangia globose, 4-6 μm in diamter, terminal or lateral on primary and secondary branchlets. Carpogonium-bearing branch arising from the basal cell of primary branchlet, consisting of 5-15 barrel-shaped cells, twisted strongly; carpogonium 25-40 μm long, 4-5 μm wide at the base, 7-8 μm wide at the apex; trichogyne ellipsoidal or urn-shaped, more or less distinctly stalked. Bracts numerous and short. Gonimoblasts single or couple, globose or semiglobose, 140-170 μm wide, 80-160 μm high, inserted centrally. Carposporangia obovoidal, 7-12 μm wide, 12-14 μm long.

Holotype: Upper reaches of the Mahlac River, Talofofo, Guam, Mariana Islands (BOWDEN-KERBY 25/VIII 1983), Herbarium of Faculty of Science, Kobe University, Japan. Isotype: (BOWDEN-KERBY 25/VIII 1983), University of Guam Herbarium, U. S. A..

Other specimens examined: Upper reaches of Mahlac River, Talofofo, Guam, Mariana Islands (BOWDEN-KERBY 15/VII 1984).

Habitat: Attached on rocks in a perennial spring, and epiphytic on *Phragmites* in another nearby spring-fed rivulet. The pH value of water was 7.2 and water temperature was 25°C during the July 1984 collection.

Distribution: Known from the type locality and Ibobang in Palau, Western Caroline Islands.

2. *Batrachospermum doboense* KUMANO et BOWDEN-KERBY, sp. nov. (Figs. 13-16, 17-25).

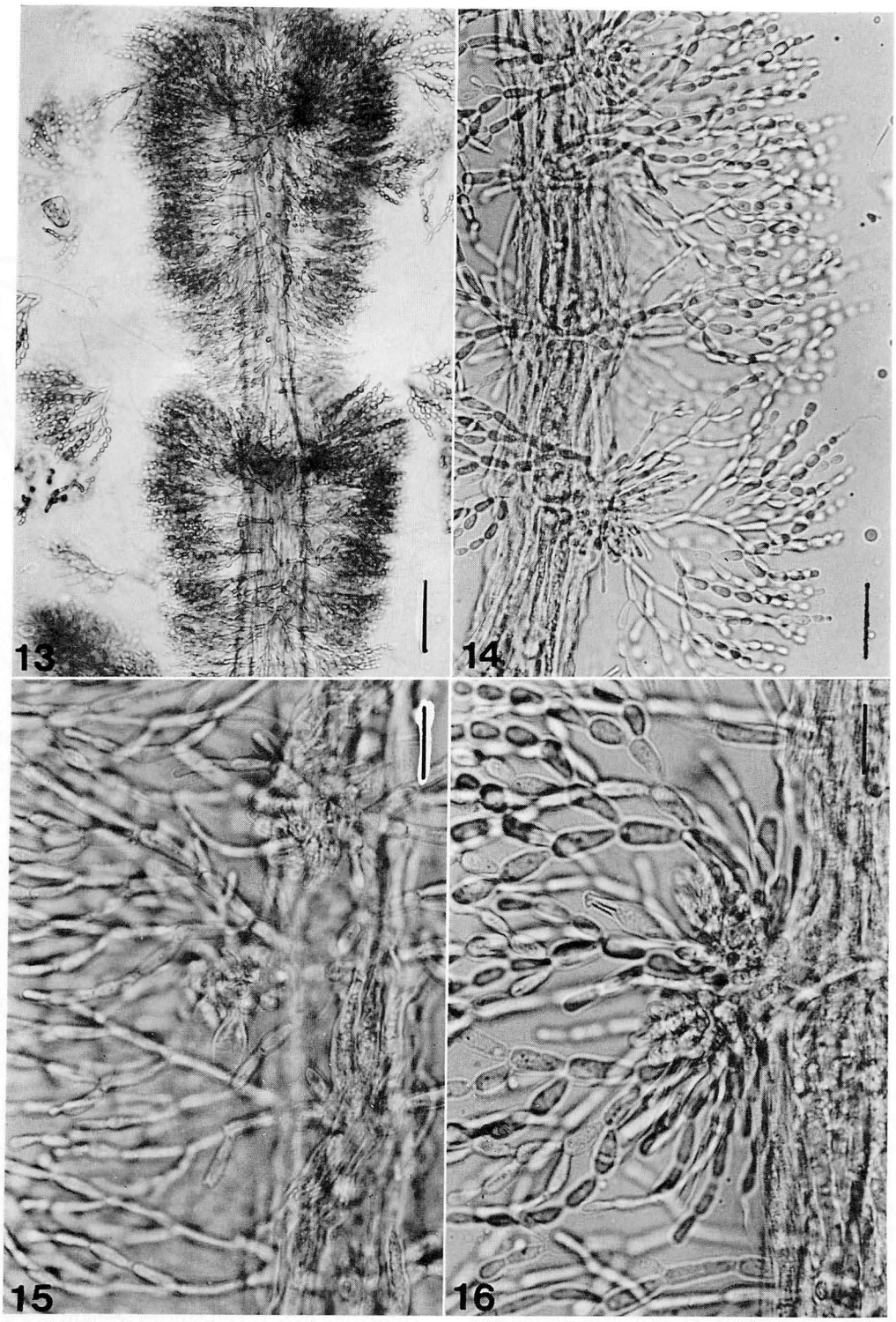
Frons dioica?, ca. 4 cm alta, 300-400 μm crassa, abundanter irregulariterque ramosa, mucosa, viridia. Cellulae axiales cylindricae, 30-90 μm crassae, 70-350 μm longae. Verticilli pyriformes, in parte vetustiore frondis contigui. Ramuli primarii dichotome ramificantes, ex 9-14 cellulis constantes; cellulae proximales fasciculorum lanceolato-claviformes, cellulae distales fusiformes vel obovoideae; pili breves. Fila corticales densissime evoluta. Ramuli secundarii numerosi, dichotome ramificantes, ex 9-12 cellulis constantes. Spermatangia ignota. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, ex cellulis 5-11 doliiformibus constantes, tortuosi; carpogonium 25-40 μm longum, basi 3-7 μm crassum, apice 7-9 μm crassum; trichogyne ellipsoidea vel claviformes, indistincte pedicellata, ad basim saepe flexa. Bractea breves. Gonimoblasti et carposporangia ignota.

Fronds dioecious?, ca, 4 cm high, 300-400 μm wide, abundantly and irregularly branched, mucilaginous, green. Axial cells cylindrical. 30-90 μm wide, 70-350 μm long. Whorls pear-shaped, touching each other in aged part of the fronds. Primary branchlets dichotomously branched consisting of 9-14 cell-stories; proximal cells of fascicles lanceolate club-shaped, distal cells fusiform or obovoidal; hairs short. Cortical filaments very densely developed. Secondary branchlets numerous and dichotomously branched, consisting of 9-12 cell-stories. Spermatangia unknown. Carpogonium-bearing branches arising from the basal cells of primary branchlets, consisting of 5-11 barrelshaped cells twisted; carpogonium 25-40 μm long, 3-7 μm wide at the base, 7-9 μm wide at the apex; trichogyne ellipsoidal or club-shaped, indistinctly stalked, often bent at the base. Bracts short. Gonimoblasts and carposporangia unknown.

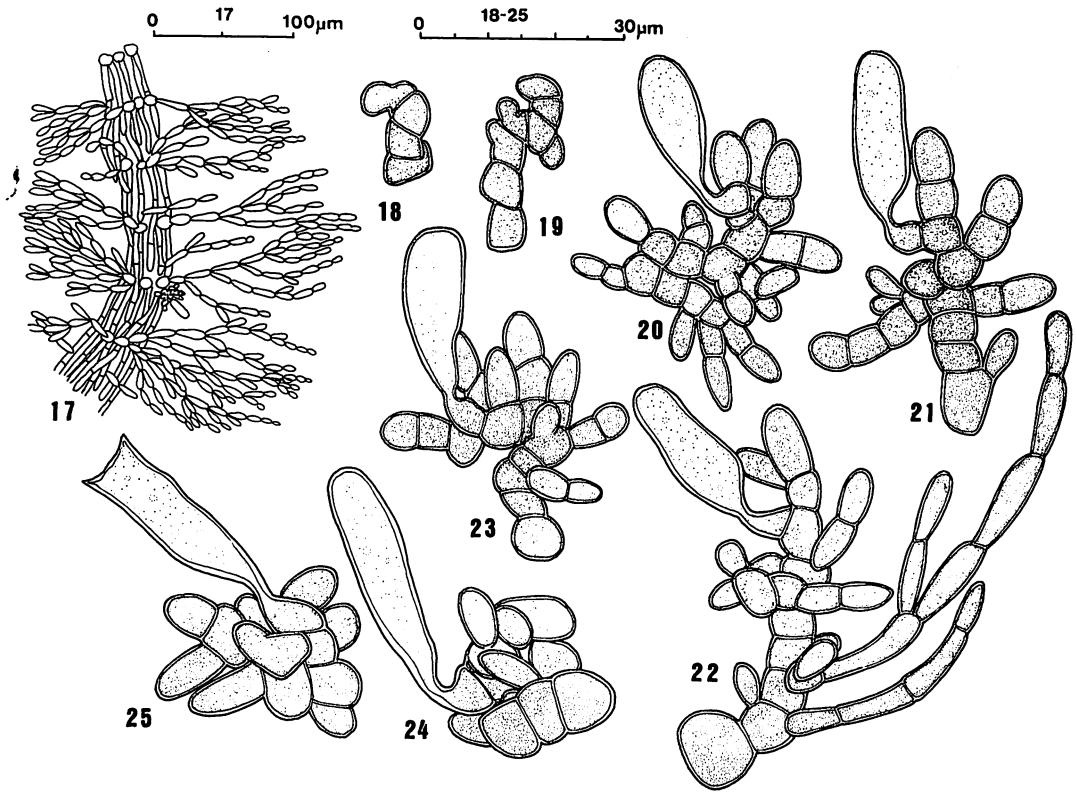
Holotype: Dobo Spring, Guam, Mariana Islands (BOWDEN-KERBY 7/VII 1984), Herbarium of Faculty of Science, Kobe University, Japan. Isotype: (BOWDEN-KERBY 7/VII 1984), University of Guam Herbarium, U. S. A..

Habitat: Growing in a perennial spring of flowing water, with *Thorea gaudichaudii*, the pH value was 7.5 on July 7, 1984.

Distribution: Known from the type locality only.



Figs. 13-16. *Batrachospermum doboense* KUMANO et BOWDEN-KERBY, sp. nov. 13. A part of thallus showing well-developed cortical filaments and pear-shaped whorls; 14. A part of young thallus showing well-developed cortical filaments, primary branchlets and two carpogonia; 15. Cortical filaments, primary branchlets and carpogonia; 16. A carpogonium-bering branch with a mature carpogonium. (Scale bar; 100 μm for Fig. 13; 40 μm for Fig. 14; 20 μm for Figs. 15-16).

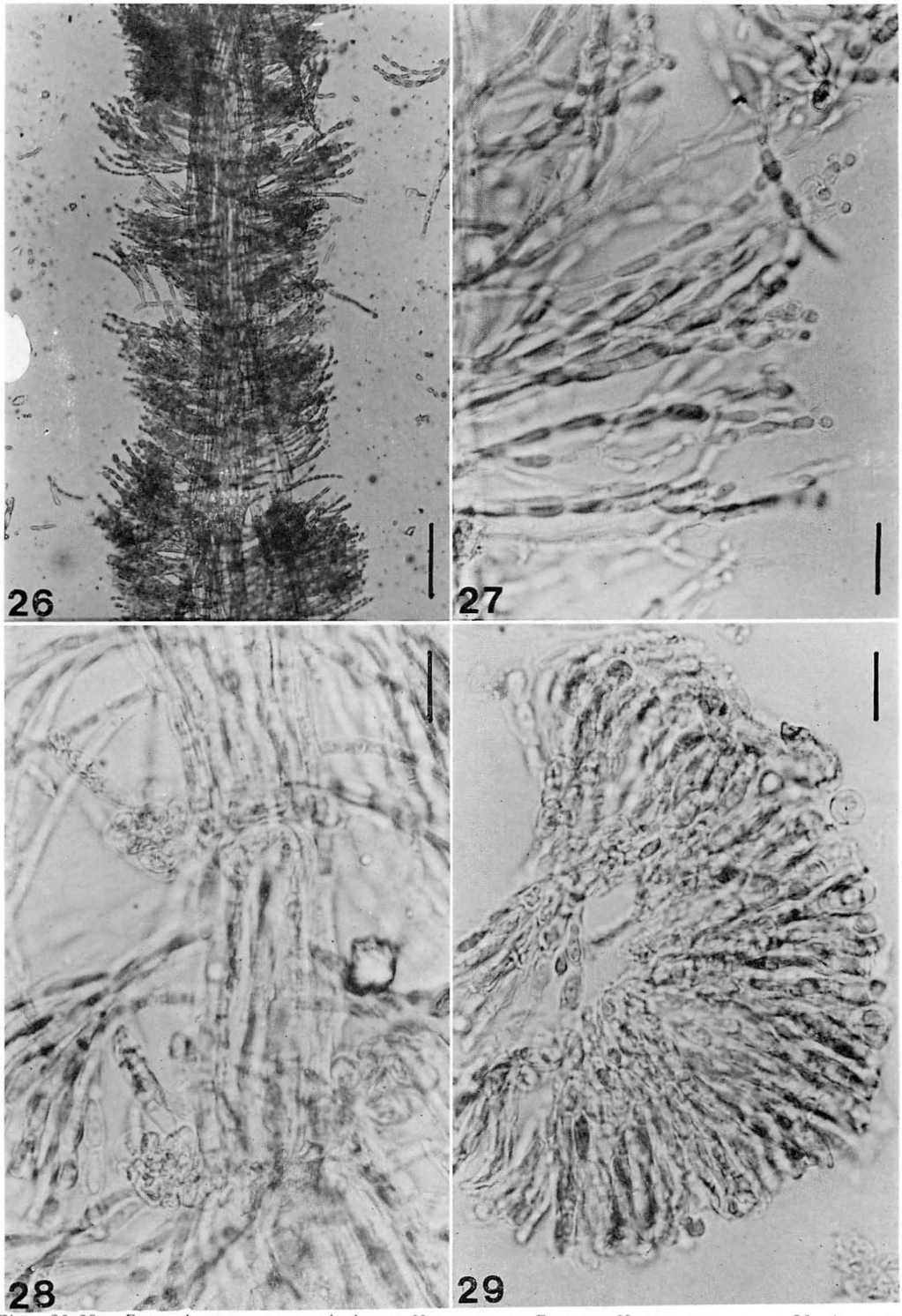


Figs. 17-25. *Batrachospermum doboense* KUMANO et BOWEDN-KERBY, sp. nov. 17. Apart of thallus showing axial cells, primary branchlets and a carpogonium-bearing branch; 18-19. Curved carpogonium-bearing branches at very young stages in development; 20-25. Carpogonium-bearing branches.

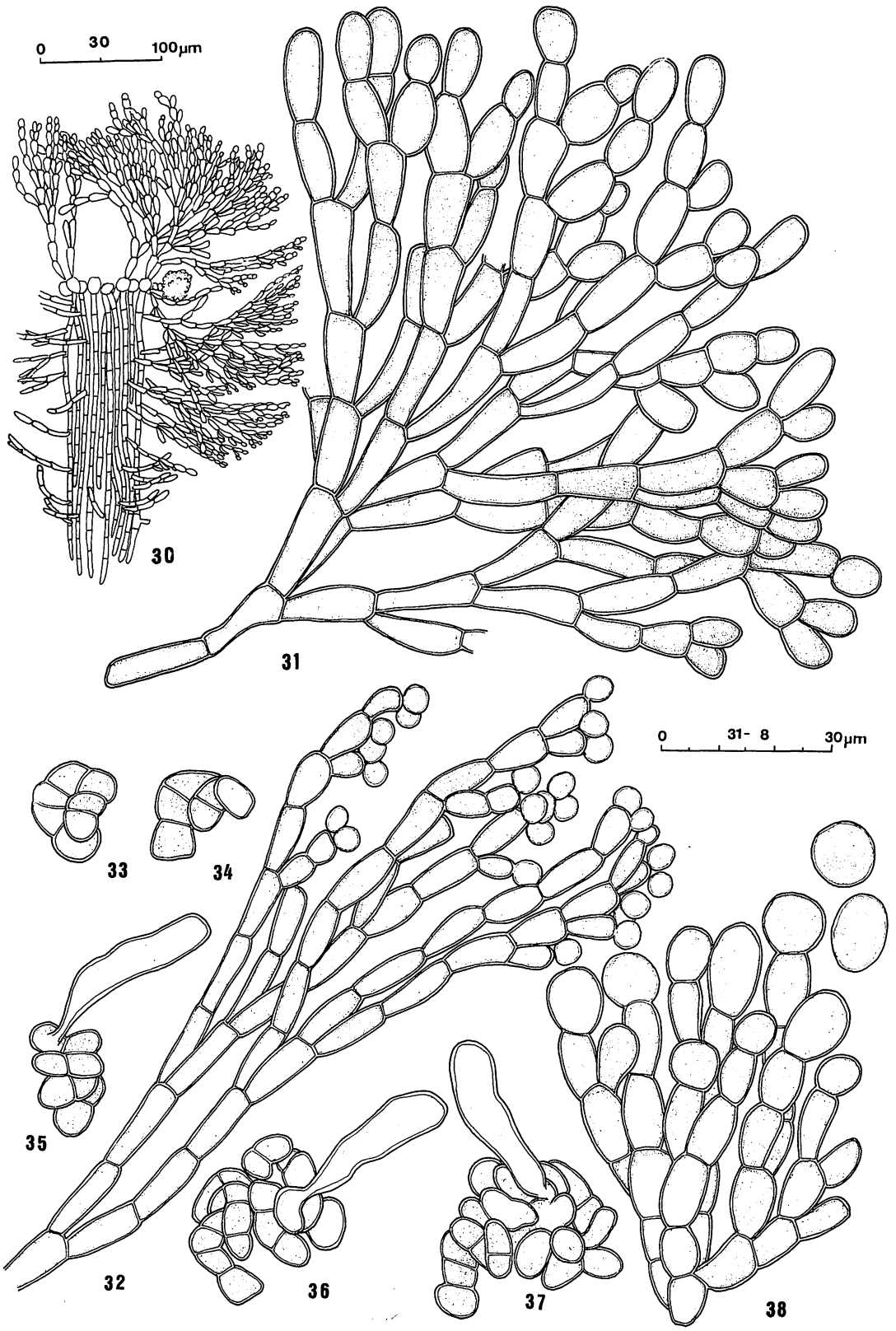
3. *Batrachospermum omobodoense* KUMANO et BOWDEN-KERBY sp. nov. (Figs. 26-29, 30-38).

Frons monoica, ca. 4 cm alta, 250-350 μm crassa, plerumque pseudo-dichotome ramosa, mucosa, atrovirens. Cellulae axiales cylindricae, 35-60 μm crassae, 90-320 μm longae. Verticilli doliiformes, in parte vetustiore frondis contigui. Ramuli primarii plus minusve unilateraliter ramificantes, ex 8-12 cellulis constantes; cellulae fasciculorum ellipticae; pili nuli. Fila corticales bene evoluta. Ramuli secundarii numerosi, ex 6-12 cellulis constantes, non vel dichotome ramificantes, totum internodium obtegentes. Spermatangia globosa, 3-5 μm diametro, in ramulis secundariis et primariis terminalia vel lateralia. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, ex cellulis 5-7 doliiformibus constantes, valde spiratim tortuosi; carpogonium 35-40 μm longum, basi 3-5 μm crassum, apice 7-8 μm crassum, trichogyne claviformes, indistincte pedicellata. Bracteae sparsae et breves. Gonimoblasti singuli vel duo, globosi vel semiglobosi, 170-220 μm crassi, 120-190 μm alti, in centro verticilli inserti. Carposporangia obovoidea, 8-11 μm crassa, 10-14 μm longa.

Frond monoecious, ca. 4 cm high, 250-350 μm wide, very frequently pseudo-dichotomously branched, mucilaginous, deep green. Axial cells cylindrical, 35-60 μm wide, 90-320 μm long. Whorls barrel-shaped, touching each other in aged parts of fronds. Primary branchlets more or less unilaterally branched, consisting of 8-12 cell-stories; cells of fascicles ellipsoidal; hairs lacking. Cortical filaments well-developed. Secoudary branchlets numerous, non or dichotomously branched,



Figs. 26-29. *Batrachospermum omobodoense* KUMANO et BOWDEN-KERBY, sp. nov. 26. A part of thallus showing barrel-shaped whorls; 27. Spermatangia terminal on secondary branchlets; 28. A part of thallus showing axial cells, primary branchlets and two carpogonium-bearing branches; 29. Carposporangia terminal on compactly agglomerated gonimoblasts. (Scale bar; 100 μm for Fig. 26; 20 μm for Figs. 27-29).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consisting of 6-12 cell-stories, covering all the internodes. Spermatangia globose, 3-5 μm in diameter, terminal or lateral on secondary and rarely on primary branchlets. Carpogonium-bearing branch arising from the basal cell of the primary branchlet, consisting of 5-7 barrel-shaped cells, spirally twisted; carpogonium 35-40 μm long, 3-5 μm wide at the base, 7-8 μm wide at the apex; trichogyne club-shaped. Bracts sparse and short. Gonimoblasts single or couple, globose or semiglobose, 170-220 μm wide, 120-190 μm high, inserted centrally. Carposporangia obovoidal, 8-11 μm wide, 10-14 μm long.

Holotype: Omobodo Stream, Ngeremlengui State, Palau (BOWDEN-KERBY 25/XII 1983), Herbarium of Faculty of Science, Kobe University. Isotype: (BOWDEN-KERBY 25/XII 1983), University of Guam Herbarium.

Habitat: Attached to rocks in a slightly to moderately flowing current with several hours of direct sunlight per day, and in a large pool in Omobodo Stream which arises from the Ngeremlengui taro swamp.

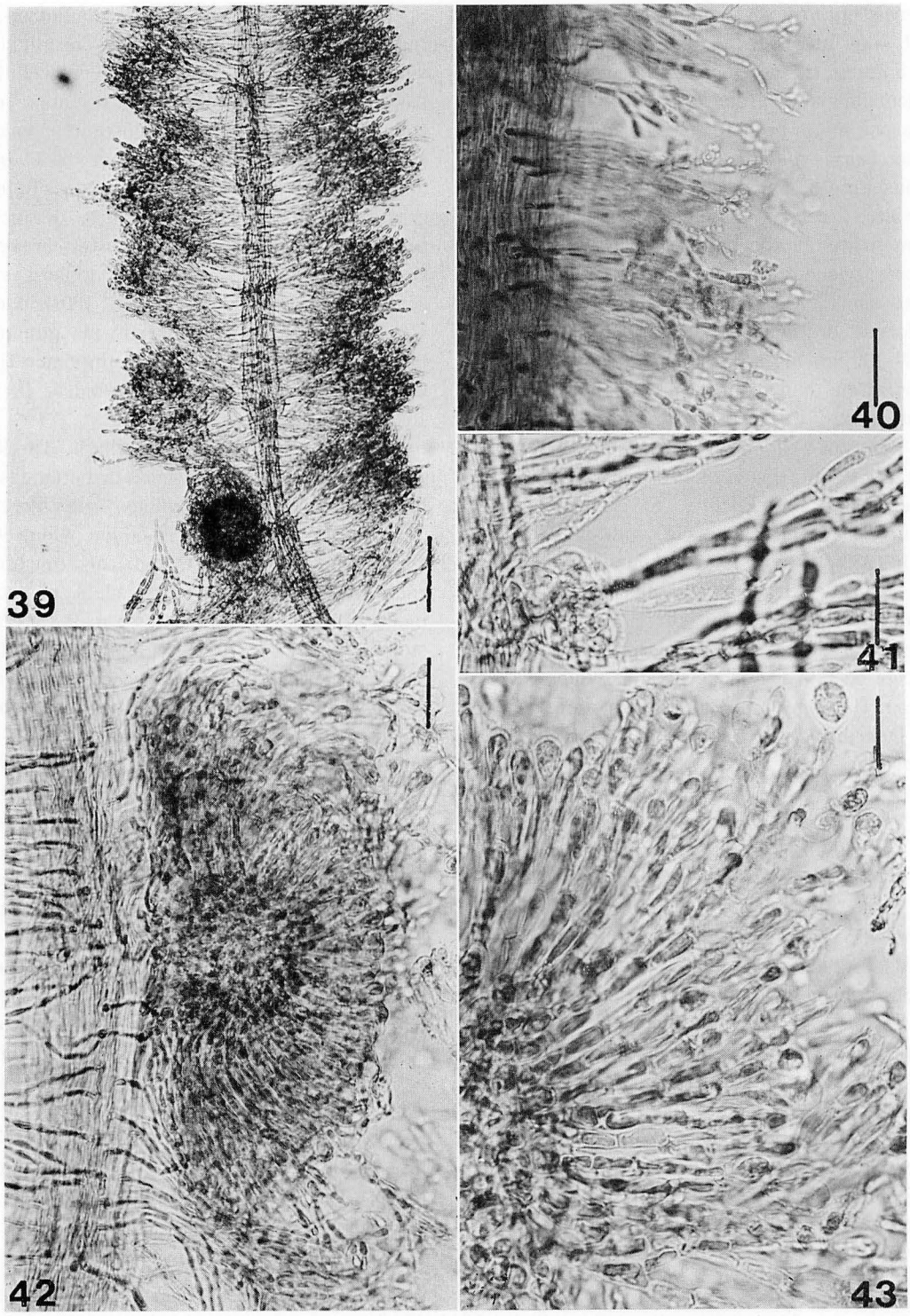
Distribution: Known from the type locality only.

4. *Batrachospermum tabagatenense* KUMANO et BOWDEN-KERBY, sp. nov. (Figs. 39-43, 44-52).

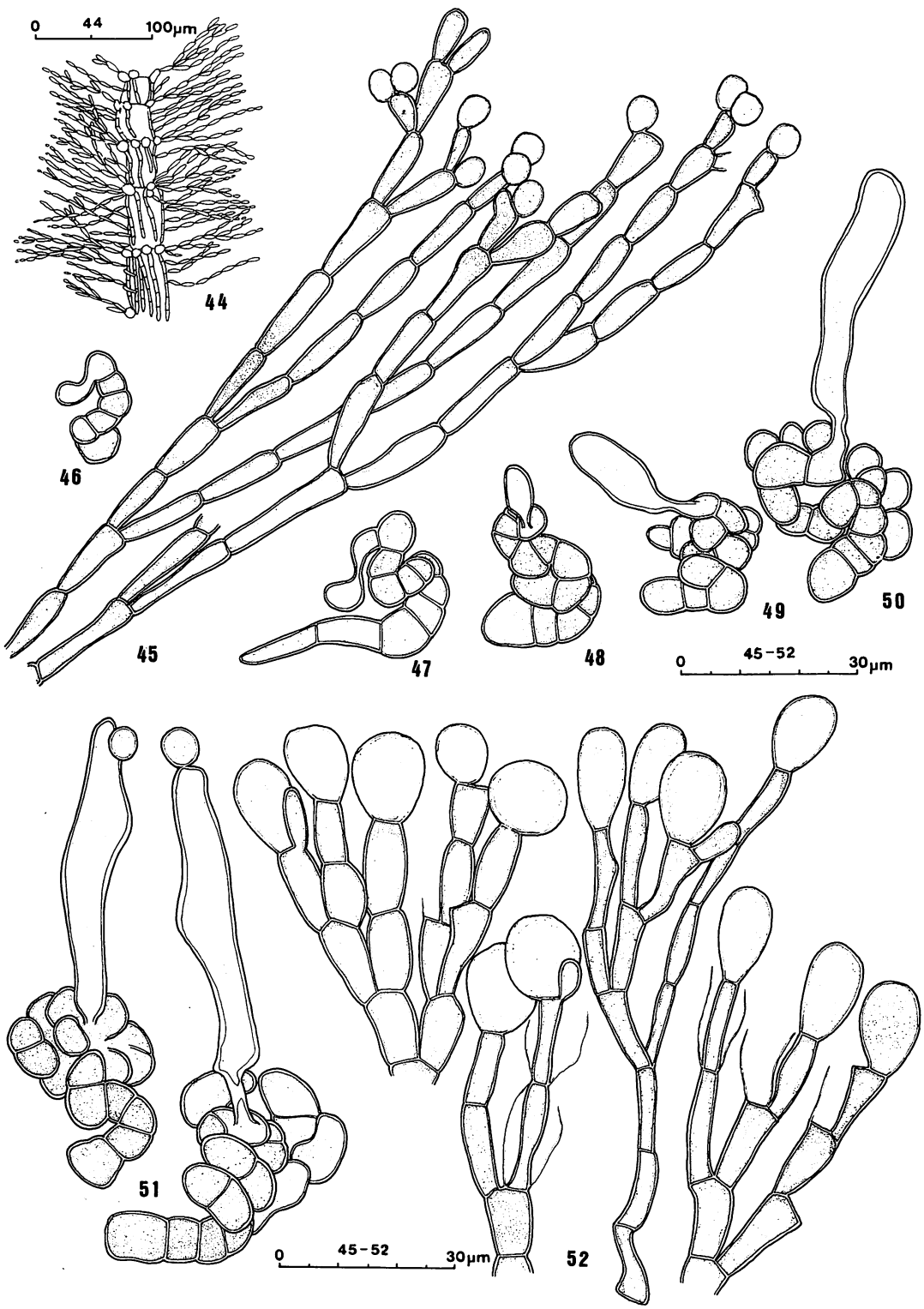
Frons mononica, ca. 3cm alta, 350-550 μm crassa, sparsim pseudo-dichotome ramosa, valde mucosa, glauca. Cellulae axiales cylindricae, 20-50 μm crassae, 80-180 μm longae. Verticilli cylindricae contigui. Ramuli primarii dichotome ramificantes, ex 9-13 cellulis constantes; cellulae fasciculorum primariorum lanceolato-claviformes; pili raro. Fila corticales bene evoluta. Ramuli secundarii numerosi, dichotome ramificantes, ex 8-11 cellulis constantes, totum internodium obtegentes, ramuli primarii aequantes. Spermatangia globosa, 4-5 μm diametro, in ramulis primariis et secundariis terminalia vel lateralia. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, ex cellulis 6-13 doliiformibus constantes, valde spiratim tortuosi; carpogonium 50-65 μm longum, basi 3-6 μm crassum, apice 8-10 μm crassum; trichogyne claviformes, distincte pedicellata. Bracteae sparsae et breves. Gonimoblasti singuli vel duo, globosi vel semiglobosi, 180-300 μm crassi, 130-250 μm alti, in centro verticilli inserti; fila gonimoblastorum plus minusve laxe agglomeratia. Carposporangia globosa vel obovoidea, 10-14 μm crassa, 12-16 μm longa.

Frond monoecious, ca. 3 cm high, 350-550 μm wide, sparsely and pseudo-dichotomously branched, very mucilaginous, gray-green. Axial cells cylindrical, 20-50 μm wide, 80-180 μm long. Whorls cylindrical, touching each other. Primary branchlets dichotomously branched, consisting of 9-13 cell-stories; cells of fascicles lanceolate club-shaped; hairs rare. Cortical filaments well-developed. Secondary branchlets numerous, dichotomously branched, consisting of 8-11 cell-stories, covering all the internodes and equaling primary branchlets. Spermatangia globose, 4-5 μm in diameter, terminal or lateral on primary and secondary branchlets. Carpogonium-bearing branch arising from the basal cell of primary branchlet, consisting of 6-13 barrel-shaped cells, spirally coiled; carpogonium 50-65 μm long, 3-6 μm wide at the base, 8-10 μm wide at the apex; trichogyne club-shaped, indistinctly stalked. Bracts sparse and short. Gonimoblasts single or couple, globose or semiglobose, 180-300 μm wide, 130-250 μm high, centrally inserted; gonimoblast filaments more or less loosely agglomerated. Carposporangia globose or obovidal, 10-14 μm wide, 12-16 μm long.

Figs. 30-38. *Batrachospermum omodoboense* KUMANO et BOWDEN-KERBY, sp. nov. 30. A part of thallus showing an axial cell, primary branchlets, secondary branchlets and a young gonimoblast; 31. Primary branchlets more or less unilaterally branched; 32. Spermatangia terminal or lateral on secondary branchlets; 33-34. Coiled carpogonium-bearing branches at very young stages in development; 35-37. Coiled carpogonium-bearing branches with mature trichogynes; 38. Carposporangia terminal on gonimoblast filaments.



Figs. 39-43. *Batrachospermum tabagatense* KUMANO et BOWDEN-KERBY, sp. nov. 39. A part of thallus showing cylindrical whorls and a gonimoblast; 40. Spermatangia terminal or lateral on secondary branchlets; 41. A carpogonium-bearing branch with a mature trichogyne; 42. Semiglobose gonimoblast; 43. Carposporangia terminal on more or less loosely agglomerated gonimoblast filaments. (Scale bar; 100 μm for Fig. 39; 40 μm for Figs. 40, 42; 20 μm for Figs. 41, 43).



Figs. 44-52. *Batrachospermum tabagatenense* KUMANO et BOWDEN-KERBY, sp. nov. 44. A part of thallus showing axial cells, primary branchlets, secondary branchlets and cortical filaments; 45. Spermatangia terminal or lateral on secondary branchlets; 46-49. Coiled carpogonium-bearing branches at very young stages in development; 50. A carpogonium-bearing branch with a mature trichogyne; 51. Fertilized carpogonia with spermatia; 52. Carposporangia terminal on more or less loosely agglomerated gonimoblast filaments.

Holotype: Tabagaten River, Nekking, Palau, (BOWDEN-KERBY 19/V 1984), Herbarium of Faculty of Science, Kobe University. Isotype: (BOWDEN-KERBY 19/V 1984), University of Guam Herbarium.

Other specimens examined: Seep-fed pond in Ibobang, Palau (BOWDEN-KERBY 26/V 1984).

Habitat: Attached to rocks and free roots in a small rivulet of gentle current, arising from a leaf-clogged spring, receiving about one hour of direct sunlight per day. The pH value was 6.0 in a man-made pond from a seep in Ibobang on Babeldaob Island on May 26, 1984.

Distribution: Known from the type locality and a seep-fed pond in Ibobang, Palau.

5. *Batrachospermum nechochoense* KUMANO et BOWDEN-KERBY, sp. nov. (Figs. 53-57, 58-65).

Frons monoica, ca. 2 cm alta, 350-550 μm crassa, abundanter irregulariterque ramosa, mucosa, glauca. Cellulae axiales cylindricae, 30-70 μm crassae, 100-330 μm longae. Verticilli doliiformes, in parte vetustiore frondis contigui. Ramuli primarii dichotome, raro tetrachotome ramificantes, ex 11-14 cellulis constantes; celllulae proximales fasciculorum lanceolato-claviformes, cllulae distales obovoideae vel pyriformes; pili breves. Fila corticales bene evoluta. Ramuli secundarii dichotome ramificantes, ex 8-11 cellulis constantes, bene evolutae. Spermatangia globosa vel pyriformia, 5-7 μm diametro, praecipue in ramulis primariis terminalia vel lateralia. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, ex cellulis 7-11 doliiformibus constantes, valde spiratim tortuosi; carpogonium 25-30 μm long, basi 5-6 μm crassum, apice 7-12 μm crassum; trichogyne clavivel urn-formes, plus minusve indistincte pedicellata. Bracteae breves. Gonimonlasti singuli, semiglobosi, 150-220 μm crassi, 140-180 μm alti, in centro verticilli inserti; fila gonimoblastorum laxe agglomeratia. Carposporangia obovoidea, 7-8 μm crassa, 10-16 μm longae.

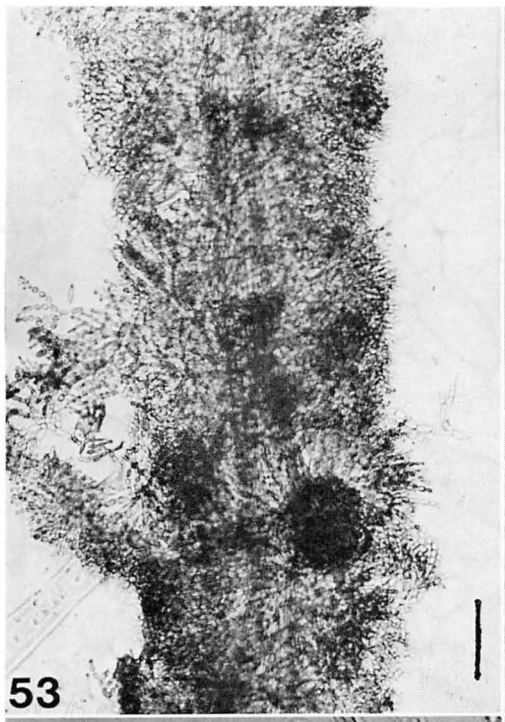
Frond monoecious, ca. 2 cm high, 350-550 μm wide, abundantly and irregularly branched, mucilaginous, gray-green. Axial cells cylindrical, 30-70 μm wide, 100-330 μm long. Whorls barrel-shaped, touching each other in aged fronds. Primary branchlets dichotomously, trichotomously, rarely tetrachotomously branched, consisting of 11-14 cell-stories; proximal cells of fascicles lanceolate club-shaped, distal cells obovoidal or pear-shaped; hairs short. Cortical cells well-developed. Secondary branchlets dichotomously branched, consisting of 8-11 cell-stories, well-developed. Spermatangia globose or pear-shaped, 5-7 μm in diameter, terminal and lateral mainly on primary branchlets. Carpogonium-bearing branch arising from the basal cell of the primary branchlet, consisting of 7-14 barrel-shaped cells; spirally twisted; carpogonium 25-30 μm long, 5-6 μm wide at the base, 7-12 μm wide at the apex; trichogyne club- or urn-shaped, more or less indistinctly stalked. Bracts short. Gonimoblasts single semiglobose, 150-220 μm wide, 140-180 μm high, centrally inserted; gonimoblast filaments loosely agglomerated. Carposporangia obovoidal, 7-8 μm wide, 10-16 μm long.

Holotype: A small spring-fed stream, Nechocho, Tol Island, Truk, (BOWDEN-KERBY 14/III 1982), Herbarium of Faculty of Science, Kobe University. Isotype: (BOWDEN-KERBY 14/III 1982), University of Guam Herbarium.

Other specimens examined: Wichen River, Moen Island, Truk (BOWDEN-KERBY 18/VI 1982).

Habitat: Attached on rocks in a spring-fed

Figs. 53-57. *Batrachospermum nechochoense* KUMANO et BOWDEN-KERBY, sp. nov. 53. A part of thallus showing barrel-shaped or cylindrical whorls; 54. Primary branchlets di- or trichotomously branched with hairs; 55. A carpogonium-bearing branch with fertilized trichogyne; 56. A part of thallus showing axial cells cortical filments, primary and secondary branchlets and a carpogonium bearing-branch; 57. Carposporangia terminal on loosely agglomerated gonimoblast filaments. (Scale bar; 100 μm for Fig. 53; 40 μm for Figs. 54, 56; 20 μm for Figs. 55, 57).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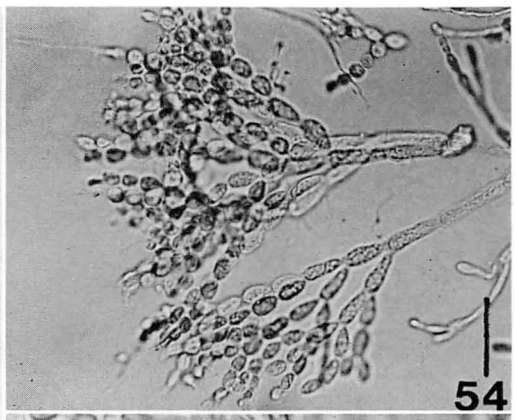
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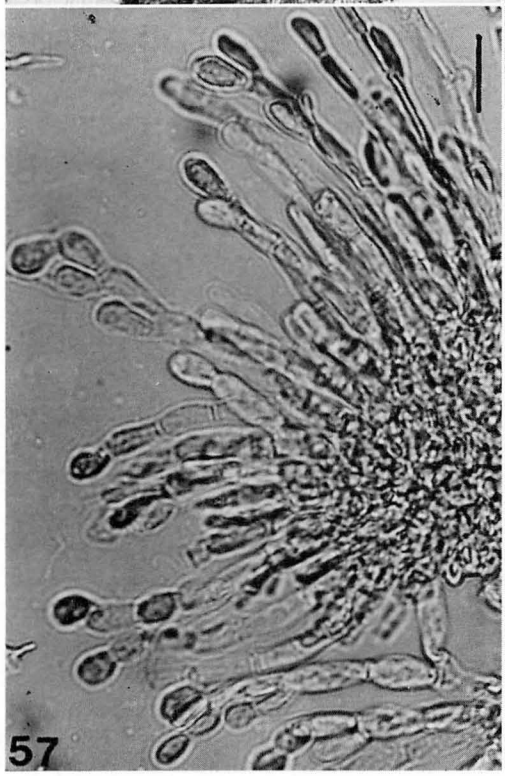
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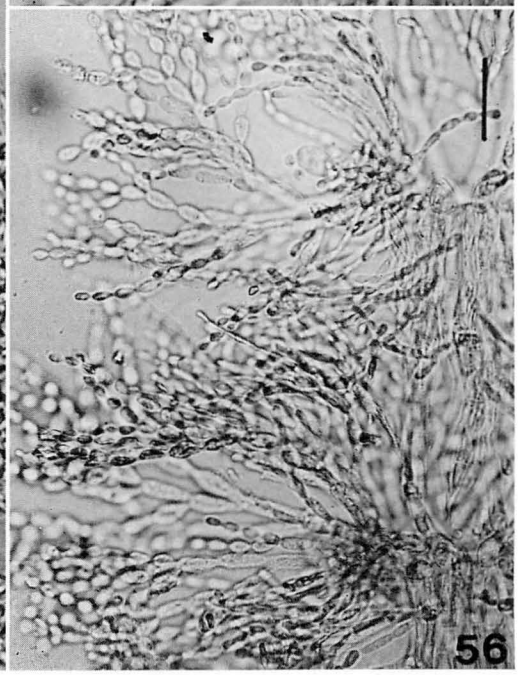
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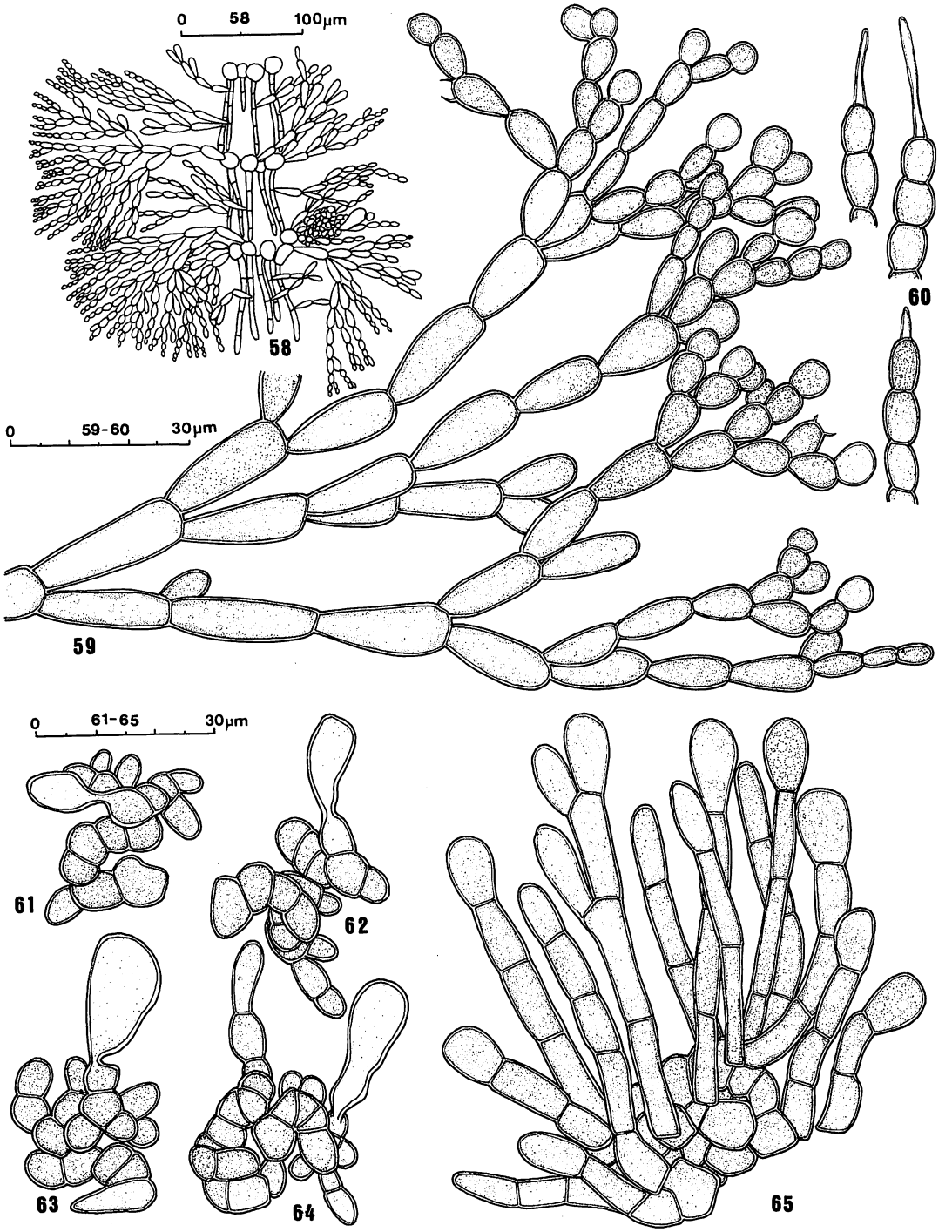


Figs. 58-65. *Batrachospermum nechochoense* KUMANO et BOWDEN-KERBY, sp. nov. 58. A part of thallus showing axial cells, cortical filaments, primary and secondary branchlets and a carpogonium-bearing branch; 59. Spermatangia terminal and lateral on primary branchlets; 60. Short hairs; 61-64. Coiled carpogonium-bearing branches with trichogynes; 65. Carposporangia terminal on loosely agglomerated gonimoblast filaments.

stream and on a pool wall in slowly-flowing water. On Moen the water temperature was 27°C and the pH value 6.5 in August, 1984.

Distribution : Known from the type locality and the Wichen Stream on Moen Island, Truk.

6. *Batrachospermum faroense* KUMANO et BOWDEN-KERBY, sp. nov. (Figs. 66-70, 71-81).

Frons monoica, ca. 3.5 cm alta, 300-500 μm crassa, abundanter irregulariterque ramosa, mucosa, aeruginosa. Cellulae axiales cylindricae, 50-100 μm crassae, 230-320 μm longae. Verticilli doliiformes, in parte vetustiore frondis contigui. Ramuli primarii dichotome raminificantes, ex 7-10 cellulis constantes; cellulae proximales fasciculorum lanceolato-claviformes, cellulae distales obovoideae vel pyriformes; pili breves. Fila corticales bene evoluta. Ramuli secundarii non vel dichotome raminificantes, 5-10 cellulis constantes, totum internodium obtegentes. Spermatangia globosa, 4-6 μm diametro, in ramulis primariis et secundariis terminalia vel lateralia. Ramuli carpogoniferi e cellulis basi primariorum orientes, ex cellulis 5-10 doliiformibus constantes, tortuosi; carpogonium 30-40 μm longum, basi 4-6 μm crassum, apice 5-9 μm crassum; trichogyne claviformes, indistincte pedicellata. Bracteae plus minusve breves. Gonimoblasti singuli, semiglobosi, 200-250 μm crassi, 150-200 μm alti, in centro verticilli inserti; fila gonimoblastorum, in parte distalibus, plus minusve laxe agglomeratia. Carposporangia obovoidea, 7-11 μm crassa, 12-15 μm longa.

Frond monoecious, ca. 3.5 cm high, 300-500 μm wide, abundantly and irregularly branched, mucilaginous, deep green. Axial cells cylindrical, 50-100 μm wide, 230-320 μm long. Whorls barrel-shaped, touching each other in aged fronds. Primary branchlets dichotomously branched, consisting of 7-10 cell-stories; proximal cells of fascicles lanceolate club-shaped, distal cells obovoidal or pear-shaped; hairs short. Cortical filaments well-developed. Secondary branchlets non or dichotomously branched, consisting of 5-10 cell-stories, covering all the internodes. Spermatangia globose, 4-6 μm in diameter, terminal or lateral on primary and secondary branchlets. Carpogonium-bearing branch arising from the basal cell of the primary branchlet, consisting of 5-10 barrel-shaped cells, twisted; carpogonium 30-40 μm long, 4-6 μm wide at the base, 5-9 μm wide at the apex; trichogyne club-shaped indistinctly stalked. Bracts more or less short. Gonimoblasts single, semiglobose, 200-250 μm wide, 150-200 μm high, centrally inserted; distal portion of gonimoblast filaments more or less loosely agglomerated. Carposporangia obovoidal, 7-11 μm wide, 12-15 μm long.

Holotype: A rivulet flowing from a taro swamp, Faro Village, Tol Island, Truk, (BOWDEN-KERBY 11/V 1982), Herbarium of Faculty of Science, Kobe University.

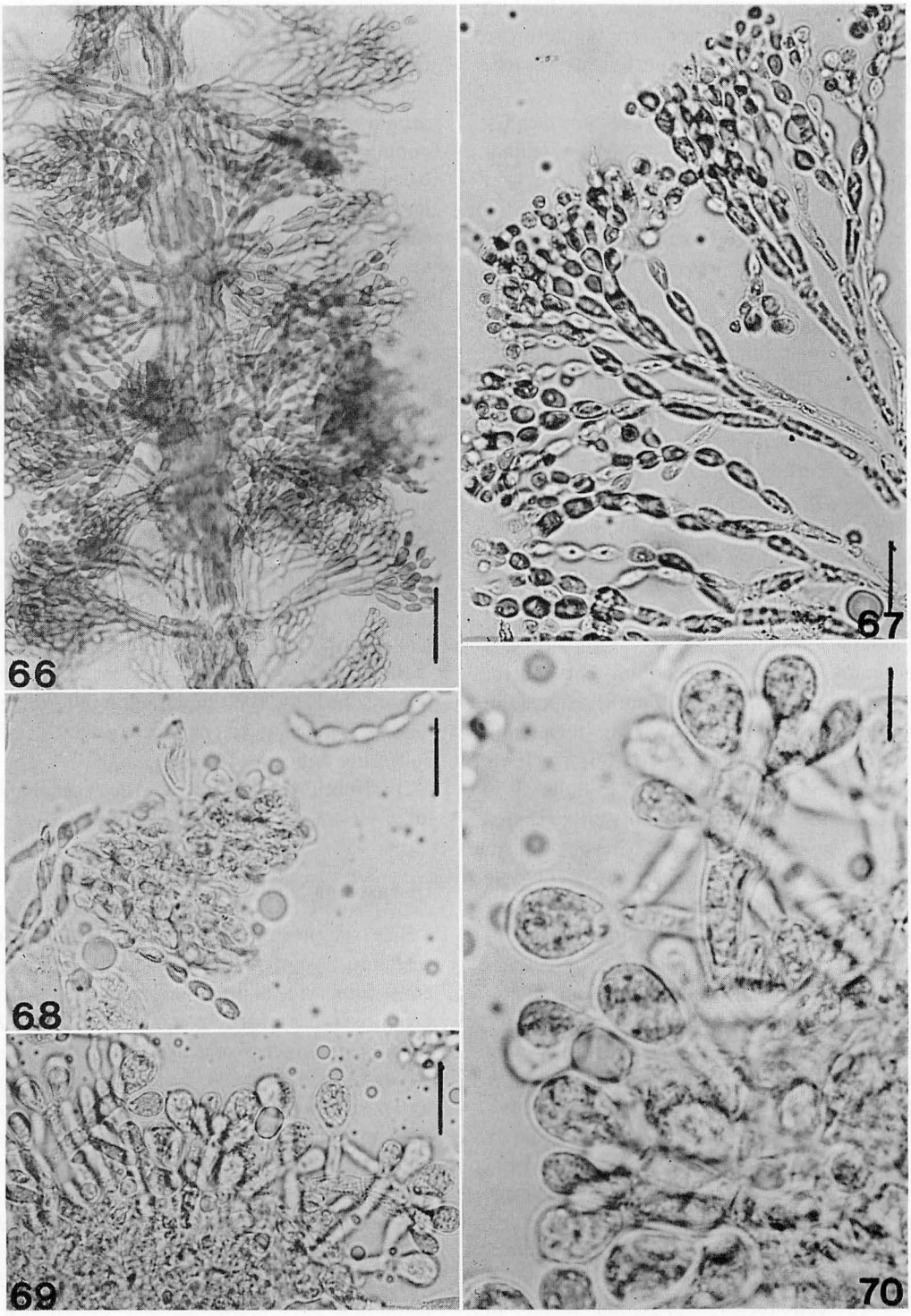
Isotype: (BOWDEN-KERDY 11/V 1982), University of Guam Herbarium.

Habitat: Growing on small rocks on the muddy bed of the slowly flowing rivulet. The pH value of the water was 6.0 at the collecting time in August, 1982.

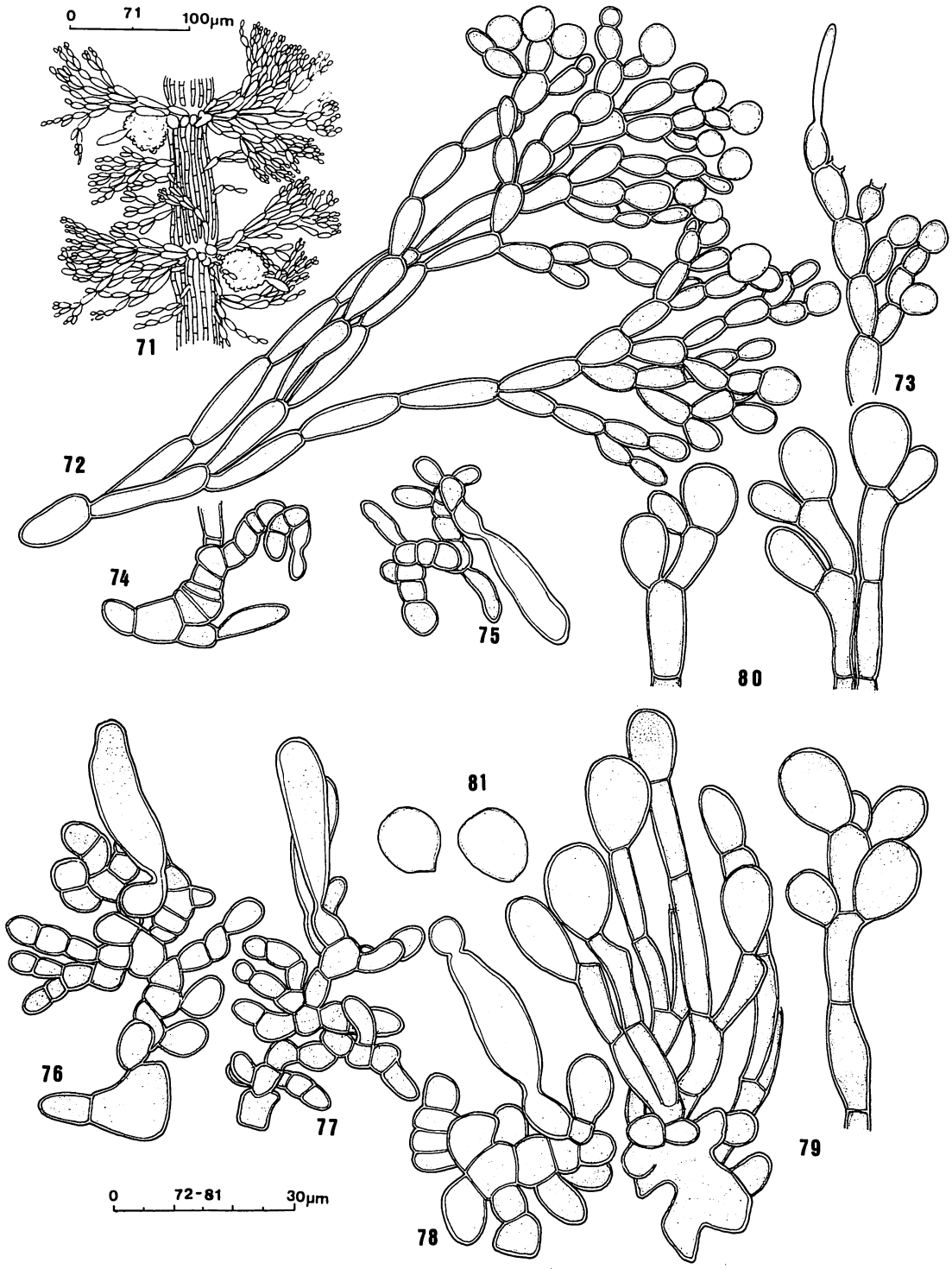
Distribution : Known from the type locality only.

Discussions

The six presently described new species seems to assign to the section *Contorta* and constitute two distinct groups. The first group is represented by *B. doboense* and *B. faroense*, which resemble *B. tortuosum* KUMANO (1978) and *B. tortuosum* var. *majus* KUMANO (1982) in having the curved carpogonium-bearing branches. However, they differ from the latter two taxa in the cell number per carpogonium-bearing branch. The carpogonium-bearing branches for *B. doboense* and *B. faroense* consist of 5-11 cells, while those for *B. tortuosum* and *B. tortuosum* var. *majus* consist of only 2-4 cells. *B. faroense* differs from *B. doboense* in the number of cells consisting a fascicle and the shape of whorls and trichogynes;



Figs. 66-70. *Batrachospermum faroense* KUMANO et BOWDEN-KERBY, sp. nov. 66. A part of thallus showing barrel-shaped worls; 67. Spermatangia terminal and lateral on primary branchlets; 68. A coiled carpogonium-bearing branch; 69-70. Carposporangia terminal on more or less loosely agglomerated gonimoblast filaments. (Scale bar; 40 μm for Fig. 66; 20 μm for Figs. 67-69; 10 μm for Fig. 70).



Figs. 71-81. *Batrachospermum faroense* KUMANO et BOWDEN-KERBY, sp. nov. 71. A part of thallus showing axial cells, cortical filaments, primary and secondary branchlets and two gonimoblasts; 72. Spermatangia terminal and lateral on primary branchlets; 73. Hairs; 74. An early stage in development of a coiled carpogonium-bearing branch; 75-77. Coiled carpogonium-bearing branches with mature trichogynes; 78. Fertilized carpogonium with a spermatium; 79-80. Carposporangia terminal on more or less loosely agglomerated gonimoblast filaments; 81. Carpospores.

for *B. doboense*, whorls are pear-shaped, the fascicle is composed of 9-14 cell-stories and the trichogyne is club-shaped and bent at the base.

The second group characterized by the spirally coiled carpogonium-bearing branches is divided into two subgroups. The first subgroup is represented by *B. tabagatenense* and *B. nechochoense*, which resemble *B. iriomotense* KUMANO (1982) in having the loosely agglomerated gonimoblasts. However, they differ from the latter species in the size of carpogonia and carposporangia. *B. nechochoense* differs from *B. tabagatenense* in the length of trichogyne; 25-30 μm v. s. 50-65 μm. *B. nechochoense* differs from *B. iriomotense* in the size of whorls and carposporangia and the shape of trichogyne; whorls are 150-240 μm wide, carposporangia are 16-19 μm long and the trichogyne are club-shaped for *B. iriomotense*. The second subgroup is represented by *B. omobodoense*, which resembles *B. hirosei* RATNASABAPATHY et KUMANO (1982) and *B. mahlacense* in having the compactly agglomerate gonimoblasts. However, *B. omobodoense* differs from the latter two species in the fascicles more or less unilaterally branched. This species differs from *B. hirosei* in the number of cells per carpogonium-bearing branch and fascicle, the size of whorls and the shape of trichogyne; for *B. hirosei*, the carpogonium-bearing branch consisting of 6-13 cells, the fascicle is composed of 6-8 cell-stories, the whorls are 100-220 μm wide and the trichogyne is ellipsoidal. *B. omobodoense* differs from *B. mahlacense* in the shape of whorls and trichogyne and the number of cells per fascicle and carpogonium-bearing branch; for *B. mahlacens*, whorls are pear-shaped, fascicle consist of 7-9 cell-stories, the carpogonium-bearing branch is composed of 5-15 cells and the trichogyne is ellipsoidal or urn-shaped.

The section *Contorta* was established by SKUJA (1931) based on *Batrachospermum procarpum* SKUJA. The main characteristics of the section *Contorta* is the curved, spirally coiled or hook-like carpogonium-bearing branch, while the carpogonium-bearing brances are straight for the other sections of the genus *Batrachospermum*. The section *Contorta* appears to contain the most numerous species among the sections of the genus *Batrachospermum*, and was pointed out by KUMANO and NECCHI (1985) to be very heterogenous. A tentative key to the known taxa of the section is shown as follow (* reported in the present paper):

Tentative Key to the Taxa of the Section *Contorta*

1. Monosporangia present.
   2. Monosporangia terminating the laterals of carpogonium-bearing branches, sometimes primary and secondary branchlets.
      3. Monosporangia 11-15 μm long. .... *B. intortum* JAO
      3. Monosporangia 13-23 μm long. ....*B. pseudocarpum* REIS
   2. Monosporangia terminating the primary and secondary branchlets.
      4. Carpogonium-bearing branch consisting of 4-7 cells. .... *B. woitapense* KUMANO
      4. Carpogonium-bearing branch consisting of 6-14 cells. ....*B. lusitanicum* REIS
1. Monosporangia absent.
   5. Carpogonium-bearing branch curved.
      6. Carpogonium-bearing branch consisting of 2-4 cells.
         7. Gonimoblast 50-60 μm in diameter. ..... *B. tortuosum* KUMANO
         7. Gonimoblast 220-300 μm in diameter. .... *B. tortuosum* KUMANO var. *majus* KUMANO
      6. Carpogonium-bearing branch consisting of 5-11 cells.
         8. Trichogyne bent at the base. .... **B. doboense* KUMANO et BOWDEN-KERBY
         8. Trichogyne does not bent at the base. ....**B. faroense* KUMANO et BOWDEN-KERBY
   5. Carpogonium-bearing branch twisted,

consisting of 3-8 cells.
9. Fascicles di- or trichotomously branched.
10. Carpogonium 17-34 μm long. .... *B. kushiroense* KUMANO et OHSAKI
10. Carpogonium 40-72 μm long.
11. Gonimoblast 400-550 μm in diameter, primary branchlets consisting of 4-5 cell-stories. .... *B. capense* STARMACH ex NECCHI et KUMANO var. *breviarticulatum* NECCHI et KUMANO
11. Gonimoblast 600-860 μm in diameter, primary branchlets consisting of 7-13 cell-stories. .... *B. capense* STARMACH ex NECCHI et KUMANO
9. Fascicles alternately branched, consisting of cylindrical cells.
12. Gonimoblast 100-300 μm in diameter..... *B. procarpum* SKUJA
12. Gonimoblast 300-900 μm in diameter.
13. Carposporangia 8-15 μm long. *B. cipoense* KUMANO et NECCHI
13. Carposporangia 19-24 μm long. .. *B. equisetoideum* KUMANO et NECCHI
5. Carpogonium-bearing branch spirally coiled, consisting of 6-15 cells.
14. Gonimoblast loosely agglomerated.
15. Carpogonium 50-65 μm long. .... *B. tabagatenense* KUMANO et BOWDEN-KERBY
15. Carpogonium 25-40 μm long.
16. Carposporangia 10-16 μm long. .. *B. nechochoense* KUMANO et BOWDEN-KERBY
16. Carposporangia 16-19 μm long. ..... *B. iriomotense* KUMANO
14. Gonimoblast compactly agglomerated.
17. Fascicles sparsely branched. .... *B. tiomanese* KUMANO et RATNASABAPATHY
17. Fascicles well-branched.
18. Fascicles unilaterally branched. .. **B. omobodoense* KUMANO et BOWDEN-KERBY
18. Fascicles dichotomously branched.
19. Whorls 100-200 μm wide. .. .. *B. hirosei* KUMANO et RATNASABAPATHY
19. Whorls 250-400 μm wide. .. .... **B. mahlacense* KUMANO et BOWDEN-KERBY

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熊野 茂*・ボーデンケルビー, W. A.：ミクロネシアの淡水産紅藻 I. カワモズク属の6新種**

カワモズク属の6新種がミクロネシアから記載された。*B. mahlacense* は *B. hirosei* RATNASABAPATHY et KUMANO 1982 に似るが輪生枝叢および中軸細胞の形と大きさとで後者と区別できる。*B. doboense* は *B. tortuosum* KUMANO 1978 に似るが造果器をつける枝の細胞数，輪生枝叢および受精毛の形とで後者と区別できる。*B. omobodoense* は *B. mahlacense* に似るが輪生枝叢と受精毛の形，輪生枝と造果器をつける枝の細胞数とで後者と区別できる。*B. tabagatenense* は *B. iriomotense* KUMANO 1982 に似るが輪生枝叢および造果器と果胞子の大きさで後者と区別できる。*B. nechochoense* は *B. tabagatenese* と *B. iriomotense* KUMANO 1982 とに似るが受精毛の大きさで *B. tabagatenense* と，輪生枝叢および果胞子の大きさ，受精毛の形で *B. iriomotense* KUMANO 1982 と区別できる。*B. faroense* は *B. doboense* に似るが輪生枝叢と受精毛の形，輪生枝の細胞数で後者と区別できる。ミクロネシアから記載された6新種を含むコントルタ節の既知種の検索表を示す。 (*657 神戸市灘区六甲台 神戸大学理学部生物学教室，**96941 ミクロネシア連邦，ポナペ，コロニア私書箱 159，ミクロネシア教員養成大学科学部)

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日本産キタニセモズク *Acrothrix gracilis* KYLIN (褐藻類ナガマツモ目) の生活史

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AJISAKA, T. and KAWAI, H. 1986. The life history of *Acrothrix gracilis* KYLIN (Phaeophyceae, Chordariales) in Japan. Jap. J. Phycol. 34: 129-136.

The life history and the influences of culture conditions (water temperature and photoperiods) were studied in *Acrothrix gracilis* collected from Maizuru (Japan Sea coast of central Honshu) and Akkeshi (Pacific coast of eastern Hokkaido). In culture, both of the plants showed the same type of direct life history: zoospores germinated unipolarly to develop into irregular prostrate systems with branched filaments, which formed plurilocular sporangia or direetly issued characteristic erect thalli of trichothallic growth. In the Akkeshi culture, the erect thalli formed unilocular sporangia and completed the life history. But the responses of the plants to culture conditions differed with each other. In principle, in the Akkeshi culture, the erect thalli issued only in long-day conditions, while plurilocular sporangia were formed in short-day conditions. On the other hand, in the Maizuru culture, the erect thalli issued irrespective of photoperiods except in warmer temperature conditions, but did not form unilocular sporangia. Plurilocular sporangia were formed in most of the conditions examined. Swarmers from plurilocular sporangia did not show sexual conjugation and developed in the same manner as the zoospores. However, in 10°C and long-day conditions in the Maizuru culture, a few swarmers showed another germling process like that of zygotes of *Acrothrix pacifica*. Assimilatory filaments on the developed erect thallus shortened gradually by means of degenerations of the cells on the upper part or on the basal part.

Key Index Words: Acrothrix gracilis; *Acrotrichaceae*; *Chordariales*; *life history*; *Phaeophyceae*.
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キタニセモズク *Acrothrix gracilis* KYLIN (1907) はスウェーデン, デンマーク, ノルウェー, イギリス, アイルランドなどの北大西洋東部に広く分布する。本邦でも, KAWAI (1983) は北海道東岸の厚岸に分布することを報告しており, また著者らは日本海沿岸の舞鶴湾と男鹿半島で生育を確認している。

ニセモズク属は, ナガマツモ目ニセモズク科 (Chordariales, Acrotrichaceae) に含まれる唯一の属で, 頂毛生長を行う1本の中心軸細胞糸を有する (KYLIN 1940)。本属にはこれまで本種を含み4種, キタニセモズク *Acrothrix gracilis*, *A. novae-angliae* TAYLOR (1928), ニセモズク *A. pacifica* OKAMURA et YAMADA (in YAMADA 1932), *A. norvegica* LEVRING (1937) が報告されている。しかし, 最近になって FORWARD & SOUTH (1985) は, *A. gracilis* の同基準標本, *A. novae-angliae* と *A. norvegica* の正基準標本及びニューファウンドランド (カナダ大西洋岸) 産の材料の観察結果から, *A. novae-angliae* と *A. norvegica* がタイプ種の *A. gracilis* の異名であるとの考えを示している。また, 彼らは, ニューファウンドランド産の *A. gracilis* の培養結果で, 無性的な複子嚢と同時に直立藻体が遊走子から発達した匍匐糸状体上に直接に形成されることを報告している。一方, 太平洋岸のニセモズク属の生活史に関しては新崎 (1948) と AJISAKA (1979) によるニセモズクの報告があるが, キタニセモズク (*Acrothrix gracilis*) に

ついての報告はない。そこで，著者らは，日本産のキタニセモズクの生活史型を調査して互いにその結果を比較するために，厚岸産と舞鶴産の材料に基づき培養を行った。

材料と方法

材料は，1978年6月7日に日本海中部の舞鶴湾(35°30′N, 135°20′E) で潜水により採集したものと，1982年6月27日に北海道太平洋東部の厚岸湾アイニンカップ岬 (43°02′N, 144°52′E) で採集したものを用いた。前者は水深約5mの漸深帯の石の上に，後者は低潮線付近の漸深帯の岩上やピリヒバ上に生育していた。

厚岸産の材料の同定に関しては，KAWAI (1983) に詳しい。また，舞鶴産の材料について自然藻体のホルマリン海水固定標本を形態学的に観察したところ，その外形と同化糸の形状が KYLIN (1907, 1940) と KAWAI (1983) の *Acrothrix gracilis* の記載 (特に成熟した藻体の記載) とよく一致したために，著者らはこれを本種と同定した。

培養の手順については，両者で少し異なるので Table 1 に対比して示す。

結果

A 舞鶴産キタニセモズク

20°C と 15°C の長日・短日条件とも12日目に，また 10°C の短日条件では22日目に，単子嚢を単離した 10 m*l* 試験管の内壁に遊走子由来の発芽体を多数肉眼で確認した。

20°C の短日条件では，ガラス面に密着した径 130～200 μm 匍匐糸状体 (Fig. 1a) は中央部が肥厚して，2週間後には径 0.5～1.2 mm の濃褐色の叢状発芽体となった (Fig. 1b)。褐藻型の毛状体もわずかに直立したが，同化糸の形成はなかった。

20°C の長日条件では，径 250 μm の密に分枝した匍匐糸状体 (Fig. 1c) 上に時折同化糸が形成されたが，直立藻体にはならなかった。

15°C と 10°C では，長日・短日条件とも匍匐糸状体 (Fig. 1d) となり，やがて同化糸や毛状体が直立した (Fig. 1e)。そして，毛状体の基部での頂毛生長によりキタニセモズク直立藻体になった (Fig. 1f)。ところが，短日条件では次第に直立部が枯れて基部の糸状体部分のみ残った。

直立藻体上の同化糸は，6～20個の円柱状または長

Table 1. A comparison of the isolation and culture conditions between Maizuru and Akkeshi materials.

	Maizuru	Akkeshi
Initial isolation	Zoospore germlings	Zoospores
Medium	PES (PROVASOLI 1968)	PESI (TATEWAKI 1966)
Changing interval	10 days—2 weeks	2—3 weeks
Illumination	Cool-white fluorescent tubes	
	3000—4000 lux	2000—3000 lux
Combinations of temperature and photoperiod	25°C long-day (16 : $\bar{8}$)*	
	20°C long-day (16 : $\bar{8}$)	20°C long-day (16 : $\bar{8}$)
	20°C short-day (10 : $\overline{14}$)	20°C short-day (8 : $\overline{16}$)
	15°C long-day (14 : $\overline{10}$)	15°C long-day (16 : $\bar{8}$)
	15°C short-day (10 : $\overline{14}$)	15°C short-day (8 : $\overline{16}$)
	10°C long-day (14 : $\overline{10}$)	10°C long-day (16 : $\bar{8}$)
	10°C short-day (10 : $\overline{14}$)	10°C short-day (8 : $\overline{16}$)
	—	5°C long-day (16 : $\bar{8}$)
	5°C short-day (10 : $\overline{14}$)*	5°C short-day (8 : $\overline{16}$)

* Only swarmer germlings were cultured in the additional conditions.

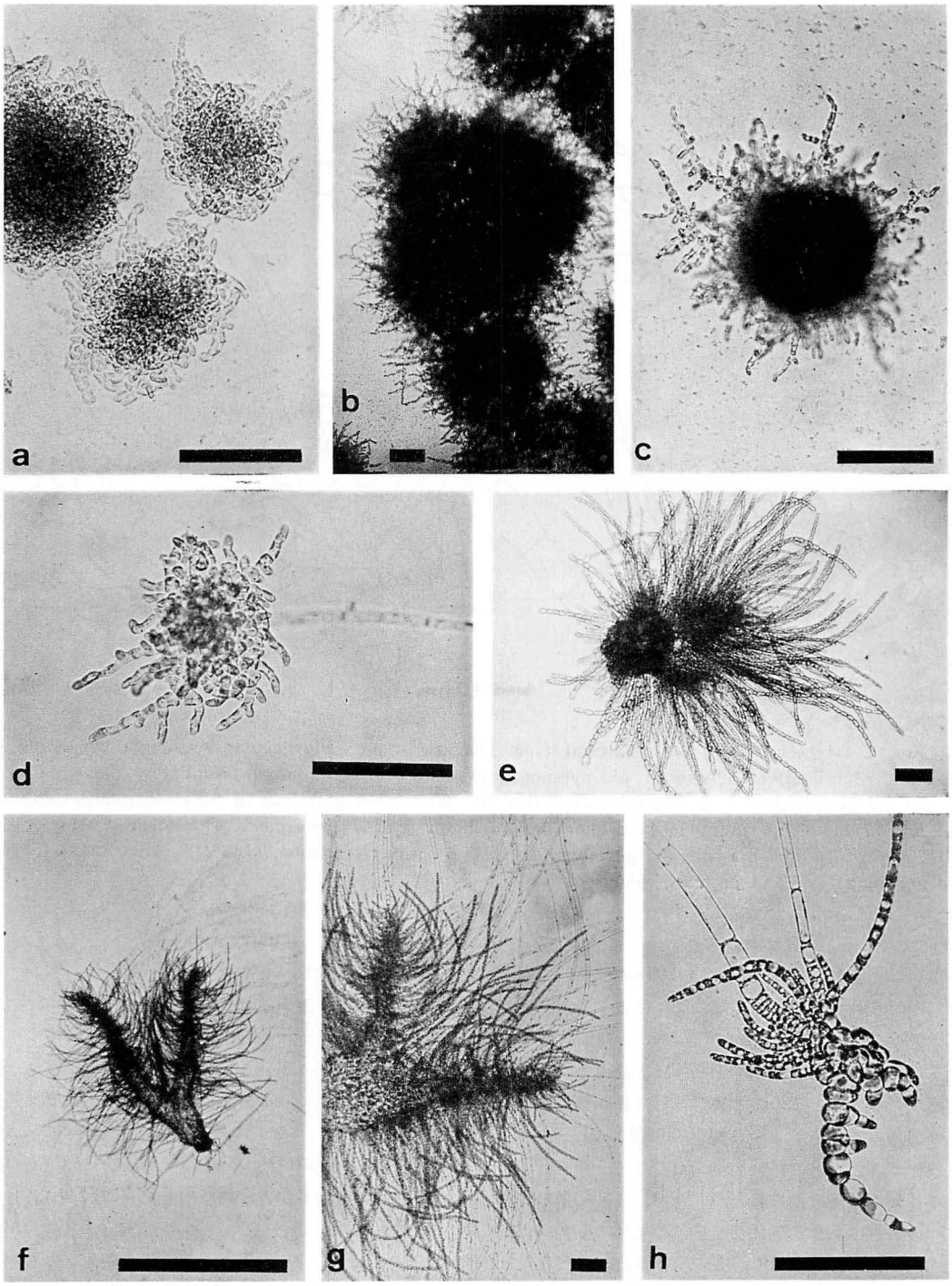

Fig. 1. *Acrothrix gracilis* (material from Maizuru). a-g: Developmental stages of zoospores. 14(a) and 28(b) day-old germlings in 20°C short day condition. 14(c) day-old germling in 20°C long-day condition. 14(d) and 20(e) day-old germling in 15°C short-day condition. 36(f, g) day-old erect thallus in 5°C short-day condition. h: 13 day-old swarmer germling in 10°C long-day condition. Scale: a-e, g, h 100 μm: f 1 mm.

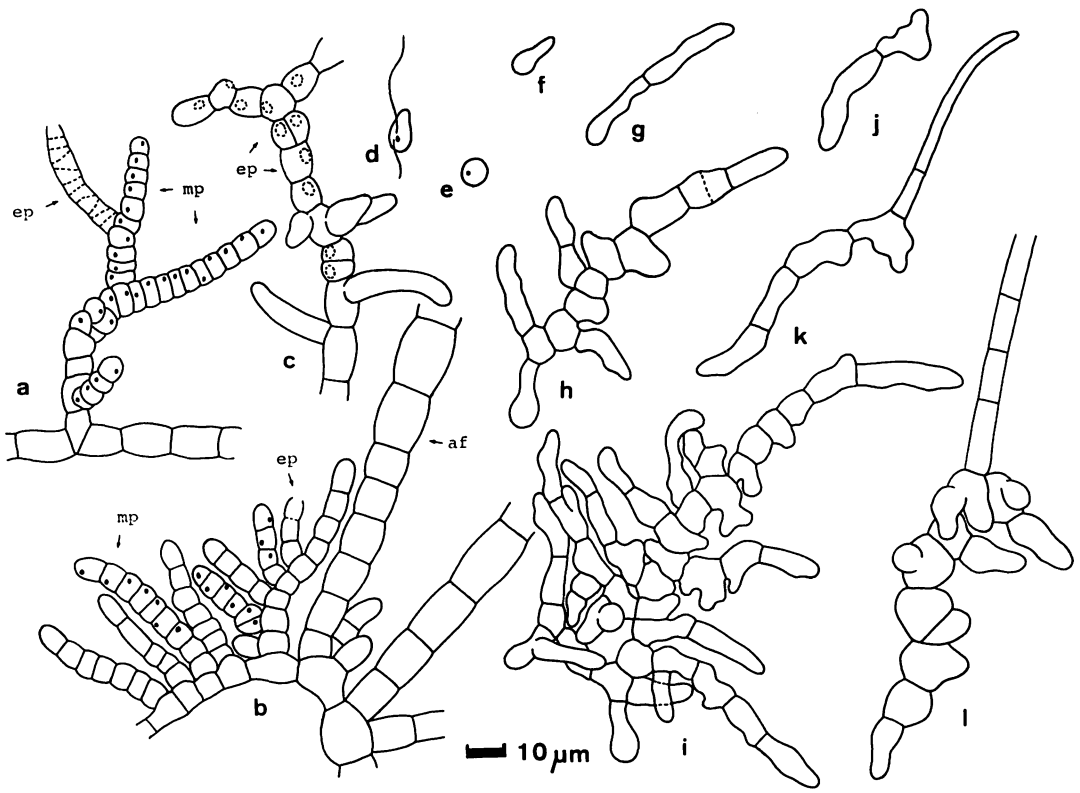

Fig. 2. *Acrothrix gracilis* (material from Maizuru). a-c: Plurilocular sporangia consisting of matured reproductive cells with red eyespot (mp), empty ones (ep) and assimilatory filaments (af). 35 day-old germling in 10°C short-day condition (a), 60 day-old germling in 10°C long-day condition (b) and 27 day-old germling in 10°C short-day condition (c). d: Swarmer. e: Settled swarmer. f-i: 2(f), 3(g), 6(h) and 8(i) day-old germlings in 15°C short-day condition. j-l: 2(j), 4(k) and 7(l) day-old germlings in 10°C long-day condition.

楕円形の細胞からなり，全長は 200～480 μm であった (Fig. 1g)。同化糸の先端の細胞の大きさは，長さ 32～42 μm，幅 10～12 μm であった。初期に形成されるこれらの長い同化糸や毛状体は，高温条件で特に脱落が目立った。このことは，6月に舞鶴湾で採集された母藻の同化糸が 4～11細胞 (40～50 μm) と短く，毛状体もほとんどみられなかったことと一致した。

単子嚢の形成はみられなかったが，5～10週間で同化糸の直立の有無に関係なく全ての条件の匍匐糸状体上に複子嚢が形成された。この複子嚢は，単列または基部で二列の 8～16室からなり，時折分枝した (Fig. 2a, b)。また，10°C の短日条件では，匍匐糸状体の構成細胞がそのまま 1～3 個の生殖細胞に変成するものもみられた (Fig. 2c)。

複子嚢から放出された遊走細胞は，約 8.2 μm×4.1 μm の西洋梨型で，不等長の鞭毛を側生し，ピレノイドを伴う 1 個の色素体と眼点を持っていた (Fig. 2d)。それらは活発に遊泳したが，接合はみられず，すぐに基質に付着して径 4.9～6.1 μm の球形となった (Fig. 2e)。

着生した細胞は，1～2 日目には単極的に発芽管を伸し (Fig. 2f)，やがて横分裂して 2 細胞になった (Fig. 2g)。発芽体はくり返し分裂して一列細胞の糸状体になったのち側方に枝を出した (Fig. 2h)。それらはさらにこの分枝をくり返して匍匐糸状体 (Fig. 2i) となったが，その後の発達は先の遊走子のものと同じであった。しかし，25°C の長日条件では，同化糸が直立せず，匍匐糸状体も盤状に近い形態であった。また，5°C の短日条件では，それらは直立藻体に生長したが基部の匍匐糸状体に複子嚢が形成されなかった。

10°C の長日条件では，先に述べた発生様式と異なる発芽体が稀に観察された。初め 2～4 細胞からなる一列細胞の糸状体 (Fig. 2j) となったのち，一端から 1 本の毛状体が発出した (Fig. 2k)。やがて一列細胞糸の毛状体に近い部分で側方への分枝が始った (Fig. 2l)。毛状体の基部から同化糸が形成されると同時にその反対側の細胞が径 10～15 μm の樽状に肥大した (Fig. 1h)。これらの細胞はさらに膨張し，色素体の少ない髄層細胞に変成した。この発芽体は最初の毛状体の基部で頂毛生長して直立藻体となった。

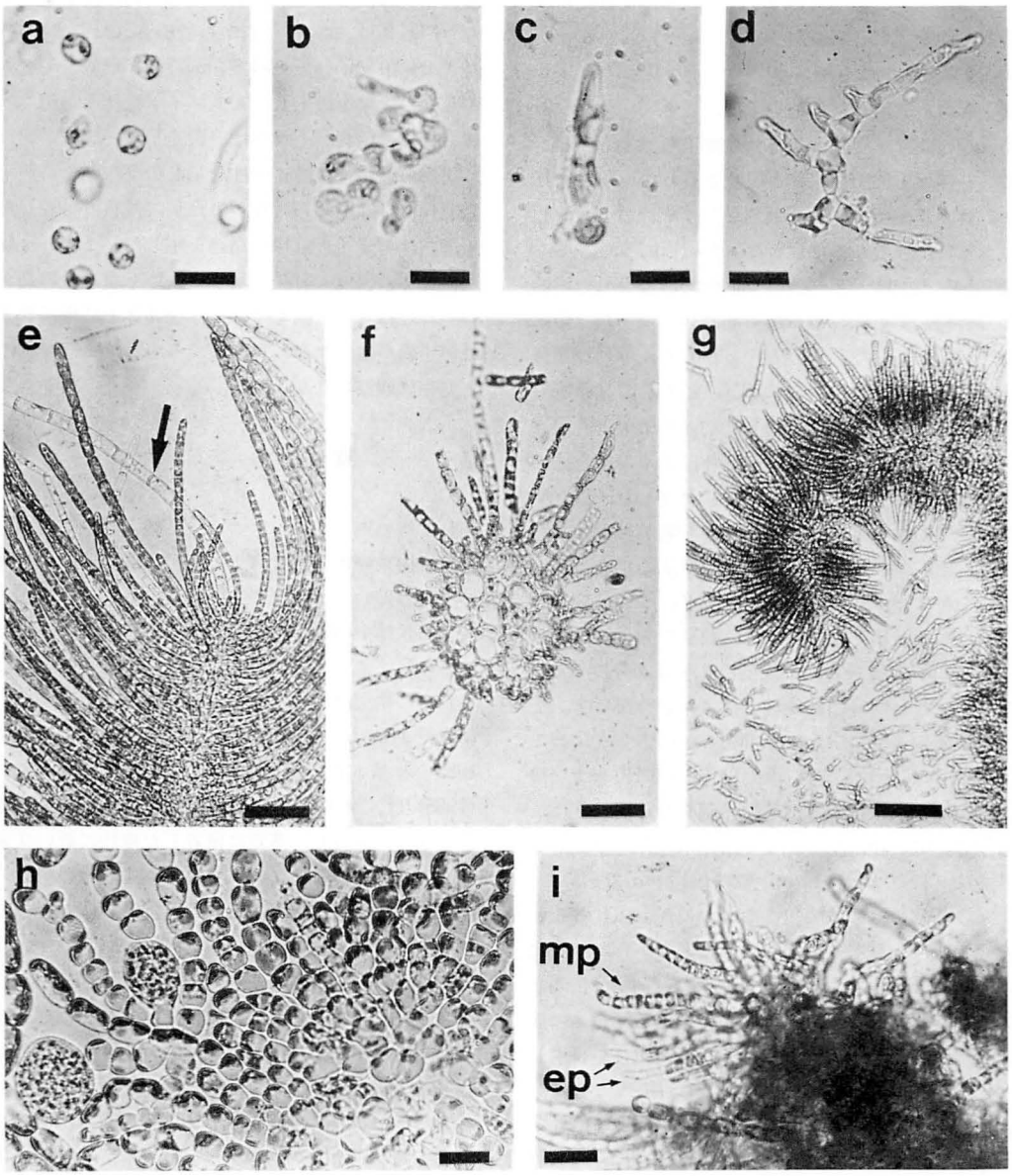

Fig. 3. *Acrothrix gracilis* (material from Akkeshi). a: Zoospores from the plant in nature. b: Germination of zoospores. c: Three celled germling. d: Branched uniseriate germling. e: Young erect thallus (sporophyte) consisting of a trichothallic hair (arrow) and long assimilatory filaments. f: Cross section of the erect thallus. g: Regenerated short assimilatory filaments on the aged thallus. h; Unilocular sporangia on the erect thallus. i: A matured plurilocular sporangium (mp) and empty ones (ep) on the prostrate system. Scale: a-d 10 μm; e and f 50 μm; g 100 μm; h and i 20 μm.

20°C 以上で短日条件下の同化糸を生じていない匍匐糸状体を低温条件 (10～15°C) に移すと，それらは同化糸を生じた。一方，長日条件で得た遊走細胞由来の発芽体を2～3細胞期に高温 (20～25°C) の短日条件に移して培養すると，それらは同化糸を生じなかった。また，同化糸を直立している状態の発芽体を高温短日条件に移すと，それらはすぐに同化糸部分が枯れて基部の匍匐部のみ残った。

B 厚岸産キタニセモズク

単子嚢から放出された遊走子は，長さ 6～8 μm，幅 4～5 μm の西洋梨型で，不等長の鞭毛を側生し，ピレノイドを伴う1個の色素体と眼点を持っていた。それらは，負の走光性を示し，数分またはそれ以上遊泳したのち基質に付着して球形となった (Fig. 3a)。

着生した細胞は，1～2日で単極的に発芽し (Fig. 3b)，横分裂により一列細胞の糸状体となった (Fig. 3c)。それらは，やがて側方に分枝して，単列の匍匐糸状体になった (Fig. 3d)。20°C を除く長日条件では2～7週間で，単列で分枝しない同化糸がこの匍匐糸状体からまず生じ，続いて発芽体は1本の中心軸細胞糸により頂毛生長する直立藻体に発達した。直立藻体では，中心軸の生長点のすぐ下の細胞から同化糸を生じた (Fig. 3e)。また，同化糸の基部の細胞から中心軸に沿って下に伸びる細胞糸を生じ，ここから二次的な同化糸を発出した。藻体は，髄層を分化しながら高さ約 2 cm に生長し，不規則に2～3回分枝した。しかし，それらは自然藻体ほどには大きくならず，また自然藻体のように中～下部で明らかに中空となることもなかった (Fig. 3f)。直立藻体上の同化糸は，初め 16-31 個の円柱状でほぼ等径の細胞から構成され，長さ 210～613 μm であった。同化糸の先端の細胞の大きさは，長さ 24～34 μm，幅 6～13 μm であった。同化糸の基部付近には突起または分枝がみられることもあったが，それより上部では分枝しなかった。同化糸はある程度生長すると，ふつう上方の細胞が枯死または脱落して下部だけが残った。そのあと同化糸の残った部分または表層の細胞から新たに同化糸が再生したが，それらは初めの同化糸のようには長くならなかった (Fig. 3g)。直立藻体には，頂毛に加えて直径7～13 μm の褐藻型の毛状体が側生した。20°C の長日条件でも直立藻体が形成されたが，髄層の分化が起こらず，同化糸も長円形の細胞からなり他条件に比べて短かった。

8～11週間で 15°C と 20°C の長日条件の直立藻体上に単子嚢が形成された (Fig. 3h)。単子嚢は，長円形または倒卵形で，同化糸の基部に生じ，長さ35～45 μm，幅 30～35 μm であった。直立藻体上に複子嚢は生じなかった。

一方，短日条件では，5°C と 10°C の低温でのみ発芽体はわずかに同化糸を直立したが，いずれの条件でも直立藻体に発達することはなかった。9～15週間で匍匐糸状体に介生または頂生する単列の複子嚢が生じた (Fig. 3i)。この複子嚢から放出された遊走細胞は，長さ 8～10 μm×幅 4～4.5 μm の西洋梨型で，2本の不等長の鞭毛を側生し，ピレノイドを伴う1個の色素体を持っていた。それらは，遊走子ほど眼点が明らかでなかったが，負の走光性を示して遊泳した。遊走細胞間の接合は認められなかったが，基質に付着した遊走細胞は遊走子と同様の発達を示した。また，それらの発芽体の温度と日長に対する反応も遊走子の発芽体のそれとほとんど同じであり，発芽体上に複子嚢または単子嚢が生じたが，舞鶴産でみられたような別の発生過程は観察されなかった。

考　　察

日本産のキタニセモズクは，舞鶴と厚岸の両株とも遊走子由来の匍匐糸状体上に直接に直立藻体(胞子体)を生じるという“直接型”の生活史型を示した。また，匍匐糸状体上の複子嚢に由来する遊走細胞間に接合が認められず，それらは遊走子と同様の発達を示した。これらの結果は，ニューファウンドランド産の *Acrothrix gracilis* の培養結果 (FORWARD & SOUTH 1985) と基本的に一致する。FORWARD & SOUTH (1985) は，本種の遊走子から発達した匍匐糸状体はかなり密に分枝し，基質に密着した盤状に近い状態であると述べている。これに対し日本産の材料では，匍匐糸状体は一般に叢状であったが，厚岸産のものでは 15°C と 20°C の短日条件で，舞鶴産のものでは 25°C の長日条件で，基質に密着し盤状に近い形態のものがみられた。さらに彼らは，匍匐糸状体の一部の栄養細胞がそのまま生殖細胞に変成する介生的な複子嚢を報告し，1個の細胞から1個の遊走細胞が放出されるとしている。日本産でも頂生のものと同時に上記のような介生的な複子嚢がみられた。従ってこれら発芽体や複子嚢の形態は，培養環境等によって変化するものと考えられる。

一方，日本産の両株の温度と日長条件に対する反応の比較では，若干の違いがみられた (Fig. 4)。厚岸産のものでは，高温を除き一般に長日条件で直立藻体

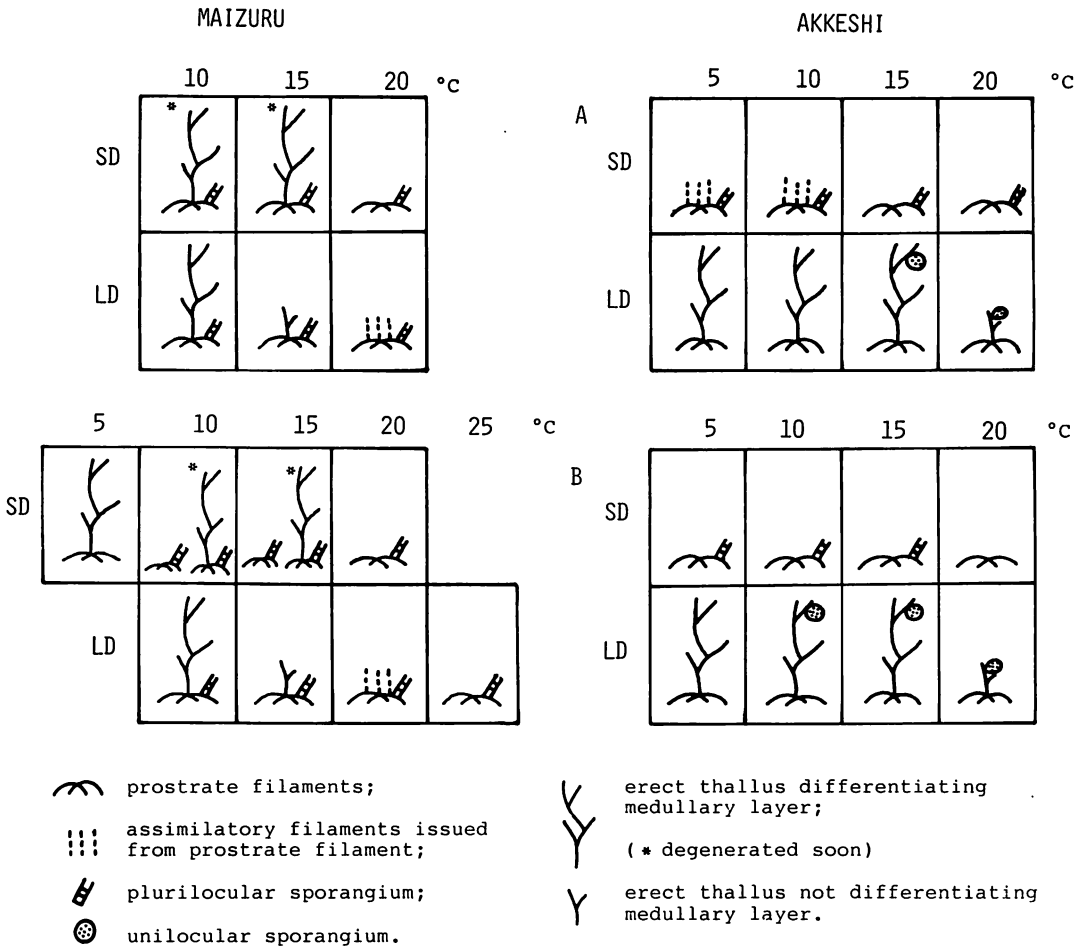

Fig. 4. *Acrothrix gracilis*. Diagrams of results of culture from zoospores of erect thalli in nature(A) and swarmers of prostrate filaments in culture(B) in diverse culture conditions. SD: short day conditions, 10 : $\overline{14}$ (Maizuru) ; 8 : $\overline{16}$ (Akkeshi). LD: long day conditions, 16 : $\bar{8}$ or 14 : $\overline{10}$ (Maizuru) ; 16 : $\bar{8}$ (Akkeshi).

の形成がみられたが，短日条件では複子嚢が形成されるなど日長による制御が顕著であった。これに対し舞鶴産のものでは，長日条件で直立藻体の形成がみられるが，厚岸産のものに比べて低い温度 (15°C) での直立藻体の発達が悪い。そして，短日条件でも直立藻体が比較的低い温度で形成され，それらはあとの段階でしだいに脱落した。また，温度と日長条件に関わらずほとんどの条件で糸状体に複子嚢を生じるなど日長の効果は厚岸産に比べてあまり顕著ではなかった。これに関しては，両培養間で使用した照明の強さや培養液の細部の組成が異なり，舞鶴産の株の培養では短日条件が14時間暗期であるのに対し厚岸産の株の培養では16時間暗期としたことなどから単純な比較はできないが，それぞれ地域的な温度と日長に対する反応に変異がみられる可能性を示している。

厚岸産のキタニセモズクでは，5～15°C の長日条件で自然藻体と似た直立藻体が発達し，10°C 以上で単子嚢が生じた。これは，本種がこの地域で春から夏に観察される一年藻であり，成熟時の水温が 10～15°C であることと一致する。一方，短日条件では発芽体が直立藻体をつくらず複子嚢を形成したことから，本種は匍匐糸状体で越冬し，遊走細胞により無性的に繁殖していると考えられる。ニューファウンドランド産の培養結果 (Forward & South 1985) では，5～15°C で直立藻体が形成され，20°C と 25°C の両条件では遊走子及びその発芽体の生育が阻害されるという。そ

の日長条件は長日 (16 : 8) だけであるが，これはほぼ同じ生育条件にある厚岸産の今回の結果に似ている。

ところが，舞鶴産の場合では，厚岸産と比べて短日条件による同化糸形成の抑制が弱い (20°C 以上の高温を除く)。そして，いったん直立藻体を形成しながら，それがしだいに枯れて匍匐部のみ残る傾向にあった。また，厚岸産ではふつうに直立藻体が生長する 15°C の長日条件でも，舞鶴産ではその発達が悪かった。このことは，今までの報告から低水温域に分布するとされるキタニセモズクにとって舞鶴が南限に近く，本種の生育できる温度範囲が狭くなっている結果と考えられる。それは，本種が厚岸で低潮線近くに生育しているのに対し，舞鶴では水深約 5 m とより深所に生育していることとも関連していると考えられる。ただし，遊走細胞の初期発芽体の移植実験から，同化糸や直立藻体の形成抑制が 20°C 以上で明瞭に現われることは厚岸産と同じであった。本種と同属のニセモズクの生活史については，新崎 (1948) と AJISAKA (1979) の報告がある。後者の研究によると，自然藻体の単子嚢由来の遊走子は，発芽したのち単相の配偶体になる。配偶体は，高温条件では密に分枝した叢状であるが，低温条件ではさらに特徴的な単列形成的藻体を直立する。これらの配偶体は単列ないしは基部で二列の頂生複子嚢を生じ，それに由来する遊走細胞 (配偶子) 間で接合が行われる。接合子は，発芽したのち一方に毛状体を他方に仮根を伸す発生過程によって肉眼的な大きさの胞子体に生長する。一方，接合しなかった遊走細胞は，無性的に発芽して，高温で配偶体に，低温で単相の胞子体に発達する。従って，ニセモズクの生活史型は典型的な異形世代交代型を示すのに対して，キタニセモズクは匍匐糸状体から直接に直立藻体 (胞子体) を生じる“直接型”である点で異なる。ニセモズクの配偶体では低温で特徴的な直立糸状体を生じるが，キタニセモズクの匍匐糸状体ではそのようなことはなかった。さらに，複子嚢由来の遊走細胞の機能も異なり，キタニセモズクの場合にはそれらはニセモズクのように配偶子として機能せず，遊走子と同じ発生を示した。ただし，舞鶴産キタニセモズクの遊走細胞が 10°C の長日条件で稀にニセモズクの接合子や低温条件下の未接合遊走細胞の場合にみられるような同じ発生過程を示したことは，同属内の 2 種の系統分類を考える上で興味深い。

KAWAI (1983) のキタニセモズクの自然藻体の形態学的観察では，若い藻体の同化糸が特に長く，分枝しないのに対して，成熟藻体のものは短くなり，しばしば片側に出る突起や小枝を生じると報告されている。今回の培養実験でも，同化糸は初めは長いがある程度生長すると上部が脱落して短くなることや再生した同化糸がもとのようには長くならないことが観察され，このことは自然藻体での観察と一致した。しかし，同化糸に生じる突起や小枝は，培養中に観察されなかった。

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海藻の初期発生におよぼす温度と塩分濃度の影響
II. アカモクの仮根形成

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OGAWA, H. 1986. Combined effects of temperature and salinity on the early development of marine algae II. Rhizoid development of *Sargassum horneri* (TURNER) C. AGARDH. Jap. J. Phycol. 34: 137-141.

The rhizoid development of embryos of *Sargassum horneri* (TURNER) C. AGARDH collected at Shichigahama, Miyagi-ken, Japan, is described at various culture conditions of temperature and salinity. The optimal ranges of temperature and salinity for the germination rate, the elongation and the number of rhizoids are 10-20°C and 22.7-42.1‰ S, in which the secondary rhizoid development is observed. The highest values of them are obtained at 15°C and 32.0‰ S. At higher temperature (25°C) and lower or higher salinities (under 22.7‰ S or above 42.1‰ S), the germination rate and the elongation of rhizoids become low, and the number of rhizoids is less than that of the optimal conditions.

Key Index Words: *Marine algae*; *Phaeophyta*; *rhizoid development*; *salinity*; Sargassum horneri; *temperature*.

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潮深帯に生育するホンダタラ類を主とした群落は，生物生産力が高いところであるために海洋生態系の中で重要な役割を果しているとされている。アカモク (*Sargassum horneri*) はこのような群落の主要な構成種であるため，群落造成に必要な種苗生産あるいは群落への温排水の影響判定という観点から，本種の幼胚の生長と温度との関係については良く調べられている（河本・冨山 1968; 冨山 1974, 1981; 大分県浅海漁試 1976; 松井・大貝 1981; 小河 1981; 梅林 1981)。しかし，一年生藻類のアカモクの再生産，繁殖を考える際に重要と思われる幼胚の基物への付着・固着に関係する仮根の形成については一，二の報告があるものの（大分県浅海漁試 1976; 小河 1981)，幼胚の仮根形成と環境要因との関係については未だよく知られていない。

ここでは，仮根発芽，仮根伸長，仮根数などアカモクの幼胚の仮根形成におよぼす環境要因，とくに温度と塩分の複合影響について観察した。

材料と方法

実験に用いたアカモクの幼胚は，1984年6月に宮城県七ケ浜町松ケ浜湊浜地先に生育していた雌性成熟藻体から採取した。採取した幼胚は，ろ過海水で数回洗浄したのち，未だ仮根が形成されていない，発生の揃ったものを実体顕微鏡下で集め，塩分を調整した試水 10 ml を入れたペトリ皿（60×15 mm）に，1枚当り 40～70個散布した。

試水作製には1984年3月，宮城県女川町小乗浜地先で採水した海水（32.0‰S）を用いた。試水の塩分調整は，前報（小河 1985）に準じて行ない 12.9, 16.3, 19.4, 22.7, 25.9, 32.0, 38.9, 42.1, 45.3, 48.6, 51.8‰Sの11段階とした。栄養塩は添加しなかった。温度は 10, 15, 20, 25°C の4段階に，光は白色螢光灯を用いて 1,600～1,800 lux, 1日14時間照明とした。

このような条件下でアカモクの幼胚を培養し，仮根の発芽，最大仮根長，仮根数を7日目，14日目に観察，測定した。

結果

仮根の発芽：観察結果を Fig. 1 に示す。仮根の発芽がみられなかった塩分は，7日目は低塩分側で各温度とも16.3‰S以下，高塩分側では各温度ともおおむ

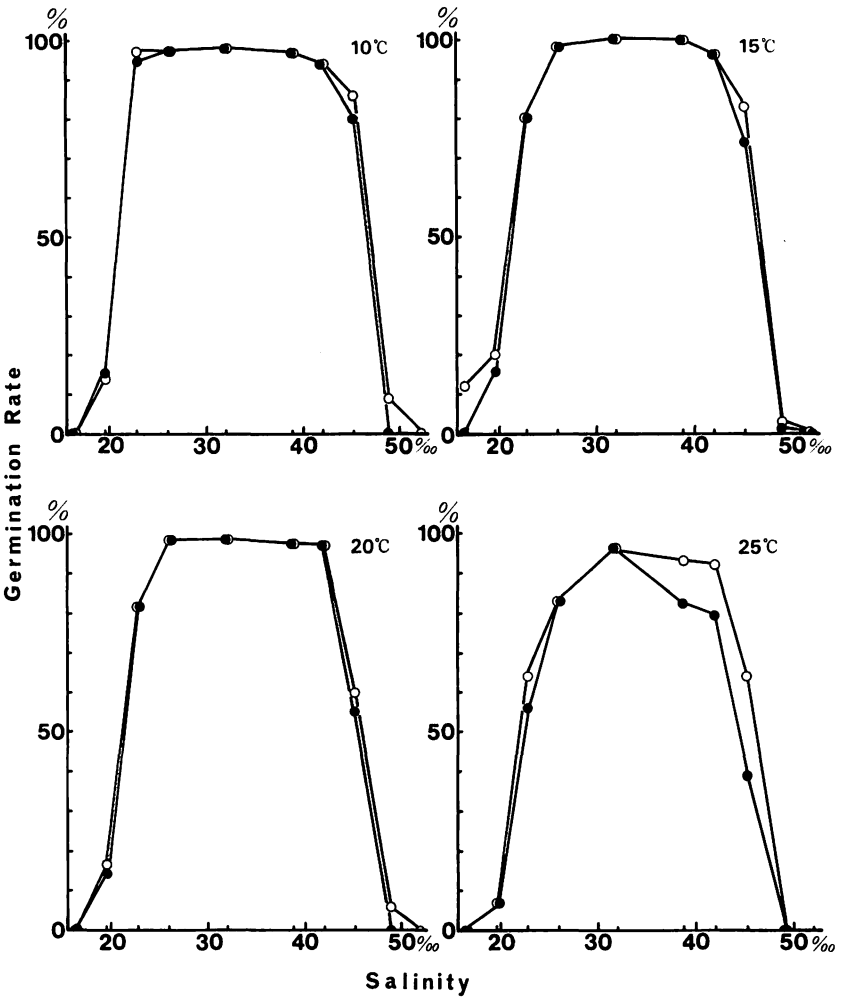

Fig. 1. Germination rate of embryos of *Sargassum horneri* at various temperatures and salinities. ●: 7 days, ○: 14 days.

ね48.6‰S以上であった。14日目は,低塩分側の15°C, 16.3‰Sで仮根の発芽はみられたが,それ以外の温度では7日目と同様に16.3‰Sで仮根の発芽はみられなかった。高塩分側では,10°C, 15°C, 20°Cでは51.8‰S以上,25°Cでは48.6‰S以上で仮根の発芽はみられなかった。

最も高い仮根の発芽率は各温度とも塩分が32.0‰Sのときにみられた。温度について,7日目と14日目の仮根の発芽率を比べてみると,10°C, 15°C, 20°Cでは塩分が19.6‰S以下,45.3‰S以上の場合,14日目の値の方が7日目の値に比べて高かった。しかし,塩分が19.6～45.3‰Sの範囲では14日目の値は7日目の同じであり,幼胚は7日目までに仮根を発芽したことを示している。これに対して,温度が25°Cのとき,塩分が25.1～32.0‰Sの範囲では,仮根の発芽率は7日目,14日目とも同じ値であったが,これ以外の仮根の発芽がみられた塩分では,14日目の値の方が7日目の値に比べて8～25%も高かった。このような仮根の発芽の遅れは,低塩分側よりも高塩分側の方で顕著に表われており,仮根の発芽は高温・高塩分下では大きな抑制を受けることが認められた。

仮根の発芽がみられなかった幼胚は,低塩分側では細胞の中身が抜けて白くなり,死滅していた。高塩分側では幼胚の色は塩分が高くなるほど黒味を帯び,飴

色から茶褐色へと変化した。また，細胞は収縮し，幼胚は死滅した。

仮根の伸長：観察結果を Fig. 2 に示す。仮根の長さは，高塩分側では不揃いで差異が大きく，42.1‰S以上では仮根を発芽しても基物に十分付着していない発芽体がみられた。

仮根の伸長がみられなかった塩分についてみると，7日目は低塩分側で各温度とも16.3‰S以下，高塩分側で15°Cの51.8‰S以外の温度では48.6‰S以上からであった。14日目は，低塩分側で15°Cの16.3‰S以外の温度では16.3‰S以下，高塩分側は25°Cの48.6‰Sを除いて各温度とも51.8‰S以上で仮根の伸長はみられなかった。

最大仮根長についてみると，仮根が最もよく伸びていた塩分は各温度とも32.0‰Sであった。その長さは，7日目では20°Cで800 μm，15°Cと25°Cでは700 μm，10°Cでは 680 μm であった。14日目になると15°Cのときに最もよく伸長して 1,120 μm に達し，10°Cで1,030 μm，20°Cで 930 μm，25°Cでは 720 μm となった。この7日目の値に対する14日目のそれの比をとってみると，10°Cでは1.51，15°Cでは1.60，20°Cでは1.16，25°Cでは1.03となり，15°Cのときが最も

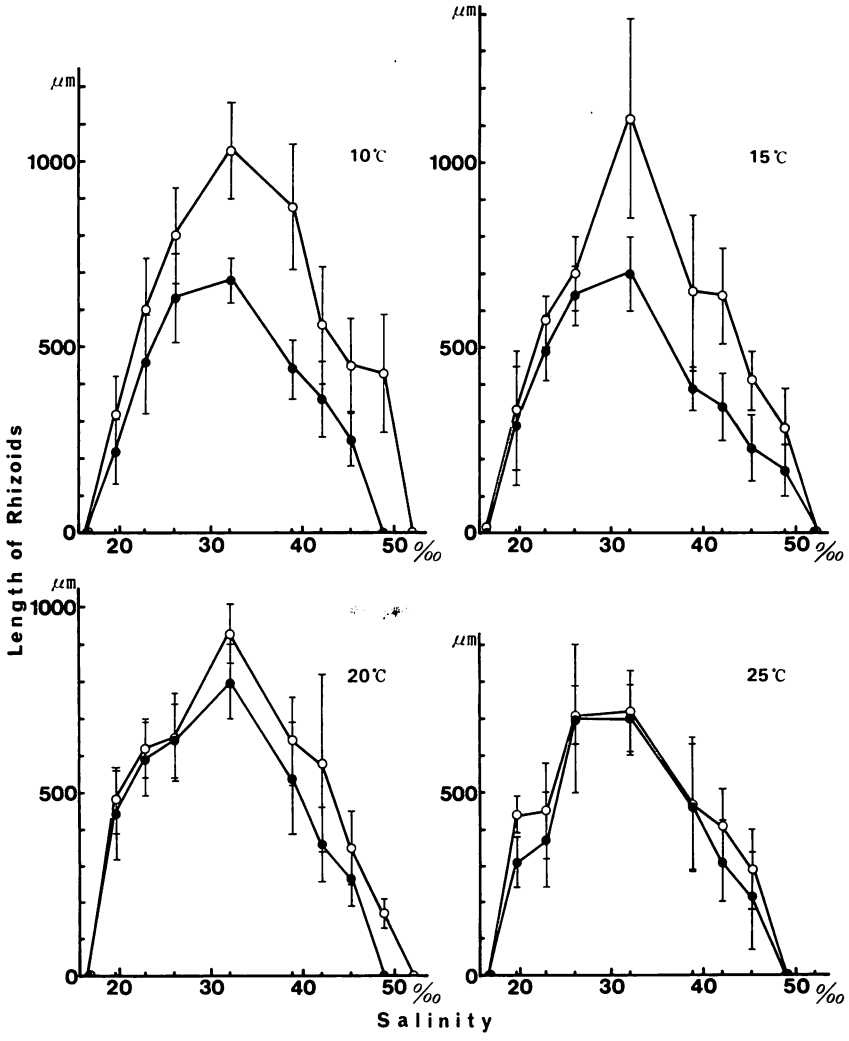

Fig. 2. Mean length of the longest rhizoid of germlings of *Sargassum horneri* at various temperatures and salinities. Vertical bars indicate standard deviations (n=10 to 25). ●: 7 days, ○: 14 days.

高い値を示した。それに対して，25°Cではこの比は1.03と最も小さく，7日目から14日目にかけての期間に仮根は殆んど伸長していないことがわかった。

32.0‰S以外の塩分についてこの比をとってみると，低塩分側の10°Cでは1.27～1.46，15°Cでは1.09～1.16，20°Cでは1.02～1.09，25°Cでは，22.7‰Sの場合の1.42を除くと，1.01～1.20となり，温度が20°C以上の場合に比べて15°C以下の方が7日目から14日目にかけての期間の仮根の伸長はまさっていた。高塩分側の10°Cでは1.56～2.00，15°Cでは1.67～1.88，20°Cでは1.19～1.61，25°Cでは1.02～1.38となり，低塩分側と同様に，この期間の仮根の伸長は15°C以下でまさっていた。

仮根数：8本の一次仮根を発芽した幼胚は，その周囲から8本の二次仮根を伸長し，この二次仮根によって基物に固着できることが知られている（猪野 1947，冨山 1981）。この基物への固着に重要な役割を果している二次仮根の形成に重点を置いて，7日目の発芽体について仮根数（平均値）を調べてみた（Fig. 3）。

仮根数が最も多かったのは，各温度とも塩分が32.0‰Sのときで，最高は20°Cの37.9本，最低は10°Cの34.4本であった。二次仮根は各温度とも形成されていた。低塩分側では仮根数は，塩分が22.7‰Sまでは25°Cの22.7‰Sのときに15.7本で最低であったが，それ以外ではすべて16本以上あり，二次仮根の形成が認められた。塩分が19.4‰Sのときの仮根数は，15°Cで17.0本，20°Cで23.0本と二次仮根は形成されていたものの，10°Cと20°Cでの仮根数はそれぞれ8.1本，8.3本であり，二次仮根の形成は認められなかった。高塩分側での仮根数は，塩分が38.9‰Sまでは各温度とも16本以上あり，二次仮根は形成されいてた。塩分が42.1‰Sのとき，10°C，15°C，20°Cでの仮根数は最低でも13.5本（10°C）以上あり，二次仮根の形成が認められたが，25°Cでのそれは5.7本と少なく，二次仮根の形成は認められなかった。また塩分が45.3‰Sのときは，仮根数は各温度とも7本以下であり，二次仮根は形成されていなかった。

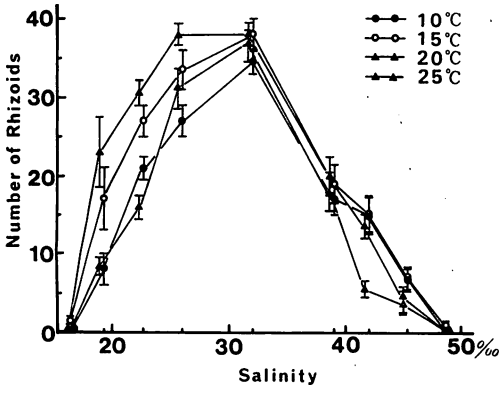

Fig. 3. Number of rhizoids of germlings of *Sargassum horneri* at various temperatures and salinities after seven days in culture. Vertical bars indicate standard errors (n=2 to 19).

仮根数が最も少ない値を示した温度は，低塩分側では10°Cと25°C，高塩分側では25°Cであり，塩分が低下または上昇するほど仮根数は低温下よりも高温下で急激に減少しており，仮根形成に対する高温の影響が大きく表われていた。また，塩分について仮根数の差をとってみると，低塩分側では9.3～14.9本，高塩分側では2.9-4.9本であり，仮根数のばらつきは高塩分側よりも低塩分側の方で大きかった。

7日目の観察で二次仮根の形成が認められなかった塩分条件下の発芽体について，14日目に仮根数を計測した。低塩分側の19.4‰Sの10°Cでは，仮根数が8本の発芽もみられたが，殆んどのもので仮根数は16本以上みられ，二次仮根の形成が認められた。しかし，25°Cでは発芽体の仮根数は8本以下であり，二次仮根の形成は認められなかった。高塩分側の42.1‰Sでの仮根数は，10°Cは15本，25°Cは8本であり，10°Cでは二次仮根の形成が認められたが，25°Cでは認められなかった。塩分が45.3‰Sのときの仮根数は，15°Cは9本であったが，それ以外の温度では8本以下であり，二次仮根の形成は認められなかった。塩分が48.6‰Sのときの仮根数は，10°C，15°C，20°Cとも3本以下，25°Cでは0本で，二次仮根の形成は認められなかった。

考　　察

アカモク幼胚の生長，仮根形成と温度との関係については，研究に用いた母藻の産地によって得られた結果はさまざまである。山口県産のアカモク幼胚は水温が20°Cよりも低いと仮根発芽を始めるまでの発生は遅れ，水温が高いとこの逆になること（河本・冨山 1968，冨山 1981），大分県産のアカモク幼胚の発芽最適水温は16～20°C，適水温は12～25°Cであり（大分県浅海漁試 1976），神奈川県産のアカモク幼胚の生長は26°Cまでは現場水温23°Cよりは少し高目の方が適しており（梅林 1981），宮城県女川産のアカモク幼胚の生長・仮根形成は15°Cのときが最もよく，次いで，

8°C, 25°Cの順である（小河 1981）ことなどが観察されている。松井・大貝（1981）は産地は記載していないが，用いたアカモク幼胚の生長適温は23～28.5°Cの範囲にあり，15°C，30°Cでは劣ると報告している。

今回の観察では仮根の発芽・伸長・本数は15°Cのときが最もよく，次いで10°C，20°Cで良い結果が得られたのに対して，25°Cではすべてにおいて劣っていた。このことから，本実験に用いたアカモク幼胚の仮根形成好適温度は15°Cを中心に10～20°Cの範囲にあり，25°Cでは仮根の形成は抑制されていることが考えられる。同様の結果は，宮城県女川産のアカモク幼胚で得られており（小河 1981），宮城県産アカモク幼胚の発芽・生長適水温は神奈川県以南産のものに比べて低水温側にその中心があると思われる。これは，宮城県沿岸の海水温度は神奈川県以南の海水温度に比べて25°C以上になる期間は極めて短いのに対して，15°C以下の水温が続く期間は長いことなど温度環境に大きな違いがみられ，宮城県産のアカモクはこのような温度環境に適応した結果，幼胚の生長・仮根形成の適水温が神奈川県以南産のものに比べて低温水側へ移行したためと思われる。したがって，同一種ではあっても温度環境が異なった場所に生育していた藻体から得られた幼胚は，温度に対して既にそれぞれ固有の性質を持っているため，その生長，仮根形成の好適水温に相違がみられるものと考えられる。

幼胚の仮根の発芽・伸長と塩分の関係については，大分県産アカモク幼胚の場合，仮根の発芽は塩素量17.15‰（31.0‰S）のときが最もよく，次いで，11.68‰（21.1‰C），23.79‰（43.0‰S）の順とされており，8.68‰（15.7‰S）以下，37.39‰（67.5‰S）以上では発芽がみられていない（大分県浅海漁試 1976）。宮城県女川産アカモク幼胚の場合，仮根の発芽は0.3倍海水（約10‰S：論文中の図より求めたもの）以下，1.6倍海水（約50‰S：論文中の図より求めたもの）以上ではみられず，仮根の伸長は無処理の海水（約32.0‰S：論文中の図より求めたもの）のとき最もよい結果が得られている（小河 1981）。

今回の観察でも幼胚の仮根の発芽・伸長・本数はともに塩分が32.0‰Sのときに最もよい値が得られており，これよりも塩分が低下または上昇するとそれぞれの値は低下しており，仮根の形成は抑制される。この仮根の形成の塩分による抑制は，20°C以下の温度の場合に比べて25°Cのときに顕著にみられ，仮根の形成が可能な塩分の範囲は温度によって異なることを示唆している。

発芽した幼胚が基物に固着するためには二次仮根の形成が必要だとされている（冨山 1981）。固着に重要な役割を果している二次仮根の発芽がみられた塩分の範囲は，一次仮根の発芽がみられた範囲よりも狭くなっている。これは，仮根の形成に不適な塩分の範囲ではあっても仮根の発芽がみられたのは，一次仮根の原基が既に形成された幼胚を実験に用いたためと思われる。しかし，このような塩分条件下では二次仮根の原基形成は不可能であるため，結果として二次仮根の発芽がみられた塩分の範囲は一次仮根のそれに比べて狭くなったものと考えられる。

この二次仮根の発芽が認められた塩分範囲を仮根形成の好適塩分範囲とすると，10～20°Cでは22.7～42.1‰S，25°Cでは22.7～38·9‰Sとなり，25°Cでは他の温度に比べて塩分範囲は狭く，二次仮根の形成が可能な塩分範囲もまた温度によって変ることを示しており，その影響は低塩分側よりも高塩分側で大きく表われている。

温度の場合と異なり，仮根の好適塩分範囲は藻体の産地が異なっても，また種が異なっても大きな相違は認められない。これは外洋に面する沿岸域の海水の塩分変化は水温の変動に比べて少ないことに起因すると考えることができそうである。なお，この点については，今後検討する必要があると考えられる。

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藻類 Jap. J. Phycol. 34: 142. June 20, 1986

斎藤 譲: 北海道の南端付近でクロミルを記録 Yuzuru SAITO: A record of *Codium divaricatum* HOLMES near the southernmost point of Hokkaido

1976年7月21日，北海道函館の西部に位置する知内町の涌元（北緯41度34分，東径140度25分）沖3km，水深 30-35 m にしかけられた底刺網で数個体の *Codium divaricatum* HOLMES クロミルが採集された。最大の個体（写真の右側のもの）で，長さ 25 cm，どれも未熟で，胞嚢は太さが 160-330 μm，長さ 750-900 μm に達し，先端は丸く，その部分の細胞膜が半月形に肥厚しているのがめだつ。

同時に採れた多数の *Nitophyllum yezoensis* (YAMADA & TOKIDA) MIKAMI アツバスジギヌは小石に着いたものもあったが，クロミルの方にその様なものは見られなかったので，漂流して北上したものではない，との確証を欠くとはいえ，いきいきしたあざやかな色彩や，数個体が同時に採れたこと，などから考えるならば，この水域で生育したもの，と見るのが妥当なのではなかろうか。

山田（1942）は，木下虎一郎氏が松前の西約 20 km にある日本海の小島で，潜水によって採集した海藻をしらべ，合計62種を報告したが，南方系と思われるフクリンアミジ，サナダグサ，アオワカメ，ヒラキントキ，キヌゲグサ，カザシグサ等は水深 17-33 m から得られ，ユカリ，キヌダルス，ヤレウスバノリ，イソハギ等は浅所で見られず，打ち揚げられたものだけだったことに注目し，「南方系の種の深所での生育に注意すべき」と述べた。斎藤（1972）はその理由として，日本海沿岸を蛇行して北上する対馬海流の本邦寄りには右巻き渦流が誘発されるので，北半球の右巻き渦流は下降流を生じ，山田（1942）の述べた「日本海沿岸では南方系の海藻は深所に生育する」という結果を招いた，と考えた。

今回得られたクロミルは，かなりの南方系種であり，採集されたのが 30 m 以上と深いので，前回の考察に役だつ新しい資料を加えたもの，といえるのではなかろうか。

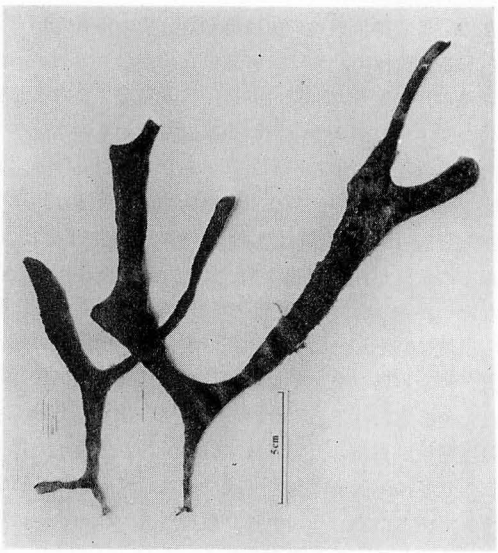

Fig. 1. *Codium divaricatum* HOLMES collected on July 21, 1976, from the depth of 30-35 m, off Wakimoto, Shiriuchi-Machi, near the southernmost point of Hokkaido.

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野崎久義：微細藻類ノート（10） *Eudorina illinoisensis*（緑藻・オオヒゲマワリ目）。Hisayoshi NOZAKI：Notes on microalgae in Japan (10). *Eudorina illinoisensis* (Chlorophyta, Volvocales).

筆者は1984年1月神奈川県川崎市中原区南加瀬にある水田の表土より，日本未記録と思われる本種を分離・単藻培養した。

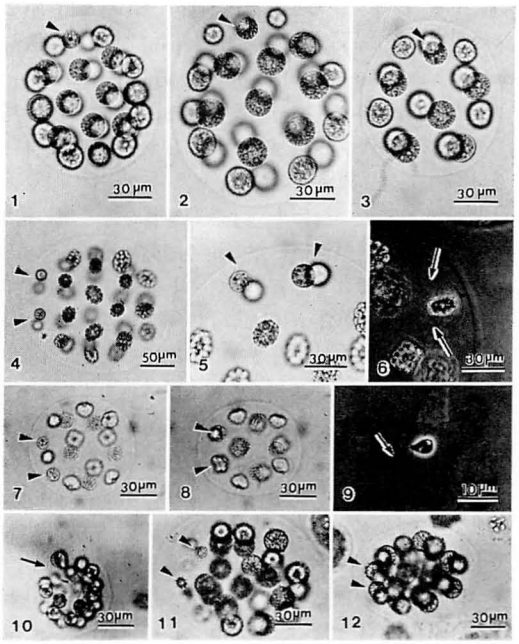
遊泳性の楕円体状の群体で，32または16個の等長2鞭毛型の細胞が寒天状基質の表層に配列。最前層の4細胞は他のものより小さく，成長した群体ではその差は明瞭である。細胞はほぼ球形で1個の杯状の葉緑体と，鞭毛基部に2個と細胞表層に散在する複数個の収縮胞をもつ。ピレノイドは最前層の小さい細胞で1から3個，他のものでは5から8個，葉緑体中にある。眼点は1個で，群体の前半部の細胞にある。細胞は最前層のもので最大で直径16μm，他のものは最大で直径22μm。群体は最大で長さ140μm。最前層の小さい4細胞は無性・有性生殖に関与する場合としない場合とがある。無性生殖は娘群体形成。有性生殖はヘテロタリックで異型配偶子接合。雄性群体の細胞は分裂して16または32個の雄性配偶子からなる精子束を形成する。泳ぎ出た精子束は雌性群体のそばで分散し，個々の雄性配偶子となり，雌性群体に侵入する。雄性配偶子は等長2鞭毛型で，鞭毛基部に細長い細胞質状の突起をもつ。雌性群体の細胞はそのまま雌性配偶子となり，侵入した雄性配偶子と接合して接合子となる。成熟した接合子は赤褐色，直径15—27μm。

タイプ産地：イリノイ川（アメリカ）。

分布：アメリカ，欧州，ロシア，パナマ，日本。

本種は最前層に4個の非生殖細胞をもつ*Pleodorina*属の新種として KOFOID が1898年に記載したものである。PASCHER (1927) は本種を *Eudorina* 属に移行させたが，研究者によっては本種を *Pleodorina* として扱うことがある（e.g. BOLD and WYNNE 1978）。WATERS (1960) は本種の無性・有性生殖を観察し，今回と同様に群体の最前層の細胞が無性・有性生殖に関与する場合（Figs. 8, 12）としない場合（Figs. 4-5, 7, 11）があるとしている。従って本種の最前層の細胞が完全に非生殖細胞に分化していない点は *Pleodorina* とは異なり，本種を *Eudorina* に所属させるのが，*E. elegans* EHR. 類似しているということから考えても妥当であると思われる。

尚，雄性配偶子の前端の突起（Fig. 9）は本種において今まで報告がないが，同様の構造は NOZAKI (1983) により *E. elegans* で報告されており，接合構造 (mating structure) であることが推測されている。



Figs. 1-12. *Eudorina illinoisensis*. Arrow head indicates one of the anterior four, facultatively somatic cells. 1-3. Vegetative colonies; 4-5. Asexual reproduction; 6. Newly formed daughter colony within transparent vesicle (arrows); 7-8. Male colonies producing sperm packets; 9. Male gamete bearing cytoplasmic protrusion (arrow); 10. Male gametes (arrow) penetrating female colony; 11-12. Female colonies containing mature zygotes.

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（慶応義塾高等学校）

野崎久義：微細藻類ノート（9） *Basichlamys sacculifera*（緑藻・オオヒゲマワリ目）。Hisayoshi NOZAKI: Notes on microalgae in Japan (9). *Basichlamys sacculifera* (Chlorophyta, Volvocales).

筆者は1983年8月神奈川県藤沢市亀井野の日本大学農獣医学部内にある池の泥より，日本未記録と思われる本種を分離・単藻培養した。

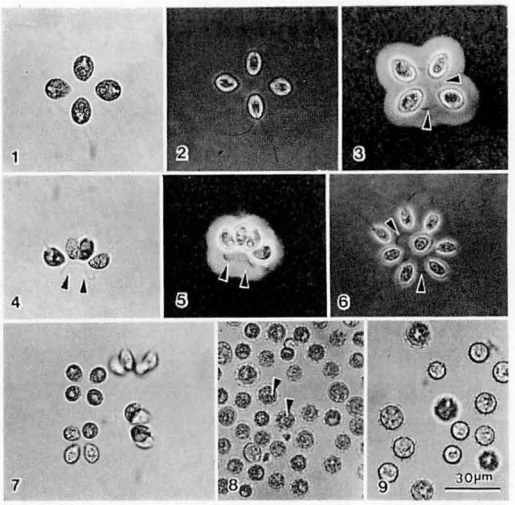
遊泳性の菱形の群体で，4個の等長2鞭毛型の細胞がその基部で親の世代の寒天状の細胞被鞘（sac）に十字型に互いに離れて付着する。まれに8細胞性の群体の場合もある。群体全体はうすい寒天状基質に囲まれる。細胞は横から見るとやや非対称の卵形で，1個の杯状の葉緑体と鞭毛基部に2個の収縮胞をもつ。ピレノイドは1個で葉緑体の底部にある。眼点は1個で細胞の中位よりやや前方側面にある。細胞は最大で長さ18μm。群体は最大で巾48μm。無性生殖は娘群体形成。すべての細胞が2回分裂して，親の細胞被鞘の中で4個の娘細胞ができる。各娘細胞から鞭毛が伸び出すと，4個を包む親の細胞被鞘はやぶれ，反転し，娘細胞を付着した娘群体となる。娘群体は前の世代の被鞘(sac)より離れ，自由に泳ぎ出す。各細胞はばらばらになり，無性的に厚膜胞子を形成することもある。厚膜胞子は網目状の細胞壁をもち，若いものではピレノイドを1個もつ。成熟するとピレノイドは見えなくなり，赤褐色を呈し直径12から17μm となる。

タイプ産地：ブタペスト（ハンガリー）。

分布：欧州，アメリカ，ロシア，日本。

本種は SCHERFFEL が1904年に *Gonium* 属の新種 *G. sacculiferum* として記載したものである。SKUJA (1956) は本種が *Gonium* とは群体の構造が基本的に異なることを確認し，本種のために *Basichlamys* 属を設立した。しかし STEIN (1959) は本種を *Gonium* 属に所属させている。その後本種は *G. sacculiferum* として扱われることが多い（PICKETT-HEAPS 1975, BOLD and WYNNE 1978, STARR 1978）。しかし，本種の群体が，親の世代の細胞被鞘 (sac) に個々の細胞が付着している点 (Figs. 3-6)は *Gonium* の群体が構成細胞同士の被鞘の結合から構成されているのと本質的に異なると思われる。従って SKUJA (1956) の見解を筆者は支持する。

STEIN (1959) は本種の有性生殖が同型配偶子接合であることを観察している。筆者は分離した12株を色々と組み合わせて，*Gonium sociale* (DUJARDIN) WARMING で使用した接合培地（NOZAKI 1986）に変換したが，いずれも有性生殖は起こらず，厚膜胞子を形成した（Figs. 8-9）。また，接種する期間を2から3日にしてくり返すと，まれに8細胞性の群体が認められた（Fig. 6）。この様な群体に関する報告はいままでにない。



Figs. 1-9. *Basichlamys sacculifera*. All at same magnification. 1-6. Vegetative colonies. Arrows indicate parental cellular sheath (sac) 7. Autocolony formation; 8. Young akinetes having a single pyrenoid (arrow); 9. Mature akinetes.

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（慶応義塾高等学校）

——学 会 録 事——

1. 日本藻類学会第10回大会

昭和61年3月30日・31日の両日，筑波大学・生物農林学系A棟において第10回大会を開催した。大会会長は福島博氏（東女体大）で，参加者は146人であった。講演は58の一般講演のほかに米国ブラウン大学のAnnette W. Coleman博士，同じく米国カリフォルニア大学のPaul C. Silva博士による特別講演があった。

大会第一日目，Silva博士の講演終了後，同会場において総会を開催し，引き続き筑波大学第二学群食堂で約2時間にわたって懇親会を開催した。懇親会は南雲保氏（日本歯科大）の司会，元会長西澤一俊氏の乾杯の音頭で始まり，盛会裡に終了した。参加者は96名であった。

大会の商品展示室では東邦大学吉崎誠氏らの作成したコンピューターゲーム「海藻名前当てクイズ」なども展示され，好評であった。東邦大学の教官・学生諸氏にはこのほかにも大会運営にあたって種々のご協力を頂いた。厚くお礼申し上げる。

懇親会参加者

赤塚伊佐武，鯵坂哲朗，新井朱美，新井章吾，新崎盛敏，有賀祐勝，池原宏二，石川依久子，石代俊則，出井雅彦，井上　勲，市村輝宜，居平昌士，巌佐耕三，浦野浩二，榎本幸人，恵良田真由美，小沢淳子，大谷修司，大野正夫，大葉英雄，岡崎恵視，奥田一雄，笠井文絵，加崎英男，加藤季夫，香村真徳，川井浩史，川嶋昭二，喜田和四郎，熊野　茂，黒田充恵，小亀一弘，後藤　弘，小林和行，小林艶子，小林秀明，小林弘，Annette W. Coleman，今野敏徳，斉藤捷一，嵯峨直恒，佐野　修，佐藤恵美，佐藤祐司，Paul C. Silva，須田彰一郎，瀬戸良三，高橋京子，高橋永治，田中志穂子，田中次郎，千原光雄，寺本賢一郎，寺脇利信，徳田欣之，徳田　広，中島　泰，長島秀行，長田敬五，中道聡美，中村利家，南雲　保，西澤一俊，野崎久義，能登谷正浩，鳩貝太郎，速見　剛，原　成光，原　慶明，半田信司，肥塚利江，日野修次，福島　博，藤田大介，藤田隆夫，藤田雄二，堀　輝三，前川行幸，松山恵二，真山茂樹，右田清治，宮地和幸，持田和男，本村泰三，山岸高旺，山田家正，山本真規子，横浜康継，吉崎　誠，吉田忠生，米村好朗，Richardo J. Haroun，若菜　勇，渡辺　信（富山大），渡辺　信（国立公害研），渡辺真之

2. 評議員会・編集委員会

第10回大会の前日，3月29日に筑波大学・生物農林学系A棟において，編集委員会（15：00～16：00）および評議会（16：30～18：30）を開催し，昭和61年度総会に提出する報告事項・議題等の審議を行った。議題については総会の項を参照されたい。

評議員会出席者：千原光雄会長，有賀祐勝，市村輝宜，巌佐耕三，岩崎英雄，榎本幸人，大野正夫，喜田和四郎，小林　弘，谷口和也，堀　輝三，右田清治，山田家正，山岸高旺，吉田忠生の各評議員および井上　勲，加藤季夫各幹事。

編集委員会出席者：小林　弘編集委員長，有賀祐勝，市村輝宜，堀　輝三の各編集実行委員，巌佐耕三，岩崎英雄，右田清治，吉田忠生の各編集委員，千原光雄会長および岡崎恵視，井上　勲，加藤季夫各幹事。

3. 昭和61年度総会

昭和61年3月30日，筑波大学・生物農林学系A棟において，大会1日目の講演終了後，総会を開催した。千原会長の挨拶に続いて，喜田和四郎氏（三重大）を議長に選出して議事に入った。

Ⅰ．報告事項

1．庶務関係

(1) 会員状況（61年2月現在）：名誉会員3名，普通会員518名，学生会員71名，団体会員42名，賛助会員13名，外国会員87名，購読・寄贈・交換143件。(2) 昭和60年度文部省科学研究費刊行助成金「研究成果刊行費」は110万円で，責任頁は296頁である。なお，昭和61年度分として185万8千円の助成金の申請を行い責任頁は300頁である。(3) 日本学会事務センターに会員業務を委託した。委託料は61万8千円である。(4) 日本学術会議第13期会員候補者の学会推薦について，持ち回り評議員会での選挙結果に従って，千原光雄氏を推薦した。なお，植物科学分野の学術会議会員には今堀宏三氏が就任した。(5) 昭和60年度の国際生物学賞授賞者の学会推薦について持ち回り評議員会で検討した結果，学会としての推薦は行わないことにした。

2．会計関係

(1) 昭和61年度の会費納入率は2月末日現在で普通会員52%，学生会員65%である。(2) 昭和60年度一般会計と同山田幸男博士記念事業基金特別会計の決算報告は昭和61年2月10日，猪川倫好（筑波大），渡辺真

之（国立科博）の両会計監事により適正であると承認された。

3. 編集関係

(1) 昭和60年度に発行した第33巻1～4号は，総頁数348頁，掲載論文数31編，短報6編，広告頁12である。(2) 昭和61年度第34巻1号は，掲載論文8編，第10回大会講演要旨を含め67頁で発行した。同巻2号以降に掲載予定の論文は審査中のものを含めて13編である。

4. その他

(1) 第12回国際海藻会議について有賀祐勝氏（東水大）より説明があった。

(2) 会則の趣旨に沿って日本藻類学会主催の淡水藻の分類・同定のワークショップを，山岸高旺（日大），高橋永治（神戸大），渡辺真之（国立科博），南雲　保（日歯大）を講師として大会終了後筑波大学で開催 (3) 日本藻類学会昭和60年度秋季シンポジウムを植物学会大会前日の昭和60年10月2日午後に新潟市で開催。

Ⅱ. 審議事項

1. 昭和60年度一般会計決算報告および同監査報告は表-1のとおり承認された。2. 昭和60年度山田幸男博士記念事業基金特別会計の決算報告および監査報告は表-2のとおり承認された。3. 昭和61年度一般会計予算案は表-3のように可決承認された。4. 日本学会事務センターとの契約更新に伴い，昭和61年から昭和62年にかけて約10%の値上りが見込まれているが，このことを含めて同センターに続けて業務を委託することが承認された。5. 山田基金による事業について，ワーキンググループの答申に従って将来山田賞を設ける方向であるが，事業を円滑に実施運営するにはなお資金が不足であり，今後できるだけ基金の充足を図るよう努力することが決められた。6. 学会誌「藻類」の投稿規定を次のように改訂することが了承された。投稿論文はオリジナルの他にコピーを2部つけることとする。論文の図版は写真の場合は印刷の原寸大とし，カメラで複写したコピーを2部添付すること，線画の大きさは特別の場合を除きA4サイズを上限とする。7. 従来東京と周辺地区を中心に行ってきた大会を，東京周辺地区1～複数回と地方との交互開催にすることが望ましいとの結論が得られた。

8. 昭和61・62年度事業計画として次の事項が決めら

表-1　昭和60年度　一般会計決算報告（60.1.1～60.12.31）　日本藻類学会

収入の部	(円)	支出の部	(円)
会費	4,126,203	印刷費	5,378,616
普通会員	3,088,500	印刷代	4,683,741
学生会員	313,500	別刷代	694,875
外国会員	322,603	編集費	299,935
団体会員	201,600	論文審査料	38,000
賛助会員	200,000	英文校閲料	80,000
販売	616,050	編集補助費	47,165
定期購読	440,400	通信連絡費	134,770
バックナンバー	175,650	会誌発送費	237,030
別刷代	765,450	庶務費	511,750
超過頁負担金	912,000	事務用品費	16,510
広告代	155,000	会議費	49,550
利子	5,760	通信・印刷費	144,820
プログラム代	16,500	事務整理補助	24,000
雑収入	122,154	諸雑費	77,070
刊行助成金	1,100,000	幹事旅費補助	19,800
		幹事手当	180,000
		学会センター業務委託費	618,860
		第9回大会補助	100,000
小計	7,819,117	小計	7,146,191
前年度繰越金	620,520	次年度繰越金	1,293,446
合計	8,439,637	合計	8,439,637

貸借対照表　　60.12.31

借方	(円)	貸方	(円)
普通預金（常陽銀行）	1,103,752	借入金	55,310
普通預金（常陽銀行）	603,426	未払金	1,402,771
郵便振替	60,000	前受会費	55,000
小口現金	203,604	前期繰越金	620,520
未収金	823,695	当期繰越金	672,926
仮払い金	12,050	次期繰越金	1,293,446
合計	2,806,527	合計	2,806,527

昭和61年2月10日

日本藻類学会　会長　千原光雄　㊞
日本藻類学会　会計幹事　加藤季夫　㊞

本会計決算報告は適正であることを認める。
昭和61年2月10日

日本藻類学会　会計監事　猪川倫好　㊞
日本藻類学会　会計監事　渡辺真之　㊞

表-2　昭和60年度　山田幸男博士記念事業基金特別会計決算報告（60.1.1～60.12.31）　日本藻類学会

収入の部	(円)	支出の部	(円)
山田追悼号（2冊）	11,000		
学会出版物売上金			
コンブ論文集（1冊）	700		
日米セミナー（1冊）	4,000		
寄付（1件）	100,000		
利子	10,179		0
小計	125,879	小計	0
前年度繰越金	1,226,776	次年度繰越金	1,352,655
合計	1,352,655	合計	1,352,655

貸借対照表　　60.12.31

借方	(円)	貸方	(円)
普通預金（常陽銀行）	1,341,655	前期繰越金	1,226,776
未収金	11,000	当期繰越金	125,879
		次期繰越金	1,352,655
合計	1,352,655	合計	1,352,655

昭和61年2月10日

日本藻類学会　会長　千原光雄　㊞
日本藻類学会　会計幹事　加藤季夫　㊞

本会計決算報告は適正であることを認める。
昭和61年2月10日

日本藻類学会　会計監事　猪川倫好　㊞
日本藻類学会　会計監事　渡辺真之　㊞

れた。1) 来年度は会長および評議員の交代の年にあたるので，本年8月末から9月初旬にかけて選挙を行い，秋季シンポジウム開催時までに新会長と評議員を決定する。2) 本年度の秋季シンポジウムは鹿児島大学で開かれる日本植物学会第51回大会前日の10月6日に鹿児島大学の野沢治治氏を世話人として鹿児島市で開催する。3) 来年度の日本藻類学会第11回大会は梅崎勇氏を世話人として京都大学で開催する。4) 国際生物学賞授賞者の学会推薦については，会員から特に推薦したい旨の申し出がない限り行わない。9. 第4回国際藻類学会議の日本開催について打診があったが，国際植物学会議と開催時期が近接しているため見送ることになった。

表-3 昭和61年度 一般会計予算案 日本藻類学会

収入の部	(円)	支出の部	(円)
会費	4,531,400	印刷費	4,905,760
普通会員	3,262,000	印刷代	4,205,760
学生会員	320,000	別刷代	700,000
外国会員	427,000	編集費	350,000
団体会員	302,400	論文審査料	40,000
賛助会員	220,000	英文校閲料	100,000
販売	940,400	編集補助費	60,000
定期購読	770,400	通信連絡費	150,000
バックナンバー	170,000	会誌発送費	250,000
別刷代	770,000	庶務費	915,000
超過頁負担金	240,000	事務用品費	30,000
広告代	200,000	会議費	50,000
利子	15,000	通信・印刷費	310,000
プログラム代	20,000	事務整理補助費	60,000
雑収入	30,000	諸雑費	175,000
刊行助成金	1,100,000	幹事旅費補助	110,000
		幹事手当	180,000
		学会センター業務委託費	640,000
		第10回大会補助	100,000
		秋季シンポジウム会場費	40,000
小計	7,846,800	小計	7,200,760
前年度繰越金	1,293,446	予備費	1,939,486
合計	9,140,246	合計	9,140,246

4. 日本藻類学会ワーク・ショップ報告

昭和61年3月31日（月）日本藻類学会第10回大会終了後より4月2日（水）正午まで筑波大学学群棟などにおいて，淡水産藻類の採集・分類同定法をテーマにワーク・ショップを開催した。高橋永治（神戸大），南雲保（日本歯科大），山岸高旺（日本大），渡辺真之（国立科博）の4氏を講師に迎え，本学会員を中心に下記の34名（手伝いを兼ねた筑波大学の学生・大学院生8名を含む）が参加した。山岸講師による採集の要領と試料整理の講義から始まり，土浦市郊外の宍塚大池における採集（4月1日午前中），渡辺講師のアオコ等，淡水産藍藻の同定法と培養法の実習までほぼ計画通りに実施できた。なお講師に予定していた秋山優氏(島根大)は講義・実習の準備をして下さったが公用で出席不能となり，急遽南雲保氏に講師をお願いした。なお本ワーク・ショップの内容の詳細は川井浩史氏(北大・理・植)の参加記（次号掲載予定）を参照されたい。

参加者：鳩貝太郎（市立船橋高），藤田隆夫（日大習志野高），菅野徳彦，立沢秀高（以上明大・農），川

井浩史（北大・理），長島秀行（東京理大・理），石川依久子（阪大・教養），鰺坂哲朗（京大・農），保坂三継，高松雅子（以上東京都水道局），真山茂樹（東学大・生），神谷　仁（福島大・教育），鳥海三郎（横浜市立東高），鳥海孝枝（京浜女大），奥田一雄（高知大・理），藤井修平（手塚山短大），清沢浩志（都立大・理），大谷修司（国立極地研），古川一夫，市村　治，葛西厚子（以上弘前大・教育），田中志穂子，肥塚利江，山本真規子（以上奈良女大・理），松林恒夫（クロレラ工業），箕島良一（日清製油），恵良田真由美，出井雅彦，佐藤　卓，河地正伸，蠭　和久，笠間真弓，篠塚未夏，金築祥子（以上筑波大・生）　　—申込み順—

日本藻類学会第10回大会会計報告　日本藻類学会大会準備委員会

収入の部	(円)	支出の部	(円)
大会参加費		プログラム代	19,500
予約（82件）	164,000	会場使用料	24,442
当日（43件）	86,000	懇親会会食代	224,660
懇親会費		アルバイト代	196,000
予約（73件）	146,000	諸雑費	55,066
当日（19件）	38,000	学会返還金	54,332
学会補助金	100,000		
商品展示代金（2件）	30,000		
寄付（1件）	10,000		
合計	574,000		574,000

昭和61年4月23日

第10回大会幹事　　加藤季夫 ㊞

会員移動

新入会

住所変更

退　　会

丸山秀佳（北海道），田中静夫（千葉県），鈴木　敞（東京都），藤木昭義（神奈川県），増田清孝（大阪府），畑田太美子（兵庫県），宮本文子（兵庫県），小島勝彦（広島県），津田敏明（広島県），田辺満子（愛媛県），田畑重行（熊本県），藤山和恵（沖縄県）

投　稿　案　内

Ⅰ．編集の方針　本誌には藻学と応用藻学に関する会員の**未発表**の，論文・総説・短報（速報・短い調査報告など）・雑録（抄録・採集地案内・分布資料・ニュース・所見・新刊紹介など）を掲載します。論文はデータや考察の独創性の有無に重点を置いた編集委員会の審査を経たのち受理されます。原稿の取捨，掲載順序，体裁などは編集委員会および編集幹事で決めます。原稿は**和文**または**英文**とし，論文は刷上り英文8頁，和文6頁，総説は英文，和文共10頁，短報は2頁，雑録は1頁以内を無料とします。頁の超過は制限しませんが，頁の超過分（1頁12,000円），折込み，色刷りなどの費用は著者負担となります。和文原稿では5枚（ワープロでは2枚）が，英文原稿では2枚が刷上り1頁となる見当です。

Ⅱ．報文の書き方　和文原稿は400字詰原稿用紙（横書きB5またはA4）に，当用漢字，新仮名使い（生物名は片仮名）を用い楷書体で書き，ワープロの場合は1行35字，28行にタイプして下さい。英文原稿は厚手タイプ用紙を用い，ダブルスペースで1行65字，28行にタイプまたはワープロで打ち，十分な英文添削または校閲を経たのち提出して下さい。新種の発表や学名の記載に当っては国際植物命名規約に従って下さい。なお，アラビア数字・メートル法・摂氏温度を用い，学名などのイタリック体には下線1本，人名などのスモールキャピタルには下線2本，ゴジック体には波状線1本を記入して下さい。

例：Batrachospermum ectocarpum Sirod., Summary, sec, min, hr, nm, μm, mm, cm, m, μl, ml, l, μg, mg, g, N, M, ppm, lux, g(gravity), 25°C など.

原稿は，標題・英文要約（和文・英文原稿共）・本文・引用文献・和文摘要（英文原稿のみ）・表と図とその説明（英文）の順にまとめて1組とし，コピー共3組（写真は現物1組と現物または写真コピー2組）にしてお送り下さい。

(1) **標題と要約**　英文原稿では，欄外見出し・標題・著者名・宛先・要約の順に，和文原稿では，欄外見出し(英)・標題と著者名（和と英）・要約（英）の順に記入して下さい。要約は著者名・標題・雑誌名・まとめ（200字・必要に応じて400字まで）・アルファベット順のキーワード（5〜10語）・著者と宛先の順に記入し研究費に対する謝辞は脚注に入れて下さい。

(2) **本文**　標題紙に記した以外の謝辞は，なるべく本文の末尾に入れて下さい。表と図は必ず本文中に引用(Fig. 1, Table 1 のように）し，文献の引用は次の例にならって，著者名と出版年および必要に応じて頁（単行本の場合）を明示して下さい。

例：····aquatic ecosystems (WELCH 1972, 1974), Liebig's (1840 p. 23) "low of the minimum" is····, ····が知られている (YAMADA 1949), 岡村 (1907 p. 56) は,

(3) **引用文献**　本文中で引用した文献のみを，別紙にアルファベット順に列挙して下さい。引用は，①原著の引用と，②図書目録を見て目的の書物を捜し当てるための引用の2本立てとし，それぞれが イ）著者名 ロ）出版年 ハ）標題（巻次を含む）ニ）対照事項（頁・図など）ホ）出版事項（出版者・出版地）のうちの必要部分からなるよう順を追って下例にならって記入して下さい。

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(雑誌の中の1論文)　①森　通保(イ) 1970.(ロ) *Batrachospermum ectocarpum* SIROD. の分類学的研究。(ハ) ②藻類 8(ハ): 1-8.(ニ)

①MORI, M.(イ) 1975.(ロ) Studies on the genus *Batrachospermum* in Japan.(ハ) ②Jap. Journ. Bot. 20(ハ): 461-485.(ニ)

(4) **和文摘要**　英文原稿の場合のみ，和文で，著者名・標題・宛先も入れ400字以内にまとめて下さい。

(5) **表と図およびその説明**　英文で書き，表と図は原寸大（**印刷頁**の寸法は 14×20.5 cm，片段のときは幅 6.6 cm）またはA4版程度に仕上げ，図には倍率を示すスケールを入れ，線や記号，文字，数字はレタリング用具などを用いて鮮明に記入し，そのまま印刷に廻せるようにして下さい。なお，特に表の組版を希望の場合はその旨明記して下さい。表と図の上には割付，指定，レタリングや写真の脱落防止の必要上，必らずトレーシングペーパを付け，その下端に著者名・番号・希望縮尺を記入して下さい。表と図の説明は別紙とし，それを入れる場所を本文原稿右**欄外**に明示して下さい。

Ⅲ．校正と別刷　著者校正は初校のみとし，編集幹事から送りますので，3日以内に校正して同封の別刷申込書に所定の事項を記入して返送して下さい。別刷は，論文・総説・短報に限って50部を学会で負担します。

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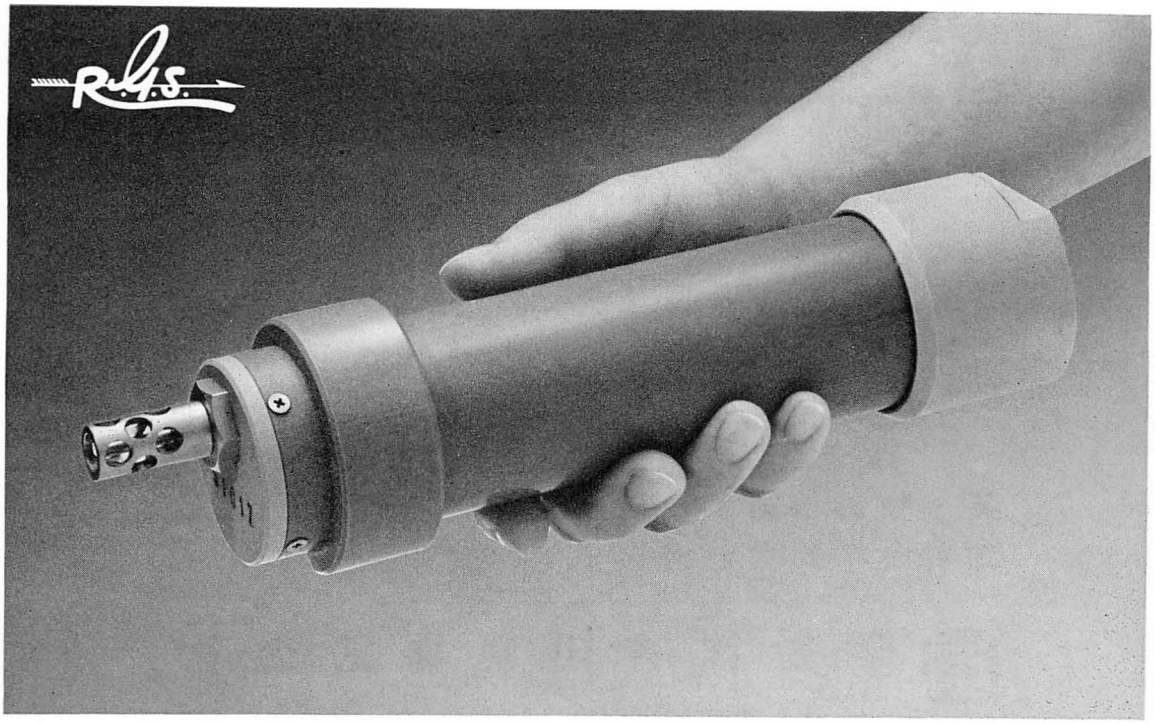

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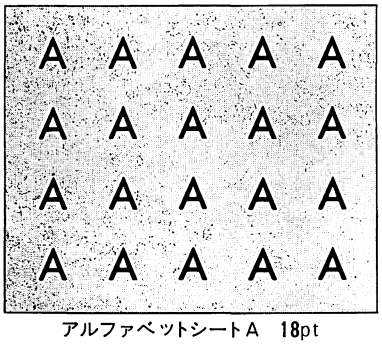

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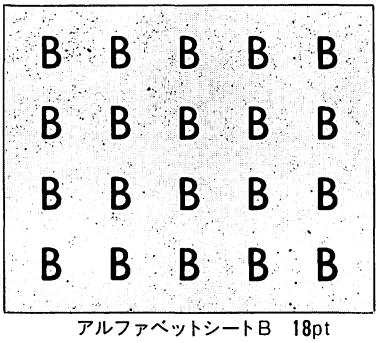

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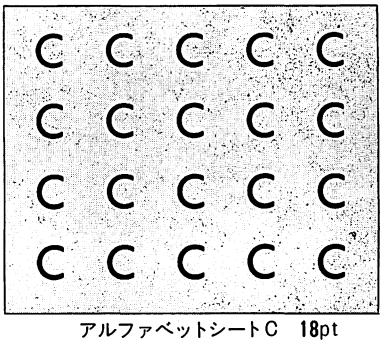

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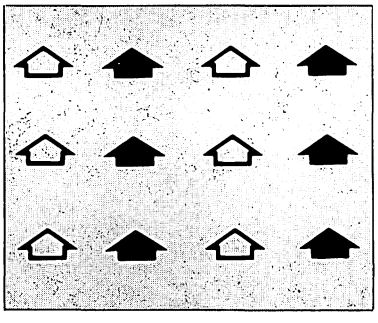

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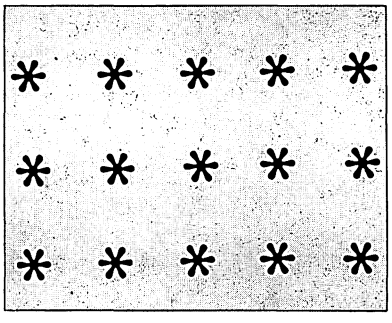

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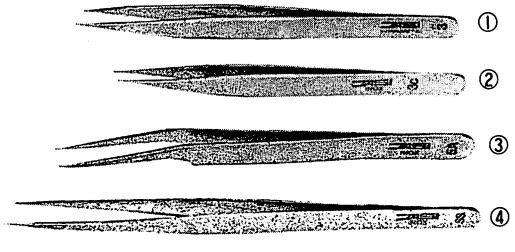

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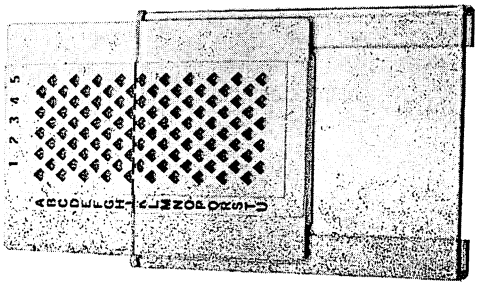

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2. **Index of the Bulletin of Japanese Society of Phycology.** Vol. 1 (1953)-Vol. 10 (1962) Price 2,000 Yen for member, 2,500 Yen for non member, Vol. 11 (1963)-Vol. 20 (1972), Price 3,000 Yen for member, 4,000 Yen for non member. Vol. 1 (1953)—Vol. 30 (1982). Price 4,000 Yen for member, 5,000 Yen for non member (incl. postage, surface mail).

3. **A Memorial Issue Honouring the late Professor Yukio YAMADA** (Supplement to Volume 25, the Bulletin of Japanese Society of Phycology). 1977. xxviii+418 pages. This issue includes 50 articles (26 in English, 24 in Japanese with English summary) on phycology, with photographies and list of publications of the late Professor Yukio YAMADA. ¥8,500 (incl. postage, surface mail).

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