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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　**108 東京都港区港南4-5-7　東京水産大学 有賀祐勝気付　日本藻類学会編集委員会**宛にされたい。

The Japanese Society of Phycology

The Japanese Society of Phycology, founded in 1952, is open to all who are interested in any aspect of phycology. Either individuals or organizations may become members of the Society. The Japanese Journal of Phycology (SÔRUI) is published quarterly and distributed to members free of charge.

Inquiries and other information regarding the society should be addressed to **The Japanese Society of Phycology, Shimotachiuri Ogawa Higashi, Kamikyoku, Kyoto, 602 Japan.** The annual dues (1990) for overseas members are 7,000 Yen (Send the remittance to The Japanese Society of Phycology at the above address).

Manuscript for publication should be submitted directly to the Editor-in-Chief, **Prof. Y. Aruga, Tokyo University of Fisheries, Konan-4, Minato-ku, Tokyo, 108 Japan.**

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日本藻類学会第15回大会のお知らせ

日本藻類学会第15回大会を下記の要領で開催します。奮ってご参加下さい。

会　　場：琉球大学教養部　〒903-01 沖縄県中頭郡西原町字千原 1 番地
　　電話　098 (895) 2221　大学代表

会　　期：1991年 3 月26日（火）編集委員会・評議員会
　　27日（水）口頭発表・特別講演・懇親会
　　28日（木）口頭発表・展示発表・総会
　　29日（金）┐海藻採集会
　　30日（土）┘於　琉球大学熱帯海洋科学センター

申　込　先：

大会・懇親会・発表の申込票，発表要旨の送付，連絡は下記宛にお願いします。

〒905-02 沖縄県国頭郡本部町字瀬底3422
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日本藻類学会第15回大会準備委員会
電話　0980 (47) 2888（香村）
FAX　0980 (47) 4919（発表要旨以外の通信のみ可）

参加申込：

1）大会参加者は，発表の有無にかかわらず，本誌に綴込みの大会申込票に必要事項を記入して，上記の第15回大会準備委員会あて，お送り下さい。
2）大会費2,500円（学生2,000円），および懇親会費3,000円を同封の振替用紙でお送り下さい。
送金先：振替　鹿児島1-45036　日本藻類学会第15回大会準備委員会。
3）大会参加申込み，送金，下記の発表要旨送付の締切は**1991年 1 月10日**です。

発　　表：発表を希望される方は，本誌に綴込みの発表申込票に必要事項を記入し，発表要旨の原稿を添えて，お申込み下さい。

1）発表には，口頭発表と展示発表の 2 種類があります。希望する方を○で囲んで下さい。
2）口頭発表：発表時間は，質疑応答の時間を含めて15分です。
使用スライドは 35 mm 版，スライド枠には，図 1 のように発表者氏名，発表番号（大会プログラムに記されているもの），スライド総枚数，映写順序，上辺マークを御記入下さい。同じスライドを繰返し映写する場合は，それに見合う枚数を御用意下さい。
3）展示発表：パネルの大きさは，1 題につき，縦 1.8 m × 横 0.9 m の予定です。展示パネルの上部には，図 2 のように発表番号，演題，氏名，所属を明記して下さい。その他のスペースは自由に利用して下さい。
表題には 5 cm 以上，説明文には 1 cm 以上の文字を使用し，文章は必要最小限にとどめて下さい。
展示物の糊付けは27日午前中にお願いします。
4）発表（口頭発表・展示発表）の申込は，本誌の綴込みの原稿用紙に要旨を記入して，**1991年 1 月10日必着**で，上記の準備委員会宛にお送り下さい。
原稿はそのままオフセット印刷に回します。タイプライター，ワード・プロセッサー，パソコン等何れを使っても結構ですが，印字は明瞭な黒字でお願いします。

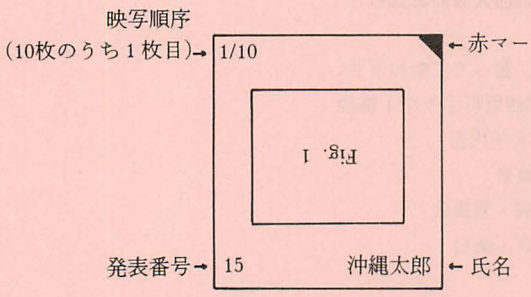

図1. 使用スライド記入例.

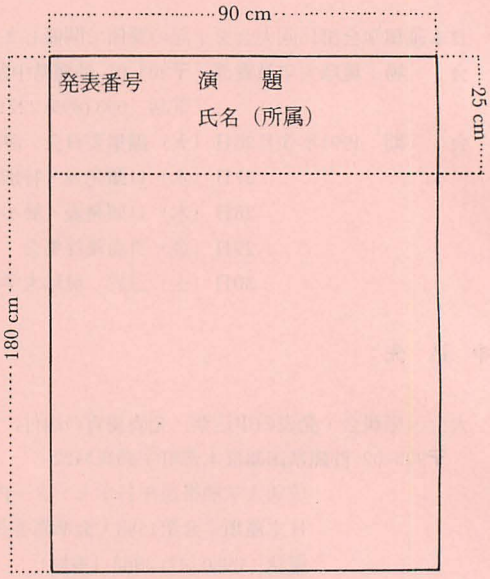

図2. 展示パネル説明図.

宿泊案内：会場周辺には，1宿泊施設（ぎのわんセミナーハウス　宜野湾市内，会場まで徒歩約10分）しかありません。那覇市内のバス停に近い宿泊施設を紹介いたします（大学近くまでの所用時間約40～50分）。下記の表を参考に直接予約下さい。大会期間中は観光シーズンにあたりますので，予約はお早目にしてください。

会場周辺（宜野湾市内）

施　設　名	料　　金	TEL (098)	所　在　地
ぎのわんセミナーハウス	2,600～6,000	898-4361	志真志

仮予約（40名：シングル，ツイン，和室など）してあります。希望者は**平成3年1月15日までに**大会準備委員会宛お申込み下さい。準備委員会で調整後，申込者各位に直接連絡いたします。

那覇市内

施　設　名	料　　金	TEL (098)	所在地とバス停
ローヤルホテル	4,000 (6,000)	863-2131	安里（安里）
ホテル山市	4,200 (7,400)	866-5421	牧志（牧志）
沖縄郵便貯金会館	4,800 (8,400)	887-5000	松川（観音堂前）
ニューオーシャンホテル	5,000 (9,500)	887-6023	安里（安里）
第一ホテル	5,000 (10,000)	867-3116	安里（安里）
ホテル共同	5,150 (9,270)	868-5771	東（バスターミナル）
ホテルエメラルド	5,360 (10,300)	862-1320	安里（安里）
共済会館八汐荘	5,500 (9,900)	867-1191	松尾（松尾）
ナハグランドホテル	5,500 (9,800)	862-6161	松尾（松尾）
ホテルタイラ	5,500 (10,000)	868-4515	松山（バスターミナル）
のざき観光ホテル	5,500 (10,000)	862-6121	松尾（松尾）
自治会館	5,650 (9,000)	862-8181	旭町（バスターミナル）
ホテル国際プラザ	6,000 (11,400)	862-4243	松尾（松尾）

沖縄ホテル	6,600 (12,100)	884-3191	大道（坂下）
那覇セントラルホテル	7,000 (13,000)	867-3466	牧志（牧志）
沖縄不二ホテル	7,000 (13,000)	868-1118	西（バスターミナル）
南西観光ホテル	7,500 (14,000)	862-7144	牧志（安里）
ホテル西武オリオン	8,000 (16,000)	866-5533	安里（安里）
沖縄都ホテル	8,500 (14,000)	887-1111	松川（観音堂前）
ハーバービューホテル	9,000 (18,000)	853-2111	泉崎（バスターミナル）
沖縄グランドキャッスル	10,000 (15,000)	886-5454	山川（山川）

* 宿泊料金はシングルのルームチャージ料金です。括弧内はツイン料金です。
* 那覇市内の宿泊施設は町名のみを示してあります。括弧内は最寄りの市外バス停です。那覇市内のバス停には市内線と市外線がありますので御注意下さい。
* 那覇空港から宜野湾市内の宿泊施設（ぎのわんセミナーハウス）へは，高速バス（系統番号111)をご利用下さい（琉大入口下車徒歩約5分)。
* 那覇市内から会場へは，琉大線（系統番号98，琉球バス：琉大北口下車徒歩約5分），宜野湾線（系統番号97，那覇交通：琉大東口下車徒歩約5分），石川（首里経由）線（系統番号25，那覇交通：中部商業高校前下車徒歩約15分），屋慶名（大謝名経由）線（系統番号27，那覇交通：中部商業高校前下車徒歩約15分）をご利用下さい。

日本藻類学会主催海藻採集会のお知らせ

下記の要領により瀬底島周辺での海藻採集会を開催します。ご希望の方は下記の琉球大学熱帯海洋科学センターに直接お申込み下さい。

1. 期　日：1991年3月28日(木)-3月31日(日)
2. 日　程：(天候等により一部変更する場合もあります)
   3月28日(木) 大会終了後，大学のバスで熱帯海洋科学センターへ移動。または個人で行かれる方は19:00にセンターに到着のこと。
   夕食・日程説明・センター宿泊
   3月29日(金) 瀬底島周辺で採集　センター宿泊
   3月30日(土) 備瀬（沖縄海洋博記念公園近く）で採集　懇親会・センター宿泊
   3月31日(日) 朝食後，自由解散
3. 会　場：琉球大学熱帯海洋科学センター
   〒905-02 沖縄県国頭郡本部町字瀬底3422
   電話　0980-47-2888
   FAX　0980-47-4919
4. 講　師：北海道大学理学部　吉田　忠生，国立科学博物館　田中　次郎，
   琉球大学熱帯海洋科学センター　香村　真徳
5. 参加費：臨海クラブ費　1泊　350円
   食　　費　3食　2,000円
   クリーニング代　550円
   懇親会費　1,000円
   参加希望者に参加の可否，日程等の詳細をお送りし，参加希望日程，希望事項等を御返信いただき，参加者の日程から参加費を算出，納入期日など参加者各位に直接連絡いたします。
6. 定　員：20名
   希望者多数の場合には先着順としますので予めご了承下さい。
7. 申　込：**1991年1月末日までに**葉書に1）氏名，2）連絡先，3）所属を明記の上，上記の熱帯海洋科学センターに直接お申込み下さい。
9. その他：採集具，標本作製・整理用品などはご希望により出来る限り用意いたします。潜水器具（マスク，フィン，ウェットスーツ）は各自各御持参下さい。

要旨原稿の体裁見本

○田中二郎* ・伊藤真理**：褐藻アミジグサ科のフクリンアミジとサナダグサの形態

アミジグサ目アミジグサ科のニセアミジ属とサナダグサ属には日本産の種類としてそれぞれフクリンアミ

・・・・・・が中央部付近で多糖になることがある。精子のうは表皮上に盛り上がって形成される。

（*国立科博・植物研．**日本女子大・家政）

○渡辺　信* ・ L. GARY**：クラミドモナス目とクロロコックム目（緑藻綱）の６種における２本鞭毛遊走細胞の微細構造

Dunaliella lateralis（クラミドモナス目），Spongiochloris spongiosa，Protosiphon botryoides，Tetracystis aeria，・・・・・・

・・・・・・には ABBがみられず，BBのなす角度が大きく変化し，細胞は裸である。

（*富山大，**オハイオ州立大）

日本藻類学会第15回大会申込用紙

大会・懇親会申込票

（フリガナ）
氏　　名：＿＿＿＿＿＿＿＿＿＿　所　属：＿＿＿＿＿＿＿＿＿＿

連絡先（自宅・勤務先）：〒＿＿＿＿＿＿＿＿＿＿

発　　表：　す　る（単独・連名），しない。

懇親会：　参　加，不参加。

送　金　額：（不必要な個所を消して下さい。同封の振替用紙で御送金下さい。）

大会参加費　2,500円（学生　2,000円）

懇親会費　3,000円　　送金合計額＿＿＿＿円

発表申込票

（連名の場合は演者が申込みをし，演者の左肩に*印をつけて下さい）

発表の種類（希望する方を○で囲んで下さい）：

口頭発表，　　展示発表。

発表番号（当方で記入します）：＿＿＿＿＿＿

氏　名（所属）：＿＿＿＿＿＿＿＿＿＿

＿＿＿＿＿＿＿＿＿＿

演　題：＿＿＿＿＿＿＿＿＿＿

連絡先：（連名の場合は演者）＿＿＿＿＿＿＿＿＿＿ ☎＿＿＿＿＿＿

要旨原稿の書きかた

(1) 横 100 mm 縦 150 mm の枠内に24字×22行の印字を標準とする。
(2) 著者名，表題，要旨本文，所属の順に書く。
(3) 1 行目は初めの 3 字分（約 12.6 mm）をあける。
(4) 著者が複数の場合は，講演者に○をつける。
(5) 表題が 2 行または 3 行にわたる場合は，初めの 1 字分（約 4.2 mm）をあける。
(6) 表題と要旨本文との間は 1 行分あける。
(7) 要旨本文は初めの 1 字分をあける。
(8) 所属は（ ）内に入れる。
(9) 区読点は「,」（コンマ）と「。」（マル）を使う。

Jpn. J. Phycol. (Sôrui) 38: 327–332, December 10, 1990

Chrysophytes in the southern part of Hyogo Prefecture, Japan (I) Chrysophyte flora in three ponds and a reservoir

Hiroyuki Ito

Water Quality Laboratory, Kobe City Waterworks Bureau, Kusutani-cho 37–1, Hyogo-ku, Kobe, 652 Japan

Ito, H. 1990. Chrysophytes in the southern part of Hyogo Prefecture, Japan (I) Chrysophyte flora in three ponds and a reservoir. Jpn. J. Phycol. **38**: 327–332.

In a total of 472 samples collected from Doro-ike Pond, Hoshino-ike Pond, Sengari Reservoir and Yasuba-ike Pond in the southern part of Hyogo Prefecture, Japan between April 1975 and March 1987, 105 taxa of chrysophytes were found by light and electron microscopy: 37 species, 2 varieties, 2 forms and 2 unidentified species of *Mallomonas*; 7 species of *Synura*; 2 species each of *Chrysococcus* and *Uroglena*; 7 species, 1 variety and 1 unidentified species of *Dinobryon*; 4 species of *Pseudokephyrion*; 11 species and 2 unidentified species of *Spiniferomonas*; 19 species, 1 subspecies and 1 form of *Paraphysomonas*; and 1 species each of *Chrysodidymus, Kephyrion, Chrysolykos* and *Chrysosphaerella*. Out of them, 20 taxa were new to Japan: *Mallomonas bangladeshica, M. calceolus, M. rasilis, M. insignis, M. retifera, M. pillula* f. *valdiviana, M. ocellata, M. mangofera* var. *sulcata, Chrysococcus triporus, Kephyrion globosum, Uroglena lindii, Dinobryon urceolatum, Pseudokephyrion cylindricum, P. pseudospirale, P. conicum, P. hypermaculatum, Spiniferomonas silverensis, Paraphysomonas subrotacea, P. stephanolepis* and *P. eiffelii*. The number of taxa of chrysophytes found was 51 in Doro-ike Pond, 38 in Hoshino-ike Pond, 68 in Sengari Reservoir and 76 in Yasuba-ike Pond, occupying respectively 38.6, 27.0, 31.9 and 33.9% of the total number of algal species found in each pond or reservoir.

Key Index Words: chrysophytes—flora—Hyogo Prefecture—Japan—pond—reservoir.

Chrysophytes mainly inhabit in freshwater as plankton. Though many workers have been studying algal flora in Japanese ponds and lakes with the light microscope, only one to five species of *Dinobryon, Mallomonas* and *Synura* have been found in one locality (Kokubo and Masiko 1939, Hada 1959, Mizuno 1961, Negoro 1968, Yasuda *et al.* 1975, Imazu 1979). Takahashi (1978a), however, reported 74 taxa of chrysophytes from about one hundred Japanese ponds and lakes by electron microscopy, and Ito (1988) 42 taxa from Lake Biwa. These results indicate that electron microscopy is necessary to study chrysophyte flora.

In Hyogo Prefecture, *Dinobryon divergens* has been found from Sara-ike Pond in the Kanzaki district (Imazu 1979), many ponds in Nishinomiya City, Itami City, the Hojo district and the Tsuchiyama district (Mizuno 1961), and 22 taxa of scale-bearing chrysophytes from 6 ponds and lakes including Doro-ike Pond and Sengari Reservoir (Takahashi 1978a). Ito and Takahashi (1982) reported the seasonal fluctuation of 8 taxa of *Spiniferomonas* including 3 taxa previously recorded in Doro-ike Pond and Hoshino-ike Pond. In total, 28 taxa of chrysophytes have been found in Hyogo Prefecture up to now, but many taxa are thought to be still overlooked.

The purpose of this paper is to report chrysophyte flora found by light and electron microscopy in three ponds and a reservoir situated in the southern part of Hyogo Prefecture.

Materials and Methods

A total of 472 samples were collected by plankton net (Rigosha NXX25) and 1 *l* bottles from the surface in Doro-ike Pond, Hoshino-ike Pond, Sengari Reservoir and Yasuba-ike Pond (Fig. 1). Immediately after

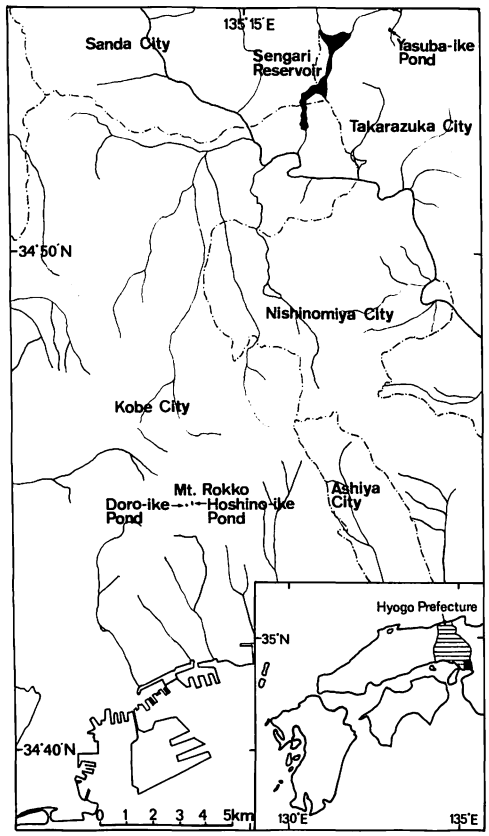

Fig. 1. Locations of three ponds and a reservoir investigated in the southern part of Hyogo Prefecture, Japan.

collection, net samples and 0.5 *l* of each water sample were fixed with 0.5% Lugol's solution and subsequently with 2% formalin. These fixed samples were settled for a week and concentrated to 10 or 20 m*l*. The concentrated samples were used for identification of algae including chrysophytes with light and electron microscopes. Unfixed water sample of 0.5 *l* each was centrifuged at 3,000 r.p.m. for 10 min. and concentrated to 1 to 2 m*l*. For transmission electron microscopy, 10 μl of each concentrated fixed and unfixed samples was mounted on collodion-carbon coated grids, desiccated in an oven, and then shadowed with chromium or Pt-Pd alloy at an angle of about 20°C. Additional observations of some chrysophyte specimens were made on samples isolated with a micropipette and transferred to collodion-carbon coated grids. For scanning electron microscopy, 10 or 20 m*l* of each unfixed water sample were filtered by Nuclepore filter (25 mm in diameter, 0.4 μm in pore size), desiccated in an oven and then coated with gold. Electron microscopes, JEM-100B and JSM-U_3, at Faculty of Science, Kobe University, and a scanning electron microscope, JEM-T200, in Water Quality Laboratory, Kobe City Waterworks Bureau, were used for the study.

Study Areas

Doro-ike Pond

This pond, which was made to obtain ice between 1873 and 1874, is situated 800 m above sea level on Mt. Rokko in Kobe City. It has a surface area of about 600 m^2 and a maximum depth of 1 m. The pond fronts the road on the west and is surrounded by a coniferous forest on the other sides. Pond water looked always brown in color. *Potamogeton distincus* covered about 70% of the pond surface throughout the year. Samples were collected at a distance of 1 m from the shore once a month from April 1975 to October 1976 and once a week or two weeks from November 1976 to August 1977. The material consists of 42 water samples and 42 net samples. In the study period, ice covered the pond from 19 December 1975 to 23 January 1976 and from 10 December 1976 to 5 March 1977, reaching a maximum thickness of 23 cm on 17 February 1977.

Hoshino-ike Pond

This pond is 200 m to the east of Doro-ike Pond. It has a surface area of about 2,800 m^2. Until 1975, this pond was polluted by the sewage from bungalows around it. Pond water looked always greenish brown in color. *Hydrilla verticillata* covered the bottom of the pond between July and August. Samples were collected at a distance of 1 m from the shore on the same days as in Doro-ike Pond. The material consists of 42 water samples and 42 net samples. The ice-covered period in Hoshino-ike Pond was the same as in Doro-ike Pond.

Sengari Reservoir

This reservoir is situated over three cities, Kobe, Sanda and Takarazuka. It was made in 1919 and has a surface area of 112 ha, a volume of 11,610,000 m^3 and a maximum depth of 31 m. Water looked green/brown in color. Samples were collected at the center of the reservoir, where the depth is about 14 m, once a month from April 1978 to March 1987. The material consists of 108 water samples and 108 net samples. Light and electron microscopy were done from December 1980 to May 1981 and from April 1982 to March 1983, and only light microscopy was done in other period.

Yasuba-ike Pond

This pond is situated in the northwestern part of Takarazuka City. It is an irrigation pond and has a surface area of 2,500 m^2 and a maximum depth of 2 m. Pond water looked always brown in color. In summer, *Trapa natans* var. *bisinosa* covered the pond surface near the shore. Samples were collected at a distance of 50 cm from the shore once to five times a month from November 1978 to December 1983. The material consists of 80 water samples and 8 net samples. Light and electron microscopy were done in November and December 1978, January, November and December 1979 and from February 1980 to January 1981, and only light microscopy was done in other period.

Results and Discussion

In total 105 taxa were found: 37 species, 2 varieties, 2 forms and 2 unidentified species of *Mallomonas*; 7 species of *Synura*; 2 species each of *Chrysococcus* and *Uroglena*; 7 species, 1 variety and 1 unidentified species of *Dinobryon*; 4 species of *Pseudokephyrion*; 11 species and 2 unidentified species of *Spiniferomonas*; 19 species, 1 subspecies and 1 form of *Paraphysomonas*; and 1 species each of *Chrysodidymus, Kephyrion, Chrysolykos* and *Chrysosphaerella* (Table 1). Out of them, 20 taxa were new to Japan: *Mallomonas bangladeshica, M. calceolus, M. rasilis, M. insignis, M. retifera, M. pillula* f. *valdiviana, M. ocellata, M. mangofera* var. *sulcata, Chrysococcus triporus, Kephyrion globosum, Uroglena lindii, Dinobryon urceolatum, Pseudokephyrion cylindricum, P. pseudospirale, P. conicum, P. hypermaculatum, Spiniferomonas silverensis, Paraphysomonas subrotacea, P. stephanolepis* and *P. eiffelii*. Species belonging to *Kephyrion* and *Pseudokephyrion* have not been reported previously. From the results of this study and 110 species, 1 subspecies, 3 varieties and 8 forms belonging to 24 genera of chrysophytes which have been reported hitherto (Takahashi 1959, 1960, 1972, 1977, 1978a, Preisig and Takahashi 1978, Ito and Takahashi 1982, Wakabayashi and Ichise 1986, Ito 1988), it becomes that in total 128 species, 1 subspecies, 4 varieties and 9 forms belonging to 26 genera have been found in Japanese freshwater bodies.

Out of 100 taxa excluding 5 unidentified species found in this study, 90 taxa are found widely in the world (Takahashi 1978a, Preisig and Hibberd 1982a, 1982b, Starmach 1985, Asmund and Kristiansen 1986, ito 1988). *Mallomonas conspersa* has been found only in New Zealand (Dürrschmidt 1986), *M. mangofera* var. *sulcata* in Chile (Dürrschmidt 1983), *Dinobryon urceolatum* in Switzerland (Reverdin 1919), *Pseudokephyrion hypermaculatum* in Czechoslovakia (Ettl 1978), and *Spiniferomonas minuta* and *S. silverensis* in Canada (Nicholls 1984). Although these six species have been recorded respectively only from one different country, finding of them in Japan, which is far away from the above-mentioned countries, suggests that they are also distributed widely in the world. *Mallomonas grata* which was reported only in Japan (Takahashi 1963) was recently found in Thailand (Ito unpublished) and China (Kristiansen 1989) and *M. ocellata* only in Malaysia (Dürrschmidt and Croome 1985). These two species of *Mallomonas* were found only in Asia. *M. harrisiae* and *M. recticostata*, which are found widely in Japan (Takahashi 1978a), have not been found in other countries and they seem to be endemic to Japan.

The number of taxa of chrysophytes found in this study was 51 in Doro-ike Pond, 38 in

Table 1. Chrysophytes found in three ponds and a reservoir (D, Doro-ike Pond; H, Hoshino-ike Pond; S, Sengari Reservoir; Y, Yasuba-ike Pond) in the southern part of Hyogo Prefecture, Japan.

Taxa	D	H	S	Y	Taxa	D	H	S	Y
Mallomonas matvienkoae	●	●		●	*Kephyrion globosum**				●
M. parvula	●	●	●	●	*Uroglena lindii**				●
M. ouradion	●				*U. volvox*				●
M. peronoides				●	*Dinobryon sertularia*	●	●	●	●
*M. bangladeshica**			●		*D. cylindricum*			●	
M. multisetigera	●	●			*D. sociale*	●	●	●	●
*M. calceolus**			●		*D. bavaricum*			●	●
M. conspersa			●		*D. divergens*	●	●	●	●
M. paxillata			●		*D. korsikovii*		●		●
M. papillosa var. *ellipsoidea*	●	●	●	●	*D. suecicum* var. *longispinum*			●	●
*M. rasilis**			●		*D. urceolatum**	●			
M. guttata				●	*D.* sp.				●
M. caudata			●		*Chrysolykos planktonicus*	●	●		●
*M. insignis**				●	*Pseudokephyrion cylindricum**	●	●		●
M. punctifera	●	●	●	●	*P. pseudospirale**	●	●	●	●
M. heterospina		●	●	●	*P. conicum**			●	●
M. harrisiae	●	●	●	●	*P. hypermaculatum**	●	●		●
M. akrokomos	●	●	●	●	*Chrysosphaerella brevispina*			●	●
M. striata	●	●	●	●	*Spiniferomonas trioralis*	●	●	●	●
*M. retifera**			●		*S. minuta*	●			●
M. flora			●		*S. silverensis**	●			
M. cristata	●				*S. bilacunosa*	●	●	●	●
M. alpina			●		*S. cornutus*	●		●	●
M. areolata			●	●	*S. crucigera*	●			●
M. elongata		●	●	●	*S. takahashii*				●
M. tonsurata	●	●	●	●	*S. alata*			●	
M. portae-ferreae			●		*S. bourrellyi*	●	●	●	●
M. crassisquama	●	●	●	●	*S. coronacircumspina*	●		●	●
M. lelymene	●	●			*S. abei*	●	●	●	●
M. pillula f. *valdiviana**	●			●	*S.* sp. No. 1	●			
M. annulata			●	●	*S.* sp. No. 2	●			●
M. pumilio	●	●	●	●	*Paraphysomonas subrotacea**			●	●
M. alata				●	*P. circumvallata*			●	
M. eoa	●		●		*P. punctata*	●		●	●
*M. ocellata**	●				*P. runcinifera*				●
M. mangofera f. *mangofera*	●	●	●	●	*P. subquadrangularis*			●	●
M. mangofera f. *foveata*	●			●	*P. diademifera*		●	●	●
M. mangofera var. *sulcata**				●	*P. butcheri*	●			●
M. grata			●		*P. stephanolepis**			●	●
M. recticostata			●	●	*P. morchella*			●	●
M. splendens	●	●	●	●	*P. eiffelii**	●			●
M. sp. No. 1			●	●	*P. quadrispina*				●
M. sp. No. 2	●	●		●	*P. poteriophora* ssp. *manubriata*			●	
Synura petersenii	●		●	●	*P. coronata*				●
S. glabra		●	●	●	*P. stelligera*			●	
S. sphagnicola	●	●	●	●	*P. capreolata*			●	●
S. mammillosa	●	●	●		*P. glandiata*	●		●	●
S. uvella				●	*P. imperforata* f. No. 2	●	●	●	●
S. curtispina			●	●	*P. bandaiensis*		●	●	●
S. spinosa	●	●	●	●	*P. vestita*	●	●	●	●
Chrysodidymus synuroides	●		●		*P. takahashii*			●	
Chrysococcus rufescens		●			*P. caelifrica*				●
*C. triporus**			●	●	Total number of taxa	51	38	68	76

* Taxa new to Japan.

Hoshino-ike Pond, 68 in Sengari Reservoir and 76 in Yasuba-ike Pond, occupying respectively 38.6, 27.0, 31.9 and 33.9% of the total number of algal species found in each pond or reservoir. Several studies on freshwater algal flora with light and electron microscopes covering a long period of time have been done. In three ponds at Tsuruoka Park, Yamagata Prefecture, Japan, 24 to 27 taxa of chrysophytes have been reported and their percentage to the total number of algal species was from 19.4 to 21.8% (TAKAHASHI 1978b). In Lake Biwa, Shiga Prefecture, Japan, 60 taxa of chrysophytes have been reported and its percentage to the total number of algal species found was 17.1% (NEGORO 1968, WAKABAYASHI and ICHISE 1986, ITO 1988). In other countries, three localities, a pond of Oude Waal in the Netherlands (ROIJACKERS 1984, 1986), Lake Tystrup Sø in Denmark (KRISTIANSEN 1985) and Lake Trummen in Sweden (CRONBERG 1982) have been investigated. The number of taxa of chrysophytes found was 49 in a pond of Oude Waal, 40 in Lake Tystrup Sø and 44 in Lake Trummen, occupying respectively 25.0, 19.0 and 13.8% of the total number of algal species found. Though many studies with the light microscope only on freshwater algal flora have been done, no or only a few species of chrysophytes have been found in each lake (SMITH 1920, KOKUBO and MASIKO 1939, HADA 1959, PRESCOTT 1962, HORTOBÁGYI 1973). From this and the above-mentioned results, however, it is clear that chrysophytes are commonly found in freshwater localities and constitute an important group of algal flora if examinations by electron microscopy are carried out for a long period of time.

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伊藤裕之：兵庫県南部産黄金藻（I）3池と1ダム湖における黄金藻フローラ

兵庫県南部の泥池，星野池，千苅貯水池，安場池において，1975年4月から1987年3月の間採集した合計472試料から，光学顕微鏡と電子顕微鏡を用いて黄金藻105種類を見出した。その内訳は，*Mallomonas* 属37種2変種2品種2未同定種，*Synura* 属7種，*Chrysodidymus* 属1種，*Chrysococcus* 属2種，*Kephyrion* 属1種，*Uroglena* 属2種，*Dinobryon* 属7種1変種1未同定種，*Chrysolykos* 属1種，*Pseudokephyrion* 属4種，*Chrysosphaerella* 属1種，*Spiniferomonas* 属11種2未同定種，*Paraphysomonas* 属19種1亜種1品種であった。その内，*Mallomonas bangladeshica, M. calceolus, M. rasilis, M. insignis, M. retifera, M. pillula* f. *valdiviana, M. ocellata, M. mangofera* var. *sulcata, Chrysococcus triporus, Kephyrion globosum, Uroglena lindii, Dinobryon urceolatum, Pseudokephyrion cylindricum, P. pseudospirale, P. conicum, P. hypermaculatum, Spiniferomonas silverensis, Paraphysomonas subrotacea, P. stephanolepis, P. eiffelii* の20種類は日本新産であった。黄金藻は，泥池では51種類，全藻類種類数の38.6%を占め，星野池では38種類，27.0%，千苅貯水池では68種類，31.9%，安場池では76種類，33.9%であった。（652 神戸市兵庫区楠谷町37-1 神戸市水道局水質試験所）

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Species composition and vertical distribution of diatoms occurring in a Japanese mangrove forest

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NAGUMO, T. and HARA, Y. 1990. Species composition and vertical distribution of diatoms occurring in a Japanese mangrove forest. Jpn. J. Phycol. **38**: 333-343.

The species composition and vertical distribution of diatoms occurring on mangrove roots within the intertidal zone were studied in mangrove forests at Iriomote Island, Okinawa Prefecture. Among 116 taxa of diatoms belonging to 26 genera found there, the main dominant and subdominant species were *Achnanthes brevipes* var. *intermedia, Amphora luciae, A. tenerrima, Denticula subtilis, Navicula contenta, N. guluensis, N. pusilla, Nitzschia frustulum, N. hemistriata* and *Rhopalodia* sp. The vertical distribution of dominant diatoms on mangrove roots were shown as follows: *N. contenta* and *D. subtilis* on the uppermost part of the intertidal zone, *N. guluensis, N. hemistriata* and *Rhopalodia* sp. on the middle part, and *A. brevipes* var. *intermedia, A. luciae, A. tenerrima* and *N. pusilla* on the lower part. Comparisons with previous studies indicate that the species compositions of epiphytic and benthic diatoms on mangroves in this study are very similar to those of any other mangrove.

Key Index Words: diatoms—Iriomote Island—mangrove—species composition—vertical distribution.

Mangrove forests develop well but not extensively along the rivers and their mouths located in the Ryukyu and Satunan Islands, Japan. Mangrove forests serve as unique and specific habitats for benthic macro- and microalgae, which are exposed to water of varying salinity and/or desiccation, but are offered suitable substrata and interception of intensive sunshine by their stilt roots and canopies. In these habitats, benthic and epiphytic algae were usually much diverse and also abundant. Diatoms are one of the dominant members among them (RICARD and DELESALLE 1979). However, there are few taxonomic or floristic studies of diatoms associated with these Japanese mangrove forests. Almost all studies of diatoms in other mangrove regions have been confined to the large mangrove lagoons in the tropics such as in Puerto Rico (HAGELSTEIN 1938), in Louisiana (MAPELS 1983), in Florida (NAVARRO 1982), in Venezuela (REYES-VASQUEZ 1975), in Guadeloupe (RICARD and DELESALLE 1979), in Bahamas (SULLIVAN 1981), in Singapore and southern Malaysia (WAH and WEE 1988) and in the temperate regions of the southern hemisphere, such as in Australia (FOGED 1979).

The taxonomical and ecological researches for the macroalgae associated with Japanese mangrove forests have been carried out by TANAKA and CHIHARA (1984a, 1984b, 1985, 1987) and TANAKA (1987). They have shown that macroalgae are abundant on mangrove roots and have distinct zonate distributions in the intertidal zone.

We have undertaken a survey of diatom species composition and analyzed their vertical distribution in mangrove forests at Iriomote Island. This study represents the first report on Japanese mangrove diatoms, and should be valuable as a distributional record for more comprehensive work with this complex and diverse flora.

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Study sites and methods

In Iriomote Island of the Yaeyama Archipelago, Okinawa Prefecture, some small mangrove forests have developed in estuaries of the rivers, but they are the largest in Japan. They are dominated by Rhizophoracean trees, including the species of such genera as *Rhizophora, Kandelia* and *Bruguiera*. Their stilt or knee roots and pneumatophores offer suitable substrata for benthic diatoms.

Our main study sites were along the Shiiragawa (Shiira River) in Iriomote Island (Fig. 1). Eleven points of intervals of 200 m from the river mouth were previously set up by other Ryukyu University research staff (Fig. 1). The tide exerts its influence to the upper stream region of the river, about 2 km from the river mouth. In this region, the exchange of seawater with freshwater and their turbulence occur regularly twice a day throughout the year, and tidal range is 1.0–1.5 m near the river mouth. The mean high water (M.H.W.) reaches to the uppermost part of the stilt roots or higher. The lowermost part of the stilt roots is submerged even at mean low water (M.L.W.) (Fig. 2). Salinity of water at the study sites varied from fresh (0‰) to marine (3‰) depending on tide and freshwater current. However, a gradual variation of salinity was always recognizable at each study site.

Samples of the roots of mangrove trees and surface soils in the forest or river beds were taken from every study site on Apr. 21, 1982. For investigating the vertical distribution of benthic diatoms, some root samples from each point were sectioned to provide 10 cm segments. Diatoms on the segments were collected by toothbrush. All samples were cleaned by conventional methods (KOBAYASI and NAGUMO 1985). Samples were observed with both light and electron microscopes to identify the diatom species. The species composition and relative quantities of diatoms at each site were recorded by counting and identifying three hundred valves randomly selected from slides.

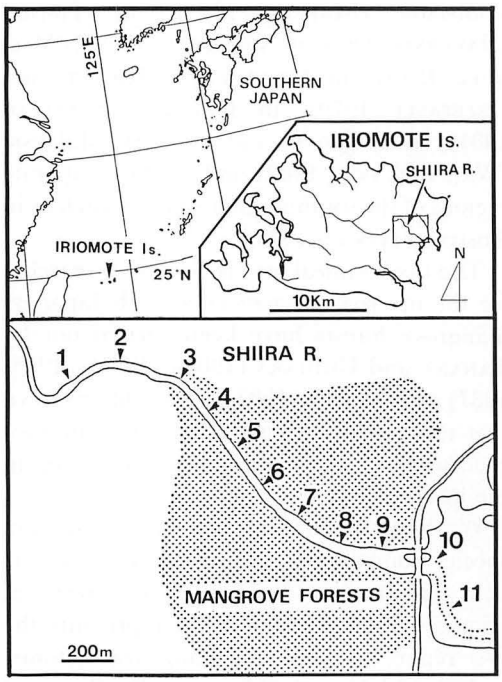


Fig. 1. Map of the study sites, showing the sampling points (1–11) indicated by arrow heads along the Shiira River.

Results

A total of 116 taxa including forma and varieties, in 26 genera, of epiphytic and benthic diatoms from all points are alphabetically listed in Table 1. The dominant four genera, in terms of number of taxa encountered, were *Navicula* (26), *Nitzschia* (18), *Amphora* (11) and *Achnanthes* (10). Representatives of epiphytic

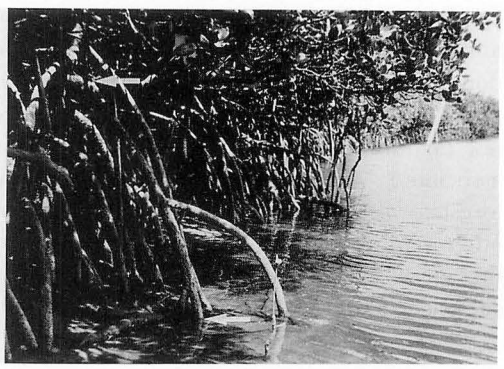


Fig. 2. A photograph of the Shiira River near point 8 showing a mangrove stilt root (arrows) from which diatoms were collected at low tide.

Table 1. List of diatom taxa found in the mangrove forest along the Shiira River.

Achnanthes amoena HUST.
brevipes AG. var. *brevipes*
brevipes var. *intermedia* (KÜTZ.) CL.
clevei GRUN.
delicatula (KÜTZ.) GRUN.
javanica GRUN.
kuwaitensis HENDEY
lanceolata (BREB.) GRUN.
longipes AG.
manifera BRUN.
oblongella ÖSTR.
Amphora angusta GREG. var. *angusta*
angusta var. *ventricosa* (GREG.) CL.
aponina KÜTZ.
arenicola GRUN. var. *oculata* CL.
holsatica HUST.
luciae CHOLN.
porita KRASSKE
tenerrima AL. *et* HUST.
turgida GREG.
veneta KÜTZ.
1 sp.
Auricula machutchoniae GIFFEN
Bacillaria paradoxa GMEL.
Biddulphia aurita (LYNGB.) BREB. et GODY.
Caloneis elongata (GRUN.) BOYER
excentrica (GRUN.) BOYER
liber (W. SM.) var. *umbilicata* (GRUN.) CL.
samoensis (GRUN.) CL.
Campylodiscus decorus BREB.
fastuosa EHR.
Cocconeis brevicostata HUST.
dirupta GREG.
placentula EHR. var. *pseudolineata* GEITL.
scutellum EHR.
Denticula subtilis GRUN.
Diploneis bombus EHR.
gravelleana HAGELST.
litoralis (DONK.) CL.
pseudovalis HUST.
reichardtii (GRUN.) HEIDEN
smithii (BREB.) CL.
Entomoneis alata (EHR.) EHR.
paludosa (W. SM.) REIM. var. *paludosa*
paludosa var. *subsalina* CL.
Gomphonema clavatum EHR.
pseudoaugur L.-BERTALOT
parvulum (KÜTZ.) KÜTZ.
Gyrosigma spenceri (GRUN.) CL.
Mastogloia angulata LEWIS
elliptica (AG.) CL. var. *dansei* (THWAIT.) CL.
macdonaldii GREY.
pumila (CL. et MÖLL.) CL.
pusilla GRUN.
varians HUST.
Melosira nummuloides (DILLW.) AG.
Navicula acephala HERIB.
cincta (EHR.) var. *leptocephala* (KÜTZ.) GRUN.
contenta GRUN.
decussis ÖSTR.
digitoradiata (GREG.) RALFS
dissipata HUST.
gregaria DONK.
guluensis GIFFEN
hastaeformis CHOLN.
indicatrix VANLAND.
infaceta CHOLN.
inserata HUST. var. *inserata*
inserata var. *undulata* HUST.
maculosa DONK.
mannii HAGELST.
mollis (W. SM.) CL.
paeninsulae CHOLN.
platyventris MEIST.
punctigera HUST.
pusilla W. SM.
salinarum GRUN.
schroeteri MEIST. var. *escambia* PATR.
subvalida CHOLN.
4 spp.
Nitzschia aerophila HUST.
debilis (ARNOTT) GRUN.
dissipata (KÜTZ.) GRUN.
fussiformis PANTOC.
frustulum (KÜTZ.) GRUN.
granulata GRUN.
hemistriata HAGELST.
lorenziana GRUN.
novaehollandiae (GRUN.) GRUN.
obtusa W. SM. var. *scalpelliformis* GRUN.
palea (KÜTZ.) W. SM.
panduriformis GREG. var. *pustulata* VOIGT
ponciensis HAGELST.
pseudohungarica HUST.
trybrionella HANTZ. var. *victoriae* (GRUN.) GRUN.
3 spp.
Opephora pacifica (GRUN.) PETIT
Pinnularia allansonii CHOLN.
mesolepta (EHR.) W. SM.
subcapitata GREG.
Pleurosigma salinarum GRUN.
Rhopalodia gibberula (EHR.) MÜLL.
operculata (AG.) HAKANS.
1 sp.
Stauroneis pachycephala CL.
Surirella armoricana PERAG.
ovata KÜTZ.
Synedra tabulata (AG.) KÜTZ. var. *tabulata*
tabulata var. *parva* (KÜTZ.) HUST.
Thalassiosira lacustris (GRUN.) HASLE
Trachyneis aspera (EHR.) EHR.

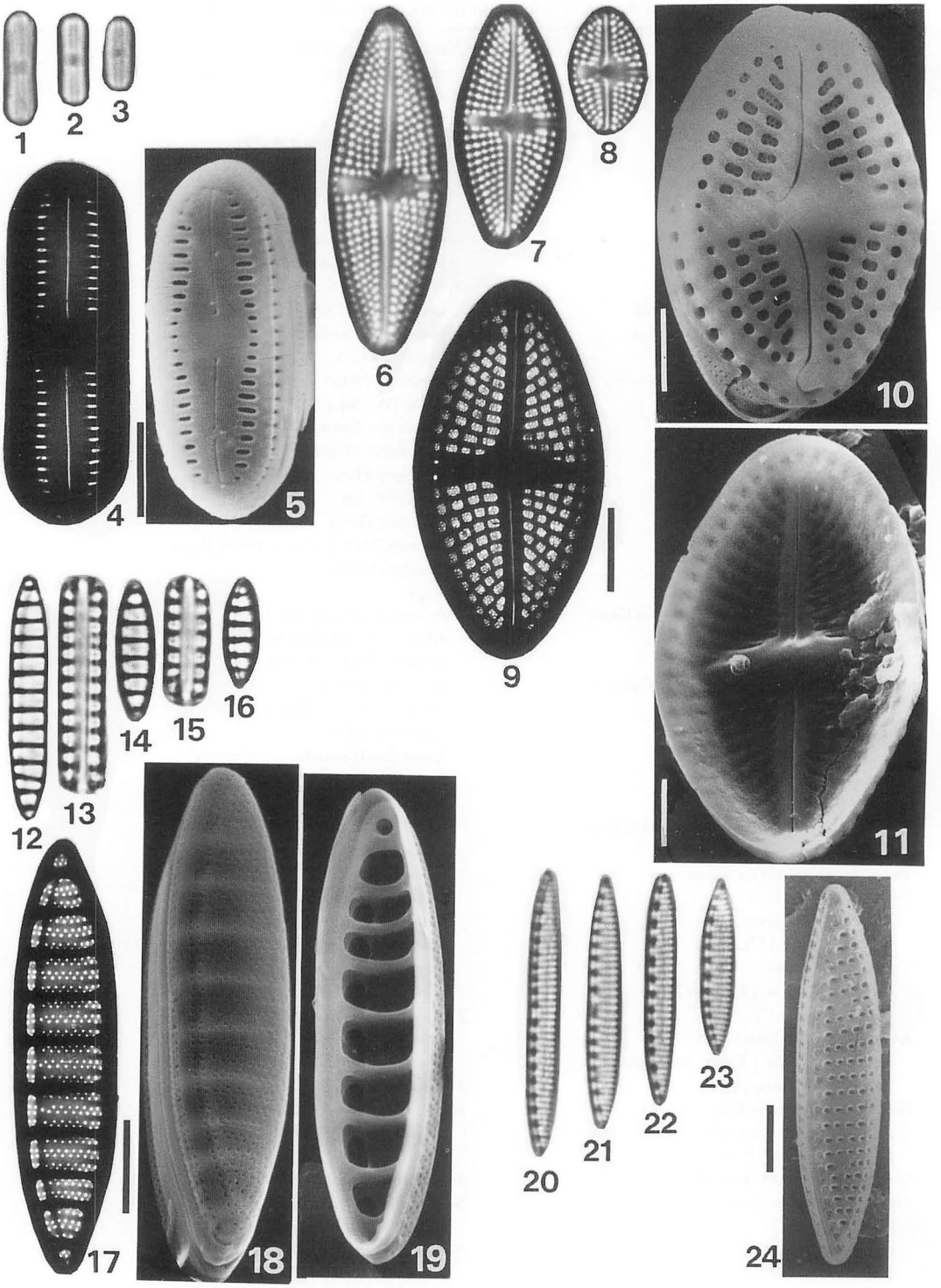


Plate 1. Figs. 1–5. *Navicula contenta*; 1–3, Light microscopy (LM). 4, TEM. 5, SEM. Figs. 6–11. *N. guluensis*; 6–8, LM. 9, TEM. 10 & 11, SEM. Figs. 12–19. *Denticula subtilis*; 12–16, LM. 13 & 15, Girdle view of the frustule. 17, TEM. 18 & 19, SEM. Figs. 20–24. *Nitzschia frustulum*; 20–23, LM. 24, SEM. LM=×2,000. Bars=5 μm for SEM and TEM photos.

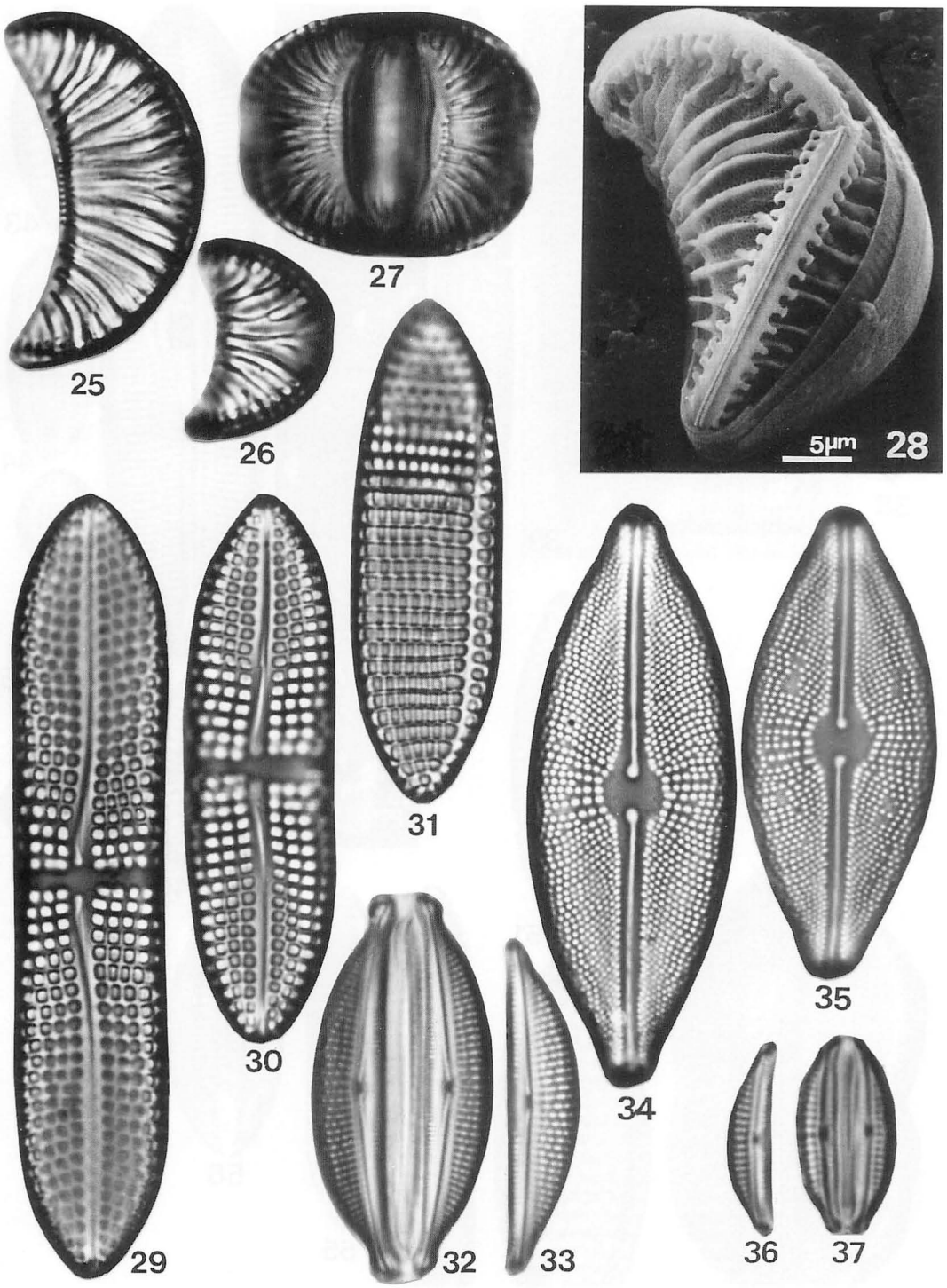
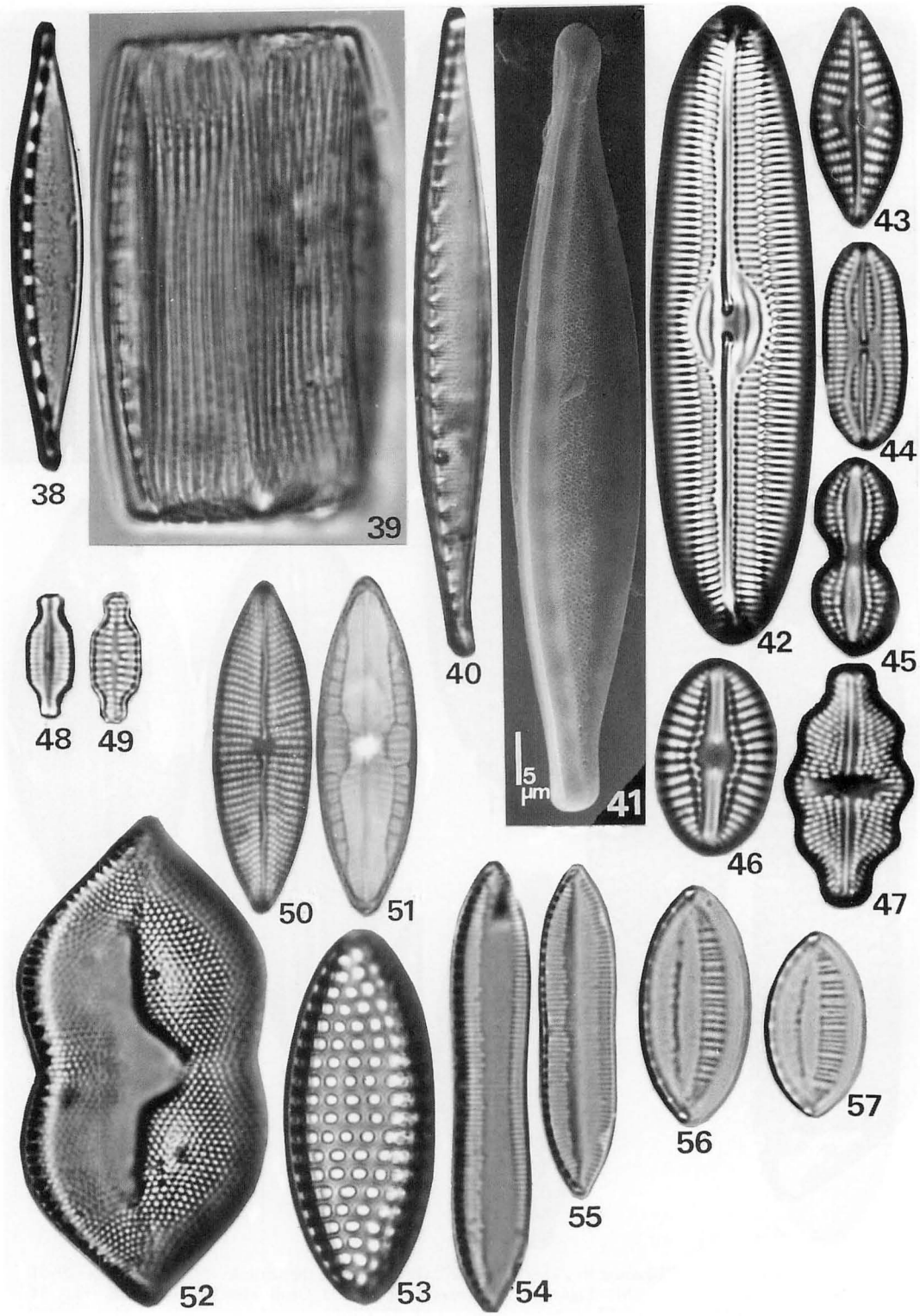


Plate 2. Figs. 25–28. *Rhopalodia* sp.; 25–27, LM. 27, Girdle view of the frustule. 28, SEM. Figs. 29–31. *Achnanthes brevipes* var. *intermedia*; LM. Figs. 32, 33. *Amphora luciae*; LM. 32, Girdle view of the frustule. Figs. 34, 35. *Navicula pusilla*; LM. Figs. 36, 37. *Amphora tenerrima*; LM. 37, Girdle view of the frustule. LM = ×2,000.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taxa on roots are as follows: *Achnanthes brevipes* Ag. var. *intermedia* (Kütz.) Cl. (1895, p. 193) (Pl. 2. Figs. 29-31), *Amphora luciae* Choln. (1960, p. 23, *f. 58-61*) (Pl. 2, Figs. 32, 33), *A. tenerrima* Aleem *et* Hust. (1951, p. 16, *f. 3.*) (Pl. 2, Figs. 36, 37), *Denticula subtilis* Grun. (1862, p. 547, *pl. 12, f. 36*) cf. Krammer & L.-Bertalot (1988, p. 140, 141, *pl. 96, f. 1-9*) (Pl. 1, Figs. 12-19), *Navicula contenta* Grun. (*in* V. H. 1884, p. 109) cf. Krammer & L.-Bertalot (1986, p. 219, *pl. 75, f. 1-5*) (Pl. 1, Figs. 1-5), *N. guluensis* Giffen (1963, p. 238, *f. 70*) (Pl. 1, Figs. 6-11), *N. pusilla* W. Sm. (1853, p. 52, *pl. 17, f. 145*) (Pl. 2, Figs. 34, 35), *Nitzschia hemistriata* Hagelst. (1938, p. 396, *pl. 8, f. 1*) (Pl. 3, Figs. 38-40), *N. frustulum* (Kütz.) Grun. (*in* Cl. *et* Grun. 1880, p. 98) cf. Krammer & L.-Bertalot (1988, p. 94, 95. *pl. 68, f. 1-19*) (Pl. 1, Figs. 20-24), *Rhopalodia* sp. (Pl 2, Figs. 25-28).

Common species appeared in every study site are represented in Pl. 3, Figs. 42-57. Almost all mangrove-associated diatoms including common species listed in Table 1 are regarded as brackish water or marine diatoms.

Aerobic species, *N. contenta* and *D. subtilis*, appeared dominantly or subdominantly at the upper portions of all study sites (Points 1-11).

In the lower stream regions of the river (Points 5-9), brackish species, *N. guluensis, N. hemistriata* and *Rhopalodia* sp., were dominant or subdominant at the upper to middle parts of the intertidal zone.

At the mouth and outlet of the river (Points 10, 11), the following marine species were dominant or subdominant at the lower to middle parts of the intertidal zone: *A. brevipes* var. *intermedia, A. luciae, A. tenerrima*, and *N. pusilla*.

Dominant or subdominant diatoms in the intertidal zones of all the examined sites ditributed in clear zonation. These vertical distribution pattern of diatom species attached to mangrove roots are summarized in Table 2; at the upper stream region of the mangrove (P-2), at the middle stream region (P-5), and at the lower stream region (P-8).

Discussion

The epiphytic and benthic diatom flora in the mangroves were more diverse than in estuaries without mangrove forests in the main island of Japan as shown in Table 3 (Gotoh 1978, 1979, 1986, Mayama and Kobayasi 1982).

The vertical distribution of dominant and subdominant diatoms on mangrove roots showed a clear zonation (Fig. 3), similar to mangrove-associated macroalgae, as mentioned below (Tanaka and Chihara 1987). Of the dominant species occupying the upper part of intertidal zone, *N. contenta* Grun. is a representative of the aerobic diatoms (Hustedt 1959). *A. brevipes* Ag. var. *intermedia* (Kütz.) Cl., *N. hemistriata* Hagelst. and *Rhopalodia* sp., which are dominant in the middle or lower part of intertidal

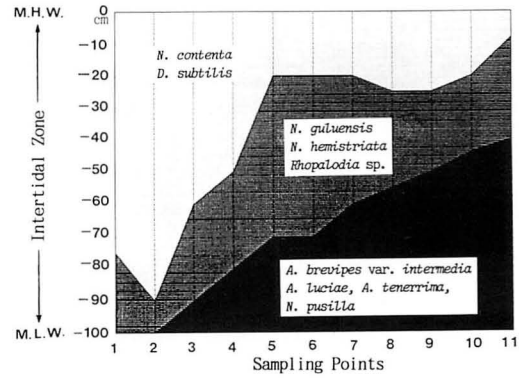

Fig. 3. Vertical distribution pattern of the dominant and subdominant diatoms on mangrove stilt roots at all sampling points. M.H.W., mean high water; M.L.W., mean low water.

Plate 3. Figs. 38–41. *Nitzschia hemistriata*; 38–40, LM. 39, Girdle view of the frustule. 41, SEM. Fig. 42. *Caloneis liber* var. *umbilicata*; LM. Fig. 43. *Navicula platyventris*; LM. Fig. 44. *N. punctigera*; LM. Fig. 45. *Diploneis gravelleana*; LM. Fig. 46. *D. pseudovalis*; LM. Fig. 47. *Navicula inserata* var. *undulata*; LM. Figs. 48, 49. *Achnanthes amoena*; LM. 48, Raphe valve. 49, Rapheless valve. Figs. 50, 51. *Mastogloia pusilla*; LM. Fig. 52. *Nitzschia panduriformis* var. *pustulata*; LM. Fig. 53. *N. granulata*, LM. Figs. 54, 55. *N. ponciensis*; LM. Figs. 56, 57. *N. debilis*; LM. LM = ×2,000.

Table 2. Vertical distribution of dominant and subdominant diatoms on mangrove stilt roots at the Shiira River. P-2, point 2; P-5, point 5; and P-8, point 8.

P-2

Relative tide level (cm)	Dominant species	Subdominant species
0		
	Denticula subtilis	*Navicula contenta*
−10		
	D. subtilis	*N. contenta*
−20		
	D. subtilis	*N. contenta*
−30		
	D. subtilis	*N. contenta*
−40		
	D. subtilis	*N. contenta*
−50		
	Nitzschia frustulum	*Denticula subtilis*
−60		
	N. frustulum	*D. subtilis*
−70		
	D. subtilis	*D. subtilis*
−80		
	D. subtilis	*Navicula guluensis*
−90		
	N. guluensis	*Nitzschia hemistriata*
−100		

P-5

Relative tide level (cm)	Dominant species	Subdominant species
0		
	Denticula subtilis	*Navicula contenta*
−10		
	D. subtilis	*N. contenta*
−20		
	D. subtilis	*N. contenta*
−30		
	Nitzschia hemistriata	*D. subtilis*
−40		
	N. hemistriata	*Navicula guluensis*
−50		
	N. hemistriata	*N. guluensis*
−60		
	N. hemistriata	*N. guluensis* *N. pusila*
−70		
	Navicula guluensis	*Nitzschia hemistriata* *Navicula pusila*
−80		
	N. pusila	*N. hemistriata* *Navicula gregaria*
−90		
	Achnanthes brevipes var. *intermedia*	*N. pusila*
−100		

P-8

Relative tide level (cm)	Dominant species	Subdominant species
0		
	Navicula contenta	*Denticula subtilis*
−10		
	D. subtilis	*Navicula guluensis* *N. hemistriata*
−20		
	D. subtilis	*N. guluensis* *N. hemistriata*
−30		
	D. subtilis	*N. hemistriata*
−40		
	N. hemistriata	*Rhopalodia* sp.
−50		
	N. hemistriata	*Rhopalodia* sp.
−60		
	Rhopalodia sp.	*D. subtilis* *Achnanthes brevipes* var. *intermedia*
−70		
	Rhopalodia sp.	*A. brevipes* var. *intermedia*
−80		
	Rhopalodia sp.	*A. brevipes* var. *intermedia*
−90		
	Amphora luciae	*A. brevipes* var. *intermedia* *Navicula pusila*
−100		
	A. tenerrima	*N. pusila*

zones, are commonly found as epiphytic or benthic species in marine waters. *N. hemistriata*, which was originally recorded from the sample collected from mangrove swamps in Martin Pena, Puerto Rico by HAGELSTEIN (1938), is also present. *D. subtilis* GRUN. is widely distributed in brackish environments such as estuaries and salt marshes, and is often associated with *Rhizoclonium* (GRUNOW 1862) or *Bostrychia* (GIFFEN 1970) which are common brackish macroalgae. These results show that some benthic diatoms from marine or brackish water are well adapted to the mangrove forest habitats exposed to waters with various salinities, and have their own niche or ecological status in the mangrove forest with close relation to other benthic macroalgae.

There is a limited work for diatom flora and its vertical distribution in brackish waters in the temperate and subtropical regions of Japan. Floristic studies of diatoms in

Table 3. A comparison of the number of taxa occurring in the mangrove forest and estuaries without mangrove forests in Japan.

Locality	Number of diatom taxa	Reference
Shiira-gawa, Mangrove, Okinawa Pref.	116	Present paper
Aono-gawa, Estuary, Shizuoka Pref.	108	MAYAMA & KOBAYASI (1982)
Kumano-gawa, Estuary, Wakayama Pref.	75	GOTOH (1986)
Yodo-gawa, Estuary, Osaka Pref.	86	GOTOH (1978)
Yodo-gawa, Estuary, Osaka Pref.	49	GOTOH (1979)

mangrove forests are also limited even in all over the world (FOGED 1979, HAGELSTEIN 1938, NAVARRO 1982, RICARD and DELESALLE 1979, WAH and WEE 1988). Community structure studies of mangrove diatoms have been confined to the USA (MAPLES 1983, SULLIVAN 1981). The dominant genera, *Achnanthes, Denticula, Navicula, Nitzschia* and *Rhopalodia*, found in this study are the same as reported by MAPLES (1983) as ephiphytes on pneumatophores of the black mangrove, *Avicenia germicans*, in a Louisiana salt marsh. In comparison to the epiphytic diatom flora associated with mangrove roots from Indian River by NAVARRO (1982), the dominant or subdominant species composition at Iriomote resembles to that of Indian River. These representative taxa found in the Japanese mangroves seem to be widely distributed in any tropical areas where mangrove forests are well developed.

According to TANAKA and CHIHARA (1987), the distribution of macroalgae on stilt roots and knee roots of mangrove trees in lower stream regions were divided into four main vertical zones; the *Rhizoclonium* zone, *Bostrychia* zone, *Caloglossa* zone, and *Catenella* zone. The vertical distribution pattern of macroalgae was not so clearly defined at the upper stream regions of the river, because the intertidal zone is too narrow for macroalgae of marine, brackish and fresh waters to be well separated. However, the dominant and subdominant diatoms showed clear zonation even in narrow spaces of the upper stream regions. Such typical zonation patterns of macroalgae in the lower stream regions fit well with those of diatoms as shown in Fig. 3.

The upper zone of *N. contenta* and *D. subtilis* generally corresponds to *Rhizoclonium* or *Bostrychia* zone, the middle zone of *N. guluensis, N. hemistriata* and *Rhopalodia* sp. to *Caloglossa* zone, and the lower zone of *Achnanthes* and others to *Catenella* zone. *D. subtilis* is well known to inhabit brackish water environments and to coexist with *Rhizoclonium* (GRUNOW 1862) or *Bostrychia* (GIFFEN 1970).

The vertical distribution of diatoms in the Japanese mangroves appears to be influenced by water movement, salinity and desiccation. The regular tide may be the main factor for the formation of vertical zonation of diatoms.

Acknowledgements

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南雲　保*・原　慶明**：本邦マングローブ林に生育するケイソウ類の種類組成と鉛直分布

沖縄県西表島の後良川マングローブ林内の上流から河口までの200 m毎に定めた11地点からマングローブの柱状根および周囲の表土を採取し，マングローブ林に生育するケイソウ類の種類組成と鉛直分布を調べた。その結果，26属に所属する116分類群の生育を確認した。また，全観察試料中，主要な優占および亜優占種は，*Achnanthes brevipes* var. *intermedia, Amphora luciae, A. tenerrima, Denticula subtilis, Navicula contenta, N. guluensis, N. pusilla, Nitzschia frustulum, N. hemistriata* and *Rhopalodia* sp. であった。また，それらは各調査地点で共通して，上部では *N. contenta* と *D. subtilis*, 中央部では *N. guluensis, N. hemistriata* と *Rhopalodia* sp., 下部では *A. brevipes* var. *intermedia, A. luciae, A. tenerrima* と *N. pusilla* が明瞭な帯状分布することを確認した。出現した種類の大半は，汽水あるいは海産の種類であり，マングローブ林の特異な塩分環境に良く適応している種組成と分布を示すと思われる。（*102 千代田区富士見1-9-20　日本歯科大学生物学教室，**305 茨城県つくば市天王台1-1-1　筑波大学生物科学系）

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Taxonomic notes on Japanese *Ptilota* (Ceramiales, Rhodophyta)

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The correct names of two species of *Ptilota* growing in Japan are established. The alga known as *Ptilota pectinata* (GUNNERUS) KJELLMAN or *P. serrata* KÜTZING including *Ptilota californica* (=*Neoptilota californica*) sensu OKAMURA is identical with *P. filicina* J. AGARDH. The entity known as *P. pectinata* forma *litoralis* KJELLMAN is referred to *P. phacelocarpoides* A. ZINOVA. Diagnostic features of all the known species of the genus are discussed. It is concluded that the growth manner of first-order branches on the primary axis, the serration of leaflet-like determinate branchlets, the nature of thalli (erect or decumbent), and the shape of tetrasporangial clusters are of primary taxonomic significance at the species level. A full description of *P. phacelocarpoides*, which is poorly known in Japan, is given.

Key Index Words: *Ceramiales*—Ptilota—Ptilota filicina—Ptilota pectinata—Ptilota pectinata *f.* litoralis—Ptilota phacelocarpoides—Ptilota plumosa—Ptilota serrata—*taxonomy*—*Rhodophyta*.

The red algal genus *Ptilota* (Ceramiales) currently includes four species; these species and their type localities are as follows: *P. plumosa* (LINNAEUS). C. AGARDH (1817, unspecified in Atlantic Ocean), the type species, *P. serrata* KÜTZING (1847, Newfoundland, Canada) which includes (WHITTICK 1977) *P. pectinata* (GUNNERUS) KJELLMAN (1883), *P. filicina* J. AGARDH (1876, Vancouver Island, Canada) which includes (ABBOTT and HOLLENBERG 1976) *P. tenuis* KYLIN (1925), and *P. phacelocarpoides* A. ZINOVA (1972, Ussuri Bay in Peter the Great Bay, Primorskiy, USSR). *Ptilota plumosa* has been reported from various localities in Arctic Sea and North Atlantic Ocean (HARVEY 1853, KJELLMAN 1883, KYLIN 1923, ROSENVINGE 1923-24, TAYLOR 1957). The latter two species have been recorded from North Pacific Ocean (YENDO 1916, ABBOTT and HOLLENBERG 1976, PERESTENKO 1980, GABRIELSON *et al.* 1989). *Ptilota serrata* has been widely recorded from both regions (HARVEY 1853, KJELLMAN 1883, OKAMURA 1909, 1933, 1936 as *P. pectinata*, TAYLOR 1957, LEE and KANG 1986, GABRIELSON *et al.* 1989).

In Japan, the alga referred to as *Ptilota pectinata* or *P. serrata* is common in the intertidal and subtidal zones of Hokkaido and northern Honshu. Our recent studies show that this alga is different from the genuine *P. serrata*. Another entity which has been called *P. pectinata* f. *litoralis* KJELLMAN (OKAMURA 1909, 1936, SEGAWA 1956) is often found at the subtidal zone of Hokkaido coasts. In this report the correct names for these two Japanese algae are established.

Materials and Methods

Herbarium specimens deposited in the Herbarium, Department of Botany, Faculty of Science, Hokkaido University (SAP) were chiefly examined (Table 1). Several specimens identified by Japanese phycologists are voucher specimens mentioned in their publications: OKAMURA (1909, 1933, 1936), YAMADA (1934), KAWABATA (1936), NAGAI (1941), KAWASHIMA (1955), FUNAHASHI (1966) and TAZAWA (1975). In addition, our collections from Usu, Toyoura, Shizukari, Shiriuchi, Oshoro Bay, and Atsuta on the Hokkaido coast during 1985–1989 were used. These latter specimens are preserved in

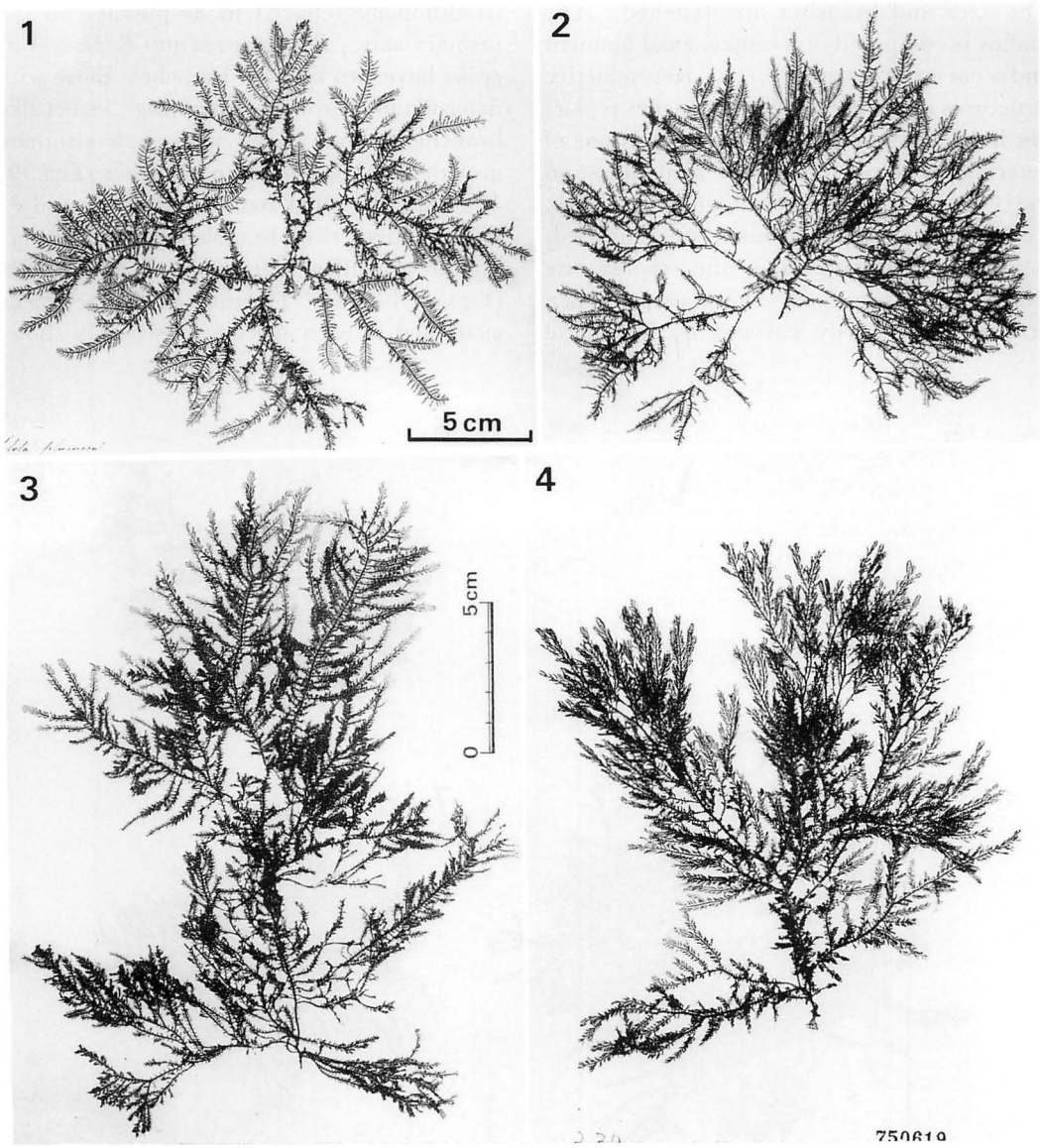
Table 1. *Ptilota* specimens examined in SAP.

Identified as	Locality	Date	Collected/identified by	Specimen number
Ptilota plumosa				
P. plumosa	Bohuslan, Sweden	undated	anonymous	040916
P. plumosa	Bohuslan, Sweden	22. vii. 1925	W.M. Rystrom	040929
P. plumosa	Bohuslan, Sweden	4. vii. 1946	T. Levring	040929A
P. plumosa	Mandals Skargard, Norway	18. vii. 1930	T. Arwidsson	040928
P. plumosa	Novaya Zemlya, USSR	24. vi. 1875	F.R. Kjellman	040918
Ptilota serrata				
P. serrata	Spitzbergen, Norway	viii. 1872	F.R. Kjellman	040936
P. serrata	Spitzbergen, Norway	vii. 1873	F.R. Kjellman	040926
P. serrata	Spitzbergen, Norway	12. v. 1873	F.R. Kjellman	040938
P. serrata	Novaya Zemlya, USSR	24. vi. 1875	F.R. Kjellman	040938A
P. serrata	Clam Bay, Nova Scotia, Canada	5. iii. 1969	E. Ogata/T. Edelstein	031046
Ptilota filicina				
P. filicina	Santa Cruz, California, USA	10. xi. 1965	L.E. Hair/I.A. Abbott	029115
P. filicina	Vancouver Island, Canada	vi. 1901	K. Yendo	048484
P. sp.	Shipley Bay, Alaska, USA	20. vi. 1913	T.C. Frye/W.A. Setchell	051412
P. pectinata	Atka Island, Aleutians, USA	v. 1931	Y. Kobayashi/K. Okamura	040939, Okamura Herb.
P. filicina	Shemya Island, Aleutians, USA	22. viii. 1975	N. Masuda/M. Masuda	053262, 053263
P. pectinata	Matsuwa Island, Kuriles, USSR	14. viii. 1935	M. Nagai	022038
P. pectinata	Urup Island, Kuriles, USSR	viii. 1933	Y. Yamada	015143, 026670
P. pectinata	Shikotan Island, Kuriles, USSR	vii. 1934	S. Kawabata	020978
P. californica	Robben Island, Sakhalin, USSR	9. ix. 1906	R. Kubo/K. Okamura	Okamura Herb.
P. pectinata	Peter the Great Bay, USSR	19. vii. 1928	A. Kuznetsov/S. Funahashi	032410
P. pectinata	Akkeshi, Hokkaido, Japan	1. vi. 1946	M. Kurogi	051160
P. pectinata	Hiroo, Hokkaido, Japan	30. iii. 1975	M. Ohta	047885
P. pectinata	Urakawa, Hokkaido, Japan	vi. 1902	N. Hattori/K. Okamura	Okamura Herb.
P. californica	Muroran, Hokkaido, Japan	15. viii. 1929	S. Yagi/K. Okamura	Okamura Herb.
P. pectinata	Muroran, Hokkaido, Japan	29. vi. 1935	T. Muraoka	019824
P. pectinata	Otaru, Hokkaido, Japan	2. v. 1954	N. Tazawa	028517, 028518
P. pectinata	Oshoro, Hokkaido, Japan	vi. 1932	K. Inagaki	022842
P. pectinata	Okushiri, Hokkaido, Japan	6. vii. 1944	Y. Hasegawa	025231, 025232
P. serrata	Shimofuro, Aomori, Japan	18. iv. 1987	T. Kitayama	052831
P. pectinata	Nakano, Iwate, Japan	1. vii. 1954	S. Kawashima	027881
Ptilota phacelocarpoides				
P. pectinata f. *litoralis*	Peter the Great Bay, USSR	31. viii. 1926	A. Kuznetsov/S. Funahashi	032408
P. pectinata f. *litoralis*	Nemuro, Hokkaido, Japan	27. vi. 1987	M. Matsumoto	052487
P. pectinata f. *litoralis*	Muroran, Hokkaido, Japan	vii. 1933	T. Kanda	023358
P. pectinata f. *litoralis*	Hakodate, Hokkaido, Japan	25. iv. 1943	T. Moritake/Y. Yamada	024271
P. pectinata f. *litoralis*	Usu, Hokkaido, Japan	16. vii. 1954	N. Tazawa	051155
P. pectinata f. *litoralis*	Rishiri, Hokkaido, Japan	28. viii. 1934	K. Inagaki	022835, 047733
P. pectinata f. *litoralis*	Yagishiri, Hokkaido, Japan	2. viii. 1981	M. Marui	044071
P. pectinata f. *litoralis*	Obira, Hokkaido, Japan	12. vi. 1981	M. Marui	044072
P. pectinata f. *litoralis*	Mashike, Hokkaido, Japan	26. vii. 1897	F. Nakajima/K. Okamura	Okamura Herb.
P. pectinata f. *litoralis*	Shioya, Hokkaido, Japan	vi. 1940	Y. Nakamura	023616
P. pectinata f. *litoralis*	Kesen-numa, Iwate, Japan	undated	K. Okamura	Okamura Herb.

SAP (053614-053650). The herbarium specimens were examined using a dissecting microscope with fiber-optical light (Nikon SMZ-10). Small portions of them were removed and prepared for microscope slides.

Results and Discussion

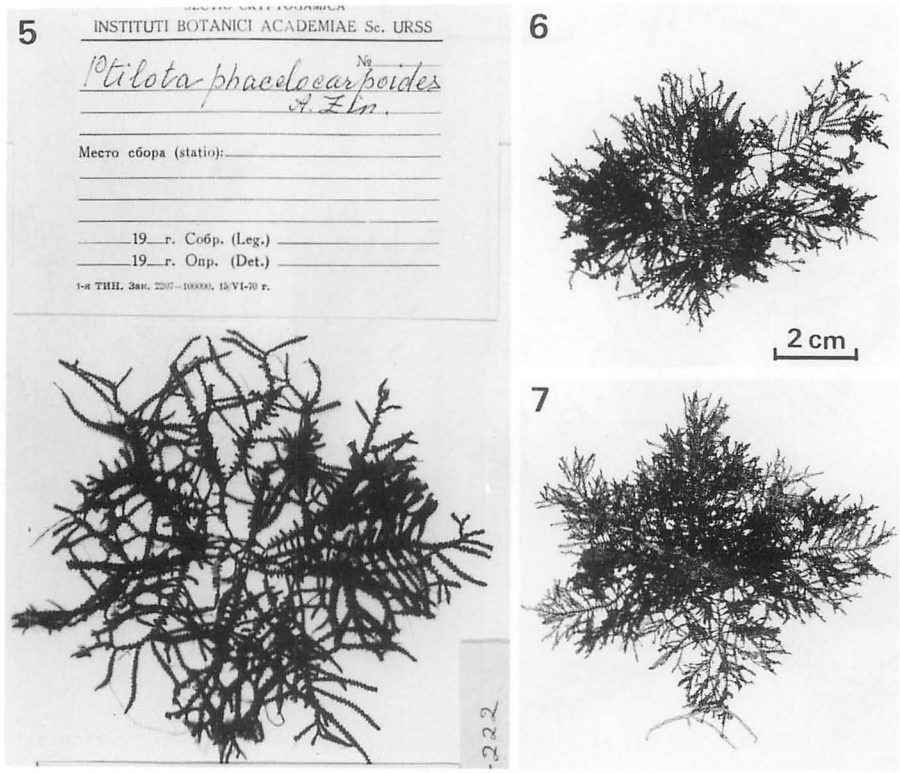
Specimens examined have the following features in common. Thalli are flattened, densely branched in an alternately pinnate manner in a single plane (Figs. 1-7). Primary axes of the thalli produce a pair of



Figs. 1–4. Herbarium specimens of three species of *Ptilota*. Fig. 1. *Ptilota plumosa* (Linnaeus) C. Agardh with cystocarps collected at Bohuslan, Sweden (SAP 040916). Fig. 2. *Ptilota serrata* Kützing with tetrasporangia collected at Spitzbergen, Norway on May 12, 1873 (SAP 040938). Fig. 3. *Ptilota filicina* J. Agardh with tetrasporangia collected at Vancouver Island, Canada in June 1901 (SAP 048484). Fig. 4. *Ptilota filicina* with procarps collected at Hiroo, Hokkaido, Japan on March 30, 1975 (SAP 047885). Scale in Fig. 1 applies also to Fig. 2; scale in Fig. 3 applies also to Fig. 4.

lateral opposite branches, one of which develops before the other. Some of the indeterminate branches grow well in a manner similar to that of the primary axis and so the primary axis becomes obscured. Determinate branches are leaflet-like and have reproductive activity. Adventitious branches are formed from the outermost cortical cells. The axes and branches are flattened. The thallus is composed of a central axial filament and a cortex of several layers. Reproductive structures are borne on short branches replacing indeterminate branches, on serrations of determinate branchlets, and sometimes on the apex of indeterminate branches. Tetrasporangia are terminal on clustered, uniseriate filaments and the spores are tetrahedrally arranged. Cystocarps, when present, are heavily covered by involucral bracts arising from the lower portion of their parent branches or branchlets. Spermatangia, when present, are in irregular clusters and are borne on specially developed branchlets.

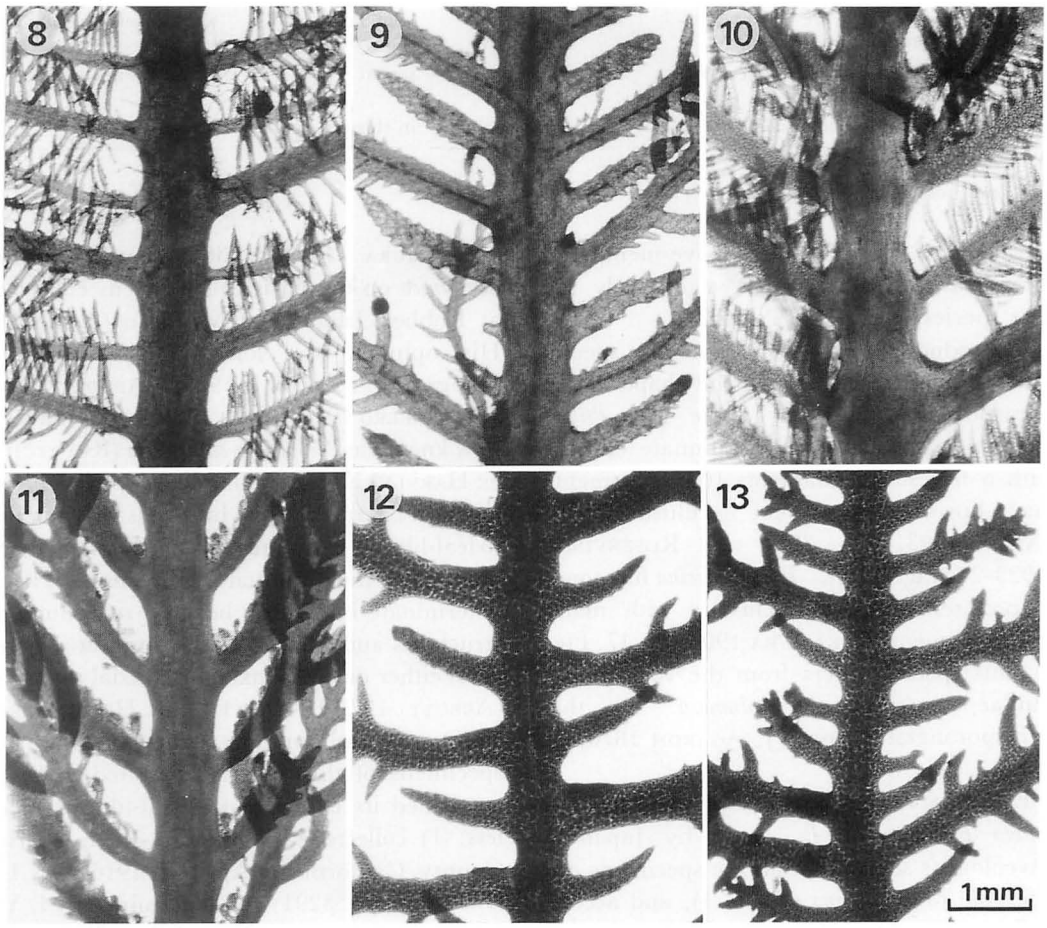
The most conspicuous diagnostic feature for the identification of individual specimens is the growth manner of first-order branches (traditionally referred to as pinnae) on the primary axis. *Ptilota serrata* and *P. phacelocarpoides* have two types of branches, those with determinate growth becoming leaflet-like branchlets and those with indeterminate growth becoming pinnate branches (Figs. 9, 12). On the other hand, *P. plumosa* and *P. filicina* have two branches with indeterminate growth which are dissimilar in size (Figs. 8, 10, 11). The majority of specimens examined of each species consistently shows



Figs. 5–7. Herbarium specimens of *Ptilota phacelocarpoides* A. ZINOVA. Fig. 5. Holotype specimen collected at Ussuri Bay in Peter the Great Bay, Primorskiy, USSR in August 1966 and deposited in LE (the photograph taken by I. YAMADA). Fig. 6. Vegetative specimen collected at Atsuta, Hokkaido on August 11, 1989 (SAP 053648). Fig. 7. Vegetative specimen collected at Oshoro Bay, Hokkaido on August 15, 1989 (SAP 053643). Scale in Fig. 6 applies also to Figs. 5 & 7.

this feature, but some specimens have irregular patterns. For example, in some plants of *P. phacelocarpoides* two of a pair of first-order branches develop indeterminately like the primary axis and even pinnate branches cease growth at early stages (Fig. 13). To judge from the original description (ZINOVA 1972) and from the holotype specimen (Fig. 5), some of the original material of *P. phacelocarpoides* may have a similar irregular pattern. In some specimens of *P. filicina* one of a pair of the first- or second-order branches cease vegetative growth at an early stage and often form reproductive structures.

Leaflet-like determinate branchlets of *Ptilota plumosa, P. serrata* and *P. filicina* are serrate both on the adaxial and abaxial margins. Those of *P. phacelocarpoides* are usually entire, but are sometimes serrate only on the abaxial margin. Furthermore, thalli of *P. phacelocarpoides* are decumbent, being attached to the substratum by adventitious rhizoids (Fig. 14), whereas those of the other



Figs. 8–13. Portion of main axes of four species of *Ptilota*, showing the growth manner of first-order branches. Fig. 8. *Ptilota plumosa* from Mandals Skargard, Norway (SAP 040928); note both of each opposite pair with indeterminate growth. Fig. 9. *Ptilota serrata* from Novaya Zemlya, USSR (SAP 040938A); note one of each opposite pair with determinate growth. Figs. 10, 11. *Ptilota filicina*: 10, from Vancouver Island (SAP 048484); 11, from Hiroo, Hokkaido (SAP 047885); note both of each pair with indeterminate growth. Figs. 12, 13. *Ptilota phacelocarpoides*: 12, from Atsuta, Hokkaido (SAP 053648); 13, collected at Oshoro Bay, Hokkaido on September 18, 1989 (SAP 053644); note a regular arrangement of opposite pairs, one with determinate growth, another with indeterminate growth in Fig. 12, and an irregular arrangement in Fig. 13. Scale in Fig. 13 applies also to Figs. 8–12.

Table 2. A comparison of four species of *Ptilota*.

Feature	*P. plumosa*	*P. serrata*	*P. filicina*	*P. phacelocarpoides*
Thallus erect or decumbent	erect	erect	erect	decumbent
Shape of opposite branch pairs on primary axis	similar	dissimilar	similar	dissimilar
Serration on determinate branches	abundant on both sides	abundant on both sides	abundant on both sides	sometimes on abaxial side
Position of reproductive structures	apex of short branches, serrations of determinate branches	apex of short branches, serrations of determinate branches, sometimes apex of indeterminate branches	apex of short branches, serrations of determinate branches, sometimes apex of indeterminate branches	apex of short branches, serrations of determinate branches, sometimes apex of indeterminate branches
Shape of tetrasporangial clusters	pinnate	cone-shaped	cone-shaped	cone-shaped
Sterile filaments on tetrasporangial pinnules	rare	abundant	abundant	abundant
Involucral bracts enveloping cystocarps	entire or serrate	entire or serrate[1)]	serrate	entire, sometimes serrate
Spermatangia	in clusters[2)]	?	in clusters	in clusters

[1)] Data from Harvey (1853)
[2)] Data from Rosenvinge (1923–24)

species are erect. The above-mentioned three features characterize vegetatively the four species examined (Table 2).

Reproductive features of the four species are very similar except for the shape of the tetrasporangial clusters (Table 2). *Ptilota plumosa* bears characteristic pinnate clusters with a few sterile filaments [these filaments may, however, be absent as illustrated by KYLIN (1923, Fig. 39C) and ROSENVINGE (1923-24, Fig. 291)]. *Ptilota filicina* has cone-shaped tetrasporangial clusters with many sterile filaments (OKAMURA 1909, Pl. 47, Fig. 8); this species differs from the vegetatively similar species, *P. plumosa* in this tetrasporangial feature (J. AGARDH 1876, p. 76).

Examination of specimens identified as *Ptilota pectinata* or *P. serrata* by Japanese phycologists shows that all the specimens are referable to *P. filicina* (Table 1), and accord well with J. AGARDH's original description. Thus, the voucher specimens of *Ptilota pectinata* of the following publications can be identified as *P. filicina*: OKAMURA (1909, 1933, 1936), YAMADA (1934), KAWABATA (1936), NAGAI (1941), KAWASHIMA (1955), FUNAHASHI (1966) and TAZAWA (1975).

OKAMURA (1909, 1936) recorded *Ptilota californica* on the basis of specimens collected at Robben Island and Muroran (Table 1). His opinion was followed by later investigators (TOKIDA 1954, ABBOTT and HOLLENBERG 1976, SAKAI 1986). This entity, now known as *Neoptilota californica* (RUPRECHT ex HARVEY) KYLIN, is characterized by one of a pair of lateral opposite branches growing into leaf-like determinate branchlets which alternate with indeterminate branches. These determinate branchlets bear no reproductive structures and sometimes have minute serrations either on the abaxial or adaxial margins (ABBOTT 1972, ABBOTT and HOLLENBERG 1976). An examination of the following two specimens of this species deposited in SAP confirmed its characteristic leaf-like branchlets: 1) collected at Duxbury Reef, Marin County, California on April 22, 1916 by N.L. GARDNER (No. 3291) and determined by E.Y. DAWSON (SAP 040914) and 2) collected at Tomales Bay, Marin County, California in August 1916 by N.L. GARDNER (No. 3443) and determined by P.C. SILVA (SAP 046617). OKAMURA's voucher specimens cited in Table 1 have no such leaf-like branchlets. OKAMURA (1909, 1936) emphasized

the occurrence of pinnate serrations on involucral bracts of his specimens. However, *P. filicina* often has pinnately serrated involucral bracts, as reported by PERESTENKO (1980). *Ptilota californica* sensu OKAMURA (1909, 1936) is identical with *P. filicina*.

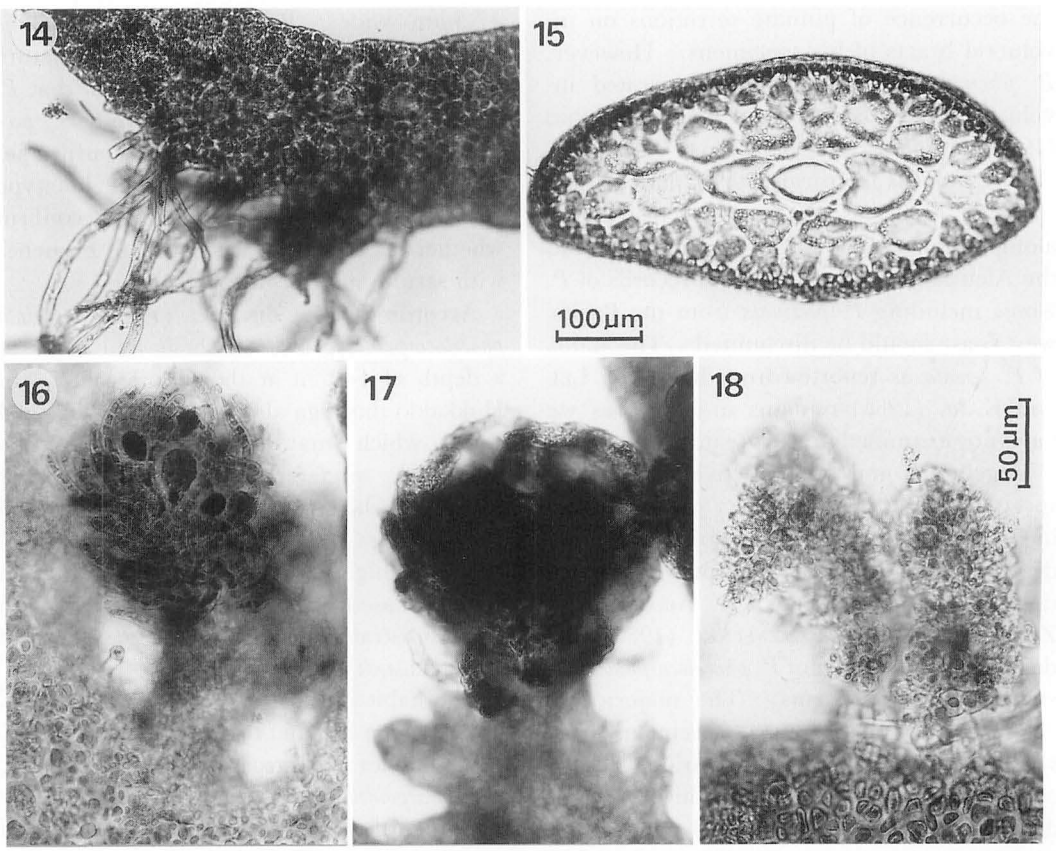
Ptilota filicina is thus widely distributed along both coasts of North Pacific Ocean and the Aleutian Islands. Previous records of *P. serrata* including *P. pectinata* from the Pacific west coast should be discounted. The status of *P. serrata* as reported from Korea by LEE and KANG (1986) remains uncertain as we have not examined any Korean specimens.

Vegetative and reproductive features of specimens identified as *Ptilota phacelocarpoides* in Table 1 agree with those of the original description (ZINOVA 1972) except for the serration of determinate branches. According to ZINOVA (1972) and PERESTENKO (1980), the determinate branches of *P. phacelocarpoides* are smooth at the margins. The majority of determinate branches in the specimens of *P. phacelocarpoides* collected at various localities in Hokkaido is smooth, but a few of them are serrate on the abaxial margin. A tetrasporangial specimen collected at Sobol Bay in Peter the Great Bay (SAP 032408) has no serration, but it is a small fragment 2 cm in length. PERESTENKO (1980) reported the presence of serrations on involucral bracts of her specimens from the type locality. This strongly suggests the possibility that *P. phacelocarpoides* has determinate branches with minute serrations on some margins. Fertile plants collected from Hokkaido bear adaxial serrations on which reproductive structures are produced. This feature has also been reported by ZINOVA (1972) and PERESTENKO (1980). Another discrepancy that requires consideration is the size of tetrasporangia. The size of tetrasporangia given by PERESTENKO (1980) on the basis of material from the Peter the Great Bay is 22–28 μm in diameter. The tetrasporangia of our Hokkaido plants are 42.5–67.5 μm long × 40.0–57.5 μm wide and those of a specimen collected at Sobol Bay (SAP 032408) are 50.0–62.5 μm long × 37.5–47.5 μm wide. PERESTENKO's dimensions may, however, be based on immature tetrasporangia. At present we think that *P. phacelocarpoides* and the alga known as *P. pectinata* f. *litoralis* in Japan are conspecific, although a re-examination of the holotype specimen is necessary in order to confirm whether or not a few determinate branches with serrate margins are present.

According to ZINOVA (1972), *Ptilota phacelocarpoides* grows on shells and rocks at a depth of 4–26 m at the type locality. In Hokkaido this alga also grows in the subtidal zone, which may be indicative of the ecological preference of this species. Although OKAMURA (1909, 1936) reported that this alga (as *P. pectinata* f. *litoralis*) grew near the high tidemark. His observation may be based on specimens entangled with some substrata after drifting or may depend on KJELLMAN (1883).

The habit illustration of *Ptilota pectinata* f. *litoralis* given by KJELLMAN (1883, Pl. 5, Fig. 2) resembles the gross morphology of *P. phacelocarpoides*. OKAMURA (1909) may have identified his specimens on the basis of this similarlity. This similarity is, however, superficial; KJELLMAN (1883) mentioned that his f. *litoralis* differed from the typical *P. pectinata* in the inner thallus structure: the axial cells of the former were not surrounded with a complete circle of large, paler-colored cells, whereas those of the latter were surrounded completely with such a circle. Our specimens have a inner structure similar to KJELLMAN's typical *P. pectinata* (=*P. serrata*) (Fig. 15). As the taxonomic significance of this difference is uncertain at present and no other critical features are available, it cannot be determined whether *P. pectinata* f. *litoralis* is a growth form (ecad) of *P. serrata* or an independent taxon.

The geographical distribution of *Ptilota phacelocarpoides* is limited to Hokkaido and northern Honshu in Japan and Primorskiy in the USSR. As an adequate description of this alga as found in Japan is unavailable, a description is given below based on specimens collected from Hokkaido.



Figs. 14–18. *Ptilota phacelocarpoides* collected at Oshoro Bay on September 18, 1989 (Figs. 14, 15) and on October 17, 1988 (Figs. 16–18). Fig. 14. Adventitious rhizoids from the surface cells. Fig. 15. Cross section of a main axis. Fig. 16. Tetrasporangial cluster on a short branch. Fig. 17. Cystocarp enveloped with well-developed involucral bracts. Fig. 18. Spermatangial clusters on the adaxial side of a determinate branchlet. Scale in Fig. 15 applies also to Figs. 14, 16 & 17.

Ptilota phacelocarpoides A. ZINOVA

Thalli decumbent, attached to substratum by basal rhizoids and adventitious rhizoids arising from surface cells of the thalli (Fig. 14), 3–10 cm long, dark red in color, pinnately branched in a single plane; primary axis forming a pair of lateral opposite branches, one with determinate growth, becoming cuneate, leaflet-like branchlets with or without abaxial serrations and the other with indeterminate growth, becoming pinnate branches (Fig. 12), some of which growing well in a manner similar to that of the primary axis and so the axis becoming obscured, sometimes both of an opposite pair growing indetermiantely and even pinnate branches ceasing growth at early stages, becoming determinate branchlets (Fig. 13); these axis and well-developed branches flattened, 600–1400 μm wide × 240–350 μm thick; tetrasporangial cluster cone-like in shape, on the apices of short branches (Fig. 16) and on the adaxial side of determinate branches, sometimes on the apices of indeterminate branches; tetrasporangia terminal on uniseriate filaments, provided with lots of sterile, uniseriate filaments, 42.5–67.5 μm long, 40.0–57.5 μm wide, spores tetrahedrally arranged; cystocarps on the apices of short branches replacing indeterminate branches and on minute branchlets borne on the adaxial side of determinate branches, globular, enveloped by involucral bracts (Fig. 17) sometimes with serrated margins; spermatangia in irregular clusters on

special branchlets borne on short branches and on the serrations of determinate branches (Fig. 18).

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増田道夫・佐々木真人：日本産紅藻クシベニヒバ属（イギス目）について

日本産のクシベニヒバとコバノクシベニヒバを，外国産の種と比較した結果，前者は *Ptilota filicina* J. AGARDH，後者は *P. phacelocarpoides* A. ZINOVA に該当することが明らかになった。また，カシワバベニヒバ *Ptilota californica* (＝*Neoptilota californica*) sensu OKAMURA は該種とは異なり，クシベニヒバと同一種であることが判明した。世界に産するこの属全4種の分類学的に重要な特徴について，1）主軸上の第一位枝の成長様式，2）小葉状の有限成長枝の鋸歯の有無，3）藻体が直立するか傾伏するか，及び4）四分胞子嚢群の形が種のレベルで意義のある形質であることを示した。コバノクシベニヒバについては北海道産の標本に基づいて記載を行なった。(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)

Jpn. J. Phycol. (Sôrui) 38: 355–364, December 10, 1990

Effect of vinblastin and cytochalasin B on cell division in *Oedogonium capilliforme*

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Nakagawa, M., Noguchi, T. and UEDA, K. 1990. Effect of vinblastin and cytochalasin B on cell division in *Oedogonium capilliforme*. Jap. J. Phycol. 38: 355–364.

Effects of vinblastin and cytochalasin B on the progress of individual stages of cell division in *Oedogonium capilliforme* were examined by light and electron microscopy. Vinblastin at a concentration of 100 μg/m*l* strongly inhibited the progress of mitosis and the formation of the cytoplasmic septum, processes in which microtubules were involved. It also inhibited the division of chloroplasts, but it did not inhibit the opening and the stretching of the rings of cell walls. Cytochalasin B at 100 μg/m*l* did not inhibit the progress of mitosis, the formation of the cytoplasmic septum, or the division of chloroplasts, but it did inhibit the elongation of the new lateral cell wall and the fusion of vesicles that probably contain substances necessary for the synthesis of new cell walls. The involvement of microtubules and microfilaments at various stages of cell division is discussed.

Key Index Words: cell division—cytochalasin B—Oedogonium—*microfilament—microtubule—vinblastin.*

Cell division in *Oedogonium*, a green alga, provides an unusual example of the formation of a new cell wall. A wall-ring appears at the top of the cell before mitosis, and it splits circularly and is pulled longitudinally to form the new cell wall after mitosis. Accordingly, many reports have been published on details of nuclear and cell division in this interesting alga in the past one hundred years (KLEBAHN 1892, VAN WISSELINGH 1908, UEDA 1960). Electron microscopic observations by PICKETT-HEAPS and FOWKE (1969, 1970 a, b) revealed the ultrastructural details of the formation and splitting of the cell-wall ring, of the process of mitosis, and of the formation of the septum.

The cell division in *Oedogonium* occurs as an integrated sequence of individual phenomena: ring formation, mitosis, septum formation, ring splitting, chloroplast division, and new wall formation. Movements associated with the individual phenomena should be driven by specific forces. In general, various cellular movements are driven by either microtubules or microfilaments, or by a combination of both. No reports have been published that have concentrated on the nature of the driving forces of the phenomena and movements that occur during cell division in *Oedogonium*.

We have examined the effects of vinblastin and of cytochalasin B upon various phenomena during cell division in *Oedogonium*. Vinblastin destroys microtubules and cytochalasin B destroys microfilaments. The driving forces involved in cell division are discussed with reference to our results.

Materials and Methods

Oedogonium capilliforme was cultured in ICHIMURA's C medium (1971) with a daily cycle of 13 hours of illumination under fluorescent light (2,000 lux) and 11 hours of darkness, at 20°C. Cells in division were transferred into media that contained vinblastin or cytochalasin B and were examined under a light microscope equipped with Nomarsky apparatus at hourly intervals after transfer. Vinblastin was dissolved in the culture medium at a concentration of 100 μg/m*l*. Cytochalasin B was first dissolv-

ed in dimethyl sulfoxide (2 mg/100 μl), and then diluted to 200, 100, or 50 μg/ml with 20 mM Hepes buffer (pH 7.4) that contained 20 mM KCl, and 0.1 mM $CaCl_2$. Cellulose was detected by fluorescence microscopy (Olympus, Tokyo, Japan; type BH2 RFA, with a violet exciter filter) in cells mounted in an aqueous solution of 25 μg/ml fluostain-1 (Dojin Chem.).

For electron microscopy, cells were fixed for 3 hours with 4% glutaraldehyde dissolved in phosphate buffer (pH 7.4) at room temperature. They were washed with water and postfixed for 12 hours with 1% osmium tetroxide at 4°C. After washing with water, cells were treated with 0.7% uranyl acetate, dehydrated with acetone, and embedded in SPURR's resin. Ultrathin sections were stained with lead citrate and examined with a Hitachi H700-S transmission electron microscope.

Results

1. *The process of cell division*

The first visible sign that indicated the start of cell division was the formation of the cell-wall ring at the top of the cell (Fig. 1A). The nucleus then divided into two (Fig. 1B). A thin sheet of cytoplasm appeared between the closely situated daughter nuclei (Fig. 1C), and this sheet developed until it traversed the centrally located large vacuole, finally dividing the cell into two (Fig. 1D). This cytoplasmic septum developed later into the lateral cell wall. After the daughter nuclei had moved apart from each other, chloroplasts (dotted regions in Fig. 1) divided around the septum (Fig. 1E). At the same time, the wall ring splitted circularly and was pulled longitudinally (Fig. 1F). Ring substances turned into new cell-wall substances which covered the plasma membrane previously located inside the ring. The new cell wall stretched to the same length as the average length of a cell. During the stretching of the new cell wall, the position of the septum shifted to the boundary between the old and the new cell walls. Chloroplasts

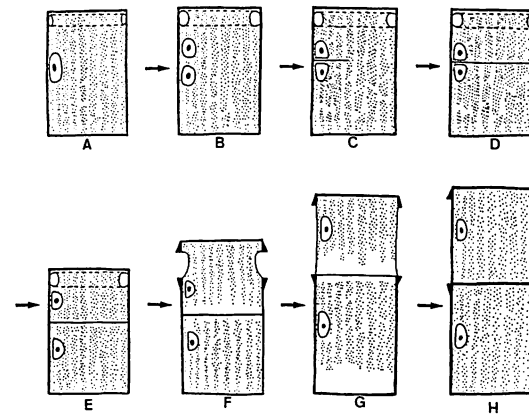


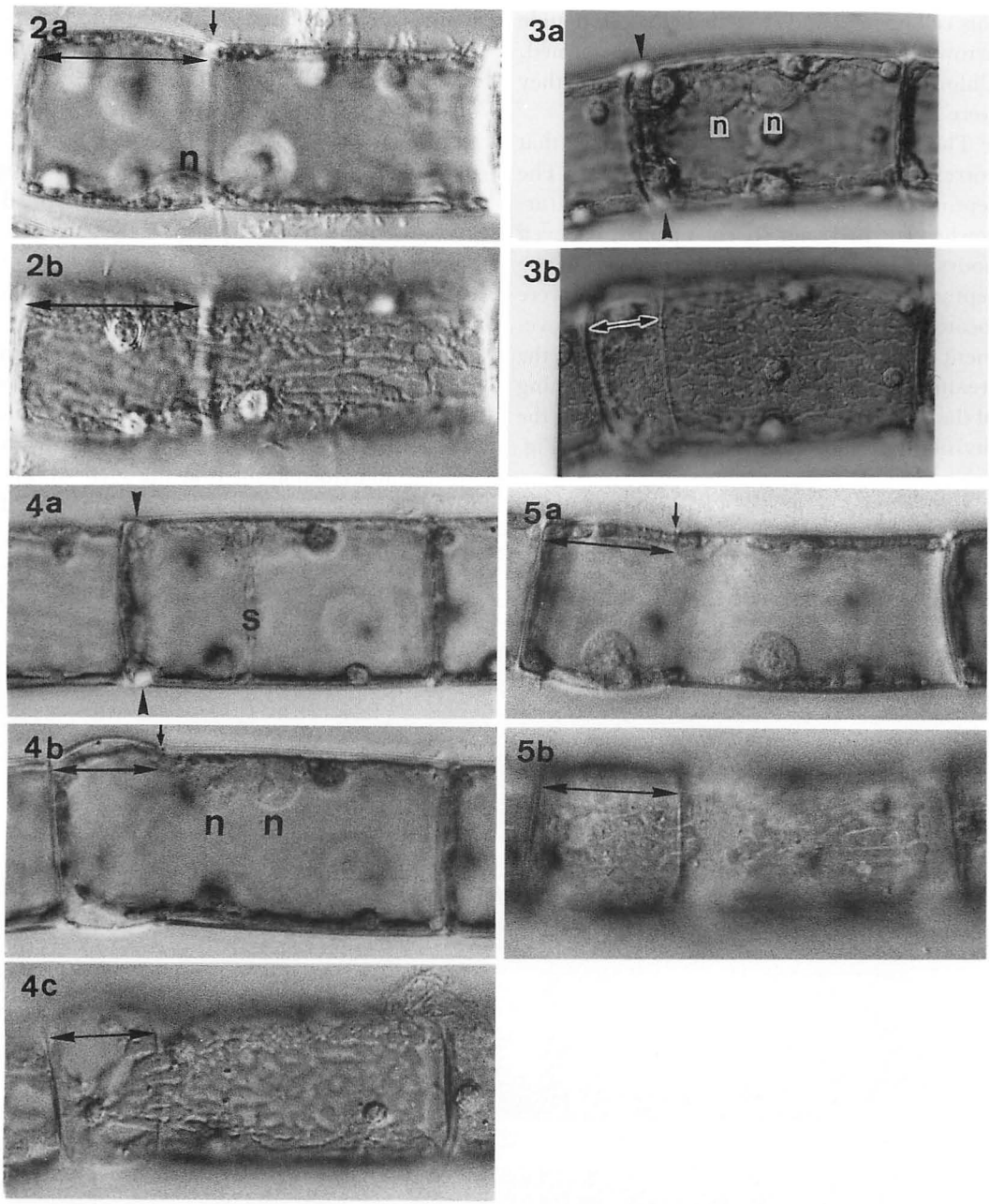
Fig. 1. Progress of cell division. A: Formation of the cell-wall ring before mitosis. B: Formation of two daughter nuclei after mitosis. C: Beginning of formation of the cytoplasmic septum. D: Completion of the cytoplasmic septum. E: Division of chloroplasts. F: Opening of the ring. G: stretching of the new cell wall. H: Completion of the daughter cells.

which were located in the region covered by the old cell wall also shifted slightly towards the new cell, so that a chloroplast-free region appeared at the bottom of the old cell (Fig. 1G). Later, the new cell wall thickened, the chloroplasts in both cells increased in size, and the chloroplast-free region disappeared (Fig. 1H).

Among these successive stages of cell division, the stages at which the division of chloroplasts and the movement of chloroplasts occur (Fig. 1E-G) are described for the first time here.

2. *Effects of vinblastin on cell division*

When cells at an early stage of cell division, corresponding to Figure 1A, were treated with 100 μg/ml vinblastin, the cell-wall rings opened and stretched as usual but nuclear division was inhibited (Fig. 2). No septum was formed and no division of chloroplasts occurred. The left portion of the cell in Figure 2 (indicated by a double arrow) was formed by the opening and the stretching of the ring during the treatment with vinblastin for 10 hours. A central vacuole and a nucleus were visible. The boundary between the new and the old cell walls was so strongly enhanced, as shown in Figure 2a (small arrow), as to suggest the misinterpretation that this cell had been



Figs. 2–5. Cells treated with 100 μg/m*l* vinblastin. ×830.

Fig. 2. A cell treated for 10 hours from a stage before mitosis. a: center view. b: surface view. Fig. 3. A cell treated at the end of mitosis. a: immediately after treatment. b: 7 hours after treatment. Fig. 4. A cell treated after completion of the cytoplasmic septum. a: immediate after treatment. b and c: 7 hours after treatment; center and surface view, respectively. Fig. 5. A cell treated for 7 hours after division of chloroplasts. a: center view. b: surface view. n: nuclei. s: septa. double arrows: regions of new cell wall. arrowheads: rings. small arrows: boundaries between the old and the new cell wall.

divided by a septum.

The cell shown in Figure 3a had just finished nuclear division and two daughter nuclei (n) had been formed. The wall ring (arrowheads) had not opened. After treatment with vinblastin for 7 hours, the wall ring of

this cell opened and stretched (Fig. 3b double arrow) but no septum was formed. Chloroplasts remained undivided as they were at the beginning of the treatment.

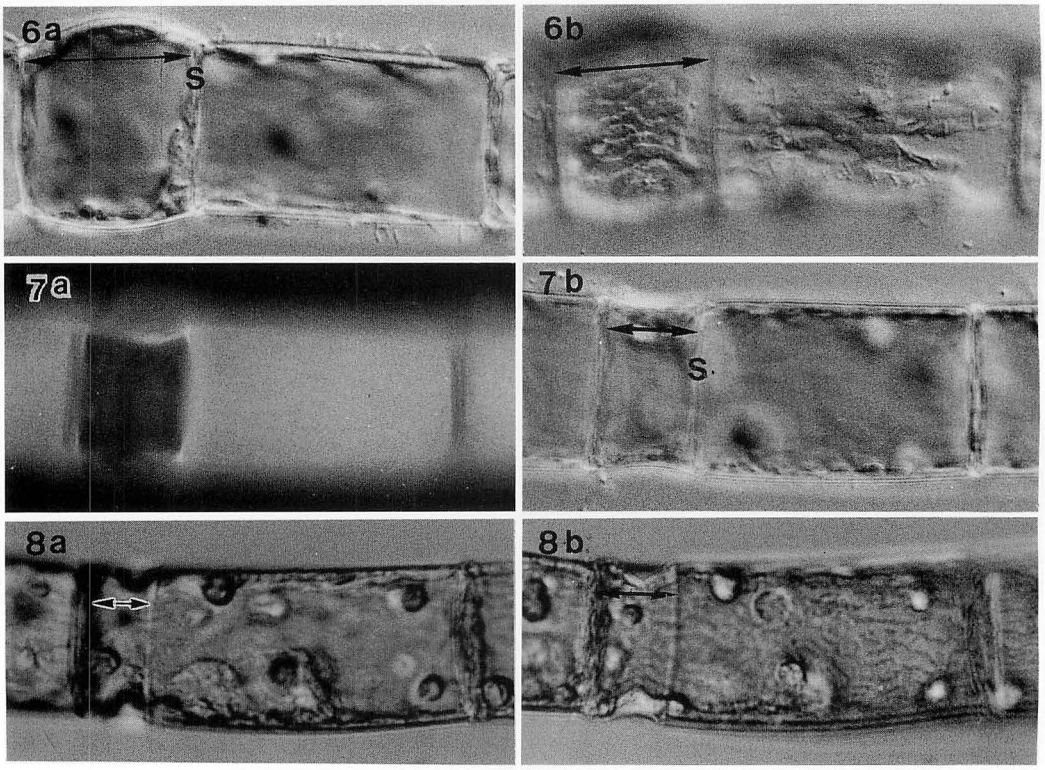
The cell in Figure 4a was at the stage that corresponded to the cell in Figure 1D. The septum (s) had been formed, but the ring (arrowheads) had not been opened. Seven hours of treatment caused breakdown of the septum (Fig. 4b). Two daughter nuclei were located close to each other without any movement from their initial site at the start of the treatment. The opening and the stretching of the ring was evident (double arrow) but the division of chloroplasts did not occur (Fig. 4c).

When cells at a stage equivalent to that shown in Figure 1E, where chloroplasts had divided and the daughter nuclei had moved apart, were treated with vinblastin for 7 hours, the ring opened, the septum disappeared and the chloroplast-free region at the middle of the cell did not decrease as a result of the stopping of a volume-increase of the chloroplasts (Fig. 5).

3. Effects of cytochalasin B on cell division

The treatment of cells with cytochalasin B at a concentration of 50 μg/m*l* had a relatively small effect on cell division. The division of the nucleus advanced normally, the septum was formed, and the chloroplasts divided. However, the rate of stretching of the opened ring decreased to about half of that in untreated cells.

The cell in Figure 6 was treated with 100 μg/m*l* cytochalasin B at the stage of septum formation. In this cell, the formation of the septum was completed (Fig. 6a, s), the ring opened, and the new cell wall was stretched (double arrow). Chloroplasts divided and



Figs. 6–7. Cells treated with 100 μg/m*l* cytochalasin B for 8 hours. ×830.

Fig. 6. A cell in which treatment started during septum formation. a: center view. b: surface view. Fig. 7. A cell treated from mitotic metaphase onwards. a: observed with a fluorescence microscope after staining with fluostain-1. b: center view. Fig. 8. A cell treated with 200 μg/m*l* cytochalasin B from mitotic metaphase onwards. ×830. a: center view. b: surface view. s: septa. double arrows: regions of new cell wall.

the septum migrated to the boundary between the old and the new cell walls (Fig. 6b). The new wall of daughter cells (left-side cell in Fig. 6) that had developed in cytochalasin B frequently had a convex curvature. Cells with such walls tended to rupture later. Concave new walls were formed when cells were treated with cytochalasin B before septum formation (Fig. 7). Figure 7a is a fluorescence micrograph of a cell treated with 100 μg/m*l* cytochalasin B, from the stage of mitotic metaphase, for 8 hours and then stained with fluostain-1. Old cell walls radiated fluorescence, while new walls did not radiate fluorescence. This difference suggests that synthesis of the cell wall is inhibited by cytochalasin B. The septum was formed and the chloroplasts divided in the cell (Fig. 7b).

Treatment with 200 μg/m*l* cytochalasin B strongly inhibited the progress of cell division at almost all stages; division of the nucleus, septum formation, and wall stretching ceased within 10 minutes. Only the opening of the ring was not inhibited. The cell in Figure 8 had been treated with 200 μg/m*l* cytochalasin B for 8 hours at a mitotic stage. The ring of this cell was opened but stretched to a lesser extent than normal (double arrows).

4. Ultrastructure of dividing cells

Since PICKETT-HEAPS and FOWKE (1969, 1970a, b) have clarified details of the ultrastructure of the mitotic process and of the opening of the ring, descriptions are restricted here to the processes of formation of the septum and the cell wall which were affected by treatment with vinblastin and cytochalasin B.

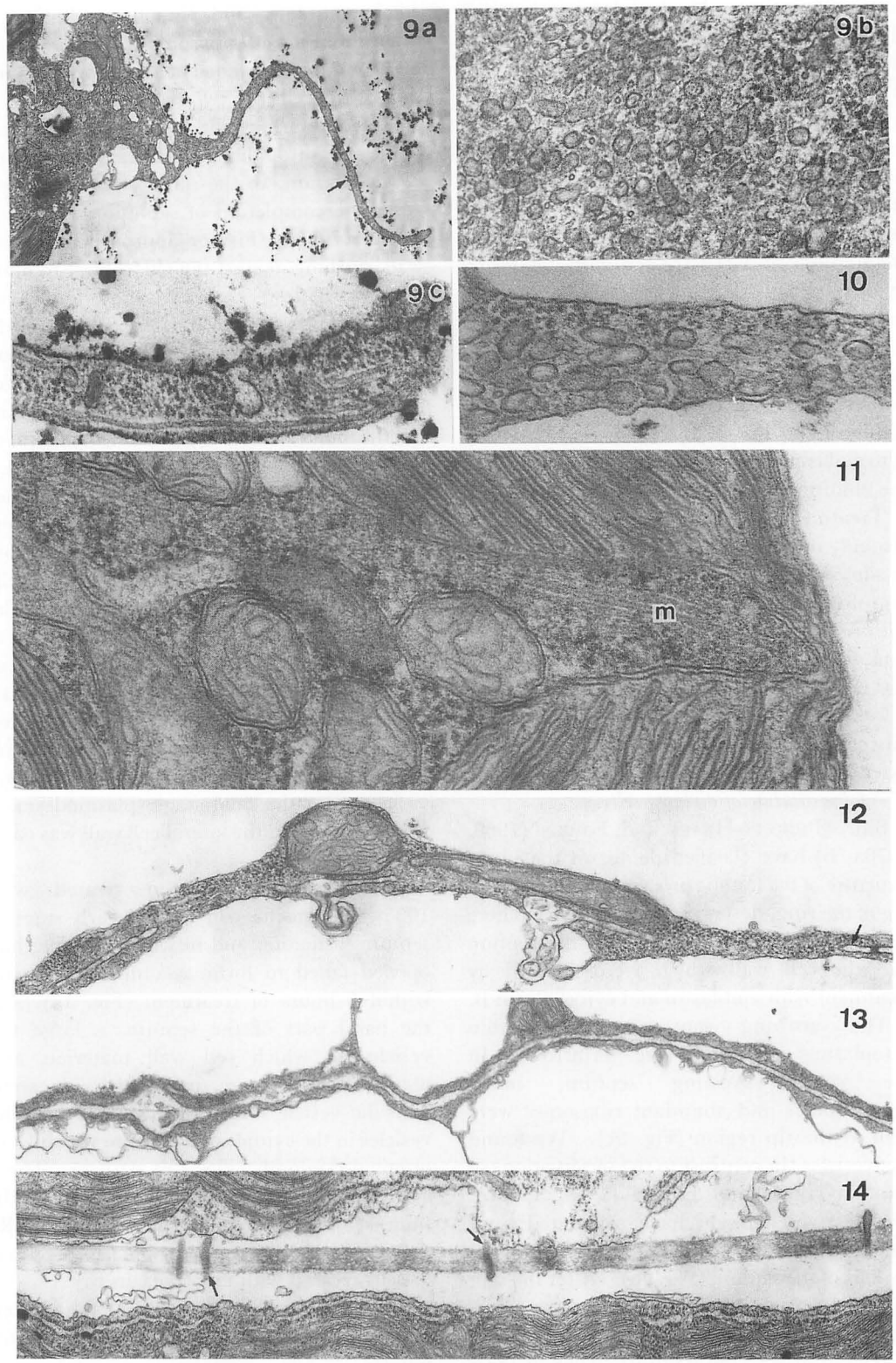
The growing septum was a thin cytoplasmic membrane (Fig. 9a arrow). In the young growing septum, many microtubules and abundant ribosomes were seen at the tip region (Fig. 9c). We found few vesicles, in contrast to the observations of PICKETT-HEAPS and FOWKE (1969, 1970b). Vesicles which might have originated from dictyosomes were distributed at the basal regions of the septum (Fig. 9b). After the septum had covered more than half of the cross-sectional area of the cell, these vesicles became visible in the septum. They increased in number, and they, in addition to microtubules and ribosomes, occupied most of the septum which had completed the separation of the cell into two parts (Fig. 10).

Microtubules extended from the periphery of the cell, through a region near to the center of the septum, to the other side of the cell. After the completion of septation, terminals of microtubules further approached the cell wall, pushing against the chloroplast to make narrow cavities. Figure 11 shows the cavity of a chloroplast, which is so deep that the envelope on one side of the chloroplast almost reaches the envelope on the other side which is in contact with the cell wall. Many microtubules, which are parallel to the plane of the cavity, are evident in Figure 11 (m).

Vesicles in the septum began to fuse to each other to make flat sheets (Fig. 12). These sheets extended their surface area by continuous fusion with vesicles and finally became a flat sheet that divided the septum into two (Fig. 13). Fusion of vesicles started at the periphery of the cell and advanced towards the center of the septum. The lumen of the flat sheet was transparent at the earlier stages of its formation, and later, gradually increased in electron density by taking up vesicles. At the final stage, plasmodesmata were formed and the lateral cell wall was completed (Fig. 14).

Cells which had been treated with 100 μg/m*l* cytochalasin B at an early stage of septum formation and in which the ring had opened failed to form a complete cell wall within 8 hours of treatment (Fig. 15). At the basal part of the septum, a large flat vesicle, in which cell wall materials and plasmodesmata were included, was seen. This flat vesicle was not continuous with the vesicles in the cytoplasmic septum which were oriented randomly (Fig. 15b arrows). These vesicles probably contained cell wall substances. There were many mitochondria, ER, and small vacuoles in the cytoplasmic septum of cells treated with cytochalasin B.

Figure 16 shows part of a cell that had been treated with cytochalasin B for 8 hours after mitosis. The stretching of the new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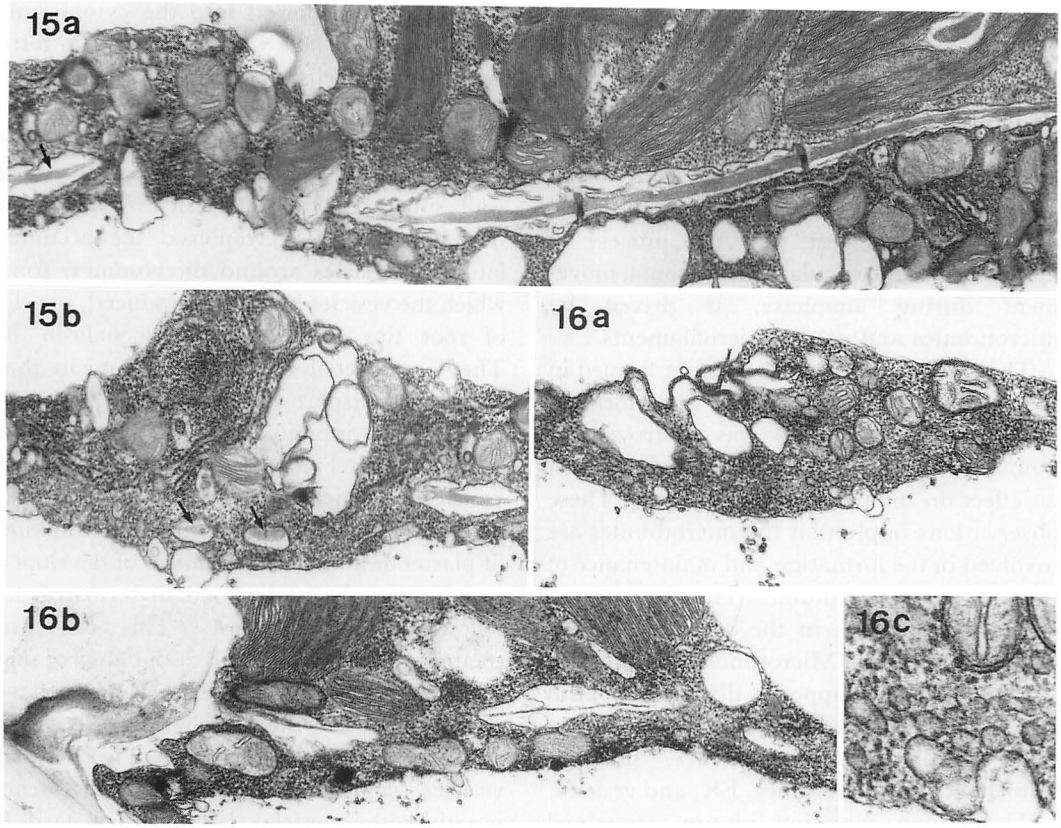

Fig. 15. A cell treated with cytochalasin B for 8 hours from an early stage of septum formation. a: basal part of the septum. ×16,000. b: central part of the septum. ×16,000.

Fig. 16. A cell treated with cytochalasin B for 8 hours from mitosis. a: central part of the septum. ×16,000. b: basal part of the septum. ×16,000. c: Portion of Fig. 16a is enlarged. ×53,000.

longitudinal cell wall in this cell did not extend as far as that of the cell in Figure 15. The central part and the basal part of the cytoplasmic septum are shown in Figure 16a and b, respectively. In the basal region, vesicles contained few wall substances, and in the middle region no such vesicles were seen. These observations indicate that the cell in Figure 16 was less actively involved in the formation of lateral cell wall than was the cell in Figure 15. In both cells, small vesicles, as shown in Figures 9b and 10, were seen in the cytoplasmic septum (Fig. 16c).

Discussion

The progress of mitosis in *Oedogonium* was sharply interrupted by vinblastin. This result is in complete accord with many reports of the inhibitory effect of anti-tubulin drugs on the progress of mitosis (Dustin 1984). By contrast, cytochalasin B at a concentration of less than 100 μg/m*l* did not inhibit the progress of mitosis. Similar results have been

Figs. 9–14. Portions of untreated cells.

Fig. 9. Beginning of the formation of the cytoplasmic septum. a: at low magnification. ×6,000. b: vesicles at the basal region of the septum. ×45,000. c: microtubules and ribosomes at the tip of the septum. ×45,000. Fig. 10. Vesicles in the completed septum. ×68,000. Fig. 11. Microtubules that terminate in a concavity of the chloroplast. ×60,000. Fig. 12. Flat vesicles in the septum. ×24,000. Fig. 13. Separation of two cells by a flat sheet. ×24,000. Fig. 14. Young lateral wall with plasmodesmata (arrows). ×19,000. m: microtubules.

reported in *Cyanidium* by MITA and KUROIWA (1988), who found that mitosis proceeded in the presence of 20 μg/m*l* cytochalasin B. GOTO and UEDA (1988) could not detect microfilaments in the mitotic spindle in *Spirogyra* by fluorescence microscopy using cells stained with rhodamine-phalloidin. All these results suggest that the process of mitosis, and in particular chromosomal movement during anaphase, is driven by microtubules and not by microfilaments.

The cytoplasmic septum was not formed in the presence of vinblastin and, when formed, the cytoplasmic septum was destroyed by vinblastin. Cytochalasin B did not have such an effect on the cytoplasmic septum. These observations imply that the microtubules are involved in the formation and maintenance of the cytoplasmic septum. The presence of many microtubules in the septum supports this hypothesis. Microtubules should be strong enough to support a disk of cytoplasm 30 μm in diameter and 0.3 μm in thickness that contains many organelles, such as mitochondria, dictyosomes, ER, and vesicles.

The young, growing septum contained mainly microtubules and ribosomes, and the vesicles were transported into the growing septum at later stages. Thus, the transport system of vesicles need not be formed or need not be activated at the early stages of septum formation. Two types of transport systems for vesicles are known, operated by microtubules and by microfilaments (FRANKE *et al.* 1972, Nagai and HAYAMA 1979, DUSTIN 1984, SCHLIWA 1985). The presence of vesicles in the septum that has developed in the presence of cytochalasin B may indicate that the microfilaments are not involved in vesicle transport in the septum of *Oedogonium*. Microtubules are probably deeply involved in the migration of these vesicles. The septum, therefore, grows at early stages by the lateral growth of microtubules accompanied by the ground cytoplasm and ribosomes, and grows at later stages by the accumulation of various components of the cytoplasm many of which are transported by a microtubular system after its activation.

Vesicles transported into the cytoplasmic septum did not fuse with each other to form flat sheets in cells treated with cytochalasin B. Cytochalasin B seems to inhibit the fusion of vesicles. The inhibition of fusion of vesicles may also prevent the supply of cell wall substances to flat vesicles. MOLLENHAUER *et al.* (1976) reported the accumulation of vesicles around dictyosomes, from which the vesicles had been produced, in cells of root tips treated with cytochalasin B. They interpreted their result to mean that both the transport system and the fusion of vesicles were inhibited in this case.

The cell in Figure 15a had a large fused vesicle in which wall substances had accumulated at high levels, with the formation of plasmodesmata. This image of developed vesicles may be understood in terms of the following considerations. This cell was treated with cytochalasin B at the stage of septum development, and vesicles would have partially fused at the periphery of the cell at the moment of treatment. These fused vesicles could develop somewhat, incorporating other vesicles, before cytochalasin B reached them and inhibited completely the fusion of vesicles.

Chloroplasts in *Oedogonium* were divided at the basal part of the septum. Recently, the involvement of microfilaments in the division of chloroplasts has been described (MITA and KUROIWA 1988, OROSS and POSSINGHAM 1989). MITA and KUROIWA reported that the division of chloroplasts in *Cyanidium* is inhibited by cytochalasin B but not by antitubulin drugs and they suggested that F-actin is deeply involved in the division of chloroplasts. By contrast, the division of chloroplasts in *Oedogonium* was inhibited by vinblastin and not by cytochalasin B. The difference in behavior between the chloroplasts of two species may derive from differences in the mode of division of the two types of chloroplast. In *Cyanidium*, chloroplasts are divided at their middles by furrowing, while in *Oedogonium* they are so strongly compressed by microtubules towards the cell wall that they are probably pinched off into two

daughter chloroplasts between the microtubules and the cell wall. If the microtubules are destroyed by vinblastin, chloroplasts are not compressed by microtubules and are not divided into two.

Rings of the cell wall could be opened after inhibition of both the progress of mitosis and formation of the septum by vinblastin. The opening of rings and the subsequent elongation of the new cell wall, in spite of the inhibition of the two processes by long-term treatment with vinblastin is surprising. The opening of the rings is, therefore, assumed to be an independent phenomenon which is not affected by the destruction of microtubules.

The elongation of the new cell wall may result from the longitudinal elongation of the protoplasm. The absence of an inhibitory effect of vinblastin on the elongation and the decrease in the rate of elongation by cytochalasin B suggest that microfilaments are involved in this elongation. Microfilaments that are longitudinally oriented may be involved. If such microfilaments are elongated in such a manner as to pull the protoplasm upwards, then the new cell wall would elongate. Accompanying the pulling upward of the protoplasm, the upward shifting of the positions of the septum and the chloroplasts might occur, as shown in Figures 1F and 1G.

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中川満代・野口哲子・植田勝巳：*Oedogonium capilliforme* の細胞分裂におよぼすビンブラスチンとサイトカラシン B の影響

光学顕微鏡と電子顕微鏡を使用して *Oedogonium capilliforme* の細胞分裂に及ぼすビンブラスチンとサイトカラシン B の影響について研究を行った。ビンブラスチンは 100 μg/ml の濃度において微小管の関与する核分裂の進行及び細胞質性隔壁の形成を阻害した。また，葉緑体分裂も阻害するが，細胞壁リングの開裂と伸長は阻害しなかった。サイトカラシン B は 100 μg/ml の濃度では核分裂の進行，細胞質性隔壁の形成，葉緑体分裂などを阻害しなかったが，細胞壁形成に関与する物質を含むと考えられる小胞の融合を阻害し新しい細胞壁の伸長を阻害した。これらのデータから，微小管や微繊維と各細胞分裂期の進行との関わりについて考察がおこなわれた。(630 奈良市北魚屋西町　奈良女子大学理学部生物学教室)

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Ozone hole and its correlation with the characteristic UV-absorbing substance in marine algae

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SIVALINGAM, P. M. and NISIZAWA, K. 1990. Ozone hole and UV-absorbing substance. Jpn. J. Phycol. 38: 365–370.

Calculations have indicated that a 10 percent depletion of the stratospheric ozone layer gives an increase in UV-irradiation in the tropics and subtropics of ca. 19.0 and 10.9 percent respectively. In this connection, determination of the characteristic UV-absorbing substance in tropical marine algae was carried out in 1989 and the result was compared with that obtained from corresponding algal samples investigated in 1975. Such astonishing increases were observed in the order of 5.67–6.20 fold for Cyanophyta, 1.78–10.93 fold for Rhodophyta, 4.44–28.38 fold for Phaeophyta and 1.53–7.31 fold for Chlorophyta. This at least suggests that the substance must be produced by the algae in response to the increasing UV-radiant energy penetrating the ozone hole formed at the stratospheric ozone layer.

Key Index Words: ozone hole—tropical marine algae—UV-absorbing substance.

In 1985 the journal, British Antarctic Survey Scientist, reported a completely unexpected finding that springtime ozone levels in the atmosphere over Halley Bay (76°S 27°W), Antartica, had depleted by more than 40 percent between 1977 and 1984 (STOLARSKI, 1988), i.e. from 300 to ca. 180 Dobson Units (1 DU $=10^{-3}$atm. cm). This depletion is most significant at McMurdo Station (78°S), Antarctica, and ranges at heights between 10–17 km of the stratosphere (HOFMANN 1989). Furthermore, according to the Nimbus 7 Total Ozone Mapping Spectrometer Scan this is extending to over at 15° in latitude (MCELROY *et al.* 1986). Data from Chubachi with regard to the Syowa Station (69°S 39°E), Antarctica, over the years from 1966 until 1982 had also transpired such closely related information (SOLOMON *et al.* 1986). Similar tendencies of ozone depletion have also been observed at Thule (76.5°N), Arctic, in 1988 (MOUNT *et al.* 1988) with values ranging between 325 and 400 Dobson Units. The lower comparable effects in the Northern Hemisphere to that in the Southern Hemisphere, which is one third its size, could be attributed to the fact that the winter polar stratospheric vortex is less cold and less stable than its southern counterpart. This represents a close relationship in the generation of polar stratospheric clouds (=PSCs) which occur in the stratosphere when temperature prevail below ca. −80°C.

The causative agent for the depletion of the ozone layer is strongly proven to be in the increase of atmospheric chlorofluorocarbons (=CFCs) due to anthropogenic releases in combination with heterogeneous chemistry involving particles in the clouds (=PSCs), which form during polar nights. The odd nitrogen chain (NO, NO_2) is also believed to be intimately regulating the O_3 level in the atmosphere. Nevertheless, at stratospheric temperatures, C10 reacts with O six times faster than NO_2. Bromine is also believed to be involved in a similar related process. The increase in production and use of CH_3Br, a fumigant, and CF_3Br and CF_2ClBr, employed extensively as fire extinguishers, should also be borne in mind as one of the culprits.

Based on the foregoing, as a consequence of the increase in UV-irradiation, it is an-

ticipated that more sunburns (i.e. UV solar irradiation of 293.7 nm) and skin cancer, i.e. 8,000 new cases in the USA (WOODS 1988), of mankind will transpire as the consequence of augmenting UV-light energy amounting to nearly 6% of the total strength from the sun by the depleting ozone layer shield. Plants have been proven to be unable to photosynthesize as efficiently when exposed to UV-irradiation and as a result yield smaller amounts of seeds or fruits (WOODS 1988).

Marine life does also depend directly on the level of UV-irradiation which is deleterious in relation to their photosynthetic capacity. The limit of their tolerance for far UV solar irradiation is not yet well illustrated. It is apprehended that near UV (i.e. 300-400 nm) penetrates seawater relatively easily, whereas extreme UV (i.e. shorter than 200 nm) would not penetrate at all and far UV is intermedeiate. Organisms thriving at a depth of 5 m in clear water will receive a maximum of ca. 75% of incident surface UV-irradiation in the band from 320-400 nm, 60% at 320 nm and 50% at 300 nm. On this basis ca. half of all marine fishes, all nearshore flora and fauna (including coral reefs) and much of the biota of estuaries, lagoons and freshwater ecosystems could be at risk. As these organisms are already exposed to some UV it can be assumed they possess strategies to cope with at least this level of radiation; but whether these are enough to cope with any increase in UV radiation is another question (WOODS 1988). In this regard, an Australian researcher Bill WOOD of the University of Sydney has just initiated studies on UV penetration in Antarctic waters, measuring the effects of UV on planktonic algae which constitutes the base of the Antarctic food chain (WOODS 1988).

Notwithstanding the foregoing TSUJINO and SAITO (1961) and YABE *et al.* (1965, 1966) had reported of a characteristic UV-absorbing substance from 5 species of red algae, viz. *Neodilsea yendoana, Chondrus ocellatus, Chondrus crassicaulis, Laurencia glandifera* and *Trichocarpus crinitus*. However, these substances appeared different in some properties from the UV-absorbing substances reported by KALLE (1938), FOGG and BOALCH (1958), HANG and LARSEN (1958), CRAGGIE and MCLACHLAN (1964), YENTSCH and REICHERT (1962) and KROES (1970). SIVALINGAM *et al.* (1974 a, b, c) had indicated that the compound existed ubiquitously in all the algal groups and the level of content of the compound fluctuates with depth of their habitat in correlation to the levels of chlorophyll and phycoerythrin. OKAICHI *et al.* (1974) extracted a substance resembling this compound from 2 species of *Noctiluca* harvested from water blooms and they postulated that it is of phenolic nature.

In 1976 SIVALINGAM *et al.* (1976a, b) isolated the compound from the red alga, *Porphyra yezoensis*, and investigated its physicochemical properties. It was concluded at the time that this substance seems to play a role in the photosynthetic pathway as a metabolic regulator or a temporal energy transferring substance in the form of fluorescence energy relay SIVALINGAM *et al.* (1976a). Prior to this, SHIBATA (1969) had reported that the similar UV-absorbing substance is present in corals and a blue-green alga. Then, he had hypothetically suggested it as possibly playing the role of an UV-solar radiation biofilter similar to that of the flavonoids.

Comparative studies on the content of the UV-absorbing substance from tropical algae had been reported by SIVALINGAM *et al.* (1976c). With the advent of the ozone hole problem a study was undertaken in a similar manner to elucidate whether the increase in UV-solar irradiation penetration through the ozone layer would have exerted any effect on the content of the UV-absorbing substance so as to it acting as a biofilter in the algal body. Furthermore, we estimated the possible increase in the penetration of UV-solar irradiation at different areas the world over when depletion of the stratospheric ozone layer attained a level of 10% of the total.

Materials and methods

The increase in ultraviolet radiation at

various localities the world over was calculated based on data reported by ILYAS (1990), being due to 10 percent depletion in the ozone layer.

The algal samples employed for the comparative evaluation of the UV-absorbing substance were harvested mostly from 0.5 to 1 m in depth at Batu Ferringhi, Sungai Dua and Batu Maung shores of Penang Island, West Malaysia, in the season between February and April 1989. The ambient seawater temperature was around 28°C. After careful elimination of the microscopic epiphytes and other contaminating material, the algal thalli were homogenized in 80% ethanol in a mortar and centrifuged at 4,000 × g for 20 min. The supernatant was analyzed for the UV-absorbing substance 334, employing an automatic Beckmann ACTA 111 spectrophotometer. The precise procedure had been reported previously by SIVALINGAM *et al.* (1974a, b, c, 1976b). Two grams of thalli of each algal species in triplicates were employed in the investigations. The results thus obtained were compared with those reported from the same area by SIVALINGAM *et al.* (1976c).

Results

Table 1 indicates the percentage increase in UV-radiation intensity the world over, using the value of 10% depletion in stratospheric ozone layer. Evidently, areas in the tropics, viz. Kuala Lumpur and Brazil, are the most extremely exposed to UV-radiation in the region of ca. 19% followed by those in the subtropics, viz. Adelaide and Washington D.C., to the tune of 11.3% while lowest in the regions closest to the Northern Hemisphere, viz. London and Oslo, to the tune of 10.9%.

In relation to such fluctuation in UV-radiation exposure at the various regions of the world concomitantly with the recent advent of the ozone hole in both polar regions, Table 2 illustrates the increment in content of the characteristic UV-absorbing substance in tropical marine algae currently as compared to those values evaluated in 1975 in the same species collected from nearly the same habitats in the same months.

Table 1. Calculated percentage increase in UV-radiation intensity in various areas the world over with 10% depletion of stratospheric ozone layer.

Areas/Towns	% Increase in UV-radiation
London	10.9
Oslo	10.9
Washington D.C.	11.3
Adelaide	11.5
Brazil	18.8
Kuala Lumpur (Malaysia)	19.0

It is evident that increments in content of the UV-absorbing substance are astonishing, ranging from 5.67–6.20 fold for Cyanophyta, 1.08–10.93 fold for Rhodophyta, 2.10–28.38 fold for Phaeophyta and 1.53–7.31 fold for Chlorophyta. Out of the 19 species of tropical algae investigated, it is obvious that *Padina* sp., the intermediate tidal level zone species, in the Phaeophyta has the highest increment in content, i.e. 28.38 fold, followed by *Acanthophora specifera* and *Jania* sp., i.e. 10.93 and 6.40 fold respectively, in the Rhodophyta and *Lyngbya* sp., i.e. 6.20 fold, in the Cyanophyta.

Discussion

The current results on the investigation of the levels of the UV-absorbing substance in tropical marine algae at present as compared to those evaluated in 1975 are substantially significant, whereby it is apprehensible that the increase is in the range of 5.67–6.20 fold for Cyanophyta, 1.78–10.93 for Rhodophyta, 4.44–28.38 for Phaeophyta and 1.53–7.31 for Chlorophyta.

Regarding this UV-absorbing substance, it had been proposed on the basis of precise experiments (SIVALINGAM *et al.* 1976c) that the substance interacts physiologically in the photosynthetic pathway as the possible metabolic regulator or temporal energy transfer in the form of fluorescence energy relay. Similarly, it had also been proposed by the same authors (1976a) that the

Table 2. Increment in content of the UV-absorbing substance in tropical marine algae as compared to those measured during 1975.

Algal species	UV-absorption maxima (nm)	OD Subst./100 mg wet weight thalli		OD increase in percentage
		1975	1989	
Cyanophyta				
Species growing at HTL*				
Lyngbya sp.	330	0.98	6.08	620
Oscillatoria sp.	330	1.08	6.12	567
Rhodophyta				
Species growing at HTL				
Gracilaria sp.	329	0.81	3.69	456
Species growing at ITL**				
Jania sp.	331	0.30	1.92	640
Acanthophora specifera	325	0.44	4.81	1093
Gracilaria sp.	323	1.20	3.17	264
Laurencia sp. 1	325–330	0.20	1.45	725
Laurencia sp. 2	333	0.36	2.11	586
Gelidiopsis sp.	316	2.82	5.01	178
Gracilaria sp.	331	1.98	2.14	108
Species growing at LTL***				
Laurencia sp. 2	328	0.18	0.97	539
Phaeophyta				
Species growing at HTL				
Chnospore minima	331	0.92	4.08	444
Species growing at ITL				
Dictyota bartayresii	331	0.54	4.83	894
Sargassum sp.	325	0.25	1.32	528
Sphaceria furcigera	321	0.90	1.89	210
Padina sp.	316	0.28	7.94	2838
Chlorophyta				
Species growing at HTL				
Enteromorpha flexuosa	332	0.42	0.64	153
Species growing at ITL				
Valoniopsis pachynema	331	0.22	0.89	405
Cladophora sp.	330	0.13	0.95	731

* HTL, High Tidal Level; ** ITL, Intermediate Tidal Level; *** LTL, Low Tidal Level.

substance further interacts in the algal photosynthetic pathway at PS I having the potentiality of reducing site specifically NADP. Indirectly, SHIBATA (1969) had hypothetically suggested that the substance might possibly be playing the role of also an UV-solar radiation biofilter similar to those of the flavonoid pigments based on his findings of its existence in corals and a blue-green alga in waters of the Great Barrier Reef. It may, therefore, be evident that the algal UV-absorbing substance plays a regulatory role for radiant energy in photosynthesis. Such drastic increase in this physiologically important substance of tropical marine algae may be none other than the reflection of enhancing UV-irradiation in the marine environment.

Lately TEVINI (1990), WELLMANN (1990) and CALDWELL (1990) have indicated the existence of new protective pigments in terresterial plants against increased UV-β radiation other than the flavonoids. Such

pigments have also been indicated to be lesser in content in conifer plants found in higher latitudes as compared to those in the tropics and subtropics. Under this context, thus, it should be brought into focus that in order to protect against the gradual expansion of the ozone hole in the stratospheric ozone layer culminating in the increase in penetration of UV-radiation into marine organisms a combat mechanism of biofilter has been generated in marine algae similar to terrestrial plants. This is verified by the tremendous increase in levels of the UV-absorbing substance in marine tropical algae over the span of the last 14 years.

It is concluded that the characteristic UV-absorbing substance in marine algae besides playing the roles of energy transfer and fluorescence energy relay in the photosynthetic pathway functions additionally as a biofilter of solar UV-β radiation. At this juncture, it is extremely pertinent to state that there is an imperative need in the near future to delve on the biosynthetic pathway culminating in the formation of such a biochemical mechanism and the genetic codes leading to a phenomenon of this nature. It should also be borne in mind that this is eventually the first report clarifying the prevalence of a UV-β radiation biofilter substance in marine algae eliminating the counter argument of such rays being detrimental adversely to the primary productivity of the oceans.

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P. M. SIVALINGAM*・西澤一俊**：オゾンホールと海藻の紫外部吸光物質との相関

成層圏のオゾン層が10%減少すると，熱帯では19.0%，亜熱帯では10.9%紫外線が増加することが示された。このことと関連して，1989年に熱帯域の海藻の紫外部吸光物質を定量し，その結果を1975年に同海域の海藻で得られている値と比較した。海藻の紫外部吸光物質は，藍藻では5.67–6.20倍に，紅藻では1.78–10.93倍に，褐藻では4.44–28.38倍に，緑藻では1.53–7.31倍に増加していることが明らかとなった。このことは，少なくとも，この物質が成層圏オゾン層にできたオゾンホールを通して透入してくる紫外線の増加に反応して海藻によって生産されていることを示唆するものである。(*School of Biological Sciences, The University of Sciences Malaysia, Minden, 11800 Penang, Malaysia; **154 東京都世田谷区下馬3-34-1　日本大学農獣医学部水産学科)

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Porphyra fallax, a new species of Rhodophyta from British Columbia and northern Washington*

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Lindstrom, S.C. and COLE, K.M. 1990. *Porphyra fallax*, a new species of Rhodophyta from British Columbia and northern Washington. Jpn. J. Phycol. 38: 371–376.

Porphyra fallax sp. nov. is described from British Columbia and northern Washington. This species, like *Porphyra perforata* with which it has been confused, is a monoecious, monostromatic species with one chloroplast per cell. If differs from *P. perforata* in thallus shape, color, thickness, vegetative cell size and shape, and arrangement of spermatangia and carposporangia. It has a haploid chromosome number of n=2 compared to n=3 for *P. perforata*.

Key Index Words: British Columbia—chromosome number—new species—Porphyra fallax—*Rhodophyta—Washington.*

The genus *Porphyra* currently boasts 20 species in British Columbia and northern Washington (SCAGEL *et al.* 1989). These species have been distinguished primarily on morphological features—size, shape, color, and thickness of the thallus, number of cell layers, numbers of chloroplasts per cell, and arrangement of sporangia and sporangial packets (CONWAY *et al.* 1975). Habitat and seasonality have also been used (GARBARY *et al.* 1980), and chromosome counts have helped confirm the distinctness of some species (MUMFORD and COLE 1977, COLE 1990).

During a recent electrophoretic survey of the species of *Porphyra* in British Columbia, it became obvious that one well-known species in the local flora was incorrectly identified (LINDSTROM and COLE 1990). This species is described below and compared with the species with which it had been confused.

Porphyra fallax sp. nov. Figs. 1, 3, 5, 7

Thallus lanceolatus; margo undulatus. Ubi iuvenis viridulus in medio, marturitate porphyrus usque ad chalybeum factus. Monoecius. Carposporangia matura in stratis 4 aut raro 8 ordinatis. Spermatangia in stratis 8 ordinatis, in maculis irregularibus aut in lineis. Unum stroma formans, uno chloroplasto per cellulam. Chromosomata 2 (haploidea). In saxis in zona interaestuali e media usque ad superam, in regionibus moderate umbritilibus, crescens.

Thallus lanceolate, margin ruffled. Initially greenish in center with reddish margin, becoming reddish-brown to steel blue-gray at maturity. Monoecious. Mature carposporangia in tiers of four or rarely eight. Spermatangia in tiers of eight, in irregular patches or streaks. Monostromatic, one chloroplast per cell. Two chromosomes (haploid number). Occurring on mid to upper intertidal rock in moderately sheltered areas.

This species has been confused with *Porphyra perforata* J. AGARDH, the first-described species of *Porphyra* from the Pacific coast of North America. Both are monostromatic and monoecious, with a single chloroplast per cell. *Porphyra fallax* differs from *P. perforata* in thallus shape, color, thickness, vegetative cell

* Dedicated to the memory of the late Dr. Munenao KUROGI (1921–1988), Professor Emeritus, Hokkaido University.

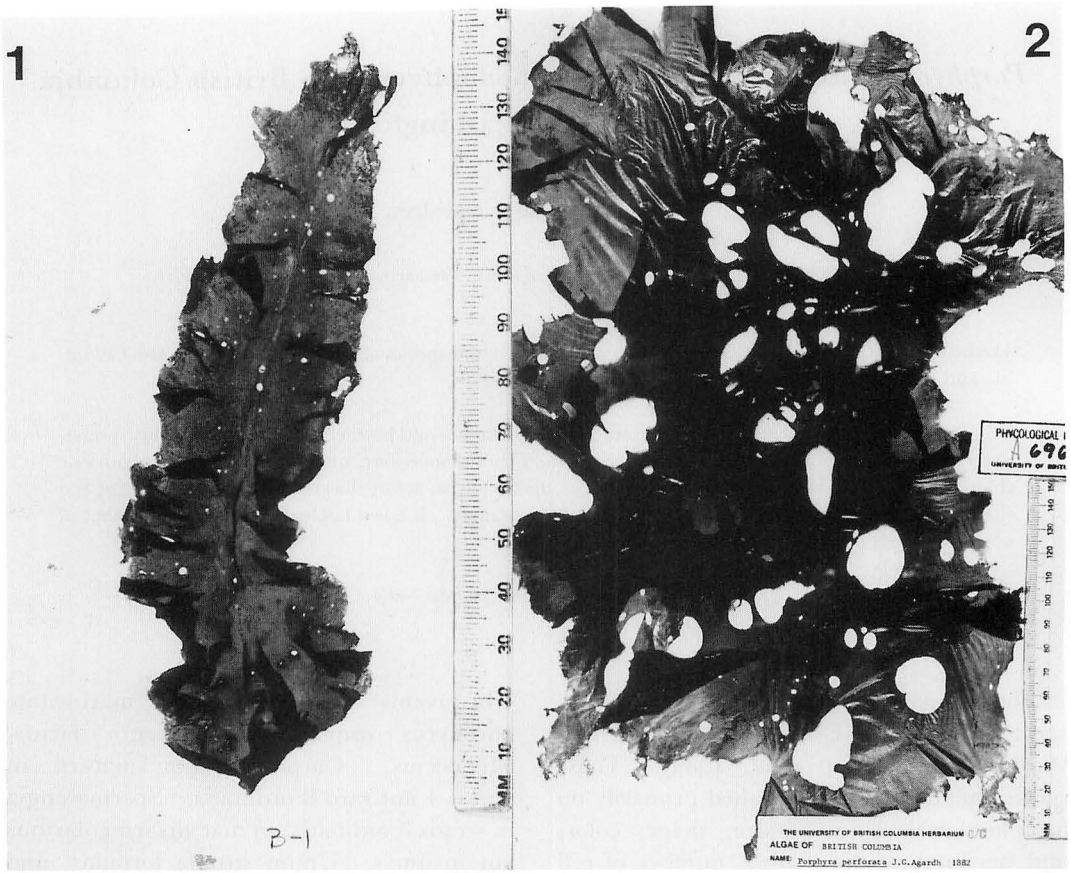

Fig. 1. *Porphyra fallax* holotype. UBC A69860. Golden Gardens, Seattle, Washington. 5 April 1983. Leg. E.C.S. DUFFIELD.

Fig. 2. *Porphyra perforata*. UBC A69678. Miracle Beach, Vancouver Island, British Columbia. 9 October 1988. Leg. M.W. HAWKES.

size and shape, and arrangement of spermatangia and carposporangia (Table 1). Differences in thallus morphology and size between *P. fallax* and *P. perforata* are evident in Figs. 1 and 2. Another difference can be seen in Figs. 3-6. Spermatangia in *P. perforata* occur in discrete packets (probably due to the relatively thick cell wall) that are recognizable in both surface view (Fig. 4) and transverse section (Fig. 6). In contrast, spermatangia in *P. fallax* reveal confluent cells when viewed superficially (Fig. 3) and a nearly indistinguishable mass when viewed transversely (Fig. 5). These male reproductive units are arranged a/(1)2, b/2(4), c/8 in *P. fallax* and a/(2)4, b/4, c/(8)16 in *P. perforata* according to HUS' (1902) formula.

Porphyra fallax occurs primarily on upper intertidal rock in moderately protected habitats as a winter-spring (Strait of Georgia) or spring-summer (other locations) species. It becomes reproductive within a month or two of its appearance on the shore. *Porphyra perforata* occurs on moderately exposed to protected mid intertidal rock, between ~1.5 and 3.5 m; it can occur epiphytically, primarily on *Fucus*. *Porphyra perforata* is found year-round: young thalli are most abundant in fall-winter, and reproductive thalli are evident in late summer-late fall. Whereas *P. fallax* is known with certainty only from northern Washington to northern British Columbia (see Appendix: Representative specimens examined), *P. perforata* has a recorded range

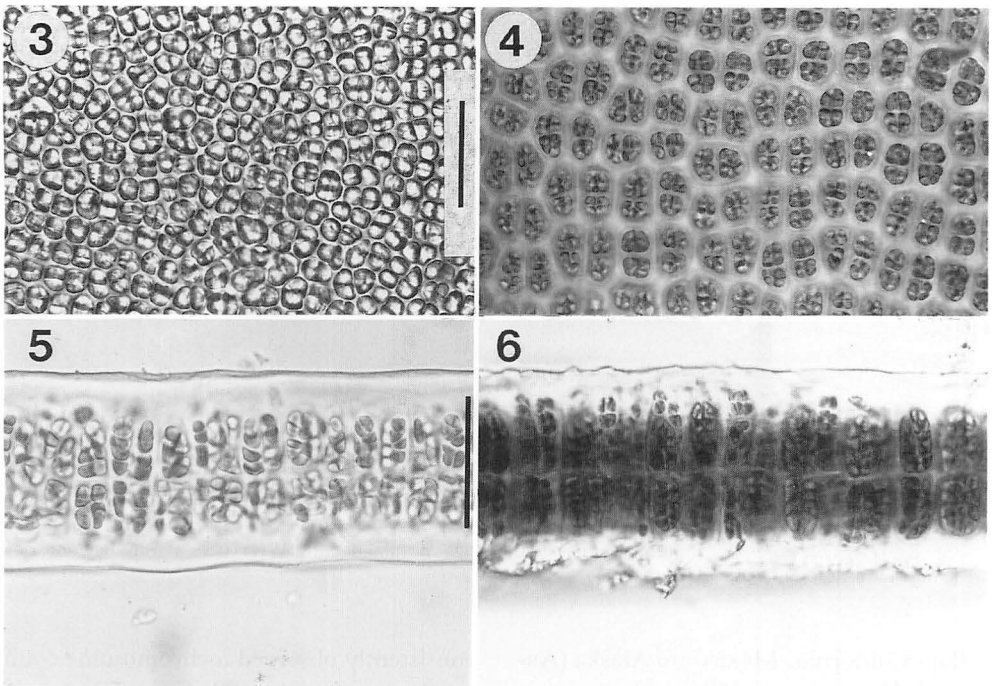

Fig. 3. *Porphyra fallax*. Surface view of spermatangia. UBC A70140. Wreck Beach, B. C. 26 Jan. 1988. Leg. S.C. LINDSTROM. Scale bar=50 μm

Fig. 4. *Porphyra perforata*. Surface view of spermatangia. Bamfield, B. C. 4 Nov. 1989. Leg. S.C. LINDSTROM. Scale bar same as Fig. 3.

Fig. 5. *Porphyra fallax*. Transverse section of spermatangia. Same specimen as Fig. 3. Scale bar=50 μm

Fig. 6. *Porphyra perforata*. Transverse section of spermatangia. Same specimen as Fig. 4. Scale bar same as Fig. 5.

Table 1. Comparison of *Porphyra fallax* and *P. perforata*.

	Porphyra fallax	*Porphyra perforata*
Shape of thallus	Lanceolate, margin ruffled, can become expanded and flattened at maturity	Orbiculate, broadly expanded, not ruffled
Base of mature thallus	Slightly to distinctly umbilicate	Distinctly umbilicate
Color of fresh thallus	Greenish center, reddish margin, becoming reddish brown to steel blue-gray at maturity	Brown(ish) purple, sometimes dark olive green, but uniform color throughout
Maximum thallus size	~30 cm long	~40 cm diam.
Thallus thickness (vegetative)	49–66 μm	73–81 μm
Vegetative cell size and shape	16–20 μm wide × 20–24 μm long, nearly quadrate	4–20 μm wide × 28–43 μm long, oblong
Macroscopic arrangement of spermatangia	Patches or streaks	Squares, patches, streaks
Microscopic arrangement of spermatangia	Packets indistinguishable	Packets clearly distinguishable
Maximum tiers of spermatangia	8	16
Macroscopic arrangement of carposporangia	Submarginal patches, mottles, streaks and hieroglyphs	Continuous marginal zone, submarginal streaks
Maximum tiers of carposporangia	4 (8)	8
Chromosome number	n=2	n=3

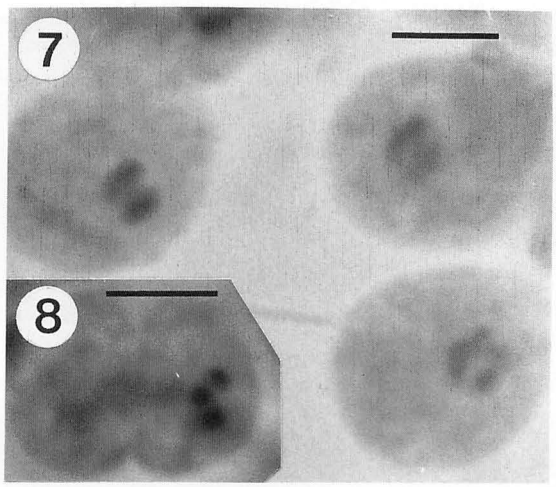

Fig. 7. *Porphyra fallax*. Spermatangial mother cells stained with WITTMANN's iron haematoxylin. Two medium-sized "lumpy" chromosomes. Scale bar=3 μm

Fig. 8. *Porphyra perforata*. Spermatangial mother cell(s) stained with WITTMANN's iron haematoxylin. Three short chromosomes. Scale bar=3 μm

from Baja California, Mexico, to Alaska (ABBOTT and HOLLENBERG 1976). LINDSTROM and COLE (1990) have shown, moreover, that the two species have distinct banding patterns for 13 of 15 loci examined using starch gel electrophoresis.

Holotype: UBC A69860. Golden Gardens, Seattle, Washington, collected 5 April 1983 by E.C.S. DUFFIELD. Isotype in WTU. (Herbarium abbreviations after HOLMGREN *et al.* 1981)

Known Distribution: Northern British Columbia to northern Washington.

Etymology: The species epithet, from the Latin word meaning deceptive or fallacious, commemorates the lengthy success of this species in remaining confused with *Porphyra perforata*.

Chromosomes were examined in specimens of *P. fallax* from Wreck Beach, B. C. (Leg. S. LINDSTROM, 1 Dec. 1988) and specimens of *P. perforata* from Bamfield, B. C. (Leg. S. LINDSTROM, 4 Nov. 1989) using WITTMANN's aceto-iron-haematoxylin-chloral hydrate technique (MUMFORD and COLE 1977). Haploid *P. fallax* clearly has two chromosomes of medium length (Fig. 7) whereas haploid *P. perforata* has three small chromosomes (Fig. 8). WAALAND and co-workers (pers. comm.) have consistently observed a chromosome count of n=2 in specimens of *P. fallax* from the type locality.

Discussion

A chromosome number of n=2 distinguishes *Porphyra fallax* from most other species of *Porphyra*. Only *Porphyra schizophylla* HOLLENBERG, among the species that have been studied, has been consistently reported to have a haploid chromosome count of 2, but the large size of its choromosomes clearly distinguishes it from its congeners that have been studied to date. Although *Porphyra fucicola* KRISHNAMURTHY, *P. kuniedae* KUROGI, and *P. suborbiculata* KJELLMAN have been reported to have a haploid chromosome number of 2, these species have also been reported to have other, haploid chromosome counts (COLE 1990). Moreover, none of these species conforms morphologically to the species under consideration. It seems unlikely, therefore, that our new species corresponds to any that has been described previously.

Acknowledgments

We appreciate the generosity of Dr. J.R. WAALAND of the University of Washington in sharing his knowledge and his specimens of this species with us. This work was supported by NSERCC Grant 580645 to K.M. COLE. Angela SHIPMAN kindly supplied the Latin diagnosis.

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Appendix: Representative specimens examined.

Porphyra fallax			
UBC A70148	Lion's Bay, B. C.	13 Jan. 1989	Leg. S.C. LINDSTROM
UBC A50188	Lion's Bay, B. C.	17 Jan. 1974	Leg. J.N.C. WHYTE
UBC A70140	Wreck Beach, B. C.	26 Jan. 1988	Leg. S.C. LINDSTROM
UBC A66905	Pt. Atkinson, B. C.	2 Feb. 1981	Leg. D. GARBARY, L. GOLDEN
UBC A63492	Wreck Beach, B. C.	22 Mar. 1981	Leg. D. GARBARY
UBC A1496	Whytecliffe, B. C.	8 Apr. 1949	Leg. R.F. SCAGEL
UBC A70136	Ridley I., B. C.	15 May 1988	Leg. S.C. LINDSTROM
UBC A69053	West Beach, Deception Pass State Park, Wash.	17 May 1987	Leg. S.C. LINDSTROM
UBC A64279	Tsawwassen, B. C.	30 June 1981	Leg. C. LOWTHER
UBC A51068	Cattle Point, Wash.	1 July 1974	Leg. T.F. MUMFORD, Jr.
UBC A70142	Wreck Beach, B. C.	28 Dec. 1987	Leg. S.C. LINDSTROM
Porphyra perforata			
UBC A15346	Sointula, B. C.	30 June 1962	Leg. T.B. WIDDOWSON
UBC A69655	Moss Beach, Calif.	29 July 1988	Leg. S.C. LINDSTROM
UBC A37663	Nootka I., B. C.	24 Aug. 1968	Leg. J. MARKHAM
UBC A69672	Miracle Beach, Vancouver I., B. C.	9 Oct. 1988	Leg. M.W. HAWKES
Unnumbered	Bamfield, B. C.	4 Nov. 1989	Leg. S.C. LINDSTROM

S. C. LINDSTROM・K. M. COLE: ブリティシュコロンビア州および北部ワシントン州産の新種 *Porphyra fallax* (紅藻)

ブリティシュコロンビア州および北部ワシントン州産の新種 *Porphyra fallax* (紅藻) を記載した。本種は，これまで混同されていた *Porphyra perforata* と同様に，葉状体は雌雄同株で単層であり，1細胞に1個の葉緑体をもつ。*P. perforata* とは，葉状体の形状，色彩，厚さ，栄養細胞の大きさと形状，精子嚢群および果胞子嚢群の配列などにおいて異なる。染色体数は，*P. perforata* の n=3 に対して n=2 である。(Department of Botany, University of British Columbia, Vancouver, B.C., Canada V6T 2B1)

藻類 Jpn. J. Phycol. 38: 377–382, December 10, 1990

紅藻エゴノリの養殖

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KIRIHARA, S., NOTOYA, M. and ARUGA, Y. 1990. Cultivation of *Campylaephora hypnaeoides* J. AGARDH (Ceramiales, Rhodophyta). Jpn. J. Phycol. **38**: 377–382.

The edible red alga, *Campylaephora hypnaeoides* J. AGARDH, was investigated for good indoor seeding and outdoor cultivation. Effects of the temperature and photoperiod on the growth and maturation of tetrasporophytes and female gametophytes were studied in laboratory culture. Tetrasporophytes and female gametophytes grew well and matured at 25°C and a photoperiod of 14L: 10D. When female gametophytes were cocultured with mature male gametophytes at 20 or 25°C, fertilization occurred, gonimoblasts developed and carpospores were liberated within a week of culture. Large female gametophytes were grwon by cultures isolated from male gametophytes, and on cocultured afterwards with male gametophytes a great amount of carpospores were obtained for indoor seeding. Seedlings (4–5 cm long), 35 g/cage, were outplanted in a cage (lantern net) at Shiranuka, Aomori Prefecture, in May. They grew up 1403 g per cage in July.

Key Index Words: Campylaephora hypnaeoides—*cultivation—growth—inddor seeding—photoperiod—Rhodophyta—temperature.*
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エゴノリ *Campylaephora hypnaeoides* J. AGARDH は紅藻のイギス科に属し，北海道南部以南の本邦の沿岸に広く見られ（千原 1970, NAKAMURA 1965），主に寒天原藻として利用されているが，徳田ら（1987）は「新潟，佐渡，能登ではエゴノリ *Campylaephora hypnaeoides* からエゴテンあるいはエゴモチを作っており，福岡で親しまれている『おきうと』もエゴノリを材料としている」と記している。また，一部の地域では酢の物にして生食することも知られている（工藤他 1986）。

全国及び青森県における最近14年間の漁獲量の変化 (Fig. 1) を見ると，年による豊凶の変動が大きい上に，漸減の傾向も窺われる。そのため，エゴノリ漁業者は天然藻体よりも安定的に多量に収穫できる養殖技術の開発を望んでいる。

これまでエゴノリの養殖や人工採苗についての報告はないが，能登谷（1979）は室内培養により生活史を完結させ，雌雄配偶体はごく小さい体のうちから成熟し，受精して果胞子を形成すること，四分胞子体は配偶体に比べてはるかに大きく成長すること，更に，四分胞子体及び配偶体の生長に及ぼす温度の影響を調べ，それぞれの生長や成熟条件などを明らかにした。これらの結果を踏まえて著者らはエゴノリ養殖のための効率的な人工種苗の生産や養成の方法を検討するため，いろいろな光周期と温度を組み合わせた条件下で四分胞子体及び雌性配偶体の生長特性や雌雄配偶体の混合培養による果胞子の成熟や放出条件などを調べ，更に人工種苗の天然海域での養成試験を行った。以下にその結果を報告する。

材料と方法

材料のエゴノリは，1987年 8 月21日に青森県三厩村上宇鉄 (Fig. 2) の水深 3 m から採取した成熟した四分胞子体である。藻体からよく成熟した枝の一部分 5～10 cm を十数本切り取り，ペーパータオルまたは筆を用いて表面に付着している他の藻類やごみ等を取り除き，滅菌海水で数回洗浄した後，二酸化ゲルマニウムを 5 ppm 加えた滅菌海水中に数時間放置して胞子の放出を待った。放出された胞子は直ちに実体顕微鏡下でマイクロピペットを用いて吸い取り，新たに用

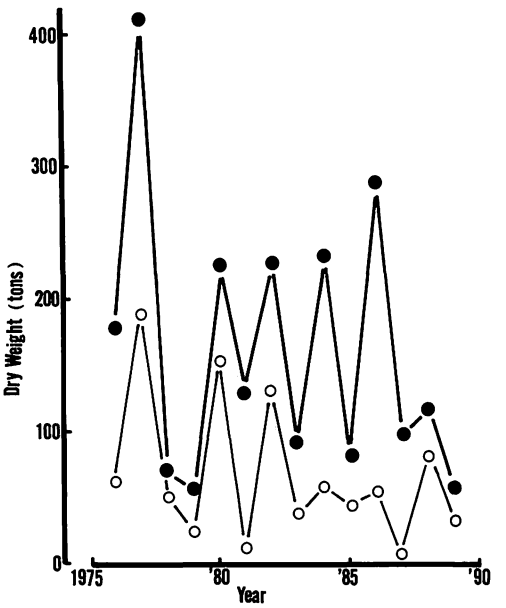

Fig. 1. Changes of the annual harvest of *Campylaephora hypnaeoides* from 1976 to 1989 in Aomori Prefecture (○) and in Japan (●).

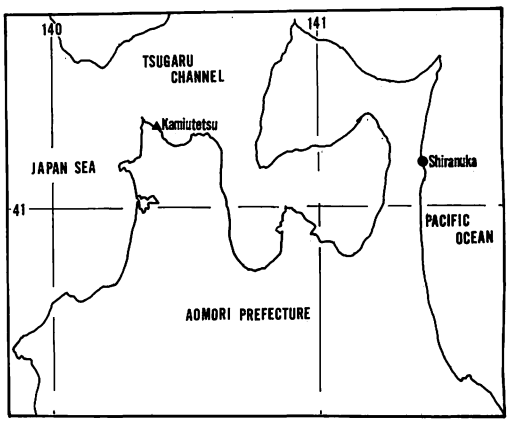

Fig. 2. A map showing the sites of collection (▲) and cultivation (●) of *Campylaephora hypnaeoides*.

意した滅菌海水中に移し，更にそれらの胞子を別の滅菌海水へ移す操作を数回繰り返して胞子の洗浄を行い，最後に Grund 改変培地 (McLACHLAN 1973) の中に入れ，20°C，2000 lux（白色蛍光灯）の条件下で培養を行った。

1週間後にこれらの胞子は発芽生長して雌雄の判別ができるようになったため，それぞれの配偶体は分離して培養，保存した。また，一部は雌雄配偶体を混合培養して果胞子を得，更に果胞子を発芽させ，次世代の四分胞子体を得た。

四分胞子体及び雌性配偶体の生長は，500 ml 丸底フラスコを用いて通気培養し，温度は15°C，20°C，

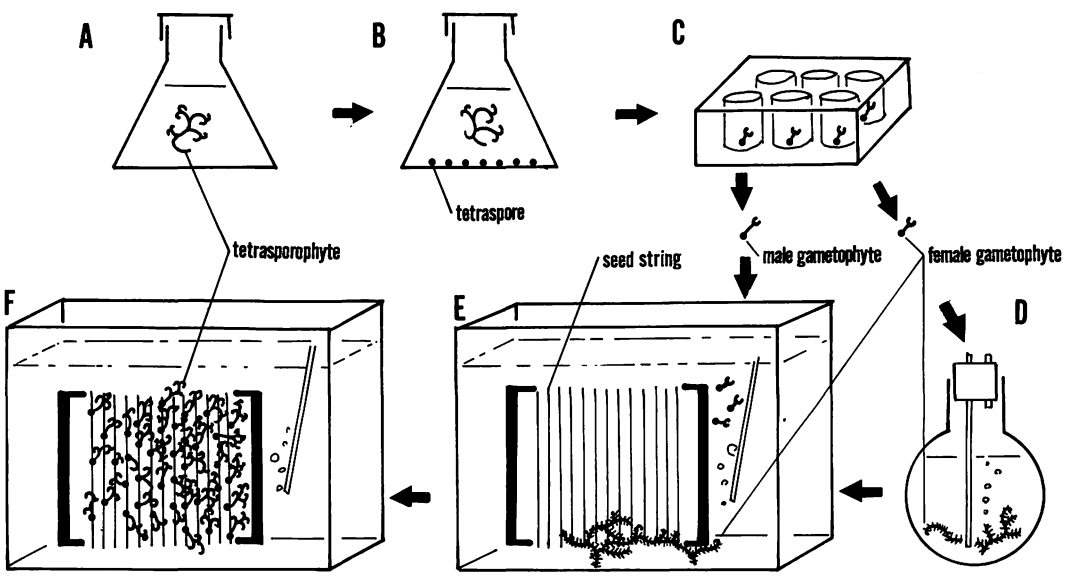

Fig. 3. Manual of indoor seeding of *Campylaephora hypnaeoides*. A, maintenance of sporophytes (15°C, 14L: 10D); B, libelation of tetraspores (20–25°C, 14L : 10D); C, isolation of male and female gametophytes; D, culture of female gametophytes (20–25°C, 14L : 10D); E, mixed culture of male and female gametophytes for fertilization, development of gonimoblasts and carpospore liberation; F, carpospore germlings (tetrasporophytes) on the seed strings.

25°C, 30°C の4段階，光周期は長日 (14L: 10D)，中日 (12L: 12D)，短日 (10L: 14D) の3段階をそれぞれ組み合わせて12段階の各条件下で観察した。照度は全て2000 lux とした。それぞれの藻体は培養1週間目ごとに長さと藻体表面の水分を濾紙でよく取り除いた後の湿重量を測定した。培養液には Grund 改変培地を用い，藻体測定時にその全量を更新した。

人工種苗は，Fig. 3 に示す手順に従い，温度25°C，照度 2000 lux，長日条件下で雌性配偶体約 20 g に成熟した雄性配偶体（藻長 3–5 mm のもの約50個体）を混合して4週間培養することによって得た。

養成には藻長 1～5 cm の四分胞子体が15個体/cm 程度着生したクレモナ糸を，約 10 cm の長さに切断して養成篭の格段に10本ずつ結着した。養成篭にはホタテ貝養殖用の目合4分，直径 50 cm，高さ 15 cm の10段式丸篭を用い，1988年5月7日に青森県東通村白糠 (Fig. 2) の沿岸の水深 5 m に設置した施設で養成を開始し，その後1か月ごとに9月まで計4回，藻体の生長（湿重量）と養成篭に着生した海藻類の湿重量を測定した。

結　果

1. 生長に及ぼす光周期と温度の影響

室内培養における四分胞子体の生長を Fig 4 に示す。30°C では長日，中日いずれの条件下でも殆ど生長が認められなかったが，短日条件下ではわずかに生長が認められ，5週間後には藻長 5.7 mm，湿重量 30 mg に達したものの，他の温度条件に比べ生長量は小さく，四分胞子嚢の形成は認められなかった。25°C では長日および中日条件下で，既に1週間後には四分胞子の放出が認められ，各培養条件中でもっとも早く四分胞子嚢の形成と胞子の放出が認められ，5週間後まで継続して多量の四分胞子の放出が見られた。しかし，藻体は胞子を放出した部分から枯死し，5週間後には成熟の遅い短日条件下のほうが大きな藻体となった。20°C では四分胞子嚢の形成は各光周期条件下とも1週間後に認められたが，胞子の放出は長日と中日条件下では2週間後に，短日条件下では3週間後にそれぞれ認められ，藻体の大きさは25°C に比べて長日と中日条件下では大きく，短日条件下では小さかった。15°C では四分胞子嚢の形成は長日条件下では2週間

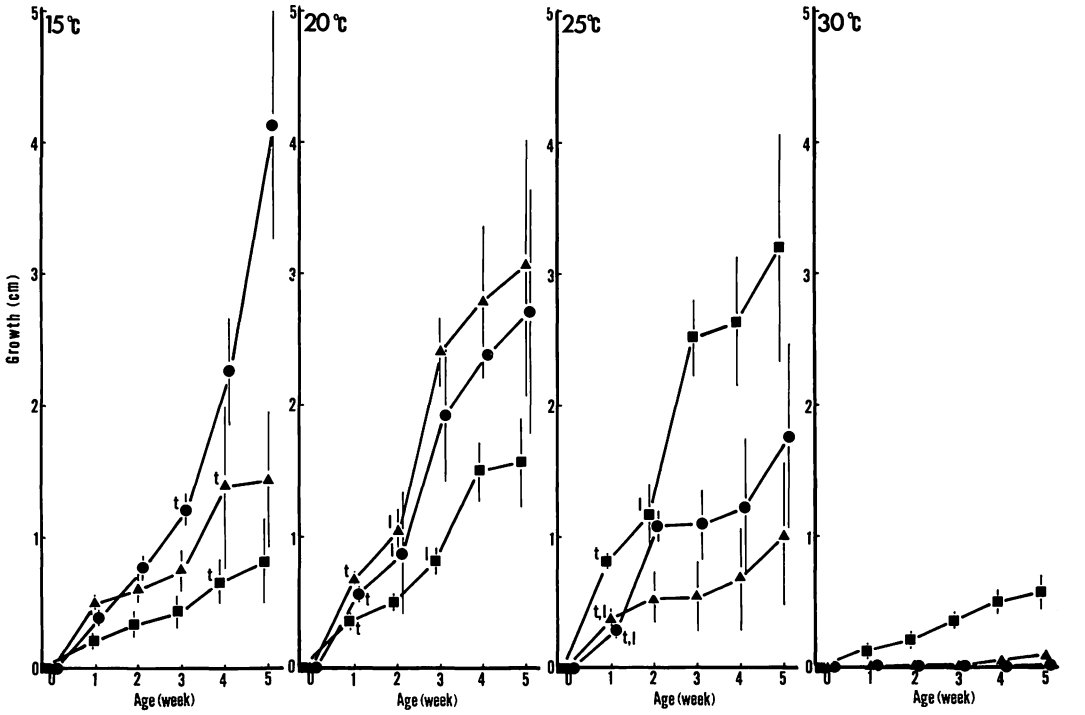

Fig. 4. Growth of tetrasporophytes of *Campylaephora hypnaeoides* under various photoperiods and temperatures. Solid circles, 14L : 10D; solid triangles, 12L : 12D; solid rectangles, 10L : 14D. Vertical bar, standard deviation; t, development of tetrasporangia; l, liberation of tetraspores.

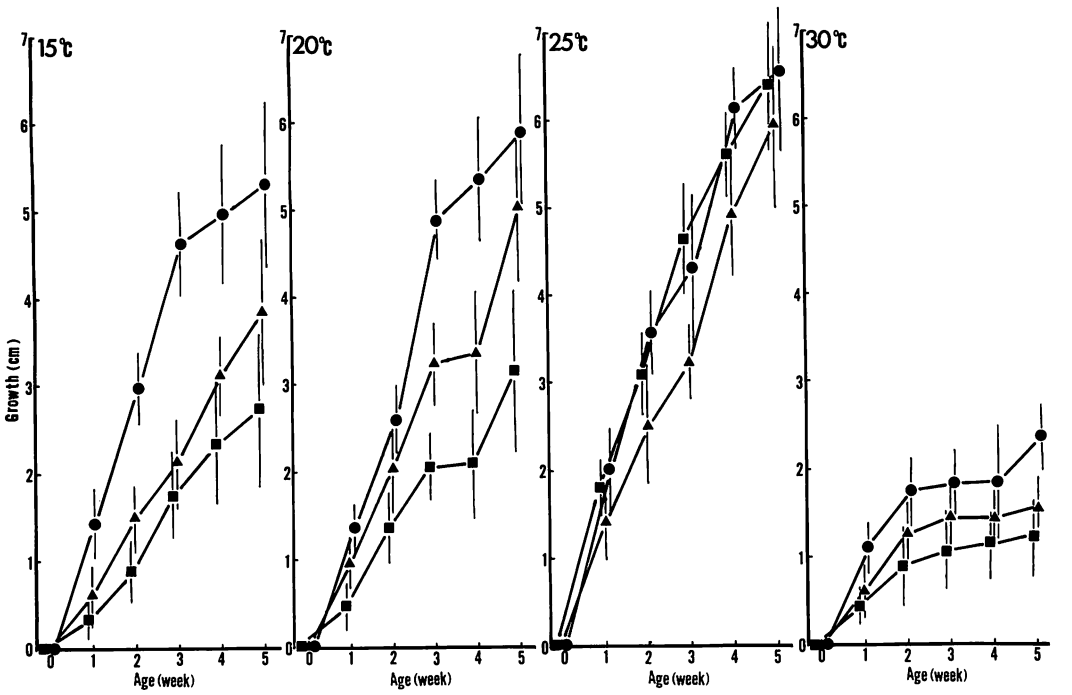

Fig. 5. Growth of female gametophytes of *Campylaephora hypnaeoides* under various photoperiods and temperatures. Solid circles, 14L : 10D; solid triangles, 12L : 12D; solid rectangles, 10L : 14D. Vertical bar, standard deviation.

後に，中日と短日条件下では3週間後に認められたが，胞子の放出は5週間後でも認められなかった。従って，25°C および20°C における藻体のように胞子放出部分からの枯死流失は認められず，培養期間を通じて藻体の重量が増加し続けた。特に，長日条件下ではよく生長し，5週間後には藻長 44 mm，湿重量 430 mg に達し，各組合せ条件の中でもっとも大きな藻体となった。

室内培養における雌性配偶体の生長を Fig. 5 に示す。四分胞子体とは異なり雌性配偶体は 25°C でもっともよく生長し，続いて 20°C, 15°C と生長量は少なくなった。30°C では藻体は枝の発生数が少なく，色彩も黄褐色を呈し，他の温度条件下に比べ極端に生長

Table 1. Changes of wet weight (g) per cage (lantern net) of *Campylaephora hypnaeoides* and other seaweeds attached on cage.

	22 June	18 July	20 August	21 September
Campylaephora hypnaeoides	530.1	1403.2	237.0	60.7
Ulva pertusa				13.6
Cladophora sp.		0.7		
Hydroclathrus clathratus		1.0		
Kjellmaniella crassifolia				0.7
Bonnemaisonia hamifera	770.7	1150.0		
Ptilota serrata	29.2	5.2	8.4	14.0
Delesseria serrulata				2.1
Acrosorium yendoi				10.6
Heterosiphonia pulchra			0.5	0.3
Laurencia pinnata		3.6		0.7
Total	1330.0	2563.7	245.9	102.7

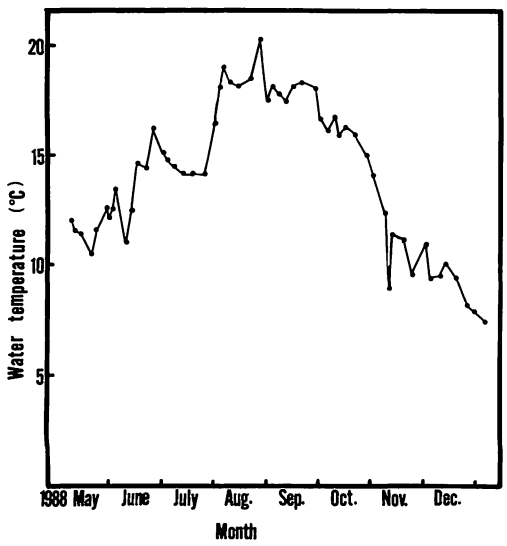

Fig. 6. Changes of surface water temperature at cultivation site of Shiranuka, Aomori Prefecture, in 1988.

が遅れた。また，光周期に関してはいずれの温度でも長日条件下ほどよく生長した。

これら各条件で培養した雌性配偶体に，成熟した雄性配偶体を混合して培養したところ，15°C ではいずれの光周期においても 2 週間後までに嚢果の形成が認められたが，果胞子の放出は観察されなかった。これに対して，25°C と20°C ではいずれの光周期においても 1 週間後までに嚢果が形成され，果胞子の放出が認められた。また，30°C では 4 週間後まで観察したが，いずれの藻体にも嚢果の形成は認められなかった。

2. 天然海域での養成

藻体の長さ 4～5 cm のエゴノリ種苗は 2 ～ 3 本の枝を持つが，それぞれの枝の先端は未だ鉤状ではなかった。しかし，生長するに従って鉤状に屈曲した枝の先端を篭の網糸に絡ませて藻体を固定させながら生長するのが認められた。

6 月から 9 月までのエゴノリの成育藻体と養成篭に付着した他の藻体の湿重量の増減を Table 1 に示す。エゴノリの湿重量は 7 月に最大の 1403 g となり，それ以降 8 月からは四分胞子の放出部分から藻体の枯死流失が認められ，減少傾向に転じて，9 月には約 61 g となった。

養成篭に付着，成育した他の藻類のうち，クシベニヒバ *Ptilota serrata* は調査期間を通じて着生がみられ，カギノリ *Bonnemaisonia hamifera* は 6 月および 7 月に大量の着生が認められたが，8 月以降にはほとんど流失した。その他の藻類は極く短期間に少量着生しただけであった。

考　察

エゴノリの生産対象となる藻体は夏季に大型となる四分胞子体である。従って，養殖には大量の果胞子を得て，果胞子発芽体を種苗とする方法を用いることになる。エゴノリの雌性配偶体は天然または室内培養いずれの条件においても四分胞子体より遙かに小さい矮小体から成熟するため(Nakamura 1965, 能登谷1979)，1 雌性配偶体には数個の嚢果が形成されるだけで，それら嚢果の 1 個から放出される果胞子の和は数十個～百数十個程度（能登谷　未発表）であるため，種苗生産のために使用するには少なすぎる。そこで，本実験では雌性配偶体のみを分離培養することにより大型の雌性配偶体を得，これを 20°C～25°C で雄性配偶体と混合培養することによって多数の嚢果を短期間に形成させ，採苗に必要，十分な量の果胞子を一度に得ることができた。

エゴノリはホンダワラ類の枝などに絡みついて成育する特性を持っている。採苗操作で撚糸上に付着した果胞子は一定期間の培養によって長さ数 cm の藻体に生長するが，鉤状の枝を形成しない。しかし，その大きさまでは付着器によって撚糸上から離脱することなく生長する。その後，天然海域で養成すると，生長するに従って枝先端に鉤が形成され，養成篭の網糸上に絡み付き，かなりの藻体量にまで達した。したがって，エゴノリ養殖には本研究で用いた養成篭の様に藻体を流失させることなく，また鉤状枝の絡みつきやすい基質が必要と考えられる。

養成篭中の藻体の量は 7 月までは増加したが，8 月以降は減少傾向となった。これは 8 月以降に養成場所の水温が急に上昇し，20°C を越えることもあったため (Fig. 6), 四分胞子体の四分胞子放出部分からの枯死流失が始まったことによるものである。これと同様のことは本実験における四分胞子の生長に及ぼす温度の影響や能登谷 (1979)の室内培養実験の結果からも明らかである。

最近，ウミゾウメン (四井　1989)やムカデノリ (右田　1988)で試みられているように撚糸に栄養体の組織を直接付着させ，その再生による栄養繁殖を利用した簡便な養成法が報告されているが，エゴノリについても今後更に簡便な養成法を検討したい。

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Jpn. J. Phycol. (Sôrui) 38: 383–386, December 10, 1990

Doris M. Sinkora and Michael J. Wynne: On the identity of *Talarodictyon tilesii* Endlicher

Key Index Words: *Chlorophyta*—Hydroclathrus—H. clathratus—*Phaeophyta*—Talarodictyon—T. tilesii—*Tilesius*

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The discovery of syntype material of *Talarodictyon tilesii* Endlicher in MEL is of interest to algal taxonomists, since it clears up the identity of this poorly known taxon. The status of the genus *Talarodictyon* has been an enigma ever since it was first described by Endlicher (1843). Endlicher's account was reasonably detailed, including the words "Ulva reticulata, saccata..." and "viridis". Endlicher credited the description to unpublished notes by the alga's collector Tilesius along with Tilesius' illustration then deposited in the herbarium of A.W.E.T. Henschel (1790-1856), physician and Professor of Botany in Breslau (Wroclaw), then Prussia, now Poland. W.G. Tilesius (Anon. 1857), along with G.H. Langsdorff (Lindemann 1885), served as surgeon, naturalist, and artist from 1803-1806 on a voyage of circumnavigation of the globe made by Von Krusenstern (Lasègue 1845, Brockhaus 1894). The specimen was collected by Tilesius in the drift following an underwater volcanic eruption while the ship was anchored in Nagasaki Harbor in April, 1805. It was reportedly cast up along with various other seaweeds.

Kützing (1849) repeated verbatim Endlicher's description of *Talarodictyon*, and he also indicated (with "v. ic.") that he had seen the original illustration. But the specimen of *T. tilesii* presumably had disappeared shortly after Endlicher's description. Kützing placed the genus in his family Anadyomenaceae (Kützing 1843, "Anadyomeneae"), while at the same time designating it as a "Genus maxime obscurum!". Other workers, such as Gray (1866), gave occasional mention to *Talarodictyon* but without providing any new insights. Martens (1868) continued to list the genus in the Anadyomenaceae. Wille (1890) regarded *Talarodictyon* as a "Zweifelhafte Gattung", assigning it to the Valoniaceae next to *Anadyomene*. Its placement in the Anadyomenaceae, albeit with a query, was followed by Egerod in contemporary works (Farr *et al.* 1979), whereas DeToni (1889) placed it in the Cladophoraceae, subfamily Microdictyeae, again as a "genus maxime obscurum". Yet despite its having been described from southern Japan, this taxon has not been included in checklists for this region (Okamura 1932, Yoshida *et al.* 1985).

Tilesius' original manuscript notes and the unpublished plate of *Talarodictyon tilesii* with a label in F.K. Mertens' hand have been located among the Sonder collections deposited in the National Herbarium of Victoria (MEL). The handwritting of the plant name on the label has been recognized by Mag. C. Riedl-Dorn (Naturhistorisches Museum Wien) to be that of E. Fenzl, who started his career as assistant to Endlicher (Kanitz 1880). Tilesius' MS description is on the reverse side of the plate. More importantly, the actual algal specimen has also been found. How this material came into the Sonder herbarium has not been established. The Type specimen is MEL 501457, *legit* Tilesius, Nagasaki Harbor, Japan. The plate of *Talarodictyon tilesii* Endlicher (Fig. 1) is somewhat olive-green, rather more green than yellow, but a dark green, not the grass-green of an *Ulva*. Dr. C. Clemente, Curator

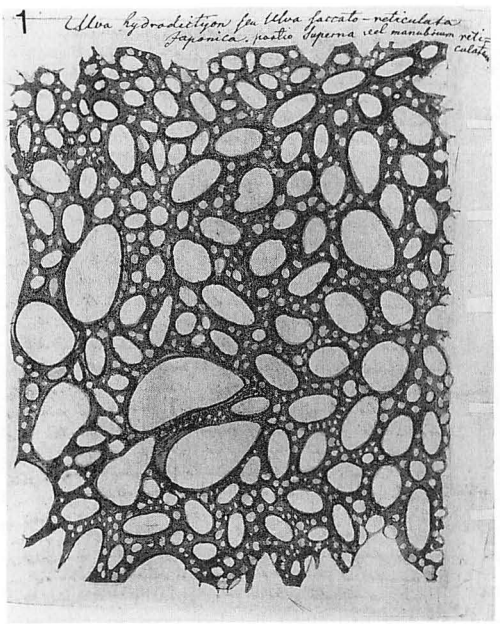

Fig. 1. Hand-coloured soft-ground etching of *Talarodictyon tilesii* in MEL.

of Prints and Drawings, National Gallery of Victoria, Melbourne, has identified the plate as a hand-coloured soft-ground etching (BRUNNER 1962, GRIFFITHS 1980).

An examination of the specimen itself (Fig. 2) revealed the presence of plurilocular sporangia, which demonstrates conclusively that it is not a green alga as has been formerly thought but a brown alga. Its generic assignment is with *Hydroclathrus* BORY (1825). The alga has the normal color of a slightly bleached drift collection of *Hydroclathrus*. Both icon and specimen exhibit a sheet perforated by a dense arrangement of holes, ranging from small to large, very similar to a specimen of *Hydroclathrus clathratus* depicted by WYNNE (1981, Fig. 2.7). The next question is: To which species of *Hydroclathrus* does it belong?

With the recent description of *Hydroclathrus tenuis* from the South China Sea by TSENG and LU BAOREN (1983), two species of *Hydroclathrus* are now recognized. *Hydroclathrus clathratus* (C. AGARDH) HOWE, the type of the genus, is known to be widely distributed in warm temperate and tropical seas (HOWE 1920). Although TSENG and LU BAOREN made no reference to SONDER (1871), in his work on tropical Australian algae SONDER used the same epithet *tenuis* to describe a new variety of *Hydroclathrus clathratus* from Cape York and the Gulf of Carpenteria. SONDER's varietal Type is deposited in MEL. SONDER's variety was initially accepted (GRUNOW 1874) but has subsequently come to be regarded within the synonymy of *H. clathratus* (*e.g.*, LEWIS 1985). Another coincidental usage of *tenuis* is that by HARVEY, who distributed "*Hydroclathrus cancellatus* var. *tenuis*" as No. 5 in his Friendly Islands Exsiccatae. This variety was not ever validated by HARVEY, but two specimens in MICH and one in MEL are identifiable as *Hydroclathrus tenuis* TSENG & LU BAOREN.

Colored plates of *Hydroclathrus tenuis* and *H. clathratus* are presented in TSENG's (1983) "Common Seaweeds of China". TSENG and LU BAOREN (1983) distinguished *H. tenuis* from *H. clathratus* by the comparatively softer, much more slender texture of the former and by anatomical differences: thinner membrane (250-300 μm thick vs. 600-800 μm thick in *H. clathratus*); smaller medullary cells (70-80 μm diam. vs. 100-130 μm diam.); and its longer plurilocular organs (22-25 μm long vs. 10-15 μm long). For southern Australian material of *H. clathratus*, WOMERSLEY (1987) reported the length of plurilocular organs to be 15-20 μm, a range intermediate in comparison with the measurements given by TSENG and LU BAOREN. Our examination of the type specimen of *Talarodictyon tilesii* showed medullary cells to range 60-130 μm in diameter and the plurilocular sporangia to be mostly uniseriate, comprised of 3-7 cells. We concluded that the most reasonable assignment is *Hydroclathrus clathratus*. Consequently, *Talarodictyon tilesii* ENDLICHER (1843) is to be regarded as a junior taxonomic synonym of *H. clathratus*.

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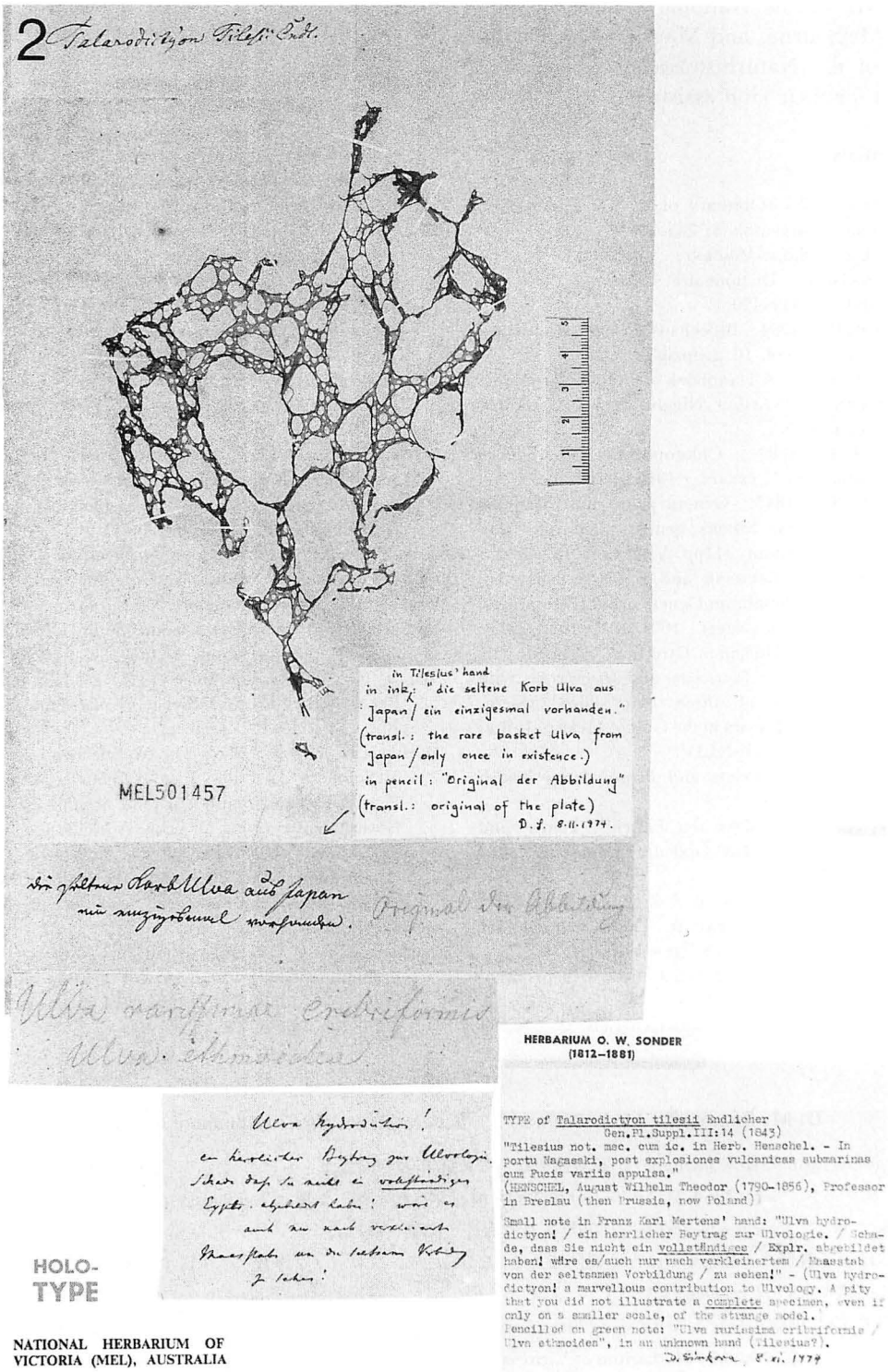

Fig. 2. Type specimen of *Talarodictyon tilesii* ENDL. (MEL 501457).

CLEMENTE of the National Gallery of Victoria, Melbourne, and Mag. Christa RIEDL-DORN of the Naturhistorisches Museum of Vienna for their kind assistance.

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D. M. SINKORA* · M. J. WYNNE**: *Talarodictyon tilesii* ENDLICHER の正体

Talarodictyon tilesii の標本 (syntype) が記載原稿ならびに未発表の図版とともにビクトリア国立標本館 (MEL) の SONDER コレクションの中から見つかり，分類学的な検討を行なった。本種は ENDLICHER (1843) によって記載され，標本は W.G. TILESIUS が長崎港で1805年4月に海底火山噴火後の打上げの中から採集したものである。標本の藻体には複子嚢があり，緑藻ではなく褐藻である。*Hydroclathrus* (カゴメノリ属) に所属すべきものと判断され，図版および標本とも *H. clathratus* (カゴメノリ) によく似ていた。髄細胞は直径 60–130 μm であり，複子嚢はほとんど単列で 3–7 細胞からなることから，*Talarodictyon tilesii* は *Hydroclathrus clathratus* であるとするのが最も妥当との結論となった。(* National Herbarium of Victoria, South Yarra, Vic. 3141, Australia; ** Department of Biology and Herbarium, University of Michigan, Ann Arbor, MI 48109, U.S.A.)

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Masahiro Notoya and Yusho Aruga: Tissue culture from the explant of stipe of *Eisenia bicyclis* (Kjellman) Setchell (Laminariales, Phaeophyta)

Key Index Words: Eisenia bicyclis—*Phaeophyta—tissue culture.*
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There have been reports of tissue culture in eleven species of Laminariales (Saga *et al.* 1978, Fries 1980, Fang *et al.* 1983, Saga and Sakai 1983, Yan 1984, Lee 1985, Polne-Fuller *et al.* 1986, Polne-Fuller and Gibor 1987, Notoya 1988, Heather *et al.* 1989, Notoya and Aruga 1989) (cf. Table 1). Among them it is reported that in *Laminaria japonica, Undaria pinnatifida* (Fang *et al.* 1983, Yan 1984) and *Ecklonia cava* (Notoya and Aruga 1989) sporophytes developed directly from callus which was formed from excised tissues, whereas in three species of *Laminaria, L. digitata, L. hyperborea* (Fries 1980) and *L. sacchrina* (Lee 1985), explants formed callus and the callus differentiated into aposporous male and female gametophytes, from which were formed sporophytes by fertilization. In *L. angustata*, Saga *et al.* (1978) reported that a single cell of the callus-like structure formed from a long-term cultured sporophyte blade developed to a sporophyte.

In this paper, we describe the culture of tissue excised from the stipe of *Eisenia bicyclis* (Kjellman) Setchell.

A sporophyte of *Eisenia bicyclis* was collected at Enoshima, Kanagawa Prefecture, on July 23, 1989. Tissues were excised from the stipe. The surface was cleaned up with paper towels. The sterilization procedures of the explants for tissue cultures were the same as described in a previous report (Notoya 1988).

Solid and liquid culture media were prepared using artificial seawater "Jamarin S" (Jamarin Laboratory) enriched with PESI medium (Tatewaki 1966). For the solid medium was used 1.5% bacto-agar (Difco Laboratories) in 60×10 mm Petri dishes. The cultures were incubated at 20°C and 500–1000 lux or at 15°C and 10000–12000 lux. The illumination was supplied by cool white fluorescent lamps under a photoperiod of 14L:10D. The liquid medium was renewed at one week intervals.

The explants of tissue from the stipe were cultured on the solid medium for a month at 20°C and 500–1000 lux. Filamentous cells began to grow on some explants in 1–2 weeks, and within 3 weeks they were observed on most explants. Massive filamentous cells were formed mainly on the medullary part (Fig. 1, A). Their development was morphologically very similar to those from tissues of *Ecklonia stolonifera* (Notoya 1988) and *E. cava* (Notoya and Aruga 1989) (Fig. 1, B). These filamentous callus-like cells became gradually long and dense. Then, the tissues with the filamentous callus-like cells were transferred into the liquid medium and cultured at 15°C and 10000–12000 lux or 20°C and 500–1000 lux. Massive filamentous cells grew slowly at 15°C and 10000–12000 lux in the liquid medium. These cells had very few, small pigments (Fig. 1, C), and their color was white or pale yellow.

After four months in liquid medium, a part of these massive filamentous cells was cut off from the original tissue, and cultured further under the same conditions. After another week, color of some cells of the massive filaments changed to yellow or brownish yellow, and shape of such cells became globular. Next week, some of the globular cells became more brownish and blade-like structures were observed after transverse cell

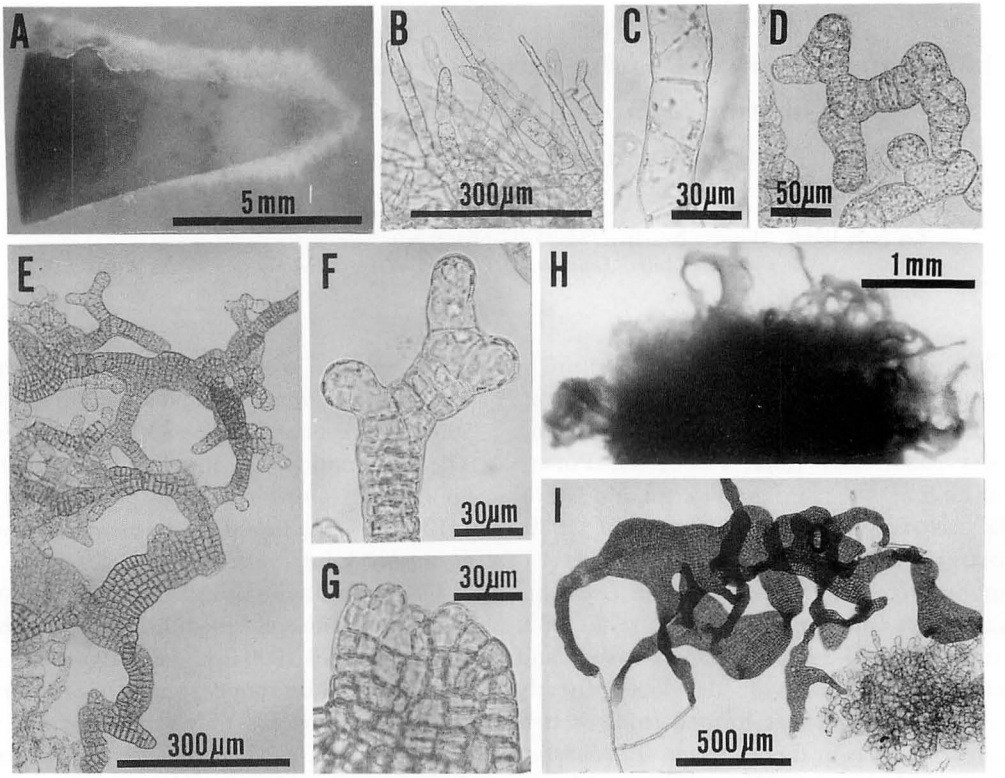

Fig. 1. Tissue culture from the stipe explant of *Eisenia bicyclis* (KJELLMAN) SETCHELL. (A) Filamentous callus-like cells formed on the explant mostly at medullary part one month after on the agar plate. (B) An enlarged part of the developed filamentous callus-like cells. (C) Pigments in developed filamentous callus-like cells. (D) Initial stage of blade-like plantlets developed from callus-like globular cells. (E) Blade-like plantlets formed by irregular cell divisions. (F) & (G) One cell or arranged cell lines on the apex of the blade-like plantlet. (H) A clump of callus with blade-like plantlets six months after in the liquid medium. (I) Formation of transparent rhizoidal cells on the tip of a blade-like plantlet.

divisions (Fig. 1, D). Thus, the initial stage of blade-like plantlets developed from callus-like cells was similar to that observed in *Ecklonia cava* (NOTOYA and ARUGA 1989). From the blade-like cell mass were formed irregularly shaped blade-like sporophytes by repeated transverse, longitudinal or irregular cell divisions (Fig. 1, E).

There were two types of cells at the apex of these plantlets, one cell or arranged lines of some cells (Fig. 1, F and G). These apex cells were distinguished from the blade-like cells by pigment content in the cell. They did not have so many pigments, and were more faint in color than the blade-like cells.

After the culture for six months in the liquid medium, the clump of callus with blade-like plantlets (sporophytes) grew to about 3 mm in diameter (Fig. 1, H). Transparent rhizoidal cells were observed at the tip of these irregular plantlets (Fig. 1, I).

The filamentous callus-like cells formed at 20°C and 500–1000 lux did not differentiate into blade-like plantlets within seven months of culture in the liquid medium.

From the above results, it seems that light intensity and/or temperature are very important factors for differentiation of callus into blade-like plantlet.

Blade tissues were used for the tissue culture of *E. cava* and most of other Laminariales species in which callus differentiated directly into blade-like plantlets (sporophytes) (FANG *et al.* 1983, SAGA *et al.* 1978, YAN 1984, NOTOYA and ARUGA 1989) (Table 1). In this study, however, stipe

Table 1. Results of tissue cultures in Laminariales seaweeds.

Species	Tissue	Result	Reference
Ecklonia stolonifera	Blade	Callus	NOTOYA 1988
E. stolonifera	Stipe	Callus	NOTOYA 1988
E. stolonifera	Haptera	Callus	NOTOYA 1988
E. cava	Blade	Callus→Sporophyte	NOTOYA & ARUGA 1989
E. radiata	Stipe	Callus	HEATHER *et al.* 1989
Egregia menziesii	Stipe	Callus	POLNE-FULLER & GIBOR 1987
Eisenia bicyclis	Stipe	Callus→Sporophyte	Present study
Laminaria angustata	Blade	*Callus→Sporophyte	SAGA *et al.* 1978
L. angustata	Stipe	Callus	SAGA & SAKAI 1983
L. digitata	Blade	Callus→♂ ♀ →Sporophyte	FRIES 1980
L. hyperborea	Blade	Callus→♂ ♀ →Sporophyte	FRIES 1980
L. japonica	Blade	Callus→Sporophyte	FANG *et al.* 1983
L. japonica	Blade	Callus→Sporophyte	YAN 1984
L. saccharina	Stipe	Callus→♂ ♀ →Sporophyte	LEE 1985
Macrocystis pyrifera	Stipe	Callus	POLNE-FULLER *et al.* 1986
Undaria pinnatifida	Blade	Callus→Sporophyte	FANG *et al.* 1983
U. pinnatifida	Blade	Callus→Sporophyte	YAN 1984

* Callus-like structure formed from cultured sporophyte blade.

tissues were used; from these tissues the filamentous callus was formed and the callus differentiated into plantlet like the sporophyte. This result suggests that cells of the stipe tissue possibly have totipotency in *Eisenia bicyclis*.

It was shown in this study that callus cells from the explant of *Eisenia bicyclis*, in a similar way as in *Ecklonia cava* (NOTOYA and ARUGA 1989), *Laminaria japonica* and *Undaria pinnatifida* (FANG *et al.* 1983, YAN 1984), directly differentiated into new sporophytes without forming aposporous gametophytes. This suggests the application of callus cells to micropropagation in these species.

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能登谷正浩・有賀祐勝：褐藻アラメの組織培養

アラメ *Eisenia bicyclis* (KJELLMAN) SETCHELL の茎状部を用いて組織培養を行なった。寒天培地上で 20°C·500–1000 lux (14L:10D) で約1か月間培養したところ，糸状のカルス様細胞の形成が認められた。これら組織片のついた糸状のカルス様細胞塊を液体培地に移し，15°C·10000–12000 lux (14L:10D) または 20°C·500–1000 lux (14L:10D) で培養したところ，前者の条件下では糸状のカルス様細胞は色素体の多い球形の細胞に発達し，それらの細胞から葉状体（胞子体）への分化が認められ，6か月後には仮根様細胞の形成まで認められた。しかし後者の条件下では葉状体への分化は認められなかった。(108 東京都港区港南4–5–7　東京水産大学藻類学研究室)

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大葉英雄：日本の水族館におけるイワヅタ類の展示

Hideo Ohba: Exhibition of Caulerpa plants in Japanese aquaria

Key Index Words: aquarium—Caulerpa—*Chlorophyta*—*exhibition.*
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最近，国内の水族館において，海産緑藻イワヅタ類 *Caulerpa* (Caulerpales, Chlorophyta) の生態展示が盛んに行われるようになってきた。これは海産動物の展示が海藻のような大型植物のまったくない，自然とは異なった水槽内で行われていた状態を改善するものである。かつて海藻を模した人造物を水槽内に配置した時期もあったが，それは展示生物の棲む天然の景観を演出することにはならず，逆に不自然な状態を印象づけた。イワヅタ類のような生きた海藻の水槽内の生育管理が可能になったことにより，以前に比べ，より自然な環境下での海産動物の展示が可能となった。展示されている種類も豊富であり，中には本邦には分布していない種類もある。そこで，全国の水族館におけるイワヅタ類の展示状況を調べるために，日本動物水族館協会に所属している全水族館（75館）にアンケートを依頼し，展示に用いられているイワヅタ類の種類，展示目的・方法などの情報を収集した。その結果をここに報告する。

アンケートは1989年7月～8月に実施した。アンケート項目は，①イワヅタ展示の有無，②展示しているイワヅタの種類，③採集場所あるいは購入先（社名[業種]，輸入品の場合，輸入先の国名），④導入した年月日，⑤展示の目的，⑥展示水槽の種類，⑦展示量，⑧補充回数（回／年），⑨展示による効果，⑩展示上あるいは生育管理上の問題点，⑪今後の展示の継続についてであった。アンケート回収数は67館（回収率89%）で，このうちイワヅタ類を展示したことのある水族館は20館（約30%）あり，現在も展示を継続している水族館は13館（約19%）であった。

20館で展示に用いたイワヅタ類は12種類であった (Table 1, Figs. 1–8, 10–13)。一部のものを除いて，種の同定は各水族館による。*Caulerpa prolifera* (Fig. 1)，ヘライワヅタ (Fig. 2)，フサイワヅタ (Fig. 3) などがよく展示に用いられている。最もよく展示されている *C. prolifera* は，本邦には分布しておらず，輸入業者などを通して原産地（大西洋，地中海など）から国内に輸入されたものである。なお，イワヅタ類は形態的に似たものが多く，例えばこの12種類の中では，①*C. prolifera* とイワヅタ，また②タカノハヅタ (Fig. 4) とイチイヅタ (Fig. 5) およびクロキヅタ (Fig. 6) はそれぞれよく混同される種であり，種の同定には注意を要する。実際，本調査でもイチイヅタをタカノハヅタと同定している例が，送付されてきたイワヅタの写真から判断された。

各水族館でのイワヅタ類の入手方法は，①鑑賞魚等販売店より購入（回答数12館：*C. prolifera,* ヘライワヅタ，ビャクシンヅタ，スリコギヅタ，センナリヅタ，タカノハヅタ，イチイヅタ，クロキヅタ），②各水族館間での生物交換（2館：*C. prolifera,* フサイワヅタ），③水族館周辺の海岸で採集（2館：ヘライワヅタ，フサイワヅタ，スリコギヅタ，エツキヅタ），④流入海水からの自然発生（1館：ヘライワヅタ，スリコギヅタ，タカツキヅタ，コケイワヅタ）で，約70%の水族館が鑑賞魚等販売店から購入している。聞き取り調査によれば，鑑賞魚等販売店では，上記の他に *C. macrodisca* (Fig. 9) を扱っている。*C. macrodisca* はインドネシア，フィリピンに分布する種であり，本邦からはその生育に関する報告がないので，やはり *C. prolifera* と同様に海外より輸入されたものと考えられる。なお *C. macrodisca* は，今のところ鑑賞魚等販売店で販売されているだけで，水族館での展示はまだ行われていない。

イワヅタ類の展示の開始年は，①1987年（7館），②1988年（3館），③1986年，1989年，（各2館），④1981年，1984年，1985年（各1館）で，特に1987年以後に盛んになってきている。また国内の水族館での *C. prolifera* の展示は，1984年から開始されている。

イワヅタ類を展示水槽内に導入した目的は，①より自然に近い景観を水槽内に作り出すこと（12館），②水質の改善，安定化として（2館），③展示動物の餌

Table 1. Species of *Caulerpa* exhibited in Japanese aquaria.

Species	Japanese name	
Caulerpa prolifera (Forsk.) Lamouroux		(8)*
C. brachypus Harvey	ヘライワヅタ	(7)
C. okamura Weber van Bosse	フサイワヅタ	(6)
C. cupressoides (Vahl) C. Agardh var. *cupressoides*	ビャクシンヅタ	(4)
C. racemosa (Forsk.) J. Agardh var. *laetevirens* (Mond.) Weber van Bosse	スリコギヅタ	(4)
C. sertularioides (Gmel.) Howe f. *longipes* (J. Ag.) Collins	タカノハヅタ	(4)
C. racemosa var. *clavifera* (Turn.) Weber van Bosse f. *macrophysa* (Kütz.) Weber van Bosse	センナリヅタ	(2)
C. scalpelliformis (R. Br. ex Turn.) C. Agardh var. *intermedia* Weber van Bosse	クロキヅタ	(2)
C. racemosa var. *peltata* (Lamx.) Eubank	タカツキヅタ	(1)
C. racemosa var. *chemnitzia* (Esper) Weber van Bosse	エツキヅタ	(1)
C. taxifolia (Vahl) C. Agardh	イチイヅタ	(1)
C. webbiana Montagne f. *tomentella* (Harv.) Weber van Bosse	コケイワヅタ	(1)

* Number of aquaria exhibiting *Caulerpas*.

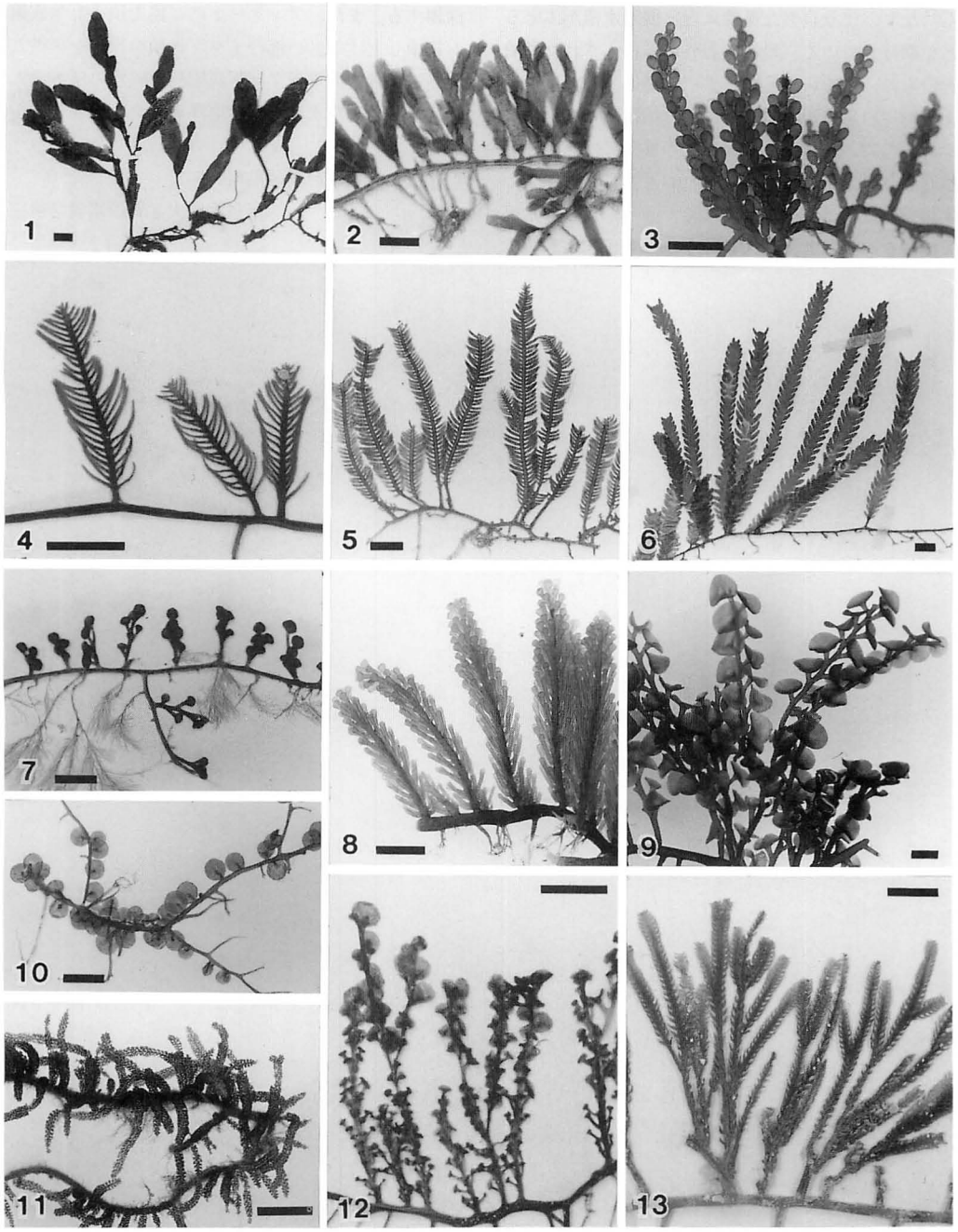
料として（2館），④展示動物休息場として（1館），⑤イワヅタ類そのものを見せるため（1館）などであった。約70%の水族館が，展示水槽内の環境をより自然に近いものにすることを目的としていた。イワヅタそのものを展示することを目的とした例ではヘライワヅタ，ビャクシンヅタ，センナリヅタ，クロキヅタが用いられていた。

イワヅタ類を展示水槽内に導入した効果について，①より自然に近い環境が作出でき，展示上の演出効果が上がった（14館），②展示動物の休息場となり，動物が落ち着いた（4館），③水質の浄化・安定化に対する効果があった（2館）といった回答があり，天然海藻の水槽内導入の効果は高いようである。一方，イワヅタ類を他の海産動物と一緒に展示することによって，次のような問題点も生じている。それは①イワヅタ類の藻体に付着し水槽内に導入された動植物が繁殖し，当初の目的を達成することができなかった（2館），②イワヅタ類が繁茂し過ぎて，本来の展示対象物を被ってしまった（1館），③イワヅタ類の生育を保つために，水槽底面の清掃や魚病治療用の投薬ができなくなった（1館）などである。

イワヅタ類の生育管理上の問題点あるいは留意点については，①水槽内の水温や照度がイワヅタ類の生育条件に合わず，枯死してしまう場合が多いので，生育環境条件をある程度厳密に制御する必要がある（9館），②イワヅタ類の藻体上に着生し，繁茂しやすい動植物（イソギンチャク類，珪藻類）が，イワヅタ類に付着し，藻体を汚したり枯死させたりするため，それらを繁殖させない対策が必要である（7館），③草食動物，縄張りを持つ習性の魚類および砂底に潜る習性の魚類と一緒に展示することは避ける（3館）といった回答が寄せられた。

水族館の展示に適したイワヅタ類の水槽内環境条件は，まだ充分に理解されていないようであり，生育管理自体に苦労している水族館も多い。例えば，水槽内の水温および照度の変化によって，展示中のイワヅタ類がすべて枯死してしまったという回答が7例あった。特に水温に関しては，① *C. prolifera* は18°C以下の低温になると枯死，②タカノハヅタは30°C以上の高温になると枯死，③クロキヅタおよびヘライワヅタは23°C以上になると成熟し，配偶子を放出して枯死するなどといった回答が見られた。こうしたことから，イワヅタ類の生育管理には対象種の分布域と天然における生育条件をよく把握し，一緒に展示する動物の生育条件も考慮した上で，種の選定および水槽内の環境条件の設定を行う必要がある。

現在，イワヅタ類を展示している水族館は，すべて今後も展示を継続して行く計画をもっており，さらに将来展示を予定している水族館も4館あった。水族館でのイワヅタ類の生育管理は，水槽内の環境条件さえ整えばそれほど難しいと思われないので，今後多くの水族館においてイワヅタ類をはじめとする海藻展示が



Figs. 1–13. Photos of *Caulerpa* species.
1. *C. prolifera* from Villefranche in France (SAP 037698). 2. *C. branchypus* from Shishikui, Tokusima Pref. 3. *C. okamura* from Iwaya, Hyogo, Pref. 4. *C. sertularioides* f. *longipes* from Nosoko-zaki, Ishigaki Isl., Okinawa Pref. 5. *C. taxifolia* from Ayamaru-misaki, Amami-oshima, Kagoshima Pref. 6. *C. scalpelliformis* var. *intermedia* from Oki, Shimane Pref. 7. *C. racemosa* var. *clavifera* f. *macrophysa* from Kabira, Ishigaki Isl. 8. *C. racemosa* var. *laetevirens* from Muroto-misaki, Kochi Pref. 9. *C. macrodisca* from a shop of aquarium fishes in Tokyo. 10. *C. racemosa* var. *peltata* from Ayamaru-misaki, Amami-oshima. 11. *C. racemosa* var. *chemnitzia* from Tamatori-zaki, Ishigaki Isl. 12. *C. cupressoides* var. *cupressoides* from Hirano, Ishigaki Isl. 13. *C. webbiana* f. *tomentella* from Ushuku, Amami-oshima.
Figs. 3, 8, 9, and 13 are living specimens and others are herbarium specimens. Scale: 10 mm.

盛んになり，より自然な条件に近い展示水槽がふえることを期待している。最後に海外から移入された動植物そのもの，あるいはそれと共に運び込まれた生物が日本国内で自然繁殖することによって生態系を乱すことがあるので，海外からの動植物の移入には充分注意を払う必要があることを付記しておく。

本稿を作成する機会を与えてくださり，さらに本稿のご校閲を賜った北海道大学理学部の吉田忠生教授に深謝する。また，アンケートにご協力頂いた水族館にお礼申し上げる。一部のイワヅタ類の標本を提供して下さった神戸大学理学部附属臨海実験所の榎本幸人教授，並びに東京水産大学の塩澤憲君にも感謝の意を表する。

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日本藻類学会第5回ワークショップ：海藻採集会参加記

The 5th Japanese Society of Phycology Workshop

The 5th Japanese Society of Phycology Workshop was held after the 14th Japanese Society of Phycology Symposium ended March 30, 1990 at Kobe Univeristy. The workshop was held at the Marine Biological Station of Kobe University at Iwaya, Awaji-cho, Tsuna-gun, Hyogo Ken, from March 31 to April 2, 1990. The main objective was collection of seaweeds in the Seto Inland Sea.

Workshop coodinator was Dr. Sachito Enomoto, Marine Station Director who was assisted by Dr. Tadao Yoshida (Hokkaido Univ.), Dr. Michio Masuda (Hokkaido Univ.), Dr. Tetsuro Ajisaka (Kyoto Univ.) and Dr. Hideo Ohba (Tokyo Univ. of Fisheries).

There were 11 participants: Shogo Arai (Seweed Research Lab), Jiro Tanaka (National Science Museum), Miyuki Maegawa (Mie Univ.), Tadahide Noro (Kagoshima Univ.), Isao Tsutsui (Kochi Univ.), Christine A. Orosco (Kochi Univ.), Mitsunobu Kamiya (Tsukuba Univ.), Daisuke Honda (Tsukuba Univ.), Kouichi Nakanishi (Tokyo Univ.), Patricia L. G. Kodaka (Tohoku Univ.) and Masafumi Iima (Nagasaki Univ.).

Upon arrival at the Marine Station in late afternoon of March 30, some of the participants went along the coast of Iwaya and collected some drift algae.

The group went out to Takeshima and Kameshima Islands on board the 8.5 t research vessel, Onokoro on March 31. Collected seaweeds were processed and identified.

The scheduled trip to Bisanseto on April 1 was cancelled when the boat had to turn back to the Marine Station due to very thick fog. Instead, collcection was done in Yura along the southeast coasts of Awajishima. The intertidal area provided a wide assortment of algae. It was also the site of commercial collection and drying of the agarophyte, *Gelidium*. Discussions and comparions of the Seto Inland Sea samples with those of other areas in Japan continued well into the night.

The weather had considerably improved the next day (April 2) to push through with the trip to Bisanseto. *Ulva, Sargassum, Gracilaria* and other species abounded in Megashima Island. Some endemic species were also collected.

A total of 107 species belonging to 70 generea were collected. These were:

Chlorophyceae (10 genera, 14 species):
Collinsiella cava, Ulothrix sp., *Monostroma nitidum, Blidingia minima, Ulva conglobta, U. per-*

Fig. 1. Workshop participants and marine station staff in Yura, Awajima.

Fig. 2. Participants on board "Onokoro" returning from the collection trip to Bisanseto.

tusa, Cladophora opaca, C. sakaii, Valonia macrophysa, Bryopsis plumosa, B. sp., *Caulerpa okamurae, Codium divaricatum, C. fragile.*

Phaeophycae (20 genera, 31 species):
Ectocarpus sp., *Papenfussiella kuromo, Ishige okamurae, I. sinicola, Leathesia difformis, Petrospongium rugosum, Colpomenia bullosa, C. sinuosa, Petalonia fascia, Scytosiphon lomentaria, Punctaria* sp., *Cutleria cylindrica, Desmarestia viridis, Undaria pinnatifida, Ecklonia cava, E. kurome, Dictyopteris latiuscula, D. prolifera, D. undulata, Dictyota maxima, Dilophus okamurae, Pachydictyon coriaceum, Spatoglossum pacificum, Hizikia fusiformis, Sargassum filicinum, S. hemiphyllum, S. horneri, S. micracanthum, S. muticum, S. ringgoldianum, S. thunbergii.*

Rhodophyceae (40 genera, 62 species):
Bangia atropurpurea, Porphyra dentata, P. tenuipedalis?, P. suborbiculata, P. yezoensis, Gelidium amansii, G. divaricatum, G. japonicum, G. pusillum, G. sp., *Dudresnaya japonica, Hyalosiphonia caespitosa, Amphiroa beauvoisii, Corallina pilulifera, Carpopeltis prolifera, Grateloupia filicina, G. imbricata, G. turuturu, Pachymeniopsis elliptica, P. lanceolata, Polyopes polyideoides, Prionitis ramosissima, Gloiosiphonia capillaris, Gloiopeltis furcata, Callophyllis japonica, Schizymenia dubyi, Halarachnion latissimum, Solieria mollis, Caulacanthus okamurae, Plocamium leptophyllum, P. telfairiae, Hypnea variabilis, Gracilaria chorda, G. textorii, G. verrucosa, Gymnogongrus divaricatus, G. flabelliformis, Chondrus giganteus, C. ocellatus, Gigartina intermedia, G. teedii, G. tenella, Chrysymenia wrightii, Binghamia californica, Lomentaria catenata, L. hakodatensis, Antithamnion defectum, Ceramium boydenii, C. kondoi, Platythamnion yezoense, Acrosorium flabellatum, Sorella repens, Dasya* sp., *Heterosiphonia japonica, Chondria crassicaulis, C. tenuissima, Laurencia intermedia, Neorhodomela munita, Polysiphonia japonica, P. urceolata, Symphyocladia marchantioides, S. pennata.*

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日本藻類学会秋季シンポジウム講演要旨

1) 紅藻の生育水深と紫外線

前川行幸（三重大・生物資源）

三重県志摩半島沿岸の低潮線付近の浅所および水深25–30 mの深所から採取したいくつかの紅藻について，光合成や光合成色素の特性および紫外線吸収物質の分布などを測定し，紫外線も含めた光環境の面から紅藻の垂直分布特性を解明しようとした。

可視光域 (400–700 nm) の光環境からみた場合，太陽光に近い白色光と水深25 m付近の波長特性に近似させた緑色光の下で光合成–光曲線を求めたところ，浅所産のものは白色光を，深所産のものは緑色光を効率よく光合成に利用していた。これはクロロフィル*a*に対するフィコエリスリンの含有比 (PE/Chl.*a*) が，浅所産のものでは1–4であるのに対し，深所産のものでは4–9と高いためである。すなわち，浅所産および深所産紅藻はそれぞれの生育水深の光環境によく適応した光合成特性と色素特性を持っていた。

次に，深所の紅藻が浅所に生育できない理由を明らかにするため，紫外線による光合成の阻害と紅藻や藍藻特有に含まれる紫外線吸収物質を考えた。紫外線は水中では急激に吸収されるが，水深5 mでも水面の約10%程度あり，これまで考えられていた以上に紫外線は水中に透過する。紫外線や強光が紅藻の光合成に及ぼす影響を測定したところ，浅所産のものは阻害の程度が少なく，生育水深が深くなるにつれ阻害が顕著に現れた。特に水深25–35 mから採取された深所産紅藻では，紫外線を含む太陽からの直射光を数10分照射しただけで光合成活性は失われた。

紫外線吸収物質の生態学的な役割を明らかにするため，様々な水深から採取された紅藻について紫外部吸光度を測定し，紫外線吸収物質の量を比較した。その結果，水深5 m以浅の浅所から採取された紅藻には紫外線吸収物質が多量に含まれているのに対し，水深25–30 mから採取された深所産紅藻にはごくわずかしか含まれておらず，紫外線吸収物質が検出されない種類もいくつかあった。水深2 mの浅所から採取されたミゾオゴノリと水深25 mから採取されたトサカノリを用いて，0–10 mの範囲で移植実験を行ったところ，いずれの場合にも浅所に移植されたものは紫外線吸収物質が増加し，深い場所に移植されたものについては紫外線吸収物質は減少した。

これらのことから，紫外線吸収物質は浅所の強い紫外線から藻体を保護する役割があると考えられ，紫外線吸収物質をほとんど持たない，もしくはまったく持たない深所の紅藻は，浅所では生育できないものと考えられた。

2) 海洋における藻類の炭酸カルシウム沈着と地球環境

岡崎恵視（東京学芸大）

大気中のCO_2濃度は現在では340 ppmであるが，過去200年間に確実に増加しており，21世紀末には560 ppmに達すると予測されている。その結果，CO_2の「温室効果」によって地球の平均温度は3°C上昇し，海水面は平均65 cm上昇すると予想され世界的に危惧されている。現在の大気中には，地球に存在する炭素量のわずか0.001%しか存在せず，海洋にはその56倍，堆積石灰岩中には9万倍の炭素が存在している。しかし原始大気は97%ものCO_2を含み，現在の金星，火星の大気組成と類似していたが，地球には液体の水が存在できたことから，CO_2はこれに溶け，海洋で石灰岩が形成され，この中にCO_2が包埋されたと推定されている。この過程では，十数億年の海洋生物による石灰化が重要な役割を演じたとされている。海洋での石灰化は，主に石灰藻，珊瑚虫，有孔虫及び軟体動物などによって行われている。これらの生物は海水中 (pH 8.2) に豊富に存在するHCO_3^-を使い，

$$2HCO_3^- + Ca^{2+} \longrightarrow CaCO_3 + H_2O + CO_2$$

なる反応で炭酸カルシウムを形成する。石灰藻や，体内に共生藻をもつ珊瑚虫や有孔虫の場合は，この反応は光合成と共役しており，光合成のCO_2固定が石灰化の駆動力となっている。大型石灰藻の場合には，外部海水から隔離された石灰化の為の「半閉鎖空間」が存在し，上記反応を確実なものとしている。現在の海洋で，これらの生物による年間の石灰化量については詳細は不明である。最近，人工衛星のCZCS像による円石藻類（ハプト植物門）の赤潮の研究から，北西ヨーロッパの大陸棚では，少なくとも年間32万トンのCO_2が炭酸カルシウムとして，*Emiliania huxleyi*によって沈着されていると推定されている。また珊瑚礁での石灰化量は，CO_2に換算して年間6.2〜62億トンと試算されており，これは年間の化石燃料消費量（約200

億トンのCO_2量）の3～30%にも相当する。海洋での石灰化は，前述の式で示されるように，石灰化が進行すれば，海水に溶存しているHCO_3^-から大気中に逆にCO_2が放出されることになる。石灰藻や珊瑚虫は，このCO_2を光合成により有機物中に固定するので，石灰化時には問題にならない。しかし，この有機物の一部は，いずれは海水中で分解され，CO_2となるとすれば，どの程度分解されずに留まるかが，海洋生物の石灰化の意義を論ずる上で重要な点となる。

—学 会 録 事—

1. 1991・92年度会長及び評議員選挙

去る8月28日に投票用紙と選挙人名簿を発送し，次期会長と評議員の選挙を実施した。9月15日に投票を締め切り，9月17日に石川依久子・岡崎恵視（東京学芸大学）両氏の立会いのもとに開票が行われ，次の方々が選出された。

会　長　有賀祐勝

評議員　舘脇正和・増田道夫（北海道地区）
小河久朗（東北地区）
井上　勲・山岸高旺・渡辺　信（関東地区）
石川依久子・福島　博（東京地区）
岩崎英雄・喜田和四郎（中部地区）
榎本幸人・中原紘之（近畿地区）
大野正夫・月舘潤一（中国・四国地区）
香村真徳・右田清治（九州地区）

2. 日本藻類学会秋季シンポジウムと懇談会

1990年10月1日，日本植物学会第55回大会関連集会として日本藻類学会秋季シンポジウムが横浜康継（筑波大学）・片山舒康（東京学芸大学）の両氏を世話人にして，静岡市のクーポール会館で開催された。座長は有賀祐勝氏（東京水産大学）で，前川行幸氏（三重大学）による「紅藻の生育深度と紫外線」と，岡崎恵視氏（東京学芸大学）による「海洋における藻類の炭酸カルシウム沈着と地球環境」の2つの講演があった。全国から60名の参加者があり，1時間半にわたって講演と活発な論議が行われた。

シンポジウム終了後，引き続いて同会館において懇親会が開催された。会は世話人の横浜康継氏の開会の辞に始まり，小林　弘会長の挨拶と地元静岡の山田信夫氏（東海大学）の乾杯の音頭で幕を開け，料理を楽しみながら2時間近くにわたってなごやかに行われた。

シンポジウム参加者は次の通り（○印は懇親会出席者）。

秋岡英承，○鯵坂哲朗，足立恭子，○有賀祐勝，石上三雄，○石川依久子，○市村輝宜，○出井雅彦，○井上　勲，猪熊正則，○恵良田真由美，○太田雅隆，大森長朗，○岡崎恵視，○奥田武男，○高 坤 山，○加崎英男，○片山舒康，○川井浩史，○河合正充，○小亀一弘，○小林　弘，○坂西芳彦，○澤口友宏，○白岩善博，新庄尚史，○鈴木章方，○瀬戸良三，立沢秀高，○都築幹夫，○徳田　廣，○長島秀行，○中西弘一，根木由美子○野崎久義，○能登谷正浩，○馬場將輔，○原　慶明，○福田育二郎，○藤田大介，○本多大輔，○前川行幸，正置富太郎，増田道夫，○松本正喜，○真部永地，○真山茂樹，マリベル・ディオニシオ・セセ，○三浦昭雄，三浦有樹，○御園生拓，○本村泰三，山内貞次，○山岸高旺，山田尚志，○山田信夫，○山中良一，山本正之，○横浜康継，○渡辺　信（50音順）

横浜康継・片山舒康氏には，会場の手配から当日の運営にわたる全てに行き届いた配慮を頂いた。記してお礼を申し上げる。

日本藻類学会編集委員会移転のお知らせ

1991年1月1日から編集委員会の宛先が変ります。1991・1992年度は，「藻類」への投稿原稿の送付ならびに編集関係の連絡は下記宛にお願いします。

〒184 小金井市貫井北町4-1-1
東京学芸大学教育学部生物学教室内
日本藻類学会編集委員会　Tel. 0423-25-2111（内線 2665, 2672, 2667）

Change of Address of the Editor

The new Editor of the Japanese Journal of Phycology for 1991–1992 is Prof. Ikuko Shihira-Ishikawa, Tokyo Gakugei University. Starting in January 1991, manuscript to the Journal and related correspondence should be addressed to:

Prof. Ikuko Shihira-Ishikawa
Department of Biology,
Tokyo Gakugei University,
Nukuikita-machi, Koganei-shi,
184 Japan

—会 員 移 動—
新　人　会

住 所 変 更

訃　　報

本会会員　竹本常松氏は去る1989年1月23日逝去されました。謹んで哀悼の意を表します。　日本藻類学会

本会会員　遠藤光治郎氏は去る1989年8月20日に逝去されました。謹んで哀悼の意を表します。日本藻類学会

お 知 ら せ

第4回国際藻類学会議
Fourth International Phycological Congress

第4回国際藻類学会議は**1991年8月4–10日**にアメリカ North Carolina 州 Durham の Duke University で開催されます。会議では15の Symposia と contributed paper の session および会期前後の excursions が計画されています。

参加される方は下記の事務局に直接申込むか，日本交通公社に代行を委託してください。登録料は1991年2月1日までは270ドル，それ以後は340ドルとなっています。申込み用紙は Second Circular についています。

事務局 The Secretariat
Fourth International Phycological Congress
Department of Botany
Duke University
Durham, North Carolina
U.S.A. 27706
Tel (919) 684–3375 (Searles)
Fax (919) 684–5412 (Searles)

なお，日本では日本交通公社を Official Travel Agent に指定することにしました。会員には日本交通公社からの連絡が届く筈ですが，サーキュラーの請求や登録の代行などを含めて，お問合せは次のところにお願いします。

〒100 東京都千代田区麹町4–3–5
日本交通公社 麹町支店
国際会議センター
担当：石井・花山
Tel 03–239–9286
FAX 03–239–9285

（北大・理 吉田忠生）

第14回国際海藻シンポジウム
XIVth International Seweed Symposium

第14回国際海藻シンポジウムは，**1992年8月16–21日**にフランスのブルターニュ地方で開催されます。16–18日はブレストで，また19–21日はサンマローに移動して行われます。本シンポジウムには，全体講演，招待者による特別セッション（“ミニシンポジウム”），通常発表，ポスター発表，ワークショップ，海藻製品の展示などが含まれています。現在ならびに将来利用可能な大型藻と微細藻の生物学，これら藻類及びその製品の開発と利用などが中心テーマとなります。また，シンポジウム中日のエクスカーションのほか，シンポジウム前後のブルターニュ地方・北ヨーロッパ・地中海地方などへのエクスカーション，同伴者のための特別プログラムが検討されています。セカンドサーキュラーその他の案内を御希望の方は，下記事務局宛にご連絡ください。セカンドサーキュラー申込用紙は，東京水産大学藻類学研究室にもあります。

事務局 The Secretariat
XIVth International Seaweed Symposium
Universitate de Bretange Occidentale
Institut d'Etudes Marines–Faculté des Sciences
29287 Brest–CEDEX France

Tel. 98–31–74–41 または 98–31–61–29
FAX 98–31–61–31

（東京水産大 有賀祐勝）

Acknowledgements to reviewers for Vol. 38

The Editorial Board is grateful to the following persons for their cooperation in reviewing the manuscripts submitted to the Japanese Journal of Phycology Volume 38.

S. ENOMOTO, Y. HARA, T. HORI, T. ICHIMURA, I. INOUYE, W. KITA, H. KITO, H. KOBAYASI, M. MAEGAWA, M. MASUDA, A. MIURA, K. NISIZAWA, H. NODA, M. NOTOYA, M. OHNO, T. OKUDA, N. SAGA, Y. SAITO, I. SHIHIRA-ISHIKAWA, F. B. SOTTO, E. TAKAHASHI, M. TAKAHASHI, J. TANAKA, M. TATEWAKI, M. M. WATANABE, H. YABU, I. YAMADA, Y. YAMAGUCHI, Y. YOKOHAMA, T. YOSHIDA, M. YOSHIZAKI

正 誤 表 Errata

（第38巻 第3号 Vol. 38 No. 3）

	誤 For	正 Read
Front cover (Contents), L. 4	Masakazu Terawaki	Masakazu Tatewaki
Back cover（目次), L. 15	中島 泰	中嶋 泰
p. 273 left, L. 4 from bottom	wrightii	*wrightii*
p. 275 left, L. 1 from bottom	MACRAILD	MACRAILD
p. 286 right, L. 3 from bottom	べんであまのり	べんてんあまのり
p. 299 left, L. 9 from bottom	(J. AGARDH)	(C. AGARDH)
p. 302 left, L. 1	Menez	Meñez
p. 302 left, L. 14	KAMURA	OKAMURA
p. 302 left, L. 13 from bottom	あみごろも属	べにあみごろも属
p. 302 left, L. 11 from bottom	あみごろも	べにあみごろも
p. 313 right, L. 19	Fac. Hokkaido	Fac. Sci. Hokkaido
p. 317 middle, L. 10 from bottom	あみごろも属, **302**	(削除 delete)
p. 319 right, add between L. 18 & L. 19 from bottom		べにあみごろも属, **302**

日本学術会議だより　No.19

「創薬基礎科学研究の推進について(勧告)」を採択

平成2年11月　日本学術会議広報委員会

日本学術会議は，去る10月17日から19日まで，第110回総会を開催しました。今回の日本学術会議だよりでは，その総会で採択された勧告等を中心に，同総会の議事内容等についてお知らせします。

日本学術会議第110回総会報告

日本学術会議第110回総会（第14期・第6回）は，平成2年10月17～19日の3日間開催された。

1　総会第1日目の冒頭に，先に逝去された，時永淑会員（第3部）及び大谷茂盛会員（第5部）を追悼して黙禱を捧げた。続いて，会長からの経過報告，各部・委員会報告の後，内規改正，勧告，対外報告の3案件の提案説明が行われた。これらの案件については，同日の午後の各部会での審議を経た上で，第2日目の午前中に審議・採択された。

2　今回総会で採択された事項は次のとおりである。

(1)日本学術会議の運営の細則に関する内規の一部改正

本件は，①来年春の第14期最後の総会が5月（通常は4月）開催になったことに伴い，「副会長世話担当研究連絡委員会の運営に関する総会決定」の適用期間を，1か月間延長するとともに，②第14期限りの措置として，地球圏－生物圏国際協同研究計画(IGBP)のフォローアップ組織として，地理学研究連絡委員会に「IGBP専門委員会」を設置するために，関係各部等の研究連絡委員会委員定数について必要な処理を行ったものである。

(2)創薬基礎科学研究の推進について(勧告)

本件は，薬科学系の3研究連絡委員会と薬理学研究連絡委員会が従来からの検討結果を勧告案として取りまとめ，第7部提案として，今回総会に付議したものである（この勧告の詳細は，別掲参照)。この勧告は，同日午後直ちに内閣総理大臣に提出され，関係省庁に送付された。

(3)第6常置委員会報告－外国人研究者・大学院留学生受入れに関する問題点と改善の方策について－

本件は，第6常置委員会が，今期の重要課題の一つとして審議を重ねてきた結果を「対外報告」として取りまとめたものを，外部に発表することについて承認したものである（この報告の詳細は，別掲参照)。

3　以上の諸報告及び提案審議のほかに，特に，近藤会長から，前回総会で討議された南アフリカ共和国科学者の我が国入国をめぐる諸問題については，その後，外務省と折衝した結果，ビザ発給手続きの合理化措置が講じられ，国際学術連合会議(ICSU)の理解が得られたとの報告があった。また，提案事項採決後行われた自由討議では，大学等高等教育関係予算拡充問題，遺伝子操作に関する法規制問題等について意見交換が行われた。

4　第2日目午後には，「特別委員会審議状況報告に基づく意見交換」が開催された（この意見交換の詳細は，別掲参照)。また，第3日目の午前中には各特別委員会が，午後には各常置委員会がそれぞれ開催された。

創薬基礎科学研究の推進について(勧告)

(勧告本文)

優れた医薬の創製すなわち創薬の研究は，空前の老齢化社会を目前にして，健やかな長寿を目指す健康社会実現のため，さらには国際的立場から地球上の全人類の福祉に貢献するため，我が国にとって大きな意味を持つものである。特に，多くの成人病，老年病，またエイズやいわゆる難病等についての的確な予防薬・治療薬の創製が待望されている。しかしながら，これらの疾患に対する優れた医薬の創製は世界的にみて，医薬創製のよりどころとなるべき基礎理論，研究技術の発展が十分でないため遅々として進んでいない。

とりわけ我が国は先進国の一角を占めているとはいえ，大学，企業，公的研究機関共に，ひとつの疾患の予防・治療に変革をもたらし得るほどの画期的医薬創製の実績に乏しく，国の内外から研究態勢の遅れが指摘されている。とはいえ，最近のバイオサイエンス分野の急速な展開と，我が国科学者のこの方面での活躍の実績をみるならば，学際的な創薬基礎科学研究の推進を図り，これによって人類の福祉向上に貢献することは，現下の我が国にとって緊要の課題である。

このため，早急に創薬基礎科学研究の推進組織を設け，これを核とした強力かつ広範な研究態勢の確立を図るべきである。これに当たっては，医薬の創製における倫理の尊重を基本理念とし，生体機構及び病態の解析研究とそれに基づいた独創的・画期的医薬の創製を指向する分子設計並びに薬効・安全性評価の基礎理論の樹立，さらに薬効・安全性の測定技術・ヒトの病態のシミュレーション技術等，各種の新技術の開発研究を特に重視すべきである。

この研究推進組織の設置には，関係省庁が関与すると共に，地方自治体，大学及び民間の参画を可能とし，また，関連科学各分野の学際的なネットワークを構築するなど多次元的な協力と交流による研究の推進を図るため，格段の効果的措置を講じ得る形態とすべきである。

日本学術会議は，創薬基礎科学研究の推進を図るため，上記の趣旨に基づいて必要な施策を速やかに講ずるよう勧告する。

第6常置委員会報告－外国人研究者・大学院留学生受入れに関する問題点と改善の方策について－(要旨)

(平成2年10月18日　第110回総会承認)

外国人研究者・大学院留学生の受入れを促進するうえで，言語，研究環境，外国人研究者の任用，大学院留学生の学位，外国人研究者・大学院留学生の選考が問題になる。

日本語能力は研究の対象とする学問分野や研究課題との関係が留意されねばならない。分野によっては，日本語能力は日常生活に必要なもので足り，研究のためには英語の能力が必須である。研究者の受入れに当たり，その研究に耐え得る日本語又は英語の能力を備えているかを十分に審査しておくことが，研究を実りあるものとするために必要である。

貧弱な研究設備のまま，また十分な研究費を持たないままで外国人研究者を受け入れる事は受け入れた外国人研究者を失望させるだけでなく，日本人研究者の研究を阻害する。また劣悪な居住環境や，事務局等の対応組織の不備も，外国人研究者の研究活動を妨げる。国は，研究環境を整備することに対して十分な予算措置を講ずべきである。

我が国の大学における外国人研究者の任用は，その道が開かれているとはいえ，まだ十分でない。外国人研究者の任用に関して広く情報を提供する機関の設置，あるいは大学等において外国人研究者を一定数受け入れる体制の確立が望まれる。

大学院留学生の博士学位の取得は，帰国後の処遇と関係して問題となっている。受入れ大学院において，博士学位の取得促進につき一層の改善努力が払われることが期待される。

外国人研究者の選考については，受入れ側が研究者の素質をよく理解し，公正な基準によって行うことが大切である。大学院留学生については，素質の多様化と学生数の急増に伴い多くの問題が生じており，その選考方法に対し抜本的改善が要望される。

解剖学研究連絡委員会報告－日本における解剖学の教育と研究（現状の考察と将来への展望)－(要旨)

(平成2年9月21日　第758回運営審議会承認)

自然科学の急速な発展に伴い，医学部・医科大学における教育・研究・診療のすべての分野に，大きな変化が生じた。すなわち研究手法の開発，研究機器の発達により，既存の学問領域の進歩に加えて，新たな学問分野が分化し，教育内容は多様化すると共に著しく増大した。さらに人口の増加と高齢化，経済の成長など種々の社会的要因の変化も複合されて，医学における教育と研究の重点と目標にも変化が生じた。それらは，これまで医学の基礎を形成して来た伝統的な講座に，とりわけ強い影響を与え，その在り方について検討し，改善をはかる必要性を生じさせた。

本報告は，このような状況を踏まえ，我が国における解剖学の教育と研究について，現状を考察し，今後の在り方に関する指針をまとめたものである。報告では，解剖学の定義と使命，医学教育と研究における解剖学，解剖学教室の構成，解剖学者の養成，医学部他教室及び社会との関係などの，現状と問題点について検討し，医学の変貌に対処すべき改善の方途を明らかにすると共に，将来に向けての展望が示唆された。

総会中の「特別委員会審議状況報告に基づく意見交換」

今回総会の第2日目の午後には，1時から4時間にわたって「特別委員会審議状況報告に基づく意見交換」が行われた。従来この時間帯には，その時々の学術上の重要課題を取り上げて，会員による「自由討議」が行われてきた。今回は，これに代わり，第14期も2年余を経過し，余すところ9か月足らずとなったこの機会に，今期の当初に決定された第14期活動計画において，「緊急に調査審議を行って第14期中に適切な形で報告・提言を取りまとめるべき課題」ごとに設置された各特別委員会から，今までの審議状況を報告してもらい，それに基いて会員間の意見交換を行って，各特別委員会の今後の審議の参考に供することにしたものである。

1　まず最初に，医療技術と社会に関する特別委員会の水越治委員長（第7部）から，同委員会における「脳死をめぐる問題」に関する審議の経過を取りまとめた「中間まとめ」について報告がなされた後，「日本人の国民性に根ざした死の概念との関わり」，「臓器移植を必要とする患者と臓器提供者の需給関係の問題」，「死の認定基準のあり方」，「前期の学術会議における脳死問題に関する審議状況との関係」等について意見交換が行われた。

2　次に，農業・農村問題特別委員会の水間豊委員長（第6部）から，同委員会が今後取りまとめることを予定している「農業・農村のもつ今日的意義と課題(仮題)」の概要について報告がなされた後，「他の先進諸国の農業との比較の必要性」，「国内外の政治との関わり」，「世界の食糧問題に対する日本農業の果すべき役割」，「他産業を絡めた農業・農村の振興策」等について意見交換が行われた。

3　最後に，人間活動と地球環境に関する特別委員会の吉野正敏委員長（第4部）から，同委員会が現在取りまとめを行っている「人間活動と地球環境に関する日本学術会議の見解(案)」について報告がなされた後，「地球環境教育の重要性」，「国際学術協力事業等国際的対応のあり方」，「医学・保健問題との関わり」，「地球環境保全と経済成長との関係」，「南北問題との関わり」等について意見交換が行われた。

第15期日本学術会議会員選出のための登録学術団体の概況

本会議では，現在第15期（平成3年7月22日～平成6年7月21日）会員（定員210人）選出のための手続きが進められているが，先般6月末日を締切期限として，学術研究団体からの登録申請が受け付けられた。その後日本学術会議会員推薦管理会で審査が行われ，結果は次のとおりであった。

学術研究団体の登録申請の審査結果
　申請団体数…… 952団体
　登録団体数…… 915団体

※日本学術会議会員推薦管理会が登録した915団体名は，日本学術会議月報平成2年12月号に掲載されるので，御参照願いたい。

御意見・お問い合わせ等がありましたら，下記までお寄せください。
〒106 東京都港区六本木7-22-34
日本学術会議広報委員会　電話03(403)6291

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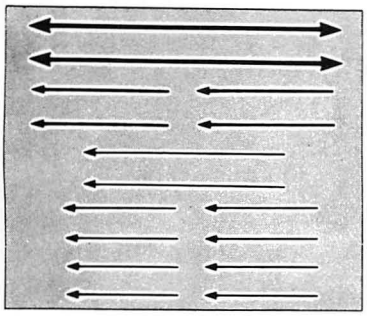

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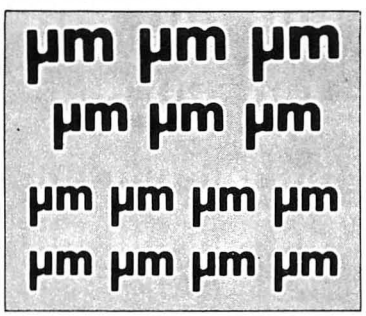

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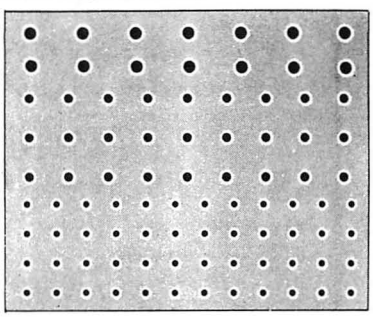

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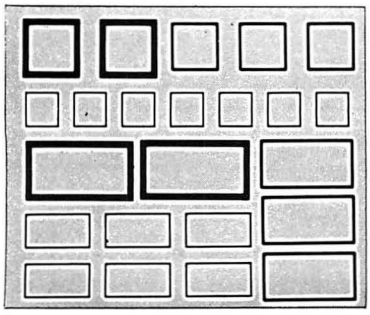

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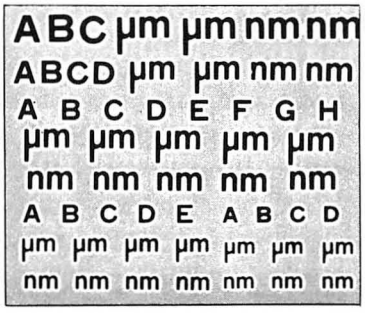

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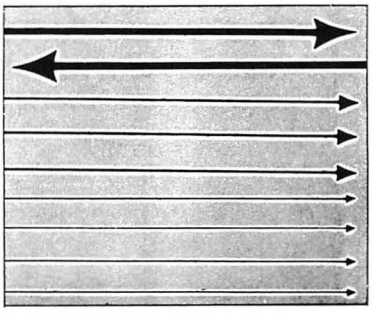

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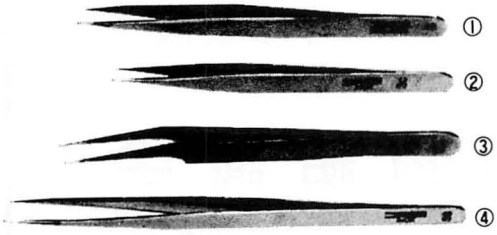

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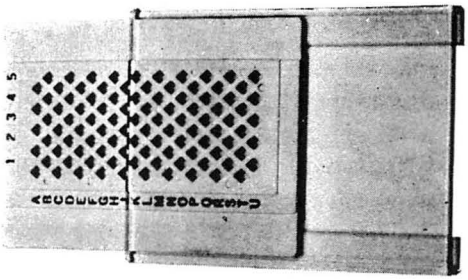

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2. 「藻類」索引　1—10巻，価格，会員1,500円，非会員2,000円，11—20巻，会員2,000円，非会員3,000円，創立30周年記念「藻類」索引，1—30巻，会員3,000円，非会員4,000円。

3. 山田幸男先生追悼号　藻類25巻増補．1977．A5版，xxviii＋418頁．山田先生の遺影・経歴・業績一覧・追悼文及び内外の藻類学者より寄稿された論文50編（英文26，和文24）を掲載，価格7,000円。

4. 日米科学セミナー記録　Contributions to the systematics of the benthic marine algae of the North Pacific. I. A. Abbott・黒木宗尚共編．1972．B5版，xiv＋280頁，6図版．昭和46年8月に札幌で開催された北太平洋産海藻に関する日米科学セミナーの記録で，20編の研究報告（英文）を掲載。価格4,000円。

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

Publications of the Society

Inquiries concerning copies of the following publications should be sent to the **Japanese Society of Phycology, Shimotachiuri Ogawa Higashi, Kamikyoku, Kyoto, 602 Japan.**

1. **Back numbers of the Japanese Journal of Phycology** (Vols. 1–28, Bulletin of Japanese Society of Phycology). Price, 2,000 Yen per issue for member, or 3, 500 Yen per issue for nonmember; price of Vol. 30, No. 4 (30th Anniversary Issue), with cumulative index (Vols. 1–30), 6,000 Yen for member, or 7,500 Yen for nonmember (incl. postage, surface mail). Lack: Vol. 1, Nos. 1–2; Vol. 4, Nos. 1, 3; Vol. 5, Nos. 1–2; Vol. 6–Vol. 9, Nos. 1–3.

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

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

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

5. **Recent Studies on the Cultivation of *Laminaria* in Hokkaido** (in Japanese). 1977. 65 pages. Four papers followed by discussion are included, which were presented in a symposium on *Laminaria*, sponsored by the Society, held in Sapporo, September 1977. 1,200 Yen (incl. postage, surface mail).

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