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THE JAPANESE SOCIETY OF PHYCOLOGY

日 本 藻 類 学 会

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Manuscript for publication should be submitted directly to the Editor-in-chief, **Prof. Y. Tsubo, Department of Biology, College of Liberal Arts, Kobe University, Tsurukabuto 1–2–1, Nada-ku, Kobe, 657 Japan.** Inquiries and other information regarding the society should be addressed to the **Japanese Society of Phycology, c/o Division of Tropical Agriculture, Faculty of Agriculture, Kyoto University, Kitashirakawa-oiwakecho, Sakyo-ku, Kyoto, 606 Japan.**

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日本藻類学会第12回大会のお知らせ

昭和63年度日本藻類学会第12回大会を下記の要領で開催します。藻類に関係のあるあらゆる分野の研究についての発表を広く歓迎します。所属機関長への出張要請等の文書などご入用の方は宛先を明記して大会準備委員会までご遠慮なくお申込み下さい。

大会終了後には日本藻類学会主催で英虞湾における海藻採集会を企画しています（裏面参照）。奮ってご参加下さい。

(1) 期　日：昭和63年3月30日（水）～ 3 月 31 日（木）

(2) 会　場：三重大学生物資源学部水産学校舎
津市江戸橋2丁目80　TEL. 0592-32-1211（大学代表）

津駅東口の三交バス4番乗り場発バスで，新江戸橋または大学病院前停留所で下車（徒歩約7分）。ただし，倉紡前行きのバスの場合は倉紡前終点下車（徒歩約2分）。

(3) 研究発表：発表形式は口頭発表と展示発表とします。口頭発表は1演題につき討論を含めて15分を予定しています。展示発表は原則として大会期間中とし，演者はポスターの前で決められた時間に説明と質疑応答を行なうことになります。

(4) 参加申込み：講演の有無に関わらず，大会に参加を希望される方は，同封の振替用紙にてお申込み下さい。参加費は2,500円です。ただし学生は2,000円とします。懇親会（3月30日夜開催）に出席ご希望の方はさらに会費2,500円を添えてお送り下さい。

(5) 講演申込み：講演ご希望の方は，氏名（共同の場合は講演者の左肩に◎印）所属，題名，要旨，（A 4 400字詰横書き原稿用紙使用，題名共に600字以内）を添えて大会準備委員会までお申込み下さい。

本大会では発表形式が2通りになっています。ご希望の発表形式を，「口頭」あるいは「展示」と，用紙1枚目の原稿用紙の右上欄外に朱記して下さい。記入のない場合は大会本部で振り分けさせていただきます。

(6) 発表形式　口頭発表の場合：図・表はすべて35 mm のスライドに限ります。スライド枠には，右図のように講演者氏名，講演番号（大会プログラムに記されているもの），スライド総枚数，映写順序，上辺マークを記入して下さい。同一の図，表を繰り返し映写する場合は，それに見合う枚数をご用意下さい。

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(7) 宿泊案内：会場への交通が便利な宿泊施設を紹介します。共済関係の施設は収容人員が少ないのでお早目に各自でお申込み下さい。

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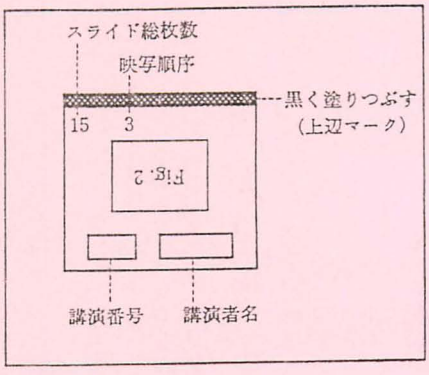

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(8) 大会参加申込み・講演要旨締切：**昭和63年1月10日**

(9) 申込み先・要旨送り先：〒514 津市江戸橋2丁目80 三重大学生物資源学部水産学校舎海藻増殖学研究室 日本藻類学会第12回大会準備委員会。TEL. 0592-32-1211（内線2531，2532）郵便振替口座「名古屋」5-43454

—日本藻類学会主催海藻採集会のお知らせ—

下記の要領により英虞湾周辺での海藻採集会を開催いたします。ご希望の方はお申込み下さい。

(1) 期 日：昭和63年3月31日（木）午後4時30分（第12回大会終了後）～4月2日（土）正午

(2) 日程と内容（予定）：3月31日（木），大会終了後，会場前から大学専用バスにて志摩町和具まで移動後付属水産実験所に宿泊。4月1日（金），9時～13時，英虞湾口（浜島）での磯採集，14～18時，室内観察・分類同定。4月2日（土），9時～12時，室内観察の続き 昼食後解散。

(3) 会 場：三重大学生物資源学部付属水産実験所 三重県志摩郡志摩町和具，TEL. 05998-5-4604

(4) 参加費：宿泊費（2泊1,000円），食費（3月31日夕食～4月2日昼食，実費），およびその他（採集交通費，資料作製費，消耗品費など）で約5,500円かかる見込です。納入期日など詳しくは後日参加者にお知らせいたします。

(5) 定員・参加資格など：定員は宿泊施設の都合から25名とします。参加者の資格などは全く問いませんが，申込み者が多数の場合には先着順としますのであらかじめご了承下さい。

(6) 申込み：ハガキにて下記に参加申込みして下さい。

〒514 三重県津市江戸橋2-80 三重大学生物資源学部水産学校舎 藻類増殖学研究室 前川行幸 TEL. 0592-32-1211（内線2532）

(7) 申込み締切：申込みは**昭和63年3月10日**までとします。

Jap. J. Phycol. (Sôrui) **35**: 241–250, December 10, 1987

On the life history and host-specificity of *Blastophysa rhizopus* (Codiales, Chaetosiphonaceae), an endophytic green alga from Muroran in laboratory cultures[1)]

Masafumi IIMA and Masakazu TATEWAKI

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IIMA, M. and TATEWAKI, M. 1987. On the life history and host-specificity of *Blastophysa rhizopus* (Codiales, Chaetosiphonaceae), an endophytic green alga from Muroran in laboratory cultures. Jap. J. Phycol. **35**: 241–250.

The developmental morphology and life history of the endophytic green alga *Blastophysa rhizopus* REINKE from Muroran were investigated in unialgal and bialgal cultures. The results in unialgal culture correspond with the previous descriptions obtained from North American strains. Bialgal cultures between *B. rhizopus* and various other species of seaweeds as host plants were carried out for the first time. Although *B. rhizopus* has been reported as the endophyte of various plants, it only shows quick and strong penetration into the original host *Grateloupia turuturu* with slow and weak penetration into some other red algae. It does not naturally penetrate the other green, brown and red algae examined, however penetration can be induced by artificial wounding. *B. rhizopus* does not have host-specificity, but seems to have favorable limited hosts as substrates growing in the same season at different habitats. The mode of host tissue penetration is also discussed.

Since the temperature response of laboratory cultures was found to reflect the seasonal variation in nature, this endophyte from Muroran may be considered to share its life with *G. turuturu* as the host.

Key Index Words: bialgal culture; Blastophysa rhizopus; *Chlorophyta; endophyte; host-specificity; life history.*

The endophytic green alga, *Blastophysa rhizopus*, was first described by REINKE (1888) growing in the basal disc of *Dumontia filiformis* and the thallus of *Hildenbrandia* sp.. Since then many workers have reported various hosts for *B. rhizopus: Enteromorpha compressa* (HUBER 1892), *Nemalion schrammi* (BØRGESEN 1911), *Sphacelaria tribuloides, Ruppia maritima* and *Ulva lactuca* (COLLINS and HERVEY 1917), *Hildenbrandia* sp. and *Zostera* sp. (PRINTZ 1926), *Anadyomene stellata* (SCHUSSING 1930), *Neodilsea yendoana, Grateloupia turuturu* and *Schizymenia dubyi* (TOKIDA and MASAKI 1948), *Dumontia incrassata, Eudesme virescens, Punctaria* sp. and *Acrothrix novae-angliae* (SEARS 1966), *Dumontia* sp. (IRVINE *et al.* 1975), *Predaea feldmannii* (SEARLES and LEISTER 1980), *Dudresnaya* sp. and *Liagoropsis schrammi* (BALLANTINE and WYNNE 1986).

Of those investigations, only SEARS (1966) performed culture experiments with *B. rhizopus*. He worked on the developmental morphology, life history and cytology of this alga in both plants from unialgal culture and nature.

There are, however, no culture experiments to distinguish this alga as a true endophyte and not an epiphyte. It appears to have neither a few restricted or specific hosts nor indiscriminate substrates,

1) This work was supported by Grant-in-Aid No. 60480013 from the Scientific Research Fund of the Ministry of Education, Science and Culture, Japan.

although it seems to be endophytic in a wide range of algal species in the descriptions as mentioned above.

We have carried out the present study to confirm the development, life history and host-specificity in *B. rhizopus* from Muroran in unialgal and bialgal cultures. We describe here in detail the morphogenesis of this endophyte, especially in bialgal cultures and also consider the relationship between the effects of culture conditions and seasonal changes on the occurrence of this alga.

Materials and Methods

Isolation and unialgal culture

Blastophysa rhizopus was collected at Charatsunai, Muroran on Sep. 8 and 22, 1984, Sep. 14, 27, Oct. 14, 22 and Nov. 16, 1985, growing in vegetative and fertile thalli of *Grateloupia turuturu*.

Fertile sporangia of *B. rhizopus* were isolated by pipetting from cross-sectioned *G. turuturu* blades. Vegetative coenocytes were also crude cultured within the pieces of original host tissue, generating fertile sporangia in high temperature conditions (18–22°C) within 1–2 weeks. These fertile sporangia released bi- or quadriflagellate swarmers. Swarmers were pipetted onto glass slides with a few drops of medium and maintained as unialgal cultures in vessels (6.5 cm × 8.0 cm) containing 180–200 m*l* medium.

The culture medium employed was PES (PROVASOLI 1966) and was renewed every month. Culture experiments were conducted in 10 incubators equipped with Cool-White 40 W fluorescent lamps (ca. 12–18 W. m^{-2}) under the following temperature and photoperiod regimes: 5°C, $\underline{14}:\overline{10}$ (no. 1) or $\underline{10}:\overline{14}$ (no. 2); 10°C, $\underline{14}:\overline{10}$ (no. 3) or $\underline{10}:\overline{14}$ (no. 4); 14°C, $\underline{14}:\overline{10}$ (no. 5) or $\underline{10}:\overline{14}$ (no. 6); 18°C, $\underline{14}:\overline{10}$ (no. 7) or $\underline{10}:\overline{14}$ (no. 8); 22°C, $14:\overline{10}$ (no. 9) or $10:\overline{14}$ (no. 10).

Cytology

Chromosome counts were made using unialgal culture plants derived from bi- and quadriflagellate zoospores. These coenocytes were fixed in ethanol: acetic acid (3:1 v/v) and stained with an aceto-iron-haematoxylin-chloral hydrate solution (WITTMANN 1965).

Bialgal culture

For bialgal cultures with *B. rhizopus* cultured from swarmers, tetraspores and carpospores of the original host species *Grateloupia turuturu* were isolated and cultured by the capillary pipette method. Other algal species listed in Table 1 were also used. Most species were cultured from spores released from fertile plants collected at Charatsunai, Muroran by the capillary pipette method. Only one species, *Pachymeniopsis lanceolata*, was collected at Shimoda, Shizuoka and obtained as a unialgal culture from tetraspores.

Electron microscopy

Bialgal cultured plants were prepared for scanning and transmission electron microscopy as follows:

For the SEM, samples were fixed in 1% glutaraldehyde in seawater for 2 hr at 4°C, post-fixed in 1% OsO_4 for 2 hr at 4°C, and then dehydrated in a graded acetone series. They were critical point dried, coated with gold, and viewed with a Hitachi S–510 SEM.

For the TEM, samples were fixed in 2% glutaraldehyde and 1% paraformaldehyde in 0.1M cacodylate buffer (pH 7.2) with 2% NaCl for 2 hr at 4°C; and post-fixed in 2% OsO_4 for 3 hr at 4°C in the same buffer with 2% NaCl; then they were bloc-stained with 2% uranyl acetate, dehydrated in acetone and embedded in SPURR's epoxy resins (SPURR 1969). Sections were cut with a diamond knife on a Porter-Blum MT–1 ultramicrotome and double stained with uranyl acetate and REINOLD's lead citrate solution (REINOLD 1963). They were observed with a Hitachi H–300 elec-

tron microscope.

Results

Field observation

Blastophysa rhizopus grows as an endophyte only in the thallus of *Grateloupia turuturu* in the lower intertidal zone at Charatsunai, Muroran, from August to December, the period of occurrence of the host alga (Figs. 1, 2). It disappears in December with the decaying of *G. turuturu* and is not found from January to July even in or on other algae.

At the beginning of its occurrence, *B. rhizopus* is restricted to the basal portion of the *G. turuturu* thallus. Most other parts of the host thallus are not affected by the endophytic infection (Fig. 2). During maturation period of *G. turuturu, B. rhizopus* extends into various parts of the matured host tissue as a green patch about 1–2 cm in diameter, while the host cells around these green patches bleach and die.

Plant morphology

Endophytic plants grow abundantly in the cortical tissue of *Grateloupia turuturu* (Fig. 3). Cells vary in shape, from spherical to tubular and 20–60 μm in diam. or 60–150 μm in length. Each cell is connected by colorless slender filaments ranging from 5–10 μm in diam.. Cells are multi-nucleate coenocytes and have numerous pyrenoids. Plants growing in host tissue project colorless hairs (3–5 μm in diam.) into the outer surface of the host.

Reproduction and development

Fertile cells are more round than vegetative ones and become sporangia (Fig. 4) which produce about 30–60 swarmers. Swarmers are released one by one through the opening of a colorless tube projected into the outer surface of the host (Fig. 5). They are bi- (Fig. 6) or quadri-flagellate (Fig. 7) asexual zoospores and do not show any sexual behavior. These two kinds of zoospores are not released from the same sporangium, but are produced from different sporangia of one individual plant.

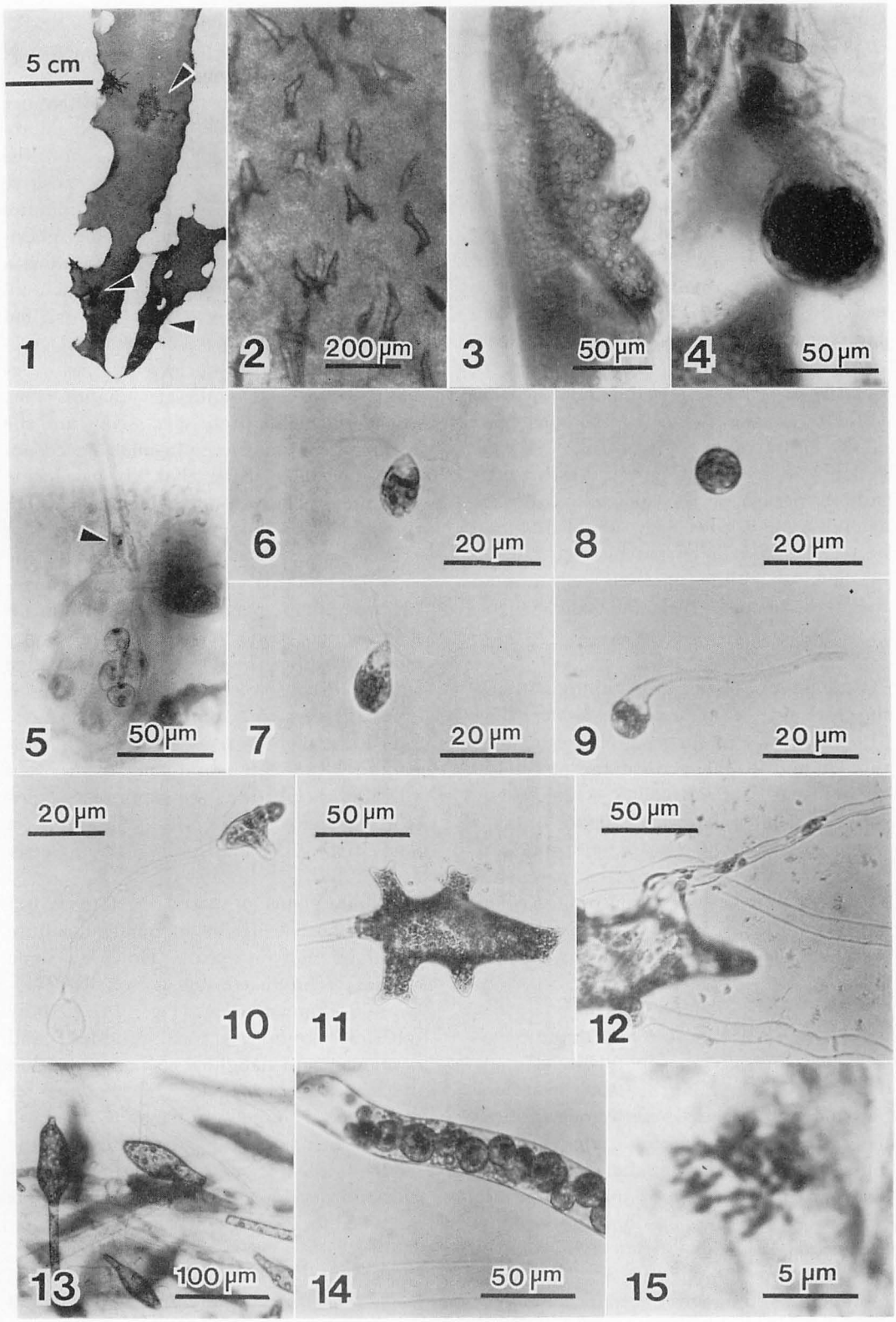
Both kinds of zoospores are pyriform or subspherical shaped measuring 16–18 μm $\times$ 8–10 μm and there is no marked difference in size between them. They have a chloroplast with an orange-colored eye-spot in the posterior of the cell. They show positive phototaxis and after swimming 1–5 minutes settle to the substratum and become spherical (Fig. 8). Settled zoospores produce a germination tube (Fig. 9) into which all the cytoplasm migrate, leaving the original cell empty (Fig. 10). The migrated cytoplasm with a single nucleus enlarges irregularly at the end of the germination tube. Nuclear divisions occur successively and the germling becomes a multi-nucleate coenocyte (Fig. 11). After that, the coenocyte elongates its growth tubes in one or more directions and its cytoplasm migrates into the elongated growth tube little by little (Fig. 12) and enlarges at the distal end forming a daughter coenocyte. Finally it forms a net-work of coenocytes connected by many elongated tubes (Fig. 13). This vegetative tubular extension occurs in all directions, especially toward a source of light.

Culture plants grew well at high temperatures (18–22°C) and long day (14:10 LD), but their growth was suppressed slightly at low temperatures (10–14°C) and short day (10:14 LD), and inhibited completely at 5°C.

Culture plants grew well vegetatively but did not become fertile in unialgal culture for more than one year. However, some of them reproduced vegetatively by cytoplasmic segmentation (Fig. 14). Many spherical protoplasts were produced and developed into daughter coenocytes within the mother coenocyte. Such daughter coenocytes enlarged in size and were all released at one time by the rupture of the mother wall. They settled on the substratum and developed in the same pattern as described for zoospore-development.

Cytology

The chromosome number was about 30


5 cm
1
2
200 μm
3
50 μm
4
50 μm
5
50 μm
6
20 μm
8
20 μm
7
20 μm
9
20 μm
20 μm
10
50 μm
11
50 μm
12
13
100 μm
14
50 μm
15
5 μm

regardless of the flagellum number of zoospore (Fig. 15). Nuclear division occurred synchronously in each coenocyte.

Bialgal cultures

a) *Blastophysa rhizopus* with *Grateloupia turuturu*

A colony of coenocytes brought into contact with a basal disc or blade of *G. turuturu* adhered to the surface of such a host material tightly after a few days (Fig. 16). These coenocytes then began to penetrate into the host material and their endophytic growth occurred in one week-old culture (Fig. 17). When coenocytes were placed apart from a host material in the same culture vessel they produced long tubular filaments which enlarged toward the host and adhered to the host by their tip (Fig. 18). The host cells adjacent to the penetrating coenocyte gradually discolored and bleached completely within 3 months culture (Fig. 19).

An electron microscopic observation showed that the host cells were penetrated via pressure of the endophytic growth of coenocytes. Neighboring host cells were completely dead, but no evidence of any enzymatic digestion of these host cells was seen ultrastructurally (Figs. 20, 21).

b) *B. rhizopus* with other species

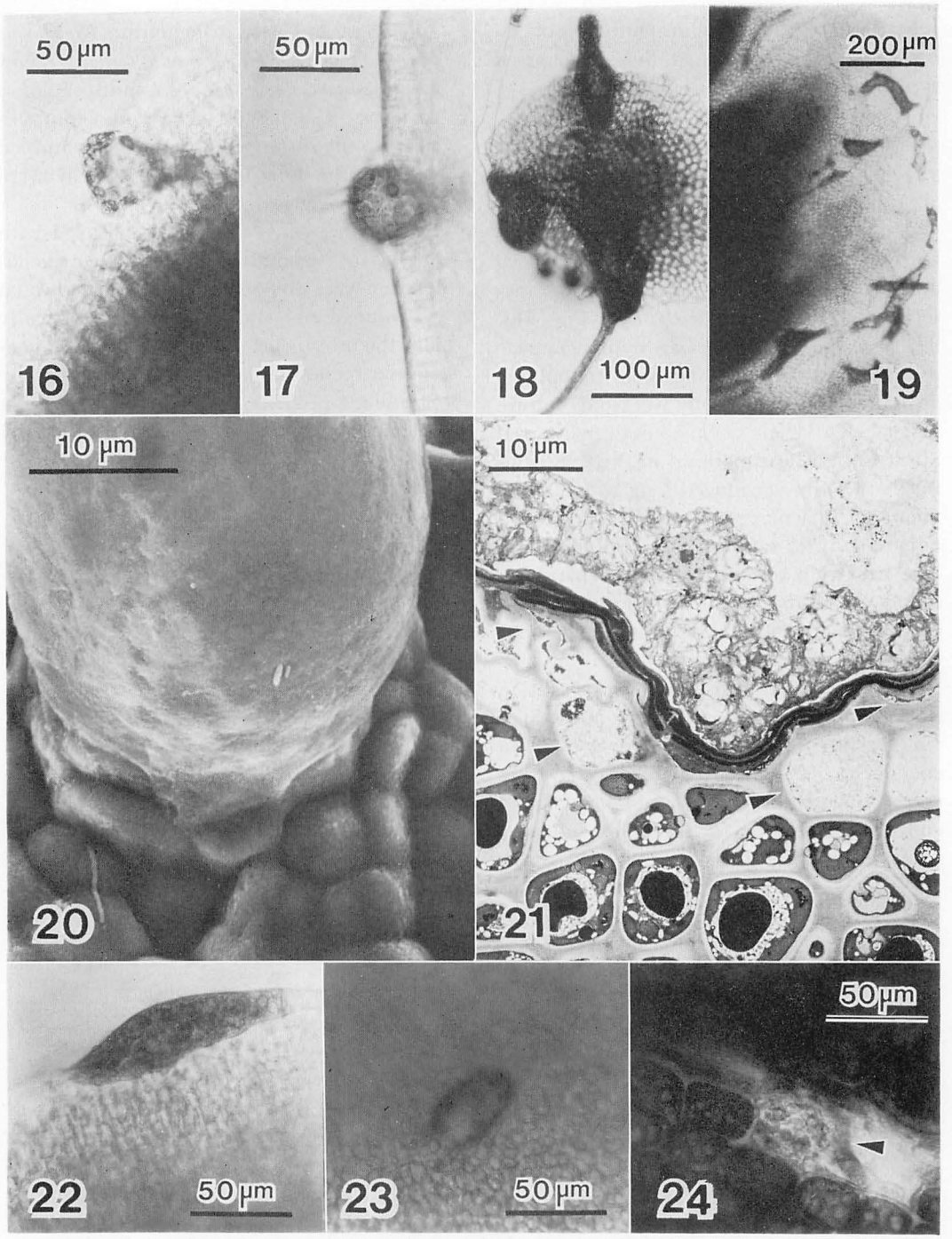
Results of bialgal cultures with other species, including the host algae reported by previous authors, are shown in Table 1. *B. rhizopus* from Muroran did not show any endophytic behavior with a short-term bialgal culture for up to 2 weeks. Coenocytes grown epiphytically on their surface were easily removed similar to those grown on a glass slide. In long-term bialgal cultures (1–3 months) however, they could adhere to and weakly penetrate *Grateloupia filicina* (Fig. 22), *Rhodymenia pertusa, Pachymeniopsis lanceolata* (Fig. 23) and *Neodilsea yendoana*. Coenocytes grew only epiphytically on the surface of other algae examined even in the long-term cultures and were easily removed.

However, when they were cultured with host tissues wounded or abraded artificially, they were able to penetrate through such a wounded site and extend endophytically into the host tissue. Fig. 24 shows that coenocytes penetrated into the wounded site of a blade of *Dictyopteris divaricata* although *B. rhizopus* could not penetrate a healthy blade of this brown alga.

Table 1. Results of bialgal culture of *B. rhizopus* with various algal species as hosts (−: only epiphytic, +: weak penetration, ++: strong penetration).

	short-term cul. (1–2 weeks)	long-term cul. (1–3 months)
Chlorophyta		
Ulva pertusa	−	−
Phaeophyta		
Dictyopteris divaricata	−	−
Laminaria japonica	−	−
Fucus evanescens	−	−
Pelvetia wrightii	−	−
Rhodophyta		
Grateloupia turuturu	+	++
G. filicina	−	+
Neodilsea yendoana	−	+
Pachymeniopsis lanceolata	−	+
Chondrus yendoi	−	−
Gigartina japonica	−	−
Rhodymenia pertusa	−	+
Palmaria palmata	−	−
Ptilota pectinata	−	−

Fig. 1, *Blastophysa rhizopus* as green patches (arrowheads) on *Grateloupia turuturu* (mature carposporophytes). Fig. 2, Surface view of the vegetative host thallus infected by many coenocytes. Fig. 3, Cross section of the host thallus and a vegetative coenocyte of *B. rhizopus*. Fig. 4, Fertile sporangium. Fig. 5, Release of zoospore (arrowhead). Figs. 6–14, Reproduction and development of *B. rhizopus* in unialgal culture: Fig. 6, Biflagellate zoospore. Fig. 7, Quadriflagellate zoospore. Fig. 8, Settled zoospore. Fig. 9, Settled zoospore producing germination tube. Fig. 10, One-day-old germling. Fig. 11, Terminated coenocyte elongating growth tubes in many directions. Fig. 12, Cytoplasmic migration through growth tubes. Fig. 13, Coenocytes net working connected by tubes. Fig. 14, Coenocytes produced by cytoplasmic segmentation. Fig. 15, Chromosomes of *B. rhizopus* counted about 30.



Figs. 16–21. Bialgal culture of *B. rhizopus* with the natural host, *Grateloupia turuturu*: Fig. 16, A coenocyte adhered to a basal disc (in 1 week bialgal culture). Fig. 17, Penetration into a thallus surface (in 1 week). Fig. 18, Adhesion to a young germling. Fig. 19, A basal disc infected by many coenocytes (after 3 months). Fig. 20, SEM photograph of penetration of a coenocyte into a thallus surface (after 1 week). Fig. 21, TEM photograph of a section of boundary region between a coenocyte and host cells. Neighboring host cells are pressed and bleached, but no digestion seems to have occurred (arrowheads). Figs. 22–24, Bialgal culture with other species: Fig. 22, Adhesion to a basal disc of *Grateloupia filicina* (in 3-week-old bialgal culture). Fig. 23, Weak penetration of a thallus of *Pachymeniopsis lanceolata* (after 3 weeks). Fig. 24, Penetration of artificially wounded sites of a thallus of *Dictyopteris divaricata* (arrowhead).

Reproductive maturation

In unialgal culture *Blastophysa rhizopus* only grew vegetatively. However, in bialgal culture with *Grateloupia turuturu*, *B. rhizopus* reached reproductive maturity within 5–6 months. Each coenocyte became round and produced bi- or quadriflagellate zoospores again. These zoospores were released through an opening in the distal end of a tube projected into the outer surface of the host tissue in the same manner as described for field plants. Further development of zoospores occurred as described previously. However, these second generation coenocytes reproduced zoospores in 2–3 month-old culture even in unialgal cultures.

Discussion

The present results of reproduction, development and cytology in unialgal culture of *Blastophysa rhizopus* from Muroran, Hokkaido (Figs. 6–15) agree with those of SEARS (1966), working on the materials from North America (including UTEX no. 1029 BROOKS strain). A coenocyte makes vegetative tube growth and forms a net-work of numerous coenocytes connected to each other with a filamentous colorless tube. Reproduction is either vegetative by cytoplasmic segmentation, or asexual by bi- and quadriflagellate zoospores. Crossing experiments between biflagellate swarmers derived from different individuals were attempted several times, but sexual behavior was not observed, the chromosome number was always about 30 and meiotic figures were not seen in any phase of development. According to SEARS (1966), it is possible that this species is dioecious and the proper mating strains have not been crossed, although sexual fusion between biflagellate zoospores was not observed. Moreover, in plants collected from Nagasaki, Kyushu (MIGITA, personal comm.), both macro- and micro-swarmers are often found. Therefore further crossing experiments between different geographically isolated strains will be needed to prove the absence of sexual reproduction in this species.

As noted in the introduction, other authors have reported various species as host plants for *Blastophysa rhizopus*. Therefore, this endophyte is considered to be apparently indiscriminate regarding substrate species. SEARS (1966) already pointed out that *B. rhizopus* can grow unialgally in various growth media without specific host tissues, and the relationship between this alga and its host tissue is apparently that of a substrate requirement for a coenocyte which lacks a holdfast mechanism. In the present study, however, it was found only in *Grateloupia turuturu* tissue and was not found to grow in other species or host free in the natural habitat of Muroran.

In bialgal cultures between *B. rhizopus* and other species, the results suggest that the plant from Muroran has few hosts or nearly complete host specificity (Table 1). This endophyte showed quick and strong penetration of the original host plant, *Grateloupia turuturu*, but slow and weak penetration of four red algae; *G. filicina*, *Neodilsea yendoana*, *Rhodymenia pertusa* and *Pachymeniopsis lanceolata*. In other species examined as partners in bialgal cultures, *B. rhizopus* coenocytes showed only epiphytic growth even in long-term culture (6 months). However, in bialgal cultures with those partners wounded or abraded artificially, the coenocyte can easily infect its partners at a wound site and grow endophytically in their tissue (Fig. 24). From this, it is understandable that various plants, including species of spermatophytes, have been reported as the host plants by previous authors. It is clear that *B. rhizopus* seems to commonly have limited host plants in each habitat but penetrates indiscriminately in wounded plant. It can grow well vegetatively on the glass slide in unialgal culture and completely repeat a monophasic life cycle without any host plant, although zoosporogenesis in unialgal culture lags behind the one in bialgal cultures by several months. It means that this endophyte does not need a supply of any nutrients from the

host. Therefore, it does not have a host-specificity, but does have favorable limited hosts as substrates. These are coarser algae of soft tissue and belong mainly to the Cryptonemiales or Nemalionales (Rhodophyta) and some of the Chordariales (Phaeophyta). They grow with *Blastophysa* in the same season at each habitat as described by previous authors.

The mode of penetration into the host tissue is important because it gives an understanding of how the endophytic relationship is established. It is well known that endophytic and parasitic algae that require a wound or abraded site on the host material usually penetrate by either enzymatic action or through the pressure effect of the terminal cell of the filamentous germling (including rhizoidal cell). A parasitic red alga, *Harveyella mirabilis* requires wound site on the host *Odonthalia floccosa* for spore penetration and development (GOFF and COLE 1976), while the spores of *Janczewskia* spp. do not require any wound or abraded site on the host plants *Laurencia* spp. for their penetration (FELDMANN and FELDMANN 1958, NONOMURA 1979). According to NONOMURA, working on spore development of *Janczewskia morimotoi*, the rhizoid of this alga elongates, pushing between or directly through the host cells. However, penetration may occur partly as a result of digestive rather than a completely mechanical mode. RAWLENCE (1972) investigated the relationship between an obligate epiphyte *Polysiphonia lanosa* and its specific host *Ascophyllum nodosum* ultrastructurally. The rhizoid of this epiphyte was found to digest its way into the host tissue. According to WHITE and BONEY (1969), working on an endophytic filamentous alga *Acrochaetium endophyticum*, the mode of entry of the filament appears to be due to pressure effects on the surface of the host *Heterosiphonia plumosa*, but there is no evidence of any enzymatic dissolution of the host wall. In *Blastophysa polymorpha*, PRINTZ (1926) described that the germination tube enters between the surface cells of the host tissue and later is restricted to the cortical layer of the host cells. Thus the enlarging coenocytes are pushed out of shape, but generally are not destroyed.

In the present study, ultrastructural observations showed that the coenocytic filament can penetrate any part of *Grateloupia turuturu* without any wound sites through pressure effects of the tip of the filament (Fig. 20). No evidence of enzymatic action for penetration of the host wall was found. However, in a long-term culture (Fig. 19), the host tissue adjacent to endophytic coenocytes became gradually discolored producing white patches. In nature, young host cells adjacent to coenocytes are not killed, but when both the host and endophyte become mature, the host cells around endophytic cells bleach and die.

Although there are no reports that host plants are ever killed by parasitic or endophytic algae, the two red parasites *Harveyella* and *Choreocolax* do cause some degree of minor host disruption (KUGRENS and WEST 1973, GOFF 1976, CALLOW *et al.* 1979). Still, there is no appearance of substantial deleterious effect on the hosts. TOKIDA and MASAKI (1948) reported that *B. rhizopus* is a pathogenic green alga which causes "green spot rotting" on *Neodilsea yendoana*. According to them, however, the endophytic growth of *B. rhizopus* only destroys host tissue mechanically. These wound sites become discolored patches resulting from bacterial activity which does not have deleterious effect on the endophyte. If the endophytic coenocyte has no ability to digest or lyse the host tissue, it is possible that some bacteria may have something to do with penetration of the host. If so, further experiments on the mode of infection process are needed to be carried out in axenic bialgal cultures.

Development of zoospores is influenced by culture conditions, especially temperature. The coenocytes derived from zoospores can grow at temperatures ranging from 10–25°C, remarkably well at 18–22°C, but cease to grow completely at 5°C. This

laboratory temperature response is reflected in the seasonal variation of *Blastophysa rhizopus* growth in nature. The water temperatures at Muroran range from 20–10°C from August to November, during which *B. rhizopus* grows abundantly in the host *Grateloupia turuturu*. This temperature range is suitable for growth and reproductive maturity of this endophyte. In December, however, the host plants decay and water temperature falls to below 5°C. During the winter months (3–5°C), *B. rhizopus* growth is completely suppressed and can not be found in or on any algal species. It may survive in the prostrate discs (remaining holdfasts or new germlings) of host plants as a spherical coenocyte or a few celled colony until June-July when temperature rises to 10–14°C. With the growth of erect blades from the prostrate discs of *G. turuturu* in summer, the endophytes grow rapidly in the host tissue and finally appear as green patches. As mentioned above, the growth in relation to regarding temperature in culture agrees well with the short-term appearance of this species at Muroran. Therefore, *B. rhizopus* from Muroran may be considered to share its life with the host plant *G. turuturu*. Still, there seems to be geographical variation of host plants reflected in the presence of various substrate species in different localities (but with other host plants in different habitats).

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References

BALLANTINE, D.L. and WYNNE, M.J. 1986. Notes on the marine algae of Puerto Rico. I. Addition to the Flora. Bot. Mar. **29**: 131–135.

BØRGESEN, F. 1911. Some Chlorophyceae from the West Indies. I. Bot. Tidsskr. **31**: 127–152.

CALLOW, J.A., CALLOW, M.E. and EVANS, L.V. 1979. Nutritional studies on the parasitic red alga *Choreocolax polysiphoniae*. New Phytol. **83**: 451–462.

COLLINS, F.S. and HERVEY, A.B. 1917. The algae of Bermuda. Proc. Am. Acad. Arts Sci. **53**: 1–195.

FELDMANN, J. and FELDMANN, G. 1958. Recherches sur quelques Floridées parasites. Rev. Gén. Bot. **65**: 49–124.

GOFF, L.J. 1976. The biology of *Harveyella mirabilis* (Cryptonemiales, Rhodophyceae) V. Host responses to parasite infection. J. Phycol. **12**: 318–28.

GOFF, L.J. and COLE, K. 1976. The biology of *Harveyella mirabilis* (Cryptonemiales, Rhodophyceae) III. Spore germination and subsequent development within the host *Odonthalia floccosa* (Ceramiales, Rhodophyceae). Can. J. Bot. **54**: 268–80.

HUBER, M.J. 1892. Contributions à la connaissance des Chaetophorées épiphytes et endophytes et de leurs affinites. Ann. Sci. Nat., Bot. VII **16**: 265–359.

IRVINE, D.E.G., GUIRY, M.D., TITTLEY, I. and RUSSEL, G. 1975. New and interesting marine algae from the Shetland isles. Br. phycol. J. **10**: 57–71.

KUGRENS, P. and WEST, J.A. 1973. The ultrastructure of an alloparasitic red alga *Choreocolax polysiphoniae*. Phycologia. **12**: 175–86.

NONOMURA, A.M. 1979. Development of *Janczewskia morimotoi* (Ceramiales) on its host *Laurencia nipponica* (Ceramiales, Rhodophyceae). J. Phycol. **15**: 154–162.

PRINTZ, H. 1926. Die Algenvegetation des Trondhjemsfjordes. Skrift. Norsk. Vidensk-Akad. I, Oslo, I, Mat.-Nat. Kl. No. 5: 1–274.

PROVASOLI, L. 1966. Media and prospects for the cultivation of marine algae. pp. 63–75. *In* WATANABE, A. and HATTORI, A. [eds.] Culture and Collections of Algae. Jap. Soc. Plant Physiol., Tokyo.

RAWLENCE, D.J. 1972. An ultrastructural study of the relationship between rhizoids of *Polysiphonia lanosa* (L.) TANDY (Rhodophyceae) and tissue of *Ascophyllum nodosum* (L.) LE JOLIS (Phaeophyceae). Phycologia **11**: 279–290.

REINOLD, E.S. 1963. The use of lead citrate at high pH as an electron-opaque stain in electron microscopy. J. Cell Biol. **17**: 208–212.

REINKE, J. 1888. Einige neue braune und grüne Algen in der Kieler Bucht. Ber. Deutsch. Bot. Ges., **6**: 240–241.

SCHUSSING, B. 1930. Phycologische Beiträge II. Oesterr. Bot. Zeitsch. **79**: 171–179.

SEARLES, R.B. and LEISTER, G.L. 1980. North

Carolina marine algae. IX. *Onslowia endophytica* gen. et sp. nov. (Phaeophyta, Sphacelariales) and notes on other new records for North Carolina. J. Phycol. **16**: 35–40.

Sears, J.R. 1966. Morphology and life history of *Blastophysa rhizopus* Reinke. Master's Thesis, University of Massachusetts, 30pp.

Spurr, A.R. 1969. A low-viscosity epoxy resin-embedding medium for electron microscopy. J. Ultrastruct. Res. **26**: 31–43.

Tokida, J. and Masaki, T. 1948. Koryô kôsô Akaba no ryokuhanbyô to byôgen ryokusô. Hokusuishi Geppô **5**: 14–17 (in Japanese).

White, E.B. and Boney, A.D. 1969. Experiments with some endophytic and endozoic *Acrochaetium* species. J. exp. mar. Biol. Ecol. **3**: 246–274.

Wittmann, W. 1965. Aceto-iron-haematoxylin-chloral hydrate for chromosome staining. Stain Tech. **40**: 161–164.

飯間雅文・舘脇正和：室内培養における室蘭産内生緑藻アワミドリ（ミル目ケートシフォン科）の発生・生活史と宿主特異性について

室蘭産内生緑藻アワミドリ *Blastophysa rhizopus* Reinke の発生・生活史が，単藻及び種々の海藻との二藻培養で調べられた。単藻培養の結果，生活史はこれまでの北米産の報告と一致した。アワミドリの宿主海藻との二藻培養は初めて行われ，これまで様々な海藻が宿主として記載されているにもかかわらず，室蘭産アワミドリは天然宿主紅藻ツルツルにのみ速やかな着生と組織への侵入を示し，数種類の紅藻に対してゆっくりとした弱い侵入を示した。他の多くの緑藻，褐藻，紅藻の組織には全く侵入しなかったが，それらの海藻にも人偽的に傷をつけたところその部位に侵入を示した。本種には宿主特異性はないが，地域ごとに着生基質として同時期に生育する宿主藻が限られていることが推察される。また宿主藻組織への侵入方法についても考察された。さらに室蘭産アワミドリの生長の温度に対する反応は，天然での季節的消長を反映していることから，この内生藻は宿主藻ツルツルと一体の生活史を営んでいると考えられる。（051 室蘭市母恋南町1-13 北海道大学理学部附属海藻研究施設）

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Cytoskeleton in cell morphogenesis of the coenocytic green alga *Valonia ventricosa* I. Two microtubule systems and their roles in positioning of chloroplasts and nuclei[1)]

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SHIHIRA-ISHIKAWA, I. 1987. Cytoskeleton in cell morphogenesis of the coenocytic green alga *Valonia ventricosa*. I. Two microtubule systems and their roles in positioning of chloroplasts and nuclei. Jap. J. Phycol. **35**: 251–258.

In vegetative cells of the coenocytic green alga, *Valonia ventricosa*, the spatial organization of microtubules in a thin cytoplasmic layer located between a huge central vacuole and the spherical cell wall was observed by using indirect immunofluorescence microscopy.

The cortical microtubules ran parallel to each other on the inner surface of the plasmalemma. The cortical microtubule system adhered on one side to the plasmalemma and on the other to surface of each chloroplast, anchoring the chloroplasts immediately next to the plasmalemma, forming a monolayered chloroplast sheet.

The nuclear-associated microtubule systems consisted of two different types of bundles: one that randomely surrounded the nuclear envelope, and another extending radially from the nucleus. The radial microtubules adhered to the chloroplast surface anchoring the nucleus to the chloroplast sheet, maintaining discreet distances between nuclei.

From the disorganization and reorganization of these microtubule systems, their roles in positioning chloroplasts and nuclei is discussed.

Key Index Words: coenocytic alga, cytoskeleton organization, Valonia, *cortical microtubules, nuclear -associated microtubules, indirect immunofluorescence.*

In the giant coenocytic cell *Valonia ventricosa*, the cytoplasm can be cleaved in response to mechanical stimulation and is converted into many protoplasts called aplanospores (KOPAC 1933). In culture these protoplasts develop into vacuolated coenocytic cells within 40 hrs like those of *Boergesenia forbesii* (ENOMOTO and HIROSE 1972) and *Bryopsis plumosa* (TATEWAKI and NAGATA 1970). Preliminary observations have shown that the dynamic behavior of the cytoplasm of *Valonia* proceeds under the control of the cytoskeleton (Shihira-Ishikawa unpublished). The study presented here describes the spatial organization of microtubules in a thin cytoplasmic layer inside the spherical cell wall of the vegetative phase of *Valonia ventricosa*. Indirect immunofluorescence has been used in analyzing the role of the cytoskeleton in the positioning of the cytoplasmic constituents.

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Material and Methods

Cell culture

Valonia ventricosa was cellected in Okinawa in 1983 and has been maintained in artificial sea water (Jamarin sea water, Jamarin Lab. Japan) under dim light at 20–25°C. For the experiments, the plants were transferred to Müller's synthetic medium (MÜLLER

1962) and cultured for 2–3 weeks at 22°C under a light-dark cycle of 12/12 hr (2000 lux, fluorescent lamps). Parts of the observations reported here were made on plants derived from a plant collected at Palau, Western Caroline Islands, in 1986.

Indirect immunofluorescence

Whole plants were immersed in prechilled methanol (−10°C) for 10 min and immediately transferred into phosphate buffered saline (PBS) at room temperature. This caused the cytoplasmic layer to detach from the cell wall and collapse into the central vacuole; the cell wall also cracked and the vacuolar contents leaked away. The cytoplasm was removed from the cell through the broken wall in PBS. Pieces of cytoplasmic layer were placed on a drop of PBS on a glass slide (previously coated with poly-lysine). After removal of the buffer, the samples were treated with 20 μl of the primary antibody (mouse ascites fluid containing monoclonal anti-α tubulin IgG which was raised against native chick brain microtubules) and incubated for 30 min at 37°C. After washing with 0.03 % Tween 20 in PBS for 15 min, fluorescein isothiocyanate (FITC)-labeled sheep anti-mouse IgG was applied and the samples were incubated for 30 min at 37°C. The samples were washed again with Tween 20 in PBS for 15 min and were mounted in Glycerin containing the anti-fade, p-phenylene-diamine (1 mg/ml, pH 9.0). Fluorescence micrographs were taken using an Olympus epifluorescence microscope (BH2-RFK) loaded with Ektachrome ASA 400 color positive film or Kodak Tri-X pan film.

Chemicals

Monoclonal anti-α tubulin (Amersham International, England) was diluted to 1/500, and fluorescein linked sheep anti-mouse IgG (Amersham International, England) were diluted to 1/10 with 1% of BSA and 0.1% of NaN_3. DAPI (4′-6-diamidino-2-phenylindole) was dissolved in S-buffer (NISHIBAYASHI and KUROIWA 1980) to make a solution of 1 μg/ml and a drop of this solution was used for nuclei staining.

Results

1. Microtubule organization in interphase cells.

The cytoplasm is a sheet, being placed between the cell wall and the huge central vacuole. At the plasmalemma, flat chloroplasts spread mostly in a single layer, although in older, non-dividing plants they can lie one upon another. All the nuclei are located adjacent to the central vacuole and are arranged between the chloroplast layer and the tonoplast (Fig. 1, a, b). The nuclei are placed roughly equidistant from each other (Fig. 2, a, b).

a) Cortical microtubules.

The cortical microtubules run in parallel on the inner surface of the plasmalemma (Fig. 3). The distances between adjacent bundles of the microtubules are approximately the same, but can differ depending on the age or condition of the plant. After the cold methanol treatment, the plasmalemma plus cortical microtubules separates from other constituents of the cytoplasm (Fig. 4), suggesting that one side of the bundles tightly adheres to the plasmalemma. Bundles of microtubules also adhere to the surface of each chloroplast and link the chloroplasts with each other in a sheet, suggesting that the other side of the bundles adheres to each chloroplast and anchors them immediately next to the plasmalemma (Fig. 5). The parts of the cortical microtubules located between the chloroplasts are liable to damage and are easily lost during the preparation of the sample (arrows in Fig. 5).

b) Nuclear associated microtubules.

Bundles of microtubules randomly surround the surface of every nucleus (Fig. 6) and large bundles extend radially from the nuclei to the chloroplast layer (Fig. 7). Those two types of bundles are connected

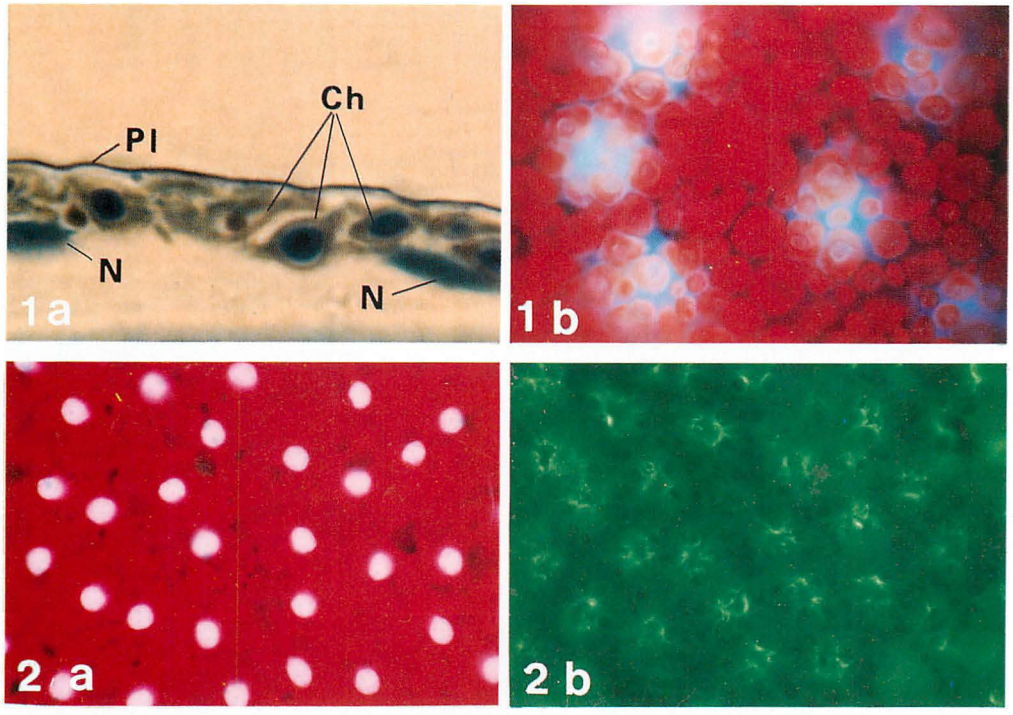


Fig. 1. Positional relationship of nuclei and chloroplasts in the thin cytoplasmic layer. (a) Section of the cytoplasmic layer. Methylene blue-staining. N: nucleus, Ch: chloroplast, Pl: plasmalemma. (b) Isolated cytoplasmic layer. DAPI-staining. Nuclei (white) are located underneath the chloroplast monolayer (red.). ×1000.

Fig. 2. Roughly equidistant distribution of nuclei. (a) DAPI-staining of cytoplasmic layer. White: nuclei, red: chloroplasts. (b) Indirect immunofluorescence. Microtubules around each nucleus are shown. ×300.

to each other at the surface of the nuclei; the bundles of peri-nuclear microtubules extend radially into the cytoplasm surrounding the nuclei (Fig. 8).

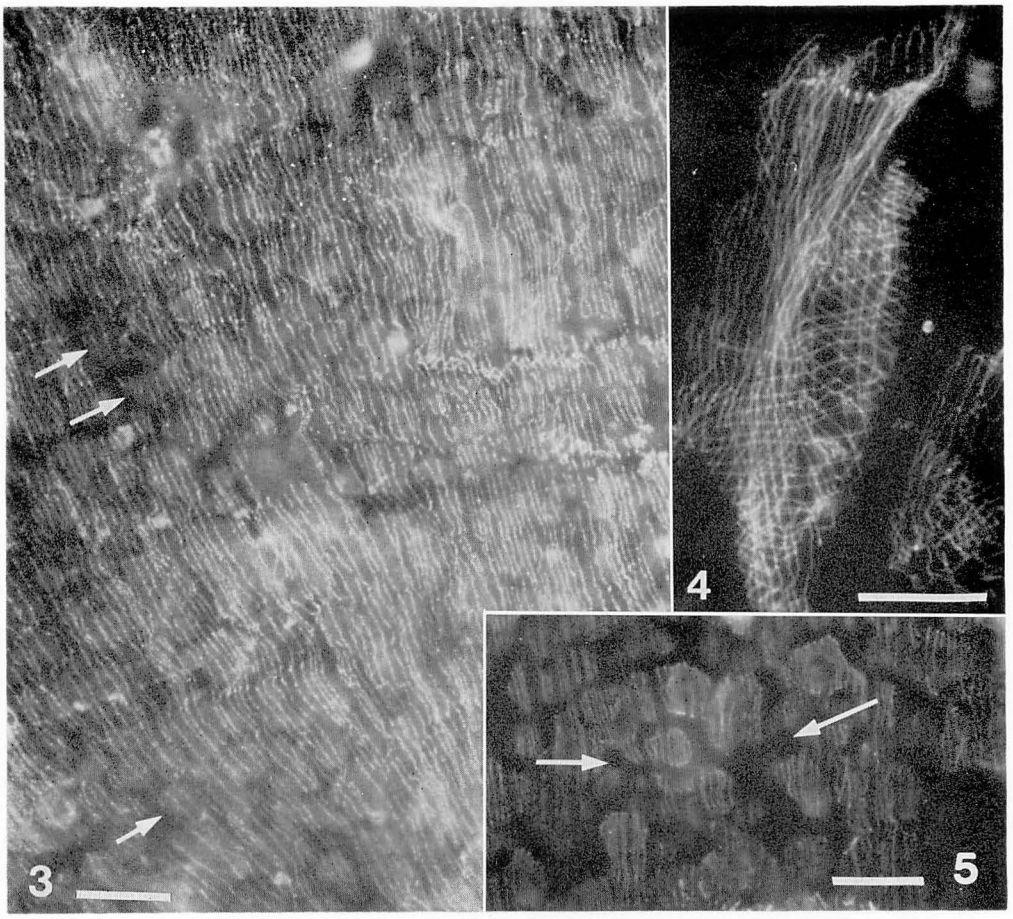
During preparation of the sample, pieces of the cytoplasmic layer became loose at the edges, and nuclei could frequently be observed with chloroplasts attached (Fig. 9). Microtubule links between nuclei and chloroplasts were observed, and it appeared that the ends of the radial microtubule bundles adhered to the chloroplast surface (arrows in Fig. 9).

The nuclear-associated microtubules and the cortical ones are not connected with each other.

2. Disorganization and reconstruction of microtubule systems.

a) Cortical microtubules

The organization of cortical microtubules was destroyed by mechanical stimulation. Immersion of cells in pure water at room temperature induced the destruction in 15 min (Fig. 10). Under the dissection microscope, many crater-like holes were observed in the cytoplasmic layer, which had partially collapsed into the central vacuole as a result of the destruction of cortical microtubules (Fig. 11). This treatment did not cause the destruction of nuclear-associated microtubules. The cortical microtubules reassembled after the cells were transferred into the culture medium and the cytoplasmic layer became smooth in appearance again. The crater-like holes were also induced by stimulation with a needle to the cytoplasm, in which case the cell proceeded to aplanospore formation without the recovery of cortical microtubule

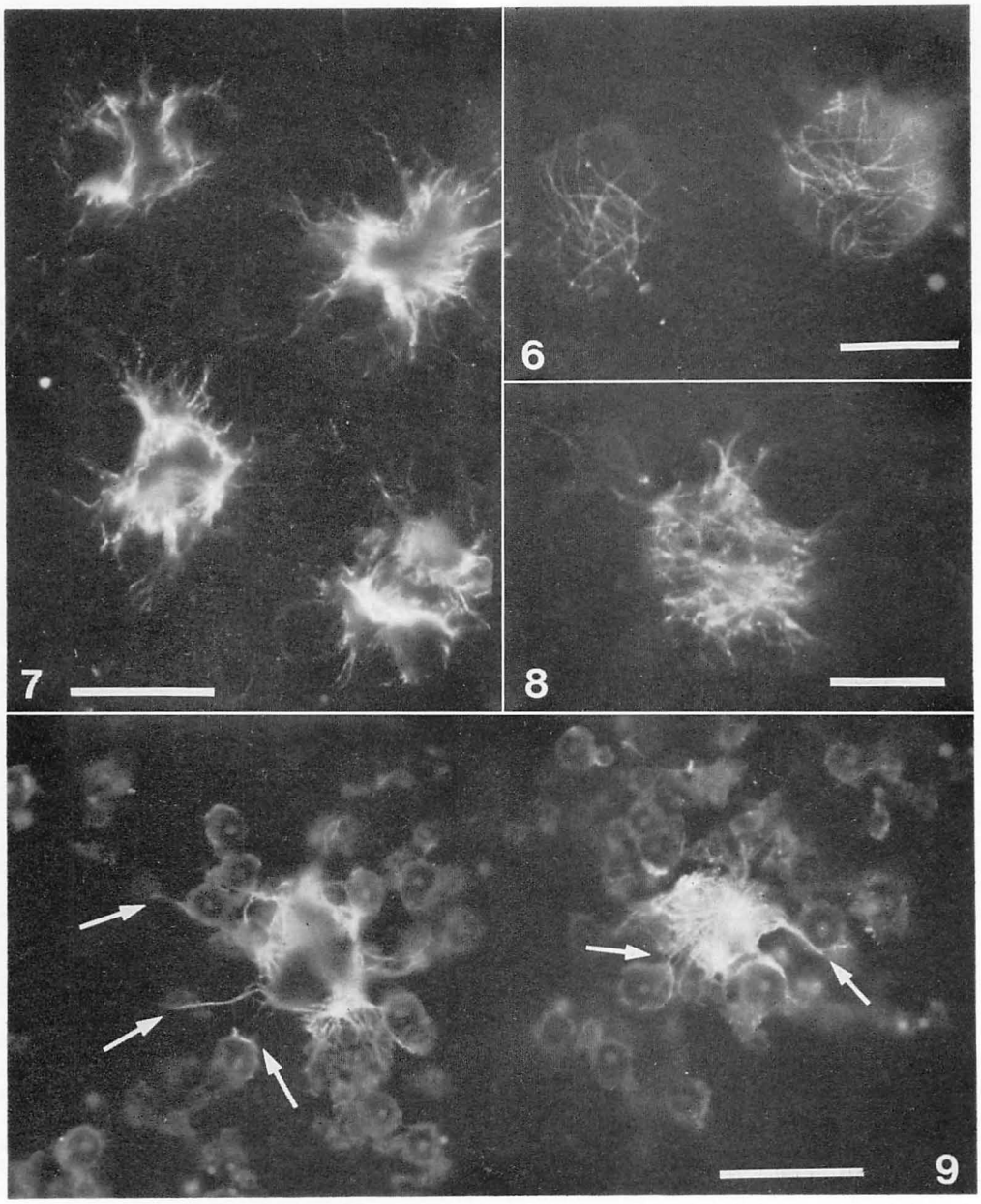


Figs. 3–5. Cortical microtubules. 3. Parallel arrangement of cortical microtubules covering the total inner surface of the plasmalemma. Chloroplasts are faintly seen under the cortical microtubules (arrow). 4. Cortical microtubules adhering to the plasmalemma which has been separated from other cytoplasmic constituents. The rolled pieces of plasmalemma were pressed by a cover glass onto a glass slide. The parallel structure of cortical microtubules are seen as being folded. 5. Cortical microtubules adhering to chloroplast surfaces. The parts of the cortical microtubules between chloroplasts are liable to be lost (arrows). (Scale bar: 10 μm).

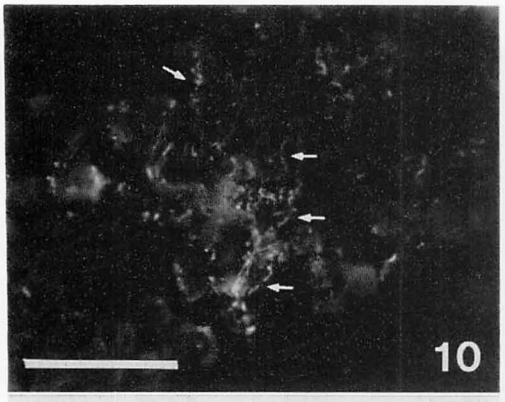
organization. These results suggest that the cortical microtubules stretch the protoplasm to a thin layer, sandwiching it between the huge central vacuole and cell wall.

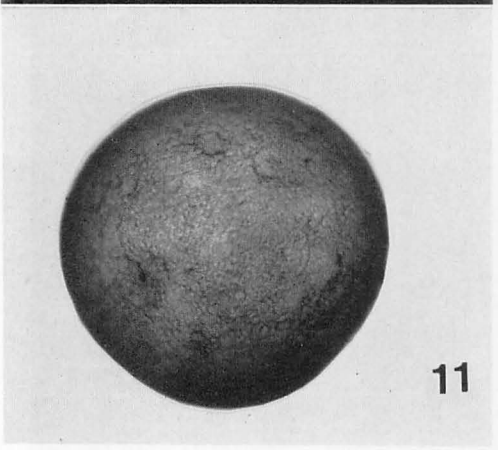
b) Nuclear-associated microtubules

Preceeding mitosis, polar microtubules appeared at both ends of the long axis of the nuclei (Fig. 12). The nuclear-associated microtubule bundles, either surrounding the nucleus or radiating from it, decreased at the same time. During nuclear division, the presence of microtubules increased, forming interzonal spindles (HORI and ENOMOTO 1980) suggesting the reorganization of previously depolymerized nuclear-associated microtubules (Fig. 13). At the final course of nuclear division, interzonal spindle microtubules were scattered, probably because of the break of the nuclear envelope. Each of the divided nuclei turned about 90°, in the same rotation. The scattered microtubule bundles wound about the nucleus and radially arranged microtubules were reorganized (Fig. 14). As the nuclear division took place syn-



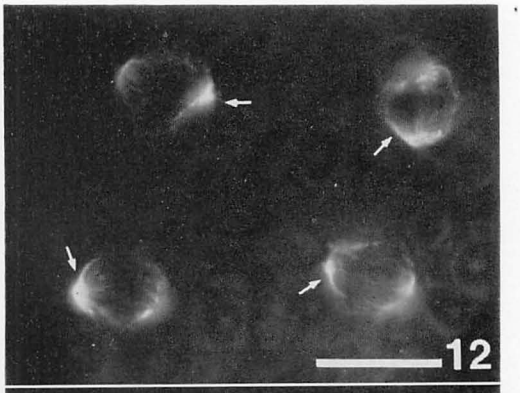
Figs. 6–9. Nuclear-associated microtubules. 6. Microtubules surrounding the surface of nuclei. 7. Radially-extending microtubules from the nuclear surface. 8. Peri-nuclear microtubules and radially-extending microtubules are continuous. (Peri-nuclear microtubules, radially-extending microtubules and the connection region of above lie at the slightly different focal levels.) 9. Radially-extending microtubules attached to the chloroplast surface (arrows) suggesting a positional linkage between nucleus and chloroplast. (Scale bars: 10 μm for Figs. 6 and 8; 20 μm for Figs. 7 and 9)

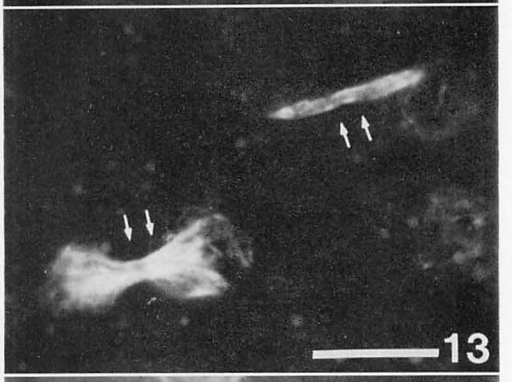


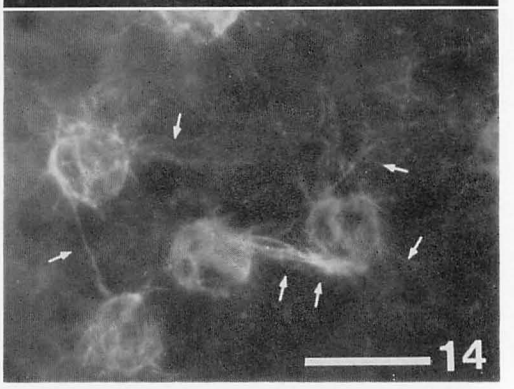


Figs. 10–11. Destruction of cortical microtubules. 10. Disorganized cortical microtubules (arrows) 15 min after immersion of whole cells in pure water. (Scale bar: 20 μm). 11. Crater-like holes on the cytoplasmic layer as a result of the destruction of cortical microtubules. $\times$20.

chronously, but the direction of axis of each nucleus was different, the equidistant distribution of nuclei was disordered at the end of mitosis. As the nuclei-associated radial microtubule system re-formed, chloroplasts became evenly distributed and gaps were filled by an increase of chloroplasts. The equidistant arrangement between each nuclei was restored again. The link between nuclei and chloroplasts became weak during nuclear division, however, the chloroplasts remained tightly linked with the cortical microtubules. Mitosis proceeded adjacent to the chloroplast monolayer.







Figs. 12–14. Probable conversion of nuclear-associated microtubules to spindles in mitosis. Microtubules are shown by arrows. 12. Initial step of mitosis. Nuclear-associated microtubules disappear. 13. Formation of interzonal spindles. 14. Final stage of mitosis. Nuclear microtubules are reorganized. (scale bar: 20 μm)

Discussion

In coenocytic green algae, the cytoskeleton is thought to be involved in cytoplasmic cleavage for spore formation. Actin and microtubule are known to be involved in cyst formation of *Acetabularia acetabulum*

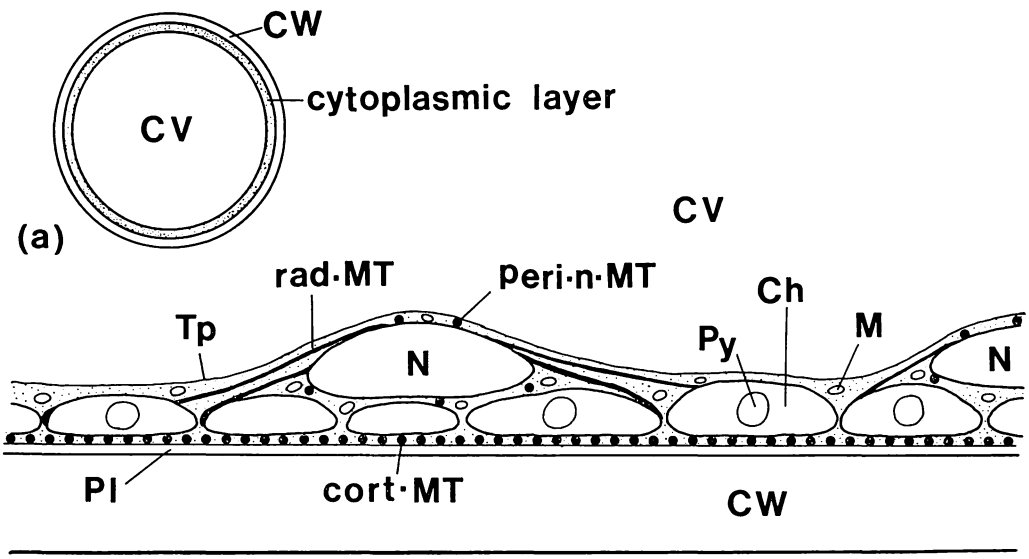


Fig. 15. The spatial organization of two microtubule systems and the relationships with other constituents of cytoplasmic layer. (a) Locality of the cytoplasmic layer in the whole plant of *Valonia ventricosa* is diagramatically presented. (b) Cross sectional view of cytoplasmic layer. (Relative size of each constituent is not exact) CW: cell wall, CV: central vacuole, Pl: plasmalemma, Tp: tonoplast, N: nucleus, Ch: chloroplast, Py: pyrenoid, M: mitochondrion, cort-MT: cortical microtubule bundle, rad-MT: radially-extending microtubule bundle, peri-n-MT: peri-nuclear microtubule bundle.

(Menzel 1986). I have also studied the cytoskeletal organization in the multinucleate cap-ray of *A. calyculus* and observed an even cytoplasmic cleavage with a sole nucleus as the center of each piece of cleaved cytoplasm (unpubl. data). In *V. ventricosa,* the size of cleaved cytoplasm and the number of nuclei in a piece of the cytoplasm were uneven in the aplanospore formation, but on the other hand each swarmer was formed by an equal size of delimitted cytoplasm and a sole nucleus. In the search for general and spacific mechanisms of cytoskeletal organization in the cell differentiation of multinucleate cells, *V. ventricosa* is a useful material. In this report, the spatial organization of microtubules in vegetative phase was investigated which form the basic knowledge for the dynamic organization of cytoskeleton during the cell morphogenesis of *V. ventricosa.*

Coexistance of two microtubule systems was essential for the protoplasmic organization in the stationary phase of *V. ventricosa.* Cortical microtubules spread chloroplasts in a monolayer adjacent to the plasmalemma while nuclear-associated microtubules support an even distribution of nuclei next to chloroplast monolayer, adjacent to the inner surface of cytoplasmic layer, at the tonoplast. The two microtubule systems are illustrated in Figure 15.

The bundles of cortical microtubules were closely arranged in some samples but more loosely in others. Physiological significance of this difference is, however, not known. The rapid disorganization of the cortical microtubule system was caused by immersion of the plant in pure water, although the nuclear-associated microtubule system remained intact. The disorganization of the cortical microtubule system also occurred in the early step of aplanospore formation, which was started by wounding of the cytoplasm.

The terminal portion of the radial microtubule bundles adhered to the chloroplast surface. The positional relationships be-

tween nuclei and chloroplasts and also chloroplasts and plasmalemma were maintained by the organization of microtubule bundles that specifically bound to each cell component. The fine structure and molecular organization of these bindings are under investigation.

The nuclei are distributed roughly equidistantly on the chloroplasts sheet in *V. ventricosa*. The distances between adjacent nuclei are maintained by radial microtubules around the nuclei. The recovery of an even distribution of nuclei after synchronous division of nuclei suggests that the radially-extending microtubules shift the nuclei to certain positions, maintaining equidistance by binding with surrounding chloroplasts at what appears to be their terminal portion. At the same time, the chloroplasts increase in number by division which results in the enlargement of the chloroplasts sheet as well as the cytoplasmic layer, resulting in the enlargement of the whole cell.

LACLAIRE (1987) could not find a common function between the cortical microtubules of the two coenocytic algae, *E. verticillata* and *B. forbesii*. To know the generality of the roles of microtubules in coenocytic algal cells, further observation is now in progress using other coenocytic green algae.

Acknowledgement

The author is grateful to Dr. R. NAGAI (Osaka University) and Dr. K. KURODA (Osaka University) for their valuable advice throughout the work. Thanks are also due to Dr. S. ENOMOTO (Kobe University) for providing a *Valonia* cell which he collected at Palau Island in 1986 and Dr. R. RIDGE (Tsukuba University) and Dr. T. HORI (Tsukuba University) for helpful advice in preparation of the manuscript.

References

ENOMOTO, S. and HIROSE, H. 1972. Culture studies on artificially induced aplanospores and their development in the marine alga *Boergesenia forbesii* (Harvey) FELDMANN (Chlorophyceae, Siphonocladales). Phycologia **11**: 119–122.

HORI, T. and ENOMOTO, S. 1978. Electron microscope observations on the nuclear division in *Valonia ventricosa* (Chlorophyceae, Siphonocladales). Phycologia **17**: 133–142.

KOPAC, M.J. 1933. Physiological studies on *Valonia ventricosa*. Report of Torgtugas Lab., Carnegie Inst. Wash. Year Book No. 32, 273–276.

LACLAIRE, J.W., II. 1987. Microtubule cytoskeleton in intact and wounded coenocytic green algae. Planta, **171**: 30–42.

MENZEL, D. 1986. Visualization on cytoskeletal changes through the life cycle in *Acetabularia*. Protoplasma **134**: 30–42.

MÜLLER, M. 1962. Uber jahres- und lunar- periodische Ersheinungen bei einigen Braunalgen. Botanica Marina, **4**: 130–155.

NISHIBAYASHI, S. and KUROIWA, T. 1982. Behavior of leucoplast nucleoids in the epidermal cell of onion (*Allium cepa*) bulb. Protoplasma **110**: 177–184.

TATEWAKI, M. and NAGATA, K. 1970. Surviving protoplasts *in vitro* and their development in *Bryopsis*. J. Phycol. **6**: 401-403.

石川依久子：多核細胞性緑藻バロニアの形態形成における細胞骨格 I.
核・葉緑体配置に寄生する2つの微小管系

巨大細胞性緑藻バロニアの成長および形態分化の過程が細胞骨格の動的構成に導かれることを予備実験で確かめ一連の研究を計画した。本研究では栄養成長過程および休止期にある藻体中の微小管構成とその役割を間接蛍光抗体法により解析した。細胞質は巨大液胞と細胞壁にはさまれた薄層として存在し，細胞膜側に一層をなす葉緑体群と液胞側に分布する多くの核をもつ。微小管は細胞膜に接して密に平行配列し，細胞膜と葉緑体の双方に接着することによって葉緑体を細胞膜直下に固定している。一方，核の表面から微小管が放射状にひろがって葉緑体表面に接着し，葉緑体群上に核を固定し，同時に，一定数の葉緑体を核の周辺に確保することによって核の均等分布を助けている。(560 豊中市待兼山町1-1，大阪大学教養部生物学教室)

Jap. J. Phycol. (Sôrui) **35**: 259–264, December 10, 1987

Studies on freshwater red algae of Malaysia VII. *Batrachospermum tapirense* sp. nov. from Sungai Tapir, Johor, Peninsular Malaysia

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KUMANO, S. and PHANG, S.M. 1987. Studies on freshwater red algae of Malaysia VII. *Batrachospermum tapirense* sp. nov. from Sungai Tapir, Johor, Peninsular Malaysia Jap. J. Phycol. **35**: 259–264.

Batrachospermum tapirense is described here as a new species from Sungi Tapir, Johor, Peninsular Malaysia. *Batrachospermum tapirense* resembles *B. bakarense* KUMANO et RATNASABAPATHY (1984) in having the short carpogonium-bearing branch consisting of 2–6 cells, and the carpogonium with club-shaped trichogyne more or less bent at the base. This species, however, differs from the latter in having the carpogonium-bearing branch, which arises descendantly from the rear side of the basal cell of the primary branchlet and grows toward the same direction that cortical filaments are formed, moreover, in having the radially branched and diffused gonimoblast filaments. Because of these characteristics, this species is described here as a new species of the genus *Batrachospermum*, and seems to be an intermediate form between the genus *Batrachospermum* and the genus *Sirodotia*.

Key Index Words: Batrachospermum tapirense *sp. nov.; freshwater Rhodophyta; diffused gonimoblast filaments; radially branched gonimoblast filaments; taxonomy; West Malaysia.*

The genus *Sirodotia* KYLIN (1912) is vegetatively similar to the genus *Batrachospermum* ROTH (1797), but differs reproductively in having diffused rather than radially branched gonimoblast filaments and an asymmetrical rather than an isodiametric carpogonium base (KYLIN 1912, ENTWISLE & KRAFT 1984). The present paper deals with a Malaysian species of the genus *Batrachospermum*, which seems to be an intermediate form between the genus *Batrachospermum* and the genus *Sirodotia*.

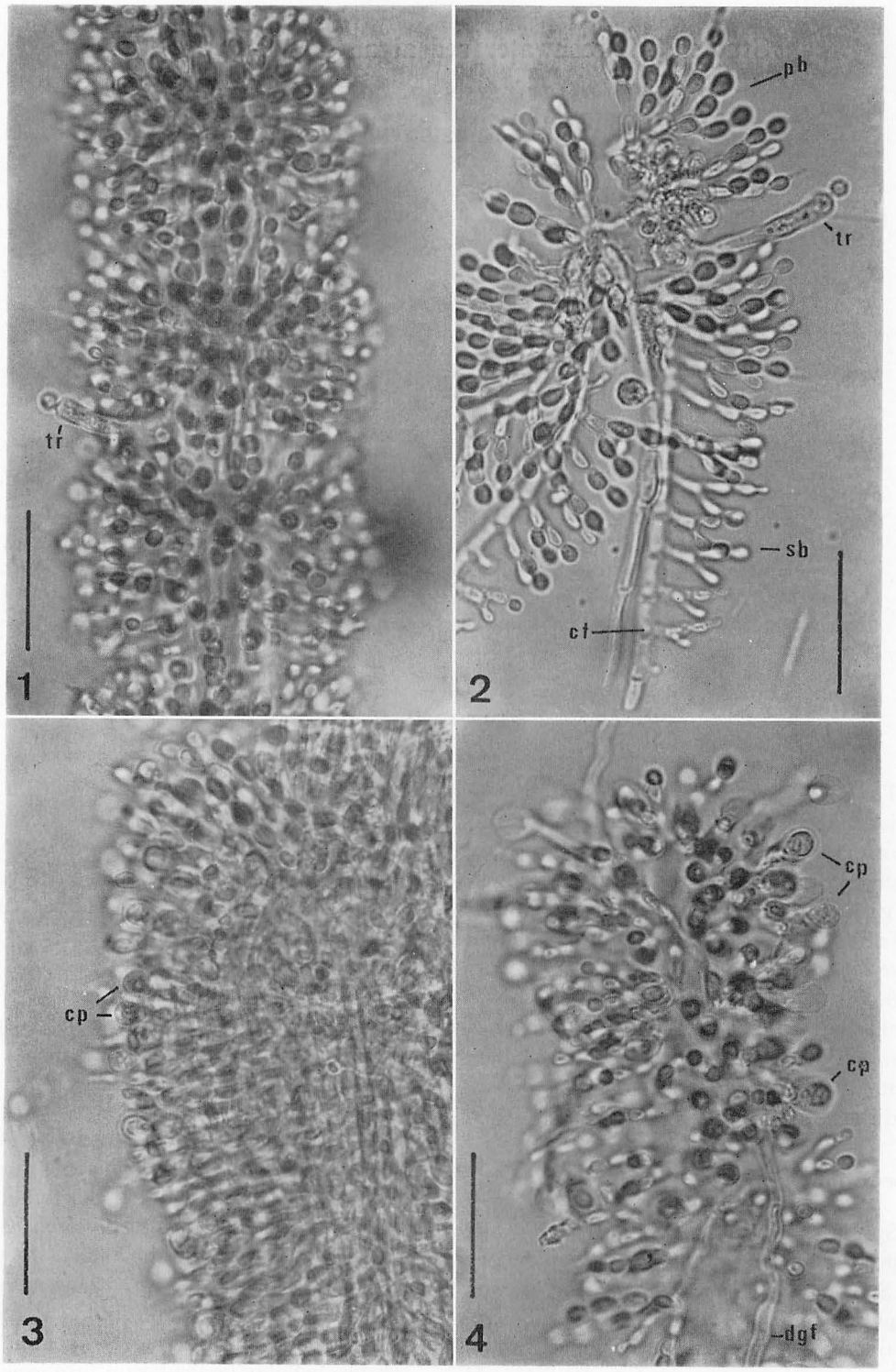
Specimen Examined

Specimens examined in this study were collected from Sungei Tapir, a tributary of Sungei Endau, by PHANG Siew Moi on September 30, 1985. At the time of collecting the specimens, the water was about 10 cm deep, the temperature 24.7°C, pH 6.2, dissolved oxygen 6.47 mg/l, conductivity 20.0 μ mho/cm, total alkalinity 3.6 mg $CaCO_3$/l, and NO_3-N 68.0 μg/l. The specimens examined (No. 216) were deposited in the Herbarium of Faculty of Science, Kobe University and the Herbarium of Department of Botany, University of Malaya.

Description of Species and Discussions

Batrachospermum tapirense KUMANO et PHANG sp. nov. (Figs. 1–17)

Frons monoica, ca. 6 cm alta, 80–170 μm crassa, plus minusve dichotome ramosa, modice mucosa, aeruginosa. Cellulae axiales cylindricae, 20–80 μm crassae, 70–300 μm longae. Verticilli obconici, in parte vetustiore frondis contigui et plus minusve compressi. Ramuli primarii dichotome vel trichotome ramificantes, ex 4–5 cellulis constantes; cellulae fasciculorum fusiformes vel ellipsoideae, 3–5 μm crassae, 4–11 μm longae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(Fig. 10); pili praesentes. Fila corticales bene evoluta (Fig. 10, 15). Ramuli secundarii ex 2–4 cellulis constantes, numerosi, totum internodium obtegentes; cellulae fasciculorum fusiformes vel ellipsoideae (Fig. 1, 2, 10, 15). Spermatangia globosa, 4–6 μm diametro, in ramulis primariis et secundariis terminalia (Fig. 5). Rmuli carpogoniferi e cellulis pericentrali (cellulis basi ramulorum) desendens orientes, ex cellulis 4–6 disc- vel dolliformibus constantes; carpogonium basi 4–5 μm crassum, apice 5–6 μm crassum, 30–40 μm longum; trichogyne claviformis, plus minusve indistincte pedicellata, ad basim saepe flexa (Fig. 8–13). Bracteae breves, Carposporophytum indefinitum, verticillum aequans; fila gonimoblastorum radiale ramificantes (Fig. 14), diffusa, et circum nodium et instrato corticali reptantia (Fig. 14, 16, 17). Carposporangia globosa vel ellipsoidea, 5–8 μm crassa, 8–12 μm longa (Fig. 14, 17).

Frond monoecious, ca. 6 cm high, 80–170 μm wide, more or less dichotomously branch -ed, moderately mucilaginous, green with a bluish tinge. Axial cells cylindrical, 20–80 μm wide, 70–300 μm long. Whorls obconical, continuous and more or less compressed in the aged fronds. Primary branchlets dichotomously or trichotomously branched, consisting of 4–5 cell-stories; cells of fascicles fusiform or ellipsoidal, 3–5 μm wide, 4–11 μm long (Fig. 10); hairs present. Cortical filaments well-developed (Figs. 10, 15). Secondary branchlets consisting of 2–4 cell-stories, numerous, covering all the internodes (Figs. 1, 2, 10, 15). Spermatangia globose, 4–6 μm in diameter, terminal on primary and secondary branchlets (Fig. 5). Carpogonium-bearing branch arising descendantly from the pericentral cell (the basal cell of the primary branchlet), consisting of 4–6 disc- or barrel-shaped cells; carpopgonium 4–5 μm wide at the base, 5–6 μm wide at the apex, 30–40 μm long; trichogyne club-shaped, more or less indistinctly stalked, often bent at the base (Figs. 8–13). Bracts very short, more or less laterally issued. Carposporophyte indefinite and indistinguishable from the whorl and equalling in length; gonimoblast filaments radially branched (Fig. 14), diffused and creeping along the cortical filaments (Figs. 14, 15, 17). Carposporangia globose or ellipsoidal, 5–8 μm wide, 8–12 μm long (Figs. 14, 17).

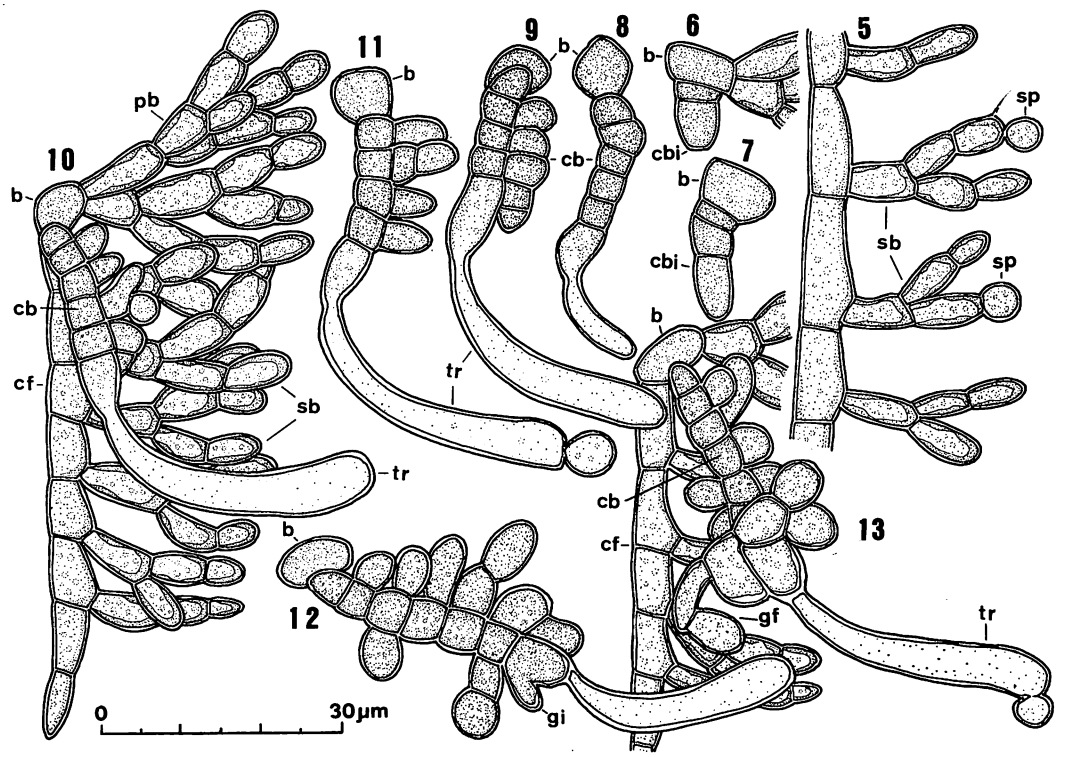
Holotype: PHANG Siew Moi (No. 216), 30/IX, 1985, Herbarium of Faculty of Science, Kobe University. Isotype: Herbarium of Department of Botany, University of Malaya.

Type locality: Sungei Tapir, a tributary of Sungei Endau, Johor, Malaysia.

Distribution; Known from the type locality only.

The initial of the carpogonium-bearing branch of *B. tapirense* is produced from the rear side of the pericentral cell (the basal cell of the primary branchlets), which is in the same side where the initial of the cortical filament is formed (Figs. 6, 7). Usually, a carpogonium-bearing branch is prduced at each whorl and grows toward the similar direction that cortical filaments descendantly eongate (Fig. 10, cb). The terminal portion of the carpogonium sticks out and finally gives rise to a club-shaped and slightly curved trichogyne indistinctly stalked and often bent or curved at the base (Figs. 8–11, tr). In hitherto known species of the genus *Batrachospermum* such as *B. cayennense* MONTAGNE (1850), *B. virgatum* (KUTZING) SIRODOT (1884), *B. bakarense* KUMANO et RATNASABAPATHY

Figs. 1–4. *Batrachospermum tapirense* KUMANO et PHANG 1. Structure of thallus, note the extruding terminalportion of trichogyne; 2. A part of thallus showing primary branchlets, a carpogonium-bearing branch, cortical filaments and secondary brancylets; 3. Carposporophyte is indistinguishable from the whorl; 4. Radially branched and diffused gonimoblast filaments. (cp, carposporangium; cf, cortical filament; dgf, diffused gonimoblast filament; pb, primary branchlets; sb, secondary branchlets; tr, trichogyne, Scale bar: 40 μm for Figs. 1–4)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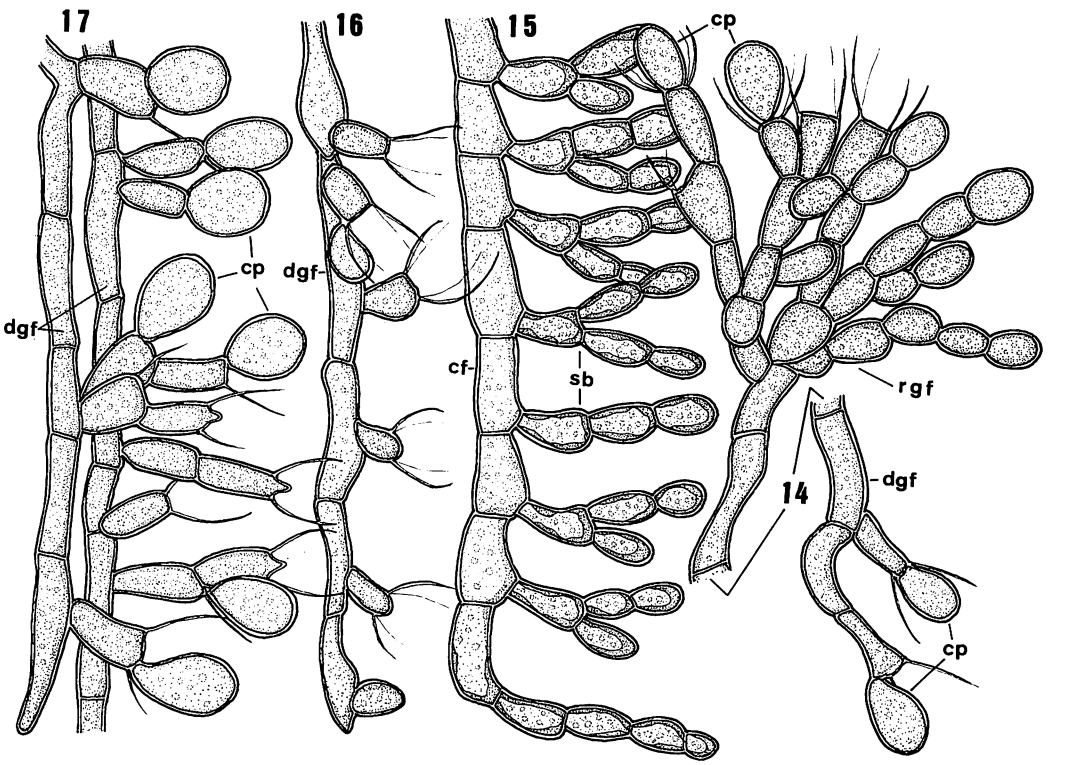
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(1984), *B. vagum* var. *periplocum* SKUJA (1969) and *B. orthostichum* SKUJA (1931), the carpogonium-bearing branch usually arises ascendantly from the pericentral cell (the basal cell). On the other hand, *B. tapirense* resembles *B. bakarense* KUMANO et RATNASABAPATHY (1984) in having a relatively short carpogonium-bearing branch and a club-shaped trichogyne, so that it might be assigned to the section *Viridia*. However, *B. tapirense* differs from *B. bakarense* and also from the rest of the species of the genus *Batrachospermum* in having the carpogonium-bearing branch, which arises from the rear side of the pericentral cell (the basal cell of the primary branchlets) and grows descendantly in the same way as the cortical filaments elongate (Figs. 10, 13, cb). As a result of the above-mentioned development, the terminal portion of trichogyne faces outward of the whorl and extrudes at the internode of the whorl (Fig. 1, tr).

After fertilization (Fig. 11) the basal portion of the carpogonium extends and forms the initial of the gonimoblast filament (Fig. 12, gi), and farther gonimoblast filaments (Fig. 13, gf). The carposporophyte grows out into radially branched (Fig. 14, rgf) and diffused gonimoblast filaments (Fig. 14, dgf), which are extended along the cortical filaments (Fig. 16, 17, dgf). The carposporangia are produced terminally or subterminally on the short laterals of the diffused gonimoblast filaments (Fig. 16, 17, cp).

The genus *Sirodotia* was established and separated from the genus *Batrachospermum* on the characteristics of carposporophyte and carpogonium (KYLIN 1912). The carposporophyte of the genus *Sirodotia* consists of diffused filaments that extend along the cortical filaments, and the carpogonium has a distinct protuberance on one side of the base.

Batrachospermum tapirense is described as a new species and assigned to the genus *Batrachospermum* because of its essentially symmetrical carpogonium. On the other hand, *B. orthostichum* SKUJA (1931) was also assigned to the genus *Batrachospermum* because of its symmetrical trichogyne and essentially globular carposporophyte although SKUJA observed some diffused filaments extending out from a globular carposporophyte of *B. orthostichum* SKUJA (1931) and *B. vagum* var. *periplocum* SKUJA (1969). KUMANO et al. (1970) also observed some diffused gonimoblats filaments extending out from a globular carposporophyte of *B. vagum*.

The gonimoblast of *B. tapirense* is indistinguishable from the whorl to which the length is equal (Fig. 3). Moreover, two types of gonimoblast filaments are observed: one is radially branched (Fig. 14, rgf), and is usually found in the genus *Batrachospermum*; the other is defused (Figs. 4, 14, 16, 17, dgf), and is typically found in the genus *Sirodotia* and rarely in a few species of the genus *Batrachospermum* such as *B. orthostichum* and *B. vagum*. Because of these characteristics, the above-mentioned taxa of the genus *Batrachospermum* and *B. tapirense* seem to be apparently intermediate forms linking the genus *Batrachospermum* and the genus *Sirodotia*. *B. orthostichum*, *B. vagum*, *B. vagum* var. *periplocum* and *B. tapirense* might be assigned to the section *Turficola* or a separate new section.

Figs. 5–17. *Batrachospermum tapirense* KUMANO et PHANG 5, Spermatangium terminal on the secondary branchlets; 6–9, Early stages of development of carpogonium-bearing branch; 10, A part of thallus showing primary branchlet, cortical filament, secondary branchlets and carpogonium-bearing branch, which grows toward the same direction that cortical filament elongates; 11, A carpogonuim-bearing branch with a fertilized trichogyne; 12, 13, Early stages of development of carposporophyte; 14, Radially branched gonimoblast filaments and diffused one; 15, Cortical filament and secondary branchlets; 16–17, Carposporangia terminal on the laterals of diffused gonimoblast filaments, (b, basal cell of primary branchlet; cb, carpogonium-bearing branch; cbi, initial of carpogonium-bearing branch; cf, cortical filament; cp, carposporangium; dgf, diffused gonimoblast filament; gf, gonimoblast filament; gi, initial of gonimoblast filament; rgf, radially branched gonimbolast filament; sb, secondary branchlet; sp, spermatangium)

References

ENTWISLE, T.J. and KRAFT, G.T. 1984. Survey of freshwater red algae (Rhodophyta) of Southeastern Australia. Aust. J. Mar. Freshw. Res., **35**: 213–259.

KUMANO, S., SETO, R. and HIROSE, H. 1970. On the development of the carposporophytes with special reference to their phylogenetic relations. Bull. Jap. Soc. Phycol. **18**: 116–120. (In Japanese).

KUMANO, S. and RATNASABAPATHY, M. 1984. Studies on freshwater red algae of Malaysia IV. *Batrachospermum bakarense*, sp. nov. from Sungei Bakar, Kelantan, West Malaysia. Jap. J. Phycol. **32**: 19–23.

KYLIN, H. 1912. Studien über die schwedischen Arten der Gattungen *Batrachospermum* ROTH und *Sirodotia* nov. gen., Nov. Act. Reg. Soc. Sci. Upsaliensis. IV. **3**: 1–40.

MONTAGNE, C. 1850. Cryptogamia Guyanensis, seu Plantarum cellularium in Guyana gallica annis 1835–1849 a Cl. Leprieur collectarum enumeratio universalis. Ann. Sci. Nat., Bot. (3 ser.) **14**: 283–309.

ROTH, A.G. 1797. Bemerkungen über das Studium der kryptogamische Wassergewächse. Tentamen Florae Germinae p. 36.

SIRODOT, S. 1884. Les Batrachospermes. Libairie l'Academie de Medicine, Pairs.

SKUJA, H. 1931. Einiges zur Kenntnis der brasilianischen Batrachsopermen. Hedwigia **71**: 78–87.

SKUJA, H. 1969. Eigentümliche morphologische Anpassung eines *Batrachospermum* gegen mechanische Schädigung in fließendem Wasser. Österr, Bot. Z., **116**: 55–64.

熊野　茂*・PHANG Siew Moi：マレーシアの淡水産紅藻　VII. 半島マレーシア，ジョホール州，タピア川の *Batrachospermum tapirense*, sp. nov.**

ジョホール州，エンドウ川の支流，タピア川からカワモヅク属の1新種 *Batrachospermum tapirense* が記載された。既知のカワモヅク属の他の種と違って，本種の造果器をつける枝は，皮層糸が伸長するのと同じ方向，即ち下方に発出する。また，放射状に分枝する造胞糸と皮層糸に沿って伸長する造胞糸との，2種類の造胞糸をもつことから，本種とユタカカワモヅク属との密接な関連が考えられる。(*657　神戸市灘区六甲台　神戸大学理学部生物学教室，**Institute of Advanced Studies, University of Malaya)

Jap. J. Phycol. (Sôrui) 35: 265–267 December 10, 1987

Study of a freshwater red alga, *Compsopogonopsis fruticosa* (JAO) SETO comb. nov. (Compsopogonales, Rhodophyta) from China

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SETO, R. 1987. Study of a freshwater red alga, *Compsopogonopsis fruticosa* (JAO) SETO comb. nov. (*Compsopogonales*, Rhodophyta) from China. Jap. J. Phycol. **35**: 265–267.

The isotype specimen of *Compsopogon fruticosus* JAO 1941 (SC1145) was examined and ascertained to have a mode of formation of cortex characteristic for the genus *Compsopogonopsis*. Therefore, *Compsopogon fruticosus* is transferred from the genus *Compsopogon* to the genus *Compsopogonopsis* as *Compsopogonopsis fruticosa* (JAO) SETO comb. nov..

Key Index Words: *China;* Compsopogonopsis fruticosa; *freshwater Rhodophyta; study; taxonomy.*

The genus *Compsopogonopsis* was established by KRISHNAMURTHY (1962) with *Compsopogonopsis leptoclados* (MONTAGNE) KRISHNAMURTHY. This species was separated from the genus *Compsopogon* based on the characteristic mode of formation of cortex.

CHIHARA (1976) described *Compsopogonopsis japonica* as a new species from Sakai, Gunma Prefecture, Japan. JAO (1941) described *Compsopogon fruticosus* as a new species from Kan-tungtze, Pehpei, Szechwan, China, however, he did not observe the mode of formation of cortex in that species. In the present study, the isotype of *Compsopogon fruticosus* was examined to ascertain the mode of formation of cortex.

Specimen examined

The isotype specimen of *Compsopogon fruticosus* (SC1145) was collected by JAO Chin Chih from Kan-tungtze, Pehpei, Szechwan, China in February, 1940, deposited at the Herbarium of Institute of Hydrobiology, Academia Sinica Wuhan, People's Republic of China. This specimen was found on the concrete wall of a mill dam, where the water was fast-running and comming from a cave of limestone.

Observations

Thallus of *Compsopogon fruticosus* is filamentous, cylindrical, constricted here and there, about 15 cm long, profusely branched, main branches are 0.2–0.5 mm in diameter (Fig. 1). Uniseriate parts of thallus are composed of discoid axial cells. Apical cells of the uniseriate part of the thallus are dome-shaped, 11.0–12.5 μm long and 12.5–13.8 μm wide (Fig. 2). The initials of cortical cells are produced from the lower part of the axial cells of the uniseriate part of the thallus; the protuberances are formed from the lower part of the axial cells. The initials of the cortical cells are separated from the protuberances by oblique or horizontal walls, which then grow downwards as rhizoid-like cortex filaments (Figs. 6–9). The cortex consists of two layers of cells, of which the outermost cortical cells are trito pentagonal, and 14.0–55.0 × 12.0–35.0 μm in size (Figs. 4–5). Central cells are short, disc-shaped, some of which are retained even in the aged parts of the branch-

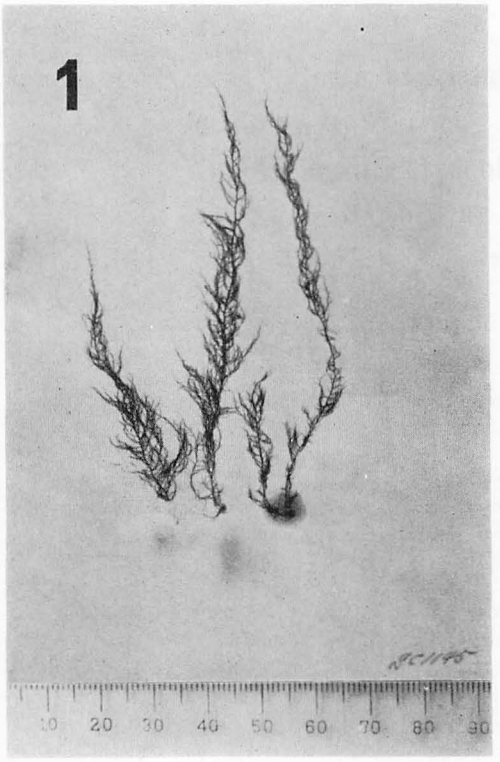
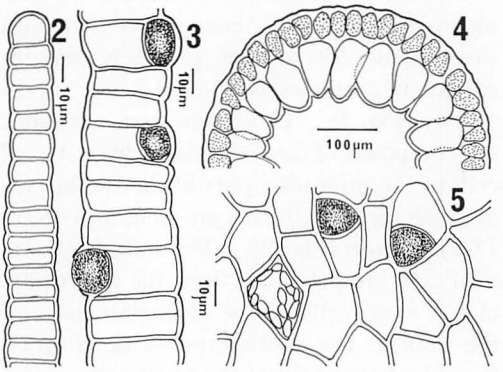
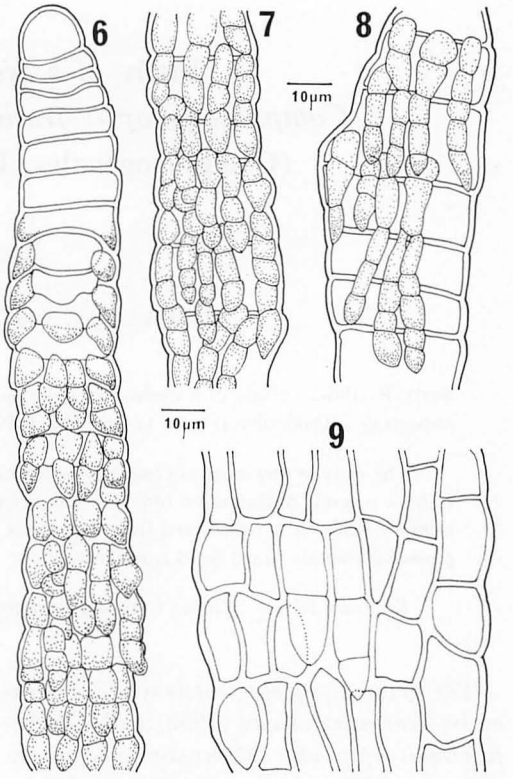


Fig. 1. Isotype of *Compsopogonopsis fruticosa* (JAO) SETO comb. nov. (SC 1145). Scale=mm.



Figs. 2–5. *Compsopogonopsis fruticosa* (JAO) SETO comb. nov.: Fig. 2. An apical part of the uncorticated axis showing discoid cells and the apical cell; Fig. 3. Formation of monosporangia in the young uncorticated branch; Fig. 4. Cross section of the main branch showing two layered cortex and the retaining central cell; Fig. 5. Outermost cells of cortex showing two monosporangia and plastids in the cells respectively.

es. Monosporangia are produced by an unequal division of cortical cells or cells of



Figs. 6–9. The formation of cortex in *Compsopogonopsis fruticosa* (JAO) SETO comb. nov.: Fig. 6. An apical part of the uniseriate axis showing rhizoid-like filaments initiated from the tubular outgrowths on axial cells; Figs. 7 and 8. Well grown parts of cortical rhizoid-like filaments from axial cells; Fig. 9. Surface view of young cortical cells formed from rhizoid-like filaments.

uniseriate parts of the thallus, 15.0–22.5 μm in diameter (Figs. 3, 5). Microsporangia were not observed.

Discussion

The genus *Compsopogonopsis* was separated from the genus *Compsopogon* by the characteristic mode of formation of cortex (KRISHNAMURTHY 1962). According to CHIHARA (1976) *Compsopogonopsis japonica* differs from *C. leptoclados* in their outermost cells of cortex being larger than those of the latter. SETO (1982) reported an additional criterion for *C. japonica,* namely, the axial cell of an uniseriate part of the thallus is divided vertically to produce the

initials of cortical cells on both sides of axial cells, and each initial grows downwards forming the rhizoid-like cortical filament. On the other hand, for *C. leptoclados* the tubular outgrowths are formed from the lower part of the axial cell of an uniserite part of the thallus. The initials of cortical cells are separated from the tubular outgrowths by horizontal or oblique walls which then elongate downward as rhizoid-like cortical filaments. Thus there is a difference between *C. japonica* and *C. leptoclados* in the early development of the rhizoid-like cortical filaments. JAO (1941) mentioned that *Compsopogon fruticosus* resembles *Compsopogon leptoclados* MONTAGNE (=*Compsopogonopsis leptoclados* (MONTAGNE) KRISHNAMURTHY 1962) in height of plants and the densely branched property, but differs from the latter in having 1) greater diameter of the fully developed part of the thallus, 2) very short axial cells, and 3) all parts of the thallus being distinctly constricted here and there into segments. He did not observe the mode of the early formation of cortex for *C. fruticosus*.

In the present study, the examination of the isotype specimen of *Compsopogon fruticosus* (SC1145) shows that the initials of cortical cells are produced from the lower part of the axial cells, and cut off from the tubular outgrowths by oblique or horizontal walls in a mode similar to that observed in *Compsopogonopsis leptoclados*. The Chinese specimen examined in the present study differs from *Compsopogonopsis leptoclados* in above mentioned, three characteristics and it also differs from *C. japonica* in the mode of the early formation of cortex. Therefore, the Chinese specimen, *Compsopogon fruticosus*, should be transferred from the genus *Compsopogon* to the genus *Compsopogonopsis* as follows:

Compsopogonopsis fruticosa (JAO) SETO comb. nov. Basionym: *Compsopogon fruticosus* JAO 1941, p. 248, Tab. II, figs. 10–14.

Acknowledgements

The author wishes to express his sincere thanks to Professor C.C. JAO of Institute of Hydrobiology, Academia Sinica Wuhan, China for providing valuable specimen. He also wishes to express his appreciation to Professor I. UMEZAKI of Kyoto University for his constant guidance and a critical reading of the manuscript and to Dr. S. KUMANO of Kobe University for his useful suggestions and kind assistance in this study.

References

CHIHARA, M. 1976. *Compsopogonopsis japonica*, a new species of freshwater red alga. J. Jap. Bot. **51**: 289–294.

JAO, C.C. 1941. Studies on the freshwater algae of China. VIII. A preliminary account of the Chinese freshwater Rhodophyceae. Sinensia **12**: 245–285.

KRISHNAMURTHY, V. 1962. The morphology and taxonomy of the genus *Compsopogon Montagne*. J. Linn. Soc. (Bot.) **58**: 207–222, pl. 1–4.

SETO, R. 1982. Notes on the family *Compsopogonaceae* (Rhodophyta, Bangiales) in Okinawa Prefecture, Japan. Jap. J. Phycol. **30**: 57–62. (In Japanese)

瀬戸良三：中国産淡水紅藻類 *Compsopogonopsis fruticosa* (JAO SETO) comb. nov. について

中国科学院武漢水生生物研究所の饒欽止(C. C. JAO)教授から提供された *Compsopogon fruticosus* JAO の isotype を観察した結果，本種の皮層形成の様式は，オオイシソウ属と基本的に異るオオイシソウモドキ属の様式であることが判明した。また，後に皮層に成る若い藻体の主軸細胞に生ずる仮根状糸の始原細胞の発生は，*Compsopogonopsis japonica* と異り，*C. leptoclados* によく似ている。後者に比べて，本藻は，1) 藻体主枝の幅が広く，2) 中軸細胞の各々が短く，3) 藻体の各節部がよくくびれている，これらの3つの特徴から，*C. leptoclados* と区別される。新しい組合せとして，本藻を *Compsopogonopsis fruticosa* (JAO) SETO comb. nov. として報告する。

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Jap. J. Phycol. (Sôrui) 35: 268-276, December 10, 1987

Fine structure and taxonomy of the small and tiny *Stephanodiscus* (Bacillariophyceae) species in Japan 5. *S. delicatus* GENKEL and the characters useful in identifying five small species[1)]

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KOBAYASI, H. and KOBAYASHI, H. 1987. Fine structure and taxonomy of the small and tiny *Stephanodiscus* (Bacillariophyceae) species in Japan. 5. *Stephanodiscus delicatus* GENKEL and the characters useful in identifying five small species. Jap. J. Phycol. **35**: 268-276.

Five small *Stephanodiscus* taxa, *S. invisitatus* HOHN & HELL., *S. costatilimbus* H. KOB., *S. hantzschii* GRUN. f. *tenuis* (HUST.) HÅK. & STOERM., *S. delicatus* GENK., *S. minutullus* (KÜTZ.) CL. & MÖLL. (incl. *S. parvus* STOERM. & HÅK.) have hitherto been found in Japan not only by light microscopy but also by scanning and transmission electron microscopy. Among these species, four species were reported in this series of papers. Presently, the fifth one, *S. delicatus* is examined in detail by using transmission electron microscope (TEM) and scanning electron microscope (SEM).

S. delicatus is characterized by the fascicles composed of two to three densely arranged rows of areolae, insertion of short fascicles not reaching the centre between every two to five longer fascicles, and the variable shape of the external opening of the labiate process.

The characters useful in identifying the above five small species are listed. These include the shape of the mantle costa, the shape and position of the external opening of the labiate process and the number of the struts of the central and marginal strutted processes. These characters are quite constant within each species.

Key Index Words: *Centric diatom*; *fine structure*; *plankton*; Stephanodiscus delicatus.

As emphasized by HÅKANSSON et al. (1986), the identification of the small and tiny *Stephanodiscus* species whose valves are less than 15 μm in diameter has been especially difficult by the lack of taxonomic precision and confusion concerning the nomenclature of some small but widely distributed and ecologically important species.

However, the types or authentic slides and materials of some species which were very often incorrectly identified and which caused confusion in the literature, have been examined precisely one after another (ROUND 1981; HÅKANSSON & STOERMER 1984 a, b; STOERMER & HÅKANSSON 1984). Consequently, the five Japanese small species which had hitherto been found by the authors and their co-workers have been clarified and the four of them including one new species, *S. costatilimbus* H. KOB., were reported (KOBAYASI & INOUE 1985, KOBAYASI et al. 1985 a, b. KOBAYASI & KOBAYASHI 1986).

In the present paper, the fifth one, *S. delicatus* GENKEL, is examined in detail by SEM and TEM and the characteristics useful in identifying the five small *Stephanodiscus* species are discussed.

1) This work was partly supported by a grant from the Nissan Science Foundation.

Materials and Methods

Materials used here were collected from the following three localities. (1) Plankton from a small fresh water lake, Waku-ike (pH 8.6, wt. 19.9°C), Nagano Prefecture, on Sept. 21, 1972, sample number K–2118. (2) Plankton from lagoon Hachiro-gata (pH 7.5, wt. 12.8°C, salinity 17.2‰), Akita Prefecture, on Oct. 4, 1985. N–1005. (3) Plankton from the estuary of the Naka River (pH 7.0, wt. 14°C, salinity 18‰) at the Siodome Bridge, Tokyo, on Nov. 9, 1984, N–935. In addition to the above materials, the following samples were used for the observations and the occurrence check. (4) Bottom mud from Inogashira Pond (pH 9.5, wt. 26°C, salinity 0‰, conductivity 146 $\mu S \cdot cm^{-1}$), Tokyo, on Sept. 13, 1983, K–1737. (5) Bottom mud from a small lake, Hime-numa (pH 7.7, wt. 15°C, salinity 0‰) in Rishiri Island, northern Hokkaido, on Aug. 25, 1984, K–1950. (6) Bottom mud from brackish lake Oo-numa (pH 8.5, wt. 17°C, salinity 9‰), northern Hokkaido, on Aug. 25, 1984, K–1954. (7) Epiphytic in brackish river, Hinuma-gawa (pH 9.6, wt. 20°C, salinity 3‰, conductivity 4800 $\mu S \cdot cm^{-1}$) Ibaragi Prefecture, Central Japan, on Apr. 17, 1985, K–2612.

Methods of cleaning, washing, preparing samples for light and electron microscopy are previously reported (KOBAYASI et al. 1985b).

Results

Under light microscope (LM), specimens are circular with strongly elevated or depressed central region. In our material, valve diameters are in a range of 6 to 14 μm. The number of striae is 14–18 in 10 μm measured along the valve margin. These values coincide well with that of the original description, though the Japanese specimens are a little larger than those from Rybinski Reservoirs, USSR (GENKEL, 1985). The striation in a fascicle is so delicate that the punctae forming striae are unresolvable both in central and marginal regions. A single central strutted process, slightly excentric, can occasionally be distinguished (Figs 2–4, arrowed) and the central elevation or depression is so strong in most valves in our specimens that the central structure usually is out of focus when the marginal striae are in focus (Figs 1, 3, 4).

In contrast to the invisible marginal spines, the marginal strutted processes are visible as a dot occurring on every 3rd to 6th interfascicles in almost all valves observed.

In SEM observations, those characteristics observed by LM are well comfirmed and these are in agreement with the SEM photographs presented by GENKEL (1985) except the degree of central undulation. Frustules and the diagramatic representation of the features are shown in Figs 5–10. The central elevation and depression of our specimens are more conspicuous in exterior views than that shown by GENKEL (1985). However, the same specimens with small and less prominent central elevation or depression as shown in GENKEL's paper (1985, Figs 2, 3) are also observed in our materials.

The interfascicles are generally elevated in the external view. The elevation is less conspicuous in the heavily silicified valves as shown in Figs 9, 10. These two photographs are hypo- and epi-valves of the same frustule taken from different angles. In the weakly silicified valve with central depression, the elevation of the interfascicles is more prominent than those of the heavily silicified valve. In the latter, the exterior surface is almost smooth and the smaller exterior openings of the areolae are visible (Figs 10, also 18–22).

The spines are often slightly bent upward and occur on the end of every interfascicle. The fasciculate organization of the areolae on the valve mantle is lost below the spine insertion and the asteroid pore ring surrounding spines and marginal strutted processes is seen in general (Figs 7–8, 14, 17–

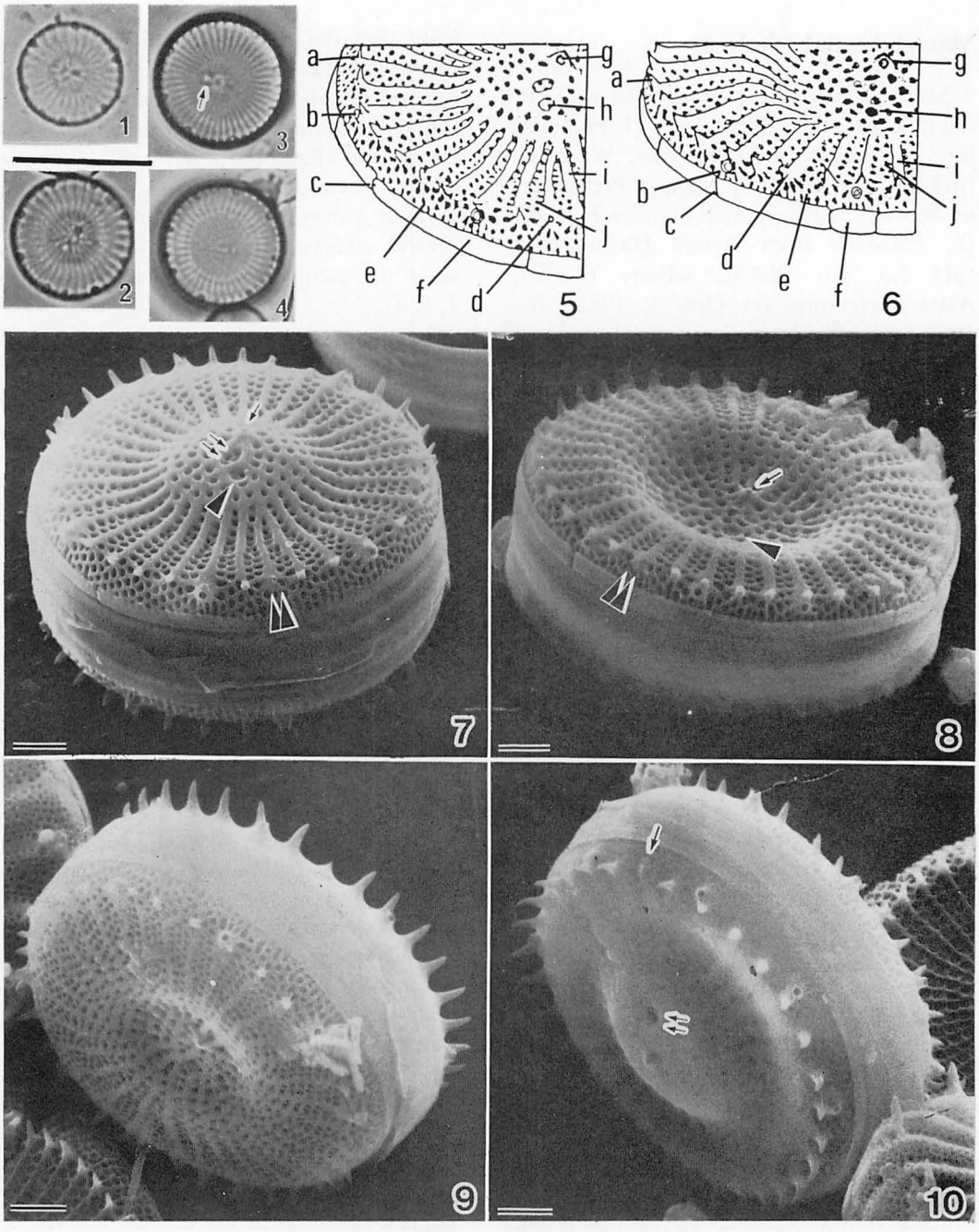

Plate 1. *Stephanodiscus delicatus* GENK. (Waku-ike). Figs 1–4. Whole valves showing the central strutted process (arrow) and marginal strutted processes. LM×2000 (bar=10 μm). Figs 5, 6. Diagrammatic representation of the valves with central elevation and depression, a. marginal spine, b. marginal strutted process, c. vertical slit-like marking of the flange, d. external opening of the labiate process, e. areolar rows on the valve mantle, f. flange, g. central strutted process, h. impression of the central strutted process of the sibling valve, i. interfascicle, j. fascicle. Figs 7, 8. Exterior valves with central elevation and depression showing the central strutted process (arrow), pattern centre (double arrow), impression of the central strutted process of the sibling valve (arrow head) and exterior opening of the marginal labiate process (double arrow head) SEM×7500 (bar=1 μm). Figs 9, 10. Epitheca with a central depression and hypotheca with a central elevation of the same frustule showing exterior opening of the labiate process (arrow) and impression of the central strutted process of the sibling valve (double arrow) SEM×8000 (bar=1 μm).

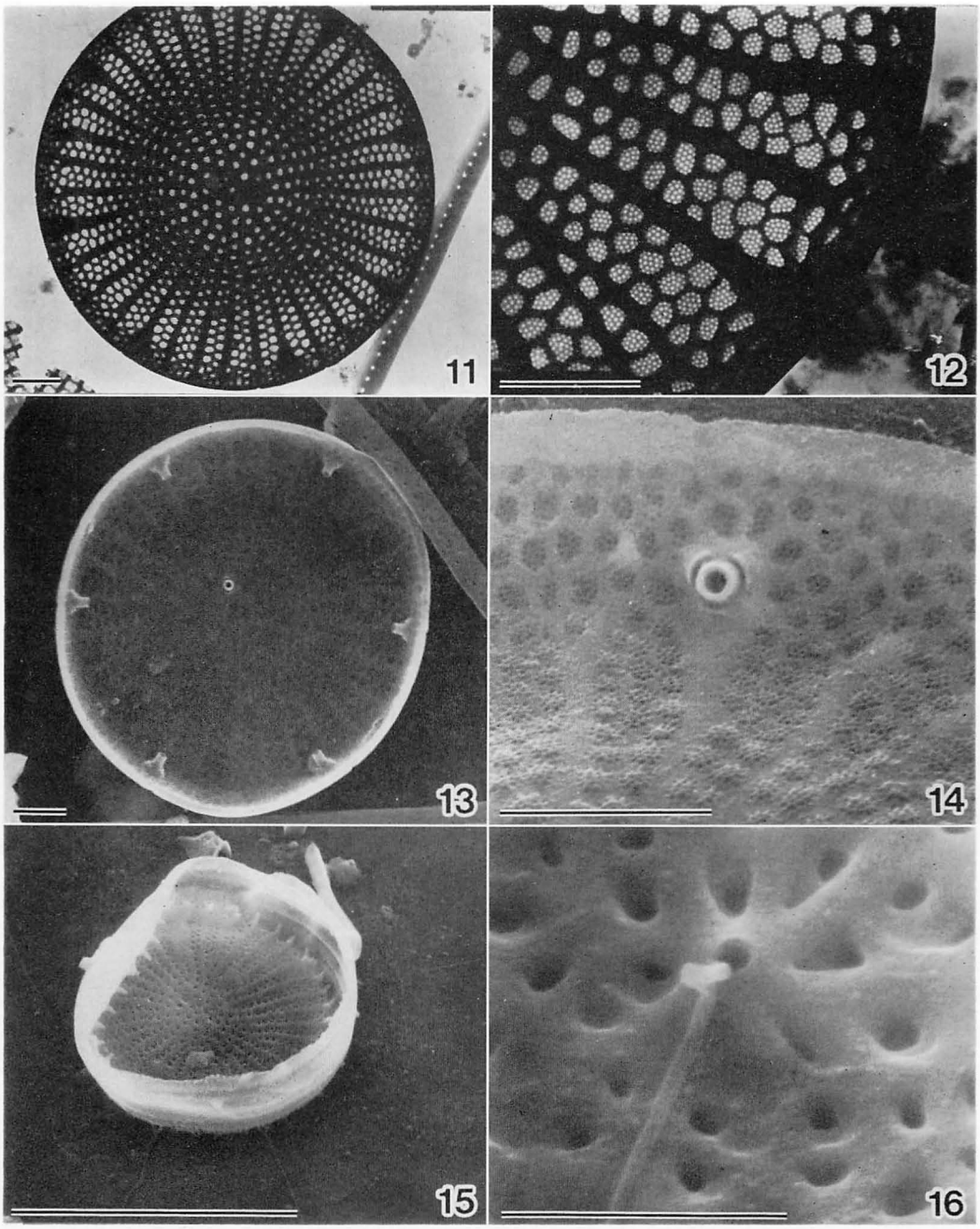

Plate 2. *Stephanodiscus delicatus* GENK. (Figs 11–14. Waku-ike, Figs 15, 16. Hachiro-gata) Fig. 11. Valve view. TEM×7000 (bar=1 μm). Fig. 12. Enlargement of the valve margin showing the densely arranged pores and pore occlusions with regularly scattered perforations. TEM×20000 (bar=0.1 μm). Fig. 13. Interior view of whole valve showing the central strutted process with two arc type buttresses and a labium placed parallel to the radial axis of the valve. Fig. 14. Enlargement of the interior valve margin showing the marginal strutted process with unequal arc type buttresses. SEM×30000 (bar=0.1 μm). Fig. 15. Whole uncleaned frustule showing chitan threads extruding from marginal strutted processes. SEM×4000 (bar=10 μm). Fig. 16. Chitan thread extruding from the central strutted process. SEM×40000 (bar=0.1 μm).

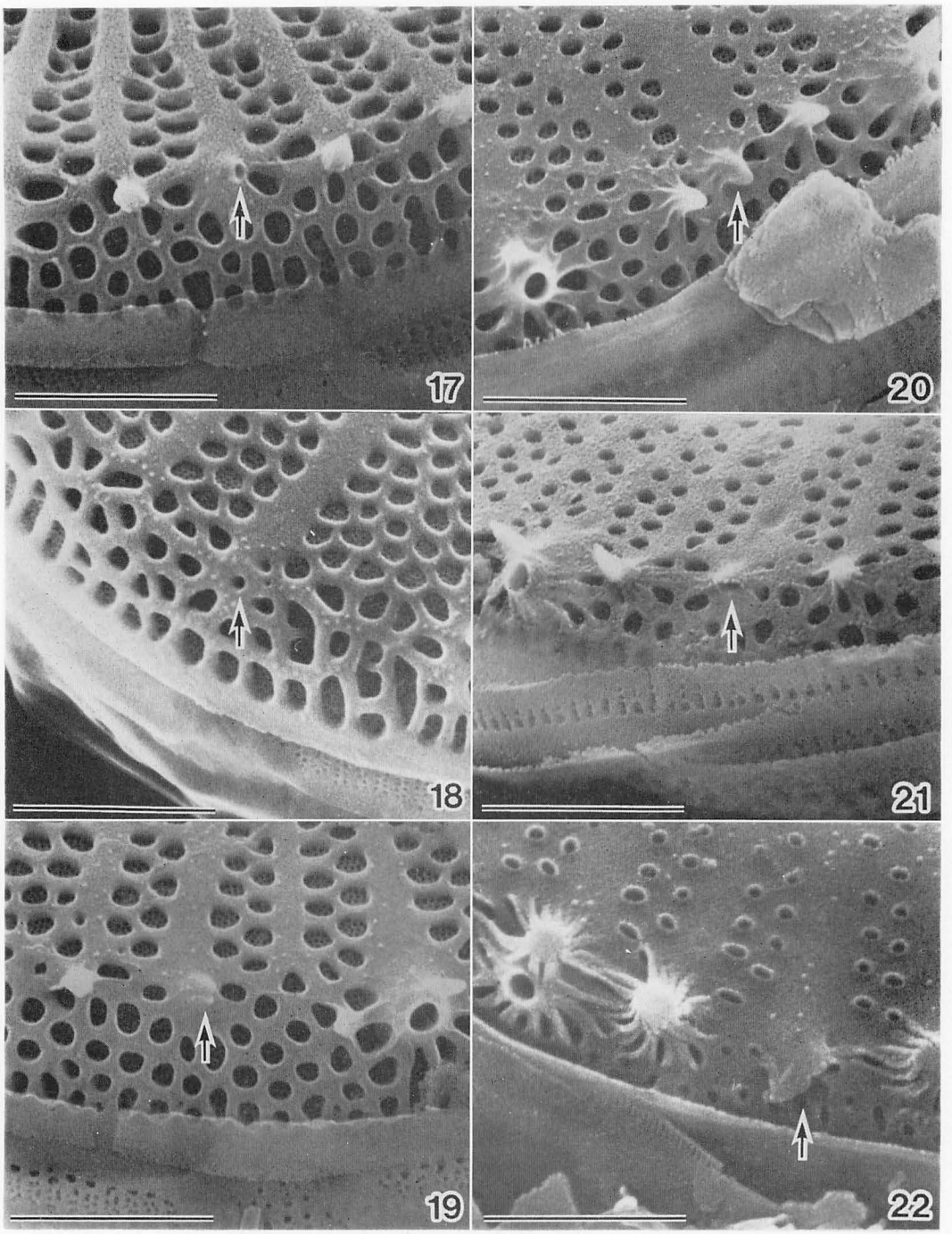

Plate 3. *Stephanodiscus delicatus* GENK. (Waku-ike). Figs 17–22. Exterior openings of the marginal labiate processes varying in shape. Fig. 17. Somewhat raised tubular opening. Fig. 18. Small round opening. Figs 19, 20, 22. Occluded spine-like opening. Fig. 21. Spine-like projection with underside opening. SEM×30000 (bar=0.1 μm).

22) as seen in *Stephanodiscus minutullus* (KOBAYASI et al. 1985b, Figs 5, 6).

In the interior views (Figs 13, 14), areolae on the valve face have domed cribra but those of the valve mantle have flat cribra like a windowpane. In the exterior views, the central strutted process is apparent as a slightly raised opening (Figs 7, 8, arrow). The impression of the central strutted process of the sibling valve occurs opposite the opening of the central strutted process as a prominent depression (Fig. 7, arrow head). Both central strutted process and central impression are more prominent on the heavily silicified valves (Fig. 10 double arrow). The areolae forming fascicles are arranged densely in the marginal zone of the valve, the number being about 50 in 10 μm at the margin. This arrangement is clearly seen in TEM photographs (Figs 11, 12).

The central strutted process has two struts interiorly (ROUND 1981) (Fig. 13) and the marginal one has three struts, two of which are more developed than the one facing the valve face (Fig. 14). The chitan threads (MCLACHAN et al. 1965) extruding from the central and marginal strutted process can be noticed on the uncleaned frustules (Figs 15, 16).

A single labiate process occurs at the junction of the valve face/mantle and at almost the same level as the spine insertion (Figs 17–22, arrowed). However, some are slightly higher (Figs 17, 19, 20) and some are slightly lower than the spine level (Figs 18, 22). The outer shape of the labiate process is variable, being a somewhat raised tube (Fig. 17), or a sunken hole smaller than the exterior opening of the areolae (Fig. 18), like a spine with an underside opening (Fig. 21) and fully occluded (Figs 19, 20, 22). Though the occluded external labiate process has rarely been pointed out by HÅKANSSON et al. (1986), this is also quite new to us. The labium is parallel to the radial axis (Fig. 13) and occurs on the end of a interfascicle on the side nearly opposite the central strutted process (Figs 8, 10, 13).

Discussion

Comparative studies of the five small *Stephanodiscus* species in Japan using SEM and TEM show both similarities and differences in specific characters between the taxa, even though their gross appearances under the light microscope are similar to each other.

Those characters which are useful in identifying the taxa are listed in Table I. All taxa listed are small and with their valve diameter in a range of 5–16 μm.

S. invisitatus HOHN & HELL. (KOBAYASI & INOUE 1985) and *S. costatilimbus* H. KOB. (KOBAYASI & KOBAYASHI 1986) are quite similar in both LM and SEM views but can be clearly distinguished only by the shape of costae on the valve mantle and the position of the exterior opening of the marginal labiate process. The former has costae branched in V-shape or fork-shape and the latter has linear ones as an elongation of the interfascicles. There are many features that can be detected by LM when once they have been recognized by SEM (REICHARDT 1986). However, clear distinction between *S. invisitatus* and *S. costatilimbus* with LM is very difficult except the very rare case presented in our previous paper (KOBAYASI & KOBAYASHI 1986, Figs 1, 2).

The interfascicles often elongate to the strutted processes on the mantle as seen in many *Stephanodiscus* species such as *S. alpinus* HUST (HÅKANSSON and STOERMER 1984 b), *S. aegypticus* EHR. (HÅKANSSON and LOCKER 1981), *S. niagarae* EHR. (ROUND 1981, 1982b, THERIOT and STOERMER 1981). It is very rare that the interfascicle elongation reaches to the valve edge beyond the marginal strutted process, as seen in *S. incognitus* KUZMIN et GENKEL (GENKEL and KUZUMIN 1978). This is an important generic and specific character of the genus *Cyclostephanos* ROUND (1982a). The mantle costae of *S. invisitatus* and *S. costatilimbus* are slightly elevated interiorly but not so visual-

Table I Characteristics of five *Stephanodiscus* species

Characters / Species	Valve diam. (μm)	Central elevation or depression	Fascicles		Elevation of Interfascicles (IF)		Strutted processes		Valve mantle		Labiate process	
			Number in 10 μm at margin	Marginal pore rows	Exterior	Interior	Central	Marginal	Depth (Pore number between spines and valve edge)	Costae	Number & placement of labium to radial axis	Shape and place of external opening
S. invisitatus HOHN & HELL.	5–14	without	14–20	2	with	without to with (thin valves)	one with two arc	on every 4–7th IF with 2 arc	3–4	V or fork	parallel	slightly raised small round pore, on a branch of V or fork marginal costa, lower than marginal strutted process level
S. costatilimbus H. KOB	7–11	without	14	2–3	with	with	one with two arc	on every 3–8th IF with 2 arc	5–6	linear	parallel	small pore on linear marginal costa, between spine and marginal strutted process levels
S. hantzschii GRUN. f. *tenuis* (HUST.) HÅK. & STOERM.	7–16	without	8–16	2–4	without to with (thin valves)	without	without	on every 3–4th IF with 3 arc	5–7	without	crosswise or oblique	tubular, replaced with spine
S. delicatus GENKEL	6–14	with	14–18	2–3	without to with (thin valves)	without	one with two arc	on every 3–6th IF with 3 arc (incl. 1 small)	2–3	without	parallel	variable in shape, some are occluded, replaced with spine, upper than spine level
S. minutullus (KÜTZ.) CL. & MÖLL. (incl. *S. parvus* STOERM. & HÅK.)	6–10	without to with	10–13	2–3	with	without	one with two arc	on every 3–6th IF with 3 arc	2–3	without	oblique	tubular but variable in shape, replaced with spine

ly prominent, even though they reached to the valve edge, and this is a reason why we placed these two species under *Stephanodiscus*.

S. hantzschii GRUN. f. *tenuis* (HUST.) HÅK. & STOERM. (KOBAYASI et al. 1985a) has a flat valve face similar to the above two species. This species is distingished by the absence of a central strutted process and by the absence of a costal structure on the valve mantle. Valve face strutted processes are considered to be an important diagnostic structure in the genus *Stephanodiscus*. Their absence or presence was used to separate *S. parvus* and *S. hantzschii* by STOERMER and HÅKANSSON (1984) and HÅKANSSON and STOERMER (1984a).

S. delicatus GENKEL is characterized by having the central elevation or depression, the delicately areolate structure and a central strutted process of the valve. Although it resembles *S. minutullus* (KÜTZ.) CL. & MÖLL. in some features detectable with SEM, it can be distinguished with ease by its unresolvably fine punctation of the fascicles with LM. As listed in Table I, the striae number as measured along the valve margin of *S. delicatus* observed is clearly greater than that of *S. minutullus*. Each marginal strutted process is surrounded by three arc-shaped buttresses (ROUND 1981, 1982b) in both species, but the one facing the valve face is smaller than the other two in *S. delicatus*.

As clearly shown in our previous paper (KOBAYASI et al. 1985b) with Plate 3 showing a series of gradations in the degree of central valve elevation of *S. minutullus*, specimens collected from Hime-numa, a small fresh-water lake in Hokkaido, are characterized by having both flat and undulate valves. Consequently it is sometimes very difficult to make a distinction between this species and *S. hantzschii* f. *tenuis* where these species co-occurred. Careful focussing of the valve at different focus levels in the way suggested by REICHARDT (1986) may resolve this problem in finding a central strutted process changing from white to black dot under LM (KOBAYASI et al. 1985b, Figs 2, 3).

Small centric diatoms are abundant and ecologically important in many fresh-water ecosystems (HÅKANSSON et al. 1986), but the difficulty of identification of these small taxa, especially that of *Stephanodiscus* having the polymorphic nature of the valves (HÅKANSSON and STOERMER 1984a, THERIOT and STOERMER 1981, KOBAYASI and INOUE 1985, KOBAYASI et al. 1985a, 1985b), has been one of the serious problems to the workers in the field. The occurrence in Japanese waters of the five species whose identities were ascertained by SEM are shown in Table II. All species occurred both in fresh and brackish waters except *S. costatilimbus* which was quite scarce in the original material. In a brackish lagoon, Hachiro-gata, all taxa were found in a small bottle of plankton sample. Therefore the exsistence of slightly different, but

Table II Occurrence of five *Stephanodiscus* species

Localities / Species	Inogasira Pond	Hime-numa Lake	Waku Pond	Hachiro Lagoon	Oo-numa Lake	Hinuma River	Naka River
	fresh	fresh	fresh	brackish	brackish	brackish	brackish
S. invisitatus		r	r	++			r
S. costatilimbus				r r			
S. hantzschii f. *tenuis*	+		+++	r		+	+
S. delicatus		+	++	r r		+	
S. minutullus	++	+++		r	r	++	+

+++=abundant, ++=frequent, +=common, r=rare, rr=very rare.

overlapping ecological features of these taxa are significant. After correctly distinguishing each of them, further work will be necessary to define their ecological ranges.

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References

GENKEL, S.I. 1985. Species nova e genere *Stephanodiscus* EHR. (Bacillariophyta). Nov. Syst. Plant. non Vasc. **22**: 30–32. +2pls.

GENKEL, S.I. and KUZMIN, G.V. 1978. New taxa of the genus *Stephanodiscus* EHR. (Bacillariophyta). Bot. Zhr. **63**(9): 1309–1317. +4pls.

HÅKANSSON, H. and LOCKER, S. 1981. *Stephanodiscus* EHRENBERG 1846, a revision of the species described by EHRENBERG. Nova Hedwigia **35**: 117–150.

HÅKANSSON, H. and STOERMER, E.F. 1984a. Observations on the type material of *Stephanodiscus hantzschii* GRUNOW in CLEVE & GRUNOW. Nova Hedwigia **39**: 477–495.

HÅKANSSON, H. and STOERMER, E.F. 1984b. An investigation of the morphology of *Stephanodiscus alpinus* HUST. Bacillaria **7**: 159–172.

HÅKANSSON, H., THERIOT, E.C. and STOERMER, E.F. 1986. Morphology and taxonomy of *Stephanodiscus vestibulis* sp. nov. (Bacillariophyta) Nord. J. Bot. -Sect. Phycol. **6**: 501–505.

KOBAYASI, H. and INOUE, H. 1985. Fine structure and taxonomy of the small and tiny *Stephanodiscus* (Bacillariophyceae) species in Japan. 1. *Stephanodiscus invisitatus* HOHN & HELL. (in Japanese) Jap. J. Phycol. **33**: 149–154.

KOBAYASI, H., INOUE, H. and KOBAYASHI, H. 1985a. Fine structure and taxonomy of the small and tiny *Stephanodiscus* (Bacillariophyceae) species in Japan. 2. *Stephanodiscus hantzschii* GRUN. form. *tenuis* (HUST.) HÅK. & STOERM. (in Japanese) Jap. J. Phycol. **33**: 233–238.

KOBAYASI, H., KOBAYASHI, H. and IDEI, M. 1985b. Fine structure and taxonomy of the small and tiny *Stephanodiscus* (Bacillariophyceae) species in Japan. 3. *Stephanodiscus minutullus* (KÜTZ.) ROUND and *S. parvus* STOERM. & HÅK. Jap. J. Phycol. **33**: 293–300.

KOBAYASI, H. and KOBAYASHI, H. 1986. Fine structure and taxonomy of the small and tiny *Stephanodiscus* (Bacillariophyceae) species in Japan. 4. *Stephanodiscus costatilimbus* sp. nov. Jap. J. Phycol. **34**: 8–12.

MCLACHLAN, J., MCINNES, A.G. and FALK, M. 1965. Studies on the chitan (chitin: poly-N-acetylglucosamine) fibers of the diatom *Thalassiosira fluviatilis* HUSTEDT. 1. Production and isolation of chitan fibers. Can. J. Bot. **43**: 707–713.

REICHARDT, E. 1986. Ultrastructural elements of some forms of *Stephanodiscus* EHR. (Bacillariophyceae) observed in the light microscope. Nova Hedwigia **42**: 283–294.

ROUND, F.E. 1981. The diatom genus *Stephanodiscus*: An electron-microscopic view of the classical species. Arch. Protistenk. **124**: 455–470.

ROUND, F.E. 1982a. *Cyclostephanos*—a new genus within the Sceletonemaceae. Arch. Protistenk. **125**: 323–329.

ROUND, F.E. 1982b. Some forms of *Stephanodiscus* species. Arch. Protistenk. **125**: 357–371.

STOERMER, F.E. and HÅKANSSON, H. 1984. *Stephanodiscus parvus*: Validation of an enigmatic and widely misconstrued taxon. Nova Hedwigia **39**: 497–511.

THERIOT, E. and STOERMER, E.F. 1981. Some aspects of morphological variation in *Stephanodiscus niagarae* (Bacillariophyceae). J. Phycol. **17**: 64–72.

小林　弘*, 小林秀明：日本産小型ステファノデスクス属（ケイソウ類）の微細構造と分類　5．*Stephanodiscus delicatus* GENKEL と小型種5種類の同定に有用な形質**

本邦の淡水および汽水の湖沼や河川に出現する4種類の小型 *Stephanodiscus* 属珪藻，*S. invisitatus*, *S. hantzschii* f. *tenuis*, *S. minutullus*, *S. costatilimbus* については，すでに本誌上に報告を行った。今回は *S. delicatus* について，おもに SEM によって諸形質を明らかにした。この種類は *S. minutullus* に似ているが，構造がより微細である点を特徴としている。

なお，今までのところ上述の5種類が本邦に見られた本属のすべてであるが，これらを識別するのに役立つ形質の比較を行い，併せて，本邦での出現状態を SEM によって確認しながら調べた。(*184　小金井市貫井北町4-1-1　東京学芸大学生物学教室，**108　東京都港区三田2-17-23　慶応義塾女子高等学校)

Jap. J. Phycol. (Sôrui) **35**: 277–278, December 10, 1987

Hirotoshi YAMAMOTO and Jun SASAKI: On the pseudocystocarp of *Gracilaria verrucosa* (HUDS.) PAPENF. (Gracilariaceae)

Key Index Words: Gracilaria; *Pseudocystocarp.*
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On both main axis and branches of a frond, which were incubated under unialgal and isolated conditions from a tetraspore of *Gracilaria verrucosa* collected at Shinori in Hakodate, Hokkaido, cystocarp-like swellings (pseudocystocarps, see BIRD and MCLACHLAN, 1982, p. 560) appeared without the presence of spermatia. The pseudocystocarps were so abundant as to count 50 per cm along a main axis of 2 mm diam. The number was much larger than those on a frond which was cultured together with spermatangial plants (Fig. 1).

One of the tetraspore-derived fronds, cultured until approximately 3 mm long in a deep petri dish, was transferred into a flask of 100 m*l* to be incubated alone. This culture was continued under the conditions of 20–21°C, about 4000 lux of white fluorescent lamp and a photocycle of 14 (light)-10 (dark). PROVASOLI's ES medium without vitamin was applied with aeration throughout the culture.

The external appearance of the pseudocystocarps is almost the same as those developed by fertilization except their smaller size, up to 0.45 mm high, up to 0.6 mm wide. A longitudinal section shows features of a pericarp with a single ostiole at its top that are similar to a normal one. However, neither gonimoblast tissue nor carposporangia occur, so the cavity is empty except some hair-like filaments rising from the bottom cells. Although a carpogonial branch is formed, a fusion cell, which can be seen frequently in a normal cystocarp, is not found. These observations suggest that the pericarp and ostiole can be formed regardless of the existence of a gonimoblast. It is not known what kinds of factors induce the development of this abnormal cystocarp.

The possible autogamy and mixture of spermatia of the same or different species during culture were reviewed and not considered feasible because other fronds which were incubated under the same conditions failed to form such pseudocystocarps. Since the cultured fronds from other localities did not develop such abnormalities, the

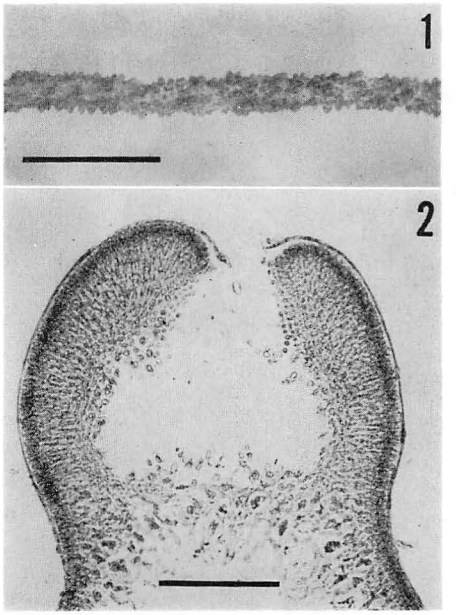

Fig. 1. Pseudocystocarps developed in main axis, showing crowded occurrence. Scale: 1 cm.

Fig. 2. Longitudinal section of pseudocystocarp, showing a normal pericarp with an ostiole. Scale: 200 μm.

fronds from Shinori had a different set of characters.

If these pseudocystocarps resulted from fertilization, their lack of a fusion cell and gonimoblast tissue is very interesting, because the formation of a fusion cell has been recognized as the first step in the developmental process of cystocarps in this family (Gracilariaceae). We have never found such a cystocarp in the field.

A similar pseudocystocarp is reported in the crossing experiment between distinct species (MCLACHLAN *et al.*, 1977; BIRD and MCLACHLAN, 1982). MCLACHLAN *et al.* describe their pseudocystocarp to be filled with small and round cells resembling cortical cells, and exceptionally with non-viable spores. They also suggest, on the basis of some supporting experiments, that they were a result of syngamy rather than merely a chemical stimulation. BIRD and MCLACHLAN, however, remark that their pseudocystocarp was empty or with abortive carposporangia.

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References

BIRD, C.J. and MCLACHLAN, J. 1982. Some underutilized taxonomic criteria in *Gracilaria* (Rhodophyta, Gigartinales). Bot. Mar. **25**: 557–562.

MCLACHLAN, J., VAN DER MEER, J.P. and BIRD, N.L. 1977. Chromosome numbers of *Gracilaria foliifera* and *Gracilaria* sp. (Rhodophyta) and attempted hybridizations. J. mar. biol. Ass. U. K. **57**: 1137–1141.

山本弘敏*，佐々木潤：オゴノリの偽嚢果について**

北海道函館市志海苔産のオゴノリの四分胞子を単離培養したところ，体全体に嚢果様の突起（偽嚢果，pseudocystocarp）が形成された。偽嚢果はかなり小さい（高さ 0.45 mm まで，巾 0.6 mm まで）が，外観上通常の嚢果と変らない。これを縦断面で見ると，果皮は頂端に一つの果孔を持ち正常な観を呈するが，融合細胞，造胞糸柔組織，果胞子嚢を欠き中空である。このような偽嚢果を誘起した要因は不明であるが，興味深い現象である。（*041-16 北海道南茅部町字臼尻 北海道大学水産学部臼尻水産実験所，**041 北海道函館市港町北海道大学水産学部水産植物学講座）

藻類 Jap. J. Phycol. (Sôrui) **35**: 279–288, December 10, 1987

付着珪藻類組成の主成分分析による解析 —— 広島県沼田川水系[1)]

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HANDA, S. and NAKANO, T. 1987. Analysis of the epilithic diatom communities by principal component analysis method (The Nuta-gawa River, Hiroshima Prefecture). Jap. J. Phycol. **35**: 279–288.

The epilithic diatom communities in the Nuta-gawa River, Hiroshima Prefecture were analyzed by the principal component analysis (PCA) method. The samples studied were divided into three groups of autumn, winter-spring and summer samples according to the second and third principal components. The summer samples were distinctly different from the other samples.

Except the summer samples, the other ones were divided into three groups of stand 1, 2 and 3 according to the third and fourth (or fifth) principal components. The inorganic water quality was similar in all stands. But, the type of the river bed was distinctly different at each stand. The epilithic diatom communities of the upper stream seem to be in the primary stage of its development because the bed of the upper stream is unstable. The characteristic species of the upper stream were *Cocconeis pediculus, C. placentula* var. *euglypta, Gomphonema minutum* and *Achnanthes lanceolata*. They seem to be pioneer species in this river.

Information on the dominant species was obtained from the data of relative frequency. On the other hand, other useful information were obtained from logarithmic data and presence/absence data. By using the presence/absence data, the uncommon species were overvalued. The results obtained from the data based on the cell number or degree of coverage were similar to those from the logarithmic data.

Key Index Words: community structure; epilithic diatom; principal component analysis; pioneer species; seasonal change.

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河川の付着珪藻類組成に関する報告は数多くなされており，本邦においても有機汚濁，濁度などの水質との関係について言及した例は多い。ところが，季節変化をはじめ，水温，日照，その他の基本的な環境因子とのかかわりあいについての考察は，充分になされていない。

本研究は，広島県沼田川水系の3地点において，年4回付着珪藻類を調査した結果をもとに，付着珪藻類組成と季節変化をはじめとした環境要因とのかかわりあいについて考察を行ったものである。解析に利用した主成分分析 (Principal Component Analysis, PCA と略称) は多変量解析の一手法で，互いに相関のある多数の変数 (複雑な多次元情報) を，互いに無相関な少数の主成分 (因子) に要約する方法で，基本となるデータの持っている複雑な情報を，より明確に解析することができる。更に，本研究では主成分分析を行う際の入力データの様式の差異による解析結果の違いについての検討も行った。

1) Contribution from the phytotaxonomical and Geobotanical Laboratory, Hiroshima University, N. Ser. No. 348.

調査地点の概要及び調査時期

調査を行った沼田川水系は，広島県中央部に位置し，三原市を経て瀬戸内海へ流入している。調査地点は沼田川水系中流域にあたり，沼田川本流 (St. 3)，支流の入野川 (St. 2)，及びさらに支流の入寺川 (St. 1)

Table 1. Inorganic water quality at the sampling stands.

	St. 1	St. 2	St. 3
Water temperature (°C)	14.7	15.1	15.0
pH	7.5 ±0.3	7.7 ±0.2	7.6 ±0.2
BOD (mg/l)	0.7 ±0.2	1.0 ±0.3	0.9 ±0.2
T-N (mg/l)	0.83 ±0.17	0.92 ±0.13	0.66 ±0.18
T-P (mg/l)	0.025±0.009	0.039±0.013	0.027±0.013
Flow (m^3/sec)	0.08 ±0.05	0.65 ±0.40	2.69 ±1.38

(Average and standard deviation of Mar. 1984–Mar. 1985)

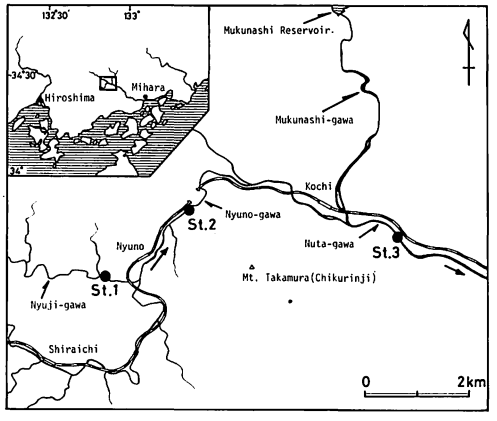


Fig. 1. Map showing the sampling stands.

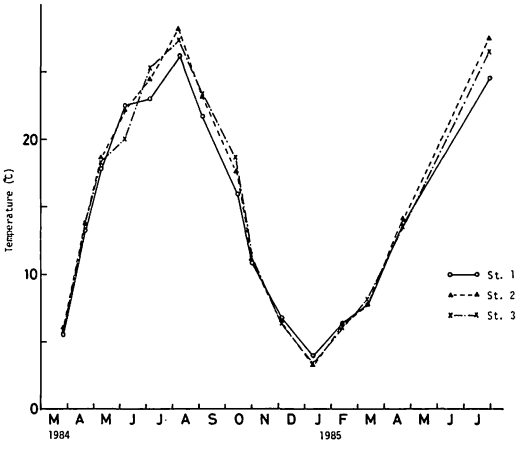


Fig. 2. Seasonal variation of water temperature.

で,いずれも谷部の農村地帯に位置する(Fig. 1)。各地点の水質環境については,測定項目に関する限り水温を除いて季節変動は認められなかった。1984年3月～1985年3月までの13回の調査結果の平均値と標準偏差を Table 1 に示す。これによると,各地点とも BOD が 1 mg/l 前後の比較的清浄な水域で,栄養塩に関しては St. 2 で他の地点よりやや高くなっているものの,pH,水温はほぼ同様な値となっている。一方,河川規模は各地点とも異なっており,その概況は以下のとおりである。

St. 1：入寺川(幹線流路延長 7.4 km, 流域面積 10.2 km^2)の下流部で,入野川への合流点手前約 1 km の地点。流れ幅 2 m 程度,流量は通常 0.1 m^3/sec 以下の小流で,河床は小型の石礫からなる。

St. 2：入野川(幹線流路延長 20.8 km, 流域面積 74.3 km^2)の下流部で,沼田川への合流点手前約 2 km の地点。流れ幅約 5 m, 流量は通常 1 m^3/sec 以下で,河床は直径 10～50 cm の石礫からなる。

St. 3：沼田川(幹線流路延長 46.9 km, 流域面積 540.0 km^2)の中流部にあたり,途中で椋梨川を合流する。流れ幅約 10 m, 流量は入野川の 3 倍以上に及び,通常 3 m^3/sec となっている。河床は直径 1 m 程度の岩塊が多く,安定している。

付着珪藻類組成の調査は,1984年10月15日(秋期),1985年1月11日(冬期),4月22日(春期),7月30日(夏期)に行った。Fig. 2 の水温変化図に示したように,秋期調査では17℃,冬期調査では最低水温期にあたる4℃,春期調査では14℃,夏期調査では最高水温期にあたる26℃前後であり,調査地点間の差は特に認められない。

調 査 方 法

各地点において,流速 0.5～0.7 m/sec, 水深 10～30 cm の所にある石礫3個を採取し,それぞれ上面に 5 cm×5 cm の方形枠を設定し,方形枠内の付着物をこすり落とし混合したものを試料とした。試料の一定量を酸処理し,プレウラックスに封入した後光学顕微鏡によって観察し,種の同定と計数を行った。

調査結果の解析に用いた主成分分析のプログラムは守谷,井口(1972)に準じ,相関係数行列に基づいて

行った。入力データの型式として用いたのは次の7 Case で，各 Case とも試料を変量とし，種を標本として解析を行った。

Case-0：相対頻度（%）。実際は 1 mm² あたりの細胞数をそのまま入力したが，主成分分析の数値処理の段階で規準化が行われるため，相対頻度を入力したものと同じ結果を得ることができる。

Case-1：対数（log）処理。対数処理を行った値として負の値が出現しないよう，桁数を調整し最小値が1を越えるよう配慮した。

Case-2：1・0変換。出現した種はすべて“1”，出現しなかった種は“0”とした。

Case-3：細胞数による6段階区分。出現しなかった種は“0”，5 cells/mm² 未満を“1”，以下10倍ごとに“2～4”を与え，5,000 cell/mm² 以上を“5”とした。

Case-4：細胞数による4段階区分。出現しなかった種は“0”，100 cells/mm² 未満を“1”，100～1,000 cells/mm² 未満を“2”，1,000 cells/mm² 以上を“3”とした。

Case-5：被度（6段階区分）。細胞の大きさを考慮して，プレパラート中での被度により，6段階に区分した。

Case-6：被度（4段階区分）。Case-5と同様に4段階に区分した。ただし，1細胞しか確認されなかった種は“0”とした。

結果および考察

1. 主成分分析による解析結果

(1) 全試料による主成分分析

3地点での4回の調査をあわせて25属88種類の珪藻類が観察され，それぞれの種の各試料における相対頻度を Table 2 に示す。全試料による主成分分析は，この相対頻度を用いた Case-0 のほか，対数処理（Case-1），1・0変換（Case-2）について行い，その結果として各 Case ごとの第1主成分～第3主成分の寄与率，因子負荷量を Table 3 に示す。

a. 第1主成分についての解析

各 Case とも第1主成分の因子負荷量には，試料間で顕著な差は認められなかった。この第1主成分について，各 Case ごとの寄与率及び主要種の因子得点を Table 4 に示す。

Case-0 では，全試料で観察され相対頻度も高い *Achnanthes convergens*, *Cymbella silesiaca* の因子得点が高いほか，特定の試料で卓越して相対頻度が高かった *Cocconeis pediculus*, *Gomphonema olivaceum* var. *minutissimum* の因子得点が高くなっている。このことから Case-0 では，第1主成分として優占種の因子が抽出されたと考えることができる。

Case-2 では，1・0変換を行っており，量的な要素が加わらないため，全試料に出現した種はすべて同等な高い評価がなされ，3.28の因子得点を示している。一方 *Cocconeis pediculus*, *Gomphonema olivaceum* var. *minutissimum* は，優占種であるにもかかわらず，出現しなかった試料があるため，低い得点となっている。つまり，Case-2 の場合，第1主成分は常在種の因子と考えることができる。

Case-1 では，Case-0 と Case-2 の中間的な評価がなされており，第1主成分の因子得点の高い種は，調査地域全域で年間を通じて出現し，相対頻度も比較的高く，本調査地域全体を代表する種と考えることができる。これによると，沼田川水系中流域を代表する種は，*Achnanthes convergens*, *Cymbella silesiaca*, *Navicula gregaria*, *N. cryptotenella*, *Fragilaria capucina* var. *vaucheriae* などである。

b. 第2，第3主成分についての解析

Case-0，1，2の第2，第3主成分の因子負荷量を Fig. 3 に，因子得点を Fig. 4 に示した。

Case-0 の第2主成分は，寄与率17.7%で，因子負荷量（Fig. 3-a）は，St. 1 の秋期，春期などが負で特に高い値を示していた。そこで第2主成分の因子得点（Fig. 4-a）をみると，*Cocconeis pediculus* が他の種より卓越して負で高い値を示しており，この第2主成分は *C. pediculus* の因子を抽出したにすぎない。同様に，寄与率13.5%の第3主成分も，*Gomphonema olivaceum* var. *minutissimum* の因子を抽出しているだけであった。

Case-2 では，寄与率11.7%の第2主成分と，寄与率9.8%の第3主成分により，試料は，秋期，冬期—春期，夏期の3つの集団に類別された（Fig. 3-c）。これら両主成分をあわせたものは季節変化の因子であり，水温，日照などのさまざまな環境要因が複合的に影響した結果として現われたものである。この因子に大きく関与している種を因子得点（Fig. 4-c）からみると，秋期を特徴づける種として *Navicula bacillum*, *Fragilaria pinnata*, *Bacillaria paxillifer*, 冬期—春期を特徴づける種として *Fragilaria capucina*, *Surirella ovata* var. *pinnata* などが抽出された。また，夏期は *Gomphonema gracile* によって特徴づけられるとともに，*Cocconeis placentula* var. *euglypta*, *Nitzschia linearis* な

Table 2. Epilithic diatoms found in this study and their relative frequency.

Species	Stands / Seasons*	Relative frequency (%) St. 1 A	St. 1 W	St. 1 Sp	St. 1 Sm	St. 2 A	St. 2 W	St. 2 Sp	St. 2 Sm	St. 3 A	St. 3 W	St. 3 Sp	St. 3 Sm
Achnanthes convergens		18.8	13.8	7.3	16.8	26.5	12.4	14.7	4.9	49.5	26.8	7.9	6.7
A. delicatula		-	-	-	-	1.2	1.9	+	-	-	-	-	-
A. lanceolata		1.1	10.8	12.2	0.6	1.3	0.6	0.9	0.4	0.1	+	0.3	0.1
A. laterostrata		0.1	-	-	-	-	-	-	-	-	-	-	-
A. minutissima		-	4.9	11.4	1.6	-	0.1	1.4	1.4	-	0.1	0.1	1.4
A. subhudsonis		0.8	2.8	0.2	0.8	0.3	2.2	2.3	3.7	-	0.1	0.2	0.5
Amphora pediculus		-	-	-	-	-	+	-	-	-	+	-	-
Bacillaria paxillifer		0.3	0.6	+	-	0.8	+	-	-	+	+	-	-
Caloneis bacillum		-	-	+	+	-	-	-	-	-	-	-	-
Ceratoneis arcus var. hattoriana		-	0.9	0.1	-	-	-	+	-	-	-	+	-
Cocconeis pediculus		41.1	11.9	44.0	+	12.0	0.4	+	-	0.2	+	0.2	-
C. placentula var. placentula		0.7	1.7	0.1	0.2	0.4	0.1	0.4	+	3.2	0.2	0.2	+
C. placentula var. euglypta		6.6	3.5	0.3	-	12.8	0.8	0.1	-	2.3	0.4	0.1	-
Cyclotella comta		-	-	-	-	-	-	+	-	-	-	-	-
C. meneghiniana		-	-	-	+	0.9	+	-	-	0.2	-	-	-
Cymbella aspera		0.1	0.1	-	-	0.1	-	-	-	+	-	+	-
C. japonica		-	-	-	-	-	-	-	-	-	-	0.1	-
C. naviculiformis		-	-	-	-	-	-	-	+	-	-	-	-
C. silesiaca		2.8	6.9	11.4	21.6	3.4	8.1	15.8	7.3	3.6	5.0	47.1	11.7
C. sinuata		-	0.2	+	0.2	-	0.2	1.3	+	-	-	0.1	+
C. tumida		-	0.1	+	0.9	0.1	0.3	0.6	0.9	0.2	2.5	5.8	2.2
C. turgidula		0.5	0.1	-	2.2	8.8	0.3	-	4.3	7.3	0.9	0.1	4.2
Fragilaria capucina var. capucina		-	0.1	1.4	-	-	0.6	0.1	-	-	0.8	0.5	0.3
F. capucina var. vaucheriae		0.4	0.9	0.9	0.6	0.4	1.6	2.6	1.2	1.9	1.6	5.2	13.4
F. construens var. construens		-	-	-	-	-	0.1	-	-	-	0.1	0.1	-
F. construens var. binodis		-	-	-	-	0.9	+	-	-	-	-	-	-
F. intermedia		-	2.1	0.1	0.1	-	-	0.1	-	-	-	0.1	0.1
F. pinnata		0.1	0.1	-	-	0.2	-	-	0.1	+	-	-	+
Frustulia rhombiodes		-	0.1	-	-	-	-	-	-	-	-	-	-
F. vulgaris		0.3	0.9	+	-	0.1	-	-	-	-	-	-	-
Gomphonema angustatum		-	0.4	-	-	-	+	-	-	-	+	+	-
G. augur var. sphaerophorum		-	-	-	-	0.2	-	-	-	-	-	-	-
G. clevei		0.1	-	+	-	0.3	0.1	0.2	-	0.2	+	0.1	-
G. gracile		-	-	-	0.3	-	-	-	0.1	0.1	-	-	0.1
G. helveticum		-	-	-	-	+	-	-	-	2.4	10.0	-	8.4
G. minutum		4.7	2.5	0.6	-	-	-	-	-	-	-	-	-
G. olivaceum var. minutissimum		-	0.9	1.6	-	-	41.5	9.6	+	-	41.9	7.9	+
G. parvulum		0.1	0.9	0.6	3.6	0.3	1.1	1.5	7.3	-	-	0.9	16.4
G. pseudotenellum		3.3	2.8	3.1	3.0	0.2	0.1	0.2	1.4	-	-	2.1	0.1
Gyrosigma spencerii		-	0.4	+	-	+	-	-	-	-	-	-	-
Hantzschia amphioxys		-	-	-	-	-	-	+	-	-	-	+	-
Hydrosera triquetra		0.1	1.0	+	-	-	-	-	-	-	+	-	-
Melosira varians		0.5	5.3	0.5	2.6	1.3	1.2	0.5	2.0	0.2	1.6	0.7	0.3
Meridion circulare var. constricta		0.1	0.2	-	-	-	-	+	-	-	-	-	-
Navicula bacillum		0.1	0.1	-	-	0.3	-	-	+	+	-	-	-
N. cinctaeformis		0.4	0.6	-	0.9	0.2	0.1	+	14.1	-	0.6	3.7	10.0
N. clementis		0.3	-	-	-	0.5	0.1	-	-	-	-	-	-
N. contenta		0.1	-	-	-	-	-	-	+	-	-	-	+
N. cryptocephala		1.1	0.2	+	1.6	0.3	0.1	+	2.0	-	0.1	0.1	0.1
N. cryptotenella		2.4	2.5	0.6	6.0	2.7	0.9	1.7	1.6	13.0	1.3	1.1	0.8
N. decusis		0.3	0.2	-	-	0.2	0.2	0.1	+	0.3	0.1	0.1	+
N. elginensis		-	0.1	-	+	-	-	+	-	-	-	-	-
N. goeppertiana		-	-	-	+	0.1	-	-	0.1	-	-	+	-
N. gregaria		4.7	2.1	0.6	8.4	9.6	7.4	23.7	2.2	3.9	3.4	5.2	0.1
N. lanceolata		0.3	-	-	2.0	0.2	-	-	0.1	0.4	0.1	0.6	-
N. minima		-	-	-	-	-	-	-	20.1	-	-	-	0.1
N. mutica var. ventricosa		-	-	-	-	-	-	-	-	-	-	-	+
N. perminuta		3.8	6.6	+	1.7	3.1	6.2	0.5	+	0.6	0.1	+	+
N. protracta		-	-	-	-	+	0.1	+	-	-	-	-	-
N. pseudolanceolata var. denselineolata		0.1	0.6	0.3	0.1	-	0.1	0.2	+	-	0.1	0.2	+
N. pupula		0.1	0.9	-	+	0.8	+	+	+	-	+	+	+
N. rhynchocephala		-	-	-	-	-	-	+	-	-	-	0.1	-
N. schroeterii		0.7	-	0.1	1.6	1.2	0.1	+	0.4	0.1	+	-	0.1
N. slesvicensis		0.1	-	+	5.2	2.7	0.1	+	4.9	4.9	+	-	5.9
N. ventralis		0.2	0.1	-	-	0.8	+	+	0.5	+	-	-	-
N. viridula var. viridula		0.1	-	-	2.6	0.5	+	-	1.0	0.9	-	0.1	0.2
N. viridula var. rostellata		0.1	0.1	0.2	3.9	0.1	+	-	+	-	-	-	-

(continue)

Nitzschia amphibia	0.3	0.2	+	0.3	1.1	2.8	2.6	0.1	-	-	0.1	0.1
N. dissipata	0.3	-	0.7	-	-	+	1.1	+	-	+	5.8	-
N. frustulum	-	-	+	-	0.2	1.9	2.8	1.0	0.1	0.1	-	0.5
N. gracilis	-	-	-	-	0.2	-	-	-	-	-	-	-
N. linearis	0.8	4.2	0.7	-	+	0.7	0.1	-	-	+	0.2	-
N. palea	0.7	0.6	0.1	6.2	2.4	0.6	1.1	7.9	3.9	0.3	0.9	1.7
N. paleacea	-	0.2	-	-	-	0.2	-	0.1	-	0.1	0.1	-
N. parvula	0.1	-	-	-	-	-	-	-	-	-	-	-
N. romana	-	1.4	0.1	1.3	0.2	3.4	11.2	0.1	0.1	0.8	0.7	0.5
Pinnularia gibba	0.1	0.1	-	-	+	-	-	-	-	-	0.1	-
Rhoicosphenia abbreviata	-	-	0.2	-	-	0.1	2.0	-	0.1	-	0.1	-
Rhopalodia gibberula	-	-	-	-	-	-	+	-	-	-	-	-
Stauroneis phoenicenteron	-	-	+	-	-	-	-	-	+	-	-	-
Surirella angusta	0.1	1.3	0.2	2.0	0.1	1.0	0.4	0.2	0.1	0.6	0.3	+
S. linearis	-	0.6	+	0.1	+	+	-	-	0.1	+	0.1	+
S. ovata var. pinnata	-	0.2	0.2	-	-	+	0.1	-	-	0.1	0.3	-
Synedra inaequalis	-	-	-	-	-	0.1	-	-	-	0.1	-	-
S. rumpens var. rumpens	-	-	0.1	0.1	-	-	0.1	0.1	+	+	0.2	2.2
S. rumpens var. meneghiniana	-	-	-	-	-	-	-	+	-	+	+	0.1
S. ulna	0.1	0.2	0.1	0.9	+	0.1	+	8.5	0.1	0.1	0.1	11.7
Tabellaria fenestrata	-	-	-	+	-	-	-	-	-	-	-	-

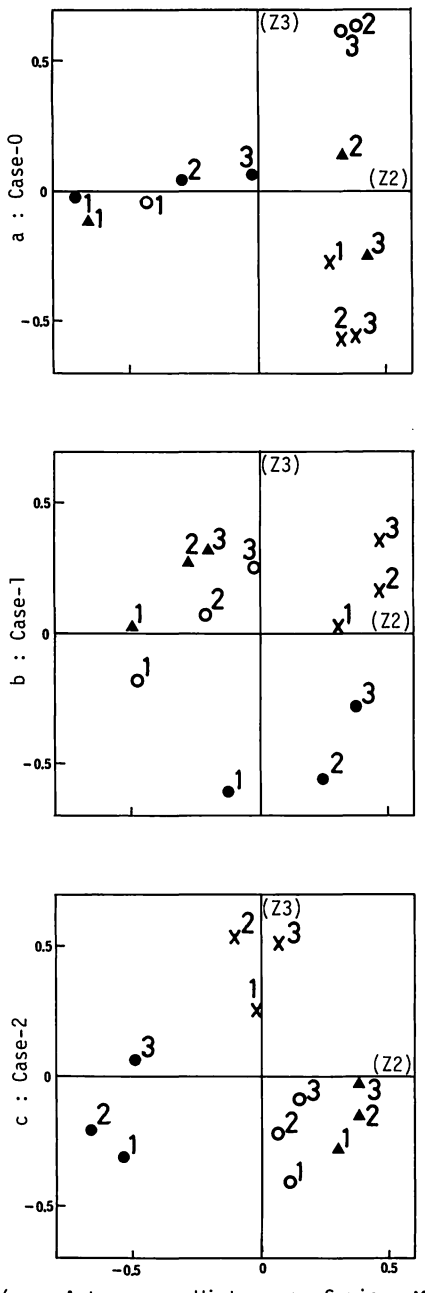
* A: Autumn, W: Winter, Sp: Spring, Sm: Summer (+ < 0.05)

Table 3. The Factor loadings by PCA.

Data processing		Case-0			Case-1			Case-2		
Factors		Z1	Z2	Z3	Z1	Z2	Z3	Z1	Z2	Z3
Proportion of eigenvalues (%)		41.6	17.7	13.5	55.5	11.6	10.2	41.4	11.7	9.8
St. 1	Autumn	0.62	-0.71	-0.02	0.68	-0.13	-0.61	0.52	-0.53	-0.30
	Winter	0.77	-0.45	-0.05	0.69	-0.48	-0.18	0.60	0.12	-0.41
	Spring	0.52	-0.68	-0.12	0.72	-0.50	0.03	0.66	0.30	-0.28
	Summer	0.82	0.29	-0.28	0.81	0.30	0.01	0.70	-0.03	0.37
St. 2	Autumn	0.81	-0.30	0.04	0.68	0.23	-0.59	0.53	-0.66	-0.20
	Winter	0.54	0.38	0.64	0.82	-0.22	0.07	0.73	0.08	-0.22
	Spring	0.74	0.34	0.14	0.81	-0.28	0.28	0.66	0.39	-0.15
	Summer	0.31	0.33	-0.58	0.72	0.47	0.17	0.66	-0.10	0.55
St. 3	Autumn	0.74	-0.02	0.06	0.71	0.38	-0.28	0.56	-0.49	0.07
	Winter	0.62	0.32	0.61	0.76	-0.00	0.25	0.68	0.15	-0.09
	Spring	0.61	0.42	-0.25	0.80	-0.20	0.32	0.66	0.39	-0.02
	Summer	0.41	0.39	-0.56	0.71	0.47	0.36	0.71	0.07	0.52

どを欠くことが特徴的であった。さらに，夏期に少ない種は概して上流地点ほど多くみられることから，第3主成分は夏期の試料を類別しているとともに，地点を類別する因子も含まれていると思われる。なお，Case-2 で特徴的な種は *Gomphonema gracile*, *Fragilaria pinnata*, *Navicula bacillum* など，出現細胞数の少ない偶在種が主体となっていた。

Case-1 では，寄与率11.6%の第2主成分と寄与率10.2%の第3主成分の因子負荷量により，試料は Case-2 とほぼ同様な類別がなされている (Fig. 3-b)。Case-1 の因子得点 (Fig. 4-b) によると，夏期一秋期を特徴づける種は *Cymbella turgidula*, *Navicula slesvicensis*, *N. viridula* など，冬期一春期を特徴づける種は *Gomphonema olivaceum* var. *minutissimum*, *Fragilaria capucina*, *Nitzschia linearis* などとなっている。また，右斜め方向の軸をみると，全体としては夏期を特徴づけ，季節ごとでは下流の地点を特徴づけている種として，*Cymbella tumida*, *Gomphonema helveticum* が抽出された。夏期に少なく，季節ごとでは上流の地点を特徴づけている種として，*Cocconies pediculus*, *C. placentula*



(● : Autumn, o : Winter, ▲ : Spring, X : Summer)

Fig. 3. Diagram of samples plotted on the second and third factors.

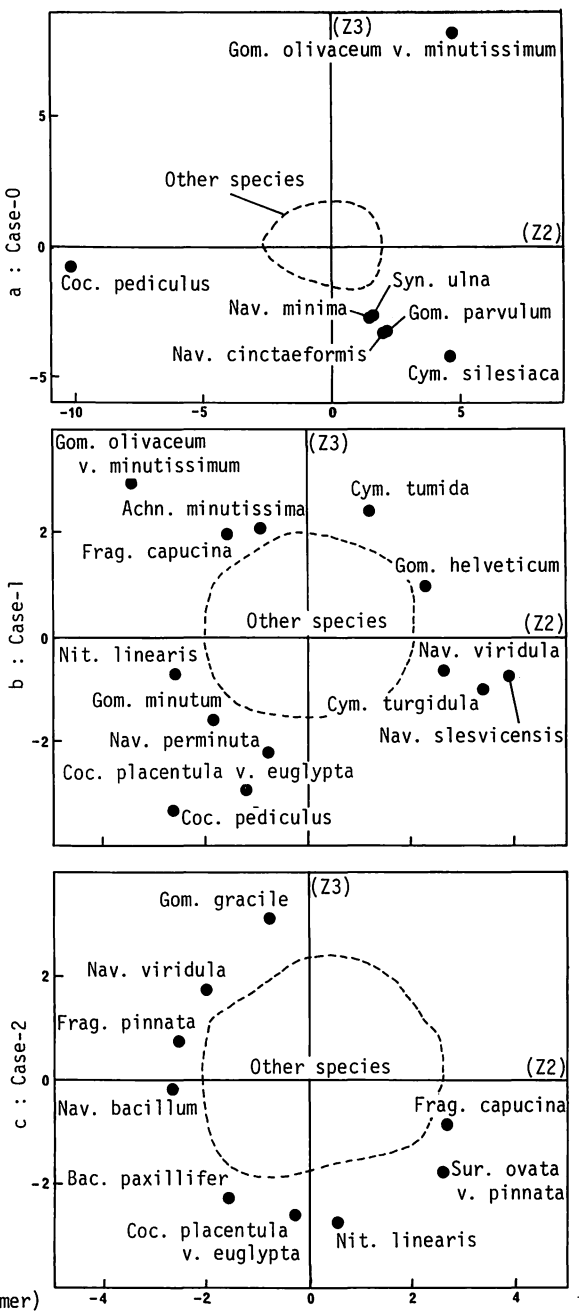


Fig. 4. Diagram of species plotted on the second and third factor scores.

var. *euglypta*, *Nitzschia linearis*, *Gomphonema minutum*, *Navicula perminuta* が抽出された。また，Case-2 に比較して Case-1 では，特徴的な種はいずれも出現率の高いもので，優占種も含まれていた。

(2) 夏期の試料を除いた主成分分析

全試料による主成分分析では，季節の因子が抽出されたものの，夏期を類別する因子と地点を類別する因子が複合的に現われているため，充分な解析が行えなかった。そこで，夏期の試料を除いた 9 つの試料につ

Table 4. Factor scores of the first principal components for the main species.

Data processing	Case-0	Case-1	Case-2
Factor	Z1	Z1	Z1
Proportion of eigenvalue (%)	41.6	55.5	41.4
Achnanthes convergens	14.24	8.40	3.28
Cymbella silesiaca	9.21	7.70	3.28
Cocconeis pediculus	6.24	2.77	2.05
Navicula gregaria	4.84	6.17	3.28
Gomphonema olivaceum var. minutissimum.	4.77	2.82	1.20
Navicula cryptotenella	1.65	6.17	3.28
Achnanthes lanceolata	1.47	3.37	3.28
Fragilaria capucina var. vaucheriae	0.92	4.95	3.28
Cocconeis placentula	-0.38	1.96	3.28
Melosira varians	0.57	4.17	3.28
Navicula peruminuta	1.05	2.81	3.28
Nitzschia palea	0.99	4.49	3.28
Surirella angusta	-0.41	2.32	3.28
Synedra ulna	0.23	1.73	3.28

いて主成分分析を行った。以下に Case-1～Case-6 の第2～第5主成分で得られた季節の因子と地点の因子について示す。

a. 季節の因子についての解析

Case-1 では，第2，第5主成分の因子負荷量により，試料は季節ごとに3つの群に類別され (Fig. 5-a)，Case-3，5，6 でも同様な類別がなされた。ところが Case-2 では冬期の試料を類別する因子が抽出されておらず，季節ごとの類別は不充分で(Fig. 5-b)，Case-4 もこれと同様な結果となっていた。

秋期と冬期一春期を類別している第2主成分について，各季節を特徴づける種を抽出するために，第2主成分の因子得点の絶対値が大きい種をまとめたものが Table 5 である。秋期を特徴づける種としては，*Cymbella turgidula*, *Navicula viridula* var. *slesvicensis*, *Cocconeis placentula* var. *euglypta* などがあげられる。ここで Case-2 では，これらの種に比較して *Fragilaria pinnata*, *Navicula bacillum* などの偶在種の評価が高くなっていた。一方，冬期一春期を特徴づける種としては，*Gomphonema olivaceum* var. *minutissimum*, *Achnanthes minutissima*, *Fragilaria capucina* などが抽出された。

b. 地点の因子についての解析

各 Case とも，第3主成分は St. 1 と St. 3 を類別しており，第4 (Case-2，4 では第5) 主成分は，St. 2 を他の地点と類別していた。類別は，対数処理を行っ

Table 5. Factor scores of the second principal components for the main species.

Data processing	Case-1	Case-2	Case-3	Case-4	Case-5	Case-6
Factor	Z2	Z2	Z2	Z2	Z2	Z2
Proportion of eigenvalue	13.3	15.0	14.2	15.3	15.6	16.9
Cymbella turgidula	3.35	-1.45	2.95	-2.98	3.96	3.23
Navicula slesvicensis	2.59	-1.19	2.84	-1.23	1.88	1.77
Cocconeis placentula var. euglypta	2.37	-0.35	1.67	-1.58	1.56	2.18
Navicula viridula	1.52	-1.91	1.82	-1.62	2.10	1.58
Cocconeis pediculus	1.16	-0.35	0.54	-1.86	2.26	3.00
Fragilaria pinnata	0.31	-2.55	1.27	-2.20	1.36	0.39
Navicula bacillum	0.27	-2.55	1.78	-2.20	1.80	1.06
Gomphonema olivaceum var. minutissimum.	-3.10	2.53	-3.29	3.83	-3.58	-3.55
Achnanthes minutissima	-2.36	2.53	-2.67	2.72	-2.42	-1.77
Fragilaria capucina	-1.75	2.53	-2.02	2.32	-2.45	-2.24
Surirella angusta	-1.56	-0.35	-0.75	-0.51	-1.40	-2.19
Cymbella sinuata	-1.33	2.24	-2.03	1.99	-1.81	-1.35
Surirella ovata var. pinnata	-1.29	2.53	-1.86	1.75	-1.84	-1.21
Fragilaria intermedia	-1.15	2.11	-1.84	1.48	-1.56	-1.01
Ceratoneis arcus var. hattoriana	-0.76	2.11	-1.22	1.48	-1.16	-0.26

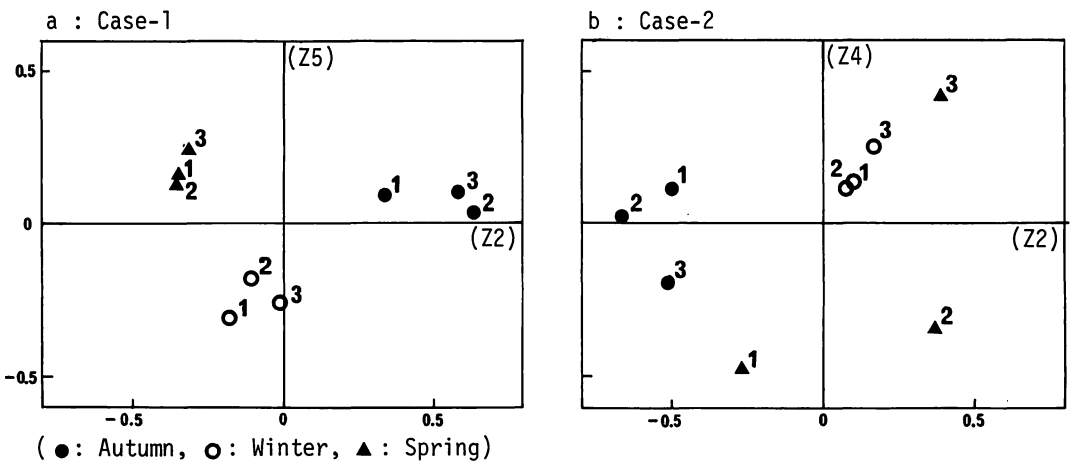


Fig. 5. Diagram of samples plotted on the second and fifth (fourth) factors.

た Case-1 で最も明瞭で (Fig. 6-a), 1・0 変換の Case-2 でやや不明瞭になっている (Fig. 6-b) ものの, Case 間に大幅な差は認められなかった。

St. 1 と St. 3 を類別している第3主成分について, 因子得点の絶対値が大きい種をまとめたものを Table 6 に示す。St. 1 を特徴づける種としては, *Cocconeis pediculus*, *Gomphonema pseudotenellum*, *Ahnanthes lanceolata* や, St. 1 でのみ観察された *Gomphonema minutum* があげられ, これらの多くは夏期には出現頻度が低かったものである。Case ごとに因子得点を比較すると, St. 1 で最も特徴的に出現した *C. pediculus* は, St. 2, 3 においても極くわずか出現しているため, 1・0変換の Case-2 ではほとんど評価されていなかった。また, 大型の *Nitzschia linearis* は, 被度により区分した Case-5, 6 で高い値を示していた。St. 3 を特徴づける種としては, *Gomphonema helveticum* のほか, St. 1 で出現数の少ない *Cymbella tumida*, *Gomphonema olivaceum* var. *minutissimum* などがあげられる。

なお, 第4 (Case-2, 4 では第5) 主成分で St. 2 を特徴づけている種は, *Achnanthes delicatula*, *Nitzschia amphibia*, *N. frustulum* などであった。

2. 付着珪藻類組成の特徴

調査結果を, 優占種に着目し相対頻度からみた場合, St. 1 で多量に出現した *Cocconeis pediculus*, St. 2, 3 で冬期に大増殖していた *Gomphonema olivaceum* var. *minutissimum* が特に目立っていた。次に, データに対数処理, 細胞数及び被度による段階区分をほどこして

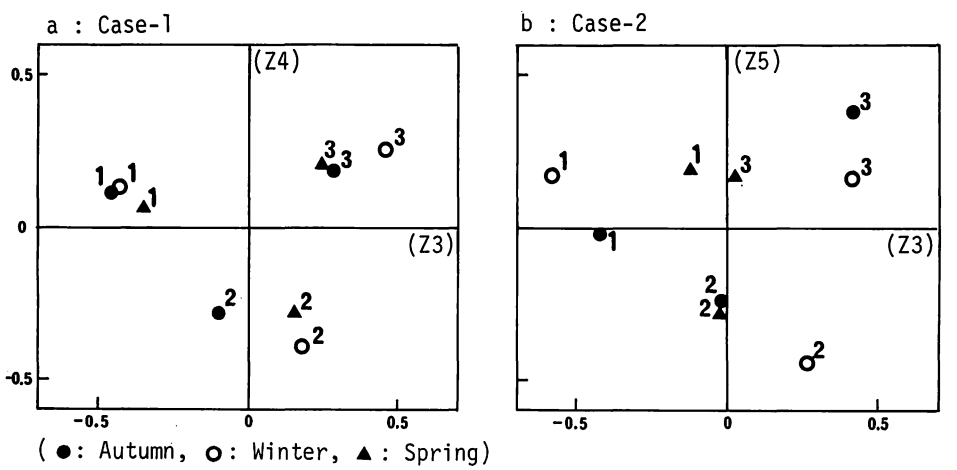


Fig. 6. Diagram of samples plotted on the third and fourth (fifth) factors.

Table 6. Factor scores of the third principal components for the main species.

Data processing	Case-1	Case-2	Case-3	Case-4	Case-5	Case-6
Factor	Z3	Z3	Z3	Z3	Z3	Z3
Proportion of eigenvalue (%)	10.3	10.4	10.2	9.7	11.7	14.1
Cocconeis pediculus.....	-3.82	0.08	-2.26	-2.06	-3.33	-2.94
Gomphonema minutum.....	-3.09	-2.14	-3.02	-1.78	-2.98	-2.74
G. pseudotenellum.....	-2.22	-1.62	-2.09	-1.65	-2.25	-2.20
Achnanthes lanceolata.....	-2.12	-0.68	-1.31	-1.30	-1.19	-1.89
Frustulia vulgaris.....	-1.52	-2.15	-1.85	-1.67	-1.71	-0.95
Nitzschia linearis.....	-1.50	-0.78	-1.72	-1.58	-2.31	-3.14
Cymbella tumida.....	2.29	0.95	2.26	1.50	2.91	3.31
Gomphonema helveticum.....	2.21	1.88	1.96	2.71	2.56	2.67
G. olivaceum var. minutissimum....	2.08	0.10	2.03	0.96	1.57	0.79
Cymbella turgidula.....	1.53	0.39	1.11	1.79	1.90	2.62
Nitzschia frustulum.....	1.23	2.12	1.82	1.69	1.69	1.29

主成分分析により解析した結果，付着珪藻類組成の季節変化が明らかとなった。本調査地域における常在種及び各季節を特徴づける種は，以下のとおりであった。

常在種：*Achnanthes convergens*, *Cymbella silesiaca*, *Navicula gregaria*, *N. cryptotenella*, *Fragilaria capucina* var. *vaucheriae*, *Nitzschia palea*, *Melosira varians*.

冬期—春期型：*Gomphonema olivaceum* var. *minutissimum*, *Fragilaria capucina*.

春期型：*Nitzschia dissipata*, *Rhoicosphenia abbreviata*.

夏期型：*Synedra ulna*, *Navicula cinctaeformis*, *Gomphonema parvulum*.

夏期—秋期型：*Navicula slesvicensis*, *N. viridula*, *Cymbella turgidula*.

秋期—冬期型：*Navicula perminuta*, *Cocconeis placentula* var. *euglypta*.

また，各調査地点はいずれも沼田川水系の中流域にあたり，水質，水温などの環境はほぼ等しいにもかかわらず，地点により付着珪藻類組成が異なっていた。この原因としては，同じ水質環境下でも，遷移の段階が異なっていることが考えられる。つまり，本調査地域においては，上流部の地点ほど河床の石礫が小さく，水量の変動も大きいことから，増水時の河床の撹乱などによる付着珪藻類組成への影響が大きいと推察される。このため，上流の地点ほど遷移の初期段階にある可能性が強い。また，水温が高いほど遷移速度が速いと思われ，高水温期には極相段階にある可能性が強い。これらのことを考えあわせると，夏期に多く出現する種は本調査地域の上流地点に少なく，逆に上流地点ほど多く出現する種は夏期にはあまり出現しなかったことが説明できる。前者の例としては *Fragilaria capucina* var. *vaucheriae*, *Cymbella turgidula*, *Gomphonema parvulum*, *Navicula cinctaeformis*, *Synedra ulna* が，後者の例としては *Cocconeis pediculus*, *C. placentula* var. *euglypta*, *Gomphonema minutum*, *Navicula perminuta*, *Nitzschia linearis* があげられる。このうち *Cocconeis placentula* var. *euglypta* は，遷移の初期段階に出現することが知られている（Korte and Blinn 1983）。この他に年間を通じて地点による出現傾向の異なる種としては，上流部ほど多くみられた *Achnanthes lanceolata*, *Gomphonema pseudotenellum*, 下流部ほど多くみられた *Cymbella tumida*, *Gomphonema helveticum* があげられ，前者はパイオニア種，後者は極相の構成種と思われる。

なお，冬期には St. 2, 3 で *Gomphonema olivaceum* var. *minutissimum* の群体が形成されており，低水温期の極相状態と考えられる。

遷移に関する報告は，本邦でも人工水路を用いたもの（渡辺，山本 1982）など若干なされているものの，充分なものではない。今後，河床の撹乱のほか，魚類

水生昆虫による捕食など遷移の進行を妨げる要因も含めて，水温，日照などの影響を総合的に検討する必要がある。

3. 主成分分析に用いるデータ型式について

付着珪藻類組成の解析を行うために主成分分析を行う際，相対頻度のような生データをそのまま用いた場合は，限られた優占種の因子が抽出されただけであった。これは，ALLEN and KOONCE (1973) が湖の植物プランクトン組成の変化の解析において，未処理のデータを用いた場合は，極くわずかの情報しか得られなかったとしていることと一致する。彼らは，対数処理と1・0変換ではほぼ同様な結果が得られたとしている。しかし本調査においては，対数処理と1・0変換では試料を類別している因子負荷量は類似しているものの，種ごとの因子得点をみると，1・0変換では偶在種が過大に扱われていた。このため，1・0変換は標徴種を抽出するには有効と思われるが，調査精度に高いものが要求され，偶然性に左右される危険を免れない。なお，広島県太田川について，同じ河川付着珪藻類組成に主成分分析を適用した筆者らの研究（半田，中野 1986）では3段階区分を用いた。この場合も偶在種の評価が高くなる傾向があった。

本調査においては，対数処理を行ったデータで有効な情報を充分に抽出することができた。対数処理は，MCINTIRE (1973), AMSPOKER (1977) が，内湾の珪藻類組成の解析に用いている。主成分分析は，用いるデータが正規分布をしていることを前提としている。対数処理を行った場合，データが正規分布に近いものになることから，珪藻類組成に対数処理を用いることにより，総合的な情報が抽出されるものと思われる。

細胞数による段階区分や，被度による区分もデータは正規分布に近く，対数処理とほぼ同様な結果が得られている。なお，被度によるものはバイオマスも考慮されるため，より意味のあるデータと考えられる。

Case-6 は，1細胞しか観察されなかった場合に“0”を与えているにもかかわらず，解析結果はその他の Case と類似しており，段階区分したデータにより主成分分析を行う際，調査精度は顕著な影響を与えないことが明らかとなった。

終りに本稿の御校閲を賜った広島大学の岩月善之助教授に深甚の謝意を表したい。さらに，水質分析に御協力頂いた広島県地区衛生組織連合会の職員の方々に御礼申しあげる。

引 用 文 献

ALLEN, T.F.H. and KOONCE, J.F. 1973. Multivariate approaches to algae stratagems and tactics in systems analysis of phytoplankton. Ecology **54**: 1234–1246.

AMSPOKER, M.C. 1977. The distribution of intertidal diatoms associated with the sediments in Yaquina Estuary, Oregon. Ph. D. Thesis, 172pp.

半田信司・中野武登 1986. 付着珪藻類組成の主成分分析による解析——広島県太田川. ヒコビア **9**: 501-507.

KORTE, V.L. and BLINN, D.W. 1983. Diatom colonization on artificial substrata in pool and riffle zones studied by light and scanning electron microscopy. J. Phycol. **19**: 332–341.

MCINTIRE, C.D. 1973. Diatom associations in Yaquina estuary, Oregon: A multivariate analysis. J. Phycol. **9**: 254–259.

森谷栄一・井口晴弘 1972. 多変量解析とコンピュータプログラム. 日刊工業新聞社 東京 273 pp.

渡辺仁治・山本裕美 1982. 人工水路における河川性藻被の遷移に伴う構造の変化.「環境科学」研究報告集 B 121-R 12-10. 実験水路による底生生物の環境指標性の研究. 81-91.

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佐々木茂，菊地和夫，*松山恵二：ムチモの新産地 Shigeru SASAKI, Kazuo KIKUCHI and Keiji MATSUYAMA: *Cutleria cylindrica*; a new record from Hokkaido

ムチモ *Cutleria cylindrica* は，岡村（1902）が初めて新種として記載した褐藻類ムチモ科に属する海藻である。

本種の分布については，岡村が伊勢，志摩，相模，安房を掲げたように，その後もわが国では主に表日本中部や九州西北岸などの暖流域から報告され（MIGITA and KAMBARA 1961，林田・桜井1969，廣瀬1971，林田1972，中庭1975），太平洋と日本海における北限は，それぞれ福島県小名浜（岡本1963）と佐渡ケ島東岸（野田1963）が知られている。また外国では朝鮮半島の東岸や南岸からも報告されている（COTTON 1906, KANG 1966）。

ところで，TAKAMATSU（1938）はこれらの多くの記録よりもかなり早い時期に津軽海峡南岸の青森県大間から本種を得ている。大間では今日でも本種の生育が認められるが（能登谷正浩博士私信），上述の小名浜や佐渡ケ島からそれぞれ 500 km ほども離れた場所に本種が生育していながら，その間のどこからも採取の記録がない。

著者らは1986年2月，3月および4月に北海道渡島管内の知内（しりうち）町小谷石（こたにいし）で，また，1987年3月に函館市石崎町でムチモの生育を確認した。新産地はいずれも津軽海峡に面し，前者は津軽海峡西口から約 25 km，後者は東口から約 30 km の距離にある（Fig. 1）。ムチモの藻体が着生していたのは知内町では前年の9月に，また石崎町では同じく7月に水深 6—7 m の海底に造成された約 900 m² の自然石のコンブ人工礁上である。

両地点で採取された藻体は，いずれも雌性体だけで雄性体は発見できなかった。体は小盤状根から単独に生じ，あるいは2—3個体が叢生し，長さは 35—45 cm，太さは 2—3 mm の糸状体で，7—10回やや広い角度で又状に分岐し，ゆるやかに曲り，基部と先端部を除く枝の各所に雌性配偶子嚢をもった多数の細胞糸の集まりが斑点状にみられる（Fig. 2, A）。体組織は糸状細胞より成る髄層，楕円状細胞より成る皮層および1列の色素体を含む小細胞より成る表層の3層で構成される。雌性配偶子嚢は表層から生ずる1列または1—3回分岐する無色の細胞糸の先端に形成され，長さ 50—90 μm，太さ 20 μm ほどの円柱状で，表面観で2列の小室に分かれ，配偶子は黄褐色の色素体を含む（Fig. 2, B, C）。生体の色は濃いオリーブ色である。

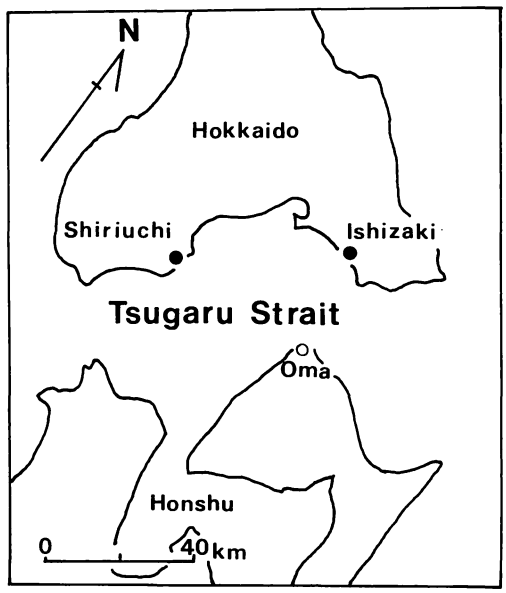

Fig. 1. A map showing two new (●) and an already known one (○) habitats of *Cutleria cylindrica* OKAM. along Tsugaru Strait.

ムチモが発見されたのは両地点とも前年に造成された新しい人工礁上で，枠取り（面積 0.25 m²）調査では常に数 g から 100 g を越える藻体が得られるほど良く繁茂していた。しかし，その周辺の天然礁上からは発見できなかった。また，知内町での発見は1986年のみで1987年4月の調査では人工礁，天然礁とも全く生育していなかった。このように両地点における本種の出現や生活状態にはいくつかの注目すべき点が見られる。

津軽海峡はその西口附近で対島暖流の，また東口附近では親潮寒流の影響を大きく受ける。山本（1965）や斎藤（1986）は，すでに津軽海峡西口の松前町から函館市にかけての沿岸で，わが国の中南部地方に分布する暖海性海藻を合計10種類得ており，山本は海峡北岸でのそれらの分布は，ほぼ函館以西に限られると述べている。

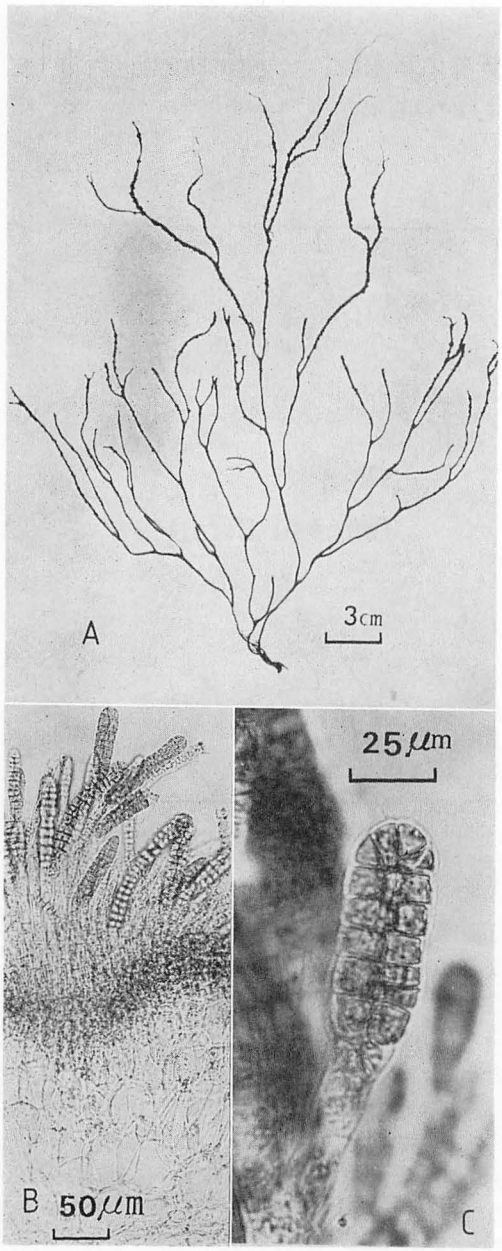

Fig. 2. *Cutleria cylindrica* OKAM. A. A female frond (Ishizaki, Hakodate City, 19 March, 1987). B. A part of cross section of the frond showing inner structure and female sori. C. A female gametangium.

今回の著者らによるムチモの発見は北海道沿岸では最初の記録であり，その分布域は山本（1965）の述べていることとほぼ一致する。しかし，函館市対岸の青森県大間町を含めた津軽海峡内での本種の生育は，それぞれの生育地における暖寒両流の勢力の変動に支配されて，毎年変化のある消長をくりかえしているのではないかと考えられる。

終りにムチモの最終同定および本稿のご校閲をいただいた函館水産試験場の川嶋昭二博士に，また大間町における本種の知見を御教示いただいた青森県水産増殖センターの能登谷正浩博士にお礼申しあげる。

引 用 文 献

COTTON, A.D. 1906. Marine algae from Corea. Bull. Misc. Inform., Royal Bot. Gard., Kew **9**: 366–373.

林田文郎 1972. 駿河湾・御前崎の海藻. 教師の広場 静岡県出版文化会：116–174.

林田文郎，桜井武磨 1969. 駿河湾用宗海岸の海藻相と海藻群落. 日本生態学会誌 **19**：52–56.

廣瀬弘幸 1971. 瀬戸内海沿岸特に播磨灘・大阪湾沿岸を主とした工業発展に伴う水質海況の変遷と海藻植生の変遷との関係. 山陽放送学術文化財団リポート **13**：26–36.

KANG, J.W. 1966. On the geographical distribution of marine algae in Korea. Bull. Pusan Fish. College. **7**: 1–125.

MIGITA, S. and KAMBARA, S. 1961. A list of the marine algae from Hirado Island and its vicinity. Bull. Fac. Fish., Nagasaki Univ. **10**: 174–186.

中庭正人 1975. 茨城県沿岸の海藻相. 藻類 **23**：99–110.

野田光蔵 1963. 佐渡海峡の海藻. 藻類**11**：109–114.

岡本一彦 1963. 東道太郎氏コレクションの海藻目録(1). 藻類 **11**：118–125.

岡村金太郎 1902. 日本海藻図説. 丸善書店，東京.

斎藤 譲 1986. 北海道の南端付近でクロミルを記録. 藻類 **34**：142.

TAKAMATSU, M. 1938. Marine algae from Tsugaru Strait, Northeast Honshu, Japan. Saito Ho-on Kai Museum Research Bull. **14**: 1–75.

山本弘敏 1965. 津軽海峡で初めて採取された暖海性海藻について. 北大水産学部彙報 **15**：215–220.

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吉﨑　誠：パソコンを用いた名前当てゲーム　Makoto Yoshizaki: On a personal computer game "What is this algal name?"

近頃どこの研究室にもパソコンの一台や二台は設置され，中には個人でもパソコンを持つ人もいるように，パソコンの普及率は高くなった。そしてどこの研究室にもパソコンに詳しい学生がいるようになってきた。しかし，大半のパソコンが，ワープロとしての機能ばかりに使われていて，実際の教育面に活用されている所は少ないことも事実である。そこで，私共の研究室では，子供のクイズゲームをもとに，習志野市役所の井浦宏司主任技師の協力を得て，学生の教育用の教材として植物の名前当てクイズを作り，利用している。学生からは楽しく植物名を覚えられると好評である。また，キーボードの扱い方の教育にも最適である。この教材は，1986年の日本藻類学会第10回大会（於 筑波大学）での展示コーナーに日立のパーソナルコンピューターを展示した折りに，藻類の名前当てクイズとして出品させてもらい大変に好評であった。その後，私の所にはプログラムの請求が相次ぎ，別刷りの請求よりもこのプログラムの請求の方が多い位である。そこで，このプログラムの基礎的な一部をここに紹介することにした。

このプログラムの流れは次のようである。掛け点を決める（数字入力）⟶学名が表示される⟶和名を入力する（ローマ字カタカナ入力）⟶答えが正しければ掛け点が加算され，誤っていれば減点される。これは誰にでもすぐに理解できるゲームの原則である。これを繰り返して最後に最終得点が表示され，同時にメッセージが表示される。A$ と B$ とは設問と答えを示し，それぞれの（ ）内の数は DATA の総数をあらわす。ここでは設問が25あることを意味する。設問の数を変更する時は20行目，30行目と70行目の25も設問数と同数に変更しなければならない。私の経験から設問の数は20または25が適当である。A$ と B$ の順序を変えると学名を当てるクイズとなる。

このプログラムは，Basic のごく初歩のものである。Basic で，表計算程度のプログラムを組める人ならすぐに理解できるし，全く Basic の知識のない人でも理解するのにそう時間はかからない。いたって簡単なプログラムではある。また，設問と答が，1対1対応するものの全てに応用できる便利さがある。私共はこのようなプログラムを多数用意し，これらを menu 画面から，簡単に呼び出せるようにしている。

参 考 文 献

LS 愛ちゃん．6年の科学6月教材 **30**(3)：51-55，学研．1985.

（274 船橋市三山2-2-1　東邦大学理学部生物学科）

```
10 CLS
20 DIM A$(25),B$(25):S=100
30 FOR I=1 TO 25:READ A$(I),B$(I):NEXT I
40 COLOR 5:PRINT"*****  海藻学名当て げーむ（七里ケ浜編）難易度 B  ***14"
50 COLOR 7:PRINT:PRINT"アナタノ持チ点ハ  １００点 デス"
60 FOR I=1 TO 25
70 PRINT:PRINT:INPUT"掛ケ点ハ イクラニ シマスカ";C
80 IF C<1 THEN GOTO 70
90 IF C>S THEN GOTO 70
100 PRINT:PRINT A$(I);" の和名は";:INPUT C$
110 IF C$=B$(I) THEN COLOR 3:PRINT "正解です！":S=S+C:GOTO 130
120 BEEP:COLOR 6:PRINT "ちがいます！ 正解は";:COLOR 3:PRINT B$(I);:COLOR 6:PRIN
T"です":S=S-C
130 IF S=0 THEN PRINT:PRINT "貴方は，破産しました．もっと勉強しなさい．":GOTO 18
0
140 COLOR 7:PRINT "アナタノ持チ点ハ";S;"点ニ ナリマシタ．"
150 NEXT
160 COLOR 7:PRINT"貴方の最終得点は";S;"点です．"
170 PRINT:PRINT"大量に得点をしたあなたは，大変に磯歩きの得意な人ですね．"
180 PRINT:PRINT"  岡村金太郎先生や，山田幸男先生は，海藻の採集によく江ノ島に行か
れたそうです．その頃の江ノ島は，島の東側に平らな磯がひろがり，海藻の採集にはこの
上もないほど好条件に恵まれたところだったそうです．"
190 PRINT:PRINT"江ノ島周辺から記載された種もたくさんありますが，現在それらを江ノ
島に求めることはできません．そういう点からしても，江ノ島に隣接した七里ケ浜は，貴
重な海藻の採集地といえるでしょう "
200 PRINT:PRINT"七里ケ浜で採集した海藻の形は，岡村金太郎先生の日本海藻誌や，日本
藻類図譜の中に示されているさし絵と，ほとんど同じであるものが多いのです．日本の海
藻の研究の歴史は，ここから始まったのだな，ということを実感することがあります．"
210 PRINT:PRINT:COLOR 6:PRINT"  これで ゲームを 終了します．0 KEY を 押して
ください．"
220 INPUT E$ : IF E$="0" OR E$="0" THEN RUN"B:MENU" ELSE 210
230 DATA"Cutleria cylindrica OKAMURA","ムチモ"
240 DATA"Acanthopeltis japonica OKAMURA in YATABE","ユイキリ"
250 DATA"Eisenia bicyclis (KJELLMAN in KJELLMAN et PETERSEN) SETCHELL","アラメ"
260 DATA"Ecklonia cava KJELLMAN in KJELLMAN et PETERSEN","カジメ"
270 DATA"Caulerpa okamurae WEBER VAN BOSSE in OKAMURA","フサイワヅタ"
280 DATA"Caulerpa brachypus HARVEY","ヘライワヅタ"
290 DATA"Hypnea japonica TANAKA","カギイバラノリ"
300 DATA"Hypnea charoides LAMOUROUX","イバラノリ"
310 DATA"Sargassum macrocarpum C. AGARDH","ノコギリモク"
320 DATA"Sargassum sagamianum YENDO","ネジモク"
330 DATA"Pachymeniopsis elliptica (HOLMES) YAMADA in KAWABATA","タンバノリ"
340 DATA"Chondrus giganteus YENDO","オオバツノマタ"
350 DATA"Chondrococcus japonicus (HARVEY) OKAMURA in MATUMURA et MIYOSHI","ナミ
ノハナ"
360 DATA"Chondrococcus hornemanni (LYNGBYE) SCHMITZ","ホソバナミノハナ"
370 DATA"Rhodymenia intricata (OKAMURA) OKAMURA","マサゴシバリ"
380 DATA"Champia parvula (C. AGARDH) HARVEY","ワツナギソウ"
390 DATA"Acrosorium polyneurum OKAMURA","スジウスバノリ"
400 DATA"Acrosorium yendoi YAMADA","ハイウスバノリ"
410 DATA"Carpopeltis divaricata OKAMURA","ヒトツマツ"
420 DATA"Carpopeltis crispata OKAMURA","トサカマツ"
430 DATA"Marginisporum aberrans (YENDO) JOHANSEN et CHIHARA in JOHANSEN","フサカ
ニノテ"
440 DATA"Serraticardia maxima (YENDO) SILVA","オオシコロ"
450 DATA"Meristotheca papulosa (MONTAGNE) KYLIN","トサカノリ"
460 DATA"Plocamium telfairiae (HARVEY) HARVEY in KUETZING","ユカリ"
470 DATA"Cladophora wrightiana HARVEY","チャシオグサ"
480 DATA"Codium adhaerens (CABRERA) C. AGARDH","ハイミル"
490 DATA"Laurencia intermedia YAMADA","クロソゾ"
500 DATA"Gastroclonium pacificum (DAWSON) CHANG et XIA","イソマツ"
```

——学 会 録 事——

日本藻類学会秋季シンポジウム

昭和62年11月25日，茨城県筑波郡の国立公害研究所において秋季シンポジウムおよび懇親会を開催した。演題は，「陸水域の富栄養化と藻類の異常発生」というテーマで，「淡水赤潮の場合」を門田　元氏（近畿大学），「アオコの場合」を高村典子氏（国立公害研）が講演した。なお，シンポジウムの報告の詳細は次号に掲載の予定である。

——会 員 移 動——

新　入　会

住 所 変 更

退　　会

白戸　爾，提　眞治（東京都），斉藤昭二（神奈川県），平山国治（兵庫県）

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日本学術会議だより　No.7

「脳死に関する見解」採択される

― 医療技術と人間の生命特別委員会報告 ―

昭和62年11月　日本学術会議広報委員会

日本学術会議は，去る10月21日から23日まで第103回総会（第13期・6回目）を開催しました。今回の「日本学術会議だより」では，今総会で採択された勧告を中心として，同総会の議事内容をお知らせします。本会議の第13期も，余すところ9か月となり，各委員会は，期の活動の取りまとめに向けて一層活発に審議を進めています。

総　会　報　告

総会第1日目の午前中には，会長からの経過報告，各部・各委員会報告に続き，勧告・対外報告等4つが提案され，そのうちの2件が可決された。そのほかの2件に関しては，同日午後に各部会で審議が行われ，第2日目の午前中に1件が，第3日目の午前中に1件が可決された。

なお，総会前日の20日午前には連合部会が開催され，これらの案件の予備的な説明，質疑が行われた。また第2日目午後には「食糧生産と環境」についての自由討議（詳細別掲）が，第3日目の午後には常置委員会，特別委員会が開催された。

第1日目午前。まず，利根川進氏のノーベル生理学・医学賞受賞に対し日本学術会議第103回総会の名において祝電を呈することが提案され，全員一致で可決された。

次に日本学術会議の行う国際学術交流事業の実施に関する内規の一部改正についての提案がなされ，これも賛成多数で可決された。この改正は，第14期の当初3か月間における，国際学会への研連委員の代表派遣について，必要な経過措置を講ずるものである。

続いて，高齢化社会特別委員会提案の「日本高齢社会総合研究センター（仮称）の設立について」（勧告）（詳細別掲）の提案説明と質疑応答が行われた。さらに，医療技術と人間の生命特別委員会報告「脳死に関する見解」を「日本学術会議の運営の細則に関する内規」に定める対外「報告」として認めることに関する提案が行われた。これは同特別委員会がその発足以来2年間にわたって審議を重ねてきたものであり，前回4月の総会では討論の過程でさらに検討する必要があるとして同特委により取り下げられたものである。その後，委員定数を増加するなどして審議を重ね，今総会に再度提案されたものであるが，批判的意見を背後に含む多くの質問が出された。

第2日目午前。前日提案された「日本高齢社会総合研究センター（仮称）の設立について」（勧告）が，賛成多数で採択され，直ちに内閣総理大臣始め関係諸機関等に送付された。同じく前日提案の「脳死に関する見解」は，前日の部会審議で異論が続出したため，抜本的に書き改められたものが提案されたが，なおいくつかの疑問が示され，採決には至らなかった。

第3日目午前。再度修正された「脳死に関する見解」が提案された。国民的合意の形成，医学界における少数意見の存在などに関して，なお理解の不一致があり，質問討論が行われた。これら若干の点に関する討論者間の相互了解を遂げた後，数名の発言者から再度の修正を経ることによって本報告は異なった専門分野のいずれからみてもおおむね満足できるものになった，当初に危惧した点が除かれた，などの意見が述べられた。こうして多少の曲折はあったが，最後に本提案がほぼ全員一致で採択された。（見解の内容は別項参照）

日本高齢社会総合研究センター（仮称）の設立について（勧告）

急速な高齢社会への移行という厳しい問題をまえにして，日本学術会議は既に昭和55年（1980年）11月1日「国立老化・老年病センター（仮称）の設立について」の勧告を内閣総理大臣あてに行った。しかし現在にあっては，さらにこれに加えて，高齢社会をめぐる新しい理論的研究と政策開発の推進が緊急の課題となっている。そこで，このような課題を解決するために，日本学術会議は下記構想のごとき「日本高齢社会総合研究センター（仮称）」の設立をここに勧告するものである。この研究センターは，「老化・老年病センター」と緊密な連携を保ちつつ，高齢社会・高齢層・高齢者問題の総合研究を目指す，人文・社会科学中心の全国的なネットワーク型の研究センターである。

「日本高齢社会総合研究センター」（仮称）の構想

「日本高齢社会総合研究センター法（仮称）」という法律に基づく独立性の高い法人とし，国の出資による基金を基礎として設立される。なお，所管官庁の選定に当たっては，21世紀の重要な国民的課題たる高齢者政策の総合性を考え，特定の行政分野に偏ることなく，全行政分野が連携を保ち得るような所管の在り方が望まれる。

総合研究センターの運営は以下のように行う。

(1)本研究センターは，国の出資による基金を基礎として設立されるが，さらにまた一般寄付，並びに研究受託費を加えて，弾力的に運営されるところの公的で全国的なネットワーク型の研究センターとする。(2)本研究センターの運営を統括する理事会を構成する理事の半数は研究者をもって充てる。(3)研究課題の選択は，関連学会（例えば，日本学術会議の選定による）から推挙され，一定の任期をもつ30名前後の「研究評議員会」で行うことによって研究の総合性を図るとともに，また研究評価をも行う。(4)専任研究員制度（一定の任期を設ける）を置き，それにより総合研究センターの研究の組織化並びに相互調整を行う。各プロジェクト毎に専任研究員を中心に流動研究員（客員研究員，出向研究員等）やその他の研究者を募ってこれに加え，常時300名程度の研究者が活動している状態が望ましい。（詳細は，日本学術会議月報11月号を参照されたい。）

脳死に関する見解

―医療技術と人間の生命特別委員会報告―

最近の医療技術の発展に伴って生じてきた人間の生命とその尊厳にかかわる諸問題のうち特に脳死の問題は末期医療，臓器移植等をめぐって大きな社会的問題となっている。医療の現場では脳死の状態に陥った多くの患者をめぐって，日夜その家族や医師が苦悩に満ちた対応を迫られつつある。脳死の問題は，必ずしも心臓や肝臓などの臓器移植との関連においてだけでなく，むしろ現実的には多くの場合，末期医療の現場において深刻化している。このような現状にかんがみ，脳死にかかわる諸問題を様々の角度から十分に議論し，問題の所在を考察して，その解決への展望を示したものである。これが本特別委員会の今回の報告である。

本報告は脳死を医学的に，法的にそして心理的，倫理的及び社会的側面から考察した。全脳の機能が不可逆的に喪失した状態と定義される脳死は，医学的にみて個体の死を意味する。これは第7部会員の一致した意見であり，医学界の大勢と判断されるが，医学界の中にも少数ながら疑義を持つ者もある。脳死を人の死と認めるか否かについては，法律的にはこれを肯定，否定する見解が対立している。否定している場合にも脳死になった際，人工呼吸器を外してはならないということでなく，事情によっては違法性阻却ないし，責任阻却事由があり得ることまで否定するものでない。

人の死は単なる医学的現象ではなく，その人の人格，社会的存在にもかかわるものである。したがってその取扱いについては，本人の生前の意思，家族の感情，一般的倫理観，習俗，社会的慣習等を尊重しなければならない。しかし脳死をめぐっては三徴候に基づく伝統的な死の概念にとらわれることなく，深刻化している医療の現状に対処して新しい死の概念の確立に努めるべきであろう。このため関係方面において脳死をめぐる諸問題が検討され，速やかな解決への展望が開かれることを希望する。

以上の見解を第103回総会の承認を得て対外報告としてこれを公表することとした。

（詳細は，日本学術会議月報11月号を参照されたい。）

自由討議―食糧生産と環境―

この自由討議は，今期設置された「生物資源・食糧と環境特別委員会」のメンバーが主となり，個人の立場で，食糧生産と環境の問題について意見を発表したものである。会長近藤次郎(食糧に対する環境からのアプローチ)，第6部，生物資源特委委員長阪本楠彦(食糧問題の展望)，第6部（以下すべて特委委員）武田友四郎（環境変化が農業生態系に及ぼす影響），第5部岩佐義朗（水資源の立場から）の各会員がそれぞれに付記したサブテーマについて問題を提起した。これに続いて第3部大石嘉一郎（経済学の立場から），第1部石川栄吉（数量主義の反省），第6部水間豊（畜産学の立場から），第2部及川伸(食糧管理制度について)，第6部福場博保（栄養面から見た食糧資源開発問題），第1部水津一朗（歴史地理学の立場から），第7部小泉明（人口と食糧・環境）の各会員から関連発言があり，質疑応答が行われた。

1973～81年頃のいわゆる“世界食糧危機”は既に去り，今や食糧の輸出競争が激化している。しかしアフリカ等の飢餓問題が解消したわけでは決してないし，開発途上国の所得増から来る食糧需要は決して楽観を許さない。まるで，栄養過剰の大国に“追いつき，追い越そう”としているかのようでさえある。

生産の面でも，自然の節理を無視した増産が進められている。森や山に住む神々への迷信的な怖れを失った後，自然破壊に対してかけるべき有効な抑制力を，人類はまだ見出せずにいる。破壊された自然の復旧（砂漠の緑化など）もまだほとんどできないままである。(この自由討議は日学双書5刊として出版されます。)

日本学術会議月報

日本学術会議は，その日常的な活動の状況を科学者や学術研究団体を始め関係諸機関・団体等に広く理解してもらうため，毎月1回，「日本学術会議月報」（B 5版・6～12ページ）を発行し，無料で配布している。

その内容は，総会の決定事項，運営審議会の審議事項，研究連絡委員会の開催状況，関係学術研究団体と共同主催する国際会議の開催状況，後援する国際会議及び研究連絡委員会等が主催するシンポジウム・講演会のお知らせ等を中心として，その折々のトピック事項を掲載している。また，会員の随筆なども取り入れ，なるべく読み易い紙面となるよう努めている。

現在，当「月報」を送付している機関・団体等は，次のとおりである。

大学・短期大学，関係国・公・私立研究機関，公立図書館，関係省庁，関係報道機関，日本学術会議広報協力学術団体* 等

＊　本会議活動の周知を図るとともに，各学術研究分野との緊密な連絡・協力関係を維持・強化するため，本会議の広報活動に協力してもらう学・協会

第14期日本学術会議会員選出のための登録学術研究団体の概況

本会議では，現在第14期（昭和63年7月22日～昭和66年7月21日）会員（定員210人）選出のための手続きが進められているが，先頃6月末日を締切期限として，学術研究団体からの登録申請が受け付けられた。その後日本学術会議会員推薦管理会で審査が行われたが，結果は次のとおりであった。

学術研究団体の登録申請の審査結果

申請団体数……900団体

登録団体数……836団体

＊　日本学術会議会員推薦管理会が登録した836団体名は「日本学術会議月報」11月号に掲載されるので，ご参照願いたい。

日学双書「高度情報社会の展望と課題」

日本学術会議第101回総会における自由討議「高度情報社会の展望と課題」の記録及び「高度情報社会特別委員会」のヒアリングを編集し，日学双書No. 3として刊行されました。

日学双書No. 3「高度情報社会の展望と課題」

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多数の学術研究団体の御協力により，「日本学術会議だより」を掲載していただくことができ，ありがとうございます。

なお，御意見・お問い合わせ等がありましたら下記までお寄せください。

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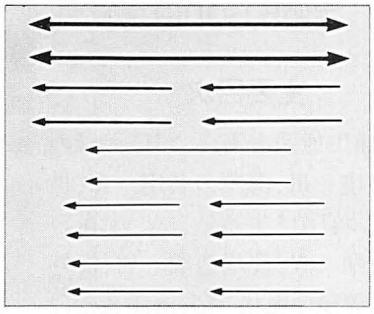

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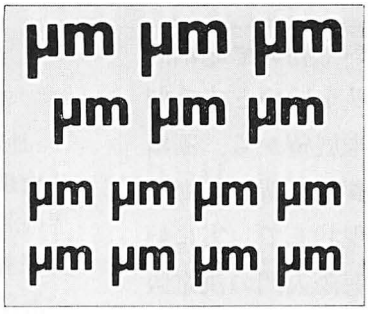

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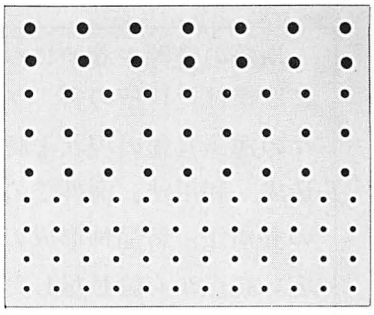

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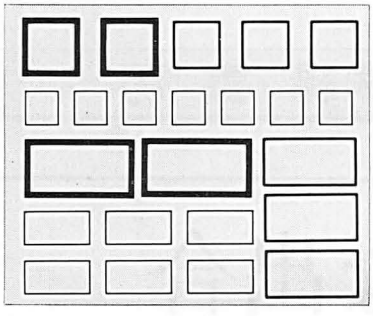

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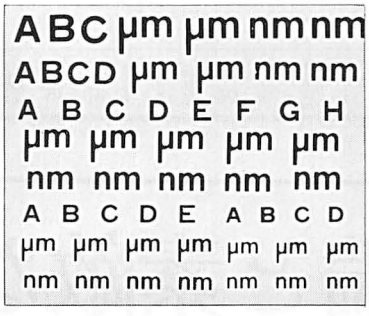

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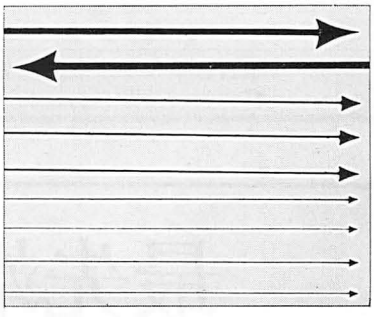

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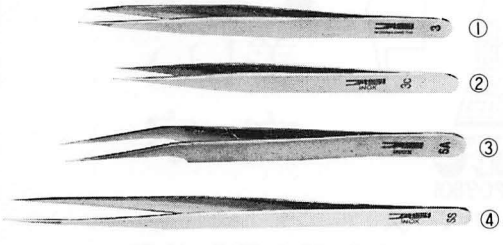

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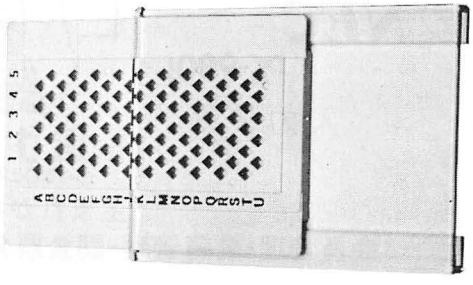

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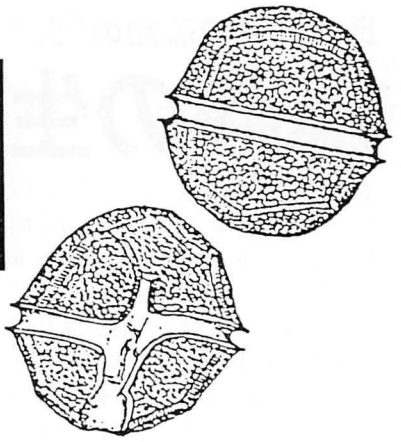

門田　元編

取水上の衛生問題，不快臭の発生，養殖淡水魚のへい死原因などに関連し，湖沼・人工湖における“水の華”発生が社会問題化している。

本書は1979年９月，環境庁水質保全局の肝煎りで組織された淡水赤潮研究会（座長　門田　元博士）の研究成果を広く関係者に利用していただくために公刊するもので，淡水赤潮に関する生物学的知見を網羅し，その発生機構の解明と対策も論究される。また琵琶湖におけるウログレナ *Uroglena* 及び永瀬ダム湖におけるペリディニウム *Peridinium* の調査研究をケーススタディに，我が国各地で頻発する淡水赤潮問題解決の資料を直接に提供するものである。

主な内容と執筆者　①淡水赤潮をひき起こすプランクトン（根来健一郎）　②淡水植物プランクトンの生活史（中原紘之・左子芳彦）　③淡水赤潮プランクトンをめぐる生物間相互関係（安野正之・花里孝幸・深見公雄・門田　元・石田祐三郎・内田有恒）　④湖沼の富栄養化と植物プランクトンの異常増殖（坂本　充）　⑤赤潮による被害（岡市友利・門田　元）　⑥わが国各地における淡水赤潮の発生状況（山中芳夫）　⑦琵琶湖における淡水赤潮の発生（門田　元・中西正己・吉田陽一・石田祐三郎）　⑧ダム湖における淡水赤潮の発生事例（畑　幸彦）

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5. **北海道周辺のコンブ類と最近の増養殖学的研究**　1977．B5版，65頁。昭和49年9月に札幌で行なわれた日本藻類学会主催「コンブに関する講演会」の記録。4論文と討論の要旨。価格1,000円。

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

4. **Contributions to the Systematics of the Benthic Marine Algae of the North Pacific.** Edited by I.A. Abbott and M. Kurogi, 1972. xiv＋280 pages, 6 plates. Twenty papers followed by discussions are included, which were presented in the U.S.-Japan Seminar on the North Pacific benthic marine algae, held in Sapporo, Japan, August 13–16, 1971. ¥ 5,000 (incl. postage, surface mail).

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