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The Japanese Journal of PHYCOLOGY

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Miscellanea

THE JAPANESE SOCIETY OF PHYCOLOGY

日 本 藻 類 学 会

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

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

The Japanese Society of Phycology

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 (1993) 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. I. Shihira-Ishikawa, Department of Biology, Tokyo Gakugei University, Nukuikita-machi, Koganei-shi, Tokyo,184 Japan.**

Important Announcement

The Japanese society of Phycology publishes quarterly the English edition "*Phycological Research*" succeeding *The Japanese Journal of Phycology* from 1995. All of the individual members of the Society will receive the edition directly from the publisher, Blackwell Science. The Society also publishes the Japanese edition "*Sorui*" (*The Japanese Journal of Phycology*) (3 nos. a year), containing original articles and various topics written in Japanese. Those individual members who wish to receive the Japanese edition are kindly requested to write to the Society. For those other than the individual members of the Society, the annual subscription for *Phycological Research* (US $170.00) should be sent to the publisher. The non-member annual subscription for the Japanese edition *Sorui* (US $90.00) should be sent to the Society.

Address of the publisher of *Phycological Research*:

Blackwell Science
PO Box 378, Carlton South, Victoria 3053, Australia
Telephone (+61 3) 347 0300 Facsimile (+61 3) 347 5001

Address of the Society from January 1, 1995:

The Japanese Society of Phycology
c/o Dr. Taiju Kitayama
National Science Museum
Hyakunincho 3-23-1, Shinjuku-ku, Tokyo, 169 Japan
Telephone (+81) 3 3364 7136 Facsimile (+81) 3 3364 7104

Changes of the fromert and instructions for the new jouranal, "Phycological Research", are on pages 448–450.

お　知　ら　せ

本誌「藻類」(The Japanese Journal of Phycolgy) は，明1995年から英文誌 "Phycological Research" と和文誌 "藻類 (The Japanese Jouranal of Phycology)" に分割されます。"Phycological Research" は年4回（4号）刊行され，出版社 Blackwell Science から会員に直接送付されます。また，"藻類" は年3回（3号）刊行され，学会事務局から国内会員に送付されます。非会員の "Phycological Research" の購読料は年17,000円，"藻類" の購読料は年9,000円です。今回の雑誌分割にともなう会員会費の改定はありません。

学会事務局は1995年1月1日から下記の通り変更になります。

〒169 東京都新宿区百人町3-23-1
国立科学博物館　植物研究部
北 山　太 樹　気付
日 本 藻 類 学 会
TEL 03-3364-7136　FAX 03-3364-7104

和文誌，英文誌の概要および投稿案内は本誌445～450頁に掲載されています。

日本藻類学会第19回大会のお知らせ

—高知・1995—

日本藻類学会第19回大会を下記のスケジュールで開催いたします。奮ってご参加下さいますようご案内申し上げます。

1. 日　程：

1995年 3 月27日（月）評議員会・編集委員会
3 月28日（火）口頭発表・総会・懇親会
3 月29日（水）口頭発表・展示発表
3 月30日（木）エクスカーション

2. 会　場：

高知城ホール　〒780 高知市丸ノ内2-1-10
TEL. 0888-22-2035　FAX. 0888-22-2037
土佐御苑（懇親会）〒780 高知市大川筋一丁目4-8
TEL. 0888-22-4491

3. エクスカーション：

(1) 四万十川の青のり（ヒトエグサ）養殖場見学：高知城ホール 7 時30分出発，13時30分に JR 中村駅帰着（中村駅13時34分発岡山駅18時10分着の直通列車がある）

(2) 高知県海洋深層水研究所（室戸岬）にてコンブ，カジメ，トサカノリの養殖を見学：高知城ホール 7 時30分出発，16時高知空港及び16時40分 JR 高知駅に帰着

＊　参加者の都合で時刻の変更がありうる。

4. 経　費：

大会参加者は4,000円（学生3,000円），懇親会費は，4,000円です。エクスカーションの費用は2,000円です。

5. 参加および発表申込：

(1) 大会参加者は発表の有無または共同発表者の有無に拘らず各自本紙綴じ込みの**参加申込票**に必要事項を記入し，大会準備委員会宛にお送りください。

(2) 研究発表される方（演者のみ）は**発表要旨の原稿**を大会準備委員会宛にお送りください。また，口頭発表される方は，大会準備委員会からあらかじめ発表日時をお知らせするために，その方の住所氏名を宛名書きした**官製はがき**を 1 枚同封してください。

(3) 大会参加費，懇親会費，エクスカーションの参加費は本紙綴じ込みの**郵便振替用紙**を使って送金してください。

(4) 参加申込票と発表要旨の原稿の送付，および送金の締め切りは1995年 **1 月10日**（必着）です。

6. 宛　先：

(1)参加申込票および発表要旨の送付先
〒780 高知市曙町 2 丁目5-1
高知大学理学部生物学教室　日本藻類学会第19回大会準備委員会

(2)送金先
郵便振替口座　01640-1-8897
日本藻類学会第19回大会準備委員会

7. その他の連絡先：

(1)〒780-11 土佐市宇佐町井尻194
高知大学海洋生物教育研究センター　日本藻類学会第19回大会会長　大野正夫
TEL. 0888-56-0422　FAX. 0888-56-0425

(2)〒780 高知市曙町 2 丁目5-1
高知大学理学部生物学教室　日本藻類学会第19回大会準備委員長　奥田一雄
TEL.0888-44-8314　FAX. 0888-44-8356
e-mail: okuda@cc.kochi-u.ac.jp

8. 会場までの交通案内：

(1) JR 土讃線高知駅下車，車で 5 分または徒歩20分。

(2) 高知空港から車で30分（約5000円）。

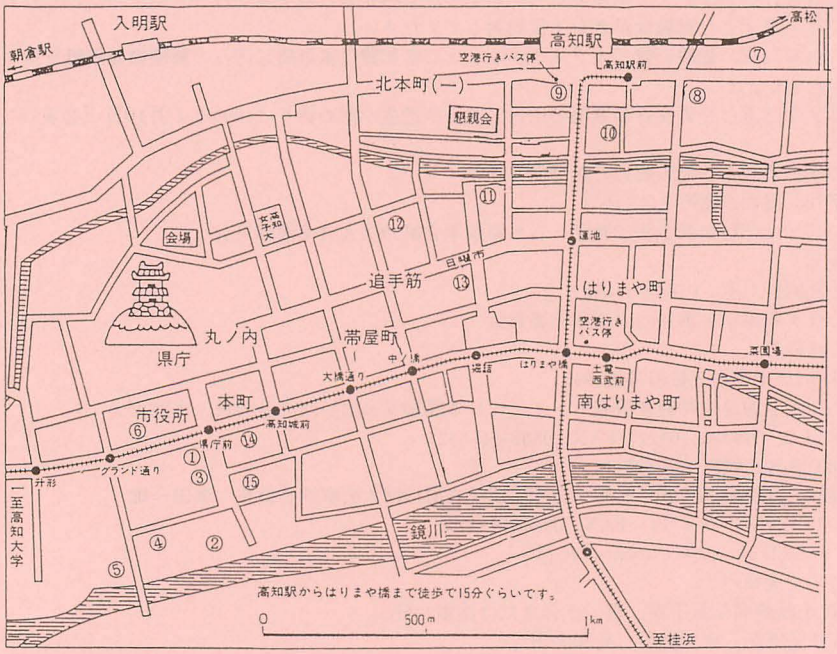
(3) 高知空港から空港連絡バスに乗り，はりまや橋または高知駅前（終点）で下車，車で 5 分または徒歩20分。（連絡バスの所要時間は37分，20分毎に運行され，料金は700円。空港行きは高知駅前または，はりまや橋から乗車する。）

(4) 土佐電鉄電停高知城前下車，徒歩５分。
(5) 高知港から車で15分。
(6) 高知自動車道南区インターを出てすぐ右折し南進，大津バイパスまたは国道55号線の交差点で右折して西進，高知駅前またははりまや橋に出る。（会場の駐車料金は，はじめの30分は無料，その後30分毎に100円追加。営業時間：8:00-22:00）

9．宿泊案内：

以下に会場周辺の主な宿泊施設を掲げます。案内図を参考にして所在地を確かめ，各自宿泊の予約をしてください。（料金は税込，サービス料込）

所在地	名　称	シングル（円）	ツイン（円）	電話（0888）
	共済関係宿舎			
1	高知会館（公）	5211	8156	23-7123
2	鷹匠苑（連）	4532(朝食付)	9970(朝食付)	22-5145
3	高知グリーン会館（林）	5098	9516	25-2701
4	土佐寮（地）	4500	7600	73-4318
5	さんご荘（警）	5400(和室のみ)		23-6221
6	高知共済会館（市）	5985	9516	23-3211
	ホ テ ル			
7	高知パレスホテル	6000，6600	12000，14000	84-1100
8	ホテル　ロス・イン	6695	12360	84-1110
9	高知ホテル	7591～	13290～	22-8008
10	ホテル　サンルート	7210	11330，14420	23-1311
11	タウンセンターホテル	5500	8000	24-1800
12	タウン錦川	5500	8000	24-1811
13	高知ワシントンホテル	8832	17221	23-6111
14	高知新阪急ホテル	10763，12463～	18720～	73-7155
15	三翠苑ホテル	10000～		22-0131



大会会場（高知城ホール）周辺の案内図。数字は宿泊施設の所在地を示す。

10. 発表形式および発表要領：

(1)口頭発表

- 1つの発表につき発表12分，質疑応答3分です。(1鈴10分，2鈴12分，3鈴15分)
- 映写スライドは 35 mm 版を使用し，スライドの枠には1図のように演者氏名，発表番号（大会プログラム参照），スライド総枚数，映写順序，手前上を示す赤マークを記入してください。
- 繰り返し映写するスライドは必要回数分の枚数を用意してください。
- OHP を使用するときは，あらかじめ発表受付でその旨申し出てください。

(2)展示発表

- 展示パネルの大きさは，縦 180 cm，横 90 cm です。
- 展示パネルの上部には図2のように発表番号，表題，氏名（所属）を明記してください。
- 研究目的，実験結果，結論などについてそれぞれ簡潔にまとめた文章を付けてください。また，写真や図表には簡単な説明文を添付してください。
- 文字と図表の大きさは，少し離れた場所からでも判読できるように調整してください。
- 展示発表の紹介時間は5分を予定しています。
- 展示物は28日の午前中までに貼り出してください。

11. 発表要旨原稿の作成要領（要旨原稿の見本を参照）：

- 原稿はワープロを使用し，黒字で明瞭に印刷してください。
- 原稿は B5 用紙を用い，縦 150 mm，横 100 mm の範囲内に収まるように作成してください。外枠は付けないでください。
- 1行目は左から 12.6 mm 空けてから書きはじめてください。(この空白部分に発表番号が入ります。)
- 著者名，演題，本文，所属の順に書いてください。
- 共著の場合は演者名の前に○を付けてください。また，所属が異なるときは各著者名の後に＊印を付し，所属の項目でそれらを区別してください。
- 和文原稿の場合，区読点は「,」(コンマ)と「。」(マル)を使用してください。
- 学名はイタリックで表示するか下線を付してください。
- 所属は（ ）でくくり，枠内の最下段に位置するように書いてください。
- 原稿はそのまま約 2/3 に縮小されオフセット印刷されます。縮小後も十分に判読できるように配慮してください。また，原稿は折り曲げずに台紙を入れて郵送してください。尚，著者校正はありません。

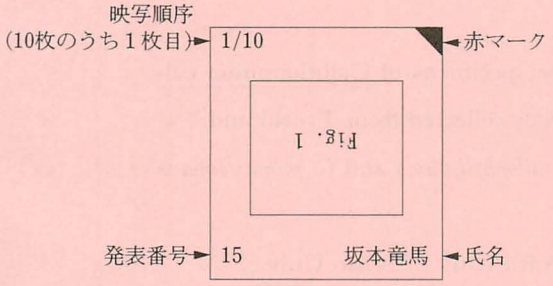


図1. 使用スライド記入例.

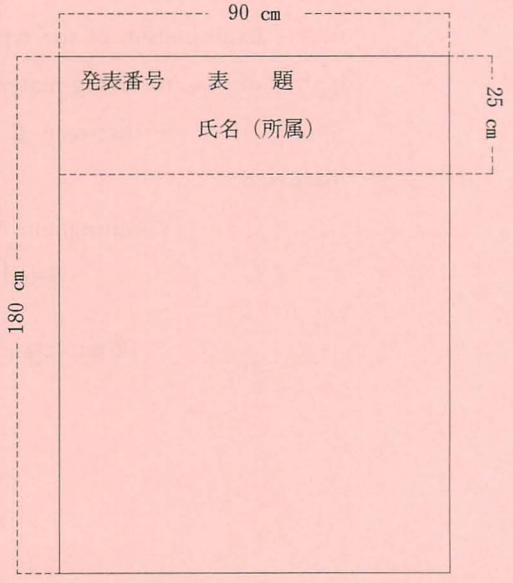


図2. 展示パネル説明図.

要旨原稿の見本

○工藤利彦*・増田道夫**：紅藻ショウジョウケノリの形態学的研究

日本沿岸各地に生育する紅藻ショウジョウケノリには，Polysiphonia urceolata (Dillwyn) Greville の学名が与えられてきた。……

……したがって，本邦産ショウジョウケノリの学名は P. senticulosa に変更されるべきであると結論された。

（*札幌大・生物，**北大・理・植物）

○Boo, S. M.*, J. Rueness**, I. K. Lee*** and T. Yoshida****: A New Combination in Aglaothamnion (Ceramiaceae: Rhodophyta)

Examination of the type specimens of Callithamnion callophyllidicola and living materials collected from Tyoshi and……

……between *A. callophyllidicola* and *C. minutissima* is discussed.

(*Chungnam Nat'l Univ., **Oslo Univ.,***
Seoul Nat'l Univ.,****Hokkaido Univ.)

（原稿には枠をつけないで下さい）

日本藻類学会第19回大会参加申込票

整理番号　　発表番号

(　　)　　(　　)

(フリガナ)
氏　　名：＿＿＿＿＿＿＿＿＿＿＿＿　所　属：＿＿＿＿＿＿＿＿＿＿＿＿

連絡先住所：〒＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

電話またはファックス番号：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

電子メイルのアドレス：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

参加形態：(希望の番号を○で囲んでください。)

研究発表：　1. 演者としてする；　2. 共著者としてする；　3. しない。
懇 親 会：　1. 出席する；　2. 欠席する。
エクスカーション：　1. 参加する；　2. 参加しない。

送金内訳：(該当の番号を○で囲み，送金合計額を算出してください。)

1. 大会参加費（一般）　4000円
2. 大会参加費（学生）　3000円
3. 懇親会費　4000円
4. エクスカーション費用　2000円

送金合計額＿＿＿＿＿円

以下は，研究発表について演者のみ記入してください。2つ以上研究発表される方は，この申込票をコピーして追加してください。

発表形式：口頭発表；展示発表（該当するのを○で囲んでください。）
OHPの使用：する；しない（該当するのを○で囲んでください。）
演　題：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

発表者氏名（所属）（共著者がいる場合演者の左肩に○を付けてください。）：

＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

申込票は下記宛に1995年 **1月10日**までに送付してください。

〒780　高知市曙町2丁目5-1
高知大学理学部生物学教室

日本藻類学会第19回大会準備委員会

Jpn. J. Phycol. (Sôrui) 42: 365–375, December 10, 1994

Two new species of *Laurencia* (Ceramiales, Rhodophyta) from the Mediterranean Sea: *Laurencia pelagiensis* sp. nov. and *Laurencia verlaquei* sp. nov.

Mario Cormaci, Giovanni Furnari and Donatella Serio

Dipartimento di Botanica, Università di Catania, via A. Longo 19, 95125 Catania, Italy

Cormaci, M., Furnari, G. and Serio, D. 1994. Two new species of *Laurencia* (Ceramiales, Rhodophyta) from the Mediterranean Sea: *Laurencia pelagiensis* sp nov. and *Lanrencia verlaquei* sp. nov. Jpn. J. Phycol. 42: 365–375.

Two new species with compressed axes of the genus *Laurencia* (Ceramiales, Rhodophyta) from the Mediterranean Sea are described: *L. pelagiensis* sp. nov. and *L. verlaquei* sp. nov. The first species, from the Pelagean Islands, shows the following main features: epidermal cells without secondary pit connections, appearing in transverse section radially elongated and palisade-like; tetrasporangia, in parallel arrangement, cut off from the mother epidermal cells laterally; spermatangial branches unbranched, inserted in shallow and broad receptacles with indeterminate arrangement. The second species, from Sausset (Marseille, France), Livorno (Italy) and Capo Colonna (Catanzaro, Italy), shows epidermal cells with secondary pit connections appearing in transverse section neither radially elongated nor palisade-like; tetrasporangia, in parallel arrangement, cut off from the mother epidermal cells laterally; spermatangial branches simple or irregularly branched, inserted in deep receptacles with indeterminate arrangement. Records of *L. undulata* Yamada from the Mediterranean Sea should be referred to either *L. pelagiensis* or to *L. verlaquei*.

Key Index Words: Laurencia pelagiensis—Laurencia verlaquei—*Mediterranean Sea*—*Rhodomelaceae*—*Rhodophyta*—*Taxonomy*.

In the frame of the research on Mediterranean species of the genus *Laurencia* (Furnari and Serio 1993a, b), some specimens with a compressed thallus, collected at the island of Lampedusa (Pelagean Islands), were studied. They were compared with specimens from the island of Linosa (Pelagean Islands, Straits of Sicily) (identified as *L. undulata* Yamada), as well with specimens collected by Dr Verlaque at Sausset (Marseille, France) [labelled as "*L. undulata* de Mediterranée (≠celui du Japon)"] and with specimens collected at Livorno (Italy) by Dr Papi (labelled as *Laurencia* sp.) and at Capo Colonna (Catanzaro, Italy) by M. Cormaci (labelled as *Laurencia* sp.). From the comparisons, we concluded that we were dealing with two new distinct species: *L. pelagiensis* sp. nov. and *L. verlaquei* sp. nov. To the first species belong specimens from the Pelagean Islands, to the second species, specimens from Marseille, Livorno and Capo Colonna (Fig. 1).

Materials and Methods

The investigations have been carried out on both fluid preserved and herbarium specimens. Herbarium specimens are held at the Department of Botany of University of Catania. For microscopic observations, some specimens of both species were stained on glass slides with 1% aqueous aniline blue acidified with dilute HCl which enhances pit connections. Sections were made by razor blade and freezing microtome. Sections of tetrasporic specimens of *L. pelagiensis* were prepared from material dehydrated and embedded in paraffin. Sections were stained with ruthenium red.

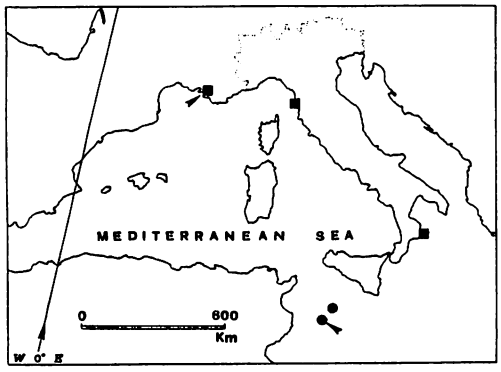


Fig. 1. Map showing the known distribution of *Laurencia pelagiensis* (solid circle) and *L. verlaquei* (solid square). Arrowheads indicate type localities.

Specimens examined

"*Laurencia undulata*" Yamada: Linosa (Pelagean Islands), 23. v. 1973, midlittoral, male gametophyte, tetrasporophyte, CAT 1115 (ex Giaccone Herbarium), liquid-preserved specimens.

"*Laurencia* sp.=*L. undulata* de Mediterranée (≠celui du Japon)".: Sausset (Bouches du Rhône, France), Verlaque Herbarium University of Aix-Marseille, France: 9. iii. 1983, midlittoral, F1359, tetrasporophyte and male gametophyte, liquid-preserved specimens; H2511 tetrasporophyte; H2512 male gametophyte; 8. iii. 1994, midlittoral, male and female gametophytes, tetrasporophyte, liquid-preserved specimens in unnumbered vials.

"*Laurencia* sp.": Livorno (Italy), 16. iv. 1993, midlittoral, male gametophyte, tetrasporophyte, CAT 1312, specimens sent by Dr Papi, liquid-preserved specimens.

"*Laurencia* sp.": Capo Colonna (Catanzaro, Italy), 20. v. 1982, midlittoral, tetrasporophyte, CAT 1076, liquid-preserved specimens.

For comparison, the following specimen was also examined:

Laurencia undulata Yamada: Enoshima (Japan) May 1927, Holotype SAP 13869.

Observations

***Laurencia pelagiensis* sp. nov.** Figs. 2-12 and 26.

DIAGNOSIS: Thalli rosei, epilithici, usque ad 10 cm alti, axibus 2-3 mm latis, ex crassa extendenti crusta basali orientibus, complanatis, portione basali tereti excepta, simplicibus vel pauciramosis. Ramuli teretes, vel disticha, vel unilaterali, vel irregulari dispositione, in axium dimidio superiore instructi, usque ad 10 mm longi, irregulariter ramosi, aliquando simplices. Cellulae corticales, externe visae, parum longitudinaliter elongatae prope apices [15-25(18) μm × 10-20(15) μm], multo magis in thalli medianis basalibusque portionibus [20-40(30) μm × 8-15(12) μm], non exstantes, sine conjunctionibus secundariis; in sectione transversa radialiter elongatae atque paliformes. Cellulae interiores sine crassitudinibus lenticularibus. Duae pericentrales cellulae per cellulam axialem. Tetrasporangia, dispositione parallela, ex cellulis corticalibus lateraliter facta. Cystocarpia, 600-700 μm × 700-800 μm, sessilia atque ovoidea, plerumque in ramulorum subapicalibus portionibus disposita. Rami spermatangiales simplices, inserti in non profundis latisque, 600-1800(1200) μm × 150-750(450) μm, ramulorum divisione vel prope apicem lateraliter dispositis, depressionibus. Nulla axialium cellularum series ad maturorum depressionum spermatangialium infimum manifesta.

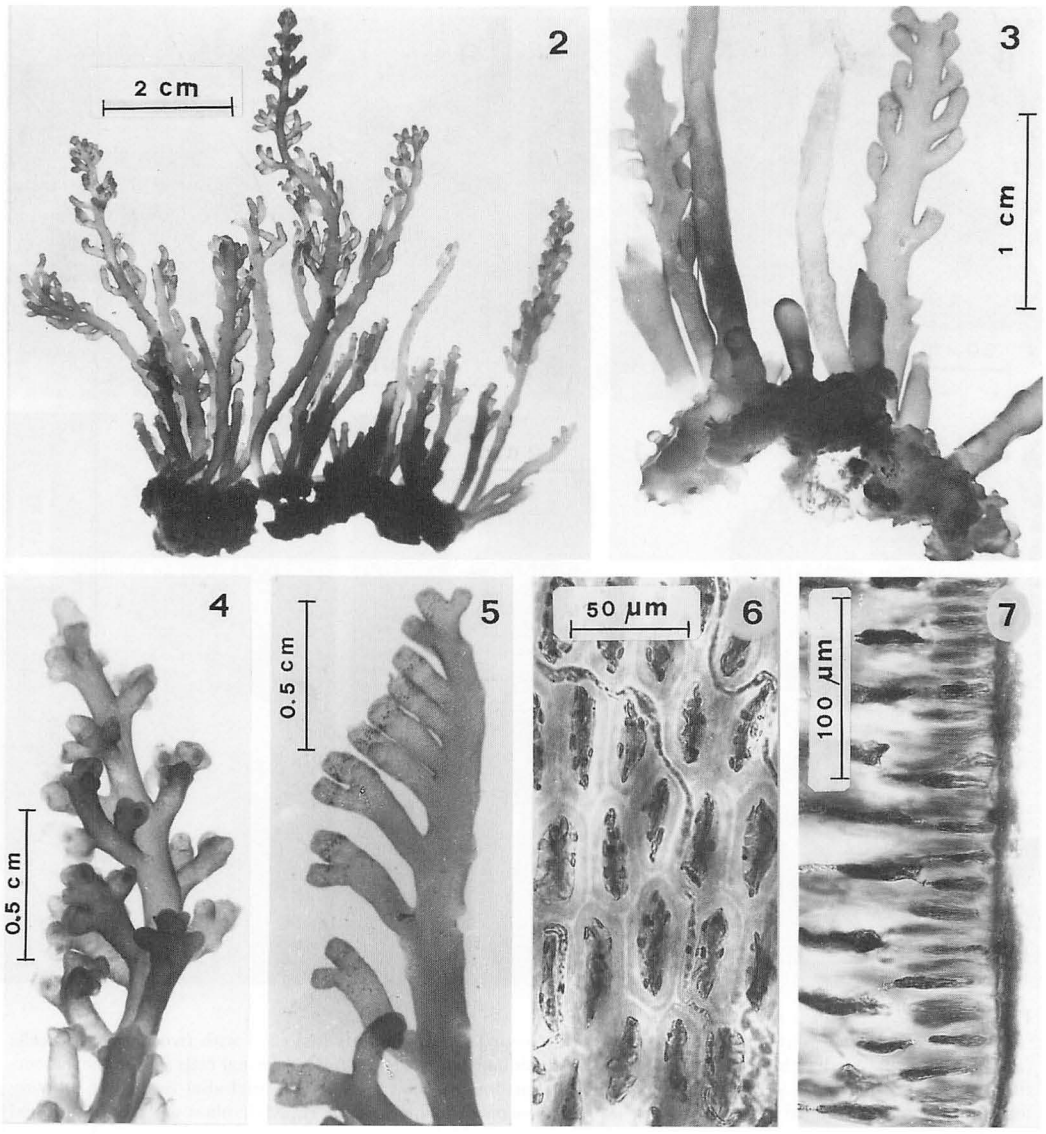
TYPE LOCALITY: Lampedusa Island (Pelagean Islands), lower midlittoral.

HOLOTYPE: CAT 1234, male and female gametophytes, tetrasporophyte. Collected on 23. vi. 1991.

DISTRIBUTION: type locality; Linosa Island (Pelagean Islands) (Fig. 1).

ETYMOLOGY: The specific epithet refers to the name of the Pelagean Islands where the species is distributed.

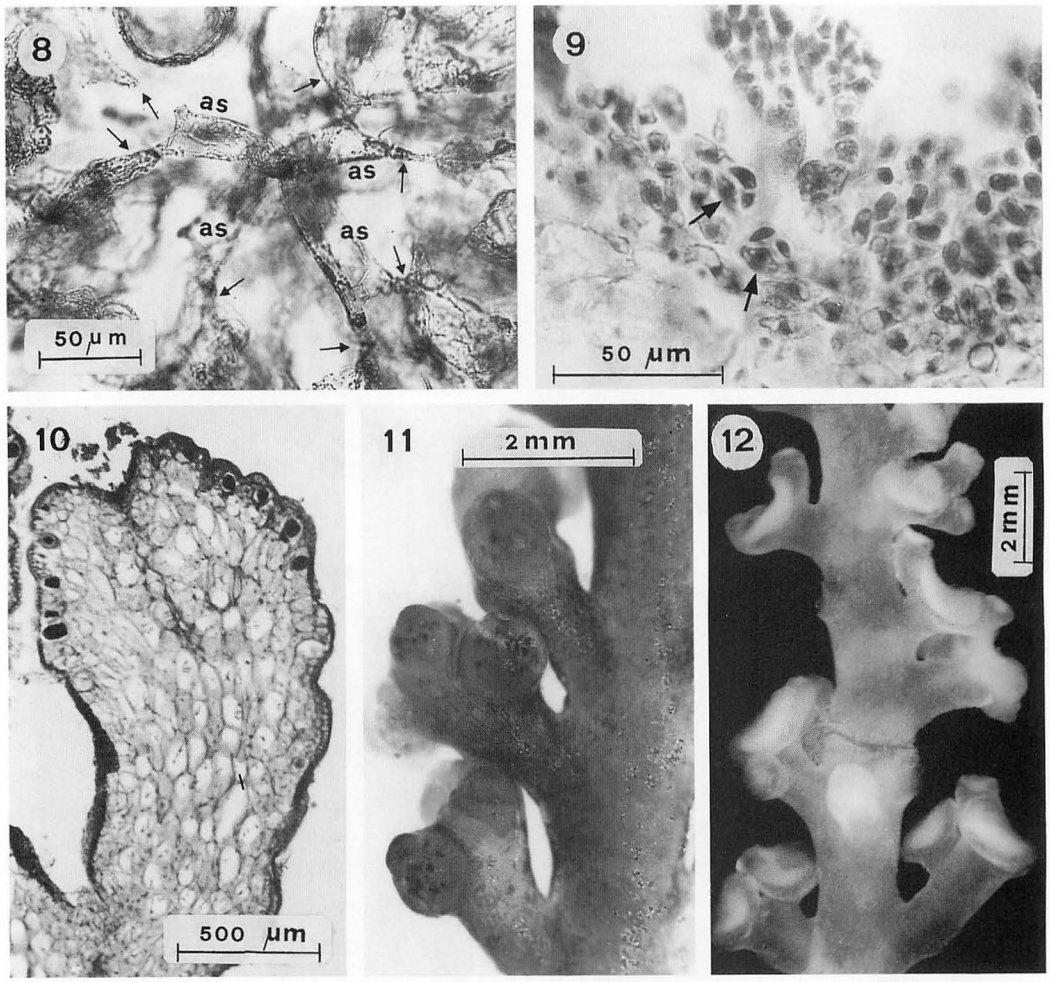
Thalli light red, epilithic, up to 10 cm high (Fig. 2), with axes 2-3 mm broad, arising from a thick, spreading basal crust (Fig. 3), compressed except near the base, simple or scarsely ramified. Branchlets terete, distichously, unilaterally or irregularly arranged, borne in the upper half of axes, up to 10



Figs. 2–7. *L. pelagiensis* sp. nov.

Fig. 2. General appearance. Fig. 3. Detail of basal crust. Two axes with simple branchlets distichously arranged are visible. Fig. 4. Axis with ramified branchlets irregularly arranged, bearing cystocarps. Fig. 5. Axis with ramified branchlets unilaterally arranged. Fig. 6. Epidermal cells in surface view. No secondary pit connections occur. Fig. 7. Transverse section of a branchlet showing epidermal cells radially elongated and palisade-like.

mm long, irregularly ramified, sometimes simple (Figs. 3, 4, 5). Epidermal cells in surface view slightly elongated longitudinally near apices [15-25(18) μm × 10-20(15) μm] much more in median and basal portions of the thallus [20-40(30) μm × 8-15(12) μm], not projecting, without secondary pit-connections (Fig. 6); in transverse section radially elongated and palisade like (Fig. 7). Medullary cells without lenticular thickenings. Two pericentral cells per axial segment (Fig. 8). Tetrasporangia, produced from epidermal cells (Fig. 9), are cut off from the mother cells laterally (Fig. 26) and show a parallel arrangement (Fig. 10). Cystocarps, 600-700 μm × 700-800 μm, sessile and ovoid in shape gener-



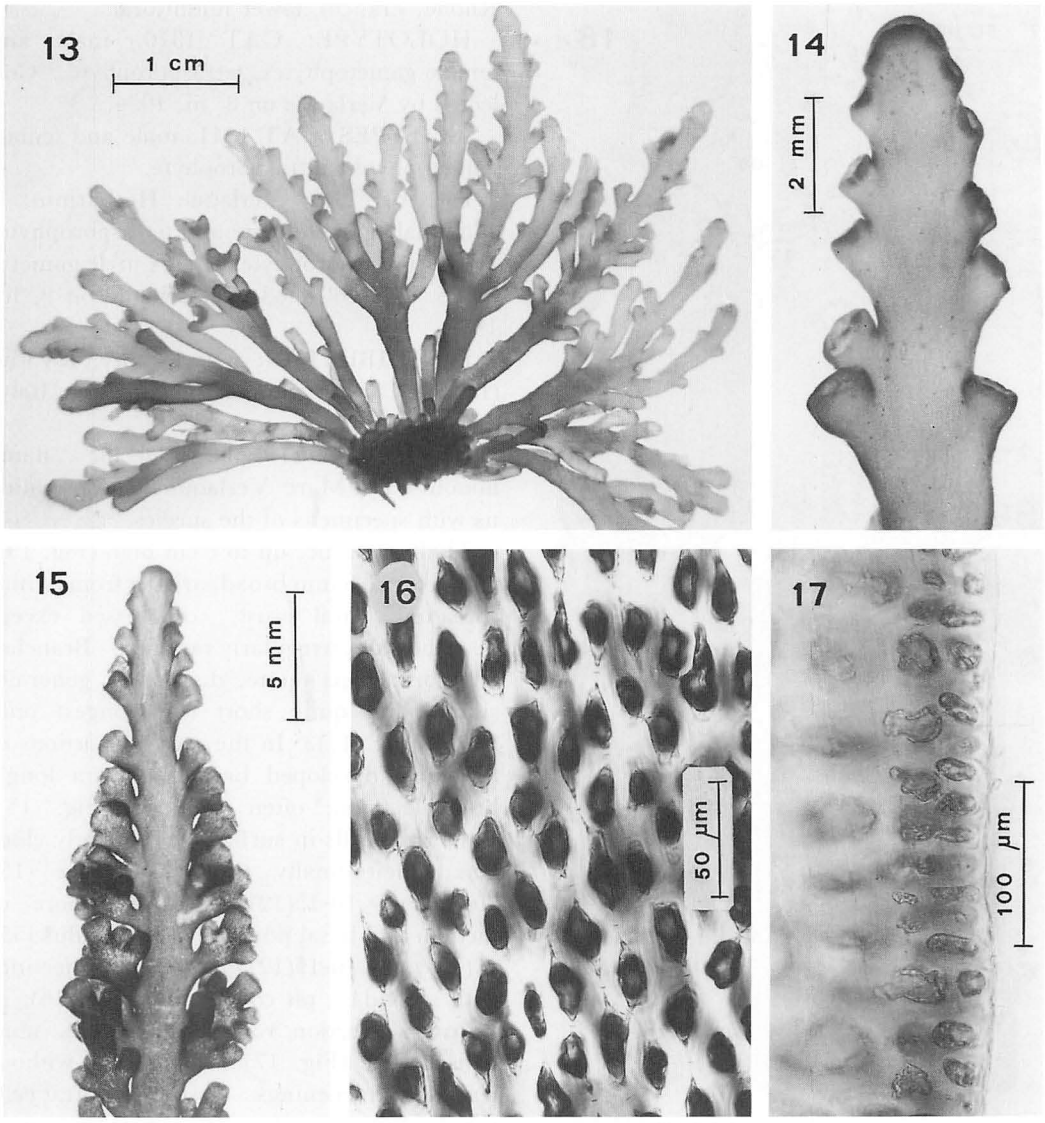
Figs. 8–12. *L. pelagiensis* sp. nov.

Fig. 8. Transverse section near branchlet apex showing axial segments (as) each with two pericentral cells (arrows). Fig. 9. Median longitudinal section of a stichidial branchlet showing epidermal cells (arrows) each cutting off two presporangial cover cells. Fig. 10. Median longitudinal section of a stichidial branchlet showing tetrasporangia in parallel arrangement. Fig. 11. Cystocarpic branchlets. Fig. 12. Male plant with spermatangial receptacles.

ally disposed in the subapical portions of branchlets (Fig. 11). Spermatangial branches unramified, inserted in depressions broad and shallow, 600-1800(1200) μm × 150-750(450) μm, located either at the bifurcation of branchlets or laterally near apices (Fig. 12). No rows of axial cells evident on the bottom of mature spermatangial depressions.

***Laurencia verlaquei* sp. nov.** Figs. 13-22 and 27.

DIAGNOSIS: Thalli epilithici, usque ad 6 cm alti, axibus 2-3 mm latis, ex tenui extendenti crusta basali orientibus, complanatis, portione basali tereti excepta, irregulariter ramosis. Rami ramulos teretes, distichos, plerumque simplices, admodum breves (longissimos solum 2 mm longos) ferentes; ramuli saepe ramosi in longissimorum ramorum (usque 2 cm) medianis partibus. Duae pericentrales cellulae per cellulam axialem. Cellulae corticales, externe visae, parum longitudinaliter elongatae prope apices [15-30(22) μm × 10-15(12) μm], multo magis in

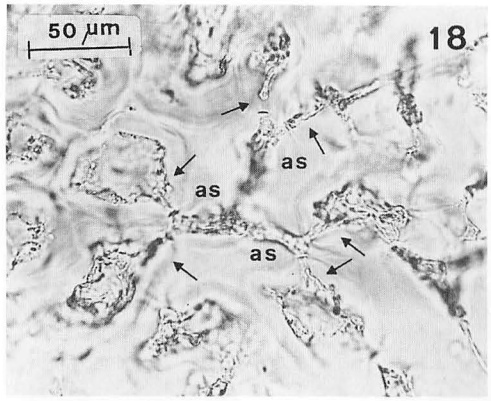


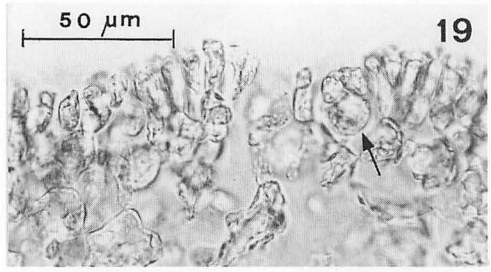
Figs. 13–17. *Laurencia verlaquei* sp. nov.

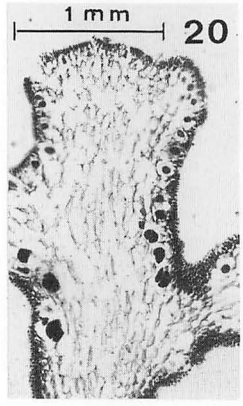
Fig. 13. General appearance. Fig. 14. Upper portion of main axis with short branchlets. Fig. 15. Well developed branch showing ramified branchlets in the middle portion. Fig. 16. Secondary pit connections between epidermal cells in surface view. Fig. 17. Transverse section of a branchlet.

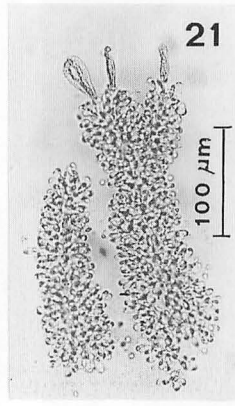
thalli medianis basalibusque portionibus [35-45(40) μm × 10-15(12) μm], non exstantes, conjunctionibus secundariis praeditae; in sectione transversa rotundatae vel ovoideae, non paliformes. Cellulae interiores sine crassitudinibus lenticularibus. Tetrasporangia, dispositione parallela, ex cellulis corticalibus lateraliter facta. Rami spermatangiales plerumque simplices (aliquando brevibus apicalibus ramulis), inserti in profundis [570-900(700) μm × 810-1100(900) μm], ramulorum divisione vel prope apices lateraliter dispositis, depressionibus. Nulla axialium cellularum series ad maturorum depressionum spermatangialium infimum manifesta. Immatura cystocarpia 160-180 μm × 200-300 μm. Matura cystocarpia non observata.

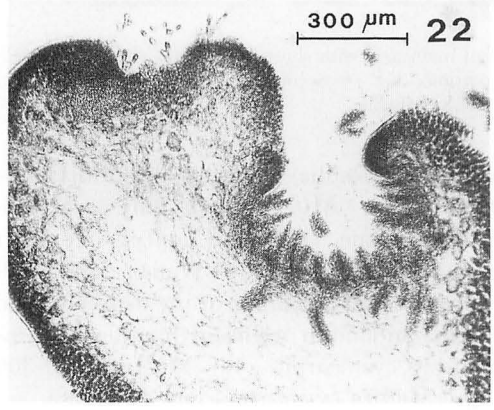
TYPE LOCALITY: Sausset (Bouches du











Rhône, France), lower midlittoral.

HOLOTYPE: CAT 1370, male and female gametophytes, tetrasporophyte. Collected by Verlaque on 8. iii. 1994.

ISOTYPES: CAT 1241, male and female gametophytes, tetrasporophyte.

PARATYPES: Verlaque Herbarium, F 1359 male gametophyte and tetrasporophyte; H2511 tetrasporophyte; H2512 male gametophyte. All collected by Verlaque on 9. iii. 1983.

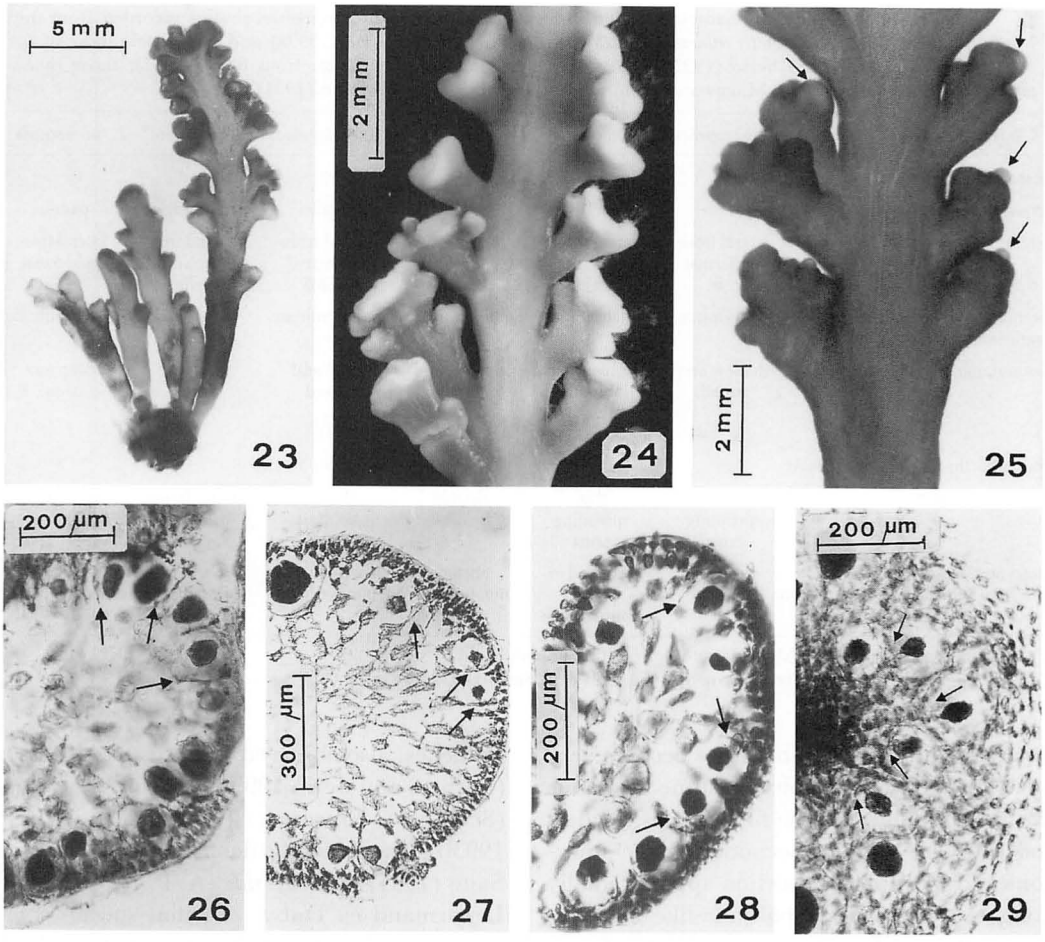
DISTRIBUTION: type locality; Livorno (Italy); Capo Colonna (Catanzaro, Italy) (Fig. 1).

ETYMOLOGY: the specific name honours Dr Marc Verlaque who provided us with specimens of the species.

Thalli epilithic, up to 6 cm high (Fig. 13), with axes, 2-3 mm broad, arising from a thin, spreading basal crust, compressed except near the base, irregularly ramified. Branches with branchlets terete, distichous, generally simple and quite short (the longest only 2 mm) (Fig. 14). In the median portions of the most developed branches (2 cm long), branchlets are often ramified (Fig. 15). Epidermal cells in surface view slightly elongate longitudinally near the apices [15-30(22) µm × 10-15(12) µm] much more in median and basal portions of the thallus [35-45(40) µm × 10-15(12) µm], not projecting, with secondary pit connections (Fig. 16); in transverse section rounded to ovoid, non-palisade-like (Fig. 17). Inner cells without lenticular thickenings. Two pericentral cells per axial segment (Fig. 18). Tetrasporangia produced from epidermal cells (Fig. 19) in

Figs. 18–22. *Laurencia verlaquei* sp. nov.

Fig. 18. Transverse section near branchlet apex showing axial segments (as) each with two pericentral cells (arrows). Fig. 19. Detail of a longitudinal section of a stichidial branchlet showing an epidermal cell (arrow) cutting off two presporangial cover cells. Fig. 20. Longitudinal section of a stichidial branchlet showing tetrasporangia in parallel arrangement. Fig. 21. Spermatangial branches with short apical branchlets each ending with an elongate apical cell. Fig. 22. Longitudinal section showing a spermatangial depression located laterally near the apex. A row of axial cells is absent on the bottom of the spermatangial depression.



Figs. 23–25. *Laurencia verlaquei* sp. nov.

Fig. 23. General appearance of a male plant. Fig. 24. Detail of a male plant showing the localization of spermatangial depressions. Fig. 25. Detail of a female plant showing immature cystocarps (arrows).

Figs. 26–29. Transverse sections near the apex of stichidial branchlets showing the cut of tetrasporangia. In Figs. 26–28, mother cells (arrows) appear in the direction of a radius and tetrasporangia are cut off laterally to them clock- or counterclockwise. In Fig. 29, mother cells (arrows) appear perpendicular to the radius and tetrasporangia are cut off in the direction of the radius.

Fig. 26. *L. pelagiensis*. Fig. 27. *L. verlaquei*. Fig. 28. *L. truncata*. Specimen collected at Lachea Island (Catania, Italy) in the infralittoral fringe on 22. iv. 1992 (CAT 1174). Fig. 29. *L. obtusa*. Specimen collected at Capo Passero (Siracusa, Italy) at 50 cm depth on 26. ii. 1994 (CAT 1239).

parallel arrangement (Fig. 20), cut off from the mother cells laterally (Fig. 27). Spermatangial branches simple or irregularly ramified (Fig. 21), inserted in deep depressions (Fig. 22) 570–900(700) μm × 810–1100(900) μm, located either at the bifurcation of branchlets or laterally near apices (Figs. 23, 24). No rows of axial cells evident on the bottom of mature spermatangial depressions (Fig. 22). Immature cystocarps, 160–180 μm × 200–300 μm (Fig. 25). Mature cystocarps not observed.

Discussion

Laurencia pelagiensis and *L. verlaquei* are two distinct species in both vegetative and reproductive characters (Table 1). In fact, *L. pelagiensis* shows axes not or scarcely ramified with branchlets rather long and irregularly ramified while *L. verlaquei* shows axes irregularly ramified with branchlets

Table 1. Comparison of characters in the species of *Laurencia* with compressed thallus recorded from the Mediterranean Sea. Data of *L. truncata* are drawn from Furnari and Serio (1993a) and this paper; those of *L. pelagosae* from Furnari and Serio (1993b) and this paper; those of *L. undulata* from Saito (1967); those of *L. pinnatifida* from Saito (1982), Maggs and Hommersand (1993), Nam and Saito (1994).

Characters	*L. pelagiensis*	*L. verlaquei*	*L. truncata*	*L. pelagosae*	*L. undulata**	*L. pinnatifida***
Secondary pits in epidermis	−	+	+	+	−	−
Arrangement of tetrasporangia	parallel	parallel	parallel	parallel	right-angle	parallel
Origin of tetrasporangia	lateral from epidermal cells	lateral from epidermal cells	lateral from epidermal cells	lateral from epidermal cells	abaxial from pericentral cells	lateral from epidermal cells
Spermatangial receptacle arrangement	indeterminate	indeterminate	indeterminate	indeterminate	unknown	indeterminate
Spermatangial receptacle shape	shallow and broad	deeper than broad slightly sunken	shallow and broad	deep and ovoid	unknown	deep and ovoid
Lenticular thickenings in medulla	−	−	+	+	−	+
Type of attachment	thick spreading crust	thin spreading crust	discoid holdfast	discoid holdfast	stoloniferous holdfast	stoloniferous holdfast
Shape and arrangement of epidermal cells in transverse section	elongate palisade	rounded to ovoid non-palisade	obconic non-palisade	subquadrate non-palisade	obconic non-palisade	obconic non-palisade

*To be confirmed in the Mediterranean Sea (this paper).
**Not present in the Mediterranean Sea (Furnari and Serio 1993a).

generally simple and short, that become very short apically so that apices assume a sinuous outline (Fig. 14). In the first species, epidermal cells are without secondary pit connections and in transverse section appear radially elongated and with a palisade-like arrangement, while in *L. verlaquei* secondary pit connections occur between epidermal cells which, in transverse section, appear rounded to ovoid. To be noted, that both species show a crustose type of attachment with crusts up to 4-5 cm in diameter with 30-40 axes per cm^2 in *L. pelagiensis* and up to 2 cm in diameter with 50-60 axes per cm^2 in *L. verlaquei*. This type of attachment is quite rare; it occurs only in the two terete species *L. crustiformans* McDermid and *L. flagellifera* J. Agardh (McDermid 1989).

In both species spermatangial branches originate from epidermal cells and spermatangial depressions are indeterminate and cup-shaped, but they are 2-3 times broader than deep with edges turned outwardly in *L. pelagiensis* while in *L. verlaquei* they are 1-1.5 deeper than broad with edges turned inwardly. Epidermal origin of spermatangial branches, also observed in *L. truncata* Kützing (Furnari and Serio 1993a) and in *L. pelagosae* (Schiffner) Ercegovic (Furnari and Serio 1993b), was recently described by Nam and Saito (1994) in *L. hybrida* (A. P. de Candolle) Lenormand ex Duby. In that species spermatangial branches form directly from both apical and epidermal cells inside apical pits of fertile branchlets. In such branchlets, when spermatangial depressions are completely developed, the row of axial cells becomes unrecognizable. In our species we never observed spermatangial branches originating from apical cells; it seems that spermatangial depressions do not form in correspondence of apical pits. Nevertheless, since we couldn't observe the developmental process of male reproductive structures from the initial stage, the possibility that in our species spermatangial branches originate as in *L. hybrida* can not be excluded at all.

In both species tetrasporangia, in parallel arrangement, are produced from epidermal cells and are cut off from the mother cells laterally. The origin is the same of that described by Nam and Saito (1994) in *L. hybrida*. Their

observations on developmental stages of tetrasporangia are based on median longitudinal sections near apices. Nevertheless, in such sections, as well in surface view, tetrasporangia often appear cut off ab- or adaxially from the mother cells due to a process of distortion in the course of their development. Such process seems to not influence the correct interpretation of the orientation of the cut of tetrasporangia, if the observations are made in transverse sections (Verlaque, personal communication). In fact, in such sections in the species with lateral cut of tetrasporangia from epidermal cells, the mother cells appear in the direction of a radius and tetrasporangia are cut off laterally to them clock- or counterclockwise (Figs. 26-28). On the contrary, in the species with abaxial or adaxial (the latter to be confirmed in the genus) cut of tetrasporangia from pericentral cells, the mother cells appear perpendicular to the radius and tetrasporangia are cut off in the direction of the radius (Fig. 29).

On the basis of Nam and Saito's (1994) paper we re-examined tetrasporophytes of both *L. truncata* (Fig. 28) and *L. pelagosae*. In both species tetrasporangia originate from epidermal cells and are cut off from the mother cells laterally. The abaxial cut of tetrasporangia from the mother cells in *L. truncata* reported by Furnari and Serio (1993a) and Maggs and Hommersand (1993), as well the adaxial cut in *L. pelagosae* reported by Furnari and Serio (1993b), are due to a misinterpretation. Therefore, *L. truncata, L. pelagosae* and *L. verlaquei* have the same combination of characters (Table 1) (occurrence of secondary pit connections between epidermal cells, parallel arrangement and lateral cut from epidermal mother cells of tetrasporangia, indeterminate arrangement of spermatangial depressions) but the last species differs from the first two in some external features like habit, branching pattern, type of attachment, greater thickness of the thallus, as well as in the anatomical character of the absence of lenticular thickenings in the inner cells.

Moreover, the above mentioned three species appear related in both the origin of tetrasporangia and in the arrangement of spermatangial depressions also to *L. pelagiensis* (which, however, does not show secondary pit connections between epidermal cells) and to *L. hybrida* (which has a cylindrical thallus). Nevertheless, we agree with Nam and Saito (1994) that prior to any new infrageneric proposal for these species the infrageneric criteria of Saito (1967, 1969) followed by Furnari and Serio (1993a, b), should be re-evaluated.

Among the other species of *Laurencia* with compressed thallus, only *L. pinnatifida* (Hudson) Lamouroux is reported having tetrasporangia originating from epidermal cells (Nam and Saito 1994). But it differs from *L. verlaquei* mainly in the absence of secondary pit connections between epidermal cells and from *L. pelagiensis* in the type of attachment, shape and arrangement of epidermal cells in transverse section as well in spermatangial receptacle shape (Table 1). In the same paper, Nam and Saito put forward the hypothesis that also in some Californian species of the "Spectabilis Group" tetrasporangia could be produced from epidermal cells. But the species of that "Group" differ from *L. verlaquei* mainly in the absence of secondary pit connections between epidermal cells and from *L. pelagiensis* in the habit, vegetative features and spermatangial receptacle shape.

Finally, since specimens from the island of Linosa [recorded as *L. undulata* Yamada by Cinelli *et al.* (1976)] belong to *L. pelagiensis* and those from France, labelled by Verlaque as "*L. undulata* de Mediterranée (≠celui du Japon)", belong to *L. verlaquei*, is highly probable that to *L. undulata* were referred specimens having habit and morphology different from both the "Mediterranean *L. pinnatifida*" [to be referred to *L. truncata* (Furnari and Serio 1993a)] and from *L. pelagosae*. In our opinion, *L. undulata* [characterized by absence of secondary pit connections between epidermal cells; rightangle type of tetrasporangial arrangement; epidermal cells neither projecting nor palisade-like in transverse section (Saito 1967)] does not occur in the Mediterranean

Sea and those records should be referred to either *L. pelagiensis* or *L. verlaquei*.

Laurencia undulata was firstly recorded in the Mediterranean Sea by J. and G. Feldmann (1942) from Algeria. Afterwards, the species was recorded from Tunisia (Ben Maiz and Boudouresque 1986); France (Augier and Boudouresque 1976); Corsica (Boudouresque and Perret-Boudouresque 1987); Sardinia (Cossu *et al.* 1993); Tuscan Archipelago (Papi *et al.* 1992) and Sicily (Giaccone *et al.* 1985). However, the description reported by J. and G. Feldmann (1942), based only on sterile and male gametophytic specimens, raises doubts on the exact identification of Algerian material. In fact, nothing is said on the occurence or not of secondary pit connections between epidermal cells nor, due to the absence of tetrasporangial material, on the arrangement and origin of tetrasporangia. Unfortunately, the impossibility to examine J. and G. Feldmann's specimens did not allow us to resolve with certainty these doubts.

According to J. and G. Feldmann's (1942) description, Algerian specimens show a palisade-like arrangement of cortical cells ("...plus ou moins allongées radialement et ainsi disposées en palissade...") that excludes their belongings to *L. undulata* which, on the contrary, shows a not palisade-like arrangement. Moreover, they show a type and disposition of spermatangial branches ("...Les spermatangiophores, très nombreux et groupés parallèlement les uns aux autres sont costitués par un filament central, généralement non ramifié portant un manchon continu de spermatanges...) similar to both *L. pelagiensis* and *L. verlaquei*. But, for the palisade-like arrangement of cortical cells (occurring only in *L. pelagiensis*) as well as for the southern Mediterranean distribution area, it is more probable they belong to *L. pelagiensis*.

Acknowledgements

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Mario Cormaci・Giovanni Furnari・Donatella Serio：地中海産の紅藻ソゾ属（イギス目）の2新種，*Laurencia pelagiensis* と *Laurencia verlaquei*

地中海産の紅藻ソゾ属（イギス目）の扁平な軸を持つ2新種，*Laurencia pelagiensis* と *Laurencia verlaquei* を記載した。*Laurencia pelagiensis* は Pelagean 諸島産で次のような特徴をもつ。すなわち表皮細胞は二次的な原形質連絡を欠き，横断面では放射状に伸び，柵状の形状をなす。四分胞子嚢は平行に配列し側生する表皮細胞からなる母細胞から切り出される。精子嚢枝は分枝せず浅くて広い生殖器床に生ずる。*Laurencia verlaquei* は Sausset (Marseille, France), Livorno (Italy), Capo Colonna (Catanzaro, Italy) で採集され，表皮細胞は二次的な原形質連絡を有し，横断面では放射状でも柵状でもない。四分胞子嚢は平行して配列し側生する表皮細胞からなる母細胞から切り出される。精子嚢枝は分枝しないか不規則に分枝し，深い生殖器床に生ずる。地中海で報告されている *Laurencia undulata* Yamada はこれらの2種のいずれかに相当すると考える。(Department of Botany, University of Catania, via A. Longo 19, 95125 Catania, Italy)

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Note added in proof

While this paper was printing the genus *Osmundea* Stackhouse was resurrected [see Nam, K. W., Maggs, C. A. and Garbary, D. J. 1994. Resurrection of the genus *Osmundea* with an emendation of the generic delineation of *Laurencia* (Ceramiales, Rhodophyta). Phycologia **33**(5): 384–395].

Since the two new species described in this paper fall within the circumscription of the genus *Osmundea*, the following new combinations are here proposed:

Osmundea pelagiensis (Cormaci *et al.*) Furnari comb. nov.

Basionym: *Laurencia pelagiensis* Cormaci *et al.* 1994, Jpn. J. Phycol. **42:** 366 (this paper).

Osmundea verlaquei (Cormaci *et al.*) Furnari comb. nov.

Basionym: *Laurencia verlaquei* Cormaci *et al.* 1994, Jpn. J. Phycol., **42:** 368 (this paper).

Jpn. J. Phycol. (Sôrui) 42: 377–384, December 10, 1994

Studies on *Dictyopteris longifolia* (Dictyotales, Phaeophyta) from South Africa. I. Production and morphogenesis of tetraspores

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Blackmore, N. L., Critchley, A. T. and Pienaar, R. N. 1994. Studies on *Dictyopteris longifolia* (Dictyotales, Phaeophyta) from South Africa. I. Production and morphogenesis of tetraspores. Jpn. J. Phycol. 42: 377–384.

The production and germination of tetraspores of *Dictyopteris longifolia* Papenfuss (in ed.), were promoted at 20°C and 22 μmol·m^{-2}·s^{-1} irradiance. Growth rates of the thalli and primary rhizoids of germinating tetraspores were compared at different temperatures; 20°C was found to be optimal. Production of tetrasporangia began within the cortex, followed by the elevation of a "cuticle" by the enlarging spore mother cell, prior to meiotic division. Germination of the tetraspores was initiated by elongation and division of a single primary rhizoid which established attachment, before production of a secondary rhizoid or thallus development. The production of unusual tip morphology of rhizoids, not reported in the genus before, is described.

Key Index Words: brown algal reproduction—Dictyopteris longifolia—*tetrasporogenesis and tetraspore morphogenesis—South African brown algae*

Members of the genus *Dictyopteris* (Dictyotales, Phaeophyceae) are found world-wide in tropical and temperate regions (Allender and Kraft 1983). This study investigates *Dictyopteris longifolia* Papenfuss (in ed.), which is found locally abundant along the sub-tropical east coast of South Africa (Stephenson and Stephenson 1972). The mature thallus (Fig. 1) consists of a fibrous holdfast and flat, dichotomously branching laminae which may reach a width of 2 cm and attain a length of 70 cm. The plants occur in clumped stands in areas of varying exposure to waves and sand inundation.

Tetrasporogenesis in *Dictyopteris divaricata* was examined by Inoh (1936) and Ishii *et al.* (1959). Germination of the tetraspores of the latter species was compared to two other members of the Dictyotales, namely *Padina japonica* Yamada and *Dictyota dichotoma* (Hudson) Lamouroux (Nishibayashi and Inoh 1959). Various studies have been performed to determine the effects of environmental parameters on the germination process in members of the order. Few reports, however, report the effect of temperature on the production and morphogenesis of tetraspores in members of the Dictyotales.

This investigation examines tetraspore formation on the surface of the lamina, morphogenesis following release and the effect of temperature on these features in *D. longifolia*.

Materials and Methods

Dictyopteris longifolia was collected at Palm Beach on the Natal coast of eastern South Africa (Fig. 2) in mid-May (autumn) 1989. Entire plants were removed from shallow pools and exposed reefs, at low water of spring tides. The material was collected in plastic bags and transferred to the laboratory in cooled, insulated boxes. After being cleaned of superficial epiphytes, individual

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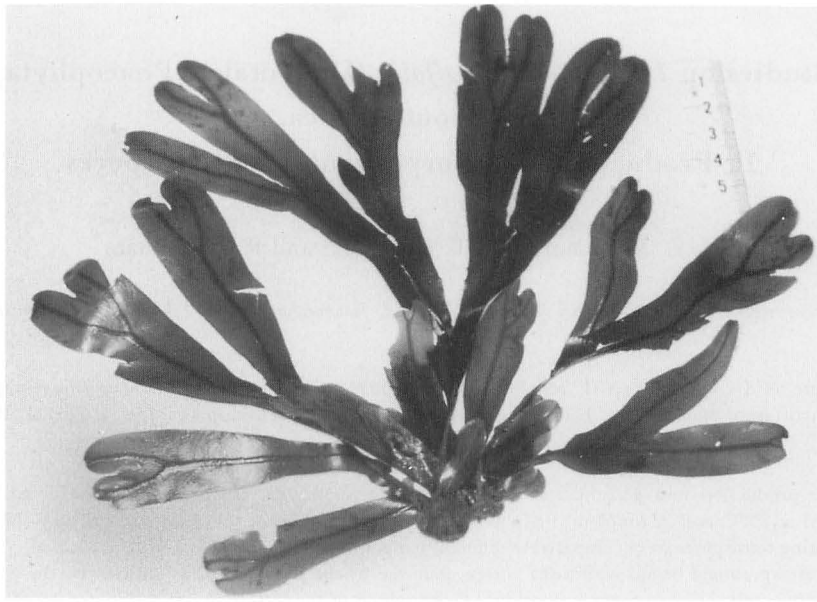

Fig. 1. Habit of *Dictyopteris longifolia*.

laminae were wiped with 100% alcohol and dipped in a germanium dioxide solution ($1\ mg \cdot l^{-1}$) in order to reduce subsequent diatom contamination (Lewin 1966). Each lamina was cut into segments (approximately 1.5 cm by 1.0 cm) and placed in "Sterilin" repli-dishes, in 5 ml of unfiltered seawater. The dishes were kept in a Labex (model L.T.G.C.) growth chamber at a temperature of 21.5°C (±2°C) and an irradiance of 22 $\mu mol \cdot m^{-2} \cdot s^{-1}$ with a 14 : 10 light : dark cycle, for 30 days.

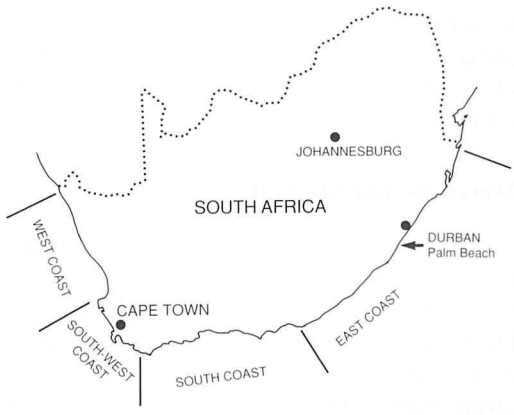

Fig. 2. Map showing the southern African coastline and the position of Palm Beach on the Natal coast (biogeographic zones after Stephenson and Stephenson, 1972).

Following release, tetraspores of *D. longifolia* were transferred to 50 ml, pre-sterilized Erlemeyer flasks, using Pasteur pipettes. The flasks were maintained in thermostatically controlled water-baths at an irradiance of 70 $\mu mol \cdot m^{-2} \cdot s^{-1}$, supplied by "cool" white fluorescent tubes. Cultures were kept at temperatures of 10, 15, 20, 25, 30 and 35°C (±2°C maximum variation). Tetraspore growth was measured on a Wild Inverted Microscope with a calibrated, graduated eyepiece. The mean of 30 measurements of the length of both the thallus and longest rhizoid were taken and graphed.

Sections (50 μm thick) of the spore producing thallus were cut using a freezing microtome, in a supporting medium of Tissue-Tek (Miles Laboratories, USA). Sections were stained with Toluidine Blue and mounted in glycerol for viewing under a Zeiss Photomicroscope. Drawings and photographs were recorded.

Results

Tetrasporogenesis was found to occur after 28 days in material maintained at 21.5°C

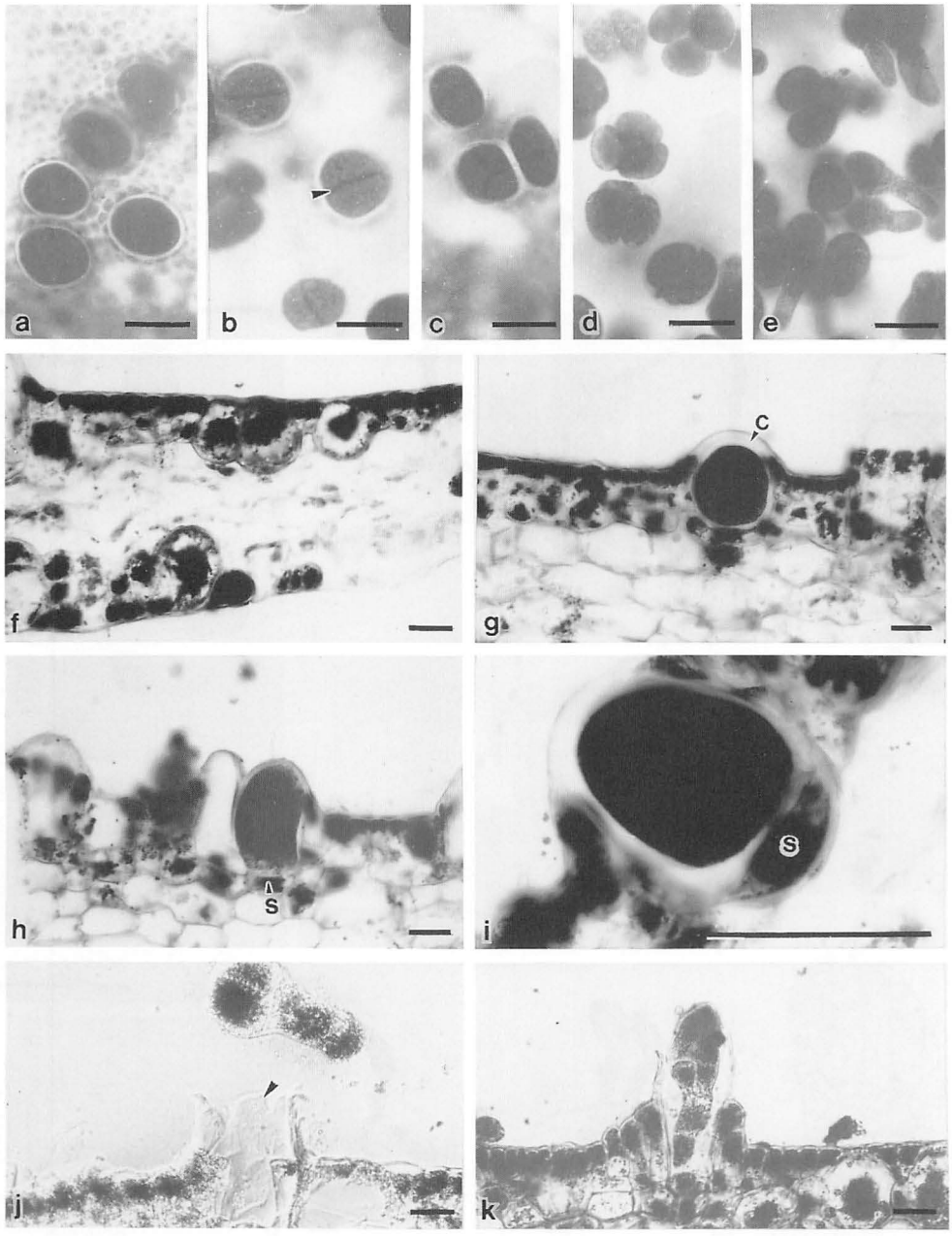

Fig. 3. a) Early spore mother cell development prior to division; b) Spore mother cell division (arrow); c, d) Formation of the individual tetraspores; e) Initiation of tetraspore germination whilst still in a clump on the lamina surface; f) Formation of the tetrasporangium within the cortex of the lamina; g) Early stages of spore mother cell protrusion, showing the raised cuticle (c); h, i) Mature spore mother cell, prior to meiotic division, partially embedded with the cortex, showing the stalk cell (s); j) Vacated tetrasporangium (arrow) following release of the tetraspores; k) Unreleased tetraspore germinating within the tetrasporangium. Scale bar=1000 μm.

(± 2°C), at an irradiance of 22 μmol·m^{-2}·s^{-1}. Tetrasporangia developed within sori at the surface of the laminae (Fig. 3a). The sporangia (i.e., site of meiosis) each produced four tetrahedrally arranged tetraspores (Figs. 3b, c, d). The sporangium began develop-

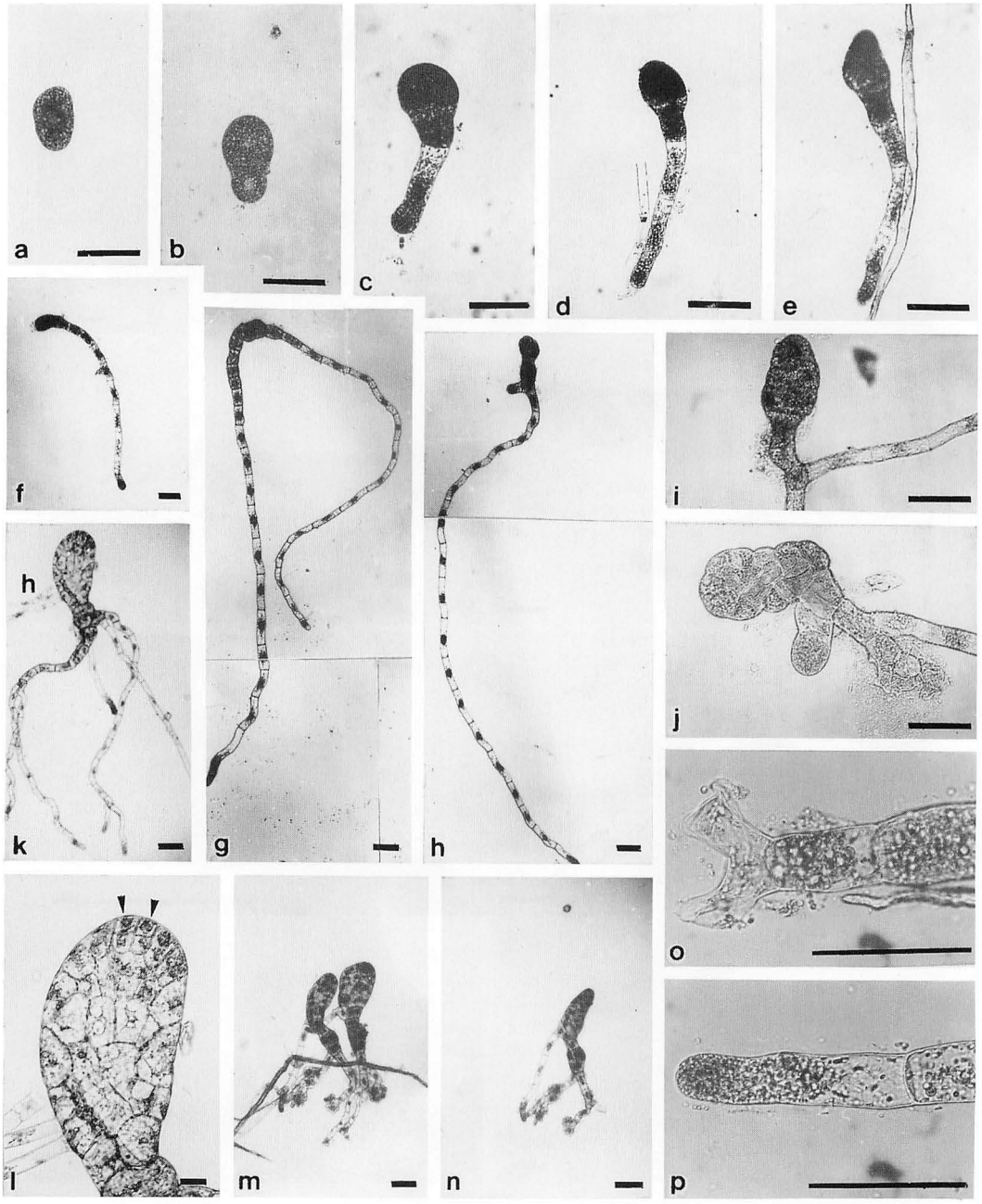

Fig. 4. a–f) Tetraspore germination (juvenile gametophyte), primary rhizoid elongation prior to development of the thallus or secondary rhizoid; g) Tetraspore with two well-developed rhizoids; h) Tetraspore showing early development of secondary rhizoid and thallus; i, j) Multicellular thallus in early stages of development; k) Juvenile gametophyte with multiple rhizoids and hairs (h); l) Apex of juvenile gametophyte showing dividing meristematic cells (arrow); m–o) Enlarging gametophyte and "jigsaw puzzle", aseptate, terminal outgrowths of rhizoids grown at 20°C; p) Normal rhizoid apex. Scale bar = 1000 μm.

ment from a sub-epidermal cell (Fig. 3f), which divided unequally to give rise to a stalk (basal) cell and sporangial initial. The sporangium increased in size and secreted a bi-layered cuticle (Figs. 3g, h, i) before dividing and releasing the tetraspores (Fig. 3j).

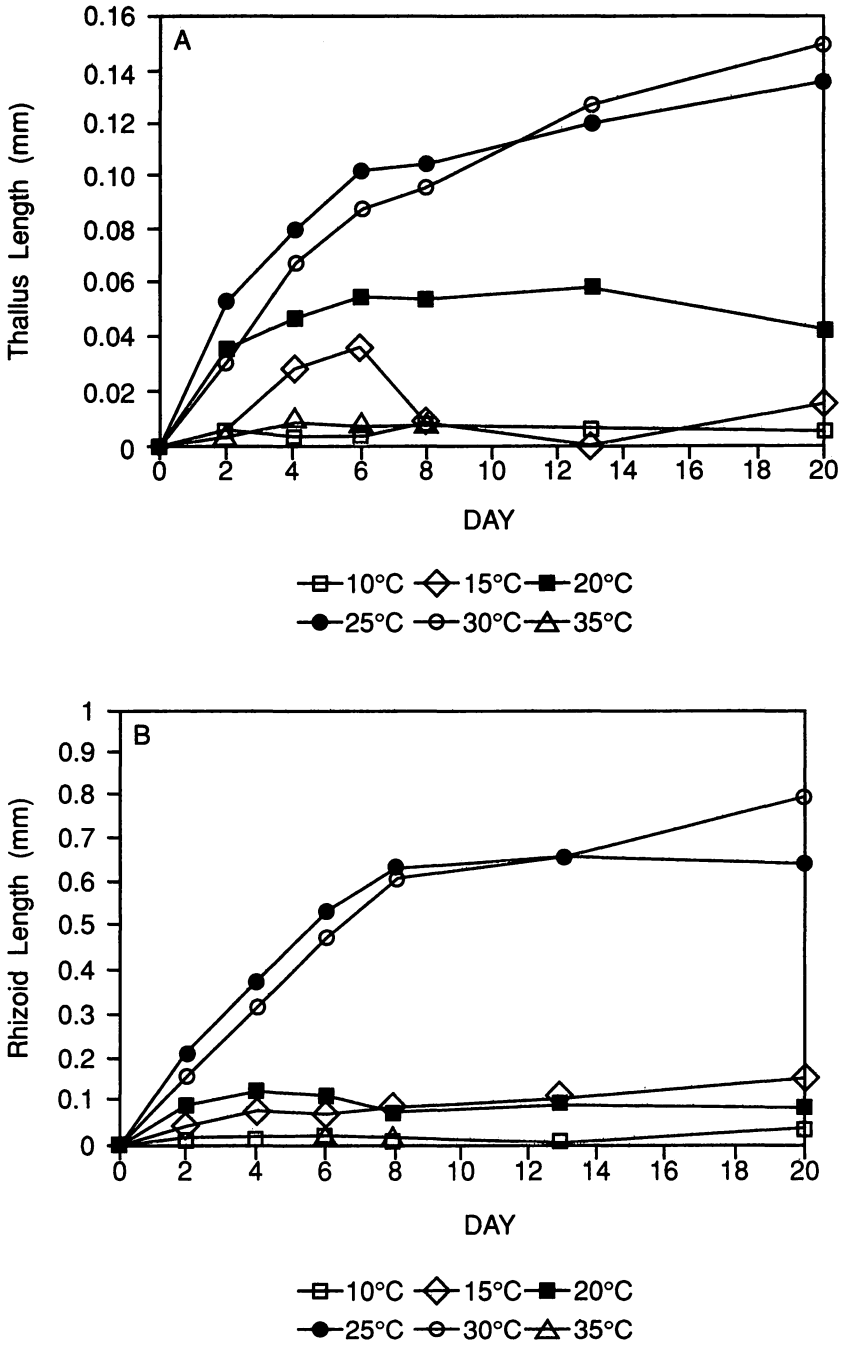

Fig. 5. Thallus (A) and rhizoid (B) elongation rates with respect to temperature.

Observations indicated that the stalk cell did not divide further (Figs. 3g, h, i). In some cases the four spores produced by meiosis, did not separate before germination began (Fig. 3e) and occasionally were not released from the sporangium at all before germination was initiated (Fig. 3k). Lack of water movement around the spores under experimental conditions may account for the *in situ* developmental patterns observed. Germinating tetra-

spores on the blades of *D. longifolia* have not been observed in the field.

Morphogenesis of the spores began with an initial elongation of one side of the cell (Fig. 4a), before the first division occurred (Fig. 4b). The latter polarised the spore into rhizoidal and thalloid poles (Figs. 4b, c). Further growth was observed to occur with rapid elongation and division of the cells of the rhizoid (Figs. 4c, e, f). In some spores a secondary rhizoid was observed to develop prior to, or during, thallus development (Figs. 4g, h, respectively). Once the thallus became multicellular (Figs. 4h, i, j, k, l) and well established, the apical meristematic cells and pit became visible; hairs were also produced (Figs. 4k, l). It was observed that a large number of the individuals maintained at 20°C developed a highly branched "jigsaw puzzle" terminal rhizoid system (Figs. 4m, n, o), as opposed to the normal rounded tip (Fig. 4p). This phenomenon was rare in cultures kept at other temperatures.

Growth and development of the tetraspores differed under the various temperatures (Fig. 5). The optimum temperature range for development of both thallus and rhizoid was between 20°C and 25°C, at 70 $\mu mol \cdot m^{-2} \cdot s^{-1}$. The increase in length of the longest (primary) rhizoid at 20°C and 25°C, and to a lesser extent at 15°C and 30°C, was considerable up until day 8. After this the rate of elongation decreased in all treatments. No elongation of the primary rhizoid occurred at 10°C or 35°C. The thalli elongated at a much slower rate than the rhizoids, but the 20°C and 25°C individuals still had the greatest growth rate. There was either a slight initial elongation (15°C and 30°C) or no elongation at all (10°C and 35°C) of the thalli at the other temperatures. At 35°C there was no development of either the thallus or the rhizoid.

Discussion

Development of the tetrasporangium in *D. longifolia* differs from that described for *D. divaricata* (Ishii *et al.* 1959; Fig. 6). The latter is reported to have a supporting stalk cell which divides into two to four cells. The tetraspore mother cell is initiated and develops superficially and there was no elevated cuticle reported for the field collected material. *D longifolia*, however, has a single stalk cell (Figs. 3h, i) and the sporangium elevates a bi-layered cuticle (Figs. 3g, h, i; 6). The spore mother cell remains partially embedded in the cortex of the thallus. Meiosis results in the production of four tetraspores on the surface of the thallus. This pattern of tetrasporogenesis is similar to that described for *Padina japonica* (Ishii *et al.* 1959) which similarly has one stalk cell and an elevated cuticle. However, the tetrasporangium in *P. japonica* develops externally, which is more similar to *D. divaricata*.

The lack of separation of released spores, or lack of release of spores from the sporangium altogether, prior to germination (Figs. 3e, k) was not observed to occur in the field where plants are exposed to wave activity. All the aggregated spores appeared to be equally viable in culture and germinated in the same way and at the same rate as separately released spores.

Development of the tetraspores of *D. divaricata* was described as first producing a "multicellular, oval body" that developed one or several protruding cells, which later became the meristematic, apical cell of the juvenile gametophyte plant (Nishibayashi and Inoh 1959). Inoh (1936) described the division and elongation of the rhizoid, prior to the development of the protrusion from which the thallus developed. A tetraspore may produce more than one of these protruding cells. Although *D. longifolia* was not observed to produce more than one protrusion, the process of the initial elongation of the rhizoid followed by the development of the thallus, was similar to the previous author's descriptions.

Initial morphogenesis of *D. longifolia* tetraspores was similar at all temperatures investigated. However, at the stage when a secondary rhizoid emerged or the thallus began development, there was considerable variation and a large number of peculiarities were

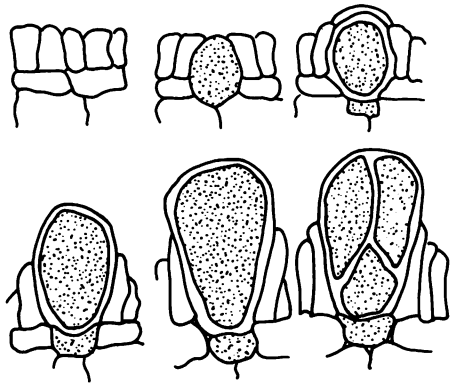

Fig. 6. Tetrasporogenesis in *Dictyopteris longifolia*.

observed. The "jigsaw puzzle" terminal rhizoid observed in *D. longifolia* (Figs. 4 m, n, o; 7), has been reported for the developing tetraspore rhizoids in *Dictyota dichotoma* (Nishibayashi and Inoh 1959; Gaillard 1977; Gaillard *et al.* 1986). The structures consist of lobed proliferations of the terminal cell of the rhizoid, lacking any cross-walls. This undivided proliferation of the rhizoid has not previously been reported for other species of *Dictyopteris*. Other than this peculiarity, morphogenesis was similar to that described by Nishibayashi and Inoh (1959) and Inoh (1936), with the primary rhizoid emerging and developing prior to the development of the thallus from a protrusion of the original spore (Figs. 4a-h). Taking similarities of spore production, germination and juvenile gametophyte development into consideration, there seems to be a high degree of consistency in the Order Dictyotales.

D. longifolia is found in sub-tropical to temperate waters with a seawater temperature range of 15-25°C. Temperatures lower or higher than these are rarely experienced. It could thus be expected that the optimal temperature range for spore germination and growth would occur in this range. The growth study performed on the spores of *D. longifolia* showed that maximum growth of both the rhizoid and the thallus occurred at 20°C to 25°C. There was slight initial growth at temperatures lower than 20°C but this ceased after the first five days. At temperatures greater than 25°C, there was an initial

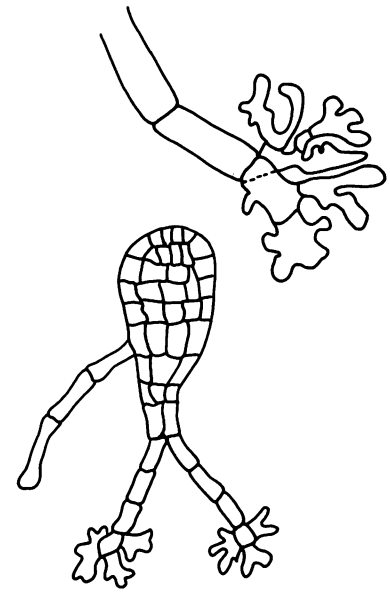

Fig. 7. "Jigsaw puzzle" terminal rhizoid proliferations in *Dictyopteris longifolia*.

increase and then subsequent decrease in length due to necrosis (Fig. 5).

Large numbers of tetraspores are produced by a single lamina and, although many do not germinate, prolific production may explain the clumped appearance of patches of *D. longifolia* in the field. Tetraspores may get caught in the mats of rhizoids and laminae of adult plants and germinate without dispersal. Alternatively, the unreleased or unseparated spores may increase clump size. A further possible explanation for clumping has been reported in *D. membranacea* (Katsaros and Galatis 1988), in which it was observed that cells of the germinating spore were capable of vegetatively producing plantules. This may account for the very localised distribution of the plants. *D. longifolia* was not observed to produce more than one plantule from each tetraspore. However, isolated rhizoids from the holdfast of *D. longifolia* are capable of producing plantules vegetatively (own observation), as has been reported for *D. divaricata* (Tokida *et al.* 1953); this may be another contributing factor to the clumped distribution of individuals in natural stands.

Acknowledgements

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Blackmore[1], N. L. · Critchley[2], A. T. · Pienaar[2], R. N.：南アフリカ産褐藻 *Dictyopteris longifolia*（アミジグサ目）の研究 I．四分胞子の生殖と形態形成

褐藻 *Dictyopteris longifolia* Papenfuss の四分胞子嚢形成と四分胞子の発芽は 20°C，光強度 22 μmol·m^{-2}·s^{-1} の条件下でおこった。葉状体と四分胞子の発芽体の一次仮根の成長速度を様々な温度条件下で比較したところ 20°C で最も成長が良かった。四分胞子嚢の形成は皮層内で始まり，続いて減数分裂に先立つ胞子嚢母細胞の増大によるクチクラの上昇がおこった。四分胞子の発芽は一本の一次仮根の成長と分裂により始まり，これにより基物に付着した。続いて二次仮根の発達と葉状体の発達がおこった。この属でこれまでに報告されていない特異な形態の仮根末端部の形態につき報告した。([1]Natal Parks Board, St. Lucia, Natal, South Africa, [2]Department of Botany, University of the Witwatersrand, Johannesburg, P O WITS 2050, South Africa)

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Jpn. J. Phycol. (Sôrui) 42: 385–391, December 10, 1994

Nuclear migration during wound-healing process in three ceramiacean species: *Antithamnion nipponicum, Aglaothamnion oosumiense* and *Platythamnion yezoense* (Rhodophyta)

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Hwang, M. S., Kim, G. H., Fritz, L. and Lee, I. K. 1994. Nuclear migration during wound-healing process in three ceramiacean species: Antithamnion nipponicum, Algaothamnion oosumiense and Platythamnion yezoense (Rhodophyta). Jpn J. Phycol. 42: 385–391.

The wound-healing process of three filamentous red algae, *Antithamnion nipponicum, Aglaothamnion oosumiense* and *Platythamnion yezoense* was examined using the fluorescent nuclear stain DAPI. The nuclear movement during the process was followed to observe how the plants manage the heterogenous nuclear condition caused by the process. A strong relationship between nuclear movement and wound-healing response during the process was observed. In all three species the process included the early migration of adjacent cell nuclei toward the wounded region and their later return to the central portion. When the nuclei of adjacent cells remained at the central portion, the repair process did not proceed. The ratio of nuclear DNA to cytoplasmic volume seemed to break down during wound-healing response. The ratio increased in *Antithamnion nipponicum* and *Aglaothamnion oosumiense*, but it decreased in *Platythamnion yezoense*.

Key Index Words: Aglaothamnion oosumiense—Antithamnion nipponicum—*nuclear DNA to cytoplasmic volume ratio—nuclear movement*—Platythamnion yezoense—*wound-healing response*

Red algae are exceedingly diverse with respect to their nuclear features. The number, size and position of nuclei in cells as well as their DNA content (ploidy) vary considerably in different taxa (Goff and Coleman 1990). One constant nuclear trait expressed in the class Florideophyceae, whether in uninucleate or multinucleate plants, is that the total nuclear DNA within a cell is very closely correlated with the total cytoplasmic volume; there is a reasonably constant ratio between nuclear DNA and cytoplasmic volume (Goff and Coleman 1986, 1987, 1990).

This constant ratio appears to break down during cellular events involving nuclear migration resulting in secondarily derived multinucleate cells (L'Hardy-Halos 1969, Cabioch 1972, Goff and Coleman 1984a, 1985, 1986). Perhaps the best known example is nuclear transfer during the formation of secondary pit-connections (Rosenvinge 1888 Goff and Coleman 1984b, 1986). The nuclei transferred from one cell to another by somatic cell fusion, sometimes fuse with resident nuclei, thereby resulting in an increase in cell ploidy levels (Goff and Coleman 1985).

An increase in cell ploidy levels may also occur during the wound-healing response. In many filamentous red algae the damaged intercalary cells are replaced through a process of cell repair. In a detailed study of red algal wound-healing, Kim *et al.* (1988) observed the process in 11 genera, 16 species and grouped them into three typical patterns; fusion type, non-fusion type and elongation type. During the fusion-type wound-healing response two kinds of specialized somatic cells are produced, one to several upper repair rhizoid cells and a lower repair shoot cell.

These cells grow to each other and fuse to replace the dead intercalary cell (Waaland and Clreland 1974, Kim *et al.* 1988, Kim and Fritz 1993). Because the region occupied by the intercalary cell maintains a relatively constant volume, the fused repair cell prossesses at least two times more DNA than the prior intercalary cell, thus resulting in an imbalance in the DNA to cytoplasmic volume ratio. Imbalance of the ratio can be induced in non-fusion type and elongation type as well.

In this study, using the fluorescent nuclear stain DAPI, we examined the nuclear movement during the wound-healing process in three filamentous red algae representing each of the typical patterns of wound-healing response (Kim *et al.* 1988); *Antithamnion nipponicum* (fusion type), *Aglaothamnion oosumiense* (non-fusion type), and *Platythamnion yezoense* (elongation type), with an aim toward understanding how the plants manage the heterogenous nuclear condition caused by the process.

Materials and Methods

The marine red algae *Antithamnion nipponicum* Yamada, *Aglaothamnion oosumiense* Itono and *Platythamnion yezoense* Yamada et Inagaki (Rhodophyta, Ceramiales) were cultured as described previously (Kim *et al.* 1988) in modified Provasoli's enriched medium (PES; Provasoli 1968) at 20°C on a 16h light: 8h dark cycle under 12 $\mu Em^{-2}s^{-1}$ cool-white fluorescent lamp.

For wound-healing experiment, intercalary cells in the upper part of an actively growing thallus were wounded with a razor blade and the cytoplasm was carefully removed so as not to sever the wall. Wounded plants were placed in fresh culture medium and observed every hour. For observations of cell nuclei, wounded plants were transferred into a solution of DAPI nuclear stain (0.5 μg/ml) and fixed by microwave at high level for 10-15 seconds (Goff and Coleman 1987).

All specimens were examined with a Reichert-Jung Polyvar and Olympus BH-2 microscope equipped with epifluorescence illumination and differential interference optics.

Results

***Antithamnion nipponicum* (Fusion type):** This species is composed of uninucleated cells (Fig. 1-8). The size of nuclei in the intercalary cells is in direct proportion to their cytoplasmic volume (Fig. 1). Each axial cell is in contact with four cells, two adjacent axial cells and two small basal cells, all of which are involved in the wound-healing response.

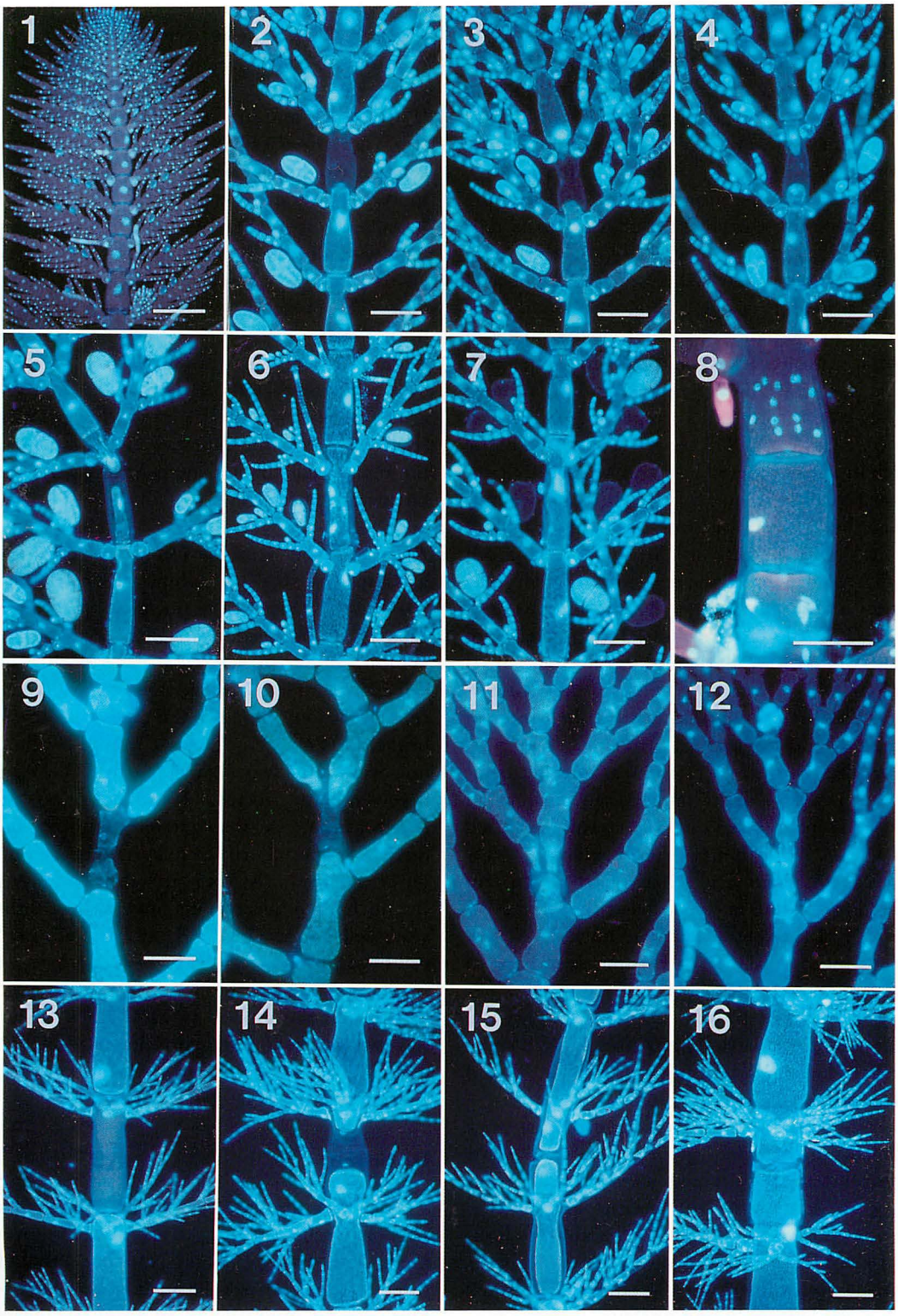
When the nuclear stain DAPI was added immediately after wounding, nuclei of adjacent cells were observed to be located close to the center of each cell (Fig. 2). Within two to three hours after wounding the nuclei of adja-

Figs. 1-16. Nuclear movement during wound-healing response in three ceramiacean algae.

Figs. 1-8. *Antithamnion nipponicum* (Fusion type). Fig. 1. Before wounding. Nuclear size is in proportion to cell size. Scale bar=200 μm. Fig. 2. 1 h after wounding. Nuclei of adjacent cells are situated in the center of cells. Scale bar=100 μm. Fig. 3. 3 h after wounding. Nuclei of adjacent cells moved toward wounded portion. Scale bar=100 μm. Fig. 4. 6 h after wounding. Each adjacent cell divided repair cell. Scale bar=100 μm. Fig. 5. 12 h after wounding. The repair cells grew toward each other. Scale bar=100 μm. Fig. 6. 18 h after wounding. The repair cells were fused. Four nuclei were present in the fusion cell. Scale bar=100 μm. Fig. 7. 24 h after wounding. Nuclei from each repair cell fused into one big nucleus. Scale bar=100 μm. Fig. 8. 48 h after wounding. A fusion cell divided into three small cells containing various number and size of nuclei. Scale bar=50 μm.

Figs. 9-12. *Aglaothamnion oosumiense* (Non-fusion type). Scale bars=50 μm. Fig. 9. 2 h after wounding. Nuclei of adjacent cells moved toward wounded portion. Fig. 10. 6 h after wounding. Repair cells were formed from each adjacent cell. Fig. 11. 18 h after wounding. Repair cells grew in the wounded portion. Fig. 12. 24 h after wounding. Repair cells were attached to each other without cell fusion.

Figs. 13-16. *Platythamnion yezoense* (Elongation type). Scale bar=100 μm. Fig. 13. 6 h after wounding. Nuclei of adjacent cells moved toward wounded portion. Fig. 14. 10 h after wounding. Elongation of adjacent cells began. Fig. 15. 18 h after wounding. Fig. 16. 24 h after wounding. Two adjacent cells attach to each other and nuclei of both cells moved back to the center.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cent cells have moved closer to the wounded region (Fig. 3), and have divided to form daughter nuclei. In the rare cases where the wound-healing process was not initiated even in 24 hours after wounding, the nuclei of adjacent cells remained at the central position of the cell and never underwent division.

In the normal situation, four to six hours after wounding each of the adjacent axial cells divided to produce small repair cells with nuclei approximately the same size as those of the large adjacent cells (Fig. 4). Upon completion of repair cell formation the nuclei of adjacent cells moved back to their earlier central position. Each basal cell of lateral branches also produced a respective repair cell with a single small nucleus. The fusion of the repair cells occurred first among the three upper repair cells, and by 12 hours post-wounding three nuclei (a large one and two small ones) were present in the upper repair cell (Fig. 5). The upper and lower repair cells grew and fused at about 18 hours after wounding (Fig. 6). At this time four nuclei were distributed irregularly within the single fused repair cell. Twenty four hours after wounding the nuclei migrated toward the center of the cell and fused (Fig. 7).

Although nuclear fusion was a rather common process after somatic cell fusion, all fused repair cells did not result in fused nuclei. By 72 hours after wounding, 56% (14/25) of fusion cells had fused nuclei and 24% (6/25) had partially fused ones, but 20% (4/25) of them still had four nuclei. At five days after wounding it became very hard to distinguish the fused repair cell from other adjacent cells. In rare cases (1/25), however, the fusion cell divided again into three small cells which had various number (1-13) and size of nuclei (Fig. 8).

When the filament was severed just after the fusion of three upper repair cells, three nuclei in the cell divided once or twice, resulting in six to twelve heterogenous nuclei. Later, the rhizoidal initial cell divided to form a new cell with two of four nuclei. A subsequent divisions of this daughter cell resulted in a cell with only one nucleus.

***Aglaothamnion oosumiense* (Non-fusion type)**: This species has non-polyploid uninucleate cells. The size of nucleus is relatively constant throughout the filament (Figs. 9-12), and intercalary cells are in contact with three cells. When an intercalary cell was wounded, the nuclei of adjacent cells moved from their central position toward the wounded region (Fig. 9). Four to six hours after wounding each of the adjacent cells divided to produce a respective repair cell (Fig. 10). The nuclei in the repair cells were approximately in same size as those of the mother cells. When the formation of repair cells was completed, the nuclei of adjacent cells moved back to their central position (Fig. 11). Within 24 hours after wounding the repair cells made contact with each other but without cell fusion (Fig. 12).

***Platythamnion yezoense* (Elongation type)**: This species also has uninucleate cells (Figs 13-16). The size of the nuclei in intercalary cells is in proportion to their cytoplasmic volume similar to *A. nipponicum*. Each axial cell is in contact with six cells, two adjacent cells and four small basal cells of lateral branches (Fig. 13). During wound-healing, however, only two adjacent axial cells were involved in the process. Four basal cells elongated a little. At the time of wounding, the nuclei of adjacent cells were located at the center of each cell. At six hours after wounding the nuclei of adjacent cells moved toward the wounded region (Fig. 13), and the adjacent cell began to elongate (Fig. 14). Both of the nuclei remained at the tip of the adjacent cell throughout the process (Figs 13-15). When the two adjacent cells came in contact with each other, both nuclei moved back to their central position (Fig. 16).

Discussion

The data presented show that there is a very close relationship between nuclear movement and wound-healing response. In all three species the wound-healing process begins with the migration of adjacent cell nuclei

toward the wounded cell, and upon completion of the process the nuclei return to a central position. As ceramiacean species are supported to lack cyclosis and their organelles are fixed in the peripheral cytoplasm that surrounds the large central vacuole (Goff and Coleman 1987, Koslowsky and Waaland 1984), the nuclear migration suggests a major rearrangement of cell organelles.

To ensure concurrent migration of adjacent cell nuclei and development of compatible repair cells, transmission of chemical messages between the cells is necessary during the wound-healing process. To date, only one endogenous development regulating substance has been isolated from a red alga, rhodomorphin of *Griffithsia pacifica* (Watson and Waaland 1983, 1986). Rhodomorphin is an α-D-mannosyl-linked glycoprotein, which is purported to induce cell division, to control cell elongation and morphogenesis in the cells involved in wound-healing response (Waaland 1990). Recently, Kim and Fritz (1993) reported a signal glycoprotein with α-D-mannosyl residues is involved in the wound-healing response of *Antithamnion sparsum*. By the use of FITC-conjugated lectins combined with the fluorescent nuclear stain DAPI, they distinguish the wound-healing process into three principle steps and suggest that the first step of the process which comprises with concurrent migration of adjacent nuclei may be dependent on another cellular signal because there is no apparent labelling of the signal glycoprotein at this step (Kim and Fritz 1993). The concurrent migration of adjacent cell nuclei observed in non-fusion type (*Aglaothamnion oosumiense*) and elongation type (*Platythamnion yezoense*) wound-healing response which seems to lack cell fusion hormone may support the idea.

In both prokaryotic and eukaryotic cells strong correlations have been reported between genome size and cell volume and there is a reasonably constant ratio between nuclear DNA and cytoplasmic volume (Cavalier-Smith 1978, 1985, Watanabe and Tanaka 1982, Shutter *et al.* 1983, Brodsky and Uryvaena 1985, Lewis 1985, Goff and Coleman 1986, 1987, 1990).

During the wound-healing process of filamentous red algae, however, this constant ratio appears to break down. In *Antithamnion nipponicum*, two large nuclei and two small nuclei participate in the fused repair cell, thereby increase the ratio more than two times. In *Aglaothamnion oosumiense*, the ratio also increases three times because the region of the dead cell is replaced by three repair cells which have their own nuclei. In contrast, in *Platythamnion yezoense* both of the adjacent cells increase in cytoplasmic volume about 1.5 fold without apparent increase in DNA amount, which may result in decrease of the DNA to cytoplasmic volume ratio.

Heterokaryons can be produced experimentally by fusing male and female gametophytes during the fusion-type wound-healing process (Waaland 1978, Hwang *et al.* 1991). The regenerated plants were shown to be morphologically and genetically different from either gametophyte, giving rise to tetrasporangia characteristic of the tetrasporophyte (diploid) generation. Waaland (1978) suggested that tetrasporangia formed on regenerated plants might be a result of a co-action between male and female nuclei in the cell. Hwang *et al.* (1991), however, obtained viable tetrasporangia from the regenerated plants, and suggested that at least some of the nuclei might fuse with each other to form diploid nuclei. Our data from *Antithamnion nipponicum* of which wound-healing response resulted in fusion of the nuclei involved in the process appears to support this hypothesis.

Aknowledgements

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イギス科3種，*Antithamnion nipponicum, Aglaothamnion oosumiense* および *Platythaminion yezoense* でみられた創傷治癒における核移動

3種の糸状紅藻，*Antithamnion nipponicum, Aglaothamnion oosumiense* および *Platythamnion yezoense* の創傷治癒過程をDAPI蛍光核染色で調べた。藻体が創傷治癒で引き起こされた異質の核条件にどの様に対応するか，核の移動を追跡した。核の移動と創傷治癒反応には強い関係がみられた。3種すべてにおいて傷を受けた細胞に隣接する細胞の核は傷に向かってすみやかに移動した。隣接した細胞の核が中心部に残っている場合には傷の修復が行われなかった。細胞質量に対する核DNAの割合は創傷治癒に際し破られるようである。*A. nipponicum* と *A. oosumiense* ではこの割合は増加し，*P. yezoense* では低下した。(*Development of Biology, Seoul National University, Seoul, 151–74 Korea; **Department of Biology, Kongju National University, Kongjushi, Chungnam, 314–702 Korea; ***Institute for Marine Bioscience, National Research Council of Canada, Halifax, Nova Scotia, B3H3ZI, Canada)

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Sargassum denticarpum Ajisaka sp. nov. and *S. longifructum* Tseng et Lu; two zygocarpic species of *Sargassum* (Phaeophyta) from Vietnam

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Ajisaka, T., Huynh, Q. N. and Nguyen, H. D. 1994. *Sargassum denticarpum* Ajisaka sp. nov. and *S. longifructum* Tseng et Lu; two zygocarpic species of *Sargassum* (Phaeophyta) from Vietnam. Jpn. J. Phycol. 42: 393–400.

Two species of the section *Zygocarpicae*, subgenus *Sargassum* (Phaeophyta, Fucales, genus *Sargassum*) are reported for the first time from Vietnam. *Sargassum denticarpum* Ajisaka sp. nov. has pseudozygocarpic, androgynous receptacles, which are compressed and dentate at the margin. This species is endemic to Vietnam. *Sargassum longifructum* Tseng et Lu has holozygocarpic, dioecious receptacles. Its female receptacle is compressed with a dentate margin. The male receptacle is terete or slightly compressed, with an entire margin or a few spines. Female receptacles are described for the first time.

Key Index Words: *Fucales—Phaeophyta—Sargassaceae*—Sargassum denticarpum—Sargassum longifructum—*Taxonomy—Vietnam*—Zygocarpicae.

Pham-Hoang (1967, 1969) reported 39 species of the genus *Sargassum* from Vietnam, of which 31 belonged to the subgenus *Sargassum*. However, the identification of some species is doubtful, e.g. Tseng and Lu (1988) considered that *S. carpophyllum* sensu Pham-Hoang was infact *S. parvivesiculosum* Tseng et Lu.

Recently, Nguyen (1986a, b) reported 22 *Sargassum* species from Vietnam, of which 19 species belonged to the subgenus *Sargassum*. However, he reported only 10 species, which have already been identified by Pham-Hoang (1967, 1969).

As a part of a critical re-survey of the marine flora of the Vietnamese coasts, we collected many specimens during a scientific survey of central to southern Vietnam in Jan. —Feb. 1993. Amongst the many species of the genus *Sargassum* which were collected, some belonged to the subgenus *Bactrophycus*, and others to the subgenus *Sargassum*.

This study was supported by The Monbusho International Scientific Research Program—Field Research (No. 04041015) from the Ministry of Education, Science and Culture, Japan.

In this paper, we record the presence of two species in the section *Zygocarpicae* of the subgenus *Sargassum*, *Sargassum denticarpum* Ajisaka sp. nov. and *S. longifructum* Tseng et Lu, for the first time from Vietnam. The latter species was described from Naozhou Island, southern China (Tseng and Lu, 1987, 1988).

Materials and Methods

Plants of a new species, *S. denticarpum* were collected by snorkeling from St. 3 (Son Hai, Ninh Phuoc, Ninh Thuan Province: Jan. 21, 1993) and *S. longifructum* from St. 16 (Mui Nai, Ha Tien, Kien Giang Province: Feb. 5, 1993) in central to southern Vietnam (Fig. 1). *Sargassum denticarpum* grew on rocks at a depth of 1-5 m in clear water at the reef edge of a wide lagoon. *S. longifructum* grew on rocks or dead corals at a depth of 1 m along the fringing reef. The water was less clear at Station 16 due to suspended sediments and *S. longifructum* was restricted to shallow waters.

In addition, herbarium specimens collected in 1992 from central Vietnam were examined. The holotype specimen of *S. longifruc-*

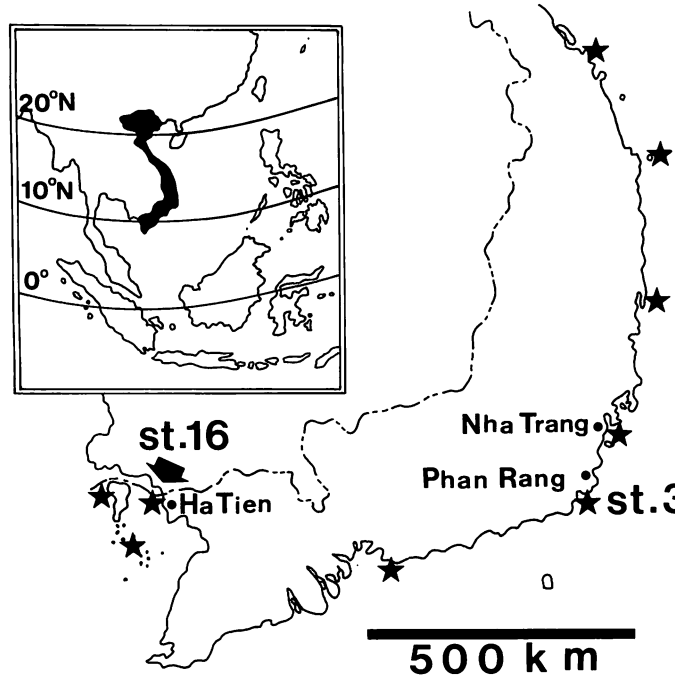

Fig. 1. Collection sites (solid stars) in the scientific survey of southern Vietnam from January to February, 1993. The type locality of *Sargassum denticarpum* is St. 3.

tum (AST 551767), deposited in the Herbarium of Institute of Oceanology, Academia Sinica, Qingdao was also examined. Abbreviations for herbaria follow Holmgren *et al.* (1990).

Observations and Discussion

***Sargassum denticarpum* Ajisaka sp. nov.** (Figs. 2-10)

Hapteron discoideum vel conicum, usque ad 14 mm in diametro. Caulis erectus, teres, usque ad 10 mm in altitudine, usque ad 5 mm in diametro, pagina laevi, usque ad 5 ramos principales e parte distali ferens. Rami principales usque ad 50 cm longi, compressi prope partem proximalem, usque ad 5 mm lati, parum compressi vel angulares ad partem distalem, usque ad 3 mm lati, pagina laevi. Rami secundarii distiche 5 cm intervallo exorientes, usque ad 50 cm longi, pagina laevi. Folia breviter petiolata, simplica, elongato-elliptica vel liniari-lanceolata, usque ad 5 cm longa, ad 2 cm lata, basi asymmetricis et apice acuto; margines irregulariter dentati; cryptostomata conspicue effecta sed irregulariter in pagina omnino dispersa; costa conspicua, evanescens vel percurrens, interdum spinosa (Figs. 3 & 5). Vesiculae sphericae vel ellipsoideae, usque ad 8.5 mm longae, ad 7 mm latae, apiculatae, cum vel sine appendiculis spinosis aut integeris ad apicem vel ad marginem, cryptostomatibus dispersis (Figs. 3 & 5-7, 9 & 10); petiolus brevis, teres vel foliaceus, usque ad 3 mm longus (Fig. 5).

Planta monoecia. Receptacula androgyna (conceptacula mascula pauca inter conceptacula femina, Fig. 4), compressa vel triquetra, usque ad 4 mm longa et 1 mm lata, simplicia furcata vel bifurcata, margine acute dentato, pseudozygocarpica.

Specimina viridi-brunnea ubi exsiccata.

Holdfast discoidal or conical, up to 14 mm in diameter. Stem erect, terete, up to 10 mm in height, up to 5 mm in diameter, with a smooth surface, bearing up to five primary branches from the distal portion. Primary branches up to 50 cm long, compressed near the proximal portion, up to 5 mm wide,

Fig. 2. Plant of *Sargassum denticarpum* (Holotype KYA930201) Scale: 10 cm.
Fig. 3. Apical portion of secondary branches of *S. denticarpum*, collected at Nha Trang, 21 Mar. 1992.
Fig. 4. Transverse section of an androgynous receptable of *S. denticarpum*, showing antheridial and oogonial conceptacles on the same section. Plant collected at Nha Trang, 21 Mar. 1992. Scale: 100 μm.

slightly compressed or angular at the distal portion, up to 3 mm wide, with a smooth surface. Secondary branches arising distichously at 5 cm intervals, up to 50 cm long, with a smooth surface. Leaves shortly petiolate, simple, elongate-elliptical or linear-lanceolate, up to 5 cm long, up to 2 cm wide, with an asymmetrical base and an acute apex; margins irregularly dentate; cryptostomata conspicuously developed but irregularly scattered throughout the surface; midrib conspicuous, evanescent or percurrent, sometimes spinose (Figs. 3 & 5). Vesicles spherical to ellipsoid, up to 8.5 mm long, up to 7 mm wide, apiculate, with or without spinose or entire appendages at the apex or margin, with scattered cryptostomata (Figs. 3, 5-7, 9 & 10): stalk short, terete or foliaceous, up to 3 mm long (Fig. 5).

Plant monoecious. Receptacles androgynous (few male conceptacles amongst the female conceptacles; Fig. 4), compressed or triquetrous, up to 4 mm long, up to 1 mm wide, simple, furcate or bifurcate, with acutely dentate margin, pseudozygocarpic (Figs. 3, 5-10).

Specimens greenish-brown when dried.

Holotype specimen: Son Hai, Ninh Phuoc, Ninh Thuan Province, central Vietnam, 21 Jan. 1993, deposited in the Herbarium of Fisheries Resources, Faculty of Agriculture, Kyoto University (KYA 930201). Isosyntype specimens will be distributed to SAP and UC.

Other specimens examined: Nha Trang, Khanh Hoa Province, central Vietnam, 21 Mar. 1992, deposited in the Herbarium of Fisheries Resources, Faculty of Agriculture, Kyoto University.

Distribution: Endemic to central Vietnam.

Remarks: *Sargassum* subgenus *Sargassum* includes the following 3 sections: *Zygocarpicae, Acanthocarpicae* and *Malacocarpicae* (Abbott *et al.* 1988). The section *Zygocarpicae* is characterized by bearing fertile older branchlets with receptacles provided with leaves and/or vesicles (Setchell 1935, Tseng et Lu 1988). Two subsections, *Pseudozygocarpicae* and *Holozygocarpicae* can be recognized in *Zygocarpicae*. *Pseudozygocarpicae* presents pedicels of receptacles, and receptacles are provided with leaves, or receptacles provided with vesicles. On the other hand, *Holozygocarpicae* has no pedicel for the receptacle, and are provided with leaves, or with both leaves and vesicles (Tseng et Lu 1988).

Sargassum denticarpum is characterized by the

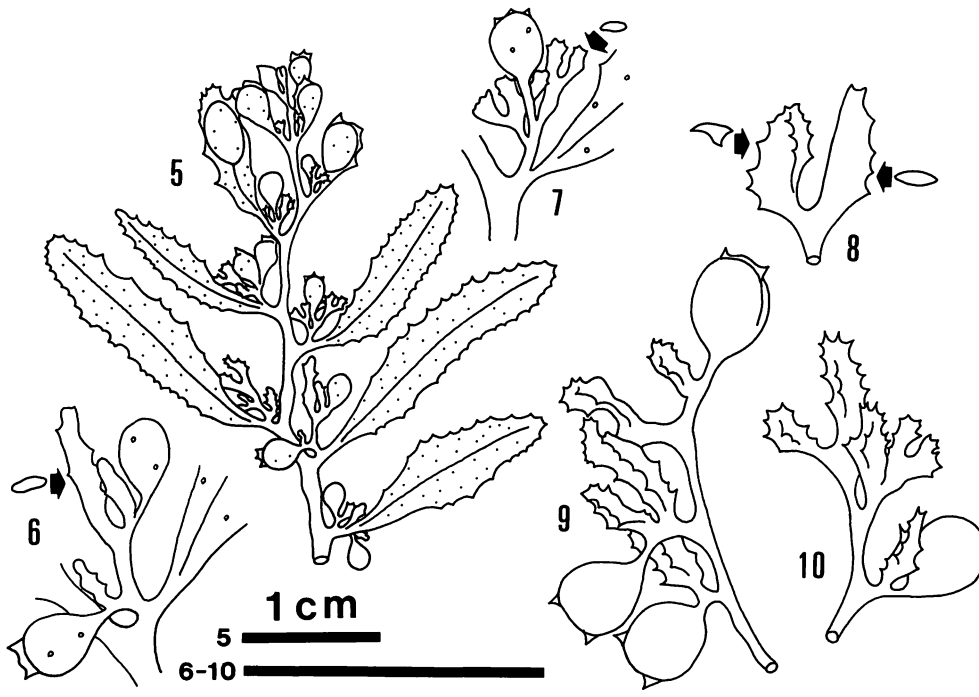

Fig. 5. Apical portion of a secondary branch of *S. denticarpum*, collected at Ninh Phuoc, 21 Jan. 1993.
Figs. 6–10. Compressed or triquetrous, pseudozygocarpic receptacles of *S. denticarpum* with dentate margins. Plants collected at Ninh Phuoc, 21 Jan. 1993.

androgynous receptacles, which are compressed or triquetrous and have a dentate margin, among the species of the subsection *Pseudozygocarpicae* (see the key to species described below). Although *S. bulbiferum* Yoshida and *S. incanum* Grunow also possessed androgynous receptacles, the former has a bulbous structure due to stunted main branches (Yoshida 1994) and the latter has fusiform receptacles with a smooth margin (Grunow 1915).

Key to species in subsection *Pseudozygocarpicae*

1. Plant androgynous ····· 2
1. Plant dioecious ····· 4
2. With bulbous structure by stunted main branches ····· *S. bulbiferum*
2. Without bulbous structure ····· 3
3. Receptacles terete to fusiform ····· ····· *S. incanum*
3. Receptacles compressed or triquetrous ····· *S. denticarpum*
4. Male and female receptacles terete to fusiform ····· 5
4. Male receptacles terete, female receptacles compressed ····· 6
5. Leaves thicker, with cryptostomata ····· ····· *S. vachellianum*
5. Leaves thinner, without cryptostomata ····· *S. graminifolium*
6. Upper leaves almost without vein, lower leaves with vein vanishing below the middle ····· *S. cinereum*
6. Leaves with vein midway to well above the middle ····· *S. glaucescens*

***Sargassum longifructum* Tseng et Lu** (Figs. 11-22)

Holdfast discoid to scutellate, up to 10 mm in diam. Stem erect, terete, up to 2 cm in height, up to 4 mm in diam., with a warty surface, bearing up to eight primary branches from the distal portion. Primary branches (Figs. 11, 12, 15 & 16) slender, terete, up to 50 cm long, up to 2 mm in diam., with a smooth surface. Secondary branches arising alternately at 5 cm interval, up to 25 cm long,

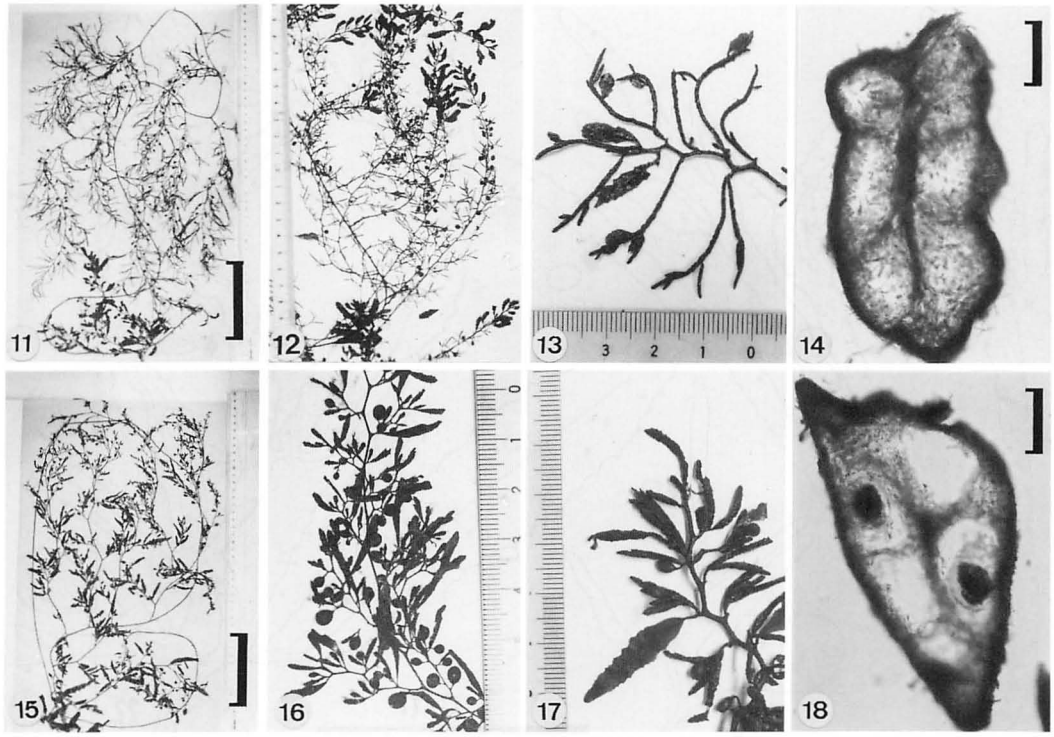

Fig. 11. Male plant of *Sargassum longifuctum*, collected at Nha Trang, 4 Mar. 1992. Scale: 10 cm.
Fig. 12. Apical portion of secondary branches of *S. longifructum* (male plant), collected at Ha Tien, 5 Feb. 1993.
Fig. 13. Holozygocarpic, male receptacles of *S. longifructum*, collected at Ha Tien, 5 Feb. 1993.
Fig. 14. Transverse section of a male receptacle of *S. longifructum*, showing antheridial conceptacles. Plant collected at Nha Trang, 4 Mar. 1992. Scale: 200 μm.
Fig. 15. Female plant of *S. longifructum*, collected at Nha Trang, 4 Mar. 1992. Scale: 10 cm.
Fig. 16. Apical portion of secondary branches of *S. longifructum* (female plant), collected at Ha Tien, 5 Feb. 1993.
Fig. 17. Holozygocarpic female receptacles of *S. longifructum*, collected at Ha Tien, 5 Feb. 1993.
Fig. 18. Transverse section of a female receptable of *S. longifructum*, showing oogonial conceptacles. Plant collected at Nha Trang, 4 Mar. 1992. Scale: 200 μm.

with a smooth surface. Leaves with a short petiole, simple or rarely once divided, elongate-lanceolate, up to 5 cm long, up to 13 mm wide, with a cuneate base and an acute apex; margin slightly to coarsely dentate; cryptostomata scattered or arranged in rows on the both sides of the midrib in linear leaves; midrib distinct, evanescent or percurrent (Figs. 12, 16 & 22). Vesicles spherical to ellipsoid, up to 7.5 mm long, up to 5 mm wide, with or without spinose or entire appendages at the apex, with inconspicuously scattered cryptostomata; stalk terete, up to 3 mm long (Figs. 19-22).

Plant dioecious. Male receptacles (Figs. 13, 14, 19 & 20) terete to slightly compressed, up to 30 mm long, up to 1 mm wide, simple or branched furcately once to several times, entire (Fig. 20) or sometimes with a few spines at the margin (Fig. 19), pseudozygocarpic (Fig. 20) to holozygocarpic (Figs. 13 & 19); only antheridial conceptacles found in the transverse section (Fig. 14). Female receptacles (Figs. 17, 18, 21 & 22) compressed or triquetrous, sometimes twisted, up to 6 mm long, up to 2 mm wide, simple or furcate, with a dentate margin, pseudozygocarpic (Fig. 21) or holozygocarpic (Figs. 17 & 22); only oogonial conceptacles found in the transverse section (Fig. 18).

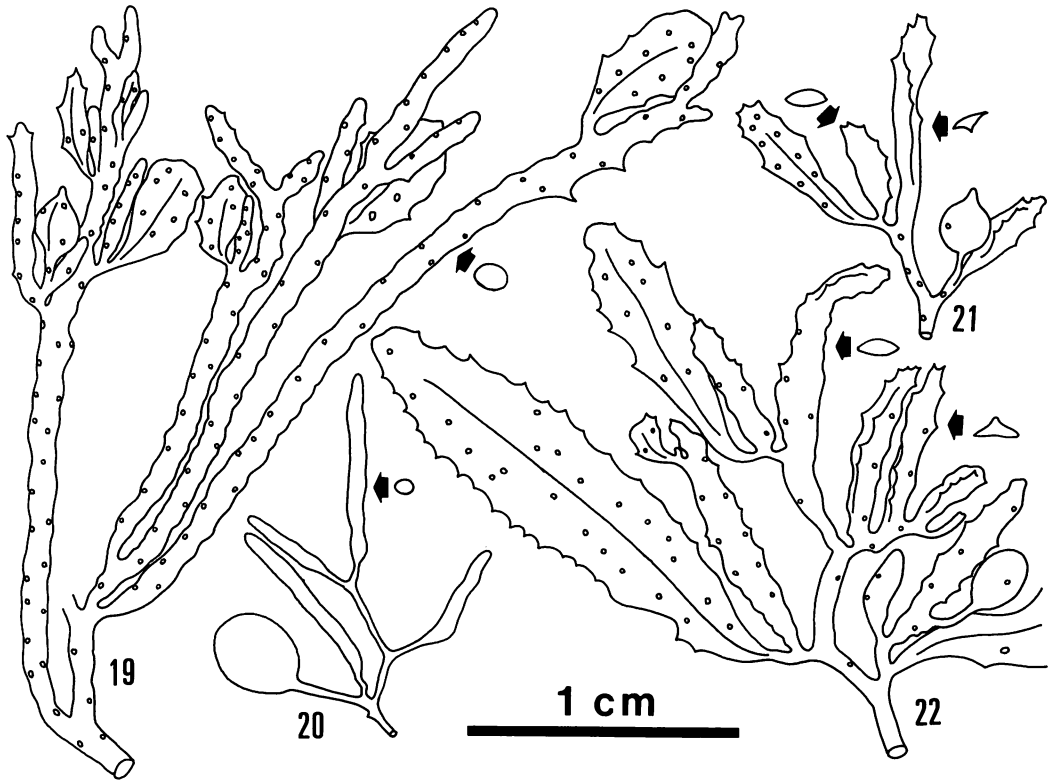

Fig. 19. Long, terete, holozygocarpic, male receptacles of *S. longifructum* with smooth surface or with a few spines. Plant collected at Ha Tien, 5 Feb. 1993.

Fig. 20. Short terete, pseudozygocarpic, male receptacles of *S. longifructum* with smooth surface. Plant collected at Nha Trang, 4 Mar. 1992.

Fig. 21. Compressed or triquetrous, pseudozygocarpic, female receptacles of *S. longifructum*, collected at Nha Trang, 4 Mar. 1992.

Fig. 22. Compressed or triquetrous, holozygocarpic, female receptacles of *S. longifructum*, collected at Ha Tien, 5 Feb. 1993.

Specimens greenish brown when dried.

Specimens examined: Mui Nia, Ha Tien, Kien Giang Province, southern Vietnam, 5 Feb. 1993, and Cauda Nha Trang, Khanh Hoa Province, central Vietnam, 4 May 1992, deposited in the Herbarium of Fisheries Resources, Faculty of Agriculture, Kyoto University.

Distribution: Naozhou Island (type locality) in southern China, Okinawa in Japan and Vietnam.

Remarks: Vietnamese specimens have the dioecious, pseudozygocarpic or holozygocarpic receptacles. Female receptacle is compressed or triquetrous with a dentate margin; male receptacle is usually very long, terete or sometimes slightly compressed, with an entire margin or sometimes a few marginal spines. The characteristics of male plants have been found in *S. longifructum* collected from Naozhou Island, southern China (Tseng and Lu 1987, 1988). However, as this species was described on the basis of male material only, the above is the first description of the female receptacle characteristics (Table 1). In this table, vesicles from Chinese specimen are 1-2 mm in diameter, and seem to be much smaller than vesicles of the Vietnamese specimens. However, Chinese holotype specimen (AST 551767), which we observed, was a mature plant, possessing secondary or tertiary vesicles only. These were usually 3-5 mm in

Table 1. A comparison of *Sargassum longifructum* from China and Vietnam

	China (Tseng et Lu, 1987)	Vietnam (present paper)
Holdfast	unknown	discoid to scutellate
Stem	terete	terete
height	up to 6 mm	up to 2 cm
Primary branch	terete	terete
length	up to 39 cm	up to 50 cm
Leaves	lanceolate	lanceolate
length	up to 6 cm	up to 5 cm
width	up to 7 mm	up to 1.3 cm
Vesicles	spherical to ovate	spherical to ellipsoid
size	1–2 mm in diam.	7.5 mm × 5 mm (max.)
apex	round or apiculate	round or apiculate
stalk	terete to foliaceous	terete
Receptacles	dioecious	dioecious
male morphology	terete	terete to slightly compressed
length	up to 4 cm	up to 3 cm
margin	entire	entire or with a few spines
female morphology	unknown	compressed to triquetrous
length	unkown	up to 6 mm
margin	unkown	dentate

diameter by our estimation. Furthermore, we can see the vesicles which are 3–4 mm in diameter even in Fig. 25 of Tseng et Lu (1988). On the other hand, in the Vietnamese specimen we observed many plants, at several stages of development, from young to mature. We found the largest dimension (7.5 mm × 5 mm) in their primary vesicles, but usually they were 3–7 mm in length in their vesicles on secondary and tertiary branches. When the male receptacles of the holotype specimen were also examined, they were not always holozygocarpic, and sometimes pseudozygocarpic. They were usually terete without spines, but sometimes slightly compressed with a few spines near their apex.

Nguyen (1986b) reported on zygocarpaic species, *S. vietnamense* Zinova et Nguyen from Quang Ninh, northern Vietnam. The male receptacle is longer than the female one and branches alternately, compressed with a dentate margin. The female receptacle is unbranched, terete or compressed or triquetrous, with a dentate margin. Male receptacles are holozygocarpic and provided with leaves, or provided with vesicles. However, female receptacles are pseudozygocarpic. It seems to be easy to distinguish *S. vietnamense* from the male plant of *S. longifructum* by the latter's terete and longer male receptacles. However, in Vietnamese populations, the receptacles of *S. longifructum* were sometimes pseudozygocarpic (plants from Nha Trang, Figs. 20 & 21) and sometimes holozygocarpic (plants from Ha Tien, Figs. 19 & 22). Furthermore, though male receptacles were usually terete, without spines (Fig. 20), they were sometimes slightly compressed at the apices with a few spines (Fig. 19). Usually in *Sargassum*, these characteristics may be variable within the populations and/or even in one plant. We should re-examine these variations for the morphological characteristics of *S. vietnamense*.

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鯵坂哲朗*・Huynh, Q. N.**・Nguyen, H. D.**：*Sargassum denticarpum* Ajisaka sp. nov. and *S. longifructum* Tseng et Lu：ベトナム産ホンダワラ属（褐藻綱）で，生殖器床に気胞が混在する2種

ホンダワラ亜属の *Zygocarpicae* 節（褐藻類，ホンダワラ科，ホンダワラ属）に属する2種をベトナムから初めて報告する。*Sargassum denticarpum* Ajisaka sp. nov. は，気胞と混在する雌雄同株・同床の生殖器床をもつが，それらは扁平で，縁辺に歯状突起がある。本種はベトナム特産種である。*Sargassum longifructum* Tseng et Lu は，気胞と混在する雌雄異株の生殖器床をもつ。今回初めて観察された雌性生殖器床は扁平で縁辺に歯状突起がある。雄性生殖器床は円柱状か，またはやや扁平で，縁辺が全縁あるいはわずかに刺をもつ。(*606 京都市左京区北白河追分町　京都大学農学部熱帯農学専攻，**Nha Trang Institute of Material Science, Center for Science, Production of Seaweed, 2-Hung Vuong, Nha Trang, Vietnam)

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Mapping of centromere distances of light green and light red genes in *Porphyra yezoensis* (Rhodophyta, Bangiales)

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Hamada, J., Shin, J.-A. and Miura, A. 1994. Mapping of centromere distances of light green and light red genes in *Porphyra yezoensis* (Rhodophyta, Bangiales). Jpn. J. Phycol. **42**: 401–406.

Centromere distances (CDs) of thallus-colour genes, light green (*lg*) and light red (*lr*) types in *Porphyra yezoensis* were calculated by the data of Ohme *et al.* (1986) and Ohme and Miura (1988) according to the formula of Whitehouse (1949) and Perkins (1949). The CDs were 21.6 and 14.1 centimorgan for *lg* and *lr*, respectively. The present study discussed the CDs calculated from monohybrid or dihybrid crosses and different viabilities of chimeric thallus for several colour mutant genes.

Key Index Words: Bangiales—centromere distance—genetics—mapping—Porphyra yezoensis *Rhodophyta—tetrad analysis*

Mapping of CD in ordered tetrad was established in Ascomycete *Neurospora crassa* (Beadle 1945). In *Porphyra yezoensis*, Ohme *et al.* (1986) and Ohme and Miura (1988) showed that the four-cell germlings from conchospores were equivalent to the ordered tetrads. The latter revealed that the genes for green type thallus colour (abbreviation: phenotype is G, gene symbol is *g*) and red colour type (R, *r*) were located in the different arms of the same chromosome, i.e., linkage group I. The map distances of *g* and *r* were demonstrated to be 15.9 (15.8 in Ohme and Miura 1988) and 17.9 centimorgan apart from the centromere, respectively (Fig. 1). Ohme and Miura (1988) showed that the other colour mutant genes, light green type (LG, *lg*) and light red type (LR, *lr*), belonged to two different linkage groups. The chromosomes which carry *lg* and *lr* were coined as linkage groups II and III, respectively (Fig. 1). Ohme and Miura (1988), however, did not show the data of the crosses between W × LG and W × LR, nor CDs of *lg* and *lr*.

In the present study, we could calculate the CDs of *lg* and *lr* from their data. We applied a formula which deals with a relation between the proportion of tetratype tetrads and that of the second division segregations (SDS) in dihybrid crosses. However, precise mapping of the genes in *P. yezoensis* is difficult, because there may be different viabilities and development among several colour mutants in a chimeric thallus, and the resultant trouble in the detection of SDS from first division segregation (FDS) in some cases. In spite of these difficulties at the present time, we hope the study of *P. yezoensis* become more popular since this alga is important for Japanese people traditionally.

Materials and Methods

Genetical data of colour mutant genes in *Porphyra yezoensis* Ueda were cited from Miura (1985), Ohme *et al.* (1986), Ohme and Miura (1988), and Niwa *et al.* (1993).

CDs of colour mutant genes in *P. yezoensis* were calculated according to the formula of Whitehouse (1949) and Perkins (1949): In case of dihybrid, when two allelomorphic genes, *A/a* and *B/b*, are located in different chromosomes each other, and *Ab* and *aB*, for instance, are crossed as parents, parental

Table 1. Proportion of parental ditype (PD), non-parental ditype (NPD) and tetratype (TT) tetrads in the F_1 progenies of the cross between two allelomorphic genes, *A/a* and *B/b*, which are located in different chromosomes each other.

Type of cross-over*	PD	NPD	TT	Proportion**
No cross-over	1/2	1/2	0	$(1-x)\quad(1-y)$
Cross-over in 1 locus	0	0	1	$x(1-y)+y(1-x)$
Cross-over in 2 loci	1/4	1/4	1/2	xy

* Cross-over between a gene(s) and the centrometer(s).
** x and y are the proportion of SDS at the *A* and *B* loci, respectively.

ditype (PD), non-parental ditype (NPD) and tetratype (TT) tetrads are produced in the F_1 progenies. As shown in Table 1, if x and y were postulated to be the proportion of SDS at the *A* and *B* loci, respectively, the proportion of TT, p, in the F_1 progenies is as follows (Whitehouse 1949, Perkins 1949):

$$p=x(1-y)+y(1-x)+xy/2$$
$$=x+y-3xy/2, \cdots\cdots \text{Form. 1}$$

Results

If it was assumed that the proportion of tetratype tetrads for the cross between G and LR is **q**, and that of SDS for G and LR are **g** and **lr**, respectively, Form. 1 is replaced by the equation as follows:

$$q=g+lr-3g\cdot lr/2 \cdots\cdots \text{Eq. 1}$$

The left side is able to be calculated from the cross, G × LR (Table 2), as below:

$$q=346/(210+187+346)=0.466$$

When the value of 0.318 (Table 3) is applied to **g**, Eq. 1 becomes as follows:

$$0.466=0.318+lr-3\cdot 0.318\cdot lr/2$$
$$lr=0.282$$

Therefore, CD of *lr* is:

$$0.282/2\times 100=14.1 \text{ (centimorgan)}$$

Then, concerning the cross between LG and R in Table 2, if we assume that the proportion of the tetratype tetrads as **s**, and that of SDS for R and LG as **r** and **lg**, respectively, Form. 1 is replaced by the equation as follows:

$$s=r+lg-3r\cdot lg/2 \cdots\cdots \text{Eq. 2}$$

If the values in Table 2 were applied to Eq. 2,

$$\text{left side}=1386/(557+539+1386)=0.558.$$

When **r** is replaced by 0.359 (Table 3), Eq. 2 becomes as follows:

$$0.558=0.359+lg-3\cdot 0.359\cdot lg/2$$
$$lg=0.432$$

Therefore, CD of *lg* becomes as below:

$$0.432/2\times 100=21.6 \text{ (centimorgan)}$$

Next, we could go over these calculations by applying the data of LR × LG (Table 2) to the following equation as below:

$$t=lr+lg-3lr\cdot lg/2 \cdots\cdots \text{Eq. 3}$$

where **t** is the proportion of tetratype tetrads in the cross, LR × LG.

Table 2. Frequencies of parental ditype (PD), non-parental ditype (NPD) and tetratype (TT) tetrads, and the ratio of PD to NPD in the F_1 thalli of the crosses among light red (LR), light green (LG), red (R) and green (G) (Ohme and Miura 1988).

Crosses	PD	NPD	TT	PD/NPD
G × LR	210	187	346	1.12
LG × R	557	539	1386	1.03
LR × LG	153	170	401	0.90
Eptd LR × LG*	169.778	169.778	384.444	1.00

* Expected values from the cross, LR × LG. See the text.

Table 3. Types of coloured thalli and their frequencies in the F_1 progenies of the crosses, green type (G) × wild type (W), and wild type (W) × red type (R) (Ohme et al. 1986).

G (♀) × W (♂)			W (♀) × R (♂)		
Colour types		(TOS)*	Colour types		(TOS)*
Single colour			Single colour		
W	186		W	26	
G	114		R	24	
Chimera		2884 (FDS)	Chimera		1069 (FDS)
W+G	2584		W+R	1019	
W+G+W	691		W+R+W	280	
G+W+G	637	1344** (SDS)	R+W+R	316	598 (SDS)
W+G+W+G	16		W+R+W+R	2	
Proportion of SDS		0.318			0.359
CD (centimorgan)		15.9**			17.9

* Types of segregations: first (FDS) or second (SDS) division segregation.
** In Ohme and Miura (1988), CD of *g* was calculated as 15.8, because the number of SDS was totalled as 1334.

left side
$=401/(153+170+401)=0.554$

right side$=0.282$
$+0.432-3\cdot0.282\cdot0.432/2=0.531$

Thus.

left side≒right side.

Here, x^2 was calcuated to confirm if the left side value fitted to the right. The expected values were put on the basis that t be 0.531, and the ratio of PD/NPD be 1.0.

$$x^2=[(153-169.778)^2/169.778]+[(170-169.778)^2/169.778]+[(401-384.444)^2/384.444]=2.371^{N.S.}\ (P>0.3)$$

Therefore, CDs of 14.1 and 21.6 for *lr* and *lg*, respectively, were consistent with each other. The linkage map of the four colour mutants of *P. yezoensis* is shown in Fig. 1.

Discussion

In *Porphyra yezoensis*, meiosis starts when a conchospore germinates and is completed at the four-cell conchospore germling stage (Ohme *et al.* 1986, Ohme and Miura 1988). The tetrads after the meiosis arranged linearly in the haploid leafy thallus, and CDs were determined by the tetrad analysis (Ohme and Miura 1988, Niwa *et al.* 1993).

In the present study, CDs of two thallus-colour genes, *lg* and *lr*, were calculated according to the formula of Whitehouse (1949) and Perkins (1949). There was no contradiction among these values, statistically. Therefore, CDs of *lg* and *lr* thus obtained were estimated to be reliable.

On the contrary, Miura (1985) reported the results of reciprocal crosses between the wild type and LG (Table 4). If the chimeric thalli of W+LG+W, LG+W+LG, and W+LG+W+LG were supposed to be SDS, the CD of *lg* is calculated to be 16.0 or 12.3 by the crosses of W (♀) × LG (♂) or LG (♀) × W (♀), respectively. These values differed statistically from the one obtained in the present study (21.6 centimorgan; $x^2=48.209^{**}$ and 275.899^{**} for W (♀) × LG (♂) and LG (♀) × W (♂), respectively). The discrepancy means that three of the other colour type thalli (W, LG, and W+ LG) in Table 4 should have SDS which could not be detected under the conditions they observed.

A similar phenomenon was observed in the reciprocal crosses between the wild type and LR (Table 5, Miura 1985). If the chimeric thalli of W+LR+W, LR+W+LR, and W+LR+W+LR were supposed to be SDS, CD of LR (*lr*) is calculated as 12.5 and 12.0

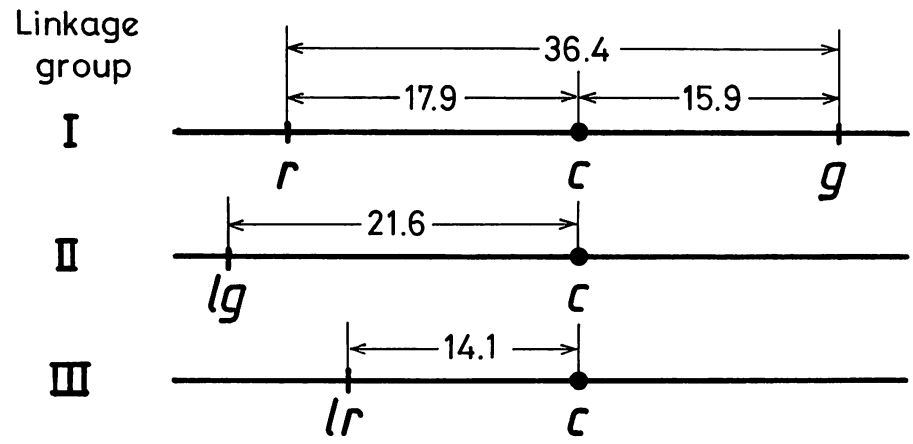

Fig. 1. Linkage map of colour mutant genes in *Porphyra yezoensis* Ueda. The units are in centimorgan. *r*: red type, *g*: green type, *lg*: light green type, *lr*: light red type, and *c*: centromere.

centimorgan from the crosses of W (♀)×LR (♂) and LR (♀)×W (♂), respectively. However the difference between these values and that obtained in the present study (14.1 centimorgan) was small, the x^2 values were significant (3.979* and 12.869** for W (♀)×LR (♂) and LR (♀)×W (♂), respectively). The value obtained from the dihybrid was also bigger than that obtained from the monohybrid. The other three colour type thalli (W, LR, and W+LR) may have undetectable thalli which have carried out SDS.

The discrepancy between the data from the monohybrid and those from dihybrid may be originated from unequal growth of four tetrad cells. To overcome this problem, dihybrid, trihybrid, or multihybrid crosses as well as the monohybrid crosses are desirable. Although the discrimination of the colour order between from the top and from the base of a thallus have not been recorded except in Miura and Ohme-Takagi (1994), it is necessary for the genetical and developmental studies of *P. yezoensis*. According to their data, it is presumable that there were some differences in viability among various colours of tetrads. If the order of from the top or from the base were distinguished, the development of thalli, vigour of each colour among the tetrads and

Table 4. Types of coloured thalli and their frequencies in the F_1 progenies of the reciprocal crosses between the wild type (W) and light green type (LG) (Miura 1985).

Colour types	Number of F_1 thalli			
	W (♀)×LG (♂)		LG (♀)×W (♂)	
	Emnt*	Eptd**	Emnt*	Eptd**
Single-coloured thallus				
W	64		133	
LG	46		84	
Chimeric thallus		529.944 (FDS)***		1100.784 (FDS)***
W+LG	525		1246	
W+LG+W	146		234	
LG+W+LG	136	403.056 (SDS)***	241	837.216 (SDS)***
W+LG+W+LG	16		0	

* Experimental data.
** Expected values supposing that CD of *lg* as 21.6.
*** FDS and SDS represent first and second division segregation, respectively.

Table 5. Types of coloured thalli and their frequencies in the F_1 progenies of the reciprocal crosses between the wild type (W) and light red type (LR) (Miura 1985).

Colour types	Number of F_1 thalli					
	W (♀) × LR (♂)			LR (♀) × W (♂)		
	Emnt*	Eptd**		Emnt*	Eptd**	
Single-coloured thallus						
W	77			129		
LR	45			24		
Chimeric thallus		598.094 (FDS)***			1061.922 (FDS)***	
W + LR	502			971		
W + LR + W	107			212		
LR + W + LR	80	234.906 (SDS)***		139	417.078 (SDS)***	
W + LR + W + LR	22			4		

* Experimental data.
** Expected values supposing that centromere distance of *lr* as 14.1.
*** For FDS and SDS, see the legend to Table 4.

genetics of the thalli will be disclosed more precisely.

Recently, Niwa *et al.* (1993) studied the thallus-colour of violet (V) and demonstrated that the violet gene (*v*) was located in a different chromosome from the linkage group I. They located *v* in 7.78 or 9.84 centimorgan apart from the centromere (Table 6). Their genetical results, however, have some contradictions. For instance, the difference in recombination frequencies obtained from the reciprocal crosses was not small (Table 6) and in the cross of V (♀) × G (♂), the ratio of PD to NPD is greatly apart from 1 ($x^2=9.511$*, Table 7). As the proportion of tetratype tetrad in the cross of G (♀) × V (♂) be 0.434 (Table 7) and that of the SDS of *g* be 0.318 (Table 3), **v**, the proportion of the SDS of the gene, *v*, becomes as follows:

$$0.434=0.318+\mathbf{v}-3\cdot0.318\cdot\mathbf{v}/2$$
$$\mathbf{v}=0.243$$

Therefore, CD of gene *v* becomes as below:

$$0.243/2\times100=12.2 \text{ (centimorgan)}.$$

Here, the value obtained from the dihybrid (12.2 centimorgan) was also bigger than those obtained from the monohybrid. The difference might be due to the higher detectable level in dihybrid than in monohybrid.

As to the detectability of thalli which carried out SDS from those of FDS, there may be differences among the colour mutants. The differences might be due to the different viability level among them. For instance, red colour type which produces nealy the same number of W and R in the cross W (♀) × R (♂) (Table 3), may have higher viability than green colour type which produced less number of G than W in the cross, G (♀) × W (♂) (Table 3).

As *P. yezoensis* has only three haploid chromosome (Yabu and Tokida 1963, Migita 1967, Yabu 1969, Kito 1978, Ohme and Miura 1988, Tseng and Sun 1989), it is relatively easy to map any genes to each chromosome and to have a bird's eye view about the gene configuration. Mapping of colour mutant genes is interesting and important not only from genetical view point, but also from physiological one. The genetical studies of other colour mutant genes are now in progress in our laboratory.

Table 6. Frequencies of first division segregation (FDS), second division segregation (SDS) and centromere distance (CD) of the gene, *v*, from the reciprocal crosses between the violet type (V) and the wild type (W) (Niwa *et al.* 1993).

Cross (♀ × ♂)	FDS	SDS	CD
W × V	982	181	7.78
V × W	873	214	9.84

Table 7. Frequencies of parental ditype (PD), non-parental ditype (NPD) and tetratype (TT) tetrads, ratio of TT to the total tetrads and the ratio of PD to NPD in the F_1 thalli of the reciprocal crosses between violet type (V) and green type (G) thallus colour (Niwa *et al.* 1993).

Cross (♀ × ♂)	PD	NPD	TT	TT/total	PD/NPD
V × G	342	266	549	0.475	1.29
G × V	296	287	447*	0.434	1.03

* The number was corrected from original number, 477.

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濱田　仁*・申　宗岩**・三浦昭雄**：紅藻スサビノリ (*Porphyra yezoensis*) の 2 個の色素変異遺伝子，明緑色型 (light green type gene) と明赤色型 (light red type gene) の動原体距離

スサビノリ (*Porphyra yezoensis*) の色素変異体の明緑色型 (light green type) と明赤色型 (light red type) 遺伝子の動原体からの距離が，各々21.6と14.1センチモルガンであることを，Ohme *et al.* (1986) と Ohme and Miura (1988) の資料に基づき，Whitehouse (1949) と Perkins (1949) の方程式を用いて明らかにした。また，スサビノリの減数分裂後，四分子が増殖して葉状体を形成する際には，色素変異体の色の違いにより増殖力に差があることが，色の違う葉状体の交配によって出来たキメラ状葉状体の種類とその出現頻度から推定された。従って，スサビノリで遺伝子地図を作成する際には，単性雑種よりも両性雑種か三性雑種を用いる方が望ましいと考えられる。
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Four new species of *Chattonella* (Raphidophyceae, Chromophyta) from Japan

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Hara, Y., Doi, K. and Chihara, M. 1994. Four new species of *Chattonella* (Raphidophyceae, Chromophyta) from Japan. Jpn. J. Phycol. 42: 407–420.

Four new species of *Chattonella* (Raphidophyceae, Chromophyta) were described in the status of "nomen nudum" in the book entitled "Red tide organisms in Japan", edited by Fukuyo *et al.* (1990). They were *Chattonella globosa* Y. Hara et Chihara, *C. minima* Y. Hara et Chihara, *C. ovata* Y. Hara et Chihara and *C. verruculosa* Y. Hara et Chihara. In this paper, the full descriptions are given for these four species to be validly published. A key to all species of *Chattonella* is also presented.

Key Index Words: Chattonella—C. globosa—C. minima—C. ovata—C. verruculosa—*Raphidophyceae—red tide organisms—taxonomy*

On Japanerse coasts, especially those of the inland sea, red tide blooms occur frequently from spring to autumn. Many kinds of flagellates have been recognized in these red tides and one of the dominant representatives among them is *Chattonella* species.

We have isolated and obtained many strains of *Chattonella*, some from local fisheries experimental stations and other research institutes, requesting us for the identification of them. Detailed examination of cultured specimens using electron microscopy showed that there were six taxa, only two of which were described species: *Chattonella antiqua* (Hada) Ono (Ono and Takano 1980) and *C. marina* (Subrahmanyan) Y. Hara et Chihara (Hara and Chihara 1982). The four novel species were colloquially referred to as "Globular *Chattonella*" (Akizuki *et al.* 1981, Takayama 1981, 1983), "Small *Chattonella*" (Yoshida personal communication, Imai and Itoh 1985) and "Burr-shaped *Chattonella*" (Yoshimatsu et al. 1990, Yamamoto and Tanaka 1990), on the basis of their appearance. All possess two subequal or distinctly unequal flagella inserted into the shallow depression near the anterior end of the cell, and the cytoplasm is divided into two parts: a cytoplasmic endoplasm and a vacuolated ectoplasm. They all lack contractile vacuoles and eyespots. In all these characteristics the four taxa fit well with the type species of *Chattonella, C. subsalsa*, described by Biecheler (1936) and with more recent observations on the ultrastructure by Mignot (1976).

In the book "Red tide organisms in Japan" (Fukuyo *et al.* 1990), the names *Chattonella globosa, C. minima, C. ovata* and *C. verruculosa* were published for the four species but in that publication they have the status of "nomen nudum". In the present paper, formal descriptions are given for valid publication of the species.

Materials and Methods

The cultures examined are listed in Table 1, along with the localities from which they were isolated, the persons who made the isolation and the institutions in which they are deposited.

All of the strains were grown in ESM medium (Okaichi et al. 1982) and maintained at a temperature of 20°C under a 14 : 10 LD

Table 1. List of cultures examined in this study.

Scientific names	Colloquial names	Collecting localities	Institutions of original isolates	Isolators
Chattonella globosa	Globular *Chattonella*	Kii Channel, Tokushima	Hiwasa Branch of Tokushima Pref. Fish. Exp. St.	M. Yoshida
C. minima	Small *Chattonella*	Kii Channel, Tokushima	Hiwasa Branch of Tokushima Pref. Fish. Exp. St.	M. Yoshida
C. ovata	Straw sandal-shaped *Chattonella*	Hiroshima Bay Hiroshima	Hiroshima Pref. Fish. Exp. St.	H. Takayama
C. verruculosa	Burr-shaped *Chattonella*	Harima-nada Kagawa	Akashiwo Research Inst. of Kagawa Pref.	S. Yoshimatsu

cycle. Light was provided by cool white fluorescent lamps at 10-30 μmol·m^{-2}·s^{-1}.

Light microscope studies were made on cultured and natural specimens of living cells or materials fixed by 1-2% osmium tetroxide solution.

Determination of chromosome numbers were made on cultured cells harvested 1 hr before onset of the light regime under 12L-12D cycle. The specimens were fixed with acetic alcohol solution (ethanol: acetic acid=3 : 1 or 2 : 1) for 2 hr prior to fixation and colcemid (ca. 0.2 μg/m*l* at the final concentration) was then added to the specimens. Cells were harvested by gentle centrifugation and treated by KCl solution (0.75 M) for 30 min just before the fixation. Fixed specimens were transferred to 5% ferric alum solution for 2-3 min and stained by aceto-carmine. Chromosome numbers were counted under light microscopy using the squash method. For reference, strains of *Chattonella antiqua* (NIES-161, Watanabe and Satake, 1991) and *C. marina* (NIES-118, Watanabe and Satake 1991) were also examined.

Cultured specimens for scanning electron microscopy were fixed with 2% osmium tetroxide solution for 5 min at room temperature. After dehydration, drying by the critical point method and coating with gold were performed. Specimens were observed with an S-430 scanning electron microscope (Hitachi).

Cells prepared for transmission electron microscopy were concentrated by centrifugation, fixed for 20 min in a mixture of 2.5% glutaraldehyde (buffered with cacodylate buffer at pH 7.2-7.4 and added 0.6 M sorbitol) and 2% osmium tetroxide in the same buffer without sorbitol at same volume, and post-fixed with 2% OsO_4 for 1 h at 4°C. After dehydration and embedding in Spurr's resin (Spurr 1969), the material was sectioned on an LKB Ultrotome 2088 using diamond knives, and stained with uranyl acetate for 30 min followed by lead citrate for 5-10 min. The sections were viewed with a JEM 100C or a JEM 100CXII electron microscope (JEOL) at 80 kV.

Results and Discussion

Results are presented as full descriptions of the four species of *Chattonella*, and associated micrographs and drawings.

(1) *Chattonella globosa* Y. Hara et Chihara sp. nov. (Figs. 1-12)

Chattonella globosa Y. Hara et Chihara, *in* Fukuyo *et al.* (1990), p. 324, nomen nudum.

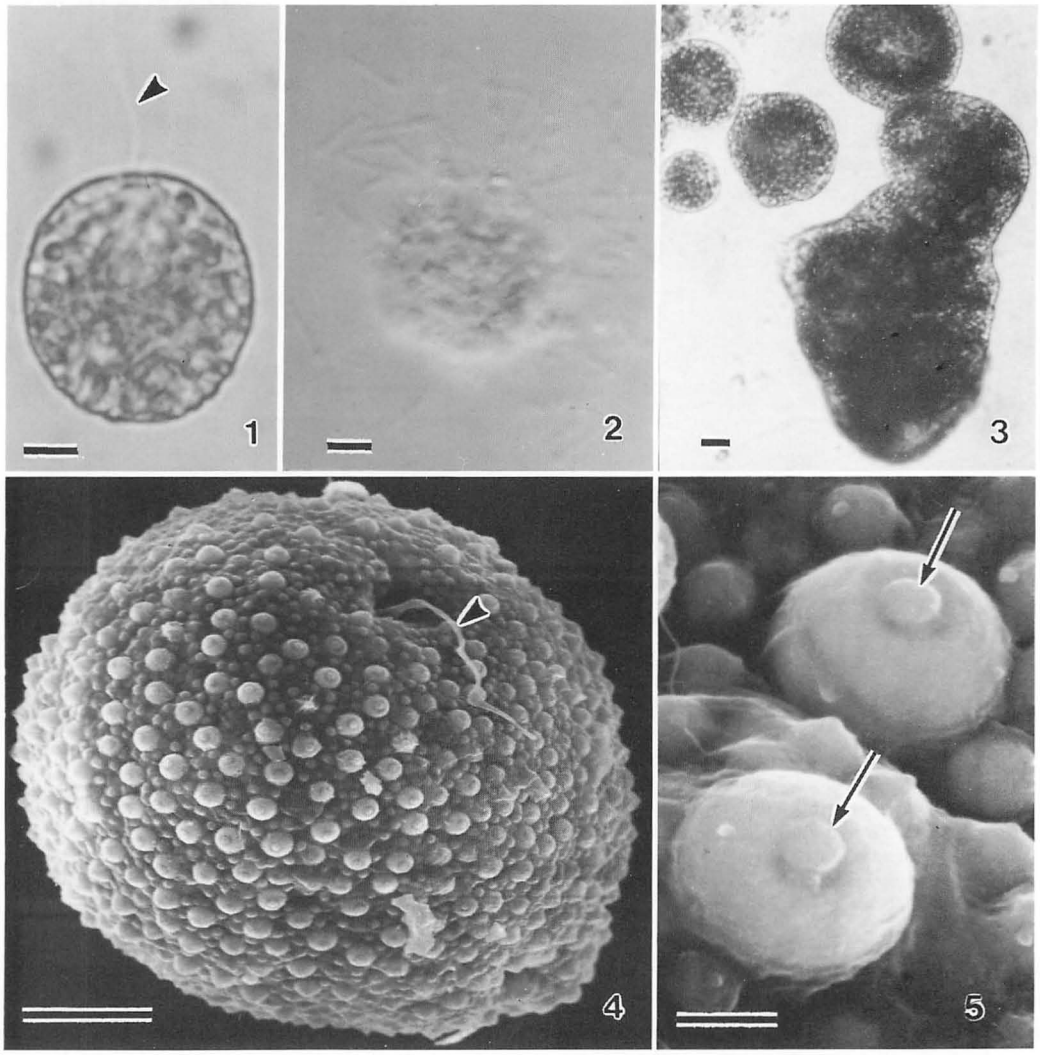
Cellulae luteolae vel brunneae, fere globosae, 40-55 μm diam.; chloroplasti discoidei, comparate parvi, 1-2 μm longi, 0.5 μm lati, multi, in ectoplasmatibus et endoplasmatibus locati, pyrenoide destituti; nucleus sphaericus; mucocystes magnae, corpusculum unguiculatum capientes, multae, secus peripheriam cellulae dispositae; vacuolae contractiles et stigma absentes.

Holotypus: Figura 11.

Type locality: Kii Channel, Tokushima, Japan.

Geographical distribution: Known to occur from central and western Japan and southeastern Asia. Probably widely distributed in temperate to tropical neritic waters.

Cell are yellowish brown, nearly globose without protrusion at the posterior end, 40-55 μm in diameter (Figs. 1, 4, 6). Two unequal flagella emerge from a shallow depression at the anterior end of the cell (Figs. 11, 12). The longer anteriorly directed flagellum is undurating during swimming, while the other, which is very short and often invisible under the light microscope, is trailing (Figs. 1, 4). Numerous small particles, which are well stained with OsO_4, are located in the cytoplasm beneath the cell surface (Figs. 6, 10). Large mucocysts containing nail-



Figs. 1–5. *Chattonella globosa*. 1: Photomicrograph of a living motile cell, showing anteriorly directed flagellum (arrowhead). 2: Photomicrograph of a punctured cell ejecting nail-shaped inclusions from mucocysts. 3: Photomicrograph of non-motile cells forming a plasmodial aggregation. 4: Scanning electron micrograph of a motile cell, showing numerous protrusions of mucocysts and fatty particles on the cell surface and the longer, anteriorly directed flagellum (arrowhead) from a funnel-shaped depression at top of the cell. 5: Scanning electron micrograph of a cell showing protrusion nail-shaped inclusion of the mucocysts (arrows). Scale bars=10 μm in Figs. 1–4; scale bar=1 μm in Fig. 5.

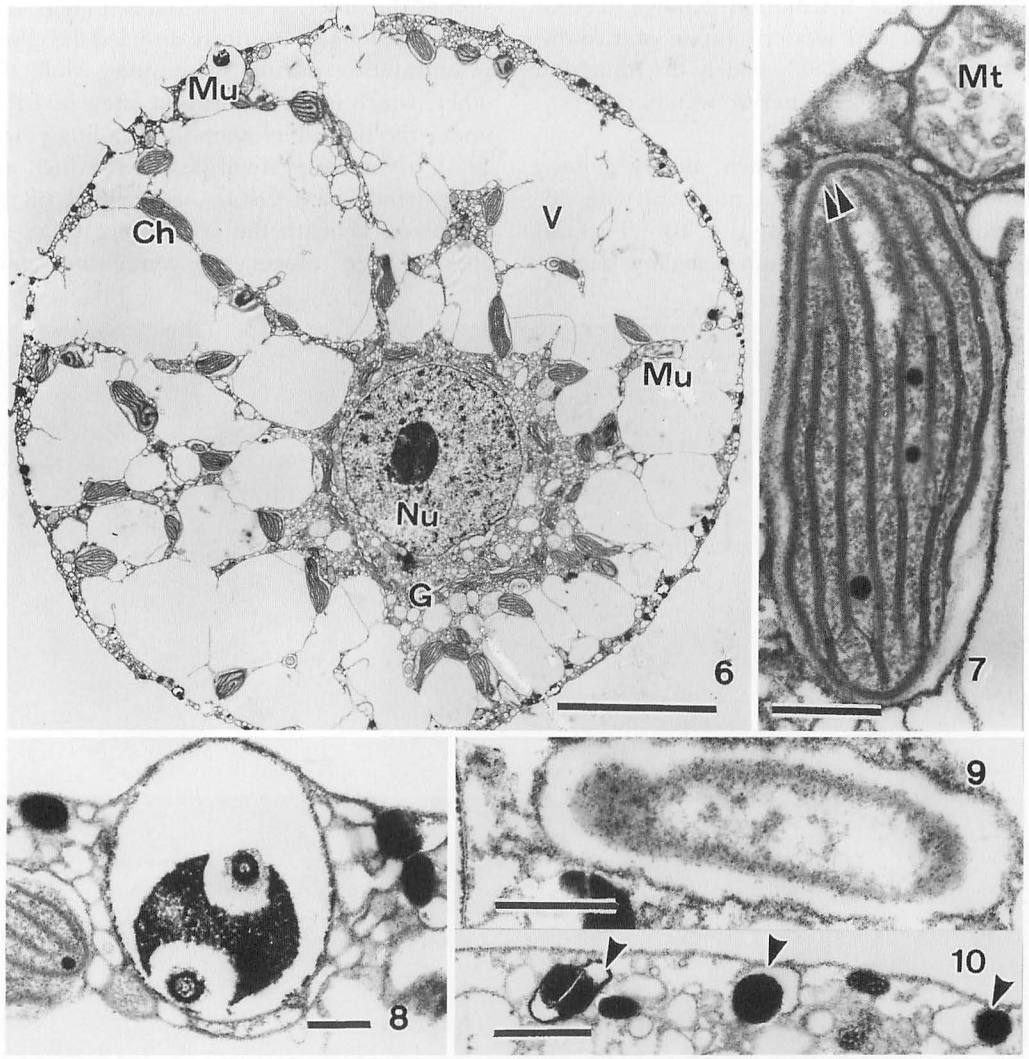
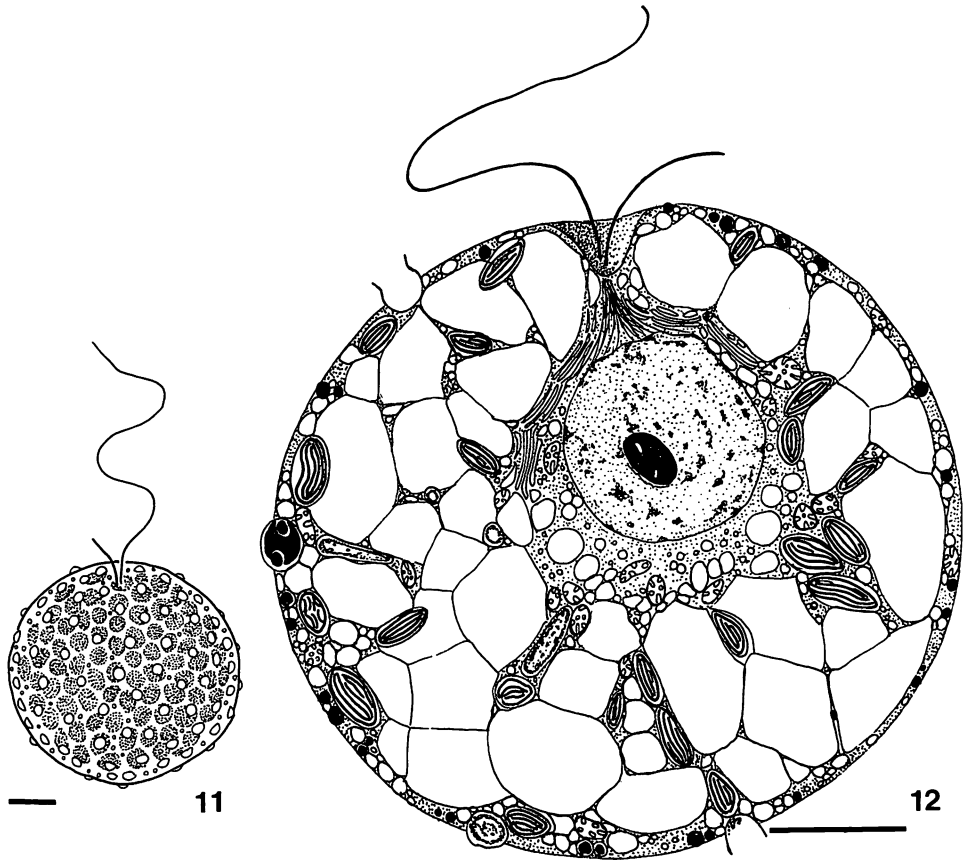


Fig. 6–10. *Chattonella globosa*. 6: Section of a motile cell, showing major cellular components and their arrangement. Ch: chloroplast, G: Golgi body, Mu: mucocyst, Nu: nucleus, V: vacuole. 7: Electron micrograph of a chloroplast, showing lamellae composed of two or three stacked thylakoids and a girdle thylakoid (double arrowheads). No pyrenoid is present. Mt: mitochondorion. 8: Electron micrograph of a part of the mucocyst, showing the head of a nail-shaped inclusion. 9: Electron micrograph of a part of mucocyst, showing the body of a nail-shaped inclusion. 10: Section of the outermost part of a cell, showing the distribution of fatty particles (arrowhead). Scale bar=10 μm in Fig. 6; scale bars=0.5 μm in Figs. 7–10.

shaped bodies are present around the cell periphery (Figs. 4-6, 8-10), and react discharge following change in the physical or chemical conditions (Fig. 2). Chloroplasts are discoidal and numerous, and are situated in both ectoplasm and endoplasm (Fig. 6). They are relatively small, 1-2 μm in length, about 0.5 μm in width, and lack pyrenoids (Fig. 7). The chloroplast is furnished with lamellae composed of two or three stacked thylakoids and a girdle thylakoid (Fig. 7). The spherical nucleus is situated in the middle of the cell (Fig. 6). Mitochondria with tubular cristae are randomly distributed in the cytoplasm. Contractile vacuoles and eye-spots are absent. Typical morphological and ultrastructural features of this species are illustrated in Figs. 11 and 12.



Figs. 11–12. *Chattonella globosa*. 11: Drawing of a motile cell. 12: Drawing showing the distribution of organelles in a motile cell. Scale bars=10 μm in Figs. 11, 12.

Asexual reproduction takes place by binary fission while cells are swimming. Cyst formation and sexual reproduction are unknwon. Plasmodial aggregations are often formed under unfavorable growth conditon (Fig. 3).

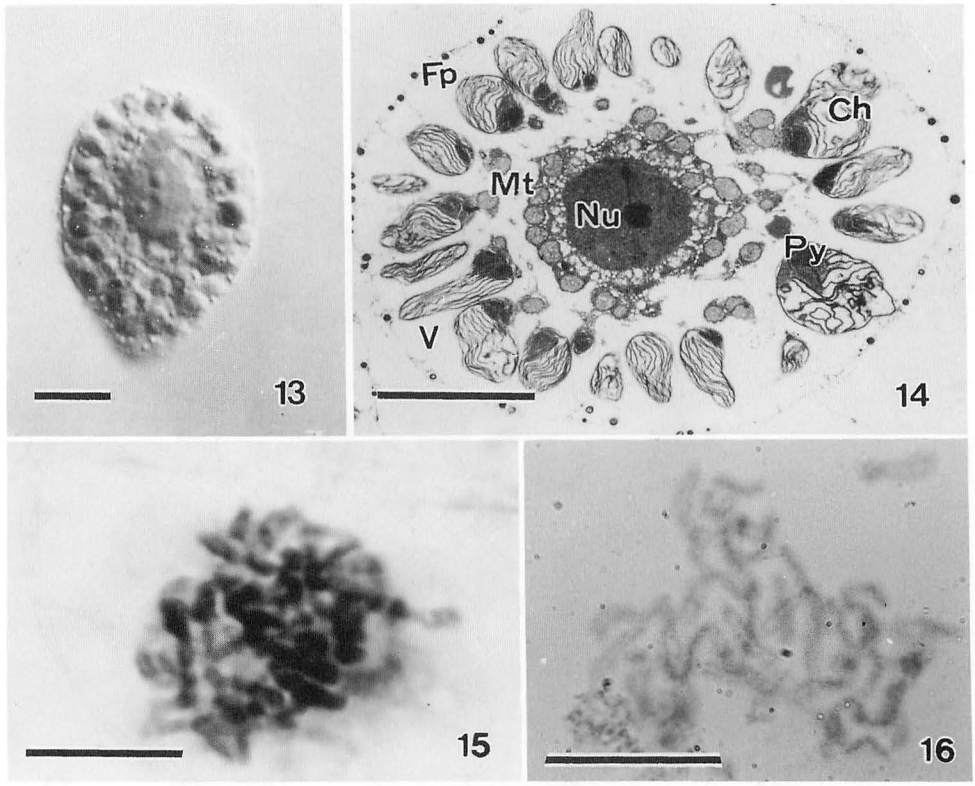
This alga is abundant in early spring and late autumn in several coastal localities in the Seto Inland Sea (Akizuki et al. 1981, where it has been referred to as the "Globular form of *Hornellia*") and in Tokyo Bay (Hosaka *et al.* 1991).

This species resembles *Chattonella subsalsa* Biecheler in the possession of a vacuolated ectoplasm, large mucocysts with nail-shaped inclusions and in the lack of a ring-shaped genophore, contractile vacuoles and eye-spots. It differs from *C. subsalsa* and other species of *Chattonella* in having a spherical shape, unequal flagella, and relatively small chloroplasts without pyrenoids. On the basis of the fact that *C. globosa* causes respiratory damages to cultivated and natural fish as do other species of *Chattonella* when the cultured cells of *C. globosa* at high concentration were added to the experimental pool of yellow tail (Akizuki *et al.* 1981), it seems appropriate to include it in this genus.

(2) ***Chattlnella minima* Y. Hara et Chihara sp. nov.** (Figs. 13–15, 17, 18)

Chattonella minima Y. Hara et Chihara, *in* Fukuyo *et al.* (1990), p. 338, nomen nudum.

Cellulae luteolae vel flavo-brunneae, leviter depressae, obovatae, acutae ad extremum posticum cellulosae, 20–45 μm longae, 20–30 μm latae, particulae parvae coloratae cum osmio tetroxidi, in cytoplasmatibus infra paginam cellulae locatae; mucocystes



Figs. 13–16. *Chattonella minima* and *C. marina*. 13: Photomicrograph of a motile cell of *C. minima*. 14: Section of a motile cell of *C. minima*, showing major cellular components. The boundary between the cytoplasmic endoplasm and vacuolated ectoplasm is clearly visible. Fp: fatty particle, Py: pyrenoid. 15: Photomicrograph of chromosomes at the metaphase of *C. minima*. 16: Photomicrograph of chromosomes at the metaphase of *C. marina*. Scale bars=10 μm in Figs. 13, 14; scale bars=5 μm in Figs. 15, 16.

carentes; chloroplasti obvati, multi in ectoplasmate locati; pyrenoides ad extremum interaneum chloroplasti locata, invasa in matrice a aliquot thylakoidibus; nucleus guttiformis; vacuolae contractiles et stigma absentes.

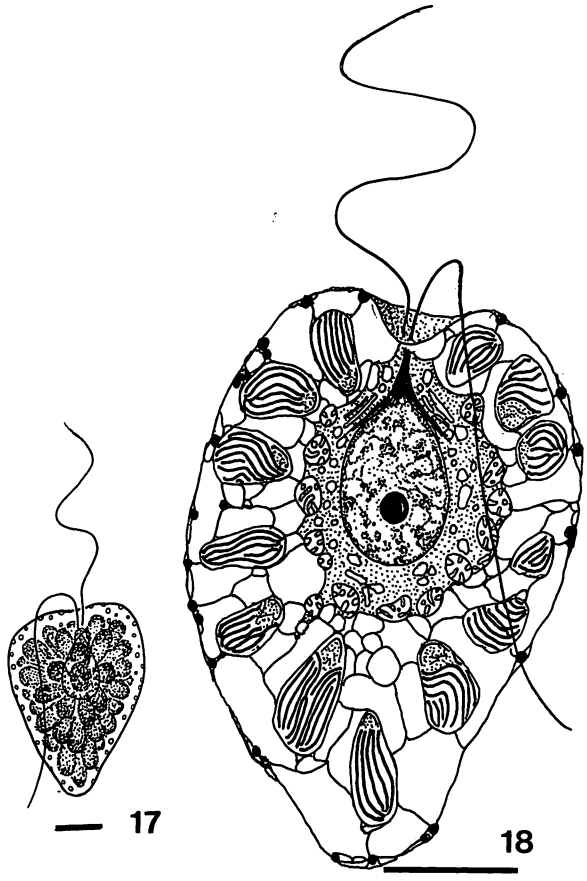
Holotypus: Figura 17.

Type locality: Kii Channel, Tokushima, Japan.

Geographical distribution: distributed in the Seto Inland Sea, Japan.

Cells are pale yellow or yellowish brown, slightly flattened, cordiform, 20-45 μm long and 20-30 μm wide, with a shallow depression at the anterior end and a tiny protrusion at the posterior end (Figs. 13, 14). Two heterodynamic flagella, subequal in length, emerge from the bottom of the depression (Figs. 17, 18). Many small particles which stain well with OsO_4 are located in the cytoplasm beneath the cell surface (Fig. 14). Chloroplasts are ellipsoid and numerous, and are arranged radially in the ectoplasm (Fig. 14). Pyrenoids are located at the inner end of each chloroplast, are scarcely visible under the light microscope. A teardrop-shaped nucleus is situated in the middle of the endoplasm (Fig. 14). Globular mitochondria with tubular cristae are located in the endoplasm. Contractile vacuoles, eye-spots and mucocysts are lacking. Diagrammatic illustrations of the morphologial are ultrastructural features are given in Figs. 17 and 18.

Asexual reproduction occurs by binary fission while cells are swimming. Cyst formation and sexual reproduction are unknown. This alga inhabits coastal waters and is known only from Japan in the Seto Inland



Figs. 17–18. *Chattonella minima*. 17: Drawing of a whole motile cell. 18: Drawing showing the features of a motile cell based on observations using electron microscopy. Scale bars=10 μm in Figs. 17, 18.

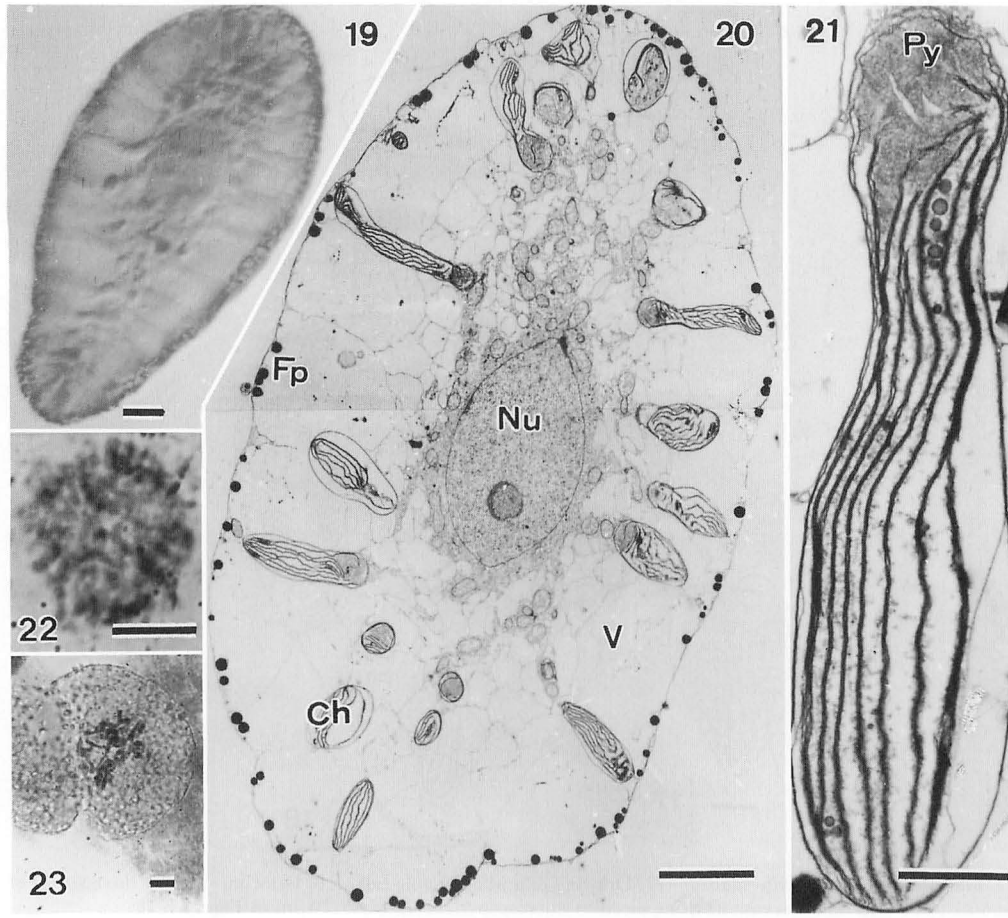
Sea along the coast of Tokushima Prefecture. It was so-called the "Small form of *Hornellia*". The species is abundant in autumn following red tides of *C. antiqua* and/or *C. marina*.

This is one of the smallest marine raphidophycean algae. It is similar in cell size to that of *Chattonella verruculosa*, but differs from it in lacking large mucocysts. The flagellation and subcellular organization are similar to those of *C. antiqua* and *C. marina*. During the preliminary survey of chromosome counts, the chromosomes of this species could be roughly recognized more than 90 (Fig. 15), while those in *C. antiqua* and *C. marina* were ca. 29 (Fig. 23) and ca. 50 (Fig. 16), respectively. Although it is earlier to discuss with their karyological properties before showing the precise chromosome number of each species, these disregarded differences are valuable to support the idea that this is a distinct species.

(3) ***Chattonella ovata* Y. Hara et Chihara sp. nov.** (Figs. 19–22, 24, 25)

Chattonella ovata Y. Hara et Chihara, *in* Fukuyo *et al.* (1990), p. 340, nomen nudum.

Cellulae flavo-brunneae, ellipticae vel obovatae, satis depressae, 50–70 μm longae, 30–45 μm latae; particulae parvae coloratae cum osmio tetroxidi, in cytoplasmatibus infra paginam cellulae locatae; chloroplasti fusiformes elongati, multi, inter ectoplasma et ectoplasma locati; pyrenoides ad extremum interaneum chloroplasti locati, invasa in matrice a aliquot thylakoidibus; vacuolae bene evolutae, inter chloroplasto locatae; nucleus guttiformis; mucocystes, vacuolae contrac-



Figs. 19–23. *Chattonella ovata* and *C. antiqua*. 19: Photomicrograph of a motile cell of *C. ovata*. 20: Section of a motile cell of *C. minima*, showing conspicuous vacuoles between the elongated chloroplasts, and the cytoplasmic endoplasm with a teardrop-shaped nucleus and mitochondria. 21: Electron micrograph of an elongated chloroplast with a naked pyrenoid invaded by thylakoids at the inner polar region. 22: Photomicrograph of chromosomes at the metaphase of *C. ovata*. 23: Photomicrograph of chromosomes at the metaphase of *C. antiqua*. Scale bars=5 μm in Figs. 19, 20 and Figs. 22, 23; scale bars=1 μm in Fig. 21.

tiles et stigma absentes.

Holotypus: Figura 24.

Type locality: Ondo, Hiroshima Bay, Hiroshima, Japan.

Geographical distribution: in western Japan, including the Seto Inland Sea, and Kagoshima Bay in Kyushu. Probably widely distributed in eutrophic coastal waters from temperate to tropical regions.

Cell are yellowish brown, naked but not exhibiting metaboly, somewhat flattened, ovoid or obovoid, 50-70 μm long and 30-45 μm wide, with a shallow depression at the anterior end, but no protrusion at the posterior end (Fig. 19). The two heterodynamic flagella are subequal in length, and emerge from the base of a depression (Figs. 24, 25). Many small particles stainable with OsO_4 occur in the cell periphery just beneath the cell surface (Fig. 20). Chloroplasts are elongated fusiform (Fig. 19) and numerous. They are distributed between the ectoplasm and the endoplasm, and are arranged radially (Figs. 19, 20). Vacuoles are well developed and occupy the spece between chloroplasts (Fig. 19, 20). A single pyrenoid, the matrix of which is invaded by a few thylakoids, is located at the

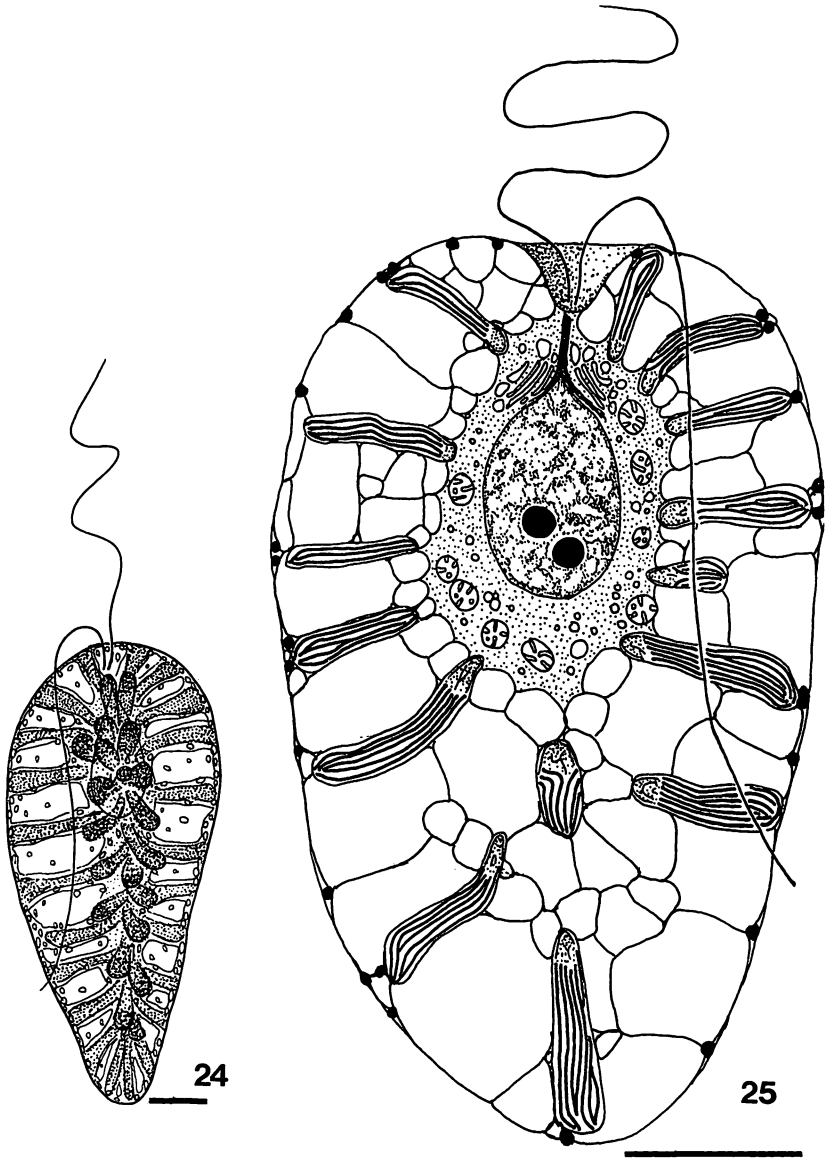


Fig. 24–25. *Chattonella ovata*. 24: Drawing of a motile cell. 25: Drawing showing the features of a motile cell based on the observations using electron microscopy. Scale bars=10 μm in Figs. 24, 25.

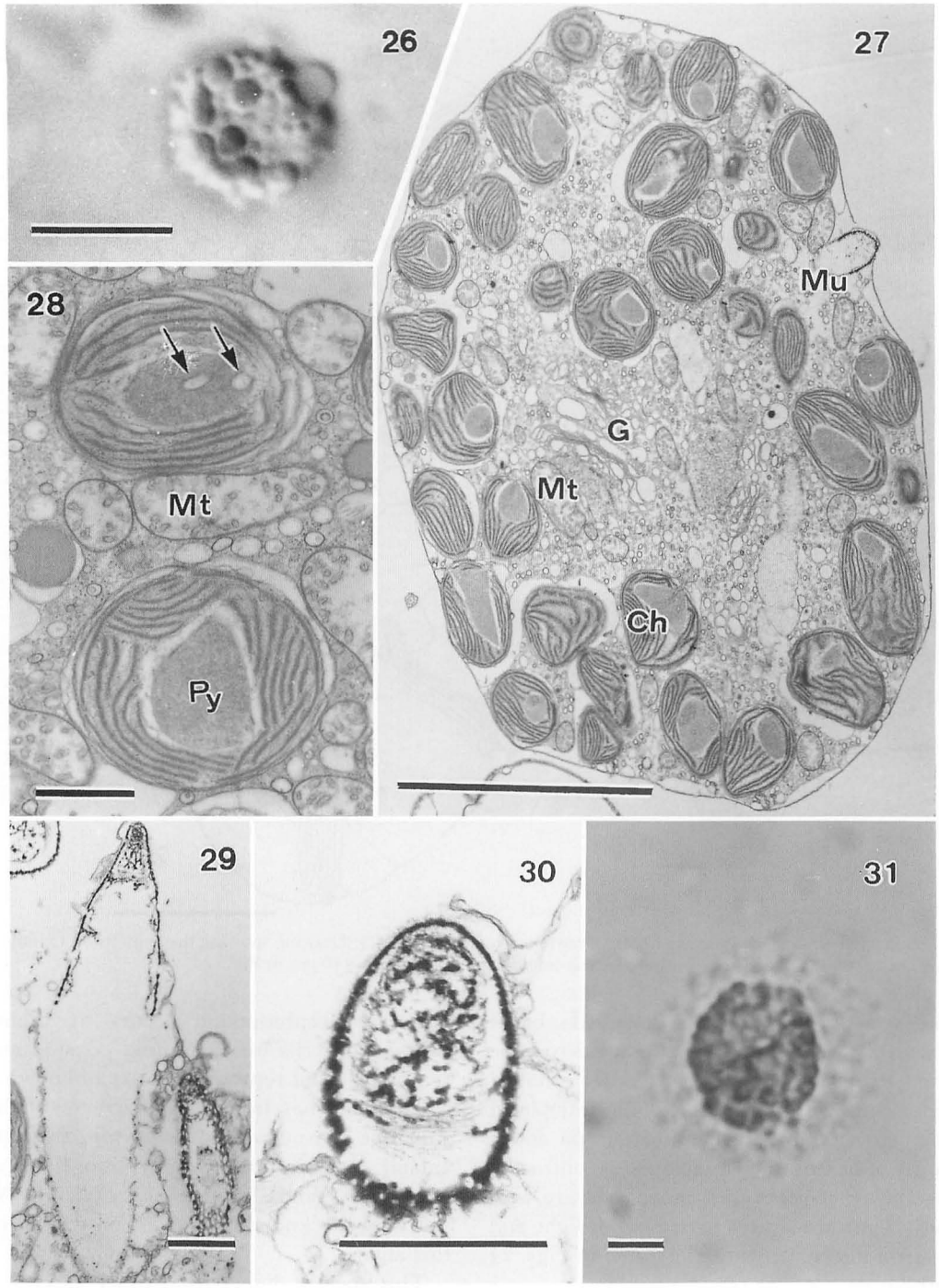
inner end of each chloroplast (Fig. 21), but it is scarcely visible under the light microscope (Fig. 19). The nucleus is teardrop-shaped and is situated in the middle of the endoplasm (Fig. 20). Many small mitochondria abundantly appear in the endoplasm. Contractile vacuoles, eye-spots and mucocysts are absent. Typical features as seen with light and electron microscopy are illustrated in Figs. 24 and 25.

Asexual reproduction occurs by binary fission while cells are swimming. Cyst formation and sexual reproduction are unknown.

This alga has been recognized to inhabit Japanese coastal waters, mainly in the Seto Inland Sea (Yoshimatsu and Ono 1986, as the "Straw sandal-shaped *Chattonella*"). No red tides are known to have been caused by this alga.

This species differs from other species of

Chattonella in the well developed vacuoles and the elongated fusiform chloroplasts. The ultrastructural chloroplast features are basically similar to those of *C. antiqua*, and this led Imai and Itoh (1985) to the conclusion that the two taxa are conspecific. However, we consider this taxon to be a distinct species characterized by a unique cell shape and a



characteristic subcellular organization related to well developed vacuolation that is maintained under various culture conditions. The difference of the chromosome numbers between them also supports our opinion (Figs. 22, 23). The chromosome number of this species was 90–110 while that of *C. antiqua* was less than 55, although they could not be determined precisely, because the squash method was not entirely successful in spreading the chromosomes (Fig. 22).

(4) ***Chattonella verruculosa* Y. Hara et Chihara sp. nov.** (Figs. 26–33)

Chattonella verruculosa Y. Hara et Chihara, *in* Fukuyo *et al.*, (1990), p. 342, nomen nudum.

Cellulae luteolae vel flavo-brunneae, fere globosae, 12–45 μm diam.; aliquot verrucula conspicua circa paginam cellulae habentes; non particulae parvae coloratae cum osmio tetroxidi, in cytoplasmatibus infra paginam cellulae locatae; mucocystes magnae, corpusculum navicularem capientes, aliquot, secus peripheriam cellulae dispostae; chloroplasti disciformes, parvi comparate, 2–3 μm longae, 1–2.5 μm latae, multi, in ectoplasmate locati; pyrenoides in chloroplastis inclusa, invasa in matrice a uno vel duobus canalibus; nucleus sphaericus; vacuolae contractiles et stigma absentes.

Holotypus: Figura 32.

Type locality: Harima-nada, Tokushima, Japan.

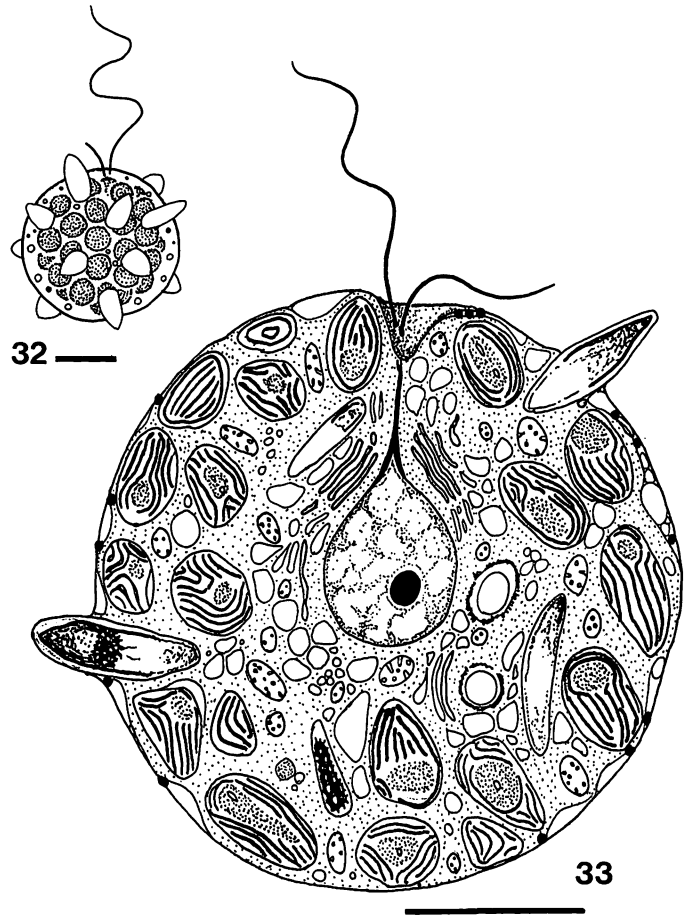
Geographical distribution: western Japan in the Seto Inland Sea and in Hakata Bay in Kyushu. Probably widely distributed in temperate regions.

Cells are pale yellow or yellowish brown, nearly globose, with conspicuous warts 12–45 μm in diameter on the surface (Fig. 26). The two unequal flagella emerge from the anterior end of the cell, the longer one being directed anteriorly and undulating during swimming, while the shorter one, which is often invisible under the light microscope, is trailing (Figs. 32, 33). No osmiophilic particles are located in the cytoplasm beneath the cell surface (Fig. 27). Several warts of large mucocysts, containing bullet-shaped inclusions in the outer half (Figs. 26, 29, 30), are distributed randomly around the cell periphery and these eject in response to slight changes in environmental conditions (Fig. 31). The discoid chloroplasts are numerous, and are situated mainly in the ectoplasm (Fig. 27). They are relatively small, 2–3 μm long and 1–2.5 μm wide, each possessing a single, embedded pyrenoid (Figs. 27, 28). The pyrenoid cannot be seen under the light microscope (Fig. 26). The pyrenoid matrix is invaded by one or two canals derived from chloroplast stroma (Fig. 28). The spherical nucleus is situated in the centre of the cell (Fig. 33). Comparatively large mitochondria are located in the endoplasm and smaller ones are in the ectoplasm. Neither contractile vacuoles nor eyespots are present.

Asexual reproduction taked place by binary fission while cells are swimming. Cyst formation and sexual reproduction are unknown. This alga inhabits coastal waters and is known to occur in Japan from Harima-nada (Akizuki et al. 1987, as the "Burr-shaped *Chattonella*") and other localities in the Seto Inland Sea.

This species is distinguished from all the known species of *Chattonella* by its verrucose cells possessing mucocysts with bullet-shaped inclusions and by the discoid chloroplasts with embedded pyrenoids invaded by one or two cytoplasmic canals. The absence of small osmiophilic particles in the peripheral cytoplasm is also characteristic. This alga is

Fig. 26–31. *Chattonella verruculosa*. 26: Photomicrograph of a motile cell, showing the protrusion of a mucocyst, chloroplasts and fatty particles located just beneath the cell surface. 27: Section of a motile cell, showing major cellular components and their arrangement, exclusive of nucleus. There is no clear boundary between ectoplasm and endoplasm. 28: Electron micrograph of chloroplasts with embedded pyrenoids possessing one or two canals (arrows). 29: Longitudinal section of a mucocyst with a bullet-shaped inclusion. 30: Transverse section of a mucocyst passing through the upper part, showing the fibrous content in the bullet shaped inclusion. 31: Light micrograph of a punctured cell, ejecting mucocysts. Scale bars = 10 μm in Figs. 26, 27 and Fig. 31; scale bars = 1 μm in Figs. 28–30.



Figs. 32–33. *Chattonella verruculosa*. 32: Drawing of a motile cell from living specimens. 33: Drawing showing the features of a motile cell based on observations using electron microscopy. Scale bars=10 μm in Figs. 32, 33.

highly vacuolated like as other species of *Chattonella*, but less clear boundary between ectoplasm and endoplasm was recognized. This alga may be retained in the genus *Chattonella*, until further examination to establish the generic delimitation of marine raphidophycean algae will be done systematically.

Biecheler (1936), in the original description of *Chattonella*, adopted as basic generic criteria the absence of contractile vacuoles and the presence of what he termed a "capsule", the clear boundary between the cytoplasmic endoplasm and the vacuolated ectoplasm. The latter character is adopted here as a main generic criterion.

Key to species of *Chattonella*

Currently, seven species including the four new species described in this paper are known to belong to *Chattonella*. A key to the species of *Chattonella* is provided as follows.

1. Mucocysts present ·····2
1. Mucocysts absent ·····4
2. Cells elongated, with pointed posterior end ·····*C. subsalsa*
2. Cells globose ·····3
3. Mucocysts with bullet-shaped inclusions ·····*C. verruculosa*
3. Mucocysts with nail-shaped inclusions·····*C. globosa*
4. Cells ovate·····*C. ovata*
4. Cells not ovate, with pointed posterior

end 5
5. Cells less than 50 μm long ...*C. minima*
5. Cells more than 50 μm long 6
6. Cells 50-70 μm long .....*C. marina*
6. Cells 70-130 μm long .....*C. antiqua*

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原　慶明*・土井考爾*・千原光雄**：日本産シャットネラ属4新種の記載

「日本の赤潮生物」（福代ら編，1990）に裸名で記載した日本産シャットネラ属（ラフィド藻綱，黄色植物門）の4新種，キュウケイシャットネラ(*Chattonella globosa*)，コガタシャットネラ(*C. minima*)，ワラジガタシャットネラ(*C. ovata*)およびイガグリシャットネラ(*C. verruculosa*)にラテン語記載文を付し，正式発表した。同時にそれらの形態的特徴，生育状況，地理的分布およびシャットネラ属の全種の検索表を提示した。（*305 つくば市天王台1-1-1　筑波大学生物科学系，**150 渋谷区広尾4-1-3　日本赤十字看護大学）

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Jpn. J. Phycol. (Sôrui) 42: 421–424, December 10, 1994

Hirotoshi Yamamoto: Review on *Gracilaria sublittoralis* Yamada et Segawa (*nom. nud.*), Gracilariaceae, Rhodophyta

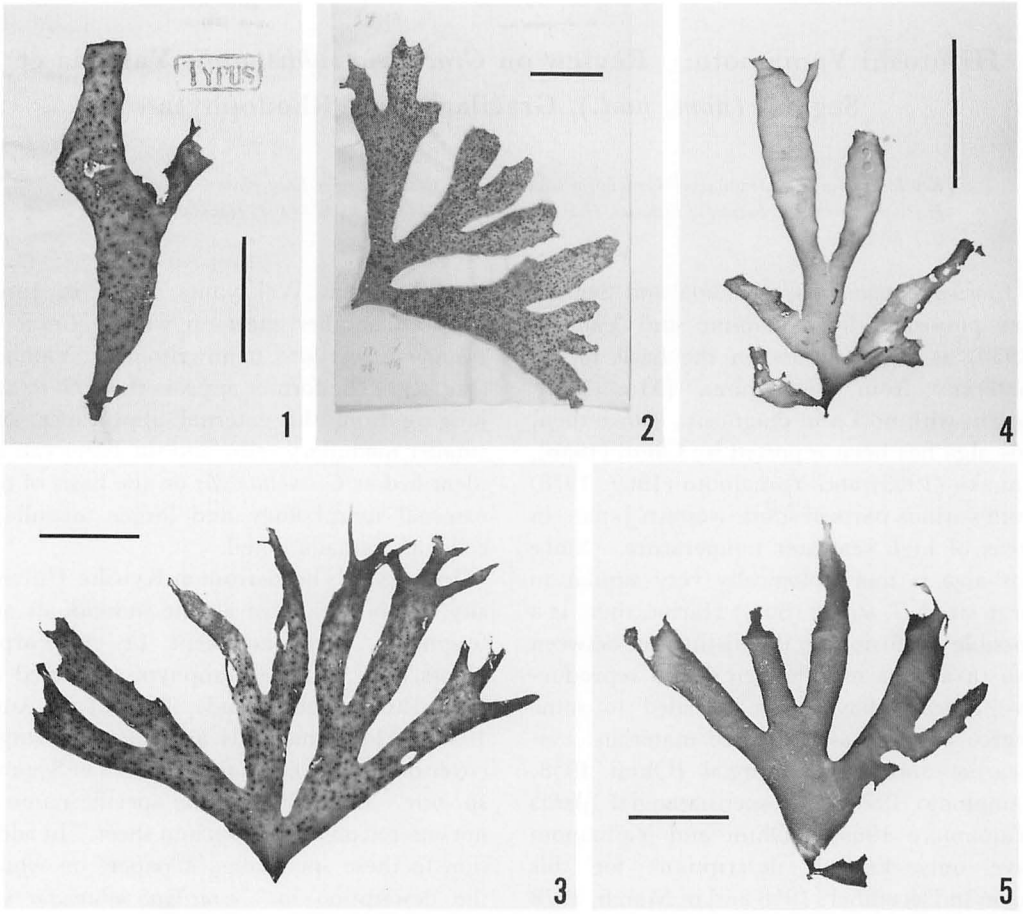
Key Index Words: Gracilaria—Gracilaria sublittoralis—*Gracilariaceae*—*Rhodophyta*—*Taxonomy*
Hirotoshi Yamamoto, Faculty of Fisheries, Hokkaido University, Minato-machi 3-1-1, Hakodate, Hokkaido, 041 Japan

Gracilaria sublittoralis Yamada and Segawa was published by Takamine and Yamada (1950) as *nomen nudum* on the basis of the materials from Suga-shima (Mie Pref., Japan) with no Latin diagnosis. Since then, this alga has been reported by Ohmi (1958), Tanaka (1963) and Yamamoto (1969, 1978) from various parts of south-western Japan, in areas of high seawater temperature. Since this alga is morphologically very similar to large sized *G. textorii* (Sur.) Hariot, there is a possible confusion on the distinction between two taxa. Its morphological and reproductive features have been revealed to some degree on the basis of these materials: cystocarpic and tetrasporangial (Ohmi 1958, Yamamoto 1978) and spermatangial plants (Yamamoto 1969). Ohmi and Yamamoto gave only English descriptions for this taxon in December, 1958 and in March, 1978 respectively. Consequently it did not fulfill the requirement for valid publication of ICBN (Art. 36-2 in Greuter *et al.* 1988) because of the absence of Latin descriptions. Accordingly, I review the history on recognition of *G. sublittoralis*, and also propose to validate the name.

I attempted to locate the type specimen of *G. sublittoralis* in the herbaria in which it could be deposited but failed. However, I confirmed that several herbarium sheets, which were annotated by either Yamada or Segawa, are kept both at the Faculty of Science, Hokkaido University (SAP) and at the Faculty of Agriculture, Kyushu University. In the herbarium SAP, there are two tetrasporangial plants collected at Suga-shima in July, 1934 on single sheet on which "*Gracilaria sublittoralis*" is handwritten by Yamada and one cystocarpic plant collected at Shirahama (Wakayama Pref.) in June, 1943 on another sheet on which "*Gracilaria sublittoralis*" is also handwritten by Yamada (Fig. 2). The former appears to be *G. textorii* judging from the external appearance and smaller medullary cells, and the latter can be identified as *G. sublittoralis* on the basis of the external morphology and larger medullary cells, as Yamada noted.

In Segawa's herbarium at Kyushu University, although almost all the individuals are fragments, there are kept 14 cystocarpic plants and 31 tetrasporophytes collected at Kozu-shima (Izu Islands, Tokyo) in Aug. 1936. These materials are placed in single cover on which "*Gracilaria* Yamada et Segawa sp. nov." is typed, but any specific name is not entered on any herbarium sheet. In addition to these specimens, a paper, on which the description for "*Gracilaria okamurai* sp. nov. Yamada et Segawa" was typed and added by Segawa's handwriting, is kept together in this cover. This diagnosis is in perfect accord with the features of Segawa's specimens. However, as far as I know, this species name has not been published.

Ohmi (1958) gave a description of *G. sublittoralis* mainly on the basis of the materials from Kozu-shima collected in Aug., 1936 and July, 1937, which were identified and provided by Segawa (*cf.* Ohmi 1958). These materials were probably a part of Segawa's herbarium deposited at Kyushu University because of the same collection site and date. According to Ohmi (1958), Takamine (pers. comm.), one of the authors (*cf.* Takamine and Yamada 1950) who listed *G. sublittoralis* for the first time, stated that this species was first collected at Suga-shima. Consequently I concluded that when Yamada and Segawa pub-



Figs. 1–5. *Gracilaria sublittoralis* Yamada and Segawa in Yamamoto. Fig. 1. Holotype (cystocarpic, SAP 059816) from Kozu-shima, showing branches decayed owing to age (*cf.* Ohmi 1958). Fig. 2. Cystocarpic plant (SAP 035361) from Shirahama. Fig. 3. Cystocarpic plant (SAP 059819) from Shirahama, showing typical form with dichotomous branching and attenuating tips. Fig. 4. Spermatangial plant (SAP 059820) from Shirahama Yamamoto (*cf.* Yamamoto 1969, 1978). Fig. 5. Tetrasporangial plant (SAP 059818) from Shirahama. Scale bars=5 cm for all.

lished the name, *G. sublittoralis*, they probably thought that this taxon was different from their *G. okamurai*, but merged the latter to the former afterwards. Thus *G. okamurai* was left unpublished.

Yamada's collection of specimens from Suga-shima (SAP) are identified by me as *G. textorii* as mentioned above. I attempted to collect *G. sublittoralis* at Suga-shima several times but failed. Accordingly I chose a plant (Fig. 1), which was already cited by Ohmi (1958), as holotype specimen among the materials of Kozu-shima collected earliest, and reestablished *G. sublittoralis*. As the epithet "*sublittoralis*" has been used several times, it is retained as the specific epithet.

Gracilaria sublittoralis Yamada and Segawa in Yamamoto sp. nov.

=*Gracilaria sublittoralis* Yamada and Segawa in Takamine and Yamada, Bot. Mag. Tokyo 63: p. 268, 1950. (*Nomen nudum*). As used by Ohmi 1958; Tanaka 1963; Yamamoto 1969, 1975, 1978).

=*Gracilaria okamurai* Yamada and Segawa sp. nov. unpublished manuscript in Herbarium, Faculty of Agriculture, Kyushu University, Fukuoka, Japan [=*okamurae*].

Frondes complanatae, 15-25 cm altae, 3-5 cm latae, aliquando usque ad 6 cm circum axillas, usque ad 1 mm crassae in parte supera, usque ad 1.6 mm crassae in parte inferna, generatim divisae dichotome 2-3 ordinibus in lobos; coriacescentes aetate.

Medulla composita 3-5 stratorum magnarum cellularum usque ad 830 μm diam. in parte supera, usque ad 1160 μm diam. in parte inferna.

Absorbentia fila praesentia.

Spermatangia portata in conceptaculis similibus ollis; conceptacula usque ad 50 μm alta, usque ad 62 μm lata.

Tetrasporangia dispersa super superficiebus ambabus frondis, regulatim cruciformia.

Fronds complanate, generally solitary, with very short terete stipe 1-2 mm diam., reaching 5 mm in length, attached to substratum by small disc 5 mm maximum diam.; fronds 15-25 cm high, 3-5 cm wide, sometimes 6 cm in greatest width around axillae, up to 1 mm thick in the upper portion, up to 1.6 mm thick in the lower portion, divided dichotomously and rarely trichotomously in 2-3 orders into lobes; lobes gradually increasing in width to the middle portion and tapering toward the tip, axillae round; apices attenuated or sometimes bifurcate, margins generally entire, but rarely proliferous; reddish brown or yellowish brown to pale brown; becoming coriaceous with age.

Cortical layer composed of 1-2 rows of cells; cells 5.6-9.8 μm long, 5.6-9 μm wide, containing 1-2 nuclei; medulla composed of 3-5 layers of large cells up to 830 μm diam. in the upper portion of frond, up to 1160 μm diam. in lower portion of frond; transition in cell size from cortex to medulla abrupt; hairs present; basal cell 13-20 $\times$ 15-17 μm.

Carpogonial branches two-celled; cystocarps borne on both surfaces of frond except basal and apical portions, up to 1.4(-1.6)mm high, up to 1.8(-2)mm wide, constricted at base, slightly beaked or non-beaked; absorbing filaments abundant, extending into the pericarp, that generally not penetrating deeply; pericarps consisting of flattened cells which are ca. 25 $\times$ 35 μm.

Spermatangia borne in pot-like conceptacles (*Verrucosa* type) on both surfaces of frond except basal and apical portions; conceptacles up to 50 μm deep, up to 62 μm wide, surrounded by elongated and curved cortical cells.

Tetrasporangia scattered over both surfaces except basal and apical portions, up to 63 μm high, up to 35(-53)μm wide, cruciately divided, surrounded by slightly elongated cortical cells.

Type locality: Kozu-shima (Izu Islands, Tokyo).

Holotype: cystocarpic (SAP 059816, Aug., 1936, Fig. 1).

Isotype: cystocarpic and tetrasporangial (Faculty of Agriculture, Kyushu Univ.).

Other materials examined: cystocarpic (SAP 035361, June, 1943, Shirahama; SAP 059819, May, 1968, Shirahama), spermatangial (SAP 059820, May, 1968, Shirahama; SAP 059817, April, 1987, Hirado), tetrasporangial (SAP 059818, May, 1968, Shirahama; April 1987, Hirado).

Habitat: 40-50 m in depth at Kozu-shima (Segawa's personal memorandum); Uwajima in Kagawa Pref. (*cf.* Ohmi 1958); Kagoshima Bay, Tanegashima and Mageshima in Kagoshima Pref. (*cf.* Tanaka 1963); *ca* 10 m in depth at Shirahama in Wakayama Pref. (Yamamoto 1978); Sado Island in Niigata Pref. (*cf.* Yamamoto 1978); *ca* 10 m in depth at Hirado in Nagasaki Pref.

This species is morphologically very close to *G. textorii*, but from which it is different in thicker, broader and coriaceous external features, and in larger medullary cells in the internal structure and especially in having a *Verrucosa* type spermatangial conceptacle rather than *Textorii* type one, which is a shallow saucer-shaped grouping of spermatangia.

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山本弘敏：シンカイカバノリ *Gracilaria sublittoralis* の再検討

シンカイカバノリ *Gracilaria sublittoralis* Yamada and Segawa は一般に使われている種名である。しかし，新種として発表された際，およびその後もラテン語による記載が付けられていなかったため，国際植物命名規約により裸名 (*nomen nudum*) として扱われている。このような理由から，本種の歴史的経過と複数の標本庫に保存されている標本を検討し，新種 *Gracilaria sublittoralis* Yamada and Segawa in Yamamoto sp. nov. とした。

本種は幅が広く厚いこと，柔細胞が大きいことにより類似のカバノリ *Gracilaria textorii* と区別することができる上，雄性生殖器官は深いつぼ状を呈し，浅い皿状のカバノリとは形状が基本的に異なる。(041 函館市港町3-1-1 北海道大学水産学部水産植物学講座)

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Katsuhisa Yuki: First report of *Alexandrium minutum* Halim (Dinophyceae) from Japan

Key Index Words: Alexandrium minutum—*Dinophyceae—first record—Matoya Bay—thecal morphology.*
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Among about 30 species hitherto described in the dinoflagellate genus *Alexandrium*, 12 species have so far been recorded from Japan (e.g. Fukuyo *et al.* 1985, Kita and Fukuyo 1988, Yuki and Fukuyo 1992). In addition to these species, I report here for the first time *Alexandrium minutum* Halim found in Japan. This species is extensively distributed in the temperate coastal waters of the world (Hallegraeff *et al.* 1988) and has been known as a paralytic shellfish toxin-producer in South Australia (Hallegraeff *et al.* 1988) and France (Erard-Le Denn 1991, Belin 1993).

The specimens were obtained from part of the samples which have been collected every roughly 3 days at a station (34°21.8′N, 136°51.9′E) in Matoya Bay, Pacific coast of central Japan, between 1956 and 1993. In sampling, 5 liters of seawater were taken from 2 m depth using a handmade pump and fixed with formaldehyde. Planktonic organisms were finally preserved in a volume of 10 m*l* by siphoning the water. Until December 1993, 4289 samples were thus collected, but about 1000 of these were already lost or unfavorable for a microscopical examination because of desiccation or decomposition of the contents. Of the remainders, about 1700 samples (about 4.7 samples per month on an average) were examined by light microscopy. *Alexandrium minutum* was present in 87 of these samples. For staining the thecal plates, Imamura and Fukuyo's (1987) solution was used.

Alexandrium minutum Halim (Figs. 1-12)

Alexandrium minutum Halim, 1960, p. 102, figs. Ia-j; Balech, 1989, p. 207, figs. 1-27; Montresor *et al.*, 1990, p. 84, figs. 3a-e, 4a-e; Honsell, 1993, p. 128, figs. 2-8.

Alexandrium ibericum Balech, 1985, p. 37, fig. 15;

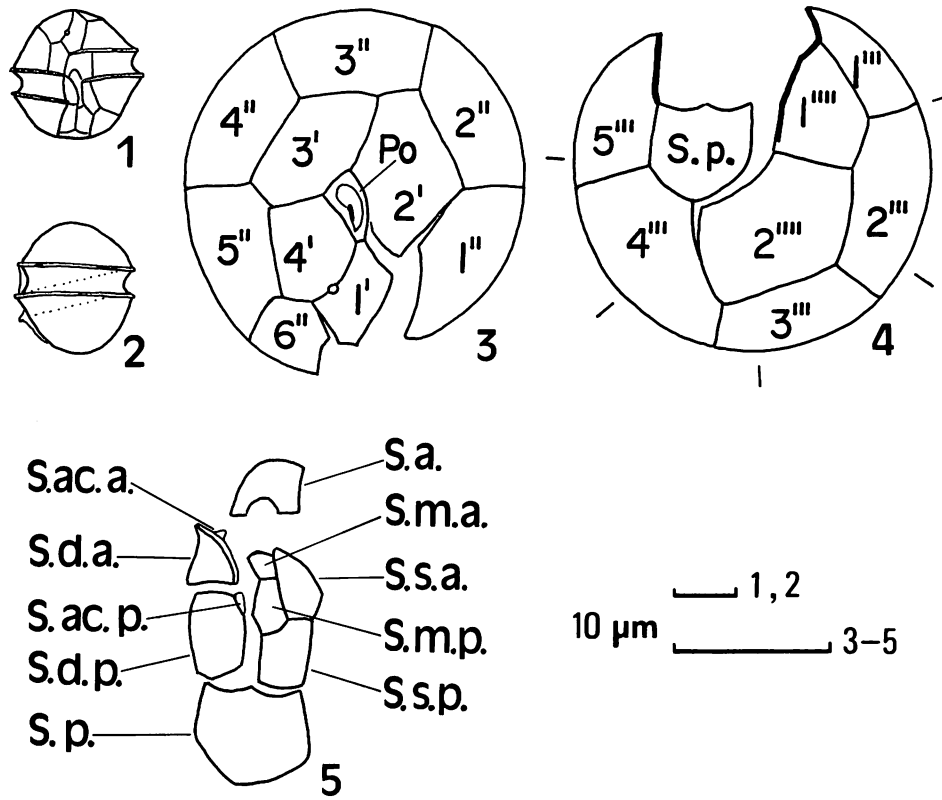
Protogonyaulax tamarensis, Su *et al.*, 1989, p. 86, figs. 1-12;

Alexandrium tamarense, Su and Chiang, 1991, p. 231, figs. 26-34.

Description: Cell solitary, globular, almost circular in cross-section, with equal epitheca and hypotheca in length, 20-26 (rarely 30) μm long, 20-25 (rarely 30) μm wide (Figs. 1, 2, 6). Epitheca hemispherical with convex shoulders. Hypotheca broadly rounded. Cingulum median, moderately wide and deep, descending one cingular width, without overhanging. Sulcus slightly widening posteriorly, faintly indenting antapex. Cingular and sulcal ridges scarcely salient. Excepting scattered nemerous pores, no ornamentation present on thecal surface in most of specimens, but coarse and irregular reticulations rarely present on surface of hypothecal and some sulcal plates (Fig. 12).

Plate formula Po, 4′, 6″, 6c, 5‴, 2⁗ and 10s (Figs. 3, 4, 5). Apical pore plate (Po) drop-shaped, tapering ventrally, with comma-shaped apical pore (Fig. 7). Callus developed. Po without attachment pore. First apical 1′ asymmetrical-rhomboidal, with truncate posterior end, in contact with Po (Figs. 3, 9). Ventral pore small, posteriorly situated on suture between apicals 1′ and 4′ (Figs. 3, 9). Precingular 6″ rather narrow, nearly twice as long as wide (Fig. 9).

Sulcus composed of ten plates (Figs. 5, 10, 11). Anterior sulcal plate (S.a.) as long as wide, with shallow posterior indentation. Right and left posterior sulcal plates (S.d.p. and S.s.p.) slightly longer than wide. Anterior inner corner of these plates roundly scraped. Right anterior sulcal plate (S.d.a.) triangular, about as long as wide. Anterior accessory sulcal plate (S.ac.a.) granular,



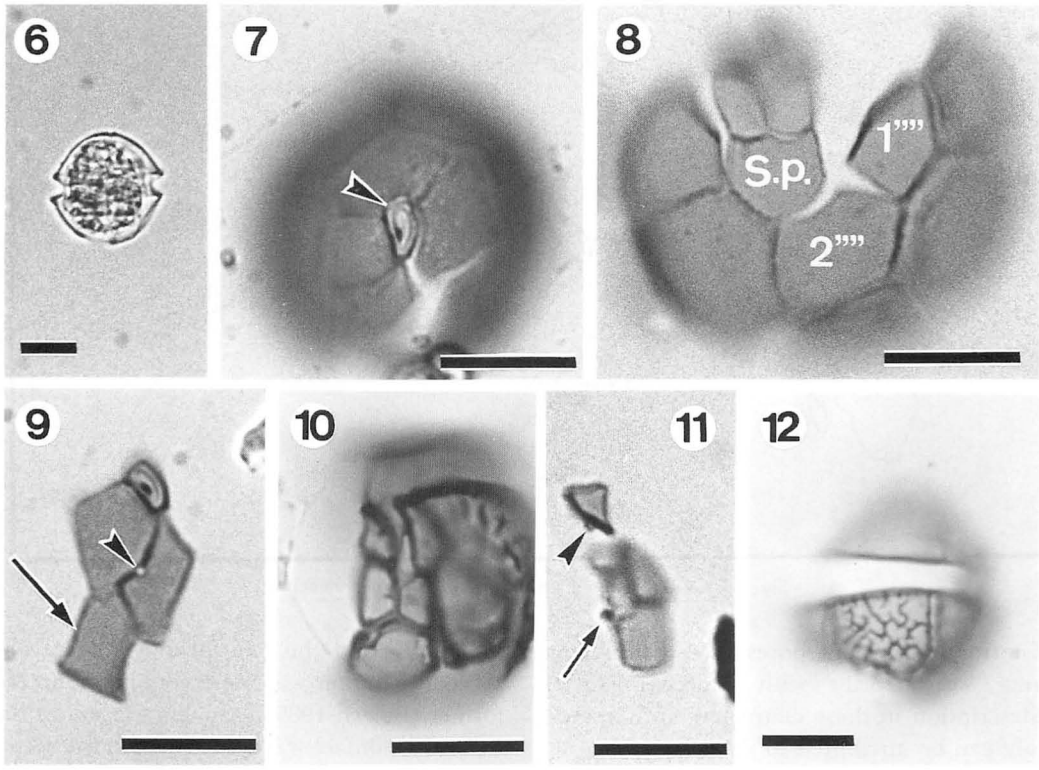
Figs. 1–5. *Alexandrium minutum* Halim collected in Matoya Bay, Japan. Fig. 1. Ventral view. Fig. 2. Left side view. Fig. 3. Epithecal plates seen apically. Fig. 4. Hypothecal plates seen antapically. Short bars denote positions of sutures of cingulars 1–6. Fig. 5. Sulcal plates, showing anterior sulcal plate (S.a.), posterior sulcal plate (S.p.), left anterior sulcal plate (S.s.a.), right anterior sulcal plate (S.d.a.), left posterior sulcal plate (S.s.p.), right posterior sulcal plate (S.d.p.), median anterior sulcal plate (S.m.a.), median posterior sulcal plate (S.m.p.), anterior accessory sulcal plate (S.ac.a.), and posterior accessory sulcal plate (S.ac.p.).

difficult to discern without dissociation of sulcal plates, adhering to thickened left anterior side of S.d.a. (Figs. 5, 11). Posterior accessory sulcal plate (S.ac.p.) very small, fitted into small indentation between left anterior corner of S.d.p. and right posterior corner of S.m.p. (Figs. 5, 11). Two median plates (S.m.a. and S.m.p.) very small, unequal in length; S.m.p. longer than S.m.a. Posterior sulcal plate (S.p.) heart-shaped or nearly rectangular, wider than long, its lateral sides almost parallel (Figs. 5, 8). No attachment pore present on S.p.

Postcingular 4‴ largest of hypothecal plate. Postcingular 5‴ second largest, four-sided, occupying right ventral side. First antapical 1⁗ bordered by six plates, with thickened right margin, connected with S.s.a. by its very short anterior side. Antapical 2⁗ wide, distorted pentagonal, but degree of distorsion slight because of rather long suture between this plate and 1⁗.

Nucleus C-shaped, located in cytoplasm behind cingulum. Chloroplasts small, numerous.

Geographic distribution: *Alexandrium minutum* was originally reported from Alexandria, Egypt (Halim 1960), and also has been recorded from Spain and Portugal (Balech 1985), coastal Tyrrhenian waters (Montresor *et al.* 1990) and Adriatic Sea (Honsell 1993) in Italy, France (Erard-Le Denn 1991), South Australia (Hallegraeff *et al.* 1988), the east coast of North America (Balech, E. cited by Hallegraeff *et al.* 1988), and southern Taiwan (Su *et al.* 1989, Su and Chiang, 1991). Newly



Figs. 6–12. Light micrographs of *Alexandrium minutum* Halim collected in Matoya Bay, Japan. Scale bars = 10 μm. Fig. 6. Optical cross-section in dorso-ventral view. Fig. 7. Apical view of the epitheca, showing apical pore plate (arrowhead). Fig. 8. Antapical view of the hypotheca. Note the posterior sulcal plate (S.p.) which is slightly wider than long. Fig. 9. Part of ventral epithecal plate, showing the Po and 1′ contact, a ventral pore (arrowhead) on the suture between 1′ and 4′, and the narrow precingular 6″ (arrow). Fig. 10. Ventral view of sulcal plate pattern. Fig. 11. Anterior (arrowhead) and posterior (arrow) accessory sulcal plates. Fig. 12. Coarse and irregular reticulations on the postcingular plate. Note the smooth epitheca.

observed from Japan (Matoya Bay, Ago Bay and Gokasho Bay located on the Pacific coast of central Honshu). These findings well document a world-wide geographic distribution of this species (Fig. 13).

Seasonal and long-term distributions: In the samples taken after 1956 in Matoya Bay, *A. minutum* was first observed in April 1967 and has continued to be found almost every year since then (Fig. 14). Although the maximal annual concentration in 1968 was considerably higher than those in other years, no noticeable long-term trend of increase or decrease in population density was observed. In Matoya Bay *A. minutum* appeared during the long period from early winter to late summer (mainly April and August); however, it was very rare or absent in fall (October-November) (Fig. 15). *Alexandrium minutum* was numerically a minor species in the bay (mostly less than 100 cells$\cdot l^{-1}$) unless it reached the concentration of about 1700 cells$\cdot l^{-1}$ in late April 1968 and became a major constituent among dinoflagellates. In Ago Bay and Gokasho Bay (within 20 km of Matoya Bay), *A. minutum* was found in March 1993, but in very low concentrations less than 20 cells$\cdot l^{-1}$.

Remarks: According to Balech's (1989) revised description, *A. minutum* is characterized by its small size (usually 17–29 μm, exceptionally 36 μm), the rhomboidal first apical 1′ which is directly or indirectly connected to the Po, a ventral pore which is situated in the posterior half of the right upper side of 1′, the small and short S.p., the narrow precingular 6″, and the constant lack of anterior and

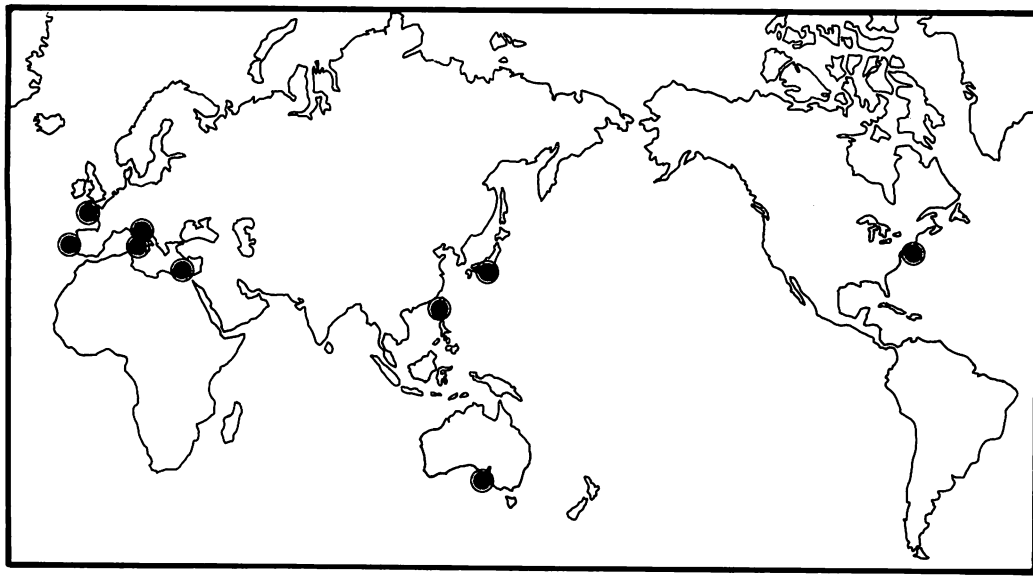


Fig. 13. Geographic distribution of *Alexandrium minutum*.

posterior attachment pores. My specimens agree satisfactorily with Balech's (1989) redescription in these characters and accordingly can be attributed to *A. minutum*.

Alexandrium minutum shows a high variability in the appearance of hypothecal surface. In the cells from coastal Tyrrhenian waters of Italy the hypotheca is smooth or highly ornamented with reticulations (Montresor *et al.* 1990) as in the Japanese specimens. Both types of cells were also observed in clonal cultures established by Montresor *et al.* (1990). Whereas, there is no obvious thecal sculpture in the specimens from other localities.

Besides, in the specimens from the type locality the cell having direct contact between Po and 1′ and the one lacking it were observed; the latter was more common than the former (Balech 1989). Such variation in the Po and 1′ contact was also shown in the specimens from South Australia (Hallegraeff *et al.* 1988), coastal Tyrrhenian waters (Montresor *et al.* 1990) and Adriatic Sea (Honsell 1993). In my specimens, however, the 1′ always made direct contact with the Po, although nearly fifty cells obtained mainly in spring and summer of several years were dissected.

Su *et al.* (1989) and Su and Chiang (1991) reported a small-sized toxic dinoflagellate from southern Taiwan as *A. tamarense* (Lebour) Balech. However, the organism shown by them possesses smaller size (14–34 μm

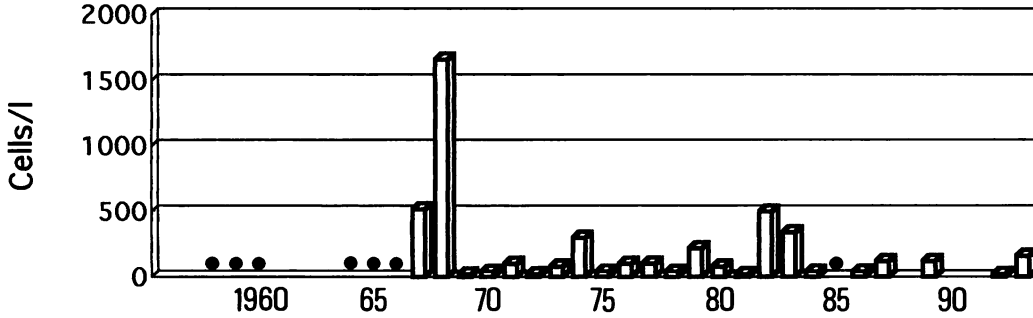


Fig. 14. Long-term changes in the maximal annual abundance of *Alexandrium minutum* in Matoya Bay. Closed circles denote the absence of data.

Fig. 15. Mean seasonal pattern of the abundance of *Alexandrium minutum* in Matoya Bay for the period 1967 to 1993 (excl. 1985).

long), the narrower precingular 6″ (Fig. 8 in Su *et al.* 1989, Fig. 31 in Su and Chiang 1991), a ventral pore which is more posteriorly situated (Fig. 8 in Su *et al.* 1989, Fig. 31 in Su and Chiang 1991), and the smaller and shorter S.p. (Fig. 9 in Su *et al.* 1989, Fig. 32 in Su and Chiang 1991) than *A. tamarense*. These characters are in satisfactory agreement with those of *A. minutum*. In addition, the resting cyst (about 22 μm) of their organism (Fig. 12 in Su *et al.* 1989, Fig. 34 in Su and Chiang 1991) is much smaller than that of *A. tamarense* (38-56 μm in Fukuyo *et al.* 1985) and is similar to that of *A. minutum* (24-29 μm) described by Bolch *et al.* (1991). I therefore consider that Su *et al.* (1989) and Su and Chiang's (1991) specimens are synonymous with *A. minutum*. In Japan no true *A. minutum* has been appeared in previous reports dealing with the morphology of *A. tamarense* and other allied species.

Acknowledgements

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結城勝久：本邦新産渦鞭毛藻 *Alexandrium minutum* Halim

三重県的矢湾とその周辺海域より得られた渦鞭毛藻 *Alexandrium minutum* Halim を記載した。細胞は長さ 20–26 μm，幅 20–25 μm の球形で，第 1 頂板の右上辺部後方に腹孔を有し，前・後部接続孔を欠く。第 1 頂板は頂孔板に接する。鎧板配列は Po, 4′, 6″, 6c, 10s, 5‴, 2⁗ と表示される。さらに，第 6 前帯板の幅が狭いことと，後縦溝板が短く，その両側部がほぼ平行な点も本種の識別上，重要である。下殻の表面には稀に粗い網目模様がみられる。連鎖群体は形成されない。本種は温帯沿岸域に広く分布し，麻痺性貝毒の原因生物として知られるが，本邦からの出現報告はこれが初めてである。的矢湾では，本種は1960年代後半以降，ほとんど毎年，低密度ながら散在的に出現している。(517-02 三重県志摩郡磯部町的矢　的矢湾養蛎研究所)

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Inderdeep Kaur and M. R. Vijayaraghavan: Histochemical studies on the mesochiton-stalk, egg and zygote of *Sargassum vulgare* C. Agardh (Fucales, Phaeophyta)

*Key Index Words: egg—germling—mesochiton-stalk—polysaccharides—**Sargassum vulgare**—zygote.*
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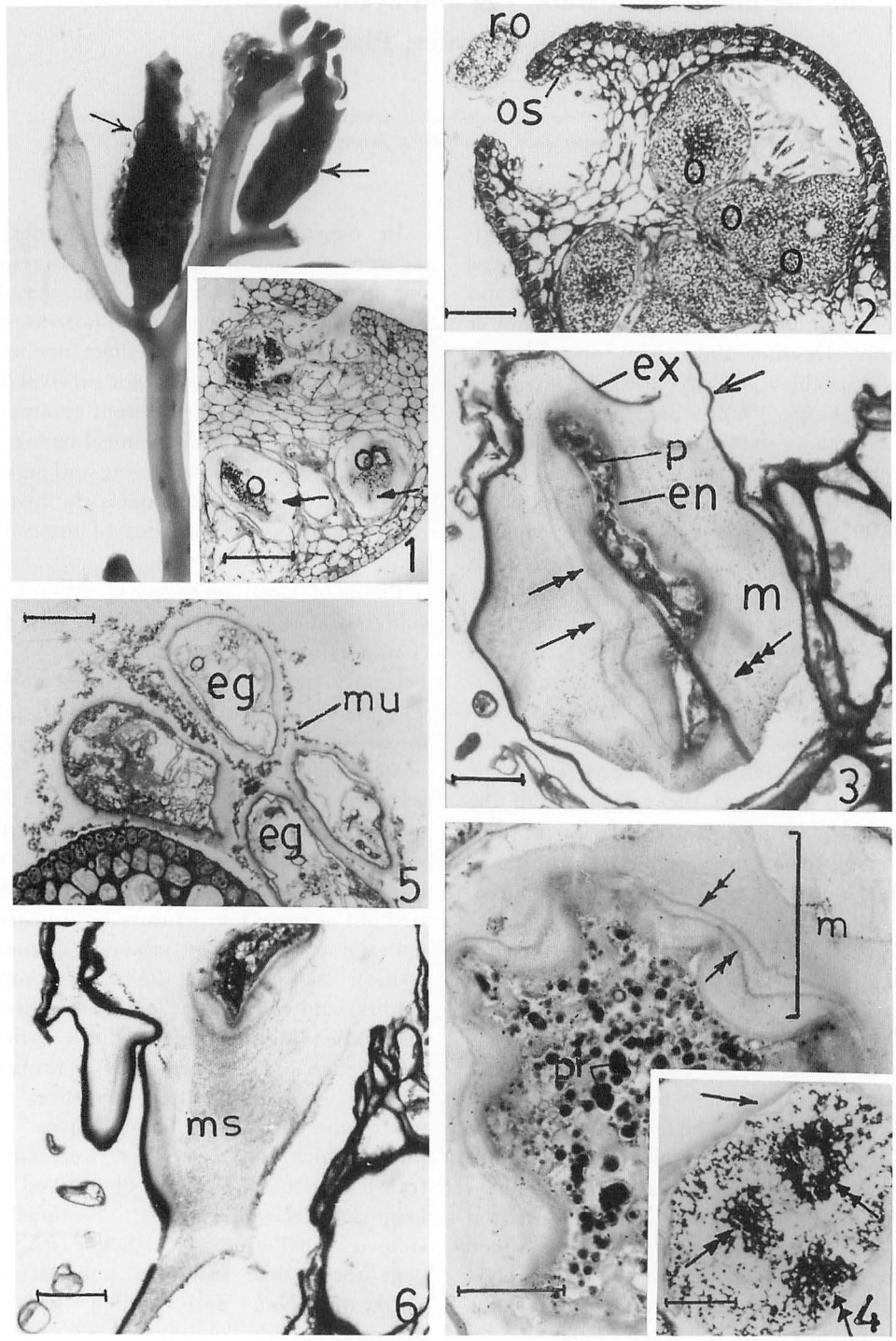
In various species of *Sargassum* the cytological, histochemical and ultrastructural changes accompanying oogenesis, fertilization and post-fertilization are documented (Ogawa et al. 1969, Deysher 1984, May and Clayton 1991; Critchley et al. 1991; Kaur and Vijayaraghavan 1992). Some confusion persists, regarding the usage of terms oogonium and egg in Fucales. Attempts have been made to clarify their usage. May and Clayton (1991) use the term oogonium when it occurs inside the conceptacle and egg when it is extruded to the exterior through the ostiole. However, Sokhi and Vijayaraghavan (1986), Critchley et al. (1991), Kaur and Vijayaraghavan (1992) use the term oogonium even after its release from the conceptacle. We use the term egg only after the histochemical changes have occurred in the mesochiton-stalk and the cytoplasm of the oogonium. In *Sargassum vulgare* C. Agardh, the oogonium has three wall layers—the outer, exochiton is rich in alginates, the middle, mesochiton consists mainly of sulphated polysaccharides and the inner, endochiton contains a mixture of alginates and sulphated polysaccharides (Kaur and Vijayaraghavan 1992). In *S. vestitum* (Brown ex Turner) C. Agardh, the eggs after release are held close to the receptacle surface by the mesochiton-stalk. This increases the fertilization efficiency. Upon fertilization, the zygote shows latent polarity which becomes apparent following the initial cell division (May and Clayton 1991). The eggs of *S. muticum*, are retained on the receptacle surface for approximately 2 or 3 days during which time early zygote development occurs (Fletcher 1980).

In *Sargassum heterophyllum* (Turner) C. Agardh, the germinating zygote is retained on the receptacle surface. The germlings are only released when they possess sticky rhizoids, which help immediate anchorage. This increases the potential for survival (Critchley et al. 1991). The present communication deals with the histochemical changes accompanying egg release, zygote and germling formation. It also emphasizes the histochemistry and varied functions of mesochiton-stalk.

Plants of *Sargassum vulgare* C. Agardh were collected at low tide period from Port Okha (Gujarat) during the months of January, February and November of 1987–89. Selected parts of the plants were processed for light microscopy, fixed on spot in 10% (v/v) aqueous acrolein for 24 hrs; washed in distilled water and post-fixed in 1% $HgCl_2$ for 24 hrs to stabilize the polyphenols. Later, the pieces were rinsed three times in distilled water at an interval of 15 minutes. Dehydration was carried out at room temperature by transferring material to 2-methoxy ethanol (2 times for 48 hrs); 100% ethanol (24 hrs); n-propanol (24 hrs) and n-butanol (24 hrs). Infiltration and embedding was done in glycol methacrylate (Feder and O'Brien 1968). Embedded samples were sectioned by a Spencer rotary microtome fitted with glass knives. Two micron thick, serial sections, were cut and transferred to small drops of distilled water kept on precleaned slides. Sections were stained with Periodic-Acid Schiff (PAS) reagent to localize insoluble polysaccharides (Vijayaraghavan and Shukla 1990) for 30 minutes; with Toluidine Blue 0 (TBO) for

sulphated and carboxylated polysaccharides (Mc Cully, 1966) for 5 minutes and with Coomassie Brilliant Blue (CBB) for proteins (Weber and Osbörn 1975) for 15 minutes. The photographs were taken using B/W, ORWO film on Reichert photomicroscope.



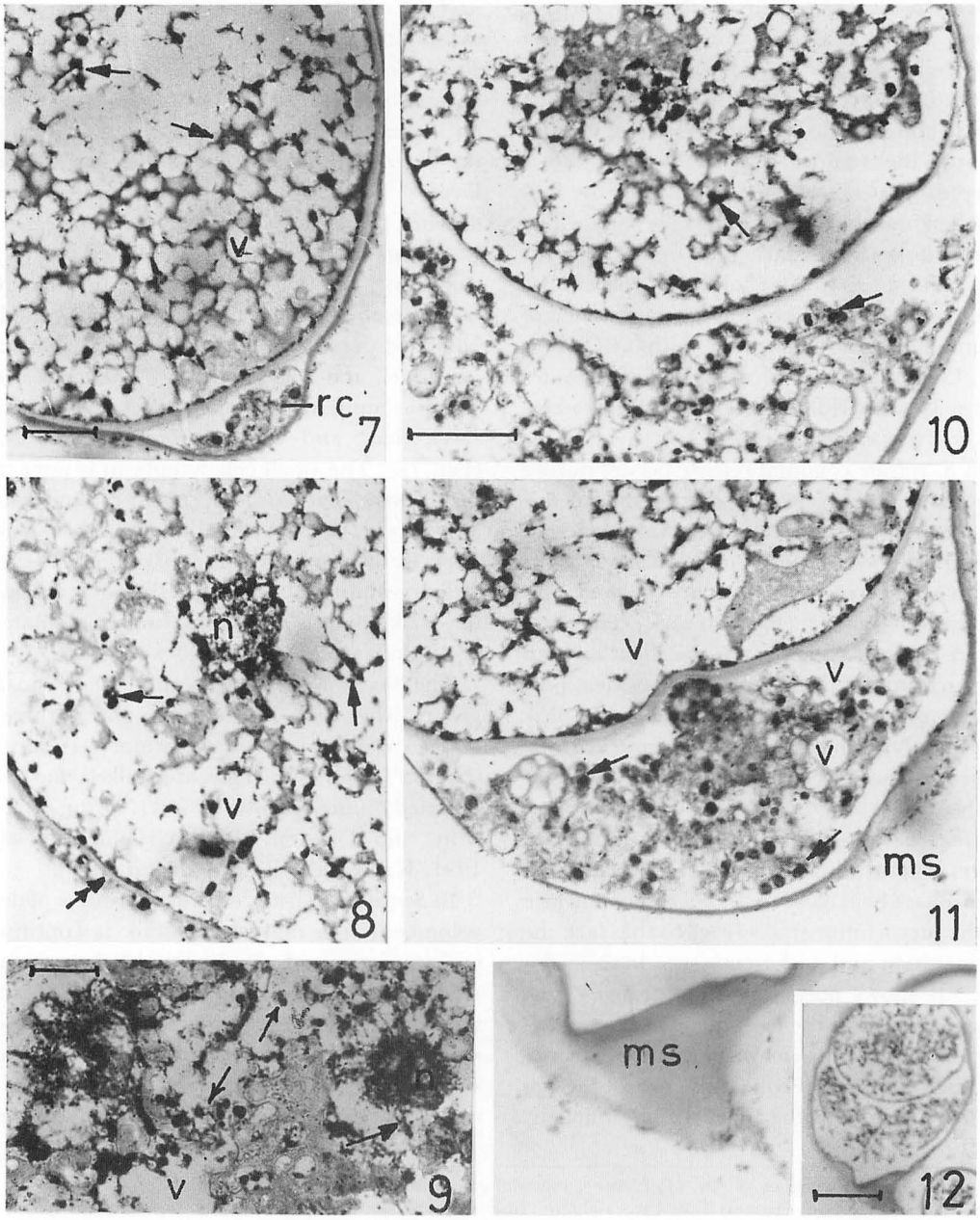
Sargassum vulgare occurs in the reproductive phase during October and January. The receptacles are axillary (Fig. 1) and contain unisexual conceptacles (Fig. 1 inset). The female conceptacle bears 3 or 4 oogonia (Fig. 2) and the mature oogonium wall shows three distinct layers—the exochiton, the mesochiton and the endochiton (Figs 3, 4). The mesochiton shows dark and light bands or zones and stains well for sulphated polysaccharides (Fig. 3). It also shows the presence of grains that stain bright blue with TBO (Fig. 3). Oogonial cytoplasm is rich in physodes and polysaccharides (Fig. 2). Total proteins are at a low ebb (Fig. 4).

In *S. vulgare* oogonial release occurs during January. Once released, the oogonium undergoes histochemical changes and is referred to as the egg. The egg cytoplasm shows eight darkly stained regions which are the presumptive sites of 8 nuclei (Fig. 4 inset). The eight nuclei of the egg appear to be identical and are surrounded by numerous physodes, protein aggregates and small vacuoles. The physodes, polysaccharides and proteins are dispersed in the egg cytoplasm. The mesochiton is present as a thin layer (Fig. 4 inset), but the mesochiton-stalk and the endochiton are prominent at this stage. The eggs, upon release, are held close to the receptacle surface by the mesochiton-stalks (Fig. 6) that lack the distinct light and dark bands seen in mesochiton. It shows polysaccharidic grains. The mucilage around the eggs helps in their cohesion (Fig. 5) and is rich in sulphated polysaccharides. During fertilization, one of the egg nucleus fuses with the male gamete nucleus, and the remaining 7 nuclei degenerate. The cytoplasm around the degenerating nuclei shows decrease in number of polysaccharides and proteins (Figs 8, 9) but there is however, an increase in the size of vacuoles. Around the zygote the mesochiton persists as a thin layer. The zygote cytoplasm shows a low amount of physodes and polysaccharides; its wall contains alginates and sulphated polysaccharides. The zygote undergoes an unequal transverse division, forming a two-celled, polarised germling (Figs 7, 12 inset), with a larger cell and a smaller cell. The large cell contains numerous small vacuoles, a few polysaccharides and many protein aggregates (Fig. 7). The small cell cytoplasm is poor in inclusions. Total proteins occur in moderate amounts in the cytoplasm of both the cells and often form aggregates (Figs 10, 11). The 2-celled germling shows a persisting mesochiton-stalk which shows a mixture of alginates and sulphated polysaccharides (Fig. 12).

The taxon *Sargassum vulgare* belongs to a group where a) the oogonia bear three-layered walls, b) the eggs are not very large (Nanba 1993), c) the eggs are stalked and are retained on the receptacle wall (Norton 1976; May and Clayton 1991, Critchley et al. 1991, Kaur and Vijayaraghavan 1992).

In *Sargassum vulgare*, during the course of development, the mesochiton-stalk is continuously present and shows variable functions. As seen in *Sargassum vestitum* (May and Clayton 1991), in *S. vulgare*, there is no collar and no apical pad to function as an attachment site. The mesochiton-stalk of *S. vulgare*, resembles that of *S. vestitum* in composition

Figs. 1–6. *Sargassum vulgare*, (1) External morphology. Portion of a reproductive plant to show fruiting bodies, the receptacles (arrows) Scale bar=100 μm. Inset shows female conceptacles containing mature oogonia (o) with thick mesochiton (arrows). TBO stained, scale bar=25 μm. (2) Transverse section of a receptacle to show female conceptacles, each one containing three oogonia (o). A released oogonium (ro) is also seen near the ostiole (os). TBO stained, scale bar=250 μm. (3, 4) Longitudinal sections of the conceptacles to show oogonia ready for release. In *3*, the exochiton (ex) is ruptured (arrow) but the mesochiton (m) and the endochiton (en) are firm. The oogonial cytoplasm is rich in physodes (p). The polysaccharide grains (triple arrows) in the mesochiton are distinct. In *4*, the cytoplasm shows protein aggregates (pr). The mesochiton shows dark and light bands (double arrows). The inset in *4* shows an egg with thin mesochiton (arrow) and three nuclear sites with perinuclear cytoplasm rich in physodes (double arrows). *3* and inset, TBO stained, *3*, scale bar=10 μm; inset, Scale bar=25 μm; *4*, CBB+PAS stained, scale bar=10 μm. (5) Longitudinal section of receptacles to show a group of four eggs (eg) settled on the receptacle wall. The mucilage (mu) that enmeshes the eggs is rich in sulphated polysaccharides. TBO stained, scale bar=250 μm. (6) Portion of the conceptacle to show mesochiton-stalk (ms) of the egg. The stalk is firm and has granular appearance. TBO stained, scale bar=10 μm.



Figs. 7–12. *Sargassum vulgare*, (7, 8, 10–12 CBB+PAS stained; 9. CBB stained). (7) The two-celled germling showing a larger cell and a smaller one, the rhizoidal cell (rc). The cells show protein aggregates (arrows) and vacuoles (v) in the cytoplasm. Scale bar=10 μm. (8, 9) The areas around degenerating nuclei (n) show decrease in number of protein aggregates (arrows) and increase in vacuoles (v). Persisting mesochiton (double arrow) is also seen. Scale bar=10 μm. (10–12) Two-celled germling (inset) to show an upper cell in *10* and a lower cell in *11* with a few protein grains (arrows) in the cytoplasm. The upper cell has a moderate amount of polysaccharides, whereas the lower cell has numerous small vacuoles (v). The mesochiton-stalk (ms) of the two-celled germling is quite prominent in *12*. (10–12, scale bar=10 μm; inset, scale bar=250 μm).

and in possessing bands (May and Clayton 1991). In the mature oogonium, the mesochiton is rich in sulphated polysaccharides, shows bands of light and dark regions and randomly distributed polysaccharide grains. The mesochiton acts as a blanket and protects oogonium against turbulent water action. It also helps to push the oogonium out of the conceptacle (Kaur and Vijayaraghavan 1992). In the released oogonium and the egg, the mesochiton remains as a thin, homogeneous layer rich in sulphated polysaccharides and gives protection against desiccation. The mesochiton also attenuates into a stalk which is homogenous and contains a mixture of alginic acids and sulphated polysaccharides (present work). The variable roles attributed to this mesochiton-stalk are: a) to anchor the released oogonium and egg to the parent thallus. This prevents the egg being lost in the vast sea and helps in its settlement and recruitment thus compensating for the low number of eggs produced in this genus (one egg per oogonium). The role of mesochiton-stalk in *S. vulgare* supports the contention of Norton (1976) in *S. muticum* (Yendo) Fensholt and Critchley et al. (1991), in *S. heterophyllum*, where the mesochiton-stalk is said to help to retain the egg close to parent body. b) To trap the spermatozoids in its mucilage ensuring fertilization.

During the post-fertilization events, the enveloping mucilaginous-stalk in zygote prevents it from damage (Fletcher 1980). The mesochiton-stalk acts merely as a 'holdfast' for the zygote and germling ensuring firm establishment (present work).

In *Sargassum vulgare* the presence of mucilage rich in sulphated polysaccharides is an adaptation for successful propagation. The mucilage helps to hold the eggs together, thereby preventing them from sinking and also make spermatozoid contact easy, ensuring successful fertilization.

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Inderdeep Kaur・Vijayaraghavan, M. R.：褐藻 *Sargassum vulgare* C. Agardh（ヒバマタ目）の中膜柄，卵および受精卵の組織化学的観察

褐藻 *Sargassum vulgare* C. Agardh の中膜柄，卵および受精卵につき組織化学的観察を行った。本種は Port Okha (Gujarat) では10月から1月にかけて成熟し，雌雄異巣である。雌性生殖器は3－4個の生卵器を生じ，成熟した生卵器の壁は顕著な3つの層，外膜，中膜，内膜からなる。中膜は硫酸多糖にとみ，同時に TBO でよく染まる顆粒も含んでいる。生卵器の細胞質はフィソードと多糖を多く含んでいる。2細胞の発芽体はアルギン酸と硫酸多糖からなる顕著な中膜柄を持つ。中膜柄は発達の過程において放出された生卵器や卵を基物に付着させたり，粘質の中に精子をとらえ受精がより効率的におこるようにするなどの様々な機能を担っていると考えられる。

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Shigeki Mayama and Ikuko Shihira-Ishikawa: Putative nucleoids scattered in chloroplast of *Pinnularia nobilis* (Bacillariophyceae)

Chloroplasts of the diatom identified as *Pinnularia nobilis* (Ehr.) Ehr. were stained with 4′,6-diamidino-2-phenylindole (DAPI) and studied with both epifluorescence microscope and confocal laser scanning microscope (LSM). Numerous DAPI-fluorescent dots were observed throughout the chloroplast. DNase treatment confirmed that these dots contained DNA. LSM observation clarified that these DNA dots were located within chloroplasts. It was suggested the chloroplast nucleoids were scattered in this species.

Key Index Words: chloroplast nucleoids—confocal laser scanning microscopy—DAPI—Pinnularia nobilis—*scattered DNA spots.*

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Geitler (1937) described sieve-like perforations in chloroplasts of *Pinnularia nobilis* (Ehr.) Ehr. with light microscopy. Each of the perforations was about 0.5 μm in diameter and they were scattered evenly throughout the plate-like chloroplasts. Further observations concerning this structure have not been published thereafter even in other diatoms. The perforations described by Geitler are identical to the scattered DNA spots in the chloroplasts of *P. nobilis* we first present in this paper.

P. nobilis was collected from a small mire in Hachigata, Saitama Pref. Some of the cells were isolated for culture and the others were cleaned with bleaching method for identification (Nagumo and Kobayasi 1990). For observations of the cleaned valves and live cells, a light microscope (Nikon SKE) and a microscope equipped with differential interference contrast (Nikon Optiphot) (DIC) were used respectively.

The isolated cells were cultured in Bold's Basal Medium (Bischoff and Bold 1963), to which was added 50 mg $Na_2SiO_3 \cdot H_2O$ per liter (pH 6.8), and then diluted with distilled water to one-fifth. The cultures were maintained at 20°C under a cool white fluorescent light of 1500–2500 lux on a 12 : 12 (L : D) photoperiod.

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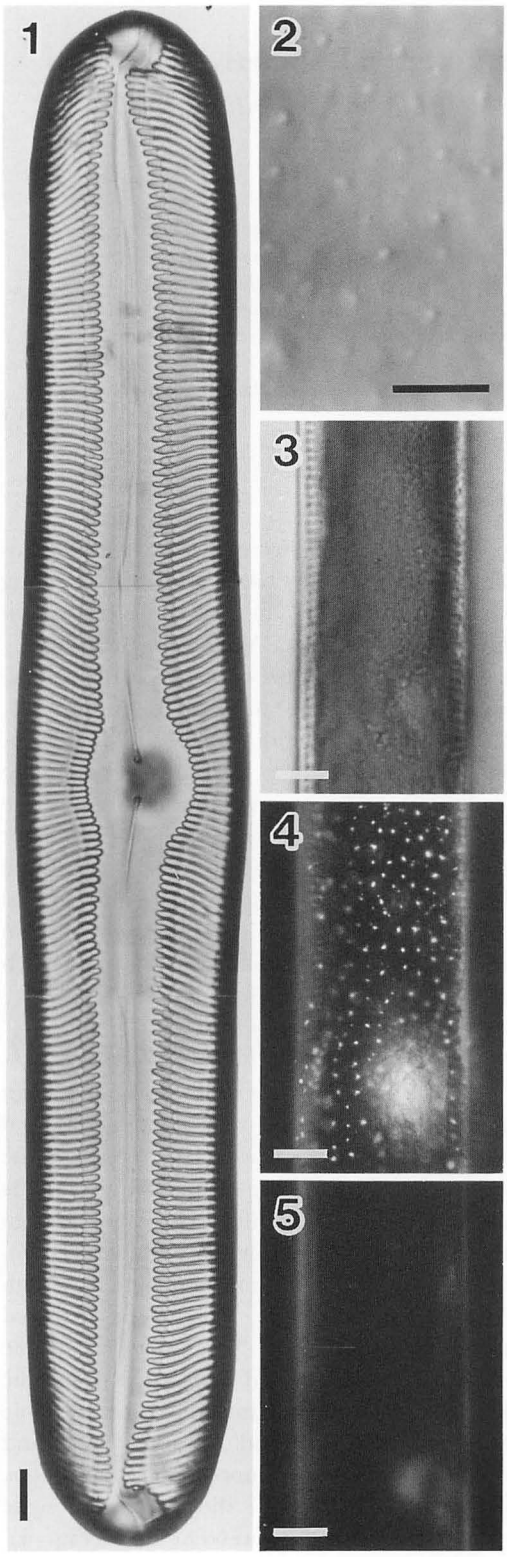
The diatoms collected were identified as *P. nobilis* on the basis of the following characteristics (Fig. 1). Frustules rectangular in girdle view. Valves linear, slightly swollen in the middle portion, broadly rounded and sometimes slightly swollen in the ends, 246–309 μm in length, 39–44 μm in width. Raphe complex with the fold of raphe slit and the strongly sigmoid outer fissure. Striae radiate in the middle portion, convergent toward the ends, 5–6 in 10 μm. Longitudinal band of striae, i.e. alignment of the internal aperture of alveoli in scanning electron microscopy, wide, about 2/3 width of each stria. Chloroplast plates, two per cell.

Light and epifluorescence microscopy

We found many dots on the chloroplasts in *P. nobilis*. With DIC microscopy, it looked as if many granules were scattered on the chloroplast surface (Fig. 2). Each granule is about 0.5 μm in diameter corresponding to the perforation described by Geitler (1937). Using bright field microscopy, although usually hardly visible, they were observed as scattered pits (Fig. 3). When the whole diatom cell was stained with a DNA specific fluorochrome 4′,6-diamidino-2-phenylindole (DAPI) (Kuroiwa and Suzuki 1980) and observed with an epifluorescence microscope (Olympus BH2-RFK), these granules were detected as DAPI-fluorescent dots (Fig. 4).



These dots completely disappeared with DNase treatment (Fig. 5). For DNase treatment, 13 units·ml^{-1} of DNase I (Type IV, Sigma) dissolved in 0.08 M sodium acetate (pH 5.0), 4 mM $MgSO_4$ and 0.025 M NaCl were applied to the specimens, followed by incubation at 30°C for 1.5 h. Before DNase application, frustules of the specimens had been broken partly near the apex with a microknife under a light microscope to improve penetration of the enzyme. In Fig. 5, the DAPI-fluorescence of the nucleus is scarcely visible, however, it entirely disappeared following 2 h in DNase. This result confirmed that the scattered DAPI-fluorescent dots contained DNA.

Confocal laser scanning microscopy (LSM)

The location of DAPI-fluorescent dots was examined in detail using LSM (Olympus LSM-GB200 UV-type) with "U-excitation". The levels of 10 serial optical sections observed in girdle view and 5 serial optical sections in valve view are diagramed in Fig. 6. The real distances between two sections were 0.9 μm in girdle view and 1.4 μm in valve view. In Fig. 7, the photographs a–f were taken at the levels of optical sections a–f indicated in Fig. 6. The photograph of the uppermost section (Fig. 7a), the girdle bands and valves, was taken using twice the exposure time of the others, because an obvious fluorescence was not observed. This section shows the obscure images of red fluorescence being reflected from the autofluorescence of chloroplast to the girdle bands (Fig. 7a, middle part) and blue fluorescence which is possibly mitochondrial DNA located in alveolate striae (Fig. 7a, clear in right side and obscure in left) and non-specifically adherent DAPI to

Figs. 1–5. *Pinnularia nobilis*. Scale bars = 10 μm (Figs. 1, 3–5) or 5 μm (Fig. 2). Fig. 1. A whole cleaned valve. Fig. 2. Enlarged chloroplast showing scattered granules in girdle view. DIC. Figs. 3–5. The same cell stained with DAPI in girdle view. Fig. 3. Bright field illumination image. Fig. 4. Epifluorescence microgram showing scattered DAPI-fluorescent dots throughout chloroplast and fluorescence of nucleus (below). Before DNase treatment. Fig. 5. DNase treatment for 1.5 h. DAPI-fluorescent dots disappeared.

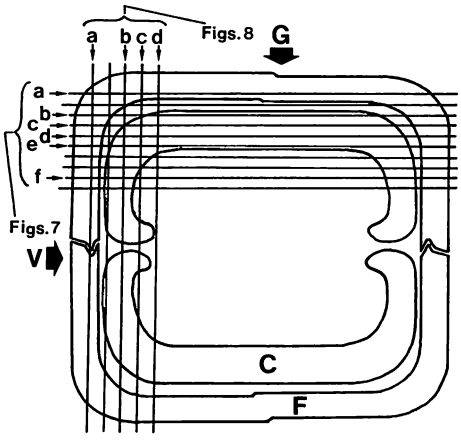


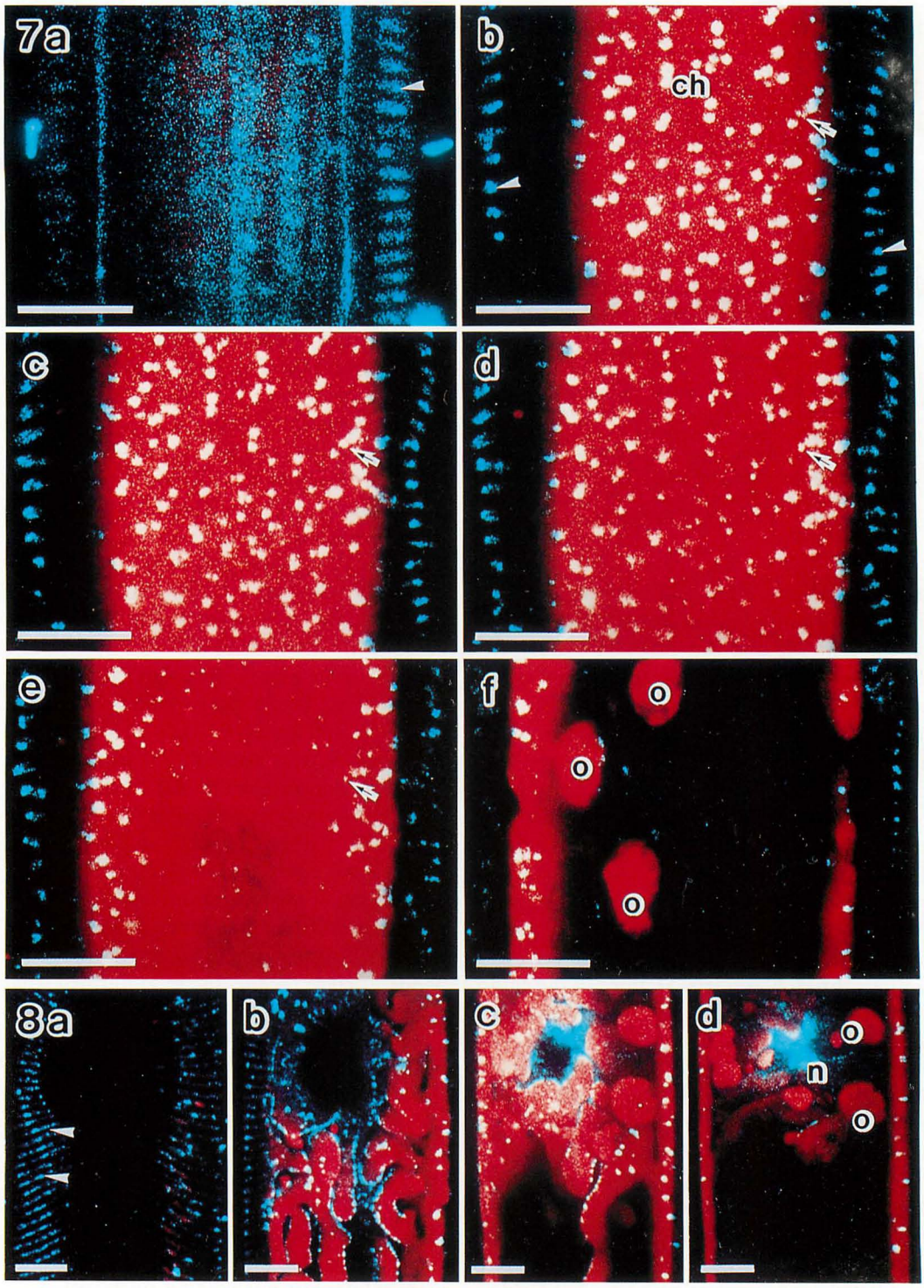
Fig. 6. Diagram showing a transapical section of the cell with lines indicating the levels of 10 serial optical sections observed in girdle view and 5 in valve view respectively. The optical sections at the levels indicated by arrows a–f and a–d are presented in Figs. 7a–f and Figs. 8a–d respectively. C=chloroplast, F=frustule, G=girdle view, V=valve view.

the valve surface, while two bacteria attached to the valve surface are also seen (Fig. 7a, one on the left side and the other on the right). The photographs b–e in Fig. 7 are the images of horizontal sections of a chloroplast. A number of scattered DAPI-fluorescent dots are observed in white. In this case, the DAPI-fluorescence is too strong to appear blue. Blue dots aligned on both sides of the chloroplast area are possibly mitochondrial DNA in the alveolate striae. The distance between sections b and e is 2.7 μm, but the chloroplast is a little thicker than that, i.e. about 3 μm. Most DAPI-fluorescent dots are continuous throughout serial sections of the chloroplast (Figs. 7b–e, arrows). The average diameters of dots in sections b and c are larger than in section d (Figs. 7b–d). Very small fluorescent dots are rarely scattered in the middle area of section e, i.e. the bottom level of the chloroplast (Fig. 7e). From this three dimensional observation, it is suggested DAPI-fluorescent dots are globular and are embedded in the chloroplast. The chloroplast-autofluorescence is not seen in the middle area of section f because of the chloroplast curvature, while three storage oil drops are visible due to the reflection of chloroplast autofluorescence (Fig. 7f). On the right side of Fig. 7f, the band of chloroplast represents a longitudinal section of the lobed chloroplast extending immediately under the valve face. The discontinuity of the band shows the fimbriation of the chloroplast edge. The thickness of the chloroplast in this portion is about 2.5 μm which is a little thinner than the distance estimated between sections b and e. DAPI-fluorescent dots are clearly located within the chloroplast itself, as shown in the chloroplast band in Fig. 7f. The left band of the chloroplast does not indicate the real thickness, as the chloroplast sinks slightly inward and the band is a tangential section of the chloroplast lobe.

Serial optical sections in valve view are shown in Figs. 8a–d. In the horizontal section of the valve, the alveolate striae with possible mitochondrial nucleoids are visible (Fig. 8a). The edge of the chloroplast is complicatedly lobed and DAPI-fluorescent dots are seen in the chloroplast (Fig. 8b). The dots are not only scattered but also arranged along the edge of the lobed chloroplast. In the next section (Fig. 8c), a part of the lobed chloroplast is still observed with DAPI-fluorescent dots in two patterns of arrangement. As DAPI-fluorescence of the nucleus is too strong, it sometimes causes flaring inside the cell. This flaring is visible as blue fluorescence in the upper middle of Figs. 8c and 8d and no part of the nucleus is included in these photographs. Fig. 8d shows a cross section of two chloroplasts extending under the girdle bands. Here again, it is confirmed that DAPI-fluorescent dots are located within the chloroplast. The thickness of the chloroplast is 2.5–3.7 μm which includes the range of thickness estimated from the observation of serial sections shown in Figs. 7b–e.

LSM was useful, in this study, to analyze the three-dimensional structure of DNA spots in chloroplast in optical sections. It revealed that DNA spots were located in the chloroplast, suggesting these scattered DNA spots were chloroplast nucleoid (ct-nucleoid).

The scattered DNA spots were also observed in several species of *Pinnularia* (in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preparation) and the fine structures of DNA spots in their chloroplasts are under investigation. The TEM observations has already revealed that these DNA spots were not derived from invagination of mitochondria or endosymbiont into the chloroplast but corresponded to the discrete areas of stacking thylakoids. In addition to the results of DNase treatment and LSM observation, these TEM observations also suggest that the scattered DNA spots are ct-nucleoids. However, it has not been proven that these DNA spots comprise the chloroplast genome. Conclusive evidence of the scattered DNA spots being ct-nucleoid is under investigation.

Coleman (1979, 1985) and Kuroiwa et al. (1981) reported the ct-nucleoids in DAPI-stained diatoms. They have examined 12 species belonging to 12 genera and described that diatoms have ct-nucleoids arranged along the chloroplast edge, i.e. ring ct-nucleoids. The *P. nobilis* we observed presumably has the scattered ct-nucleoids in addition to the ring ct-nucleoids.

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真山茂樹・石川依久子：*Pinnularia nobilis* (Ehr.) Ehr.（珪藻綱）の葉緑体中に散在する核様体様の DNA 小粒

Pinnularia nobilis と同定される珪藻を DAPI 染色し，落射型蛍光顕微鏡および共焦点走査型レーザー顕微鏡で観察した。葉緑体には DAPI 蛍光を放つ点が多数散在しているが，その蛍光は DNase で処理することにより消失するため DNA を含有することが証明された。また，これらの DNA スポットは葉緑体中に存在することが共焦点走査型レーザー顕微鏡による光学的連続切片により確認された。珪藻はリング型の葉緑体核様体を持つとされていたが，*P. nobilis* はさらに分散型の葉緑体核様体を持つことが示唆された。(184 東京都小金井市貫井北町4–1，東京学芸大学生物学教室)

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Figs. 7, 8. Serial LSM sections in *P. nobilis* stained with DAPI. Scale bars = 10 μm. ch = chloroplast with DAPI-fluorescent dots. n = flare of nucleus fluorescence. o = storage oil. arrowhead = possible mitochondrial DNA. Figs. 7a–f. Serial optical sections from girdle inward. Arrows (b-e) indicate the serial sections of single DAPI-fluorescent dot. Figs. 8a–d. Serial optical sections from valve inward.

日本藻類学会秋季シンポジウム　講演要旨

（1994年9月19日，北海道大学理学部）

海藻の生態相関物質の多様性

（北海道大学大学院地球環境科学研究科）
鈴木　稔

海洋生態系を構成する生物種間の相互関係を制御する生態相関物質（エコケミカルズ）が次々と明らかとなり，異種生物間に生起する様々な生物現象を物質レベルで議論できるようになってきた。本講演では，海藻と海洋動物との相互関係に関わっている化学物質について紹介する。

1．海洋植食動物に対する摂食阻害物質

海藻類は，魚や底生植食動物から一方的に食べられるばかりではなく，種々の化学物質を生産して化学的防御機構を備えることによって種の保存と群落の維持，拡大を図り生態的に適応していると考えられる。アワビ，ウニ，サザエなどの植食動物は，コンブ科の褐藻（アラメ，カジメ，コンブなど）を好んで食べるが，ある種の褐藻類や紅藻類をほとんど食べない。私達の開発した結晶セルロースを塗布したアルミシートを用いる生物試験法で摂食阻害活性物質を検索した。

アミジグサ科の褐藻：岩手県の三陸中北部沿岸では，コンブの優先群落が消滅した海域にフクリンアミジが繁茂することによってアワビやウニが散逸してしまうので，漁民はケカツグサ（方言で凶作草の意）と呼んで嫌っている。また，新潟県の佐渡島や粟島では，ホンダワラ類の優先群落が衰退し，その裸地にアミジグサの群落が拡大した結果，サザエやアワビが散逸してしまった現象が起きている。これらの海藻では，脂溶性の中性部に強い摂食阻害活性が見られたので，生物試験を指標として分離を行ったところ，両海藻ともスパタン型やセコスパタン型のジテルペン類が植食動物に対して摂食を阻害していることが明らかとなった。一方，秋田県金浦町飛の沿岸に見られる“磯焼け”の海底に点在する不動石の上面にはシワヤハズやアミジグサが濃密に繁茂しており，同所的に生息しているクロアワビによって摂食されない。シワヤハズではゾナロールやゾナロンなどのセスキテルペン誘導体が摂食を阻害していた。

コンブ科の褐藻：アワビなどの植食動物は同属のカジメを食べるのにツルアラメをほとんど食べない。ツルアラメの抽出物について摂食阻害物質をスクリーニングしたところ，アミジグサ科の海藻とは異なってツルアラメでは水溶性部に強い活性が見られた。水溶性部から協力な阻害活性物質としてフロログリシンのオリゴマーやポリマー（フロロタンニン）が得られた。フロロタンニン類は，褐藻類に普遍的に含有されているので，アラメについても調べてみた。予想通りアラメでも水溶性部にフロロタンニンによる阻害活性が見られた。このことは，アワビやウニが生鮮のアラメではなく寄り藻（落葉，フロロタンニン含有の低下したもの）を食べているという事実を良く説明できる。

フジマツモ科の紅藻：北海道日本海沿岸の寿都海域では，キタムラサキウニなどの植食動物と同所的にマギレソゾが生育している。マギレソゾの抽出物でも中性部に摂食阻害活性が見られ，マギレソゾの摂食阻害は含窒素ジテルペン類やトリテルペン類によるものであることが分かった。ミツデソゾやウラソゾでもその主要な二次代謝産物である含臭素化合物に強い阻害活性が見られた。ハケサキノコギリヒバでは，ブロモフェノール類が阻害活性を示した。これらの結果から紅藻類の生産している含ハロゲン化合物は，植食動物に対して化学的な防御を担っていると考える。

2．海洋植食動物幼生の着底・変態に関与する物質

コンブなどの大型の褐藻群落が消滅した跡に紅藻無節サンゴモの優先群落が広域に形成されるいわゆる“磯焼け”の海底には，キタムラサキウニなどの植食動物が多く生息している。これは，石灰を沈着する無節サンゴモがアワビやウニ幼生の着底・変態を誘起するためと考えられていた。そこで“磯焼け”現象解明の一環として植食動物幼生の着底・変態誘起物質を検索した。その結果，サンゴモはジブロモメタンを生産し分泌することによってウニ幼生の着底・変態を誘因していることが明らかとなった。陸上においては発ガン物質やオゾン層破壊物質として知られているハロメタン類は，海洋では植食動物幼生の着底・変態の過程で重要な役割を演じているだけでなく，さらに他の生物現象に関わっている可能性が示唆される。

有機化学からみた渦鞭毛藻

（北海道大学理学部）中　村　英　士

海洋生物は，生理活性の強い特異な化合物を提供する生物として有機化学者に着目され，これまでに抗ガン剤，細胞毒性物質，カルシウムイオンチャネル活性化物質など多くの有用な活性物質が単離同定され，実用的な薬剤としても期待されている。

渦鞭毛藻は，赤潮の形成，また魚介類の毒化原因生物として注目されるとともに，海洋生物から得られた生理活性物質の真の生産者として重要視されている。事実，シガテラをはじめ魚介類の毒化原因が，渦鞭毛藻であることが示された。我々は，腔腸動物イワスナギンチャクの毒パリトキシンが，共生する渦鞭毛藻に由来するものと考えスクリーニングを行い，ヒラムシに共生する Symbiodinium 種が生理活性ならびに化学的性状が類似した化合物を生産することを見出した。この物質ゾーザンテラトキシンの構造は，最近決定することが出来たが，その構造はパリトキシンとは異なり，大変大きな環状構造を持っていることが明らかとなった。

渦鞭毛藻が多彩な物質を生産することが分かるにつれ，有機化学者にとって渦鞭毛藻はますます魅力的になってきた。しかし，生育が遅く無菌化が困難であることなど，問題も多い。また，得られた物質が渦鞭毛藻にとってどのような意味を持つのか，また，赤潮の形成など渦鞭毛藻自身が示す生物現象の機構についても十分解明されているとは言えない。我々は，渦鞭毛藻の発光時計に興味を持ち，Gonyaulax polyedra の発光時計の周期を短縮する内在性物質ゴニオリンから，こうした問題に取り組んできた。渦鞭毛藻の発光は，クロロフィルより合成されるルシフェリンの酵素ルシフェラーゼによる酸化反応で，体内時計の分子機構と直接には関係しない。しかし，その発光反応を形成する成分の生合成は，体内時計によって制御され，発光反応自身の制御機構とともに興味深い。

ゴニオリンは，その構造からメチオニンから生合成されると考えられ，種々の条件でのトレーサー実験を行ったところ，以外にも当初予想したような単純なものではなかった。メチオニンは，まず，磯の香りとして知られるジメチルスルフィドの前駆体であるジメチルプロピオセチンへと分解され，炭素原子を一つ失うが，その後炭素原子を一つ追加して合成されていた。この，一見無駄に見える生体反応が意味する事は何であるのか今のところ分かっていないが，渦鞭毛藻にはメチオニンを出発とする一連の代謝システム（メチオニンカスケード）が共通して存在するようである。ゴニオリンは，Gonyaulax polyedra には極めて高濃度で含まれているが，今のところ他の渦鞭毛藻には見出されていない。また，Gonyaulax polyedra はゴニオリンに特異な能動輸送系を持っていることも分かってきた。

日本藻類学会和文誌「藻類」，英文誌 Phycological Research の概要

—和文誌の概要—

これまでの「藻類」を誌名として踏襲し，英語名は Japanese Journal of Phycology (Sorui) となります。和文誌は従来の和文学術誌としての側面を受け継ぐと同時に，これまで以上に，情報誌，啓蒙誌およびニュースレターとしての性格を強くもつものに変わります。オリジナルの和文論文のほかに，藻類に関する解説，採集地や研究技術などの情報，その他多くの企画記事を掲載します。掲載を予定している内容は概略次のようです（内容の詳細については「藻類」42巻2号ニュースを参照)。

1. 和文論文，短報，速報などのオリジナル論文；2. 総説；3. 解説；4. 採集地紹介；5. 藻類分布資料；6. 藻類誌；7. 地域活動；8. 研究技術紹介；9. 研究機関紹介；10. 藻類の教材化；11. 藻類 Q&A;12. 学会事業；13. 学会，シンポジウム情報；14. 新刊紹介；15. 英文誌 (Phycological Research) 掲載論文の和文摘要；16.その他の投稿記事；17. 会員入退会，移動，住所変更；18. 学会録事；19. 春季大会および秋季シンポジウムの案内，プログラムおよび講演要旨

以上の記事の他に，日本学術会議より「学術会議だより」の提供があります。

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—英文誌の概要—

英文誌は Phycological Research という新誌名のもと，誌面は現在よりやや大きい A4 変形版 (Short A4) となり，初年度は各号約64ページの予定です。英文誌における原稿掲載の形態は REVIEW ARTICLE, ORIGINAL RESEARCH ARTICLE, RESEARCH NOTE, BOOK REVIEW とこれまでと大きな変更はありません。英文誌の編集はこれまで通り日本で行いますが発行は Blackwell Science Pty Ltd との契約によりおこない，会員へは海外の印刷所（Allen Press の予定）から航空便 (Economic Airmail) で発送されます。編集の手順でこれまでの「藻類」と異なるのは，投稿された原稿が英文誌編集委員会による審査を経て受理された後，さらに出版社の専任の編集者 (House Editor) により論文の体裁・英語などのチェックが行われたのち出版される点です。なお財政上の理由から当分の間，別刷代の学会負担は行いません。

英文誌に関する問い合わせ及び原稿の送付先
〒657 神戸市灘区六甲台町1-1 神戸大学理学部生物学科 川井浩史
電話 078-803-0552 ファックス 078-803-0488
E-mail kawai@gradura.scitec.kobe-u.ac.jp

和文誌投稿案内

Ⅰ．編集の方針と投稿資格　本誌には藻学に関する未発表の和文論文，短報，速報のほか，総説，大会講演要旨，藻類に関する企画および投稿記事(採集地案内・分布資料・新刊紹介・シンポジウム紹介・学会事業案内など)を掲載します。論文および短報は和文誌編集委員会（以下編集委員会）が依頼する審査員による審査を経たのちに編集長によって掲載の可否が決定されます。速報およびその他の投稿原稿の掲載の可否は編集長と編集委員会で判断します。なお，編集委員会が依頼した場合を除いて，投稿は会員に限ります。共著の場合，著者の少なくとも一人は会員であることが必要です。

Ⅱ．制限頁　論文は刷り上がり10頁，総説16頁，短報4頁以内を無料とします。頁の超過は制限しませんが，超過分については超過頁代（金額未定）が必要です。その他の報文，記事については，原則として2頁以内を無料としますが，編集委員会の判断で6頁を上限として超過を認めることがあります。速報は2頁以内とします。速報は超過頁と同じ扱いになりますので有料です。2,000字で刷上がり1頁となる見当です。そのほか，折り込み頁，色刷りなどの費用は著者負担となります。

Ⅲ．原稿執筆・投稿要領　原著論文および短報は下記の様式に従って執筆し，オリジナルの原稿と図表各1組とそれぞれのコピー2組（写真を含む図版はこれを写真複写したもの。電子複写は不可）を編集委員会に提出してください。その他の報文については特に様式の制限はありませんが，最新の号を参照し，必要に応じて編集委員会に打診してください。また，原稿の種類を問わず，次の規則に従ってください。1）テキストファイル形式で保存できるワードプロセッサーを用いて作成し，A4用紙に1行40字，25行で印刷する。2）当用漢字，新かなづかいを使用する。3）本文中の句読点は「,」と「。」を用い，「、」や「.」の使用は避ける。4）学名と和名の使用：新種記載や学名の使用は最新の国際植物命名規約に従い，和名にはカタカナを使用する。5）本文中ではじめて使用する学名には命名者名をつける。また，属と小名には下線を引き，イタリック指定をする。6）単位系と省略表記：SI 単位を基本とします。原稿中で使用できる主な単位と省略形は次のとおりです(時間：hr, min, sec, 長さ：m, cm, μm, nm, 重量：g, mg, 温度：°C, 波長：nm, 光強度：lux, $\mu E \cdot m^{-2}s^{-1}$, Wm^{-2}, $\mu mol \cdot m^{-2} \cdot s^{-1}$ など)。そのほか，執筆にあたっては以下の投稿原稿の構成およびワープロ入力の注意の項を参照ください。

投稿原稿の構成　原著論文は，1）標題，2）英文要約，3）本文，4）引用文献，5）表と図およびその説明（英文）の順にまとめてください。短報は本文の構成が異なる点を除いて，原著論文に準じます。

1. **標題と要約**　欄外見出し（英文25文字以内），標題，著者名，所属，住所，著者名（英文），英文標題，英文要約（200語以内），英文キーワード（5–10語，アルファベット順），著者名（英文），宛先（英文）の順に記入してください。
2. **本文**　論文は原則として緒言，材料と方法，結果，考察（または結果と考察），謝辞で構成されます。短報ではこれらの項目を区別せず，一連の文章にすべてが含まれるように構成してください。原著論文，短報とも必要に応じて図（線画や写真）や表を用い，原稿中にそれぞれ挿入を希望する位置を指示してください。本文中での文献，表および図の引用は次の例に従ってください。

   …… 細胞表面には多数の突起がある (Fig. 5, Figs. 7–9). ……が知られている (Yamada 1949, Yamada and Yamada 1950, Yamada et al. 1951). 岡村 (1907, p56) は，……を示している．……の大きさには地域により明瞭な差異が認められる (Table 3).
3. **引用文献**　本文中で引用したすべての文献を著者名のアルファベット順に列挙してください。原著論文と単行本，叢書中の分冊等では引用の方法が異なります。下記の例にならってください。

（単行本）　岡村金太郎　1936. 日本海藻誌. 内田老鶴圃，東京.

Christensen, T. 1994. Algae. A Taxonomic Survey. AiO Print Ltd., Odense.（著者，出版年，

標題，出版社，出版社の所在地の順）

（単行本中の1章）　有賀祐勝・横浜康継　1979．光合成・呼吸の測定．p. 413–435．西沢一俊・千原光雄（編）藻類研究法．共立出版，東京．

Drebes, G. 1977. Sexuality. p. 250–283. In: Werner, D (ed.) The Biology of Diatoms. Blackwell Sci. Publ., London.（著者，出版年，引用した章の標題，同掲載頁，編者，単行本標題，出版社，出版社の所在地の順）

（叢書中の分冊）　Krammer, K., Lange-Bertalot, H. 1986. Bacillariophyceae. 1. Teil: Naviculaceae. In: Ettl, H., Gerloff, J. and Heynig, H. (eds.) Süßwasserflora von Mitteleuropa. No. 2/1. Gustav Fischer Verlag, Stuttgart.（著者，出版年，引用した章の標題，編者，単行本標題，版番号，分冊番号，出版社，出版社の所在地の順）

（雑誌中の1論文）　筒井　功・大野正夫　1992．和歌山県白浜産クロメの成長・成熟と形態の季節的変化．藻類 40: 39–46.（著者，出版年，論文標題，雑誌名，巻，同掲載頁の順）

Yoshida, T. and Silva, P. C. 1992. On the identity of Fucus babingtonii Harvey. Jpn. J. Phycol. 40: 121–124.（著者，出版年，論文標題，雑誌名，巻，同掲載頁の順）

4．表と図，及び説明　表と図は印刷版下として使用しますので原寸大で作成してください。印刷頁は2段組みで幅 14 cm，1段で幅 6.6 cm，縦 20.4 cm です。表，図ともに説明のためのスペースを含めて印刷範囲に収まるように作成してください。写真は光沢印画紙に鮮明に焼き付け，不要なスペースをカットしてレイアウトしてください。図や写真には倍率を示すスケールを入れ，必要に応じてレタリング用の矢印や文字などを貼り付けてください。表の罫線は横線のみを用いるようにしてください。表，図ともに，脱落防止のためにカバーをつけ，その下端に著者名，図の番号を記入してください。送付にあたっては，厚手の紙で保護してください。

Ⅳ．ワープロ入力の注意　本誌は DTP (Desk Top Publishing) によって作成されます。掲載が決定された後，最終原稿のファイルが保存されたフロッピーディスクを提出していただき，編集委員会ではこれを用いて印刷版下を作成します。したがって，あらかじめ，テキストレベルでデータ互換が保障された（テキストファイル形式でファイルを保存できる）パーソナルコンピューター上のワードプロセッサーまたはワープロ専用機で原稿を作成するようにしてください。互換性が不明な場合は編集委員会までお問い合わせください。編集作業を円滑に行うために，原稿作成にあっては次の点に注意して原稿を作成するようお願いします。1）学名や英単語の区切り以外にはスペースキーを使用しない。2）段落行頭や引用文献の字下げにはワープロのインデント機能を使用する。3）改行（リターンキー）の使用は段落の終わりだけに限定し，1行ごとの改行の挿入はしない（DTP 編集では，改行コードの有無で段落を判断します）。4）数字とアルファベットはすべて半角で，カタカナは全角で入力する。5）ギリシャ文字や独，仏，北欧文字を他の文字で代用しているときは，出力原稿中に赤鉛筆でその旨明記する（例：ü を u, μ を u, é を e, ß を B, φ を O で代用など）。6）数学記号などの特殊記号をワープロの外字で使用しているときは出力原稿中にその旨明記する。

Ⅴ．校正と別刷　校正は初校のみとします。DTP の最終割り付けが済み次第，レーザープリンター（300 dpi 程度の解像度）で出力したものを著者に送ります。ためし刷りですので写真等は最終印刷のイメージより劣ります。校正はレイアウトと提出したファイルからデータ変換が正しく行われているかを確認するにとどめ，図や写真の最終チェックは編集委員会におまかせください。校正は受領後3日以内に編集委員会あて返送してください。別刷は原著論文，短報，総説に限り50部を学会で負担しますが，それ以外は有料です。校正送付時に同封される別刷申込書に所定の事項を記入して返送してください。

PHYCOLOGICAL RESEARCH

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The entire manuscript, including references, should be typed double-spaced on one side only of the paper, with margins of at least 30 mm. All pages should be numbered consecutively in the top right-hand corner. The manuscript should be presented in the following order:

Title page: This should contain the title of the contribution, and the name(s) and address(es) of the author(s). The full postal address, telephone and facsimile numbers (and Internet E-Mail address if available) of the author who will receive correspondence and check the proofs should be included, as well as the present address of any author if different from that where the work was carried out. The main title should, where possible, contain the major key words used in the body of the manuscript; the title should include the class/division designation when a generic or specific name is used but should not contain authorities for scientific names. A short running title (less than 40 characters including spaces) should also be provided.

Abstract: All manuscripts must include a brief but informative Abstract intelligible without references to tha main text. It should not exceed 300 words and should describe the scope of the work and the main findings. The names of organisms used (including authorities) should be given, and new taxa that are described should be mentioned. References to the literature should not be included.

Key words: Key words (3–10) should be provided below the Abstract to assist with indexing of the article.

Introduction: This secton should include sufficient background information to set the work in context. The aims of the manuscript should be clearly stated. The introduction should not contain either findings or conlusions.

Materials and Methods: This should be concise but provide sufficient detail to allow the work to be repeated by others. The source of material should be given in detail, where possible. The strain or clone numbers of cultures used, and their availability, must be geven.

Results: Results should be presented in a logical sequence in the text, tables and figures; repetitive presentation of the same data in different forms should be avoided. The results should not contain material appropriate to the Discussion.

Discussion: This should consider the results in relation to any hypotheses advanced in the Introduction and place the study in the context of other work. Only in exceptional cases should the Results and Discussion sections be combined.

Acknowledgements: Financial and technical assistance may be acknowledged here. Anonymous reviewers should not be acknowledged. It is the author's reponsibility to obtain written permission to quote material that has appeared in another publication.

References: In the text, references should be made by giving the author's name with the year of publication in parentheses. If there are two authors use 'and' to link authors names in all cases. When reference is made to a work by three or more authors, the first name followed by *et al.* should be used on all occasions. If several manuscripts by the same author(s) and from the same year are cited, a, b, c, etc. should be put after the year of publication. Within parentheses groups of references should be cited in chronological order.

References should be listed in alphabetical order at the end of the manuscript in the following form:

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

South, G. R. & Whittick, A. 1987. *An Introduction to Phycology*. Blackwell Scientific Publications, Oxford, 350 pp.

Wynne, M. J. 1981. Phaeophyta: Morphology and classification *In* Lobban, C. S. & Wynne, M. J. (Eds) *The Biology of Seaweeds*. Blackwell Scientific Publications, Oxford, pp. 52–85.

Titles of journals should be abbreviated according to the *Serial sources for the Biosis Data Base*, available in most libraries.

Tables: Tables must be typed on separate sheets. They should be numbered consecutively in Arabic numerals with a descriptive title above the table. Column headings should be brief, with units of measurement in parentheses. Use superscript letters (not numbers) for footnotes and keep footnotes to a minimum. Vertical lines should not be used to separate columns. The approximate position of tables should be indicated in the margin of the manuscript.

Figures: Only scientifically necessary illustrations should be included. All illustrations (including photographs) are classified as figures and should be numbered consecutively. Photographs will **not** be reduced or enlarged so must be supplied so that they will fit within column width (82 mm) or the full text width (175 mm), and should be no more than 180 mm in length. Line figures shoud be drawn or grouped to fit these dimensions after reduction. A bar scale must be included for all photographs with the scale indicated above or beside the bar. Each figure should be labelled on the back indicating its number, name of author(s) and orientation of the figure.

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(7) Do no use the letter l (el) for the number 1 (one), or the letter O (upper case O) for the number 0 (zero).

(8) Page numbers should not be included in the manuscript file; the pages should be hand numbered.

(9) Tables are difficult to set from disk. Use only one Tab (not spaces) to separate each column.

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Abbreviations and units

SI units (metre, kilogram etc.) should be used wherever possible. Statistics and measurements should always be given in figures; that is, 10 mm, except where the number begins the sentence. When the number does *not* refer to a unit of measurement, it is spelt out, except where the number is greater than nine. Confusing mathematical notation, particularly subscripts and superscripts, should be avoided; negative exponents are acceptable as long as they are used consistently. Use only standard abbreviations. The word 'Figure' should be shortened to Fig. unless starting a sentence.

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The complete scientific name (genus, species and authority), and cultivar or strain where appropriate, should be given for every organism when first mentioned. The generic name may be abbreviated to an initial in subsequent references except where intervening references to other genera would cause confusion. Common names of organisms, if used, must be accompanied by the correst scientific name on first mention.

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Before sending off your manuscript, please check that: (1) three copies (one original and two copies) are enclosed; (2) the reference section is in proper format; (3) all references cited in the text are included in the reference section; (4) the pages are numbered; (5) the level of headings are indicated as A, B or C; and (6) that you have indicated where tables and figures are to be inserted.

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An offprint order form giving the cost of offprints will be sent to the corresponding author with the proofs. The order and payment should be returned with the corrected proofs within 3 days of receipt. Offprints are sent out within 3 weeks of publication, by surface mail.

藻類 Jpn. J. Phycol. 42: 451–453, December 10, 1994

舘脇正和：中村義輝先生のご逝去を悼む

Masakazu Tatewaki: Dr. Yositeru Nakamura (1910-1994) in memoriam

元北海道大学教授・理学部附属海藻研究施設長中村義輝先生は去る10月30日午後1時33分，札幌の入院先の病院で呼吸不全のため84才の生涯を閉じられた。先生は1910年（明治43年）8月28日福井県大野郡鹿谷村（現勝山市）のお生まれで，旧制松本高等学校を経て，1933年4月北海道帝国大学理学部植物学科に入学された。新設されて間もない理学部において，北大ならでは出来ない研究を望まれ，山田幸男教授のもとで海藻分類学の研究を選ばれた。1936年3月に卒業されたが，直ちに副手として研究生活に入られ，傍ら札幌市内の中学校や女学校の講師として教鞭を取られた。1942年12月に北海道帝国大学理学部附属海藻研究所（現海藻研究施設）に赴任され，助手，講師，助教授を歴任，施設長を併任し，1967年教授に昇任された。室蘭では32年間に亘って研究及び教育指導の生活を続けられ，1974年に定年退官された。

先生はこの間，海藻の分類，生態，発生，生活史と幅広く研究された。まず室蘭付近の海藻の分類から始められたが，一地域のものだけでは種の把握ができないことを痛感され，広く全国に採集旅行をされて日本産の紅藻ロドコルトン属，次いでイギス属の研究をされた。イギス属の研究には，当時としては斬新的なアイデァで，胞子及び発生形態に注目し，成体の形態とのつながりを明らかにし，日本産 *Ceramium* 属及び *Campylaephora* 属の分類学的研究を完成させて，理学博士の学位を得られた（1950）。

先生が室蘭に赴任された当時は第二次世界大戦の真最中であり，また戦後は厳しい食料難であったため，ご自分の分類学の研究だけでなく，有用海藻資源調査にも協力され，北海道胆振・日高地区を始め千島方面にまでカリウム・臭素資源を求めて調査をされた。また食用海藻の北海道沿岸浅海増殖の適地調査やコンブ類の増殖事業研究にも協力を惜しまず，増殖のための投石，コンクリートブロックの形状・投入時期等についても適切な指導をされ，現在の北海道におけるコンブの増・養殖の基礎づくりをされた。

先生は常に海に出て四季の海藻を観察しておられたが，その中で潮間帯岩礁域の海藻群落の遷移について，岩面剝離法を用いて帯状分布の成因解析を10年以上に亘って続けられた。この生態学的研究を通して一度破壊した自然環境は10年経っても元には戻らないと，早くから自然保護を主張されておられた。また後年，褐藻マツモ属とイソガワラ属について発生形態と体構造の類似性から，両者を一つにまとめてイソガワラ目(Ralfsiales)の新設を提唱されたこと（1972）や，カヤモノリ科植物の微小殻状の胞子体世代の発見（1965）も，先生の詳細な生態観察によるものである。

1964年に海藻研究施設長に就任されてからは，海藻類の室内培養設備の充実を図り，厳密に環境条件をコントロールできる培養庫を多数整備して，発生・生活史の研究に専心されたが，褐藻カヤモノリ科やウルシグサ科植物の生活史の研究はわが国の海藻学の研究水準を世界的にレベルアップさせた一つといえる。先生はこれらの研究を通して，二度に亘って文部省在外研究員として欧米諸国の大学や研究所を歴訪して，シンポジウム・セミナーに参加発表され，諸外国の研究者と交流を図られ数多くの友人を得られた。

先生は教授として，大学院生の研究指導に当たられたが，私を含めて市村（北大）・中原（京大）・斉藤（弘前大）・増田（北大）等の諸氏が直接ご指導頂いた世

代である。先生はまた，学部学生には海産植物生態学の講義指導を行い，富山大学・北海道教育大学等の他大学でも非常勤講師として藻類学の講義を担当されたが，ご自分の研究や経験を内容に多く盛り込んだ講義は，学生たちの海藻及び生態学への関心に対して大きなインパクトを与えた。

また，先生は学会活動において，日本藻類学会，国際藻類学会，日本植物学会等の役員を歴任されたが，特に日本藻類学会においてはその設立に参画され，学会誌「藻類」の編集幹事として編集兼発行者を発刊当初から12年間（1952–1964）担当され，学会長として2年間（1973–1974），学会の発展のために尽力された。この間1971年8月に札幌で開催された第7回国際海藻学会議では，組織委員並びに北海道地区準備委員長として会議準備運営の陣頭指揮をとられ，丁度ドルショックで通貨が混乱していた時であったが，各国参加者にトラブルがないように配慮して，大成功裡にこの会議を終了させた。また，長く室蘭市の文化面において幾多の貢献をされ，室蘭市社会功労者として表彰を受けるなど地域社会にも大きな足跡を残された。

先生は1974年4月1日をもって定年退職されたが，その後も数年間北海道教育大学等で非常勤講師として講義を続けられ，また㈱北海道栽培漁業振興公社顧問として，教育・研究の発展に尽力された。2年前までは学会の支部会やセミナーにもお元気な姿を見せておられ，昨年は奥様と郷里の福井にまで旅行されたと伺っておりました。今年の3月初旬体調をくずされて入院されておられたが，まさか急に亡くなられるとは思いませんでした。在りし日の先生の面影を偲びつつ，泉下のご平安とご冥福をお祈りします。

(051 室蘭市母恋南町1-13　北海道大学理学部附属海藻研究施設)

主要業績目録

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新刊紹介

Taxonomy of Economic Seaweeds. With reference to some Pacific species Volume IV. pp. 200. Isabella A. Abbott, Editor, A. Publication of the California Sea Grant College, University of California, 9500 Gilman Drive, La Jolla, CA 92093-0232. (US$ 10) 1994年2月発行

「有用海藻の分類学，第4巻，太平洋の種類について」と題される本書は，日本，アメリカ合衆国，中国，韓国，フィリピンなどの第1級の藻類分類学者が1984年以来，一堂に会して議論した上でまとめられた，最新知見満載の論文集の第4冊目である。

内容は大きく4つの節に分けられている。すなわち，ホンダワラ属，マクサ属，オゴノリ属，オキツノリ属である。

本書の特徴は，これまで種の同定がもっとも困難とされていた，これら4つのグループに焦点を当てたことであり，またそれらがいづれも有用海藻である点である。いくつかの新知見を拾ってみよう。

これまで種を見分けることがもっとも困難とされた，褐藻ホンダワラ亜属に関して，鰺坂，野呂，吉田等は，とくにアジア産の標本を対象に精力的に分類の研究を進めている。本書に載せられた論文を眺めていると，私にとっては曖昧としているこの亜属の種類が見えてくるようだ。今後の詳細なアジア産のモノグラフを期待したい。

学名に関して議論の多かったマクサ *Gelidium amansii* は Norris (1990) により *Gelidium elegans* とされたが，本書で Santelices は，現在のところ *G. amansii* のままがよいとした。しかしながらこの分類群にはいくつかのグループがあると思われ，今後の研究が必要であるとした。

オゴノリ属では，*Gracilaria dawsonii* Hoyle, *G. manilaensis* Yamamoto et Trono, *G. sullivanii* Yamamoto et Trono, *G. glomerata* Zhang and Xia, *G. yamamotoi* Zhang and Xia 5種類の新種記載がなされている。

オキツノリ属 Ahnfeltiopsis は，従来のオキツノリ属 (Gymnogongrus) サイミ属 (Ahnfeltia) のいくつかの種が移されて設立された属である (Silva et DeCew, 1992)。この新しい属に，オキツノリ (*Gymnogongrus flabelliformis*)，ハリガネ (*G. paradoxus*)，オオマタオキツノリ (*G. divaricatus*)，ホソバノヒラサイミ (*G. catenatus*)，サイミ (*Ahnefeltia concinna*)，ベサ (*A. gracilis*) など，ほとんどの日本産の種が新組み合わせされている。

本書の内容の一部を拾っただけでも，このような分類学上重要な知見があり，本書が有用海藻を扱う研究者にとり，分類上の基礎的資料になると思われる。本書の完成以降も，この研究グループによりさらに分類議論が重ねられており，シリーズ第5巻の準備も進められているようなので期待したい。

（東京水産大学，田中次郎）

Womersley, H. B. S.: The Marine Benthic Flora of Southern Australia. Rhodophyta Part IIIA Bangiophyceae & Florideophyceae (Acrochaetiales to Gigartinales). Australian Biological Resources Study, Canberta. $50.

第Ⅰ巻：海産種子植物，緑藻と車軸藻（1984），第Ⅱ巻：褐藻と黄金色藻（1987）に続くランドマークシリーズの3冊目である。508ページの本書は，南部オーストラリアに生育する紅藻のうちウシケノリ綱（チノリモ目，オオイシソウ目，ウシケノリ目）と，真正紅藻綱（アクロキシュウム目から，ウミゾウメン目，テングサ目，ベニマダラ目，スギノリ目までの）8目27科，97属234種について，検索表，異名，タイプ標本とその所在，標本とその所在，分布，主要な文献を付して述べられている。中でも検索表がしっかりしている。

Dr. K. S. Edyvane, Prof. M. D. Guiry, Dr. J. M. Huisman, Dr. G. T. Karft, Mr. J. A. Lewis と，Dr. W. J. Woelkerling の6人の共著者は，それぞれの専門分野を担当し，1新属と，新種，新組みあわせ35種を含んでいる。

オーストラリア大陸西部の Kalbarri から，南東部の Victoria の Mallacoota までのオーストラリア大陸の南部沿岸と，タスマニア島に生育する種を含んでいる。これら紅藻のほとんどは，正確な区別がむずかしいものばかりである。そこで，各種について，体構造，生殖器官と果胞子体，四分胞子体についての詳細な記述に加え正確な図と，鮮明な写真を加えていることはとてもありがたい。また，分類上の問題点をコメントしてくれていることはもっとありがたい。また，4頁14枚のカラー写真で生育地の状況と代表的な種類を紹介している。日本とオーストラリアの海藻には共通種

が多いと言われる。本書から，わが国との共通属と共通種を探したところ，共通属47，共通種30があった。写真や図から，わが国に生育する種類とよく似たものがあることから今後の比較研究が楽しみである。

オーストラリア $50 で，ABRS (Flora), GPO Box 636 Canbera ACT 2601 Australia に注文する。The Botaical Bookshop, Australian National Botanic Gardens, Clunies Ress St, Canbera. (Postal Address: PO Box 351, Jamison Center ACT 2614)，あるいは North Lodge Shop, The Botanic Gardens of Adelaide and State Herbarium, North Terrace, Adelaide SA 5000. でも取り扱っている。

続刊の IIIB はオゴノリ目，カギノリ目，サンゴモ目，マサゴシバリ目，と，イギス科（イギス目）について，IIIC はイギス目の残りの3科と，オーストラリア大陸南部沿岸各地と，他の国との関係について海藻地理が論じられて完結する予定とあり，多いに期待される。（東邦大・理・生　吉崎　誠）

ニュース

藻類学　春のワークショップのお知らせ

藻類を対象として研究を行っている大学院学生を対象に，藻類学の研究技術のレベルアップをめざして藻類学春の学校（ワークショップ）を開きます。臨海実験所での合宿期間中に講師による講義・実習を行うほか，参加者各自の研究内容の紹介と討論を行い，交流をはかりたいと思います。多数の志ある大学院学生の参加をお待ちしています。ただし教官のオブザーバー・飛び入り講師としての参加も歓迎します。

期　日：平成7年3月31日–4月2日（臨海実験所2泊3日）
場　所：神戸大学理学部付属岩屋臨海実験所（兵庫県津名郡岩屋町岩屋）
　　神戸大学理学部生物学科（最終日）（兵庫県神戸市灘区六甲台町1–1）
講　師：片岡博尚（東北大学遺伝生態研）
　　井上　勲（筑波大学生物科学）
　　本村泰三（北海道大学理学部付属海藻研究施設）
　　川井浩史（神戸大学理学部生物）
内　容：光生物学実験の基礎（講義と実習）
　　藻類の多様性と系統（講義）
　　蛍光染色・測光と蛍光抗体法（実習）
　　UV レーザー走査顕微鏡（実習）
　　研究紹介（参加者全員）と討論
定　員：約10名
参加費：臨海実験所宿泊費，食費実費（約8,000円）

参加希望者多数の場合には参加人数を調整させていただくことがあります。詳細については申し込みされた方に直接ご連絡します。

参加申し込み・問い合わせは下記までご連絡ください。

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藻類絵はがきの会

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藻類絵はがきの会という組織も場所も会則も持たない煙のような会があります。会長はもとより，誰が会員なのかそれもよく解りません。自分が会員だと自覚している人も居ないようです。それでも藻類絵はがきの会は，藻類の普及・啓蒙と学会誌充実のための資金援助という2つの目的を持って藻類の絵はがきを作ってきました。そして，最近では藻類学会以外の多分野のかたがた，さらには海外からも，絵はがきにみられる藻類の造形美と優れた撮影技術に関心が寄せられ高い評価を受けています。一体，藻類絵はがきの会とは何なのかということを学会会員の皆さんにお伝えしてご意見を伺う時期にきたように思います。

数年前に，誰からともなく藻類の絵はがきを作って，学会財政を助けるとともに，もっと世の中の人に藻類を知ってもらいたいという話題が出ました。その後，会員数人がそれぞれ写真を持ち寄ってその可能性を検討しました。しかしそれを引き受けてくれそうな出版社も博物館のような組織も見つかりませんでした。そのままその話は立消えたかのような観もありましたが，この度の学会誌改革による厳しい学会財政を少しでも援助したいという意図から，石川が発起人となって，出版社等に頼らない独自の絵はがきの製作に踏み切りました。賛否両論がありました。幸い第一回は8人の会員（川嶋，横浜，吉崎，新井，三浦，喜田，谷口，当真の諸氏）が無料でスライドを提供してくださり，また20万円の資本金を出してくださった会員もあり大変助かりました。海藻シリーズとして20枚の絵はがきができました。昨年（1993）はタイミングよく国際植物学会が横浜で開かれましたので，その場で数十万円分を頒布することができました。そのほか，つくばフォーラム，秋期シンポジウム，珪藻学会，生物教育学会などで，その趣旨を明示して販売しました。また，会員には郵便で呼びかけましたところ100名近くの方からご協力をいただきました。収益金は全額，学会誌の資金にあてるとともに，絵はがきの目的は藻類の啓蒙にあるのですから，個人の販売と間違われては困ります。そこで“藻類絵はがきの会”という名称が必要になりました。また，貴重な写真を無料で提供してくださった方々にも収益金の使途が明瞭であるように，世話役（石川）とは別に会計管理を片山氏にお願いしました。

海藻シリーズはカラー写真なので印刷経費が70万円ほどかかり，経費を差し引いて，学会誌充実のための資金は30万円余りに終わってしまいました。今年度（1994）は経費の少ない白黒写真を目指し，走査型電子顕微鏡写真に絞りました。高度な技術によって現わされたミクロの造形美は多くの人々を驚嘆させています。渦鞭毛藻（堀口），円石藻（井上），珪藻（南雲・出井・小林・真山・長田）の“生命の形”です。藻類がこのように美しいものであることは藻類の研究者でなければ表現することはできません。藻類の絵はがきから感じることは，藻類研究者は，世の中の人々がまだ全く見たことのない美しい世界を知っており，それは藻類学会の秘めた財産だということです。藻類をもっと力強く世の中にアピールすることは，文化における貢献であるとともに，藻類学会を実質ともにもっと豊かにするものであると思います。そのような観点から，絵はがきのみならずいろいろな面で，藻類学会の眠っている財産を，会員自身のために，また世の中のために，会員相互の協力によって呼び覚ましていきたいものだと思います。

この“藻類絵はがきの会”の今後を考えるためにご意見をお寄せ下さい。（東京学芸大学　石川依久子）

1994年度シリーズの頒布価格は微細藻類（A-H）・珪藻（I-P）各8枚組500円，一枚80円です。また，海藻シリーズ（カラー）（各5枚組300円）も残部がありますので，あわせてご協力いただけると幸いです。

頒布方法：1. 葉書か電話かFAXで下記に希望部数をお知らせください。
郵便振替用紙同封で絵はがきをお送りしますので後日送金してください。

2. 郵便振替で下記に送金し，振替用紙の裏に希望部数をお書きください。送料を後に請求させていただくこともあります。

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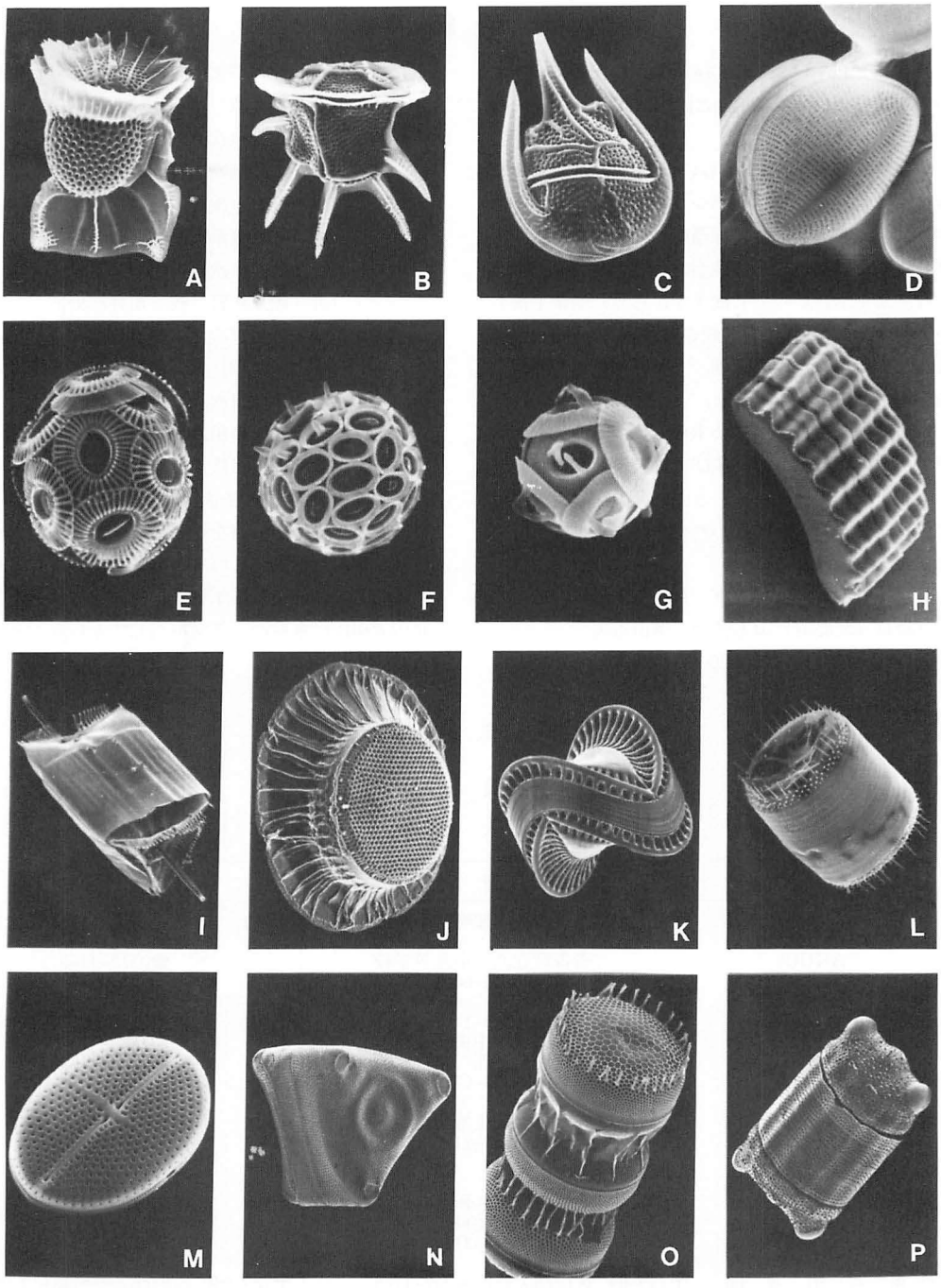
Tel. 0423-25-2111　内線 2665（石川）・2674（片山）　FAX. 0423-24-9832
郵便振替口座番号 00140-1-569892　　加入者名　藻類絵葉書の会



Algal picture post card collection 1994
Scanning electron micrographs of microalgae

—学 会 録 事—

1．英文誌“Phycological Research”の出版について1994年6月1日付で本学会と出版社Blackwell Scienceの間で契約が結ばれた。

2．1994年9月19日13:30から17:30まで，北海道大学理学部において秋季シンポジウムが開催され，(1)鈴木 稔氏（北大大学院地球環境科学研究科）の「海藻の生態相関物質の多様性」および(2)中村英士氏(北大理学部化学科）の「有機化学から見た渦鞭毛藻」の2題の講演があり，引き続き質疑応答が行われた。また，シンポジウム終了後，クラーク会館で懇親会が開催され，盛会であった。

3．1994年10月11日，本学会本部（東京水産大）において1995・1996年度会長並びに評議員選挙の開票が片山舒康氏（東京学芸大）と山口征矢氏（東京水産大）の立会いのもとに行われた。開票結果は次のとおりである。(敬称略)

会 長 吉田忠生（次点 石川依久子）

評議員（北海道）山本弘敏，増田道夫
（次点 市村輝宜）

（東 北）三本菅善昭（次点 谷口和也）

（関 東）原 慶明，渡辺 信，野崎久義
（次点 吉崎 誠）

（東 京）岡崎恵視，田中次郎
（次点 能登谷正浩）

（中 部）横浜康継，渡辺 信
（次点 梅崎 勇）

（近 畿）熊野 茂，川井浩史
（次点 鮫坂哲朗）

（中国・四国）中野武登，奥田一雄
（次点 鬼頭 鈞）

（九 州）奥田武男，藤田雄二
（次点 四井敏雄）

4．1994年3月30日開催された総会の決定に基づいて，これまで学会事務を委託してきた中西印刷㈱と協議を重ねた結果，この事務委託を1994年12月31日で解約し，1995年1月1日からは国立科学博物館の北山太樹氏に事務の一部を担当してもらうことになった。

—学 会 録 事—

—会 員 移 動—

新 入 会 員

住 所 変 更

退 会 者

Acknowledgements to reviewers for Vol. 42

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Sung-Min Boo
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日本学術会議だより　№34

第16期最初の総会開催される

平成６年８月　日本学術会議広報委員会

日本学術会議の第16期が平成６年７月22日(金)からスタートし，７月25日から７月27日までの３日間，第119回総会が開催されました。今回の日本学術会議だよりでは，総会の概要等についてお知らせします。

日本学術会議第119回総会報告

平成６年７月22日から，第16期が開始されましたが，この第16期会員による最初の総会である，日本学術会議第119回総会が，７月25日から27日までの３日間にわたって開催されました。

初日（25日）の午前は，辞令交付式が，総理大臣官邸ホールで行われ，210名の会員のうち海外出張中等の22名を除く188名の会員が出席しました。式は，村山内閣総理大臣，五十嵐内閣官房長官，石原官房副長官，文田総理府次長等の出席を得て行われ，第１部から第７部までの全会員の名前が読み上げられた後，会員を代表して最年長である中田易直第１部会員が，村山内閣総理大臣から辞令を受け取りました。この後，村山内閣総理大臣が「会員の皆様には独創性豊かな学術研究の発展等のため，総合的観点に立って学術研究に係わる諸問題の解決に御尽力いただきたい」とあいさつし，これに応えて，中田易直第１部会員が「微力ながら全力を尽くし，重要な職責を全うし，国民の期待に応えたい」とあいさつしました。午後は，日本学術会議講堂において，総会が開催され，会長，副会長（２名）の互選が行われました。その結果，会長には，伊藤正男第７部会員が，人文科学部門の副会長には，利谷信義第２部会員が，自然科学部門の副会長には，西島安則第４部会員が，それぞれ選出され，伊藤会長及び利谷副会長（西島副会長は海外出張中）からそれぞれ就任のあいさつを行いました。続いて，各部会が開かれ，各部の部長，副部長及び幹事の選出等が行われました。（第16期の役員については，別掲を参照）

２日目（26日）は，午前10時から総会が開催され，近藤前会長が海外出張中のため代理として川田前副会長が第15期の総括的な活動報告を行い，続いて，会員推薦管理会報告として，久保亮五委員長の代理として高岡事務総長が，第16期会員の推薦を決定するまでの経過報告を行いました。引き続き，事務総長から第16期会員対して実施した「第16期の日本学術会議が取り組むべき課題について」のアンケートの結果について説明がありました。総会終了後は，各運営審議会附置委員会，各部会，各常置委員会等が開催されました。また，夕方には，総理大臣官邸ホールにおいて，村山内閣総理大臣主催の日本学術会議第16期会員との懇談会が初めて開催されました。懇談会は，村山内閣総理大臣のあいさつで開会し，五十嵐内閣官房長官の発声による乾杯，伊藤会長の答礼のあいさつの後，懇談に入りました。来賓として，与謝野文部大臣，田中科学技術庁長官，吉田農林水産政務次官，藤田日本学士院院長ほか大勢の方が出席され，あふれんばかりの人々で歓談が続き盛会となりました。

３日目（27日）は，午前10時から総会が開会され，会長から「第16期活動計画の作成について」の申合せ案について提案があり，原案どおり可決されました。続いて，第16期の活動計画についての自由討議が行われ，各部長から各部会での意見が披露されるなど活発な発言がありました。総会終了後は，地区会議合同会議，各運営審議会附置委員会，各常置委員会等が行われました。その後，運営審議会が開催され，第16期の活動計画の素案作成のために，運営審議会構成員の中から起草委員を選出し，審議に入りました。

第16期日本学術会議役員

会　長　　伊藤　正男（第７部・生理科学）
　　理化学研究所国際
　　フロンティア研究システム長
副会長　　利谷　信義（第２部・基礎法学）
　　お茶の水女子大学（生活科学）教授
副会長　　西島　安則（第４部・化学）
　　日本ユネスコ国内委員会会長

〔各部役員〕

第１部	部　長	中田　易直	（歴史学）
	副部長	戸川　芳郎	（哲学）
	幹　事	堀尾　輝久	（教育学）
	幹　事	森岡　清美	（社会学）
第２部	部　長	中山　和久	（社会法学）
	副部長	山口　　定	（政治学）
	幹　事	兼子　　仁	（公法学）
	幹　事	山中永之佑	（基礎法学）
第３部	部　長	柏崎利之輔	（経済政策）
	副部長	岡本　康雄	（経営学）
	幹　事	河野　博忠	（経済政策）
	幹　事	二神　恭一	（経営学）
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	副部長	竹内　郁夫	（生物科学）
	幹　事	井口　洋夫	（化学）
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	幹　事	松尾　　稔	（土木工学）
第６部	部　長	志村　博康	（農業工学）
	副部長	北村貞太郎	（農業工学）
	幹　事	島田　淳子	（家政学）
	幹　事	平田　　熙	（農芸化学）
第７部	部　長	渥美　和彦	（内科系科学）
	副部長	金岡　祐一	（薬科学）
	幹　事	入江　　實	（内科系科学）
	幹　事	細田　榮弘	（病理科学）

〔常置委員会〕

第１常置	委員長	利谷　信義	（第２部）
第２常置	委員長	中塚　　明	（第１部）
第３常置	委員長	村上　英治	（第１部）
第４常置	委員長	増本　　健	（第５部）
第５常置	委員長	山中永之佑	（第２部）
第６常置	委員長	鹿取　廣人	（第１部）
第７常置	委員長	井口　洋夫	（第４部）

（注）カッコ内は，所属部・専門

第16期日本学術会議会員の概要について

この度任命された210人の第16期日本学術会議会員の概要を以下に紹介します。（カッコ内は第15期）

1　性別　　男性209人　　女性１人

2　年齢別　45～49歳　１人　　50～54歳　３人
　　55～59歳　26人　　60～64歳　93人
　　65～69歳　72人　　70～74歳　12人
　　75～79歳　１人
　　最年長　　75　歳（74　歳）
　　最年少　　47　歳（54　歳）
　　平均年齢　63.6歳（63.3歳）

3　勤務機関及び職名別

(1) 大学関係	国立大学	59人	
	公立大学	2人	
	私立大学	111人	
	公私立短期大学	2人	
	計	174人	
(2) 国立私立試験研究機関・病院等		9人	
(3) その他	法人・団体関係	5人	
	民間会社	6人	
	無職	14人	
	その他	2人	
	計	27人	

4　その他の分類

(1) 前・元・新別	前会員	82人	
	元会員	3人	
	新会員	125人	
(2) 地域別（居住地）			
	北海道	3人	（5人）
	東　北	9人	（8人）
	関　東	136人	（133人）
	中　部	14人	（19人）
	近　畿	41人	（34人）
	中国・四国	3人	（5人）
	九州・沖縄	4人	（6人）

（注）詳細については，日本学術会議月報７月号を参照

「日本学術会議だより」について御意見，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(3403)6291

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Contents

No. 4 (10 December)

AUTHOR INDEX

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本書の構成は，図を左頁に対面する頁に和英の解説文をつけて，２ページを１単位として組み立ててある。執筆者によるオリジナルの線図は，藻類のライフサイクルを一見して理解させそれに簡明な解説を付す。さらに教育的配慮から多くの種について分布図を，そして各巻ごとに同義語を，各巻の巻末に学名総索引・和名索引を収録して読者が使いやすいよう工夫した。藻類を専門とする研究者や中学・高校の生物の先生，水に関連する研究所や企業の方々を初め，藻類に興味をもつ人々にとって，長い間出版が望まれていた本である。

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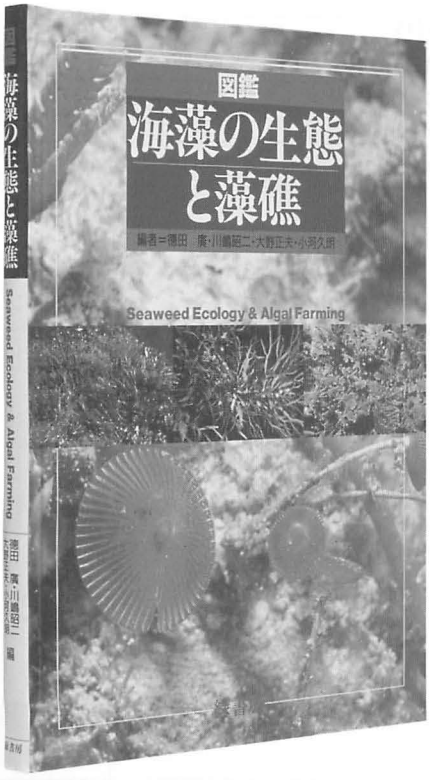

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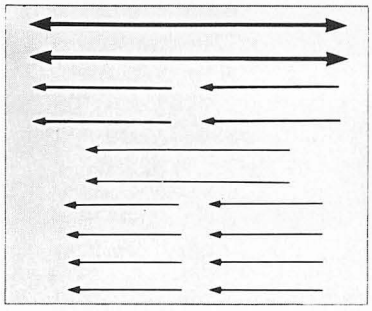

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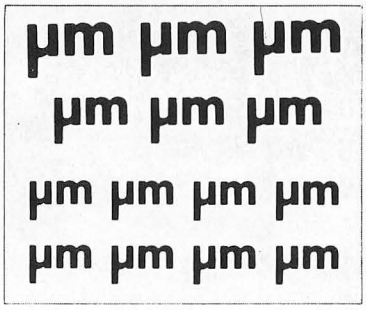

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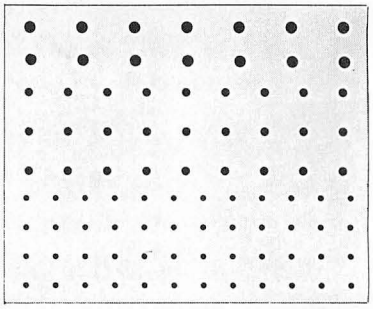

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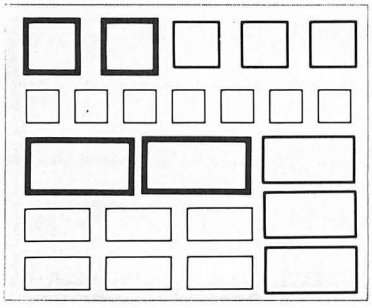

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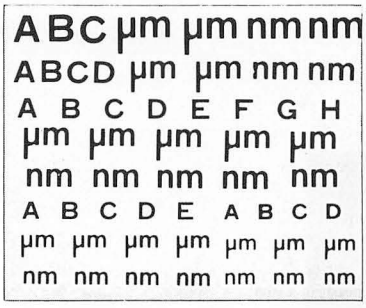

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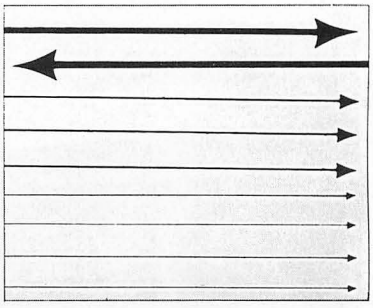

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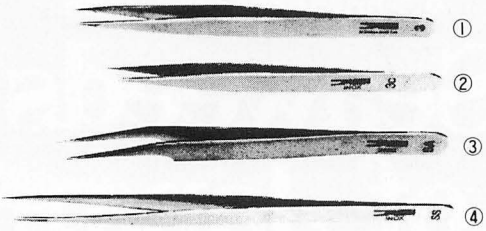

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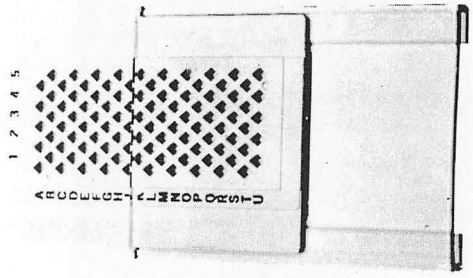

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