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CONTENTS

THE JAPANESE SOCIETY OF PHYCOLOGY

日 本 藻 類 学 会

日本藻類学会は1952年に設立され，藻学に関心をもち，本会の趣旨に賛同する個人及び団体の会員からなる。本会は定期刊行物「藻類」を年4回刊行し，会員に無料で頒布する。普通会員は本年度の年会費7,000円（学生は5,000円）を前納するものとする。団体会員の会費は12,000円，賛助会員の会費は1口20,000円とする。

庶務および会計に関する通信は，**602 京都市上京区下立売通小川東入　日本藻類学会**宛に，また「藻類」への原稿の送付は　**184 小金井市貫井北町4-1-1　東京学芸大学生物学教室内　日本藻類学会編集委員会**宛にされたい。

The Japanese Society of Phycology

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Manuscript for publication should be submitted directly to the Editor-in-Chief, **Prof. I. Shihira-Ishikawa, Department of Biology, Tokyo Gakugei University, Nukuikita-machi, Koganei-shi, Tokyo,184 Japan.**

第2回日韓藻類学シンポジウムのお知らせ

第15回日本藻類学会大会（琉球大学）前日（3月26日）の評議員会において，上記シンポジウムを日本藻類学会の**1991年度秋季シンポジウム**として開催することが正式に決定されました。以下に実施概要，日程及び参加申込要領をお知らせします。会員各位にはふるってご参加下さい。

記

主　　催：日韓藻類学シンポジウム組織委員会
有賀　祐勝（日本藻類学会会長）
小林　　弘（日本藻類学会前会長）
鄭　　濤（韓国藻類学会会長）
李　仁　圭（第1回韓日藻類学シンポジウム準備委員長）
三浦　昭雄（日本藻類学会編集委員）

共　　催：日本藻類学会・韓国藻類学会・筑波大学

企画準備：第2回日韓藻類学シンポジウム準備委員会
原　　慶明（準備委員長・筑波大学生物科学系）

内　　容：特別講演（招待），招待講演，一般講演（公募）及びワーク・ショップ

使用言語：英語

開催日程：1991年9月8日　受付（16：00–）及び歓迎懇親会（18:00–）
9月9日　受付（8：30–），特別講演，招待講演，一般講演及び若手研究者懇親会
9月10日　特別講演，招待講演，一般講演及びバンケット
9月11日　ワーク・ショップ「Introduction to the phytoflagellates」(9：00–12：00)

開催場所：筑波大学国際会議場他

参 加 費：無料（但し，ワークショップ参加費は10,000円）

懇親会等会費：歓迎懇親会 2,000円，バンケット 5,000円

連 絡 先：第2回日韓藻類学シンポジウム準備委員会
〒305 茨城県つくば市天王台1-1-1　筑波大学生物科学系内
TEL 0298-53-4533　FAX 0298-53-6614

講　演

本シンポジウムはすべて英語による講演となります。特別講演（45分）2題，招待講演（30分）17題，一般講演（15分）20題 およびワーク・ショップ（半日）で構成する予定です。各講演時間は討論時間を含みます。通常のスライド映写機とOHP（同時映写可能）を準備します。ビデオその他の器材が必要な方は事前に準備委員会にご相談下さい。

一般講演・シンポジウム参加・懇親会申込

一般講演は公募します。応募件数が予定より多い場合は申込順に採択させて戴きます。一般講演，シンポジウム参加及び懇親会等の申込は，綴込みの用紙に必要事項を記入し，上記準備委員会宛にお送り下さい（申込期限厳守）。懇親会等の会費は銀行口座（常陽銀行研究学園都市支店：**第2回日韓藻類学合同シンポジウム準備委員会　原　慶明，口座番号 104–7085521**）に振り込むか，もしくは現金書留にてお送り下さい。

一般講演申込締切：1991年8月10日

一般講演要旨締切：1991年8月20日

一般参加・懇親会等申込締切：1991年8月31日（当日参加可能。但し懇親会等の当日申込はお断りすることがあります。なお，若手研究者の集いはシンポジウム会場にて申込・会費をお受けします。）

特別講演・招待講演

招待講演者の要旨，シンポジウム参加（準備の都合上，申込んで下さい），懇親会等の申込みの締切日は一般講演と同じです。

要旨書式

要旨の原稿は以下の要領にしたがって，タイプ・ライター，ワープロまたはパソコンで作成して下さい。印字は明瞭な黒色でお願いします。

1) 要旨は全て英語で，演題・著者名・所属・住所・要旨の順に記述して下さい。
2) 活字は12ピッチのエリートを使用し，行間はシングル・スペースとして下さい。演題の前に6文字，各節の前に3文字のスペースを取って下さい。演題は全て大文字で表示して下さい。
3) 原稿はA4タイプ用紙（オニオンペーパーなどの薄手の用紙は避けて下さい）にカーボンリボンを用いて，各講演別に指定した枠内に印字して下さい。ワープロ，パソコンの場合は，24ドット以上のプリンターで印字して下さい。
4) 著者が複数の時は演者の名前に下線を付けて下さい。また，所属の異なるときは著者名の右肩に番号を付し，同じ番号を各著者の所属・住所の左肩に付けて下さい。
5) 学名等，イタリックで表示する場合は同じピッチのイタリック文字を使用するか，その部分に下線を付けて下さい。
6) 原稿は約80%に縮小し，2段組にしてそのままオフセット印刷されます。著者校正はありませんので，ご注意下さい。
7) 用紙原稿は演題等を含めてヨコ×タテを一般講演は80×120 mm（1ワク），シンポジウムは80×250 mm（1ワク），特別講演は80×250 mm（2ワク）に納めて印字して下さい。

ULTRASTRUCTURE AND TAXONOMY OF *CHLORARACHNION* SP. (CHLORARACHINIOPHYTA). Hanako Kasumi[1], Ichiro Sakura[2] and Mineo Murasaki[2]. [1]Institute of Biol. Sci., Univ. of Tsukuba, Tsukuba-shi, Ibaraki, Japan. [2]Dept. of Botany, Tokyo Univ. of Fish., Minato-ku, Tokyo, Japan

Amoeboid cells of *Chlorarachnion* sp. adhering on the surface of *Gracilaria verrucosa* were directly isolated

プログラム・要旨集の発送：1991年9月1日(参加申込をされた方に郵送します)

宿　泊

会場に比較的近い主な宿泊施設は下記の通りですので，直接予約して下さい。これら以外にも大学周辺に宿泊施設はありますが，予約する前に筑波大学への交通の便を必ず確かめて下さい。

施設名	料金	電話	交通
筑波第一ホテル	S: 9,857 T: 18,125	0298-52-1112	バス　つくばセンター　10分
トレモントホテル	S: 8,497 T: 13,596	0298-51-8711	徒歩　5分
サンルート筑波	S: 6,911 T: 13,256	0298-52-1151	バス　電電社宅前　20分
筑波研修センター	S: 2,900 T: 6,600	0298-51-5152	徒歩　20分
ホテルニュー高橋（竹園店）	S: 5,500 T: 9,000	0298-51-1208	バス　学園竹園　20分

交通案内

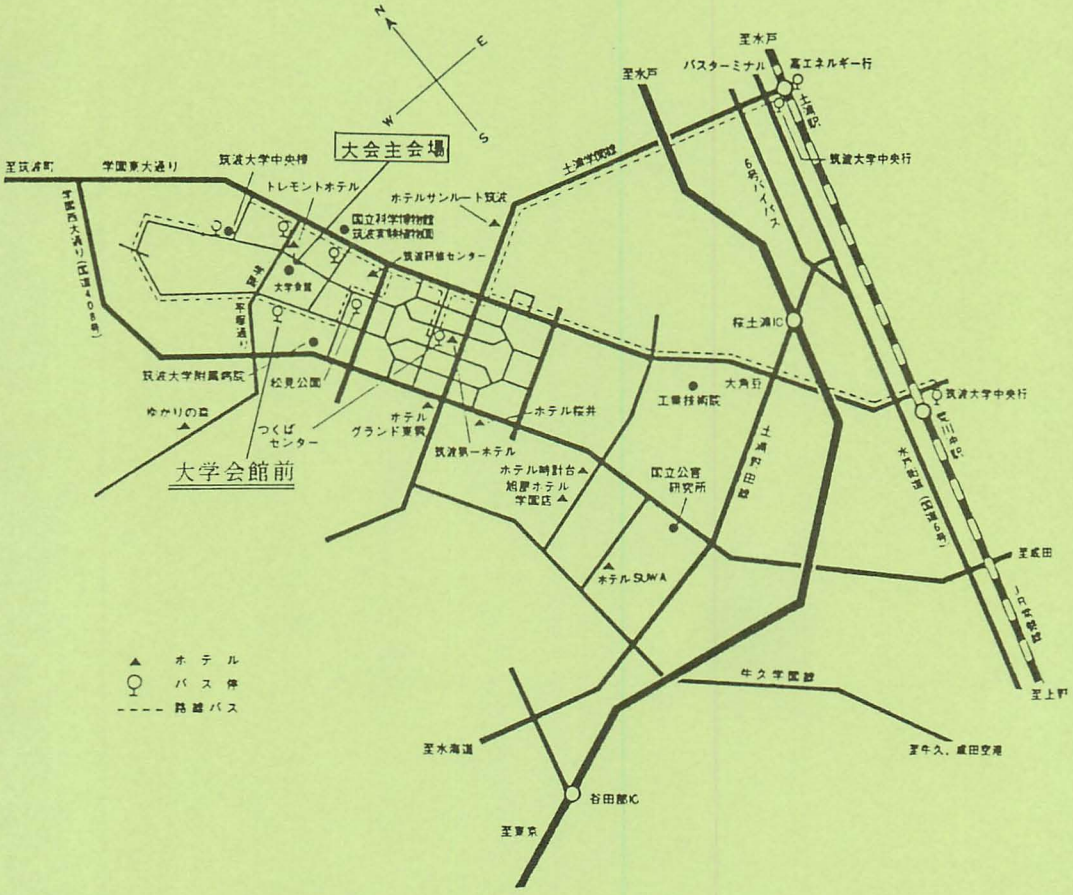
1) 東京駅八重洲南口よりつくばセンターまでJR/関東鉄道の高速バスが15-30分おきに出ています。所要時間は下りが65分，上りが150分，料金は片道1230円です（回数券5枚綴り5100円）。つくばセンターからは，関鉄

バス「筑波大学中央行」で大学会館前下車（160円，約18分），タクシーは約900円，約 7 分。

2）上野駅からJR 常磐線で荒川沖駅または土浦駅下車（70–80分），荒川沖駅東口または土浦駅西口より関鉄バス「筑波大学中央行」で大学会館前下車（荒：470円，土：510円，約50分），タクシーは約3000円，約25分。

3）自動車では首都高 6 号線→常磐道（谷田部もしくは桜土浦 IC）→土浦野田線→西大通りもしくは東大通り→筑波大学中央口→中央自由駐車場もしくは北自由駐車場→大学会館（徒歩 5 分）。案内図参照。

案内図



第2回日韓藻類学シンポジウム

（日本藻類学会秋季シンポジウム）

筑波大学国際会議場

8-11 September 1991

参 加 申 込 書

氏　　名：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

（日本語，英語で併記して下さい。）

所属・住所：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

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電　話：＿＿＿＿＿＿＿＿＿＿＿＿＿＿　FAX:＿＿＿＿＿＿＿＿＿＿＿＿＿＿

講　　演：（　　）一般講演　（　　）招待講演　（　　）特別講演

TITLE：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

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懇親会・その他：参加するものに○を記入して下さい。

（　　）歓迎懇親会（9月8日，大学会館レストランプラザ，会費：2,000円）

（　　）若手研究者の集い“筑波の夕”（9月9日，つくば市内）

（　　）バンケット（9月10日，会場未定，会費：5,000円）

（　　）ワーク・ショップ “INTRODUCTION TO THE PHYTOFLAGELLATES”
（9月11日，筑波大学第2学群実験室，参加費：10,000円）

送金合計＿＿＿＿＿＿＿＿円

要望・連絡事項

Jpn. J. Phycol. (Sôrui) 39: 115–121, June 20, 1991

Mixed phases reproduction of *Polysiphonia morrowii* Harvey (Rhodomelaceae, Rhodophyta) in culture*

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Department of Botany, Seoul National University, Seoul, 151-742 Korea

Lee, W.J. and Lee, I.K. 1991. Mixed phases reproduction of *Polysiphonia morrowii* Harvey (Rhodomelaceae, Rhodophyta) in culture. Jpn. J. Phycol. 39: 115–121.

The life history of *Polysiphonia morrowii* Harvey isolated from Gyokpo, Korea, was investigated in culture. *P. morrowii* basically showed a *Polysiphonia* type of life history. However, monoecious and mixed phases reproduction was also exhibited. The procarps on these unusual plants were proved to be sterile, while spermatia were fertile. A few tetraspores from the mixed phases plant grew to both normal tetrasporophytes and sterile plants. These tetrasporophytes released tetraspores which grew to male, female, monoecious, mixed phases, and sterile plants. Monoecious and mixed phases plants repeatedly occurred twice in cycle via tetraspores during this culture.

Key Index Words: culture study—life history—mixed phases reproduction—monoecious—Polysiphonia morowwii.

Life history of the genus *Polysiphonia* has been regarded as the typical one, so called *Polysiphonia* type. However, a few species of *Polysiphonia* were reported to produce asexual propagules in addition to sexual reproduction (Kapraun 1977, Womersley 1979, Byun and Kang 1986, Kudo and Masuda 1986) and to have mixed phases plants in field (Yoon 1981).

Such unusual phenomenon as mixed phases reproduction has been reported frequently for a number of red algae (e.g. Knaggs 1969, West and Hommersand 1981). These studies, however, are mostly limited to descriptive observations of field collections except for a few laboratory cultures (West and Norris 1966, Rueness and Rueness 1973, 1978, 1985, van der Meer and Todd 1977, Lee and West 1979, Notoya and Yabu 1981, Boo and Lee 1983, Notoya 1983, Choi and Lee 1987, West and Calumpong 1988, Kim and Lee 1989). The only satisfactory genetical explanation for such phenomena was given to *Gracilaria tikvahiae* McLachlan by van der Meer and his co-workers (van der Meer and Todd 1977, van der Meer *et al.* 1984, van der Meer 1986).

In this study, we examined the life history and the fate of the spores produced by monoecious and/or mixed phases plants of *Polysiphonia morrowii* Harvey isolated in Korea.

Materials and methods

Polysiphonia morrowii Harvey was collected from the intertidal zone of Gyokpo in the western coast of Korea in April 1985. Unialgal culture was established with vegetative branch apices. All the isolates were precultured in 1/2 PES medium under cool white fluorescence light below 500 lux for 6–7 days. Subsequent cultures were obtained from tetraspores produced from these vegetative thalli after about three weeks. Cultures were maintained in PES-enriched seawater medium at 1,000 lux (photoperiod, 16 : $\overline{8}$ hr) and 15°C.

Results

Polysiphonia morrowii was originally described by Harvey (1856) on the basis of the

* This work is partially supported by a Grant from KOSEF 871-0409-002-2

specimens collected at Hakodate, Japan. This species is characterized by the tufts of axillary tetrasporangial branchlets. The followings have been described as characters to distinguish it from the related species, *P. senticulosa* Harvey and *P. urceolata* Greville (Segi 1951, 1960, Tokida 1954): 1) tufted tetrasporangial branchlets, 2) branchlets endogenously originated, 3) dark reddish thalli, and 4) relative length of segments of the main axis. However, these characters were regarded as variable with age and habitat (Kudo and Masuda 1981, Yoon 1986). Kudo and Masuda (1981) demonstrated that the alga called *P. senticulosa* in Japan was the same as *P. morrowii*. Yoon (1986) reduced *P. senticulosa* Harvey and *P. urceolata* sensu Yamada (1928), Okamura (1936), Segi (1951), and Kang (1966) to a synonym of *P. morrowii*. Kudo and Masuda (1988), however, mentioned that *P. morrowii* differed from genuine *P. senticulosa* in having thicker thalli and 7-8 axillary branchlets which bore tetrasporangia.

Descriptive characteristics of plants: The vegetative structure of *P. morrowii* was described and illustrated by Harvey (1856), Segi (1951), Kudo and Masuda (1981) and Yoon (1986). Our plants collected at Gyokpo accorded well with them.

The thallus consists of four siphons and adheres to rocky substrata with rhizoids. It is densely tufted, slender and elongate, becoming up to 25 cm high. Unicellular rhizoids irregularly arise as outgrowth of pericentral cells. They develop on the basal portion and sometimes on middle portion of the erect thallus.

The branches arise exogenously in every 3-7 segment. However, the prostrate branch is endogenous from the lower part of erect main axes, showing variable diameters (150-250 μm). The ratio of main axial segments (dia. 270-550 μm) in length to width is variable according to age and thallus (Table 1). Ultimate branch arises alternately in 3-8 segments interval and is sharply pointed. The axillary branchlets develop endogenously from a central axial cell.

A few colorless trichoblasts arise near the apex of branch and are 2-3 furcate and deciduous, leaving inconspicuous scar cell from which cicatrigenous branch sensu Hollenberg (1942) sometimes arises. Cultured thallus shows basically the same morphological characters as field collected one (Table 1).

When a tetrasporophytic plant becomes fertile, tetrasporangia develop on ultimate branches, axillary branchlets and sometimes on indeterminate branches of the thallus. Thus, 3-8 axillary branchlets bearing tetrasporangia congregate on an axil. Mature tetrasporophytes bear few thrichoblasts and rare scare cells. Tetrasporangia mature acropetally in a stichidium. Tetraspores released are 55-75 μm in diameter. A mature spermatangial branch is slightly incurved, 650-850 μm long and 45-85 μm broad. It provides with a long sterile tip con-

Table 1. Comparison of vegetative structure between field-collected and cultured plants.

		Field-collected*		Cultured**	
		January	March	1 month	2 months
Height (cm)		3-10	10-25	2-4	3-7
L/D of axis	Upper	0.3-0.5	0.3-0.5	0.5-1.0	0.5-1.0
	Middle	1.5-2.0	2.0-3.5	1.0-2.5	1.5-3.0
	Lower	2.0-4.0	2.5-4.0	1.2-2.0	1.0-2.0
Branch interval (segment)		3-7	3-5-(7)	3-15	3-10-(15)
Trichoblast		scarce	scarce	frequent/scarce	frequent/scarce
Length of determinate branch (segment)		10-20	13-20	15-35	15-35
Axillary tetrasporangial brachlets		non	1-8	non	non/1-5

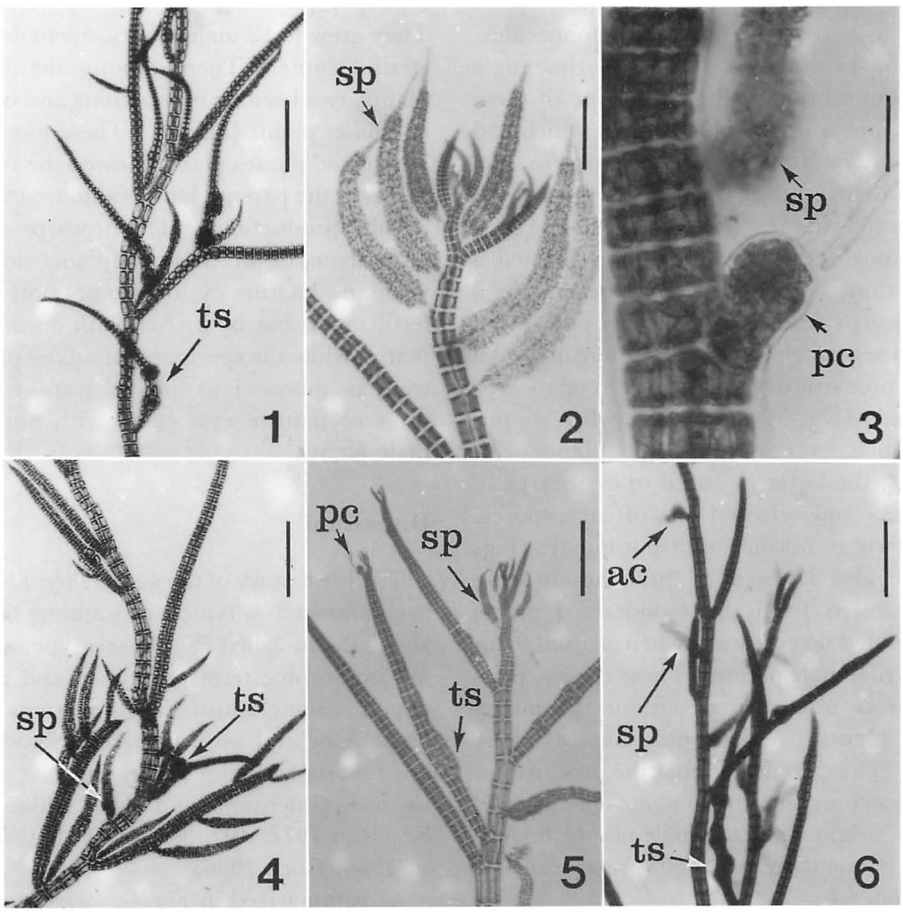
* Collected at Gyokpo.
** Cultured at 15°C and 1000 lux (18 : 6 LD).

sisting of a few elongate cells at the apex and is supported by an one-celled stalk. The branches bearing procarp arise alternately on the apical part of indeterminate branches. The mature cystocarp is urceolate, 350-450 μm long and 250-300 μm broad. The released carpospores are 50-65 μm in diameter. A fully mature pericarp is two-cell layered and has a wide ostiole at the top.

Life history in culture: Four vegetative thalli isolated from Gyokpo were proved to be tetrasporophytes in laboratory culture. All of them produced tetrasporangia in three weeks. A total of 76 tetraspores were isolated from the tetrasporophytes for further study. Among them, 33 spores grew to mature plants bearing the spermatangia in 6-7 weeks (Fig. 2), and 15 spores produced procarps one week later, while 28 spores remained vegetative (Fig. 7).

In order to examine crossability, a single female plant and two male plants were put together in a culture dish. Mature cystocarps appeared in two weeks after that. As a result, 37 carpospores were released from a cystocarp, of which 30 spores grew to tetrasporophytes in 7-8 weeks and 7 spores died in early stages of the growth.

Thus, *P. morrowii* at hand is demonstrated to show a typical *Polysiphonia* type of life histo-



Figs. 1-6. *Polysiphonia morrowii* Harvey in culture. Fig. 1. Tetrasporic plant. Fig. 2. Male plant. Fig. 3. Monoecious plant derived from male plant. Fig. 4. Mixed phases plant derived from male plant, bearing tetrasporangia and spermatangia on the same branch. Fig. 5, 6. Mixed phases plants derived from male plant, bearing procarps and tetrasporangia in addition to spermatangia on the same branch. ac, aborted cystocarp; pc, procarp; sp, spermatangial branch; ts, tetrasporangium. Scale bar: 1, 4-6, 300 μm; 2, 250 μm; 3, 130 μm.

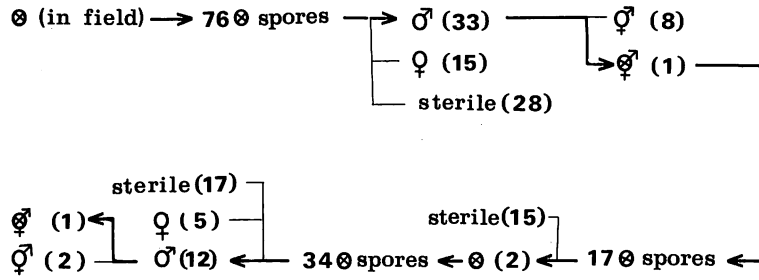


Fig. 7. The fate of tetraspores released from *Polysiphonia morrowii* Harvey in culture.

ry, and requires approximately 18-20 weeks for completion of the cycle in laboratory culture.

Unusual reproduction in culture: During the culture, some of the male plants exhibited unusual sexualities. Among 33 male plants, 8 individuals became monoecious, producing procarps as well as spermatangia on the same branch (Fig. 3). One of them later became a mixed phases plant which had tetrasporangia in addition to procarps and spermatangia on the same branch (Figs. 4-6).

In order to test the fertility of such monoecious sexual structures, we isolated a single branch which had both spermatangia and procarps from a monoecious plant, and cultured separately to check self-fertility. All of these procarps did not mature to cystocarps for 6 weeks (Fig. 3). However, when we put this branch in normal female plants with procarps, the latter matured to cystocarps in two weeks and released lots of carpospores, which grew to normal tetrasporophytes (Fig. 1). We also isolated 13 branches bearing only procarps from the monoecious plants and obtained no cystocarp when crossed them with normal male plants. These cross experiments were also carried out for the mixed phases plants, and could obtain same results. Thus, we found that the procarps on the monoecious and mixed phases plants of *P. morrowii*, originated from male plants, had no fertility, while their spermatia were normally functional.

On the other hand, tetrasporangia of the mixed phases plant released tetraspores after maturation. We could isolate 17 tetraspores among them, and traced the fate individually by separate culture. Two of them grew to produce tetrasporangia on the whole branches in 7 weeks, and other 15 spores remained as sterile thalli for 13 weeks. In addition, among the tetrasporangia obtained from two tetrasporophytes, 34 tetraspores were viable. They grew to 12 male plants, 5 female and 17 sterile plants. Then, among the 12 male plants, two became monoecious and one mixed phases plants (Fig. 7). These monoecious and mixed phases plants showed the same fertilities as the parent plants, exhibiting such unusual reproductions. The procarps on these monoecious or mixed phases plants did not develop into mature cystocarps not only by self-fertilization but by a cross with normal spermatia, while the spermatia of mixed phases as well as monoecious plants were fertile to produce mature cystocarps with normal female plants.

Discussion

The life history of the genus *Polysiphonia* has been known as a typical one among floridean algae, the so-called *Polysiphonia* type, alternating isomorphic tetrasporophyte and gametophytes. Some unusual reproductions such as propagules and mixed phases reproductions are reported among several species of *Polysiphonia* (Edelstein and McLachlan 1967, Kapraun 1977, 1978, Yoon 1981, Cheung *et al.* 1984, Koch 1986).

As summarized in Fig. 8, *P. morrowii* from Gyokpo showed a very interesting unusual life history although based on a typical *Polysiphonia* type. Especially it is remarkable that the monoecious procarps originated from

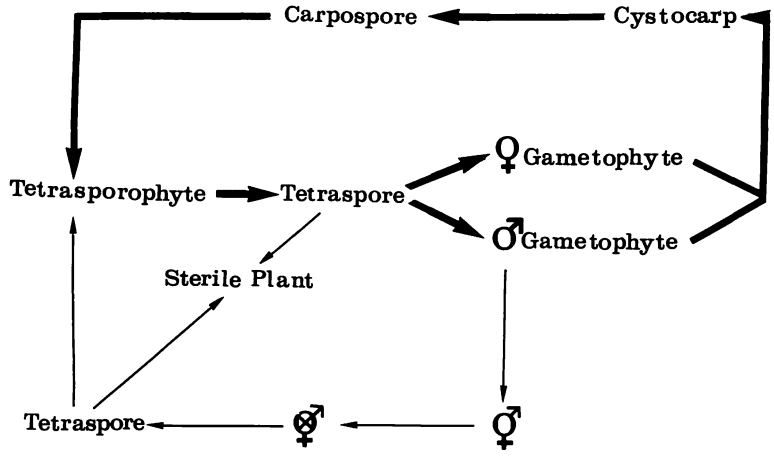


Fig. 8. Life history of *Polysiphonia morrowii* Harvey in culture.

male thallus show no fertility while spermatia are functional, and the tetraspores on the mixed phases plant exhibit viability. Moreover, this unusual life history is repeated through mixed phases tetraspores.

There have been lots of reports about such unusual sexuality during the life history, especially in Ceramiaceae (West and Hommersand 1981). For instance, Whittick and West (1979) demonstrated that monoecious plant of *Callithamnion baileyi* Harvey produced the carpospores by self-fertilization, and the spores developed into tetrasporophytes as seen in dioecious plants. Boo and Lee (1983) reported that the monoecism of *Antithamnion sparsum* Tokida showed a self-fertility and carpospores released from this plants developed into male plant, missing tetrasporophytes in culture.

On the tetraspore of mixed phases plant, West and Norris (1966) reported that the tetraspores on the gametophyte of *Antithamnion pygmaeum* Gardner developed into the same gametophytes as parent in sexuality. Rueness and Rueness (1973) demonstrated that male/tetra mixed phases plants of *Antithamnion tenuissimum* (Hauck) Schiffner were haploid and the spermatia produced by such plants were functional. Moreover, tetraspores derived from the mixed phases plants grew to nonsporangiate normal male and female plants. They demonstrated that spores produced on the male/tetra mixed phases plants were formed apomeiotically. Notoya and Yabu (1981) reported that male/tetra mixed phases plants of *Platythamnion yezoense* Inagaki were always derived from carpospores, while the mixed phases plants bearing tetrasporangia, spermatia and carpogonial branches were derived from tetraspores in culture.

Rueness and Rueness (1985) demonstrated that tetraspores of *Callithamnion tetragonum* (With.) Gray from the mixed phase plant bearing both non-functional spermatia and procarps in addition to tetrasporangia developed into similar mixed phases plants as parent, where the spermatia and procarps were also non-functional and the tetraspores were inviable. The fate of tetraspores on the mixed phases plant of *C. tetragonum* is similar to that of our study, although they did not observe the sterile plants in addition. L'Hardy-Hales (1986) reported that tetraspores on the male gametophyte of *Antithamnionella spirographidis* (Schiffner) Wollaston developed into male and female plants. Hassinger-Huizinga (1952) in *Callithamnion corymbosum* (Sm.) Lyngb., West and Norris (1966) in *Callithamnion* sp. and L'Hardy-Halos (1986) in *Antithamnionella sarniensis* Lyle reported that tetraspores on the tetrasporophyte developed into tetrasporophytes repeatedly, missing the gametophytic phases.

As a result, these unusual sexualities generally seem to exhibit their own peculiar tendency according to species. *P. morowii* at hand

also shows lack of the gametophytic phase in the unusual life history, but the result is not equivalent to those reported previously (Hassinger-Huizinga 1952, West and Norris 1966, L'Hardy-Halos 1986).

van der Meer and Todd (1977) demonstrated that the formation of gametangia on the tetrasporophyte of *Gracilaria tikvahiae* resulted from a mitotic recombination of the gene determining sexuality. But this was in case of diploid tetrasporophytes. They did not explain the mixed phases reproduction in the gametophytes observed by such as West and Norris (1966), Rueness and Rueness (1973, 1985) and in this study.

According to our culture study, *P. morrowii* demonstrates that the mixed phases reproduction occurs during the life history via tetraspores. It seems to be that the mixed phases reproduction once induced in course of the life history can be succeeded stably generation to generation, even though the frequency of occurrence is variable according to environmental conditions (Kim and Lee 1989).

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Wook Jae Lee·In Kyu Lee：モロイトグサ（紅藻フジマツモ科）の培養における混合相生殖

韓国 Gyokpo で単離したモロイトグサ (*Polysiphonia morrowii* Harvey) を培養し，その生活史を調べた。本種は基本的にはイトグサ型の生活史を示したが，雌雄同株ならびに混合相の生殖がみられた。これら正常でない藻体のプロカルプは不稔性であったが，不動精子は稔性であった。混合相の藻体に由来する若干の四分胞子は正常な四分胞子体ならびに不稔性の藻体に発達した。これら四分胞子体は四分胞子を放出し，この四分胞子からは雄性，雌性，雌雄同株，混合相，不稔性の藻体が生じた。本培養実験で，四分胞子経由のサイクルでは雌雄同株ならびに混合相の藻体は引き続いて 2 回生じた。(Department of Botany, Seoul National University, Seoul, 151–742 Korea)

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Sorella pulchra (Yamada) comb. nov., based on *Erythroglossum pulchrum* Yamada (Delesseriaceae, Rhodophyta)

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Yoshida, T. and Mikami, H. 1991. *Sorella pulchra* (Yamada) comb. nov., based on *Erythroglossum pulchrum* Yamada (Delesseriaceae, Rhodophyta). Jpn. J. Phycol. **39:** 123–129.

Erythroglossum pulchrum Yamada is shown to have *Polyneura*-type procarp structures, consisting of two carpogonial branches and one group of sterile cells on a supporting cell. The type species of the genus *Sorella, S. delicatula* (Gardner) Hollenberg also shows the *Polyneura*-type procarp. Most characteristics of *E. pulchrum are* shared with *Sorella*. It is concluded that *E. pulchrum* should be transferred to *Sorella* as *S. pulchra* comb. nov. The procarp arrangement in illustrations of *Searlesia* Schneider et Eiseman agrees also with that of the *Polyneura*-type. The transfer of *Searlesia subtropica* to *Polyneura* is thus proposed.

Key Index Words: Delesseriaceae—Erythroglossum pulchrum—Polyneura subtropica—*Rhodophyta—procarp structure*—Searlesia—Sorella delicatula—Sorella pulchra—*taxonomy*.

Erythroglossum pulchrum, a species belonging to the red algal family Delesseriaceae, was described by Yamada (1938) based on specimens collected at Hayama, Kanagawa Prefecture and sent from the Biological Laboratory, Imperial Palace. The specimens were all tetrasporophytes. There is no further record of this taxon. Recently, a new collection including female gametophytes was obtained from Kanagawa Prefecture, near the type locality. New information on this collection is presented here, and a comparison is made with the female structures of *Sorella delicatula*, the type species of the genus *Sorella*. It is concluded that *Erythroglossum pulchrum* should be placed in *Sorella*.

Materials and Methods

The specimens of *Erythroglossum pulchrum* were collected by SCUBA diving by S. Arai on 14 January 1988 off Akiya, Kanagawa Prefecture, Pacific central Japan. The plants grew between 3 to 10 meters deep as undergrowths in the *Ecklonia* forest. Specimens of *Sorella delicatula* (Gardner) Hollenberg, collected at Point Loma, California, were kindly provided by Dr. Joan Stewart. The materials were preserved in formalin sea water. Microscopic slides for observation were made by mounting in glycerine after staining with aniline blue. Sections were made by hand with a razor blade. Voucher specimens are deposited in the herbarium of Faculty of Science, Hokkaido University (SAP).

Observations

Erythroglossum pulchrum Yamada

External morphology: Female gametophytes as shown in Figure 1 are similar to the tetrasporangial plants described in the protologue (Yamada, 1938) in external morphology. Figure 2 shows an apical part of the thallus with young cystocarps (cy).

Apical organization: Figure 3 represents a young growing apex. It has an apical cell (a) dividing transversely. Intercalary divisions (i) are recognized in the primary cell row. Young procarps are located near the primary cell row.

Procarp: Procarps of this species are scat-

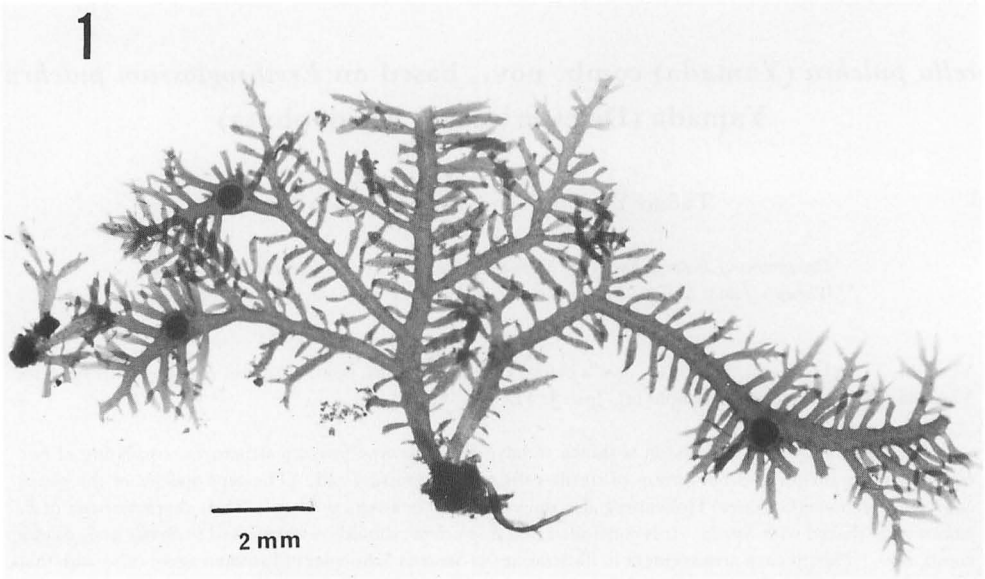

Fig. 1. Female specimen of *Sorella pulchra* (Yamada) comb. nov. collected from Akiya, near Hayama, Kanagawa Prefecture, January 14, 1988.

tered in the apical region of the branches (Fig. 3). They are composed of one group of sterile cells associated with two carpogonial branches originating from the supporting cell (sc). The development of this type of procarp, *Polyneura*-type (Kylin, 1924), is shown in Figures 4–9. Figure 4 indicates that the initial of the supporting cell (sci) cuts off a sterile cell mother cell (stmc) and laterally a mother cell of the first carpogonial branch ($cbmc_1$). The mother cell of the first carpogonial branch divides further (Fig. 5) to form a first cell of carpogonial branch (cb_1) and an initial of carpogonial branch (cbi), and the mother cell of the second carpogonial branch ($cbmc_2$) is cut off from the other side of the supporting cell. These two carpogonial branches are composed of 2 cells in Figure 6 and of 3 cells in Figure 7. At this stage, the sterile cell mother cell undergoes a division and becomes 2 cells (stc). Following two further divisions are shown in Figures 8 and 9. Here the sterile cells form a set of 4 cells and become enlarged with much nutrient material, and attached adjacent to them are the 2 carpogonial branches composed of 4 cells each with a carpogonium bearing a trichogyne (tr). In some cases, a group of sterile cells composed of 8 cells was observed.

Cystocarp: Only one cystocarp usually develops from a group of procarps formed together. Accordingly, a small number of cystocarps developed on an individual. Mature cystocarps measure 480–550 μm in diameter, nearly corresponding to the breadth of branch (Fig. 1). Figure 10 shows gonimoblast filaments in a younger cystocarp, and a cross section of nearly mature cystocarp is given in Figure 11. A large fusion cell (fu) is formed at the base and gonimoblast filaments with short segments radiate from the fusion cell. Carposporangia (ca) are formed in

Fig. 2–11. *Sorella pulchra* (Yamada) comb. nov. 2. A part of frond with young cystocarps. 3. Apex of frond showing apical segmentation and young procarps. 4–9. Stages in development of procarp in surface view. 10. Early stage in development of gonimoblasts. 11. Cross section of a cystocarp. Numerals 1–6, first-order cell row (primary segments produced by an apical cell division); a, apical cell; ca, carposporangium; cb_1, cb_2, cb_3, first, second and third cells of carpogonial branch; cbi, initial cell of carpogonial branch; $cbmc_1$, $cbmc_2$, first and second mother cells of carpogonial branch; cp, carpogonium; cy, cystocarp; fu, fusion cell; gon, gonimoblast; i, secondary cell produced by intercalary division; po, aperture of cystocarp; sc, supporting cell; sci, initial cell of supporting cell; stc, steril cell; stmc, mother cell of steril cell; tr, trichogyne.

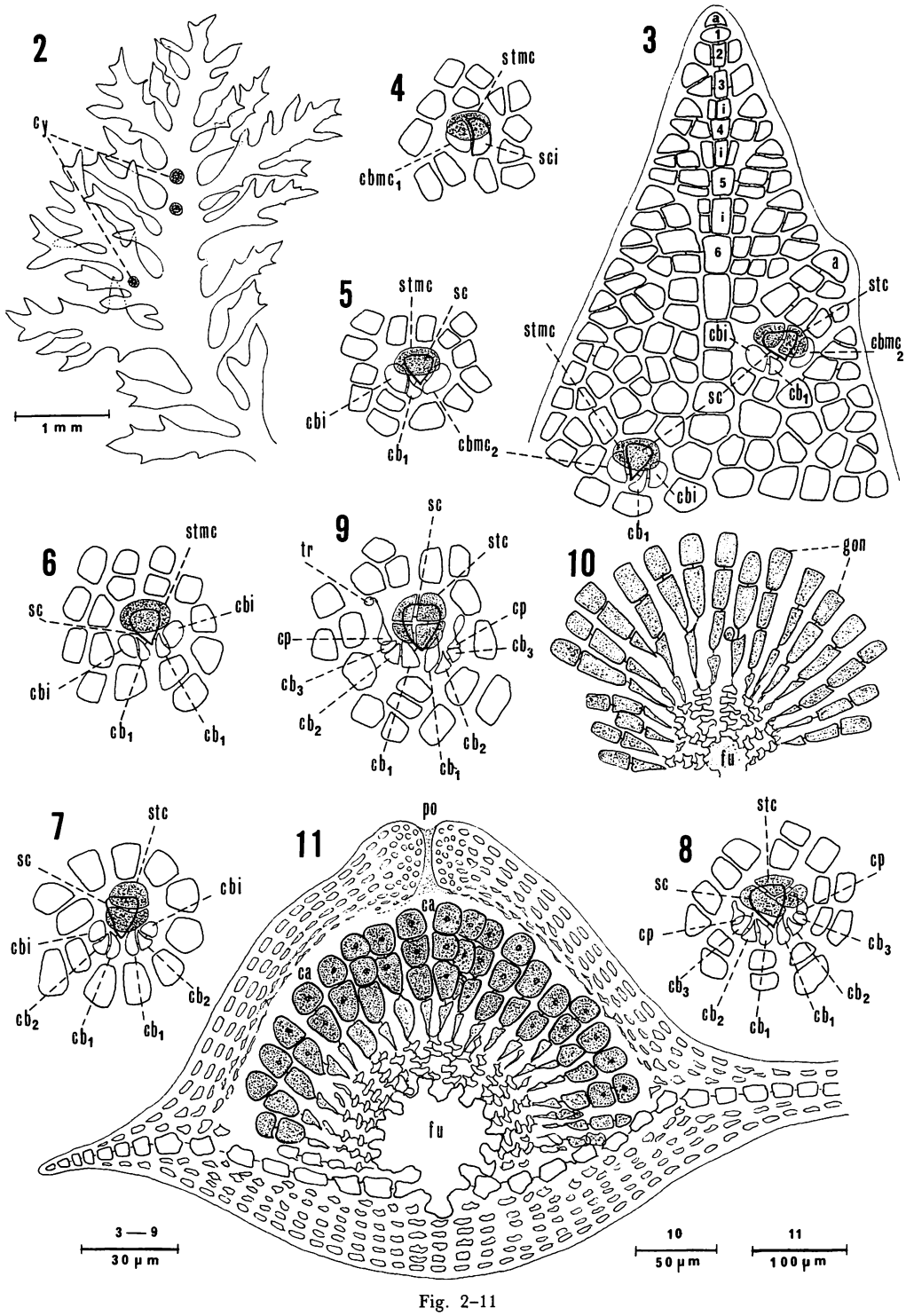
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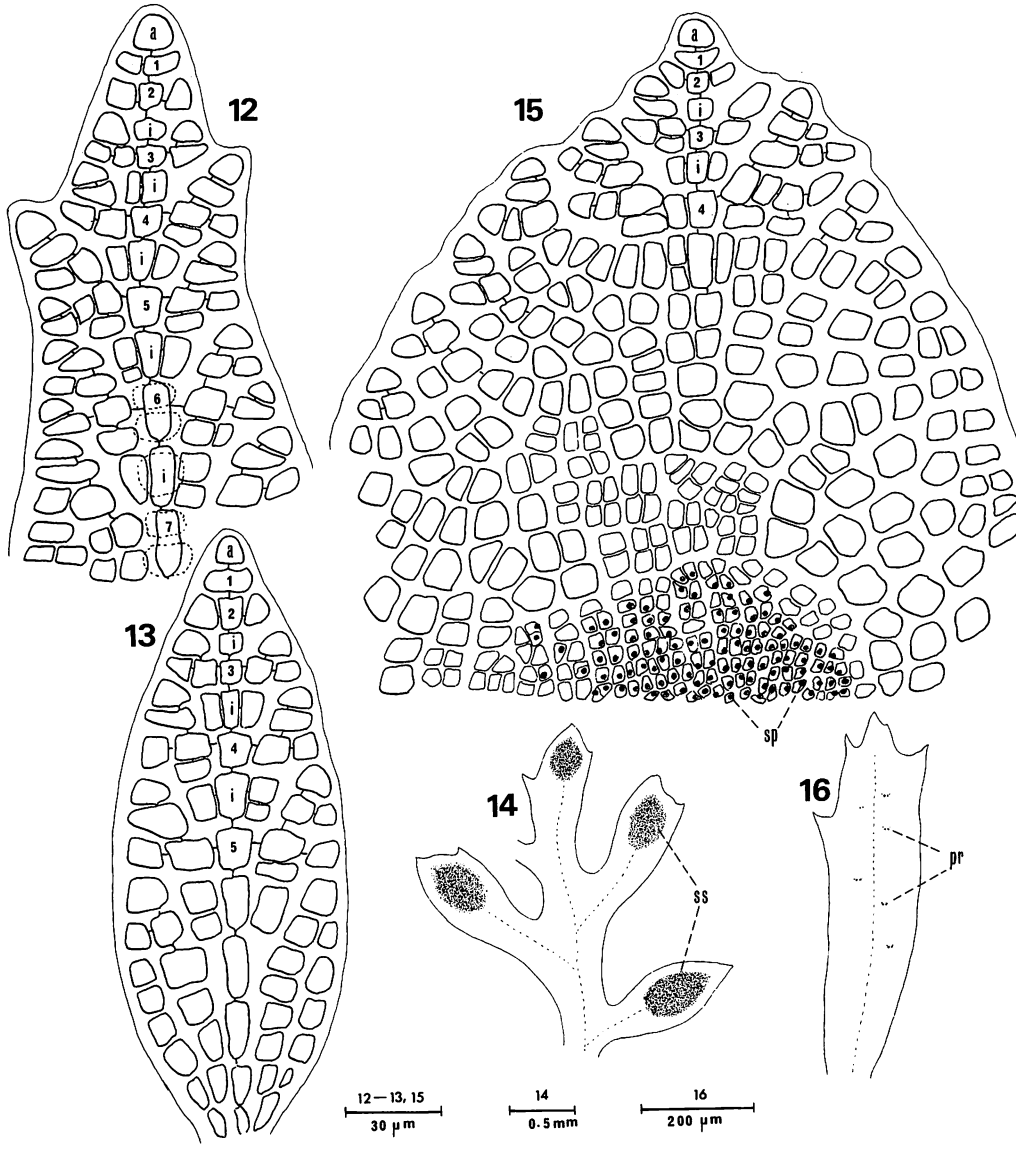
Fig. 2–11



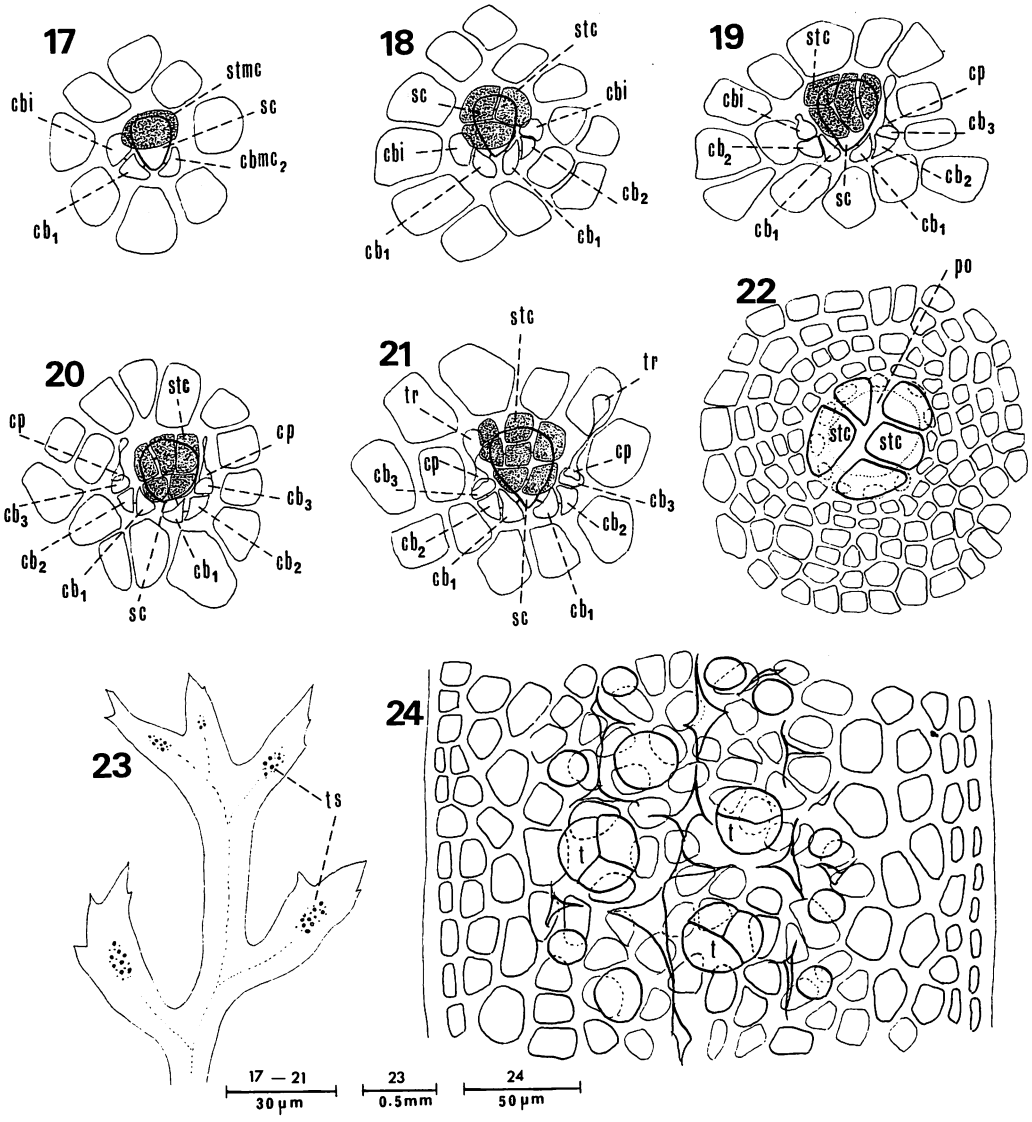
Figs. 12–16. *Sorella delicatula* (Gardner) Hollenberg. 12–13. Apex of frond showing apical segmentation. 14–15. Spermatangial sori (ss). 16. Apical portion of female frond showing the position of procarps (pr). For abbreviations see Figs. 2–11.

short chains on the distal parts of gonimoblasts. Carposporangia are 22–33 × 42–50 μm in size. Cytocarps are hemispherical in shape with an ostiole (po) on the center elevated from the surface of the branch. Because the female plants are decumbent in habit, cystocarps are usually developed on one side of the thallus.

Sorella delicatula (Gardner) Hollenberg

Apical organization: As shown in Figures 12, 13 and 15, this species has a transversely dividing apical cell (a). Intercalary divisions (i) are frequent in the cell rows of first order.

Reproductive structures: Procarps are scattered on the apical part of the branches as shown in Figture 16. Figure 17 represents an early stage in the development of the



Figs. 17–24. *Sorella delicatula* (Gardner) Hollenberg. 17–21. Stages in development of procarp in surface view. 22. Surface view of young cystocarp. 23. A part of frond with tetrasporangial sori (ts). 24. Surface view of tetrasporangial sorus. t, tetrasporangium. For abbreviations see Figs. 2–11.

procarp. Here a supporting cell cuts off a mother cell of sterile cell (stmc) and a carpogonial branch on one side and a mother cell of another carpogonial branch ($cbmc_2$) on the opposite side. The mother cell of sterile cell has divided twice to form a group of 3 cells, although carpogonial branches remain immature (Fig. 18). Figures 20 and 21 show mature stages of procarps with a group of sterile cells containing up to 7 cells and a pair of 4-celled carpogonial branches.

Spermatangial sori are oval to long elliptical in outline and located on the central region of the blade (Fig. 14).

Tetrasporangial sori are formed in similar position as spermatangial sori (Fig. 23). Tetrasporangia are cut off from the primary cells, spherical in shape and dividing tetrahedrally.

Discussion

Hollenberg (1943) established a new genus *Sorella* based upon *Erythroglossum delicatulum* Gardner and named as the type species *Sorella delicatula*. He stated that *Erythroglossum* had tetrasporangial sori formed along the margins of the thallus (Kylin, 1924) and *Sorella* was distinguished from it by the central position of sori. He failed to give detailes of the female reproductive structures. At the same time, he transferred *Erythroglossum repens* Okamura to *Sorella* as *S. repens* (Okamura) Hollenberg. I. Yamada (1971), in his work on the reproductive structure of *S. repens*, verified the characteristics of tetrasporangial and spermatangial sori pointed out by Hollenberg for *Sorella*. He made clear the structure of the procarp in the genus *Sorella* for the first time, showing that *E. repens* had the procarp characteristics of *Polyneura*-type as defined by Kylin (1924), in that the procarps were dispersed on the thallus surface and composed of only one set of sterile cell group and 2 carpogonial branches born on the same supporting cell. Stewart (1977) observed reproductive structures in *S. delicatula*, stating that the procarp organization "appeared similar to those described for *S. repens*" by I. Yamada (1971). We confirmed and showed details of procarp development.

Mikami (1987), after examining the holotype (SAP 048988) and a syntype (SAP 048986) of *Erythroglossum pulchrum* Yamada, recognized that this species had tetrasporangial and spermatangial sori formed on the central area of the branchlets, conforming to the *Sorella*-type. He stated that it was too early to decide the taxonomic status of this species because there was no information on the female plants. But through the observation on the female individuals newly discovered and collected, the procarp of this species is now shown to be of the *Polyneura*-type as demonstrated above.

It is well understood that the type of procarp structure is one of the important characteristics at generic level in this family, in that in a given genus all species have the same type of procarp structure. Among the genera of the Nitophylloideae, the taxa that have been shown to have procarps of *Polyneura*-type organization are *Sorella repens* (Yamada 1971), *S. delicatula* (Stewart 1977 and our observation), *Erythroglossum minimum* (Mikami 1976) and *E. pinnatum* (Mikami 1977), other than the species of *Polyneura*.

In this connection, ***Searlesia*** (Schneider & Eiseman 1979), described from the western Atlantic, was reported to have a procarp structure resembling the *Phycodrys*-type. This type differs principally from the *Polyneura*-type in the posession of 2 groups of sterile cells and a carpogonial branch on a supporting cell (Kylin 1956). From a careful examination of figures given in their paper (figs. 5-11), however, the procarp structure of *Searlesia* is certainly of *Polyneura*-type and not to be interpreted as *Phycodrys*-type. The structure interpreted as the first sterile cell group (stg_1) in their figs. 8 and 9 is none other than the second carpogonial branch, and the second sterile cell group (stg_2) in their fig. 11 is clearly the superimposed image of the carpogonial branch formed on the ventral side of the thallus, i.e. there is only one group of sterile cells. Therefore we conclude that they misinterpreted the procarp structure, especially the relative position of the carpogonial branch and sterile cell group in *Searlesia*. Since the procarp structure of *Membranoptera subtropica* Schneider (Schneider and Eiseman 1979) is here shown to be of the *Polyneura*-type, and characteristics of apical organization and tetrasporangial sori are also the same as those of the genus *Polyneura*, there is no need to establish the genus *Searlesia*, and this species can be accomodated in the genus *Polyneura* as *P. subtropica* (Schneider) comb. nov. (Basionym: *Membranoptera subtropica* Schneider, 1974: 1097; synonym: *Searlesia subtropica*).

In this paper, *Sorella delicatula* (Gardner) Hollenberg, the type species of *Sorella*, is shown to have the procarp structure of *Polyneura*-type.

From the viewpoint of all considered characteristics, *Erythroglossum pulchrum* is concluded to be placed in *Sorella*. Therefore we propose

the following combination:

Sorella pulchra (Yamada) Yoshida et Mikami, comb. nov.

Basionym: *Erythroglossum pulchrum* Yamada 1938: 124. *pl. 24, f. 1.*

Acknowledgements

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吉田忠生*・三上日出夫**：紅藻コノハノリ科クシノハウスベニ

***Sorella pulchra* (Yamada) comb. nov.**

神奈川県葉山沖で新たに採集されたクシノハウスベニの雌性体で，プロカルプが *Polyneura* 型であることが明らかになり，既知の精子嚢斑，四分胞子嚢斑の位置や生長点構造からクシノハウスベニは *Sorella* 属に移すべきであると結論された。これまで知られていなかった *Sorella delicatula* (Gardner) Hollenberg についてもプロカルプが *Polyneura* 型であることを示した。大西洋産の *Searlesia* 属のプロカルプについては原著者等の解釈に誤りがあることを指摘し，その結果この属を認めず，タイプ種は *Polyneura subtropica* とすべきことを提案する。(*060 札幌市北区北10条西 8 丁目　北海道大学理学部植物学教室，**062 札幌市豊平区西岡3-7-3-1 札幌大学女子短大部)

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Observations of *Eunotia arcus* Ehr., type species of the genus *Eunotia* (Bacillariophyceae)

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Mayama, S. and Kobayasi, H. 1991. Observations of *Eunotia arcus* Ehr., type species of the genus *Eunotia* (Bacillariophyceae). Jpn. J. Phycol. 39: 131–141.

Morphological studies of *Eunotia arcus* Ehr. var. *arcus*, type species of the genus, have been carried out with electron microscopy using the classical material collected from Degernäs (the type locality) and the Japanese material. The former material contains various sizes of valves including both initial and first division valves. The following characteristics of the post-initial thecae of this taxon are stable: external and internal surface structure; striae density; arrangement of the pattern center to the valve face and mantle juncture; raphe placement; location of labiate process; areola structure; areolae density; epitheca depth. As for the epitheca depth, a detailed examination comparing this taxon and *Eunotia arcus* var. *bidens* Grun. has been carried out. Special attention has been paid to the areola structure and the structure of initial valves.

Key Index Words: *areola—diatom—epitheca*—Eunotia—Eunotia arcus—*fine structure—initial valve—topotype material.*

Eunotia arcus Ehr. var. *arcus* known to be a cosmopolitan species and occurring in slightly acidic to circumneutral water, is the type species of the genus designated by Boyer (1927). Though many taxonomists and ecologists have described this species, no observation of the type specimen has been made yet. As is seen in the other *Eunotia* species, this species also shows a wide variation in valve size and shape. This seems to be one of the main reasons that many infraspecific taxa, 6 forms and 24 varieties (according to VanLandingham 1969), have been made.

We have found topotype material of *E. arcus* in the Swedish Museum and have examined it light microscopically, and this material has been strongly assumed to be taken from the same lump as examined by Ehrenberg (1837) (Mayama and Kobayasi 1990). In this material, post-initial valves in various sizes and shapes are contained in addition to the initial valves. This is a valuable material to study a whole variation of valves during the life cycle of this species. In the present study, the fine structure of the topotype specimens is observed in comparison with the Japanese ones and the stable characteristics of the species are discussed.

Materials and Methods

The material examined is listed as follows:
(1) Topotype material: diatomite from Cleve's collection 247, Degernäs in Sweden, graft, housed in the Swedish Museum of Natural History, Stockholm, (our sample number, K-6686).
(2) Recent materials from Japan: an epipelic sample from Sugenuma Pond, Gunma Pref., on 17 June 1986, K-5865; an epiphytic sample from Saino-ko Pond, Tochigi Pref., on 17 June 1986, K-5879.

These materials were boiled with sulfuric acid and potassium permanganate to remove organic matter, or were suspended with hydrogen peroxide and then cleaned softly by ultraviolet radiation so as not to take the frustule apart. After one or the other treatment specimens were washed in distilled water. For SEM observations specimens

were dried on glass coverslips which were then fixed to metal stubs. They were coated with gold-palladium using JEOL JFC-1100 and observed with JEOL F15. Specimens for TEM were placed on formvar-coated copper grids and observed with JEOL 100B.

Observations and Discussion

Specimens from the topotype material show various valve shapes and sizes (Fig. 1A). The longest valve is an initial valve and 115 μm (Figs. 1A with asterisk, 2, 4). The reason why we can recognize this specimen as an initial valve of *Eunotia arcus* is that we have found an initial valve paired with a first division valve (first vegetative valve) of *E. arcus* (Figs. 3, 5). The initial valve is rounded in the cross section and the valve face cannot be distinguished from the valve mantle. The ventral side is concave and the dorsal side is convex, and they are parallel throughout the valve. The valve ends have a semidome-like form and they have no construction of the dorsal side as seen in typical vegetative valves (Figs. 6, 7, 12, 13, 22, 25).

There has been no SEM observation of the initial valve of *Eunotia*, and even in the other raphid diatoms few observations of the fine structure have been carried out (Krammer 1982, *Cymbella silesiaca*; Mann 1982, 1984a, *Rhoicosphenia curvata, Gomphonema intricatum, Cymbella* sp., *Cocconeis pediculus*; Cohn *et al.* 1989, *Navicula cuspidata*). These initial valves are reported to have a rounded section as in *E. arcus*. Geitler (1951) observed initial cells in the specimens identified as *E. arcus*, and despite light microscopy, his description of the initial valve agrees well with our SEM observations. However, our specimen does not completely conform his description and illustrations of a bent girdle view. We have observed such a bend in *Eunotia tropica, Eunotia* sp. and *Actinella brasiliensis* (unpublished data) but have not recognized such a bend in the present specimen. Cohn *et al.* (1989) have observed that the central area is not rounded but depressed in both initial epi- and hypovalves of *Navicula cuspidata*. Mann (1984b) has

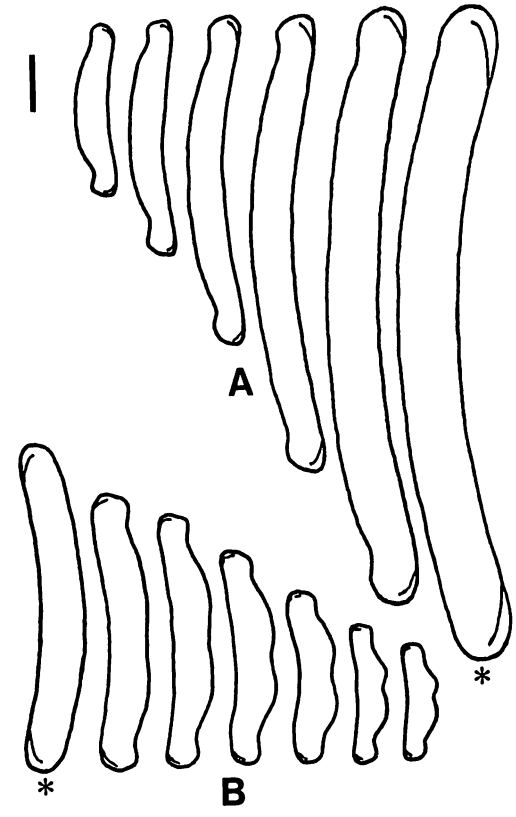
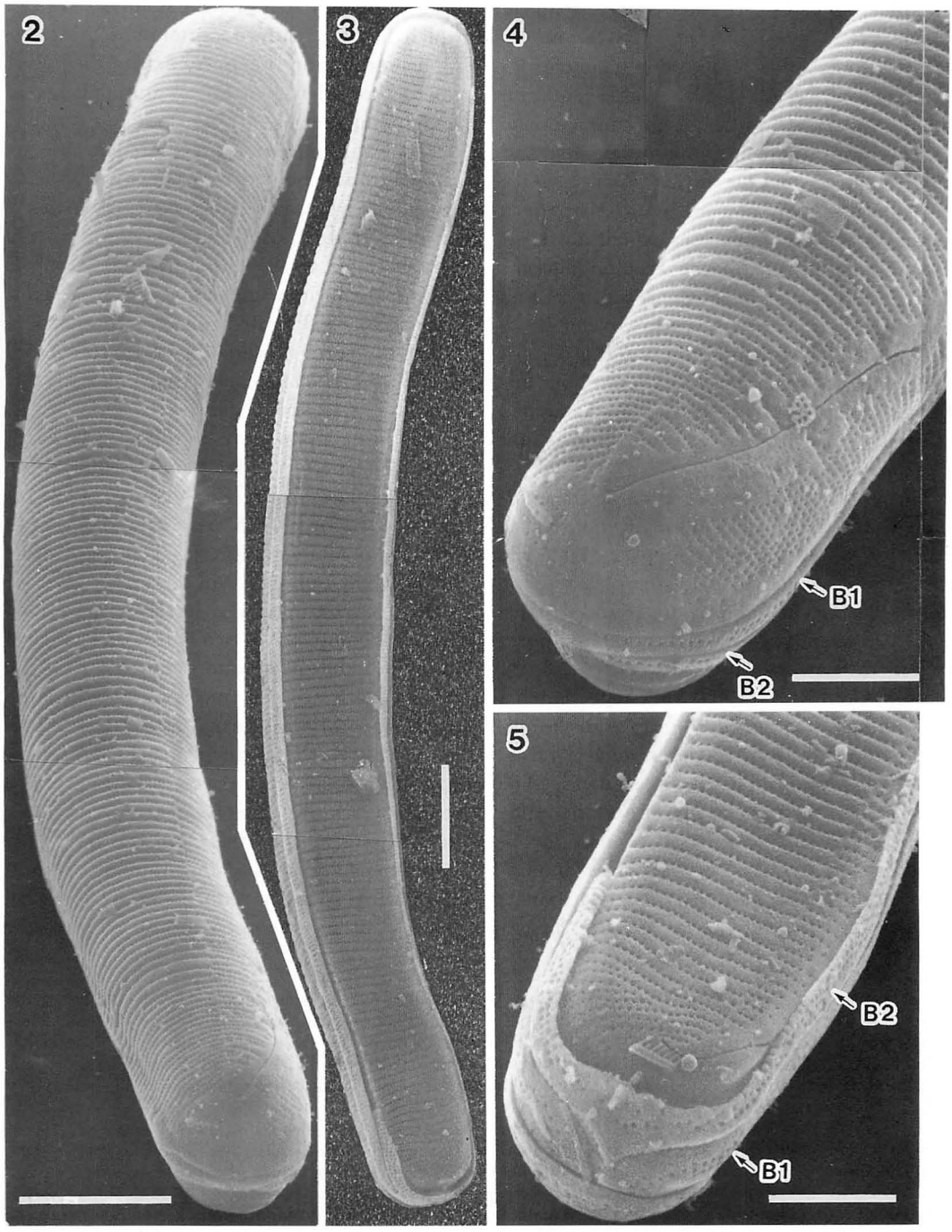


Fig. 1. Variations of valve size and outline seen in two populations of *Eunotia arcus*. The valves with asterisks are initial valves. A: *E. arcus* var. *arcus*. Topotype material, B: *E. arcus* var. *bidens*. K-5879. Scale bar=10 μm.

reported the central constriction of the initial epivalve in the girdle view in *Neidium affine*. However, our specimen has neither such a depression nor constriction at the centre. Cohn *et al.* (1989) have suggested the accumulation of mucilage secreted from the central raphe endings as one of the reasons for this depression, however, our initial valve without such a depression has no central raphe endings at the center.

Mann (1984a) has pointed out a wide hyaline marginal strip characteristic of their initial epivalves in the four species, *Rhoicosphenia curvata, Gomphonema intricatum, Cymbella* sp. and *Cocconeis pediculus*. However, our specimen does not have such a structure.

In the initial valve, a pattern centre, or a sternum, runs between both apical raphe endings (Fig. 2) which are located at the centre of



Figs. 2–5. *Eunotia arcus* var. *arcus*. Scale bars = 10 μm (Figs. 1, 2) or 5 μm (Figs. 4, 5) Fig. 2. Oblique external view of initial cell with rounded section. Topotype material. Fig. 3. External view of a first division valve with flat valve face. Topotype material. Fig. 4. Detail of Fig. 1 showing the initial epivalve with two bands (B1, valvocopula and B2). Fig. 5. Detail of Fig. 2 in oblique view. A first division valve is seen inside the initial hypotheca with two bands (B1 and B2).

the apices (Fig. 4). It runs along the apical axis near the valve ends (Figs. 1, 3) but moves away from the apical axis gradually, and its location is most eccentric at the valve centre on the ventral side (Fig. 2). This characteristic placement is only seen in the initial valve and is not in the vegetative valves (Figs. 3, 5-11, 25), however, this placement of the pattern center may imply some clues explaining a systematic relationship to the araphid diatoms such as postulated by Simonsen (1979) and Mann (1984c). The initial epivalve of *E. arcus* drawn by Geitler (1951) has the pattern center interrupted in the valve centre, but this discrepancy seems to be caused by the arched valve face and the observation with a light microscope.

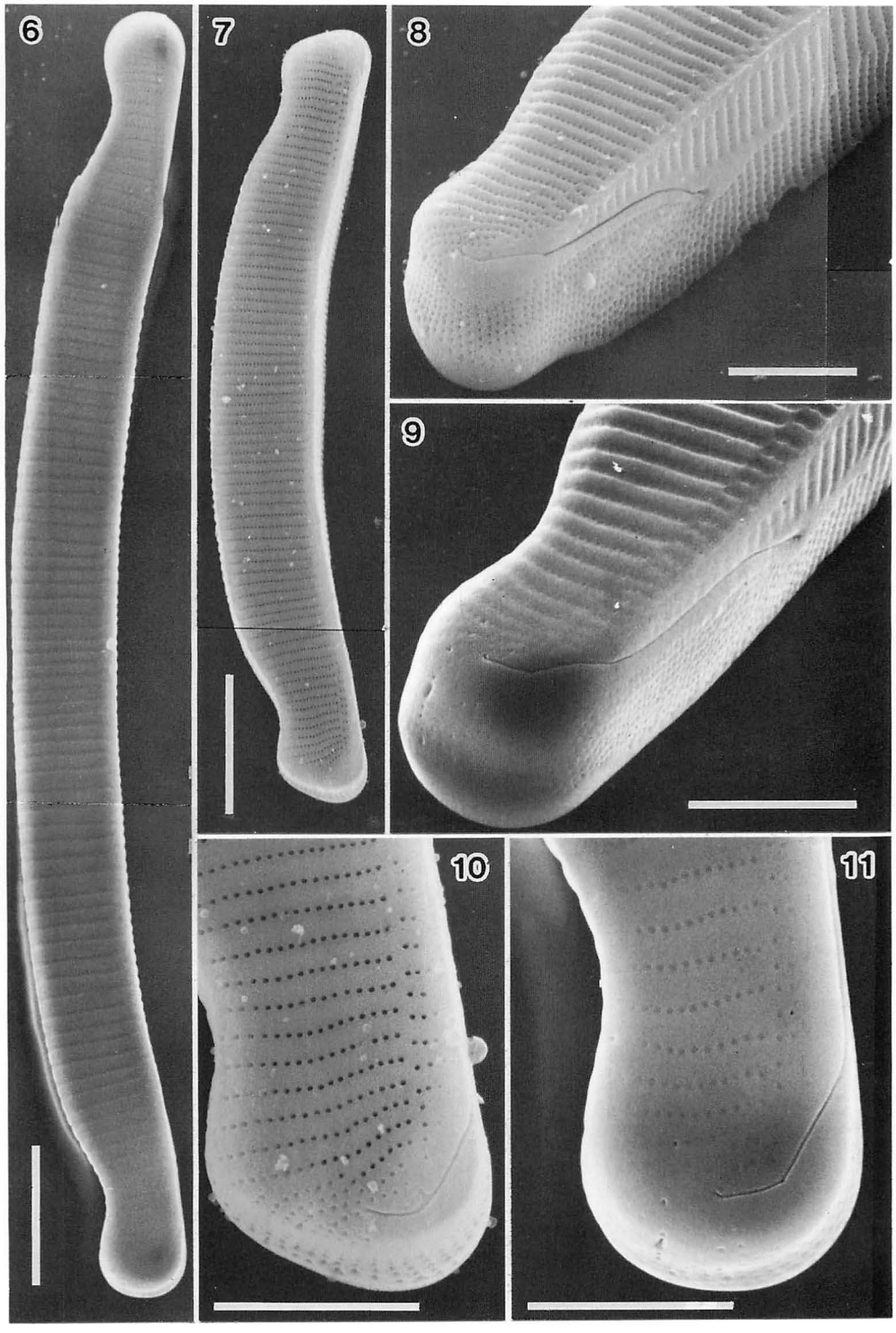
The polar raphe fissure ends at the midpoint of the valve breadth, somewhat distant from the apical margin (Figs. 2, 4). The raphe branch extends down smoothly into the central ending because of the rounded valve face, and terminates in slightly dilated pores as seen in the vegetative cells (Figs. 4, 8, 9). Though Cohn *et al.* (1989) have represented a raised area surrounding the raphe in the initial valve of *Navicula cuspidata*, such a raised area does not appear in our specimens. The placement of the pattern center and the raphe as seen in the initial valve of *E. arcus*, is observed in some other *Eunotia* species (unpublished data), and perhaps these placements are a common feature in the genus. Therefore, *Eunotia shweickerdtii* Cholnoky (1954), which has the pattern center and the polar raphe endings on the apical axis of the valve, can be considered to be an initial valve of some other species.

From the pattern centre, areolae are arranged transversely forming rows towards the dorsal and ventral sides (Figs. 2, 4). An exact measurement of the areolae density is not easy because of the curvature of the initial valve face but its value converted in 10 μm is approximately 36. Because the external opening of the pore is located lower than the level of the interstria, the stria is seen as a shallow furrow. The striae density is about 13 in 10 μm in the main valve body, but is becomes denser near the ends, being about 16 in 10 μm. The striae extending downwards from the raphe branch are a little different in their arrangement (Fig. 4). They are a little denser, being about 18 in 10 μm.

The cingulum of the initial epivalve observed is composed of two bands, the valvocopula (B1) and the second band (B2) (Fig. 4). These bands are very narrow in comparison with those of the normal vegetative valves (Figs. 22-25). The bands have a longitudinal row of short striae on the pars exterior. The striae in B1 are composed of two to three pores along most of the band but have only pore at each end, and the number of pores composing striae is reduced in B2 (Fig. 4). Each band has one open end but at alternate

Figs. 6–11. *Eunotia arcus* var. *arcus*. Scale bars=10 μm (Figs. 6, 7) or 5 μm (Figs. 8–11). Fig. 6. External view of a vegetative valve with rounded apices. K-5865. Fig. 7. External view of a vegetative valve with obliquely truncated apices. Topotype material. Fig. 8. Detail of Fig. 7 showing the whole raphe branch in the valve end. Fig. 9. Detail of Fig. 6 showing the whole raphe branch in the valve end. Fig. 10. Detail of Fig. 7 showing the polar raphe ending on the mid-line of the valve. Fig. 11. Detail of Fig. 6 showing the polar raphe ending on the mid-line of the valve.

Figs. 12–21. *Eunotia arcus* var. *arcus*. Scale bars=10 μm (Figs. 12, 13), 2 μm (Figs. 14, 15), or 0.2 μm (Figs. 16–20). Fig. 12. Internal vegetative valve. Labiate process is located on the bisecting line of the apex in the valve mantle. Topotype material. Fig. 13. Internal vegetative valve. The labiate process is located at a point shifted slightly toward the dorsal side from the bisecting line. K–5865. Fig. 14. Detail of Fig. 12 in oblique view showing a large polar nodule (=helictoglossa) and a thickened hyaline area extending from the central raphe ending toward the valve centre. Fig. 15. Detail of Fig. 13 in oblique view showing the placement of the inner fissure and the thickened hyaline area extending from the central raphe ending toward the valve centre. Fig. 16. External view of valve areolae with the pore occlusions. Some of them are broken. Note the groove between the edge of the aperture and the occlusion. Fig. 17. Broken central valve showing the areolae each with occlusions set on a narrow ledge located slightly inward of the external aperture. Fig. 18. External view of cingulum areolae showing the shallow groove between the edge of the aperture and the pore occlusion. Note the minute openings of the areola open into the groove (arrow heads). Fig. 19. Internal view of valve areolae showing a simple aperture. Fig. 20. Pore occlusions without any perforations. TEM. Fig. 21. Diagram of the areola in section.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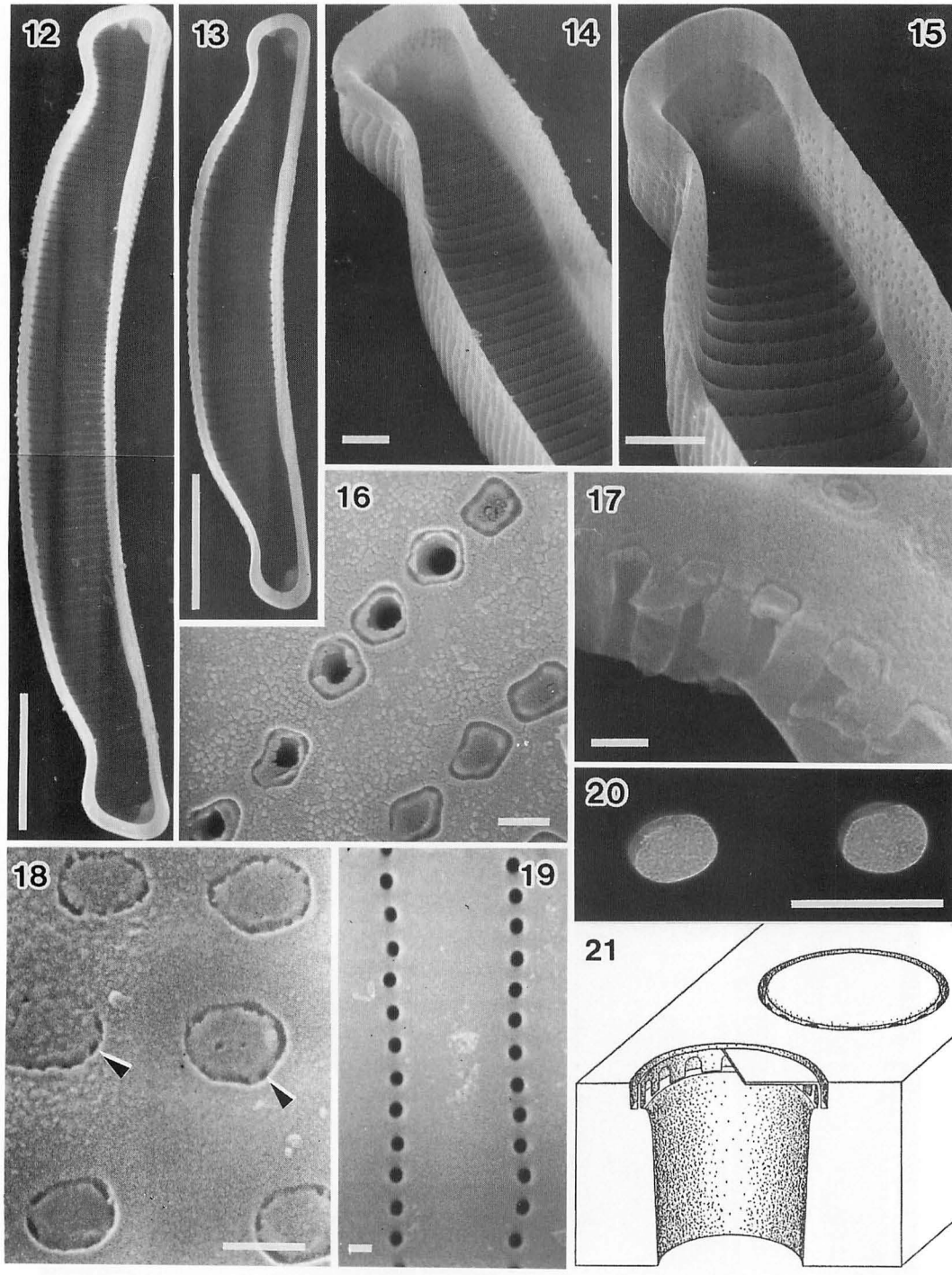
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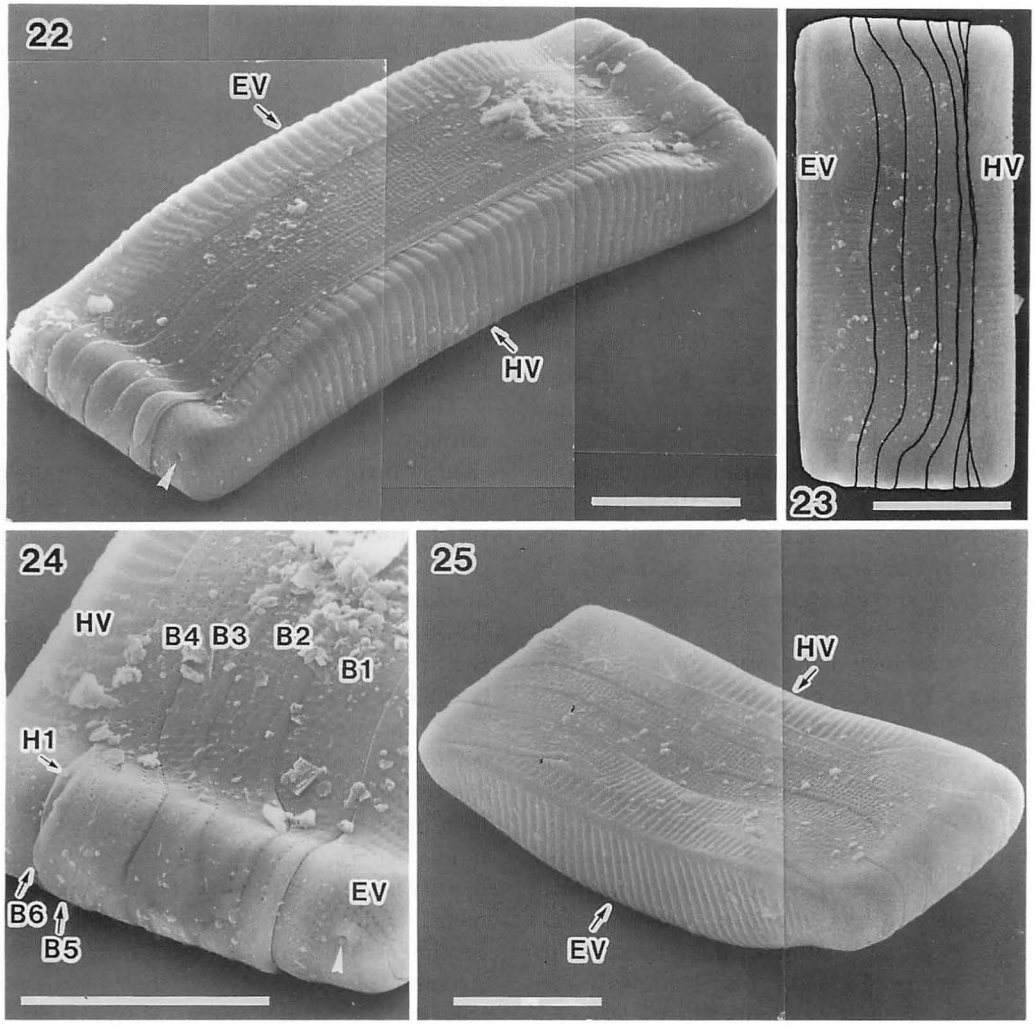

Figs. 22–25. *Eunotia arcus* var. *arcus*. Scale bars = 10 μm. EV = epivalve; HV = hypovalve; B1–B6 = first epiband (epivalvocopula) to sixth epiband; H1 = first hypoband. Fig. 22. Oblique view of a whole frustule from the dorsal side. Note the location of the outer opening of the labiate process (arrow head). Fig. 23. External view of a frustule from the ventral side showing the epitheca composed of an epivalve and six epibands. Fig. 24. Detailed figure of the far end of the frustule in Fig. 22. Note the closed end of B1, B3 and B5 located at the valve end with the labiate process (arrow head). Fig. 25. Oblique ventral view of the whole frustule in Fig. 23.

ends from each other. The cingulum of the initial hypovalve is also composed of two bands, but they are broader than those of the initial epivalves. The striae on the bands are composed of three to four pores along most of the band but reduced in number at the ends (Fig. 5). In the initial cells of *Rhoicosphenia curvata*, Mann (1984a) also observed broader bands in the hypocingulum than those of the epicingulum. Geitler (1951) has mentioned nothing about the band width in the initial cells, but found 2—4 bands in the epicingulum and 4 bands in the hypocingulum.

The post-initial valves are 29-114 μm long in the topotype material and 22-101 μm long in the Japanese material. These ranges overlap those described in the life cycle of *E. arcus* (Geitler 1951, 13.5-95.2 μm long), though our ranges are generally higher.

The vegetative valves from the topotype material are presented in Figs. 3, 5, 7-9, 12, 14 and those from Japan are in Figs. 6, 9, 11,

13, 15. In the topotype material, the longest is the first division valve formed inside the initial valve (Figs. 3, 5). This valve has a flat face and can be clearly distinguished from the initial valve. Since the first division valve has parallel sides and rounded apices and has no constriction in the dorsal side near the apices, its outline is quite different from that of the shorter vegetative valves which are considered typical shape of *E. arcus* (Figs. 6, 7), and rather resembles that of the initial valve (Fig. 2). Comparing Figs. 3, 6 and 7, it is evident that the degree of dorsal constriction and the obliquity of the valve ends increase as the valve length becomes shorter. On the other hand, Steinman and Sheath (1984) have observed just the reverse changes in apical shape in cultured *Eunotia pectinalis* var. *minor*. In their case, the constriction disappears as the valves get shorter.

The placement of the raphe and pattern center are very stable regardless of valve size or habitat. The pattern center runs between both apices, but its terminating points are different from those of the initial epivalve. In the vegetative valve, the pattern center terminates approximately at the midpoint between the polar raphe ending and the ventral valve margin (Figs. 5, 8-11). This point corresponds to the location of the internal helictoglossa (Figs. 14, 15). Just a short distance from the terminating points, the pattern center approaches the ventral margin and runs along the length of the main valve body (Figs. 3, 6, 7). In the main valve body, the pattern center does not unite with the valve margin, or the juncture of the valve face and mantle. These are always one or two areolae between them. However, the union of the pattern center and the juncture was rarely observed in small specimens and only in the stretch between both central raphe endings.

The polar ending of the outer raphe fissure always terminates on the mid-line of the valve (Figs. 5, 10, 9). This location is the same as that of the initial valve (Fig. 4), but the fissure in the valve face is very short and immediately turns down into the valve mantle. The fissure in the valve mantle is longer than that in the valve face. The central ending of the outer fissure forms a slightly dilated depression. Internally the polar ending of the raphe fissure terminates in the well developed helictoglossa (Figs. 12-15). Each raphe branch is surrounded by an obvious hyaline area (Figs. 8, 9, 14, 15). This area characteristically extends beyond the central raphe ending. The extension tapers towards the valve center externally and thickens markedly, internally. Our observations of the raphe correspond well with those of Wahrer (1981).

The striae consist of areolae as seen in the initial valve. The areolae are arranged in a shallow furrow both externally and internally. However, the furrow is detectable only in tilted observations because of its very slight depth (Figs. 8-11, 14, 15, 16, 17, 19). The areolae density in the valve face is stable, ca. 35-38 in 10 μm. There is no difference in the areolar density between the initial valve (ca. 36 in 10 μm) and the post-initial valves. Our examination supports the idea in *Navicula cuspidata* by Cohn *et al.* (1989) that the transapical spacing between pores could be a precise genetically controlled taxonomic indicator. In the main valve body, the striae density is 11-14 in 10 μm in the Swedish specimens, and 9-14 in 10 μm in the Japanese specimens. Cohn *et al.* (1989) observed finer striation more clearly in their post-initial valves than in the initial valves, but the vegetative valves from Sweden observed by us have a similar striae density as our initial valve (13 in 10 μm). In the culture of *Eunotia pectinalis*, Steinman and Sheath (1984) have stated that as time passed, the valve length decreased and striae density increased. Moreover, Mayama and Kobayasi (1988) have indicated the increase of the striae density according to the decrease of the valve length in *Navicula atomus*. However, we could not recognize any such remarkable tendencies in *E. arcus*.

Each valve has one labiate process located on the bisecting line of the apex in the valve mantle (Figs. 12, 14) or at a point shifted slightly toward the dorsal side from the bisecting line (Figs. 13, 15). Wahrer (1981) con-

cluded that the labiate process location is one of the most stable characteristics in the *Eunotia* species and he set up four placements of the labiate process in the apex. The location assigned to this species by him is the B placement (slightly above the midline). However, the labiate process is variable in placement as seen in Figs. 12-15. When the inside valve is arranged as in Figs. 12, 13, *i.e.* with the dorsal side to the left and the ventral side to the right, the labiate process is always located on the top side. This situation was first observed by Moss *et al.* (1978) and a more detailed explanation was given later by Wahrer (1981).

Because the topotype material is diatomite, all specimens are eroded to some extent so that they lack pore occlusion of the areola. Therefore, the complete areola structure has been observed only with living materials from Japan. The areolae are found in both valves (Figs. 16, 17, 19, 20) and bands (Fig. 18). The shape of the external aperture varies from circular to rectangular (Figs. 16-18). A groove is observed between the edge of the aperture and the pore occlusion. The area of the external aperture is larger than that of the circular internal aperture (Figs. 17, 20). The pore occlusion has no perforations as seen in the hymenate pore occlusion (Fig. 19) nor flaps as in the volate pore occlusion described by Mann (1981). The entire form of the occlusion is like a shallow Petri dish, which has small openings not in the ceiling but in the wall (Fig. 21). This occlusion is set on a narrow ledge placed slightly inward of the external aperture. The opening of the occlusion appears as a slit in the band because of the very shallow groove running between the edge of the aperture and the pore occlusion (Fig. 18).

The epicingulum consists of four to six open bands. The open end of B1, the valvocopula, is placed at the apical side lacking the labiate process and the closed end is at the other side (Figs. 22, 24) and this band orientation confirms the observations of Wahrer (1981). In each successive band, this orientation alternates in turn. As the location of the band

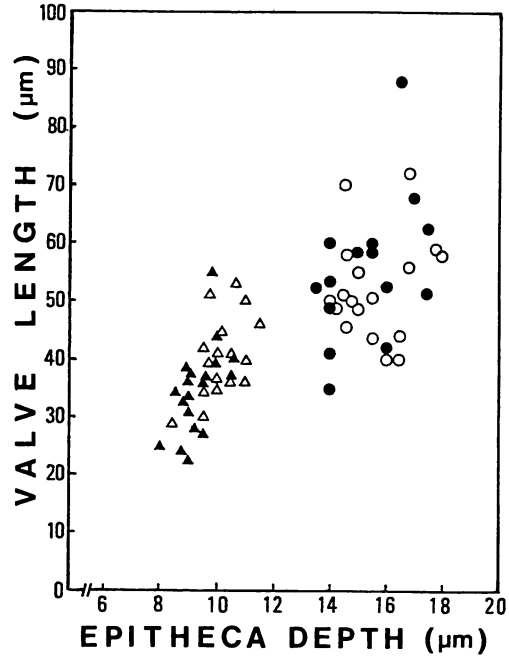

Fig. 26. Plot of valve length versus epitheca depth in *Eunotia arcus* var. *arcus* (●: topotype material, ○: K-5865) and *E. arcus* var. bidens (▲: K-5865, △: K-5879).

becomes further from the valve, the band width becomes narrower. Therefore, bands 5 and 6 are barely visible in the middle portion, but they are clearly visible at the widened band ends (Figs. 23, 25). Cingula with five bands are abundant in both Swedish and Japanese materials. The frequency for the former is 25% (four bands), 65% (five bands) and 10% (six bands) among 20 frustules examined, and in the latter it is 18% (four bands), 60% (five bands) and 22% (six bands) among 50 frustules examined. There is no firm relationship between the valve length and the band number, but there is a tendency for longer valves to have many bands.

The relationship between valve length and epitheca depth is shown in Fig. 26. Because the edge of the outermost band is not straight (Fig. 23), we have measured the depth at both the apices and the center and plotted the average. The epitheca depth is 13.7-17.5 μm in the Swedish material (closed circle) and this range agrees with that of the Japanese

materials of 14.2-18.0 μm (open circle).

To be emphasized is that the epitheca depth is a reliable taxonomic characteristic. This parameter is confirmed to be stable by us in *E. arcus* var. *arcus* (Fig. 26, circles) and var. *bidens* (Fig. 26, triangles). As is seen in Fig. 26, changes in the epitheca depth are markedly slight when compared with those in the valve length. There is a slight tendency for the epitheca depth to become shorter as the valve length decreases. This tendency is recognized in the nominate variety also, but it is more obvious in var. *bidens*. The ranges of valve length partly overlap in var. *arcus* and var. *bidens*. The longer valve of var. *bidens* is rather similar in appearance to the shorter valves of var. *arcus* because of their less undulated dorsal side (Figs. 1A, 1B). However, the difference in epitheca depth clearly classifies them into two taxa (Fig. 26).

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真山茂樹*・小林　弘**：羽状珪藻 *Eunotia* の属のタイプ種である *Eunotia arcus* Ehr. var. *arcus* の観察

スウェーデン自然史博物館所蔵の P. T. Cleve のコレクションの中の *Eunotia arcus* var. *arcus* の同地基準標本試料を，走査型および透過型電子顕微鏡を用いて観察した。この試料には初生殻を含む，さまざまな大きさと形の殻が含まれており，本種の無性生殖期における安定した形質を探ることができた。それらは，殻の外・内表面構造，条線密度，パターンセンターと殻面殻套接合線の位置関係，縦溝の位置，唇状突起の位置，胞紋構造，胞紋密度，上半被殻の深さであり，これらの形質は本邦産の個体群においても安定した形質であった。(*184 東京都小金井市貫井北町4-1-1　東京学芸大学生物学教室，**184 東京都小金井市本町3-8-9-813　東京珪藻研究所)

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A comparative study of spermatangia in *Bostrychia* Montagne (Rhodomelaceae, Rhodophyta)

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King, R. J. and Puttock, C. F. 1991. A comparative study of spermatangia in *Bostrychia* Montagne (Rhodomelaceae, Rhodophyta). Jpn. J. Phycol. 39: 143–150.

The structure of the spermatangial stichidia in seven species of *Bostrychia* Montagne is examined, and shown to be referable to the basic structure of the vegetative axis of each species. The variation shown in the arrangement of cortical cells in the stichidia is far greater than anticipated from published information, and adds little to an understanding of relationships within the genus.

Key Index Words: Bostrychia—*Rhodomelaceae—Rhodophyta—spermatangia—systematics—taxonomy.*

The Bostrychioideae is a well defined subfamily within the Rhodomelaceae, and following Post (1936) all members of the subfamily have been placed in the single genus *Bostrychia* Montagne. In a world-wide revision of the group, King and Puttock (1989) challenged this view. The genus *Bostrychia* was maintained for the eleven species in which there are two tiers of pericentral cells per axial cell, and in which cortication (when present) of the first formed pericentral tier is completed before cortication of the second pericentral tier. The genus *Stictosiphonia* J. D. Hooker et Harvey was resurrected and emended for six species with 3-5 tiers of pericentral cells per axial cell, and in which the cortication of the second and subsequent pericentral cells takes place prior to the formation of the second tier of cortical cells. The two genera, *Stictosiphonia* and *Bostrychia*, had already been recognized as subgenera by Falkenberg (1901) on the basis of the number of tiers of pericentral cells alone.

The taxonomy of the Bostrychioideae has been, and continues to be, based essentially on vegetative structures, a fact attributed to the comparative rarity of reproductive material. Smith and Norris (1988a) investigated the structure of spermatangia in cultured material of two taxa of *Bostrychia* (*B. montagnei* Harvey and *B. binderi* Harvey), and compared their observations with published information on supposedly related species. In the present paper we have made original observations on spermatangial plants of seven of the 11 species that we recognize in *Bostrychia*, and interpreted these in the light of our recent study of relationships in the genus.

Any comparative study of the development of the spermatangial stichidia in *Bostrychia* requires the careful application of terminology. Tanaka (1989) introduced the term "spermatangial stichidia" for the reproductive portion of what have been referred to as spermatangial branches (King and Puttock 1989) and this term is adopted here. Smith and Norris (1988a) introduced the terms "adaxial pit connection" for the attachment of the proximal pericentral cell to the axial cell, and "abaxial pit connection" for its attachment to the distal pericentral cell or any subsequently formed cortical cells but this is unwarranted and confusing since the latter is only rarely in a strictly abaxial position. In the Rhodomelaceae the terms dorsal and ventral refer to the cell row derived from the first and last formed pericentral cells respectively, and not simply the upper and lower side. In lateral branches, the ventral cells will be in the adaxial position and the

dorsal side will be then directed away from the axis. This results in the determinate lateral branches growing towards the indeterminate main axis rather than towards the substratum, as do the indeterminate branches.

Spermatogenous cells are not markedly differentiated from normal vegetative cells and any superficial cell can be reproductive. All cells in a spermatangial stichidium, with the exception of the axial cells, appear able to produce spermatia. Referring to the initial pericentral cells as primary parent (mother) cells which later divide to become secondary parent cells (Tanaka 1989), or referring to the proximal pericentral cell as a primary parent cell, and other corticating cells as secondary parent cells (Smith and Norris 1988a) is unnecessary since the development is essentially that in the vegetative axis and therefore there is no need to create a separate terminology.

Materials and Methods

Observations of the spermatangial stichidia of the male gametophytes of seven species of *Bostrychia* were made on permanent microscope slides held at UNSW (John T. Waterhouse Herbarium at the University of New South Wales) and LTB (Latrobe University, Melbourne), and on slides prepared from dried and pickled field collected herbarium specimens. *Bostrychia tenella* included material formerly referred to *B. binderi* Harvey. Spermatangial stichidia were analyzed for the spatial position and attachment of every cell over four consecutive axial cells. Four stichidia were examined for each species. It is virtually impossible to trace the cellular connections of all cells on mature spermatia-bearing stichidia because of the density of cells present at that stage. Therefore, since the stichidia are not secondarily reproductive, "spent" stichidia were used. Apart from these stichidia being easier to interpret, they are necessarily fully developed.

The material was examined to determine whether there is a dorsiventral bias in cell production (i.e. a diminution of cortical development from the first to last formed pericentral cell in the typical Rhodomelacean sequence); whether the dorsal cell row is in the lateral abaxial position of the branches as predicted by the arrangement of cells at the branch initiation; whether the proximal pericentral cell is more highly corticated than the distal pericentral cell ; and whether the cortication of the spermatangial stichidia reflects the degree of cortication of the vegetative axes.

Specimens examined:

Bostrychia montagnei Harvey—Key West, Florida, U.S.A., Harvey (syntype MEL 672268).

Bostrychia moritziana (Sonder ex Kuezting) J. Agardh—Daintree R. crossing, Qld, Australia, 16°15′S 145°23′E, 8.vii.1984, King and Puttock UNSW 16835.

Bostrychia pilulifera Montagne—Ilha de Marca, estado do Amapa', Brazil, 21.x.1988, de Paula SPF 54065 (UNSW).

Bostrychia pinnata J. Tanaka et Chihara—Daintree R. crossing, Qld, Australia, 16°15′S 145°23′E, 8.vii.1984, King and Puttock UNSW 16834; Cairns International Airport Road, Cairns, Qld, Australia, 16°52′S 145°45′E, 7.vii.1984, King and Puttock UNSW 16836.

Bostrychia radicans (Montagne) Montagne—Rapid Ck, Darwin, N. T., Australia, 12°27′S 130°50′E, 4.xii.1985, Kilkeary UNSW 18148.

Bostrychia tenella (Lamouroux) J. Agardh—Ellis Beach, Cairns, Qld, Australia, May (NSW 126959); Red Beach, Weipa, Qld, Australia, 12°35′S 142°52′E, 22.vii.1984, King and Puttock UNSW 17025.

Bostrychia tenuissima R. J. King et Puttock—Arno Bay, Victoria, Australia, 16.iii.1981, Woelkerling (LTB 12237, LTB 12341).

Results

Spermatangial parent cells in spermatangial stichidia

The number of cortical cells connected to distal and proximal pericentral cells were scored in sequence for each of four axial

Table 1. Cortical production per axial cell in seven species of *Bostrychia*. The values are means based on four consecutive axial cells in each of four spermatangial stichidia. The range shows the variation observed in the four separate stichidia (except for *B. radicans* where only one stichidium was available). The number of pericentral cells around the axis is not constant, and the number of cells on which the average is based is indicated [#].

Species	dorsal	subdorsal	subdorsal	subventral	ventral
B. montagnei	5.7 (4.5–7.5)	4.4 (3.5–5.5)	3.0 (2.3–4.3)	2.5 (1.5–3.5)	1.9 (1.5–2.3)
	[16]	[16]	[16]	[16]	[13]*
B. moritziana	0.9 (0–2)	0.3 (0–1.3)	0**	0**	0**
	[16]	[16]	[16]	[16]	[2]
B. pilulifera	9.7 (8.3–12)	8.3 (6.8–9)	7.3 (6.8–8.5)	6.6 (5.8–7.5)	5.3 (4.8–6)
	[16]	[16]	[16]	[16]	[15]
B. pinnata	3.8 (2.5–5.3)	3.4 (1.8–4.5)	2.7 (1.8–3.8)	2.1 (1.3–3.5)	1.9 (0.5–3.3)
	[16]	[16]	[16]	[16]	[16]
B. radicans	3.5	3.3	n/a	2	2
	[4]	[4]	—	[4]	[4]
B. tenella	5.2 (4.3–6.5)	3.7 (1.8–6.5)	3.7 (2–5.8)	3.7 (2.3–5.5)	2.9 (1–5.3)
	[16]	[16]	[16]	[16]	[16]
B. tenuissima	10.3 (9–11.8)	7.7 (6.8–8.5)	5.3 (4.8–6)	4.3 (3.3–5.3)	3 (2.3–3.8)
	[16]	[16]	[16]	[16]	[12]

* In one case *Bostrychia montagnei* had a single axial cell with 6 rather than 5 pericentral cells around the axis.
** In *Bostrychia moritziana* the development of the pericentral cells in the spermatangial stichidium is incomplete in the ventral position. In none of the material observed were pericentral cells other than those in two dorsal cell rows further corticated.

segments in a single spermatangial stichidium, and this was repeated for four stichidia. The number of cortical cells attached to a particular pericentral cell is affected by the spatial arrangement of neighbouring cells. The sequence of production of pericentral cells in the vegetative indeterminate axis of the Rhodomelaceae follows a set pattern (Parsons 1975). In corticate species of *Bostrychia* the cortical productivity of the dorsal cell row in vegetative material is higher than that of the ventral. In species in which the spermatangial stichidium is developed on polysiphonous or corticated axes the number of potentially spermatogenous cells in the dorsal cell row is highest, and lowest in the ventral row. In those few cases where the spermatangial stichidium can be developed on monosiphonous axes (*Bostrychia moritziana*, and in *B. tenella*—see Tanaka, 1989) the data are based on the presumption that the most productive cell row is the dorsal cell row. The extent of cortication from the dorsal to the ventral cell rows is presented in Table 1. The pattern in which these numbers of cortical cells can be derived from the basic axial cell/pericentral cell arrangement is indicated in Figure 1. In this schematic diagram the diversity found in each species is indicated.

The dorsal cell row in a spermatangial stichidium occurs in the abaxial position in relation to the main axis. As a consequence the spermatangial stichidia of all species examined, with the exception of those in *Bostrychia moritziana*, are curved towards the apex of the indeterminate branch from which they are derived.

Cortication of distal/proximal tiers of pericentral cells

According to King and Puttock (1989) the pattern of cortication of the pericentral cells in the spermatangial stichidia of *Bostrychia* can be interpreted as conforming to the same basic pattern as in the vegetative thallus. That is, it favours the completion of cortication of the proximal pericentral cell before that of the distal pericentral cell of an axial cell. The number of cortical cells arising from the proximal pericentral cells is compared with the number arising from distal pericentral cells in

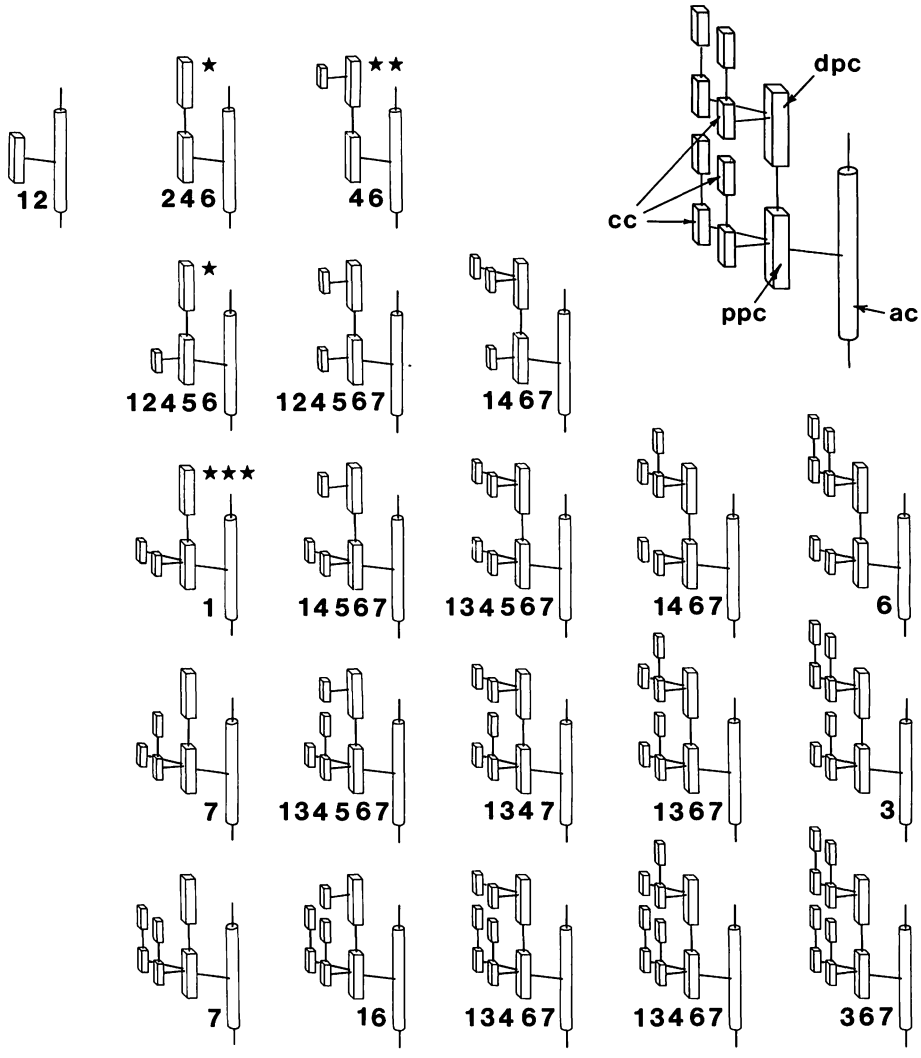

Fig. 1. Patterns of cortical development observed in the spermatangial stichidia of *Bostrychia* [1=*B. montagnei*; 2=*B. moritziana*; 3=*B. pilulifera*; 4=*B. pinnata*; 5=*B. radicans*; 6=*B. tenella*; 7=*B. tenuissima*]. The series illustrates the observed arrangements of the axial cell (ac), the proximal pericentral cell (ppc), the distal pericentral cell (dpc), and the primary cortical cells (cc). The table would be extended to the bottom and right to accommodate a third primary cortical row on the proximal pericentral cell, or a secondary cortical cell layer on the primary cortical cells. The patterns of development illustrated by Tanaka (1989) for *B. tenella**, and by Smith and Norris (1988a) for *B. binderi* (=*B. tenella*)** and *B. montagnei**** are indicated on the diagram.

Table 2.

Cortication of vegetative axes and spermatangial stichidia

The cortication observed in the vegetative axes and the spermatangial stichidia shows that there is little consistency between the amount of cortical development in the spermatangial stichidia and the vegetative thallus (Table 3). The values include the pericentral layer and therefore cannot be directly compared with values in King and Puttock (1989).

Discussion

Several recent papers have addressed aspects of the reproductive biology of *Bostrychia* species (Smith and Norris 1988a, b; Kumano

Table 2. Numbers of cortical cells arising from distal and proximal pericentral cells in seven species of *Bostrychia*. The values are means based on all cells derived from the pericentral cells produced by four consecutive axial cells, in each of four spermatangial stichidia. The range shows the variation observed in four separate stichidia (except in the case of *B. radicans* for which only one stichidium was scored).

Species	Numbers of proximal pericentral cells	Number of distal pericentral cells	Ratio of proximal to distal cell numbers
B. montagnei	2.3 (2.0–2.6)	1.4 (1.1–1.7)	0.6
B. moritziana	0.2 (0–0.5)	0.1 (0–0.3)	0.5
B. pilulifera	4.3 (4.0–4.6)	3.0 (2.2–3.5)	0.7
B. pinnata	1.8 (1.0–2.8)	1.1 (0.7–1.4)	0.6
B. radicans	1.6	1.2	0.8
B. tenella	2.3 (1.2–3.0)	1.6 (1.0–3.0)	0.7
B. tenuissima	3.8 (3.3–4.5)	2.7 (2.3–3.1)	0.7

1988; West and Calumpong 1988; Tanaka 1989). The results presented here are discussed in relation to data on the male gametangial structures in these papers, and in the monograph of the genus (King and Puttock 1989).

In the gametangial stichidia of all seven species of *Bostrychia* examined the dorsal pericentral cells were always more highly corticated than those of the ventral pericentral cells (Table 1). This can be taken as an indication that all species maintain the dorsiventral nature typical of all Rhodomelaceae even in the spermatangial stichidia. It also emphasises the unspecialized nature of the reproductive branches (Hommersand 1963; Smith and Norris 1988a). In those species where the development can be traced from the apex a greater number of cortical cells is observed in the abaxial position and the curvature of the branch is towards the apex of the indeterminate branch from which it diverged. This interpretation differs from that of Smith and Norris (1988a) who considered that curved branches resulted from a greater rate of cell division on the ventral (adaxial) sides of the fertile areas. Smith and Norris (1988a) quoted Prud'homme van Reine and Sluiman (1980) as not reporting curvature of the spermatangial branches of *Bostrychia scorpioides* and suggested that this might be attributed to 'secondarlly developed spermatangia' on relatively straight, mature branches. Secondary development of this type has, however, never been shown in any *Bostrychia* species. Furthermore the photograph of the spermatangial branches of *Bostrychia scorpioides* in Prud'homme van Reine and Sluiman (1980)

Table 3. Comparison of cortication of vegetative axes and spermatangial stichidia. The number of cell layers surrounding the axis, including the pericentral layer and the number of pericentral cells around the axis is given.

Species	vegetative cortication				reproductive cort'n	
	indeterminate axis		determinate axis		stichidia	
	number	pericentral cells	number	pericentral cells	number	pericentral cells
B. montagnei	3–5	5–7	0–3	0, 4–6	(1–)2	(4–)5(–6)
B. moritziana	1	5	0–1	0, 4–5	1(–2)	4(–5)
B. pilulifera	3–4	7–8	1–3	6–7	2(–3)	(4–)5
B. pinnata	1	6(–8)	1	4	2	(4–)5
B. radicans	1	7–8	1	5–6	2	4
B. tenella	(1) 2–4	5–7	0–3	0, 4–6	1–2	(4–)5
B. tenuissima	1	5–7	1	5–6	2(–3)	(4–)5

clearly shows the stichidia to curve towards the indeterminate axis.

In the species of *Bostrychia* examined the proximal pericentral cell in the spermatangial stichidium is always more highly corticated than the distal pericentral cell (Table 2), thus indicating for *Bostrychia* the tendency to fill up the cortication of the proximal pericentral cell before the distal cell. These cortical cells, when not forming a complete cortical layer, will be cut off posteriorally (away from the branch apex), laterally, or in the case of the distal pericentral cell, anteriorally, thus giving the appearance of the pit connection to the axis from a medial cell in *B. montagnei* (ditrichotomous arrangement, Smith and Norris 1988a: fig. 10A) or the distal of three in *B. binderi* (linear arrangement, Smith and Norris 1988a: fig. 10B) or both conditions from the same axial cell in *B. tenella* (Tanaka 1989: fig. 15). Our interpretation of these conditions is indicated in Figure 1.

In both the paper of Smith and Norris (1988a) and that of Tanaka (1989) the patterns of development illustrated do not encompass the wide variation which can be observed in individual species (Fig. 1).

Variation is shown in the number of cortical cells and their arrangement in the spermatangial stichidium. The cultivated material of *Bostrychia montagnei* described by Smith and Norris (1988a) has only partial branches developed into spermatangial stichidia, as is found in some ecological forms of *B. tenella*. This stands in contrast to the situation in the syntype material of *B. montagnei*, which is male, though this was not observed by Harvey (1853). In *B. tenella* at least, spermatangial stichidia can be borne on either monosiphonous or polysiphonous branches (see below).

The degree of cortication shown in the spermatangial branches bears no direct relationship with that of the vegetative thallus (Table 3). However, in the species with monosiphonous ultimate branches examined (*Bostrychia montagnei, B. moritziana* and *B. tenella*), the lowest numbers of cortical cells in the spermatangial stichidia are recorded.

The pattern of reproductive development on unspecialized branches that we have observed in the spermatangial stichidia is also apparent in the development of tetrasporangial and procarpial stichidia of the Bostrychioideae.

The only published case in which the spermatangial stichidia do not conform to the pattern of development described here is that in which Kumano (1988) reported both male and female organs on 'monoecious' *Bostrychia flagellifera* Post. On the basis of the illustration in that paper we would question the assignment of the specimen to *B. flagellifera* (=*B. tenella* ssp. *flagellifera* (Post) R. J. King et Puttock). In Kumano (1988, figure 2) more cortical cells are shown arising from the proximal pericentral cell than we have observed even in the most robust forms of *B. tenella*. The spermatangial branch illustrated bears a superficial resemblence to an epiphyte, but is less well developed than the alloparasite *Dawsoniocolax bostrychiae* originally described from Brazil by Joly and Yamaguishi-Tomita (1967, 1969).

Kumano (1988) is the only report of monoecious plants from field collected material. However, gametophytic plants are rarely encountered in nature and recently published observations on gametophytic stages are based on plants grown in culture (Smith and Norris 1988a, b; West and Calumpong 1988). Cultured plants may behave atypically as is seen in the mixed phase plants reported by West and Calumpong (1988).

The table prepared by Smith and Norris (1988a) comparing the vegetative morphology and spermatangia in *Bostrychia* presents a number of problems. Firstly two of the species included, *B. arbuscula* J. D. Hooker et Harvey and *B. kelanensis* Grunow ex Post, would now be placed in the genus *Stictosiphonia* (King and Puttock 1989) and another two, *Bostrychia tenella* and *B. binderi*, are considered to be synonymous (King *et al.* 1988). In the present study the data for *B. tenella* are based on two stichidia from material of *B. tenella sensu* Post (1936) and two from the ecological form previously known as *B. binderi*. The stichidia were

borne on polysiphonous axes, as was also the case in the material of *B. binderi* of Smith and Norris (1988a). They may also be borne on monosiphonous laterals (West and Calumpong 1988; Tanaka 1989). Further the circumscription of *B. scorpioides* (Hudson) Montagne does not include southern hemisphere specimens which are referred to *B. harveyi* Montagne (King and Puttock 1989). These factors, coupled with an interpretation of phylogeny in the genus based on Post (1936), make it difficult to reconcile the conclusion of Smith and Norris (1988a) that their work "indicates that male thalli are not only useful to the taxonomy of *Bostrychia*, but represent phylogenetic markers for the family Rhodomelaceae" with data now available.

In a major study on the '*Bostrychia-Caloglossa*-Assoziation', Post (1936) revised the genus *Bostrychia*. Post rejected all previous systematic classifications within the genus, but nonetheless supported the taxonomic conclusions reached earlier by Falkenberg (1901). In a brief discussion on systematics in the genus, Post (1936) made the unsupported assertion that the most valuable systematic characteristic is not the number of tiers of pericentral cells. Post made no further comment on the systematics *per se*, but did note that the species of *Bostrychia sens. lat.* (including *Stictosiphonia*) could most easily be separated on the basis of the development of the haptera. Two groups of species were recognized: the 'Ramifulcratae' (with cladohaptera) and the 'Flagellifulcratae' (with peripherohaptera). If this division was considered to be more than simply useful for identification, then it would require a major reassessment of species in the genus. On the basis of detailed studies on vegetative material of all species in the genus including a cladistic analysis, King and Puttock (1989) reiterated the systematic value of the number of tiers of pericentral cells arising from each axial cell (cf. Falkenberg 1901). Furthermore, since the cladohaptera possessed by *Bostrychia radicans* and *Stictosiphonia kelanensis* (Post) R. J. King et Puttock have been shown to be non-homologous structures (King and Puttock 1989) the type of hapteron has questionable value in an assessment of any relationships.

In recent papers Smith and Norris (1988a, b) have attributed systematic meaning to further characters used in the key to the genus *Bostrychia* in Post (1936). There is, however, no reason why one should consider the key as a systematic arrangement producing groups and subgroups of related taxa. Post's understanding of systematics is interesting, particularly when considering her expectation of yet undiscovered species which would complete various permutations of character states (see table in Post 1939). Such expectations could be considered an extension of her belief that some species were related by neoteny so that species with monosiphony were considered to be development-arrested states of the completely polysiphonous species.

The supposition of Smith and Norris (1988a, b) that *Bostrychia arbuscula, B. montagnei* and *B. scorpioides* form a subgroup of closely related species, recognized by Post (1936), is therefore unjustified. Likewise a subgroup consisting of *B. calliptera* (Montagne) Montagne, *B. binderi* and *B. tenella* cannot be maintained as related species. The two characters, extent of cortication and differentiation of the thallus into long and short shoots, listed as separating *B. binderi, B. tenella, B. calliptera* from the subgroup containing *B. arbuscula, B. montagnei* and *B. scorpioides*, have been shown to be of little or no systematic value (King and Puttock 1989) and the continued separation of *B. binderi* from *B. tenella* (and *B. flagellifera*) is unwarranted (King *et al.* 1988).

The seven species examined in the study represent all five of the informal alliances proposed by King and Puttock (1989); the 'radicans' and tenella' groups are represented by two species each. The tenella group is represented by two corticate species, *Bostrychia tenella* and *B. montagnei* with similar spermatangial stichidia cortication production, consistent with cortication in the vegetative thallus (King and Puttock 1989). The two species in the radicans group (*B. radicans* and *B. pilulifera*) differ in the degree of cortication,

which is consistent with the cortication in the vegetative thallus of *B. pilulifera* and the lack of cortication in *B. radicans*. Both species have prolonged stichidial growth with the subapical 3-12 cells fertile and a long series of spent cells behind them. In all other species the stichidia appear to be simultaneously productive, i.e. the stichidia are either completely fertile or completely empty of spermatia, and this has been confirmed in culture for *B. tenella* by West and Calumpong (1988). The data presented here also support an affinity between the tenella and moritziana groups. The tenella and moritziana groups differ in the type of hapteron although the cladistic analysis places them near each other (King and Puttock 1989).

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R. J. King・C. F. Puttock：紅藻フジマツモ科コケモドキ属の不動精子器に関する比較研究

コケモドキ属 (*Bostrychia*) の 7 種について不動精子器の四分胞子托の構造を調べた結果，それが各々の種の栄養体の軸の基本構造に関連していることが明らかになった。四分胞子托の皮層細胞の配列にみられる変異は，これまでの報告から予測されるより遙かに大きく，この属内における相互関連の理解に役立つものはほとんどなかった。(School of Biological Science, University of New South Wales, P. O. Box 1, Kensington 2033, Australia)

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Sexual reproduction of *Ectocarpus siliculosus* (Ectocarpales, Phaeophyceae) in Japan

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Müller, D. G. and Kawai, H. 1991. Sexual reproduction of *Ectocarpus siliculosus* (Ectocarpales, Phaeophyceae) in Japan. Jpn. J. Phycol. 39: 151–155.

The cosmopolitan marine brown alga *Ectocarpus siliculosus* has been isolated from Hokkaido, Japan. The full sexual life history was obtained in clonal cultures: Gametophytes are dioecious and differ from sporophytes by a more elaborate branching pattern. Unfertilized gametes develop to partheno-sporophytes. Gametes of Japanese *E. siliculosus* are sexually compatible and form zygotes with isolates of the same species from various other geographic areas in both hemispheres. A revision of the genus *Ectocarpus* with presently over 40 species reported for Japan is recommended.

Key Index Words: cosmopolitan—ectocarpales—Ectocarpus siliculosus—*life history—Phaeophyceae—sexual reproduction.*

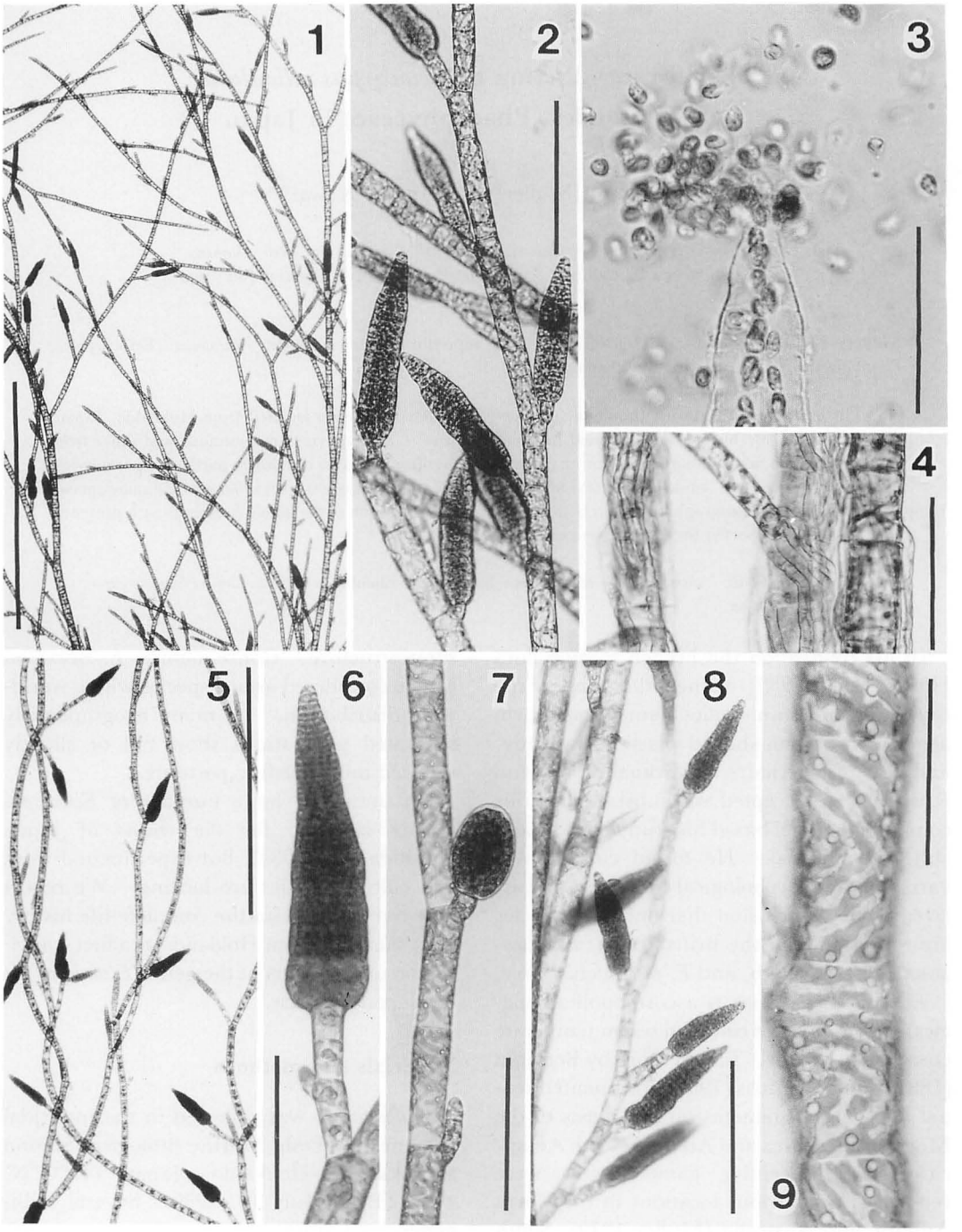
In his treatise on the French marine flora Hamel (1931-1939) defined the genus *Ectocarpus* to contain uniseriate filamentous brown algae with ribbon-shaped plastids, isogamy, and lack of true hairs. Cardinal (1964) and Russel (1966) accepted and substantiated this concept. Russell based his study on field and cultured material. He found considerable variability of morphological characters and arrived at the conclusion that only two species are represented at the British coast: *E. siliculosus* (Dillw.) Lyngb. and *E. fasciculatus* Harv.

Ectocarpus siliculosus is a cosmopolitan species, which inhabits cold and warm temperate coasts of all oceans. Earlier work by Berthold (1881) and Papenfuss (1935) documented sexual fusion of isogametes on the coasts of the Mediterranean Sea and Atlantic North America. More recently, gametophytes were reported from various locations in the North Atlantic and Australia (Müller 1979), South America (Müller 1988), and New Zealand (Müller *et al.* 1990). Crossing experiments showed that with few exceptions plasmogamy occurs between isolates from different geographic areas. In some cases segregation sterility indicates dissimilarities in chromosome structure. Consequently, *E. siliculosus* can be considered as one species with a worldwide distribution. Its many geographically separated populations show full or slightly reduced interbreeding patterns.

An unusually large number of *Ectocarpus* species is listed for the coasts of Japan (Yoshida *et al.* 1985), but experimental work and culture studies are lacking. We report here our findings on the complete life history of *E. siliculosus* from Hokkaido as a first contribution to a revision of the genus *Ectocarpus* for the Japanese coast.

Materials and methods

Leathesia sp. was collected in the intertidal zone near Akkeshi Marine Biological Station at Akkeshi, Hokkaido, Japan (43°02′N, 144°52′E) on July 18, 1989. Several millimeter-sized fragments were inoculated into plastic petri dishes in order to allow potential epiphytes to develop. By October 1989 an ectocarpoid filament appeared, which formed unilocular sporangia four weeks later. One unilocular sporangium was isolated. It released spores, which developed to gameto-



Figs. 1–9. Living cultured material of *Ectocarpus siliculosus* from Akkeshi, Hokkaido. 1: Habit of gametophyte, scale bar 1 mm. 2: Gametangia, scale bar 100 μm. 3: Gamete release from plurilocular gametangium, scale bar 50 μm. 4: Cortication in basal portion of older gametophyte, scale bar 100 μm. 5–7: Sporophyte, which developed from a zygote. Habit (Fig. 5); plurilocular sporangium (Fig. 6); unilocular sporangium (Fig. 7). Scale bars: 1 mm (Fig. 5); 100 μm (Figs. 6–7). 8: Partheno-sporophyte from unfertilized male gamete, scale bar 100 μm. 9: Gametophyte filament cells showing ribbon-shaped plastids with pyrenoids, scale bar 50 μm.

phytes. All work reported here was done with this material.

Unialgal cultures were maintained in enriched natural seawater (Provasoli-ES, Starr and Zeikus 1987) at 12±1°C. They were illuminated for 10 or 14 hr daily with a fluorescent lamp at an irradiance of 8–15 μmol m^{-2} s^{-1}. Experimental and culture techniques were the same as described previously (Müller 1988).

Specimens of our material will be deposited in the Herbarium of Department of Botany, Faculty of Science, Hokkaido University (SAP).

Results

The plants originating from the unilocular sporangium of an ectocarpoid epiphyte on a *Leathesia* species were male and female gametophytes of *Ectocarpus siliculosus* (Dillw.) Lyngb. This conclusion is based on the following morphological criteria: The plants are up to 5 cm long, and profusely branched in a sub-dichotomous manner without dominating main axis (Fig. 1). The plastids are ribbon-shaped with pyrenoids (Fig. 9), and male and female gametangia (Fig. 2) and gametes (Fig. 3) are isomorphic. True phaeophycean hairs are absent, and gametophytes are dioecious. Female isogametes settle on the substratum and attract male gametes until plasmogamy occurs. Zygotes develop to sporophytes of a few cm in size, which differ from the gametophytes by much sparser branching (Fig. 5) and larger plurilocular sporangia (Fig. 6). Older sporophytes and gametophytes show intense cortication by downward growing rhizoids (Fig. 4).

The spores from plurilocular sporangia develop to new sporophytes. Unilocular sporangia on the diploid zygotic sporophytes (Fig. 7) undergo meiosis, and their spores develop to a second generation of gametophytes with approximately equal representation of both sexes.

Unfertilized gametes develop parthenogenetically to plants with sporophyte habitus, which form unilocular and plurilocular sporangia (Fig. 8). These partheno-sporophytes were not studied further, since identical reproductive features have been found and studied in detail in *E. siliculosus* from Italy (Müller 1967).

In crossing experiments, gametes of our Japanese *Ectocarpus* cultures formed zygotes with gametes of *Ectocarpus siliculosus* from New Zealand (isolated by Müller *et al.* 1990), Naples, Italy, Wilmington, North Carolina (isolated by Müller 1979), and Chile (Müller 1988). Hybrids with the Italian isolates were fully viable, including functional meiosis. Hybrids with the North American and Chilean isolates showed reduced viability, while hybrid zygotes with New Zealand isolates did not develop (B. Stache. unpublished results).

Discussion

Morphological characters, life history, and sexual compatibility with isolates from different geographical areas provide convincing evidence that *Ectocarpus siliculosus* occurs on the coast of Japan. However, our study on cultured material does not indicate on which substrates and at what time of the year this species is expected to be found in the field in macroscopic scale. Specimens referable to *E. siliculosus* have not been collected at Akkeshi to date (Yamada and Tanaka 1944, Kawai, unpublished data).

The coasts of Japan belong to cold and warm temperate climatic zones. *E. siliculosus* is a typical representative for this temperature range, and in addition a cosmpolitan species. This opens the possibility that the genus concept for *Ectocarpus*, as specified by Russell (1966) for the British coast, may also be valid for Japan and other areas. An answer to this question requires detailed collection data as well as critical culture studies, which are not available at present.

The taxonomic treatment of the genus *Ectocarpus* in Japan is confusing. Yoshida *et al.* (1985) compiled all taxa reported for this area. The list includes *E. siliculosus* and *E. penicillatus* (C. Ag.) Kjellm., which is placed

by Hamel (1939) in the siliculosi group and considered by Russell (1966) as a transition form between *E. siliculosus* and *E. fasciculatus*. *E. breviarticulatus* J. Ag., which is also reported, has a tropical affiliation. The 44 additional taxa in the list are mainly new species, which were established by M. Noda and T. Ohta. According to their original diagnoses (Noda 1969, 1970, 1975, Ohta 1973), most of these taxa have discoid plastids, and consequently cannot be placed in the genus *Ectocarpus*. Instead, it seems likely that many of them belong to other genera such as *Feldmannia* or *Giffordia*, which has been recently renamed to *Hincksia* by Silva *et al.* (1987).

It is evident that a thorough reevaluation of type specimens, complemented with culture studies, will be needed to consolidate the taxonomy of the genus *Ectocarpus* in Japan.

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Müller, D. G.*・川井浩史**：日本産褐藻シオミドロ (*Ectocarpus siliculosus* (Dillw.) Lyngbye) の有性生殖

汎存種の褐藻シオミドロ（*Ectocarpus siliculosus*, シオミドロ目）を北海道，厚岸において採集し，クローン培養によって生活史と有性生殖について調べた。配偶体は雌雄異株であり，配偶体は胞子体より複雑な分岐をする点で形態上でも区別される。接合しなかった配偶子は雌雄のいずれも単為生殖の胞子体に発達する。日本産の *Ectocarpus siliculosus* は北半球および南半球の数地点から採集された本種の株と交配可能であることが確かめられた。日本においてこれまでに40種を越える *Ectocarpus* 属の種が記載されているが，本属の種で培養により有性生殖を含む生活史が明らかになったのはこの報告が初めてである。
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Entomoneis aequabilis sp. nov. (Bacillariophyceae), a brackish species without junction-lines

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A new brackish *Entomoneis* species without junction-lines in the winged keel is described as *Entomoneis aequabilis* Osada & H. Kob. sp. nov. from Suguchi-ike (Suguchi Pond), Kamikoshiki-jima (Kamikoshiki Island), Kagoshima Pref., Japan. The species is mainly characterized by frustules with a quarter twist, a sigmoid keel without junction-lines, denser striation in the valve body, longitudinal costa on one side of the raphe canal, and paired short projections on the interareolar costae of the bands.

Key Index Words: Bacillariophyceae—brackish diatom—Entomoneis—Entomoneis aequabilis—*fine structure—morphology—new species.*

The genus *Entomoneis* has been mainly characterized by the sigmoid keel elevated from the valve body, the junction-lines and the complex girdle (Cleve 1894 using the incorrect genus name *Amphiprora*, Reimer in Patrick and Reimer 1975). Though most species of the genus have the junction-lines which separate the winged keel from the valve body, there are some species which have no junction-lines such as *Amphiprora dusenii* Cl. (1894), *A. perplexa* Giffen (1963) and our new species. *E. aequabilis* is more similar to *A. perplexa* than *A. dusenii* in having denser striation. However, the striae of *A. aequabilis* (32–37 in 10 μm) are denser than those of *A. perplexa* (23–27 in 10 μm).

Ross *et al.* (1979) have defined the term "wing" as a kind of keel in which fenestrae alternate with alar canals as seen in *Surirella robusta* Ehr. *E. aequabilis* has only the raphe fibulae and has neither the fenestrae nor the alar canals, however, it has a well developed, wing-like structure as seen in Figs. 3 and 28. Therefore, we also use "wing" for this species as an exceptional case in the genus *Entomoneis*. All the species examined by us using SEM have a genuine wing; *E. alata* var. *japonica* (Cl.) Osada & H. Kobayasi (1985), *E. paludosa* (W. Smith) Reimer var. *paludosa*, *E. punctulata* (Grun.) Osada & H. Kobayasi, *E. pseudoduplex* Osada & H. Kobayasi (1990a), *E. decussata* (Grun.) Osada & H. Kobayasi (1990b), and *E. centrospinosa* Osada & Kobayasi (1990c). They have three kinds of fibulae in the wing in which solid parts composed of costae and fibulae alternate with canals or canal-like structures, passages between the interior of valve and the raphe canal. The longitudinal costa on one side of the raphe canal and the paired short projections on the external surface of the interareolar costae of the bands are the additional characteristics of *E. aequabilis*.

Material and methods

Materials were collected from the bottom mud of Suguchi-ike (Suguchi Pond), Kamikoshiki-jima (Kamikoshiki Island), Kagoshima Pref., on October 9, 1986 (OS-368). Salinity of the habitat was measured to be 17‰ when collecting the materials. Since individuals of the species were very rare in the materials, their clonal culture was carried out

in test tubes containing a modified PES medium (Osada and Kobayasi 1990a). Other culture conditions and methods of cleaning, washing and preparing objects for light and electron microscopy are given in Osada and Kobayasi (1985, 1990b).

The terminology used is that suggested by Anonymous (1975), Ross *et al.* (1979) and Paddock and Sims (1977, 1981).

Observations and discussion

Entomoneis aequabilis sp. nov. (Figs. 1-3, 5)

Cellulae singulares. Frustula in aspectu cingulari valde constricta et longitudinaliter torta. Valvae leviter sigmoideae, lineares, apicibus late scalpelliformibus, 47-57 μm longae, 7-9 μm latae. Carina alata sigmoidea, valdissime elevata et sine juncturi-lineis. Parietes rapho-canalis striati, costa longitudinali asymmetrice in latere uno. Striae corporis valvae continuae ex margine carinae ad marginem valvae et densissimae, 32-37 in 10 μm, et decussate superpositae in aspectu cingulari.

Cells solitary. Frustules strongly constricted in girdle view and longitudinally twisted. Valves slightly sigmoid, linear with broad scalpelliform ends, 47-57 μm long, 7-9 μm wide. Winged keel strongly sigmoid, elevated and without junction-lines. Walls of the raphe canal striated and with longitudinal costa asymmetrically on one side. Striae on the valve body continuous from the keel margin to the valve margin and extremely dense, 32-37 in 10 μm and appearing decussately to overlap in girdle view.

Holotypus: H. K. T-94. in coll. H. Kobayasi (will be housed in the Nat. Sci. Mus. Tokyo).

Type material: OS-368, coll. by K. Osada on 9 October 1986.

Type locality: Bottom mud of Suguchi-ike (Suguchi Pond), Kamikoshiki-jima (Kamikoshiki Island), Kagoshima Pref., Japan.

Etymology: Specific epithet is Latin, adjective *aequabilis*, meaning "uniform" in reference to the uniform structure of the valve body and the keel without junction-lines.

This species closely resembles *Amphiprora perplexa* Giffen described from South Africa (Giffen 1963, 1967) in having a sigmoid winged keel without junction-lines, a line of large puncta near the raphe canal and a densely striated valve body. However, according to the original description and illustration of *A. perplexa* (Giffen 1963), Giffen's species has the transapically symmetrical striation in girdle view. The striae are roughly parallel in the middle portion and radiate near apices of the valve and are slightly sparse, being 23-25 (27) in 10 μm. *E. aequabilis*, therefore, is clearly distinguished from *A. perplexa* by having denser striae, being 32-37 in 10 μm, and by the oblique striation on the valve body, and consequently, appearing decussately to overlap in girdle view (Figs. 1-3, 5, 6).

In the SEM, the frustules have a longitudinal quarter or 90° twist (Fig. 4) but represent a panduriform outline in girdle view, depending on the setup of specimens or the angle

Plate 1. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. Scale bars=10 μm. Figs. 1, 2. Frustule in girdle view. 1. KE-1216. 2. Suguchi-ike (Suguchi Pond), Kamikoshiki-jima (Kamikoshiki Island). Fig. 3. Valve view. KE-1216. Fig. 4. Oblique view of a whole frustule showing its quarter-twisted form. KE-1216. SEM. Figs. 5, 6. Girdle view of valve. KE-1216. 5. LM. 6. TEM (Scale bar with dot).

Plate 2. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. KE-1216. Scale bars=5 μm (Figs. 7, 8), 1 μm (Figs. 9-11), 0.1 μm (Figs. 12, 13). Fig. 7 External view of half valve showing the transapical costae arranged in parallel slanting toward the valve center but changing direction radially at the sub-terminal valve, and numerous warts on the costae. Fig. 8. The other half of the same valve as Fig. 7, showing the costae arranged in parallel slanting toward the valve apex. Fig. 9. Enlarged internal valve showing the smooth surface of the costae and intercostae (striae). Fig. 10. External sub-terminal valve showing the changeover portion of the costae arrangement, bifurcations and insertions of costae and longitudinal costa running along the keel margin. Fig. 11. Enlarged external valve showing warts arranged in two rows on each costa. Fig. 12. Hymenes occluding areolae on the raphe canal showing perforations forming lines arranged in parallel and densely. TEM. Fig. 13. Hymenes on the valve margin of the same valve as Fig. 12. TEM.

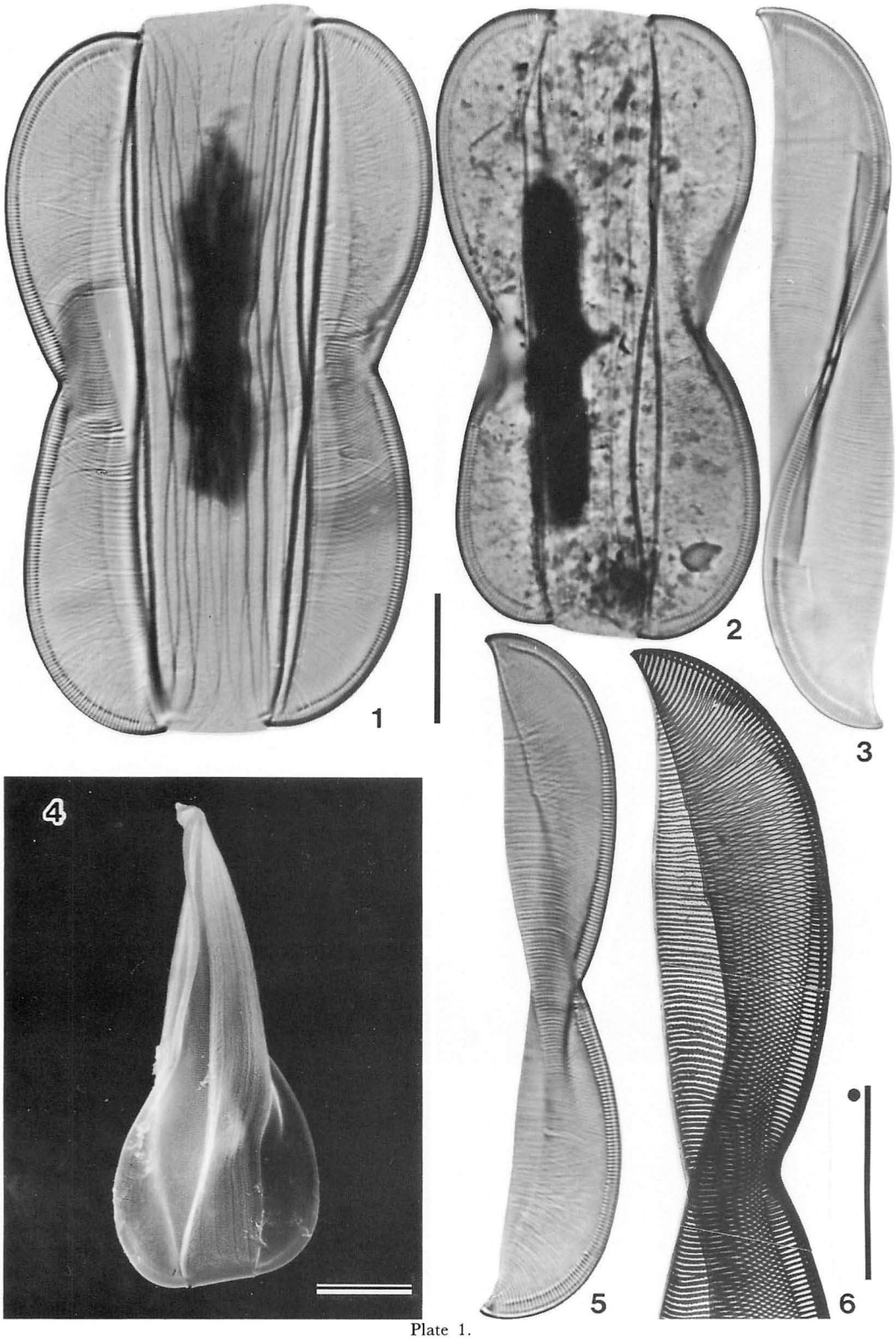


Plate 1.

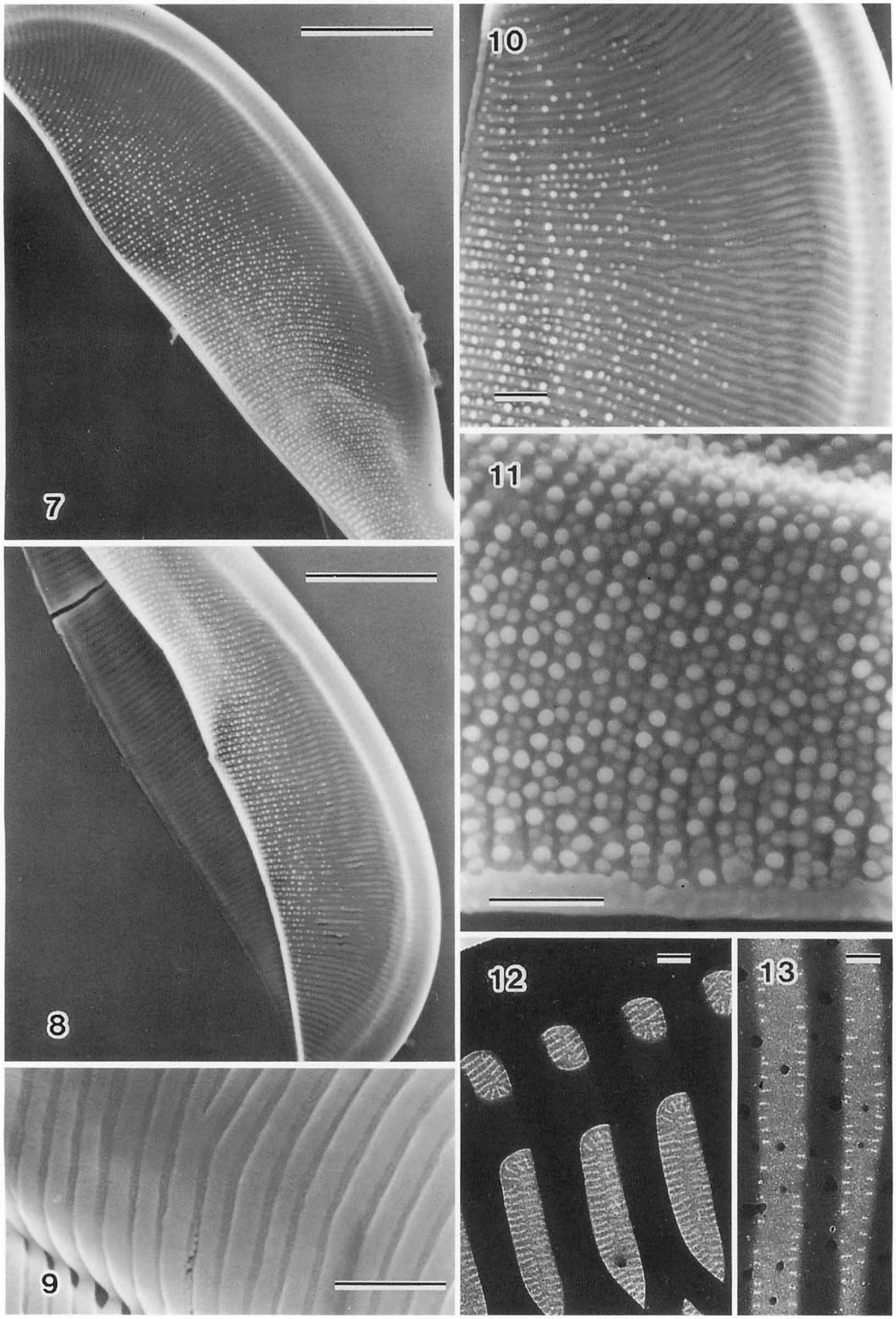


Plate 2.

from which the specimen is viewed (Fig. 20).

The transapical costae continue from the valve margin onto the raphe canal. Those of the valve body have externally numerous warts which vary in size and are arranged more or less in two rows on each costa, while internally their surfaces are smooth (Figs. 7–9, 11). Most costae of the valve body seen to be decussate in girdle view in LM and TEM (Figs. 1, 2, 5, 6) are actually arranged obliquely in the same direction on both sides of the valve. Namely, the decussating appearance in girdle view is caused by the overlapping of the costae of one side and the other side of a valve, as is seen in the wings of *E. pseudoduplex* (Osada and Kobayasi 1990a), *E. decussata* (Osada and Kobayasi 1990b) and *E. centrospinosa* (Osada and Kobayasi 1990c). The costae on one half of the valve are arranged obliquely and in parallel, slanting toward the apex (Fig. 8), while on the other half of the valve the costae are arranged curving slightly in the same direction as the former for about two-thirds of the way between the center and the apex but those in the remaining one-third change their direction radially (Fig. 7). The changeover portion of the costae arrangement, particularly, tend to have frequent bifurcations of the costae and also frequent insertions of the costae from the keel margin (Fig. 10). On the other hand, the costae on the raphe canal have no warts. As seen in Fig. 6, the striations on both sides of the raphe canal overlap exactly in the girdle view. Their arrangement is almost radial in each half of the keel (Figs. 7, 8).

Each intercosta or stria is also continuous from the valve margin onto the wall of the raphe canal on one side of the valve (Fig. 30), but on the other side of the same valve it is interrupted on the wall of the raphe canal, and divided into one distal short areola and one remaining intercosta by the longitudinal narrow costa (Figs. 6–8, 29). The distal areolae are seen as a row of marginal puncta along the edge of the wings in LM (Figs. 1, 2, 5). The longitudinal costa is narrow and continuous lengthwise and seems to have the same structure as that of the transapical costae (Fig. 19). The distal areolae and the longitudinal costa are observed to lie on the same side of the frustule, that is, the epi- and hypovalve have them on the same side (Fig. 31). The stria as well as the distal areola is closed externally by a hymen with perforations forming short lines. The perforated lines are arranged parallel to each other but perpendicular to the margin (Figs. 12, 13, 32, 33). Such structure of the striae is similar to that of *E. punctulata* (Osada and Kobayasi 1990a) and of *Auricula amphitritis* (Paddock and Sims 1980). In this species, however, the arrangement and density of the perforated lines are clearly different near the keel margin and near the valve margin. The perforated lines are longer and denser, being 40–45 in 1 μm, near the keel margin (Fig. 12) and shorter and sparser, 20–25 in 1 μm, near the valve margin (Fig. 13).

The raphe canal is proximally separated from the valve cavity by a row of raphe fibulae and has a central large inner opening (Figs. 15, 17, 18), and distally has a plicate raphe slit (Figs. 19, 32, 33). The fibulae seen as small dash-like puncta along the keel margin in LM link the costae on opposite walls of the keel (Figs. 17, 18). The raphe fissure is extremely narrow throughout, and has the central endings terminating simply on both the external and internal surfaces (Figs. 14, 15 arrows). The terminal fissures also terminate simply and straight (Fig. 16). In the transapical section of the valve, the raphe is a plicate type (Krammer 1982) (Fig. 19). The valve side with key costa, which may correspond to the primary side (Mann 1983), is observed to occur on the side possessing the longitudinal costa (Figs. 19, 32, 33).

The cingulum is composed of five to six open bands, i.e. one open valvocopula and four to five open bands. They open and close alternately at each pole of a frustule (Fig. 22), and all have similar structure except for the sixth band which is usually narrower (Fig. 21). Each band has two rows of oblong areolae, i.e. one advalvar and one abvalvar row, on the pars exterior and has a smooth edge both on the pars exterior and on the pars in-

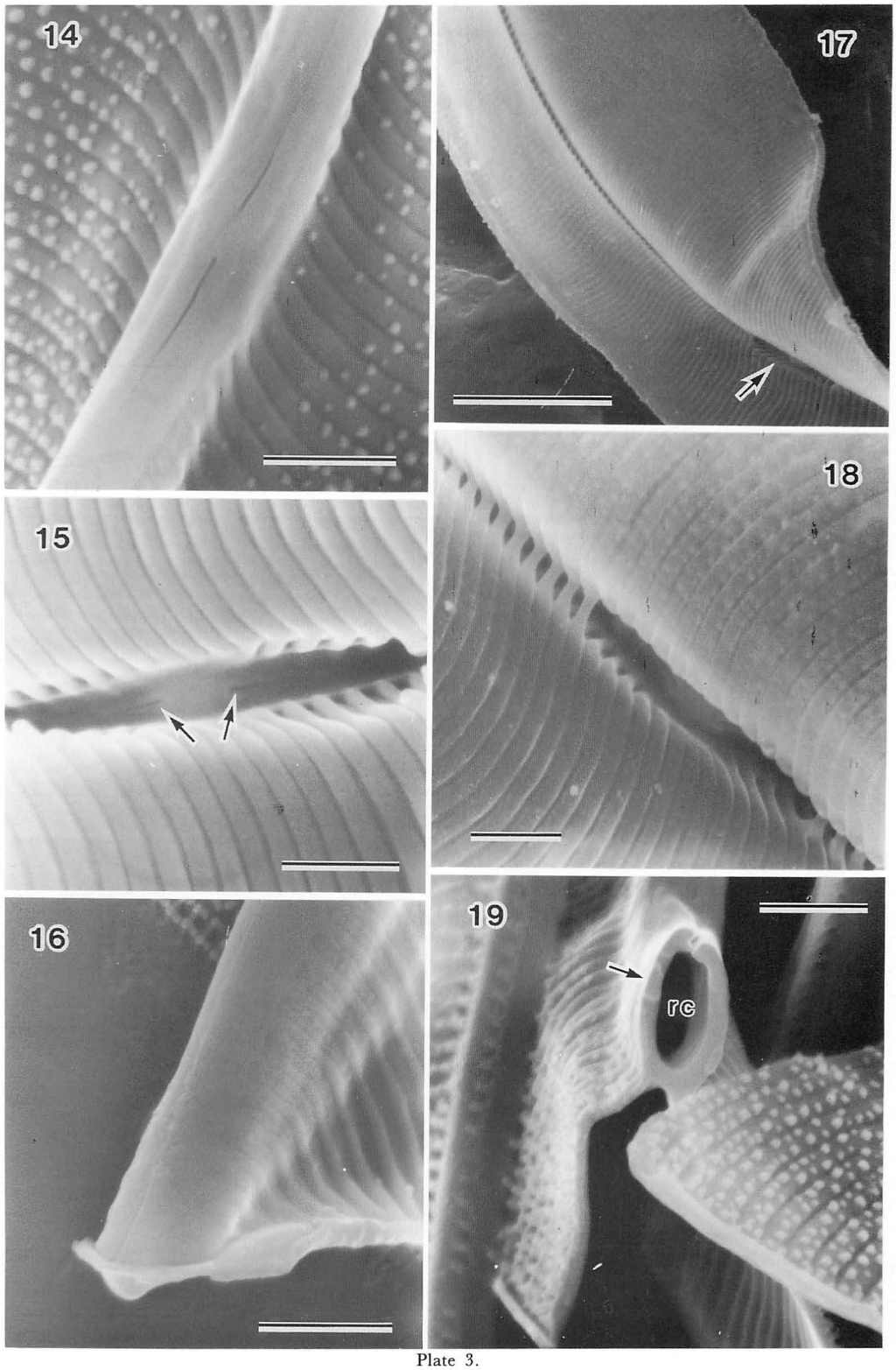
terior even in the valvocopula (Figs. 21, 23 arrows, 26). The advalvar row is composed of elliptical or round areolae, while those forming the abvalvar row are considerably elongated (Figs. 23, 26, 27). The band areolae, being 46-57 in 10 μm, are occluded by a hymen with perforations forming marginal short rows arranged roughly in parallel and with randomly scattered perforations in the remaining space (Fig. 27). The I or Y shaped projections protruding from the side wall of the areolae in Fig. 27 are shadows of the paired short projections on the interareolar costae (arrows). Most of the hymenes occlude the areolae internally, but those of the advalvar areolae of the valvocopula are near to the external surface of the band (Figs. 23-25). Externally, each interareolar costa of the bands has a row of paired short projections (Figs. 26, 27 arrows) and an abvalvar terminal spine (Fig. 26 arrows), and numerous warts are on the surface between the two areolar rows (Figs. 21, 23, 26). Internally, the band surface is almost flat (Fig. 23). The valvocopula is clearly distinguished from other bands by the round areolae forming the advalvar row and the wider warty area between the two areolar rows. The cingulum of this species is quite similar to that of *E. pseudoduplex* (Osada and Kobayasi 1990a), *E. decussata* (Osada and Kobayasi 1990b) and *E. centrospinosa* (Osada and Kobayasi 1990c) in having the oblong areolae, in the shape and arrangement of perforations of the areolar occlusion and in having numerous warts on the band surface, but differs, apparently, in the presence of the paired short projections.

Consequently, the following features are considered to be characteristic of this species: 1) Strongly and longitudinally twisted frustule: 2) Strongly elevated sigmoid keel without junction-lines: 3) Seeming decussately overlapping striation on both sides of the valve in girdle view: 4) Denser striae, being 32-37 in 10 μm: 5) Narrow longitudinal costa separating the marginal puncta from the striae on one side of the raphe canal: 6) Extremely dense band areolae forming rows,

Plate 3. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. KE-1216. Scale bars=1 μm (Figs. 14–16, 18, 19), 5 μm (Fig. 17). Fig. 14. External view of valve center showing central raphe fissures terminating simply and the smooth surface of raphe canal. Fig. 15. Internal view of valve center showing the central raphe canal opening and central raphe endings (arrows). Fig. 16. External valve end showing a straight terminal fissure. Fig. 17. Internal view of valve showing the smooth surface of the transapical, costa, the central opening of raphe canal (arrow) and a row of the raphe fibulae. Fig. 18. Enlarged internal valve center showing the central opening of the raphe canal and raphe fibulae linking opposite transapical costae. Fig. 19. Transapical section of valve showing the raphe slit on top of the keel, a longitudinal costa (arrow) on one wall of the raphe canal (rc), and raphe fibula on the border between the valve body and raphe canal.

Plate 4. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. KE-1216. Scale bars=10 μm (Fig. 20), 5 μm (Fig. 21), 1 μm (Figs. 22–26), 0.5 μm (Fig. 27). Fig. 20. External girdle view of a whole frustule. Fig. 21. External view of frustule pole showing the epicingulum composed of six bands; one valvocopula (B1), four bands (B2, B3, B4, B5) and one narrow band (B6). Fig. 22. Broken frustule pole showing the closed ends of the valvocopula (B1) and two bands (B3, B5), arranged alternately with the open ends (arrows) of the other two bands (B2, B4). V=valve. Fig. 23. Enlargement of internal valvocopula (left) and of other external valvocopula (right) showing the advalvar row of round areolae and the abvalvar row of elongated areolae, smooth pars interior edges (arrows), external paired short projections on the interareolar costa and numerous warts scattered between the two areolar rows. Figs. 24, 25. Cross section of the epicingulum and its drawing (V, valve; B1, valvocopula; B2, B3) showing the hymenes of the advalvar areolae (arrow-head) and those of abvalvar areolae (double arrow-heads), and the interareolar costae (arrows). TEM. Fig. 26. External advalvar cingulum end showing paired short projections and terminal spines (arrows) on the interareolar costae, and numerous warts between the two rows of band areolae. Note a wider warty area between the two areolar rows of the valvocopula (B1) than between the abvalvar bands (B2, B3). Fig. 27. Enlargement of a band showing both the elliptical and elongate areolar occlusions with perforations forming short rows arranged roughly in parallel, and the paired short projections on the interareolar costae (arrows). TEM.

Plate 5. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. KE-1216. Scale bars=10 μm (Fig. 28), 5 μm (Fig. 31), 1 μm (Figs. 29, 30, 32, 33). Fig. 28. External valve view of a whole valve showing the sigmoid keel. Figs. 29, 30. Enlargement of the external raphe canal of Fig. 28 showing one side with narrow longitudinal costa and the other side without longitudinal costa of the same raphe canal. Fig. 31. External girdle view of a frustule pole showing longitudinal costa (arrows) lying on the same side of the frustule. Figs. 32, 33. Transapical section of one valve (Fig. 32) and of the other valve (Fig. 33) of the same frustule showing longitudinal costa (arrow) and plicate raphe slit. TEM.



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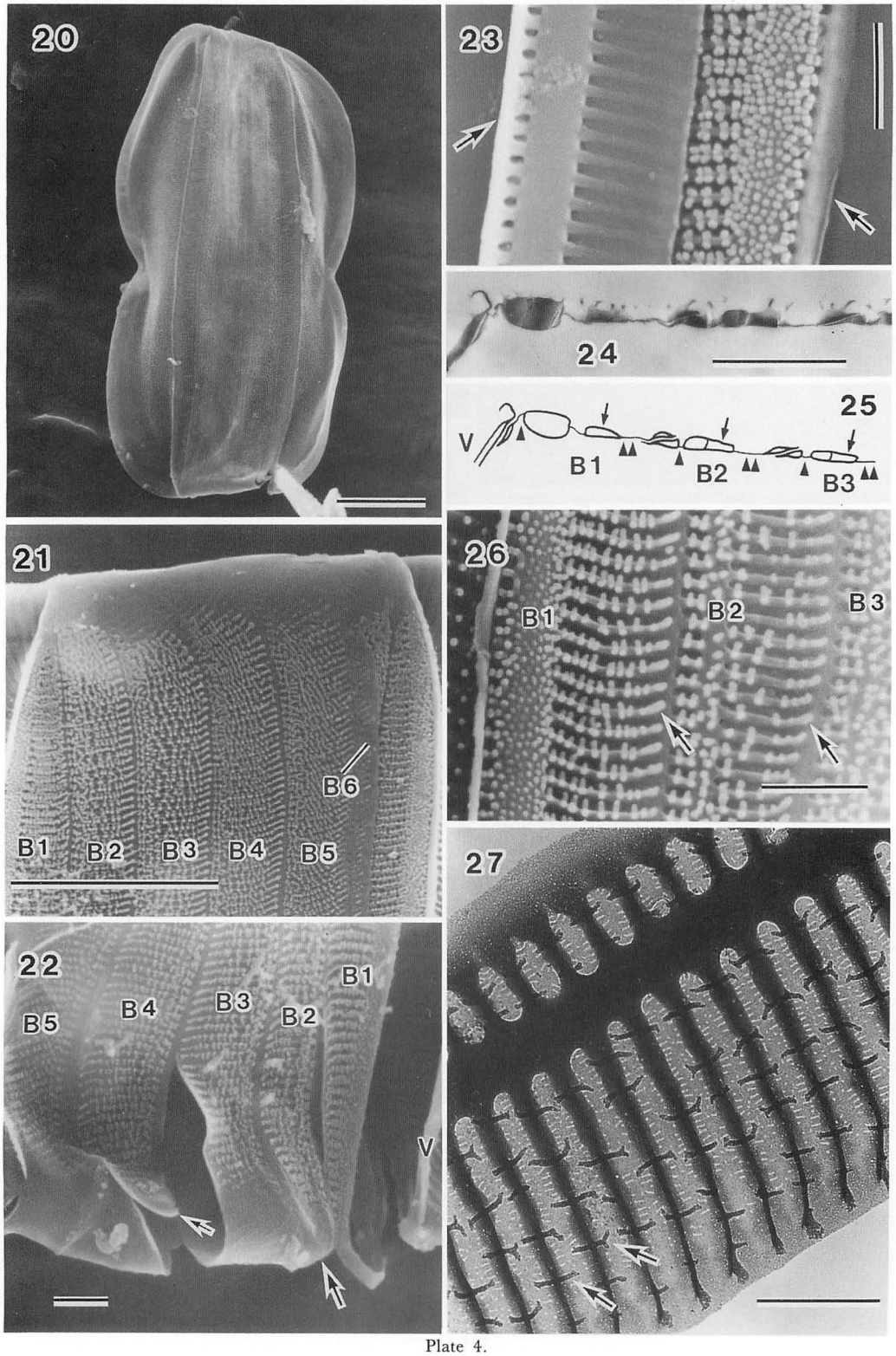
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Plate 4.

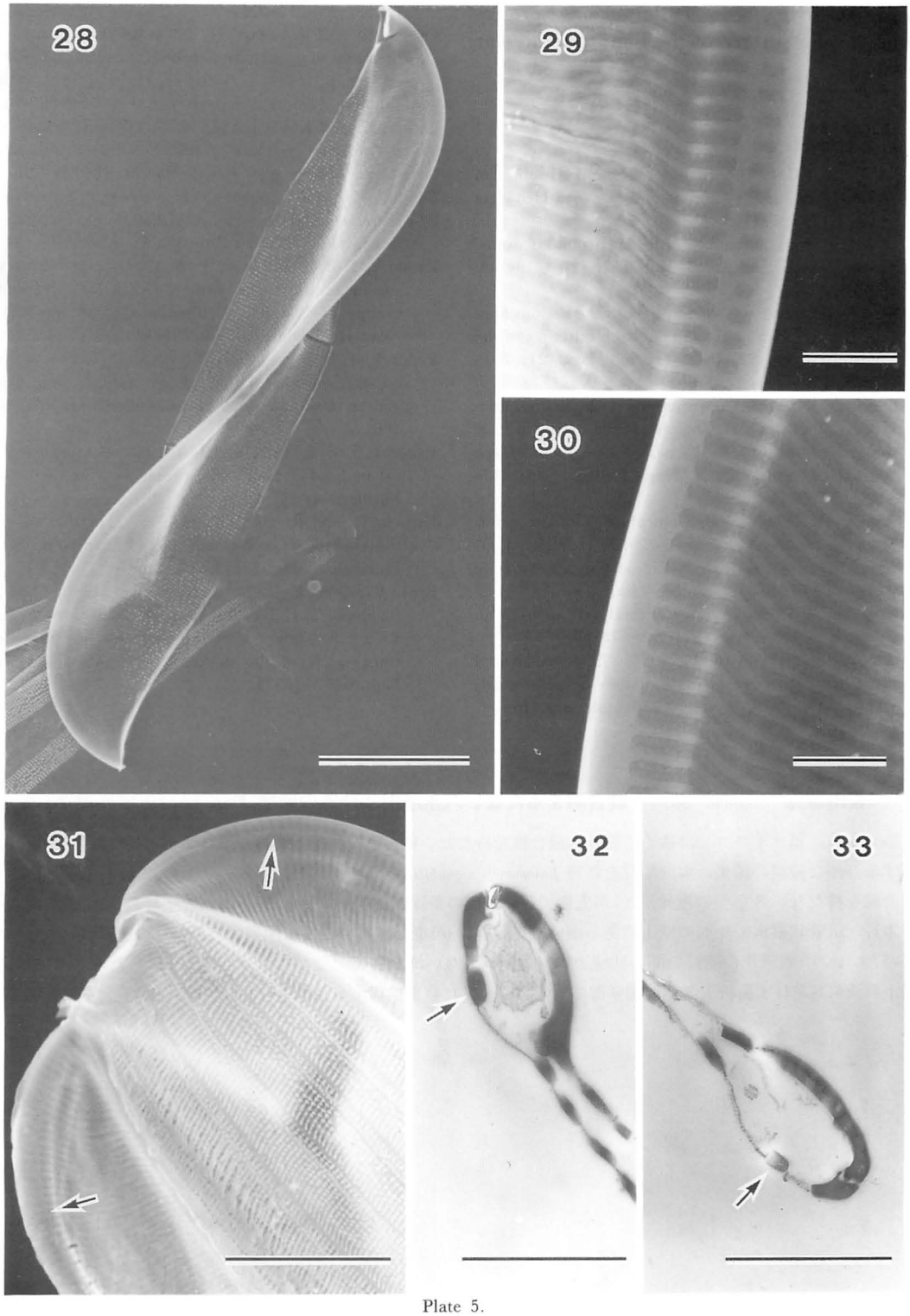

Plate 5.

being 46–57 in 10 μm: 7) Paired short projections on the surface of the band interareolar costae.

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長田敬五*・小林　弘：縫合線をもたない汽水産羽状珪藻の新種 *Entomoneis aequabilis***

Entomoneis 属ケイソウでは極めて希れな縫合線を持たない種を鹿児島県上甑島の須口池から得た。被殻構造に関する詳細な観察の結果，本分類群を新種 *Entomoneis aequabilis* として記載した。本種は 1）強く捻れる被殻，2）縫合線を持たない S 字型の竜骨，3）帯面観で殻の両側の条線は交差して見える，4）密な条線数（10 μm に32–37本），5）管状縦溝の片側の壁上にある細い縦走肋線，6）極めて高い密度で配列する殻帯片の胞紋（10 μm に46–57本），7）殻帯片の胞紋の間の肋線上に対生配列したいぼ状突起，などによって特徴づけられる。(*951 新潟市浜浦町1-8 日本歯科大学新潟歯学部生物学教室　**184 東京都小金井市本町3-8-9-813 東京珪藻研究所)

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Karyogamy in *Spirogyra verruculosa* Jao (Chlorophyceae)

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Ogawa, S. 1991. Karyogamy in *Spirogyra verruculosa* Jao (Chlorophyceae). Jpn. J. Phycol. 39: 167–172.

The karyogamy in *Spirogyra verruculosa* Jao was investigated by light and electron microscopy. In 10-day-old zygotes the two pronuclei from both the male and female gametes were connected to each other by internuclear bridges, which were various in width, ranging from 0.5 to 1.5 μm. About 12 days after plasmogamy the nucleoplasms of the two pronuclei commenced to intermingle. The fused nucleus first contained two nucleoli, which sometimes lay close to each other, but one nucleolus later, suggesting the union of the two nucleoli into a single one. The formation of synkaryon was completed by 14 days after plasmogamy in the present species.

Key Index Words: karyogamy—nucleolus—nucleus—pronucleus—Spirogyra—*synkaryon—zygote formation.*

The karyogamy is one of the most important phases in fertilization. This process in *Spirogyra* (Zygnematales, Chlorophyceae) has been repeatedly observed with the light microscope (Overton 1888, Tröndle 1907, 1911, Karsten 1908, etc.), but ultrastructural studies are few. The difficulty in embedding of the zygote which develops a thick wall to withstand various kinds of environmental stress renders the electron microscopic observations difficult (Fowke and Pickett-Heaps 1971, Jordan 1974). An improved embedding method of thick-walled zygotes (Ogawa 1982) made it possible to demonstrate the process of karyogamy in *S. verruculosa* ultrastructurally, at least to some extent (Ogawa 1981). But, the behavior of nuclear membranes and nucleoli in the fusing two pronuclei was observed only partially. This is mainly due to the lack of the information on the timing of the pronuclear fusion in this species.

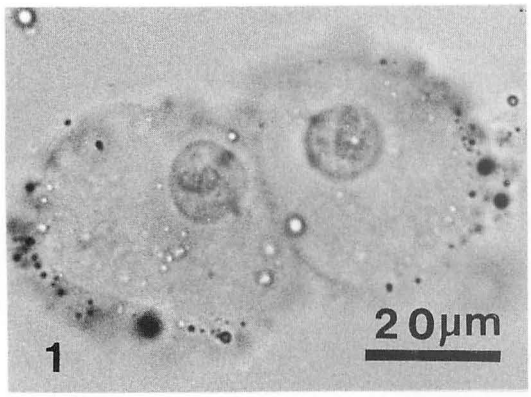
Generally in *Spirogyra*, karyogamy is known to precede the meiosis, however, some species are not the case, in which the pairing of homologous chromosomes takes place in each of the two adjacent pronuclei (Harada and Yamagishi 1984). Although the previous electron microscopic observation indicated the formation of synkaryon (Ogawa 1981), it is necessary to reinvestigate the later stage of karyogamy. The present study concentrates mainly upon clarifying the accurate time requisite for the completion of pronuclear union in *S. verruculosa* with the object of demonstrating the behavior of nuclear contents and nuclear membranes in fusing pronuclei.

Materials and methods

The filaments of *Spirogyra verruculosa* Jao, which were forming conjugation tubes, were collected from a pond in Sendai City, Miyagi Prefecture. The zygotes were allowed to mature in Erlenmeyer flasks each half-filled with the culture medium of Reichart (1967) under a 12 hr light: 12 hr dark cycle (ca. 2,000 lux, white fluorescent lamps) at 25°C.

For light microscopy, some of the zygotes were fixed every day in acetic acid-alcohol (1 : 3) fixative for 2–3 hr at 25°C. They were then gently squashed on slide glass, stained with acetic orcein, and observed with either a Zeiss light microscope or an Olympus light microscope equipped with the Nomarski differential-interference apparatus.

The embedding method of thick-walled zygotes for electron microscope observation was almost the same as that described else-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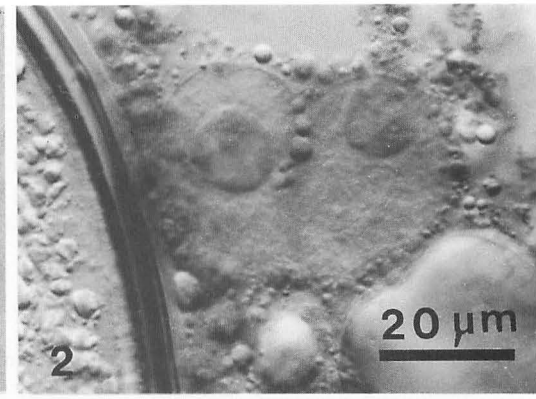
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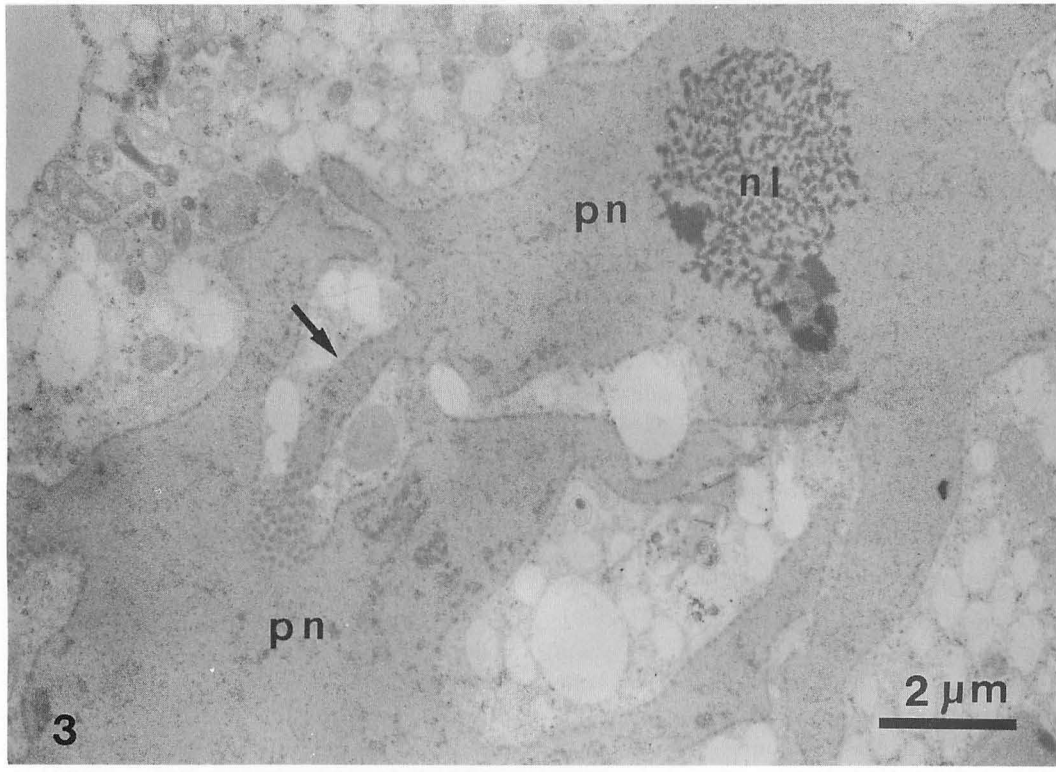
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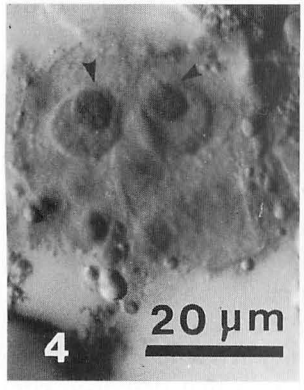
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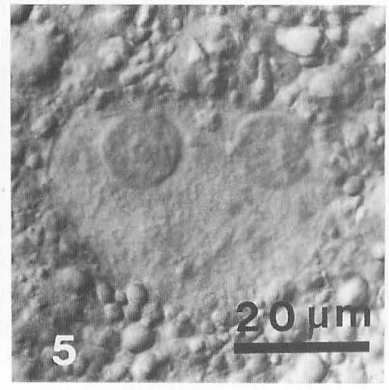
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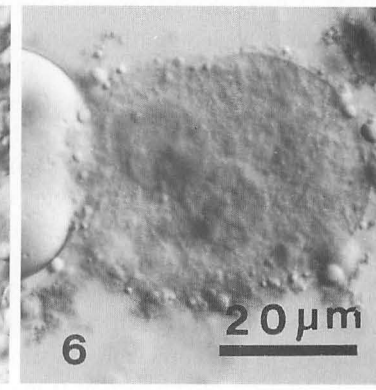
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where (Ogawa 1982). The zygotes were fixed first with 2.5% glutaraldehyde in 0.1 M phosphate buffer (pH 7.2) and then with phosphate-buffered 1% osmium tetroxide. After slight rinse in the buffer, one of the two ends of each of the ellipsoid zygotes was cut with a razor blade under a binocular dissecting microscope to facilitate the penetration of the epoxy resin embedding medium of Spurr (1969) into the zygotes. They were dehydrated in an ethanol series and embedded in the epoxy resin. Thin sections were stained with uranyl acetate and lead acetate and examined with a JEOL 2000EX electron microscope, operating at 80 kV.

Results

In individual young zygotes of several days old, the two pronuclei from both gametes were juxtaposed. Each of them included one nucleolus, and their adjacent surfaces came in contact with each other (Fig. 1). The area of contiguous surfaces of the two pronuclei seemed to extend over a wide range with time, and they assumed an ellipsoidal form on the whole. Cytoplasmic contents, probably lipid droplets, were sometimes squeezed between the two pronuclei (Fig. 2). The adjacent surfaces of the two pronuclei in 10-day-old zygotes irregularly undulated, and the two pronuclei were connected to each other by internuclear bridges (Fig. 3), which were various in width, ranging from 0.5 to 1.5 μm.

The mixture of nucleoplasms of the two pronuclei could frequently be seen at about 12 days after plasmogamy. The nuclear membranes that disturbed the complete interminglement of both nucleoplasms (Fig. 4) became obscure (Fig. 5), leaving two nucleoli present simultaneously within the same nucleus (Fig. 6). The two nucleoli sometimes lay close to each other (Fig. 6). The fused nucleus, or synkaryon, contained one nucleolus (Fig. 7). Electron microscopy revealed the presence of neither chromosomes nor synaptonemal complex within the nucleoplasm of the synkaryon (Fig. 8). As typically seen in Fig. 4, each nucleolus of pronuclei usually had an area stainable with acetic orcein somewhat densely, while the nucleolus of synkaryon in zygotes about 12 days old sometimes contained two orcein-stainable areas (Fig. 9, arrowheads).

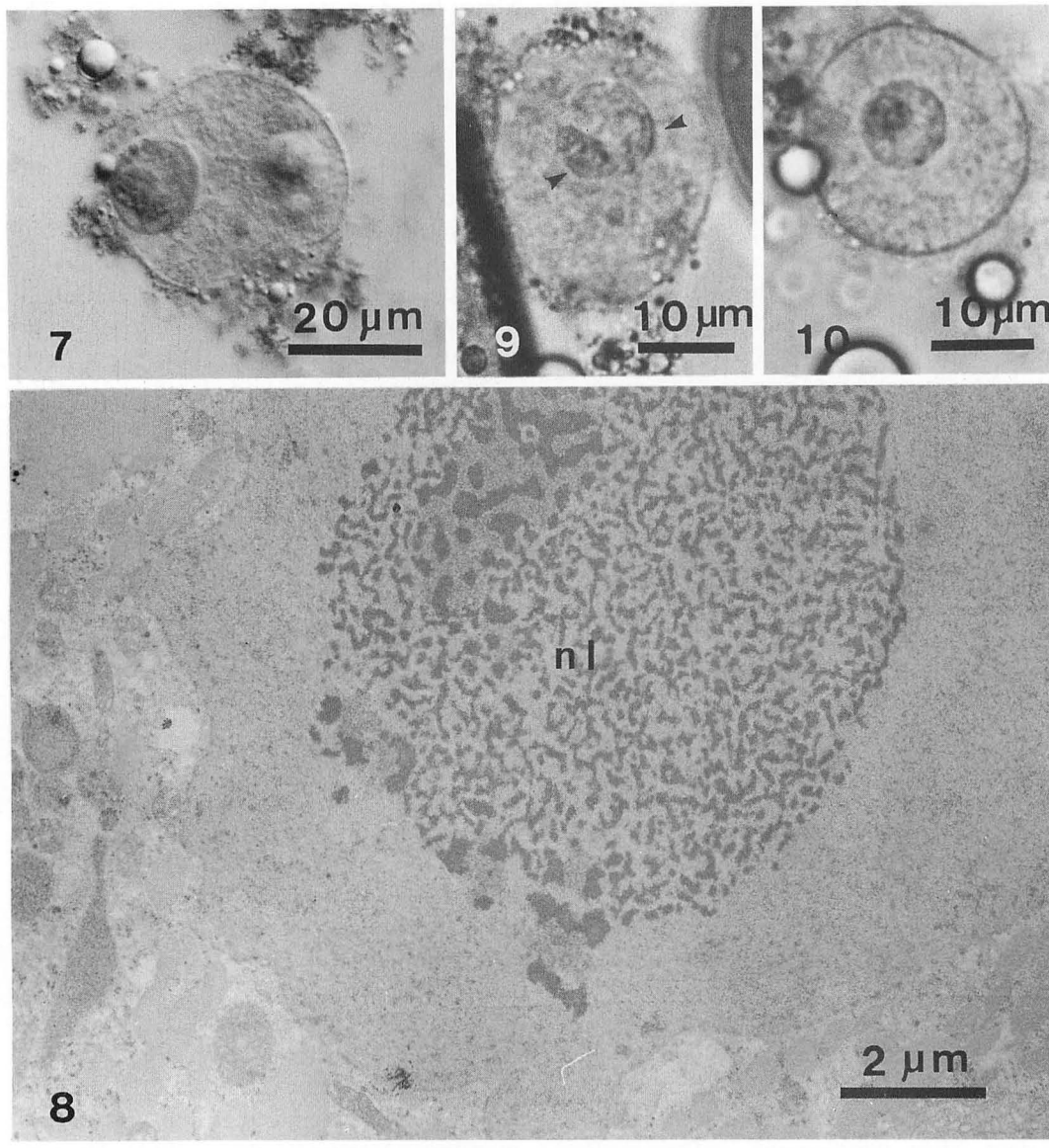
In zygotes 14 or more days old, the nucleus contained only one nucleolus with one orcein-stainable area (Fig. 10). So far as examined, meiotic division could not be observed in the present species at least within 20 days after gametic union.

Discussion

The present investigation demonstrated that in *Spirogyra verruculosa* the male and female pronuclei united together, as hitherto known in other *Spirogyra* species. The behavior of the two pronuclei during zygote maturation has been observed three times in this species. In any case examined, the two pronuclei completed their union by 14 days after plasmogamy. Accordingly, the previous description that in *S. verruculosa* karyogamy finished within 30 days after plasmogamy (Ogawa 1981) is incorrect. About three weeks elapsed until the completion of karyogamy in *S. communis* (Trödle 1907), and the two pronuclei fused together shortly after plasmogamy in *S. crassa* (Godward 1961). The timing of karyogamy may largely vary depending on the species of *Spirogyra*.

In the present species, the nucleus with two nucleoli was observed mostly at about 12 days after gametic union (Fig. 6), but the frequen-

Figs. 1–6. Light and electron micrographs of nuclei in zygotes of *Spirogyra verruculosa*. 1. Two pronuclei in a 7-day-old zygote. Each pronucleus contains one nucleolus. 2. Differential-interference-contrast micrograph of two pronuclei in a 10-day-old zygote. 3. Electron micrograph of part of two pronuclei (pn). They are connected together by internuclear bridges (arrow). Nucleolus (nl). 4. Two pronuclei in a zygote of 12 days old. Each nucleolus has an orcein-stainable area (arrow head). 5. Fusing pronuclei of a 12-day-old zygote. Nuclear membranes separating them is obscure. 6. Fused nucleus in a zygote of 12 days old. Two neucleoli lie close to each other.



Figs. 7–10. Light and electron micrographs of synkaryon of *Spirogyra verruculosa*. 7. Synkaryon in a 12-day-old zygote. It includes one nucleolus. 8. Electron micrograph of a part of a synkaryon in a zygote of 12 days old. Nucleolus (nl). 9. Synkaryon in a 12-day-old zygote. It has a single nucleolus with two orcein-stainable areas (arrowheads). 10. Synkaryon in a 14-day-old zygote.

cy of its appearance was relatively low. These results suggest that the mixture of nucleoplasms of the two pronuclei proceeds not gradually but rather quickly. This is probably a major cause for the present inadequate demonstration on the behavior of nucleoli and nuclear membranes during the mixture of nucleoplasms at the ultrastructural level.

The two pronuclei in seven-day-old zygotes were connected by internuclear bridges, each of which had a fairly regular width of about 0.17 μm (Ogawa 1981). By contrast, the internuclear bridges joining the two pronuclei of 10-day-old zygotes were various in width, ranging from 0.5 to 1.5 μm (Fig. 3), and

wider than those of seven-day-old zygotes. Though their developmental process is obscure, one of the possibilities is that the union of the internuclear bridges, each about 0.17 μm in width, results in the formation of the wider ones.

The fused nucleus first contained two nucleoli from both the male and female pronuclei (Fig. 6), but only one nucleolus later (Figs. 7 and 10). The two nucleoli in the fused nucleus were sometimes close together (Fig. 6). The nucleolus of each of the two adjacent pronuclei usually possessed one orcein-stainable area (Fig. 4), whereas that of the fused nucleus of zygotes about 12 days old sometimes included two orcein-stainable areas (Fig. 9). These results suggest that the two nucleoli unite together into a single one in *S. verruculosa* like in other species of *Spirogyra* (Tröndle 1907, 1911, Karsten 1908).

It is generally described that in *Spirogyra* the two pronuclei from both gametes fuse together into a synkaryon (Overton 1888, Tröndle 1907, 1911, Karsten 1908). But, exceptions are also known. According to Harada and Yamagishi (1984), in *S. crassa, S. hunanensis*, and *S. lacustris* homologous chromosomes begin to pair within each of the two pronuclei which merely come into contact with each other and meiotic division takes place without the formation of synkaryon. So far as examined in *S. verruculosa*, neither chromosome nor synaptonemal complex, an important criterion of meiosis, could be demonstrated throughout the karyogamy (Figs. 3-8). The appearance of pairing of chromosomes in two adjacent pronuclei may be dependent on species. The occurrence of chromosome synapsis in two adjacent pronuclei was first discovered in *S. neglecta*, in which, however, this phenomenon was not observed in all zygotes (Tröndle 1911). In *S. crassa*, the chromosome pairing was observed by Harada and Yamagishi (1984), but not by Godward (1961). The biological significance of this remarkable phenomenon remains unknown. To understand its nature, ultrastructural reinvestigations, together with the extensive observations using various species, would be necessary.

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小川　茂：緑藻アオミドロ (*Spirogyra verruculosa* Jao) の核融合

アオミドロ (*Spirogyra verruculosa* Jao) の核融合を光学顕微鏡と電子顕微鏡で観察した。雌雄両配偶子の融合後10日経過した接合子では，両配偶子に由来する二つの前核は，互いに連結されていた。その連結部の幅は様々で，0.5 μm から 1.5 μm であった。約12日目になると，両前核の核質は混合を始めた。融合した核は，最初は二つ，しかし，後には一つの核小体を有していた。融合核内の二つの核小体は，時に，互いに接近して存在していた。これらの観察結果は，二つの核小体が融合して一つになることを示唆した。本種では，融合核の形成は，雌雄両配偶子の融合後14日目までに終了した。(943 新潟県上越市山屋敷町　上越教育大学自然系生物)

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Distributional pattern of *Ecklonia cava* (Phaeophyta) marine forest in the coast of Shima Peninsula, central Japan

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Maegawa, M. and Kida, W. 1991. Distributional pattern of *Ecklonia cava* (Phaeophyta) marine forest in the coast of Shima Peninsula, central Japan. Jpn. J. Phycol. **39**: 173–178.

Distributional patterns and intraspecific associations of individuals in *Ecklonia cava* marine forest were studied with special reference to the structure, production ecology and regeneration process using Morisita's I_δ and R'_δ indices. Data were taken by the permanent quadrat method from 1982 to 1985. During a three year cycle, there were periodic yearly changes in the frequency distribution of stipe length i.e. regeneration process. The distributional pattern changed from contagious, through random, to regular distribution with progress of the regeneration process, gap, building and mature phases, respectively. Its pattern of changes was quite similar to that of dominant tree species of terrestrial forests. Severe intraspecific competition was also found between young and adult individuals. The distributional pattern is a result of intraspecific competition for getting light through the regeneration process, according to such a density-dependent function as self-thinning.

Key Index Words: *distributional pattern*—Ecklonia cava—*intraspecific competition*—*Phaeophyta-regeneration process*—*self thinning*.

Ecklonia cava Kjellman (Laminariales, Phaeophyta) has a wide distribution along the central to southern Pacific coast of Japan. It forms a dense and expansive marine forest in the sublittoral zone at a depth of 3–30 m as does *Eisenia bicyclis* Setchell, the latter occupying shallower water than the former. *Ec. cava* is perennial and has the potential to live at least 5 years (Hayashida 1977, Maegawa *et al.* 1988), and therefore population density and structure of this species depend to some extent on the number of recruitments and losses in a growing site.

In our previous papers (Maegawa *et al.* 1988, Maegawa and Kida 1989), we found periodic regeneration of *Ecklonia cava* marine forests and intraspecific competition for getting light by using the permanent quadrat method. Recent ecological research of macroalgal populations have represented a quantitative discipline designed to produce statistically interpretable analyses of biotic distribution and abundance patterns within defined habitats (Dayton *et al.* 1984). Nondestructive measurements, such as utilizing permanently marked sampling locations, provide a powerful method for evaluating the natural changes in dispersion of individuals and intra- and interspecific competition (Littler and Littler 1985).

In general, individuals in the population are distributed according to three fundamental patterns as follows; random, uniform and contagious distributions (Odum 1971). Random distribution is relatively rare in nature, occurring where the environment is very uniform and there is no tendency to aggregate. Uniform distribution may occur where competition between individuals is severe or where there is positive antagonism which promotes even spacing. Contagious distribution with various degrees of clumping represents by far the most common pattern, when individuals are attracted.

A lot of knowledge has been accumulated about the distributional pattern of individuals in land plant populations (cf. Tagawa 1977). However, no experiments have yet been

made which allow one to evaluate the probability that in algal populations distributional patterns change in seral stages with the process of regeneration. In this study, we intend to analyze the distributional pattern of individuals in *Ecklonia cava* marine forest with special references to structure, production ecology and regeneration process of the marine forest investigated in our previous papers (Maegawa and Kida 1987, 1989, Maegawa *et al.* 1988). This sort of study will provide the fundamental data for evaluating the intraspecific competition in marine forests.

Materials and Methods

Permanent quadrat experiments for analyzing the distributional pattern were carried out offshore at Hamajima, Shima Peninsula. In May 1982, a 1 m × 3 m quadrat constructed with ropes was set on a flat rocky substratum within the population at a depth of 8 m. The quadrat was divided into 6 small subquadrats for convenience of measuring and mapping. All individuals in the quadrat were marked by tagging sequentially numbered plastic plates (1 cm × 2 cm) around the holdfast for adult plants and plotting the position of individuals on a distribution map for young and small ones. The smallest juveniles marked in this study were 1-3 cm long which could be distinguished from ones of other species.

From the month when the plants were marked, presence or absence of individuals and plant size (stipe length) were measured by means of SCUBA diving. The census in the quadrat was carried out at two- or three-month intervals from 1982 to 1985. Total plants marked in the quadrat for 4 years reached 1000 individuals. Such numerous data enabled us to conduct a comprehensive study of distributional pattern.

Based on the quadrat technique for analyzing the spatial distribution of individuals in a population, there are many indices which express the degree of aggregation or departure from randomness of the distributional pattern. In this study we chose an index of dispersion, I_δ, by Morisita (1959a) and an index of interspecific association, R'_δ, by Morisita (1959b), both of which were influenced neither by the average number of individuals per quadrat nor by the number of quadrats.

In Morisita's I_δ-quadrat size relation, I_δ is a measure of dispersion of individuals in a population which takes the value of unity. When the individuals are distributed at random over the area and the number of individuals is very large, I_δ is almost 1. When the individuals are distributed uniformly over the area, I_δ takes the value smaller than 1. When the distribution of individuals is contagious, I_δ is larger than 1.

In addition, Morisita's index of interspecific association, R'_δ, was also used. We applied this index to analyze the intraspecific correlation between young, small fronds and adult, large fronds in *Ecklonia cava* population in the permanent quadrat, although the R'_δ index was developed for analyzing interspecific association or competition. In Morisita's R'_δ-quadrat size relation, when two species (or groups) are distributed independently of each other, R'_δ is almost 0. When the distributional pattern of two species is attractive or repulsive, R'_δ takes a value from 0 to 1 or from -1 to 0, respectively.

In this study, data for analyzing the distributional pattern were offered from the permanent quadrat experiments. A quadrat (1 m × 3 m) was divided contiguously into 6 groups in size, 0.25 m × 0.25 m, 0.25 m × 0.5 m, 0.5 m × 0.5 m, 0.5 m × 1 m, 1 m × 1 m, 1 m × 2 m for computing the I_δ and R'_δ indices. The number of young and adult individuals were recorded for each subquadrat, and were used for detection of distributional pattern index of I_δ and intraspecific correlation index of R'_δ.

Results

Yearly changes of frequency distribution of the stipe length in the quadrat in June from 1982 to 1985 are shown in Fig. 1. Shaded parts showed the number of plants lost during a period till the following year. In 1982 large fronds with stipe length of more then 20 cm oc-

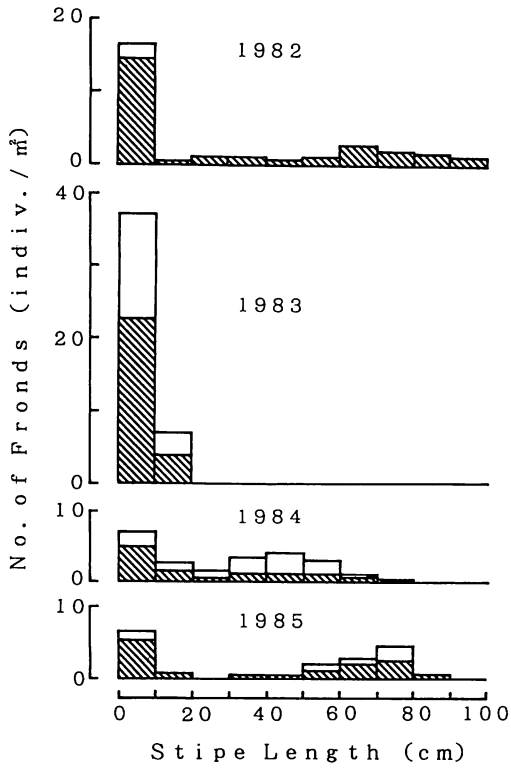

Fig. 1. Yearly changes in frequency distribution of stipe length of the *Ecklonia cava* population from 1982 to 1985. Shaded portions show the loss by the following year.

cupied greater parts, but in 1983 most of the large fronds in the canopy disappeared and many recruits were produced. In 1984 relatively large fronds which developed in 1983 occupied a large part of the population. In 1985 large fronds formed a dense canopy, showing a similar frequency distribution as in 1982. The population structure in 1983, 1984 and 1985 corresponds to gap, building and mature phase of the regeneration process, respectively, according to our previous paper (Maegawa and Kida 1989).

The number of recruits was controlled by the density of large fronds. After most of the large fronds forming the canopy were lost or drifted out, many recruits were produced and grew to the canopy 1-2 years later. Consequently, the turnover time (regeneration cycle) of the canopy layer of the *Ecklonia cava* marine forest was 3 years.

Fig. 2 shows the dispersion of individuals and the results of analysis of the distributional pattern and the intraspecific correlation of *Ecklonia cava* population in June 1982, which was in the typical mature phase. The distributional patterns were calculated in three groups; young individuals less then 20 cm in stipe length, adult individuals more than 20 cm in stipe length and total individuals. The intraspecific correlation was also computed between young and adult individuals.

Young individuals clearly had a contagious distribution which showed an I_δ value higher than one. It was also noticed that young individuals of *Ec. cava* had a small clump, and the intra-clump distribution was more or less regular. Consequently, the individuals in each clump had a tendency to keep some distance from each other, according to the classification of the distributional patterns by Morisita (1959a). On the other hand, adult individuals showed a regular distribution with a tendency to keep some distance from each other. The distributional pattern of total individuals was random. The intraspecific correlation between young and adult individuals was negative. This result indicates that two groups of young and adult individuals were repulsive to each other.

Fig. 3 shows yearly changes in dispersion of individuals which were recruited in 1983, and distributional patterns in June from 1983 to 1985 of the *Ecklonia cava* population. The dispersion of individuals in 1983, 1984 and 1985 represented the typical phase of gap, building and mature, respectively. In the gap phase in 1983, the distributional pattern was contagious, and thereafter it changed to random pattern of the building phase in 1984. From 1983 to 1984, the population density decreased rapidly as shown in the Fig. 1. Adult individuals in the mature phase in 1985 showed regular distribution. From 1984 to 1985, the population density decreased gradually. It was apparent that the distributional pattern changed with advance of the regeneration process and according to changes of the population density.

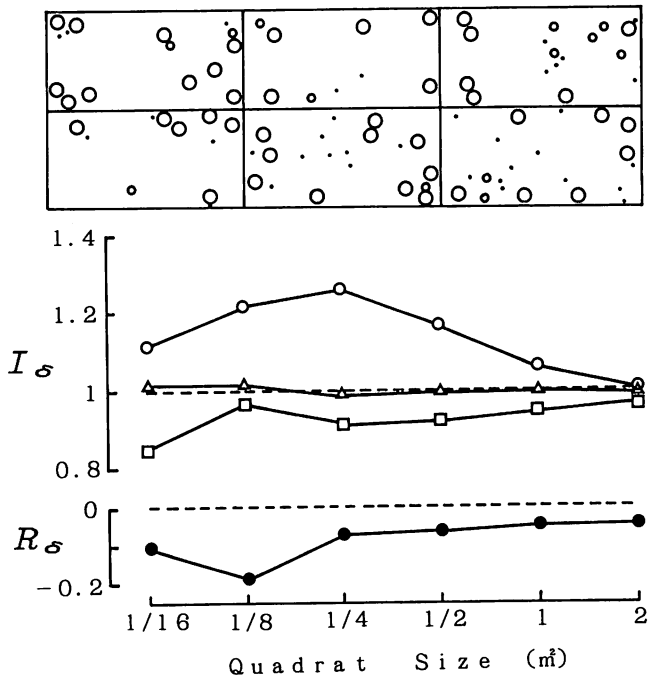

Fig. 2. Analysis of distributional patterns of the *Ecklonia cava* population in June 1982. Upper: Dispersion map of individuals in the permanent quadrat. The size of circles indicates the stipe length; large open circles, adult fronds longer than 20 cm; small open circles, young fronds of 10–20 cm; small solid circles, young fronds shorter than 10 cm. Middle: I_δ-quadrat size relationship for adult fronds (□), young fronds (○), and total fronds (△). Lower: Intraspecific association, R'_δ, between young fronds and adult fronds.

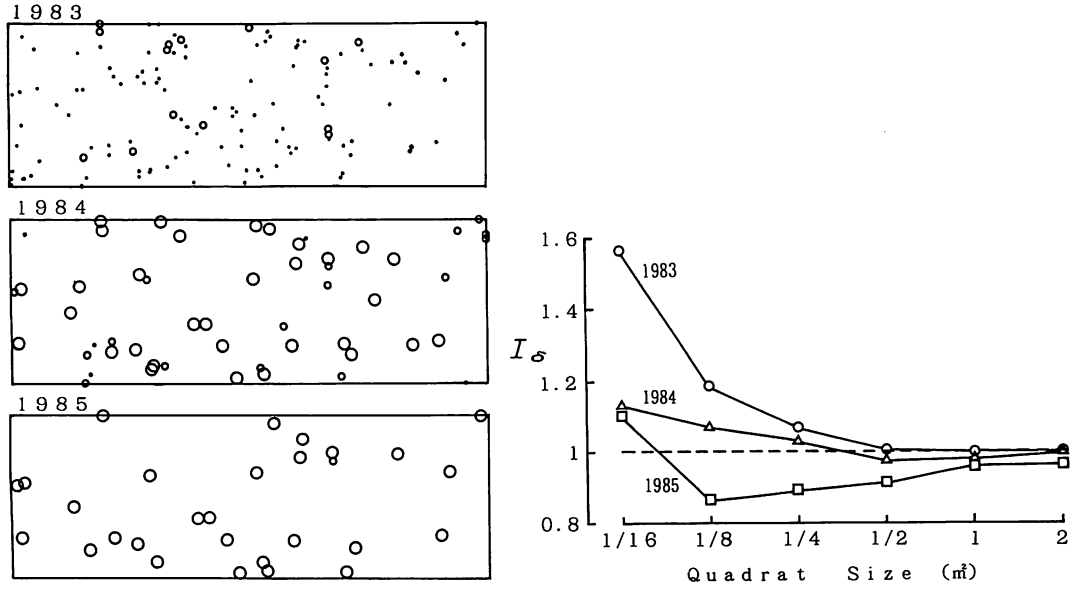

Fig. 3. Changes in the dispersion of individuals and corresponding I_δ-quadrat size relationships with advance of the regeneration process of the *Ecklonia cava* population from 1983 (○) through 1984 (△) to 1985 (□). The size of circles in the dispersion map indicates the stipe length; large open circles, longer than 20 cm; small open circles, 10–20 cm; solid circles, shorter than 10 cm.

Discussion

In this study, we found out that the distributional pattern of the *Ecklonia cava* population changes in accordance with certain principles, and with its density in the regeneration process. In other words, the change in distributional pattern with the process of regeneration is considered partly to be density-dependent. It is noteworthy that the competition between individuals of the same species is one of the most important density-dependent factors in plant communities.

In general, the distributional pattern of recruits in the gap phase is contagious. This is partially because the site available for growth of gametophytes or recruits is restricted by other sessile organisms or by the conditions of substratum, *i.e.* ups and downs of the population floor, and rock, boulder, gravel, or sand. The most important reason for the contagious distribution of recruits is the competition for getting light between young and adult individuals. Germination and growth of the recruits are suppressed by dim light just beneath the adult canopy fronds (Foster 1975, Gerard 1984, Hayashida 1986, Maegawa *et al.* 1988). As a result, the recruits can occupy only small openings where the canopy fronds leave some distance and light intensity is relatively high in the population.

The number of young fronds which fill the gap greatly decreases in the building phase. At this time, a strong intraspecific competition for light occurs according to the growth of each fronds (cf. Maegawa *et al.* 1988). This results in the death of many competitively inferior individuals which may be small and/or shaded, so that few competitively superior individuals survive and grow to canopy fronds. It is a typical model of "self-thinning". Individuals in the clump experience a stronger self-thinning than isolated individuals, so that the dispersion of individuals changes from contagious distribution to random distribution with the growth of fronds.

From the building to the mature phase, adult individuals which have reached sufficient height to form the canopy show a regular distribution, because competition for light is so great that the space occupied by individual fronds in the canopy tends to be nearly equal to each other. Such a change in the distributional pattern of *Ecklonia cava*, contagious to regular through random distribution, is quite similar to that of the dominant tree species of terrestrial forests of Type III by Tagawa (1965), although the period of the regeneration process of a marine forest is extremely shorter than that of a terrestrial forest. There appears to be fundamental similarity in behaviour at the biochemical, physiological population and community levels between at least some seaweeds and terrestrial higher plants, despite basic differences in structure and function as described in Cousens (1985).

It is concluded that one of the most important factors controlling the structure of algal population is the light condition in it as emphasized in our previous papers (Maegawa *et al.* 1988, Maegawa and Kida 1989). The distributional pattern is also a result of intraspecific competition for getting light through the regeneration process, according to such a density-dependent function as self-thinning.

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前川行幸・喜田和四郎：三重県志摩半島沿岸におけるカジメ海中林の分散構造

漸深帯に大規模な海中林を形成する大型褐藻カジメ (*Ecklonia cava*) の分散構造と種内競争を，森下 (1959a, b) の I'_δ および R'_δ 法により解析した。用いたデータは，1982年から1985年にかけて三重県志摩半島浜島沿岸に設置された永久コドラートから得られた。茎長組成の年変化から，群落更新の周期は3年であることが確かめられた。分析構造は群落更新に伴って変化し，ギャップ相では集中分布，建設相ではランダム分布，成熟相では規則分布であった。このような海中林の分散構造の変化パターンは，陸上における森林の優占種のそれと基本的に同じであった。海中林内では林冠を形成する成体と幼体との間には，厳しい種内競争がみられた。海中林を形成する個体の分散構造は，群落の更新に伴う自己間引きのような密度依存的な作用と光に対する種内競争によって決定されるものと考えられた。（514 三重県津市上浜町1515　三重大学生物資源学部藻類増殖学研究室）

藻類 Jpn. J. Phycol. 39: 179–183, June 20, 1991

淡水産ラフィド藻の日本における分布とその生育に及ぼすpH の影響

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Kato, S. Geographic distribution of freshwater raphidophycean algae in Japan and the effect of pH on their growth. Jpn. J. Phycol. 39: 179–183.

Six members of freshwater raphidophycean algae, *Vacuolaria virescens* Cienkowski var. *virescens*, *V. virescens* var. *minuta* Skuja, *V. viridis* (Dang.) Senn, *Gonyostomum semen* (Ehr.) Diesing, *G. latum* Iwanoff and *Merotricha bacillata* Mereschkowsky were collected from 17 localities in Japan. The growth of these algae was examined at different pH levels in AF-6 medium to which was added the hydrogen ion buffer (PIPES). All of these algae could not survive at pH 8.0 or higher. The results of this experiment suggest that pH is an important factor in determining the geographic distribution of freshwater raphidophycean algae.

Key Index Words: *culture—freshwater raphidophycean algae—geographic distribution*—Gonyostomum—*growth*—Merotricha—*pH*—Vacuolaria.

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淡水産のラフィド藻は比較的希産の藻とされており (Heywood 1968)，わが国でもわずかに北海道で豊頃泥炭地湿原や釧路オンネナイ水ゴケ湿原などの6カ所 (Hada 1959, 庵谷1970)，本州で茨城県の霞ケ浦や東京都大田区の宝来公園内の池などの4カ所（原ほか 1978, Kato 1983）の計10カ所から採集されているにすぎない。筆者は日本各地で淡水藻の採集をおこなった際に，既に報告した3カ所 (Kato 1983) に加え，新たに14カ所の計17カ所で日本新産の *V. virescens* var. *minuta* を含む5種1変種の淡水産ラフィド藻を採集することができた。また，それらのクローン培養株も得ることができた。ラフィド藻の生息地はいずれも弱酸性～弱アルカリ性であり，この藻の生育や分布にはpHが大きく影響していると考えられることから，今回得られた5種1変種のクローン培養株7株を用いてpHとその生育との関係を調べたのでその結果を上記の17カ所の産地とともに報告する。

材料と方法

採集は1977年から1988年までの間に主として東日本の湖，池，沼などで大型ピペット，おもりを付けた大形ポリ瓶およびバンドン式採水器を用いて行った。採集した試料は低温に保って持ちかえり，直ちに顕微鏡で観察し，ラフィド藻の有無を調べた。

実験には，ピペット洗浄法で単離し，AF-6培地（加藤1982）にpH緩衝剤のPIPES（ピペラジン-N, N-ビス［2-エタンスルホン酸］）を1 mMの濃度になるように加えた培地 (pH 6.7) で継代培養した以下のラフィド藻を用いた：*V. virescens* var. *virescens* のR-12株（茨城県土浦市郊外の宍塚大地，1978年8月16日採集），*V. virescens* var. *minuta* のR-1020株（茨城県つくば市の乙戸沼，1985年8月22日採集），*V. viridis* のR-352株（東京都大田区の宝来公園内の池，1978年8月31日採集），*G. semen* のR-424株（茨城県取手市郊外の中沼，1978年9月7日採集），*G. latum* のR-336株（東京都文京区の旧東京教育大学講内の池，1978年7月23日採集）とR-1002株（東京都港区の有栖川公園内の池，1985年8月2日採集）および *M. bacillata* のR-339株（青森県五所ガ原市郊外の二ノ沢溜池，1978年7月29日採集）。継代培養は温度20°C, 12時間明期・12時間暗期の明暗周期，照度は *V. virescens* var. *virescens*, *V. viridis* および *G. semen* では1500 lux, また，*V. virescens* var. *minuta*, *G. latum* および *M. bacillata* では3000 luxの条件下で行った。

実験では接種後のpHが3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5になるように調節した培地（AF-6培地にPIPESを加えた培地）を10 m*l*入れた試験管をそれぞれ3本用意し，次にこれらの試験管に細胞数が25–50個／m*l*になるように7株のラフィド藻を接種

して，継代培養と同じ条件下で培養した。観察は毎日行い，2週間後にその生死を調べた。なお，pHの測定は野外ではpH比色計（共立理化，PCR型）を，培地ではpHメーター（掘場製作所，L-7LC型）をそれぞれ用いた。また，細胞数の測定には血球計算盤（白血球用），容積0.1 m*l* のガラス製チェンバー（10 mm×10 mm×1 mm）および容積1 m*l* のラフター・チェンバー（50 mm×20 mm×1 mm）を用いた。

結　果

（1） 日本における分布：Fig. 1 とTable 1 に示された北海道，東北，関東および中部地方の17カ所でラフィド藻の *V. virescens* var. *virescens*, *V. virescens* var. *minuta*, *V. viridis*, *G. semen*, *G. latum* および *M. bacillata* の5種1変種が得られた。

北海道渡島支庁七飯町の道路わきの小さな沼からは *V. virescens* var. *virescens*, *G. semen* および *M. bacillata* の3

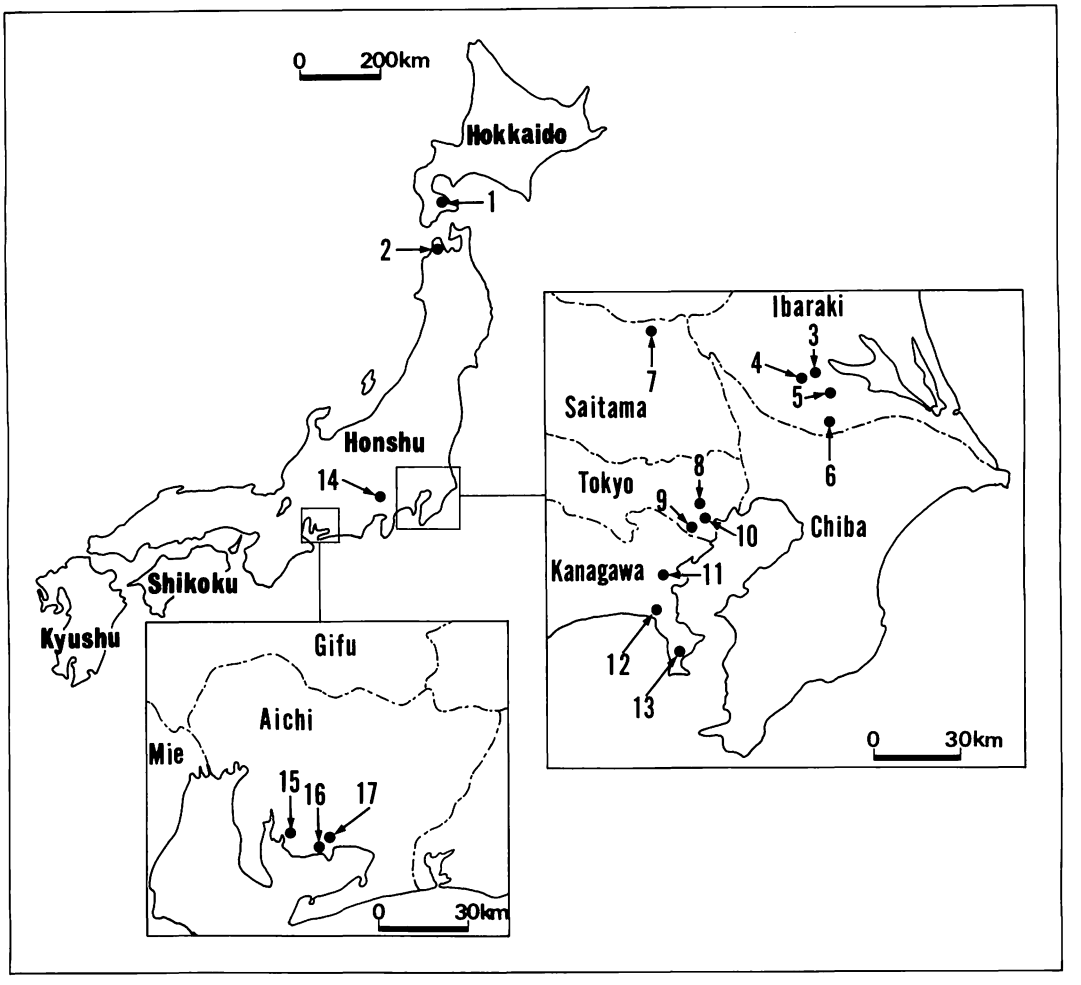

Fig. 1. Map showing the localities where freshwater raphidophycean algae were collected. Numbers of the localities correspond with those in Table 1. 1. A roadside small swamp, Nanae-cho, Oshima, Hokkaido. 2. Ninosawa tameike pond, Goshogawara, Aomori. 3. Shishizuka-ooike pond, Tsuchiura, Ibaraki. 4. Otsutonuma swamp, Tsukuba, Ibaraki. 5. Hebinuma swamp, Ryugasaki, Ibarakki. 6. Lake Nakanuma, Toride, Ibaraki. 7. Hozojinuma swamp. Hanyu, Saitama. 8. A small pond, the former Tokyo Kyoiku University campus, Tokyo. 9. A pond, Horai Park, Tokyo. 10. A small pond, Arisugawa Park, Tokyo. 11. Kamiyabeike pond, Yokohama, Kanagawa. 12. Meotoike pond, Kamakura, Kanagawa. 13. Komatsugaike pond, Miura, Kanagawa. 14. Lake Kawaguchi, Yamanashi. 15. A small pond, Hachiman Shinto Shrine, Komi-cho, Nishio, Aichi. 16. Kandaike pond, Gamagori, Aichi. 17. Bankakuike pond, Gamagori, Aichi.

Table 1. Collection data at each locality.

Locality No.	Date	Species	pH
1	Aug. 29, 1983	*V. virescens* var. *virescens*	7.1
		G. semen	
		M. bacillata	
2	July 29, 1978	*M. bacillata*	6.9
3	Aug. 16, 1978	*V. virescens* var. *virescens*	7.1
	May 29, 1984	*V. virescens* var. *virescens*	6.9
		M. bacillata	
	Nov. 8, 1984	*V. virescens* var. *virescens*	6.8
		M. bacillata	
4	Aug. 22, 1985	*V. virescens* var. *minuta*	7.2
5	June 18, 1978	*G. semen*	7.2
6	Sept. 7, 1978	*G. semen*	6.7
7	July 29, 1981	*V. virescens* var. *virescens*	6.5
8	July 23, 1978	*V. viridis*	7.2
		G. latum	
9	Aug. 31, 1978	*V. viridis*	6.8
		G. latum	
10	Aug. 2, 1985	*G. latum*	7.3
11	Aug. 24, 1988	*G. latum*	7.3
12	May 24, 1981	*G. latum*	7.4
13	Apr. 18, 1979	*G. latum*	7.2
14	May 25, 1982	*G. semen*	7.4
15	Aug. 15, 1987	*V. viridis*	6.9
16	July 28, 1979	*G. semen*	6.9
17	July 28, 1979	*G. semen*	6.7

V, Vacuolavia; G, Gonyostomum; M, Merotricha.

種が得られ，3種ともその個体数は1 m*l* 中に数細胞と少なかった。青森県五所ガ原市郊外の二ノ沢溜池からは *M. bacillata* が得られ，その個体数は1 m*l* 中に1細胞以下とかなり少なかった。2カ所とも採集してから観察するまで2日間あり，さらにラフィド藻は死滅しやすいことから採集時での個体数はもっと多かったと推測される。茨城県土浦市郊外にある農業用溜池の宍塚大池からは *V. virescens* var. *virescens* および *M. bacillata* の2種が得られた。その個体数は1 m*l* 中に *V. virescens* var. *virescens* では50–200細胞，*M. bacillata* では15–30細胞と比較的多かった。茨城県つくば市にある乙戸沼からは Skuja (1964) の原記載以外にその報告がなされていない *V. virescens* var. *minuta* が得られ，その個体数は1 m*l* 中に1細胞以下とかなり少なかった。茨城県竜ヶ崎市郊外の蛇沼および茨城県取手市郊外の中沼の2カ所からは *G. semen* が得られ，ともにその個体数は1 m*l* 中に数細胞と少なかった。中沼においては表面近くからは採集できず，水深6–8 m の層のみから得られた。埼玉県羽生市郊外にある農業用掘割の宝蔵寺沼からは *V. virescens* var. *virescens* が得られ，その個体数は1 m*l* あたり2–3細胞と少なかった。東京都文京区の旧東京教育大学講内の占春園の池からは *V. viridis* と *G. latum* の2種が得られ，その個体数は1 m*l* 中に *V. viridis* が1560細胞，*G. latum* が430細胞とかなり多かった。東京都大田区の宝来公園内の池からは占春園の池と同様 *V. viridis* と *G. latum* が得られ，その個体数も1 m*l* 中に *V. viridis* が2420細胞，*G. latum* が670細胞とかなり多かった。東京都港区の有栖川公園内の池，神奈川県横浜市戸塚区にある上矢部池，神奈川県鎌倉市郊外の夫婦池および神奈川県三浦市南下浦町にある農業用溜池の小松ケ池の4カ所からは *G. latum* が得られたが，その個体数はいずれも1 m*l* 中に数細胞と少なかった。山梨県南都留郡の河口湖の岸辺近くからは *G. semen* が得られたが，その個体数は1 m*l* 中に

2–3細胞と少なかった。愛知県西尾市巨海町の八幡神社境内の池からは *V. viridis* が得られ，その個体数は1 m*l* 中に1840細胞とかなり多かった。愛知県蒲郡市西浦町にある農業用溜池の神田池と愛知県蒲郡市一色町にある農業用溜池の板角池の2カ所から *G. semen* が得られたが，その個体数は1 m*l* 中にそれぞれ2–3細胞および1–2細胞と少なかった。なお，宍塚大池，占春園の池および宝来公園内の池の3カ所については，すでにラフィド藻の *Vacuolaria* 2種の出現を報告しているが (Kato 1983)，他に *Gonyostomum* や *Merotricha* も出現したのでここにあらためて報告しておく。

（2） 生育に及ぼすpHの影響：Fig. 2にpH 3.5からpH 8.5までの11段階にpHを調節した培地における接種後2週間目（継代培養条件下では対数増殖期中期）の7株のラフィド藻の生存範囲が示されている（3本の試験管のうち1本でも生存していた場合も生存範囲に入れた）。

V. virescens var. *virescens* のR-12株ではpH 4.0から7.5までの範囲で生存しており，pH 3.5および8.0以上では死滅していた。また，pH 4.0と7.5では接種時と比べてほとんど細胞数の増加はみられず，さらに，pH 4.0では細胞は球形をし，ゼラチン状の鞘で覆われて遊泳していなかった。*V. virescens* var. *minuta* のR-1020株ではpH 4.5から7.5までの範囲で生存しており，pH 4.0以下および8.0以上では死滅していた。*V. viridis* のR-352株ではpH 4.5から7.0までの範囲で生存しており，pH 4.0以下および7.5以上では死滅していた。

G. semen のR-424株ではpH 4.0から7.5までの範囲で生存しており，pH 3.5および8.0以上では死滅していた。また，pH 7.5では破裂した細胞の残骸が多数みられた。*G. latum* のR-366株ではpH 4.5から7.5までの範囲で生存しており，pH 4.0以下および8.0以上では死滅していた。さらに，pH 4.5ではパルメラ状になり，遊泳していなかった。一方，R-1002株ではpH 4.0から7.5までの範囲で生存しており，pH 3.5および8.0以上では死滅していた。さらに，pH 4.0と4.5ではパルメラ状になり，遊泳しておらず，pH 4.0では接種時より細胞数は減少していた。

M. bacillata のR-339株ではpH 4.0から7.5までの範囲で生存しており，pH 3.5および8.0以上では死滅していた。また，pH 4.0ではほとんど増殖せず，遊泳していなかった。さらに，pH 7.5では接種時より細胞数は減少していた。

実験に用いた7株のラフィド藻では，接種後2週間目には死滅していたpHの培地中でも接種直後にはその藻体に変化はみられず，接種後1日目でも活発に遊泳していた。しかし，2日目には変化が現れ，pHの低い方の培地中では藻体が褐色になって遊泳しなくなった。一方，pHの高い方の培地中では緑色のまま藻体が破裂しはじめた。なお，培地のpHの変化は小さく，接種後2週間目でもその変化が最大0.2を越える

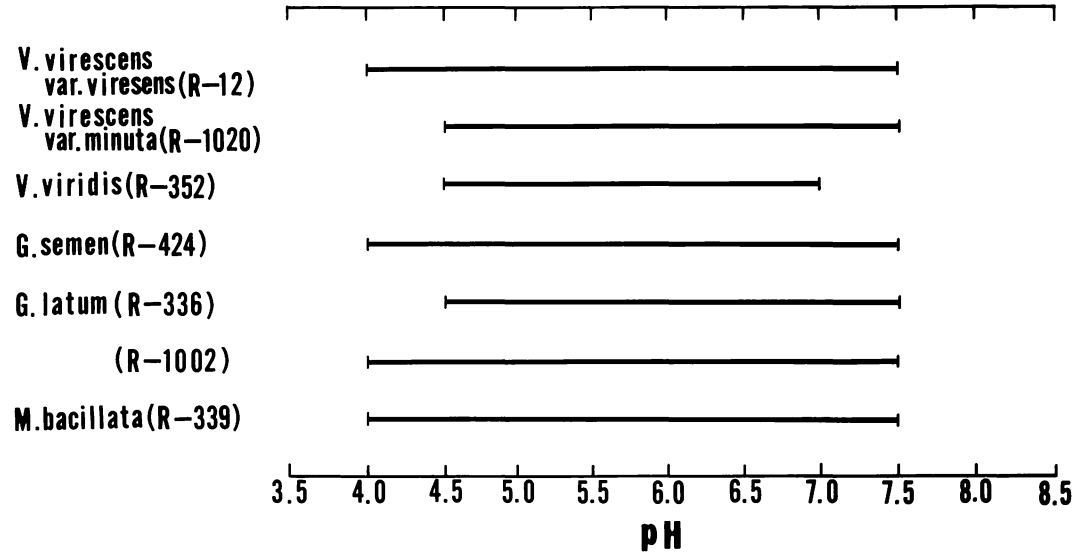

Fig. 2. Relationship between pH and the growth of freshwater raphidophycean algae. The bars indicate the range of pH in which the algae existed.

ことはなかった。

考　察

今回新たにラフィド藻の生息が確認された14カ所とすでに筆者により報告されている3カ所 (Kato 1983) の計17カ所はいずれもそのpHが6.5–7.4で，それらの近くに存在していた他の池沼とくらべてpHが低いという共通性がみられた (Table 1)。さらに，Hada (1959) や庵谷 (1970) によってその生息が報告された北海道の泥炭地や水ゴケ湿原内の池沼のpHが5.8–7.0であること，ヨーロッパやアメリカでの生息地が酸性～中性であること (Heywood 1968) などから，この藻の分布にはpHがきわめて大きく影響しており，特に，アルカリ性の水域では生育しにくいものと思われるが，この点について何も調べられていない。そこで，酸性域からアルカリ性域の広い範囲においてpHの緩衝作用をもち，さらにラフィド藻の生育に影響を与えないpH緩衝剤のPIPESを加えたAF-6培地を用いて，培地のpHと5種1変種のラフィド藻の生育との関係を調べた。その結果，これらのラフィド藻は酸性側では広い範囲で生育できるのに対して，アルカリ性側では狭い範囲でしか生育できず，pH 8.0以上ですべてが死滅しており，実験的にも淡水産のラフィド藻はアルカリ性の水域では生育しにくいことが確かめられた。このことは，pHがこの藻の分布を決定する極めて重要な要因となっていることを示している。

今回筆者は東日本の日本海側や西日本ではほとんど採集をおこなっていないが，これらの地域でも酸性～弱アルカリ性の池沼にはラフィド藻が生息している可能性は大きいと考えられる。

終わりに，本研究を行うにあたり逐次便宜をはかってくださった日本大学農獣医学部の山岸高旺教授，大島海一助教授およびラフィド藻の採集にあたり貴重な助言をくださった筑波大学生物科学系の原慶明助教授に深く感謝いたします。

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Hiroshi Yabu and Hajime Yasui: Chromosome number in four species of *Laminaria* (Phaeophyta)

Key Index Words: *chromosome number*—Laminaria angustata—Laminaria japonica—Laminaria ochotensis—Laminaria religiosa—*Phaeophyta*.
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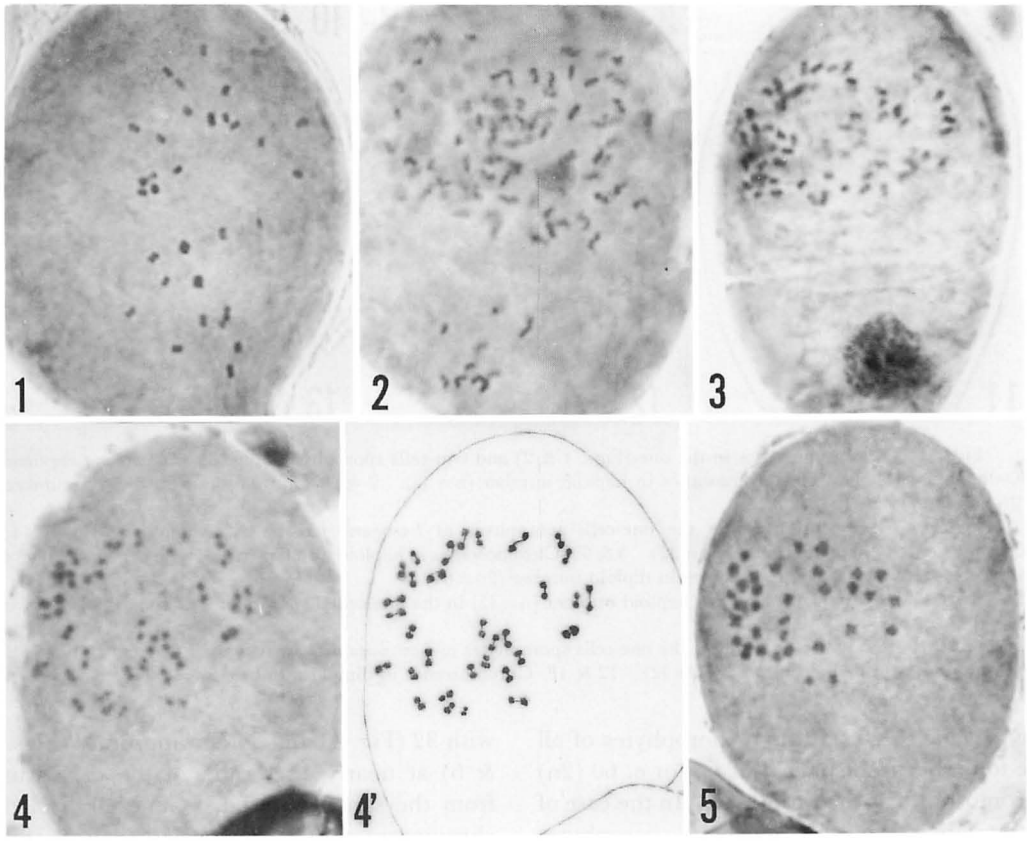
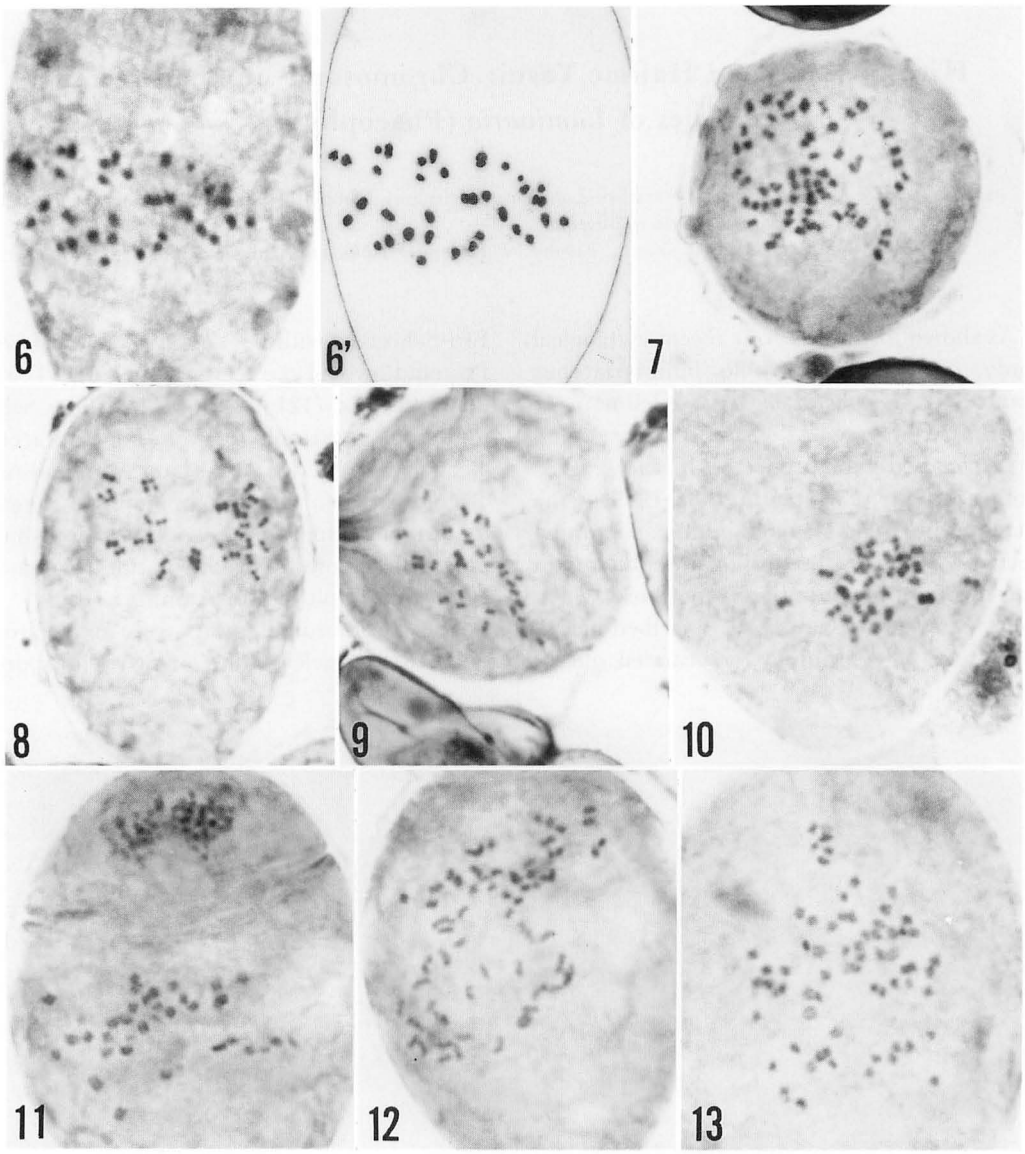
As shown in Table 1, our recent cytological study on the four edible laminariaceous plants, viz. *Laminaria angustata* Kjellman, *L. japonica* Areschoug, *L. ochotensis* Miyabe and *L. religiosa* Miyabe, collected in the seasons from autumn to winter in 1988-1989 at the localities in Hokkaido cited in the table, unexpectedly exhibited the results quite differed in the chromosome number from those which were recorded previously as described here.

Culture of zoospores were carried out in Erd-Schreiber with 0.01% SLP (Squid Liver Protein Powder) extract (Yabu *et al.* 1984) under 3,000 lux (12L-12D). The slides with numerous gametophytes were put into acetic alcohol (1 : 3) at two weeks later from the start of culture when female gametophytes began to produce sporophytes. Aceto-iron-haematoxylin chloral hydrate solution (Wittman 1965) was employed for staining.

The chromosome counts were made from the dividing nuclei in one- or two-celld sporo-





Figs. 1–3. Chromosomes in the one-(Figs. 1 & 2) and two-cells sporophytes (Fig. 3) of *Laminaria angustata* Kjellman. ×1,600. 1. Chromosomes in haploid number (n=32). 2 & 3. Chromosomes in diploid number (2n=c. 60).

Figs. 4–7. Chromosomes in the one-cells sporophyes of *Laminaria japonica* Areschoug. ×1,600. 4. Chromosomes in haploid number (n=32). 5 & 6. Chromosomes in haploid number (n=34). 4′& 6′. Drawing of 4 & 6 respectively. 7. Chromosomes in diploid number (2n=64).

Figs. 8 & 9. Chromosomes in haploid number (n=32) in the one-celled sporophytes of *Laminaria ochotensis* Miyabe. ×1,600.

Figs. 10–13. Chromosomes in the one-cells sporophytes of *Laminaria religiosa* Miyabe. ×1,600. 10 & 11. Chromosomes in haploid number (n=32). 12 & 13. Chromosomes in diploid number (2n=c. 60).

phytes (Figs. 1-13). Such sporophytes of all the four species displayed 32 (n) or c. 60 (2n) chromosomes at the ratio 1 : 5. In the case of *L. japonica*, we met the partheno-sporophytes with 32 (Fig. 4) and 34 chromosomes (Figs. 5 & 6) at nearly 1 : 1 ratio in the derivatives from the same material. Generally, all the chromosomes in each species show median

Table 1. Chromosome number in four secies of *Laminaria* used for this study.

Species	Locality	Chromosome number	Investigator
Laminaria angustata	Muroran	n=22	Nishibayashi & Inoh (1956)
	Muroran	n=22	Ohmori (1967)
	Shikabe	n=22	Funano (1978)
	Mitsuishi	n=22	Funano (1980)
	Usujiri	n=32, 2n=c. 60	Present study
L. japonica	Muroran	n=22	Abe (1939)
	Shikabe	n=22	Funano (1978)
	Usujiri	n=22, 2n=44	Yabu (1973)
	Usujiri	n=32 or 34*, 2n=c. 60	Present study
L. ochotensis	Wakkanai	n=22	Kaneko (1972)
	Kafuka	n=22	Funano (1978)
	Wakkanai	n=32, 2n=c. 60	Present study
L. religiosa	Oshoro	n=22	Funano (1978)
	Oshoro	n=22	Funano (1983)
	Oshoro	n=32, 2n=c. 60	Present study

* See text.

constriction.

As the results of our chromosome counts in the numerous sporophytes at this time, we came to a conclusion that the chromosome number of *Laminaria angustata, L. japonica, L. ochotensis* and *L. religiosa* is normally n=32, although they have been reported all as n=22 until now.

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籔　熙・安井　肇：コンブ科植物4種についての染色体数

ミツイシコンブ，マコンブ，リシリコンブ，ホソメコンブについての染色体数は今迄 n=22 とされている。しかし，今回，北海道産のこれらの種について1～2細胞期の幼芽胞体細胞内核分裂で調べた結果，何れの種も n=32 であると見做された。(041 函館市港町3-1-1　北海道大学水産学部)

Jpn. J. Phycol. (Sôrui) 39: 189–193, June 20, 1991

Taiju Kitayama, Hiroshi Kawai and Tadao Yoshida: Morphological observations on *Sphacelaria californica* Sauvageau ex Setchell et Gardner (Sphacelariales, Phaeophyceae), new to Japan

Key Index Words: *brown algae—morphology—Phaeophyceae*—Sphacelaria californica—*Sphacelariaceae—Sphacelariales.*

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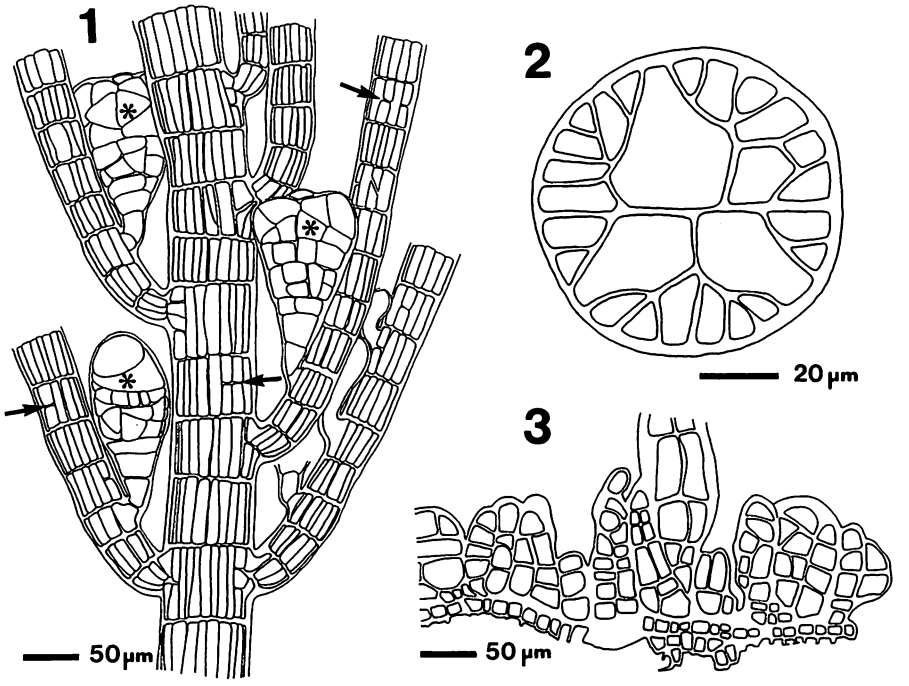
The morphology of Japanese *Sphacelaria californica* Sauvageau ex Setchell et Gardner was studied in the field and culture materials. Sauvageau (1901) described *Sphacelaria plumula* Zanardini var. *californica* Sauvageau as a new variety, based on the specimens collected at San Diego, California. He distinguished this variety from typical *S. plumula* by the following characteristics: presence of a basal disk; absence of ramifications in the lower portions of erect filaments; occurrence of transverse cell walls in the secondary segments (=secondary transverse cell walls); a slightly larger size of propagules. He also used the new specific name *Sphacelaria californica* for the taxon, although he attached a question mark to the name indicating hesitation. Setchell and Gardner (1925) treated the variety as an independent species, attributing this combination to Sauvageau. We regard *S. californica* as an independent species and follow their nomenclatural treatment. Boo and Choi (1986) mentioned the location of the propagules and the division of their lateral apical cells as the specific characteristics.

S. californica is found distributed in the Pacific Ocean (Abbott and Hollenberg 1976), but *S. plumula* has not been reported from this area. In the western Pacific Ocean, Boo and Choi (1986) reported the occurrence of drift materials of *S. californica* from the east coast of Korea, but the species has not been reported in Japan. There have been no culture works on the life history on this species. This is the first report on the distribution of *S. californica* on the Japanese coast, and on the study in culture.

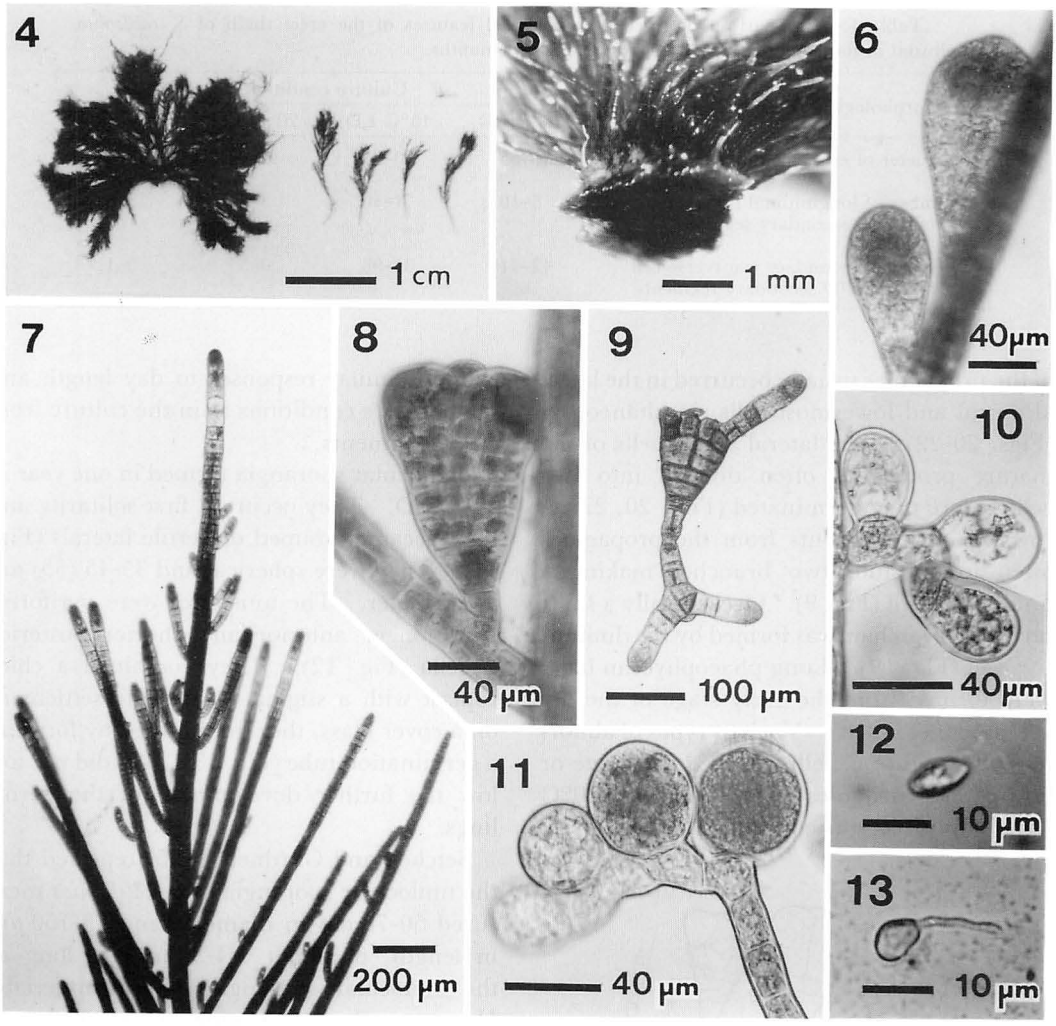
Some plants referable to *Sphacelaria californica* were collected at Ohma (41°33′N 140°55′E, 23 October 1987) and Sai (41°26′N 140°51′E, 19 January and 21 March 1988) in Aomori Pref.; Shiiya (37°28′N 138°37′E, 7 July 1990, drift) in Niigata Pref.; Seto (33°27′N 132°13′E, June 1989, coll. T. Wajima) in Ehime Pref.; and Gobo (33°52′N 135°05′E, 21 June 1989, coll. M. Matsumoto) in Wakayama Pref. The specimens examined in the present work are deposited in the herbarium of Faculty of Science, Hokkaido University, Sapporo [SAP]. They are epilithic or epiphytic and brown in color. They form erect tufts and attain to 1.6 cm in height (Fig. 4). The holdfasts are discoid (Fig. 5), polystromatic (Fig. 3), and 100–150 μm in thickness on rocks. However, when epiphytic, e.g. on *Codium fragile* (Suringar) Hariot, they become rhizoidal and penetrate into the host tissues. The erect thalli are pinnately branched and composed of main axes and laterals. The main axes are straight and terete. They are 30–50 μm in diameter in the lowermost portions, gradually increasing in diameter toward the apex, and 60–95 μm in the middle portions. The laterals are denser in the upper parts of the thalli, but sparser in the lower parts. Laterals are formed unilaterally or bilaterally. The apical cells of main axes and laterals are 45–60 μm in diameter and 90–200 μm in length. The secondary segments are 0.6–1.1 times as long as the diameter. They are divided radially into several cells in transverse section (Fig. 2). In a surface lateral view, 3–10 longitudinal walls can be observed in a large second-



Figs. 1–3. *Sphacelaria californica* Sauvageau ex Setchell et Gardner from nature (Sai, 21 March 1988). 1. Middle portion of the thallus with secondary transverse cell walls (arrows) and propagules (asterisks). 2. Transverse section of the middle portion of an erect filament. 3. Vertical section of the holdfast.

ary segment. The peripheral cells of the secondary segments are rectangular in the surface view, (3)6–15(20) μm in width. The secondary transverse cell walls often occur in the peripheral cells of the segments (Fig. 1). Phaeophycean hairs are at times observed to form adaxially. The propagules are born adaxially on the laterals (Figs. 1, 8). They are ellipsoidal when young, becoming tribuliform as they develop. Mature propagules are 140–170 μm in length and 85–105 μm in width, with three (one central and two lateral) apical cells, containing abundant discoid chloroplasts without pyrenoids. Unilocular sporangia were observed on one plant collected in March 1988. They were formed solitarily or in groups on fertile laterals, spherical to somewhat ellipsoidal, 30–50 μm in diameter and 40–50 μm in length (Fig. 10). Plurilocular sporangia were not found. Our specimens agreed well with the original description of *S. plumula* var. *californica* by Sauvageau (1901) and the description by Setchell and Gardner (1925) except for the smaller size of unilocular sporangia.

Unialgal culture was established from the apical segments of the plant collected at Sai in March 1988, using PESI medium (Tatewaki 1966). Culture conditions used were 5°C SD (short day; 8 : 16 h light : dark), 5°C LD (long day; 16 : 8 h light : dark), 10°C SD, 10°C LD, 15°C SD, 15°C LD, 20°C SD and 20°C LD, under white fluorescent light of about 30 $\mu Mm^{-2}s^{-1}$ (10°C) or 50 $\mu Mm^{-2}s^{-1}$ (5°C, 15°C and 20°C). The initial filaments grew well and many were produced in 10°C, 15°C and 20°C conditions. However, they did not elongate and finally died in 5°C conditions. Phaeophycean hairs were formed from the early stage of the development. In 10°C SD, 10°C LD, 15°C SD, 15°C LD and 20°C LD within 2 months, many laterals were formed on the filaments spirally or radially, but not pinnately as in the natural plants (Fig. 7). Movement of water may be required for the normal morphogenesis of pinnate thallus construction. In 20°C LD the filaments grew rapidly, but arrangements of



Figs. 4–13. *Sphacelaria californica* Sauvageau ex Setchell et Gardner from nature and in culture. 4–5. Habit of the erect thallus and detail of the holdfast of specimens collected at Sai on 21 March 1988. 6. Immature propagules in culture. 7. Upper part of the thallus grown at 15°C SD. 8. Mature propagule of the thallus from nature. 9. Germination of a propagule in culture. 10. Three unilocular sporangia on a fertile lateral of the thallus from nature. 11. Four unilocular sporangia on a fertile lateral in culture (15°C SD). 12. Released unispore with two flagella. 13. Germination of a unispore.

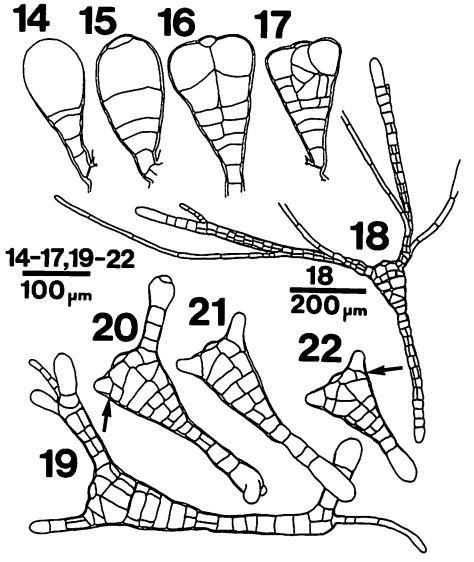
the laterals tended to be irregular. In 20°C SD the filaments remained rhizoidal for several weeks and then formed erect filaments with a few laterals after 5 months. The diameter of erect filaments and the number of longitudinal cell walls in a secondary segment were rather stable in various culture conditions. However, the number of secondary transverse cell walls tended to increase in lower temperature conditions (Table 1). Very few secondary transverse walls were observed under 20°C conditions.

The tribuliform propagules were formed within 2 months in 10°C SD, 10°C LD, 15°C SD, 15°C LD, 20°C SD. They were ellipsoidal in the early stage of the development (Figs. 6, 14). The apical cells of the young propagules were divided successively into a diminutive cell (a central apical cell) and two large cells (Figs. 15-16). The latter developed into the lateral apical cells by further unequal divisions (Fig. 17). The germinations

Table 1. Comparison of three morphological features of the erect thalli of *S. californica* cultured in four different culture conditions after 5 months.

Morphological features	Culture conditions			
	10°C LD	15°C LD	20°C LD	20°C SD
Diameter of erect filaments (μm)	48–65	50–65	30–46	45–63
Number of longitudinal cell walls in a secondary segment	5–10	4–10	3–5	3–6
Number of secondary transverse cell walls per 100 secondary segments	42–114	31–98	0–5	0–1

of the propagules usually occurred in the lateral apical and lowermost cells simultaneously (Figs. 20–22). The lateral apical cells of the mature propagules often divided into two cells before they germinated (Figs. 20, 22 arrows). New filaments from the propagules often forked into two branches making a diminutive cell (Fig. 9). Occasionally a short phaeophycean hair was formed by the diminutive cell (Fig. 19). Long phaeophycean hairs were formed from the early stage of the development (Fig. 18). Various types of abnormally shaped (e.g., ellipsoidal, bicornuate or bifurcate) propagules were formed in 20°C LD. Cultures started from the propagules showed similar responses to day length and temperature conditions as in the culture from apical segments.



Figs. 14–22. *Sphacelaria californica* Sauvageau ex Setchell et Gardner in culture (10°C LD). 14–17. Various stages of development of propagules. 18–22. Various stages of germivation of propagules showing occasional divisions of the lateral apical cells (arrows).

Unilocular sporangia formed in one year in 15°C SD. They occurred first solitarily and then became grouped on fertile laterals (Fig. 11). They were spherical and 35–45 (55) μm in diameter. The unispores were pyriform, with longer anterior and shorter posterior flagella (Fig. 12). They contained a chloroplast with a stigma. After the settlement on a cover glass, they germinated by forming a germination tube (Fig. 13). We did not follow the further development of the germlings.

Setchell and Gardner (1925) reported that the unilocular sporangia of *S. californica* measured 50–70 μm in diameter and 75–150 μm in length, or about 1.4–3 times as long as the unilocular sporangia in our materials. However, the description of Setchell and Gardner on the sizes of unilocular sporangia seems to be based on the Saunder's description on the plurilocular sporangia of *S. tribuloides* Meneghini sensu Saunders (=*S. californica*) and illustrations lacking explanations (Saunders 1898, Plate 26, Figs. 4–6). The plurilocular sporangia in the illustrations of Saunders and the unilocular sporangium in the illustration of Setchell and Gardner (1925, Plate 37, Fig. 27) resemble the young propagules in our materials. In the Sphacelariales it is sometimes difficult to distinguish young propagules from true plurilocular and unilocular sporangia. In our study, we confirmed the presence of many nuclei in a sporangium in the field materials, and observed actual release of swarmers in culture materials.

Accordingly, the solitary unilocular sporangium illustrated by Setchell and Gardner could be an immature propagule.

Our plants also resemble *S. novae-hollandiae* Sonder from South Australia (Womersley 1987) in having cymose unilocular sporangia and tribuliform propagules with occasional divided lateral apical cells. However, this species differs from *S. californica* in lacking pinnate ramifications and the secondary transverse cell walls.

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北山太樹・川井浩史・吉田忠生：日本新産褐藻 *Sphacelaria californica* Sauvageau ex Setchell et Gardner（ハネグンセンクロガシラ：新称，クロガシラ目）の形態観察

青森県大間などから *Sphacelaria californica*（クロガシラ目，クロガシラ科）と同定される藻体を採取し，その形態学的観察と培養による生活史の研究を行った。自然藻体は盤状の付着器と主に上部で羽状分岐する直立部からなり，長さ 140–170 μm，幅 85–105 μm の胚芽枝をつけていた。また，secondary segments には時折，横の隔壁が認められた。3 月の藻体には集散状に形成された単子嚢が見られた。本種の単子嚢については先に Setchell and Gardner (1925) の報告があるが，それは未熟な胚芽枝を誤認したものと考えられるので，本種における単子嚢形成の報告はこれが初めてである。藻体の頂端部と胚芽枝を 5–20°C の長日・短日条件で培養した結果，20°C 長日で最も生長が速く，5°C では生長しなかった。15°C 短日では単子嚢を形成した。（060 札幌市北区北10条西 8 丁目　北海道大学理学部植物学教室）

藻類 Jpn. J. Phycol. 39: 195–197, June 20, 1991

川嶋昭二：外国産コンブ目植物の漂着記録（6）
ゴヘイコンブについて

Shoji Kawashima: Drifting records of alien species of the Laminariales (6).
Laminaria yezoensis Miyabe

Key Index Words: drifting record—Kombu stick—Laminaria yezoensis—*Phaeophyta—seaweeds.*
Shoji Kawashima, Hiyoshicho 4–29–15, Hakodate, Hokkaido, 041 Japan

(7) *Laminaria yezoensis* Miyabe ゴヘイコンブ

ゴヘイコンブは北海道釧路市から根室市ノサップ岬を経て，歯舞諸島，千島列島，アリューシャン列島，アラスカおよびカナダのバンクーバー・アイランドの北端に位置するホープ・アイランドまでの北太平洋一帯に広く分布し，掌状葉ならびに盤状根を持つことを大きな特徴としている（宮部1902，Druehl 1966）。また，本種は多年生であるが，正確な寿命はまだ不明である。

北海道沿岸では場所によって漸深帯上部に小さな群れをなして生えることもあるが，主な生育帯は水深3–10 m ほどの深いところである。葉体の大きさは一般に 30–100 cm, 時には 150 cm に達するが，茎の長さは 5–10 cm から稀に 15 cm くらいにしかならず，直径も 0.7–1.2 cm くらいが普通である。

ところで，宮部（1902）は本種の茎の長さは年令に応じて変わり，その最長なものは 2 尺 6 寸（約 80 cm），また直径はおよそ8–9分（約 2.5–2.7 cm）になると記載している。しかし，このような長く，かつ太い茎を持つものは同報文の第13図に示されているエトロフ島産の葉体のように，千島列島からしか知られておらず，Nagai (1940) は茎長 145 cm，基部の直径は 3.5 cm に達すると記載している。ちなみに，Druehl (1966) によればアリューシャン列島からカナダにかけては茎長 40 cm になるものがあるという。

このように北海道とそれ以外の北太平洋地域で本種の茎長やその直径が著しく異なるのは生育環境の違いによるものか，あるいは寿命の差なのか分らないけれども，とにかく数 10 cm あるいは 100 cm をはるかに越えるような長い茎を持ったゴヘイコンブが漂着すれば，それは北海道産のものでないことはほとんど間違いないということができる。

1981年 7 月に北海道の太平洋沿岸 2 か所からこのようなゴヘイコンブの漂着物が相次いで発見された。最初の発見は 7 月 4 日のことで，釧路支庁管内浜中町藻散布（もちりっぷ）の海浜で住民に拾われ，北海道立釧路水産試験場に保存されている。また，第二の発見

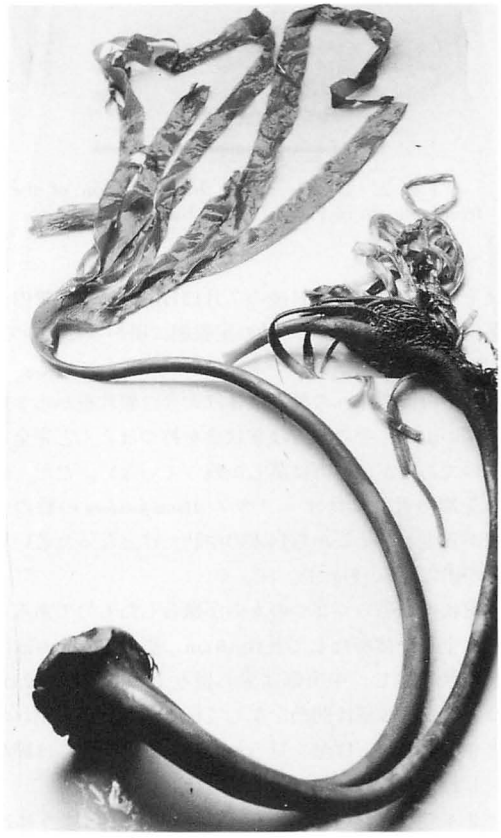

Fig. 1. *Laminaria yezoensis* Miyabe. A pair of fronds, having a large scutate disc jointly, cast ashore at Mochirippu, Hamanaka, on the Pacific coast of eastern Hokkaido on July 4, 1981. The left-hand frond: 125 cm in stipe length and 275 cm in total. The right-hand frond: 135 cm in length of stipe only. On the stipe eleven young fronds of *Alaria fistulosa* Postele et Ruprecht are attached.

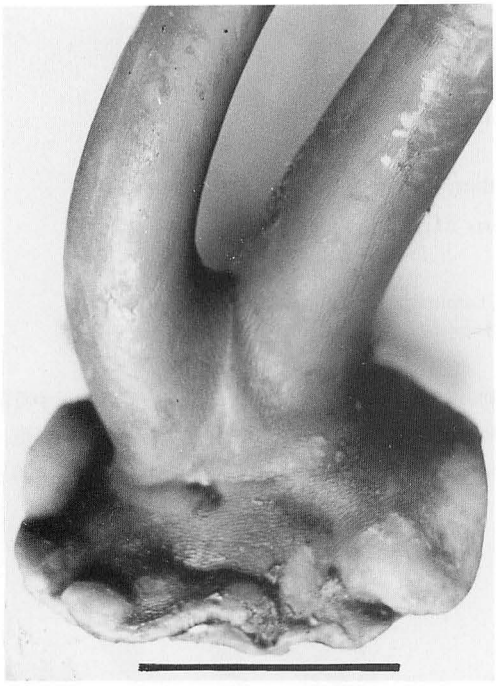

Fig. 2. Details of the basal portion of the fronds shown in Fig. 1. Scale bar, 10 cm.

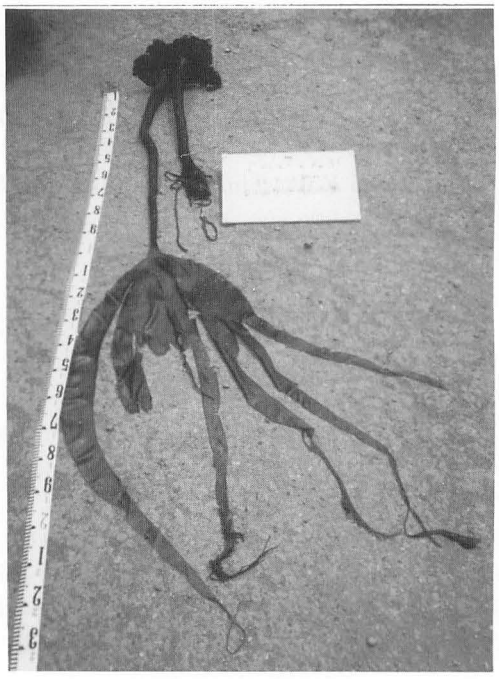

Fig. 3. *Laminaria yezoensis* Miyabe. Driftage caught in set net at Kinaoshi, Minamikayabe, on the Pacific coast of southwestern Hokkaido on July 13, 1981. The size and condition of the fronds fairly resemble those drifted to Mochirippu (Fig. 1).

はそれからわずか9日後の7月13日，渡島支庁管内南茅部町木直（きなおし）沖の定置網に掛かったもので，同町の地場産業振興センター内に展示されている。

浜中町藻散布への漂着葉体は大きな盤状根から2本の茎が出て，その一方は掌状葉を持つほとんど完全なものであるが，他方は茎しか残っていない。ただ，その先端の近くにはオニワカメ *Alaria fistulosa* の根の一塊が着生し，そこから14本の中肋だけとなった若い葉体が出ている (Fig. 1)。

盤状根は恐らく2つのものが融合したものであろうが，全く一体をなして長径18 cm，短径12 cmのほぼ楕円状を呈し，中央部は少し盛り上がって厚さ2 cmほど，また縁部は凹凸をなしているが基質から剝れたときの損傷などは全く見られない。表面全体には細かいしわが多数見られる (Fig. 2)。

2本の茎は盤状根の中央部から相接するように出て，いずれも基部は円柱状を呈し，上の方に次第に細く，かつ扁円となる。掌状葉を持つ方の茎は長さ125 cm，基部の直径6.4 cmあり，茎だけの方は同じく135 cmおよび8.3 cmもある。表面は平滑で硬く，弾力性に富み，植物体というよりもむしろ鞣し皮のような質感がある。

掌状葉は基部が広いくさび状で11枚の葉片に深く切れ込み，その多くは途中から切れているが，先端まで残っている2枚は150 cmの長さがある。また，各葉片の幅は8–12 cmある。葉質は柔らかい。

次に，南茅部町木直への漂着物も盤状根から2本の葉体が出て，その一方にはほぼ完全な掌状葉があり，他方は茎のみでその先に数本の中肋だけの小さいオニワカメが着生していて，偶然とは言え藻散布への漂着物の状態に非常に良く似ているのには驚かされる (Fig. 3)。この標本については生時の計測データは無いが，ここに掲げた写真からも分かるように盤状根は非常に大きく，掌状葉を持つ葉体は全長270 cm前後，茎長も120 cmはあると思われるほど大きなものである。

ここに紹介した2地点への漂着ゴヘイコンブは，その発見日や葉体の大きさなどから，恐らくエトロフ島からウルップ島あたりの同じ生育地から同時に漂流し始め，オホーツク海からこれらの島の間を抜けて北海道の太平洋沿岸を流れる道東沿岸流（小笠原　1985）によって運ばれてきたものと推測される。1981年は冬以来初秋に至るまで親潮系水の勢力が異常に強く，根

Fig. 4. A Kombu stick, 85 cm in total length, made of the stipe of *Laminaria yezoensis* Miyabe cast ashore at Mochirippu, Hamanaka, more than sixty-five years ago. The stick is reinforced by piercing an iron pole through the whole length of the stipe. Preserved in The Kushiro City Museum.

室から函館に至る太平洋沿岸各地の旬別平均水温は親潮の勢力が最も強くなる5月から7月にかけて平年より1–4°Cも低かった（北海道栽培漁業振興公社1982）。このようなこの年の異常な寒流の勢力もまた漂着物の運搬に大きく作用したものと言えるだろう。

浜中町から南茅部町までの漂流経路も推測の域を出ないが，南茅部町に漂着した葉体が仮に浜中町の沖合10ないし15海里のあたりを通過し，そのまま沿岸と平行に9日間で運ばれてきたものとすれば，その間の距離は約215海里となるので，1日あたりの漂流距離は24海里，すなわち1海里／時の速度と推算される。

今日まで，このような長い茎を持ったゴヘイコンブの漂着に関する正確な記録はない。ただ，著者はかつて釧路市立郷土博物館（現釧路市立博物館）所蔵の「昆布杖」(Fig. 4) の鑑定を依頼されてその由来を調べ，それが漂着ゴヘイコンブで製作されたものであることを報告している（川嶋1970）。ここに，この珍しい昆布杖について簡単に再録しておく。

この昆布杖は，かつて浜中町藻散布に在住した故片桐才記氏が同地に漂着したゴヘイコンブの茎を利用して製作したものである。漂着年は不明であるが，後年この杖を譲り受けた浜中町の坂野貞蔵氏の証言によれば，片桐氏がこれを持っていることを初めて知ったのは大正15年（1926）のことであったというから，少なくとも今から65年以上も前のことになる。

杖は全長85 cmあるが，実際のコンブの部分は73.5 cmで，その中心を貫通する鉄棒（直径5.3 mm）が先端に11 cmほど突き出し，こうもりがさの石突きらしい金具が付いている。杖の上端は盤状根を整形して作った扁平な握り部分となっていて，それより先端にかけての茎の部分は緩やかに曲がりくねり，乾燥のために変形しているが次第に細くなっている。質は非常に硬く，濃褐色で光沢がある。製作にあたって，漂着コンブが生のうちにその茎に鉄棒を通し，川水に晒してから時間をかけて乾燥したものであると言う。

宮部（1902）も本種の茎で烟管を作るものがあると記している。著者もまた，根室地方で漂着したコンブで杖を作り所持している人の情報を得たことがあるが，恐らくこれもゴヘイコンブであろう。ただ，その詳細は残念ながら不明のままである。

浜中町に漂着した標本の調査には高杉新弥氏，佐々木茂氏の協力を得た。南茅部町に漂着した時の葉体の写真は四ツ屋義則氏から提供を受けた。また，昆布杖の再録については釧路市立博物館澤四郎館長のご好意を戴いた。これらの方がたに厚く御礼申し上げる。

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（041 函館市日吉町4丁目29–15）

新刊紹介

Watanabe, M. & Malla, S. B. (ed.): Cryptogams of the Himalayas. Vol. 1. The Kathmandu Valley. i–vi＋226 pp.＋1 map. 1988. (Academia Scientific Book Inc., Tokyo. paper ¥8,000; hard ¥9,600). **Vol. 2. Central and Eastern Nepal.** i–x＋212 pp＋27 pls. 1990. (Academia Scientific Book Inc., Tokyo. paper ¥9,600; hard ¥12,800).

国立科学博物館では自然史の調査研究と標本試料蒐集の目的で調査隊を国の内外に派遣している。国内の調査は「自然史科学的総合研究」と呼ばれ，ほぼ2年の周期で調査地域を変え，国立公園を含む地域を主たる対象として海藻を含む植物，動物，古生物等の自然史の研究を行い，得た成果を国立科学博物館専報として刊行している（現在まで23号を刊行）。これに対し，国外の場合は主として文部省科学研究費補助金国際学術研究・学術調査によるもので，生物地理学上興味のある地域が対象に選ばれ，自然史の調査研究が行われている。研究成果は同じく科学研究費研究成果促進費により刊行されることが多く，従って出版の時期は必ずしも一定していない。

本書は国立科博植物第3研究室長の渡辺真之博士を隊長とし，2回に亘って実施したヒマラヤ・ネパール地方の隠花植物調査の研究成果をまとめたもので，2巻から成る。第1巻は1986年にネパールのカトマンズ地方での調査，第2巻は1988年にカトマンズを含むネパール中央部と東部において行った調査のそれぞれの研究成果を収録する。

第1巻は24編から成り，藻類に関する論文の題目と著者名は次のようである。カトマンズの藍藻（渡辺真之とJ. Komárek），カトマンズのユウグレナ類（庵谷晃），カトマンズの群体性ボルボクス目（野崎久義），カトマンズの糸状緑藻（芳賀　卓），ネパールのクロロコックム目（中野武登と渡辺真之）。なおこれらの他に，緒言(S. B. Malla)，調査研究の概要（渡辺真之），カトマンズの細胞粘菌，ネパールの粘菌の1新種，ネパールのミズカビ類，ネパールカトマンズのケカビ目，カトマンズのサビ菌類，ネパールのクロボ菌類，カトマンズの軟質担子菌類，カトマンズの*Russula*属（担子菌），ネパール針葉樹林床の不完全菌，ヒフォミケス類，カトマンズの地衣類ゲジゲジゴケ属とウメノキゴケ属，カトマンズ地方に生育する特記すべき蘚類，カトマンズのハイゴケ科の蘚類，カトマンズのシダ類の染色体，カトマンズのシダ類の分布地図等の論文が掲載され，さらに読者の便の為に，カトマンズの気候，カトマンズの地理，カトマンズの森林に関する解説的な論文があり，最後にカトマンズの地図が添えられる。

第2巻は18編から成る。藻類関係としては，藍藻*Coleodesmium*属（J. Komárek と渡辺真之），ネパールの群体性ボルボックス目（野崎久義），ネパール，チベット及び琉球から採集した*Gonium pectorale*（ボルボックス目）の和合性の研究（斉藤捷一）があり，その他に緒言（金井弘夫），調査研究の概要（渡辺真之とS. B. Malla），ネパールの接合菌類ハエカビ目，ネパールの子嚢菌類，ネパールのクロボ菌*Coleosporium*属，ネパールのサビ菌類，ネパールの担子菌*Russula*属，ネパールの地衣類ゲジゲジゴケ属とウメノキゴケ属，ネパールのハイゴケ科蘚類の染色体，ネパールの蘚類，ネパールのシダ類，特に日本に関係のあるものの染色体数，ネパールのチャセンシダ属の1種のフラボノイドと分類，ネパール・カトマンズのシダ類分布地図。なお第2巻には美しい現地のカラー写真27葉が添えられ，読者を楽しませてくれる。

隊長の渡辺真之博士が所属する国立科博植物第3研究室は微生物研究室とも呼ばれ，先の室長，大谷吉雄博士により組織された微生物調査隊は1979年と1980年にネパールで採集と調査研究を行い，その成果を1982年に Otani, Y. ed. Reports of Cryptogamic Study in Nepal. The National Science Museum, Tokyo. 等に報告している。従って今回のものは，ヒマラヤの隠花植物の研究第2報及び第3報ということになろう。

ヒマラヤの植物相の研究は，維管束植物に関してはかなり行われてきたが，下等隠花植物については少く，特に藻類についてのわれわれの知見は貧弱である。藻類を含むヒマラヤの下等隠花植物研究の今後の進展への本書の貢献は極めて大きく，よく調査隊を組織され，成果をまとめられた渡辺真之博士の労苦を多とし，深く敬意を表したい。

（日本赤十字看護大学　千原光雄）

新刊紹介

濱田　仁：接合藻の生物学

264頁，私家版 1990，2,200円

アオミドロ，ツヅミモ，そして“接合”といった言葉は中学の頃に覚え，誰にも親しまれているが，いつどこで採集すれば“接合”を見ることが出来るのか，接合した後はどのようになるのか，“接合”を観察するにはどのように培養すればよいのか，などを教えてくれる手軽な本は意外と少ない。著者は元来遺伝の研究者であり，研究材料に接合藻を選び，採集・培養・観察にいろいろと苦労したことから，自身の経験したことや確かめたことに基づいて本書を書き上げたという。

本書は9章から成る。前半の第1章 接合藻の採集と観察，第2章 接合藻の培養，第5章 接合藻の構造と分類は，接合藻を研究材料に取り上げた当初は藻類について門外漢であったというだけに，著者の記述は具体的かつ詳細で，この藻群を調べて見たい人に良い手引の役を果してくれる。第3章 水質環境と接合藻，第4章 環境の汚染と指標生物としての接合藻，第6章 放射線と接合藻の形態形成は，著者の本来の興味もさることながら，勤務機関（著者は富山医科薬科大学勤務）の関係もあって行ったと思われる著者自身の研究成果を中心に記述が展開しており，環境や公害の問題に興味をもつ人には参考となるところが多い。第4章の第4節「ゴルフ場周辺の排水のミカヅキモに及ぼす影響・まとめと苦言」は為政者にとってまさに頂門の一針ともいうべきものである。著者が最も力を注いだと思われる部分は第7章 接合藻の生殖に続く第8章 接合藻の生活史と第9章 接合藻の遺伝の項であり，ここで接合藻の核相に関し，著者はかねてより主張する，従来の教科書的な説と異なる新しい考えについて詳述している。著者の説の根拠の出発はミカヅキモを蛍光色素 DAPI で染色し，蛍光顕微鏡で観察して核の部分の DNA 量を測定した結果に基づくもので，それによると栄養細胞は2倍体であるという。著者は多くの頁を割いてこの問題を解説し，そして論議を行っている。多くの方々に一読を奨めたい章である。それにしてもことが重要であるだけに，他の幾つかの接合藻についても同様な実験と観察の実施が望まれる。本書は末尾に「接合藻の名前とその由来」，「用語の説明」及び「引用文献」の項があり読者の便に供される。また口絵には蛍光顕微鏡像等の美しいカラープレート8葉が添えられる。本書の題名は「接合藻の生物学」がであるが，「培養，分類，生活史，遺伝から環境，公害の問題迄」の副題があり，興味のあるユニークな内容となっている。私家版のせいか，目次と本文の章や節の題目に不一致のところが若干見られるのは残念である。また図のレイアウトや図中の文字に今一歩の工夫があれば良かったと思われる。なお，「接合藻の名前と由来」の項に20余の新称和名が提唱されているが，これはこの本の性質上早い機会に「藻類」等への公表を望みたい。本書の入手希望者は発行所である〒939-03 富山県射水郡小杉町南太閤9-44の著者の自宅（電話0766-56-6658）に直接申し込むこと。

（日本赤十字看護大学　千原光雄）

日本藻類学会第15回大会ワークショップ（海藻採集会）参加記

琉球大学での日本藻類学会第15回大会終了後の3月29，30日に，第6回ワークショップが開かれた。琉球大学から車で2時間半ほどの，本部町瀬底島にある琉球大学熱帯海洋科学センターが会場となった。足を運ぶ機会の少ない沖縄ということもあって，学会同様参加希望者が多数であったが，先着27名に講師の吉田忠生氏（北大・理），田中次郎氏（国立科学博物館），香村真徳氏（琉大・熱帯）を加えた総勢30名での採集会となった。なかでもデンマークからは Moestrup, Øjvind 氏 (Copenhagen Univ.), 韓国からは Lee, In Kyu 氏，Boo, Sung-Min 氏，Shin, Woong-Gee 氏 (Chungnam National Univ.) が参加されたことで，国際的なワークショップとなった。

一日目は，海洋記念公園を見学後，その北側にある備瀬海岸で採集が行われた。あいにく天気は曇りで波が高く，リーフ外は危険なため採集はリーフ内で行われた。参加者の半数は各自用意したウェットスーツを着用してシュノーケリングで採集を行った。手軽に珊瑚が見えるところはほとんどないということであったが，沖縄の海は期待以上に美しく，ポツリポツリと色鮮やかな枝状の珊瑚と熱帯魚は，参加者を満足させるのに十分であった。筆者にとっては，見なれた北海道の海と海藻相がまるで異なるため，初めてみる種がほとんどで，すべてが目新しかった。その中でも特に多くの参加者の目を引いた *Prochloron* はたいへん印象深く，また意外に身近な生物であると感じた。2時間ほど採集し昼食をとった後，センターに戻って採集物の種分け，同定などの作業を行った。瀬底島海藻リストが香村先生より配布され，改めて北海道と比べ生育している海藻の種類の違いと，褐藻の種の少なさを再認識した。夕食後，有志による懇親会がセンターの食堂で行われた。

夜には，雨が降り始め，そのため二日目のセンター前での採集は希望者だけで行うことになったが，ほとんど全員で行われた。波が高く，波打ち際での採集が主であったが，雨のなか熱心に採集が続けられた。午後になっても雨がやまなかったが，数人の希望者が瀬底島北側のクンリ浜での採集に出かけた。浅瀬の巨大なナマコとウニの群れに歓迎され，途中激しい雨にみまわれながらの採集であった。センターに戻り，実験室では相変わらず熱心な観察が行われた。

夕食はワークショップ最後の夜ということで，センターの方々の心尽くしでバーベキューパーティが催された。香村先生に感謝の気持ちを込めて心ばかりの品が贈られたあと，宴会が始まり，有意義だったワークショップはしめくくられた。

備瀬海岸での昼食後の風景

最後に，いろいろお世話になった香村先生，センターの職員，学生の方々にお礼申し上げます。

採集された海藻；

緑藻：ヒトエグサ，アナアオサ，ヒラアオノリ，ウキオリソウ，ミドリゲ，キツネノオ，アオモグサ，キッコウグサ，ムクキッコウグサ，マガタマモ，ミズタマ，フデノホ，ビャクシンゾタ，センナリゾタ，ヨレゾタ，コケイワゾタ，マユハキモ，ウチワサボテングサ，シワヤハズ，ハイオオギ，ウスバベニウチワ，オキナワモズク，ムラチドリ，カゴメノリ，フクロノリ，ラッパモク，ウミトラノオ，アツバモク

紅藻：ハイコナハダ，ビロウドガラガラ，ガラガラ，シマベニモヅク，カギケノリ，ホソバナミノハナ，ガラガラモドキ，キリンサイ，ベニゴウシ，ウブゲグサ，マクリ，トゲノリ，コケモドキ，パピラソゾ，カタソゾ，ナンカイソゾ

（小亀安代：北大・理・植物）

ニュース

第15回国際植物科学会議（東京）—XV International Botanical Congress, Tokyo—における藻類関係シンポジウムのお知らせ

上記国際会議のあらましは first circularその他でご存知と思います。ここでは会議で取り上げられる藻類関係のシンポジウムについて，これまでの経緯と進行状況をお知らせします。

同会議の組織委員会・プログラム委員（河野昭一，京大・理・植）より藻類関係のシンポジウムの立案・企画・実施の世話人として市村輝宜（東大・応微研）と原慶明（筑波大・生物科学系）が指名され，連絡調整の任務を行なってきました。日本藻類学会会長と連絡をとり，シンポジウムの立案・企画を担当する実務委員を選出し，その方々にシンポジウムの立案企画にお骨折りいただき，以下のような具体案が出来上りました。現在，実務担当者がコンビーナーと相談しながら，講演者の依頼と演題の検討を進めています。

藻類学ないしは藻類として正式に取り上げられたシンポジウム（講演時間は1シンポジウム当り2時間30分で，講演者の人数には制限はありません）は現在4件です。会議全体は8つの柱(1st circular参照)で構成され，その1つ，Systematics and Evolution に Algae and Prokaryotes のセッション（全部で13セッション）が設けられ，そこに取り上げられています。なお他のセッションで藻類関係のシンポジウムが採択されているかどうかは不明です。各シンポジウムの題目とコンビーナー及び実務担当者（ローカル・コンビーナーを兼ねる）を紹介します。

① Ultrastructure, Morecular Biology and Systematic Relationships of the Green Algae.
Convener: G. L. Floyd (Dept. of Biology, Ohio St. Univ., USA)
実務担当：渡辺　信（富山大・教育・生）

② Taxonomy and Evolutionary Biology of Prokaryotic Algae.
Convener: J. Komarek (Dept. of Hydrobiol., Inst. of Bot., CSAU, Czechoslovakia)
実務担当：渡辺真之（国立科学博・植物），渡辺信（国立環境研・地球環境）

③ Biology and Systematics of the Chromophyte Algae.
Convener: D. G. Muller (Fach. Biol., Univ. Konstanz, Germany)
実務担当：川井浩史（北大・理・植）

④ Population Differentiation, Species Relationships and Phylogeny of Rhodophyta.
Convener: D. Guiry (Dept. of Botany, Univ. College, Galway, Ireland)
実務担当：増田道夫（北大・理・植）

各シンポジウムにおける講演者と演題は正式決定後，お知らせ致します。

文責：原慶明（筑波大・生物科学系）

—学 会 録 事—

1. 日本藻類学会第15回大会

1991年3月27日・28日の両日，琉球大学教養部において第15回大会を開催した。大会会長は香村真徳氏(琉球大学）で，参加者は133名であった。講演は72題の一般講演（うち展示10題）および，特別講演3題があった。

大会第1日目に同会場において総会を開催し，引き続き同大学生協食堂で約2時間にわたって懇親会を開催した。懇親会は香村真徳大会会長（琉球大学）の挨拶，当真　武氏（沖縄水試）の司会，有賀祐勝会長の乾杯の音頭で始まり，119名という多数の参加で，盛会裡に終了した。琉球大学教養部生物学教室，理学部生物学科，海洋学科，熱帯海洋科学センターの教官，職員，学生の皆様，および沖縄県水産試験場の関係者には大会運営にあたっていろいろご協力頂き，厚くお礼申し上げる。

懇親会参加者

秋岡英承・秋山　優・餉坂哲朗・新井章吾・有賀祐勝・飯田高明・飯田勇治・飯間雅文・庵谷　晃・石川依久子・石川　豊・石田健一郎・石原利章・市村輝宜・井上　勲・岩崎英雄・内田卓志・恵良田眞由美・太田雅隆・大野正夫・岡崎恵視・荻野洸太郎・奥田弘枝・Christine A. Orosco・笠井文絵・笠松美代子・加崎英男・梶村光男・片山舒康・勝俣亜生・加藤辰己・加藤哲也・神谷充伸・香村真徳・川井浩史・川嶋昭二・河地正伸・菊池則雄・木村憲司・工藤利彦・久場安次・黒澤健二・桑野和可・高　坤山・小亀一弘・小亀安代・小林艶子・小林　弘・斉藤昭二・斉藤宗勝・杉山孝一・嵯峨直恒・佐々　勤・佐々木次郎・佐藤弘典・佐藤征弥・瀬戸良三・竹下俊治・立澤英高・田中次郎・月館真理雄・筒井　功・綱川亜紀子・寺脇利信・Anong Chirapart・土居高爾・当真　武・渡口慈啓・友利徹男・中嶋　泰・長島秀行・長嶋美香子・中野武登・中村美峰子・中村　直・中村宗一・中山　剛・野崎久義・野澤洽治・能登谷正浩・鍋島靖信・成原淳一・南波　聡・橋爪淳子・畠山典子・畠中芳郎・原奈保美・原　慶明・比嘉辰雄・馬場将輔・林　至宏・半田信司・平松　亘・樋渡武彦・福田育二郎・福島　博・藤田隆夫・藤田大介・藤森　泰・堀　輝三・堀美保子・本多大輔・正置富太郎・増田道夫・松田伸也・真山茂樹・三浦昭雄・右田清治・御園生拓・宮村新一・Øjvind Moestrup・山本虎男・山本鎔子・横浜康継・吉崎　誠・吉田忠生・吉武佐紀子・In Kyu Lee・綿貫友彦。

2. 編集委員会・評議員会

第15回大会の前日，3月26日に宣野湾セミナーハウスにおいて編集委員会および評議員会を併せて開催し，1991年度総会に提出する報告事項・議題などの審議を行った。審議の内容については総会の項を参照されたい。

出席者：福島　博，井上　勲，石川依久子，岩崎英雄，香村真徳，増田道夫，右田清治，大野正夫，原慶明，岡崎恵視，堀　輝三，加藤哲也，小林　弘，三浦昭雄，横浜康継，吉田忠生の各編集委員と評議員，有賀祐勝会長，および真山茂樹，能登谷正浩，庵谷晃の各幹事。

3. 1991年度総会

1991年3月27日（大会第1日目）の講演終了後，琉球大学教養部において総会を開催した。有賀祐勝会長の挨拶に続いて，野澤洽治氏を議長に選出して議事に入った。

Ⅰ．報告事項

1. 庶務関係

(1)会員状況（1991年3月現在）：名誉会員3名，普通会員550名，学生会員47名，団体会員45名，賛助会員11名，外国会員95名，購読49件，寄贈・交換27件。(2)1990年度文部省科学研究費刊行助成金「研究成果公開促進費」交付額は，970千円で，責任頁は320頁である。なお，1991年度として補助要求額2,536千円，責任頁360頁を申請した。(3)1990年度秋季シンポジウムを1990年10月1日に静岡市クーポール会館で開催した（藻類38巻4号参照)。(4)第15回大会後（3月28日～3月31日）にワークショップ（海藻採集会，講師：吉田忠生氏，田中次郎氏，香村真徳氏）を琉球大学熱帯海洋科学センターで実施する。(5)日本学術会議第15期会員選出に際し，本会からは評議員会で千原光雄氏を推薦した。また，会員推薦人および推薦人予備者には，石川依久子氏，岡崎恵視氏をそれぞれ会長が依頼した。

2. 会計関係

(1)12月31日現在の1990年度の会費納入率は，普通会

員85%，学生会員66%，賛助会員100%，団体会員18%，外国会員42%である。(2)1990年度一般会計と同山田幸男博士記念事業基金特別会計の決算報告は，1991年3月8日，岡崎恵視（東京学芸大学），加藤季夫（国学院大学）の両会計監事により適正であると承認された。

3. 編集関係

(1)1990年度に発行した「藻類」第38巻第1～4号は，総頁数403頁，掲載論文数30編，短報10編，総説0編，その他16編，広告12頁であった。頁当たりの平均経費は10,908円であった。掲載論文の超過頁は76頁と多かったが，これは日本産海藻目録が長編であったためである。(2)1991年3月10日に発行した第39巻第1号は，掲載論文数9編，短報1編，総説1編，訃報，第15回大会講演要旨などを含めて114頁であった。(3)1991年3月26日現在の投稿論文数は36編である。

Ⅱ．審議事項

1. 庶務関係

以下のことが審議され，承認された。(1)本年度秋季シンポジウムとして，第2回日韓藻類学シンポジウムを9月8日～11日に筑波大学国際会議場で開催する。世話人は原　慶明氏にお願いする。(2)日本藻類学会第16回大会は1992年3月30日・31日に三浦昭雄氏（東京水産大学）を世話人として東京水産大学で開催する。ワークショップ実施については検討する。(3)日本藻類学会賞を設けるためと寄付の受入れのために，別記のように会則を改正する。(4)1991～1992年度会計監査に，市村輝宜氏（東京大学）と片山舒康氏（東京学芸大学）を選出した。

2. 会計関係

(1)1990年度一般会計決算報告および同監査報告は，表-1のとおり承認された。(2)1990年度山田幸男博士記念事業特別会計の決算報告および同監査報告は表-2のとおり承認された。(3)1991年度一般会計予算は表-3のように可決承認された。

4. 日本藻類学会第15回大会ワークショップ（海藻採集会）報告

1991年3月28日，日本藻類学会第15回大会終了後，琉球大学熱帯海洋科学センターに移動して，3月29日～31日に海藻採集会を開催した。吉田忠生氏（北大・理），田中次郎氏（国立科博），香村真徳氏（琉大）を講師に，下記の30名が参加した。なお，採集会の内容は小亀安代氏の参加記を参照されたい。

参加者：新井章吾・飯田勇治・笠松美代子・香村真徳・川井浩史・菊池則雄・工藤利彦・桑野和可・小亀一弘・小亀安代・斉藤昭二・斉藤宗勝・佐藤征弥・Wong-Gee Shin・田中次郎・中西弘一・長嶋美香子・野澤洽治・能登谷正浩・鍋島靖信・馬場将輔・Sung-Min Boo・堀　輝三・増田道夫・御園生拓・宮村新一・Øjvind Moestrup・山本虎夫・吉田忠生・In Kyu Lee.

なお，ワークショップの開催にあたってお世話になった，本部町役場産業観光課にお礼申し上げる。

会 則 改 正

〔現　行〕

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

（付則）

第6条　本会則は平成2年1月1日より改正施行する。

〔改　正〕

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

2. 本会の趣旨に賛同する個人又は団体は，本会に寄付金又は物品を寄付することができる。寄付された金品の使途は，第11条に定める評議員会で決定する。

第13条　1. 本会は会員の研究奨励のため，「藻類」に掲載された優秀な論文の著者に日本藻類学会賞を授与する。

2. 日本藻類学会賞受賞者の選考は別に定める内規による。

（付則）

第6条　本会則は1991年3月31日より改正施行する。

日本藻類学会賞受賞者選考内規

1. 日本藻類学会会則第13条に基づき，日本藻類学会賞（以下，学会賞という）受賞者選考のために学会賞受賞者選考委員会（以下委員会という）を設ける。委員会は，本会役員および編集委員を委員（以下，委員という）とし，会長が委員長をつとめる。
2. 受賞者は，各年の「藻類」に掲載された研究論文の著者の中から選考する。
3. 受賞者を選考するため，委員は当該年の「藻類」に掲載された研究論文の中から学会賞授与に値すると思われる3編を選び，委員長に推薦する。推薦数が最も多かった論文の著者を受賞者とする。
4. 委員長は受賞者を総会に報告し，学会賞の授与はその総会で行う。

表-1　1990年度　一般会計決算報告　(90. 1. 1–90.12.31)　　日本藻類学会

収入の部 (円)		支出の部 (円)	
会費	4,360,405	印刷費	5,116,293
普通会員	3,619,150	印刷代	4,396,040
学生会員	155,000	別刷代	720,253
外国会員	270,255	編集費	331,762
団体会員	96,000	英文校閲料	100,000
賛助会員	220,000	編集補助費	50,000
販売	1,171,640	通信連絡費	181,762
定期購読	1,094,640	会誌発送費	382,079
バックナンバー	77,000	庶務費	781,612
別刷代	772,100	事務用品費	18,932
超過頁負担金	912,000	会議費	34,000
広告代	180,000	通信・印刷費	413,488
受取利息	57,448	事務整理補助費	34,000
プログラム代	33,750	幹事旅費補助	53,000
文部省刊行助成金	970,000	幹事手当	160,000
雑収入	21,586	諸雑費	68,192
		学会業務委託費	1,483,200
		第14回大会補助費	120,000
		秋季シンポジウム会場費	50,000
小計	8,478,929	小計	8,264,946
前年度繰越金	4,947,624	次年度繰越金	5,161,607
合計	13,426,553	合計	13,426,553

貸借対照表　(90.12.31 現在)

借方 (円)		貸方 (円)	
定期預金 (第一勧業)	1,000,000	未払金	1,924,395
普通預金 (第一勧業)	1,766,565	前受会費	720,570
郵便振替貯金	3,314,646		
小口現金	74,692	前期繰越金	4,947,624
事務局	21,762	当期剰余金	213,983
編集局	52,930		
受取小切手	24,150	次期繰越金	5,161,607
カード	28,000		
UCカード	28,000		
アメリカンエキスプレス	0		
未収金	1,478,519		
*仮払金	120,000		
合計	7,806,572	合計	7,806,572

*第15回大会補助費前払い

1991年3月8日

本会計決算報告は適正である事を認める。
1991年3月8日

日本藻類学会会長　小林　弘 ㊞
日本藻類学会会計幹事　真山茂樹 ㊞

日本藻類学会会計監事　岡崎恵視 ㊞
日本藻類学会会計監事　加藤季夫 ㊞

表-2　1990年度山田幸男博士記念事業特別基金会計決算　(90. 1. 1-90.12.31)　　日本薬類学会

収入の部（円）		支出の部（円）	
山田追悼号売上金	7,000		
日米セミナー売上金	16,000		
受取利息	71,303		
小計	94,303	小計	0
前年度繰越金	2,002,167	次年度繰越金	2,096,470
合計	2,096,470	合計	2,096,470

貸借対照表（90.12.31現在）

借方（円）		貸方（円）	
定期預金（住友銀行）	1,900,000	前期繰越金	2,002,167
普通預金（住友銀行）	173,470	当期剰余金	94,303
現金	23,000		
		次期繰越金	2,096,470
合計	2,096,470	合計	2,096,470

1991年3月8日

日本薬類学会会長　小林　弘 ㊞
日本薬類学会会計幹事　真山茂樹 ㊞

本会計決算報告は適正である事を認める。
1991年3月8日

日本薬類学会会計監事　岡崎恵視 ㊞
日本薬類学会会計監事　加藤季夫 ㊞

表-3　1991年度　一般会計予算　　日本藻類学会

収入の部	(円)	支出の部	(円)
会費	4,970,000	印刷費	4,949,000
普通会員	3,465,000	印刷代	4,160,000
学生会員	210,000	別刷代	789,000
外国会員	595,000	編集費	407,000
団体会員	480,000	事務用品費	35,000
賛助会員	220,000	英文校閲料	100,000
販売	1,048,000	編集補助費	50,000
定期購読	948,000	通信連絡費	222,000
バックナンバー	100,000	会誌発送費	390,000
別刷代	600,000	庶務費	804,000
超過頁負担金	200,000	事務用品費	20,000
広告代	180,000	会議費	60,000
受取利息	30,000	通信・印刷費	351,000
プログラム代	30,000	事務整理補助費	60,000
文部省刊行助成金	970,000	幹事旅費補助	53,000
雑収入	20,000	幹事手当	160,000
		諸雑費	100,000
		学会業務委託費	1,483,000
		第15回大会補助費	120,000
		秋季シンポジウム会場費	50,000
小計	8,048,000	小計	8,203,200
前年度繰越金	5,161,607	予備費	5,006,407
合計	13,209,607	合計	13,209,607

―会　員　移　動―

新　　入　　会

住 所 変 更

退　　会

岩城住江（北海道），秋山和夫（宮城県），S. KESHAB（京都府），宮沢三雄（大阪府），森　通保（熊本県），LOUIS D. DRUEHL (CANADA).

日本藻類学会々則

第1条　本会は日本藻類学会と称する。
第2条　本会は藻学の進歩普及を図り，併せて会員相互の連絡並に親睦を図ることを目的とする。
第3条　本会は前条の目的を達するために次の事業を行なう。
1. 総会の開催（年1回）
2. 藻類に関する研究会，講習会，採集会等の開催
3. 定期刊行物の発刊
4. その他前条の目的を達するために必要な事業

第4条　本会の事務所は会長が適当と認める場所に置く。
第5条　本会の事業年度は1月1日に始まり，同年12月31日に終わる。
第6条　会員は次の4種とする。
1. 普通会員（藻類に関心をもち，本会の趣旨に賛同する個人で，役員会の承認するもの）
2. 団体会員（本会の趣旨に賛同する団体で，役員会の承認するもの）
3. 名誉会員（藻学の発達に貢献があり，本会の趣旨に賛同する個人で，役員会の推薦するもの）
4. 賛助会員（本会の趣旨に賛同し，賛助会員会費を納入する個人又は団体で，役員会の推薦するもの）

第7条　本会に入会するには，住所，氏名（団体名），職業を記入した入会申込書を会長に差出すものとする。
第8条　1. 普通会員は毎年会費7,000円（学生は5,000円）を前納するものとする。但し，名誉会員（次条に定める名誉会長を含む）は会費を要しない。外国会員の会費は7,000円とする。会長の承認を得た外国人留学生は帰国前に学生会費の10年分を前納することができる。団体会員の会費は12,000円とする。賛助会員の会費は1口20,000円とする。
2. 本会の趣旨に賛同する個人又は団体は，本会に寄付金又は物品を寄付することができる。寄付された金品の使途は，第11条に定める評議員会で決定する。

第9条　本会には次の役員を置く。
会長　1名　　幹事　若干名　　評議員　若干名　　会計監事　2名
役員の任期は2カ年とし重任することが出来る。但し，会長と評議員は引続き3期選出されることは出来ない。役員選出の規定は別に定める（付則第1条～第4条）。本会に名誉会長を置くことが出来る。
第10条　会長は会を代表し，会務の全体を統べる。幹事は会長の意を受けて日常の会務を行う。会計監事は前年度の決算財産の状況などを監査する。
第11条　評議員は評議員会を構成し，会の要務に関し会長の諮問にあずかる。評議員会は会長が招集し，また文書をもって，これに代えることが出来る。
第12条　1. 本会は定期刊行物「藻類」を年4回刊行し，会員に無料で頒布する。
2. 「藻類」の編集・刊行のために編集委員会を置く。
3. 編集委員会の構成・運営などについては別に定める内規による。

第13条　1. 本会は会員の研究奨励のため，「藻類」に掲載された優秀な論文の著者に日本藻類学会賞を授与する。
2. 日本藻類学会賞受賞者の選考は別に定める内規による。

（付則）
第1条　会長は国内在住の全会員の投票により，会員の互選で定める（その際評議員会は参考のため若干名の候補者を推薦することが出来る）。幹事は会長が会員中よりこれを指名委嘱する。会計監事は評議員会の協議により会員中から選び総会において承認を受ける。
第2条　評議員選出は次の二方法による。
1. 各地区別に会員中より選出される。その定員は各地区1名とし，会員数が50名を越える地区では50名までごとに1名を加える。
2. 総会において会長が会員中より若干名を推薦する。但し，その数は全評議員の1/3を越えることは出来ない。
地区割は次の8地区とする。北海道地区，東北地区，関東地区，東京地区，中部地区（三重を含む），近畿地区，中国・四国地区，九州地区（沖縄を含む）。

第3条　会長，幹事及び会計監事は評議員を兼任することは出来ない。
第4条　会長および地区選出の評議員に欠員を生じた場合は，前任者の残余期間次点者をもって充当する。
第5条　会員がバックナンバーを求めるときは各号1,750円とし，非会員の予約購読料は各号3,000円とする。
第6条　本会則は1991年3月31日より改正施行する。

投　稿　案　内

Ⅰ．編集の方針　本誌には藻学と応用藻学に関する会員の未発表の，論文・総説・短報（短い調査報告など）・速報・雑録（採集地案内・分布資料・ニュース・所見・新刊紹介など）を掲載します。論文はデータや考察の独創性の有無に重点を置いた編集委員会の審査を経たのち受理されます。原稿の取捨，掲載順序，体裁などは編集委員会および編集幹事で決めます。原稿は和文または英文とし，論文は刷上り英文10頁，和文6頁，総説15頁，短報3頁，雑録1頁以内を無料とします。頁の超過は制限しませんが，超過頁分については1頁当たり12,000円が必要です。折り込み，色刷りなどの費用は著者負担となります。また，速報は2頁以内と制限があり，有料で1頁12,000円の掲載料が必要です。和文原稿では5枚（ワープロでは2枚）が，英文原稿では2枚が刷上り1頁となる見当です。

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Information for Authors (Revised March 1990)

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

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

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

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

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

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

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

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

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

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

日本学術会議だより　No.20

公開講演会成功裡に開催さる

平成３年２月　日本学術会議広報委員会

日本学術会議は，例年どおり，平成２年度においても，主催の公開講演会を３回開催しました。今回の日本学術会議だよりでは，その講演会に加えて，本会議の国際的活動や最近公表された「委員会報告」などについてお知らせします。

平成２年度日本学術会議主催公開講演会

本会議は，本会議の会員が，学術の成果について広く市民と語り合う機会として，時宜にかなったテーマを選定して，毎年，公開講演会を開催している。本年度は，次の３回の講演会を開催したが，いずれも成功裡に終了した。

Ⅰ　公開講演会「高度技術と市民生活」

標記講演会は，去る平成２年10月13日（土）13時30分～17時に，兵庫県加東郡社町の社町福祉センターホールで，約250人の聴講者を得て開催された。各演題と講師は，①「高齢化社会と高度技術」原沢道美（第７部会員，東京逓信病院院長），②「消費生活と高度技術」正田彬（第２部会員，上智大学教授），③「地域振興と人間主導型高度技術」竹内啓（第３部会員，東京大学教授）であった。

Ⅱ　公開講演会「資源エネルギーと地球環境に関する展望」

標記講演会は，去る平成２年10月30日（火）13時～17時に，本会議講堂で，約330人の聴講者を得て開催された。各演題と講師は，①「人間と環境」大島康行（第４部会員，早稲田大学教授），②「エネルギーと環境」石井吉徳（第５部会員，東京大学教授），③「エネルギーと経済問題」則武保夫（第３部会員，立正大学教授），④「エネルギーとCO_2対策」上之園親佐（第５部会員，摂南大学教授）であった。

Ⅲ　公開講演会「人間は21世紀を生きられるか」

標記講演会は，去る平成３年２月19日（火）13時30分～17時に，本会議講堂で約200人の聴講者を得て開催された。各演題と講師は，①「科学・技術・政策」杉本大一郎（第４部会員，東京大学教授），②「科学と人間－生存のための条件づくり」下山瑛二（第２部会員，大東文化大学教授），③「人間の適応能力とリスク」土屋健三郎（第７部会員，産業医科大学長）であった。

いずれの講演会も，時期にあった，関心の呼ぶ企画であったため，外くの聴講者が来場する盛会となり，また，各講師の講演後の質疑応答では，聴講者から活発な質問や意見の開陳がなされ，まさに市民との対話の感があり，極めて有意義であった。

なお，これらの講演会については，後日，「日学双書」として，（財）日本学術協力財団から出版される予定である。

平成２年度二国間学術交流事業

本会議では，二国間学術交流事業として，毎年２つの代表団を外国に派遣し，各訪問国の科学者等と学術上の諸問題について意見交換を行って，相互理解の促進を図る事業を行っている。

この事業は，昭和58年度から実施されており，これまで，アメリカ，マレイシア，西ドイツ，インドネシア，スウェーデン，タイ，フランス，大韓民国，連合王国，シンガポール，チェッコスロヴァキア，ポーランド，カナダ，イタリア，スイス及びインドの16か国に代表団を派遣してきた。

平成２年度には，①９月11日から22日まで，中華人民共和国へ，渡辺格副会長以下４名の会員等から成る代表団を，②９月17日から27日まで，オーストラリア及びニュー・ジーランドへ，大石泰彦副会長以下５名の会員等から成る代表団をそれぞれ派遣した。

中華人民共和国派遣代表団は，中国科学院，中国社会科学院，中国医学科学院，北京大学，西安交通大学，復旦大学など約20機関を訪問し，中華人民共和国の学術や今後の交流の推進策などについて会談，意見交換を行った。中華人民共和国側からは，すでに，日本の多くの大学，研究機関と交流を行っているが，さらに交流を拡大したいとの期待が表明され，両国間の今後のより積極的な交流・協力をめぐって活発な意見の交換が行われた。

オーストラリア及びニュー・ジーランド派遣代表団は，オーストラリアでは，オーストラリア科学アカデミー，オーストラリア国立大学，シドニー大学，連邦科学・産業研究機構など，ニュー・ジーランドでは，ニュー・ジーランド王立協会，マッセイ大学，ヴィクトリア大学，科学技術研究機構など，両国合わせて20を越える諸機関を訪問し，それぞれの国の学術，今後の交流の可能性などについて，会談，意見交換を行った。特に，両国では近年，国家，国民に実際に役立つ技術の発展を目指した科学技術の大きな改革が進められており，これらの問題等について，熱心に意見の交換が行われた。

今回の成果は，代表団派遣時だけのものではなく，今後のわが国の学術の国際交流・協力の進展に大きく役立つものと期待される。

平成３年(1991年)度共同主催国際会議

本会議は，国際的な活活の一環として，毎年，日本で開催される学術関係国際会議を関係学術研究団体と共同主催してきている。平成３年（1991年）度には，次の６件の国際会議を開催する。

■第21回国際農業経済学会議
開催期間　平成３年８月22日～29日
開催場所　京王プラザホテル（東京都新宿区）
参加者数　国外550人，国内950人，計1,500人
共催団体　日本農業経済学会外４学会

■国際医用物理・生体工学会議（第16回国際医用生体工学会議・第９回国際医学物理会議）
開催期間　平成３年７月７日～12日
開催場所　国立京都国際会館（京都市）
参加者数　国外1,000人，国内1,500人，計2,500人
共催団体　（社）日本エム・イー学会，日本医学物理学会

■国際純正・応用化学連合1991国際分析科学会議
開催期間　平成３年８月25日～31日
開催場所　日本コンベンションセンター（千葉市）
参加者数　国外500人，国内1,000人，計1,500人
共催団体　（社）日本分析化学会

■第22回国際シミュレーション＆ゲーミング学会総会
開催期間　平成３年７月15日～19日
開催場所　立命館大学，国立京都国際会館（京都市）
参加者数　国外170人，国内300人，計470人
共催団体　日本シミュレーション＆ゲーミング学会

■一般相対論に関する第６回マーセルグロスマン会議
開催期間　平成３年６月23日～29日
開催場所　国立京都国際会館（京都市）
参加者数　国外380人，国内170人、計550人
共催団体　（社）日本物理学会

■第22回国際動物行動学会議
開催期間　平成３年８月22日～29日
開催場所　大谷大学（京都市）
参加者数　国外400人，国内400人，計800人
共催団体　日本動物行動学会

経営学研究連絡委員会報告－経営学教育改善のために－（要旨）

（平成２年11月26日　第763回運営審議会承認）

企業環境の激変，就中技術革新，高度情報化，国際化等々の急進展に伴って，経営学教育は，大きく見直され，かつ新たな体系化と一層の内容の充実の必要性に迫られている。すなわち，学術的分野の広がり，国際化や情報化の急進展は，経営学の外延的拡大を要請し，また経営管理の高度化，複雑化および戦略的視点の重要性増加は，斯学の多面的な内容の充実強化を要求している。本報告は，かかる状況下において経営学教育の現状分析を行い，かつ(1)教育体系（とくにカリキュラム）の再編成と(2)教育方式の新たな在り方を探り，もって経営学に対する社会的ニーズへの即応と経営学教育の総合的な体系化への試みを展開したものである。とくに教育する側，される側両面での人材育成を強く念頭に置いて経営学教育改善の方途を示すとともに，大学院教育へのつながりを意識しながら将来への展望を示唆しようとしたものである。

統計学研究連絡委員会報告－統計学研究教育体制の整備のための具体的方策について（要旨）

（平成２年12月21日　第764回運営審議会承認）

現今，高度情報化の進展による情報資源の多激な蓄積にともない，統計的情報処理を適切に行える人材に対する社会的需要が著しく高まっている。現在米国では60を超える大学に統計学科が存在するのに対し，我が国では統計学関連の大学院専攻はただ一つあるのみである。最近の学術研究における，調査，実験，観測等の活動の急速な増大を考慮するとき，データ有効利用の学としての統計学の研究教育体制の不備は，我が国の学術研究の将来に対し，国際的に見て著しく不利な状況を生み出しつつある。

本報告では，統計学を一つの専門分野として狭く把える従来の考え方を避け，本来学際的な性格を持つ統計学研究の実態に即して，諸科学との関連をより重視する統計科学の概念を確立し，広範な関連分野の研究者の協力により統計科学研究所あるいは専攻等を設立することの推進を提案する。この提案を具体化することにより，国際的に見ても先進的な統計学研究教育体制を実現することが可能になるものと期待される。

実験動物研究連絡委員会報告－動物実験を支援する人材育成について－（要旨）

（平成２年12月21日　第764回運営審議会承認）

医学，生物学領域において，動物を用いた実験研究が先導的な形で寄与し，社会に貢献してきたことの意義は大きい。遺伝子・分子・細胞の各レベルにおける研究成果を総合して個体の生物機能・生理現像を理解し，病的現象に適確な対応を計るために，個体レベルの研究，すわわち，動物実験による研究の必要性はますます増加し，多種類かつ高品質の動物が精細な計画・技術のもとで実験に供されるようになった。以上の観点から動物実験を取り囲む現状を詳しく検討した結果，動物実験の高度化・多様化に対応できる，専門的知識と技術を習得した技術者の数が著しく不足していることを強く認識するに至った。

本報告は，このような現状に対する改善の方向を明らかにするとともに，バイオサイエンス研究支援体制を一層整備するための方策として，特に動物実験技術者の教育機関の設立を中心に，技術の審査・認定制度の確立，技術者の採用制度の検討，身分・処遇保障等についての将来展望を示唆するものである。

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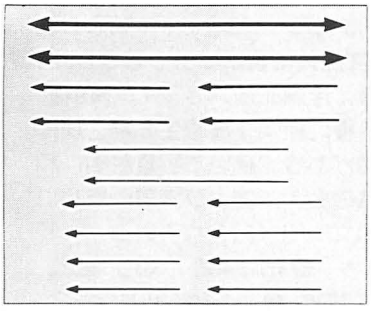

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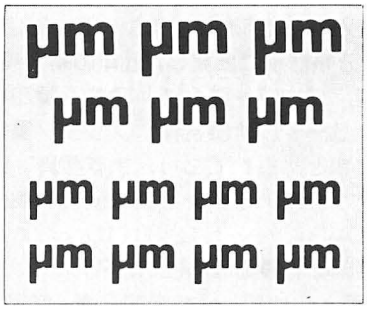

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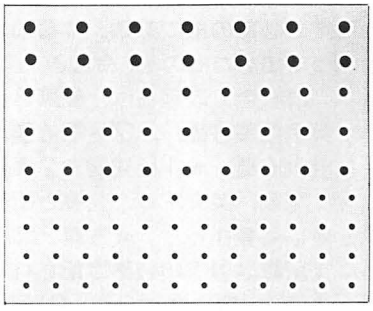

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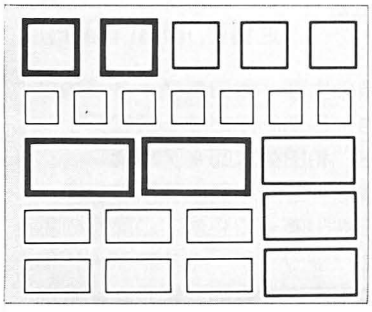

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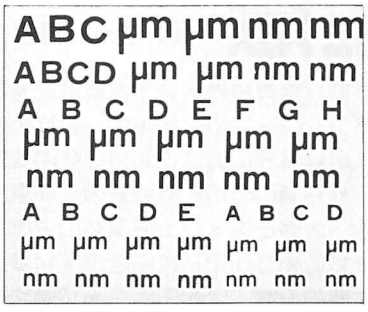

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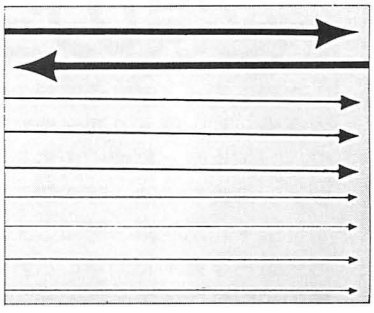

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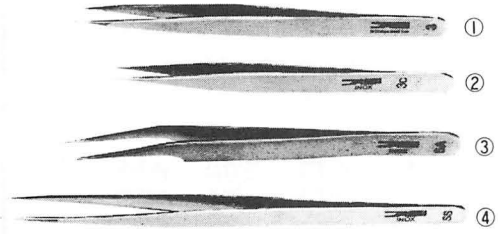

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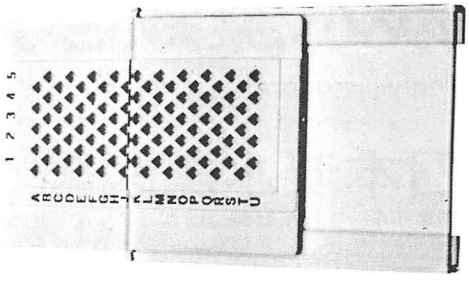

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