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The Japanese Journal of PHYCOLOGY

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THE JAPANESE SOCIETY OF PHYCOLOGY

日 本 藻 類 学 会

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本学会では日本植物学会第53回大会（岡山大学）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63年10月12日（水）
14：30〜16：30　シンポジウム
17：00〜19：00　懇親会

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山陽学園短期大学
D棟（国際教養棟）2階　中講義室

演題・演者：海藻の利用と組織培養
(1) 海藻の特殊成分とその利用
西澤一俊（日本大学）
(2) 海藻の組織培養研究の現状
—第3回国際藻類学会議に参加して—
嵯峨直恒（北海道区水産研究所）

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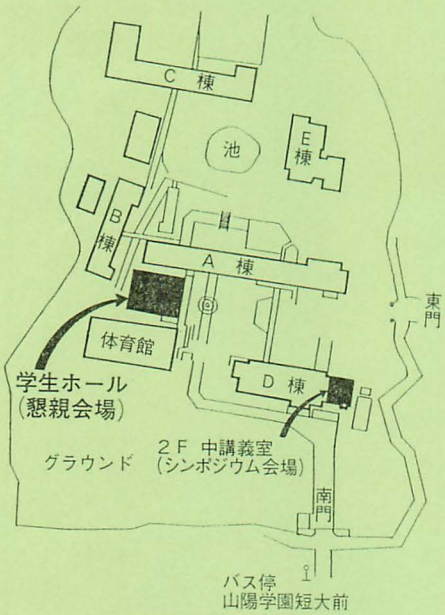

◦交　通

1. JR 岡山駅前より，両備バス山陽短大・四軒屋経由新岡山港行に乗車。山陽学園短大前下車。（約20分，料金220円）両備バスの乗車場所は岡山ターミナルビルの東③番のりば。バスは10分毎に出ています。
2. JR 岡山駅前よりタクシーで15分。（約1,100円）

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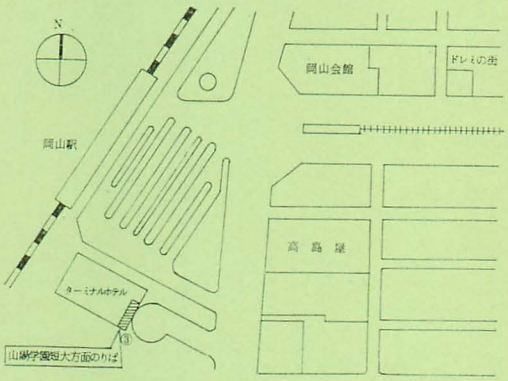
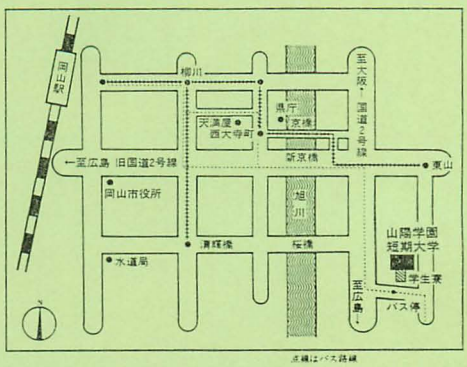




Jpn. J. Phycol. (Sôrui) **36**: 113–126, June 20, 1988

Ultrastructure of gametes and gametic fusion in *Bryopsis maxima* Okamura (Chlorophyceae)

Terumitsu Hori

Institute of Biological Sciences, University of Tsukuba, Tsukuba, Ibaraki, 305 Japan

Hori, T. 1988. Ultrastructure of gametes and gametic fusion in *Bryopsis maxima* Okamura (Chlorophyceae). Jpn. J. Phycol. **36**: 113–126.

The fine structure of gametic fusion in the coenocytic, anisogamous green alga, *Bryopsis maxima* Okamura, is described and compared with those of the isogamous and other anisogamous green algae. Female gametes possess a putative mating structure similar in ultrastructure to that found in many other green algae so far studied. This is a structure absent in male gametes. The general mode of gametic conjugation is by fusion of male gametes at or near the mating structure of the female gamete, but other modes of fusion occur without involvement of this structure. These observations suggest that the mating structure does not function properly in the higher green algae, especially in the anisogamous groups. The mating structure in these algae may thus represent a vestigial sexual organ.

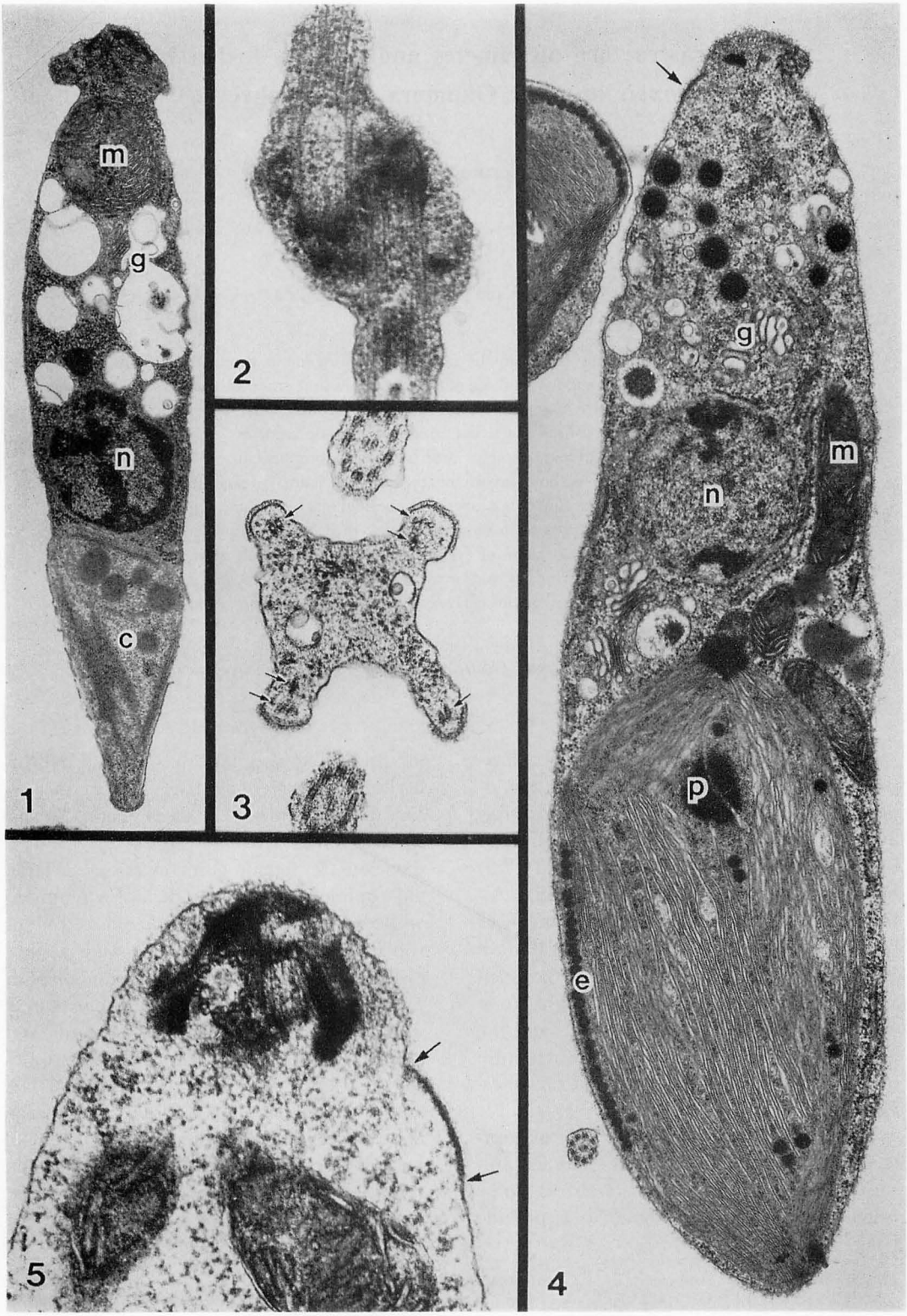
Nuclear fusion occurs at an early stage of zygote formation (25 minutes after mixing gametes), but fusion or disintegration of chloroplasts and/or mitochondria does not occur at this stage. The behaviour of the flagellar apparatuses in the early zygote from both mating types of gametes is discussed.

Key Index Words: Bryopsis maxima—*Chlorophyceae—conjugation—gamete—gametic fusion—green alga—mating structure.*

The first ultrastructural study of fertilization in green algae was made in the oogamous alga *Prasiola stipitata* (Manton and Friedmann 1960). Only a limited number of genera (*Chlamydomonas* and *Ulva*) have since been studied in detail. Although it is generally accepted that *Ulva* is anisogamous (e.g. Bold and Wynne 1985), the difference in cell size between female and male gametes is slight (e.g. Melkonian 1980b, Koeman 1985), and the general mating behaviour and the structure of gametes are similar to those of *Chlamydomonas* (Melkonian 1980b).

I have studied the fine structure of gametes and the fertilization processes of anisogamous green algae, as well as some other isogamous green algae, as a prelude for analyzing mechanism of maternal inheritance in green plants. The main reasons for selecting *B. maxima* were, 1) this species shows extreme anisogamy and is dioecious, 2) female gametes possess a large chloroplast with an eyespot and a pyrenoid while male gametes possess a reduced chloroplast with fewer thylakoids and neither eyespot nor pyrenoid, 3) behaviour of both male- and female-derived chloroplasts in a zygote can be easily followed by light and electron microscopy. A part of the studies showing that both male chloroplast-DNA and male mitochondrial-DNA of this alga are preferentially digested during the late period of gametogenesis has already been reported (Kuroiwa and Hori 1986). In contrast to this, in isogamous species of *Chlamydomonas*, the preferential degradation of male chloroplast-DNA occurs in young zygotes after gamete conjugation (Kuroiwa *et al.* 1982, Kuroiwa *et al.* 1985, Tsubo and

This study was partly supported by a Grant-in-Aid from the Ministry of Education, Science and Culture of Japan (No. 62219002).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MATSUDA 1984, COLEMAN and MAGUIRE 1983).

This paper presents the fine structure of gametes and the early stage of zygote formation.

Materials and Methods

Bryopsis maxima is dioecious. Gametophyte fronds were collected a few nights before full and new moon at Kimiga-hama, Chyoshi, Chiba and brought back to the laboratory, where they were kept in a tank of seawater provided with aeration. Close to full or new moon, the fronds become fertile and change colour to orange (male) and dark-green (female). At this stage the female and male fronds were separated and maintained as above.

In gametic fusion experiments two volumes of a suspension of female gametes and one volume of male gametes were mixed and fixed for electron microscopy at 0.5, 2, 5, 10, 15 and 25 minutes after mixing.

Initial fixation was done by adding 50% glutaraldehyde to gamete suspensions, giving a final glutaraldehyde concentration of 0.5%. The fixed cells were stored no longer than 12 hr before further processing. After centrifugation the zygotes were further fixed in 3% glutaraldehyde (made up in 0.28 M sucrose in 0.1 M cacodylate buffer, pH 7.1) for 1 hr at room temperature. The cells were then washed in a series of 0.1 M cacodylate buffer solutions containing 0.28, 0.14, 0.07 M sucrose and no sucrose, each step taking 15–20 minutes. Post-fixation was made in 1% OsO_4 (prepared as a 2% solution and mixed with equal volumes of 0.2 M cacodylate buffer, pH 7.1) overnight at 4° C. The fixed cells were centrifuged and stained for 8 minutes in a saturated solution of uranyl acetate in distilled water. After dehydration through a graded series of ethanol, the cells were embedded in Spurr's resin. Sections were cut with a diamond knife and stained with lead citrate. Observations were made using a JEOL 100 CXII electron microscope.

Observations

Dioecious fronds of *Bryopsis maxima* produce different types of gametes which can be clearly distinguished from each other by cell size and intracellular structure. The fine structure of these gametes is quite different and their components are useful as definitive morphological markers for analyzing the behaviour of cell organelles in zygotes.

I. *Male gamete*

The biflagellate male gametes of *B. maxima* are pear-shaped, measuring 4–7 μm in length and around 2 μm in width. The cell anterior differentiates into a papilla in which two basal bodies overlap at their most proximal ends (Fig. 2). They continue with the flagellar proper, which are 15–17 μm in length, slightly shorter than the female flagella (mean length 18 μm).

The fine structure of the male flagellar apparatus has already been described in detail for *B. maxima* (HORI 1977) and *B. lyngbyei* (MELKONIAN 1980a) and will not be

Figs. 1–3. Male gamete of *Bryopsis maxima*. 1. Median longitudinal section showing relative positions of organelles; mitochondrion (m), Golgi-body (g), nucleus (n) and a reduced chloroplast (c). The posterior end of the cell body is overlain by one of four ridges that extends down from the papillae. ×19,000. 2. Cross-section of the flagellar apparatus showing the overlapping basal bodies which are displaced in a counter-clockwise direction. ×52,000. 3. Cross-section just under the flagellar apparatus showing four ridges. In the upper left and lower right ridges a two-membered microtubular root can be seen; and a five-membered root can be seen in the upper right and lower left ridges (arrows). ×40,600.

Figs. 4–5. Female gamete of *B. maxima*. 4. Near-longitudinal section of the cell showing relative positions of organelles; the putative mating structure (arrow), many electron dense granules, Golgi body (g), nucleus (n), mitochondrion (m), a large chloroplast with pyrenoid (p) and eyespot (e). Note the location of the mating structure and eyespot on the same side of the cell. ×19,000. 5. Enlargement of the putative mating structure (arrows). ×48,000.

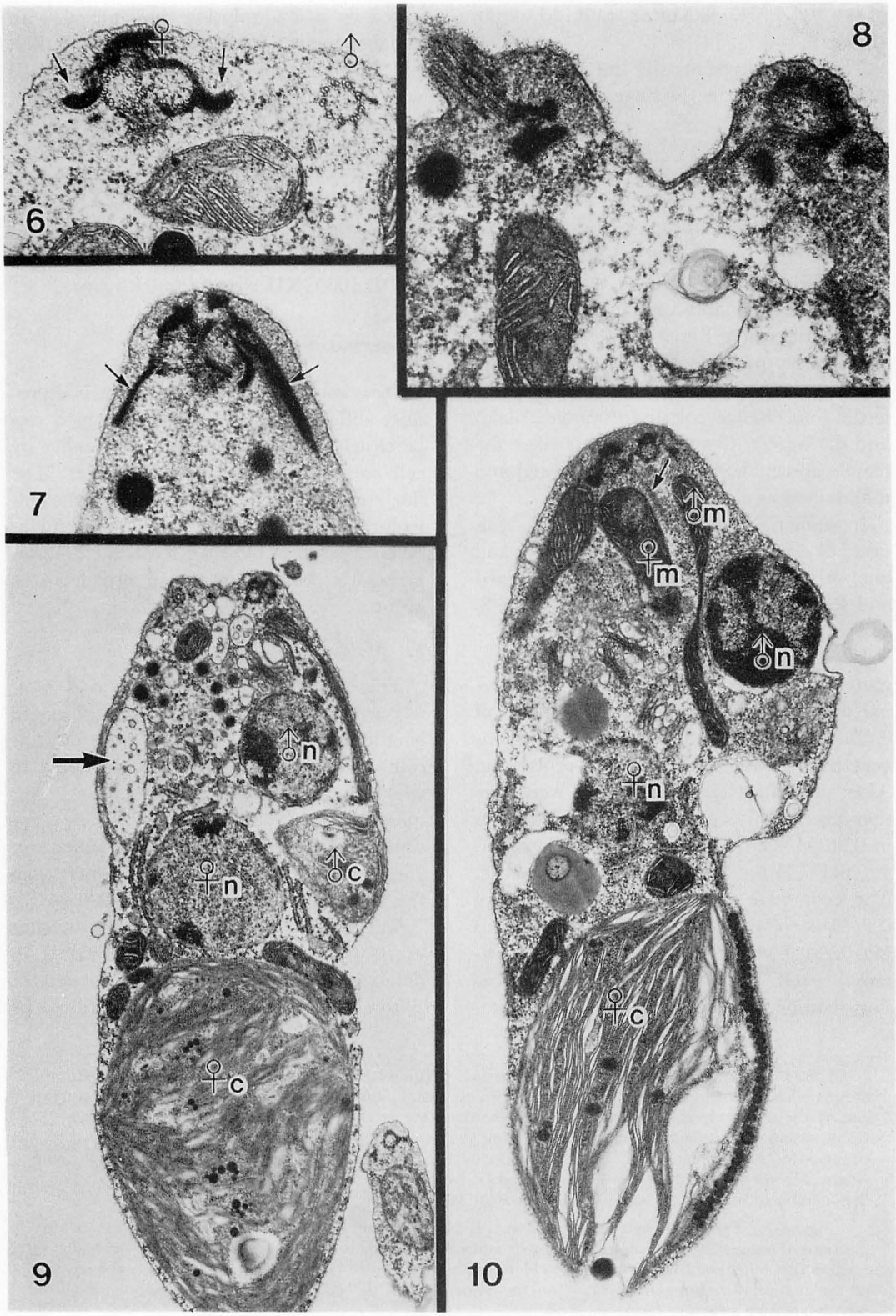
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Fig. 3 is a section just under the flagellar apparatus in which are discernible the basal part of a cruciform papilla composed of four ridges. The ridges originate from this point and extend downward. Some of them taper at an uncertain point in the posterior half of the cell before they reach the cell end, but others reach it (Fig. 1). Along the whole length of each ridge overlies a meniscus-shaped membranous material which is connected to the cell membrane by regularly-shaped bridges (Fig. 3). Microtubular flagellar roots pass along the bulge of each ridge (Fig. 3 arrows, Fig. 11b small arrows). In the upper left and lower right ridges of Fig. 3 (arrow) a two-membered root can be seen, and a five-membered root can be seen in the upper right and lower left ridges (Fig. 3, arrows).

A longitudinal section of a male gamete (Fig. 1) reveals relative positions of major cell organelles; under the flagellar apparatus is the cross profile of a giant U-shaped mitochondrion, the bottom of which is close to the posterior surfaces of the basal bodies. Two mitochondrial arms extend downwards beneath the cell membrane. In the cytoplasm surrounded by these mitochondrial arms are one or two Golgi-bodies and small vacuoles (Fig. 1). The posterior half of the cell body is occupied by a nucleus with condensed chromatin material (compare to female gamete in Fig. 4) and a small chloroplast. The chloroplast has a few thylakoids but no pyrenoid or eyespot.

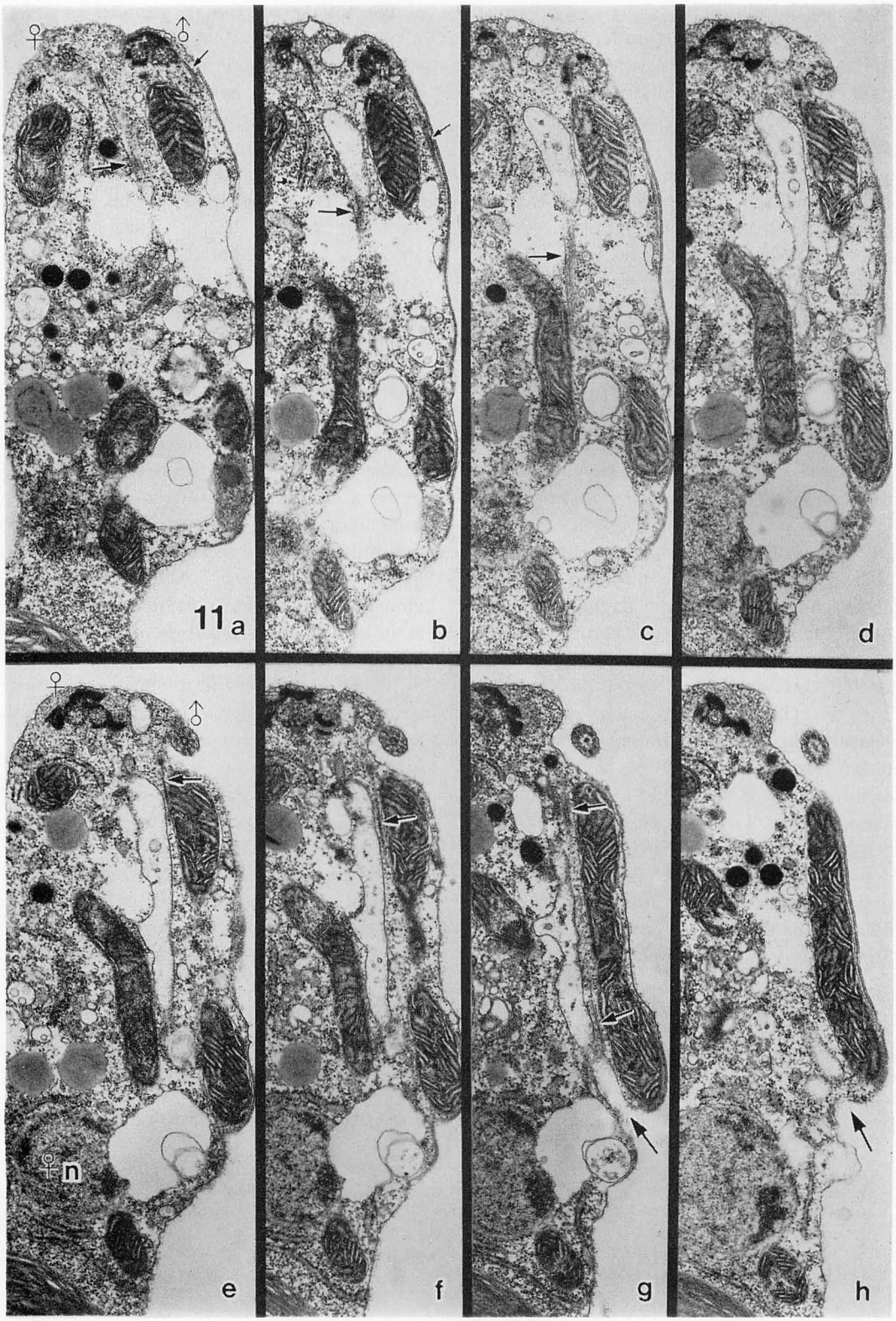
II. *Female gamete*

The biflagellate female gametes measure about 8–14 μm in length and 4–7 μm in width. Two isokont flagella, being 17.5–19.5 μm in length, extend from the papilla. Two basal bodies lie in exactly the same way as those in male gametes. The flagellar apparatus of female gametes has a pair of unusual crescent-shaped bodies (Fig. 6) (see MELKONIAN 1981, ROBERTS *et al.* 1982); a two-membered root is associated with each crescent-shaped body (Fig. 7). These are absent from male gametes and other green coenocytes. Another component associated with the two-membered root is the electron dense material which overlies the root for some distance (Fig. 7). MELKONIAN (1981) demonstrated that in female gametes of *B. lyngbyei* this material forms a cylinder and suggested that it represents a mating structure. Such a configuration is not discernible in the female gametes of *B. maxima*. At the shoulder region under the basal portion of the papilla is an area of thicker cell membrane underlain by an electron-dense material (Figs. 4, 5), which may represent the putative mating structure of this alga. Longitudinal serial sections through this area revealed that it measures 500 nm in length and 240–350 nm in width. The cytoplasm between the flagellar apparatus and nucleus contains four to five Golgi-bodies, small vacuoles and many granules filled with electron-dense material (Fig. 4). Individual granules measure 100 to 300 nm in diameter and sometimes a single limiting-membrane is discernible. These granules are present only in female gametes, and disappear in

Fig. 6. Part of a longitudinal section of conjugating gametes showing the female flagellar apparatus (♀) with crescent bodies (arrows) and one basal body of the male (♂). ×40,600.

Fig. 7. Part of a longitudinal section of the cell anterior of a female gamete showing the electron dense material (arrows) lying over the emerging roots. ×33,500.

Figs. 8–10. Early stage of gametic fusion fixed 2 minutes after copulation. 8. Section illustrating the distinct individuality of each papilla from both female (left) and male (right) gametes. ×49,400. 9. A slightly later stage of gametic fusion than that shown in Fig. 8. Note a vesicle (arrow) that stemmed from the cell gap originally formed between the two conjugating gametes. n, nucleus; c, chloroplast. ×12,000. 10. A more advanced stage than that shown in Fig. 9, showing that the cell anterior becomes more round due to the disappearance of the groove between male and female gamete papillae (compare to Fig. 8). Arrow indicates the flagellar root of the female apparatus extending down along the fusion site. ×16,200.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the zygote cytoplasm after conjugation (Fig. 16).

The female chloroplast contains a pyrenoid and an eyespot (Fig. 4). The eyespot is composed of a layer of granules 80 nm in diameter and is located on the same side of the cell body as the putative mating structure (Fig. 4).

The whole cell surface is covered by a fuzzy material similar to the male gamete (Fig. 4).

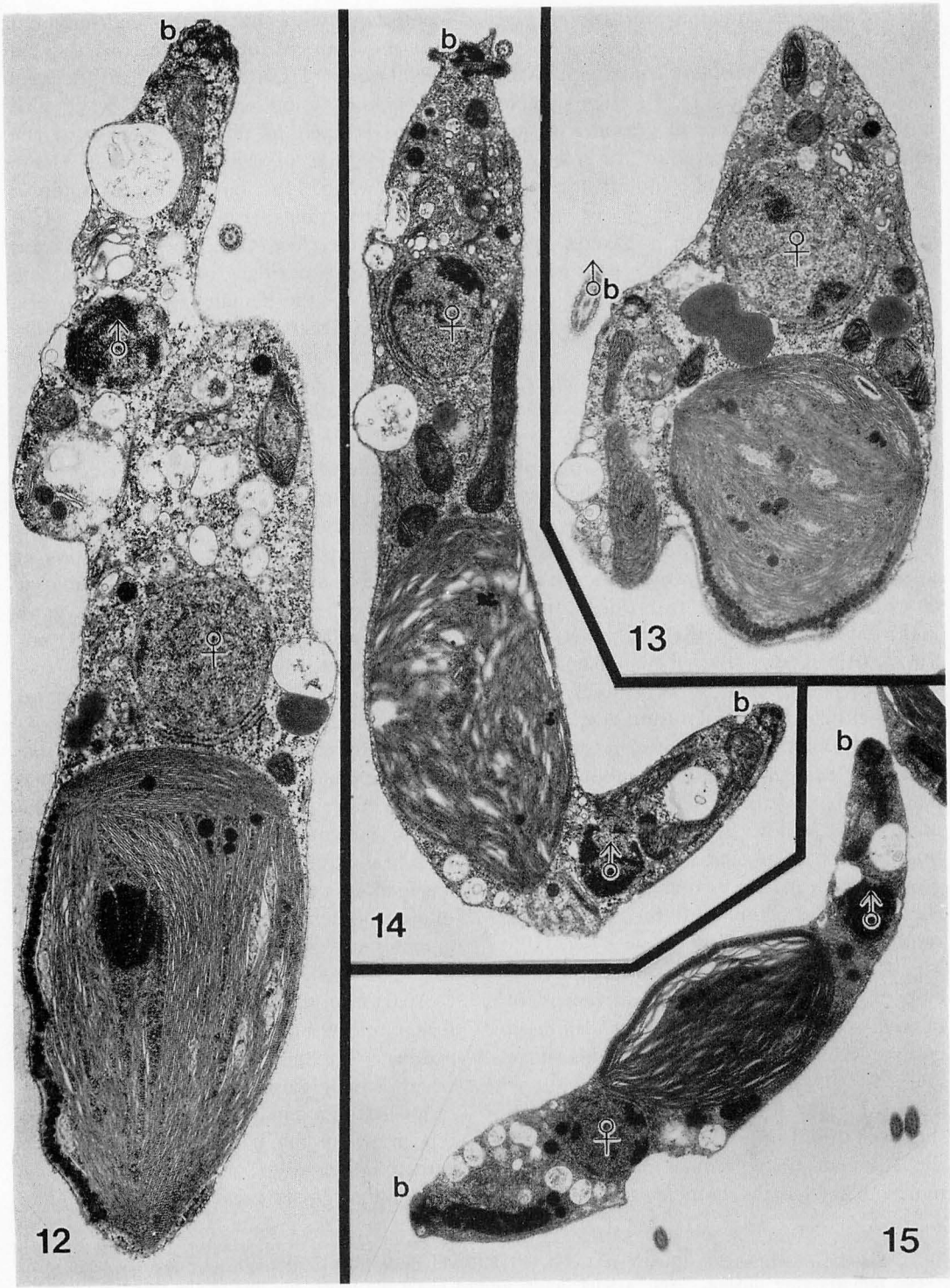
III. *Gametic fusion*

Early zygote fixed 2 minutes after mixing: The most general mode of gametic fusion is initiated at the anterior of female gametes, including the area of the putative mating structure located near the basal bodies (Figs. 8, 9). In many cases the fusion site of the male gamete is restricted to the cell anterior, but sometimes the posterior half or posterior two thirds of the male gamete fuses to the cell anterior of the female body (Fig. 12). The initial fusion process appears to be a quick event, since neither the initial fusion nor activation of the mating structure were detected. At a very early stage of conjugation, papillae from both female (left in Fig. 9) and male (right in Fig. 9) gametes can be distinguished. At a slightly later stage the groove between the two papillae (Fig. 8) rises up as the cytoplasmic fusion proceeds, resulting in a rounded dome (Fig. 10). Fig. 9 shows the two sets of basal bodies close together. The original arrangement of cell organelles found in each unfused gamete is maintained even at this stage (Figs. 9, 10).

Fig. 11 is a set of serial sections which show the initial fusion event of the gametes, the left half being female and the right male. The female gamete cytoplasm is continuous with that of the male gamete, but a cylindrical lumen formed by the cell membranes of both gametes can be seen along the fusion site (Fig. 11b-f). The lumen is open to the cell exterior at the posterior end of the male gamete (large arrow in Fig. 11g), but it is closed again in the next section (arrow in Fig. 11h). It is possible therefore that when the anterior portion of two ridges of the male gamete attaches to the female cell surface, the initial coalescence of gamete membranes begins both around the outer most margin of the male gamete body, which tightly attaches to the female body and to the margin of the lumen formed by the cell surface of the female gamete and the inter-ridge concave cell surface of the male gamete (Fig. 4). The continuity of the cytoplasm expands inwards, resulting in a reduction of lumen size and the formation of vesicles. These vesicles are released into the zygotic cytoplasm (Fig. 9) and later released outside the zygote. Along the cytoplasmic surface of the lumen two flagellar roots extend down, one from the female flagellar apparatus (large arrows in Figs. 11a-c) and one from the male (small arrows in Fig. 11e-g). Fuzzy material on the inner side of the lumen indicates the origin of the lumen membrane from the gamete cell membranes engaged in the cell fusion. The presence of electron-dense granules specific to female gametes was not observed near the fusion site.

Apart from this common mode of gametic fusion, other modes were observed in *B. maxima*. The first type is shown in Fig. 13, where a male gamete has fused to the posterior half of a female gamete. The second type is where the posterior half of a male gamete attaches to or near the posterior end of the female gamete (Fig. 14). The

Fig. 11. Eight sections (numbers 1, 3, 4, 6, 7, 8, 10, 13) from a series through a young zygote fixed two minutes after mixing. Note a long lumen formed along the fusion site due to the incompleteness of cytoplasmic continuity. It is open to the cell exterior at the posterior end of the male gamete (large arrow in Fig. 11g). Flagellar roots extend down from the female flagellar apparatus (♀) (large arrows Fig. 11a-c) and from the male (♂) (small arrows in Fig. 11a-b, and small arrows in Fig. 11e-g). See details in the text. ×16,000.



Figs. 12–15. Conjugating gametes fixed two minutes after mixing. Figures showing atypical modes of gametic fusion. b, basal bodies; ♂, male nucleus; ♀, female nucleus. 12, ×14,500. 13, ×13,000. 14, ×11,000. 15, ×8,300.

third type is where both gametes fuse to each other at their posterior ends (Fig. 15).

Zygotes fixed 25 minutes after mixing:

Zygotes are spherical at this stage (Fig. 16), but new cell wall has not been formed yet. The most prominent feature of zygotes at this stage is the appearance of variously-sized vacuoles containing small vesicles of about 60 nm in diameter. These vesicles are not present in unfused gametes. The flagellar apparatuses from both gametes are present as separate entities in the periphery of the zygotic cytoplasm (Fig. 16). The origin of each flagellar apparatus is identified by the presence of the crescent-shaped bodies specific to female gametes. The composition of the flagellar apparatus is the same as in unmixed gametes, except that the microtubular roots appear to dissolve as the cytoplasmic coalescence proceeds. The two sets of paired basal bodies are still continuous with their flagellar axonemes, indicating that they are absorbed into the cytoplasm through the cell surface (Fig. 17), similar to *Ulva mutabilis* (BRÅTEN 1971). Another event characteristic to this stage is nuclear fusion. Once the continuity of the outer nuclear membranes of both nuclei is established (Fig. 17), then the inner membranes coalesce (Fig. 18). The fusion or disintegration of chloroplasts and mitochondria was not observed. These events occur in this alga at a later stage of zygote maturation (HORI and KUROIWA in prep.).

Discussion

The mating reaction of the isogamous, biflagellate alga, *Chlamydomonas reinhardtii*, is initiated by an agglutination between the flagellar tips of mating type plus (mt^+) and minus (mt^-) gametes (SAGER and GRANICK 1954, GOODENOUGH and WEISS 1975), and then the extension of the fertilization tubule from the mt^+ cell surface to the mt^- cell, an event mediated by a mating structure of specialized cell membrane (FRIEDMANN *et al.* 1968, CAVALIER-SMITH 1975, GOODENOUGH and WEISS 1975, TRIEMER and BROWN 1975, WEISS *et al.* 1977).

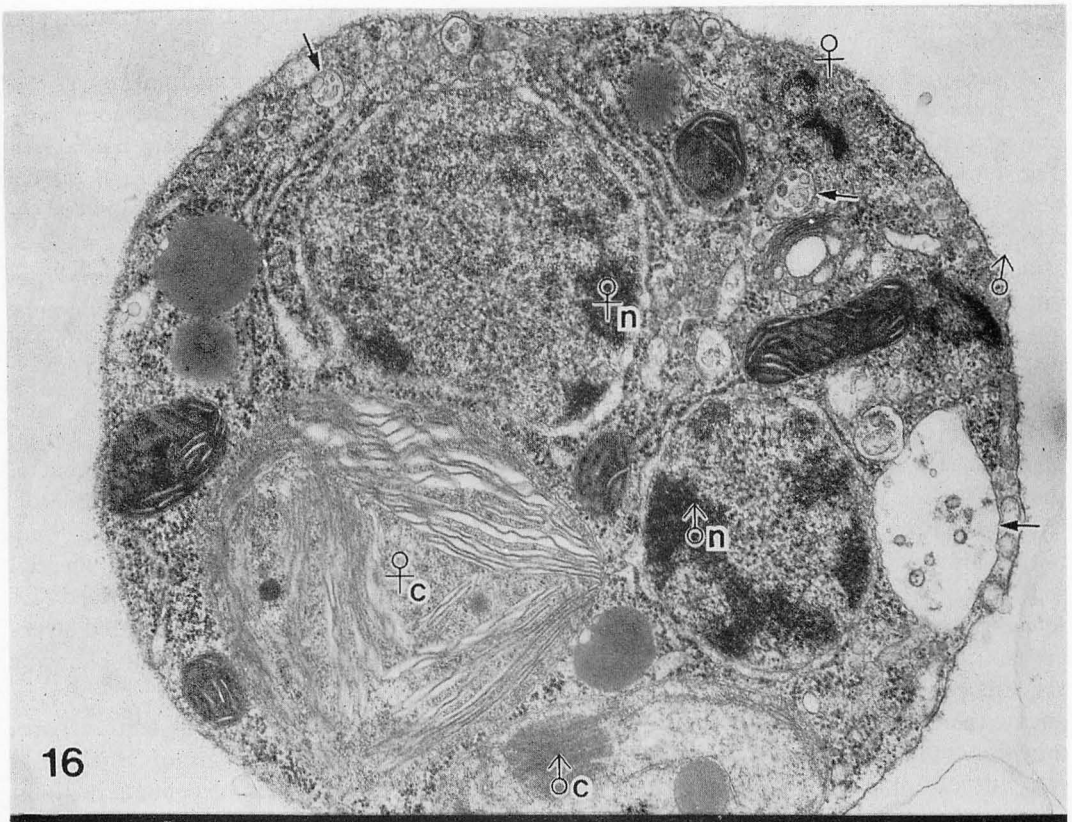
The multicellular green alga, *Hydrodictyon reticulatum*, produces isogamous gametes. One of the mating pair has a specialized structure of cell membrane (apical cap) which mediates gametic fusion (MARCHANT and PICKETT-HEAPS 1972).

BRÅTEN (1971) described *Ulva mutabilis* as isogamous and no morphological difference can be found between the two sex types of gametes even at the ultrastructural level. Another species, *U. lactuca*, produces a female gamete slightly larger than the male, but their ultrastructure is similar to that of *U. mutabilis* gametes (MELKONIAN 1980b). The mating structure of both gamete types of *U. lactuca* is a special region of the cell membrane. This region is oval-shaped (1.1 –0.7 μm) and is a rather complicated structure composed of four different elements (MELKONIAN 1980b).

Another more conspicuous feature common to this isogamous group of algae is that their gametes can germinate without fertilization (MARCHANT and PICKETT-HEAPS 1971, KOCHERT 1982, KOEMAN 1985).

In the oogamous alga, *Prasiola stipitata*, the membrane of one of the two spermatozoid flagella coalesces with the membrane of the egg, and the axoneme of that flagellum is incorporated into the egg protoplast (MANTON and FRIEDMANN 1960).

Male gametes of the coenocytic, anisogamous green algae, *Bryopsis maxima* (HORI 1977) and *B. lyngbyei* (MELKONIAN 1980a) have no mating structure. In female gametes of *B. lyngbyei* a cylindrical structure which is linked to the basal bodies overlies the two-membered microtubular root for some distance. This cylinder is suggested to represent a mating structure (MELKONIAN 1980b), but it has yet to be confirmed that it functions as such during gametic fusion because of an insufficient number of gamete pairs studied by electron microscopy (MELKONIAN 1980b). In the posterior region of the cylindrical structure, however, there is



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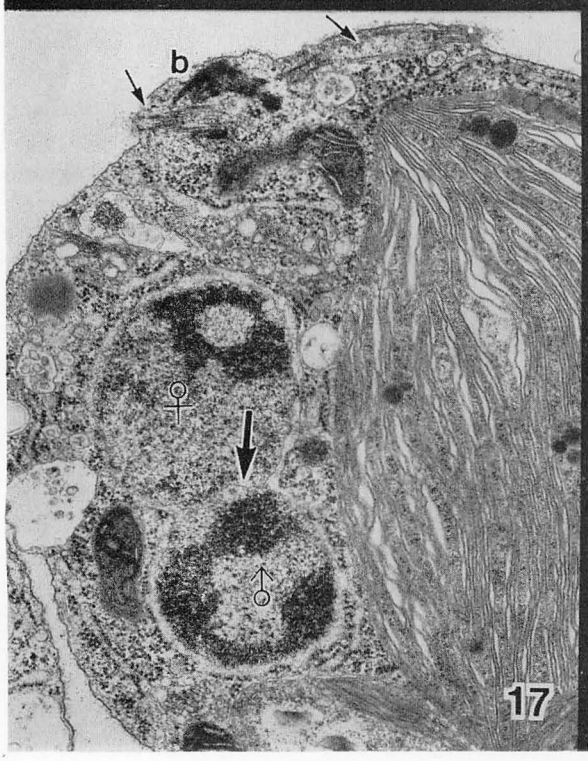

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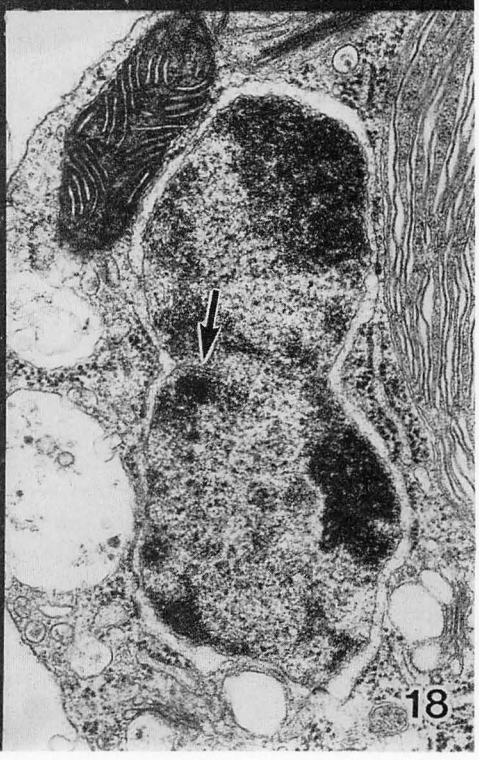

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an area of thickened cell membrane (which measures 300–400 nm in cross section) adjacent to the cell membrane overlaying the cylindrical structure. This specialized area of cell membrane resembles the mating structure found in the isogamous algae discussed above and in *B. maxima* (as well as in other ulvalean algae).

The gametic fusion of *B. maxima* usually occurs in a certain area of the female gamete membrane, which corresponds to the putative mating structure. In this alga, however, gametic fusion also occurs elsewhere on the female cell body. The male gametes do not have a putative mating structure and their fusion with the female gametes commonly occurs at an area near the basal part of the papilla, though it does occur at other areas of the male cell body too. This is conspicuously different from that in isogamous algae described above. Female and male gametes of *B. maxima* are not able to germinate without fertilization (TATEWAKI 1973).

Light microscopists have shown that anisogametes of coenocytic green algae can fuse with each other at any site as well as at the cell anterior; examples are found in *Pseudobryopsis* sp. (Figs. 262–3, 5a in OLTMANNS 1922), *Codium tomentosum* (Fig. 258 in OLTMANNS 1922), *C. fragile* (Fig. 1–7 in ARASAKI *et al.* 1956), *Halimeda cuneata* (Figs. 4M, N, P in CHIHARA 1956) and some other halimedean algae (Plate II-I in KAMURA 1966).

It has been observed by electron microscopy that female gametes of *Pseudobryopsis* sp. possess a dense staining region at cell membrane, and an electron-dense tubular extension along one of the outer microtubular roots (ROBERTS *et al.* 1982). These structures correspond to the features which MELKONIAN (1981) considered to be a putative mating structure in the female gamete of *B. lyngbyei*. The male gamete does not have these structures. *Derbesia* is also anisogamous, but both gamete types lack the mating structure and eyespot (ROBERTS *et al.* 1981). MELKONIAN (1981) suggested that the absence of a mating structure in the female gamete of *Derbesia* might be due to its lack of an eyespot.

The genus *Halimeda* is anisogamous and from light microscope studies female gametes are known to have an eyespot, but not male gametes (CHIHARA 1956, KAMURA 1966). GORI (1979) studied *Halimeda tuna* by electron microscopy, but he mentioned nothing about the presence or absence of a mating structure in the male gamete. If MELKONIAN's suggestion mentioned above is correct, the female gametes of *Halimeda* possess a putative mating structure as in other green siphons having eyespots. The male gametes of coenocytic green algae have no mating structure (ROBERTS *et al.* 1982), and no species is known in which the male gametes have an eyespot.

The putative mating structure has since been found in many other green algae by electron microscopy (O'KELLY and FLOYD 1983, FLOYD and O'KELLY 1984, O'KELLY *et al.* 1984, MIYAJI and HORI 1984). In all these cases the structure is similar to an area of thickened cell membrane as found in *U. lactuca* and *Chlamydomonas*. The position of the structure is restricted to a region close to the flagellar apparatus. At present, there is no evidence that the mating structure can move freely in the cell membrane. It has also been suggested that the mating structures are fixed at a certain position in the cell by the flagellar roots (GOODENOUGH and WEISS 1978, MELKONIAN 1980b). If the conjugation property of the mating structure of the coenocytic or anisogamous green

Figs. 16–18. Zygotes fixed 25 minutes after mixing. 16. Female (♀) and male (♂) nuclei (n), chloroplast (c) and basal bodies are present. Arrows indicate vesicles which specifically appear in the zygote cytoplasm after copulation. ×25,000. 17. Part of a zygote illustrating the uptake of the flagellar axonemes (small arrows) through the cell surface. Note nuclear fusion where the outer nuclear membrane is continuous, but the inner one (large arrow) is still intact. ×20,900. 18. A later stage of nuclear fusion than in Fig. 17. Arrow indicates remnants of the inner membrane. ×52,200.

algae functions properly as in isogamous algae, their gametes will fuse only at the cell anterior, at least in the female gametes. However, note that gamete fusion of anisogamous algae often occurs at a region far away from the putative mating structure of female gametes. Thus, it may be concluded that the mating structure, even if it occurs, does not function properly in the green siphons, or more generally, in anisogamous green algae. The mating structure found in female gametes of these algae probably represent a vestigial sexual organ.

The young zygotes of *U. lactuca* contain two sets of flagellar apparatuses originated from both sexes of gametes. They lie side by side within the zygote (see Fig. 29 in MELKONIAN 1980b). This arrangement indicates that the gametes fuse parallel to each other by using their mating structures. As the process ensues, zygotes become spherical. At present, the fate of these two sets of flagellar apparatuses at a much later stage of zygote maturation in *U. lactuca* is not known.

The two flagellar apparatuses in the early zygote of *B. maxima* lie in the same way as in *U. lactuca*. However, they soon separate in the zygote cytoplasm of *B. maxima* and later disappear. According to preliminary observations on early zygotes of *Monostroma latissimum* (unpublished observation) and *U. nitidum* (MOTOMURA personal communication) (both were fixed 30 minutes after mixing), four basal bodies originated from the two gamete types are arranged in the same manner as in quadriflagellate zoospores of *U. lactuca* (MELKONIAN 1979). At a very early stage of zygotic fusion (20 seconds after mixing) two sets of the flagellar apparatuses in *M. latissimum* lie in the same way (unpublished observation) as in the early zygotes of *B. maxima* and *U. lactuca*, that is, gamete pairs lie side by side with their longitudinal axes parallel to one another. These observations strongly suggest that the arrangement of the two sets of basal bodies is changed and rearranged as the zygotic maturation proceeds. Although the basal body arrangement in quadriflagellate zoospores of *M. latissimum* and *U. nitidum* has not been observed, they probably have the similar arrangement as that of the zoospores of *U. lactuca*.

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堀　輝三：オオハネモ（緑藻綱）の配偶子および配偶子接合の微細構造

異型配偶子緑藻オオハネモの配偶子，接合および接合子初期を微細構造的に解析し，他の異型および同型配偶子緑藻のそれと比較した。雌性配偶子は，他の多くの緑藻の配偶子でも知られているものと微細構造的に類似した配偶子接合装置をもつが，雄性配偶子はこれを欠く。配偶子の接合は雌性配偶子の接合装置か，あるいはそれに近傍の部位で起るのが最も一般的な様式である。しかし，本藻においては接合装置が関与しない接合もあるこ

とがわかった。これは，配偶子接合装置が同型配偶子緑藻における程には有効に機能しなくなっていることを示唆するものと考えられる。従って，より進んだ緑藻，特に異型性のグループでは接合装置が有性生殖に関わる一種の痕跡器官となっているのであろう。

接合子形成の初期（配偶子混合25分後まで）で，既に雌・雄核の融合は起るが，葉緑体，ミトコンドリアの融合または分解は起らない。接合子中における雌・雄配偶子由来の鞭毛装置構造の挙動についても論議した。

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Structure and Occurrence of Spermatangia in Caribbean *Bostrychia montagnei* HARVEY and *B. biuderi* HARVEY (Rhodomelaceae, Ceramiales)

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SMITH, C.M. and NORRIS, J.N. 1988. Structure and occurrece of spermtangia in Caribbean *Bostrychia montagnei* HARVEY and *B. binderi* HARVEY (Rhodomelaceae, Ceramiales). Jpn. J. Phycol. **36**: 123–137.

Plants of *Bostrychia montagnei* HARV. and *B. binderi* HARV. in culture conditions show different patterns of spermatangial development, and are described here for the first time. Male thalli of *B. montagnei* produced spermatangia continuously over a fertile branch, from the third to at least the 44th axial cell. Four primary parent cells were found per axial cell of recurved, fertile branches. Each primary parent cell (PPC) was pit-connected to at least three spermatium producing, secondary parent cells (SPC). A PPC bore as many as 19 cells in a dense aggregate, 4 of which were SPCs, and 15 immature and mature spermatia.

Male thalli of *B. binderi* produced spermatangia from the second to at least the 23rd axial cell. Four to five PPCs were observed borne from each axial cell of fertile areas on straight branches. Each PPC was pit-connected to a single secondary parent cell, which in turn was pit-connected to two SPCs and formed a row of cells. A PPC bore as many as 24 cells, 8 of which were SPCs, and 16 spermatia. For *B. binderi*, spermatangia produced by an individual branch could occur in as many as four distinct areas.

Spermatangial structures also differed among the closely related species group of *B. montagnei*, *B. arbuscula* HOOK. et HARV., *B. scorpioides* (HUDS.) MONT. ex KÜTZ. Similarly, spermatangial formation differed between closely related species, *B. binderi* and *B. tenella* (LAMOUR.) J. AG. These differences among male reproductive structures suggest that they may be important in the systematics of *Bostrychia* MONT. The simple nature of spermatangial construction among species of *Bostrychia* suggests that this is a primitive genus in the Rhodomelaceae.

Key Index Words: Bostrychia—*mangrove algae*—*Rhodophyta*—*Rhodomelaceae*—*species concepts*—*spermatangia*

The taxonomy of the red algal genus *Bostrychia* MONTAGNE (1842) (Rhodomelaceae, Ceramiales) is based exclusively on vegetative morphology, and includes several subgeneric groups (POST 1936). For example, within the group "Flagellifulcratae" (POST 1936:7) is a subgroup of *B. scorpioides* (HUDS.) MONT. ex KÜTZ., *B. arbuscula* HOOK. et HARV. and *B. montagnei* HARV. that has 1) haptera derived from pericentral cells, 2) two pericentral cells per axis cell when viewed laterally, 3) at least one layer of cortication, 4) no differentiation between upright and prostrate axes, and 5) only polysiphonous ultimate branchlets. These species differ in the extent of cortication, and form of main axes (POST 1936).

Another subgroup of "Flagellifulcratae" (POST 1936:6) is composed of *B. binderi* HARV. and *B. tenella* (LAMOUR.) J. AG., which share haptera derived from pericentral cells, and have one to three layers of cortication, but *B. calliptera* MONT. differs from the latter two in having a cortex of rhizoidal filaments (POST 1936). The siphonous nature of branchlets differs among these species (POST 1936; TSENG 1943).

These taxonomic characters given by POST (1936) have been widely accepted and used to identify species of *Bostrychia* (e.g.,

TSENG 1943; DAWSON 1954; JOLY 1954; TAYLOR 1960; WOMERSLEY and BAILEY 1970; TSUDA and WRAY 1977; CORDEIRO-MARINO 1978; KUMANO 1979; LAWSON and JOHN 1982; SCHNETTER and BULA-MEYER 1982; TANAKA and CHIHARA 1984 a, b; KING and PUTTOCK 1986; LEWIS and NORRIS 1987; SILVA *et al.* 1987). Use of vegetative morphology for species definitions, possibly because of the apparent rarity of reproductive thalli in field collections, has resulted in few detailed descriptions for gametangial and tetrasporangial stages of *Bostrychia* species. About one third of the known species have spermatangial plants described in detail (FALKENBERG 1901; NEWTON 1931; HOMMERSAND 1963; PRUD'HOMME VAN REINE and SLUIMAN 1980; TANAKA and CHIHARA 1984; KING and PUTTOCK 1986).

Reproductive structures used as taxonomic characters, as are so widely employed in the taxonomy of other algae, have been rarely employed in the systematics of *Bostrychia*. Here, we describe spermatangial development in *B. montagnei* HARV. (1853) and *B. binderi* HARV. (1848), species which represent different subgroups in the genus. Our work indicates that male thalli are not only useful to the taxonomy of *Bostrychia*, but represent phylogenetic markers for the family Rhodomelaceae.

Materials and Methods

Isolates for culture of *B. montagnei* were collected in February and March 1986 from red mangrove prop roots (*Rhizophora mangle* L.) growing at Twin Cays, Belize (Lat. 16°48′ N, Long. 88°05′ W) and Big Pine Key, Florida, U.S.A. (Lat. 24°39′ N, Long. 81°20′ W). Whole plants were cleaned of contaminants and placed in 100 mls of 0.22 μm Millepore-filtered seawater, enriched to 1% of Enriched Seawater Recipe (PES) (MCLACHLAN 1973) at 32‰ salinity, under culture numbers *CMS* –10011, –10040, –10079 and –10086. Cultured isolates of *B. binderi* from Puerto Rico were obtained from John A. WEST, University of California, under culture number *JAW* 2514. Thalli of both species were allowed to grow under a 14:10 L:D at <100 μmol quanta from fluorescent cool white bulbs, at a temperature of 25°C.

Media was changed approximately every two months. At the end of the first interval, nutrient levels were elevated by a 10% increase in PES; all other conditions were held constant.

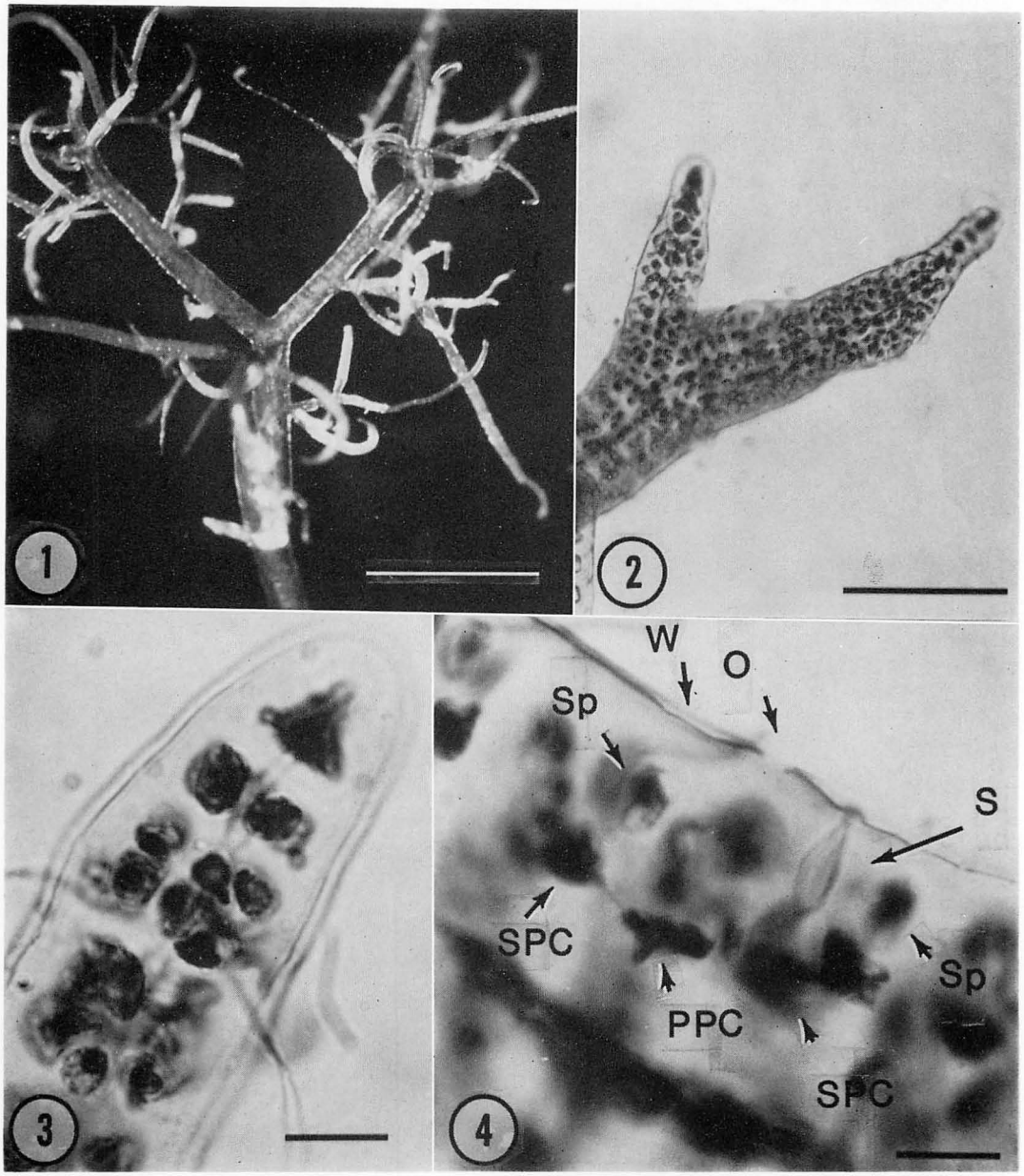
Specimens for morphological study were stained with aniline blue, and permanently mounted on microscope slides (TSUDA and ABBOTT 1985). Voucher specimens and microscope slides are deposited in the Algal Collection of the U.S. National Herbarium (US), National Museum of Natural History, Smithsonian Institution, Washington D.C., U.S.A.

Results

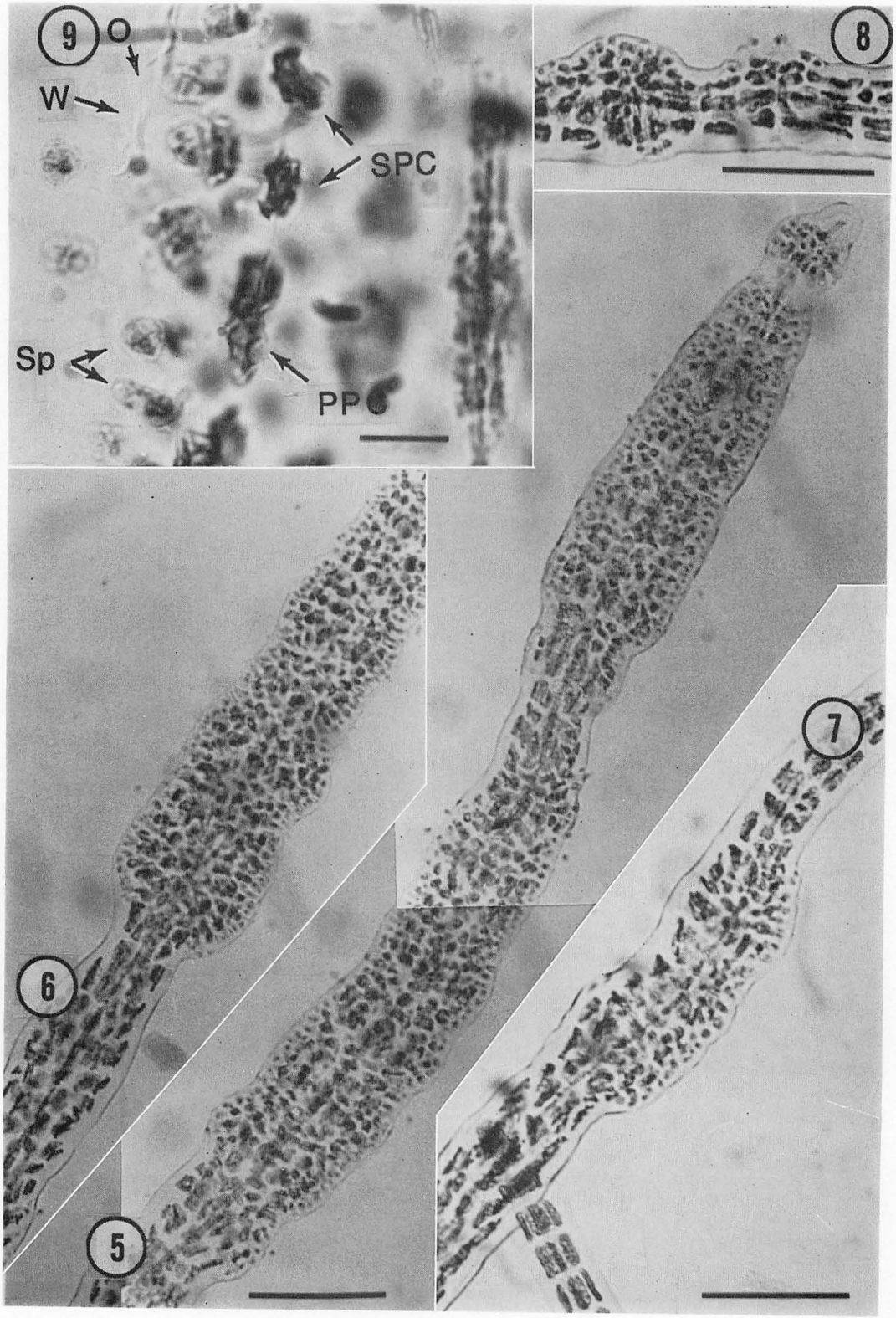
Spermatangia of Bostrychia montagnei.

By the end of the third month in culture, fertile areas developed from newly developed branches as cortical tissues became reproductive (Figs. 1, 2). A greater rate of cell division on ventral (adaxial) sides of fertile areas was evident at the third to fifth axial cells, and resulted in curved branches which frequently rebranched (Figs. 1, 2). Spermatangial areas developed behind a prominent dome-shaped apical cell and a small, plate-like, second axial cell. Frequently by the third axial cell, immature spermatangia were present (Fig. 3). Spermatangial areas extended over as many as 44 axial cells, with $\bar{X}=31.3$ cells ± 8.11 S.D., $n=12$.

Bases of spermatangia were larger than adjoining vegetative areas, and axial cells were shorter cells than cells in vegetative areas ($\bar{X}=31.7$ μm ± 8.06 S.D. for reproductive axial cells versus 53.2 μm ± 14.70 S.D. for vegetative axial cells, $n=12$). Because axial cells were equivalent in width ($\bar{X}=6.1$ μm ± 1.55 S.D. vs. 6.4 μm ± 1.25 S.D., $n=12$, respectively), axial cells in spermatangial areas appeared more



Figures 1 to 4. Male thalli of *Bostrychia montagnei*. Fig. 1. Fertile curved branches of a mature male thallus. Scale bar=250 mm. Fig. 2. Young male branch showing branching. Scale bar=100 μm. Fig. 3. Immature spermatangia are present at the third axial cell. Scale bar=10 μm. Fig. 4. Details of primary parent cell (PPC) and secondary parent cells (SPCs), and spermatia (Sp) focused near the plane of the axial cell. Note empty spermatangium (S) and an opening (O) in the cell wall (W) through which spermatia are released. Scale bar=10 μm.


9
O
W
SPC
Sp
PPC
8
7
6
5

prominently than cells in vegetative areas.

From the third and to the end of a spermatangial area, four primary parent cells (=mother cells)[1] were found per axial cell. A primary parent cell (PPC) was adaxially pit-connected to the axial cell, and abaxially pit-connected to two or three secondary parent cells (SPC) (Figs. 4, 10). In contrast to mature ovoid spermatia, parent cells were larger, darkly stained, had dense cytoplasm, and were somewhat star-shaped (Figs. 4, 10). These cells produced multiple spermatia. In several, a third row of cells was also observed to produce multiple spermatia. Empty spermatangia remain after release of spermatia (Fig. 4).

Thus, one PPC produced as many as 19 cells in a dense aggregate, four of which were SPCs, and 15 of which developed into spermatangia. Lengths of parent cells ranged from 5.2 to 9.9 μm on the longer axis, with a mean length, $\bar{X}=7.4$ μm ± 1.61 S.D., and mean width, $\bar{X}=4.7$ μm ± 0.87 S.D., n=12.

Production of spermatangia was prolific by *B. montagnei*, with every major growing point producing spermatia, including newly developed monosiphonous filaments which were re-growing from an excised end of the main axis. Mature spermatia were nearly ovoid, highly vacuolate cells, each with a single large nucleus (Fig. 4). Sizes of spermatia ranged from 6.4 to 9.9 μm with a mean length, $\bar{X}=6.9$ μm ± 1.47 S.D. and a mean width, $\bar{X}=4.3$ μm ± 0.76 S.D., n=12. As mature spermatia were released from the overlying cell wall, they lacked conspicuous wings or projections.

[1] The term "mother" in botany is "usually used in the sense of 'parent'" (JACKSON 1928); herein we follow SCHMID (1977) in an effort to avoid inaccuracies and bias in anatomical and morphological terminology.

Spermatangia of Bostrychia binderi.

Fertile areas on branches of *B. binderi* occurred either apically or distally on otherwise unmodified, corticated, vegetative branches, and about half of all fertile branches in this isolate had discontinuous areas of spermatangial production (Figs. 5, 8). One branch for example, had four discrete areas where spermatangia were produced, an apical area and three other spermatangial regions separated by regions of three to as many as nine vegetative axial cells (Fig. 5). Spermatangial production began at the third to the seventh axial cell in apical patch, and continued to as many as the 23rd axial cell. Axial cells in reproductive portions were as long as cells in vegetative branches of similar length (38.1 μm ± 3.48 S.D. versus 39.7 μm ± 8.40 S.D., n=12, respectively, Fig. 6). Lateral, partially monosiphonous branchlets never bore spermatangia.

In five fertile branches, spermatangia were produced predominantly on one side for as many as six axial cells (Figs. 7, 8). These asymmetric developments of spermatangia were distal to a branch apex, and were usually less than four axial cell long.

In apical areas, four PPCs were observed, while at distal regions, up to five PPCs were found. A PPC was pit-connected to a SPC which in turn was pit-connected to other SPCs in an uniseriate row; a row was composed of two to three SPCs (Figs. 9, 10). A PPC was larger than SPCs, and ranged in length from 6.4 to 11.6 μm, with a mean length, $\bar{X}=8.6$ μm ± 5.57 S.D., and a mean width, $\bar{X}=6.3$ μm ± 1.84 S.D., n=12.

One PPC supported as many as 24 cells, 8 SPCs, and 16 developing spermatia. The ovoid spermatia of *B. binderi* ranged in length from 5.2 to 7.5 μm with a mean

Figures 5 to 9. Male thalli of *Bostrychia binderi*. Fig. 5. Fertile portions separated by vegetative cells on a mature branch. Scale bar=100 μm. Fig. 6. Enlarged base of a fertile area. Scale bar=100 μm. Fig. 7. Asymmetric development of a fertile patch on a branch. Scale bar=100 μm. Fig. 8. Asymmetric and disjoint developments of spermatangia on a branch. Scale bar=100 μm. Fig. 9. Details of primary (PPC) and secondary (SPC) spermatangial parent cells and spermatia (Sp) focused on the plane of the axial cell. Note an opening (O) in the cell wall (W) through which spermatia are released. Scale bar=10 μm.

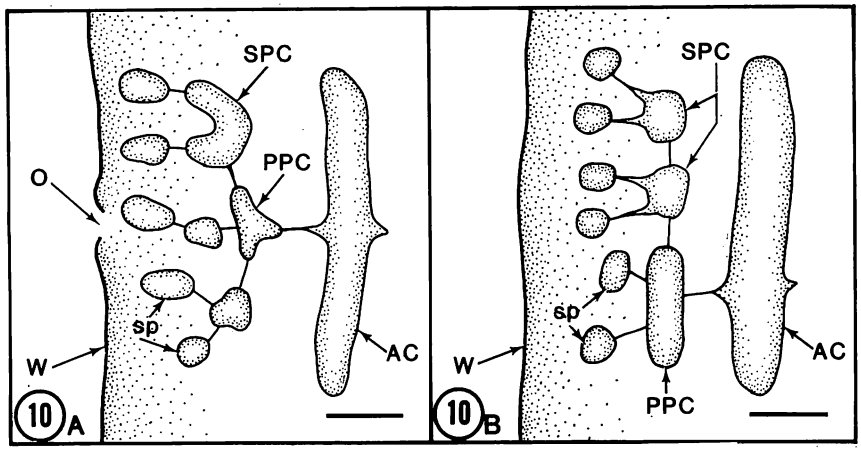


Fig. 10. Comparison of male reproductive structures showing (10A) the branched relationship of a primary parent cell (PPC) to secondary parent cells (SPCs) in a di- or trichotomous arrangement for *B. montangnei*, and (10B) the linear arrangement of a single primary parent cell (PPC) connection to chains of secondary parent cells (SPCs) for *B. binderi*. Scale bar=10 μm.

length, $\bar{X}$=6.4 μm ±0.63 S.D., and a mean width, $\bar{X}$=4.3 μm ±0.63 S.D., n=12.

Discussion

The goal of this research was to describe spermatangia for two species of *Bostrychia* (sensu POST 1936) which, on vegetative grounds, belong to two species groups (sensu POST 1936). Even though *B. montagnei* and *B. binderi* are not apparently closely allied species, we found that spermatangia developed in ordinary branches, and spermatangia supplanted superficial cortical cells in fertile branches. Both species had similarly sized, ovoid, vacuolate spermatia which lacked the conspicuous wings as seen in *Agloathmnion neglectum* (MAGRUDER 1984). Thus, certain characteristics of spermatangial development appear to be conserved in this genus.

However, these species did differ in the shape of thallus branches which bear spermatangia, and details of primary and secondary parent cell arrangements (Table 1). For *B. montagnei*, the tissues which produced spermatangia recurved, and entire branches were dedicated to prolific spermatangial production. For *B. binderi* under similar growth conditions, there was little modification of polysiphonous vegetative branches which ultimately bore spermatangia. *Bostrychia binderi* had as many as four distinct areas which produced spermatangia on a branch, and some areas developed asymmetric fertile regions. In comparison to *B. montagnei*, spermatangial production by *B. binderi* was less regular, with less differentiation of specialized branches.

Because *B. binderi* was able to produce spermatangia in small, unmodified areas, this species and its close relative *B. tenella* may produce small numbers of spermatangia under a wide range of environmental conditions. In contrast, because whole branches were dedicated to spermatangial production for *B. montagnei*, that species may produce large numbers of spermatangia, infrequently. This hypothesis would help explain why males had not been reported before for *B. montagnei* and why they are rare for its closest relative *B. scorpioides* (PRUD'HOMME VAN REINE and SLUIMAN 1980). By comparison, males for *B. tenella* have been described since 1901 (FALKENBERG 1901).

Other differences existed among these

two species. For *B. montagnei*, a PPC was directly pit-connected to several SPCs in a di- or trichotomy of cells, while for *B. binderi*, a PPC was pit-connected to a uniseriate filament of parent cells, and not directly pit-connected to each parent cell (Figs. 4, 9, 10). Pit-connections of PPC to axial cells were centrally located for *B. montagnei* while somewhat more basally located for *B. binderi* as well as for *B. tenella* as described by FALKENBERG (1901) based on Tongan specimens, not type-locality material.

Comparison of spermatangia of B. montagnei, B. arbuscula and B. scorpioides.

Some similarities exist in the production of spermatangia among *B. montagnei* and its morphologically similar species, *B. arbuscula* and *B. scorpioides*. Similar to *B. montagnei*, spermatangia in *B. arbuscula* and *B. scorpioides* develop in ordinary branches (HOMMERSAND 1963, PRUD'HOMME VAN REINE and SLUIMAN 1980), and spermatangia replace cortical cells in a branch. Spermatangial branches of *B. arbuscula* coil to the ventral side, as a result of the development of a two-layered cortex on the dorsal side of these branches (HOMMERSAND 1963). Spermatangial branches of *B. montagnei* coil to the ventral side because of a multiplication of cells in the existing layer on the dorsal side of a branch. Though no curve is reported in male branches of *B. scorpioides* (PRUD'HOMME VAN REINE and SLUIMAN 1980), those branches studied may have been relatively straight, mature branches which secondarily developed spermatangia. An illustration of mature spermatangial branches for *B. scorpioides* (Fig. 206-E, NEWTON 1931) shows inflated, somewhat curved branches, only slightly similar to those pictured for *B. arbuscula* by HOMMERSAND (Plate 5, HOMMERSAND 1963).

Some of the differences between *B. arbuscula* and *B. montagnei* are found in analysis of fertile branch construction. In *B. arbuscula*, fertile portions are found at the morphological point in a branch where six pericentral cells occurred per axial cell (Table 1, HOMMERSAND 1963). With continued growth of these branches, the number of pericentral cells reduces to four per axial cell, i.e., the number per axial cell observed here for fertile branches of *B. montagnei*. For *B. arbuscula*, fertile apices cease branching at that time, and tips grow to lengths of 50 or more segments (HOMMERSAND 1963); spermatangia are formed at the sixth or eighth segment behind the apex, and continue for the next 10 to 15 segments; beyond that region, empty spermatangia are found (HOMMERSAND 1963). For *B. montagnei*, we found spermatangia produced at the third axial cell, to at least a length of about 30 segments of fertile tissue. In this species, branching of fertile branches occurred at many stages of spermatangial production.

Mature branches are found to produce spermatangia in *B. scorpioides* (PRUD'HOMME VAN REINE and SLUIMAN 1980), and in NEWTON's (1931) illustration they bear a resemblance to some branches seen here for *B. montagnei*. Further comparisons between *B. montagnei* and *B. scorpioides* are limited (Table 1) because *B. scorpioides* did not produce males in culture (PRUD'HOMME VAN REINE and SLUIMAN 1980).

Bostrychia arbuscula and *B. montagnei* were similar in many aspects of spermatangial tissues. Geographical distributions of these related species, however, does not overlap (Table 1). Supplemental investigations are needed to test if Atlantic isolates of the widespread species *B. scorpioides* and *B. montagnei* are closely related by providing missing details of male development for *B. scorpioides*. These data may also identify interesting population-based differences for Australian individuals of *B. scorpioides*, and help clarify the relation between *B. arbuscula* and *B. montagnei*.

Comparison of spermatangia of B. binderi, B. tenella and B. calliptera.

FALKENBERG's illustration of a cross-section through male tissues of *B. tenella* from the south Pacific island of Tonga (Fig. 11, FALKENBERG 1901) shows a very similar

Table 1. Comparison of vegetative morphology, spermatangial characteristics and distribution for species of *Bostrychia* where spermatangia have been described.

	MORPHOLOGY		DISTRIBUTION
Species	Vegetative	Spermatial	Type locality & Range
B. arbuscula	several layers cort[1] haptera: no ax habit: flattened	4 to 6 pc/ax[2] 6 to 50 segs ? spc/ax 3 sp/spc ventral diff	Otago, New Zealand[1,2] endemic to New Zealand
B. montagnei	several layers (<7) cort[1] haptera: no ax habit: radial	4 pc/ax 3 to >44 segs 16 to 20 spc/ax 2 to 3 sp/spc ventral diff	Key West, Florida[3,4] Caribbean, W Africa
B. scorpioides	1 to 2 layer cort[1] haptera: no ax habit: distichous branching	6 (?) pc/ax[5,10] ? segs ? spc/ax 2 to 3 sp/spc no ventral diff	Selsey, England[3,4,5] Australia, So. Africa Europe, New Zealand S America,
B. binderi	1 to 3 layers[1,3] haptera: no ax habit: tripinnate branching	4 to 5 pc/ax 1 to 23 segs 12 to 45 spc/ax 3 to 4 sp/spc no ventral diff	Durban, So. Africa[1] Caribbean, S America Indian, Australia W tropical Pacific
B. tenella	1 to 3 layers cort[1,9] haptera: no ax habit: distichous branching	4 (?) pc/ax[8] 8 to ? segs ? spc/ax 2 (?) sp/spc no ventral diff	Christiansted, St. Croix[1,9] Caribbean, Africa Indian, China W tropical Pacific
B. kelanensis	no cort[1] haptera: w/ ax habit: short branches	5 to 6 pc/ax[6] 6 to 26 segs 14 to 19 spc/ax 1 to 2 sp/spc diff not noted	Kelana, New Guinea[1] India, Sumatra Australia
B. pinnata	no cort[6,7] haptera: w/ ax habit: pinnate branching	5 pc/ax[7] 9 to 15 segs 40 to 60 spc/ax 1 to 4 sp/spc ventral diff	Okinawa, Japan[6,7] Japan, Australia

Key to Terms: ax=axial cell; segs=length of fertile area in numbers of axial cells; cort=cortication; diff=fertile branch differentation; pc=pericentral cell; spc=spermatangial parent cell; sp=spermatium (a).

References: [1]POST 1936; [2]HOMMERSAND 1963; [3]TAYLOR 1960; [4]SLUIMAN 1979; [5]PRUD'HOMME VAN REINE and SLUIMAN 1980; [6]TANAKA and CHIHARA 1984a; [7]KING and PUTTOCK 1986; [8]FALKENBERG 1901; [9]BØRGESEN 1918; [10]NEWTON 1931.

shape of spermatangial branches and arrangement of primary and secondary parent cells as reported here for *B. binderi*. FALKENBERG depicts a PPC pit-connected to the base of an axial cell, which in turn is pit-connected to a SPC. Both types of parent cells have two associated spermatangia. For *B. binderi*, two or more SPCs were pit-connected in a row (Fig. 10B) with one or more rows of SPCs pit-connected to a single

primary parent cell. Primary parent cells were typically pit-connected near the base of axial cells. For *B. binderi*, no PPC was observed producing spermatangia, while for *B. tenella*, our interpretation of FALKENBERG's illustration suggests that spermatangia are produced by PPC. In contrast with two or more SPCs observed here for *B. binderi*, *B. tenella* (FALKENBERG 1901) had only one SPC attached to each PPC.

Bostrychia tenella and *B. binderi* are pantropical (Table 1), with nearly complete overlap in distribution, and vegetative habit (POST 1936, TSENG 1943). While these species are similar in details of construction of spermatangial tissues, how much these details may vary with biogeographical distribution is unknown. Comparisons with the other species of this subgeneric group such as *B. calliptera*, are not possible because no description for its males exists. Descriptions of males from Pacific and Atlantic populations of *B. calliptera* might help test recognition of this group.

Among related species of *Bostrychia*, there are distinctions in the spermatangial developmental processes. Comparisons with details of males for other, less related species, *B. kelanensis* Grunow (TANAKA and CHIHARA 1984b), and *B. pinnata* TANAKA et CHIHARA (KING and PUTTOCK 1986), demonstrate that numbers of pericentral cells per axial cell, numbers of fertile segments, as well as spermatangial parent cells per axial cell differ (Table 1).

Comparison of spermatangia among genera.

A comparison of spermatangial tissues among genera of the Rhodomelaceae demonstrates that *Bostrychia* has the least complex spermatangia. Spermatangia of *Murrayella* SCHMITZ and some species of *Polysiphonia* GREV. are strikingly similar in gross morphology to those of *B. binderi* and *B. tenella* (GRUBB 1924; APONTE and BALLANTINE 1987). In contrast, many genera have highly modified spermatangia, such as those derived from trichoblasts for some species of *Herposiphonia* NÄEGLI (BØRGESEN 1918; NORRIS and BUCHER 1982) and *Polysiphonia* GREV. (BØRGESEN 1918), conceptacle-like terminal pockets in branchlets of *Laurencia* LAMOUR. (SAITO 1967), kidney-shaped appendages for *Digenia* C. AG. (BØRGESEN 1920), or plate-like forms for *Chondria* C. AG. and *Acanthophora* LAMOUR. (BØRGESEN 1918). These comparisons suggest that based on anatomy of spermatangial tissues, *Bostrychia* is a relatively primitive genus in the Rhodomelaceae, as suggested by HOMMERSAND (1963).

For species of *Bostrychia*, these studies show the details of spermatangial development, reveal similarities and differences between different subgeneric groups associated on vegetative grounds. Additionally, comparison with other genera in the Rhodomelaceae suggests that *Bostrychia* is a primitive genus of relatively simple, undifferentiated reproductive structures.

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Celia M. SMITH*, & James N. NORRIS: カリブ海産 *Bostrychia montagnei* HARVEY と *B. binderi* HARVEY（フジマツモ科，イギス目）における精子嚢の存在と構造**

表記の2種を培養した結果，それぞれ精子嚢の発達のタイプが異ることが分かった。

B. montagnei の雄株では，精子嚢は3番目から少なくとも44番目までの中軸細胞から形成される。カーブした成熟した枝の中軸細胞1細胞当たり，4個の精子嚢の親細胞が生じる。それぞれの精子嚢の1次親細胞 (PPC) は，精子嚢を造る少なくとも3個の2次親細胞 (SPC) とピット・コネクションで連絡する。1次親細胞 (PPC) は，15細胞が集合しており，内4細胞が2次親細胞 (SPC)，15細胞が不捻または捻性のある精子嚢である。

B. binderi の雄株では，精子嚢は2番目から少なくとも23番目までの中軸細胞から形成される。真っ直ぐの成熟した枝の中軸細胞1細胞当たり，4－5個の精子嚢の親細胞が生じる。それぞれの精子嚢の1次親細胞 (PPC) は，1個の2次親細胞 (SPC) と，更に順に2個の2次親細胞と，1列に連絡している。1次親細胞 (PPC) は，24細胞が集合しており，内8細胞が2次親細胞 (SPC)，16細胞が精子嚢である。 (*Department of Botany, National Museum of Natural History, Smithsonian Institution, **Department of Botany, University of Hawaii)

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Taxonomic notes on *Polysiphonia senticulosa* HARVEY and *P. pungens* HOLLENBERG (Ceramiales, Rhodophyta)

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KUDO, T. and MASUDA, M. 1988. Taxonomic notes on *Polysiphonia senticulosa* HARVEY and *P. pungens* HOLLENBERG (Ceramiales, Rhodophyta). Jpn. J. Phycol. **36**: 138–142.

The holotype specimens of *Polysiphonia senticulosa* HARVEY and *P. pungens* HOLLENBERG were examined. These specimens have the following features in common: the thallus is slender and profusely branched; it has four pericentral cells; it lacks cortical cells; axillary branches are formed endogenously from the central axial cells; and ultimate branchlets are sharply pointed. The similarity between the two species warrants the reduction of *P. pungens* to a synonym of *P. senticulosa*. This species is similar to *P. morrowii* HARVEY in many of the above features. However, *P. morrowii* is distinguished from *P. senticulosa* by its thicker thalli and greater number of axillary tetrasporangial branchlets.

Key Index Words: Ceramiales—Polysiphonia—P. morrowii—P. pungens—P. senticulosa—*Rhodomelaceae—Rhodophyta—taxonomy.*

Polysiphonia senticulosa was first described by HARVEY (1862) on the basis of materials collected at Orcas Island, Washington, U.S.A. Since then, it has been reported from several localities in the north-eastern and north-western Pacific (KYLIN 1941, SEGI 1951), although its reported occurrence in Japan was discounted later by KUDO and MASUDA (1981).

KYLIN (1941) described a new genus, *Orcasia,* based on *P. senticulosa*. He believed that the presence of endogenously derived indeterminate axillary branches separated species in the genus *Orcasia* from those in *Polysiphonia*, though this distinction has not been recognized at the generic level (SEGI 1951, KUDO and MASUDA 1981, LINDSTROM *et al.* 1986). The occurrence of axillary branches arising endogenously from central axial cells is characteristic of two additional species: *Polysiphonia morrowii* HARVEY (KYLIN 1941, SEGI 1951, KUDO and MASUDA 1981, YOON 1986) and *P. pungens* HOLLENBERG (WOMERSLEY 1979).

P. morrowii was originally described by HARVEY (1856) from specimens collected at Hakodate, Hokkaido, Japan. This species is characterized by thick main axes and tufts of axillary tetrasporangial branchlets (SEGI 1951, KUDO and MASUDA 1981).

P. pungens was first described by HOLLENBERG (1942) on the basis of materials collected from Gravina Island, Alaska. This species is characterized by slender main axes and sharply pointed determinate branchlets. WOMERSLEY (1979) reported the presence of axillary branches in the holotype specimen, although HOLLENBERG (1942) did not mention this feature.

The geographical range of *P. pungens* overlaps that of *P. senticulosa* except in Australia, where *P. pungens* may have been introduced on the hulls of ships (WOMERSLEY 1979). Similarities between *P. senticulosa* and *P. pungens* have been noted by LINDSTROM *et al.* (1986). In this paper we demonstrate the conspecificity of these two species based on an examination of the

holotype specimens.

Materials and Methods

The holotype specimen of *Polysiphonia senticulosa* collected from Orcas Island (48° 40'N, 122°55'W) in April 1858 by D. LYALL and now preserved in the British Museum (Natural History) (BM) was examined on loan with the kind help of Mrs. L.M. IRVINE and Mr. S.I. HONEY. Three herbarium specimens of *P. pungens* determined by G.J. HOLLENBERG and now deposited in the Herbarium of the University of California, Berkeley were examined on loan with the kind help of Dr. P.C. SILVA: 1) the holotype specimen (tetrasporangial) collected at Vallenar Rock, Gravina Island (55°20'N, 131°45'W), Alaska in May 1913 by R.B. WYLIE (UC 314925); 2) tetrasporangial specimen collected at Qualicum, Vancouver Island, British Columbia by J. MACOUN (without date, UC 90940); and 3) vegetative specimen collected from Vancouver Island by J. MACOUN (No. 93, without date; UC 276575). The latter two specimens are also cited in the original description (HOLLENBERG 1942).

In addition, the following herbarium specimens of Alaskan *P. senticulosa* collected by S.C. LINDSTROM and deposited in the Phycological Herbarium, the University of British Columbia were examined on loan with the kind help of Mrs. J.C. OLIVEIRA: 1) tetrasporangial specimens from Campsite, Sea Otter Sound (55°48'40"N, 133°29'36" W) on June 1, 1981 (UBC A18303); 2) cystocarpic and tetrasporangial specimens from Southern Sea Otter Sound (55°47'54" N, 133°28'52"W) on June 1, 1981 (UBC A32726, 32727); and 3) cystocarpic and tetrasporangial specimens from Bridget Cove (58°38'N, 134°57'W) on July 24, 1979 (UBC A66021).

The specimens cited above were examined under a dissecting microscope. Small portions were mounted in 50% glycerol-seawater on microscope slides.

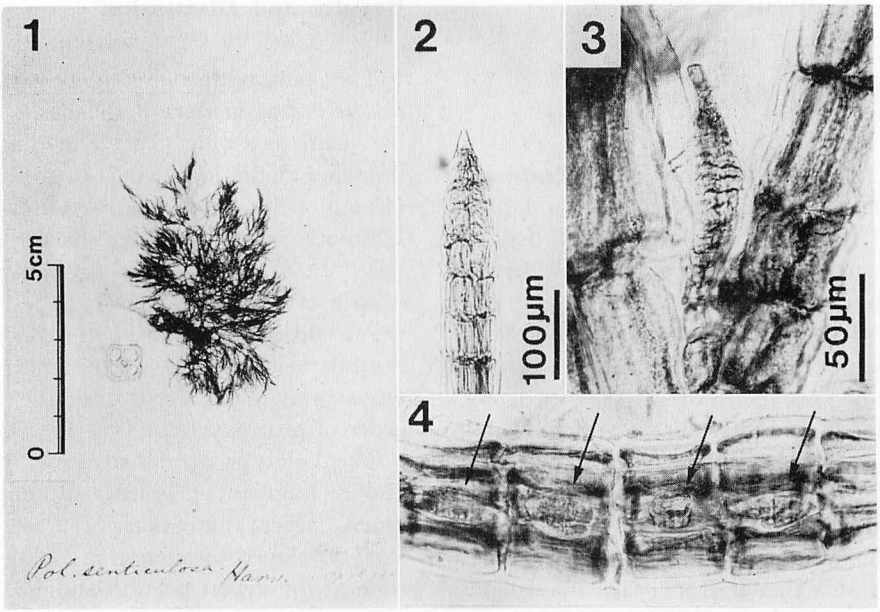
Results and Discussion

The holotype specimen of *Polysiphonia senticulosa* is fragmentary and lacks a discernible main axis (Fig. 1). The diameter of branches at the lowest part of the specimen (45 mm below the apex) are 200–215 μm. Ultimate branchlets are sharply pointed (Fig. 2). Each axillary branch develops from a central axial cell (Fig. 3). Adventitious rhizoids may arise from lower pericentral cells without septations. Young tetrasporangia are formed in the ultimate order of ordinary branches (Fig. 4).

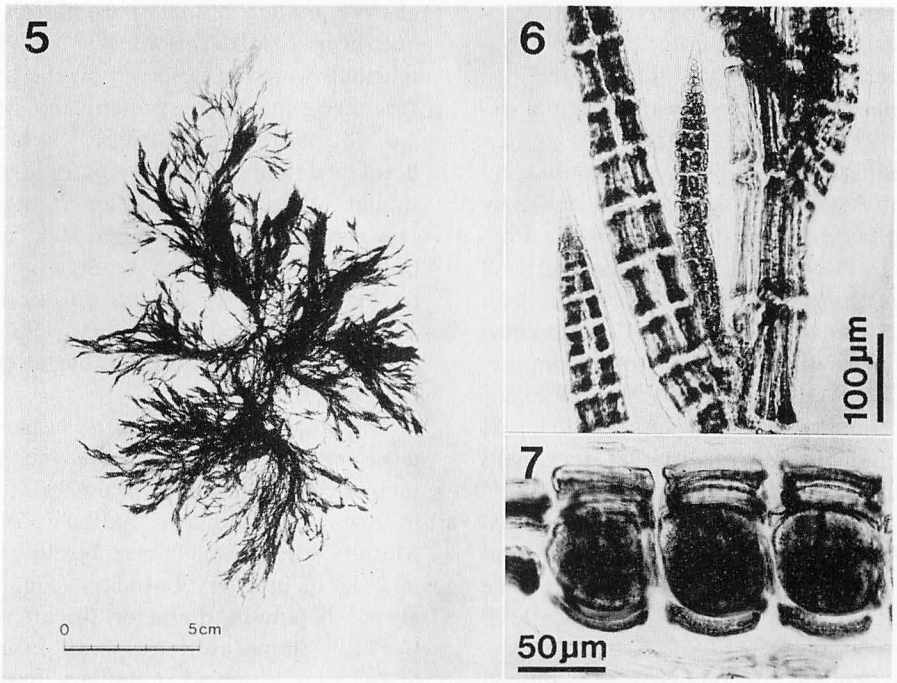
The holotype specimen of *P. pungens* is also a fragment (Fig. 5), although it is much larger than that of *P. senticulosa*. Well-developed branches are 235–240 μm wide at the lowest portion and 190–200 μm wide at 45 mm below the apex. Ultimate branchlets are sharply pointed as shown in the original illustration (HOLLENBERG 1942). One to three axillary branches develop from a single central axial cell (Fig. 6). Some of these axillary branches are indeterminate and bear 7–8 laterals in a spiral manner. Rhizoids were not observed on the holotype specimen, but were present on MACOUN No. 93 specimen (UC 276575), where they developed without septations in a manner similar to that described for *P. senticulosa*. However, since this specimen lacks ultimate branch tips and axillary branches, it cannot be identified as *P. pungens* with certainty. The other MACOUN specimen (UC 90940) is more complete and referable to the species concerned.

The holotype specimen of *P. pungens* bears tetrasporangia in the ultimate and penultimate orders of ordinary branches as well as in one of unbranched axillary branches. Mature tetrasporangia are borne in series of 2–12 in ordinary branches (Fig. 7) and are 65–85 μm in diameter (mean=73 μm, n=44). Immature tetrasporangia in series of 2–7 were observed in axillary branches.

The entire holotype specimen of *P. senticulosa* resembles the upper portion of the holotype of *P. pungens*. The more profuse



Figs 1–4. *Polysiphonia senticulosa* HARVEY. 1. Holotype specimen collected at Orcas Island in April 1858 by D. LYALL and deposited in BM. 2. Sharply pointed ultimate branchlet. 3. Young axillary branch arising endogenously from a central axial cell. 4. Young tetrasporangia (arrows) formed in an ordinary branch of the ultimate order. Figs 2–4 from the holotype specimen shown in Fig. 1. Scale in Fig. 3 applies also to Fig. 4.

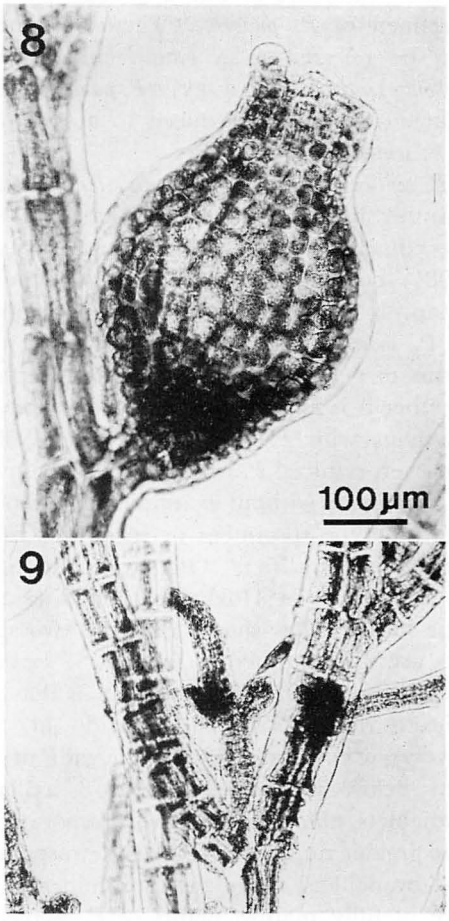


Figs 5–7. *Polysiphonia pungens* HOLLENBERG. 5. Holotype specimen collected at Vallenar Rock, Gravina Island in May 1913 by R. B. WYLIE and deposited in UC (90940). 6. Axillary branch arising endogenously from a central axial cell. 7. Mature tetrasporangia formed in an ordinary branch of the ultimate order. Figs 6, 7 from the holotype specimen shown in Fig. 5.

development of axillary branches in the May specimen of *P. pungens* suggests that the specimen represents more mature plants than the April specimen of *P. senticulosa*. The Alaskan specimens of *P. senticulosa* in UBC, collected in June and July near the type locality of *P. pungens*, show a development of axillary branches similar to that of the holotype of *P. pungens*.

The Alaskan specimens examined appear to be damaged, their uppermost portions were lacking. Adventitious branches are developed from some of the injured branches and from other positions on the plants. These Alaskan specimens are 130–150 μm wide at the lowest portion and have sharply pointed ultimate branchlets. One to three axillary branches originate from the central axial cell and are 320–750 μm long. Adventitious rhizoids develop from some of lower pericentral cells which are not cut off by septa from their parent cells. Tetrasporangia are formed both in ordinary branches in 2–9 series and in axillary branches in 2–7 series (sometimes individually). June tetrasporangial specimens bear three axillary branches, but only one of them form tetrasporangia. The majority of tetrasporangia in ordinary branches have already released their spores, but those in axillary branches bear both mature and immature sporangia. Mature sporangia are 65–80 μm in diameter. The maturation of tetrasporangia and occurrence of adventitious branches suggest that the Alaskan specimens examined were older than the holotype specimens of *P. senticulosa* and *P. pungens*.

Cystocarps of the Alaskan specimens are formed on the upper portions of ordinary branches. They are usually individually formed 2–4 segments apart. Mature cystocarps are urceolate and 430–560 μm long × 300–460 μm wide. Their ostiolar rims are 140–230 μm wide and almost equal to the diameter of necks (Fig. 8). Cystocarpic plants also bear single axillary branches (Fig. 9). These axillary branches are 250–550 μm long and bear procarpic trichoblasts and young cystocarps. They also form vegetative trichoblasts. Scar cells (the basal cells of fallen trichoblasts) are found at their proximal end.



Figs 8, 9. *Polysiphonia senticulosa* collected at Southern Sea Otter Sound, Alaska on June 1, 1981 by S. C. Lindstrom and deposited in UBC (A32726). 8. Mature cystocarp. 9. Axillary branch bearing young cystocarps. Scale in Fig. 8 applies also to Fig. 9.

All the specimens examined, except Macoun No. 93 (UC 276575), possess the following features in common: (1) the thallus is slender and profusely branched; (2) it has four pericentral cells; (3) it lacks cortical cells; (4) axillary branches originate endogenously from the central axial cells and contribute to reproductive activity; and (5) ultimate branchlets with limited growth are sharply pointed. The holotype

specimen of *P. senticulosa* is youngest among the specimens examined and bears young tetrasporangia only in ordinary branches. With age tetrasporangia may be formed in axillary branches as found in the holotype specimen of *P. pungens*. These specimens can be referred to a single entity, *Polysiphonia senticulosa* HARVEY. *P. pungens* HOLLENBERG should be reduced to a synonym of *P. senticulosa*.

P. senticulosa is similar to *P. morrowii* HARVEY in many of features stated in the preceding paragraph. KUDO and MASUDA (1981) concluded that *P. senticulosa* auct. japon. is included in the circumscription of *P. morrowii*, and pointed out that the status of genuine *P. senticulosa* is uncertain whether it is an independent species or synonymous with *P. morrowii*. YOON (1986), however, reduced *P. senticulosa* to a synonym of *P. morrowii* without examining the respective holotype specimens or specimens from their type localities. Our examination of *P. morrowii* from Hokkaido, including the type locality, has shown that the two species are distinguished as follows. *P. morrowii* differs from *P. senticulosa* in having thicker thalli (320–550 μm wide at the lower portion and 280–370 μm wide at 45 mm below the apex) and 7–8 axillary branchlets, all of which bear tetrasporangia. The greater number of axillary tetrasporangial branchlets is the most prominent feature of fully mature plants of *P. morrowii*, although their number varies according to season and ontogeny (KUDO and MASUDA 1981). On the other hand, the number of axillary tetrasporangial branchlets is 3 or less for fully mature plants of *P. senticulosa* and one of such branchlets is functional.

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工藤利彦・増田道夫：紅藻 *Polysiphonia senticulosa* HARVEY と *P. pungens* HOLLENBERG（イギス目フジマツモ科）について

Polysiphonia senticulosa HARVEY と *P. pungens* HOLLENBERG の正基準標本を調査した。これらの標本は以下の共通する特徴を持っている。(1) 藻体は細く，多数の枝を生じる。(2) 各節間には4個の周心細胞がある。(3) 皮層細胞を欠く。(4) 中心細胞から内生的に形成される枝が通常枝の腋から発達する（axillary branch）。(5) 限定生長する最末小枝の先端は鋭く尖る。このような類似から両者は同一種として扱われるべきであり，*P. pungens* は *P. senticulosa* の異名となる。上述したこの種の特徴の多くはモロイトグサ *P. morrowii* HARVEY とも共通する。しかし，モロイトグサは太い藻体を持つこと及び四分胞子嚢を形成する axillary branchlets が多数生じることで区別される。（060 札幌市北区北10条西8丁目 北海道大学理学部植物学教室）

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Scale-bearing chrysophytes in the south basin of Lake Biwa, Japan

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Ito. H. 1988. Scale-bearing chrysophytes in the south basin of Lake Biwa, Japan. Jpn. J. Phycol. **36**: 143–153.

In the south basin of Lake Biwa, 42 taxa of scale-bearing chrysophytes belonging to Mallomonadaceae and Paraphysomonadaceae; 14 species of *Mallomonas*, 5 of *Synura*, 1 of *Chrysosphaerella*, 5 of *Spiniferomonas* and 15 species, 1 subspecies and 1 forma of *Paraphysomonas* were found. Among them, 17 taxa; *Mallomonas portae-ferreae*, *M. pseudocoronata*, *M. striata* var. *striata*, *Spiniferomonas takahashii*, *Paraphysomonas caelifrica*, *P. capreolata*, *P. circumvallata*, *P. coronata*, *P. corynephora*, *P. glandiata*, *P. poteriophora* ssp. *manubriata*, *P. punctata*, *P. quadrispina*, *P. runcinifera*, *P. stelligera*, *P. subquadrangularis* and *P. undulata* were new to Japan.

Key Index Words: *Chrysophyceae*—Chrysosphaerella—*Lake Biwa*—*Mallomonadaceae*—Mallomonas—*Paraphysomonadaceae*—Paraphysomonas—Spiniferomonas—Synura—*Synurophyceae*.

Lake Biwa, with the surface area of 674 km^2 and the maximum depth of 104 m, is the largest lake in Japan and classified as the mesotrophic lake (Tezuka 1984). It is composed of two parts; a large and deep north basin, and a small and shallow south basin.

Of the scale-bearing chrysophytes only 3 species; *Mallomonas fastigata*, *M. helvetica* and *Synura uvella* have been recorded by a light microscopical study (Mori 1945; Negoro 1968). The scale-bearing chrysophytes such as *Mallomonas* and *Synura* (Mallomonadaceae) and *Paraphysomonas* (Paraphysomonadaceae) possess their charactaristics of species on their minute scales and bristles as well as their lorica form, therefore the electron microscopy is the most useful method to identify them accurately. Of the scale-bearing chrysophytes 55 taxa have been recorded from about 100 lakes and ponds excepting Lake Biwa in Japan by Takahashi (1978). Ito *et al.* (1981) found 12 taxa of scale-bearing chrysophytes by the electron microscopical investigation of one water sample which was collected from the south basin and they concluded that further study must give more new knowledge on the chrysophyte flora of this lake. Thereafter the author has carried out the floristic study on the scale-bearing chrysophytes in Lake Biwa. This paper deals with results of survey in the south basin of Lake Biwa during the period from 1980 to 1984.

Materials and Methods

Twenty five water samples were collected in 1 *l* bottles from the surface at 10 stations of the south basin of Lake Biwa (Fig. 1) in four seasons between January 1980 and July 1984 (Table 1). The water temperature at sampling sites ranged from 3.0 to 30.6°C and the pH from 7.0 to 9.5 throughout the study period. 0.5 *l* of each unfixed water sample was centrifuged at 3,000 r.p.m. for 10 min. and then concentrated to 1 m*l*. For transmission electron microscopy, 10 μl of each concentrated water sample was mounted on collodion-carbon coated grids,

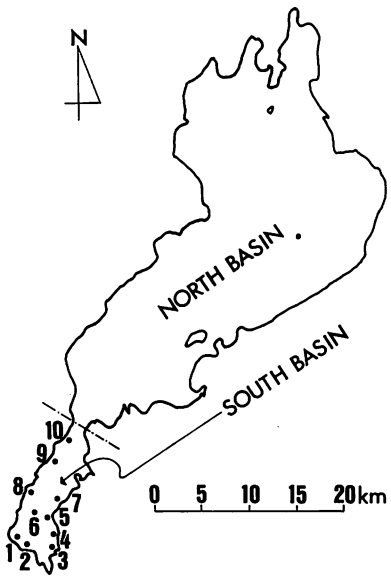

Fig. 1. Map showing Lake Biwa and ten sampling stations in the south basin.

Table 1 Sampling stations and dates in the south basin of Lake Biwa (1980–1984).

Stations	Dates	
Sta. 1	May 26, 1981	May 25, 1982
	Jul. 2, 1982	Aug. 20, 1982
	Sep. 3, 1982	Jan. 21, 1983
	May 20, 1983	Aug. 19, 1983
	Sep. 16, 1983	Oct. 21, 1983
	Apr. 2, 1984	
Sta. 2	Jul. 6, 1984	
Sta. 3	May 29, 1981	
Sta. 4	Jan. 25, 1980	Oct. 24, 1980
	Jan. 23, 1981	Mar. 26, 1981
	Jan. 22, 1982	Mar. 19, 1982
Sta. 5	Oct. 16, 1981	
Sta. 6	Aug. 21, 1981	
Sta. 7	Sep. 22, 1981	
Sta. 8	Sep. 22, 1981	
Sta. 9	Sep. 22, 1981	
Sta. 10	May 29, 1981	

desiccated in an oven, and then shadowed at about 20 degrees with Pt-Pd alloy. These samples were examined with a transmission electron microscope (JEM-100B). For scanning electron microscopy, 20 m*l* of each unfixed water sample was filtered with nuclepore filter (25 mm in diameter, 0.4 μm in pore size) and sometimes millipore filter (47 mm in diameter, 0.45 μm in pore size), desiccated in an oven and then coated with gold. These samples were examined with a scanning electron microscope (JEM-T200).

Results and Discussion

Out of 42 taxa found in the south basin of Lake Biwa;

Total 42 taxa; 14 species belonged to *Mallomonas*, 5 to *Synura*, 1 to *Chrysosphaerella*, 5 to *Spiniferomonas* and 15 species, 1 subspecies and 1 forma to *Paraphysomonas* (Table 2). The species whose distribution is not shown are widely distributed in the world.

Family Mallomonadaceae DIESING (1866)
Genus *Mallomonas* PERTY (1851)

Three species; *M. portae-ferreae*, *M. pseudocoronata* and *M. striata* var. *striata* were new to Japan.

M. acaroides PERTY emend. IVANOV (1899) Figs. 2, 3

Cells and scales were found in summer. This species generally occurs in summer (CRONBERG and KRISTIANSEN 1980).

M. akrokomos RUTTNER in PASCHER (1913) Fig. 4

Cells were found in winter and spring, and scales in summer. Although this species is classified as eurythermal (TAKAHASHI 1978), it has a preference for a low temperature (HARRIS 1958; KRISTIANSEN 1985; ROIJACKERS 1986; TAKAHASHI 1978).

M. alpina PASCHER et RUTTNER in PASCHER (1913) Fig. 5

Syn. *M. monograptus* HARRIS et BRADLEY (1960).

Cells and scales were found in spring. This species has also occurred during Feburary and April in a pond in The Netherlands (ROIJACKERS 1984).

M. annulata (HARRIS et BRADLEY) HARRIS (1967)

Cells were found in winter, and scales in spring.

M. caudata IVANOV emend. KRIEGER (1930)

Table 2. Scale-bearing chrysophytes collected from the south basin of Lake Biwa (1980–1984).

Season	W.		Spring					Summer				Autumn						
Month and sampling stations / Taxa	Jan. Sta. 1	Jan. Sta. 4	Mar. Sta. 4	Apr. Sta. 1	May Sta. 1	May Sta. 3	May Sta. 10	Jul. Sta. 1	Jul. Sta. 2	Aug. Sta. 1	Aug. Sta. 6	Sep. Sta. 1	Sep. Sta. 7	Sep. Sta. 8	Sep. Sta. 9	Oct. Sta. 1	Oct. Sta. 4	Oct. Sta. 5
Mallomonas acaroides									●	○								
M. akrokomos	○	●	●					○										
M. alpina				●	○													
M. annulata	●	●	○		○													
M. caudata		●														○		
M. crassisquama	○	○	○		○													
M. elongata	○	●			○				●	○								
M. heterospina		○																
M. parvula			○															
*M. portae-ferreae**				○								○				○		
*M. pseudocoronata**									●									
M. punctifera		○	○															
M. striata var. *striata**			●															
M. tonsurata	●	●	○	●	○		○	○	●	○				○		○	○	○
Synura curtispina			○														○	
S. glabra	○	●	●		○		○			○							○	
S. petersenii	○	○	○															
S. sphagnicola																	○	
S. spinosa		○																
Chrysosphaerella brevispina		○	○					●		○								
Spiniferomonas bourrellyi	●	●	○		●		○	●				○	○			●	○	
S. cornutus	●		●		○												○	
S. coronacircumspina					○			○									○	
*S. takahashii**		○	○								●							
S. trioralis	○	●	●		●		○	○		○	○	○	○	○	○	○		○
Paraphysomonas bandaiensis		○			●			●			○	●					●	
*P. caelifrica**							○				○		○		○		○	
*P. capreoiata**																	○	
*P. circumvallata**					○						○				○			
*P. coronata**	●																	
*P. corynephora**		○									○							
P. diademifera					○			○				●					●	
*P. glandiata**	○	○	○		○													
P. imperforata forma No. 2	○	●	○		●	○		○						○	○	○	●	
*P. poteriophora ssp. manubriata**		●	●															
*P. punctata**		○																
*P. quadrispina**			○								○							
*P. runcinifera**													○		○			
*P. stelligera**		○	●															
*P. subquadrangularis**		●						○										
*P. undulata**								○			○	○	○			●	●	
P. vestita	○	●	●		●	○	○	○		○	○	○	○		○	●	●	●
Number of taxa	14	24	21	3	16	2	6	12	4	7	9	8	5	3	6	8	14	3

● showing cells collected
○ showing scales collected
* showing taxon new to Japan
W. showing Winter

Fig. 6

Syn. *M. fastigata* ZACHARIAS (1903).

Cells were found in winter, and scales in autumn. This species has been recorded as *M. fastigata* in the previous papers (ITO, YANO and HARIMAYA 1981; MORI 1971; NEGORO 1968). MORI (1971) reported that it was a dominant species in the north basin of Lake Biwa in Feburary 1968.

M. crassisquama (ASMUND) FOTT (1962)

Scales were found in winter and spring.

M. elongata REVERDIN (1919)

Cells were found in winter and summer, and scales in spring.

M. heterospina LUND (1942) Fig. 7

Scales were found in winter.

M. parvula DÜRRSCHMIDT (1982) Fig. 8

Scales were found in spring.

M. portae-ferreae PETERFI et ASMUND (1972) Fig. 9

Scales were found in spring and autumn.

M. pseudocoronata PRESCOTT (1944) Fig. 10

Cells were found in summer.

Distribution: Canada, USA (ASMUND and KRISTIANSEN 1986), Panama (WUJEK 1986).

M. punctifera KORSHIKOV (1941)

Syn. *M. reginae* TEILING (1946).

Scales were found in winter and spring. This species has been recorded as *M. reginae* in the previous paper (ITO, YANO and HARIMAYA 1981).

M. striata ASMUND (1959) var. *striata* Figs. 11, 12

Cells were found in spring. Var. *striata* differs from var. *serrata* in having smooth bristle. Var. *serrata* has been recorded from NE Japan (TAKAHASHI 1978).

M. tonsurata TEILING emend. KRIEGER (1959)

This species occurred in four seasons. Cells were found in winter, spring and summer, and scales in autumn. This species has also occurred almost all the year round in a pond in Tsuruoka Park, Yamagata Prefecture, Japan (TAKAHASHI 1978).

Genus *Synura* EHRENBERG (1835)

S. curtispina (PETERSEN et HANSEN) ASMUND (1968) Fig. 13

Scales were found in spring and autumn.

S. glabra H-PESTALOZZI (1941) Fig. 14

This species occurred in four seasons. Cells were found in winter and spring, and scales in other seasons.

S. petersenii KORSHIKOV (1929)

Scales were found in winter and spring.

S. sphagnicola (KORSHIKOV) KORSHIKOV (1929)

Scales were found in autumn.

S. spinosa KORSHIKOV (1929)

Scales were found in winter.

Family Paraphysomonadaceae PREISIG et HIBBERD (1983)

Genus *Chrysosphaerella* LAUTERBORN (1896)

C. brevispina KORSHIKOV emend. HARRIS et BRADLEY (1958) Fig. 15

Dissociated cells were found in summer, and scales in winter and spring.

Genus *Spiniferomonas* TAKAHASHI (1973)

A species; *S. takahashii* was new to Japan.

S. bourrellyi TAKAHASHI (1973) Fig. 16

This species occurred in four seasons. In a pond on Mt Rokko, it has also occurred all the year round (ITO and TAKAHASHI 1982).

S. cornutus BALONOV (1978)

Cells were found in winter and spring, and scales in autumn. In a pond on Mt. Rokko, it has also occurred between these seasons (ITO and TAKAHASHI 1982).

S. coronacircumspina (WUJEK et KRISTIANSEN) NICHOLLS (1984) Fig. 17

Syn. *Chrysosphaerella coronacircumspina* WUJEK et KRISTIANSEN (1977), *C. solitaria* PREISIG et TAKAHASHI (1978).

Scales were found in spring, summer and autumn.

S. takahashii NICHOLLS (1981) Fig. 18

Cells were found in summer, and scales in winter and spring.

Distribution: Canada (NICHOLLS 1981; KLING and KRISTIANSEN 1983), Norway (SKOGSTAD 1986).

S. trioralis TAKAHASHI (1973) Fig. 19

This species occurred in four seasons. Cells were found in winter and spring, and scales in other seasons.

Genus *Paraphysomonas* DE SAEDELEER (1929)

Thirteen taxa; *P. caelifrica*, *P. capreolata*, *P. circumvallata*, *P. coronata*, *P. corynephora*, *P. glandiata*, *P. poteriophora* ssp. *manubriata*, *P. punctata*, *P. quadrispina*, *P. runcinifera*, *P. stelligera*, *P. subquadrangularis* and *P. undulata* were new to Japan.

P. bandaiensis TAKAHASHI (1976) Fig. 20

This species occurred in four seasons. Cells were found in spring, summer and autumn, and scales in winter.

P. caelifrica PREISIG et HIBBERD (1982) Fig. 21

Scales were found in spring, summer and autumn.

Distribution: Denmark, England (PREISIG and HIBBERD 1982a).

P. capreolata PREISIG et HIBBERD (1982) Fig. 22

Scales were found in autumn.

Distribution: England (PREISIG and HIBBERD 1982a), Greece (KRISTIANSEN 1983).

P. circumvallata THOMSEN (1981) Fig. 23

Scales were found in spring, summer and autumn.

Distribution: Canada (KLING and KRISTIANSEN 1983), Denmark (THOMSEN *et al.* 1981), England (PREISIG and HIBBERD 1982b), Greece (KRISTIANSEN 1983).

P. coronata MOESTRUP et ZIMMERMANN (1981) Fig. 24

Cells were found in winter.

Distribution: Canada (NICHOLLS 1984), Denmark (KRISTIANSEN 1985; THOMSEN *et al.* 1981), England (PREISIG and HIBBERD 1982b), Greece (KRISTIANSEN 1983).

P. corynephora PREISIG et HIBBERD (1982) Fig. 25

Scales were found in winter and summer.

Distribution: Canada (NICHOLLS 1984), England (PREISIG and HIBBERD 1982a).

P. diademifera (TAKAHASHI) PREISIG et HIBBERD (1982) Fig. 26

Syn. *Ochromonas diademifera* TAKAHASHI (1972), *Lepidochromonas diademifera* (TAKAHASHI) KRISTIANSEN (1980).

Cells were found in autumn, and scales in spring and summer.

P. glandiata PREISIG et HIBBERD (1982) Figs. 27, 28

Scales were found in winter and spring.

Distribution: Canada (NICHOLLS 1984), Denmark (KRISTIANSEN 1985), England (PREISIG and HIBBERD 1982a).

P. imperforata LUCAS (1967) forma No. 2 sensu TAKAHASHI (1978) Fig. 29

This species occurred in four seasons. Cells were found in winter, spring and autumn, and scales in summer. This forma differs from the type in having the spine with acutely pointed tip, and PREISIG and HIBBERD (1982a) and TAKAHASHI (1987) suggested that it may be a separate taxon.

P. poteriophora ssp. *manubriata* PREISIG et HIBBERD (1982) Fig. 30

Cells were found in winter and spring.

Distribution: Denmark (THOMSEN *et al.* 1981), England (PREISIG and HIBBERD 1982b), Greece (KRISTIANSEN 1983).

P. punctata ZIMMERMANN (1981) Fig. 31

Scales were found in winter.

Distribution: Canada (NICHOLLS 1984), Denmark (THOMSEN *et al.* 1981), England (PREISIG and HIBBERD 1982b).

P. quadrispina THOMSEN et KRISTIANSEN (1981) Fig. 32

Scales were found in spring and summer.

Distribution: Denmark (THOMSEN *et al.* 1981), England (PREISIG and HIBBERD 1982b), Greece (KRISTIANSEN 1983).

P. runcinifera PREISIG et HIBBERD (1982) Fig. 33

Scales were found in autumn.

Distribution: Denmark, England (PREISIG and HIBBERD 1982b).

P. stelligera PREISIG et HIBBERD (1982) Fig. 34

Cells were found in spring, and scales in winter.

Distribution: Denmark (THOMSEN *et al.* 1981), England (PREISIG and HIBBERD 1982b), Greece (KRISTIANSEN 1983), The Netherlands (ROIJACKERS and KESSELS 1981).

P. subquadrangularis PREISIG et HIBBERD (1982) Fig. 35

Cells were found in winter, and scales in summer.

Distribution: England (PREISIG and HIB-

BERD 1982b), Greece (KRISTIANSEN 1983).

P. undulata PREISIG et HIBBERD (1982) Fig. 36

Cells were found in autumn, and scales in summer.

Distribution: Denmark, England (PREISIG and HIBBERD 1982b).

P. vestita (STOKES) DE SAEDELEER (1929) Fig. 37

This species occurred in four seasons. Cells were found in winter, spring and autumn, and scales in summer.

By the present study, 42 taxa of scale-bearing chrysophytes and the seasons of occurrence of them in the south basia of Lake Biwa were revealed, and 30 taxa among them, 17 new to Japan and 13 previously recorded, were added to the algal flora of this lake. These 17 taxa might be also distributed widely in Japan and occur in the same season as that in Lake Biwa.

Almost all taxa of scale-bearing chrysophytes previously recorded in Japan are widely distributed in the world (ASMUND and KRISTIANSEN 1986; PREISIG and HIBBERD 1982a, 1982b; STARMACH 1985; TAKAHASHI 1978). Among 17 taxa new to Japan, 2 species of *Mallomonas; M. portaeferreae* and *M. striata* var. *striata* have been recorded from many countries of the world (ASMUND and KRISTIANSEN 1986), whereas, *M. pseudocoronata, Spiniferomonas takahashii* and 13 taxa of *Paraphysomonas* from a few countries of Europe and/or N America. Recently 22 new taxa of *Paraphysomonas* were discovered in the Cambridge area, England by PREISIG and HIBBERD (1982a, 1982b). This fact shows that these taxa have been overlooked for a long time because their cells are very small and easily broken by fixatives. Finding of these 17 taxa new to Japan which is far away from Europe, N America, SE Asia (Bangladesh) and W Africa (Cameroun) indicates that they are widely distributed in the world as well as other scale-bearing chrysophytes.

The north basin of Lake Biwa has less eutrophic waters and volume about 140 times larger than the south one (ICHISE and WAKABAYASHI 1985; TEZUKA 1984). The species composition and the seasons of occurrence of scale-bearing chrysophytes in the north basin has not yet been clarified, therefore such floristic study in this basin is necessary and will produce many interesting results.

PALMER (1959) has pointed out that naked and scale-bearing chrysophytes are the most significant cause of the fishy odor in waters. As Lake Biwa is the most important water resource for 13 million people living in four prefectures; Shiga, Kyoto, Oosaka and Hyogo, the multiplication of these chrysophytes in this lake is a great concern for waterworks at present. Actually a bloom of *Uroglena americana* (Ochromonadales, Chrysophyceae) has appeared during the period from late spring to early summer in both south and north basins since 1977 and done much damage to both the water supply and fresh-water fishery (YOSHIDA *et al.* 1983). Recently, a great bloom, not so great, of *Mallomonas tonsurata* has appeared in the south basin and produced fishy odor (NEGORO and TAKAGI 1985). Accordingly it is an important and urgent subject to elucidate their quantitative seasonal fluctuation as well as to make clear the chrysophyte flora in this lake.

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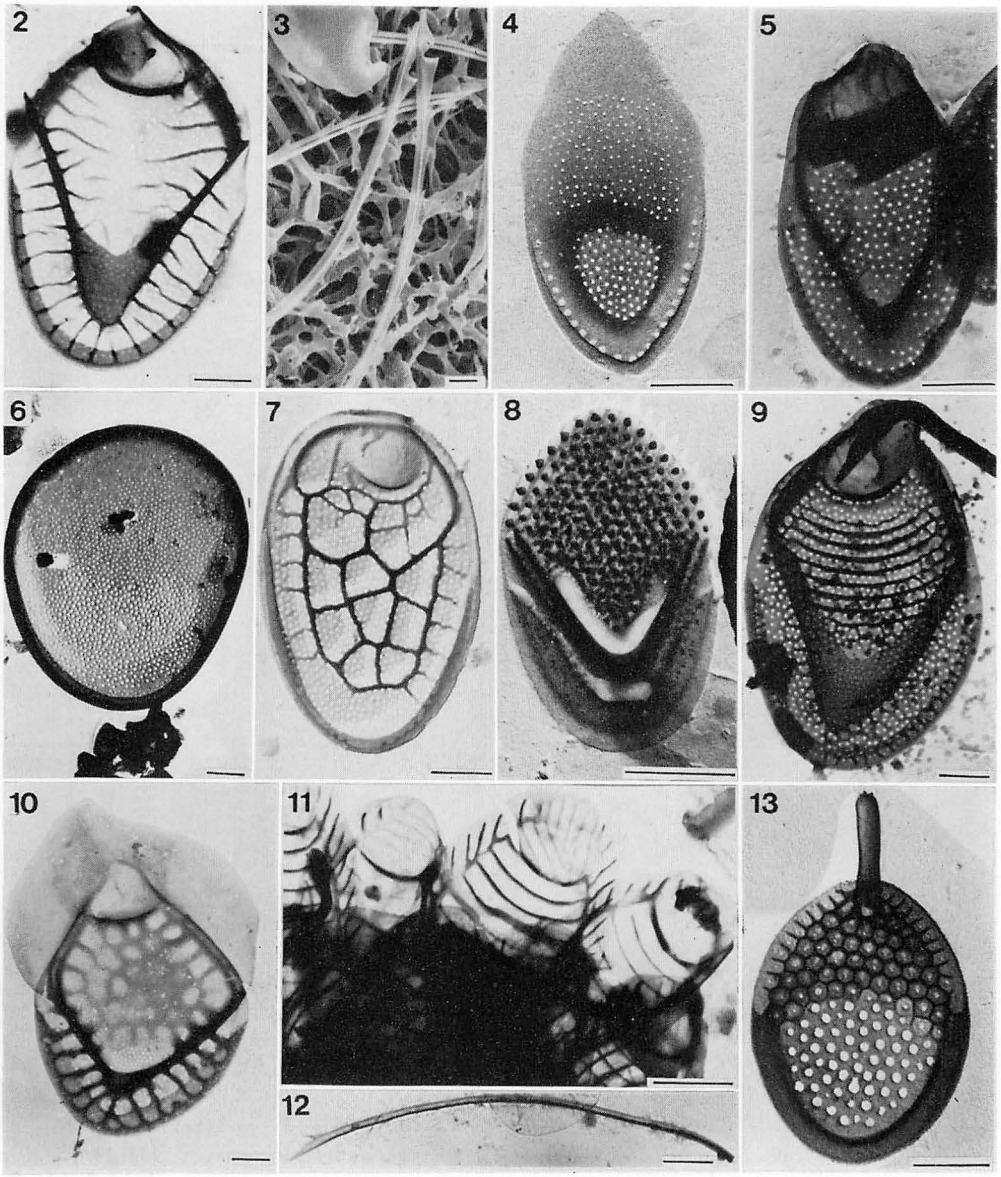
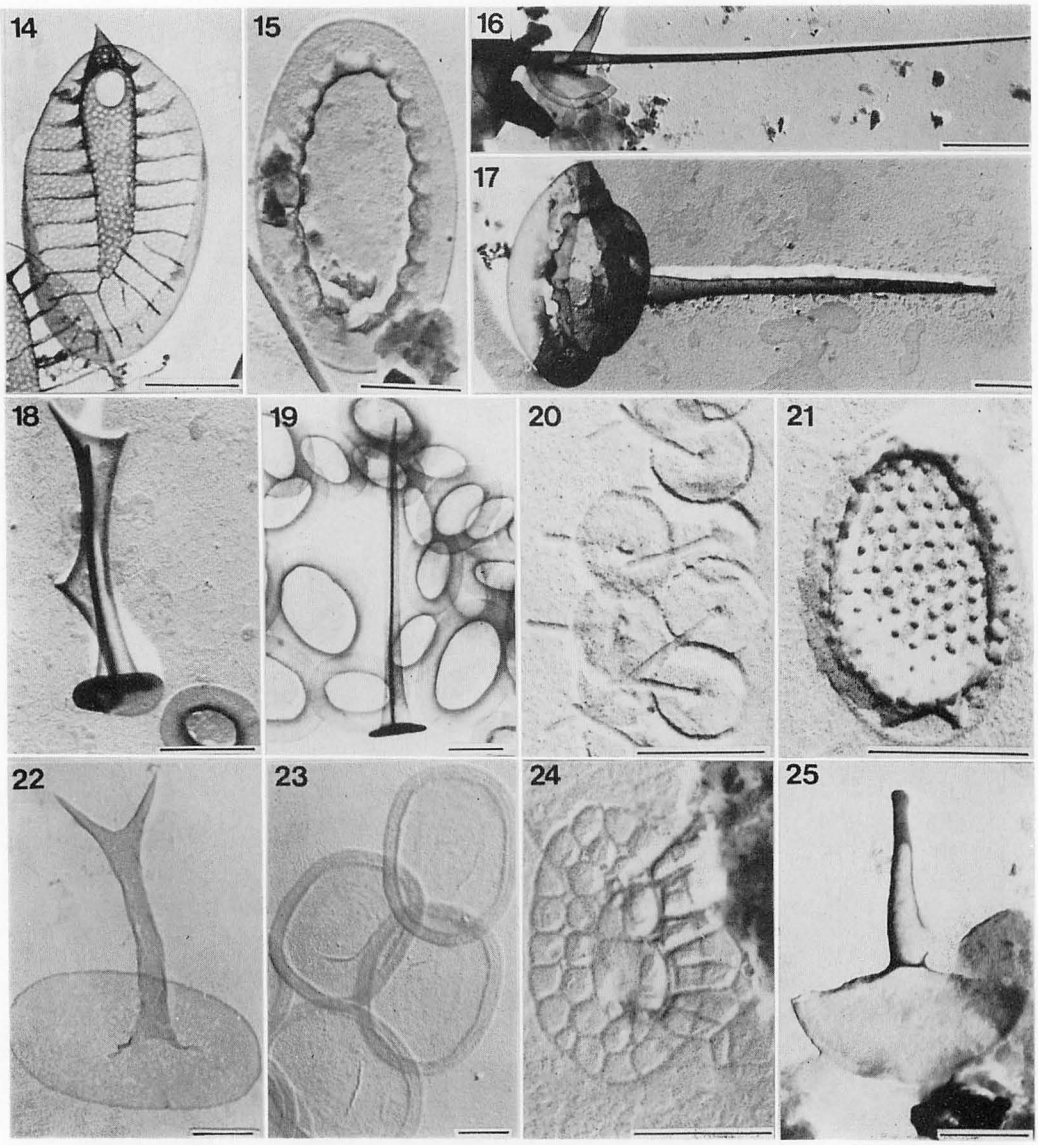
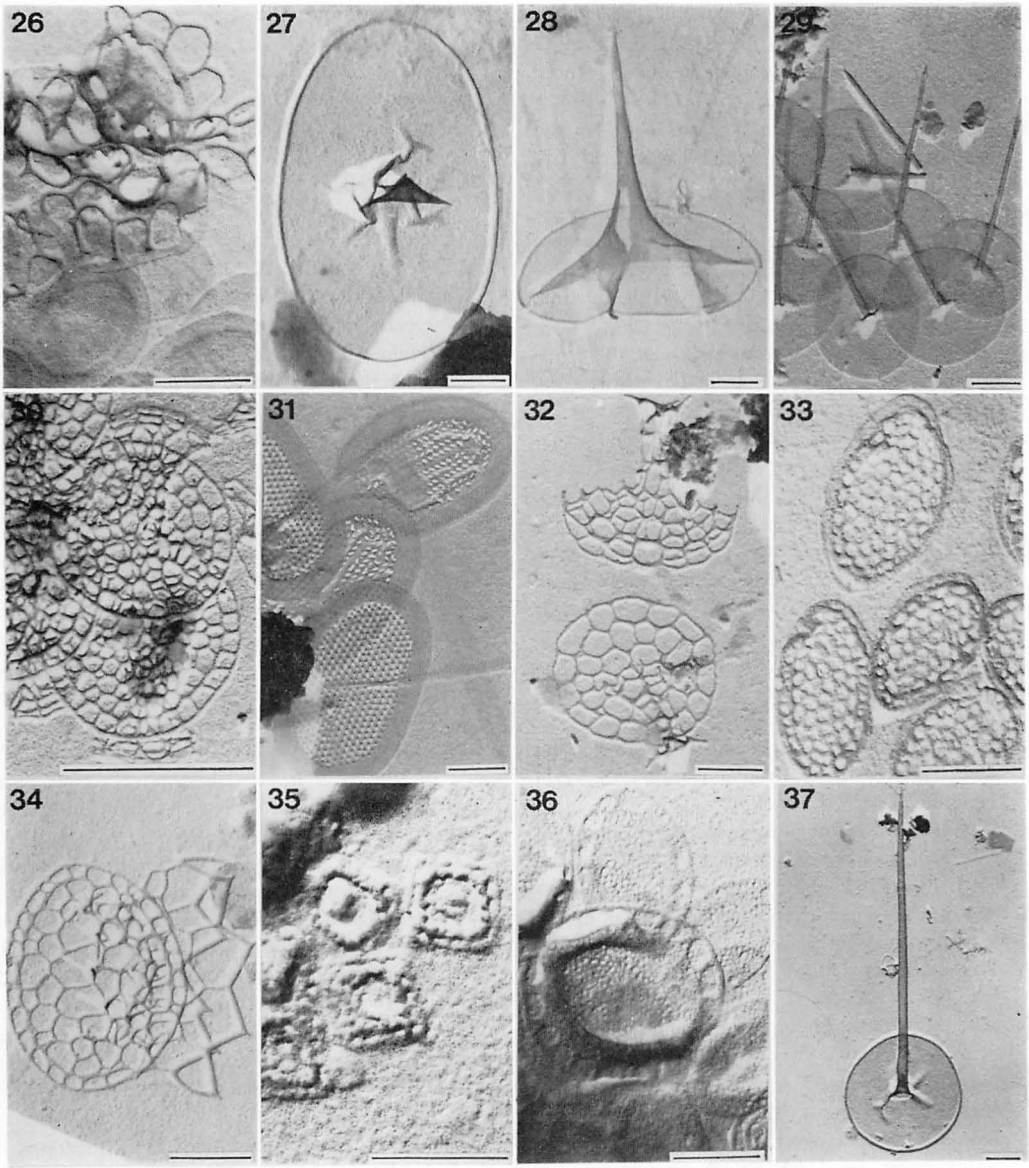


Figs. 2–13. Scales and bristles of *Mallomonas* and *Synura*: Figs. 2, 3. *M. acaroides*. Fig. 4. *M. akrokomos*. Fig. 5. *M. alpinn*. Fig. 6. *M. caudata*. Fig. 7. *M. heterospina*. Fig. 8. *M. parvula*. Fig. 9. *M. portae-ferreae*. Fig. 10. *M. pseudocoronata*. Figs. 11, 12. *M. striata* var. *striata*. Fig. 13. *S. curtispina*. (Scales: 1 μm).



Figs. 14–25. Scales of *Synura*, *Chrysosphaerella*, *Spiniferomonas* and *Paraphysomonas*: Fig. 14. *S. glabra*. Fig. 15. *C. brevispina*. Fig. 16. *S. bourrellyi*. Fig. 17. *S. coronacircumspina*. Fig. 18. *S. takahashii*. Fig. 19. *S. trioralis*. Fig. 20. *P. bandaiensis*. Fig. 21. *P. caelifrica*. Fig. 22. *P. capreolata*. Fig. 23. *P. circumvallata*. Fig. 24. *P. coronata*. Fig. 25. *P. corynephora*. (Scales: Figs. 14–19, 1 μm; Figs. 20–25, 0.5 μm).



Figs. 26–37. Scales of *Paraphysomonas*: Fig. 26. *P. diademifera*. Figs. 27, 28. *P. glandiata*. Fig. 29. *P. imperforata* forma No. 2. Fig. 30. *P. poteriophora* ssp. *manubriata*. Fig. 31. *P. punctata*. Fig. 32. *P. quadrispina*. Fig. 33. *P. runcinifera*. Fig. 34. *P. stelligera*. Fig. 35. *P. subquadrangularis*. Fig. 36. *P. undulata*. Fig. 37. *P. vestita*. (Scales: 0.5 μm).

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伊藤裕之：琵琶湖南湖の鱗片を有する黄金藻

1980年1月から1984年7月まで，琵琶湖南湖10地点から25試料を得た。この試料から *Mallomonas* 属14種，*Synura* 属5種，*Chrysosphaerella* 属1種，*Spiniferomonas* 属5種，*Paraphysomonas* 属15種1亜種1品種，計42種類の鱗片を有する黄金藻が見出された。その中で17種類（*Mallomonas portae-ferreae*, *M. pseudocoronata*, *M. striata* var. *striata*, *Spiniferomonas takahashii*, *Paraphysomonas caelifrica*, *P. capreolata*, *P. circumvallata*, *P. coronata*, *P. corynephora*, *P. glandiata*, *P. poteriophora* ssp. *manubriata*, *P. punctata*, *P. quadrispina*, *P. runcinifera*, *P. stelligera*, *P. subquadrangularis*, *P. undulata*）は日本新産であった。（652　神戸市兵庫区楠谷町37-1　神戸市水道局水質試験所）

Jpn. J. Phycol. (Sôrui) **36**: 154–165, June 20, 1988

Spatial differences in *Cyclotella comta* populations in the Nishina-sanko Lakes, Nagano Prefecture, Japan

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MARUYAMA, K. 1988. Spatial differences in *Cyclotella comta* populations in the Nishina-sanko Lakes, Nagano Prefecture, Japan. Jpn. J. Phycol. **36**: 154–165.

The horizontal and seasonal variations in the cell size distribution and standing crops of *C. comta* populations on coastal surface water in the Nishina-sanko lakes were examined during 1972 and 1973. KOLMOGOROV-SMIRNOV two-sample test (KTT) in summer populations revealed that the subgroups have different distribution at 0.1, 0.5 and <0.1 per cent levels of significances in Lakes Aoki, Nakatsuna and Kizaki, respectively. The differences in population within each lake were, however, below that among lakes. The population in Lake Aoki exhibited a slight deviation from the normal trend and had a small size of location of distribution and higher cell density, while the case was the opposite in all the above aspects in Lake Kizaki. The populations in Lakes Nakatsuna and Aoki resembled each other in the form and location of distribution and the standing crop, because the water in Lake Aoki had direct effect upon the surface water in Lake Nakatsuna during summer. The cell size in summer populations in these three lakes was smallest as compared to that in other seasons. On the other hand, the standing crop, water temperature and electric conductivity were high.

Key Index Words: Aoki Lake—cell size distributions—Cyclotella comta—*horizontal changes—intraspecific variation—Kizaki Lake—local populations—Nakatsuna Lake—Nishina-sanko Lake—seasonal changes—spatial differences—standing crops.*

The plankton species flourish in open water bodies and often develop into blooms. Except a few situations, considerable inter- and intraspecific variations occur in their populations. The existence of intra-specific variation of plankton species has been suggested by KNUDSEN (1955 in ROUND, 1965), GUILLARD and RYTHER (1962), CARPENTER and GUILLARD (1971) and FISHER *et al.* (1973). The clones isolated by them may be part of a widespread population having a number of intergrading morphological and physiologiacl types, while the spatial differences and their expanses are still obscure (WIMPENNY, 1936, 1946, 1966; NAMIKI *et al.*, 1985) and not verified genetically.

Diatom *Cyclotella comta* (EHR.) KÜTZ. and its synonyms have been included in VAN LANDINGHAM (1969). The taxonomic position, the morphological biometrics, and ultrastructure of valves of this taxon have begun to receive some critical attention (PLANAS, 1972; LOWE, 1975; MAHOOD *et al.*, 1984; GENKAL, 1984). Fresh and slightly brackish water is the habitat of *C. comta* (AL-KAISI, 1974). *C. comta* exhibits one or two pulses in annual fluctuation (WEST and WEST, 1912; DORGELO *et al.*, 1981; FLIK, 1986) and appears in the latest diatom of phosphate-limited sequnece (DORGELO *et al.*, 1981; VAN DONK, 1984). Successional pathways in lakes of different trophic status are also generalized by RAYNOLDS (1984). The presence of this taxon indicates deep oligotrophic types of lakes (BRUGAM, 1983) and is found only in small numbers in mesotrophic lakes (HOLLAND and CLAFLIN, 1975; DORGELO *et al.*, 1981; JOHANSEN *et al.*, 1982; FLIK, 1986). In small manmade lakes rich

Table 1. The loccations, areas, and depths of the Nishina-sanko lakes (TANAKA, 1930; HORIE, 1956; HORIUCHI *et al.*, 1963)

Lake	Longitude	Latitude	Sea level (m)	Area (Km^2)	Maximum depth (m)	Mean depth (m)
Aoki	137°51′	36°37′	822	1.863	58.0	29.0
Nakatsuna	137°51′	36°36′	815	0.141	12.0	5.7
Kizaki	137°50′	36°33′	764	1.413	29.5	17.9

in nutrients, the cell number reaches 55×10^3/m*l* for *C. comta* and *C. stelligera* (TIEFENBRUNNER and ROTT, 1975).

The Nishina-sanko Lakes are situated in the east side of the Japan Alps. Mt. Sanozaka forms the watershed from where the Hime-kawa River flows to the north and the Nogu-gawa River in the Nishina-sanko valley southward. The locations, areas, and depths of the Nishina-sanko lakes are shown in Table 1 (TANAKA, 1930; HORIE, 1956; HORIUCHI *et al.*, 1963). Since 1954, the water depth in Lake Aoki has decreased markedly to a minimum depth of 37 m, because of the water-intake for the power plant. It would take about eight months to recover from a drop. Gradual decrease of transeparency from north to south in Lake Kizaki was also observed (HORIUCHI *et al.*, 1963). Lakes Aoki, Nakatsuna, and Kizaki have been defined as oligo-, eu-, and mesotrophic types, respectively by SAIJO (1956), YASUDA *et al.* (1975) and MAEDA and TOMIOKA (1977), while according to KITAGAWA (1973) Lakes Aoki and Kizaki belong to meso- and eutrophic types, respectively. *C. comta* group in the Nishina-sanko valley are described by HUSTEDT (1927), KAWAMURA (1928), SKVORTZOW (1936), KO-BAYASHI *et al.* (1971), and YASUDA *et al.* (1975).

Materials and Methods

Forty-one sampling stations were chosen along the shore, *viz.* 16 in Lake Aoki (Stations A1–A16), 10 in Lake Nakatsuna (Stations N1–N10), and 15 in Lake Kizaki (Stations K1–K15) (Figs. 1–3). Surface water samples were collected five times druing 1972–73 in 500 m*l* polyethylene bottles (November 4–5, 1972; December 10, 1972; January 3, April 2, and July 31 to August 1 or August 26, 1973). The pH and electric conductivity (EC) were measured by using both portable pH (Toa DM–1A) and EC (Toa CM–3M) meters.

For the estimation of the standing crops and cell size distributions, 30, 50, 100, 200 or 300 m*l* water samples were filtered through a membrane filter (Millipore RAWP 04700, 1.2 μm pore size and 47 mm diam.) reducing the pressure by using a miniature vacuum pump (Millipore XX61 00000), and cells on a filter fixed with a 10 per cent neutral formalin solution and stored in a petrislide (Millipore PD15 04700).

Population estimates were based on the cell counts of 10 to 70 block samples drawn at random from imaginary 910 occular quadrates and expressed as number of cells per m*l*. The means and the standard error of the means (SEM) were estimated. The diameter of the frustles were measured in 200 cells in each population by using a video-writer (FOR.A FVW300) connected to a computer (FM–11). The point and 95 per cent confidence interval of population means and medians, SEM, and the point and 90 per cent confidence interval of the standard deviation were estimated. KOLMOGOROV-SMIRNOV one sample test (KOT) for detecting the departure from normality, BARTLET's test (BT) for homogeneity of varinace, and KOLMOGOROV-SMIRNOV two sample test (KTT) for the detection of difference in form and location of distribution were also employed (BLISS, 1967; CAMPBELL, 1974).

Results

Environmental conditions: a. *Horizontal changes.* The water temperature, pH and EC of the surface water in Lake Aoki on July 31 are shown in Fig. 1. The water temperatures were 21.2 to 23.2°C, pH 6.8 to 7.4 (except 8.2 and 8.4 at stations 1 and 16 respectively), and EC between 31.0 and 33.0 μ mho/cm (except 38.0 μ mho/cm at station 16).

The water temperatures (°C) in Lake Nakatsuna were 12.5 to 12.6 (except 13.0 at station 6), 6.3 to 6.8 (except 5.7 at station 6), 3.3 to 3.7, 4.4 to 6.0, and 23.2 to 23.8 (except 21.7 and 24.4 at stations 6 and 7 respectively), on Nov. 4, Dec. 10, Jan. 3, Apr. 2, and Aug. 1, respectively (Fig. 1). The water temperatures were almost the same at fixed times, except slight deviation found at stations 6 and 7 and a contrast between east and west shores on April 2. The pH was 6.8 to 7.2, 6.8 to 7.4, and 6.2 to 8.0 on Nov. 4, Dec. 10 and Aug. 1, respectively. The pH on Aug. 1 largely depends on the station. In other seasons the values were fairly neutral. The EC (μ mho/cm) were 30.0 to 34.0, 27.5 to 29.0 (except 35.0 at station 6), 28.0 to 31.0 (except 41.0 at station 6), 29.0 to 34.0, and 35.5 to 38.0 (except 33.0 at station 6) at five different times. The EC were constant, although the value at station 6 deviated from the rest and fluctuated considerably on April 2. The Upper-Nogu-gawa River which flowed out from Lake Aoki drains into the station 6 in Lake Nakatsuna. The flow ceased from Dec. to July.

Fig. 1 also shows the situation in Lake Kizaki on August 26. The water temperatures were 25.3 to 26.8°C , pH 6.8 to 7.1 (except 6.4 at station 2), and EC 45.0 to 48.0 μ mho/cm (except 59.0 at station 2), which did not change with the station markedly except station 2.

Fig. 1 further shows the water temperature, pH, and EC at different times at the stations 10 and 12 in Lakes Aoki and Kizaki, respectively. The water temperatures (°C) were 12.6, 4.8, 5.9, and 21.6 on Nov. 5, Jan. 3, Apr. 2, and Jul. 31, respectively in Lake Aoki, and 12.9, 6.0, 7.1, and 25.5 on Nov. 5, Jan. 3, Apr. 2, and Aug. 26, respectively in Lake Kizaki. The pH was 7.6 and 6.8 on Nov. 5 and July 31, respectively in Lake Aoki, and 7.4 and 7.0 on Nov. 5 and Aug. 26, respectively in Lake Kizaki. The EC (μ mho/cm) at the same dates mentioned in the case of water temperature were 30.0, 26.0, 23.0, and 32.0 respectively in Lake Aoki, and 32.0, 27.0, 26.0, and 46.0 in Lake Kizaki. The water temperatures at Lake Nakatsuna at the same dates mentioned above were −0.1 to 0, −1.1 to −1.5, −1.5 to 0.1 and 1.6 to 2.2°C higher respectively than those in Lake Aoki. EC at the same dates were respectively 0 to 4.0, 2.0 to 5.0, 6.0 to 11.0, and 3.5 to 6.0 μ mho/cm higher in Lake Nakatsuna than those in Lake Aoki. The water temperatures at the same dates in Lake Kizaki was 0.3, 1.2 and 1.2°C higher than those of Lake Aoki. The EC in the same series were 2.0, 1.0, and 3.0 μ mho/cm higher in the former lake than those in the latter. As for the pH, there was no appreciable difference between these three lakes.

b. *Seasonal changes.* The seasonal changes of the water temperature, pH, and EC at stations 10 and 12 in Lakes Aoki and Kizaki, respectively, and all the stations in Lake Nakatsuna are shown in Fig. 1. In Lakes Aoki and Kizaki, the temperature dropped through Nov. to Jan. and rose through Apr. to Jul. or Aug., and the EC decreased from Nov. through Jan. to Apr. and increased in Jul. or Aug. In Lake Nakatsuna, situation of the temperature was similar to that in Lake Aoki. The pH remained unchanged except in Aug. and the EC was the minimum in Dec. and increased reaching a maximum in Aug.

Population density: a. *Horizontal changes.* Fig. 2 depicts the cell population at each station in Lake Aoki on July 31, showing a rather uniform number from 1155±37 to 2139±34 cells/m*l*. Relatively large num-

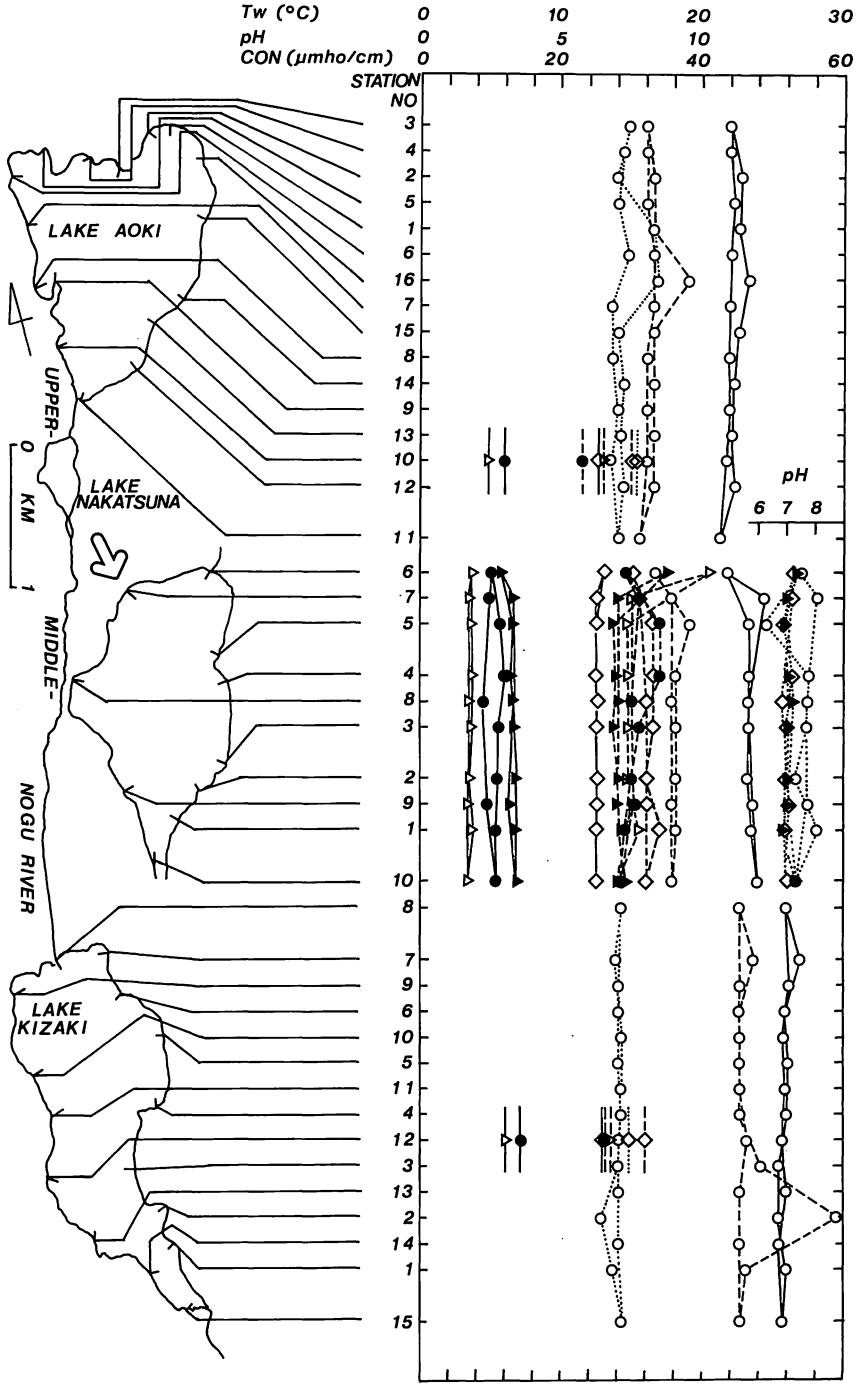

Fig. 1. Sampling locations and the horizontal and seasonal changes of the water temperature (solid line), pH value (dotted line), and electric conductivity (dashed line) of the surface water in the Nishinasanko lakes on November 4–5 (open diamond), December 10 (solid triangle), January 3 (open triangle), April 2 (solid circle), and July 31 to August 1 (Lakes Aoki and Nakatsuna) and August (Lake Kizaki) (open circle), 1972 to 1973.

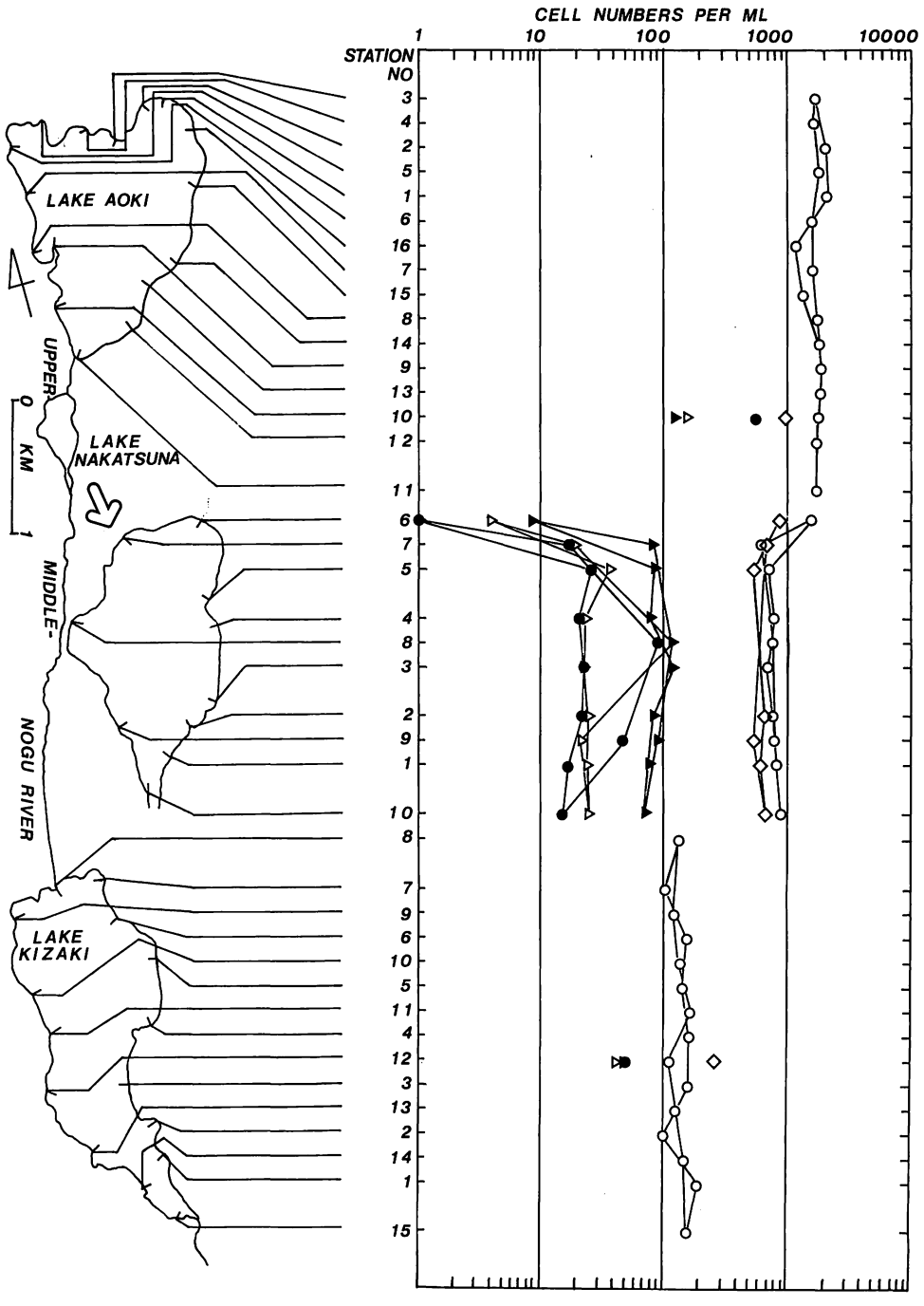

Fig. 2. Sampling locations and the horizontal and seasonal changes of the population density in surface water in the Nishina-sanko lakes on November 4–5 (open diamond), December 10 (solid triangle), January 3 (open triangle), April 2 (solid circle), and July 31 to August 1 (Lakes Aoki and Nakatsuna) and August 26 (Lake Kiazaki) (open circle), 1972 to 1973.

bers of cells (2088 and 2139 cells/m*l*) at stations 1 and 2 of north-northeastern shore, and small numbers (1155 and 1357 cells/m*l*) were observed at stations 16 and 15 of northeast-eastern.

The time-course of population density in Lake Nakatsuna is also shown in Fig. 2. At the five different sampling times, the cell numbers were 536 to 676 (655±23 at station 10)/m*l* (except 856 at station 6), 70 to 120 (70±3 at station 10)/m*l* (except 9 at station 6), 19 to 37 (25±2 at station 10)/m*l* (except 4 and 116 at stations 6 and 8 respectively), 15 to 26 (15±2 at station 10)/m*l* (except 1, 47 and 89 at stations 6, 8 and 9 respectively), and 624 to 891 (891±24 at station 10)/m*l* (except 1582 station 6). The cell number at station 6 deviated from the uniform number and increased in Nov. and Aug., but decreased in Dec., Jan. and Apr.. The Upper-Nogu-gawa River flowed out from Lake Aoki and drained into station 6 in Lake Nakatsuna, and the flow ceased from Dec. to July. Deviations were also toward large at stations 8 and 9 on April.

Fig. 2 also shows the situation in Lake Kizaki on August 26. The cell numbers in all stations ranged from 100±6 to 191±6/m*l*. The minimum and maximum numbers were observed at stations 1 and 2 respectively.

Fig. 2 also depicts the cell population at five different times of collection at stations 10 and 12 in the Lakes Aoki and Kizaki, respectively. The cell number per m*l* was 951±47, 123±5, 154±9, 545±29, and 1843±80 on Nov. 5, Dec. 10, Jan. 3, Apr. 2, and Jul. 31, respectively in Lake Aoki and 261±16, 49±3, 41±3, 50±5, and 111±6 on Nov. 5, Dec. 10, Jan. 3, Apr. 5, and Aug. 26, respectively in Lake Kizaki. The cell densities in Lake Kizaki at the same dates were respectively 690, 74, 113, and 495 cells/ml lower than those in Lake Aoki. At the same dates, the cell densities at Lake Nakatsuna were 257 to 415, 3 to 53, 117 to 135, 519 to 530, and 952 to 1219 cells/ml lower than those in Lake Aoki.

b. *Seasonal changes.* The seasonal changes in cell number at stations 10 and 12 in Lakes Aoki and Kizaki, respectively and at all the stations in Lake Nakatsuna can also be seen in Fig. 2. The population density in Lake Aoki decreased from Nov. to Dec.–Jan. and then increased through Apr., reaching a maximum of 1843 cells/m*l* on July. In Lake Kizaki, the density decreased from the maximum of 261 cells/m*l* in Nov. to Dec., Jan. and Apr. and then increased by Aug. In Lake Nakatsuna, the density decreased from Nov. through Dec. to Jan. and Apr., then increased and reached the maximum of 624 to 891 cells/m*l* on August.

Cell size distributions of the populations. a. *Horizontal changes.* The frequency distributions of living cell diameter of each population in Lake Aoki on Jul. 31 were different from each other in form, positive skew or symmetry, and location. KOT

Table 2. The observed largest differences of KOLMOGOROV-SMIRNOV one-sample test (KOT) for detecting the departure from nomality in the Nishina-sanko lakes in summer. In these cases the value for 5 per cent significance is 0.0964. If the difference exceeds this value the distributions cannot reasonably be regarded as normal.

Lake Aoki		Lake Nakatsuna		Lake Kizaki	
Station No.		Station No.		Station No.	
3	0.1001	6	0.0931	8	0.0612
4	0.0817	7	0.1142	9	0.0584
5	0.0957	8	0.1099	10	0.0604
6	0.0879	9	0.0877	11	0.0820
7	0.0999	10	0.1011	12	0.0638
8	0.0884	5	0.0711	13	0.0726
9	0.0629	4	0.0935	14	0.0603
10	0.0708	3	0.1439	15	0.0677
11	0.0642	2	0.1096	7	0.0497
2	0.0954	1	0.1037	6	0.0593
1	0.0762			5	0.0477
16	0.0622			4	0.0705
15	0.0749			3	0.0575
14	0.0656			2	0.0631
13	0.0777			1	0.0604
12	0.1003				

was used for detecting the departure from normality of the observed distribution. The largest value of the differences in each population are shown in Table 2. Since the observed differences exceed or are close to the value of 0.0964 for 5 per cent significance, the distributions cannot reasonably be regarded as normal at many stations. Thus it is inadequate to compare the population means. Fig. 3 expresses the point and interval estimates of population medians in Lake Aoki. The population medians and their 95 per cent confidnence limits were 9.88 (9.59, 10.14) to 10.67 (10.41, 11.01) μm as shown in Fig. 3. The population medians increased in the following order: stations 2, 12, 5, 3, 1, 10, 13, 7, 15, 9, 11, 4, 6, 8, 14, and 16. Table 3 shows the values of KTT in Lake Aoki by combining the population medians of stations arranged in ascending order. The KTT values over 5 per cent level of significance are indicated by a quadrate. In this case, the populations at stations 7, 15, 11, 4, and 6 were the same as others; those at stations 13 and 9 were different from station 14 only; those at stations 5 and 3 were different than the populations at station 16. The population at station 1 was different from those of station 8 and station 16. The populations at stations 2, 12 and 10 were greatly different. The populations at stations 8, 14, and 16 had the highest population medians, ranging from 10.56 to 10.67. The difference in the distribution at 0.1 per cent level of significance was found by KTT between stations 2 and 16.

The frequency distributions of living cell diameter in Lake Nakatsuna on Aug. 1 were rather positively skewed. The observed values of KOT exceeded at stations 1–3, 7, 8 and 10 and most distributions differed from normal. The population medians and their 95 per cent confidence limits were 9.37 (9.07, 9.86) to 10.01 (9.63, 10.36) μm as shown in Fig. 3. The population medians in summer increased in the following order: station 8, 7, 10, 6, 3, 9, 2, 1, 4, and 5. The differences in the distribution at 0.5 per cent level of significance were recognized by KTT between the population at station 8 and that at station 2. The population medians (μm) in other seasons were 10.88 (10.65, 11.21) to 11.21 (10.66, 11.48) except 11.59 (11.21, 12.07) at station 6, 11.30 (10.97, 11.79) to 11.76 (11.32, 12.10), and 10.99 (10.67, 11.25) to 11.66 (11.42, 12.04) on Nov. 4, Dec. 10, and Jan. 3, respectively (Fig. 3).

The frequency distributions in Lake Kizaki on Aug. 26 were rather symmetric. The observed differences of KOT were lower than 0.0964 for 5 per cent significance and the distributions are hence normal. The BT for homogeneity of variance was taken in this case. The observed value was 61.720 and higher than 24.996 for 5 per cent probability, hence the comparison of population mean was not feasible here. The population medians and their 95 per cent confidence limits were 10.43 (10.26, 10.98) to 11.48 (11.21, 11.73) μm as shown in Fig. 3. The population medians increased in the order, stations 11, 4, 14, 13, 7, 15, 8, 10, 6, 9, 5, 3, 12, 1, and 2. The difference in the distribution at <0.1 per cent level of significance were determined by KTT. Small population medians were observed in stations 4, 14 and 15 and others having large ones were stations 14 and 2.

Fig. 3 also depicts the population medians at five different times at stations 10 and 12 in Lakes Aoki and Kizaki, respectively. The median (μm) was 11.44, 11.75, 11.27, 10.95, and 10.12 on Nov. 5, Dec. 10, Jan. 3, Apr. 2, and Jul. 31, respectively in Lake Aoki and 11.36, 12.28, 12.01, 11.61, and 10.97 on Nov. 5, Dec. 10, Jan. 3, Apr. 5, and Aug. 26, respectively in Lake Kizaki. The median at the same times in Lakes Kizaki was -0.08, 0.53, 0.74, and 0.66, higher than that in Lake Aoki. The downgrades, such as a head (μm) of 0.23 to 0.56, -0.01 to 0.45, -0.39 to 0.28, and 0.11 to 0.75 in the same series, were indicated in Lakes Nakatsuna and Aoki. In Lake Kizaki, the medians were higher in all

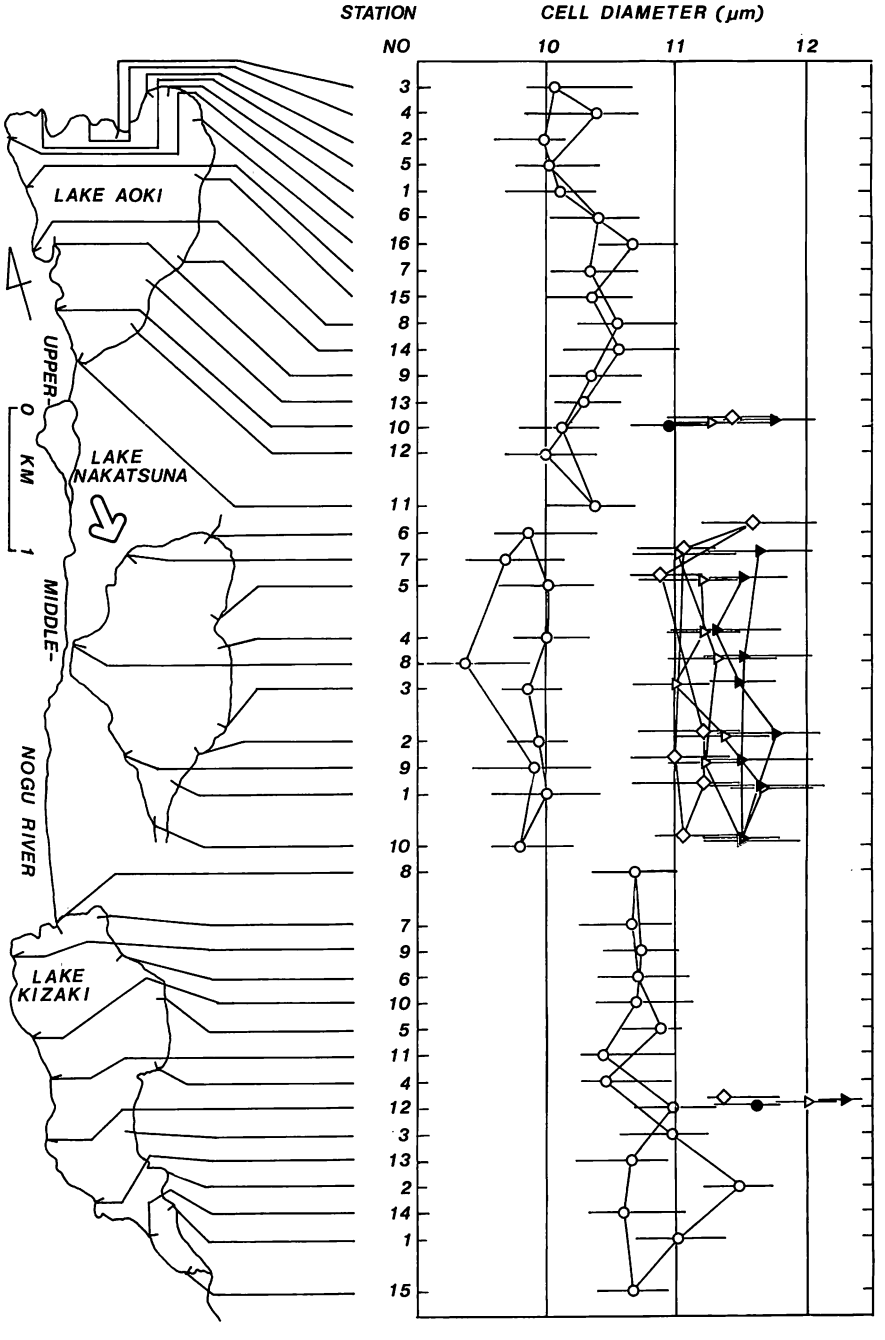

Fig. 3. Sampling locations and the horizontal and seasonal changes of the point and interval (bold line) estimates of population medians of cell diameter in the Nishina-sanko lakes on November 4–5 (open diamond), December 10 (solid triangle), January 3 (open triangle), April 2 (solid circle), and July 31 to August 1 (Lakes Aoki and Nakatsuna) and August 26 (Lake Kizaki) (open circle) from 1972 to 1973.

Table 3. The observed largest differences of KOLMOGOROV-SIMIRNOV two-sample test (KTT) in Lakes Aoki (upper), Nakatsuna (middle), and Kizaki (lower) in summer by combining the population medians of stations arranged in ascending order. In the present case the significance at 10, 5, 2.5, 1, 0.5 and 0.1 per cent level are 0.122, 0.136, 0.148, 0.163, 0.173 and 0.195, respectively. At various levels of significance two populations cannot reasonably be regarded as having the same distribution. The values over 5 percent level of significance are indicated by a quadrate.

S T	16	14	8	6	4	11	9	15	7	13	10	1	3	5	12
2	.195	.175	.165	.135	.125	.115	.120	.115	.120	.125	.060	.050	.095	.080	.070
12	.180	.140	.140	.105	.095	.085	.095	.090	.090	.090	.055	.050	.060	.095	
5	.160	.125	.135	.090	.090	.080	.090	.100	.130	.095	.110	.095	.090		
3	.150	.100	.120	.085	.055	.055	.085	.085	.075	.080	.075	.070			
1	.170	.135	.150	.105	.105	.090	.100	.115	.120	.080	.040				
10	.185	.140	.140	.115	.095	.080	.110	.110	.115	.075					
13	.130	.145	.130	.110	.105	.100	.065	.085	.120						
7	.110	.070	.065	.070	.055	.085	.120	.110							
15	.130	.120	.105	.085	.080	.070	.065								
9	.115	.150	.125	.090	.095	.080									
11	.135	.095	.085	.080	.050										
4	.120	.070	.110	.070											
6	.080	.075	.065												
8	.075	.065													
14	.095														

S T	5	4	1	2	9	3	6	10	7
8	.125	.155	.135	.165	.110	.135	.150	.130	.110
7	.080	.090	.075	.095	.065	.075	.080	.060	
10	.065	.075	.090	.080	.070	.055	.070		
6	.070	.055	.075	.065	.080	.070			
3	.060	.050	.080	.055	.060				
9	.050	.075	.085	.100					
2	.065	.045	.075						
1	.085	.060							
4	.055								

S T	2	1	12	3	5	9	6	10	8	15	7	13	14	4
11	.220	.115	.110	.090	.090	.070	.065	.070	.055	.120	.050	.075	.060	.055
4	.215	.140	.105	.090	.085	.075	.060	.070	.075	.135	.065	.055	.075	
14	.200	.150	.110	.105	.075	.080	.075	.095	.080	.080	.065	.100		
13	.210	.130	.100	.095	.085	.060	.065	.075	.075	.160	.090			
7	.200	.110	.115	.105	.070	.095	.055	.060	.055	.085				
15	.230	.145	.165	.155	.095	.140	.115	.115	.110					
8	.185	.095	.090	.075	.060	.080	.075	.050						
10	.170	.080	.080	.060	.050	.050	.060							
6	.185	.130	.095	.075	.060	.065								
9	.185	.120	.080	.065	.070									
5	.175	.105	.085	.080										
3	.130	.075	.050											
12	.125	.070												
1	.115													

Table 4. The population means and their 95 per cent confidence limis, the standard errors of the means (SEM), and the standard deviations (SD) and their 90 per cent confidence limits in the Nishina-sanko lakes in summer, 1973. Table 4 also shows the population minimum (MIN) and maximum (MAX) in summer.

	Cell diameter (μm)				
	Mean	SEM	SD	MIN	MAX
L. Aoki	10.22 (9.95, 10.49)	0.12	1.70(1.57, 1.85)	5.81	15.92
	−10.91(10.63, 11.19)	−0.15	−2.11(1.95, 2.31)	−7.41	−19.68
L. Nakatsuna	9.89 (9.62, 10.16)	0.13	1.80(1.99, 2.35)	6.15	15.59
	−10.35(10.16, 10.61)	−0.15	−2.15(1.99, 2.35)	−7.12	−19.75
L. Kizaki	10.65(10.37, 10.93)	0.12	1.59(1.47, 1.74)	6.29	14.93
	−11.47(11.22, 11.72)	−0.14	−2.05(1.89, 2.23)	−7.72	−23.79

seasons except Nov. compared with those in Lakes Aoki and Nakatsuna (except station 6).

Other estimates such as the population means and their 95 per cent confidence limits, the standard errors of the means, and the standard deviations and their 90 per cent confidence limits in three lakes in summer are shown in Table 4, which also shows the population minimum and maximum. The range of the valve diameter in the present study was 5.61 to 24.33 μm.

b. *Seasonal changes.* At all the stations in Lakes Aoki, Nakatsuna and Kizaki the population medians increased from Nov. to a maximum in Dec. or Jan., followed by a decrease to a minimum in summer (Fig. 3).

Discussion

A wide range of variation in the valve diameter exists among the different ecotypes of *C. comta*. The type species *C. comta* has been reported to have valves of 1/96''' (KÜTZING, 1849), 15 to 50 μm (HUSTEDT, 1930), 8 to 16 μm (PLANAS, 1972) or 14 to 20 μm diam. (AL-KAISI, 1974). The range is 9–17.5 μm (n=15) in var. *comta* and 21.2–53 μm (n=13) in var. *glabriuscula* (GENKAL, 1984). *C. comta* var. *paucipunctata* GRUN. from Lake Aoki is described by HUSTEDT (1927) and SKVORTZOW (1936). This variety differs markedly from the type species in its central area with scattered beads forming a star. SKVORTZOW (1936) described a new form of *C. comta* (f. *parva*) from Lake Kizaki, based on its smaller valve size of 4.2 to 6 μm, but this form is a synonym of the type (VAN LANDINGHAM, 1969). The populations in the present study showed a range from 5.61 to 24.33 μm. The specimens in the Nishina-sanko valley are either a local population having small valve or the type recorded by PLANAS (1972), AL-KAISI (1974) and GENKAL (1984).

The population at station 16 in Lake Aoki showed structural and ecological peculiarities in the difference at low level of significance by KTT, the largest location of distribution, and the minimum population density. The water in this station also had maximum temperature, pH, and EC. In Lake Kizaki the population at station 2 has similar characteristics.

Although there was such a peculiar population in each lake, the difference in cell size distributions as well as in population densities and in environmental conditions within lakes were below that among lakes. In Lake Aoki, *C. comta* population on coastal surface water in summer was exhibited slight deviation from normal trend, smaller location of distribution and higher standing crop and it had a relatively low water temperature and EC, while it was the opposite in Lake Kizaki.

The form and location of cell size distribution in this diatom seemed to depend on the population density. The positive skew

form, slight deviation from normality, and smaller location in distribution might be due to cell division specific to diatoms.

The existance of *C. comta* indicates deep, low phosphorus, high transparent (BRUGAM, 1983), oligotrophic (HOLLAND and CLAFLIN, 1975) types of lakes. As the lake became enriched *C. comta* decreased (LUND in HOLLAND and CLAFLIN, 1975). In the mesotrophic lake, the number of *C. comta* was low (DORGELO *et al.*, 1981; JOHANSEN *et al.*, 1982; VAN DONK and RINGELBERG, 1983; FLIK, 1986). Lakes Aoki and Kizaki correspond to the former and the latter, respectively.

A structural and ecological similarity was found between the populations in Lakes Nakatsuna and Aoki. The water in Lake Nakatsuna which is a small river-lake is affected considerably by Lake Aoki close to it (SAIJO, 1956). The water temperature was lowered by the inflow of water in summer (TANAKA, 1930). The water in Lake Kizaki registered the highest temperature among the three lakes in summer because the water stayed long in the large and long river-lake. The upper temperature limit might also influence the growth of *C. comta*, other than eutrofication.

Differences in population densities and in environmental conditions could be seen among the lakes. They are constant in large areas and unique in each lake, as against the structural differences in cell size ditsributions. *C. comta* seems to be sensitive to environmental condition. Abundance of the cells appears in a limited sphere such as deep oligotrophic lakes. This seems to be a general global pattern. But the direct relation between environmental condition and cell number as well as cell size cannot be fixed. The intraspecific variation of this taxon will become clear by further studies on its population dynamics in other lakes, mating frequency, fine structure and biochemical characters.

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丸山　晃：仁科三湖における *Cyclotella comta* 集団の地域的な差異

1972–3年，仁科三湖の沿岸部41地点の表層水資料を用いて，*Cyclotella comta* 集団の細胞サイズ分布，現存量などの地域差と季節的変化が調べられた。細胞サイズは，三湖とも夏期に最小となる。KOLMOGOROV-SMIRNOVの二試料検定により，この小型集団には，青木，中綱，木崎三湖で，それぞれ有意水準0.1，0.5，<0.1%で，細胞サイズ分布の湖沼内差異が見出された。しかし，この湖沼内差異は，湖沼間差異を越えない。青木湖の集団は，細胞サイズ分布の正規性が低く，分布域が小さい側にあり，高い現存量をもつ。これに対して，木崎湖では，正規性の高い，大きい側にずれた，密度の著しく低い集団からなる。中綱湖の集団は，かなり青木の湖水の影響を受けているとみられ，分布の形と位置や現存量が似ている。*C. comta* をとりまく環境の湖沼内，湖沼間差についても言及される。（113　東京都文京区弥生1-1-1　東京大学応用微生物研究所）

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Comparative studies on critical light conditions for young *Eisenia bicyclis* and *Ecklonia cava*

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MAEGAWA, M., KIDA, W., YOKOHAMA, Y. and ARUGA, Y. 1988. Comparative studies on critical light conditions for *Eisenia bicyclis* and *Ecklonia cava*. Jpn. J. Phycol. **36**: 166–174.

Ecklonia cava KJELLMAN usually occupies deeper water than does *Eisenia bicyclis* SETCHELL in sublittoral rocky areas. Young fronds of these species are growing under considerably low light condition on the community floor. Critical light intensity for young *Ei. bicyclis* and *Ec. cava* observed on the community floor was respectively 1.0–1.5% and 0.5–1.0% of the light intensity at water surface. Photosynthetic rate of young fronds of both species was saturated at 200 $\mu E/m^2/s$, and the saturated rate was higher in *Ei. bicyclis* than in *Ec. cava*. Under light lower than 50 $\mu E/m^2/s$ the net photosynthetic rate was higher in *Ec. cava* than in *Ei. bicyclis*, and the compensation light intensity was 4.8 $\mu E/m^2/s$ for the former and 8.2 $\mu E/m^2/s$ for the latter. Daily net production was calculated with the mathematical model based on photosynthesis-light equations and natural light conditions. The estimated daily compensation light of young *Ec. cava* was 0.6% (0.24 $E/m^2/day$) and that of young *Ei. bicyclis* was 1.1% (0.42 $E/m^2/day$) of the water surface light intensity on the day of average solar radiation for the period of the present study (April-July). The estimated daily compensation light intensity agreed well with the observed critical light intensity for both species on the community floor. It is clear that young *Ec. caua* fronds can grow under the lower *in situ* light intensity in deeper water as compared with young *Ei. bicyclis* fronds.

Key Index Words: compensation point—critical light intensity—Ecklonia cava—Eisenia bicyclis—*Phaeophyta—photosynthesis—seaweed.*

The two species of brown algae, *Eisenia bicyclis* SETCHELL and *Ecklonia cava* KJELLMAN, are widely distributed along the Pacific coast of central Japan, and are important algae both ecologically and economically. *Ei. bicyclis* usually grows in shallow water down to 5 m in the sublittoral zone, while *Ec. cava* occupies deeper water of 3–25 m or more, both species forming dense marine forests. A considerable knowledge has been accumulated on their distribution and population structure from the ecological point of view (HAYASHIDA 1977, IWAHASHI 1968, IWAHASHI *et al.* 1979, KIDA and MAEGAWA 1982, 1983, 1985, OHNO and ISHIKAWA 1982, TANIGUCHI and KATO 1984, MAEGAWA and KIDA 1984a, b). There are, however, few studies on their photosynthesis and respiration which are important for estimating the primary production (SAKANISHI *et al.* 1988a, b) and for production ecology (MAEGAWA *et al.* 1987).

A large part of the biomass and production of *Ei. bicyclis* and *Ec. cava* is accounted for by the adult fronds forming the canopy (HAYASHIDA 1986, TANAKA *et al.* 1984, YOKOHAMA *et al.* 1987, MAEGAWA and KIDA 1987). However, young fronds on

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the community floor play an important role as major constituents of the coming generation. The main external factor influencing the productivity of the algal communities might be an incident solar radiation. On their community floor, however, light intensity is very low (HAYASHIDA 1986, MAEGAWA and KIDA 1987), because the light is absorbed by the blades in the canopy and by water column. It is necessary for young fronds of these species to receive light greater than their compensation light intensity for their growth. Thus, the light condition in the communities is the most important factor allowing young fronds to survive and grow up to adults. In addition, it is important to know accurately the photosynthetic rate at light levels near the compensation point for estimating the daily light requirements. Furthermore, the distribution and diurnal changes in solar radiation are important for determining daily net production and daily compensation point.

The present study was undertaken to determine the critical light conditions for young fronds of *Ei. bicyclis* and *Ec. cava* with reference to the characteristics of photosynthesis and the natural light conditions in the communities, following the previous study (MAEGAWA *et al.* 1987). This kind of information will be useful in determining the factors governing the difference in vertical distributions of the two species.

Materials and Methods

Measurements of light distribution on the community floor were carried out at 5 m depth in Nabeta Bay, Izu Peninsula, Shizuoka Prefecture, on June 21, 1985, for *Ec. cava* community, and at 4 m depth off Iwaizaki, Shima Peninsula, Mie Prefecture, on June 13, 1986, for *Ei. bicyclis* community. To determine the light distribution on the community floor where young fronds were growing, light intensity was measured at 121 points 10 cm apart from each other in the community with a quantum meter (LI-COR 185B/192SB). Light in the community and on the sea surface was simultaneously monitored by a recorder (TOA EPR-152A) on a boat, and the relative light intensity was calculated.

Photosynthesis and respiration of young *Ei. bicyclis* and *Ec. cava* were measured from April to July 1986. Intact young fronds less than one year old (cf. MAEGAWA and KIDA 1984a, b) with frond area of 15–35 cm^2 and dry weight of 60–250 g were collected from the communities at depths of 3–4 m for *Ei. bicyclis* and 7–10 m for *Ec. cava* around the coast of Shima Peninsula, Mie Prefecture. When samples were collected light intensity at the growing site was measured. The collected samples were transported to the Fisheries Research Laboratory of Mie University and were rinsed with seawater to make them free of obvious epiphytes with careful handlings not to wound the fronds. After keeping the sample fronds in running seawater overnight, photosynthesis and respiration were measured with a differential gas-volumeter (YOKOHAMA and ICHIMURA 1969, YOKOHAMA *et al.* 1986, YOKOHAMA and MAEGAWA 1988). Twenty-one fronds of *Ei. bicyclis* and thirteen fronds of *Ec. cava* were used for photosynthesis and respiration measurements. The methods of measuring photosynthesis and respiration were essentially the same as those described in the previous paper (MAEGAWA *et al.* 1987).

Photosynthetically active radiation (PAR) on the horizontal plane was measured with a quantum meter (LI-COR 192SB) from April to July 1986 at the campus of Mie University about 70 km to the north of the sampling site. Values were integrated every 0.5 sec. and recorded at 10 min. intervals to the data-logger (LI-COR LI-1000).

Results

Fig. 1 shows the distribution of relative light intensity on the community floor as

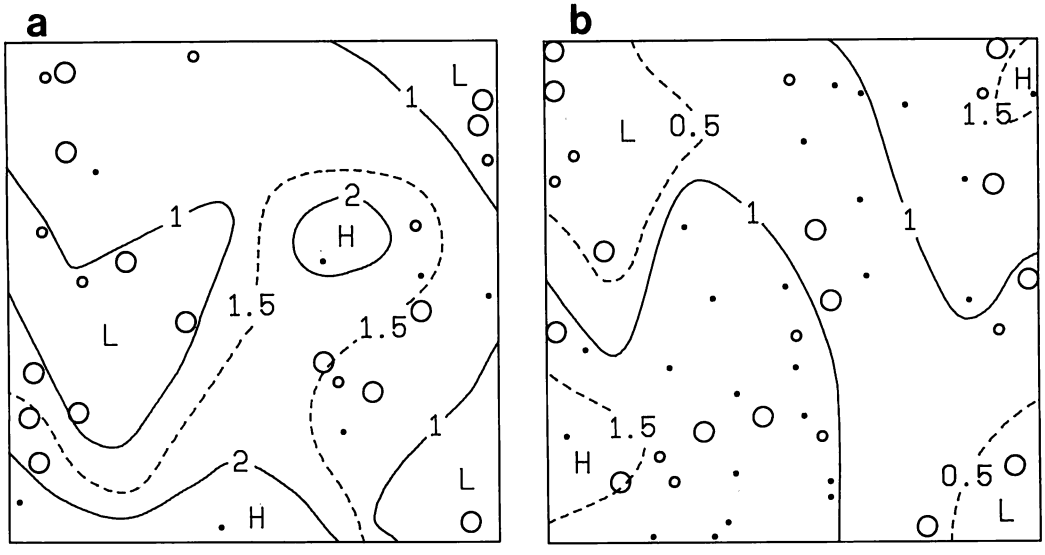

Fig. 1. Distributions of the relative light intensity (isopleths, % of the water surface value) and of individuals on the community floor of *Eisenia bicyclis* (a) and *Ecklonia cava* (b). The size of circles indicates the length of stipes: large open circles, >30 cm; small open circles, 10–30 cm; small solid circles, <10 cm. H, higher; L, lower.

well as the distribution of individual fronds for both species. Relative light intensity varied from 0.6 to 2.2% for *Ei. bicyclis*, and from 0.2 to 1.8% for *Ec. cava*. Most of the young fronds less than 10 cm of stipe length were found growing in the places where light intensity was higher than 1.0% for *Ei. bicyclis* and 0.5% for *Ec. cava*. It should be noticed that the critical light condition for survival and growth is between 1.0 and 1.5% for the former and between 0.5 and 1.0% for the latter. It is thus clear that young fronds of the two species were growing under very low light intensity on the community floor. Relative light intensity of 1% corresponds to about 20 μE/m^2/s at local noon on a fine day from April to July in the region investigated.

Photosynthesis-light curves on frond area basis of young *Ei. bicyclis* and *Ec. cava* are shown in Fig. 2. Photosynthetic rate of both species was almost saturated at 200 μE/m^2/s, and the saturated rate was higher in *Ei. bicyclis* than in *Ec. cava*. Under light intensities lower than 50 μE/m^2/s, however, the net photosynthetic rate was higher in *Ec. cava* than in *Ei. bicyclis* and it increased

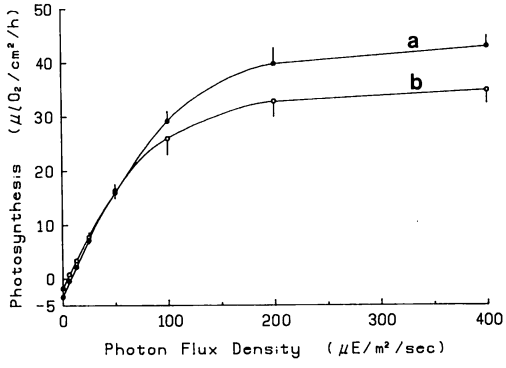

Fig. 2. Photosynthesis-light curves at 20°C of young *Eisenia bicyclis* (a) and *Ecklonia cava* (b). Vertical bars indicate SD.

Table 1. Photosynthesis-light equations on frond area basis, weight basis and chl. *a* basis in young *Eisenia bicyclis* and *Ecklonia cava*. P, net photosynthetic rate; I, photosynthetically active radiation ($0 \leqq I \leqq 25$ μE/m^2/s).

Basis	*Ei. bicyclis*	*Ec. cava*
Area	P=0.41 I−3.38	P=0.38 I−1.82
Dry weight	P=0.059 I−0.50	P=0.063 I−0.29
Chl. *a*	P=0.29 I−2.48	P=0.32 I−1.56

linearly with increase in light intensity in both of the species. Table 1 shows the

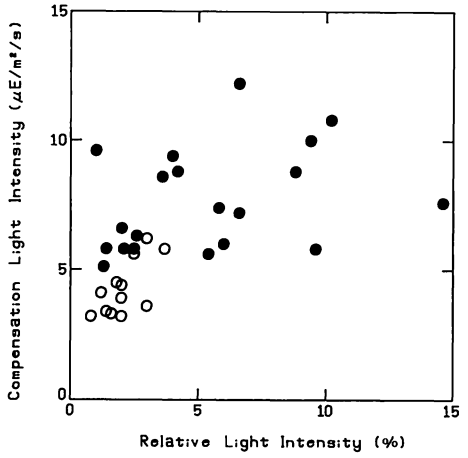

Fig. 3. Relationships between the relative light intensity at growing site and the compensation light intensity for young *Eisenia bicyclis* (●) and *Ecklonia cava* (○).

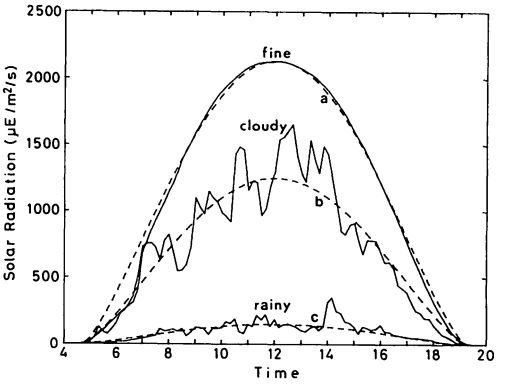

Fig. 4. Diurnal changes in photosynthetically active radiation (PAR) under 3 types of weather conditions. The broken lines show the sine curves fitted. (a) $I_0=2130\times\sin^{1.3}(\pi\cdot t/D)$; (b) $I_0=1250\times\sin^{1.3}(\pi\cdot t/D)$, and (c) $I_0=150\times\sin^{1.3}(\pi\cdot t/D)$.

linear photosynthesis-light equations represented on frond area basis, dry weight basis and chl. *a* basis, which were calculated by the squares linear regression method in the light intensity range lower than 25 μE/m^2/s. Photosynthetic rate was clearly different between the species, but the slope of each line was almost the same (no significant difference at 95% confidence level). Average respiratory rate of *Ec. cava* (1.82 μl O_2/cm^2/h) was almost half that of *Ei. bicyclis* (3.38 μl O_2/cm^2/h). The compensation light intensity was 8.2 μE/m^2/s for *Ei. bicyclis* and 4.8 μE/m^2/s for *Ec. cava*.

Fig. 3 shows the relationships between the light condition (relative light intensity) at growing sites and the compensation light intensity of young *Ei. bicyclis* and *Ec. cava*. The compensation light intensity was calculated from each photosynthesis-light equation in the range lower than 25 μE/m^2/s. There are no significant correlations between the light condition at growing sites and the compensation light intensity in both species, although the compensation light intensity of both species is clearly different.

Fig. 4 shows the diurnal changes in photosynthetically active radiation (PAR) under 3 types of weather conditions, fine, cloudy and rainy day. Solar radiation on the water surface (I_0, μE/m^2/s) at a given time t hours after sunrise is approximately given by:

$$I_0 = I_{max}\sin^{1.3}(\pi\cdot t/D), \qquad (1)$$

where I_{max} is the maximum I_0 during the daytime and D is the length of daytime (from sunrise to sunset). Table 2 summarizes the results obtained in April, May, June and July. The average I_{max} in this period was 1440 μE/m^2/s, which was 65.8% of the maximum solar radiation on fine day. The average length of daytime was 13.9 hours.

The photosynthetic rate of young *Ei. bicyclis* and *Ec. cava* when irradiated from both sides of the blade was twice as high as that when irradiated from one side of the blade in the laboratory (MAEGAWA *et al.* 1987). In addition, the relative light intensity on the blade was 80% of that of the horizontal plane immediately above the blade tip in the community (MAEGAWA *et al.* 1987). Thus, the gross photosynthetic rate (P_g, $\mu l O_2$/cm^2/h) on a frond area basis in the community can be written as follows:

$$P_g = 2\times0.8\times0.41\times I \quad \text{(for } \textit{Ei. bicyclis}\text{)}, \qquad (2)$$

$$P_g = 2\times0.8\times0.38\times I \quad \text{(for } \textit{Ec. cava}\text{)}, \qquad (3)$$

where I is the light intensity ($\mu E/m^2/s$) measured on the horizontal plane above the young frond tip in the range lower than 25 $\mu E/m^2/s$.

Based on the above equations, the daily production and daily compensation light level of young *Ei. bicyclis* fronds were estimated as follows. The light intensity on the water surface at a given time t hours after sunrise can be calculated by eq. (1). Relative light intensity on the community floor (Z) is given by:

$$Z = I/I_0.$$

Hence, the gross photosynthetic rate (P_g, eq. (2)) at a given time t hours after sunrise is given by:

$$P_g = 0.66 \times Z \times I_{max} \times \sin^{1.3}(\pi \cdot t/D). \quad (4)$$

Thus, the daily gross production (Q_g, μl $O_2/cm^2/day$) is given by:

$$Q_g = \int_0^D \{0.66 \times Z \times I_{max} \times \sin^{1.3}(\pi \cdot t/D)\}\, dt \fallingdotseq 1.21 \times Z \times I_{max} \times D/\pi \quad (5)$$

as a function of 3 parameters, the relative light intensity on the community floor (Z), maximum light intensity during the daytime (I_{max}) and the length of daytime (D, 13.9 h in the present case).

The daily net production (Q_n, μl $O_2/cm^2/day$) is also given by:

$$Q_n = 1.21 \times Z \times I_{max} \times D/\pi - 3.38 \times 24. \quad (6)$$

The daily compensation light level ($Z_{c.d}$) is given by:

$$Z_{c.d} = (3.38 \times 24 \times \pi)/(1.21 \times I_{max} \times D). \quad (7)$$

The daily production and daily compensation light level of young *Ec. cava* was calculated in the same way starting with eq. (1) and eq. (3). The gross photosynthetic rate (P_g) at a given time t hours after sunrise is given by:

$$P_g = 0.61 \times Z \times I_{max} \times \sin^{1.3}(\pi \cdot t/D). \quad (8)$$

The daily gross production (Q_g, μl $O_2/cm^2/day$) is given by:

$$Q_g = \int_0^D \{0.61 \times Z \times I_{max} \times \sin^{1.3}(\pi \cdot t/D)\}\, dt \fallingdotseq 1.12 \times Z \times I_{max} \times D/\pi. \quad (9)$$

The daily net production (Q_n, μl $O_2/cm^2/day$) is also gien by:

$$Q_n = 1.12 \times Z \times I_{max} \times D/\pi - 1.82 \times 24. \quad (10)$$

The daily compensation light level ($Z_{c.d}$) is given by:

$$Z_{c.d} = (1.82 \times 24 \times \pi)/(1.12 \times I_{max} \times D). \quad (11)$$

The relationships between daily net production (Q_n) and light condition (Z and/or I_{max}) of both species were examined in Fig. 5. Values of I_{max} represent weather conditions; e.g. 2190 $\mu E/m^2/s$ on fine day, lower than 150 $\mu E/m^2/s$ on rainy day and 1440 $\mu E/m^2/s$ on the day with average solar radiation (Table 2). Net production will equal zero at a particular daily light compensation point which depends on the relative light intensity. It is expected that young fronds of *Ei. bicyclis* and *Ec. cava* can grow when their net production exceeds the daily respiratory loss at light intensities greater than their compensation point, 1.1 % (*Ei. bicyclis*) or 0.6% (*Ec. cava*) at 1440 $\mu E/m^2/s$ of I_{max} on an average day during the present study (Fig. 5). These values agree well with the observed critical light for the species on the community floor (Fig. 1).

Table 2. The monthly maximum (I_{max}) of photosynthetically active solar radiation (PAR) on fine and average days, and the average length of daytime in April, May, June and July 1986.

Month	I_{max} ($\mu E/m^2/s$)		Daytime (h)
	fine day	average day	
April	2066	1350	13.1
May	2193	1600	14.0
June	2235	1430	14.4
July	2217	1380	14.2
Mean	2178	1440	13.9

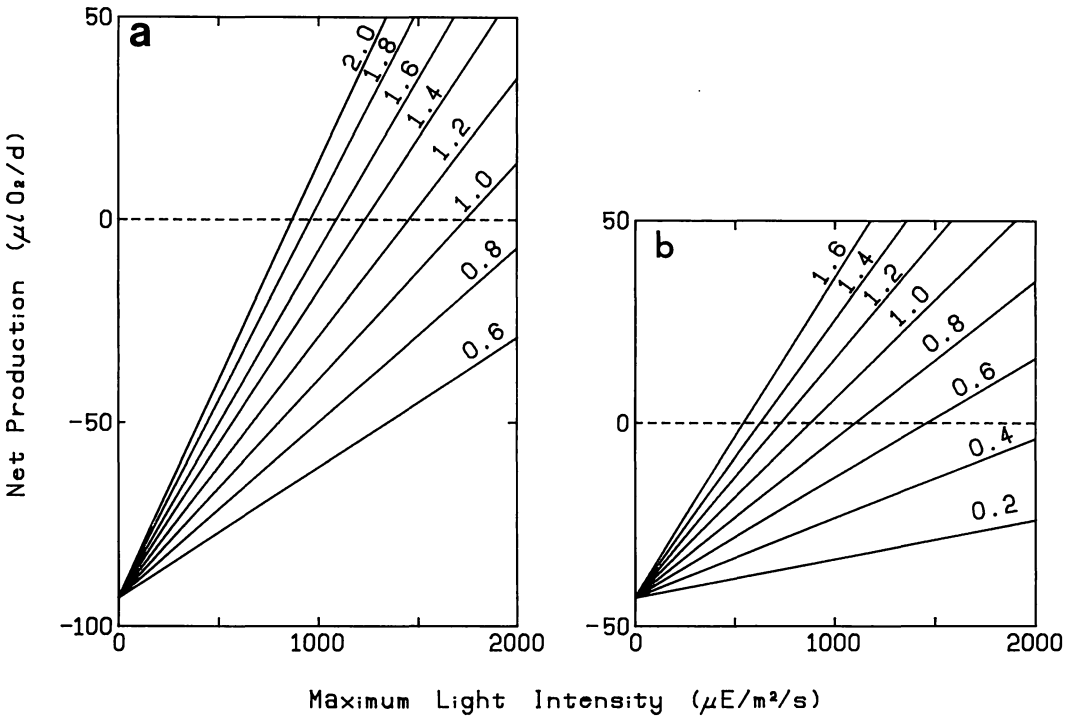

Fig. 5. Relationships of the daily net production to the maximum light intensity of daytime for young *Eisenia bicyclis* (a) and *Ecklonia cava* (b) in relation to different relative light intensities (figures on the lines).

Discussion

Solar radiation is an ultimate source of biological production which is initiated in the conversion of its radiant energy into chemical energy in organic matter through photosynthesis of plants, the primary producers. Primary production in the coastal areas of the sea is carried out mainly by macroalgae. Distribution and diurnal changes of the solar radiation, especially of the photosynthetically active radiation (PAR), are important for algal photosynthesis in the sea (RYTHER 1956, RYTHER and YENTSCH 1957, ICHIMURA *et al.* 1962). In spite of its important ecological significance, only a little attention has so far been paid to the light distribution within underwater plant communities (IKUSIMA 1965, 1966, GERARD 1984, 1986, HAYASHIDA 1986, MAEGAWA and KIDA 1987), probably because of the difficulty of light measurements under natural conditions. On the community floor of *Ei. bicyclis* and *Ec. cava* the light intensity is critical for the survival and growth of young fronds. Photosynthetic characteristics of young fronds of seaweed species under dim light condition will provide a key to understand the difference in vertical distributions of the species.

In the present study the improved differential gas-volumeter (YOKOHAMA and MAEGAWA 1988) with large reaction and compensation vessels (250 ml) was used to measure photosynthesis and respiration in intact young fronds of comparatively large area (15–35 cm^2) of *Ei. bicyclis* and *Ec. cava*, and it was possible to obtain detailed photosynthetic oxygen changes even near the compensation light level. The saturated light intensity, light compensation point and respiratory rate of young *Ei. bicyclis* and *Ec. cava* in the present study were well in agreement with those of adult fronds (SAKANISHI *et al.* 1988a, b) and almost the same as reported in a previous paper (MAEGAWA *et al.* 1987). The light com-

pensation point estimated by the linear photosynthesis-light relationship of young fronds irradiated from one side was 8.2 $\mu E/m^2/s$ for *Ei. bicyclis* and 4.8 $\mu E/m^2/s$ for *Ec. cava*. These values were higher than those of adult or young *Macrocystis pyrifera* (CLENDENNING 1971, FAIN and MURRAY, 1982) and young *Laminaria japonica* (NIHARA 1980), although the saturated light intensity was almost similar.

It was reported that mature blades of *Macrocystis pyrifera* from different depths exhibited different photosynthetic characteristics; i.e. the photosynthetic capacity of canopy blades was higher under saturating irradiance and their photosynthetic efficiency was higher at low irradiance as compared with those of deeper blades (GERARD 1986). These differences in photosynthetic characteristics of blades collected from different depths were primarily attributable to acclimation to light conditions. For young *Ei. bicyclis* and *Ec. cava* in the present study, the compensation light intensity varied with various light conditions of the growing sites from where they were collected, even though no significant correlations were found between the light condition at growing sites and the compenastion light intensity (Fig. 3). However, the level of compensation light intensity was distinguishable between the two species. The photosynthetic capacity under saturating irradiance could also be distinguished clearly between young *Ei. bicyclis* and *Ec. cava* regardless of the light conditions at their growing sites in the present study as well as in the previous study (MAEGAWA *et al.* 1987).

The difference of photosynthesis-light curve in relation to light quality was remarkable in green and red algae (YOKOHAMA 1973a, b). However, KAGEYAMA and YOKOHAMA (1974) reported that the photosynthesis-light curve was slightly different with the light quality in three species of Phaeophyta, *Ishige sinicola, Sargassum ringgoldianum* and *Undaria pinnatifida,* collected from shallow water, but was not different in *Undaria peterseniana* from deeper water. In the present study it was assumed that there is no significant difference in photosynthetic rate of *Ei. bicyclis* and *Ec. cava* in relation to light quality.

The estimation of the critical light intensity for young *Ei. bicyclis* and *Ec. cava* was carried out in the present study with special reference to the mathematical model of community photosynthesis for submerged aquatic plants by IKUSIMA (1970). In his report the light intensity on the water surface (I, klx) at a given time t hours after sunrise was approximately given by:

$$I = I_{max} \sin^2(\pi \cdot t/D),$$

where I_{max} is the maximum I during the daytime and D is the length of daytime (hr). In the present study, however, the diurnal change in solar radiation (I, $\mu E/m^2/s$) is represented by:

$$I = I_{max} \sin^{1.3}(\pi \cdot t/D).$$

It is thought that the discrepancy among the equations may be due to the difference of measuring methods and units which are illuminance (lx) in the former and photon flux density ($\mu E/m^2/s$) of PAR in the latter.

The estimated critical light level was 1.1% for *Ei. bicyclis* and 0.6% for *Ec. cava* in reference to the light intensity at the water surface (Fig. 5). These values correspond to about 0.42 $E/m^2/day$ and 0.24 $E/m^2/day$ respectively, which are almost the same as the daily compensation light of phytoplankton (PARSONS *et al.* 1984). Photosynthetic characteristics of *Ei. bicyclis* and *Ec. cava* respectively represent characters of the sun and shade types of photosynthesis in terrestrial plants (BOARDMAN 1977). It is clear that young *Ec. cava* fronds can grow under the lower *in situ* light intensity in deeper water as compared with young *Ei. bicyclis* fronds. This difference in critical light cnodition is considered to be one of the most important factors to determine the difference in their vertical distributions, particularly the lower limit of distribution of the two species. The estimated daily compensation light of both species agreed well with the observed critical light condi-

tions on the community floor. This indicates that the present measurements of light conditions in the field and photosynthetic rate in the laboratory were accurately carried out.

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前川行幸*・喜田和四郎*・横浜康継・有賀祐勝***：褐藻アラメおよびカジメ幼体の光要因からみた生育限界の比較**

三重県志摩半島沿岸および静岡県伊豆下田鍋田湾のアラメ・カジメ群落について，生育場所の光環境，幼体の光合成—光関係，日射の日変化等を測定し，日補償点を推定するためのモデル式を作り，両種幼体の光環境からみた生育限界の解明を試みた。さまざまの場所から採取されたアラメ幼体21個体，カジメ幼体13個体について光合成—光曲線を求めた。光合成—光関係，生育場所の相対光強度，日射の日変化等から1日の純生産量を求めるモデル式を作り，日補償点を推定した。得られた日補償光強度は，海面に対する相対光強度で表わされ，アラメ幼体では約1.1%，カジメ幼体では約0.6%であった。また，幼体の生育する現場での光環境を知るため群落底部の光分布を測定した結果，アラメ幼体は1.0—1.5%，カジメ幼体は0.5—1.0%相対光強度の場所に生育しており，モデル式からの推定値とよく一致した。以上の結果から，カジメはアラメに比べより深所に分布することが説明される。両種の水深の違いを，光合成の面から日補償点の差として明らかにすることができた。（*514 三重県津市江戸橋2—80 三重大学生物資源学部藻類増殖学研究室，**415 静岡県下田市5—10—1 筑波大学下田臨海実験センター，***108 東京都港区港南4—5—7 東京水産大学藻類学研究室）

Jpn. J. Phycol. (Sôrui) **36**: 175–177, June 20, 1988

Masahiro NOTOYA: Tissue culture from the explant of *Ecklonia stolonifera* OKAMURA (Phaeophyta, Laminariales)

Key Index Words: Ecklonia stolonifera *Okamura—Phaeophyta—tissue culture.*
Masahiro Notoya, Aquaculture Center Aomori Prefecture, Hiranai, Aomori-ken, 039-34 Japan

As shown in Table 1. seven species have been used for the tissue culture in Laminariaceae. The present study shows the growth of tissues of *Ecklonia stolonifera* OKAMURA in several culture media under various temperatures.

The material used was collected at Tanosawa, Aomori Prefecture, in April, 1986. The tissues removed from the portions of meristematic zone, stipe or holdfast were quickly cleaned up by paper towels, then the surface was cut off. After treatment with absolute ethanol, the surface was burned in clean bench (Fig. 1). Explants were cut into 3–4 mm segments and placed on the following culture media solidified

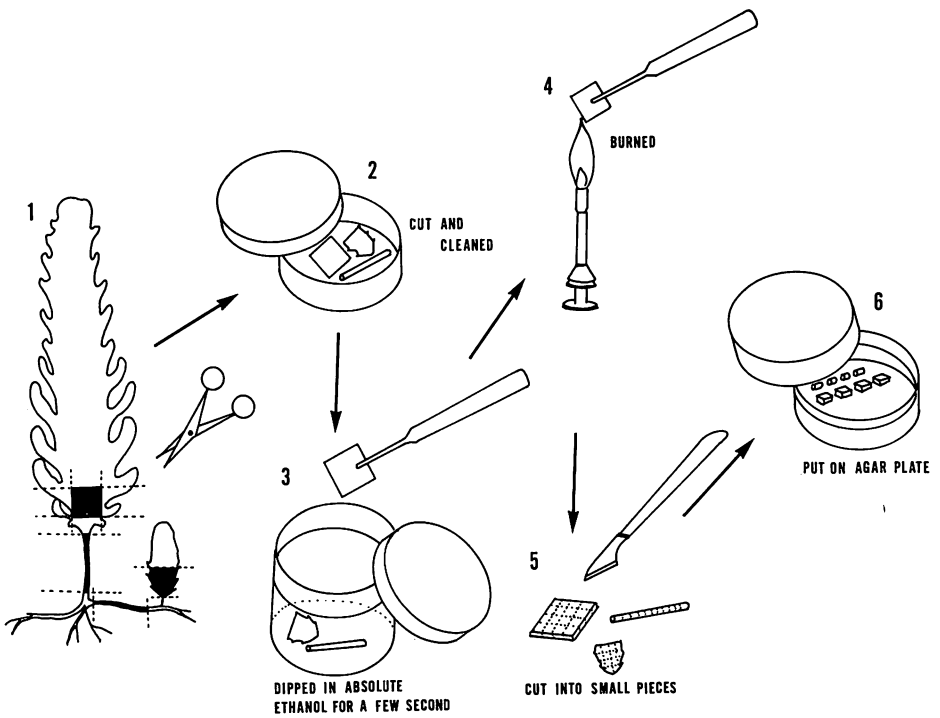

Fig. 1. Sterilization procedure for the preparation explant used in the present tissue culture experiment.

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Table 1. The species in Laminariales previously used for tissue culture.

Species	Tissue	Culture Medium		Result	Reference
Laminaria angustata	Blade	PESI	L	Callus=>Sporophyte	Saga et al. 1978
L. digitata	Blade	ASP6F2	S	Callus=>♂ ♀=>Sporophyte	Fries 1980
L. hyperborea	Blade	ASP6F2	S	Callus=>♂ ♀=>Sporophyte	Fries 1980
L. angustata	Stipe	ASP 12-NTA	S	Callus	Saga & Sakai 1983
L. japonica	Blade	MS+B_{12}+C-751	L	Callus=>Sporophye	Fang et al. 1983
L. saccharina	Stipe	ASP6F2, PESI, SWA	S,L	Callus=>♂ ♀=>Sporophyte	Lee 1985
Undaria pinnatifida	Blade	MS+B_{12}+C-751	L	Callus=>Sporophyte	Fang et al. 1983
Macrocystis pyrifera	Stipe	PESI	S,L	Callus	Polne-Fuller et al. 1986
Ecklonia stolonifera	Blade, Stipe, Holdfast	PES, PFSI, MG-JS, PESI-JS	S	Callus	Present study

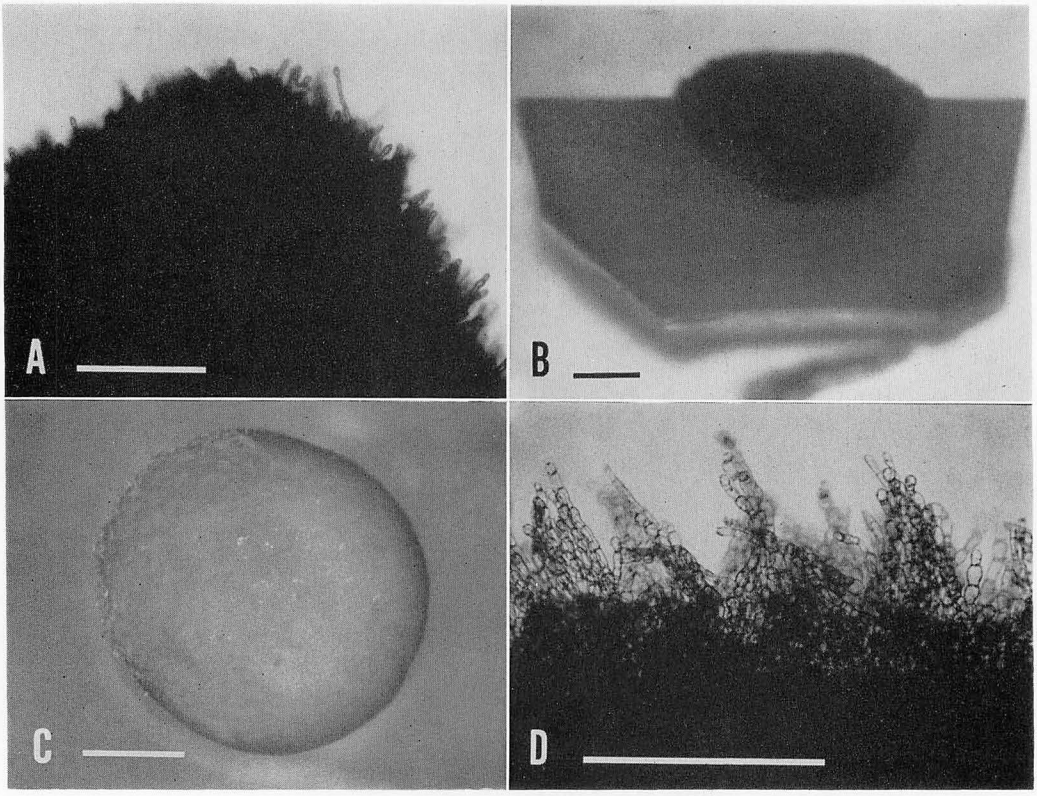

Fig. 2. Callus tissues developed into various parts of the frond of *Ecklonia stolonifera* OKAMURA. A; Blade, B; Stipe, C; Holdfast. Callus forming portion is noticed in the part which is weakly stained at the margin on the upper left side. D; Longitudinal section extending callus mass from medullary part of stipe. Scale bar= 500 μm.

with 1.5% agar in 50×15 mm Petri dishes, viz., PES (PROVASOLI 1968), PESI (TATEWAKI 1966), PESI-JS (natural seawater changed by Jamarin S in PESI) and MG-JS (natural seawater changed by Jamarin S in modified GRUND medium). The cultures were conducted at 10°C, 15°C, 20°C and 25°C, in 14h light and 10h dark cycle under 2000 lux by cool white fluorescent lamps. All the tissues gave rise to callus formation in PESI medium under 15°C (Fig. 2), of which those from the stipe grew excellently. The callus occurred mainly at the medullary part; they consisted of colourless or pale yellow branched filaments (Fig. 2C). The callus derived from the stipe tissue showed the best result in PESI-JS at 20°C (Table 2). The tissue cultures previously reported (Table 1) had been performed only at 10°C or 15°C. I guess that 20°C, a relatively high temperature, would be suitable for culture growth of the species of Laminariaceae such as *Ecklonia stolonifera* growing in the temperate region.

Acknowledgement

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Table 2. Formation of callus structure of *Ecklonia stolonifer* OKAMURA in culture. Occurrence of callus structure: (−)=not appeared, (+)=slightly appeared, (++)=abundantly appeared.

Age		1 Week				2 Week				3 Week				4 Week			
Temperature (°C)		10	15	20	25	10	15	20	25	10	15	20	25	10	15	20	25
Medium	PES	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−
	PESI	−	−	−	−	−	−	−	−	−	+	+	−	+	+	+	−
	PESI-JS	−	−	+	−	−	+	+	−	+	+	++	+	+	++	++	+
	MG-JS	−	−	−	−	−	−	−	−	−	−	+	−	−	−	+	−

能登谷正浩：ツルアラメの組織培養

ツルアラメの各組織，即ち葉部成長点付近，茎部，仮根部からの摘出組織を用いてカルス形成に及ぼす培地と温度の影響を調べた。その結果，茎の組織，ジャマリン人工海水を用いたPESI寒天培地，20°Cでそれぞれ最も良くカルスの発生が認められた。(039-34 青森県東津軽郡平内町大字茂浦字月泊10 青森県水産増殖センター)

Jpn. J. Phycol. (Sôrui) **36**: 178–179, June 20, 1988

J. Carl Stapleton: Occurrence of *Undaria pinnatifida* (Harvey) Suringar in New Zealand

Key Index Words: new record—New Zealand—Phaeophyta—seaweed—Undaria pinnatifia

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In mid-August 1987 attached *wakame*, *Undaria pinnatifida* (Harvey) Suringar (Phaeophyta), growing on a breakwater at Oriental Bay, Wellington, New Zealand (Fig. 1), was identified by Dr. Penny Luckens, a D.S.I.R. (Department of Scientific and Industrial Research) marine biologist. Dr. Luckens had spent 2 years in Japan and had seen *wakame* cultivation, so was easily able to identify the species. An article in the *Evening Post* newspaper, Wellington, September 2, 1987, shows a photograph of Dr. Luckens holding a specimen of *wakame* with holdfast attached to a bottle (Fig. 2).

The *wakame* is growing on rocky surfaces, especially on recently made artificial substrates. The largest population is near the Freyburg swimming pool with other populations between Point Jerningham and the Wellington Overseas Container Terminal (Fig. 1). The species has not been recorded from any other sites in New Zealand.

This occurrence of *wakame* in New Zealand is the first time it has been recorded in the southern hemisphere. It was suggested in the Wellington newspaper articles (*Evening Post*, September 2, 1987; *Dominion*, September 3, 1987) announcing the discovery

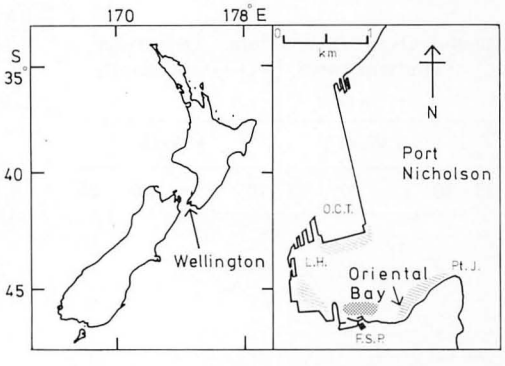

Fig. 1. Map of New Zealand (left) showing location of Wellington. Map of Wellington Harbour area (right) showing the distribution of *wakame*: Light shading at southern end of Overseas Container Terminal (O.C.T.) in Lambton Harbour (L.H). and extending as far as Point Jerningham (Pt. J.) indicates scattered populations of *wakame*. Dark shading near Freyburg Swimming Pool (F.S.P.), location of heaviest population.


NEWS

Asian seaweed invades inner harbour

Breakwater

Too late

Fig. 2. Newspaper article in the "Evening Post" (Wellington), September 2, 1987, with a photograph of Dr. Penny Luckens holding a specimen of *wakame* found in Lambton Harbour, Wellington, New Zealand.

that the species might have arrived in New Zealand as a gametophyte on the hull of Japanese or Korean fishing vessels many of which frequently berth in Lambton Harbour, Wellington. However it seems that it would be difficult for the gametophyte to survive the high temperatures of the tropical seas through which ships from the northern hemisphere must pass to reach New Zealand. Another hypothesis is that the species arrived as a gametophyte in ship ballast water. CARLTON (1985) reviews transoceanic and interoceanic dispersal of coastal marine organisms, including seaweeds, in ship ballast water. However the New Zealand authorities do not know how the species arrived there or for how long it has been growing in and near Lambton Harbour, Wellington. The plants are healthy, fertile and up to 1.5 m long (NELSON, personal communication).

It is too early to know what effect the *wakame* will have on the ecology of the harbour in which it has been found. FARNHAM (1980) discusses accidentally introduced species of seaweeds in British coastal waters and the ecological effects of the introduction of alien species in specific parts of the English coast. Dr. Cameron H. HAY, a D.S.I.R. Oceanographic Institute phycologist, will direct studies of the Wellington *wakame*. It will be necessary to survey the ecology of native seaweeds of Port Nicholson immediately to find out if the *wakame* is growing in any other locations there. The D.S.I.R. is also interested in the commercial potential of the species (HAY, personal communication). There are no plans to remove or destroy the *wakame*.

The writer would like to thank Professors A. MIURA and Y. ARUGA, Tokyo University of Fisheries, for suggesting that this information be communicated and for reading and offering advice on the manuscript, Dr. W. NELSON, National Museum of New Zealand, for communicating news of the discovery, Dr. M. GORDON, Botany Department, Victoria University of Wellington, for sending newspaper articles and other information, and Dr. C.H. HAY, D.S.I.R., for helpful information on the Wellington *wakame*.

Addendum

After submission of the manuscript of this report the paper by HAY and LUCKENS (1987) on the Wellington *wakame* was published.

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スティプルトン J.C.: ニュージーランドのウェリントン港におけるワカメ *Undaria pinnatifida* (HARVEY) SURINGAR の出現

1987年8月中旬，ニュージーランドのウェリントンのオリエンタル湾でワカメが生育しているのが発見された。どのようにしてワカメがニュージーランドへ運ばれたかは，現在のところ不明である。ワカメの生育がこの地域の他の海藻に影響を及ぼしているという情報はまだない。（〒108 東京都港区港南4—5—7 東京水産大学資源育成学科藻類学研究室）

―学 会 録 事―

1. 日本藻類学会第12回大会

昭和63年3月30日・31日の両日，三重大学・生物資源学部水産学校舎において第12回大会を開催した。大会会長は岩崎英雄氏（三重大）で，参加者は117名であった。講演は54題の一般講演があった。

大会第1日目に同会場において総会を開催し，引き続き三重大学水産食堂で約2時間にわたって懇親会を開催した。懇親会は前川行幸氏（三重大）の司会，谷口森俊氏の乾杯の音頭で始まり，盛会裡に終了した。参加者は97名であった。三重大学の教官諸氏および学生諸氏には大会運営にあたっていろいろご協力頂き，厚く御礼申し上げる。

懇親会参加者

秋岡英承，秋山　優，鰺坂哲朗，安達六郎，有賀祐勝，池原宏二，石川依久子，市村輝宜，出井雅彦，伊藤裕之，井上　勲，岩井寿夫，巌佐耕三，岩崎英雄，梅崎　勇，榎本幸人，江原友子，大喜田勝，大塚晴江，大野正夫，大葉英雄，大森長朗，奥田武男，長船哲斎，小野　淳，Christine A. Orosco，柿木孝文，笠井文絵，加藤英男，片山舒康，香村真徳，川合哲夫，川井浩史，川嶋昭二，河池正伸，菊地和夫，北沢星磁，喜田和四郎，熊野　茂，倉島　彰，黒田充恵，小林艶子，小林　弘，今野敏徳，斎藤捷一，斎藤　譲，坂西芳彦，瀬戸良三，高橋永治，高村典子，田中次郎，谷口森俊，千原光雄，張　暁明，坪　由宏，徳田　廣，戸田淳一郎，土井考爾，中原紘之，長島秀行，名畑進一，南　基完，野崎久義，野田宏行，原　慶明，Richardo J. Haroun，半田信司，馬場将輔，日野修次，福島　博，福田育二郎，藤井修平，藤村太一郎，堀　輝三，マーチャート，前川行幸，増田道夫，松井敏夫，松山恵二，真山茂樹，丸山　晃，三浦昭雄，水野　真，御園生拓，宮地和幸，村瀬　昇，安井　肇，籏　瀗，山岸高旺，山本真規子，山本虎夫，横浜康継，善家俊二，吉武佐紀子，吉田忠生，渡辺　信，渡辺里香

2. 評議員会・編集委員会

第12回大会の前日，3月29日に三重大学・生物資源学部水産学校舎2階会議室において編集委員会（14：00～15：30）および評議員会（15：30～19：30）を開催し，昭和63年度総会に提出する報告事項・議題などの審議を行った。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：梅崎　勇会長，秋山　優，石川依久子，巌佐耕三，榎本幸人，大野正夫，奥田武男，喜田和四郎，小林　弘，千原光雄，原　慶明，三浦昭雄，籏　瀗，横浜康継の各評議員，坪　由宏編集委員長および鰺坂哲朗，市村輝宜，熊野　茂，中原紘之各幹事。

編集委員会出席者：坪　由宏委員長，石川依久子，巌佐耕三，榎本幸人，高橋永治の各編集実行委員，秋山　優，有賀祐勝，岩崎英雄，奥田武男，小林　弘，堀　輝三，吉田忠生の各編集委員，梅崎　勇会長および鰺坂哲朗，市村輝宜，熊野　茂，中原紘之各幹事。

3. 昭和63年度総会

昭和63年3月30日（大会第1日目）の講演終了後，三重大学・生物資源学部水産学校舎において総会を開催した。梅崎会長の挨拶に続いて，喜田和四郎氏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（63年2月現在）：名誉会員3名，普通会員529名，学生会員47名，団体会員56名，賛助会員14名，外国会員81名，購読・寄贈・交換75件。(2)昭和62年度文部省科学研究費刊行補助金「研究成果公開促進費」は104万円で，責任頁は300頁である。なお，昭和63年度分として199万円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69万6919円である。

2. 会計関係

(1)昭和63年度の会費納入率は3月26日現在で普通会員53%，学生会員33%である。(2)昭和62年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63年3月10日，瀬戸良三（神戸女学院大学），清水　晃（奈良女子大学）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62年度に発行した第35巻1～4号は，総頁数305頁，掲載論文数28編，短報8編，広告頁17頁であった。(2)昭和62年度に発行した第36巻1号は，掲載論文数8編，短報5編，総説1編，第12回大会講演要旨，学術会議だより，を含めて，112頁で発行した。

第36巻2号以降に掲載予定の投稿論文は審査中のものを含めて24編である。(3)昭和63年度編集実行委員に，四天王寺国際仏教大学の巌佐耕三氏を委嘱する。

4. その他

(1)会則の趣旨に沿って日本藻類学会主催の海藻採集会を大会終了後，三重大学生物資源学部附属水産実験所（志摩郡志摩町）で開催する。(2)日本藻類学会昭和62年度秋季シンポジウムを植物学会大会前日の昭和62年11月25日午後に茨城県つくば市の国立公害研究所で開催した。

Ⅱ．審議事項

1. 昭和62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62年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63年度一般会計予算案は表-3のように可決承認された。 4. 編集関係では次の事項が承認された。(1)審査委員に対する謝辞の文面は現状通りとする。(2)秋季シンポジウムの記事は，発表者が各人2,000～4,000字程度に纏め，学会録事として掲載する。(3)制限頁を一部緩和し，論文（英文10頁，和文6頁），短報3頁，速報2頁，雑録1頁，総説15頁とする。速報は有料で1頁12,000円の掲載料を徴収する。以上の変更に伴って，投稿案内を改訂する。 5. 昭和63年度事業計画として次の事項が決められた。(1)本年度の秋季シンポジウムは岡山大学で開かれる日本植物学会第53回大会前日の10月12日に山陽学園短期大学の大森長朗氏を世話人として岡山市の山陽学園短期大学で開催する。(2)来年度の日本藻類学会第13回大会は福島　博氏を世話人として東京女子体育大学で開催する。 6. 会則の付則第2条の2を次のように変更することが承認された。「地区割は次の8地区とする。北海道地区，東北地区，関東地区，東京地区，中部地区（三重県を含む），近畿地区，中国・四国地区，九州地区（沖縄県を含む）。」 7. 第4回国際バイオシステマティック・シンポジウム（昭和64年7月10日～14日）の組織委員長（河野昭一氏，京大教授）及び第5回国際微生物生態学シンポジウム（昭和64年8月27日～9月1日）の組織委員長（門田　元氏，京大名誉教授・近畿大教授）からの申し出により，それぞれの後援団体及び協賛学会となることになった。 8. 日本学術会議第14期会員候補者および推薦人予備者の決定について。本年度は日本学術会議会員改選の年に当たります。本学会では会員候補者及び推薦人・推薦人予備者の選出に関する内規（昭和59年12月21日制定，昭和62年3月29日一部字句訂正）に従い，評議員による選挙をおこないました。その結果，最高得票者は千原光雄氏となりましたが，同氏は日本植物学会の推薦人になっておりますので，会員候補者を兼ねることができません。そのために次点者の下記の方に決定しました。

日本学術会議第14期会員候補者　梅崎　勇

また，次の方を推薦人，推薦人予備者に決定しました。

日本学術会議推薦人　小林　弘

日本学術会議推薦予備者　山岸高旺

4. 日本藻類学会海藻採集会報告

昭和63年3月31日（木）日本藻類学会第12回大会終了後，大学バスで三重大学生物資源学部附属水産実験所（志摩郡志摩町）に移動して，4月1日（金）～2日（土）に海藻採集集会を開催した。喜田和四郎氏と前川行幸氏（三重大）を講師に本学会会員を中心に下記の17名（手伝いを兼ねた三重大学の大学院生1名を含む）が参加した。4月1日午前中は志摩郡浜島町矢取島の海岸で磯採集，午後から2班に分かれ，カジメ群落の潜水観察やヒトエグサ養殖場の見学をした後，2日正午まで採集品の整理・同定観察と標本作成などを行った。なお，本海藻採集会の内容の詳細は田中次郎氏（国立科博・植物）の参加記（次号掲載予定）を参照されたい。

参加者：池原宏二（日本海区水研），伊藤真理（日本女子大），井本善次（高知大，海洋生物センター），大野正夫（高知大，海洋生物センター），大葉英雄（東水大，植物），Christine A. Orosco（高知大，海洋センター），片山舒康（東京学芸大，生物），川嶋昭二，喜田和四郎（三重大，生物資源），田中次郎（国立科博，植物），鍋島靖信（大阪府水試），馬場将輔（日本海洋生物研），前川行幸（三重大，生物資源），御園生拓（山梨大），村瀬　昇（三重大，生物資源），横浜康継（筑波大，臨海センター），渡辺里香（高知大，海洋生物センター）

表-1　昭和62年度　一般会計決算報告（62. 1. 1～62. 12. 31）　日本藻類学会

収入の部	（円）	支出の部	（円）
会費	5,039,957	印刷費	4,760,980
普通会員	3,588,000	印刷代	4,068,120
学生会員	302,500	別刷代	692,860
外国会員	642,657	編集費	359,800
団体会員	226,800	英文校閲料	100,000
賛助会員	280,000	編集補助費	34,000
販売	841,560	通信連絡費	225,800
定期購読	788,400	会誌発送費	224,030
バックナンバー	53,160	庶務費	568,403
別刷代	810,680	事務用品費	28,260
超過頁負担金	408,000	会議費	49,550
広告代	223,750	通信・印刷費	112,593
利子	4,293	事務整理補助費	0
プログラム代	30,000	諸雑費	142,500
雑収入	163,998	幹事旅費補助	55,500
刊行助成金	1,040,000	幹事手当	180,000
		学会センター業務委託費	696,919
		第11回大会補助	100,000
		秋季シンポジウム会場費	50,000
小計	8,562,238	小計	6,760,132
前年度繰越金	2,655,284	予備費	4,457,390
合計	11,217,522	合計	11,217,522

貸借対照表

借方	（円）	貸方	（円）
普通預金（第一勧銀）	1,996,560	未払金	65,010
学会センター預け金	1,755,287	前受会費	35,500
郵便振替	17,500		
小口現金	15,881	前期繰越金	2,655,284
未収金	672,672	当期繰越金	1,802,106
仮払い金	100,000	次期繰越金	4,457,390
合計	4,557,900	合計	4,557,900

昭和63年3月10日

日本藻類学会会長　梅崎勇　㊞
日本藻類学会会計幹事　鯵坂哲朗　㊞
日本藻類学会会計監事　瀬戸良三　㊞
日本藻類学会会計監事　清水晃　㊞

本会計決算報告は適正である事を認める。
昭和63年3月10日

表-2　昭和62年度山田幸男博士記念事業特別基金会計決算報告（62.1.1～62.12.31）　日本藻類学会

収入の部	(円)	支出の部	(円)
山田幸男博士追悼号（2冊）	14,000		
学会出版物売上金			
コンブ論文集（1冊）	1,000		
日米セミナー（4冊）	16,000		
利子	23,469		0
小計	54,469	小計	0
前年度繰越金	1,412,053	次年度繰越金	1,466,522
合計	1,466,522	合計	1,466,522

貸借対照表

借方	(円)	貸方	(円)
定期預金（住友銀行）	1,300,000	前期繰越金	1,412,053
普通預金（住友銀行）	162,522	当期繰越金	54,469
未収金	4,000		
		次期繰越金	1,466,522
合計	1,466,522	合計	1,466,522

昭和63年3月10日

日本藻類学会会長　梅崎　勇　㊞
日本藻類学会会計幹事　鰺坂哲朗　㊞
日本藻類学会会計監事　瀬戸良三　㊞
日本藻類学会会計監事　清水　晃　㊞

本会計決算報告は適正である事を認める。
昭和63年3月10日

表-3　昭和63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	4,484,200	印刷費	5,300,000
普通会員 (529)	3,332,700	印刷代	4,500,000
学生会員 (47)	211,500	別刷代	800,000
外国会員 (81)	290,000	編集費	400,000
団体会員 (56)	410,000	英文校閲料	100,000
賛助会員 (14)	240,000	編集補助費	50,000
販売	320,000	通信連絡費	250,000
定期購読 (50)	270,000	会誌発送費	250,000
バックナンバー	50,000	庶務費	1,050,000
別刷代	800,000	事務用品費	40,000
超過頁負担金	300,000	会議費	50,000
広告代	200,000	通信・印刷費	150,000
利子	5,000	事務整理補助費	60,000
プログラム代	36,000	諸雑費	500,000
雑収入	30,000	幹事旅費補助	50,000
刊行助成金	1,040,000	幹事手当	200,000
		学会センター業務委託費	710,000
		第12回大会補助	100,000
		秋季シンポジウム会場費	50,000
小計	7,215,200	小計	7,860,000
前年度繰越金	4,457,390	予備費	3,812,590
合計	11,672,590	合計	11,672,590

日本藻類学会第12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	36,000
予約 (80名)	194,500	会場使用料	2,389
当日 (37名)	91,500	懇親会会食代	296,000
懇親会費		アルバイト代	281,250
予約 (67名)	167,500	諸雑費	70,353
当日 (30名)	75,000	学会返還金	2,508
学会補助金	100,000		
商品展示代金	60,000		
合計	688,500	合計	688,500

昭和63年4月5日　　第12回大会会計幹事　岩井寿夫 ㊞

―会 員 移 動―

新　人　会

住 所 変 更

退　　会

永沼　治（長野県），鷹取晟二（岡山県），佐藤重勝（千葉県）

日本藻類学会々則

第1条　本会は日本藻類学会と称する。

第2条　本会は藻学の進歩普及を図り，併せて会員相互の連絡並に親睦を図ることを目的とする。

第3条　本会は前条の目的を達するために次の事業を行なう。

1. 総会の開催（年1回）
2. 藻類に関する研究会，講習会，採集会等の開催
3. 定期刊行物の発刊
4. その他前条の目的を達するために必要な事業

第4条　本会の事務所は会長が適当と認める場所におく。

第5条　本会の事業年度は1月1日に始まり，同年12月31日に終る。

第6条　会員は次の4種とする。

1. 普通会員（藻類に関心をもち，本会の趣旨に賛同する個人で，役員会の承認するもの）。
2. 団体会員（本会の趣旨に賛同する団体で，役員会の承認するもの）。
3. 名誉会員（藻学の発達に貢献があり，本会の趣旨に賛同する個人で，役員会の推薦するもの）。
4. 賛助会員（本会の趣旨に賛同し，賛助会員会費を納入する個人又は団体で，役員会の推薦するもの）。

第7条　本会に入会するには，住所，氏名（団体名），職業を記入した入会申込書を会長に差出すものとする。

第8条　普通会員は毎年会費7,000円（学生は5,000円）を前納するものとする。但し，名誉会員（次条に定める名誉会長を含む）は会費を要しない。外国会員の会費は8,500円とする。会長の承認を得た外国人留学生は帰国前に学生会費の10年分を前納することができる。団体会員の会費は12,000円とする。賛助会員の会費は1口20,000円とする。

第9条　本会には次の役員を置く。

会長　1名　　幹事　若干名　　評議員　若干名　　会計監事　2名

役員の任期は2カ年とし重任することが出来る。但し，会長と評議員は引続き3期選出されることは出来ない。役員選出の規定は別に定める（付則第1条～第4条）。本会に名誉会長を置くことが出来る。

第10条　会長は会を代表し，会務の全体を統べる。幹事は会長の意を受けて日常の会務を行う。会計監事は前年度の決算財産の状況などを監査する。

第11条　評議員は評議員会を構成し，会の要務に関し会長の諮問にあずかる。評議員会は会長が招集し，また文書をもって，これに代えることが出来る。

第12条　1. 本会は定期刊行物「藻類」を年4回刊行し，会員に無料で頒布する。

2. 「藻類」の編集・刊行のために編集委員会を置く。
3. 編集委員会の構成・運営などについては別に定める内規による。

（付　則）

第1条　会長は国内在住の全会員の投票により，会員の互選で定める（その際評議員会は参考のため若干名の候補者を推薦することが出来る）。幹事は会長が会員中よりこれを指名委嘱する。会計監事は評議員会の協議により会員中から選び総会において承認を受ける。

第2条　評議員選出は次の二方法による。

1. 各地区別に会員中より選出される。その定員は各地区1名とし，会員数が50名を越える地区では50名までごとに1名を加える。
2. 総会において会長が会員中より若干名を推薦する。但し，その数は全評議員の⅓を越えることは出来ない。

地区割は次の8地区とする。北海道地区，東北地区，関東地区，東京地区，中部地区(三重を含む)，近畿地区，中国・四国地区，九州地区（沖縄を含む）。

第3条　会長，幹事及び会計監事は評議員を兼任することは出来ない。

第4条　会長および地区選出の評議員に欠員を生じた場合は，前任者の残余期間次点者をもって充当する。

第5条　会員がバックナンバーを求めるときは各号1,750円とし，非会員の予約購読料は各号3,000円とする。

第6条　本会則は**昭和63年3月31日**より改正施行する。

投　稿　案　内　（昭和63年3月改訂）

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（短い調査報告など）・速報・雑録（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，論文は刷り上がり英文10頁，和文6頁，総説は15頁，短報3頁，雑録1頁以内を無料とします。頁の超過は制限しませんが，超過頁分については1頁当たり12,000円が必要です。折り込み，色刷りなどの費用は著者負担となります。また，速報は2頁以内と制限があり，有料で1頁12,000円の掲載料が必要です。和文原稿では5枚（ワープロでは2枚）が，英文原稿では2枚が刷り上がり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行に明瞭に印字して下さい。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明瞭に印字し，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た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を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℃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，電子複写などは不可）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（1970 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。

（単行本）　①，②共通　広瀬弘幸(イ) 1959.(ロ) 藻類学総説。(ハ) 内田老鶴圃，東京(ホ).

（単行本中の1章）　①Drebes, G.(イ) 1977.(ロ) Sexuality.(ハ) p. 250-283.(ニ)　②*In* D. Werner [ed.](イ) The biology of diatoms.(ハ) Blackwell Sci. Pub., London.(ホ)

（叢書中の分冊）　①Hustedt, F.(イ) 1930.(ロ) Bacillariophyta.(ハ)　②*In* A. Pascher [ed.](イ) Sübwasser-Flora Mitteleuropas. ed. 2. No. 10.(ハ) Gustav Fischer, Jena.(ホ)

（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。

Information for Authors (Revised March, 1988)

Members of the Society are invited to contribute original research reports, short communications, review articles and rapid communications in Japanese or English on all aspects of phycology. Every research paper is read and criticized by reviewers on the basis of its originality and the discussion presented. Where appropriate, reviewers other than those on the Editorial Board are consulted. Final responsibility for selection and published order of papers rests with the Editor. Research reports not longer than 10 printed pages in English and 6 printed pages in Japanese including figures and tables, short communications within 3 printed pages and review articles within 15 printed pages will be published without excess charge (exclusive of reprints); additional published pages will be charged to the author (12,000 Yen per single printed page). Rapid communications acceptable within 2 printed pages will be published in the possible earliest issue with charge at 12,000 Yen per single printed page.

The manuscript should conform exactly to the following instructions. The **manuscript** should be typewritten, double-spaced in 65 letters per line and 28 lines, on thick paper of 21.5×28 cm or A4 size. Symbols, units and nomenclature should conform to international usage. The S.I. metric system should be used for all numerical data. Words to be printed in italics should be underlined. The original copy and two duplicates are required. The first page should have only the title, full name(s) of the author(s) and institution with address, and any necessary footnote. A short running title should be included. Acknowledgements preferably follow the text but precede the references. Tables and legends for figures should be on separate pages and be placed after the references.

An **abstract** of not more than 200 words is required. At the end of the abstract, 5–10 Key Index Words should be given alphabetically for aid in indexing. A Japanese abstract will be provided by the Editor from translation of the abstract.

References. Citations in the text should read thus: LIEBIG's (1840 p. 23) ..... or ..... (WELCH 1972, 1974). In the list at the end of the paper, references should be typed in alphabetical order. Each reference should be given in the following order: Name, Initials, Date, Title, Journal Volume: first page–last page. Example:

> MIKAMI, H. 1978. On *Laingia hookeri* (Rhodophyceae, Delesseriaceae) from New Zealand. Jap. J. Phycol. **26**: 65–68.

A book title should be followed by the name of publisher and place of publication. Example:

> ABBOTT, I.A. and HOLLENBERG, G.J. 1976. Marine algae of California. Stanford Univ. Press, Stanford.

Tables should be numbered with Arabic numerals, have a title, and be referred to in the text.

Figures, whether line drawings or photographs, should be numbered consecutively in Arabic numerals, and referred to in the text. The maximum size for a full page figure is 14×20.5 cm. Line drawings should be made with black ink on white paper or blue-lined graph paper. Letters and numerals should not be made by hand, but should be made neatly with a lettering device (not a typewriter) and be of such size that the smallest character will not be less than 1 mm high when reduced. The original drawing and two sets of clear copies are required. Photographs must be of good quality. They should be grouped to conform to the page style and format of the Journal and preferably be submitted at a size that permits reproduction without reduction. Photographs should be submitted in triplicate. Coloured plates may be printed at the expense of the author. The insertion of tables and figures in the text should be indicated on the right-hand margin of the sheet.

Proofs should be checked carefully and should be returned by air mail to the Editor within three days of receipt. The author will receive 50 offprints free of charge. Additional copies can be ordered at cost on the reprint ordering form sent with the proofs.

日本学術会議だより　No.9

第13期最後の総会終わる

—「国際間の科学技術協力と研究の自由について(声明)」を採択—

昭和63年5月　日本学術会議広報委員会

日本学術会議は，4月20日から4月22日まで第104回総会を開催し，「国際間の科学技術協力と研究の自由について（声明)」を決議するとともに，4件の勧告・要望・見解を採択しました。

総会報告

総会第1日目（4月20日）の午前中には，会長からの経過報告，各部・諸委員会報告に続き，勧告・要望等6つの提案がなされ，同日午後の各部会での審議を経た上で，第2日目（21日）の午前中にこれらの6件が可決された。その後さらに1件の追加提案が行われ，同日午後これが可決された。第3日目（22日）午前は特別委員会が，午後には常置委員会が開催された。

なお，総会前日の19日午前には連合部会が開催されて前記の6案件の予備的な説明・質疑が行われ，またその午後には各部会が開催された。

第1日目午前。6件の提案につきそれぞれ提案説明が行われた後，質疑応答が行われた。午後，各部会を開催。

第2日目午前。まず，前日提案された「日本学術会議会則の一部を改正する規則の制定について」，「日本学術会議の運営の細則に関する内規の一部改正について」が賛成多数で採択された。第1常置委員会で審議を重ねてきたこれら会則・内規の改正は，(1)副会長世話担当研連のうち6研連を関係部へ移行させ，残りの12研連を副会長枠として存続させること等に伴う措置を決めたものと，(2)現存する6国際協力事業専門委員会のうち，第14期にも引き続き存続させる3専門委員会に関する措置を決めたものとである。このことに関連して，研連活動の活性化に関して活発な発言が行われた。

次に第4部提案の「太陽地球系エネルギー国際協同研究計画(STEP)の実施について」(勧告)，同じく第4部提案の「国立地図学博物館（仮称）の設立について」(勧告)，さらに第5常置委員会提案の「大学等における学術諸分野の研究情報活動の推進について」(要望)が，いずれも賛成多数で採択された。続いて，第6常置委員会提案の「我が国の国際学術交流の在り方についての日本学術会議の見解」が，これも賛成多数で採択された。

その後会長より「国際間の科学技術協力と研究の自由について（声明）—日米科学技術協力協定の改定に当たって—」が追加提案された。これは，日米科学技術協力協定の改定が行われようとしているに当たり，目下伝えられているその内容について憂慮すべき点があるというので，19日午後及び20日午後の各部会での討議を経て，そのおおよその見解の一致を踏まえて，会長が総会に提案したものである。この提案を受けて，この声明を出すことは時機を得たことであるとしながらも，文章表現に関しては質問・意見が多く出された。

第2日目午後。午前の審議に引き続き，一部の文章表現に関する修正案が数名の会員から提示され，採決の結果原案を一部修正したものが賛成多数で採択された。なお，総会で採択された前記勧告・要望は22日午後内閣総理大臣に提出され関係諸機関等に送付された。（これらの勧告・要望・見解・声明の概要は別項所載のとおりであり，詳細は日本学術会議月報5月号を参照されたい。）

国際間の科学技術協力と研究の自由について(声明)
—日米科学技術協力協定の改定に当たって—

最近，日米両国政府間で大筋が合意された「日米科学技術協力協定」の改定について，目下伝えられる内容に関しては憂慮すべき点が少なくない。

日本学術会議は，さきに「科学者憲章」(声明)，「科学の国際協力についての日本学術会議の見解」を採択し，科学者の責務と学術の国際交流に当たっての基本的な原則を明らかにした（この部分は本文を簡略化した)。

二国間の学術交流は，相手国の固有の事情があるにしても，上述の日本学術会議が宣明した全世界的な学術交流の原則と相容れない内容を含むものであってはならない。全世界的立場と個別の二国間協定の立場とには差異がありうるにせよ，いかなる場合にも自由な研究交流，成果の公開といった基本原則はかたく守られなければならないと考える。

今回の「日米科学技術協力協定」の改定は「安全保障」，「知的所有権」の問題を包含すると伝えられているが，このことによって科学者の研究・発表の自由，科学者の身分保障などが実質的に制約される恐れがある。したがって，協定の具体的内容の決定に当たっては，慎重な配慮が必要である。

われわれは，「日米科学技術協力協定」の改定に当たって，本会議が明らかにしてきた上述の諸原則の精神を最大限に尊重することを強く要望するものである。

この種の科学技術協力に関する国際的取極めについては，事前に広く科学者の意見を聴取すべきものであると考える。

太陽地球系エネルギー国際協同研究計画（STEP）の実施について（勧告）

暗黒の宇宙空間に浮かぶ青いルビーのように光る地球が，我々にとってかけがえのない惑星であることが，理解されるようになったのは，20世紀の科学研究の最大の成果の1つである。宇宙空間に浮かぶ我が惑星，地球には，太陽からの紫外線や太陽風プラズマが絶えず襲っていて，絶妙なエネルギーバランスを保ちつつ，地球の電磁圏や中間圏，

成層圏を作っている。しかしこのシステムには，未だ多くの謎が残されていて，この謎の理解は宇宙空間の基礎物理の理解とともに永続的な地球環境変化の理解の基礎ともなっている。したがって国際太陽地球系物理学・科学委員会(SCOSTEP)は，国際科学連合会議(ICSU)の承認を得て，太陽地球系エネルギー国際協同研究(Solar Terrestrial Energy Program: STEP)計画を立て，1990－1995年の6か年間にわたりその実施を行うよう，各国に要請している。

本研究計画では，太陽から，地球成層圏にわたる，全領域について，それを一つのシステムととらえ，そこに展開する電磁現象，プラズマ現象，及び化学現象について，現象の変動のみならず，エネルギー伝播の変化も合わせ，定量的に究明することを目指している。我が国でも本国際協同研究計画を実施すべく，今回，第104回日本学術会議総会において，政府に対する勧告が出された。

「国立地図学博物館」（仮称）の設立について（勧告）

国際社会における日本の役割と責任とが高まるにつれて，それぞれの国情，民族性，地域的生活様式に即した適切な対応を行う必要がある。そのためには，一国単位のみならず，主要な行政区域が大都市圏といった主要地域ごとに，新しい詳細な地理情報を組織的，継続的かつ迅速的確に収集し，整理加工して，一般の需要に応える体制作りは，焦眉の急を要する国家的課題である。ここで言うところの地理情報とは，様々な地域に即して，その風土と住民，民族と文化，人口と社会，生活と環境，資源と産業，集落と交通，経済と政治などに関して，地図，空中写真，地上景観写真，衛星画像等（地図・画像情報）によって表現される地表の空間的情報を意味する。とりわけ，「地表の地理的事象を数学的，選択的，かつ記号的に表現した地図」は，コンピュータの支援によって，ますますその情報価値を高めている。

ここに勧告する「国立地図学博物館」（仮称）は，主として諸外国の地図，画像情報の収集，整理，保存を行い，関連する地域情報を加えて，地理情報のデータ・ベース化の手法や図的解析法，表現法，利用の高度化，地図発達史等に関する研究を行い，動的，立体的な展示方法を駆使して，広く国民の国際知識の涵養，地域研究，学術文化，政治行政，経済活動等に寄与し，さらに，国内及び国際的地域情報のセンターとしても基幹的な役割を演じ，国内外の関連機関と密接に提携して，地理情報の相互補完的及び相乗的価値を高めることを目指すものである。

大学等における学術諸分野の研究情報活動の推進について（要望）

高度情報化社会に即応した新しい手段により，学術研究の基礎的情報・資料を整備すること，情報・資料や研究成果を全国的・国際的に流通させることが，学術のすべての分野を通じて強く要望されている。これらの推進のために，近年，文献資料センター，データ資料センターの整備，「学術情報センター」の設立，データベース作成の支援などが行われ，その環境はかなり整備されてきた。

これらの環境を基盤として，それを強力に補完するものこそ，個々の専門分野での研究情報活動である。このため，国公私立大学等で，国際協力を念頭に置きつつ，それぞれ特色を持つ領域を単位として，情報・資料を整備し，その分野での研究成果を提供する組織の設置と方法の推進とともに，「学術情報センター」のネット・ワークなどを通じて，全国的・国際的に流通させる体制の強化が急務であると考える。このために，下記のような体制の確立を要望する。

(1)専門分野別に研究情報センターを設置すること。(2)大学等の既存の諸機関（文献資料センター等）における研究情報活動を推進すること。(3)個別的なデータベース・知識ベースの作成と新規のデータ処理方法の開発を助成すること。(4)「学術情報センター」の拡充を図ること。(5)大学等とそれ以外の機関（官公庁，学・協会を含む）との情報の流通を円滑化すること。

我が国の国際学術交流の在り方についての日本学術会議の見解

学術の問題は国際的視点を外して考えることはできない。日本学術会議は，昭和36年10月27日第34回総会において「科学の国際協力についての日本学術会議の見解」を採択し，科学の国際協力は，(1)平和への貢献を目的とすべきこと，(2)全世界的であるべきこと，(3)自主性を重んずべきこと，(4)科学者の間で対等に行われるべきこと，(5)成果は公開されるべきことの5原則を明らかにした。この見解は，国際学術交流における一般的原則を示すもので，今日においても尊重されるべきものである。

この見解表明から四半世紀を経て，国際学術交流を取り巻く環境の変化は急速に進んでいる。その変化の速度は今後更に顕著になると思われる。しかし，このような著しい変化の中で，国際学術交流に対する我が国の人的，制度的，財政的対応は必ずしも満足すべき状態にはない。今回の見解は，こうした状況を踏まえ，我が国の国際学術交流は今後一層積極的かつ能動的な姿勢へ転換させることの重要性を指摘し，次のとおり，人の問題，国際交流の進め方の問題，組織の問題の三つの面で，新しい姿勢に見合った改革を進めて行くことの必要性を表明している。

(1) 人的交流の促進と大学・研究機関の国際的開放
(2) 学術研究活動の世界的展開
　① 国際的学術機関の活動への積極的参加
　② 国際的研究プロジェクトの策定と遂行
　③ 二国間・地域間学術交流
(3) 国際学術ネットワークの確立

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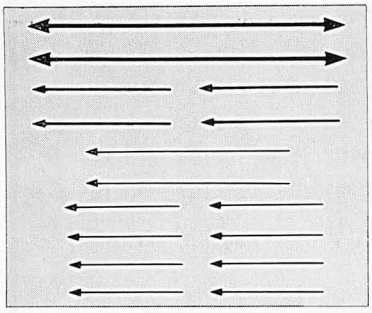

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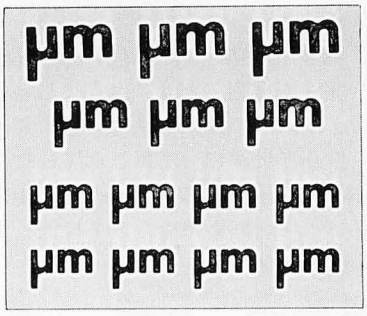

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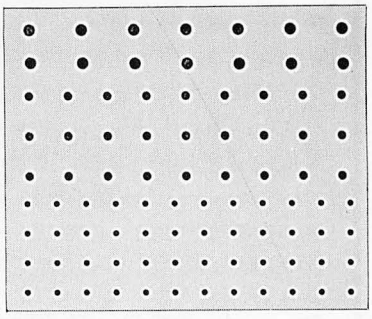

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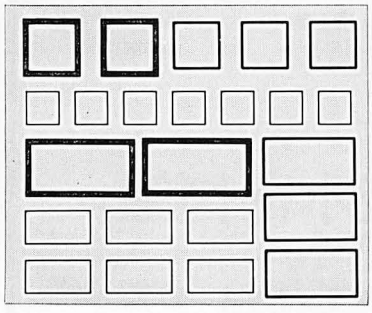

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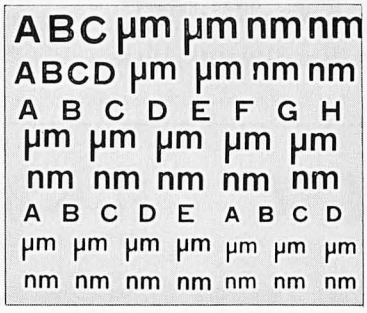

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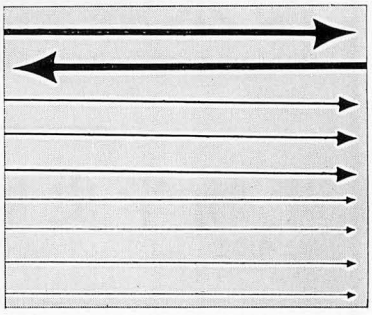

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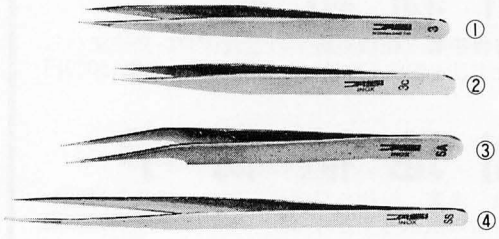

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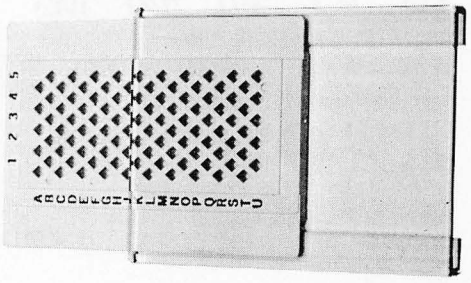

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