ISSN 0038-1578

Vol. 40 No. 2 20 June 1992

The Japanese Journal of PHYCOLOGY

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THE JAPANESE SOCIETY OF PHYCOLOGY

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日本藻類学会秋季シンポジウムのお知らせ

秋季シンポジウムおよび懇親会を，日本植物学会第57回大会（奈良，帝塚山短期大学）の前日に下記のように開催します。

日　　時：1992年９月16日（水）
15:30～17:30　シンポジウム
18:30～20:00　懇親会

シンポジウム・懇親会会場：帝塚山短期大学（〒630 奈良市学園前３）
（近鉄奈良線学園前駅南口すぐ前，会場となる教室は当日植物学会申込場付近に掲示します）

演題・演者：藻類の遺伝学　（１）微細藻類　　神戸大学名誉教授　坪　　由宏
（２）大型藻類　　青森大学教授　　三浦　昭雄

座　　長：榎本　幸人（神戸大学）

懇 親 会 費：3000円
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懇親会費送付先：
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日本藻類学会秋季シンポジウム係（郵便振替口座　京都 9-76559）

申 込 締 切：1992年８月31日

世　話　人：清水　　晃
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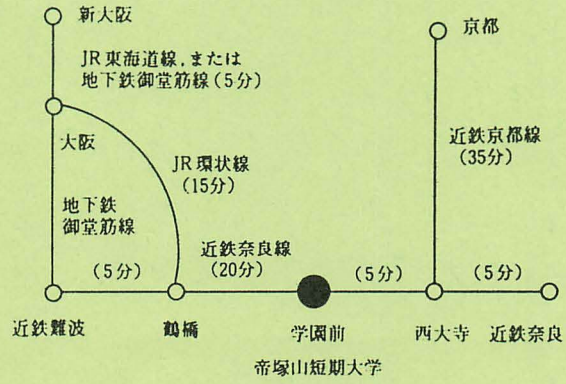

Jpn. J. Phycol. (Sôrui) 40: 111–119, June 20, 1992

An Account of *Delesseria aemula* sp. nov. (Delesseriaceae, Rhodophyta) from New South Wales, Australia

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Millar, A. J. K. and Wynne, M. J. 1992. An Account of *Delesseria aemula* sp. nov. (Delesseriaceae, Rhodophyta) from New South Wales, Australia. Jpn. J. Phycol. 40: 111–119.

Delesseria aemula sp. nov. is described from sublittoral habitats on the shores of New South Wales, eastern Australia. Distinctive characters of this new species include its habit, in which spathulate to lanceolate blades radiate out from a centrally placed rhizoidal holdfast; its small size at maturity, blades reaching heights of only 10 mm and widths of 2 mm; its spermatangial sori, which form discrete islands separated by sterile veins made up of secondary and tertiary cell rows; and its branching, in which the majority arise from a centrally placed rhizoidal holdfast. Less frequently branches arise from the midrib or from the margins as outgrowths of secondary initials. In the field, plants are indistinguishable from the diminutive alga *Apoglossum unguiculescens* Millar which shares the same habitat, habit, blade size and shape. Characters serving to separate this pair of species are the following: 1) lateral pericentral cells transversely dividing in *D. aemula* but remaining undivided in *A. unguiculescens*; 2) cells of the sterile-cell groups dividing in *D. aemula* but remaining undivided in *A. unguiculescens*; and 3) differences in the arrangements of the spermatangial sori. With the discovery of *D. aemula*, Australia now hosts three genera of the Delesseria group (*viz.*, *Delesseria*, *Apoglossum* and *Patulophycus*).

Key Index Words: Apoglossum—*Australia*—Delesseria—D. aemula—*Delesseriaceae*—*New South Wales*.

Australia is host to a large variety of genera belonging to the family Delesseriaceae (Kraft and Woelkerling 1990, Millar 1990). Of the 38 or so genera represented, some 15 are endemic, although these are known mostly from the southern Australian coast. New South Wales has 16 genera of which two (*Patulophycus* and *Valeriemaya*) are endemic (Millar and Wynne 1992a, 1992b). Although several species of *Delesseria* are known from New Zealand (Adams 1972, Adams *et al.* 1974) and the subantarctic islands of both New Zealand and Australia (Hay *et al.* 1985, Ricker 1987), current floristic treatments (Huisman and Walker 1990, Millar 1990, Price and Scott 1992) have not recognized this genus as occurring on Australian shores. Up to now five species have represented the Delesseria group in Australia: *Apoglossum spathulatum* (Sonder) Womersley and Shepley, *A. tasmanicum* (F. Mueller ex Harvey) J. Agardh, *A. unguiculescens* Millar, *Patulophycus eclipes* Millar & Wynne, and the poorly known *Delesseria lacepedeana* Reinbold. *Apoglossum unguiculescens* was recently described as a common epiphyte along most of the New South Wales coastline (Millar 1990), but closer examination reveals that some of these records actually represent an undescribed species of the closely related genus *Delesseria*, which we describe here as *D. aemula*.

Materials and Methods

Collections using SCUBA were preserved in 4% formalin/seawater. Slide material, stained in a mixture of approximately 1 ml aniline blue/7 ml acetic acid/50 ml Karo syrup/50 ml millepore-filtered, distilled water, is on file at the National Herbarium of New South Wales (NSW) and the University of Michigan (MICH). The following speci-

mens of *Apoglossum unguiculescens* were examined: Coffs Harbour, *A. Millar and J. Huisman*, 8. vii. 1981, MELU AM 1093=holotype; *A. Millar and R. Millar*, 22. ii. 1989, NSW-A006379; Macauleys Reef, between Muttonbird Island and Split Solitary Island, *A. Millar, A. Wright and R. Medhurst*, 22. viii. 1991, NSW-A010531; Twofold Bay, Honeysuckle Point, *A. Millar and P. Richards*, 7. vii. 1991, NSW-A010532. Whole-plant photographs were taken on a Wild Photomakroscope M400, and photomicrographs on a Wild Leitz MPS51 Ortholux II system. Kodak Techpan Film was used following the methods of Millar (1990).

Observations

Delesseria aemula Millar et Wynne sp. nov.

Thalli 10 mm altos, laminae pro parte maxima ovatae ad spathulatas vel lanceolatas ad 2 mm latas; laminae alteruter singulatim vel turmas radiatim ad decem ab centralibus fasciculatis rhizoideorum exorientes; costa prominens, vulgo opacam; alae nitentes, paginae reflectivae; rami ab seriebus endogenis primis cellularum exorientes, gemmis adventitiis in costas corticatas vel initiis serierum secundariarum cellularum margines; venae microscopicae praesentes sed indistincate in axibus vegetativis; spermatangia in soris insulas discretas facientia, nervis microscopicis sterilibus secundariarum et tertiarum cellularum serierum separata, aream integram paginarum ambo laminarum praeter costam corticatam tegentia; cystocarpia hemispherica vel urceolata cum colla prominentia lata; pagina pericarporum laevis; tetrasporangia ad 52 μm diametro, in stratis multis in soris longis tenuibus continuis ad 3 mm longo et 300 μm lato portata, in ambo lateribus costarum.

Thalli to 10 mm high, of simple, mostly unbranched ovate to spathulate or lanceolate blades to 10 mm in length and 2 mm in width; blades arising either singly or in radiating groups of up to ten from centrally placed pad-like aggregations of rhizoids; midrib prominent, generally opaque; wings shiny, surface reflective; branches arise endogenously from primary cell rows, adventitiously from corticated midribs or from margins as outgrowths of secondary cell row initials; microscopic veins present, not distinct in vegetative axes; spermatangia in sori forming discrete islands, separated by sterile microscopic nerves made up of secondary and tertiary cell rows, covering entire surface (except corticated midrib) of both blade sides; cystocarps either hemispherical or urceolate with prominent, broad necks; pericarp surface smooth; tetrasporangia to 52 μm diameter, borne in multiple layers in long, slender, uninterrupted sori to 3 mm long and 300 μm wide, flanking both sides of midribs.

Holotype: NSW-A010529, just east of Honeysuckle Point, Twofold Bay, Eden, New South Wales, Australia (37°05′55″S.; 149°56′10″E.), 7. vii. 1991, *A. J. K. Millar and P. G. Richards*.

Isotypes: AD, GALW, MEL, MICH, US, WELT.

Etymology: L. *aemulus*, vying with, rivalling in, alluding to its vying with *Apoglossum unguiculescens* both in habit and habitat.

Distribution: From Jervis Bay to Twofold Bay, New South Wales, Australia.

Specimens examined: **Jervis Bay**; Plantation Point, on crustose coralline in 3 m depth, 4. vi. 1990, *A. Millar and P. Richards*, NSW-A010530; 'The Docks', on crustose coralline in 22 m depth, 9.x.1989, *A. Millar and P. Richards*, NSW-A010533.

Twofold Bay, Honeysuckle Point, 6-20 m deep growing in turf algal community, 7. vii. 1991, *A. Millar and P. Richards*.

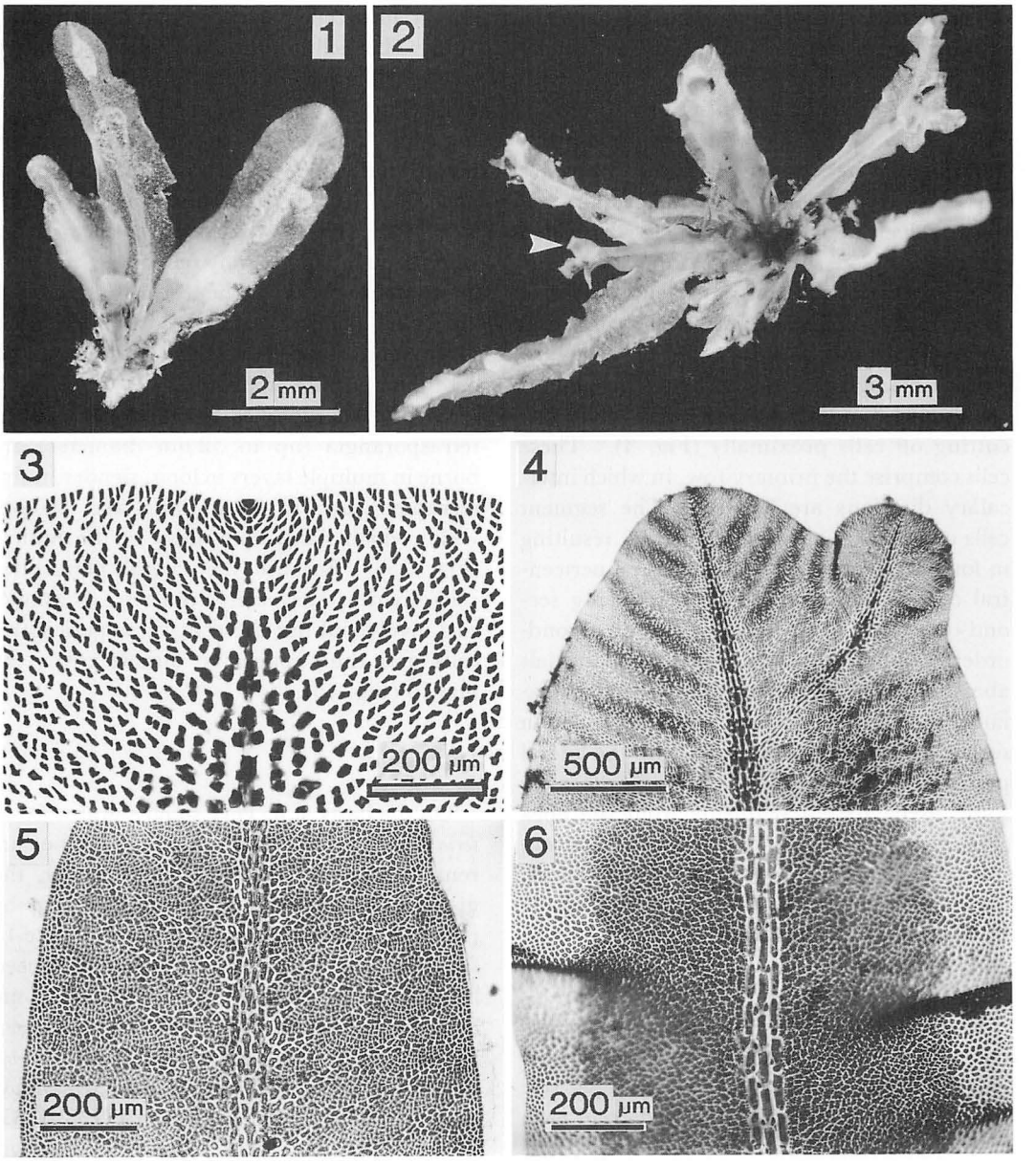
Habitat and Seasonality

Plants grow on a range of substrata such as other algae (especially crustose and articulat-

ed corallines), bryozoans, hydrozoans, sponges, and rocks in depths from 3-22 m. Collections thus far have been during June and July (austral winter) and all reproductive stages occur simultaneously on the same substratum.

Vegetative structure

Simple, mostly unbranched ovate to spathulate (Fig. 1) or lanceolate (Fig. 2) blades (reaching lengths of 8-10 mm and widths of 2 mm) arise either singly or in radiating groups of up to ten from a centrally placed



Figs. 1–5. *Delesseria aemula* sp. nov. Fig. 6. *Apoglossum unguiculescens*. Fig. 1. Habit of tetrasporophyte. Fig. 2. Habit of female gametophyte. Note cystocarp (arrow). Fig. 3. Detail of blade apex. Fig. 4. Male blade showing marginal branch where second order initial is converted into primary initial. Fig. 5. Spermatangial blade of showing islands of spermatangial sori separated by sterile veins. Fig. 6. Spermatangial blade of showing confluent spermatangial sori forming cushions on either side of the midrib. Note undivided lateral pericentral cells.

disk-like holdfast. Blades have a prominent midrib (Figs. 1, 2), the cortication of the central axial row beginning very close to the apex of the blade and becoming thick and obvious in proximal parts. The midrib is generally opaque and the wings have a shiny, reflective surface. Often the monostromatic wings erode or are lost altogether leaving only the cylindrical midrib behind which eventually becomes a substantial branched stipe with new blades arising adventitiously (Fig. 2). Microscopic nerves or veins are present but not distinct in vegetative axes. Branches may arise endogenously from the primary cell row, adventitiously from the corticated midrib and, on several occasions, from the margins (Fig. 4) as continued outgrowths of the secondary cell row initials being converted into primary initials.

Each blade is terminated by a single apical cell, which undergoes transverse divisions, cutting off cells proximally (Fig. 3). These cells comprise the primary row, in which intercalary divisions are lacking. The segment cells undergo longitudinal divisions, resulting in four pericentral cells. The lateral pericentral cells continue to divide, producing second-order cell rows. Cells of these second-order rows in turn cut off third-order initials abaxially. Fourth-order rows are cut off adaxially (Fig. 7). Intercalary divisions occur in second and higher order rows, and the lateral pericentral cells generally divide transversely some seven to ten segments from the apex (Fig. 7). In rare instances, the lateral pericentral cells do not divide, but in such instances, they are surrounded proximally and distally by divided pericentral cells (Fig. 8).

Reproductive structures

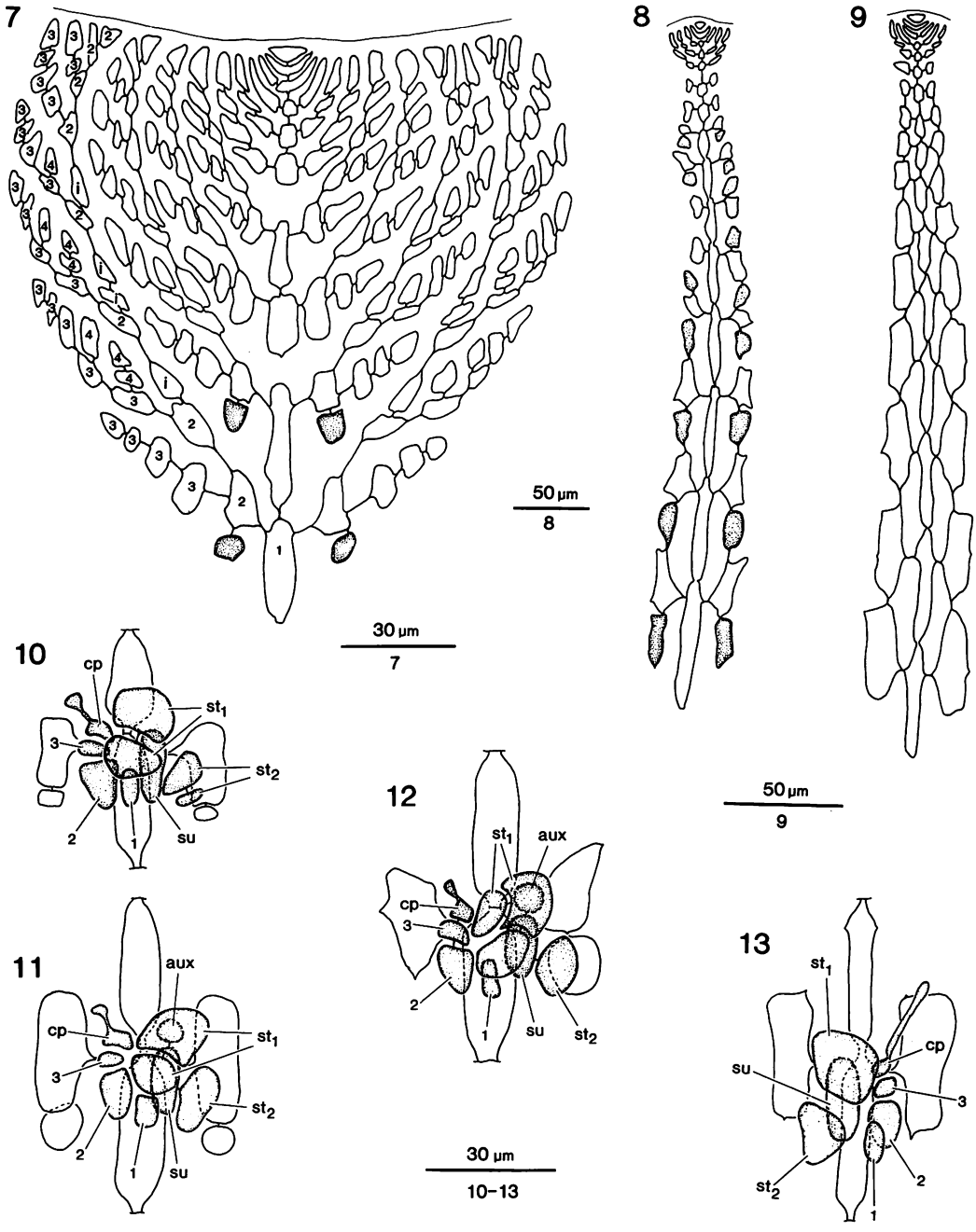
Male, female, and tetrasporic plants are isomorphic, and the gametophytes are unisexual. In male plants the spermatangial sori form discrete bands radiating out from each side of the midrib in chevron-like patterns (Fig. 5). These islands of sori are separated by sterile microscopic nerves made up of second- and third-order cell rows (Figs. 5, 17). At maturity, most of the blade surface (except the corticated midrib) bears spermatangial sori.

Female plants bear procarps on the primary cell row, the transverse pericentral cells acting as supporting cells of the carpogonial branches. The supporting cell cuts off two sterile-cell groups (one proximally and one distally) and a four-celled carpogonial branch (Fig. 10). The cell of the first, distally placed sterile-cell group divides once (Fig. 11) or twice (Fig. 12) after it is cut off by the supporting cell. The cell of the second, proximally placed sterile-cell group, however, may divide once (Fig. 10) or remain undivided (Figs. 11, 12). One (Fig. 14) to three cystocarps develop sequentially on any one blade, often on alternate surfaces. The ostiolate pericarps are either hemispherical or urceolate with a prominent, broad neck (Fig. 2), but in either case their surface is smooth.

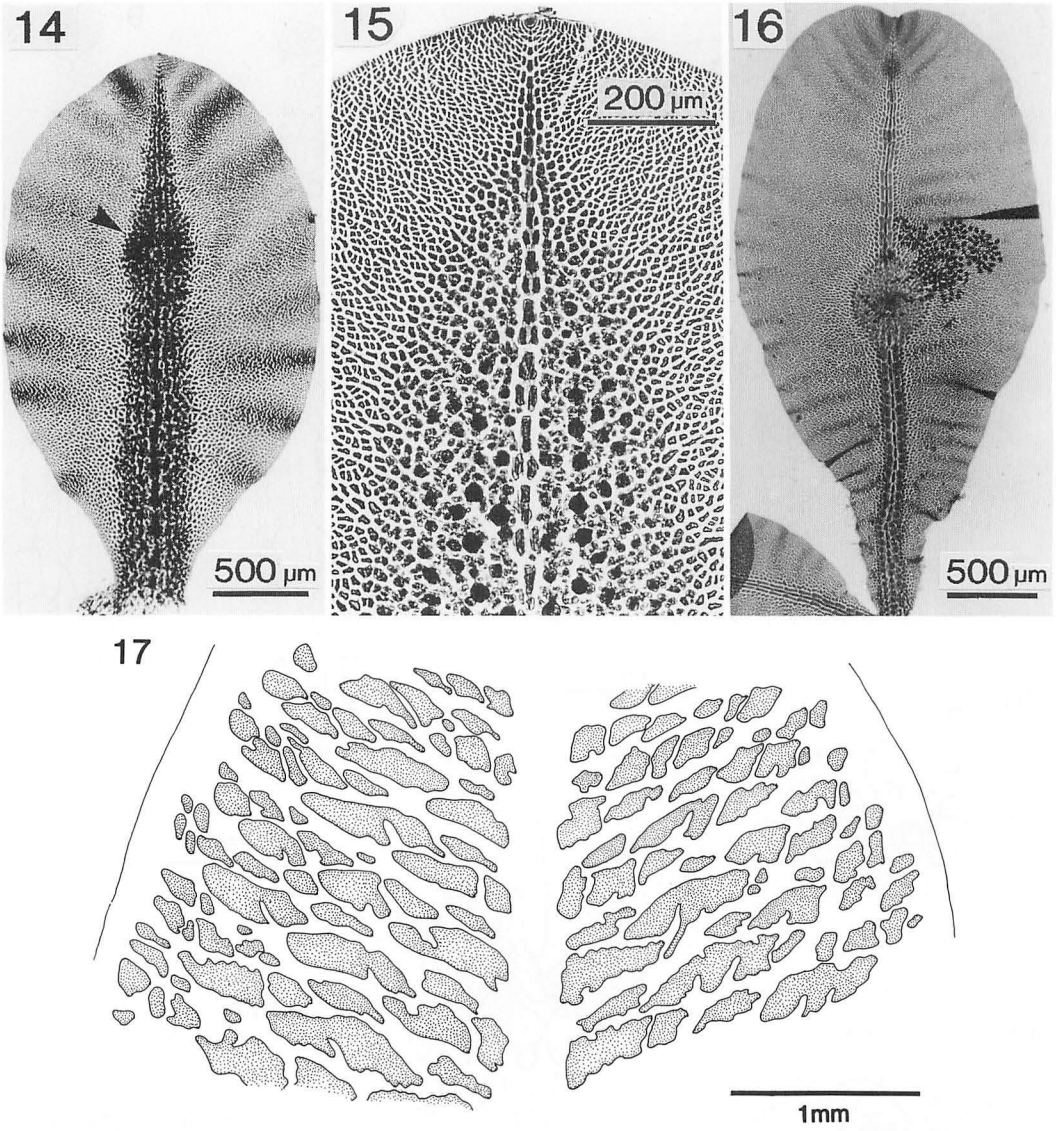
On the sporophytes tetrahedrally divided tetrasporangia (up to 52 μm diameter) are borne in multiple layers in long, slender, uninterrupted sori (to 3 mm long and 300 μm wide) which flank both sides of the midrib (Fig. 15). Because the lateral pericentral cells divide transversely, the tetrasporangial sori involve all but the transverse pericentral cells and thus appear to almost cover the midrib (Fig. 15).

Discussion

On the basis of its very small stature, *Delesseria aemula* is distinguishable from all the currently recognized species in the genus, the great majority of its species tending to be robust, relatively large-sized algae. Some 15 species based on Australian types have been assigned to *Delesseria* in the past. All but one of these, however, have subsequently been transferred to other genera, including *Branchioglossum, Hypoglossum, Apoglossum, Heterodoxia*, and *Crassilingua* (Agardh 1872, 1885, 1894, 1898, Kylin 1924, May 1965, Womersley and Shepley 1982). *Delesseria lacepedeana* Reinbold, described from southern Australia, remains an ill-known taxon. Reinbold (1898) remarked that his alga in its habit



Figs. 7–8, 10–12. *Delesseria aemula* sp. nov. Fig. 9, 13. *Apoglossum unguiculescens*. Fig. 7. Blade apex: 1, cells of first-order row; 2, cells of second-order row; 3, cells of third-order row; 4, cells of fourth-order row; i, cells resulting from intercalary divisions; stippled cells are those resulting from transverse division of lateral pericentral cells. Fig. 8. Dissected view of midrib showing cells resulting from transverse divisions of lateral pericentral cells (stippled). Note that not all lateral pericentral cells have divided. Fig. 9. Dissected view of midrib showing lateral pericentral cells remaining undivided. Fig. 10. Procarp before fertilization in which the cells of both sterile-cell groups (st_1 and st_2) have divided. cp, carpogonium; su, supporting cell; 1, 2, 3, cells of carpogonial branch. Fig. 11. Procarp after presumed fertilization in which cell of sterile-cell group 1 (st_1) has divided, but cell of sterile-cell group 2 (st_2) remains undivided. aux, auxilary cell. Fig. 12. Procarp in which cell of sterile-cell group 1 has divided twice to form 3 cells, but sterile-cell group 2 remains undivided. Fig. 13. Procarp showing both sterile-cell groups remaining undivided.



Figs. 14, 15, 17. *Delesseria aemula* sp. nov. Fig. 16. *Apoglossum unguiculescens*. Fig. 14. Female blade showing corticated midrib and immature cystocarp (arrow). Fig. 15. Tetrasporic blade with sorus. Fig. 16. Female blade showing ecorticate midrib with undivided lateral pericentral cells remaining obvious in proximal parts. Fig. 17. Camera-lucida of blade with discrete spermatangial sori.

resembled "*Delesseria denticulata*" of Harvey (1855a), currently known as *Heterodoxia denticulata* J. Agardh. De Toni (1924) reiterated this relationship. Lucas (1929) placed it in *Hypoglossum*, but according to Reinbold's description, the species does not appear to belong in that genus either. The type specimen has not been located in the Munchen Herbarium or the Rijksherbarium, Leiden, and no specimens identifiable as this taxon have been recently collected from southern Australia (H. B. S. Womersley, pers. comm.). Reinbold described *D. lacepedeana* as having thalli 15 cm tall and with blade surfaces giving rise to scattered proliferations; these features permit us to disallow *D. lacepedeana* from further consideration.

Several species of *Delesseria* are known from

New Zealand and environs (Adams 1972, Adams *et al.* 1974, Hay *et al.* 1985). These include *D. lancifolia* J. Ag., which according to Ricker (1987) is a morphologically variable entity, typically represented by robust, erect fronds reaching heights up to 50 cm. Similarly, plants of *D. crassinervia* Mont. reach substantial sizes and are branched to several orders (Montagne 1852, Kylin 1929), making this taxon clearly separable from *D. aemula*. Blades of *D. nereifolia* Harv. [=*D. laurifolia* (J. Ag.) Kyl.] are broad and with lateral veins, and plants are branched to a few orders (Harvey 1855b, Kylin 1929).

Looking beyond New Zealand waters, we can consider other species that have been assigned to *Delesseria*. Baardseth (1941) described *D. minor* from Tristan da Cunha in the South Atlantic to be a plant growing to 5 cm high and with branching from the stipe, midrib, margins or from the flat surface of the blades. Although its size immediately suggests that there is little in common between *D. minor* and *D. aemula*, the branches arising from the flat surface of the blade would appear to be unusual within the genus and quite different from the more typical branching seen in *D. aemula*. Levring (1944) described *D. crozetii* as a species growing to heights of 8 cm and with individual blades reaching lengths of 1-2 cm, sizes exceeding those in *D. aemula*.

Wynne (1984) characterized *Delesseria papenfussii* from South Africa as having thalli of moderate stature, from 4 to 6, rarely up to 9, cm tall, densely branched (to 5 orders), and with more or less cartilaginous basal stipes, features distinguishing it from *D. aemula*.

Apoglossum is a genus closely related to *Delesseria* and with which it might be confused. First established by J. Agardh (1876) as a subgenus of *Delesseria, Apoglossum* was later delineated as a distinct genus (J. Agardh 1898). Wynne (1984) summarized the six characters which had earlier been offered by Kylin (1923) to separate these genera. Wynne (1984) pointed out that one of these criteria, microscopic lateral nerves in *Apoglossum* vs. microscopic or macroscopic veins in *Delesseria*, was not a completely exclusive characteristic. *Delesseria aemula* conforms to *Delesseria* rather than to *Apoglossum* in respect to the following generic criteria: 1) lateral pericentral cells undergoing transverse divisions; 2) cross-sections of stipes showing a mixture of large cells intermingled with rhizoidal cells; 3) cells of the sterile-cell groups becoming divided; and 4) new cells from intercalary division may be cut off distally or proximally [NB: stippled cells in Fig. 7], unlike in *Apoglossum* where new cells from an intercalary division are cut off only distally. One difference from the generitype, *Delesseria sanguinea* (Hudson) Lamouroux, is that in *D. aemula* fourth-order rows are cut off adaxially rather than "usually abaxially". But this discrepancy with the generitype was also noted for *D. papenfussii* by Wynne (1984).

The problems involved in separating the two genera are not only at the morphological level. At the type locality (Twofold Bay, Australia) of *Delesseria aemula*, the diminutive alga *Apoglossum unguiculescens* grows right along side the new species on the same hosts and substrata. The two species are essentially indistinguishable to the naked eye, and only under microscopic examination can they be separated. In *A. unguiculescens*, the lateral pericentral cells remain clearly undivided (Fig. 9) and visible throughout the entire length of the midrib region (Fig. 16) of all life stages except mature cystocarp-bearing females, in which they are lightly to heavily corticated. This feature contrasts with the situation in *D. aemula*, in which the lateral pericentral cells are either obscured by heavy cortication of the midrib on spermatangial (Fig. 5) and female (Fig. 14) blades or involved in tetrasporangial production (Fig. 15). Spermatangial sori in *A. unguiculescens* are continuous and confluent from the early stages, occupying about one half to one third the blade width (Fig. 6). In *D. aemula*, however, spermatangial sori are discrete islets separated by some second- and third-order cells that remain sterile (Figs. 5, 17). Another useful difference between these two superficially similar species is their procarps. In *D. aemula* the cells of the sterile-

cell groups divide once (Fig. 10) or twice (Fig. 12) before fertilization takes place, whereas in *A. unguiculescens*, the cells of both sterile-cell groups remain undivided, at least before fertilization (Fig. 13).

Other species of *Apoglossum* with thalli of small-stature deserve mention. *Apoglossum spathulatum* (Sond.) Womersley and Shepley occurs in Western Australia (Sonder 1945) and South Africa (Wynne 1984). Sonder (1845) described this species as having dwarf fronds, and he later noted that the blades were 3.0 mm wide and marked by pellucide transverse striae, i.e., microscopic veins (Sonder 1848). Wynne (1984) reported South African plants of *A. spathulatum* to range from 5 to 11 mm in height and to have well developed midribs and ovate tetrasporangial sori overlying the midrib. *Apoglossum minimum* Yamada (Mikami 1985) and *A. gregarium* (Dawson) Wynne (Wynne 1985, Wynne and Norris 1991) are other examples of small-sized Apoglossums. In these species the lateral pericentral cells do not divide transversely, and thus these taxa clearly belong to the genus *Apoglossum* and cannot be confused with *Delesseria aemula*.

Acknowledgments

Sincere thanks to Peter Richards for diving and technical assistance. Thanks also to Roslyn Millar, Andrew Wright, Ray Medhurst, John Huisman and Gerry Kraft for partnership and help on many of the dives and collections for this project. The second author was the recipient of a Visiting Research Fellowship from the Trust of the Royal Botanic Gardens, Sydney, and he expresses his gratitude to Professor Carrick Chambers, Director, and Dr Barbara G. Briggs, Senior Assistant Director of the National Herbarium of New South Wales. Dr. Craig W. Schneider kindly provided the Latin description.

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A. J. K. Millar*・M. J. Wynne**：オーストラリア，ニューサウスウェールズ産の一新種 *Delesseria aemula* sp. nov.（紅藻，コノハノリ目）について

東オーストラリア，ニューサウスウェールズ産の亜潮間帯に生育する新種 *Delesseria aemula* sp. nov. を記載した。本新種は以下のような特徴を持つ：中央部の仮根状の付着器から放射状に生じるへら形または披針形の葉状部：成熟時においても高さ 10 mm, 幅 2 mm にしか達しない小さな藻体；二次及び三次の細胞列からなる不稔の葉脈により隔てられた不連続の細胞群からなる造精子嚢斑；大部分の枝が中央部の仮根状の付着器から生じる分枝の様式。一部の枝は中肋または縁辺部から二次的な成長により生じることもある。野外では本種は同じ場所に生育し，同様の外観，大きさと形を持つ *Apoglossum unguiculescens* Millar と区別が困難である。両種は以下の点で区別される：1）周心細胞が *D. aemula* では横方向に分裂するのに対し *A. unguiculescens* では分裂しない：2）不稔細胞群の細胞が *D. aemula* では分裂するのに対し *A. unguiculescens* では分裂しない：3）造精子嚢斑の配列が異なる。*D. aemula* の発見によりオーストラリアには 3 属（*Delesseria, Apoglossum* 及び *Patulophycus*）のコノハノリ類が生育することになる。
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Jpn. J. Phycol. (Sôrui) 40: 121–124, June 20, 1992

On the identity of *Fucus babingtonii* Harvey (Fucales, Phaeophyta)

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Yoshida, T. and Silva, P. C. 1992. On the identity of *Fucus babingtonii* Harvey (Fucales, Phaeophyta). Jpn. J. Phycol. 40: 121–124.

Examination of type materials of *Fucus babingtonii* Harvey shows that this entity is conspecific with the species now called *Pelvetia wrightii* Okamura (=*Fucus wrightii* Harvey nom. illeg.). Publication of the name *Pelvetia babingtonii* (Harvey) De Toni 1895 antedates that of *P. wrightii* Okamura 1902. Therefore, *P. babingtonii* is the correct name for this species. Specimens cited in the protologue of *F. babingtonii* collected at Shimoda, Japan and Hong Kong belong to the species now we call *Ishige okamurae* Yendo.

Key Index Words: *Fucales*—Fucus babingtonii—Fucus wrightii—*Nomenclature*—Pelvetia babingtonii—Pelvetia wrightii—*Phaeophyta*.

Harvey (1859) published a paper dealing with many new species of marine algae based on specimens collected chiefly by Charles Wright during the U.S. North Pacific Exploring Expedition of 1853–1856 under the command of Captain John Rodgers. The paper comprises only brief Latin descriptions not accompanied by illustrations, making it difficult for later phycologists to identify the new species. Nearly a century later, the manuscript of Harvey's complete report on the algae of that expedition, including colored illustrations, was discovered in the Farlow Herbarium (FH), showing that the published portion was merely an abstract. This manuscript, which was edited and published by Dawson (1959), clarifies many uncertainties presented by the abstract.

Among these new species were two that Harvey assigned to *Fucus* sect. *Fucodium* (J. Agardh) Harvey: *F. wrightii* and *F. babingtonii*. The former was said to come from the "Straits of Sanger [Tsugaru Straits], Japan", the latter from "Japan (Dr. Babington in Herb. T.C.D.); rocks at Simoda [Shimoda]; Hong Kong."

Fucodium is a name applied by J. Agardh (1848) to a collective genus that included *Pelvetia* Decaisne et Thuret (1845). De Toni (1895a, 1895b) restored the name *Pelvetia*, making appropriate combinations for species previously assigned to *Fucodium*. He included *F. babingtonii* in *Pelvetia*, but with a query. *Fucus wrightii*, however, was listed as a species of uncertain generic position, possibly referable to *Ascophyllum* (De Toni, 1895a, p. 209).

Okamura (1902) concluded that *Fucus wrightii* was properly placed in *Pelvetia* and made the appropriate combination. As pointed out by Yoshida (1977), however, *Fucus wrightii* Harvey is a later homonym of *F. wrightii* Turner (1811), a species now referred to *Gracilaria*, and hence is not priorable. The binomial *Pelvetia wrightii* must be attributed directly to Okamura and treated as a new name rather than a new combination in accordance with Art. 72 of the International Code of Botanical Nomenclature. This interpretation is important because it dates the species from 1902 rather than from 1859.

In his treatment of Japanese Fucaceae, Yendo (1907) came to the conclusion that *Fucus babingtonii* was conspecific with *P. wrightii* after examining photographs of original specimens provided by Prof. E. P. Wright, keeper of the herbarium at Trinity College, Dublin (TCD). He treated *F. babingtonii* as a form of

P. wrightii, coordinate with forma *typica* and forma *japonica* Yendo. The latter, which was first mentioned by Yendo (1905) as *P. japonica* without a description, was said to have a thinner and narrower frond than typical *P. wrightii* and to predominate in the northeastern part of the range of the species. Forma *babingtonii* was said to be intermediate between the other two forms in both morphology and geography. During his stay in Europe, Yendo visited Dublin in December 1913 and examined Harvey's collections, but the results of his observations were not published. Yendo's treatment of *Pelvetia* was adopted by Okamura (1936).

Because *Pelvetia babingtonii* (Harvey) De Toni dates from 1895 while *P. wrightii* Okamura dates from 1902, the former is the correct name for this species. With respect to Yendo's treatment, however, the question arises whether *P. wrightii* and *P. wrightii* forma *japonica* should be given nomenclatural recognition as forms of *P. babingtonii*. In view of the morphological variability exhibited by *Pelvetia* in Japan, it was necessary to re-examine the original specimens of *Fucus babingtonii* in order to determine the relationship between this species and *F. wrightii*.

The epithet *babingtonii* suggests that the Babington collection in Harvey's herbarium at TCD should be considered the type, and this suggestion is confirmed by the note in Harvey's manuscript (Dawson, 1959, p. 9), "Described from Dr. Babington's specimens." Unfortunately, TCD does not lend types, but its director, Dr. John Parnell, kindly sent a photograph of the type sheet (Fig. 1). There are two specimens, 25-30 cm high

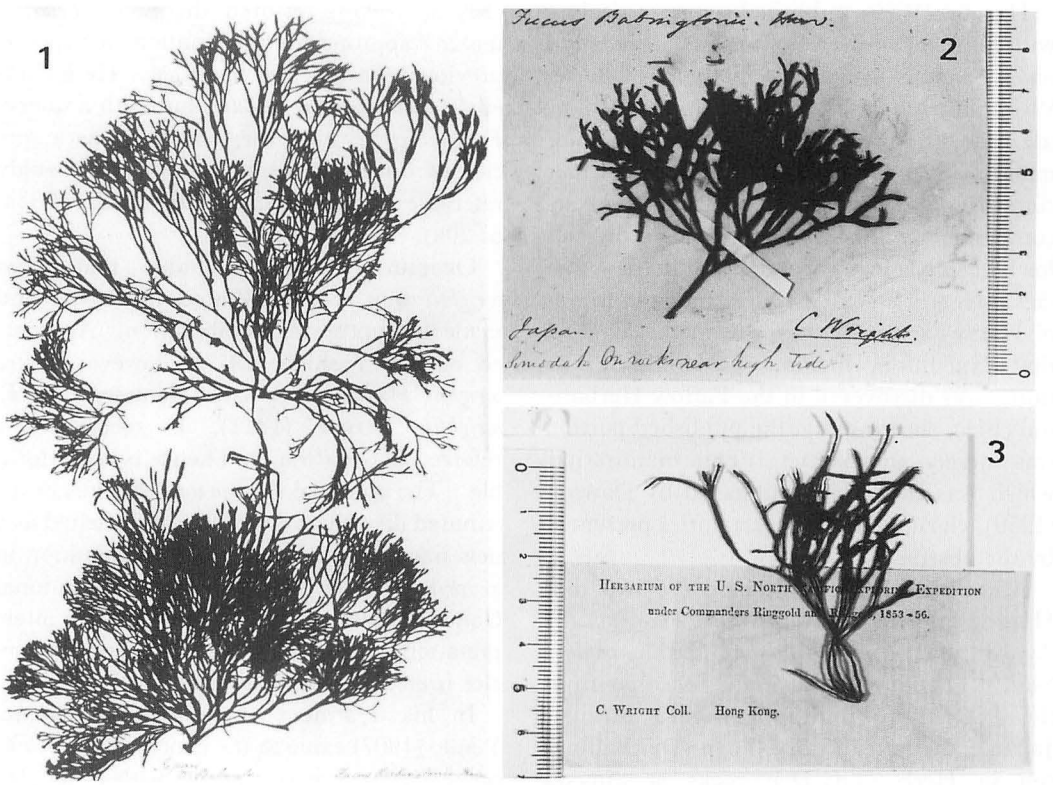

Fig. 1. Holotype sheet of *Fucus babingtonii* Harvey, collected by Dr. Babington in "Japan" (TCD). Upper specimen is herein designated lectoholotype.

Fig. 2. Specimen cited by Harvey, collected by Wright at Shimoda ('Simoda'), Shizuoka Prefecture, Japan, referable to *Ishige okamurae* Yendo.

Fig. 3. Specimen cited by Harvey, collected by Wright at Hong Kong, also referable to *I. okamurae*.

("10-12 inches long" according to Harvey's manuscript), frequently branched, the branches narrow and with a few vesicles. The locality is given only as "Japan". We can say that these two specimens, of which we designate the upper one as lectoholotype, are clearly referable to *P. wrightii*, although they are large immature plants with slender branches.

Dr. Parnell sent on loan a herbarium sheet consisting of three collections, all of which are referable to *Ishige okamurae* Yendo. The upper one, contained in a white envelope, was collected at Misaki, Kanagawa Prefecture, Japan by Yendo. It was sent to TCD by Yendo accompanied by a letter asking the curator to compare it with the type of *Fucus babingtonii*. The lower one (Fig. 2) is a specimen from Shimoda, about 7 cm high, bearing Yendo's annotation, "This is what I described as *Ishige okamurai*, Dec. 1913". The middle one (Fig. 3) was collected at Hong Kong and is smaller than the lower one. It may be noted no. 37 of Okamura's "Algae Japonicae Exsiccatae" (1899), distributed under the name *Pelvetia babingtonii*, is also representative of *I. okamurae*.

From an examination of Yendo's collections and field experience of one of us (TY) on the coast of Hokkaido, we conclude that the taxonomic recognition of three formae, as in Yendo's treatment, is not justified. Thallus size, vesicle characteristics, and receptacle morphology all vary in response to habitat and season of growth.

In summary:

Pelvetia babingtonii (Harvey) De Toni, Syll. Alg. **3:** 216. 1895; Mem. R. Ist. Veneta Sci. Lett. Arti **25:** 48. 1895. *P. wrightii* Okamura forma *babingtonii* (Harvey) Yendo, J. Coll. Sci., Imp. Univ. Tokyo **21**(12): 22. 1907.

Basionym: *Fucus* (*Fucodium*) *babingtonii* Harvey, Proc. Amer. Acad. Arts. **4:** 329. 1859.

Holotype: "Japan, Dr. Babington" in TCD; lectoholotype: upper specimen on holotype sheet.

Taxonomic synonym: *Fucus* (*Fucodium*) *wrightii* Harvey, Proc. Amer. Acad. Arts **4:** 329. 1859 (not *F. wrightii* Turner, Fuci **3:** 31. pl. 148. 1811).

Pelvetia wrightii Okamura, Nippon Sorui Meii 138. 1902.

Acknowledgments

We thank Dr. J. A. N. Parnell, Director of the Herbarium at Trinity College, Dublin, for the loan of specimens.

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Yoshida, T. 1977. Nomenclatural notes on some Japanese marine algae. Bull. Jap. Soc. Phycol. **25:** 79–82. [In Japanese]

吉田忠生*・Paul C. Silva**：エゾイシゲの学名について

日本北部に産するエゾイシゲには *Fucus wrightii* Harvey に基づく *Pelvetia wrightii* Okamura 1902 の学名が用いられている。これまで Harvey が同時に発表した *Fucus babingtonii* については，その実体が不明であった。今回 Dublin の Trinity College に保存されているタイプ標本を調べて，*F. babingtonii* の記載の元になった標本は明らかにエゾイシゲであることが確認された。このため，*Pelvetia babingtonii* (Harvey) De Toni 1895 の名前のほうが Okamura よりも早く発表されているので，これを正しい名前として採用しなければならない。また，この種の産地として挙げられている下田，香港で Charles Wright が採集した標本はイシゲ *Ishige okamurae* Yendo であることも分かった。（*060 札幌市北区北10条西 8 丁目　北海道大学理学部植物学教室；**Herbarium, University of California, Berkeley, California 94720, U.S.A.）

Jpn. J. Phycol. (Sôrui) 40: 125–133, June 20, 1992

The conspecificity of *Laurencia yendoi* Yamada and *L. nipponica* Yamada (Ceramiales, Rhodophyta)[1)]

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Masuda, M., Abe, T. and Saito, Y. 1992. The conspecificity of *Laurencia yendoi* Yamada and *L. nipponica* Yamada (Ceramiales, Rhodophyta). Jpn. J. Phycol. 40: 125–133.

Laurencia yendoi Yamada from several localities in northern Japan is shown to be synonymous with *L. nipponica* Yamada widely distributed in Japanese and adjacent waters. Lenticular thickenings, which have not been reported for *L. yendoi*, can be found in the walls of medullary cells in the lower portions of upright axes of the holotype specimen. This critical character together with other morphological features such as large upright thalli with thick, terete, main axes, irregular radial branching, and absence of projecting surface cells, warrant the treatment of these two entities as being conspecific. The lenticular thickenings are considered to be a useful specific feature. The geographical distribution of *L. nipponica* is described on the basis of historical and contemporary specimens.

Key Index Words: geographical distribution—Laurencia—Laurencia masonii var. orientalis—Laurencia nipponica—Laurencia nipponica f. orientalis—Laurencia yendoi—*lenticular thickenings—Rhodophyta—taxonomy.*

Many species of the red algal genus *Laurencia* have been reported from Japanese waters (Yamada 1931, Yamada 1932, Yamada in Okamura 1936, Yamada and Tanaka 1938, Yamada and Segawa 1953, Saito 1967, 1977, 1978, Ohba and Aruga 1982). Some have, however, been reduced to heterotypic synonyms of other species. *Laurencia amabilis* Yamada (in Yamada and Segawa 1953) is considered to be a synonym of *L. yamadana* Howe (1934) (Saito 1969) and *L. japonica* Yamada (1931) of *L. okamurae* Yamada (1931) (Saito 1989). Misidentifications are also apparent; the entity passing under the name *Laurencia glandulifera* in Japan has been shown to be an early seasonal form of *L. nipponica* Yamada (1931) without lenticular thickenings in the walls of medullary cells (Saito 1985). Twenty four species of *Laurencia* are now included in the check-list of Japanese marine algae (Yoshida *et al.* 1990). However, there are several species for which further investigations are necessary.

Yamada (1931) established *Laurencia yendoi* Yamada on the basis of specimens which were collected at Hidaka and Rishiri Island, Hokkaido and had been reported as *L. heteroclada* Harvey by Yendo (1916). This species has been characterized by an absence of lenticular thickenings and the presence of spirally arranged clusters of stichidial branchlets and large, thick, percurrent axes (Yamada 1931). The latter two features are shared with *L. nipponica* Yamada. *Laurencia yendoi* has been reported from a few other localities in Iwate Prefecture (Kawashima 1955), whereas *L. nipponica* is widely distributed in Japanese and adjacent waters (Saito 1967). In the present paper *L. yendoi* is compared with *L. nipponica*. Furthermore, the taxonomic status of an infraspecific taxon of *L. nipponica*, f. *orientalis* (Yamada) Yamada (in Okamura 1936) will be assessed.

[1)] This study was supported in part by a Grant-in-Aid for Scientific Research (No. 01540573) from the Ministry of Education, Science and Culture, Japan.

Materials and Methods

Four herbarium specimens of *Laurencia yendoi* were examined on loan from the Herbarium of University Museum, University of Tokyo (TI). These specimens, which include the holotype sheet (four plants: two tetrasporangial, one cystocarpic and one spermatangial), were collected at Hidaka (locality not described), Hokkaido in July-August 1909 by K. Yendo and determined by Y. Yamada. Two specimens of *L. nipponica* f. *orientalis* (determined by Y. Yamada as *L. masonii* var. *orientalis* Yamada) deposited in TI were examined: 1) the holotype specimen with tetrasporangia collected at Rishiri Island, Hokkaido on 6 August 1891 by K. Yendo and 2) a cystocarpic specimen collected at Nemuro in August 1924 by Y. Yamada. The following herbarium specimens deposited in the Herbarium, Department of Botany, Faculty of Science, Hokkaido University, Sapporo (SAP) were examined: 1) the holotype specimen of *Laurencia nipponica* Yamada collected at Nou, Niigata Prefecture (undated) by Y. Yamada (SAP 013877); 2) two specimens of *L. yendoi* collected at Kuji Bay, Iwate Prefecture on 22 July 1952 by S. Kawashima (SAP 027018); 3) a specimen collected at Nakano, Iwate Prefecture on 20 July 1951 by S. Kawashima (SAP 027017); and, 4) a specimen collected at Okutairahe, Aomori Prefecture on 1 May 1931 by Y. Abe and determined by Y. Yamada (SAP 050806). Furthermore, many specimens deposited in SAP were re-examined and used to describe the geographical distribution of *Laurencia nipponica*. Herbarium specimens collected recently were also used and deposited in SAP. All these specimens are listed in Appendix I.

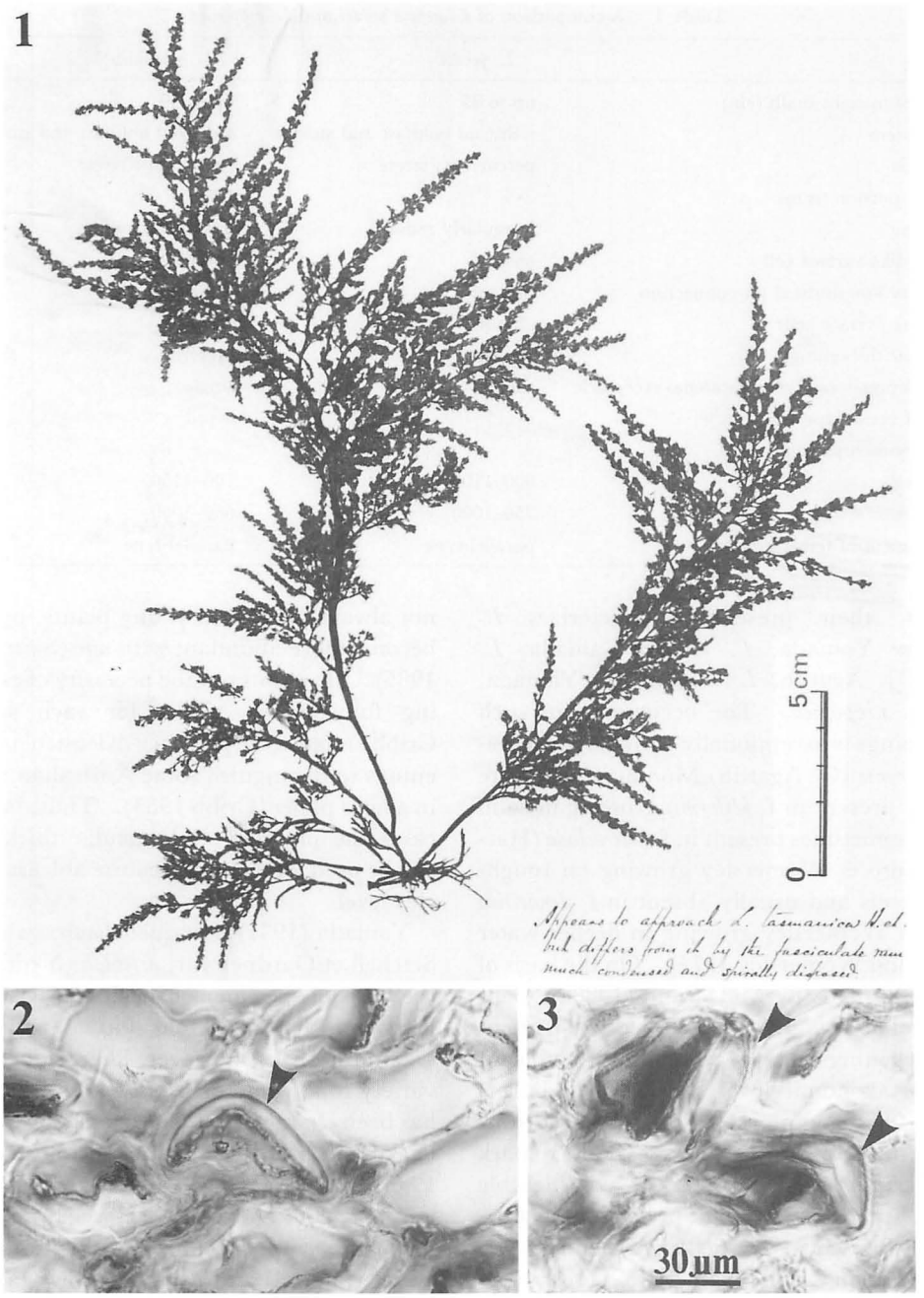
Small portions were removed from various parts of the thalli using a scalpel under a dissecting microscope and rehydrated. Sections were made by hand using a razor blade and pith stick, mounted in water on microscope slides.

Results and Discussion

The holotype specimen of *Laurencia yendoi* is tetrasporangial (Fig. 1), and is composed of a primary axis and six secondary axes which develop from the lowest portion of the primary axis and stolons. Many first-order branches with indeterminate growth are borne on the primary and secondary axes. Short adventitious branchlets are produced on the axes and branches, and are abundant on the upper portion of the axes. These branchlets are simple or divided once, and are generally fertile. Secondary longitudinal pit-connections are present between adjacent surface cells. Lenticular thickenings are frequently present in the walls of medullary cells of the lower portion of secondary upright axes (Figs. 2, 3), but they have not been found in the lateral branches of any order. Tetrasporangia are formed on ultimate and penultimate branchlets of ordinary and adventitious branches. Tetrasporangial stichidia are formed in an irregularly radial manner except for simple stichidia which may develop adventitiously and look like a cluster to the unaided eye as described by Yamada (1931). Tetrasporangia are arranged parallel to their parent branchlet axis. A cystocarpic specimen of *Laurencia yendoi* has many ovoid cystocarps which are 900–1100 μm long and 750–1000 μm wide. A spermatangial plant bears many fertile branchlets of which the terminal portions are thick and 625–1000 μm long and 800–1250 μm wide.

Herbarium specimens determined as *Laurencia yendoi* and deposited in SAP (see Materials and Methods) have lenticular thickenings in the walls of medullary cells of lateral branches or in the lower portions of secondary axes.

Taxonomic features of *Laurencia yendoi* are compared with those of *L. nipponica* in Table 1. Both of these species have large upright thalli with thick, terete, main axes and can be distinguished as such from other species of the genus found in Japan. *Laurencia yendoi*, however, does not differ from *L. nipponica* in any of morphological features listed in Table 1, and should therefore be regarded as conspecific. Of these two names of the same date



Figs. 1–3. *Laurencia yendoi* Yamada. Fig. 1. Holotype specimen deposited in TI. Figs. 2, 3. Transverse sections of the lower portion of a secondary axis of the holotype specimen, showing lenticular thickenings in the walls of medullary cells (arrowheads). Scale in Fig. 3 also applies to Fig. 2.

(Yamada 1931), *L. nipponica*, which appeared in an earlier page and has been widely known in Japan, should be chosen for the combined taxon.

The presence or absence of lenticular thickenings has been regarded as a diagnostic character of species or groups of species (Yamada 1931 as section). Of the Japanese

Table 1. A comparison of *Laurencia yendoi* and *L. nipponica*

	L. yendoi	*L. nipponica*
Length of upright thalli (cm)	up to 25	up to 40
Basal system	a discoid holdfast and stolons	a discoid holdfast and stolons
Main axis	percurrent, terete	percurrent, terete
Thickest portion (mm)	2–3	1.4–3.1
Branching	irregularly radial	irregularly radial
Palisade-like surface cell	absent	absent
Secondary longitudinal pit-connection	present	present
Projecting surface cells	absent	absent
Lenticular thickenings	present	present
Apical depression of spermatangial receptacle	single	single
Shape of cystocarps	ovoid	ovoid
Size of cystocarps (μm)		
length	900–1100	700–1150
width	750–1000	660–1000
Arrangement of tetrasporangia	parallel-type	parallel-type

species, their presence characterizes *L. okamurae* Yamada, *L. venusta* Yamada, *L. nidifica* J. Agardh, *L. mariannensis* Yamada, and *L. nipponica*. The occurrence of such thickenings is exceptionally variable in *Laurencia filiformis* (C. Agardh) Montagne: they are usually present in f. *filiformis* growing in calm water, sometimes present in f. *heteroclada* (Harvey) Saito et Womersley growing on rough-water reefs and usually absent in f. *dendritica* Saito et Womersley growing in deeper water (Saito and Womersley 1974). On the basis of a remark made by McDermid (1988a), Vandermeulen *et al.* (1990) concluded that lenticular thickenings are not particularly significant at any taxonomic level. However, McDermid (1988b) employs this feature to distinguish the Hawaiian species. Her remark (McDermid 1988a, p. 222) "considerable within-species variation of projection of cortical cells, presence of lenticular thickenings, ..." is based upon Cribb (1958, p. 159) "some species, such as *L. obtusa* and *L. rigida*, never show any lenticular thickenings in the walls of the mudullary cells, some such as *L. venusta* appear always to possess thickenings in abundance, while in others such as *L. heteroclada*, the thickenings vary from very abundant to entirely absent, depending on the specimens". In *Laurencia nipponica* these thickenings are not always present in young plants, but they become more abundant with age (Saito 1967, 1985). He points out the necessity of examining fully grown plants for such species. Cribb employs the presence of lenticular thickenings to distinguish some Australian species in a later paper (Cribb 1983). Thus, in many cases the presence of lenticular thickenings can be used for a critical feature at least at species level.

Yamada (1931) described *Laurencia masonii* Setchell et Gardner var. *orientalis* Yamada on the basis of specimens collected at Rishiri Island and Nemuro, Hokkaido. Yamada (in Okamura 1936), however, later reduced this variety to a forma of *L. nipponica*; this forma has been characterized by conspicuously longer lateral branches (Yamada in Okamura 1936), and it has been reported from a few localities of Hokkaido (Hasegawa 1949). Two herbarium specimens of this forma, cited in Materials and Methods, have been examined. The production of many, short, reproductive adventitious branchlets and less frequent occurrence of lenticular thickenings in the medullary cell-walls suggest a relationship with *L. nipponica* than *L. masonii* as Yamada (in Okamura 1936) concluded. On the contrary, *L. masonii* lacks such branchlets and possesses very abundant and much thicker len-

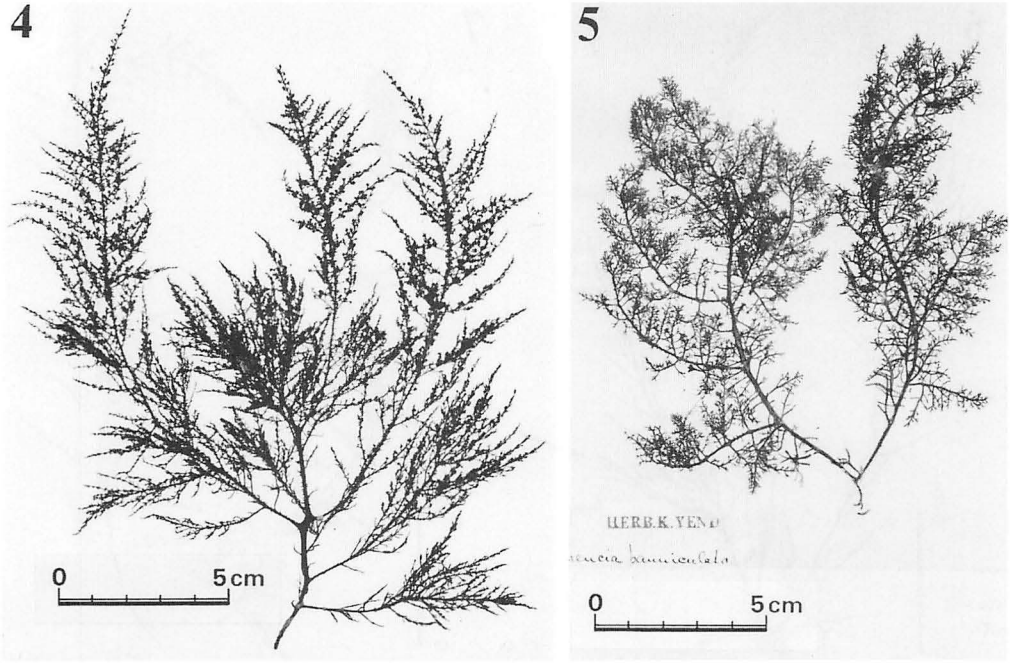


Fig. 4. Herbarium specimen of *Laurencia nipponica* with long lateral branches, collected on 7 July 1989 from a sheltered place at Oshoro, Hokkaido (SAP 056345).

Fig. 5. Holotype specimen of *L. nipponica* f. *orientalis* (Yamada) Yamada (TI, as *L. masonii* var. *orientalis* Yamada).

ticular thickenings (Yamada 1931). Other morphological features of these specimens are very similar in every respect to those of *L. nipponica*. Development of lateral branches may be affected by habitat in Japan. *Laurencia nipponica* grows on rocks or ledge in sheltered to fully wave-exposed places. Plants growing in sheltered calm places (tidal pools or ports) develop long branches (Fig. 4) as does the holotype specimen of *L. nipponica* f. *orientalis* (Fig. 5), whereas those growing in fully wave-exposed places have short lateral branches (Fig. 6) as does the holotype specimen of this species (Fig. 7). There is no need for an infraspecific taxon on the basis of such development of lateral branches. Morphological variability similar to this is common in the species of *Laurencia*, as pointed out by Yamada (1931, p. 185).

Okamura (1899) distributed an exsiccata of Japanese marine algae which included an alga under the name of *Laurencia paniculata* J. Agardh. The specimen of this alga in Okamura Herbarium housed in SAP, collected at Hakui, Noto Peninsula in May, 1894, is identical with *L. nipponica*. Okamura (1902, 1916) reported *L. paniculata* from various localities of Japan ranging from Okinawa Prefecture to Hokkaido. No specimens other than a duplicate of his exsiccata identified as *L. paniculata* by K. Okamura are included in his herbarium in SAP. His identification might have been tentative and could have been corrected later. As *L. nipponica* has not been reported from Okinawa Prefecture (Segawa and Kamura 1960, Masuda and Kamura unpublished observations), his geographical records may include other species. Yendo's (1916) *L. heteroclada*, of which voucher specimens had been known as *L. yendoi*, is identical with *L. nipponica*. Yamada's *L. glandulifera* (in Okamura 1936) is conspecific with *L. nipponica* as already reported by Saito (1985).

In summary, the synonyms of *L. nipponica* are as follows.

Laurencia nipponica Yamada [1931: 209, *pl. 9*]

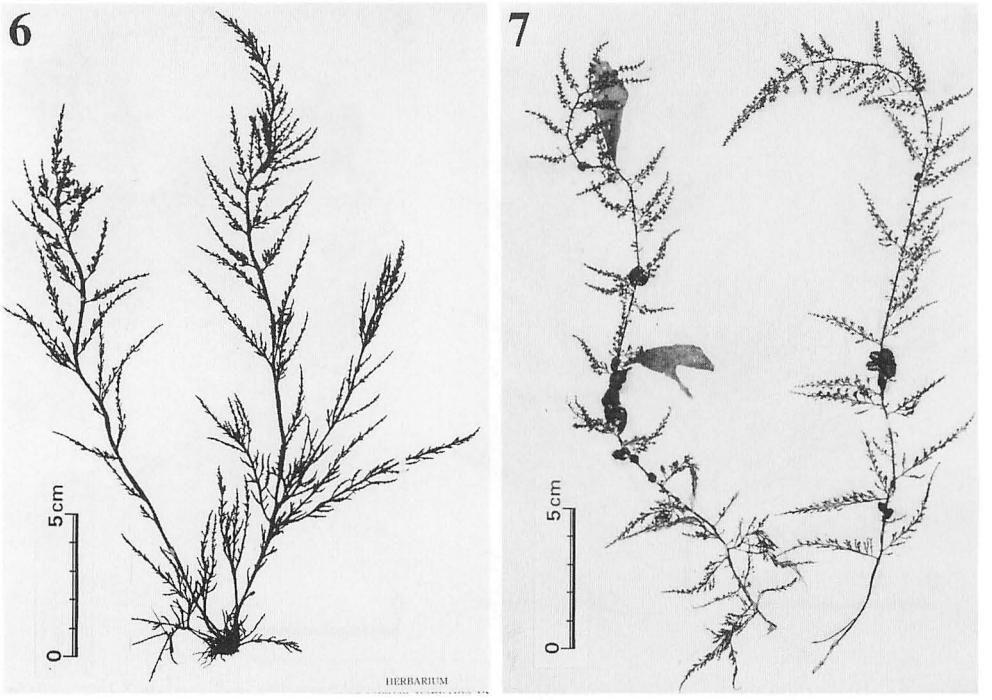


Fig. 6. Herbarium specimen of *Laurencia nipponica* with short lateral branches, collected on 24 June 1989 from a fully wave-exposed habitat at Tanesashi, Aomori Prefecture (SAP 056344).
Fig. 7. Holotype specimen of *L. nipponica* Yamada deposited in SAP (013877).

Synonyms: *Laurencia yendoi* Yamada [1931: 237, *pl. 24*]. *L. masonii* Setchell et Gardner var. *masonii* Yamada [1931: 210, *pl. 10*]. *L. nipponica* Yamada f. *orientalis* (Yamada) Yamada [in Okamura 1936: 855]. *L. paniculata* auct. non J. Agardh: Okamura [1902: 54 (*pro parte*), 1916: 68 (*pro parte*)]. *L. heteroclada* auct. non Harvey: Yendo [1916: 89]. *L. glandulifera* auct. non Kützing: Yamada [in Okamura 1936: 858].

The geographical distribution of *Laurencia nipponica* in Japan is shown in Fig. 8; it occurs along the coast of Sea of Japan and the coast of Sea of Okhotsk from Saga Prefecture to the north coast of Hokkaido including the Nemuro Straits, which are under the influence of the Tsushima Warm Current and its terminal branch, the Soya Warm Current. This alga also grows on the coast of Seto Inland Sea and along the Pacific coasts of northern Honshu and southern Hokkaido, which are influenced by the Tsushima Warm Current and its terminal branch, the Tsugaru Warm Current. Furthermore, its distribution range extends northward to eastern Hokkaido which is exclusively influenced by the Oyashio Cold Current. Of the species of *Laurencia* found in Japanese waters, *L. nipponica* is most adapted to low temperatures and exclusively occurs in north-eastern Hokkaido.

Konno *et al.* (1988) and Ohba *et al.* (1988) reported *L. nipponica* from more southerly localities of Pacific coast, Kominato and Banda, Tateyama, Chiba Prefecture. One of their voucher specimens, collected at Banda, on 15 May 1988 and donated to SAP (054428) was examined. This specimen is much more slender than *L. nipponica* and its surface cells are clearly projecting at the branch apices. Further examination is needed to clarify the occurrence of *L. nipponica* in these localities.

Acknowledgements

We are grateful to Professor T. Yoshida,

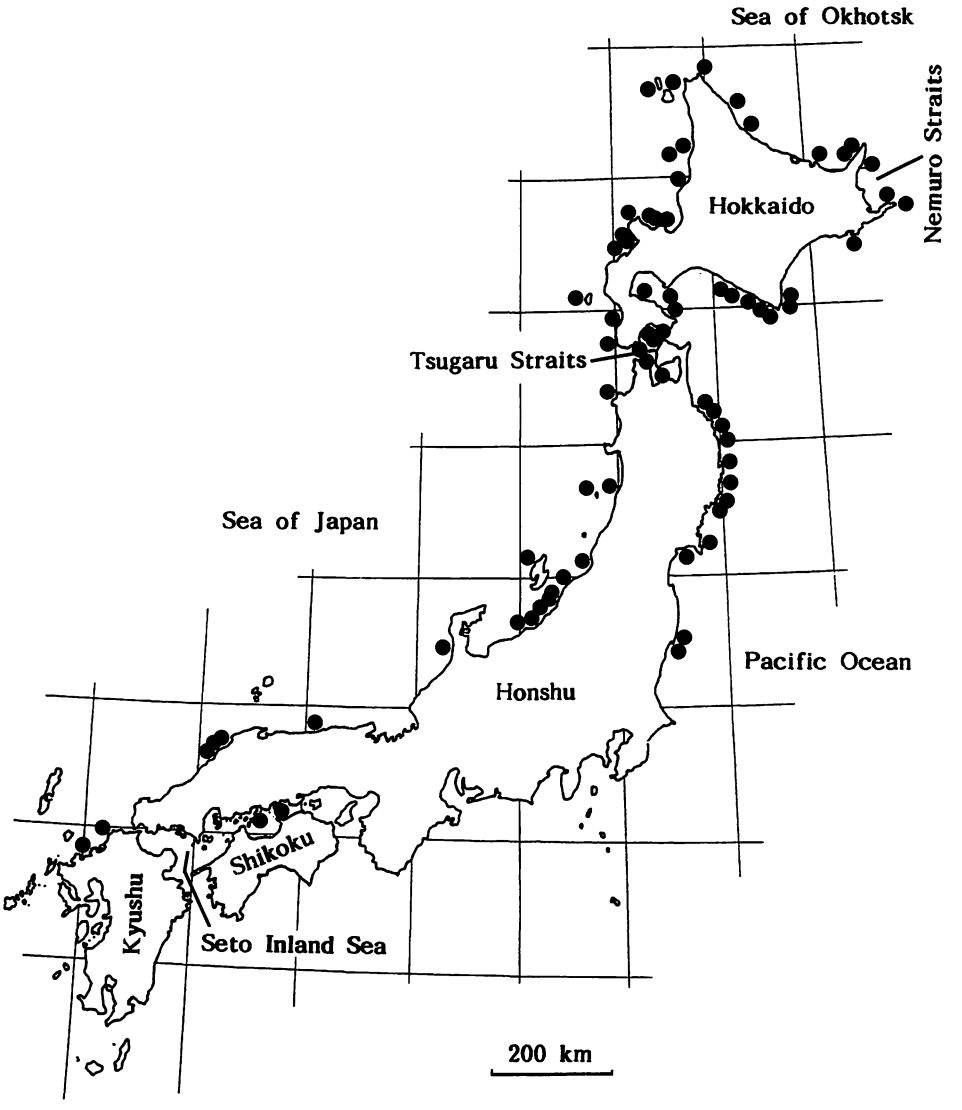


Fig. 8. Geographical distribution of *Laurencia nipponica*, compiled from herbarium specimens in SAP.

Hokkaido University and Professor M.D. Guiry, National University of Ireland, for their criticism of the manuscript. We also thank Professor K. Iwatsuki, University of Tokyo, for the loan of herbarium specimens.

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Appendix I.

Voucher specimens used in assessing the geographical distribution of *Laurencia nipponica* Yamada are listed below. All specimens are deposited in SAP and the specimen numbers refer to SAP.

Sea of Japan

Saga Pref.: Karatsu, April 1929, leg. Y. Okamoto (056299). Fukuoka Pref.: Tsuyazaki, 13 April 1957, leg. T. Sawada (031162). Shimane Pref.: Yunotsu, undated, leg. S. Takaki (021092); Shizuma, 16 July 1933, leg. S. Takaki (Okamura Herb.); Torii, 30 March 1933, leg. S. Takaki (Okamura Herb.). Tottori Pref.: Iwami, 8 July 1918, leg. Y. Ikoma (056298). Ishikawa Pref.: Hakui, 20 April 1894, leg. K. Okamura (Okamura Herb.), May 1894, leg. K. Okamura (Okamura Herb.). Niigata Pref.: Gouzu, 2 August 1957, leg. Y. Saito (028246–7); Kujiranami (Kashiwazaki), 17 May 1990, leg. M. Masuda (056317–9); Kannon-misaki (Nishiyama), 15 May 1991, leg. A. Arai (056315), 20 May 1991, leg. Y. Kajita (056316); Ishiji, 13 March 1932, leg. Y. Ikegami (Okamura Herb.), 25 May 1932, leg. Y. Ikegami (Okamura Herb.); Niigata, 8 May 1986, leg. K. Ikehara (051045); Murakami, 17 May 1990, leg. M. Masuda (056312); Ookura (Aikawa), 19 April 1956, leg. N. Tazawa (056313–4). Yamagata Pref.: Tobishima, July 1931, leg. T. Hirohashi (012089). Akita Pref.: Konoura, 20 July 1989, leg. T. Suzuki and M. Masuda (056311). Aomori Pref.: Fukaura, 19 July 1931, leg. T. Kanda (012825), 21 July 1989, leg. T. Suzuki and M. Masuda (056310). Hokkaido: Akagami (Matsumae), 24 June 1988, leg. I. Mine (053976); Esashi, 3 April 1944, leg. Y. Hasegawa (025435); Okushiri, January 1944, leg. Y. Hasegawa (025236), 3 July 1943, leg. Y. Hasegawa (025237); Suttsu, 16 June 1950, leg. S. Kawashima (052283); Kayanuma (Tomari), 25 April 1984, leg. K. Kobayashi (056326); Kawashiro, 10 August 1985, leg. K. Kobayashi (056330); Yobetsu, 6 June 1984, leg. K. Kobayashi (056327); Attoma, 1 July 1985, leg. K. Kobayashi (056329); Oshoro, 29 April 1932, leg. K. Inagaki (014054, 022307), 7 July 1989, leg. M. Masuda (056345); Shioya, June 1940, leg. Y. Nakamura (023614); Takashima, 14 June 1954, leg. N. Tazawa (054336); Otaru, 14 June 1954, leg. N. Tazawa (028562); Kumausu, 6 July 1989, leg. T. Suzuki and M.

Masuda (056341); Asari, 1 June 1954, leg. N. Tazawa (028563); Hariusu, 6 July 1989, leg. T. Suzuki and M. Masuda (056342); Rumoi, 22 June 1984, leg. E. Kurosawa and Y. Saito (056333), 5 July 1989, leg. M. Masuda (056346); Yagishiri, August 1910, leg. K. Yendo (056296); Shosanbetsu, 22 June 1984, leg. E. Kurosawa and Y. Saito (056332); Rishiri, 8 June 1899, leg. K. Yendo (056295), 21 July 1929, leg. S. Akiyama (008111–2); Rebun, July 1910, leg. K. Yendo (056297), 24 August 1934, leg. K. Inagaki (022813, 048135).

Seto Inland Sea

Ehime Pref.: Yuge-jima, 11 May 1990, leg. S. Arai and S. Ninomiya (056323–5). Okayama Pref.: Kitagi-jima (Kasaoka), 3 April 1989, leg. S. Ninomiya (056320–1). Kagawa Pref.: Awashima (Takuma), 5 April 1989, leg. S. Ninomiya (056322).

Pacific coast

Fukushima Pref.: Onahama, 22 July 1990, leg. M. Masuda (056309); Yotsukura, 22 July 1990, leg. M. Masuda (056308). Miyagi Pref.: Shichigahama, 18 May 1955, leg. Y. Tsuji (056300); Ogatsu, 22 June 1989, leg. T. Suzuki and M. Masuda (056307); Karakuwa, 23 June 1989, leg. T. Suzuki and M. Masuda (056306). Iwate Pref.: Hirota, 4 August 1956, leg. Y. Tsuji (056301); Oofunato, 21 May 1951, leg. S. Kawashima (027020); Ootsuchi, 24 July 1979, leg. S. Kawaguchi (052945), 25 July 1979, leg. S. Kawaguchi (053193); Joudogahama (Miyako), 23 June 1989, leg. T. Suzuki and M. Masuda (056305); Kurosaki (Fudai), 24 June 1989, leg. T. Suzuki and M. Masuda (056303–4); Taneichi, 14 April 1952, leg. S. Kawashima (027019, 051835), 24 June 1989, leg. T. Suzuki and M. Masuda (056302); Tanesashi (Hachinohe), 24 June 1989, leg. T. Suzuki and M. Masuda (056344). Hokkaido: Osatsube, 26 July 1938, leg. Y. Yamada (023603); Usujiri, 1 August 1989, leg. T. Suzuki and M. Masuda (056339, 056340); Otoshibe, 25 June 1986, leg. K. Kogame (050392); Muroran, 1 June 1935, leg. Y. Nakamura (023334); Higashishizunai, 26 May 1975, leg. T. Yoshida and M. Masuda (049497); Mitsuishi, 29 June 1984, leg. E. Kurosawa and T. Suzuki (056334), 4 July 1989, leg. T. Suzuki and M. Masuda (056343); Enrumu-misaki (Samani), 28 May 1975, leg. T. Yoshida and M. Masuda (049458), 24 July 1975, leg. T. Yoshida and M. Masuda (049374); Horoizumi, 4 July 1943, leg. Y. Nakamura (048899); Aburakoma, 27 May 1975, leg. T. Yoshida and M. Masuda (049535), 25 July 1975, leg. M. Kurogi and M. Masuda (049416); Syoya, 24 July 1975, leg. M. Ohta (047894); Oshirabetsu, 23 July 1975, leg. M. Ohta (047895), 18 August 1989, leg. M. Masuda (056337); Akkeshi, 25 June 1933, leg. Y. Yamada (024645); Nosappu-misaki, 25 August 1988, leg. M. Matsumoto (052642).

Tsugaru Straits

Aomori Pref.: Yunoshima, undated, leg. Y. Yamada (008107); Ooma, 16 May 1987, leg. T. Kitayama (052993, 053085). Hokkaido: Fukushima, 16 May 1988, leg. I. Mine (053973); Kikonai, 8 May 1989, leg. I. Mine (053974); Moheji (Kamiiso), 15 June 1984, leg. E. Kurosawa and Y. Saito (056331); Hakodate, undated, leg. T. Moritake (024528); Kamaya (Toi), April 1940, leg. Y. Yamada (023535).

Sea of Okhotsk

Hokkaido: Soya-misaki, 27 July 1980, leg. M. Kurogi (036873); Esashi, 6 August 1947, leg. M. Kurogi (025485); Saruru (Okkope), 28 July 1980, leg. M. Kurogi (036939, 036940); Abashiri, June 1934, leg. T. Muraoka (020035); Utoro, 16 August 1989, leg. M. Masuda (056335); Rusya, 16 September 1943, leg. Y. Yamada (024331).

Nemuro Straits

Hokkaido: Rausu, 17 August 1989, leg. M. Masuda (056336); Nemuro, 3 August 1929, leg. S. Akiyama (008113), 10 August 1987, leg. M. Matsumoto (052467, 052643), 29 June 1988, leg. M. Matsumoto (052644).

増田道夫*・阿部剛史*・齋藤　譲**：紅藻キタソゾとウラソゾは同一種

北海道と東北太平洋沿岸の数ヵ所から報告されているキタソゾ (*Laurencia yendoi* Yamada) は，日本海沿岸を主要な分布域として広い範囲に生育しているウラソゾ (*L. nipponica* Yamada) の異名である。原記載で存在しないとされていた半月状肥厚が，キタソゾの正基準標本の二次的主軸下部の髄層細胞に観察された。半月状肥厚の存在はウラソゾと共通し，太い円柱状の主軸を持つ大きな直立体を生じること，不規則に放射状に分枝すること，小枝末端の皮層最外層細胞が突出しないことなどの他の特徴も両者が同一種であることを示している。種レベルでの特徴としての半月状肥厚の重要性について論じ，ウラソゾの日本列島沿岸における地理的分布図を示した。

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Jpn. J. Phycol. (Sôrui) 40: 135–142, June 20, 1992

Light condition and photosynthetic characteristic of the subsurface chlorophyll maximum at a station in Solomon Sea

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Satoh, H., Tanaka, H. and Koike, T. 1992. Light condition and photosynthetic characteristic of the subsurface chlorophyll maximum at a station in Solomon Sea. Jpn. J. Phycol. 40: 135–142.

Photosynthetic productivity of phytoplankton was investigated at a station (5°43′S, 153°30′E) in the Solomon Sea, in early December 1989. A pronounced subsurface chlorophyll maximum (SCM) was observed at a layer of 75 m depth, where the relative light intensity was 1.2% of the incident solar radiation at water surface. The chlorophyll *a* concentration at the SCM layer was 0.61 mg m^{-3}. The chlorophyll *a* standing stock at the SCM layer was 46% of the total amount in the water column from surface to 200 m. Photosynthesis-light curve of phytoplankton from the SCM layer indicated shade adaptation. The maximum photosynthetic rate of 0.15 mgC mg·chl·a^{-1} h^{-1} was obtained at 35 μE m^{-2} s^{-1}, which was almost the same light condition at the SCM layer. The photosynthetic efficiencies of phytoplankton from surface, 25 m and the SCM layer for blue light (35 μE m^{-2} s^{-1}) were 57, 56 and 105% of those under daylight, respectively. The primary production in the SCM layer (0.086 mgC m^{-3} h^{-1}) was 17% of that in the 25 m layer (0.50 mgC m^{-3} h^{-1}).

Key Index Words: blue light—photosynthesis—Solomon Sea—subsurface chlorophyll maximum.

A subsurface chlorophyll maximum (SCM) has been often observed in marine environments (e.g. Riley *et al.* 1949, Anderson 1969, Kiefer *et al.* 1976, Yamaguchi and Ichimura 1980, Abbott *et al.* 1982, Takahashi *et al.* 1985). The SCM is commonly found at depths between 30 and 100 m in most areas, which occurred in the lower part of the photic zone where the light level is generally about 1% of the sea surface (Jerlov 1976, Kishino *et al.* 1986). Thus, it is important to know the photosynthetic rate at the light regimes near compensation point for estimating primary production at the SCM layer in the tropical area. During the cruise of the T/V Umitaka Maru III of Tokyo University of Fisheries to Solomon Sea in 1989, we carried out a series of investigations focusing on the photosynthetic characteristics of phytoplankton from the SCM layer. In this paper, we describe the characteristics of the SCM layer with reference to the light conditions.

Materials and Methods

Studying area (5°43′S, 153°30′E) was located in the central part between Bougainville Island and New Ireland (Fig. 1). The depth was approximately 4,500 m. Seawater samples were collected by using Rossete multi samplers equipped with a CTD system (Neil Brown Co. Ltd.). For measurements of size distribution and photosynthetic activity of phytoplankton and nutrients, additional water samples were collected from 0, 25 and 75 m with a Van Dorn sampler. A series of this study was carried out in early December 1989.

For measurement of phytoplankton chlorophyll *a*, seawater samples of one liter were immediately filtered through glass fiber filters (Whatman GF/F) and the filters were kept frozen in a deep freezer at −30°C until analyses. The concentrations of chlorophyll *a* were determined with a Turner Designs 10-005R fluorometer according to the pro-

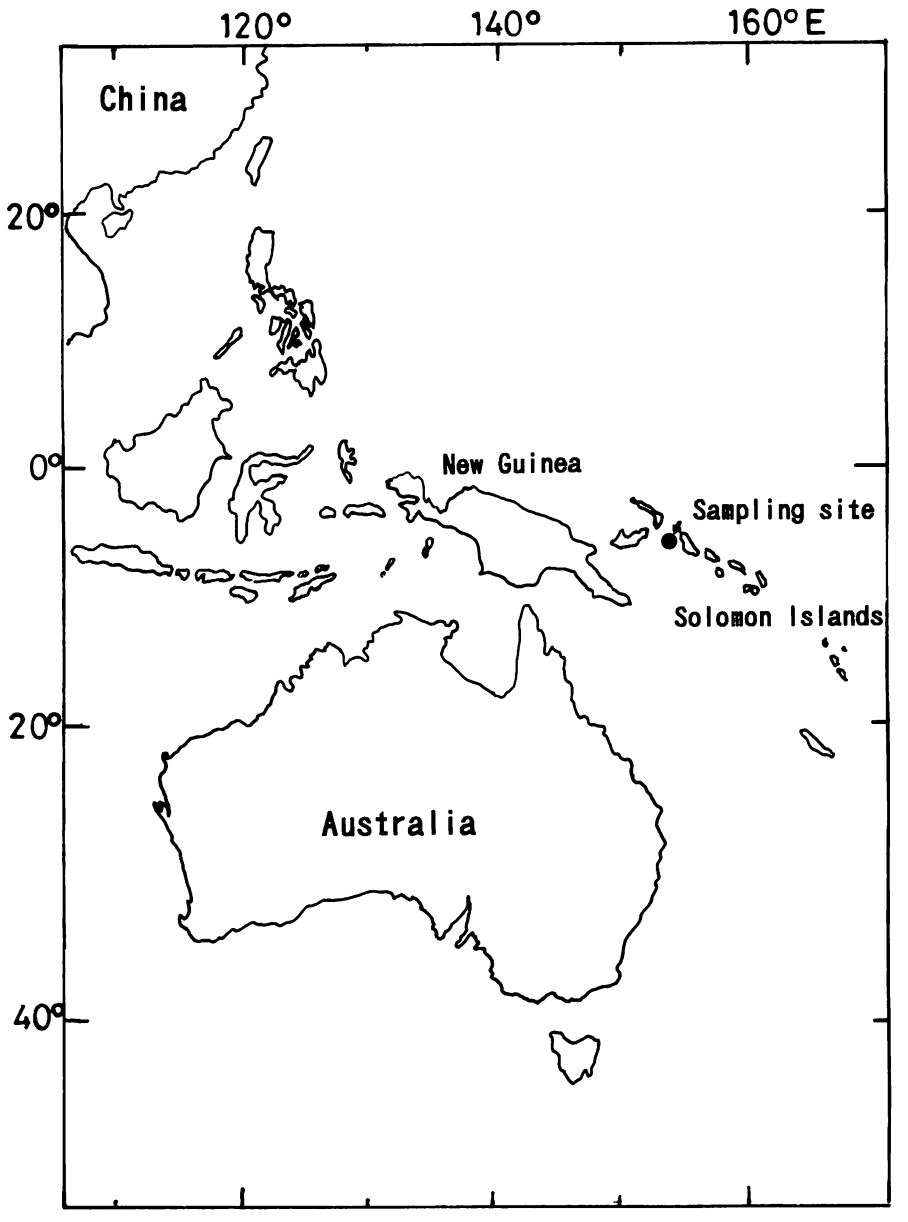

Fig. 1. The map showing location of sampling site (5°43′S, 153°30′E) in Solomon Sea.

cedures of Strickland and Parsons (1972). For determination of size distribution of phytoplankton, aliquots of seawater were filtered through membrane filters (Nuclepore 3 μm, General Electric Ltd.) and plankton nettings (Nitex, mesh size of 10 μm). Chlorophyll *a* concentrations in three fractions were determined fluorometically by the same method mentioned above.

Measurements of photosynthetic activity were made by the stable ^{13}C isotope method (Satoh *et al.* 1985). Water samples collected from 0, 25 and 75 m were transferred into 1000 ml clear polycarbonate bottles. After adding $NaH^{13}CO_3$ (10.7% of the final atom percent of ^{13}C, Prochem Co.) to the bottles, the samples were incubated for 6 hours in water bath controlled at 30°C under 325

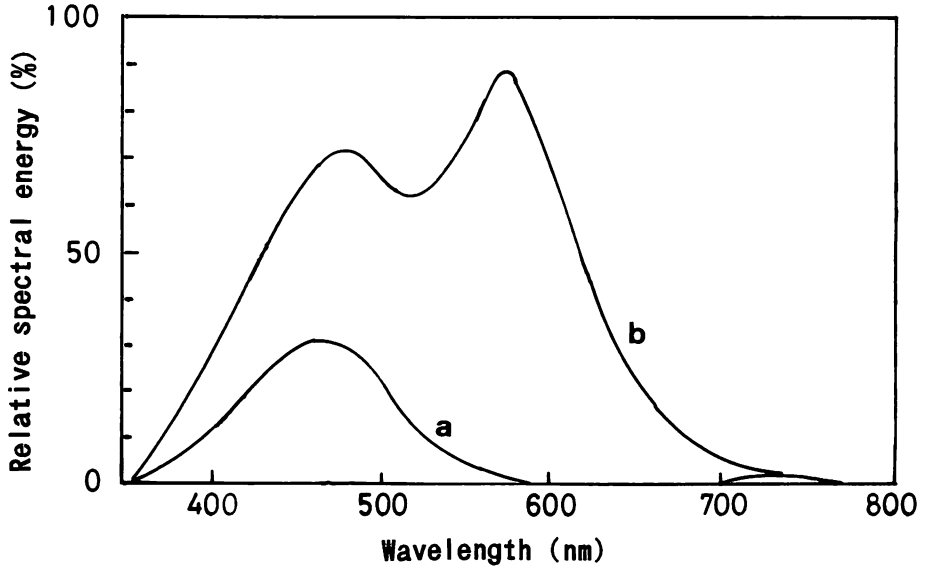

Fig. 2. Spectral energy distributions of blue light (a) and daylight fluorescence lamp (b).

$\mu E\, m^{-2}\, s^{-1}$ of daylight type fluorescence lamps (FL-40SD, Toshiba Co.), which have almost the same spectral irradiance energy as visible light at the range of 400-700 nm (Fig. 2). The light intensity was regulated by changing the number of neutral vinyl sheets wrapped around the bottles. The blue light source was also obtained by placing a blue filter of cellophane sheet in front of the lamps. After the incubation, the samples were filtered through glass fiber filters (Whatman GF/F) precombusted at 450°C for 4 hours. The filters were fumed with HCl for removing inorganic carbon, and the isotope ratios of ^{12}C and ^{13}C were determined by infrared absorption spectrometry with a ^{13}C analyzer (EX-130, JASCO). The photosynthetic rate was calculated by the method of Hama *et al.* (1983). Current velocities were determined with an Acoustic Doppler Current Profiler (CI-20-H ADPC, Furuno Electronic Co.).

Incident and underwater photosynthetically active radiation (PAR, 400-700 nm) was measured with an LI-1000 integrating quantum meter equipped with an LI-190SB air quantum sensor and an LI-192SB underwater quantum sensor, respectively. The underwater spectral irradiance was measured by an underwater irradiance meter (Ishikawa Industrial Co.) with eight interference filters of 422, 481, 513, 552, 599, 661, 682 and 709 nm.

Results and Discussion

Hydrography and light conditions in the study area

The direction of current and velocity of surface water were recorded, the latter being 30-60 cm s^{-1}. The vertical profiles of water temperature, salinity and density (sigma-t) at the study site are shown in Fig. 3a. The water column was well stratified. The water temperature in the mixed layer from surface to 75 m ranged from 30.4 to 29.6°C, and a thermocline developed in the deeper layer of 150-200 m.

A marked subsurface chlorophyll maximum (SCM) was observed at a depth of 75 m (Fig. 3b). The relative light level at the SCM layer was about 1.2% of the incident solar radiation at local noon under clear sky (Fig. 4a). The light penetrating to this depth was so weak that the photosynthesis was strictly restricted by light intensity, as mentioned by Jerlov (1976) and Kishino *et al* (1986). Further, the wavelength distribution of light energy was biased to the range of 481-

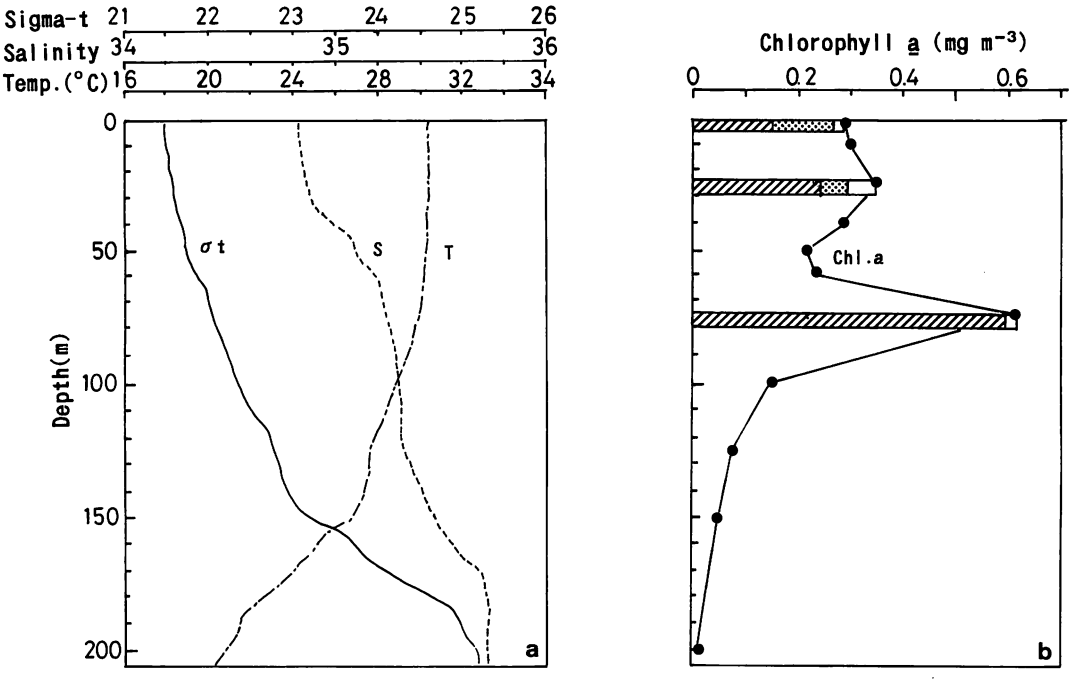

Fig. 3. (a) Vertical distributions of water temperature (T), salinity (S) and density (σt) in the upper 200 m layer. (b) Vertical profile of chlorophyll *a* concentrations (Chl. *a*) and size distribution of phytoplankton at surface, 25 and 75 m layers. The hatched, dotted and white bars indicates the fractions less than 3 μm, between 3 and 10 μm and more than 10 μm, respectively.

552 nm, and the attenuation coefficients at 481, 599 and 682 nm from surface to 10 m depth were 0.096, 0.143 and 0.377 m^{-1}, respectively (Fig. 4b). The light condition in this site was almost similar to those in the western Pacific Ocean (Matsuike 1973). Our results indicated that phytoplankton at the SCM layer could alive under such dim light and restricted wave length conditions.

The concentrations of nitrate, nitrite, phosphate and silicate at each depth are shown in Table 1. The concentrations of nutrients in surface and 25 m depth were extremely low, and increased with the depth around the SCM layer. The nutrient concentration in this area was almost the same as those in the subtropical regions (Yamaguchi and Ichimura 1980, Furuya and Marumo 1983).

In the SCM layer chlorophyll *a* concentration was 0.61 mg m^{-3} (Fig. 3b), which was 2.1 times higher than that in the surface water. The integrated chlorophyll *a* concentration from 50 m to 100 m occupied 46% (41.9 mg m^{-2}) of the total amount of chlorophyll *a* in the water column from the surface to 200 m.

Size distribution of phytoplankton

The pico-plankton (smaller than 3 μm) occupied the large parts of the fraction in every depth as shown in Fig. 3. It constituted 61% of the total chlorophyll *a* concentration, and in the SCM layer more than 90% of the chlorophyll *a* was contained in the pico-plankton. This result was coincident well with those in the tropical regions reported by Takahashi and Hori (1984) and Le Bouteiller and Herbland (1984). Phytoplankton of small size at the SCM layer was mainly composed of flagellates and monads, such as species of *Micromonas*, *Ochromonas* and *Synechococcus* (Johnson and Sieburth 1982, Furuya and Marumo 1983, Takahashi and Hori 1984). Therefore, it is concluded that the difference in vertical distribution of chlorophyll *a* concentration and size distribution of phytoplankton

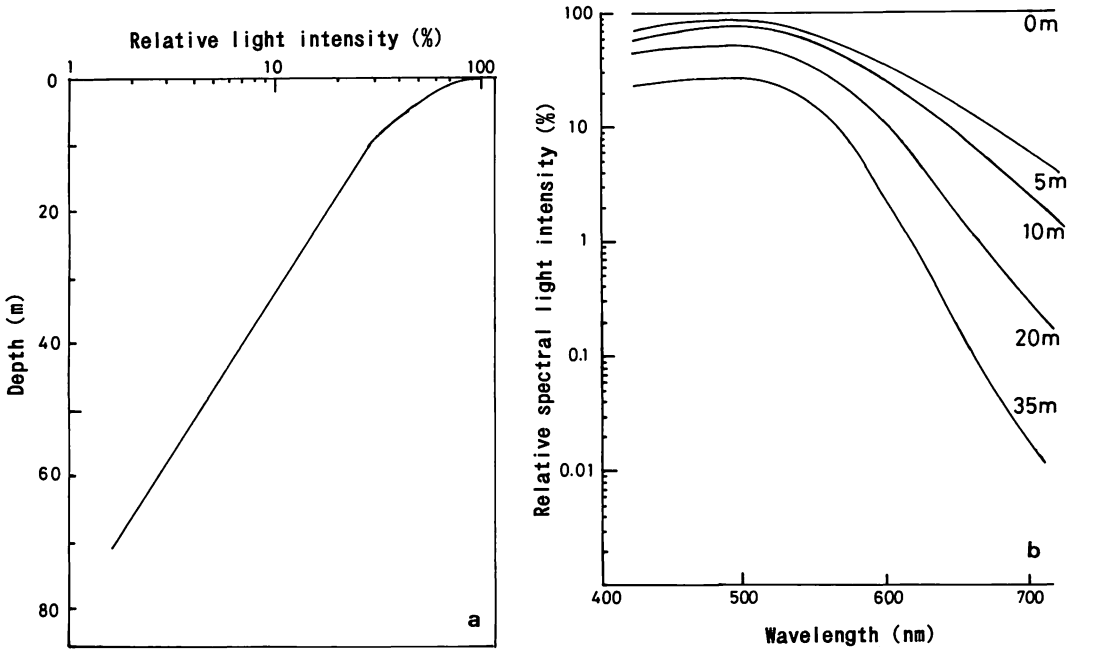

Fig. 4. (a) Relative underwater light intensity in the studying site. (b) Distributions of relative downward underwater spectral irradiance at the other site (7°40'S, 160°30'E) in Solomom Sea.

is due to the difference in species composition between the surface waters and the SCM layer.

Photosynthesis-light curves

Photosynthesis-light curves of phytoplankton from surface, 25 and 75 m layers were shown in Fig. 5a. In the curve of 75 m depth (SCM) the photosynthetic rate was 0.15 mgC mg·chl·a^{-1} h^{-1} at the saturation point of 35 μE m^{-2} s^{-1} which corresponds to 1.0% of downwelling irradiance around noon on a clear day in early December. As can be seen in Fig. 5b, such a low saturating light intensity for photosynthesis of the SCM phytoplankton suggested the shade adaptation of phytoplankton as indicated by several investigators (e.g. Ichimura *et al.* 1962, Shimura and Ichimura 1973). The photoinhibition of photosynthesis was clearly found at the irradiance stronger than 90 μE m^{-2} s^{-1} for the SCM sample. The maximum photosynthetic rate of the surface and 25 m depth samples was 0.75 and 1.1 mgC mg·chl·a^{-1} h^{-1}, respectively. As can be seen in Fig. 5a, high photosynthetic rates at the high saturating light intensities suggest that the phytoplankton at surface and 25 m layers adapted to higher light intensities. The difference in such characteristics as pho-

Table 1. Concentrations of nutrients at surface, 25 m and 75 m depth at the studying station.

Depth (m)	Silicate (μg-at l^{-1})	Phosphate (μg-at l^{-1})	Nitrate (μg-at l^{-1})	Nitrite (μg-at l^{-1})
0	4.79	0.70	0.51	0.024
25	3.52	0.72	0.87	0.027
75	2.91	0.70	0.85	0.025

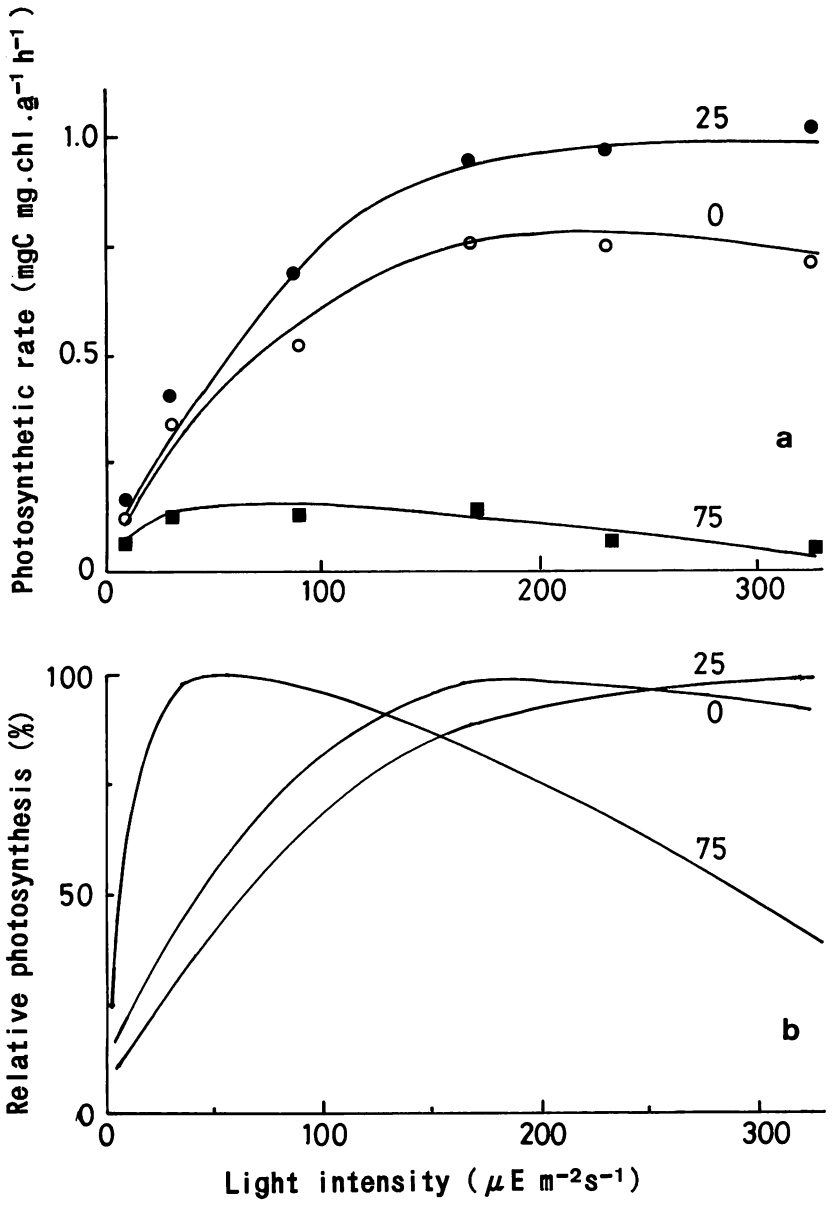

Fig. 5. Photosynthesis-light curves showed by per unit amount of chlorophyll *a* (a) and relative rate (b) of phytoplankton collected from surface, 25 and 75 m depth.

tosynthesis rate and saturation point in photosynthesis-light curves between shallow water and SCM layer phytoplankton may be caused by the light condition at each layer as mentioned above. The maximum photosynthetic production at surface at 25 and 75 m depths was 0.31, 0.50 and 0.086 mgC m^{-3} h^{-1}, respectively. These values were higher than those in the subtropical western north Pacific Ocean reported by Yamaguchi and Ichimura (1980), and lower than those in the tropical north Pacific Ocean described by Taguchi (1980).

Water samples from the surface and the SCM layers were incubated under the controlled light intensity of 35 μE m^{-2} s^{-1}.

Table 2. Quantum yield for photosynthesis [mgC mg·chl·a^{-1} h^{-1} (μE m^{-2} s^{-1})$^{-1}$] collected from surface, 25 m and 75 m depth under day-light (400–700 nm) and blue-light (400–550 nm) of 35 μE m^{-2} s^{-1}.

Depth (m)	$Q_{day\text{-}light}$	$Q_{blue\text{-}light}$	Q_{blue}/Q_{day}
0	0.015	0.0086	0.57
25	0.014	0.0078	0.56
75	0.0042	0.0044	1.05

Quantum yield of photosynthesis is determined by CO_2 molecules fixed in the biomass per quantum irradiance of light absorbed by phytoplankton (Kirk 1983). Quantum yields of photosynthesis at 35 μE m^{-2} s^{-1} under daylight (Q_{dl}) and under blue light (Q_{bl}) of phytoplankton collected from surface, 25 and 75 m depth were calculated (Table 2). The ratio of Q_{bl}/Q_{dl} is an index of utilization of blue light for photosynthesis (photosynthetic efficiency). Although the quantum yields of photosynthesis in the surface and 25 m layer samples under daylight and blue light were 1.8 times or more higher than those in the SCM, the photosynthetic efficiency of 1.05 for the SCM layer was about two times higher than those for the surface and 25 m samples. This means that the phytoplankton at the SCM layer adapted physiologically to low intensity of blue light by enhancing their photosynthetic activity similar to the cultured SCM microalgae reported by Kamiya and Miyachi (1980). Our result was also supported by the report of Ikeya *et al.* (1991) that the photosynthetic response of cyanophytes isolated from SCM layer in the Kuroshio region of Japan was active for blue-green light. This characteristic might be due to high concentration of phycoerythrin, as described by Ikeya *et al.* (1991). Futher investigations should be done in detail on the photosynthetic pigment system of phytoplankton collected from SCM layer.

In conclusion, the photosynthetic characteristic at the SCM layer was stongly influenced by the light conditions. Standing stock of chlorophyll *a* at the SCM layer was higher than those at the shallow layer, although primary production at the SCM was low because of dim light condition.

Acknowledgements

We wish to thank Prof. K. Matsuike, Tokyo Univ. of Fish., for his valuable suggestions and criticism. We are grateful to Captain K. Inoue, the officers and crew of the T/V Umitaka Maru III, Tokyo Univ. of Fish., for their cooperation during the cruise. Thanks are also extended to Prof. A. Aruga, Tokyo Univ. of Fish., and Prof. Y. Yamaguchi, Saitama Univ., for their encouragement and critical reading of the manuscript.

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佐藤博雄*・田中英夫*・小池　隆**：ソロモン海における亜表層クロロフィル極大層の光環境と光合成特性

1989年の12月上旬，ソロモン海の1測点(5°43′S, 153°30′E)において植物プランクトンの生産力を測定した。水深75 mに表層の約2.1倍の濃度(0.61 mg·chl·a m^{-3})をもつクロロフィル極大層(SCM)が認められ，この層の相対光強度は水面上の日射量の1.2%であった。クロロフィル極大を含む水深50–100 mのクロロフィルa積算値は水柱全体（0–200 mの積算値）の46%であった。クロロフィル極大層の植物プランクトンの光合成–光曲線で，光合成速度は35 μE m^{-2} s^{-1}で最大に達し0.15 mgC mg·chl·a^{-1} h^{-1}であった。青色光(35 μE m^{-2} s^{-1})を照射した場合の0，25および75 m層の植物プランクトンの昼光色光に対する光合成効率は，それぞれ57，56および105%であった。また，水深75 mのクロロフィル極大層における生産量(0.086 mgC m^{-3} h^{-1})は25 m層(0.50 mgC m^{-3} h^{-1})の17%であった。(*108 東京都港区港南4-5-7　東京水産大学，**514 三重県津市上浜町1515　三重大学生物資源学部)

Jpn. J. Phycol. (Sôrui) 40: 143–149, June 20, 1992

Regeneration of *Lithophyllum yessoense* Foslie in culture

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Fujita, D., Akioka, H. and Masaki, T. 1992. Regeneration of *Lithophyllum yessoense* Foslie in culture. Jpn. J. Phycol. **40**: 143–149.

The regeneration of *Lithophyllum yessoense* (Corallinales, Rhodophyta), a dominant encrusting coralline alga in Isoyake (urchin-dominated barren) area of southwestern Hokkaido, was examined by culturing crust fragments with artificially-made longitudinal fracture. In all conditions (water temperature, 5–25°C; irradiance, 25–1100 $\mu Em^{-2} s^{-1}$), regeneration occurred from the fractures. The regenerated thallus, consisted of primigenous and postigenous filaments, grew rapidly in higher temperatures, in higher irradiances, and in earlier stages of culture. The marginal and thickness growth rates of the regenerated thalli were much larger than cultured one-year-old plants and natural perennial plants previously reported for the same species.

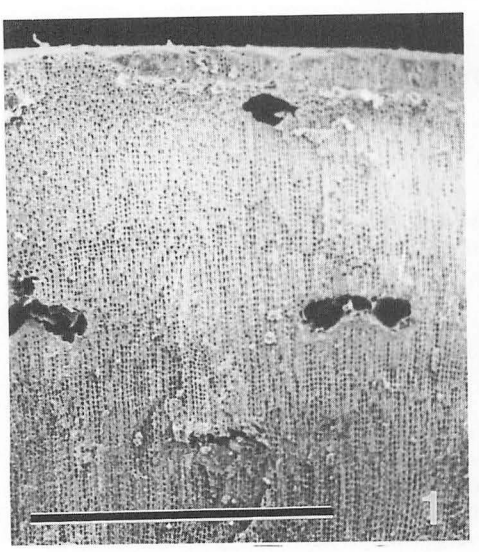
Key Index Words: Corallinaceae—Epithallial shedding—Growth rate—Isoyake—Lithophyllum yessoense—*Regeneration—Rhodophyta*

In Isoyake (urchin-dominated barren) areas along the southwestern coast of Hokkaido, subtidal substrata have been covered extensively by nongeniculate coralline algae (Corallinales, Rhodophyta), among which the perennial encrusting species *Lithophyllum yessoense* Foslie is dominant (Noro et al. 1983; Fujita 1989). This species grows slowly (Fujita 1990a, b), but its thallus surface is comparatively clean as a result of epithallial shedding (Masaki et al. 1981, 1984). It can survive grazing by sea urchins or limpets (Fujita 1992) and may suffer physical or biological damage (e.g., collision with rolling stones; strong wave action in winter; artificial removal by 'chain-swinging' method 《Nabata and Matsuda 1983》; movement of creeping animals), and consequently a large part of the plant may be lost. Artificial injury is more serious in terms of volume of lost thallus than the slight wound caused by herbivore grazing (Fujita 1992). However, there is no information on the response of this species to heavy injury. In the present paper, results of experiments on regeneration of fragmented pieces of thalli of *L. yessoense* are reported.

Materials and methods

Thalli of *L. yessoense* were removed by chiseling from subtidal rocky bottoms (1–3 m depth) at Taisei, Hiyama Province of southwestern Hokkaido on Mar. 5, 1984 and Aug. 14, 1985. Plants were immediately brought alive in sea water to the laboratory in Hakodate. Healthy thalli of several square centimeters were selected, and were broken into 4 or 5 pieces. The pieces from one thallus were placed in a waterbath (3 *l*) filled with sea water (2 *l*).

In the first experiment (Exp. I) in Mar. 1984, triplicate waterbaths were placed in three incubators set at 5, 10, and 15°C, respectively; all of the incubators were subject to light conditions of 12: 12LD with 150 $\mu Em^{-2} s^{-1}$. After 42 days, all pieces were taken out, and either fixed and decalcified with Susa's solution (Gray 1954) for measurement of length and thickness of regenerated thallus or airdried for scanning electron



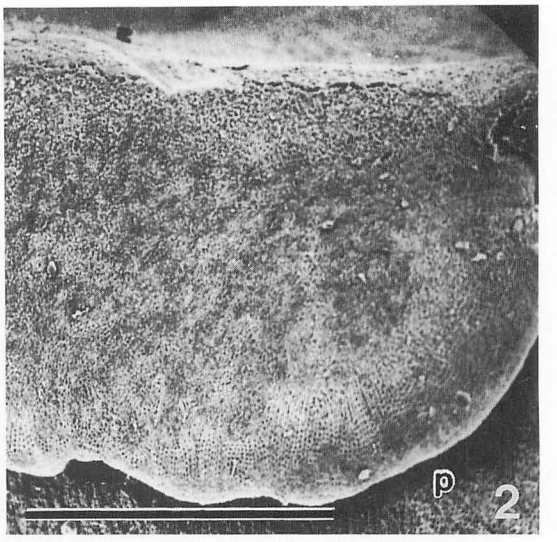


Fig. 1 Longitudinal fracture of *Lithophyllum yessoense*.

Fig. 2 The regenerated thallus extended downward the parent fragment (p) (65 days, 25°C–1100 $\mu Em^{-2} s^{-1}$). Scale bars = 100 μm

microscopy.

In the second experiment (Exp. II) in Aug. 1985, triplicate waterbaths were placed in an incubator at 25°C, and each was cultured under 3 different levels of irradiance, 25, 150 and 1100 $\mu Em^{-2} s^{-1}$, respectively. One piece of thallus from each triplicate was taken out for observation in the same way as Exp. I after 5, 15, 30 and 65 days.

Along the coast of southwestern Hokkaido, the sea water temperature is the lowest (5°C) in February and highest (25°C) in August (Fujita 1989), so that the lowest temperature in Exp. I and the highest temperature in Exp. II correspond to the winter and summer conditions, respectively.

The size (length and thickness) of regenerated thallus was measured on cross sections of paraffin-embedded decalcified pieces with a light microscopic scale. Structure of regenerated tissue was observed with a scanning electron microscope (SEM-25, Nihon Denshi K. K.), using air-dried pieces coated with gold-palladium.

Results

Morphological observation

In all conditions (water temperature: 5–25°C, irradiance: 25–1100 $\mu Em^{-2} s^{-1}$), regeneration occurred (Figs. 2–8) from fractures (Fig. 1).

At first, regeneration was initiated from one or a few distal parts where columnar cells were pigmented (Fig. 3). The regenerated thallus increased in thickness and then extended downward along the longitudinal fracture of the parent fragment (Figs. 2, 4–6). The tip of the well-developed regenerated thallus was separated from longitudinal fracture of the parent fragment.

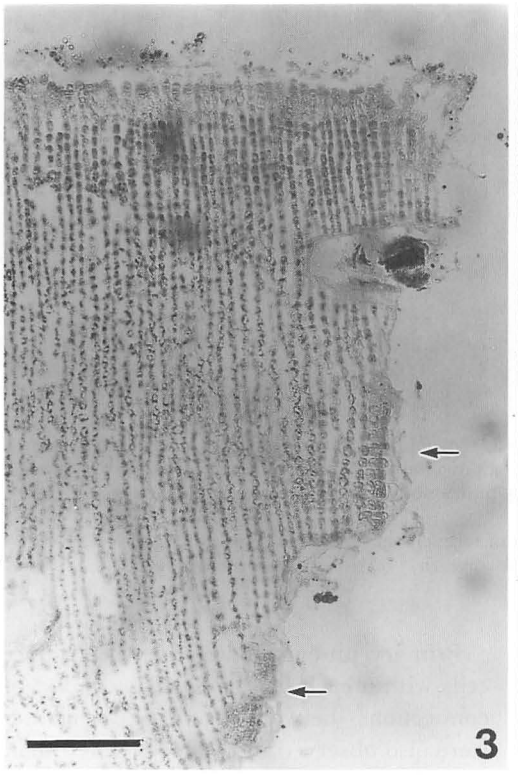
While the regenerated thallus remained at-

Fig. 3 Regenerated thallus initiated at two distal points (arrows) of a longitudinal fracture (15 days, 25°C–25 $\mu Em^{-2} s^{-1}$).

Fig. 4 Regenerated thallus (65 days, 25°C–25 $\mu Em^{-2} s^{-1}$), consisting entirely of postigenous filaments. The outermost epithallial layer is sloughing off (arrow).

Fig. 5 Regenerated thallus (65 days, 25°C–1100 $\mu Em^{-2} s^{-1}$), in which the tip is separated from parent fragment. The outermost epithallial layer was sloughing off (arrow).

Fig. 6 SEM of the free tip shown in Fig. 5, showing the primigenous cells (pr) aligned in rows from the ventral surface view. Scale bars = 100 μm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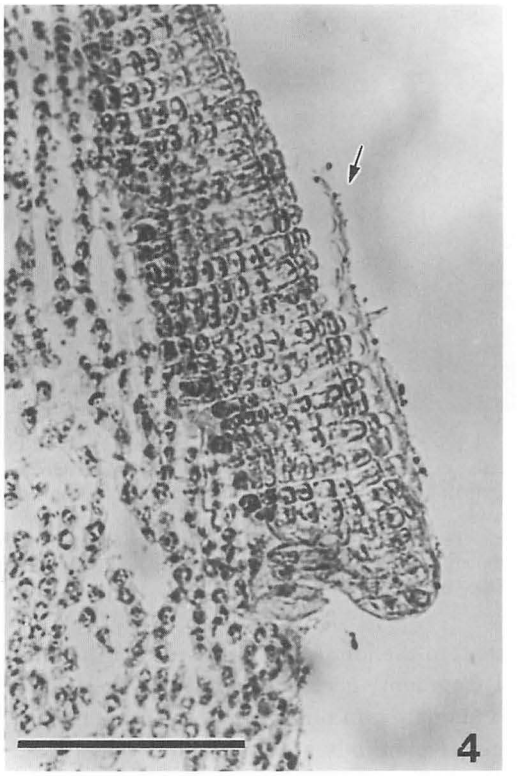
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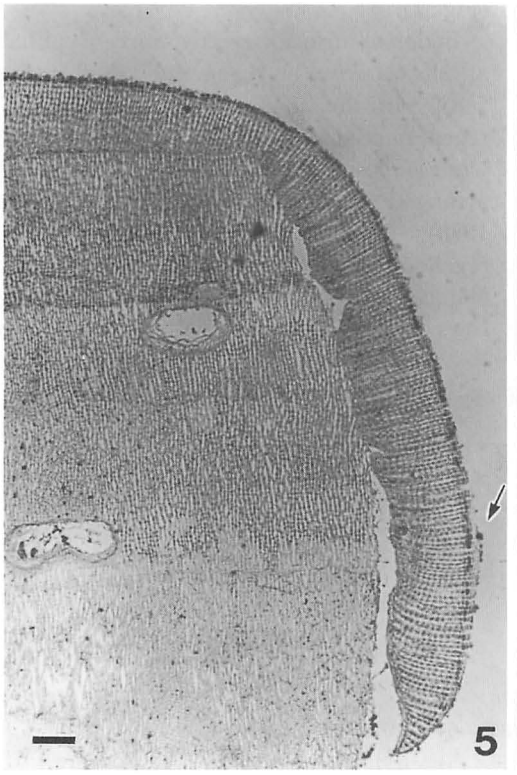
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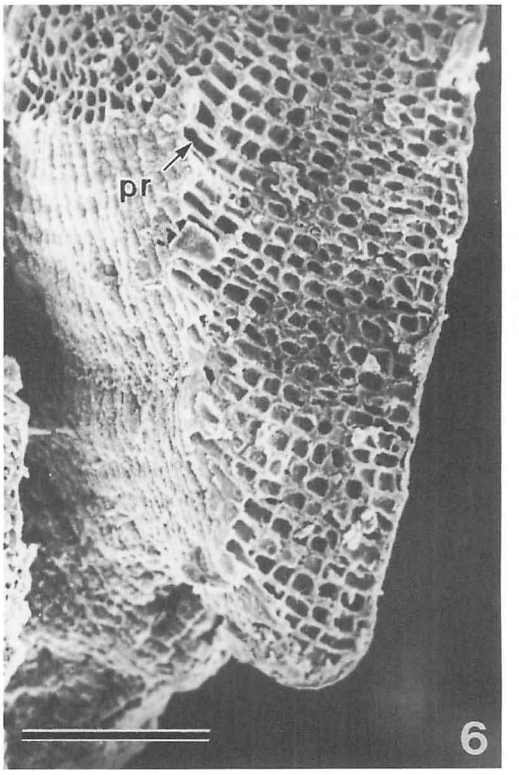
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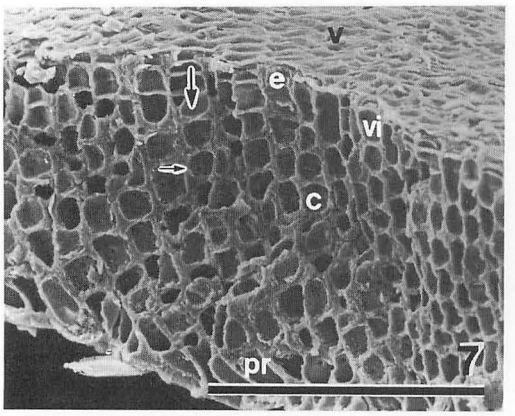

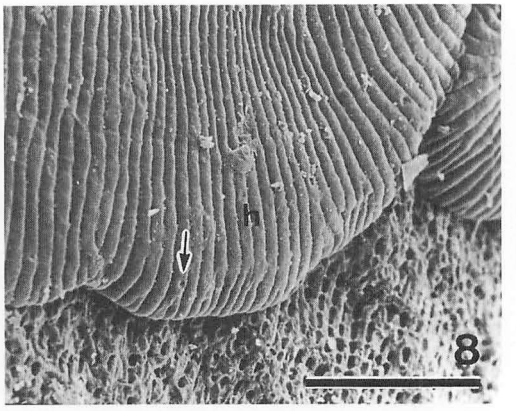

Fig. 7 Enlargement of regenerated thallus in Fig 6, showing filaments: primigenous cells (pr), columner cells (c) vegetative initials (vi) and epithallial cells (e). Epithallial cells (concavities) are arranged in vertical-growth type (v). Large and small arrows show primary pit-connections and secondary pit-connections, respectively.

Fig. 8 SEM of dorsal surface view of the margin of regenerated thallus, (65 days, 25°C–150 $\mu Em^{-2} s^{-1}$), showing epithallial cells arranged in horizontal-growth type (h). Arrows show the epithallial concavities. Scale bars = 100 μm

tached to the longitudinal fracture of the parent fragment, it consisted only of postigeneous filaments, in other words, columner cells, vegetative initials and epithallial cells (Figs. 3-4).

However, in the free tip where regenerated thallus became separated from the longitudinal fracture of the parent fragment, the ventral part was composed of newly developed primigenous filaments (Figs. 5-6) (See Woelkering 1988 for terminology of 'primigenous' and 'postigeneous'). In ventral surface view, the primigenous cells of the regenerated thallus were aligned in rows (Fig. 6).

Primary pit-connections between adjacent cells within each filament and secondary pit-connections between contiguous filaments were also observed in the regenerated thallus (Fig. 7).

In dorsal surface view, two sorts of epithallial cells occurred on regenerated thallus (Figs. 7-8). In the thickened central region of regenerated thallus, the dorsal surface (Fig. 7) was composed of honeycomb-like, randomly-arranged epithallial concavities (Garbary 1978). On the other hand, at the margin of regenerated thallus, epithallial cells were aligned in rows, and grooves between the cell rows were prominent (Fig. 8). The former

Table 1. Size (length × thickness, μm) of regenerated tissue (N = 1 in each condition) of *Lithophyllum yessoense*.

Water temperature (°C)	Irradiance ($\mu Em^{-2} s^{-1}$)	Time (days)				
		5	15	30	42	65
Exp. I						
5	150				733 × 17	
10	150				935 × 32	
15	150				1,542 × 55	
Exp. II						
25	25	341 × 33	670 × 61	—		—
25	150	414 × 29	786 × 64	1,072 × 117		1,286 × 143
25	1100	543 × 34	943 × 154	1,415 × 240		1,629 × 343

type of epithallial cell arrangement is referred to 'vertical growth-type', and the latter, 'horizontal-growth type' in the juvenile plant of the same species (Fujita 1990b). On the dorsal surface of some regenerated thallus consisting of epithallial cells of 'vertical growth-type', shedding of most distal layer of epithallial cells was observed (Figs. 4–5).

Growth of regenerated tissue

Sizes of all regenerated thalli are listed in Table 1. In Exp. I, the new thallus grew most rapidly at 15°C, and most slowly at 5°C, both in length and in thickness. And in Exp. II, regenerated thallus grew most rapidly at 1100 $\mu Em^{-2} s^{-1}$, and most slowly at 25 $\mu Em^{-2} s^{-1}$ both in length and in thickness. In the highest temperature-lowest irradiance condition examined (i.e. 25°C-25 $\mu Em^{-2} s^{-1}$), parent fragments did not survive after 15 days.

Discussion

The phenomenon of regeneration is known to occur in a wide range of marine algae (Buggeln 1981). In nongeniculate coralline algae, however, little has been known up to now, although Cabioch (1972) observed natural regeneration in many nongeniculate coralline genera. In *Lithophyllum*, she described the same pattern of regeneration in *Lithophyllum incrustans* Foslie and *Lithopyllum* sp., and called it 'reappearence of juvenile structure' (in original text of Cabioch, 'reapparition de structures juveniles'). The regeneration pattern of *L. yessoense* seems to be similar in producing primigeneous filaments which correspond to 'pseudo-hypothallium' (in original text of Cabioch, faux hypothalle').

Woelkerling (1988) noted that dimerous nongeniculate coralline algae are composed of two kinds of filaments: primigenous and postigenous filaments. The structure of regenerated thallus was dimerous like the original thallus.

The development of primary and secondary pit-connections in regenerated thallus was confirmed in the present study. These pit-connections may be important for translocation of nutrients and gas, as Steneck (1983) suggested in the case of wound-healing of grazed coralline algae, though this hypothesis requires further experimental confirmation.

Using the data of growth of regenerated thallus in Table 1, the annual marginal growth rates and thickness growth rates were calculated (Table 2). Both marginal and thickness growth rates increased at higher water temperature and at higher irradiance. These growth rates, however, decreased as the culture period became longer, probably because of reduction of exposed fracture surface.

Moreover, the annual growth rates of regenerated thallus were compared with those calculated from data of the annual plants cultured from tetraspores (Fujita 1990a) and natural perennial plants (Fijita 1990b) of the same species (Table 3). Both marginal and

Table 2. Annual growth rates (marginal × thickness, mm/year) of regenerated tissue of *Lithophyllum yessoense* calculated from data in Table 1.

Water temperature (°C)	Irradiance ($\mu Em^{-2} s^{-1}$)	Time (days)				
		5	15	30	42	65
Exp. I						
5	150				6.4×0.1	
10	150				8.1×0.3	
15	150				13.4×0.5	
Exp. II						
25	25	24.9×2.4	16.3×1.5	—		—
25	150	30.2×2.1	19.1×1.6	13.1×1.4		7.2×0.8
25	1100	39.6×2.5	22.9×3.7	17.3×2.9		9.1×1.9

Table 3. The comparison of annual growth rates (mean value and range, mm/year) of *Lithophyllum yessoense* among regenerated tissue, cultured annual plants and natural perennial plants.

Type of material	Marginal	Thickness	References
Newly generated tissue (N=13)	17.6 (6.4–39.6)	1.7 (0.1–3.7)	Present study
Cultured annual plants (N=10)	2.3 (1.6– 3.4)	0.2 (0.1–0.3)	Fujita (1990a)
Natural plants (N=100)	1.8 (0.6– 5.4)	0.5 (0.2–2.4)	Fujita (1990b)

thickness growth rates of regenerated thallus were much greater than those of cultured plants and natural plants. The comparatively high growth rates of regenerated thallus, especially in early stages of culture (in other words, just after getting damaged), must be the result of a high potential capability to recover rapidly.

The occurrence of regenerated thallus in all culture conditions suggests that this species can recover from fractures any time of year. The high growth rates of regenerated thallus in 25°C corresponds to the high photosynthetic activity at the same temperature in summer (Fujita 1988).

This study was not focused on examining the minimum thallus size for regenerating, but the recoverability of this species seems quite high, because the pieces examined in this study were much smaller than plants found naturally, which can be up to 30 cm^2 in size. In addition, the occurrence of epithallial shedding on the dorsal surface of regenerated thallus may be recognized as the recovery of the antifouling function, which was previously confirmed in the case of parent thalli (Masaki et al. 1981, 1984). Therefore, the regeneration seems to be the most important survival strategy of this nongeniculate coralline alga against various physical or biological damage as well as herbivore grazing (Fujita 1992) on the 'Isoyake' areas. The fate of regenerated thallus (e.g., reattachment to substratum of its free tip, maturity within the regenerated thallus) is unknown.

Acknowledgements

We are highly grateful to Dr. Wm. J. Woelkerling for his critical reading of the manuscript.

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藤田大介*・秋岡英承**・正置富太郎***：培養によるエゾイシゴロモの再生

北海道南西岸の磯焼け地帯の優占種エゾイシゴロモの細片を培養し，破砕面における再生を調べた。再生は実験範囲 (5–25°C, 25–1100 $\mu Em^{-2}s^{-1}$) 内のいずれの条件でも起こった。再生部の組織は初生的細胞糸及び後生的細胞糸で構成されており，水温及び光強度が高いほど，また，培養の初期ほど再生速度が速かった。さらに，再生した組織の縁辺成長速度及び肥厚成長速度は，以前に報告した同種の培養1年目個体及び天然産の多年個体の場合にくらべて非常に大きかった。(*936 滑川市高塚364　富山県水産試験場　**040 函館市八幡町1–2　北海道教育大学函館分校生物学教室　***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)

Jpn. J. Phycol. (Sôrui) **40**: 151–159, June 20, 1992

The structure and physiological properties of the cytoplasm in intact *Valonia* cell.

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Shihira-Ishikawa, I. and Nawata, T. 1992. The structure and physiological properties of the cytoplasm in intact *Valonia* cell. Jpn. J. Phycol. **40**: 151–159.

The structure and physiological characteristics of the protoplasm-layer were studied in the intact cell of *Valonia ventricosa* (*Ventricaria ventricosa*). Scanning and transmission electron microscopy revealed the three dimensional organization of the cytoplasm. The cytoplasmic matrix existed as a thin layer surrounding the chloroplasts and nuclei. Many spaces between each chloroplasts were continuous with each other and were continuous with the central vacuole. Therefore the edge of the central vacuole entered into the protoplasm-layer with intricate structure.

The turgor pressure of the intact *Valonia* cell was determined to be 3.2 atm according to the difference between the osmotic values of the vacuolar sap and of the culture medium. Ion concentrations in the vacuolar sap were determined spectrochemically. Free Ca^{2+} and Cl^- were analyzed using Ca^{2+} electrode and Ag-AgCl electrode, respectively. Significance of the each ion concentration in the vacuole is discussed.

It was observed that the loss of turgor pressure upon wounding caused the disorganization of microtubule systems which had been essential for organization of the intact protoplasm-layer and resulted in the induction of aplanospore formation.

Key Index Words: cytoplasmic matrix—ion concentration—microtubule organization—osmotic value—protoplasm-layer—stereo view—turgor pressure—vacuolar sap—Valonia.

The thallus of *Valonia ventricosa* (*Ventricaria ventricosa*, Siphonocladales) (Fig. 1) is a multinucleate vesicular cell, reaching several centimeters in diameter. A thin layer of protoplasm is located on the inner surface of the cell wall, covering a huge central vacuole. The organization of the protoplasm-layer in *V. ventricosa* is sustained by two microtubular systems, the cortical and nuclear microtubules (Shihira-Ishikawa, 1987), similar to *Ernodesmis* and *Boergesenia* (La Claire 1987, La Claire and Fulginiti 1991).

In common with several species of Siphonocladales, *Boergesenia forbesii* (Enomoto and Hirose 1972, O'Neil and La Claire 1984) and *Dictyosphaeria cavernosa* (Enomoto and Okuda 1981), *V. ventricosa* segregates its protoplasm and forms numerous protoplasts by mechanical induction (Kopac 1933). However, the mechanism of the protoplast formation has not been elucidated. Regarding the study of the mechanism of protoplast morphogenesis in *Valonia*, basic knowledge about the morphology and physiology of the cytoplasm in the intact cell has been lacking.

In this paper, to investigate the protoplasmic organization of the intact cell of *V. ventricosa*, several methods of microscopy were used

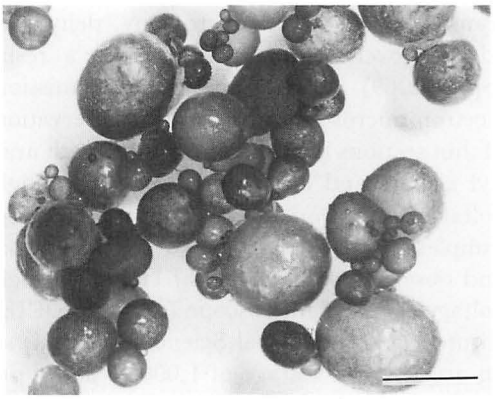

Fig. 1. Cells of *Valonia ventricosa* cultured in synthetic medium. Cells stick together by entwining rhizoids. Scale bar=5 mm.

and its physiological characteristics were discussed by measurement of the osmotic value and ion concentrations of vacuolar sap.

Material and Methods

Valonia cells

Valonia ventricosa grown in the aquarium in Kushimoto Marine Park, Wakayama, Japan, was kindly provided by Dr. S. Ui in 1989. A unialgal culture, which was started from the aplanospores, has since been maintained using Müller's synthetic sea water (Müller 1962). Cells were maintained in vessels at 22°C and under 1500 lux illumination (12: 12 hr LD) with daylight fluorescent lamps. The diameter of the cells increased about 2-3 mm per month. Cells 3-5 mm in diameter were used for the observations.

Electron microscopy

Cells were fixed in 2% glutaraldehyde in 35 mM cacodylic acid with 1% tannic acid for 2 hr at room temperature and 1% OsO_4 for 1 hr at 4°C after washing out the glutaraldehyde. Fixed cells were cut into several pieces and dehydrated stepwise in ethanol. For scanning electron microscopy, ethanol was replaced by isoamyl acetate and samples were critical-point dried in liquid CO_2 (JCPD-5, JEOL). The mounted dry cell pieces were coated with gold-palladium using ion spatter (JFC-1100, JEOL) and observed with a scanning electron microscope JEOL F-15. For transmission electron microscopy, dehydrated cells were embedded in Spurr's resin (Spurr 1969). A Hitachi H-300 transmission electron microscope was used for observation of thin sections after double staining with uranyl acetate and lead citrate. For ultrahigh voltage electron microscopy, Spurr embedded samples were sectioned (0.5-1.0 μm thick) and observed with a Hitachi H-1250M high voltage electron microscope (at National Institute for Physiological Science, Okazaki) at an accelerating voltage of 1,000 kv and a tilt angle of $+/-8°$.

Osmotic value

Osmotic values of the vacuolar sap and the culture medium were measured with a vapor pressure osmometer (Type 5500, Wescor, USA). Before measuring the osmotic value of the vacuolar sap, culture medium on the cell surface was removed with a filter paper. The vacuolar sap was then directly squeezed out onto a small filter paper disk (6 mm in diameter) by cutting the cell. For the culture medium, 10 μl of the medium was put on the filter paper disk. Calibration of the osmometer was carried out with NaCl solution of 200 mmol/kg and of 1,000 mmol/kg.

Ion concentration

Vacuolar sap was aspirated with a syringe after the cell was washed in distilled water and the water was immediately removed from the cell surface with filter paper to avoid the contamination by water outside the cell. Both in the vacuolar sap and in the culture medium, concentrations of four ions, K^+, Na^+, Mg^{2+} and Ca^{2+}, were measured by atomic absorption spectroscopy (Seiko Atomic Absorption/Frame Spectrophotometer SAS/760 connected with a terminal computer, NEC PC9801UV). Free Cl^- concentrations in the vacuole and in the culture medium were determined with an Ag-AgCl electrode (Mailman and Mullins 1966, Tazawa et al. 1974). Electric potential of an Ag-AgCl electrode in the test solution was measured against another Ag-AgCl electrode (reference electrode) which was immersed in a saturated KCl solution and connected to the test solution through an agar salt bridge containing 100 mM KNO_3 and 2% agar. Free Ca^{2+} concentration of the vacuolar sap and external medium were measured with a Ca^{2+} electrode (Philips, Ion selective electrode Ca^{2+}).

Indirect immunofluorescence

Whole cells were immersed in chilled methanol for 10 min and immediately transfered into phosphate buffered saline (PBS). The cell was cut gently in PBS on a glass slide with microscissors (Nisshin EM) and extra PBS was removed with filter paper. A prima-

ry antibody (monoclonal anti-alpha-tubulin mouse IgG, Amersham) was applied to the fixed cell pieces on the glass slide and the sample was incubated in a wet chamber for 30 min at 37°C. After washing with 0.03% Tween 20-PBS for 15 min, an FITC-labelled secondary antibody (anti-mouse Ig, fluorescein linked whole antibody, sheep, Amersham) was applied. The sample was incubated for 30 min at 37°C and washed again with 0.03% Tween 20-PBS for 15 min. The samples were mounted with p-phenylendiamine-glycerol (1 mg/ml, pH 8.0) and were observed with a epifluorescent microscope (Olympus BH2-RFK) with 490 nm excitation and G520 absorption filter.

Results

Fine structure of protoplasm-layer

Scanning electron microscopic observation showed the intricate organization of the protoplasm-layer which covered the inner surface of the cell wall (Fig. 2). Many spaces were observed in the protoplasm-layer which were continuous with each other and were also continuous with the central vacuole. Therefore, the surface of the central vacuole, which corresponded to the tonoplast, was extremely irregular with a fine intricate structure.

Most of the protoplasm was occupied by disc-shaped chloroplasts which were spread over the plasma membrane. The edge of these chloroplasts lay one above the other (Fig. 3a). However, further overlapping was disturbed by the starch accumulated around the pyrenoids which existed at the center of each chloroplast (Fig. 3a and b). Nuclei were located at the vacuolar side of the chloroplast layer (Fig. 3a and b). Each of the chloroplasts as well as the nucleus was covered by a thin layer of cytoplasmic matrix (Fig. 3c and d) and therefore each chloroplast was attached to the other *via* the cytoplasmic matrix (Fig. 3d). Mitochondria were observed in the cytoplasmic matrix around the chloroplasts and nuclei (Fig. 3d). Ultrahigh voltage electron microscopy enabled the visualization of the three dimensional images of the localization of chloroplasts and nuclei (Fig. 4).

Turgor pressure of the cell

The osmotic value of the vacuolar sap was 1092 mmol/Kg on average, while that of the culture medium was 964 mmol/Kg (Table 1). The difference between them was about

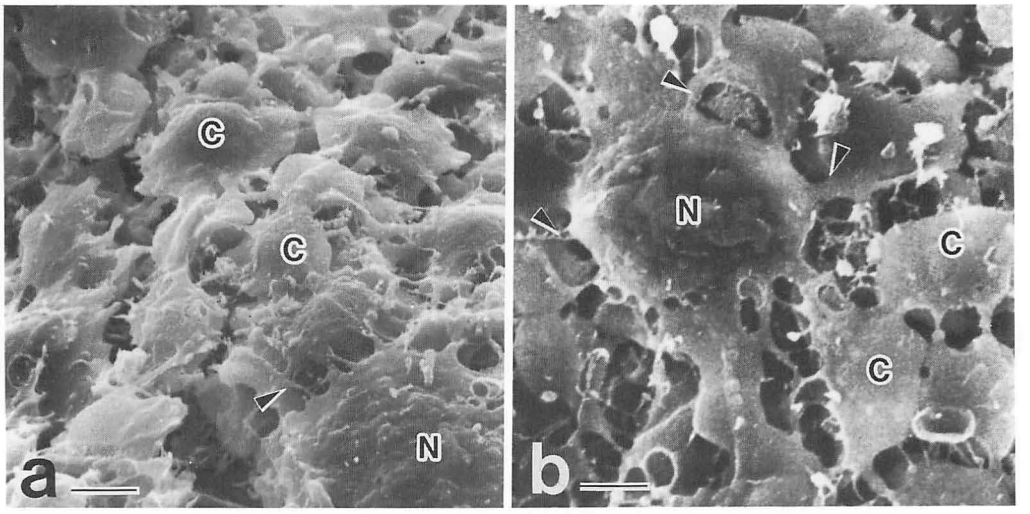

Fig. 2. Scanning electron micrographs showing the surface of protoplasm-layer facing the center of *Valonia* cell. The cell was cut into several pieces and the protoplasm-layer adhering to each piece was observed from the inside of the cell, that is, from the vacuolar side of the protoplasm-layer. Scale bars=2 μm a. tangential view. b. diametrical view. Protoplasm-layer is sponge-like and protoplasmic strands (arrowheads) are observed which are radially extending from nucleus to chloroplasts. C, chloroplast; N, nucleus.

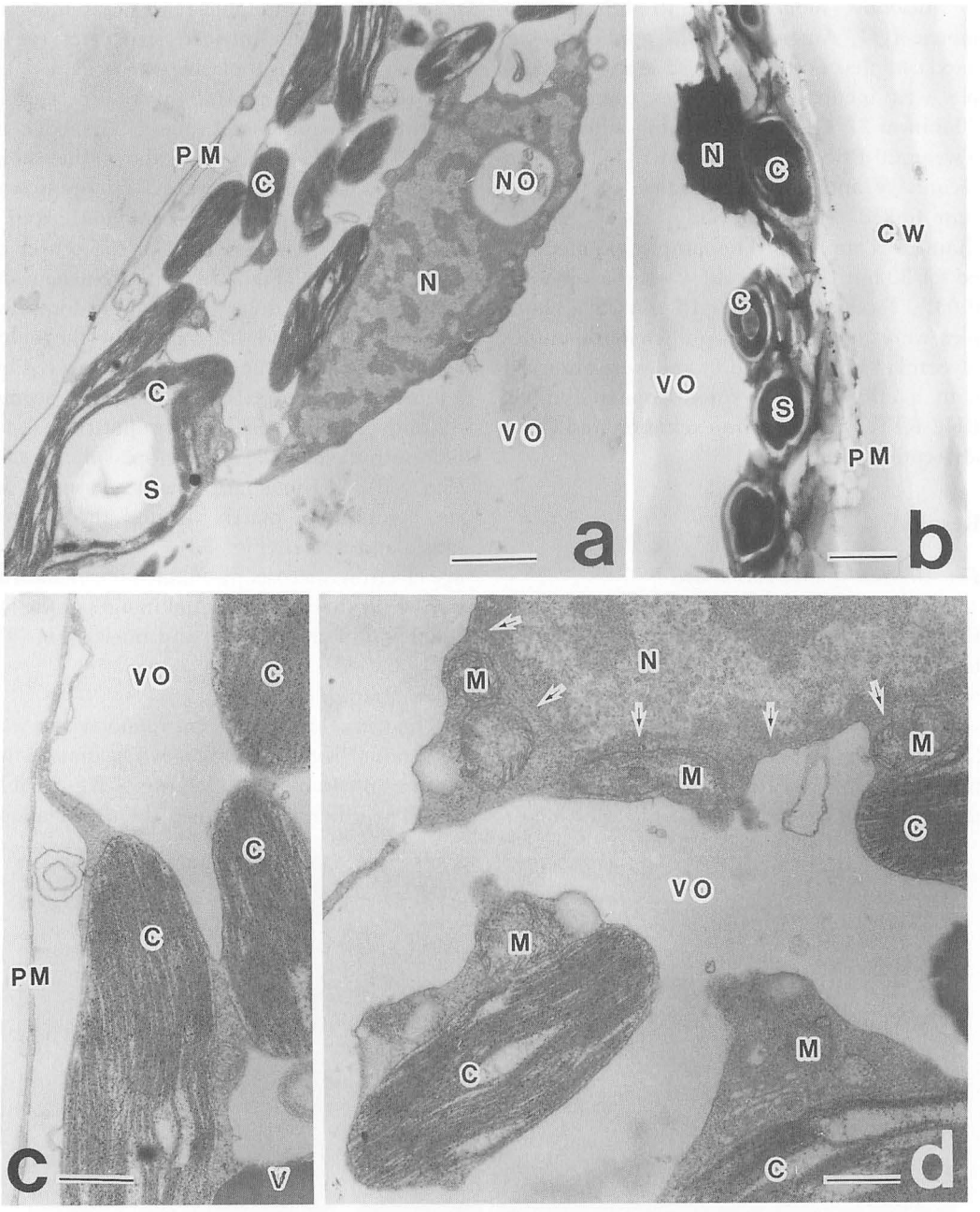

Fig. 3. Transmission electron micrographs of the protoplasm-layer. a. oblique section of the protoplasm-layer: Nucleus is situated on the chloroplast-layer, at the vacuolar side of the protoplasm-layer. The overlapping edges of chloroplasts are layered beneath the nucleus. Scale bar=2 μm. C, chloroplast; N, nucleus; NO, nucleolus; PM, plasma membrane with a layer of cytoplasmic matrix; S, starch accumulated in chloroplast; VO, vacuole. b. Thick section (1 μm thick) of the protoplasm-layer observed with high voltage electron microscope, showing the arrangement of chloroplasts. Only the edges of chloroplasts are piled up, because the overlapping of the whole chloroplast is interrupted by the accumulation of starch. Scale bar=5 μm. C, chloroplast; S, starch; N, nucleus; VO, vacuole; CW, cell wall; PM, plasma membrane. c and d. Cross sections of the protoplasm-layer. A thin layer of cytoplasmic matrix exists around the individual nucleus and chloroplast. Scale bar=0.5 μm. C, chloroplast; M, mitochondria; N, nucleus; V, vesicle; PM, plasma membrane with a layer

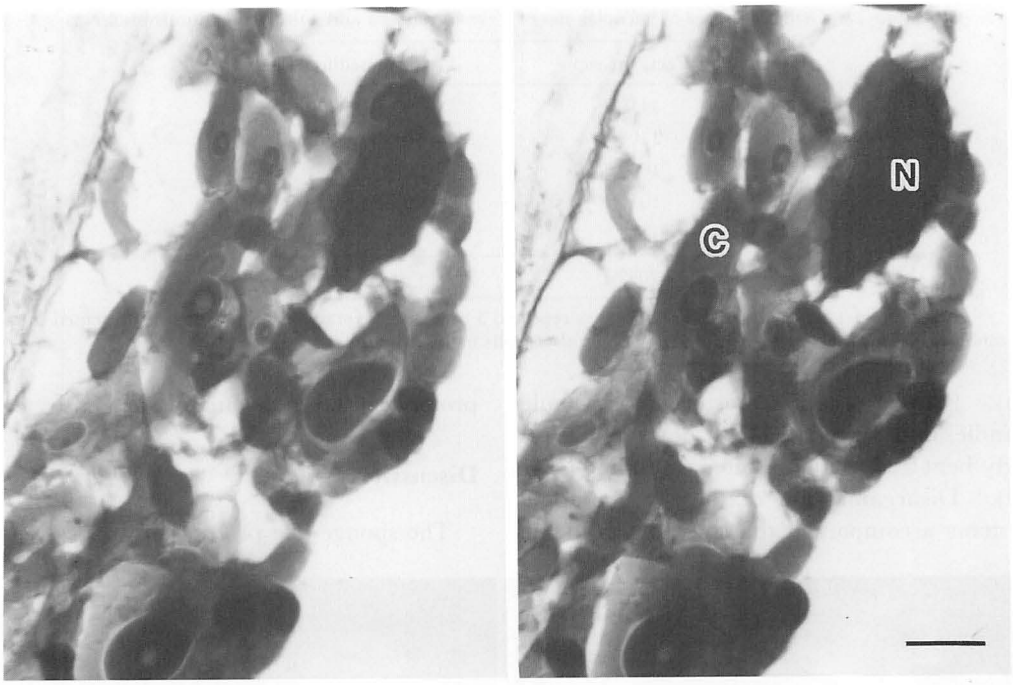

Fig. 4. Ultrahigh voltage electron micrographs showing stereo-image of the protoplasm-layer. The slant sectional views of the protoplasm-layer demonstrate three dimensional arrangement of chloroplasts and nuclli which forms a sponge-like structure of protoplasm. N, nucleus; C, chloroplast. Scale bar=2 μm.

128 mmol/Kg, which corresponds to 3.2 atm after van't Hoff's equation. Accordingly the turgor pressure of an intact cell was 3.2 atm under this culture condition.

Ion concentration in vacuolar sap

The concentrations of major cations in vacuolar sap and in culture medium, K^+, Na^+, Mg^{2+} and Ca^{2+} were determined with frame spectrophotometer and calcium eletrode (Table 2). Concentration of K^+ was about twenty times higher in the vacuolar sap than that in the culture medium, while Na^+ was about six times lower in the vacuolar sap than that in the culture medium. Free Ca^{2+} concentration in vacuolar sap which was determined with a calcium electrode was 0.5 mM, while total Ca^{2+} which was obtained by spectrochemical analysis, was 1.06 mM, showing that a considerable amount of bound Ca existed in the vacuole. Cl^- was 520 mM in vacuolar sap. Assuming that each of the major cations was a chloride form in the vacuolar sap, a solution containing 78 mM NaCl, 523 mM KCl, 26 mM $MgCl_2$ and 1 mM $CaCl_2$ was prepared. The osmotic value of this solution was determined as 1190 mmol/Kg, which was approximately the same value as that of the vacuolar sap (Table 1).

Microtubule organization in protoplasm-layer

Microtubular systems, that is, the nuclear microtubules and cortical microtubules, were disorganized simultaneously throughout the entire cell when the turgor pressure decreased upon wounding. Radially extending arrays of the nuclear microtubules in the intact cell (Fig. 5a) were lost almost 30 min after being wounded, although the ones lying close to the nuclear envelope were relatively intact (Fig.

of cytoplasmic matrix; VO, vacuole. In c, cytoplasmic matrix connecting individual chloroplast is continuous to the cytoplasmic matrix which is contiguous to plasma membrane. In d, mitochondria are located in the large masses of cytoplasmic matrix around nucleus and chloroplasts. Arrows indicate the nuclear envelope.

Table 1. Osmotic values of vacuolar sap of *Valonia ventricosa* and culture medium (mmol/Kg)

	Vacuolar sap	Culture medium
	1119[1)]	
	1109[2)]	965 (fresh medium)
	1068[3)]	
	1053[4)]	963 (used medium)
	1113[5)]	
Ave.	1092	964

[1)–5)] Different cells. Each measurement was repeated 3 times, the average value of which is presented in the table. Used medium, the medium in which *Valonia* cells had been cultured for a week.

5b). Parallel arrays of cortical microtubule bundles in the intact cell (Fig. 5c) were irregularly bent about 30 min after wounding (Fig. 5d). Disorganization of these microtubule systems accompanied the corrugation of the protoplasm-layer throughout the entire cell.

Discussion

The sponge-like protoplasm in *Valonia ven-*

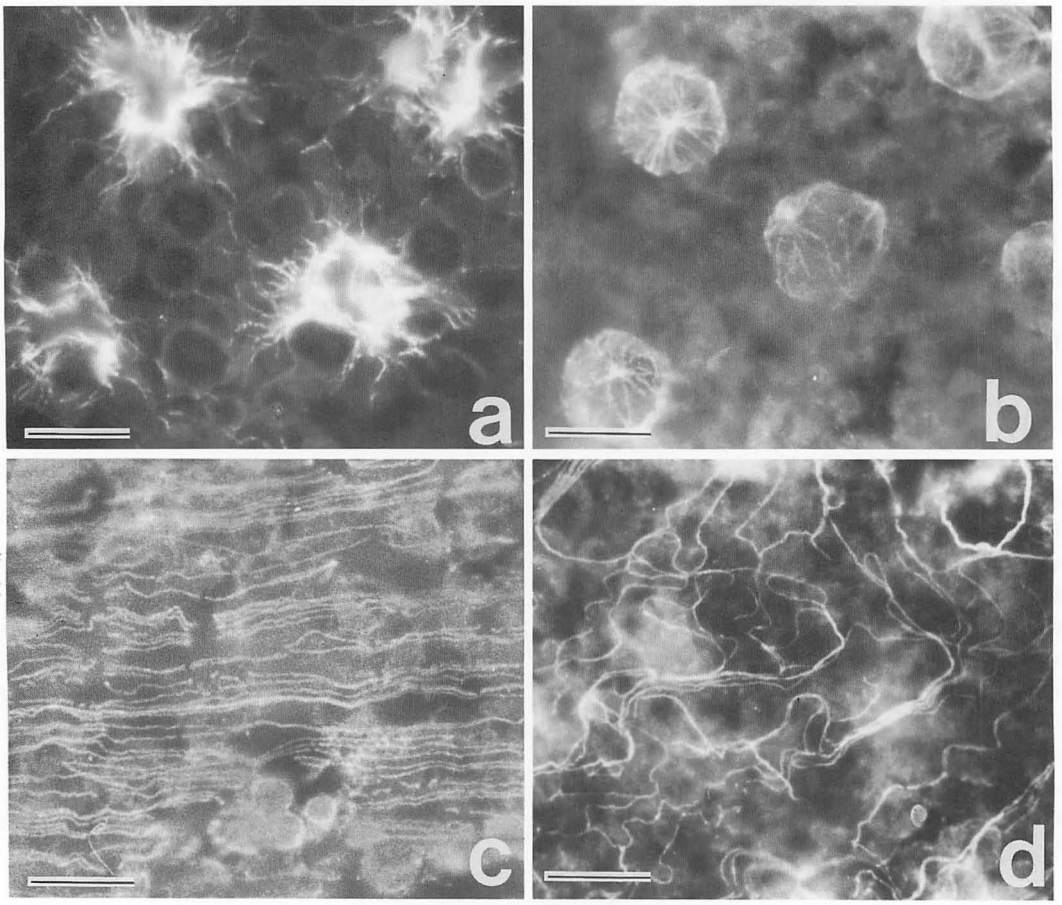

Fig. 5. Microtubule organization observed by indirect immunofluorescence. Scale bars=10 μm. a and b, nulcear microtubule systems; c and d, cortical microtubule systems; a and c, microtubule systems in intact cell; b and d, microtubule systems in wounded cell, 30 min after the reduction of turgor pressure.

Table 2. Ion concentration in vacuolar sap of *Valonia ventricosa* and the culture medium (mM)

	Cl^-	Na^+	K^+	Mg^{2+}	Ca^{2+}	Free Ca^{2+}
Vacuolar sap	520	78	523	26	1.06	0.53
Culture medium	420	500	25	48	15.9	4.8

1. Na^+, K^+, Mg^{2+} and Ca^{2+} were determined by atomic absorption spectroscopy.
2. Cl^- was determined with Ag-AgCl electrode.
3. Free Ca^{2+} was determined with calcium electrode.

tricosa lies between the cell wall and the large central vacuole, forming a thin layer less than 10 μm in thickness. The two distinct components of the protoplasm-layer are chloroplasts and nuclei. The chloroplasts are tightly arranged on the inner surface of the plasma membrane and the nuclei are distributed evenly on the inner surface of chloroplast layer (Fig. 6). Chloroplasts and nuclei are individually surrounded by a thin layer of cytoplasmic matrix and are connected each other *via* this layer in which mitochondria and vesicles were detected (Fig. 6). The radial arrays of cytoplasmic matrix extending from nucleus to chloroplasts were observed by scanning electron microscopy. These arrays apparently corresponded to the radially extending microtubule organizations which were observed with immunofluorescence as nulcear microtubules, suggesting the latter lies in the arrays of cytoplasmic matrix. The microtubule bundles in these arrays possibly connect the nucleus to the chloroplasts and sustain the protoplasm-layer.

Actin cytoskeleton was investigated with immunofluorescence, but no filaments were observed (data not shown). La Claire (1984, 1989) reported that actin bundles were disassembled in the intact cells of *Ernodesmis* and *Boergesenia*, though they were revealed during the process of wound healing. Possibly in *V. ventricosa* the disassembled actin bundles were present in the cytoplasm, although actin bundles were not detected.

The outer surface of the protoplasm-layer adheres to the cell wall via the plasma membrane, while its inner surface meshes with the outer surface of the central vacuole in an intricate fashion (Fig. 6). This sponge-like protoplasm is equilibrated with the turgor pressure

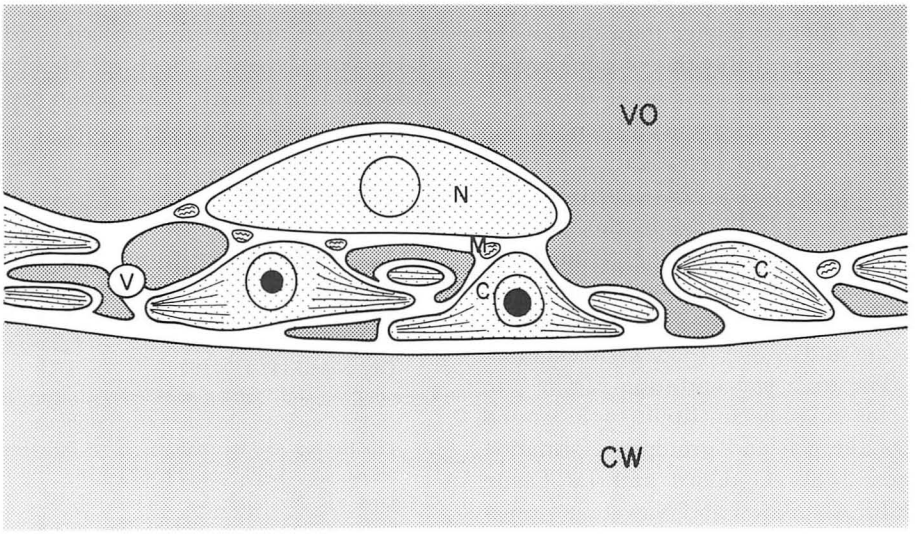

Fig. 6. Illustrated cross section of protoplasm-layer. Edge of central vacuole enters into protoplasm-layer with intricate structure. Each chloroplast and nucleus is surrounded by a thin layer of cytoplasmic matrix (white area). VO, vacuole; N, nucleus; C, chloroplast; V, vesicle; M, mitochondria; CW, cell wall.

of the central vacuole. The microtubule organization likely sustains this fragile structure of the protoplasm-layer.

The difference of osmotic pressures between the culture medium and the vacuolar sap was about 128 mmole/Kg which generates the turgor pressure of 3.2 atm in the intact cell.

The concentrations of K^+, Na^+, Mg^{2+} and Ca^{2+} in the vacuolar sap were measured by atomic absorption spectroscopy. The concentrations of K^+, Na^+ were approximately the same as those of K^+ and Na^+ which had been reported by Gutknecht and Dainty (1968). Extremely high concentration of K^+ was obtained in the vacuolar sap and it is likely correlated with the turgor pressure. Cl^- concentration was measured using Ag-AgCl electrode and was higher in vacuolar sap than that in culture medium. A solution containing NaCl, KCl, $MgCl_2$ and $CaCl_2$ prepared as the same concentrations as each of these cations found in the vacuolar sap (Table 2) showed approximate osmotic value to that of vacuolar sap. This suggests that the majority of the major cations in vacuolar sap is the chloride form. The facts that the total concentration of the major cations was higher in some degree than the concentration of Cl^- in the vacuolar sap and the osmotic value of this solution was slightly higher than that of the vacuolar sap are probably due to some organic anions or inorganic ions other than Cl^-. The preparation of an artificial vacuolar sap in *Valonia* cell is under investigation.

The protoplasm lies between two high Ca^{2+} solutions; 5×10^{-4} M in the vacuolar sap and 5×10^{-3} M in the culture medium. The cytoplasm must be maintained in a state of low Ca^{2+} concentration, less than 10^{-6} M (Williamson and Ashley 1968, Okazaki et al. 1987). The high concentration of Ca^{2+} in the vacuolar sap may contribute to the wound healing of the cell and protoplast formation (La Claire 1982, Goddard and La Claire 1991, Shihira-Ishikawa and Nawata in preparation).

The turgor pressure is lost immediately when the cell is wounded, as part of the cell sap is ejected through the wound. More than 30 min after wounding, the protoplasm-layer is partially detached from the cell wall and becomes corrugated, along with the destruction of microtubule organization. It is not known whether the disorganization of microtubule bundles is the cause of the corrugation of the protplasm-layer or the result. However, distortion of the cortical microtubule systems and the loss of the radially extending nuclear microtubules suggest that the mechanical destruction of the microtubule systems occurs after the corrugation of the protoplasm-layer. In any case, the microtubule systems were disorganized after the loss of turgor pressure upon being wounded. It is undoubted that the loss of turgor pressure and the following disorganization of microtubule systems were essential factors for aplanospore induction in intact *Valonia* cells.

Acknowledgements

The authors express their sincere thanks to Dr. J. W. La Claire II, The University of Texas, U.S.A. and Dr. M. Kikuyama, The University of the Air, Japan for their valuable advice throughout this work. We are also grateful to Dr. M. Asai, Osaka Medical College, for his kind help in measuring Ca^{2+} with the electrode and to Dr. S. Sasaki and Dr. I. Nakagaki, Hyōgo College of Medicine, for their kind help with observation using the high voltage electron microscope.

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石川依久子・繩田　利寿：多核緑藻バロニアの細胞質構造と生理学的特性

巨大単細胞性多核緑藻オオバロニア *Valonia ventricosa* (*Ventricaria ventricosa*) の原形質は細胞壁直下にスポンジ状の薄層をなしている。この原形質層を走査型および透過型電子顕微鏡で三次元的に観察した。細胞基質は個々の葉緑体や核を個別に薄く包み，それぞれの葉緑体や核は，この細胞基質の薄い層を介して接している。また核から放射状にのびる細胞基質は，核と葉緑体を連結している。細胞基質の外縁は液胞と接しているので中心液胞の縁辺部は原形質層の中に複雑に入り込んでいることになる。液胞液の主イオンの濃度を原子吸光，カルシウム電極および銀—塩化銀電極で測定し，各イオン濃度の生理学的意義を考察した。液胞液と外液（合成培地）の浸透価の差から算出したバロニア藻体の膨圧は3.2気圧であった。藻体に傷をつけることによって膨圧が減少すると，原形質層の構造を保持していた微小管系が崩壊し，原形質が凝集し不動胞子形成が誘導される。（184 東京都小金井市貫井北町4–1–1　東京学芸大学生物学教室）

藻類 Jpn. J. Phycol. 40: 161–166, June 20, 1992

接合藻類と羽状珪藻類にみられる配偶子のう接合の由来

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Nakahara, H. and Ichimura, T. Convergent evolution of gametangiogamy both in the Zygnematalean green algae and in the pennate diatoms. Jpn. J. Phycol. **40**: 161–166.

The Zygnematalean green algae and most of the pennate diatoms share the same type of sexual reproduction, so called gametangiogamy. The gametes are non-flagellated and are brought together by a prior pairing of their mother cells. This gives us an important viewpoint to infer the evolution of this type of sexual reproduction. We suggest that it has evolved from oogamy not only in the pennate diatoms but also in the Zygnematalean green algae when ancestral forms of both the algae invaded new shallow water habitats by changing their life style during the Cretaceous. The shallow water habitats, because of the large stress caused by occasional drought, are presumed to be favourable more for algae with large-sized zygotes by oogamy than for those with small-sized zygotes by isogamy. Oogamy, however, might not be convenient for such algae to make a sufficient number of zygotes, because the movement of flagellated male gametes might be restricted by the paucity of water. On the other hand, such habitats also might endanger the ancestral forms by embedding their vegetative cells into the muddy bottom or by depleting nutrients around them, if they could not move out or around on the surface of muddy bottom by means of the gliding mechanism which is well-known for the Zygnematalean green algae and the pennate diatoms. Such gliding movement could have evolved gametangiogamy which has an advantage to improve the inconvenience of sexual union by oogamy. We suggest that such evolution could be possible by heterochrony in which genes for sexual approach and some parts of conjugation process are expressed in gametangial, instead of gametic, cells and that by the accomplishment of the prior gametangial pairing, gametes produced by a male gametangium could be equalized in number and consequently in size to those produced by a female gametangium.

Key Index Words: evolution of sexual reproduction—gametangiogamy—isogamy—non-flagellated gamete—pennate diatom—Zygnematales
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水中で生活する藻類にとって，鞭毛を持った細胞を形成することは，配偶子の接近及び動胞子による個体の分散などに非常に有利である。このため有性生殖が知られている多くの藻類では，雌雄の両方または雄性の配偶子に鞭毛が存在する。しかし紅藻類，接合藻類ならびに羽状珪藻類の有性生殖においては，鞭毛を持った配偶子は全く形成されない。紅藻類はもともとの起源より，鞭毛を持たなかったと考えられているが (Searles, 1980)，接合藻類と羽状珪藻類については，系統的には鞭毛を持っていたグループより生じたと考えられている (Stewart and Mattox, 1978; 堀，1983; Round and Crawford, 1981, 1984; Mann and Marchant, 1989)。しかし，接合藻類と羽状珪藻類は系統的にかなり異なっているだけでなく，生活環の型も前者は単相環，後者は複相環とまったく異なっている（市村，1981)。しかしこの両者では，栄養細胞と同形の配偶子のうが接合し，その後各配偶子のう内に1個または2個の無鞭毛の配偶子が形成され，ほぼ同形の配偶子がアメーバ様の運動を行って接合子を形成するという，配偶子のう接合がみられるという点で共通している (Wiese, 1969)。

多くの羽状珪藻類でみられる配偶子のう接合は，現生の中心珪藻類ならびに一部の羽状珪藻類 (Subba Rao et al., 1991) で知られている卵子生殖に由来するが，その間のギャップは大きいと考えられる (Drebes, 1977)。羽状珪藻類が示す種々の生活特性のうち，どのような特性を獲得したことが，卵子生殖から配偶子のう接合が進化するのに有効であったか，またその過

程などについては考えられていない。一方，接合藻類で見られる配偶子のう接合についても，それらがかつて，陸上の湿った環境で生活していた痕跡であるとの説 (Stebbins and Hill, 1980) があるが，その有性生殖法がどのようにして進化したかについては説明されていない。微細構造の研究によると，接合藻類は主として水中で生活している多くの緑藻類とは別系統に属し，陸上に進出した緑色植物が卵子生殖を獲得する前にそれらの系列から分かれたと考えられている (Melkonian, 1982)。しかし，著者らは接合藻類の配偶子のう接合も，羽状珪藻類と同様に，卵子生殖に由来すると考えている。その根拠ならびに，それらがどのような環境のもとで，配偶子のう接合による有性生殖へと進化していったかについて，珪藻類とあわせて考えてみたい。

有性生殖法の進化と生育環境

下等真核生物にみられる様々な有性生殖法は，同形配偶から，異形配偶へと進化し，そして，大きくなった雌配偶子が運動能力を失い，卵子生殖が生じたと考えられている (Bell, 1978; Hoekstra et al., 1984; Cox and Sethian, 1985)。すなわち，一方の性が小さな配偶子に分裂することで数と運動力を増し，接合の確率を高め，次世代への資源確保については，接合相手の配偶子が所有するものに頼りきるという戦略（小配偶子戦略）が生じると，それに対応して，他方が資源を接合相手に頼れないために，自ら大きな配偶子を作り接近する相手を選ぶという戦略が発達する可能性がある (Parker et al., 1972; Parker, 1978; Maynard Smith, 1978)。同形配偶に留まるか異形配偶が進化するかは，形成される接合子の数と生存率が関係する。その理論的考察において，一定の大きさの配偶子のう (M) が分裂することによって，ある大きさの配偶子 (m) を n 個形成すること，すなわち $M=m\times n$ が前提条件とされており，小さな配偶子は多数形成されるが大きな配偶子は少数しか形成されない。大きな配偶子同志の合体が最も大きな接合子を形成するがその数は最も少なく，小さな配偶子同志の合体が最も小さな接合子となるが最も数が多く形成される。言うまでもなく，大小の配偶子の合体による接合子は，数と大きさにおいてその中間の値となる。

より大きな接合子はより高い生存率を示すと考えられるが，そのような接合子が無条件に形成されるわけではない。接合子の大きさの変異が接合子の生存率にほとんど影響を与えないような条件では，より小形の配偶子を多数形成する変異個体の遺伝子は，より大形で少数の配偶子を形成する変異個体の遺伝子よりも子孫に伝えられる確率が高いため，世代を重ねるにつれ，配偶子として機能できる最小の配偶子を最も多く形成する個体が集団を占めるようになることが予想される。従って，このような条件下では同形配偶が安定であると考えられる。しかし，接合子の大きさの変異が接合子の生存率に大きく影響する条件下では，もし仮に同数の配偶子が形成されるとすると，生存率の高い大形の接合子の要素となる大形の配偶子を形成する変異個体の方が，生存率の低い小形の接合子の要素となる小形の配偶子を形成する変異個体よりも，数多くの遺伝子を子孫に伝えることになる。ところが上記の前提条件のとおり，小形の配偶子はより多数形成されるため，大形の配偶子と比較して受精の確率がより高い。このため，大形の配偶子を形成する変異個体のみが集団を占めることはなく，小形の配偶子を形成する変異個体の存続または浸入の可能性が常に存在する。従って，接合子の大きさが選択される条件下では，異形配偶が進化的に安定な戦略と考えられる (Maynard Smith, 1978, 1982)。

上記は鞭毛で水中を自由に運動する配偶子について考察されたものであるが，異形配偶により雌雄性がより進化するにつれて，多数形成される雄配偶子はより小形化し，運動性を増すのに対して，少数しか形成されない雌配偶子はより大形化し，ついには運動能力を失い卵となり，卵子生殖にまで進化するものと考えられている。卵子生殖を行うようになったものでは，雄性配偶子の無駄はそれほど資源の損失にはならないが，受精の失敗による雌性配偶子の無駄は，資源の損失の度合いが大きい。そこで，多くの資源を含んだ雌配偶子はその無駄を少なくするためにフェロモンを放出し，雄配偶子を誘引する機構を発達させ，運動能力の高い雄配偶子による受精を確実なものとしている。

それでは実際に藻類の場合，どのような環境のもとが同形配偶にとって好ましく，どのような環境が異形配偶にとって好ましいかを考えてみる。接合子の主な死亡要因が環境ストレスではなく，病原菌の寄生や中，大形動物プランクトンなどによる補食などの様に偶然の機会に大きく左右される場合は，接合子の生存率はその大きさとあまり関係しない場合が多いと考えられる。このような場合には，小さくてもより多数の接合子を作る方が有利である。逆に接合子の主な死亡要因が環境ストレスである場合には，数が少なくても，ひ

とつひとつが多くの資源を持った接合子を形成して，そのストレスに耐えたほうが有利である。Madsen and Waller (1983) は淡水産緑藻類と黄金藻類の生育場所と有性生殖法との関係を文献から調査し，異形配偶の究極の様式である卵子生殖を行うものは，池などの浅い水域で生活するものが多く，同形配偶を行うものは，大きな安定した水域で生活するものが多いことを明らかにした。これは浅い不安定な水域，すなわちストレスの多い環境に適応したものには，異形配偶を経て卵子生殖にまで進化したものが多いことを意味しており，上記の理論の結果と良く合っている。

Parker et al. (1972) は上述の理論とは別に，実際にどのようにして異形配偶が進化したかを考察した際に，有性生殖法は体の構造の複雑さと関係が深いのではないかと考えた。これは栄養体が単細胞であるような単純な体制しかとらないものは，同形配偶を行い，複雑な組織を形成するようなものが異形配偶を進化させる傾向があるというものである。つまり単細胞性の生物では，生き残るのに接合子の数が重要であり，多細胞性の生物では，発芽後の造形に多くのエネルギーが必要なため，接合子に多くのエネルギーを注入しておく必要があるためだという考えが基礎にある (Bell, 1978)。しかしこれには例外が非常に多いことが彼らを悩ませた。そのため Bell (1982) は，単細胞性の生物でも配偶子を形成する際に母細胞が大きくなってから配偶子を形成するものでは同形配偶を行い，母細胞が大きくならない，あるいはむしろ小さくなってから配偶子を形成するものでは，異形配偶となると考えた。これにより中心珪藻類の卵子生殖は説明されるが，なぜこのような現象が珪藻類以外でも一般的に生じるかの根拠は十分には示されていない。藻類の有性生殖法は Madsen and Waller (1983) が指摘しているように，生育環境と関係が深いと考えるほうが妥当である。

珪藻類と接合藻類の有性生殖法の進化の要因

羽状珪藻類ならびに接合藻類でみられる有性生殖法，すなわち配偶子のう接合は，遊泳配偶子を持たないため，もし各個体が広い水中に分散して生活している場合には，あまり効率的に受精が行われるとは考えにくい。しかし，現在ある分類群中に含まれている種数が多いほど，それらの分類群がよく繁栄しているとすると，羽状珪藻類ならびに接合藻類は，現在非常によく繁栄していることになる。

常に大量の水に囲まれた環境のもとに生育している藻類でも，雌配偶子が次世代のための資源のほとんどを担っているものが多いが，1つの細胞からいくつかの雌配偶子が形成されるものでは，雌配偶子も鞭毛を持ち，運動能力を保つことにより受精の確率を高め，接合子数の確保を行っている。また，より大きな雌配偶子（卵細胞）を形成して鞭毛を失ったものでは，雄配偶子は小さく，多量に作られ，鞭毛によって卵細胞のほうへ活発に泳いでいく。鞭毛による運動は，卵子生殖においても非常に重要である。中心珪藻類では，雄配偶子が形成されるとき，母細胞の細胞質の一部を捨て去るものが知られている (Drebes, 1977)。これは，雄配偶子がより大きな運動力を得るためであろう。

ところが，浅く時には干上がってしまうような場所では，自由に遊泳できる空間が少なく，鞭毛による運動は大きな制約をうけ，鞭毛による運動がそれほど受精率を高めるのに有効ではないことも生じる。しかし，そこで全生活史をおくるようになった多くのものでは，有性生殖を行わなければ個体群が維持できなかったと考えられる。接合藻類では耐久細胞の機能を持った接合胞子を形成するのに，有性生殖は必須である。珪藻類では，増殖にともなって細胞の大きさが減少していくため，ある限界以下になるとサイズを回復する機構が必要であり，有性生殖により増大胞子を形成する。そして現在，それらは自由に遊泳できる空間の少ない環境下にも多く生息している。そのような環境下で生活するようになった両群の祖先にとって，受精が有効に行われるためには，ほとんど動かなくても接合できるほど，両配偶子は近接して形成されること，あるいは，すくなくともどちらかの配偶子が，鞭毛以外のなんらかの方法で動いて行くということが必要であったろうと考えられる。この場合には，一方の性の配偶子が分泌する誘引物質の介在も重要であろう。

珪藻類では卵子生殖から配偶子のう接合への進化過程の中間段階を示す例が知られている。羽状類でも，真の縦溝をもたない Araphidineae 亜目のものには，中心類の卵子生殖の時とよく似た方法で，1個の卵を持った雌細胞の近くに，1細胞中に2個の裸の雄配偶子が形成される (Drebes, 1977)。この雄配偶子には鞭毛が生じず，アメーバ運動により移動して雌配偶子と合体する。しかし，このような鞭毛のない裸の配偶子では，それほど長時間生存できないし，長距離移動もできないと考えられる。そのため雌配偶子を形成する細胞と，雄配偶子を形成する細胞とがごく近接して形成され，配偶子自体の動く距離が短くてもすむような性の発現機構の存在が考えられる。

有性生殖の問題とは別に，このような水域を生活空間として選んだものは，水の攪乱が少ないときには，すぐに底に沈み泥に埋もれて光が当たらなくなってしまう。また，何らかの方法で自らが運動していなければ，細胞の周囲の栄養塩はすぐに不足してしまう。そのため栄養細胞がそれらの生存のためにも，そのような環境に適した運動方法を獲得している必要性がある。このような理由によって，栄養細胞が滑走運動の能力を獲得したものが生じたと考えられる。この運動性は，珪藻類では羽状類のものが，原始的な中心類のものより分化し(Round and Crawford, 1981)，その後，真の縦溝を持つようになったさいに獲得されたものであろう。その運動のメカニズムも詳細に研究されている (Harper, 1977; Edgar and Pickett-Heaps, 1984)。接合藻類の運動性についても，栄養細胞 (Neuscheler, 1967a, b; Häder and Wenderoth, 1977; Wenderoth and Häder, 1979) 及び有性生殖の誘起が行われた細胞 (Brandham, 1967; Ichimura and Kasai, 1984, 1987; Coesel and de Jong, 1986) の滑走運動が研究されている。さらに，その実態はまだ明らかにされていないが，これらの分類群の性誘引物質に関して，その存在が示唆されている（市村，1977)。従って，有性生殖の時期に雌雄の配偶子のう同志がその運動能力で近づき，雌雄の配偶子を近接して形成するものが生じたと考えられる。

現生の羽状珪藻類及び接合藻類の有性生殖では，2個の配偶子のうが共通の粘質物の中に包まれた状態や，接合管で連結された状態で配偶子が形成され，受精が行われる。両配偶子は裸の原形質のかたまり（プロトプラスト）で鞭毛を持っていないが，効率よく受精が行われる。雌雄の細胞が近接したり，接合管を形成するなどの形質は，本来は配偶子において発現するはずのものである。しかし，遺伝子制御機構の何らかの変異によって，配偶子形成と上記の形質に関与する遺伝子の発現が時間的に前後する可能性を考えれば，配偶子のうが配偶子の形質の一部を発現することもそれほど不思議なことではない。生物進化において，このような形質発現の異時性が大きな役割を果たしている例が数多く知られている (Gould, 1977)。上記のように，一対の配偶子のうが作り出す限られた空間内に雌雄の配偶子が形成され，その受精の精度が高まると，当然両配偶子の数が同数であるのが最も無駄がないと考えられる。卵子生殖への進化を支えてきた，より大きな接合子への選択が継続していると考えられるから，雄配偶子の数は雌配偶子の数と同数になり，その大きさも等しくなったと考えられる。現に，羽状珪藻類の配偶子のうに形成される配偶子の数は1個か2個であり，中心珪藻類で知られている卵の数と同数である。中心珪藻類の精子は1個の配偶子のうに4個は形成されるが，羽状珪藻類ではそのような多数の配偶子を形成する例は知られていない (Drebes, 1977)。このように配偶子のうが1対1で対合する有性生殖においては，有性生殖法の進化の理論で述べたような小配偶子戦略が入り込む余地はない (Bell, 1982)。

これまでに発見された化石の資料からすると，接合藻類の出現は白亜紀の始めの頃と考えられている (Schopf, 1970)。Stebbins and Hill (1980) は接合藻類を，一度，陸上に上がった緑色植物のグループの中から再び水中生活に戻ったものだと考えている。その根拠として，動胞子を形成しないことと，運動性のある配偶子を形成しないことが挙げられている。これらの性質は，陸上生活の名残であるという訳である。そうすると，シルル紀に上陸したもののいくつかが，単細胞のまま陸上で過ごし，その間にそこで配偶子のう接合を進化させ，白亜紀の始めのころに再び水中生活に戻り，そこで分化したことになる。確かに配偶子のう接合は，受精という点では水中でなくても可能な有性生殖法である。しかし水中でなければ，両性の配偶子のうはお互いに近づくことはかなり難しい。接合藻類の祖先と考えられる緑藻類の卵子生殖を考えるとき，有性生殖の一時期に降水などを利用できるのであれば，現生の一部の陸上植物でもみられているように，鞭毛による運動能力を持った精子が，水中を泳いでいくという効率的な方法も可能である。しかしそのような陸上では，接合子の発芽個体の分散に関しても，鞭毛による運動はやはり降水の機会を待たなければならない。いっぽう，発芽個体がしっかりした細胞壁を形成し滑走運動する分散方法は，発芽個体が鞭毛運動により分散してから細胞壁を形成するのと比べても，必ずしも水中生活に適応していないとはいえない。

シルル紀の頃陸上に進出したと考えられている緑色植物の祖先のすべてが，一気に水中から陸上に上がったのでなく，より原始的なものはより多く水中生活に依存し，浅い水域に留まっていたのではないだろうか。接合藻類の直系となる分類群は知られていないが，そのような浅い水域で生活し，フラグモプラスト型の細胞分裂を行い，卵子生殖を行うもの中から接合藻類が分化したものと著者らは推察する。

羽状珪藻類も白亜紀の始めに，古中心珪藻類より，浅い水域の底棲生活に適したものとして分化したもの

と考えられている (Round and Crawford, 1981)。その有性生殖法からみても，この考えは妥当であろう。つまり，接合藻類と珪藻類でみられる非常によく似た配偶子のう接合は，両者が，白亜紀の始めのころ多く形成された環境，つまり時には干上がるような，そして底質が滑走運動に適するようになった浅い水域のもとで，底棲生活を行うようになったことによる類似であろう。そして前述したように，より生存率の高い接合子を浅い水域でも効率よく形成できたことが，この両グループがよく繁栄している理由である。現在，浮遊生活をおくっている羽状珪藻類も多く知られている。これらはその後，群体を形成したりすることにより浮遊性を増し，広い水域へ進出したものであり，配偶子のう接合を続けている種は，有性生殖時における雌雄の個体の位置関係が，浅い水域の場合と似ているからである。

最近，羽状珪藻類でありながら卵子生殖を行うものが，海産の浮遊生活種である *Nitzschia pungens* で発見された (Subba Rao et al., 1991)。このことについて，同属の他の種と同じように配偶子のう接合を行っていたものが，再度浮遊生活に適応することにより卵子生殖に祖先帰りしたのか，あるいは，この種はもともと *Nitzshia* 属の他の種とは起源が異なり，その起源から底棲生活に適応することなく，ずっと浮遊生活を続け卵子生殖を行っていたのかの２つが考えられる。羽状珪藻類の有性生殖法に関するこれまでの研究は，主に付着生活をおくっている種で行われており，浮遊生活をする種については，ほとんど調べられていない (Mann, 1984)。浮遊生活をおくる種について，広くその有性生殖法を検討する必要がある。その結果，浮遊生活をおくる羽状珪藻類のいくつかの属の種で，卵子生殖が見つかるようなことがあれば，生育環境に適応した生活史戦略の変更の重要な事例になると考えられる。また，羽状珪藻類の配偶子のう接合は，その生育場所と密接に結びついて進化してきたことの間接的な証拠にもなる。

謝　辞

校閲者の方々の適切な助言に心より感謝いたします。本研究の一部は文部省科学研究費一般 (C) 02640536 の援助の下に行われたものであり，謝意を表します。

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Jpn. J. Phycol. (Sôrui) 40: 167–172, June 20, 1992

Kazuyuki Miyaji: The occurrence of *Rhizoclonium riparium* and *R. tortuosum* (Chlorophyceae) on the coast of Hokkaido, Japan.

Key Index Words: Chaetomorpha—*Cladophoraceae*—Lola—Rhizoclonium riparium—Rhizoclonium tortuosum—*taxonomy*
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The genus *Rhizoclonium* is one of the simplest of the Cladophoraceae, but this simple structure has led to taxonomic confusion. The relationship between *Rhizoclonium implexum* (Dillwyn) Kützing, *R. riparium* (Roth) Kützing ex Harvey and *R. tortuosum* (Dillwyn) Kützing is particularly unclear. To resolve this confusion, Koster (1955) revised the taxonomy of the genus by comparing specimens of various species. She concluded that *R. implexum, R. kochianum* Kützing and *R. kerneri* Stockmayer, and also *R. riparium* and *R. tortuosum* are the same species. She placed *R. tortuosum* in synonymy with *R. riparium* f. *validum* Foslie, since the only recognizable difference between the two entities was cell width. Also, Scagel (1966) speculated that the differences in cell width between the two taxa may be a result of environmental factors, and suggested that the two species were synonymous; he also did not recognize the forma *validum*. By contrast, *R. tortuosum* is sometimes treated as a species of the genus *Lola* (Hamel 1930; Chapman 1952, 1956) or the genus *Chaetomorpha* (Kützing 1845, De-Toni 1889, Børgensen 1902, Jónsson 1903, Kornmann 1972, Kornmann and Sahling 1977).

In Hokkaido and adjacent waters, only *R. tortuosum* (Japanese name "Naga-motsure") has been reported (Kawabata 1936, Nagai 1940, Yamada and Tanaka 1944, Tokida 1954, Chihara 1972). However, I have found that *R. riparium* (Japanese name "Hoso-nedashigusa") also occurs in Hokkaido. The present study attempts to elucidate whether the two entities distributed in Japan are distinct species or the result of differing environmental conditions.

The specimens used in this study were collected at the following localities: *Rhizoclonium riparium*; Tokkarisho, Muroran (March 10, 1974), Daikoku Islet, Akkeshi (August 17, 1974), Kiritappu, Nemuro (July 25, 1972); *R. tortuosum*; Muroran (August 17, 1974), Harutachi, Hidaka (July 21, 1974), Kiritappu, Nemuro (July 25, 1972). They were preserved in 10% Formalin in sea water. Part of the liquid-preserved material was dried on herbarium sheets. The specimens examined in the present work are deposited in the Herbarium of Faculty of Science, Toho University. *Rhizoclonium riparium* occurs on rock from the upper littoral zone to the supralittoral zone where there is freshwater run-off due to rain or melting snow. This species is sometimes associated with *Blidingia minima* (Nägeli ex Kützing) Kylin. *Rhizoclonium tortuosum* is usually entangled with other algae such as *Sargassum* spp., *Cystoseira* spp., *Neorhodomela aculeata* (Perestenko) Masuda, *Tichocarpus crinitus* (S.G., Gmelin) Ruprecht ex Middendorff, which occur in the middle and lower littoral zone. Plants sometimes grow on *Corallina pilulifera* Postels et Ruprecht. However, *R. riparium* is never entwined with other algae. *Rhizoclonium riparium* grows in entangled masses of uniseriate filaments with numerous short, tapering rhizoidal branches. *Rhizoclonium tortuosum* may also be found as entangled masses of uniseriate filaments, which, however, have no intercalary rhizoidal branches, and are sometimes twisted and contorted. Filaments of *R. riparium* are (17.5–)20–25(–35) μm broad and (0.7–)1–1.5(–4.5) times as long as broad. Filaments of *R. tortuosum* are (30–)35–40(–60) μm broad with cells (1.5–)3–4(–8.0) times as long as broad. Frequency curves of

occurrence of various cell widths of the two entities from the six collection sites show that the cell width of each entity is roughly the same (Fig. 1A). However, the range of variation and the peak of the frequency curve differ slightly with each collecting locality, and the frequency curves of the two entities do not overlap (Fig. 1A). Frequency curves of the occurrence of various cell width to length ratios in each entity are shown in Fig. 2. These figures show that cell ratio is also roughly similar in the same entity except for plants of *R. riparium* from Kiritappu, and that the frequency curves of the occurrence of various cell ratios between the two entities overlap somewhat (Fig. 2). These data on cell width and the cell ratio show also that variation in the above features is usually slight in *R. riparium*, but more pronounced in *R. tortuosum*.

Aceto-carmine was used for counting numbers of the nuclei in a cell. The materials used for counting nuclear numbers were the same as liquid-preserved materials for morphological observation. Nuclei of *R. riparium* are located in the center of a cell (Fig. 3A). A histogram of the occurrence of nuclear number in a cell shows that the number is generally one or two in all collection sites; numbers greater than two were observed only infrequently, and the largest number seen being eight (Fig. 4A). The number most frequently occurring at every collection site is two, except for plants from Kiritappu, which had only one nucleus (Fig. 4A). Nuclei of *R. tortuosum* are scattered evenly near the periphery of the cell (Fig. 3B), and the number in each cell varies from eight to eighty. A histogram of occurrence of nuclear number in a cell of *R. tortuosum* shows that nuclear number is generally between 20–40 at every collection site (Fig. 4B). *Rhizoclonium tortuosum* samples show some tendency toward increased nuclear number in the cells as cell width increases (Fig. 1A, 4B).

For culture studies, plants of *Rhizoclonium riparium* were collected at Tokkarisho, Muroran on March 10, 1974 and Daikoku Islet, Akkeshi on August 17, 1974. In addition, plants of *R. tortuosum* were collected at Harutachi, Hidaka on July 17, 1974. These plants were rinsed with filtered seawater, and separated with a micropipette into small pieces, each containing three to five cells. Each piece was washed three times in autoclaved seawater. After washing, they were placed in test tubes with screw caps (2 cm × 18 cm) containing 10 ml of ESP medium (Provasoli 1966). After about a month, the plants that were not contaminated with

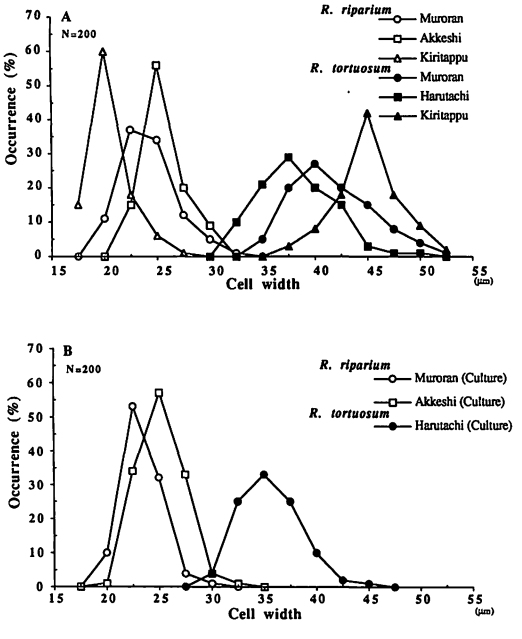

Fig. 1. Frequency curve of occurrence of cell width in two entities of *Rhizoclonium* collected from Hokkaido. A. Cell width in field plants of the two entities. B. Cell width in culture plants of the two entities.

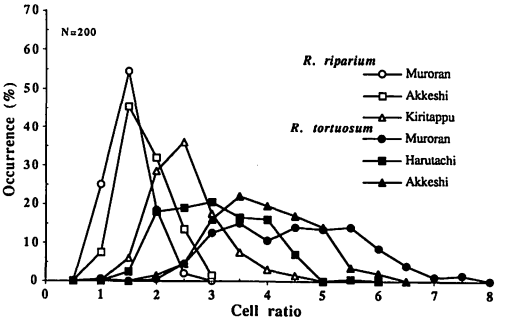

Fig. 2. Frequency curve of occurrence of length/width ratio of cells in field plants of two entities in *Rhizoclonium* collected from Hokkaido.

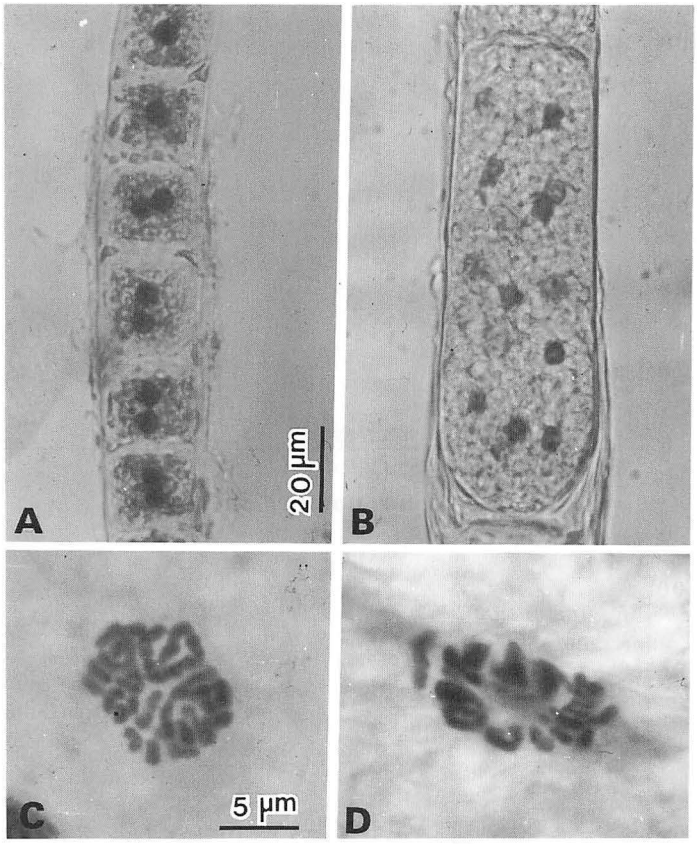

Fig. 3. *Rhizoclonium riparium* and *R. tortuosum* from culture. A. One or two nuclei in cells of *R. riparium* stained with aceto-carmine. B. Many nuclei in a cell of *R. tortuosum* stained with aceto-carmine. C. Chromosome of *R. riparium* showing a number of thirty-six. D. Chromosome of *R. tortuosum* showing a number of twenty four. Scale in A apply to B, and scale in C to D.

other algae were transferred to glass vessels (6.5 cm × 5 cm) containing 100 ml of ESP medium. The culture medium was replenished every 30 days or so. The cultures were kept in freezer-incubators illuminated with cool-white fluorescent lamps (*ca.* 4000 lux). Five temperature and photoperiod combinations were used: 5°C and 8 h of light, 10°C and 10 h or 14 h of light; 15°C and 14 h of light and 18°C and 16 h of light. The two entities grew well at 14 h of light; 15°C and 16 h of light, 18°C, but never became fertile for over a year at all conditions. For morphological observation of the two entities in culture, small clusters of vigorous plants were transferred to new vessel, placed at 15°C and 14 h of light, and incubated for one month. After this period, plants were fixed with 10% Formalin seawater. They were later used for the morphological observation and counting the nuclei. Morphology was similar to that of field plants. Intercalary rhizoidal branches in cultured plants of *R. riparium* were formed abundantly in the laboratory, as they are in the field. In cultured plants of *R. tortuosum*, intercalary rhizoidal branches were rarely formed, but this could not be observed in field plants. The frequency curves of occurrence of cell width and histograms of occurrence of the nuclear number of cultured plants in the two entities are similar to those of field plants (Fig. 1B, 4).

For observation of chromosomes, small clusters of vigorous cultured plants were transferred to a new vessel, placed at 15°C and 14 h of light, and incubated for three days.

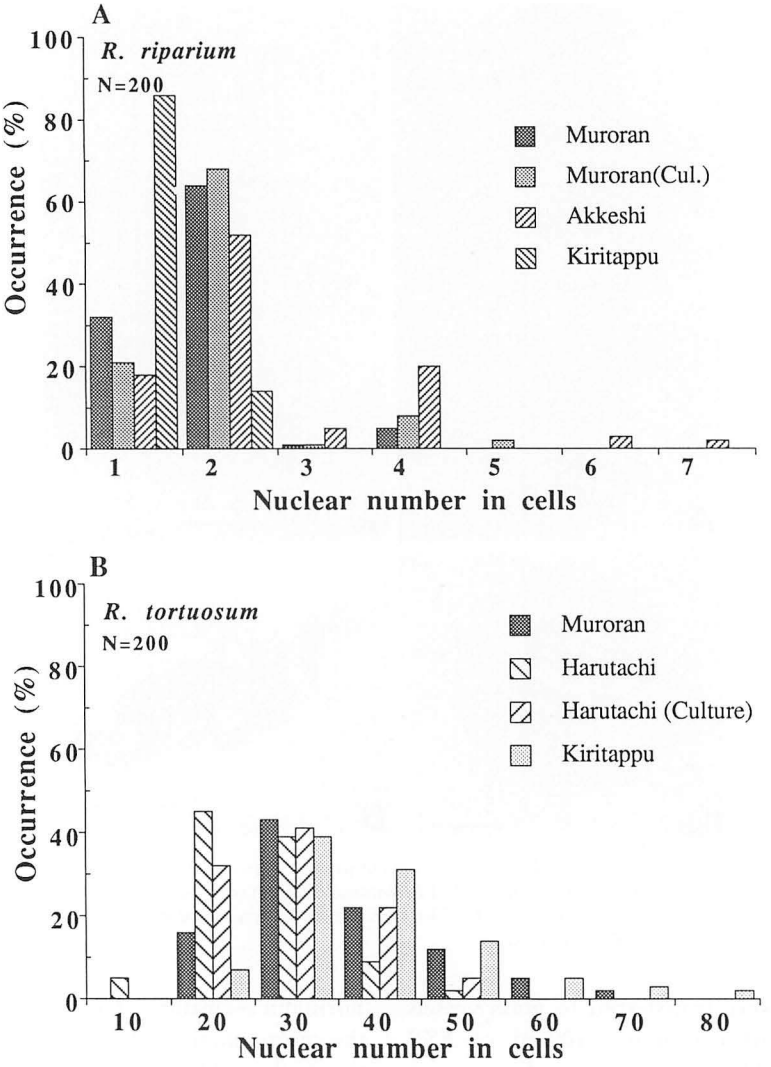

Fig. 4. Histogram of occurrence of nuclear number in a cell in *Rhizoclonium*. A. Nuclear number of *R. riparium*. B. Nuclear number of *R. tortuosum*.

Fixation was later performed with 3 : 1 ethanol: glacial acetic acid and, for the staining of chromosomes, aceto-iron-haematoxyl-in-chloral hydrate was used (Wittmann 1965). Ten chromosome counts per entity were made. At metaphase, (33-)36 chromosomes were counted in the vegetative cells of *R. riparium* (Fig. 3C). On the other hand, (22-)24 chromosomes were observed at metaphase in the vegetative cells of *R. tortuosum* (Fig. 3D). These chromosome numbers agree with the result of Sinha (1958). However, because the materials used did not reproduce, I could not be resolved whether the chromosome numbers of the two entities represent diploid or haploid numbers.

It is evident from this study that two species of *Rhizoclonium* are represented in Hokkaido, Koster (1955) has suggested that *Rhizoclonium riparium* and *R. tortuosum* are the same species, and the only difference between the two entities is cell width. However, nuclear number in a cell and the differences in chromosome number, in addition to cell width, clearly show that *Rhizoclonium riparium* and *R. tortuosum* from Japan should be regarded as two

distinct species (Fig. 2, 3C, 3D, 4). The two species are certainly separable on the bases of cell width. However, the differences of cell width in the two species between localities as shown Fig. 1A suggest that the cell width is not a good character. Instead, nuclear number in a cell and chromosome number should be adopted as a primary criterion for separating the two species. The ratio of cell width to length is not appropriate either as the frequency curves of the occurrence of various cell ratios between the two entities overlap (Fig. 2). The fact that the two entities occupy different, distinct habitats in any one place is further important evidence suggesting that the two separate species are involved.

The morphological characters and the habitat of Japanese *R. riparium* are essentially the same as those described by Koster (1955) and other authors. Migita (1967) first observed this species in Japan and described the habitat, phenology and morphology of this species in detail, and demonstrated the life cycle. I have obtained similar results except that it has not been possible to induce reproduction in culture.

Koster (1955) considered *Rhizoclonium tortuosum* to be a synonym of *R. riparium* f. *validum*, because of corresponding cell width in the two taxa. However, Foslie (1890), Rosenvinge (1893), Børgesen (1902) and Jónsson (1903) gave a different description of *R. riparium* f. *validum* and *Chaetomorpha tortuosa* (Dillwyn) Kützing; a synonym of *R. tortuosum*. In comparing of each description with Japanese plants, my observations on *R. tortuosum* does not agree with the former forma but, rather with the latter. My plants differ from *R. riparium* f. *validum* in habitat, nuclear number in cells and ratio of cell width to length. Foslie (1890), Jónsson (1903) and Waern (1952) found this entity in narrow supralittoral fissures of rock, and Koster (1955) recorded it from moist clayey or sandy soil. Jónsson (1903) noted two, or frequently, four nuclei in his *R. riparium* f. *validum*. With regard to ratio of cell width to length, Rosenvinge (1893), Jónsson (1903) and Koster (1955) described cells 1-2 times as long as broad. For these reasons, *R. tortuosum* and *R. riparium* f. *validum* may not be the same species.

Chaetomorpha tortuosa as described by Foslie (1890), Rosenvinge (1893), Børgesen (1902), Jónsson (1903), Kornmann (1972), and Kornmann and Sahling (1977) is similar to our observed plants in every respect. Rosenvinge (1893) and Kornmann (1972) noted about twenty nuclei in a cell in *C. tortuosa*. In this regard, Japanese plants agree completely with their *C. tortuosa*. Kützing placed *Conferva tortuosa* Dillwyn in *Chaetomorpha* at first (Kützing 1845) and later removed it to *Rhizoclonium* (Kützing 1849); Setchell and Gardner (1920) examined Kützing's original materials and concluded that *Ch. tortuosa* was synonymous with *Rhizoclonium tortuosum*, although they had never discussed whether this species should be regarded as belonging to the genus *Rhizoclonium* or *Chaetomorpha*.

Rhizoclonium tortuosum is also sometimes treated as a species of *Lola* (Hamel 1930; Chapman 1952, 1956); however, this genus has not been widely accepted. The question remains therefore: what is the correct genus name for Japanese plants known as "Naga-motsure" *Rhizoclonium, Chaetomorpha* or *Lola*? Until taxonomic confusion between the three genera is resolved with European material, I recommend *Rhizoclonium* as a generic name. Thus "Naga-motsure" is *Rhizoclonium tortuosum* (Dillwyn) Kützing.

I wish to express my special thank to the late Professor Emeritus Munenao Kurogi, Hokkaido University, for his kind advice as well as for his critical reading of the manuscript. I wish to thank Professor M. D. Guiry for his critical reading of the manuscript. I am grateful to Professor C., van den Hoek, for his kind advice. I wish to express my gratitude to Drs Iemasa Yamada and Makoto M. Watanabe and to Mr Kouichi Nagata for offering me their collecting materials.

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宮地和幸：北海道でのホソネダシグサとナガモツレ；両種の出現

ホソネダシグサ (*Rhizoclonium riparium* (Roth) Kützing ex Harvey) とナガモツレ (*R. tortuosum* (Dillwyn) Kützing) の両種は Koster (1955) らによって，同種のなかの品種として扱われたり，同種内の生態的変異型として扱われてきた。北海道ではホソネダシグサとナガモツレの両者が同じ場所に生育しており，同所産の標本で両者を比較することが出来る。両者が同一種なのか，それとも別種なのかを調べた。その結果，両者は細胞の幅だけでなく一細胞内の核数，染色体数，さらに生育潮位によって区別できた。ホソネダシグサは 17.5–35 μm の細胞の幅があり，一細胞内の核数は 1 - 8 個で，2 個が大半である。さらに，生育潮位は飛沫帯から潮間帯上部である。それに対して，ナガモツレは 30–60 μm の細胞の幅があり，一細胞内の核数は 8 個から80個までの変異があり，頻度の中心は20個から40個に存在する。さらに，生育潮位は潮間帯中部から潮間帯下部となっている。その他にも細胞の長さと幅の比にも若干の違いが見られ，ホソネダシグサは 0.7–4.5倍（多くは 1 –1.5倍），ナガモツレは 1.5–8.0倍（多くは 3 – 4 倍）である。これらの理由により，両者を同一種にして扱うよりは別種とし扱うほうが良いとの結論に達した。また，ナガモツレの学名はナガモツレを含めたこの周辺のグループの分類学的な問題が解決されるまでは *Rhizoclonium* 属に所属させる方が望ましい。(274 船橋市三山2-2-1　東邦大学理学部生物学教室)

Jpn. J. Phycol. (Sôrui) 40: 173–175, June 20, 1992

Hajime Yasui: Karyological observation in the young sporophytes of *Costaria costata* (Turner) Saunders (Laminariales, Phaeophyta)

Key Index Words: chromosome number—Costaria costata—*haploid*—*Laminariales*—*parthenogenesis*—*Phaeophyta.*

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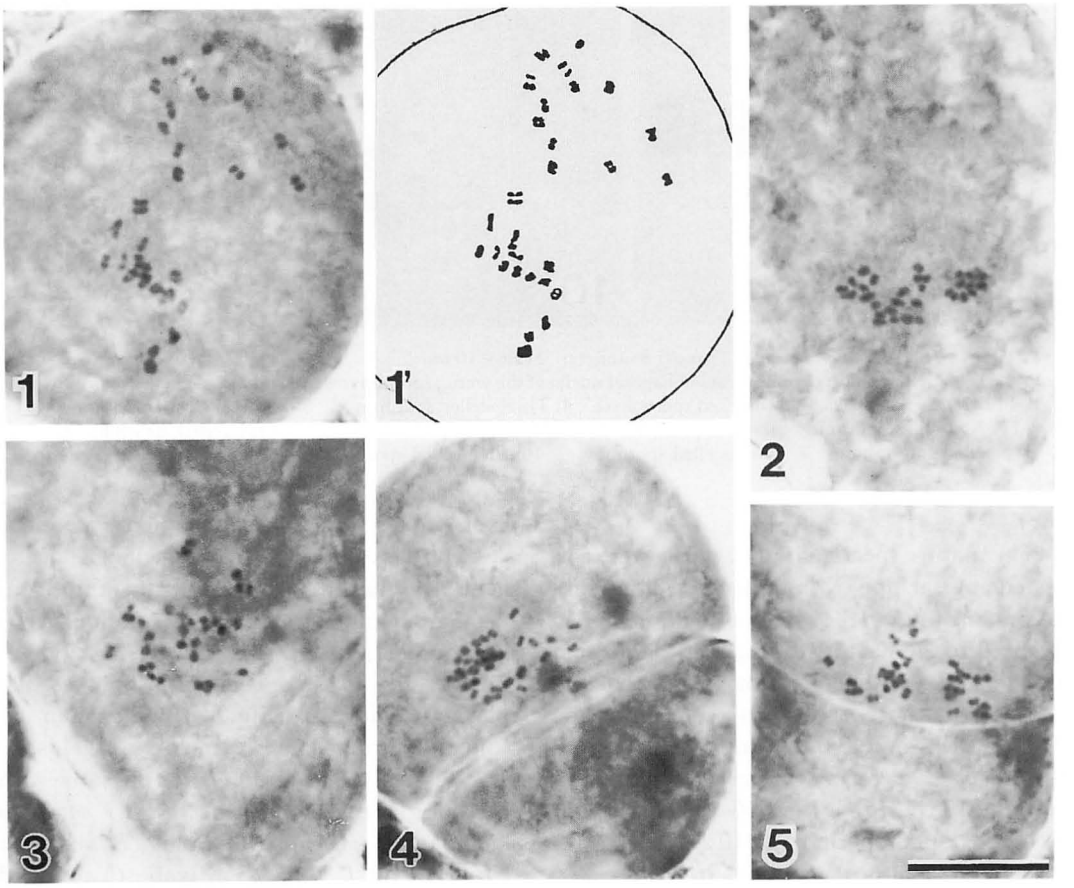
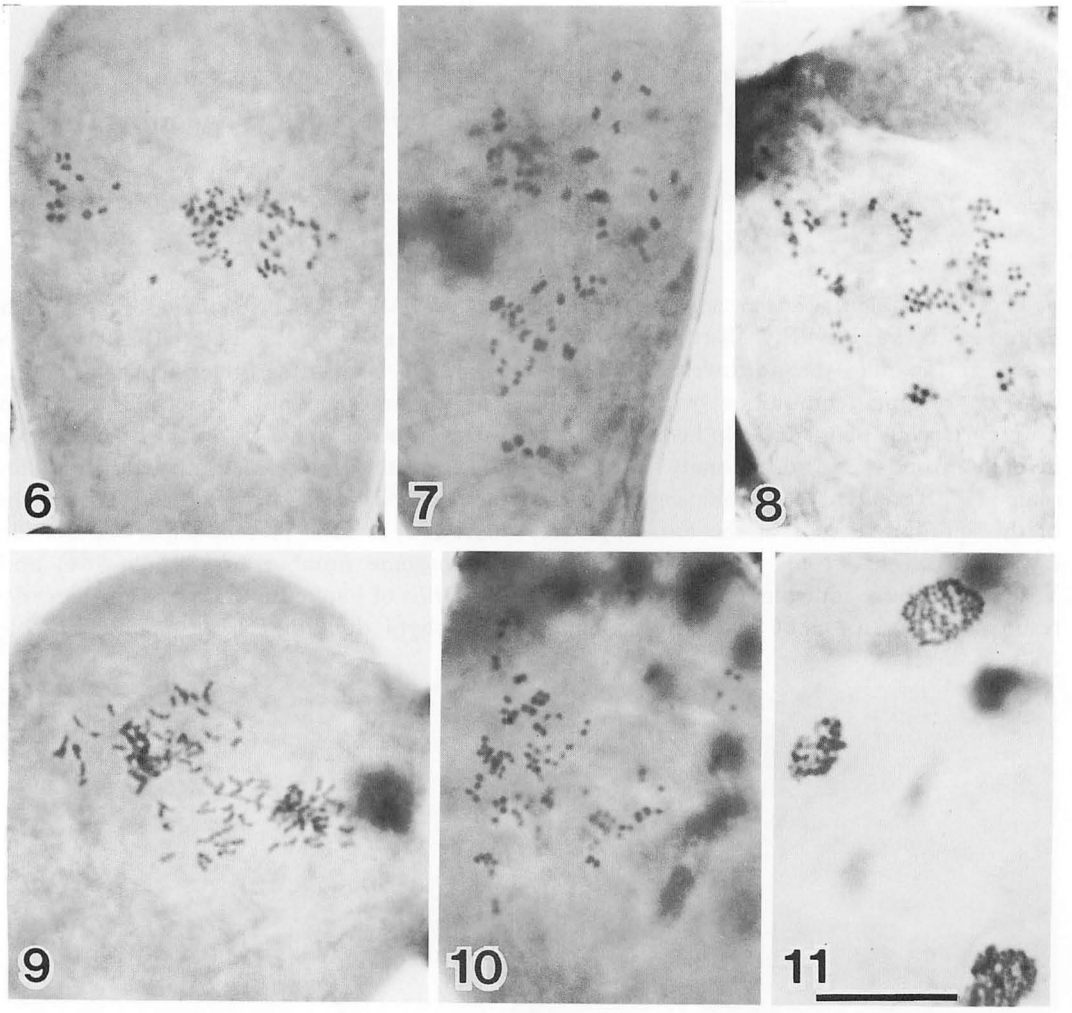
The brown alga, *Costaria costata* (Turner) Saunders is very widely distributed from northern Japan to the northwestern Pacific coasts, forming comunities with several Laminariaceous plants on kelp beds, and the juvenile fronds are occasionaly used as seafoods. Recently, the chromosome counts in the sporophyte cells of the four popular *Laminaria* species from Japan (Yabu and Yasui 1991) were indicated to have different results (n=32, 2n=ca.60) from the previous reports (Abe 1939, Nishibayashi and Inoh 1956, Kaneko 1972, Yabu 1973, Funano 1983, etc.) as n=22 in their zoosporangium. The chromosome number of this alga has been recorded to be n=ca.30 at diakinesis stage in the zoosporangium with paraffin method (Nishibayashi and Inoh 1957, Ohmori 1967). The present paper reports the chromosome number (n=32, 2n=64) and the ratios of haploid and diploid in the early sporophytic dividing cells of this alga in cul-





Figs. 1–11. *Costaria costata* (Turner) Saunders. Scale=10 μm.
Figs. 1–5. Metaphase chromosomes of haploid nuclei of the young sporophytes. 1 and 2. One-celled sporophyte. 1′. Illustration in Fig. 1. 3. Two-celled sporophyte. 4. Three-celled sporophyte. 5. Four-celled sporophyte. Figs. 6–11. Metaphase chromosomes of diploid nuclei of young sporophytes. 6 and 7. One-celled sporophytes. 8. Two-celled sporophyte. 9. Three-celled sporophyte. 10. Five-celled sporophyte. 11. Nine-celled sporophyte.

ture.

The mature specimens of *C. costata* were collected at Osatsube, Minamikayabe-cho, Hokkaido on July 11, 1990, were immediately brought to the Faculty of Fisheries, Hokkaido University. In the laboratory, liberated zoospores from those fronds were cultured in the filtered seawater containing 0.01% SLP (Squid Liver Protein Powder) extract (Yabu *et al.* 1984) under 3000–3500 lux with 12L : 12D photoperiod, at 10±1°C. After 18–22 days culture, the one- to eight-celled sporophytes were fixed at 5–6 hours from the start of dark-period by ethyl alcohol 3: acetic acid 1 solution, stained with aceto-iron-haematoxylin-chloral hydrate solution (Wittmann 1965).

The one- to three-celled sporophytes displayed to have exactly 32 (haploid) or 64 (diploid) chromosomes at metaphase (Figs. 1–4, Figs. 6–9.). The number was the same with the four species of *Laminaria*, *L. angustata* kjellman, *L. japonica* Areschoug, *L. ochotensis* Miyabe and *L. religiosa* Miyabe (Yabu and

Table 1. Number of haploid or diploid sporophytes of *Costaria costata* (Turner) Saunders obtained from chromosome count in the dividing cells.

Nuclear phase	1-celled stage	2-celled stage	3-celled stage	4-celled stage	5-celled stage
Haploid	67	22	8	2	1
Diploid	28	39	35	37	27

Yasui 1991). The ratio (haploid : diploid) of the one-celled sporophytes showed to be approximately 70% : 30%, however, the percentage of haploid was rapidly decreasing as the germination developed, became 2-4% in the four- or five-celled stage (Figs. 5 and 10, Table 1). Although it is difficult to count the chromosome number of the more developed sporophytes than nine- or ten-celled stage (Fig. 11), the rare occurrence for parthenogenetic sporophytes of *C. costata* was suggested by the above results. In size, the haploid sporophytes (Figs. 1-3) were nearly same with the diploid (Figs. 6-8), both sporophytes (width: 27-35 μm, length: 35-45 μm) at one- or two-celled stage were larger than those (width: 20-25 μm, length: 24-31 μm) of the other japanese Laminariaceous plants (Yabu *et al.* 1985, Yabu and Yasui 1991).

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安井　肇：スジメの初期胞子体に於ける核学的観察

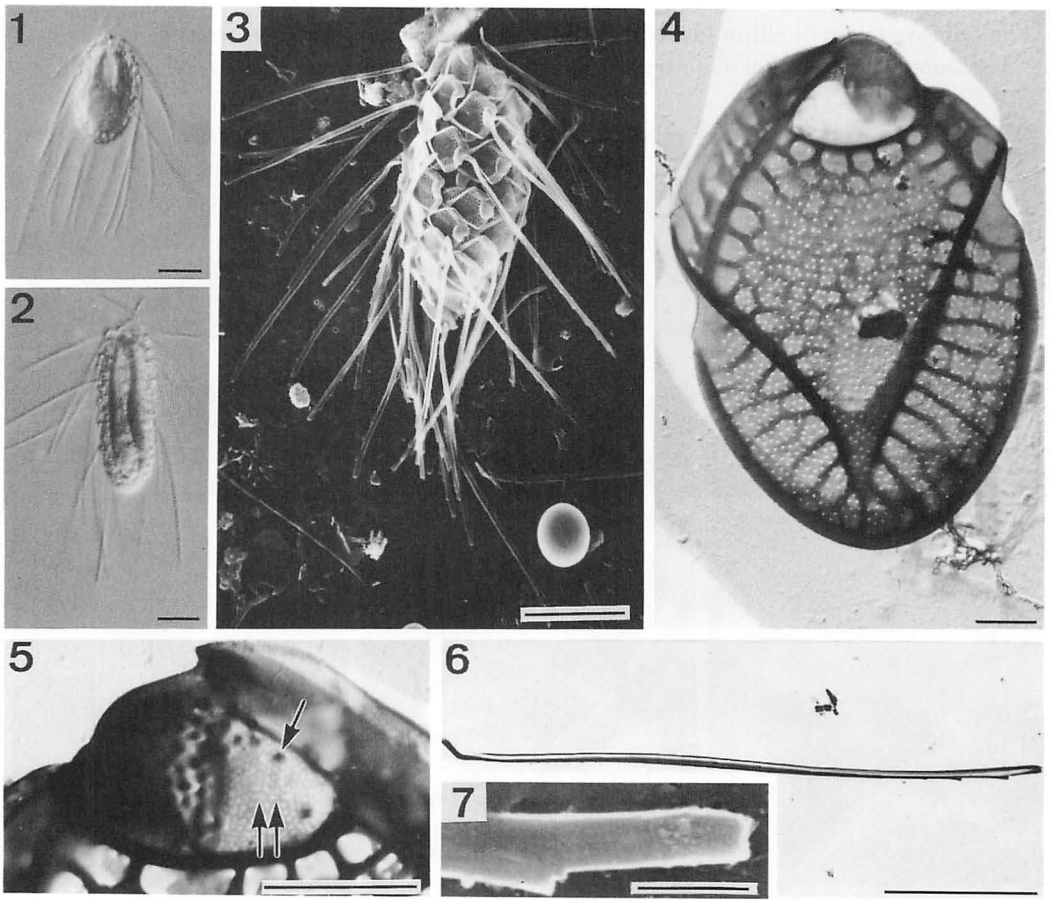
褐藻コンブ目植物スジメ *Costaria costata* (Turner) Saunders の成熟藻体より得た遊走子を培養して雌性配偶体上に形成される1-数細胞期の芽胞体について核分裂を調べたところ n=32 または 2n=64 の染色体数を有する2種類の個体が観察された。これらの芽胞体に於ける単相体の割合は1細胞期で約70%に達していたが，その後減少し，2細胞期で約36%，4-5細胞期には数%以下となった。1-2細胞期での単相体と複相体の大きさはほぼ同じであったが，何れも他の邦産コンブ科のものより幾分高い値を示した。本種では，少なくとも初期発生の段階で正常2倍体と単為発生体が混在しているものと推察された。(041 函館市港町3-1-1　北海道大学水産学部)

Jpn. J. Phycol. (Sôrui) 40: 177–180, June 20, 1992

Hiroyuki Ito: Chrysophytes in the southern part of Hyogo Prefecture, Japan (III) A new variety, *Mallomonas acaroides* var. *obtusa* (Synurophyceae, Mallomonadaceae)

Key Index Words: Hyogo Prefecture—Mallomonadaceae—Mallomonas acaroides *var.* obtusa—*new variety—Synurophyceae.*
Hiroyuki Ito, Water Quality Laboratory, Kobe City Waterworks Bureau, Kusutani-cho 37–1, Hyogo-ku, Kobe, 652 Japan

In Japan, *Mallomonas acaroides* Perty var. *acaroides* has been found in six lakes and ponds (Takahashi 1978; Ito 1988). A taxon different from the type variety occurs in Yasuba-ike Pond and Sengari Reservoir located in the southern part of Hyogo Prefecture (Ito 1991). It is described below as a new variety of *Mallomonas acaroides*.



Figs. 1–7. *Mallomonas acaroides* var. *obtusa*. Figs. 1, 2. Whole cell (light microscopy). Fig. 3. Holotype, whole cell (scanning electron microscopy: SEM). Fig. 4. Scale (transmission electron microscopy: TEM). Fig. 5. Detail of dome with papillae (arrow) and a patch of minute pores (double arrow) (TEM). Fig. 6. Bristle (TEM). Fig. 7. Apex of bristle (SEM). Scale bar: 10 μm for Figs. 1–3 and 6; 1 μm for Figs. 4, 5, 7.

Mallomonas acaroides Perty var. *obtusa* var. nov.

A var. *acaroides* differt apicibus setarum obtusis et limbis anterioribus squamarum latis.

Dimensio cellulae: 21-44 × 11-21 μm; flagella: 11-19 μm; squamae: 7.4-9.5 × 5.7-7.3 μm; setae: 16.1-42.2 μm.

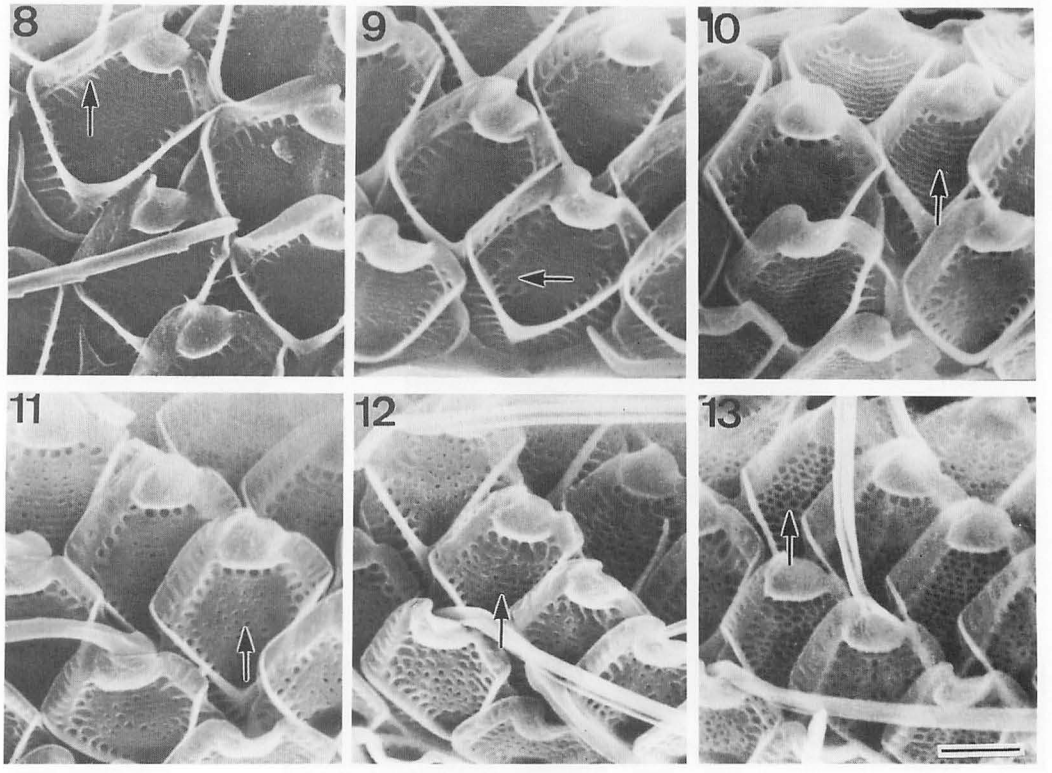
Holotype, Fig. 3; material collected February 5, 1982 from Yasuba-ike Pond, Takarazuka City, Hyogo Prefecture, Japan (No. 820205Y); deposited in Water Quality Laboratory, Kobe City Waterworks Bureau.

The epithet of the variety refers to the blunt tipped bristle.

M. acaroides var. *obtusa* differs from the type variety in having blunt tipped bristles and scales with broad anterior flanges.

The cells are ovoid or ellipsoidal with a single flagellum, one parietal chloroplast and two posteriorly located contractile vacuoles. The cells are covered with scales; there are short bristles on the anterior part and long ones on the posterior part (Figs. 1-3). The scales are tripartite and oval. The dome has papillae and a patch of minute pores (Fig. 5). The pores of the base plate are irregularly scattered or arranged in transverse rows (Fig. 4). The shield is reticulated (Fig. 4). The anterior flange is broad, wing-like, with struts. The posterior flange also has struts. The proximal border is narrow (Fig. 4). Blunt tipped bristles are slightly curved and have 3-8 teeth in the distal half part (Figs. 6, 7).

Five varieties of *Mallomonas acaroides* have been reported (Harris and Bradley 1960, Fott 1962, Nicholls 1987). Among these, *M. acaroides* var. *galeata* Harris et Bradley, *M. acaroides* var. *striatula* Asmund and *M.*



Figs. 8–13. Variations in the shield ornamentation of scales of *Mallomonas acaroides* var. *obtusa* collected from Yasuba-ike Pond (SEM). Figs. 8, 9. Shield marked with struts and rudimentary reticulation (arrow) in addition to struts. Figs. 10, 11. Shield with weakly developed reticulation (arrow). Figs. 12, 13. Shield with well-developed reticulation (arrow). Scale bar (3 μm) in Fig. 13 applies to all figures.

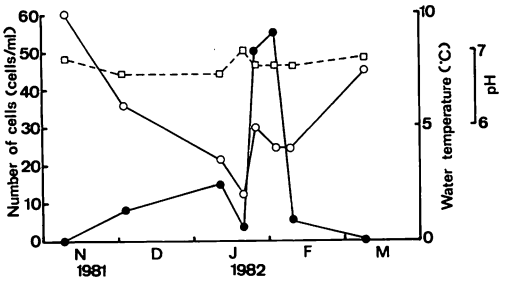


Fig. 14. Fluctuations of *Mallomonas acaroides* var. *obtusa* in Yasuba-ike Pond from November 1981 to March 1982 (solid circle), in relation to changes in surface water temperature (open circle) and pH values (open square).

acaroides var. *echinospora* (Nygaard) Fott are considered to fall in the variation range of var. *acaroides* (Asmund and Kristiansen 1986), and *M. acaroides* var. *inermis* Fott and *M. acaroides* var. *muskokana* Nicholls are presently recognized as taxonomic entities. *M. acaroides* var. *acaroides* often has helmet bristles, but populations consisting of cells which possess only serrated bristles have also been reported (Asmund and Kristiansen 1986). The serrated bristles of var. *acaroides* have well-developed teeth along their whole lengths and acutely pointed apices. The serrated bristles of var. *inermis* and var. *muskokana* are basically the same as those of var. *acaroides* (Fott 1962, Nicholls 1987). In contrast to these three taxa, *M. acaroides* var. *obtusa* has only serrated bristles with short teeth on the distal half part, and also has blunt apices.

Scales of *M. acaroides* var. *obtusa* collected from Yasuba-ike Pond have morphological variations of shield ornamentation. In most cells collected on December 2, 1981 and January 11, 1982, the shield was marked only with struts or rudimentary reticulation in addition to struts (Figs. 8, 9). The reticulation of the shield was weakly developed in scales of cells collected on January 20 and 25 (Figs. 10, 11), and it was well-developed in cells collected on February 5, when the maximum density was recorded (Figs. 12, 13). Such variations have also been observed in scales of *M. acaroides* var. *acaroides*, and it is known that the shield ornamentation of scale varies within single specimens as well as between populations (Asmund and Kristiansen 1986). The reticulum of scales is rudimentary or absent in some populations, and well-developed in others (Asmund and Kristiansen 1986). Though scale variation of *M. acaroides* var. *obtusa* is within that of *M. acaroides* var. *acaroides*, it is different from the type, var. *inermis* and var. *muskokana* in having scales with the broad anterior flanges. The taxon is therefore designated as a new variety of *M. acaroides*.

In Yasuba-ike Pond, *M. acaroides* var. *obtusa* appeared from December 2, 1981 to February 8, 1982, ranging in density from 3 to 55 cells/m*l*. The fluctuation is shown in Fig. 14 together with the pH and water temperature. A few scales were found in Sengari Reservoir in April and August 1982 and in January and February 1983.

The author thanks Dr. J. Kristiansen (Copenhagen University) and Dr. E. Takahashi (Yamagata University) for their helpful advice and reading of the manuscript.

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伊藤裕之：兵庫県南部産黄金藻（Ⅲ）シヌラ藻綱マロモナス科の新変種：*Mallomonas acaroides* var. *obtusa*

兵庫県南部に位置する安場池と千苅貯水池から出現した新変種 *Mallomonas acaroides* var. *obtusa* を記載した。本変種は先端が尖っていない剛刺と広い前部縁辺部のある鱗片をもつことで *M. acaroides* var. *acaroides* とは異なる。

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Jpn. J. Phycol. (Sôrui) 40: 181–184, June 20, 1992

Hiroyuki Ito and Eiji Takahashi: Chrysophytes in the southern part of Hyogo Prefecture, Japan (IV) Two new species, *Spiniferomonas hamata* and *S. nichollsii* (Chrysophyceae, Paraphysomonadaceae)

Key Index Words: Chrysophyceae—Hyogo Prefecture—new species—Paraphysomonadaceae—Spiniferomonas hamata—Spiniferomonas nichollsii—*taxonomy.*
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Fourteen freshwater species have been described in the genus *Spiniferomonas* Takahashi (1973) (Siver 1988, Kristiansen and Tong 1989, Nicholls 1989). In Japan, eleven species and two undescribed taxa of *Spiniferomonas* have been identified by electron microscopy (Takahashi 1973, Preisig and Takahashi 1978, Ito and Takahashi 1982, Ito 1988, 1990). These two previously reported undescribed taxa in Ito (1990) are formally described as new species.

Water samples were collected from Doro-ike Pond and Yasuba-ike Pond. Detailed descriptions of these ponds and procedures of sample collection, preparation and examination were given in a previous paper (Ito 1990). The cell number per m*l* of *Spiniferomonas hamata* was estimated by the methods of Ito and Takahashi (1982).

Spiniferomonas hamata sp. nov.

Cellulae sphaeroides, 5–7 μm diametro, squamis et spinis tectae. Squamae elliptis, 1.3–1.7 × 0.9–1.3 μm, una lacuna elliptica, cum vel sine spicula in labro lacunae. Squamae spina, 3.2–4.0 μm longae, spiculo carinato quod flacans foras in 1/3 parte terminale dimidiata ad formantas tres apices; apex longissimum terminans in apicem infractum. Cystae ignotae. Holotypus: Fig. 1.

Lecta ab H. Ito in stagno Doro-ike in monte Rokko, Praef. Hyogo, Japonia (March 26, 1976).

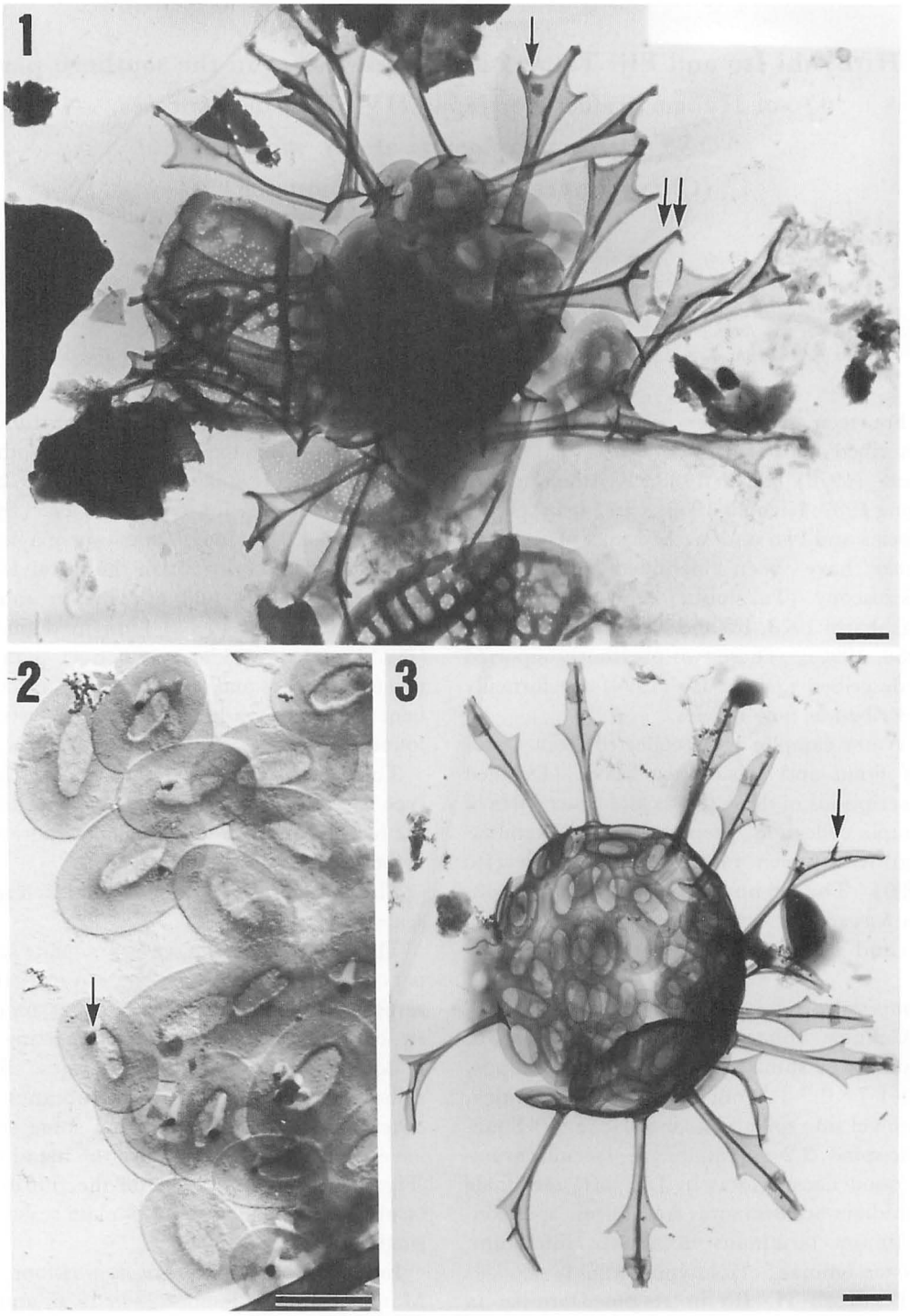
Cells spherical, 5–7 μm in diameter, covered with plate scales and spine scales (Fig. 1). Plate scales elliptical with a centrally located single elliptical lacuna and with or without a minute spike on the rim of the lacuna, 1.3–1.7 × 0.9–1.3 μm (Fig. 2). Spine scales, 3.2–4.0 μm long, consisting of a keeled shaft that flares outward in the distal 1/3 to form three apices and a plane or saucer-shaped basal disc (0.7–0.8 μm in diameter) (Fig. 1). The middle apex longer than the two other apices and terminating in a sharply bent tip forming a hook (Fig. 1). Cysts not found.

The fixed water sample that contains holotype specimen (No. 760326D) is deposited in the herbarium of Water Quality Laboratory, Kobe City Waterworks Bureau.

The epithet refers to a hooked apex of spine scale.

The number of spine scales and plate scales per cell varies from 15 to 22 and from 40 to 60 respectively. Almost all spine scales are constructed by two membranes connecting the middle ridge with the two other ridges. But a spine scale possessing three membranes was observed once (Fig. 1). Some spine scales have a tooth on the margin of the membrane (Fig. 1). A minute spike on the rim of the lacuna occurs in 10 to 40% of plate scales of a single cell.

In Doro-ike Pond, *S. hamata* was found on March 26 and September 24 in 1976, and the density was 59 and 3 cells/m*l* respectively. In Yasuba-ike Pond, the species was found on January 6, 1981 and the density was 25 cells/m*l*.



Figs. 1 & 2. *Spiniferomonas hamata* sp. nov.. 1. Whole mount cell. Arrow shows a tooth on the margin of membrane connecting ribs of spine scale and double arrows show a spine scale with three membranes. Holotype. 2. Scales. Arrow shows a minute spike on the rim of the lacuna. Figs. 3. *Spiniferomonas nichollsii* sp. nov., whole mount cell. Arrow shows the rectangular plate. Holotype. Scale bar=1 μm.

Spiniferomonas nichollsii sp. nov.

Cellulae sphaeroides, 5-6 μm diametro, squamis et spinis tectae. Squamae elliptis, 1.0-1.5 × 0.7-1.0 μm, uno lacuna elliptica. Squamae spina, 2.9-4.0 μm longae, e spiculo carinato quod flacans foras in 2/5 parte terminale dimidiata ad formantas tres apices et e discis basalibus planis vel leviter cavatatis, 0.6-0.7 μm diametro, compositae. Apex longissimus lingui formi et truncato, e membrana lata lateralis et membrana rectangulata ad centrum, 0.3-0.4 μm alta, constructo. Cystae ignotae. Holotypus: Fig. 3.

Lecta ab H. Ito in stagno Doro-ike in monte Rokko, Praef. Hyogo, Japonia (June 24, 1977).

Cells spherical, 5-6 μm in diameter, covered with plate scales and spine scales (Fig. 3). Plate scales elliptical with a centrally located single elliptical lacuna, 1.0-1.5 × 0.7-1.0 μm. Spine scales, 2.9-4.0 μm long, consisting of a keeled shaft that flares outward in the distal 2/5 to form three apices and a plane or saucer-shaped basal disc (0.6-0.7 μm in diameter). The middle apex much longer than the two other apices, truncated tongue-form, with broad membrane at both sides and a rectangular plate at central portion (Fig. 3). The rectangular plate has one or two hollows on the upper margin. Cysts not found.

The fixed water sample that contains holotype specimen (No. 770624D) is deposited in the herbarium of Water Quality Laboratory, Kobe City Waterworks Bureau.

The epithet is given in honor of Kenneth H. Nicholls.

The number of spine scales and plate scales per cell varies from 13 to 15 and from 50 to 70 respectively. No variations in the shape of plate and spine scales have been observed.

In Doro-ike Pond, *S. nichollsii* was found on June 24 and July 8 in 1977.

Fourteen species of *Spiniferomonas* have been classified into seven morphological groups (Group A-D, F-H) (Siver 1988, Kristiansen and Tong 1989, Nicholls 1989). Both *S. hamata* and *S. nichollsii* are assigned to the group C, together with *S. takahashii* and *S. alata*. The group C is characterized by one type of plate scale with a single lacuna and triangular spine scales with flared distal portion. *S. hamata* differs from *S. takahashii* and *S. alata* in having plate scales with one spike and spine scales with a hooked apex, and *S. nichollsii* differs from these two species in having spine scales with one rectangular plate.

The authors would like to thank Dr. Jørgen Kristiansen (University of Copenhagen) and Dr. Kenneth H. Nicholls (Ontario Ministry of the Environment) for their helpful advice and reading of the manuscript.

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伊藤裕之*・高橋永治**：兵庫県南部産黄金藻（Ⅳ） 2新種 *Spiniferomonas hamata* と *S. nichollsii*（黄金藻綱，パラピソモナス科）

兵庫県南部にある泥池と安場池から見出された2新種 *Spiniferomonas hamata* と *S. nichollsii* を記載した。両種は1つのくぼみのある板鱗片と外側に張り出した翼をもつ三角形の刺鱗片をもつ群に含まれる。(*652 神戸市兵庫区楠谷町37-1　神戸市水道局水質試験所，**990 山形市小白川町1-4-12　山形大学理学部生物学科)

藻類 Jpn. J. Phycol. 40: 185–188, June 20, 1992

都筑幹夫・下山直美・渡辺美由紀：IAM カルチャーコレクション保存株の利用状況（1987～1991）

Mikio Tsuzuki, Naomi Shimoyama and Miyuki Watanabe: Distribution of algal strains from IAM Culture Collection between 1987 and 1991

Numbers of strains distributed from IAM Culture Collection for last 5 years are illustrated. The strains were used mostly for basic and applied researches. Numbers of the requests for applied sciences rose in the past three years to a maximum in 1990. This was due to the initiation of research for CO_2 trap by algal photosynthesis against the increase in atmospheric CO_2 concentration. The researchers asked us information on algal culture as well as strains. Some in technological fields who have not studied biology needed our help to begin experiments on algal technology.

Key Index Words: algal strains—applied sciences—carbon dioxide concentration—culture collection—microalgae.

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今日，人類の活動によって自然環境はたえず変化している。そのため，生態系が変化し，さまざまな生物がその分布を変えている。絶滅の危機に瀕している種も多い。種を保存し後世に残すことはきわめて重要なことであり，そのためのカルチャーコレクションは不可欠の施設である。そして，保存された株が利用されれば，その価値は増大する。東京大学応用微生物研究所 (IAM) カルチャーコレクションは，文部省の援助を受け，長年にわたって研究・教育のために株を保存・分譲してきた。1989年度に，微生物微細藻類総合センターが発足し，それまで1研究部の中で行われていた藻類株の保存業務が細菌類のコレクションと統合され，体制の強化が図られた。その後，3年が経過し，藻類がどのように利用されてきたかその統計資料をまとめたので報告する。

IAM カルチャーコレクションで保存されている藻類株（保存株）は，約600株である。しかし，種名が不確かなどの理由で，保存株の中で分譲可能な株（分譲対象株）を選んでリストを作っている（市村，伊藤 1977）。分譲株282株のうち，213株が緑藻，48株がラン藻で，残りはユーグレナ，珪藻，紅藻，黄緑色藻，真眼点藻などである。なお，現在分譲株のカタログを作製中である。

Fig. 1は，IAM コレクションから分譲された株数の過去5年間の年度変化とその分譲先の内訳を示している。分譲株数は，1987年度から1990年度にかけて，年ごとに増加した。特に，1990年度に297株を記録し，1991年度には減少した。一般に，分譲株数は，国内国外における研究の動向はもとより，コレクション側における保存・分譲株の内容やコレクションの知名度・信用度などにより変化する。1989年から1990年度にかけての分譲株数の増加は顕著であり，また，保存業務の努力にも関わらず，1991年度にその数が減少したことはどんな意味があるのか検討することも大切である。そこで，その原因を探るとともに，藻類を用いた研究に関しその動向を把握しようと資料を作製した。

まず，研究者がどのような場合に株を必要とし，保存機関を利用するか整理しておくべきであろう。生理・生化学などの研究と分類・生態学などの研究では必要とする株の内容や依頼の回数が異なるからである。生理・生化学では，これまで用いていなかった株を使おうとする場合やはじめて藻類を用いようとする場合に，既に報告されている知見をもとにして研究を開始することが多い。培養が確立され情報の多い株の中から，目的にあった株を求めることになる。その株の種名は，他の種で得られたデータと比較するために必要であるが，極端な表現をすると，株番号が明らかであればよい場合すらある。多くの場合研究に用いる藻株は，1研究者あたり1ないし数株にすぎない。新しい性質を持った株を探すなどのケースを除いて，自然界からサンプリングすることは少ない。研究に用いられている株を他の研究者や保存機関から入手するのが普通で，一度入手すると，保存にトラブルが生じない限り再度分譲依頼することはない。一方，分類学や生態

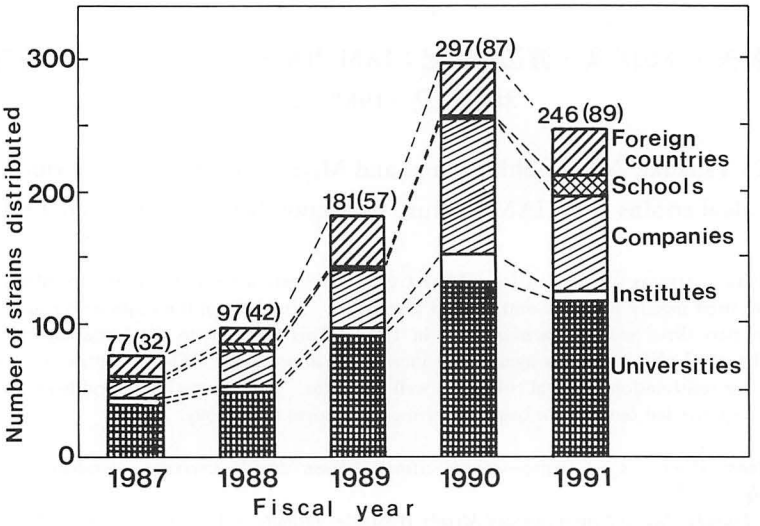

Fig. 1. Distribution of algal strains from IAM Culture Collection in each fiscal year (from April to March). Numbers above each column are those of strains distributed and of the requests (in parentheses).

学では，種の同定や新種の記載，新しい手法による再分類などの目的で保存機関などの株を利用する。そのため，生化学的研究よりも，むしろ，種名や採集場所などが正しく記載されている株を必要とする。同時に何種類もの株を扱うことになり，研究の進行に従ってさまざまな株を入手することになる。このように，研究分野によって用いる株の種類も，また，その数や分譲依頼の頻度も異なっている。

当コレクションでは，株の分譲に際して，藻類株利用の目的をうかがうようにしてきた。Table 1 は，その目的を並べたものである。目的を自由に記入するようになっていたため，その書き方は分譲依頼者によりさまざまで，研究領域や実験手段などその内容は必ずしも統一のとれたものでない。また，光合成と培養法のように互いに関連があったり，目的が複数の場合もあるなど統計に不十分な点はあるが，筆者らの判断で，依頼 1 件につき 1 つとして整理した。その結果，光合成 (Photosynthesis) や生体物質，酵素類 (Biochemicals including enzymes) などに関する基礎的な研究にも，また，大量培養 (Mass culture and culture system) や有用物質 (Beneficial materials) の探索などの応用的な研究にも藻株が利用されていることがわかる。特に外国からの依頼など利用目的が不明のものも少なくないが，「光合成とその関連領域」，「有用物質の探索とその生産性」，「大量培養・培養システムの開発」などが特に多い。酵素や細胞壁を含めた生体物質の研究やプロトプラスト化の研究などには，毎年数件ずつの依頼があった。また，当コレクションの研究者の専門が生理学であるからだろうか，分類・同定のために依頼する件数はあまり多くない。一方，「有用物質の探索とその生産性」や「大量培養・培養システムの開発」などの応用的研究が，1989年度から急増した。また，「環境問題」に関連して大気中 CO_2 の除去をめざした研究のためという分譲依頼が1990年度に突然10件となった。「光合成」の件数が最近 3 年間高くなっているが，これは，大気中から CO_2 を除去するために光合成 CO_2 固定の研究をしようとするものが含まれているからである。この時期は，大気中の CO_2 濃度が上昇し，地球の温暖化を引き起こすのではないかという社会的関心が高まった時期であり，当コレクションの藻類株がその研究に利用されていることを示している。1991年度に分譲株数が減少したのは，この研究が終了したからではなく，上にあげた理由により，研究者に藻類株が行き渡ったからであろう。担当者の個人的な接触から，「有用物質の探索」とあげた人の中には，CO_2 固定した後の藻株の利用を考えているケースが増えているようである。分譲数の多い株は，*Anabaena cylindrica* M-1, *Anacystis nidulans* M-6, M-200 (R-2 株), *Chlamydomonas reinhardtii* C-9, *Chlorella ellipsoidea* C-27, *C. pyrenoidosa* C-28, C-212, *C. saccharophila* C-211, *C. vulgaris* C-30, C-207, C-531, *Euglena gracilis* E-6, *Microcystis aeruginosa* M-176, *Nitzschia closterium* B-9, B-16, *Phaeodactylum tricornutum* B-14, *Porphyridium cruentum* R-1, *Spirulina platensis* M-135 などである。一方，まだ数は

Table 1. Number of requests to IAM Culture Collection in various purposes.

Purposes	Fiscal year				
	1987	1988	1989	1990	1991
Research					
Identification & classification	0	0	3	5	3
Photosynthesis	5	2	11	12	10
Mass culture and culture system	2	0	5	8	5
Environmental studies					
CO_2 fixation against global warming	0	0	0	10	2
Light and O_2 stress	0	0	0	2	0
Heavy metal resistance & accumulation	0	0	3	5	3
Salt stress	0	0	3	1	1
Chemical resistance	0	2	0	2	0
Freezing & cold resistances	0	1	0	0	0
N_2 fixation & N metabolism	1	3	3	3	1
Cell organella & differenciation	3	0	0	0	5
Flagella and cell movement	1	0	1	1	1
Comparison with symbiont	0	2	0	0	0
Allelopathy	0	1	0	1	0
Biochemicals including enzymes	3	5	4	4	5
Exploitation					
Beneficial materials	2	1	8	13	18
Feeds and foods	0	1	1	5	2
Biosensor	0	0	0	0	2
Bioreactor	0	0	0	0	2
Chemicals which suppress algae	0	1	0	0	1
Methods					
Protoplasts formation	2	4	2	1	0
Gene manipulation & transformation	1	1	1	0	7
Synthesis of radiocompounds	0	0	0	0	1
Unknown	11	14	8	12	15
Education (classes & extraclasses)	1	4	3	1	4
Exchange with other collections	0	0	0	1	0
Total	32	42	57	87	89

少ないが，高校など教育目的の分譲もある。その場合は，*Volvox*, *Pandorina*, *Pleodorina* などが多い。

Fig. 1 において，1990年度の総分譲株数の増加のうち，企業など民間研究機関への分譲数が特に増加したことから，民間研究機関の分譲先を業種別にしてみた(Table 2)。例年，食品，化学関係への分譲が多かったのに対して，1989年度以降は，建設，造船関係(Transport equipment)も多くなった。1990年度には，「その他（非営利団体）」に全体の44%の株が分与されている。そのほとんどは，官民共同出資による海洋研究の研究所設立に伴うもので，企業の研究者がその研究所で微細藻類の応用的研究を開始したことによる。このように，CO_2 問題を契機としてこの数年，民間企業を中心として微細藻類の応用的研究が活発になっており，今後その成果が期待される。民間企業で藻類が研究対象に取り上げられるようになったということは，藻類にはまったく縁のなかった非生物系の研究者が藻類を用いるようになってきたことでもある。この傾向は，大学の研究者にも当てはまり，東北大，東工大，広島大等の工学部系の研究者へも分譲している（データ省略）。

そのため，藻類一般の生理学的情報や生化学的実験

Table 2. Numbers of strains and the requests (in parentheses) from various types of industry.

Industries	Fiscal year				
	1987	1988	1989	1990	1991
Mining	0 (0)	0 (0)	0 (0)	4 (1)	0 (0)
Construction	0 (0)	0 (0)	7 (3)	9 (2)	3 (2)
Foods	3 (1)	3 (1)	9 (3)	11 (3)	8 (1)
Textiles	2 (1)	1 (1)	0 (0)	0 (0)	0 (0)
Chemicals	4 (3)	12 (3)	8 (4)	6 (4)	12 (4)
Medicines	0 (0)	0 (0)	4 (3)	1 (1)	21 (3)
Oil	0 (0)	1 (1)	3 (1)	5 (1)	0 (0)
Ceramics	0 (0)	1 (1)	0 (0)	2 (1)	0 (0)
Iron & steel	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)
Machinery	0 (0)	0 (0)	0 (0)	0 (0)	13 (5)
Electrical machinery	0 (0)	0 (0)	6 (2)	0 (0)	0 (0)
Transport equipment	0 (0)	0 (0)	1 (1)	17 (3)	2 (1)
Precision instruments	0 (0)	0 (0)	4 (1)	0 (0)	0 (0)
Commerce	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)
Electricity & gas	0 (0)	0 (0)	2 (1)	0 (0)	10 (3)
Others (nonprofit)	0 (0)	2 (1)	0 (0)	45 (7)	2 (2)
Total	9 (5)	20 (8)	44 (19)	102 (25)	71 (21)

法などに関する質問が多く寄せられた（1991年度には59件）。カルチャーコレクションは藻株だけでなく，情報も提供してほしいという一般研究者側からの要求が感じられる。藻類学の発展，そして，そのための藻類研究者人口の増加には，こうした基本的なサポートが必要である。専門的知識を持った人でなければ，その基礎知識を提供できるものではなく，一人ではカバーできないほどの広い領域である。そのうえ，個人レベルでの研究業績を評価される大学の研究者にとって，このサービスに時間をさくことが負担でないとは言い難い。カルチャーコレクションが，一人ではなく，複数の専門分野からなる複数の研究者によって運営されていくことが必要ではなかろうか。

Table 1 において，「遺伝子組み換え・形質転換」(Gene manipulation & transformation) に利用される数が1991年度に急増している。藻類の研究も分子レベルでの解析がすすんでいくことがうかがわれる。微細藻類が応用研究に利用されるようになり，新たな実験手法も加わって，大きな発展の時期に来ているのかもしれない。

文　　献

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日本藻類学会第16回大会ワークショップ（海苔栽培業見学会）参加記

3月30日と31日に東京水産大学で行われた藻類学会に先だち，27, 28の両日，海苔栽培業見学会が行われた。27日は東京で桜が咲き始めたとは言え，どんより曇った空からいつ雨が落ちてくるかと心配であった。集合時間の2時半少し前に千葉県の房総半島の中程，JR上総湊（かずさみなと）の駅前に着くと，春雨がポツリポツリと降ってきた。すでに7，8人の人達が集まっていた。その中に一人だけ見覚えのある品の良い女性の姿が見えたので（明治大学の山本鎔子先生であった），集合場所はこれで良かったのだと安堵した。そのうち，千原光雄先生や，R. E. Lee の Phycology という教科書に出てくる写真と同じ風貌の，ドイツの Dr. メルコニアンも来られた。メルコニアンさんには，写真と同じ顔ですね，と言って挨拶した。

ところで，私は遺伝学の出身で接合藻とお付き合いしているが，藻類学にうとい。学会には時々参加するが，紅藻については殆ど知らない。そこで，藻類学の大家，千原先生の図鑑を見ると，海苔の生活環が戦後解明されたと言って図示されていた。そこへ海苔の見学会があるというので，参加してみたくなったのである。後で思えば残念なことに，三浦先生については全く知らなかった。上から下まで黒のトレーナーと毛糸の帽子に身を固めた小柄な方を，全く失礼なことながら，JRの保線員さんかなと思ったのである。ところが，それがとんでもない間違いだということにはすぐ気が付いた。というのは，その保線員氏は，海苔の生活環について詳細に説明したプリント（図1）をいきなり皆に配り，「千原先生の図鑑の海苔の生活環の説明では，減数分裂の起こる場所が定かになっていません」と，エライことをのたまわったのである。千原先生は恐縮しながらも，笑って何やら言い訳しておられた。この方が，「海苔の神様」とまで言われる，東京水産大学の三浦昭雄先生であることは，後で千原先生にお聞きして知った。

海苔の栽培と，海苔の良し悪しの見分け方

「神様」に導かれ，我々は歩いて十分程の，天羽（あまは）漁業協同組合湊のり生産組合に着いた。そこで一行17人は，組合の川崎忠洋氏から，海苔生産工程を実際に見ながら説明して頂いた。まず，収穫した海苔を水洗し，小さく裁断する。この海苔を水と混ぜ，和紙と同じ要領で，大きな海苔すき機で順々にすく。海苔すき機は，海苔の大きさ(20×21 cm)の簀（す）が，横に8枚，縦に50列程，戦車のキャタピラーのように並んでいる。そして，最後には10束（100枚）づつになった海苔を検査し，色，ツヤ，重さなどに従って，100近い等級に分ける。製品は10束当り，最高級品が2万円，最下級品は700円程にしかならないという。「高級品は，一流の寿司屋の海苔巻き。味付け海苔や海苔の佃煮は安物。最下級品は，言っちゃ悪いが，永谷園のお茶付け海苔」と，江戸っ子ならぬ上総っ子の弁。また，「買うなら，値段の高い焼き海苔を買うといい。気の毒だけど，スーパーにはいい海苔は置いてないね」とのことである。

良い海苔は，まず色が黒く，艶があり，薄く，柔らかい。こういう海苔は，独特の良い香りがする。海苔は栽培して1週間程で収穫できる。その時，葉状体の先端部を刈り取っても，基部からまた成長してきて，一週間でまた収穫できる。これを4～5回繰り返すが，始めほど質が良くておいしい。後になると，色は赤っぽくなり，つやもなく，堅く，パサパサでまずくなるという。薄い海苔が良いというのは，粘りがあるので薄くすけるのだそうだ。粘りがなくなると，穴が空くので厚くせねばならず，「食っても旨くない」という。そう言うわけで，4～5回も収穫すると値が落ちるので，新しい殻胞子の付いた新しい網を零下20度位の冷凍庫から取り出してきて，漁場に張り直し，再び栽培する。そして一冬に4～5回これを繰り返し，10月に始めた漁は，4月始め頃終わるという。

海苔の葉状体は成育し，卵と精子が受精し，その後果胞子が出来る。果胞子から糸状体を発芽させるには，カキの殻（1枚約5円）の内側の白い面に果胞子を付着させ，海水に漬け，弱い光を当てる。糸状体を発芽させる基質には，ホタテでもアワビでも，またアサリでも良い。カキを使うのは，糸状体の成長にとり丁度良い柔らかさのうえ，カキ殻が分厚過ぎず，殻胞子を一斉に放出させるのに都合が良いから，という。また，カキ殻を使ったデータが沢山あるのでやりやすいそうだ。

その夜は，一同，天羽魚協の鈴木利定さん経営の鈴孝荘に泊めて頂き，海の幸に囲まれ，楽しい懇親会があった。海苔の神様は，また酒仙でもある。お蔭で宴席には銘酒が集まる。なかでも，小泉酒造の「しぼりたて」は，すこぶる口当りが良く，酔い心地も良い。

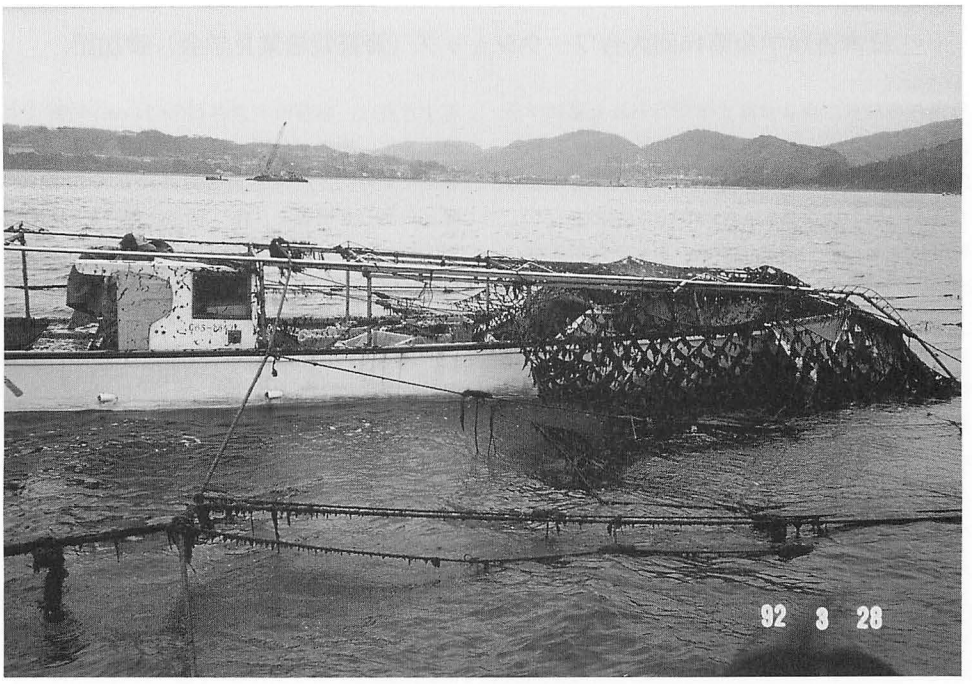


写真１．高速海苔摘採船による海苔の収穫風景（天羽漁業協同組合湊のり生産組合の海苔漁場において）

私の住む富山の銘酒，「立山」に勝るとも劣らぬ逸品で，欧米のアルコール類とは比べようもない。高度な日本文化の証明であった。

自己紹介は，有賀先生から始まった。先生は，海苔の色と色気に興味を持っておられるという。海苔が黒いのは，クロロフィルの緑と，紅藻素の紅色が合わさるからだそうで，海苔を焼くと緑になるのは，熱に弱い紅藻素が壊れ，クロロフィルの色だけが残るからと言う。さて，色気の話の方は，予告だけであった。きっと，参加された四人の御婦人が上品なうえ，揃って美人なので，遠慮されたのだろう。あとの方たちの自己紹介は，美人の色香と，「しぼりたて」のお蔭か，記憶がどうもおぼろである。夜一時近くまで，藻の話に花が咲いた。

翌朝は６時前に起床した。朝食の時，神様は誰かと迎え酒を楽しんでおられた。７時頃から湊のり生産組合の海苔漁場を，大きな舟（約20人乗り）と小さな舟（約６人乗り）に分乗し，見学させて頂いた。沖合500メートルぐらいに，海苔網が浮かんでおり，幅２m位の高速海苔摘採船が，水面近く浮いている網を船の上に持ち上げながら進み，瞬く間に１網(1.2 m×18 m)の海苔を収穫してしまう（写真１）。この間１分もあろうか。しかし，船に乗っている２人の漁師さんは，雨合羽を着てはいるが，まさに全身海苔だらけになって，寒風吹きすさぶ冬の間収穫しなければならず，その苦労が偲ばれた。

この後，一同はバスに乗り，新富津（しんふっつ）漁業協同組合に行った。ここでも，カキの殻を使い，海苔の糸状体培養を行っていた。その後，房総半島に突き出た富津岬の展望台から海苔漁場を見学した。ここでは，新しい浮き流し式栽培法と，昔の支柱式栽培法の両方が，岬の両側に見られ，まさに海苔栽培の歴史が一目瞭然であった。千葉県水産試験場富津分場で，昼食の御馳走になった後，千葉県における海苔栽培業に関する講義を受けた。その後，千葉県のり種苗センターを見学した。

最後に千葉県東京湾栽培漁業センターを見学した（写真２）。ここでは，大きな水槽が50個も有ったが，そのうち特に大きな物は直径約10メートル，深さ約1.5メートルもあり，クロダイ，ガザミ（カニの１種），マコガレイなどを養殖している。特に今は，マコガレイ稚魚の飼育期に当っているので，大きな水槽の多くで無数の小さなマコガレイが元気に泳いでいた。また，立派なクロダイが泳いでいるのを見ると，昨夜の懇親会でタイの活き造りを食べたせいか，旨そうだなと，つい思ってしまう。これらの魚の餌にするため，小さ

写真２．見学会参加者（全員）（千葉県東京湾栽培漁業センター門前にて）

な動物性のプランクトンのワムシ（輪虫類）やアルテミア（節足動物，甲殻類）を養殖し，それらプランクトンの餌として，海洋性のクロレラ（千原先生によると，本当はクロレラでなく，クロロフィルａとビオラキサンチンを持つ，真眼点藻綱の *Nannochloropsis oculata* で，緑藻とは異なる）の培養をするという具合で，全体としてすこぶる大規模なものであった。例えば，クロレラの培養のために，おおよそ縦９メートル，横３メートル，深さ２メートル程の大きな水槽が14個も屋外に並んでいる。そのうちの半分ぐらいで，クロレラがエアレーションされながら濃密に繁殖していると言う塩梅であった。こうして育てた魚は，漁業組合に出荷したり，標識を付けて東京湾に放流し，資源調査に役立てるという。今回の見学会では，千葉県海苔栽培業関係漁業協同組合のいくつかの研究室や栽培場を見せて頂いたが，それぞれの栽培場では少しづつ違った方法で栽培されており，工夫されていた。

日本が世界に誇る研究：海苔の減数分裂について

現在養殖されている海苔の殆どは北海道原産の，環境中の栄養の変化に強いスサビノリ (*Porphyra yezoensis* Ueda) で，アサクサノリ (*P. tenera* Kjellman) ではない。ここで，教わりたてのスサビノリの生活環に触れたい（図１）。

我々が食べるスサビノリの本体は，一層の細胞からなる葉状体で，単相 (n) 世代の体である。この他，糸状体と呼ばれる複相 (2n) 世代の体がある。雌雄同株の葉状体の縁辺に形成された卵 (n) は，その位置に留まり，他の縁辺部で形成された精子 (n) が流れて来て受精し，接合子 (2n) を作る。この接合子は分裂し，４個，８個或は16個の果胞子 (2n) となる。果胞子はカキなど貝の殻に穿孔して発芽し，糸状体 (2n) を形成する。糸状体は殻胞子嚢 (2n) を形成し，殻胞子嚢から殻胞子（かくほうし，2n)を放出する。この殻胞子が発芽する際に減数分裂を行い，我々が普通に見る海苔の葉状体 (n) に戻る。

生活環を見る場合，重要なのは，配偶子がどこで受精するかということと，減数分裂がどこで行われるか，ということである。一般に，受精については比較的分かり易い。しかし，減数分裂については曖昧なものが案外多い。ノリの場合も例外ではなかったという。イギリスの Drew，カナダの Hawkes らのお蔭で生活環の研究が進んだ。しかし，減数分裂がどこで行われるかについては，はっきりしなかった。それが，日本の大目・三浦らにより，殻胞子が発芽するところで減数分裂することが判明した。彼等は，葉状体の色が緑や赤の自然突然変異体に注目し，野生型（黒色）の海苔を含めて交配し，どのステージで色が分離するかを調べてみたのである。すると，葉状体（海苔の本体）にキメラ状の色の分離が起こった（図２）。もし，殻胞子嚢に殻胞子が形成される際に減数分裂が起こるとすると，１個の殻胞子由来の１枚の葉状体は１色になる筈で，色がキメラ状に分離することは遺伝学的にあり得ない。つまり，減数分裂は，殻胞子から葉状体が発

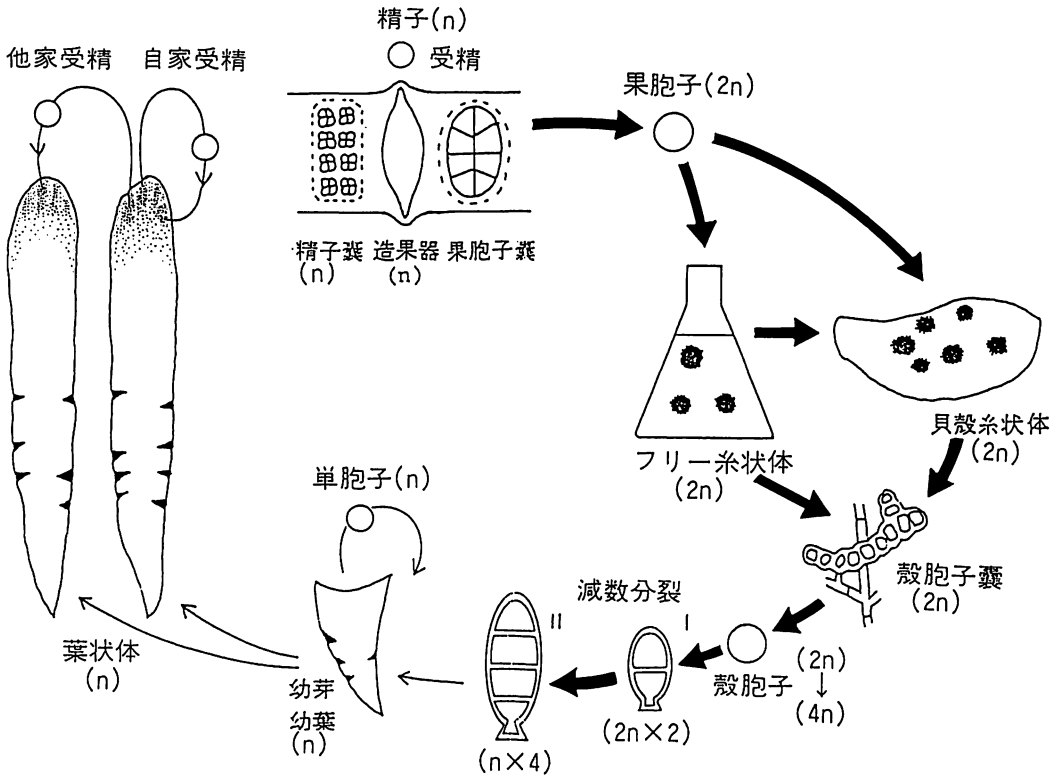


図1．スサビノリの生活環（三浦による）

芽する際に起こることの動かぬ証拠であった。この遺伝学的証拠は，さらに細胞学的にも確かめられた（因みに，n=3である）。また，四分子分析で，これらの遺伝子のマッピングもされた。

私はこれらの話に非常に興味を持ち，30日の学会の際，三浦先生の研究室にお邪魔し，実際に緑と赤のキメラになったスサビノリの葉状体を，先生と，この3月に博士になられた申さんから見せて頂いた（図2）。また，図2aのように2色が上部と下部に分かれたキメラの割合が，図2bのように2色が交互になったものより多かった。このことは，スサビノリの減数分裂が，後還元型ではなく，前還元型の減数分裂であることをも示している。もし，後還元型減数分裂であれば，2色が交互になったものの方が多くなるはずである。減数分裂をする生物の中で，最も原始的な原始紅藻類のアマノリの減数分裂は，有性生殖（減数分裂）の起源を考える上で非常に重要で興味深いので，その特徴を以下に挙げる。1）殻胞子が発芽する際に減数分裂を行う。つまり，これまでに分かっている接合子還元（例：アオミドロ），胞子還元（例：シダ），配偶子還元（例：人間）に当てはまらない。2）前還元型減数分裂である。3）減数分裂の結果生まれた四分子は，各々バラバラになるのではなく，すべてが1枚の葉状体で，分裂した順序につながっている。4）Unordered tetradではなく，Ordered tetradである。進化学的に原始的なスサビノリの減数分裂は，四分子の各細胞が全体として連続した細胞群となって，どこか体細胞分裂に似ているところに大きな特徴がある，と思った。

三浦先生は，「今まで海苔の研究は，海苔を食べない外国の藻類学者のお世話になってきて，日本人はただ食べるだけだった。しかし，やっとここで日本人として学問的にも貢献できて，非常に嬉しい」と言っておられた。「学問が正しければ儲かるはずだ」というのが三浦先生の哲学のようで，実際多くの栽培業者が三浦先生のお蔭で潤っているのを目の当たりにして，「ハアー」と言って返す言葉がなかった。あの千原先

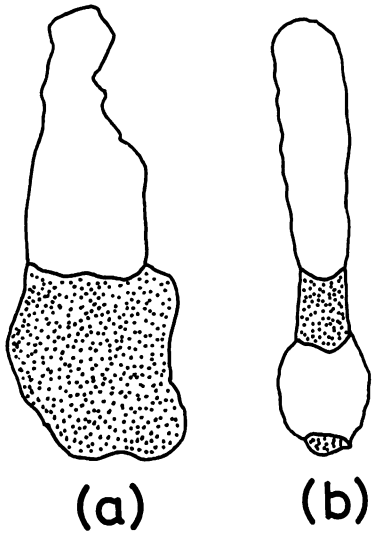


図2．スサビノリの葉状体の色の遺伝（三浦先生のご厚意によりスケッチ）
a, 2つの色の遺伝子間で交叉を起こしてない葉状体；b, 2遺伝子間で交叉を起こした葉状体。

生が，「海苔の神様」とまでおっしゃった意味がよく分かった。学問はやればやるほど赤字だと思ってきた私としては，果たしてミカヅキモでも儲かるのだろうか，と思う。

今回の見学会，そしてその後で行われた学会では，若い熱心な藻類学者が，国籍や男女を問わず，日本で育っていることを感じた。彼等のこれからの学問の発展に大いに期待したい。

最後に，この見学会のお世話をして下さった，東京水産大学の諸先生方と千葉県漁連関係の方々に，深い感謝の気持ちを表したい。特に，3月31日付けで東京水産大学を停年退官された三浦昭雄先生の，今後の益々の御活躍と御健康を心から祈る次第である。また，三浦昭雄，千原光雄の両先生には，この原稿の校閲をして戴いた。重ねてお礼を申し上げたい。

なお，見学会の参加者は以下の諸氏（17名）であった（写真2参照）。

写真前列左より：パトリシア・リリアナ・ヒル・コダカ（東北大院卒・ペルー），黒田充恵（大阪成蹊女子短大・一般教養），吉崎誠，山岡容子（以上東邦大・理），藤田隆夫（日大付属習志野高・生物），岡崎恵視（東京学芸大・生物），川井浩史（北大・理），後列左より：能登谷正浩（東京水産大），濱田仁（富山医薬大・医），山本鎔子（明治大・農），和田俊司（共立女子大・生物），有賀祐勝，申宗岩，三浦昭雄（以上東京水産大），M. Melkonian（Bot. Inst. Univ. Köln・ドイツ），千原光雄（日赤看護大），大葉英雄（東京水産大）

（濱田　仁：富山医科薬科大学）

—学 会 録 事—

1. 日本藻類学会第16回大会

1992年3月30日・31日の両日，東京水産大学講義棟において第16回大会を開催した。大会会長は三浦昭雄氏（東京水産大学）で，参加者は133名であった。講演は57題の一般講演（うち展示講演7題）および特別講演1題があった。

大会第1日目に同会場において総会を開催し，引き続き同大学生協食堂で約2時間にわたって懇親会を開催した。懇親会は野崎久義氏（慶応高校）の司会により，三浦昭雄大会会長の挨拶，有賀祐勝学会長の乾杯の音頭で始まり，118名という多数の参加で，盛会裡に終了した。東京水産大学の本会関係者ならびに学生諸君には大会運営にあたっていろいろご協力頂き，厚くお礼申し上げる。

懇親会参加者

相沢賢一・秋岡英承・秋山　優・浅井紀子・鯵坂哲朗・阿部信一郎・阿部剛史・有賀祐勝・E. Lobo Alcayaga・飯田高明・飯泉　仁・庵谷　晃・石川依久子・石田健一郎・石原利章・出井雅彦・井上　勲・猪俣秀一・榎本幸人・M. Melkonian・恵良田眞由美・遠藤記子・大野正夫・大房　剛・大葉英雄・岡崎恵視・小河久朗・小倉久学・加崎英男・梶村光男・片山舒康・神谷充伸・香村真徳・川井浩史・川合正允・川嶋昭二・河地正伸・菊地則雄・喜田和四郎・北山太樹・木津さおり・清原正高・熊野　茂・桑野和可・高原隆明・小亀一弘・小亀安代・小林　弘・駒崎　健・今野敏徳・斉藤宗勝・坂西芳彦・G. V. Deshmukhe・清水晃・杉山篤志・須田彰一朗・瀬戸良三・高橋永治・館脇正和・田中次郎・千原光雄・当真　武・土井考爾・中嶋　泰・長島秀行・長嶋美香子・中原紘之・中山恭彦・中山　剛・鍋島靖信・二宮早由子・二羽恭介・野崎久義・能登谷正浩・萩原富司・畠山典子・畠中芳郎・馬場将輔・濱田　仁・林田文郎・原　慶明・半田信司・坂東忠司・Patricia L. G. Kodaka・広部真理子・樋渡武彦・福永公平・藤井哲也・藤田隆夫・藤田大介・舟橋説往・堀口健雄・堀　輝三・本多大輔・馬　家海・前川行幸・正置富太郎・増田道夫・真山茂樹・松尾雅志・松本正喜・松山和世・丸山　晃・三浦昭雄・御園生　拓・宮村新一・宮地和幸・村瀬　昇・本村泰三・山岸高旺・山田家正・山本鎔子・横浜康継・吉崎誠・吉田忠生・吉田智成・吉永一男・渡辺　信。

2. 編集委員会・評議員会

第16回大会の前日，3月29日に東京水産大学資源育成学科会議室において編集委員会および評議員会を開催した。評議員会では1992年度総会に提出する報告事項・議題などの審議を行った。審議の内容については総会の項を参照されたい。

編集委員会出席者：有賀祐勝，井上　勲，石川依久子，大野正夫，館脇正和，渡辺　信，原　慶明，岡崎恵視，千原光雄，小林　弘，横浜康継，吉田忠生，真山茂樹。

評議員会出席者：有賀祐勝，榎本幸人，井上　勲，石川依久子，香村真徳，喜田和四郎，増田道夫，中原紘之，大野正夫，館脇正和，月館潤一，渡辺　信，原　慶明，岡崎恵視，千原光雄，小林　弘，横浜康継，吉田忠生，能登谷正浩，庵谷　晃。

3. 1992年度総会

1992年3月30日（大会第1日目）の講演終了後，東京水産大学講義棟において総会を開催した。有賀祐勝学会長の挨拶に続いて，小林　弘氏を議長に選出して議事に入った。

Ⅰ．報告事項

1. 庶務関係

(1)会員状況（1992年3月現在）：名誉会員3名，普通会員544名，学生会員52名，団体会員45名，賛助会員11名，外国会員101名，講読52件，寄贈・交換27件。(2)1991年度文部省科学研究費刊行助成金「研究成果公開促進費」交付額は970千円で，責任頁は360頁であった。なお，1992年度については補助要求額2,722千円，責任頁360頁を申請した。(3)1991年度秋季シンポジウムを1991年9月8日～11日に筑波大学で第2回日韓藻類学シンポジウムとして開催した（藻類39巻4号参照）。(4)第16回大会前（3月28日～29日）にワークショップ（海苔栽培業見学会，世話人三浦昭雄氏）が行われた。(5)第1回日本藻類学会賞は前川行幸・喜田和四郎の両氏に授与されることになった。対象論文は39巻2号掲載の，Distributional pattern of *Ecklonia cava* (Phaeophyta) marine forest in the coast of Shima Peninsula, central Japan である。

2. 会計関係

(1)12月31日現在の1991年度の会費納入率は，普通会員91%，学生会員84%，賛助会員73%，団体会員61%，外国会員42%である。(2)1991年度一般会計と同山田幸男博士記念事業基金特別会計の決算は，片山舒康（東京学芸大学），市村輝宜（東京大学）の両会計監事により1992年3月6日監査が行われ，適正であると承認された。

3. 編集関係

(1)1991年度に発行した「藻類」第39巻第1～4号は，総頁数419頁，掲載論文数34編（内，英論文29編，和論文5編），短報13編（内，英短報9編，和短報4編），総説1編，雑録24編であった。頁当たりの平均経費は10,996円であった。掲載論文の超過頁は17頁であった。

(2)1992年3月10日に発行した第40巻第1号は，掲載論文数5編（内，英論文4編，和論文1編），短報4編（内，英短報3編，和短報1編），総説0編，雑録6編で，110頁であった。

(3)1991年3月29日現在の投稿論文数は受理済み5編，却下5編，著者改訂依頼中15編，審査中13編である。

Ⅱ．審議事項

1. 庶務関係

以下のことが審議され，承認された。(1)「藻類」第40巻第1～4号を発行する。(2)秋季シンポジウムを日本植物学会大会関連集会として，中原紘之氏を窓口に計画を進める。(3)日本藻類学会第17回大会を東海大学海洋学部で，同学部所属の会員のお世話で開催してもらうよう計画を進める。

2. 会計関係

(1)1991年度一般会計の決算報告および同監査報告は表-1のとおり承認された。(2)1991年度山田幸男博士記念事業特別会計の決算報告および同監査報告は表-2のとおり承認された。(3)1992年度一般会計および山田幸男博士記念事業特別会計の予算は表-3のとおり承認された。

3. 編集関係

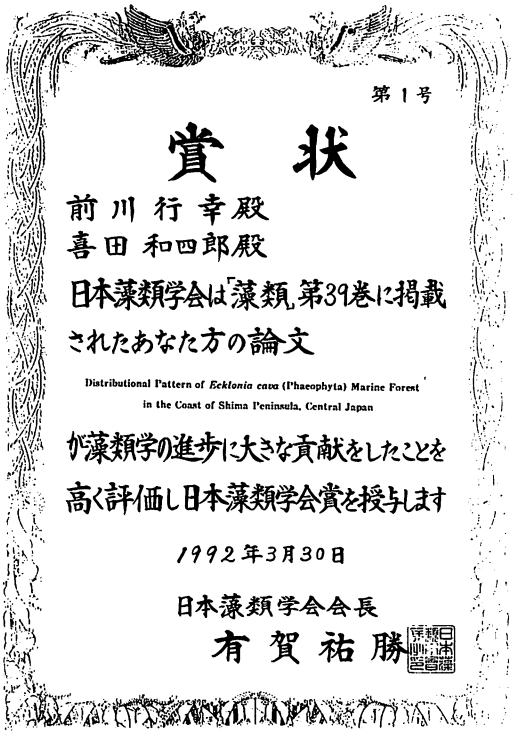
短報の制限頁数を3頁から4頁に変更することが承認された。

4. その他

(1)井上　勲，渡辺　信両評議員から提案された学会誌の改革について，石川編集委員長を世話人にワーキンググループを作り，その可能性や問題点を検討することになった。(2)高校までの理科教育における藻類の取扱について，東京学芸大学所属の会員に問題点を整理して貰うことになった。

Ⅲ．学会賞の授与

本会会則第13条および日本藻類学会賞受賞者選考内規に基づいて受賞者の選考が行われ，3月30日の総会において次のような体裁の日本藻類学会賞（第1号）が前川行幸，喜田和四郎両氏に授与された。



第1号

賞　状

前川行幸殿
喜田和四郎殿

日本藻類学会は「藻類」第39巻に掲載されたあなた方の論文

Distributional Pattern of *Ecklonia cava* (Phaeophyta) Marine Forest in the Coast of Shima Peninsula, Central Japan

が藻類学の進歩に大きな貢献をしたことを高く評価し日本藻類学会賞を授与します

1992年3月30日

日本藻類学会会長
有賀祐勝

4. 日本藻類学会第16回大会ワークショップ（海苔栽培業見学会）報告

1992年3月27日～28日に上記ワークショップを開催した。三浦昭雄氏を世話人に，16名の会員が参加した。なお，見学会の内容は参加記を参照されたい。

ワークショップの開催にあたってお世話になった天羽漁業協同組合湊のり生産組合・新富津漁業協同組合・千葉県水産試験場富津分場・千葉県のり種苗センター・千葉県東京湾栽培漁業センターにお礼申し上げる。

表-1　1991年度　一般会計決算報告　(91. 1. 1-91.12.31)　　日本藻類学会

収入の部 (円)		支出の部 (円)	
会費	5,909,035	印刷費	5,339,878
普通会員	4,083,000	印刷代	4,607,190
学生会員	260.000	別刷代	732,688
外国会員	534,035	編集費	383,294
団体会員	792,000	英文校閲料	100,000
賛助会員	240,000	編集補助費	50,000
販売	976,770	通信連絡費	209,012
定期購読	826,000	事務用品費	24,282
バックナンバー	150,770	会誌発送費	363,309
別刷代	740,410	庶務費	701,853
超過頁負担金	204,000	事務用品費	1,278
広告代	180,000	会議費	38,000
受取利息	132,107	通信・印刷費	249,906
プログラム代	51,510	事務整理補助費	0
文部省刊行助成金	970,000	幹事旅費補助	25,940
雑収入	15,429	幹事手当	160,000
		諸雑費	226,729
		事務業務委託費	1,483,200
		第15回大会補助費	120,000
		秋季シンポジウム会場費	50,000
小計	9,179,261	小計	8,441,534
前年度繰越金	5,161,607	次年度繰越金	5,899,334
合計	14,340,868	合計	14,340,868

貸借対照表　(91.12.31 現在)

借方 (円)		貸方 (円)	
定期預金 (第一勧業銀行)	1,000,000	未払金	137,845
普通預金 (第一勧業銀行)	2,520,633	前受会費	1,071,000
普通預金 (住友銀行)	100,596		
普通預金 (山梨中央銀行)	21,108	前期繰越金	5,161,607
郵便振替貯金	1,248,566	当期剰余金	737,727
小口現金	253,737		
事務局	187,037	次期繰越金	5,899,334
本部	66,700		
受取小切手	76,159		
カード	58,330		
UC カード	36,430		
アメリカンエキスプレス	21,900		
未収金	1,709,050		
仮払金	120,000		
合計	7,108,179	合計	7,108,179

1992年 3 月 6 日

本会計決算報告は適正である事を認める。
1992年 3 月 6 日

日本藻類学会会長　有賀祐勝 ㊞
日本藻類学会会計幹事　能登谷正浩 ㊞

日本藻類学会会計監事　片山舒康 ㊞
日本藻類学会会計監事　市村輝宜 ㊞

表-2　1991年度山田幸男博士記念事業特別基金会計決算　(91. 1. 1-91.12.31)　　日本藻類学会

収入の部 (円)		支出の部 (円)	
山田追悼号売上金	7,000		
論文集「コンブ類」売上金	3,000		
(内　未収金	1,000)		
日米セミナー売上金	4,000		
受取利息	79,073		
小　計	93,073	小　計	0
前年度繰越金	2,096,470	次年度繰越金	2,189,543
合　計	2,189,543	合　計	2,189,543

貸借対照表 (91.12.31現在)

借方 (円)		貸方 (円)	
定期預金 (住友銀行)	1,900,000	前期繰越金	2,096,470
普通預金 (住友銀行)	252,543	当期剰余金	93,073
現　金	23,000		
郵便振替貯金	12,000	次期繰越金	2,189,543
受取小切手	1,000		
未収金	1,000		
合　計	2,189,543	合　計	2,189,543

1992年3月6日

日本藻類学会会長　有賀祐勝 ㊞
日本藻類学会会計幹事　能登谷正浩 ㊞

本会計決算報告は適正である事を認める。
1992年3月6日

日本藻類学会会計監事　片山舒康 ㊞
日本藻類学会会計監事　市村輝宜 ㊞

1992年4月15日

日本藻類学会第16回大会決算報告

収入 (円)		支出 (円)	
大会参加費	4,000×119人=476,000	人件費 (アルバイト賃・謝金)	436,000
普通会員	3,000×　14人=　42,000	プログラム印刷費 (150部)	36,560
学生会員	3,000×118人=354,000	会場賃貸料 (4部屋×2日)	25,915
懇親会費	120,000	消耗品費 (文具・木材等)	76,932
大会補助費		休憩室お茶代	15,476
		懇親会費	360,485
		会議費	35,706
		通信費	4,926
合　計	992,000	合　計	992,000

表-3　1992年度　一般会計予算　　日本藻類学会

収入の部	(円)	支出の部	(円)
会費	4,669,050	印刷費	4,949,000
普通会員	3,213,000	印刷代（360頁）	4,160,000
学生会員	216,750	別刷代	789,000
外国会員	583,100	編集費	407,000
団体会員	469,200	英文校閲料	100,000
賛助会員	187,000	編集補助費	50,000
販売	756,000	通信連絡費	222,000
定期購読	656,000	事務用品費	35,000
バックナンバー	100,000	会誌発送費	318,000
別刷代	600,000	庶務費	860,100
超過頁負担金	200,000	事務用品費	20,000
広告代	180,000	会議費	60,000
受取利息	100,000	通信・印刷費	467,100
プログラム代	30,000	事務整理補助費	0
文部省刊行助成金	970,000	諸雑費	100,000
雑収入	20,000	幹事旅費補助	53,000
		幹事手当	160,000
		学会業務委託費	1,483,000
		第16回大会補助費	120,000
		秋季シンポジウム会場費	50,000
小計	7,525,050	小計	8,187,100
前年度繰越金	5,899,334	予備費	5,237,284
合計	13,424,384	合計	13,424,384

1991年度山田幸男博士記念事業特別基金会計決算

収入の部	(円)	支出の部	(円)
山田追悼号売上金	7,000	学会費	10,000
論文集「コンブ類」売上金	1,000		
日米セミナー売上金	4,000		
受取利息	79,073		
小計	91,073	小計	10,000
前年度繰越金	2,189,543	予備日	2,270,616
合計	2,280,616	合計	2,280,616

―会 員 移 動―

新　入　会

住 所 変 更

訃　　報

本会会員　日出武敏氏は去る1991年5月2日逝去されました。
本会設立発起人　殖田三郎氏は去る1992年3月30日逝去されました。
謹んで哀悼の意を表します。　日本藻類学会

退　　会

西田一豊（兵庫県）

日本藻類学会々則

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

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

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

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

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

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

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

投　稿　案　内

Ⅰ．編集の方針　本誌には藻学と応用藻学に関する会員の未発表の，論文・総説・短報（短い調査報告など）・速報・雑録（採集地案内・分布資料・ニュース・所見・新刊紹介など）を掲載します。論文はデータや考察の独創性の有無に重点を置いた編集委員会の審査を経たのち受理されます。原稿の取捨，掲載順序，体裁などは編集委員会および編集幹事で決めます。原稿は和文または英文とし，論文は刷上り英文10頁，和文６頁，総説15頁，短報４頁，雑録１頁以内を無料とします。頁の超過は制限しませんが，超過頁分については１頁当たり12,000円が必要です。折り込み，色刷りなどの費用は著者負担となります。また，速報は２頁以内と制限があり，有料で１頁12,000円の掲載料が必要です。和文原稿では５枚（ワープロでは２枚）が，英文原稿では２枚が刷上り１頁となる見当です。

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Information for Authors (Revised March 1990)

Members of the Society are invited to contribute original research reports, short communications, review articles and rapid communications in Japanese or English on all aspects of phycology. Every research paper is read and criticized by reviewers on the basis of its originality and the discussion presented. Where appropriate, reviewers other than those on the Editorial Board are consulted. Final responsibility for selection and published order of papers rests with the Editor. Research reports not longer than 10 printed pages in English and 6 printed pages in Japanese including figures and tables, short communications within 4 printed pages and review articles within 15 printed pages will be published without excess charge (exclusive of reprints); additional published pages will be charged to the author (12,000 Yen per single printed page). Rapid communications acceptable within 2 printed pages will be published in the possible earliest issue with charge at 12,000 Yen per single printed page.

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

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

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

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

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

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

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

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

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

日本学術会議だより　No.24

第15期特別委員会の活動始まる

平成4年3月　日本学術会議広報委員会

日本学術会議では，昨年の10月の総会において設置された第15期の各特別委員会が活動を始めましたが，今回の日本学術会議だよりでは，これらの特別委員会に加えて，日本学術会議主催ＩＧＢＰシンポジウム等についてお知らせいたします。

第15期の特別委員会

昨年10月の第113回総会で決定された，日本学術会議の第15期活動計画では，活動の重点目標として，①人類の福祉・平和・地球環境の重視，②基礎研究の重視，③学術研究の国際貢献の重視，の３本の柱を掲げるとともに，これらの重点目標を踏まえて，多方面の科学者によって構成される日本学術会議にふさわしく各分野にわたって広く対応し，かつ第15期中に適切な形で報告・提言に取りまとめるべき具体的課題として14の課題を選定している。

具体的課題のうち，今期中に一応の結論を出すことが望ましい臨時的な７つの課題については，それぞれ特別委員会を設置し，審議を開始した。

各特別委員会の名称及び任務等は次のとおりである。

◆文化としての学術
　委員長：宅間　宏（第４部会員）
（任務）学術は，人類発展の基礎である。学術研究の意義についての社会的認識を深めるため，文化としての学術の在り方を検討する。

◆平和と安全
　委員長：香西　茂（第２部会員）
（任務）平和と安全の確保や国際摩擦の解消等に関する研究推進の在り方及び研究体制等について検討する。

◆死と医療
　委員長：小坂二度見（第７部会員）
（任務）医療技術の急速な進展は，自然科学の分野だけでなく，人文・社会科学の領域にも種々の問題を提起している。終末医療における尊厳死，安楽死や医療経済の問題，さらに説明と同意などの社会的側面等人の死と医療の在り方について検討する。

◆生命科学と社会的諸問題
　委員長：山科郁男（第７部会員）
（任務）生命科学とその応用の急速な進展に伴い，倫理的，社会的諸問題並びに規制の在り方等について検討する。その際，我が国における生命科学の研究体制の在り方にも留意する。

◆人口・食糧・土地利用
　委員長：梶井　功（第６部会員）
（任務）世界人口の増加や地球環境変化による食糧需給の不安定化問題と，これらに伴う土地利用変化の諸影響等を総合的に検討して，人間活動の在り方を探る。また，一極集中の激しい我が国の現状を勘案し，今後の国土利用の在り方についても検討する。

◆資源・エネルギーと地球環境
　委員長：吉野正敏（第４部会員）
（任務）資源・エネルギーの開発と利用に伴う自然及び人間社会への影響を研究し，「持続可能な発展」のための諸方策と環境教育の在り方等について検討する。

◆巨大システムと人間
　委員長：内山喜久雄（第１部会員）
（任務）技術革新・システムの巨大化が人間に及ぼす影響について，安全性確保と人間性尊重の立場から検討する。

これらの各特別委員会は，発足以来現在までに各々２～３回の会議を開催して，それぞれの任務に添った具体的な審議課題や今後の審議計画等について熱心に審議を進めている。今後の審議の成果が大いに期待されているところであり，今後，審議成果が発表され次第紹介していく予定である。

公開講演会の開催状況

第15期に入って，初めて開催された日本学術会議主催公開講演会は，「文明の選択－都市と農業・農村の共存を目指して－」と題して，平成４年１月27日(月)13時30分～16時30分に，福岡明治生命ホール（福岡市）で開催され，水間会員(第６部)，北村会員(第６部)及び利谷会員(第２部)の講演が行われ，多数の聴講者があった。

つづいて，「子どもの人権を考える」と題して，平成４年３月７日(土)13時30分～16時30分に，日本学術会議講堂で開催され，堀尾会員(第１部)，永井会員(第２部)及び馬場会員(第７部)の講演の後，熱心な質問が続出した。

地球圏－生物圏国際協同研究計画（ＩＧＢＰ）シンポジウム

日本学術会議主催の地球圏－生物圏国際協同研究計画（ＩＧＢＰ）シンポジウム「日本のＩＧＢＰ研究の現状と将来」が去る２月４日(火)，５日(水)の両日，日本学術会議を会場として開催された。

日本学術会議においては，平成２年４月の総会において，「地球圏－生物圏国際協同研究計画（ＩＧＢＰ）の実施について(勧告)」を採択し，政府に対し研究の積極的な推進を求めたところであるが，ＩＧＢＰについて国内の各研究者，研究機関において実施される研究の促進を図るととも

に，この研究が極めて多くの分野にわたり，また多数の研究機関が関与していることから，この研究の連絡，調整を図る場として，本シンポジウムを開催することとしたものである。また，我が国のＩＧＢＰの研究が，広義のモンスーン・アジア地域，西太平洋地域，極域を中心に行われることから，これらの地域の研究者を招きそれぞれの国の研究の状況の紹介，意見交換を行った。

本シンポジウムの内容は次のとおりである。

〔１日目〕

講　演　　ＩＧＢＰについて

第１領域～大気微量成分の変動と生物圏

(1)　地球大気化学国際協同研究計画（ＩＧＡＣ）

(2)　ＩＧＡＣの東アジアにおける展開（ＡＰＡＲＥ）

第２領域～海洋における炭素循環

(3)　海洋における炭素循環

第３領域～地球変化に係わる生態系及び水循環

(4)　炭酸ガス変動が炭素循環に及ぼす影響

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〔２日目〕

特別講演～ナショナルプロジェクト紹介～

オーストラリア，中国，フィリピン，タイ及び日本

領域別個別討議

第１領域から第７領域まで

各領域からの報告

総合討論

当日は２日間にわたるシンポジウムであったが300人を超える参加者があり，盛況のうちに終了した。

本シンポジウムの成果は，報告書として取りまとめ，今後の研究の参考資料として関係機関・研究者等に配布することとしている。

なお，平成４年度にも引き続き本シンポジウムを開催する予定である。

二国間学術交流事業

日本学術会議では，二国間学術交流事業として毎年代表団を海外に派遣し，訪問国の科学者等と学術上の諸問題について意見交換を行って，相互理解の促進を図る事業を行っている。

この事業は，昭和58年度から実施されており，これまでにアメリカ合衆国，連合王国，オーストラリア，中華人民共和国等19か国に代表団を派遣してきた。

平成３年度は，11月４日から14日までの11日間の日程で，ベルギー王国及びオーストリア共和国へ，川田侃副会長を団長とする計10名（うち随行事務官２名）から成る代表団を派遣した。

ベルギー王国では，科学技術担当省，科学，文学及び芸術に関する王立アカデミー，ブリュッセル自由大学，ＥＣ本部教育関係機関，ＥＣ本部環境総局などを，また，オーストリア共和国では，科学研究省，オーストリア科学アカデミー，ウィーン大学，ドナウ河畔の国連都市にある国際原子力機関（ＩＡＥＡ），国連工業開発機関（ＵＮＩＤＯ）などを訪問した。

各訪問先では，関係者との間で，それぞれの国の学術研究体制や科学技術政策などをめぐって活発な意見交換が行われた。

特に印象的だったものとして，まずベルギー王国では，ＥＣが推進しているERASMUS計画，これは ＥＣ Action Scheme for the Mobility of University Students の略で，ＥＣ12か国の大学生を域内各国へ相互留学させて，専門課目や語学の能力向上あるいは風俗習慣の理解をはかろうとするもので，ＥＣの将来に大きく貢献するものと思われる。また，ベルギー王国は，長い歴史の流れの中で，フランス語とオランダ語の２か国語が話されてきたため，この言語間の対立が，政治・経済の発展はもとより，学問の分野にも非常に複雑な影響を与えていることであった。今回訪問した科学，文学及び芸術に関する王立アカデミーやブリュッセル自由大学もまったく同名のアカデミーと大学がフランス語系（ワロン系）とオランダ語系（フラマン系）とに分かれて存在しており，我々の代表団も，団編成を２班に分けてこれらの機関を訪問することになったことは，非常に印象的であった。

オーストリア共和国では，650年の伝統をほこるウィーン大学やオーストリア科学アカデミーの建物の重厚さに目を見はり，またドナウ河畔に作られた国連都市にＩＡＥＡとＵＮＩＤＯの２つの国連機関を訪問した際には、ＩＡＥＡのチェルノブイリ原発事故以後の核問題への積極的な取り組みやＵＮＩＤＯの開発途上諸国における工業発展に対する貢献度の大きさに団員一同大いに感激するとともに，D. L. Siason Jr. ＵＮＩＤＯ事務局長の流暢な日本語には，だれもがびっくりさせられた。

近年，学術，特に基礎研究における我が国の国際貢献の重要さがウェイトを増す中で，この種の学術交流事業は益々強化されるべきものであることを，派遣代表団員全員が強く認識させられた今回の渡欧であった。

御意見・お問い合わせ等がありましたら，下記までお寄せください。

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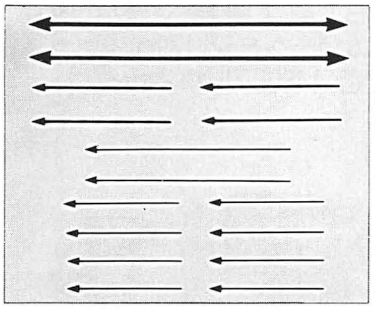

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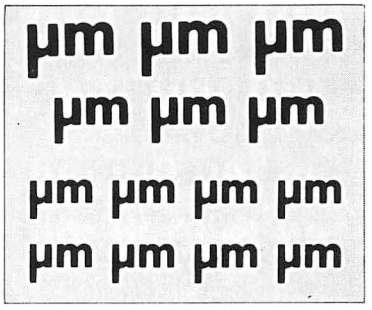

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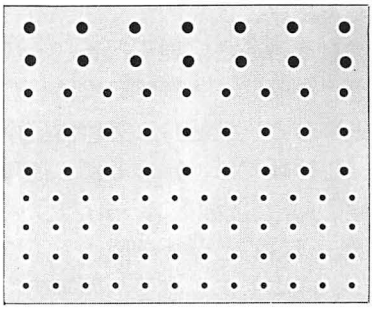

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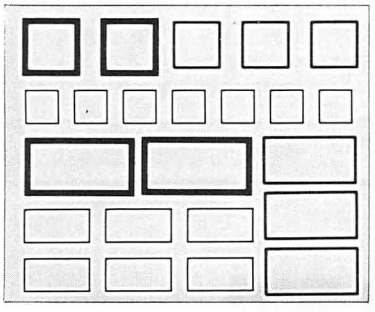

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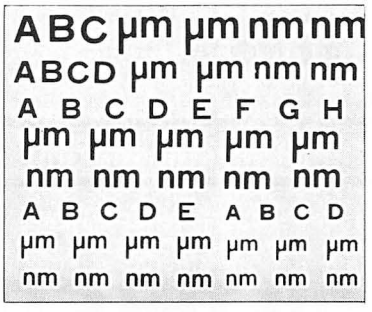

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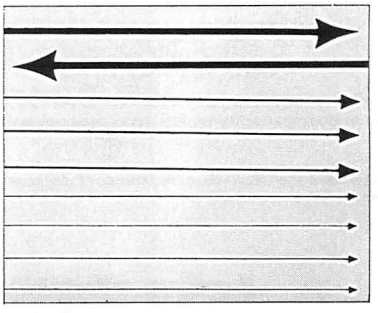

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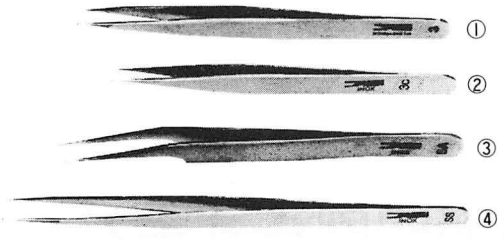

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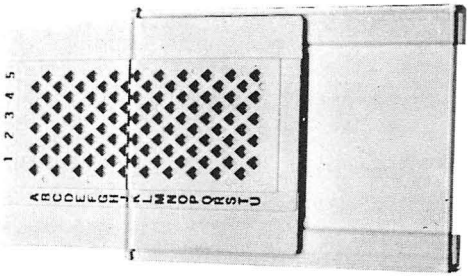

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Publications of the Society

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

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1992年6月15日 印刷
1992年6月20日 発行

Printed by Nakanishi Printing Co., Ltd.

編集兼発行 石川依久子
〒184 小金井市貫井北町 4-1-1
東京学芸大学生物学教室内
Tel. 0423-25-2111 内線 2665

印刷所 中西印刷株式会社
〒602 京都市上京区下立売通小川東入
Tel. 075-441-3155

発行所 日本藻類学会
〒602 京都市上京区下立売通小川東入
Tel. 075-441-3155
振替口座：京都 1-50488

本誌の出版費の一部は文部省科学研究費補助金「研究成果公開促進費」による。
Publication of The Japanese Journal of Phycology has been supported in part by a Grant-in-Aid for Publication of Scientific Research Result from the Ministry of Education, Science and Culture, Japan.

第40巻　第2号　1992年6月20日

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