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Nomenclatural remarks on *Agarum* (Laminariaceae, Phaeophyceae)

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Silva, P. C. 1991. Nomenclatural remarks on *Agarum* (Laminariaceae, Phaeophyceae). Jpn. J. Phycol. 30: 217–221.

The generic name *Agarum* (Laminariaceae), based on *Fucus agarum* S.G. Gmelin, is traditionally accredited to Bory de Saint-Vincent 1826, who changed the epithet of the type species to *cribrosum* in order to avoid a tautonym. In fact, the name was first used by Dumortier in 1822, in exactly the same sense, with the epithet of the type species changed to *clathratum*. The correct name of this species is thus *Agarum clathratum* Dumortier, even though the generic name has been conserved with Bory as author. While it is not necessary to emend the entry for *Agarum* in the list of conserved names (Appendix IIIA of the International Code of Botanical Nomenclature), emendation would have the desirable result of eliminating an awkward situation in which the date of the generic name is later than the date of the name of the type species.

Key Index Words: Agarum—Costaria—*Laminariaceae—nomenclature.*

The word *agarum* was first used in valid nomenclature of algae by S. G. Gmelin (1768, p. 210, pl. XXXII), who described *Fucus agarum* from "Oceanus Indiae orientalis et mare Kamtschaticum." This species, together with *F. clathrus* S. G. Gmelin (1768, p. 211, pl. XXXIII: "Oceanus indicus et Mare Kamtschatkam alluens" and *F. bracteatus* S. G. Gmelin (1768, p. 212: "Mare indicum"), constituted the seventh order of Fuci in Gmelin's classification. Gmelin named this order Agara, the plural of the substantive Agarum, which had been used as a generic name for edible seaweeds by Rumphius (1750, pp. 181, 185-187). Rumphius, in turn, derived the name from agar-agar, a Malayan word applied to certain Rhodophyceae (usually species of *Eucheuma*) that produce an edible gelatin or to the gelatin itself. (The polysaccharide from *Eucheuma*, however, fits the chemical definition of carrageenan rather than agar.) Curiously, the characters given in the diagnosis of the order Agara do not include the presence of an edible gelatin. The only discernible unifying feature is the perforate blade.

Fucus agarum and *F. clathrus*, as judged from Gmelin's illustrations, are clearly the algae currently known as *Agarum cribrosum* Bory and *Thalassiophyllum clathrus* (S. G. Gmelin) Postels and Ruprecht, respectively. Gmelin did not illustrate *Fucus bracteatus*, but he cited a description and figures published by Seba (1761, p. 192, pl. CIII, nos. 1-3), which are clearly representative of the alga currently known as *Gigartina bracteata* (S. G. Gmelin) Setchell and Gardner. The citation of the Indian Ocean as a provenance of all three species is puzzling since *Agarum cribrosum* is restricted to the North Pacific and North Atlantic, *Thalassiophyllum clathrus* to the North Pacific, and *Gigartina bracteata* to the Atlantic shores of South Africa. An explanation presents itself in the case of *Fucus bracteatus* by Gmelin's citation of *Agarum secundum*, sive *bracteatum* ["brachiatum"]... *Alga bracteolata* ["bracheolata"] of Rumphius (1750, p. 186) from Amboina, Indonesia, along with the Seba reference, but no clues are offered by the protologues of *F. agarum* and *F. clathrus*, which include no literature citations. The *Agarum secundum* sive *bracteatum* of Rumphius has been identified as *Sarcodia montagneana* (J. Hooker and Harvey) J. Agardh by Zaneveld

(1959, p. 280).

Agarum Bory de Saint-Vincent (1826, pp. 192, 193) entails the deliberate reuse of a name that had previously been applied to another alga by another author. Bory described *Agarum* in the ninth volume of the *Dictionnaire Classique d'Histoire Naturelle* as a new genus of the new family Laminariées, but he had already given, in the first volume (Bory, 1822, p. 145), a brief account of *Agarum* Link (1809, p. 7), which he referred to the genus *Delesseria* Lamouroux. *Agarum* Bory was intended to segregate those species of *Laminaria* that have one or more longitudinally percurrent ribs. The name-bringing species, and logical type, is *Fucus agarum* S. G. Gmelin, constituting an unnamed section of the genus, which was characterized as having a midrib and a cribrose blade. Bory gave a fallacious derivation of the generic name, stating that it had been borrowed by phycologists from some northern language, in which it designates edible marine algae. To avoid creating a tautonym, Bory proposed a new epithet, *cribrosum*. To *Fucus costatus* Turner (1816, p. 72, pl. 226), which has five ribs and constituted a second unnamed section, Bory applied the name *Agarum quinquecostatum*, the epithet being changed unnecessarily. Three additional species, constituting a third unnamed section, shared the feature of having "pinnules" (sporophylls) on the stipe below a blade with a midrib: *Agarum esculentum*, based on *Fucus esculentus* Linnaeus (1767, p. 135), and two new species from Newfoundland, *A. delisei* and *A. pylaii*. Gaillon (1828, pp. 357-358) accepted Bory's *Agarum*, but illegitimately changed *A. cribrosum* Bory to *A. cribrum* Gaillon.

In a worldwide synopsis of marine algae that prefaces his *Algae Britannicae*, Greville (1830, p. xxxix) recognized the three sections of Bory's *Agarum* as distinct genera. *Agarum* was restricted to species with a midrib and a cribrose blade and was assigned *Fucus clathrus* S. G. Gmelin (as *Agarum clathrus*) in addition to *A. cribrosum*. The new genus *Costaria* was established to receive *Fucus costatus* Turner, the epithet again being changed unnecessarily, to *turneri*. The three species of *Agarum* with "pinnules" constituted the new genus *Alaria*.

Postels and Ruprecht (1840, p. 11) adopted Greville's classification, but further segregated *Fucus clathrus* into its own genus, *Thalassiophyllum*. Moreover, *Thalassiophyllum*, *Agarum*, and *Costaria* were removed from the Laminarieae to their own group, Agaroideae, for which Agara S. G. Gmelin was cited as a synonym. (Although Postels and Ruprecht did not designate the rank of Agaroideae, its position is coordinate with groups currently interpreted as families). Postels and Ruprecht distinguished three species and two additional forms of *Agarum* on the basis of the width and thickness of the midrib and the pattern of the holes in the blade. Confusingly, *A. cribrosum* Bory was renamed *A. gmelinii* ("*gmelini*"), a name attributed by Postels and Ruprecht to a manuscript by the elder Mertens. The alga illustrated by Turner (1809, p. 10, pl. 75) as *Fucus agarum* was described as a new species, *A. turneri*. A third species, *A. pertusum*, based on *Fucus pertusus* Mertens fil. (1829, p. 53) from Kamchatka, comprised f. *brassicaeforme* and f. *platyneurum* in addition to the typical form.

Endlicher (1843, p. 27-28) adopted the classification proposed by Postels and Ruprecht, but reunited *Thalassiophyllum* and *Agarum* with the Laminarieae. He incorrectly attributed *Agarum* to Greville, obviously following the circumscription method rather than the type method in designating this name. The authorship was further changed to Postels and Ruprecht by J. Agardh (1848, p. 140) and to (Bory) Postels and Ruprecht by Setchell (1912, p. 154).

The various species of *Agarum* that were recognized by Postels and Ruprecht were merged into one by Setchell (1912, p. 154) and Setchell and Gardner (1925, p. 615), who restored for it what was thought to be the earliest legitimate name, *A. cribrosum*. Setchell (1912, p. 154), however, incorrectly cited its authorship as "(Mert.) Bory", confusing *Fucus cribrosus* Mertens fil. (1829, p. 52), which was a new species based on Turner's concept of *F.*

agarum and thus an earlier nomenclatural synonym of *Agarum turneri* Postels and Ruprecht, with *Agarum cribrosum* Bory. Although this error was corrected by Setchell and Gardner (1925, p. 615), it has persisted to the present (Taylor, 1937, p. 197; 1957, p. 185; South and Hooper 1980, p. 42; South and Tittley, 1986, p. 30).

The need to conserve *Agarum* Bory against the earlier homonym *Agarum* Link was recognized by Tandy, who published a formal proposal (in Sprague 1935, p. 82), which was approved by the Eighth International Botanical Congress at Paris in 1954. Although the typification and taxonomic placement of rejected earlier homonyms is purely academic, an explanation of the changes in the entry for *Agarum* in successive editions of the ICBN will be useful to those who have been puzzled. In the Paris edition (1956), the type was correctly cited as *A. rubens* (L.) Link (*Fucus rubens* L.), while its taxonomic placement was not given. In the Montreal edition (1961), it was assigned to the Phyllophoraceae and indicated as a nomenclatural synonym of *Phyllophora*. Shortly afterward, Dixon (1964), having tracked down the unequivocal type specimen of *Fucus rubens* Linnaeus (1753, p. 1162), found that it was representative of *Phycodrys* in the Delesseriaceae rather than *Phyllophora*, as previously supposed by many authors. In the Leningrad edition (1978), therefore, the type of *Agarum* Link was changed to *A. rubens* sensu Link (syn. tax. *Phyllophora crispa* (Hudson) Dixon) since it is clear from Link's description and figures that he had *Phyllophora* rather than *Phycodrys* in hand. Because two views prevailed with regard to the typification of generic names, one of which assigned overriding importance to the material in the hands of the describer, the other to species cited in the protologue, proposals were made to the Nomenclature Section of the Thirteenth International Botanical Congress at Sydney in 1981 to clarify the situation. The resulting decision favored typification by cited species rather than by material in hand, so that in the Sydney edition of the ICBN (1983) the type of *Agarum* Link was once again listed as *A. rubens* (L.) Link, but this time it was assigned to the Delesseriaceae.

One would hope that the entry for *Agarum* Bory vs. *Agarum* Link was finally stabilized, but that is not the case. Dumortier, a Belgian botanist whose work on the classification of algae is generally unknown to phycologists, foreshadowed Bory by four years in segregating the species of *Laminaria* with ribbed blades into a separate genus, which he also called, not surprisingly, *Agarum* (Dumortier, 1822, p. 102). Although Dumortier's account lacks precise literature citations, it is clear that he based his *Agarum* on *Laminaria* [sect.] *Costatae* C. Agardh (1817, p. XIII; 1820, p. 109), which included the same three species. *Laminaria agarum* (S. G. Gmelin) C. Agardh became *Agarum clathratum* Dumortier, *L. costata* C. Agardh (*Fucus costatus* Turner 1816, non Stackhouse 1801) became *A. costatum* (C. Agardh) Dumortier, and *L. esculenta* (L.) C. Agardh became *A. esculentum* (L.) Dumortier. Thus, *Agarum* Dumortier 1822 has the same circumscription as *Agarum* Bory 1826. While the disclosure of *Agarum* Dumortier does not affect the conservation of *Agarum* Bory, which is conserved against all earlier homonyms and nomenclatural synonyms, whether or not they are listed as *nomina rejicienda* (Art. 14.4 of the ICBN), it necessitates a change in the correct name of the type species. *Agarum cribrosum* Bory is an unintentionally superfluous name for *A. clathratum* Dumortier. Although *A. clathratum* antedates *Agarum* Bory, it is to be cited without change of authorship or date in accordance with Art. 68.3 of the ICBN. It is possible, however, to bring the specific name into agreement with the generic name with regard to date and authorship. To accomplish this goal it is necessary to emend the entry for *Agarum* in the list of conserved generic names. A formal proposal to make such an emendation will be published in the journal Taxon.

The nomenclatural synonyms of the various species discussed above that occur in northern Japan and nearby waters are summarized as follows:

Agarum clathratum Dumortier
Fucus agarum S. G. Gmelin 1768
Laminaria agarum (S. G. Gmelin) C. Agardh 1817
Agarum clathratum Dumortier 1822
Agarum cribrosum Bory 1826
Agarum cribrum Gaillon 1828
Agarum gmelinii Postels and Ruprecht 1840
(In addition, both *Fucus cribrosus* Mertens fil. 1829 and *Agarum turneri* Postels and Ruprecht 1840 are based on *Fucus agarum* sensu Turner 1809 and thus are nomenclatural synonyms of one another. They are currently considered taxonomic synonyms of *Agarum clathratum*.)
Thalassiophyllum clathrus (S. G. Gmelin) Postels and Ruprecht
Fucus clathrus S. G. Gmelin 1768
Laminaria clathrus (S. G. Gmelin) C. Agardh 1824
Agarum clathrus (S. G. Gmelin) Greville 1830
Thalassiophyllum clathrus (S. G. Gmelin) Postels and Ruprecht 1840
Costaria costata (C. Agardh) Saunders
Fucus costatus Turner 1816 (not *F. costatus* Stackhouse 1801)
Laminaria costata C. Agardh 1817 (treated as a new name in accordance with Art. 72, Note 1, Ex. 2 of the ICBN)
Agarum costatum (C. Agardh) Dumortier 1822
Agarum quinquecostatum Bory 1826
Costaria turneri Greville 1830
Costaria costata (C. Agardh) Saunders 1895

An unequivocally distinct species of *Agarum* with a flattened fringed stipe, *A. fimbriatum*, was described by Harvey (1862, p. 166) on the basis of collections dredged from Esquimalt Harbour, Vancouver Island, British Columbia, Canada by David Lyall and C. Wood. This species has a range with a remarkable disjunction, occurring from southeastern Alaska southward through Puget Sound and from the southern Channel Islands of California through Isla Todos Santos, Baja California, Mexico, but apparently it is absent from the vast intervening stretch of coast.

Agarum oharaense, a species with characteristics intermediate between *A. clathratum* and *A. fimbriatum* was described from Chiba Prefecture, Japan, by Y. Yamada (1958, 1961). Yet another species, *A. yakishiriense*, was proposed by Y. Yamada (1962), but not validly published, on the basis of material from Yakishiri Island, Hokkaido. In a study of local variation in *A. clathratum* (as *A. cribrosum*) in Hokkaido and adjacent regions, I. Yamada (1974) recognized four forms, one of which was f. *yakishiriense* (*A. yakishiriense* Y. Yamada). Nakahara and I. Yamada (1974) conducted crossing experiments among these forms and found a high rate of interfertility. In deciding which of the four forms was nomenclaturally typical of the species, I. Yamada (1974) was able to make comparisons with two authentic specimens of *Fucus agarum* S. G. Gmelin housed at Leningrad (LE).

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Paul C. Silva: *Agarum*（褐藻綱コンブ科）に関する命名上の所見

属名 *Agarum*（コンブ科）は，Bory de Saint-Vincent によって，*Fucus agarum* S. G. Gmelin にもとづき命名されたものとされている。彼は，反復名を避けるため，タイプ種の呼び名を *cribrosum* に変更している。しかしながら，属名 *Agarum* を使ったのは，Dumortier (1822) が最初であって，属名が *Laminaria agarum* (S. G. Gmelin) Agardh にもとづいていたことから，彼もタイプ種の呼び名を *clathratum* に変えている。したがって，たとえ属名のオーサー名として Bory を保留したとしても，タイプ種の名称は *Agarum clathratum* とするほうが正しいといえる。保留名のリスト（国際植物命名規約付録 IIIA）に *Agarum* の登録を修正する必要はないとはいえ，もし修正すれば属名の命名年がタイプ種の命名年より遅いという不格好な状態からのがれることができるであろう。

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Diffuse cell elongation in two bangiophyte red algae: *Rhodochaete parvula* and *Porphyra yezoensis*

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Garbary, D. J. and Magne, F. 1991. Diffuse cell elongation in two bangiophyte red algae: *Rhodochaete parvula* and *Porphyra yezoensis*. Jpn. J. Phycol. 39: 223–226.

Calcofluor stained plants of *Rhodochaete parvula* Thuret and conchocelis of *Porphyra yezoensis* Ueda showed tip growth in apical cells and diffuse growth in intercalary cells. Over the 4–8 day experimental period 3–7 new cells were added at each branch apex with subapical cells expanding about 40% and 70% in length, respectively, with no increase in cell diameter. Diffuse elongation is considered the primitive method of intercalary cell wall deposition in apically growing red algae, whereas band deposition, previously observed in Batrachospermales and Ceramiales, is considered the derived condition.

Key Index Words: Bangiophycidae—calcofluor—cell walls—cell elongation—cell wall deposition—Porphyra—Rhodochaete—*Rhodophyta*.

Waaland *et al.* (1972), Waaland and Waaland (1975) and Aghajanian and Hommersand (1980) demonstrated that red algae have tip growth in apical cells and band deposition in intercalary cells. Hymes and Cole (1983), however, were able to find only tip growth in the freshwater red alga *Audouinella hermannii* (Roth) Duby. More recently, diffuse cell wall deposition was demonstrated for the first time in red algae in three species of Florideophycidae in the genera *Audouinella* (Acrochaetiales), *Spermothamnion* and *Tiffaniella* (Ceramiales) (Garbary and Belliveau 1990). The occurrence of diffuse growth in the potentially primitive order of florideophyte red algae (i.e. Acrochaetiales) (Gabrielson and Garbary 1987, Garbary and Gabrielson 1987) suggests that this is the plesiomorphic or primitive character state for the subclass Florideophycidae.

Rhodochaete and conchocelis of *Porphyra* (or *Bangia*) are particularly appropriate organisms for studying the evolution of cell wall deposition characters in Rhodophyta, and establishing the primitive character state for florideophyte red algae. With their filamentous construction, apical cell division and presence of plugged pit connections, basic thallus morphology in these genera is homologous to that in florideophyte red algae (Garbary and Gabrielson 1990). Thus mechanisms of cell wall deposition are likely to provide homologous features for comparison. If diffuse elongation is present (in the absence of band deposition) in Rhodochaetales, Bangiales, and Acrochaetiales, it can be concluded that diffuse growth is the primitive mechanism of intercalary cell wall deposition in apically growing red algae.

Materials and Methods

Rhodochaete parvula was isolated from the Mediterranean Sea and cultured in enriched seawater media as described by Pueschel and Magne (1987). Conchocelis of *Porphyra yezoensis* (U-51) from Japan was grown in a modified von Stosch medium (Guiry and Cunningham 1984). Plants were stained with 0.01% or 0.001% calcofluor white (Fluorescent Brightener 28 from Sigma) for 30 min, as described by Garbary and Belliveau (1990),

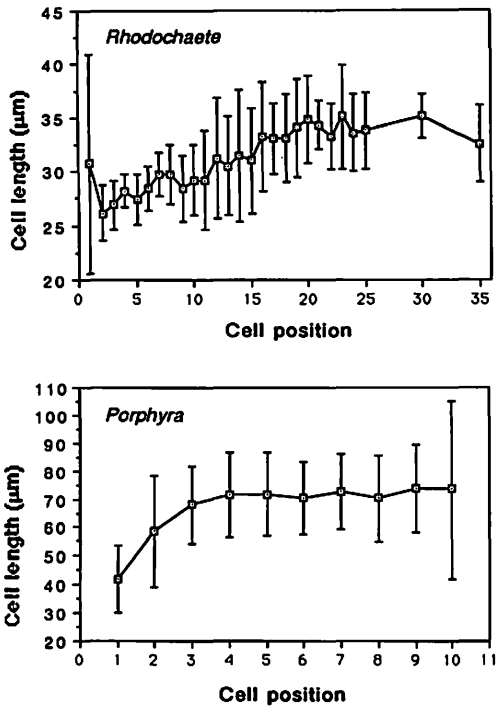

Fig. 1. Patterns of cell elongation along primary axes of *Rhodochaete parvula* and conchocelis of *Porphyra yezoensis*. Values indicate means±s.d. (n=12).

and grown for four (*Porphyra*) or eight days (*Rhodochaete*) in calcofluor-free medium. It should be noted that longer exposures or higher concentrations of calcofluor may cause reductions in growth or growth abnormalities in red algae (Belliveau *et al.* 1990).

Fluorescence microscopy and microspectrofluorometry were carried out on a Zeiss Photomicroscope III using Zeiss accessories as described in Garbary and Belliveau (1990). Measures of cell wall (calcofluor) fluorescence from 5-10 different cells were made from the middle portions of cells of *Porphyra* at cell positions 1, 3, 5, 7, 8 using a 3 µm diameter aperture. Similar measurements on *Rhodochaete* were not carried out because of high background fluorescence.

Morphometric analysis of cell length was carried out by measuring the lengths of cells 1-25, 30 and 35 in *Rhodochaete* (cell 1 is the apical cell), and cells 1-10 in conchocelis of *Porphyra*. In each case twelve filaments were measured.

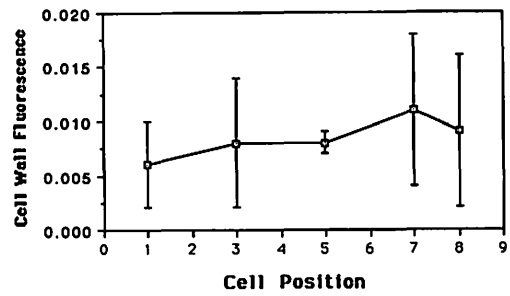

Fig. 2. Change in relative fluorescence along a filament of *Porphyra*. Note: Cell 1 would have been the subapical cell at time of staining; when material was fixed this was cell 5-8. Values indicate means±s.d. (n=5-10).

Results

Calcofluor at 0.01% and 0.001% was apparently non-toxic for *Porphyra* and *Rhodochaete*, and apical cell division proceeded at 0.5-1 cell divisions per day after staining. Cell length measurements along unstained primary axes of *Rhodochaete* and *Porphyra* show that some cell elongation is occurring in intercalary cells (Fig. 1). The average total elongation (as a % of subapical cell length) is about 40% in *Rhodochaete* and 70% in *Porphyra*. In *Rhodochaete* there is a gradual elongation to about cell 16 after which cell length remains stable. In *Porphyra* cell length increases are basically limited to cells 2-4 although occasional much larger (or smaller) cells are found in older portions of filaments (note much larger s.d. at position 10).

Growth experiments using calcofluor show that no band elongation is occurring. Microspectrofluorometry of calcofluor stained cells of *Porphyra* showed a possible increase in fluorescence away from what were previously apical cells after the 4 day growth period (Fig. 2). The slightly lower fluorescence values closer to the old apex (cells one to five) may have resulted from greater wall deposition in these cells (after staining) than cells that were more fully elongated.

Discussion

Early work by Waaland and Waaland

(1975) and Aghajanian and Hommersand (1980) suggested that band elongation was the primary method of intercalary cell wall deposition in Rhodophyta, although a later study by Hymes and Cole (1983) did not show the presence of band growth in *Audouinella hermannii*. Several other *Audouinella* species have been shown to have diffuse cell wall deposition: *A. dasyae* (Garbary and Belliveau 1990), *A. botryocarpa* and *A. pacifica* (Garbary and Guiry, unpublished). That species of *Rhodochaete, Porphyra* and *Audouinella* all have diffuse growth in intercalary cells suggests that this is the primitive condition for florideophyte red algae. Although we have not examined other angiophytes in either Compsopogonales (e.g. Erythropeltidaceae) or Porphyridiales, the small cell sizes and the patterns of thallus construction in these algae are not suitable for band elongation.

We have demonstrated that intercalary cells of both *Rhodochaete* and *Porphyra* have cell elongation. The amount of cell elongation, however, is among the smallest recorded for apically growing red algae. The absence of band deposition in elongating intercalary cells suggests that cell elongation is by diffuse growth.

The occurrence of diffuse cell wall deposition in three paraphyletic orders near the base of the red algal phylogenetic tree (Gabrielson *et al.* 1985, Gabrielson and Garbary 1987) leads to the conclusion that this is the primitive character state for florideophytes, with band elongation being the more advanced condition. Several evolutionary scenarios (Fig. 3) can be suggested from our results. In the first scheme (Fig. 3A) unicellular or multicellular morphology is considered primitive, such organisms having only diffuse cell wall deposition. With the evolution of apical cells, tip growth became possible, along with the filamentous morphologies of *Rhodochaete*, conchocelis of *Porphyra* and florideophytes. Some florideophyte red algae then evolved band deposition. The question remains whether band deposition arose once, or more than once, in separate florideophyte lineages.

A second scheme (Fig. 3B) places an organism similar to *Rhodochaete* in an ancestral position. This organism may have had only tip growth or a combination of tip growth and diffuse elongation. Some of the descendants of this organism lost the ability to form apical cells, and cell wall deposition became exclusively diffuse. As florideophytes evolved, one or more evolutionary lines then developed band elongation. The absence of band elongation in some Ceramiaceae is considered an evolutionary loss in a highly derived group of Ceramiaceae (Garbary and Belliveau 1990, Hommersand 1990). This scheme is based on the notion that *Rhodochaete*, as the archetypal red alga, is the most primitive extant member of the division. Yet another evolutionary scheme was presented by Magne

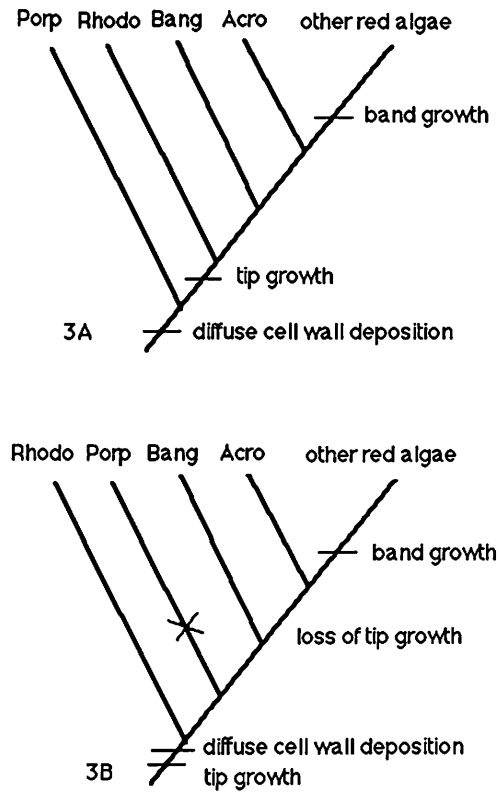

Fig. 3. Phylogenetic schemes based on the evolution of different cell wall deposition patterns. 3A-Diffuse wall deposition primitive; 3B-Tip elongation or tip and diffuse elongation primitive. See text for discussion. Abbreviations: Porp—Porphyridiales; Rhodo—Rhodochaetales; Bang—Bangiales; Acro—Acrochaetiales.

(1989) in which two evolutionary lines (subclasses) of red algae "Eurhodophycidae" and Metarhodophycidae" evolved independently from the "Archaeorhodophycidae". This scheme would require that tip growth was independently derived in *Porphyra* and *Rhodochaete*. These three evolutionary hypotheses become testable with the application of DNA and/or RNA sequencing.

Although bangiophytes are apparently consistent in terms of cell wall deposition patterns, having either diffuse or diffuse and tip growth, preliminary studies show that variation in this feature among florideophytes (Garbary and Belliveau 1990) has considerable potential as a phylogenetic feature at ordinal, family and tribal levels. Further studies of cell wall deposition patterns in red algae are clearly in order.

Acknowledgements

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D. J. Garbary*·F. Magne: 原始紅藻2種 (*Rhodochaete parvula, Porphyra yezoensis*) における分散細胞伸長**

カルコフルオール染色した *Rhodochaete parvula* 藻体とスサビノリ *Porphyra yezoensis* の糸状体は，頂端細胞では頂端成長を，介在細胞では分散成長を示した。4－8日の実験期間中に，各側枝先端で3－7細胞が新しく付け加わり，長さはそれぞれ約40%および70%増加したが，細胞の直径は増大しなかった。分散伸長は頂端成長を行なう紅藻における介在細胞壁の原始的な沈着法であり，カワモズク目とイギス目ですでに観察されている帯状沈着は派生的なものと考えられる。(*Department of Biology, St. Francis Xavier University, Antigonish, Nova Scotia, B2G 1C0, Canada; **Laboratoire de Biologie Végétale Marine, Université Pierre & Marie Curie (VI), 7 Quai Saint-Bernard, 75230 Paris, France)

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Dinoflagellates collected from aquaculture ponds in southern Taiwan

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Su, H.-M. and Chiang, Y.-M. 1991. Dinoflagellates collected from aquaculture ponds in southern Taiwan. Jpn. J. Phycol. 39: 227–237.

Five species of photosynthetic dinoflagellates, *Prorocentrum minimum, Gyrodinium instriatum, Pyrophacus horologium, Gonyaulax verior*, and *Alexandrium tamarense*, collected from aquaculture ponds in southern Taiwan where a PSP incident due to ingestion of cultured purple clams occurred and caused the death of two men, are described with some taxonomical considerations. *A. tamarense*, which previously has been reported to be the first toxic strain isolated from tropical Pacific waters, differs from those reported from temperate waters in having the ability to grow at very low salinity and high temperature, and small size (11–34 μm).

Key Index Words: Alexandrium tamarense—*dinoflagellate*—Gonyaulax verior—Gyrodinium instriatum—*phytoplankton*—Prorocentrum minimum—Pyrophacus horologium—*Taiwan*.

Dinoflagellates are widely recognized to produce "blooms" or "red tides", and some of them are found associated with the production of toxins, resulting in fish kills and mortality of other marine organisms (Baden 1983, Carmichael 1986) Those toxins also can be accumulated by filter-feeding shellfish to cause paralytic shellfish poisoning (PSP) to the mankind (Prakash 1963, Prakash and Taylor 1966, Wood 1968). As reported from various parts of the world (Taylor 1984), a PSP incident due to ingestion of cultured purple clams collected from Tungkang, Pingtung Hsien, Taiwan (Fig. 1) occurred on Jan. 1, 1986 and caused the death of two men (Hwang *et al* 1987).

The incident brought about our interest to study if there were any toxic dinoflagellates growing in the ponds of that area. Between 1986 and 1987, we made extensive investigations on the occurrences of dinoflagellates in aquaculture ponds at Tungkang area, and isolated five species of photosynthetic dinoflagellates. This paper presents the morphological and ecological characteristics of these algae with taxonomical considerations.

Unialgal cultures of these dinoflagellates are kept both in the Institute of Oceanography, National Taiwan University, Taipei and in Tungkang Marine Laboratory, Tungkang.

Materials and Methods

Dinoflagellates were collected from shrimp ponds and/or crab ponds in Tungkang area, but special attention was paid to those ponds surrounding the one from where toxicated clams were harvested (that pond was closed after the PSP event) (Fig. 1). The algae were isolated with micropipette method (Hoshaw and Rosowski 1973). Their clonal cultures were grown in "K" medium (Keller and Guillard 1985) with salinity 15 ppt, and were maintained at 25±1°C, under a 12 : 12 LD cycle at 80 $\mu E/m^2/s$ provided by cool-white fluorescent lamps. The growth rates (K) of *A. tamarense* grown in 3-45 ppt salinity and at 16-35°C were measured to find the optimum conditions.

Both living and Lugol's solution fixed cells were observed with the optical LM system filled with phase contrast and Nomarski interference contrast optics. Thecal plates were

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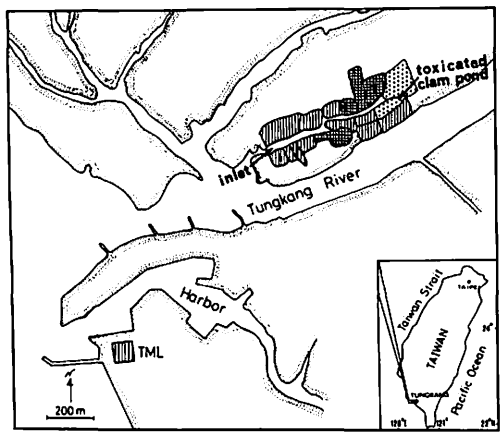

Fig. 1. Map of sampling place. ▦ Purple clam pond, ▦ crab pond, ▨ shrimp pond. TML: Tungkang Marine Laboratory.

dissociated with a slight pressure on the cover glass. For scanning electron microscopy (SEM), cells were either fixed in 1% OsO_4, or fixed in 0.5% GTA and 0.2% OsO_4 simultaneously, or double fixed in 2.5% GTA and 1% OsO_4, or fixed in Lugol's solution with the culture medium as buffer solution. The fixed cells were transferred to a capsule with a Nuclepore filters (8 μm), and then washed and dehydrated in a graded acetone series. After critical point dry, the material was shadowed with gold and viewed with a scanning electron microscope (Hitachi model S-520).

Results and Discussion

***Prorocentrum minimum* (Pavillard) Schiller** (Figs. 2-9)

Toriumi 1980, p. 107, Figs. 4, 10. Dodge 1982, p. 35, pl. I f, g.

Cells are about 14 to 20 μm long and 14 to 18 μm wide (mostly 15 to 16 μm) and ovate, triangular and sometimes heart-shaped in valve view (Figs. 2, 3). Young cells are flattened, while older cells are rounded. Cells develop, with age, a widely developed intercalary bands (Figs. 4, 5). The posterior end of the cell is usually round and the anterior one truncates with a very slight depression. The surface of the valve is covered evenly with many small, pointed spines (Figs. 2, 3, 4, 5). However, on the intercalary bands, the spines occur in rows lying perpendicular to the anterior-posterior axis (Figs. 4, 5) except in the apical area where the cell surface appears smooth (Figs. 5, 6). Trichocyst pores are mainly located around margin of the valves (Figs. 2, 3, 4). There are two unequally sized pores located at the cell's anterior end (Figs. 3, 5, 6, 7). The larger one has a oblong shape confined by a collar-like ridge. The smaller one has a circular shape. A forked structure (as) arises between the two pores (Figs. 5, 6) and is seen as a single spine (as) at the anterior end of the cell from the valve view (Fig. 2). The "apical tooth" (at) is a curved (from the valve view, Fig. 6) or a straight (from the side view, Fig. 2) bilaminar structure, which arises from a part of the edge of the smaller pore (Fig. 6). Generally, two kinds of flagella arise from the apical area of the cell (Fig. 8), one is thread-like and long (1f), the other is hemi-helical and undulate (tf). The latter rounds transversely and in an anti-clockwise direction to the anterior-posterior axis of the cell. Although it is not shown in Fig. 8 that there two flagella emerge from the larger or the smaller pore, only one

Figs. 2–9. *Prorocentrum minimum*. Fig. 2. Valve view. Showing surface spines, apical spine (as), apical tooth (at) and trichocyst pores (tp) on the border (SEM). Fig. 3. Valve view. Showing the large (l) and small (s) anterior pores. Fig. 4. Side view. Showing the straight and striate intercalary bands, and surface spines distributed evenly in the valve surface (SEM). Fig. 5. Apical view. Fig. 6. Enlargement of Fig. 5. Showing the shape and structure of large (l) and small (s) anterior pores, forked spine (as) and apical tooth (at) (SEM). Fig. 7. Valve view. Showing one longitudinal flagellum extending from the flagellar pore. Fig. 8. Apical view. Showing longitudinal (lf) and transverse flagella (tf) (SEM). Fig. 9. Apical view. Showing two transverse flagella (tf) emerging from a flagellar pore (SEM).
(Figs. 2–34, All scales=5 μm except where indicated)

Figs. 10–13. *Gyrodinium instriatum*. Fig. 10. Ventral view. Showing the contour of the cell and a large nucleus (N) in the anterior center of epicone, and many chromatophores. Fig. 11. Ventral view. Showing the girdle, sulcus and one longitudinal flagellum (SEM). Fig. 12. Dorsal view. Showing the transverse flagellum (tf) and the excavated antapex sulcus (SEM). Fig. 13. Ventral view. Showing the apical groove (ag) (SEM).

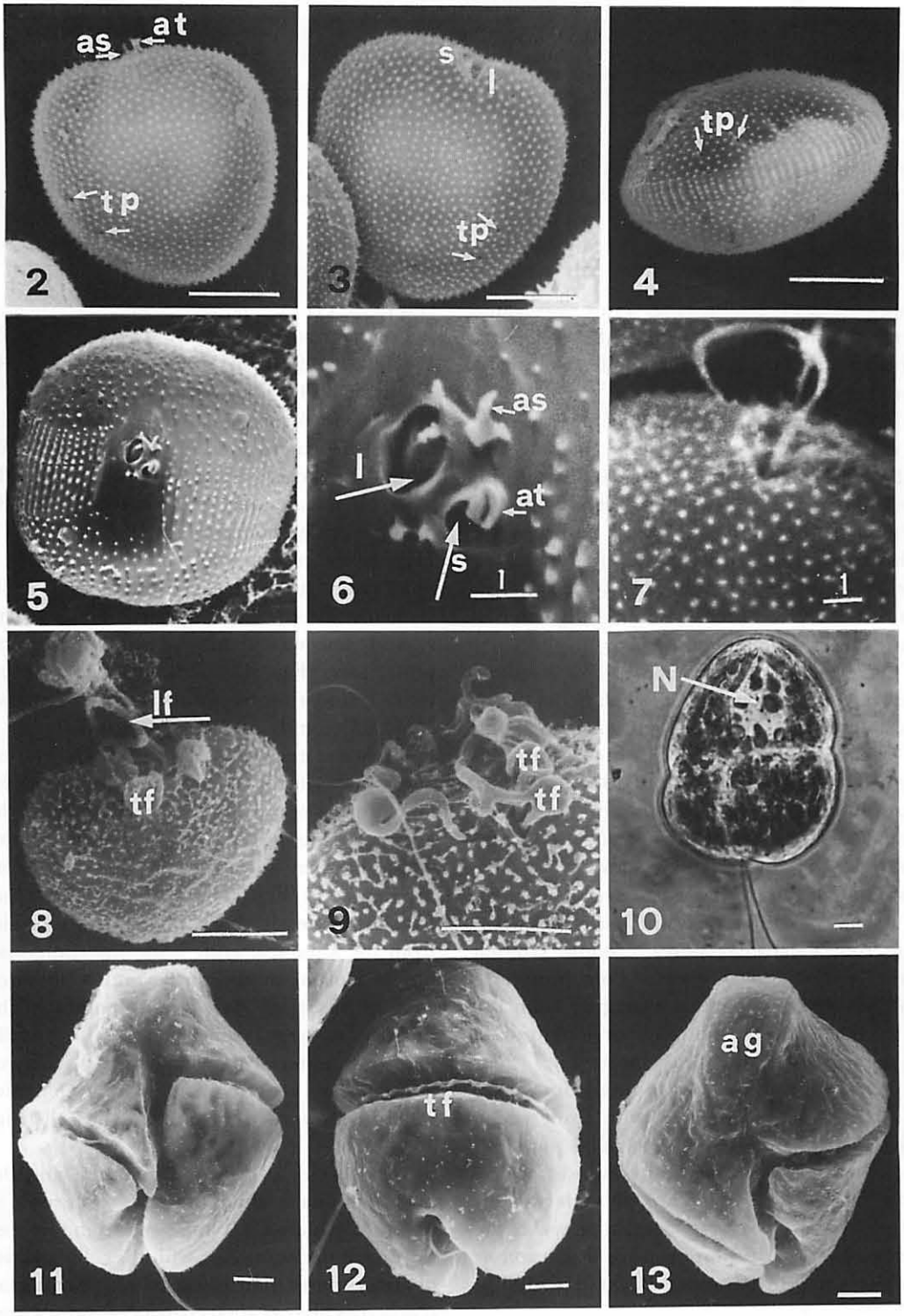
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Table 1. Occurrence of dinoflagellates and pond water parameters during 1986–1987.

Species	Month of occurrence	Maximum densities (cells/ml)	Water temperature (°C)	Salinity (ppt)	pH	D.O. (ppm)	Transparency (cm)
Prorocentrum minimum	Nov.–June	47,000	21.6–30.0	10–34	7.50–7.92	7.2–16.7	29–50
Gyrodinium instriatum	Oct.–June	1,700	17.9–30.9	10–25	7.50–8.70	3.8–16.7	20–70
Pyrophacus horologium	Oct.–Dec. Mar.–July	60	21.6–30.9	10–19	7.51–8.70	3.8–16.7	30–70
Gonyaulax verior	Nov.–July	320,000	17.9–30.9	10–25	7.51–8.70	4.1–16.7	20–68
Alexandrium tamarense	Nov.–Apr.	1,600	17.9–30.0	10–19	7.51–8.70	4.1–16.7	25–68

longitudinal flagellum (Fig. 7) or two transverse flagella (Fig. 9) emerge from a pore, which is the larger or the smaller cannot be confirmed in figures.

This alga appeared from November to June of next year (Table 1) in the area. Blooms with cell densities of more than 10,000 cells/m*l* were found in ponds with salinity 12 ppt and 32 ppt in January and April respectively. This species has been reported in Japan, the west coast of U.S.A., Gulf of Mexico, Caspian Sea, Mediterranean sea and Sargasso Sea and it often forms blooms.

Our specimens resemble *P. minimum* described by Honsell and Talarico (1985), Toriumi (1980) and Loeblich *et al* (1979) and *P. mariaeebouriae* (Faust 1974), which is the synonym of *P. minimum* (Toriumi 1980), in structure of cell surface and anterior pores, cell shape and size. Loeblich *et al.* (1979) and Croome and Tyler (1987) showed two longitudinal flagella of *P. minimum, P. rhathymum, P. triestinum, P. playfairi* and *P. foveolata* emerging from a flagellar pores. While Honsell and Talarico (1985) reported both transverse and longitudinal flagella emerging from the same pore. We found only one longitudinal flagellum emerging from a pore (Fig. 7), or two transverse flagella emerging from a pore (Fig. 9). Therefore, the pore from which both flagella emerge is the flagellar pore and the other one is auxiliary pore as indicated by Loeblich *et al.* (1979). The cells with two longitudinal or transverse flagella may be the results of sexual fusion or asexual division as that reported in *P. micans* (Soyer *et al.* 1982).

***Gyrodinium instriatum* Freudenthal and Lee** (Figs. 10-14)

Freudenthal and Lee 1963, p. 183, Figs. 8-17; Fukuyo 1980, p. 206, pl. 1 Figs. 1-14; Takayama 1985, p. 130, pl. I Fig. 9.

Cells are ovoid 34–56 μm (commonly 40–47 μm) in length and 22–40 μm (mostly 30–37 μm) in width. Epicone is tapering gently toward truncate apex and sometimes slightly dorsoventrally compressed (Figs. 10, 11). Hypocones is also tapering gradually to a moderately sulcus-grooved antapex. Girdle is narrow, deep, and its right end bends sharply and descends about 1/3 the body length posteriorly (Fig. 11). Sulcus projects anteriorly into epicone, joints the apical groove (Fig. 11), and extends posteriorly into a moderately excavated antapex, continuing across it to dorsal sulcal side (Fig. 12). The apical groove extends to the left side of the apex, crossing the dorsal surface to turn downward and then upward to the right side of its proximal end (Figs. 13, 14). The longitidual flagellum extends about a body length or less from the antapical end, while the transverse one is located in the girdle and terminated slightly short of the girdle length. The nucleus is large, spheroidal and centrally located in anterior epicone (Fig. 10). Chromatophores are many, ochre, elongate, radiating toward the center of the cell (Fig. 10).

This species is the most common and the most abundant dinoflagellates occurred in ponds of this area. It appeared from October to June of the next year, with the cell densities of always more than 100 cells/m*l*. But it may reached as high as 1000 cells/m*l* or more sometimes (Table 1). This alga was also found

blooming in Inland Sea of Japan (Fukuyo 1980) and New York waters of U.S.A. (Freudenthal and Lee 1963).

Our specimens of this alga fit very well with the features of *G. instriatum* described by Freudenthal and Lee (1963), Fukuyo (1980) and Takayama (1985) in the shape and structure of apical groove, girdle displacement of 1/3 body length and the extension of sulcus to epicone and hypocone. The differences among *G. instriatum, G. ovoidium, G. fissum, G. striatissimum, G. uncatenum* and *G. lebourae* have been discussed by Freudenthal and Lee (1963). They indicated that *G. instriatum* differs from *G. fissum* by the absence of pellicular striations in the former, and is dissimilar to *G. fissum* and *G. striatissimum* in absence of similar cytoplasmic inclusion. This species is also different from *G. lebourae* due to smaller size of the latter (15 μm). Although *G. instriatum* resembles *G. uncatenum* very closely in the ventral aspect and deeply excavated antapex (Coats *et al.* 1984, Figs. 8, 10), they differ from each other in that the former is less dorsoventrally compressed, while the latter flattens laterally.

***Pyrophacus horologium* Stein** (Figs. 15-22)

Steidinger and Davis 1967, Figs. 1-5; Wall and Dale 1971, p. 234, Figs. 31-37, Dodge 1982, p. 144, Figs. 17A, B.

Cells are 36-74 μm in transdiameter. Theca are oblate, discoidal, and almost circular in anterior and posterior views (Fig. 15), but biconvex in dorsoventral and lateral views (Fig. 16). Both epitheca and hypotheca are convex, usually the latter is slightly flattened. Girdle is equatorial and with lists (Figs. 16, 17). Thecal plates are smooth and with many trichocyst pores (Fig. 17). Plate formula is po (apical pore plate), 5-6′, 0-1a, 7-10″, 9c, 8-10‴, 0-1p, 3-5⁗, commonly is 5′, 0, 9″, 9c, 9‴, 1p, 3⁗ (Figs. 18-21). Two spores produced asexually in theca are observed in Fig. 22.

This cosmopolitan dinoflagellates occurred frequently but less abundantly than the other species of dinoflagellates in cell number in this area (Table 1).

This species can be recognized easily by its clam-like shape and many easily recognized plates. Our specimens of this alga fit clearly with the characteristics of *P. horologium* as described by Steidinger and Davis (1967), Wall and Dale (1971). The plate tabulation which may vary in some ranges in species of the genus *Pyrophacus*, as reported by Wall and Dale (1971), is also observed in our specimens (Fig. 19 with 5′, 9″, while Fig. 20 with 6′, 10″ plates in epitheca).

***Gonyaulax verior* Sournia** (Figs. 23-25)

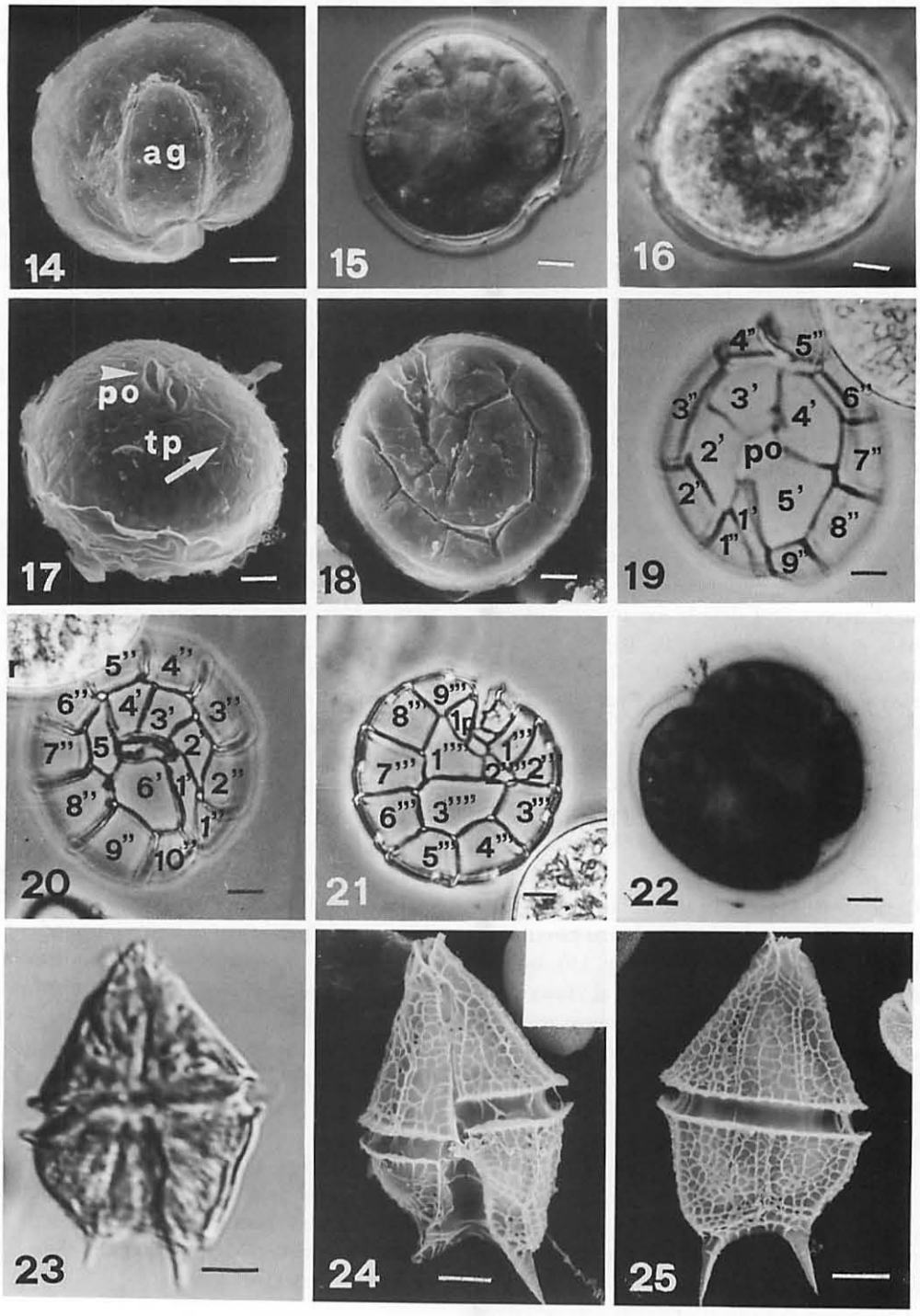
Dodge 1982, p. 217, Fig. 256; 1985, p. 81; Matsuoka *et al.* 1988, Figs. 8-14.

Cells are 30-42 μm (commonly 28-32 μm) in length, 20-34 μm (mostly 20-22 μm) in width. They are elongated, cordiform, and dorsoventrally flattened (Fig. 23). Epitheca is longer than hypotheca, and trianguloid with convex sides tapering into an apical horn. Hypotheca is trapezoid with two conspicuous spines, of which left one is longer than the right one (Figs. 24, 25). Girdle is situated below midpoint of the cell, and offset by one girdle's width. Thecal plate is reticulate. Plate formula is po, 3′, 2a, 6″, 6‴, 1p, 1⁗ and with the first apical plate narrow, smooth and unornamented. Cell is weakly pigmented, with light brown color.

The characteristic shape of the conical epitheca and two large antapical spines makes this species quite easy to be recognized. Our specimens fit quite well with the features of *G. verior* described by Dodge (1985) and Matsuoka *et al.* (1988). It occurred almost all year round with the exception during August to October (Table 1). The cell density was usually less than 1,000 cells/m*l*, but sometimes it was found blooming in some shrimp ponds with cell number as high as 300,000 cells/m*l* (Table 1). This alga has been reported from British Isles, North Sea, Belgian coast, Mediterranean Sea and Japanese coastal waters.

***Alexandrium tamarense* (Lebour) Balech** (Figs. 26-34)

Balech 1985, p. 37 Fig. 20; Fukuyo 1985,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p. 531 Figs. 2A-G.

Cells are single (Fig. 26), but form a two-celled chain shortly after cell division (Fig. 27), globular in shape and slightly longer than broad. They are 14–34 μm long, 13–31 μm wide and with length/width ratio of 1.00–1.22 (mostly 1.12), width/transdiameter ratio of 1.00–1.13. The epitheca is conical and the hypotheca has a very marked excavation in the sulcal region, both are nearly equal in altitude (Fig. 28). Apex is rounded with a slight hump at the apical pore plate (po) (Fig. 29); antapex is also rounded and slightly depressed at where the sulcus reaches (Figs. 28, 30). Both shoulders of the epitheca are convex. The hypotheca is asymmetric with the height of right half slightly shorter than the left half (Fig. 28). The girdle is equatorial, descending, without overhang, deeply excavated without lists, and its right end displaced posteriorly about its width (Figs. 26, 28, 30). Sulcus is weakly impressed, widened posteriorly, and slightly indented anteriorly (Fig. 30). The plate formula is: po, 4′, 6″, 8s, 5‴, 2⁗ (Figs. 30, 31, 32). The apical pore plate (po) (Fig. 29) is triangular and has a fishhook-shaped cleft (Fig. 33). The 1st apical plate (1′) is slightly broad and rhomboidal. A conspicuous ventral pore is present at middle of suture between apical plates 1′ and 4′ (Figs. 28, 29, 31). The sulcal plates are composed of eight platelets. They include one anterior (s.a.), transitional (t.), left (s.l.), sulcal left anterior (s.l.a.), right (s.r.), posterior (s.p.) and two medians (Figs. 30, 32). Thecal plates are thin and smooth, with trichocyst pores, and covered with a delicate outer thecal membrane. Trichocyst pores are single or in pair, and distributed evenly (Fig. 33). A large U-shaped nucleus is located beneath the cingulum. Temporary cyst is round, while hypnocyst is cylindrical and with rounded ends (Fig. 34). This strain is toxic (Su *et al.* 1989) and nonbioluminescent.

This species was found from an inlet near the mouth of Tungkang river (Fig. 1) and from ponds whose waters were introduced from that inlet. This alga appeared during winter and spring with water temperatures around 10.9-30.0°C and the salinity about 10-19 ppt (Table 1). Cell densities were about 10-100 cells/m*l*, but on Nov. 5, 1986 we found it was blooming in a crab pond with the cell densities of about 1600 cells/m*l*. It was also blooming in a shrimp pond in Tainan Shien with the cell density as high as 10,000 cells/m*l* in June 1989 and cause death of shrimp (Su, unpublished data).

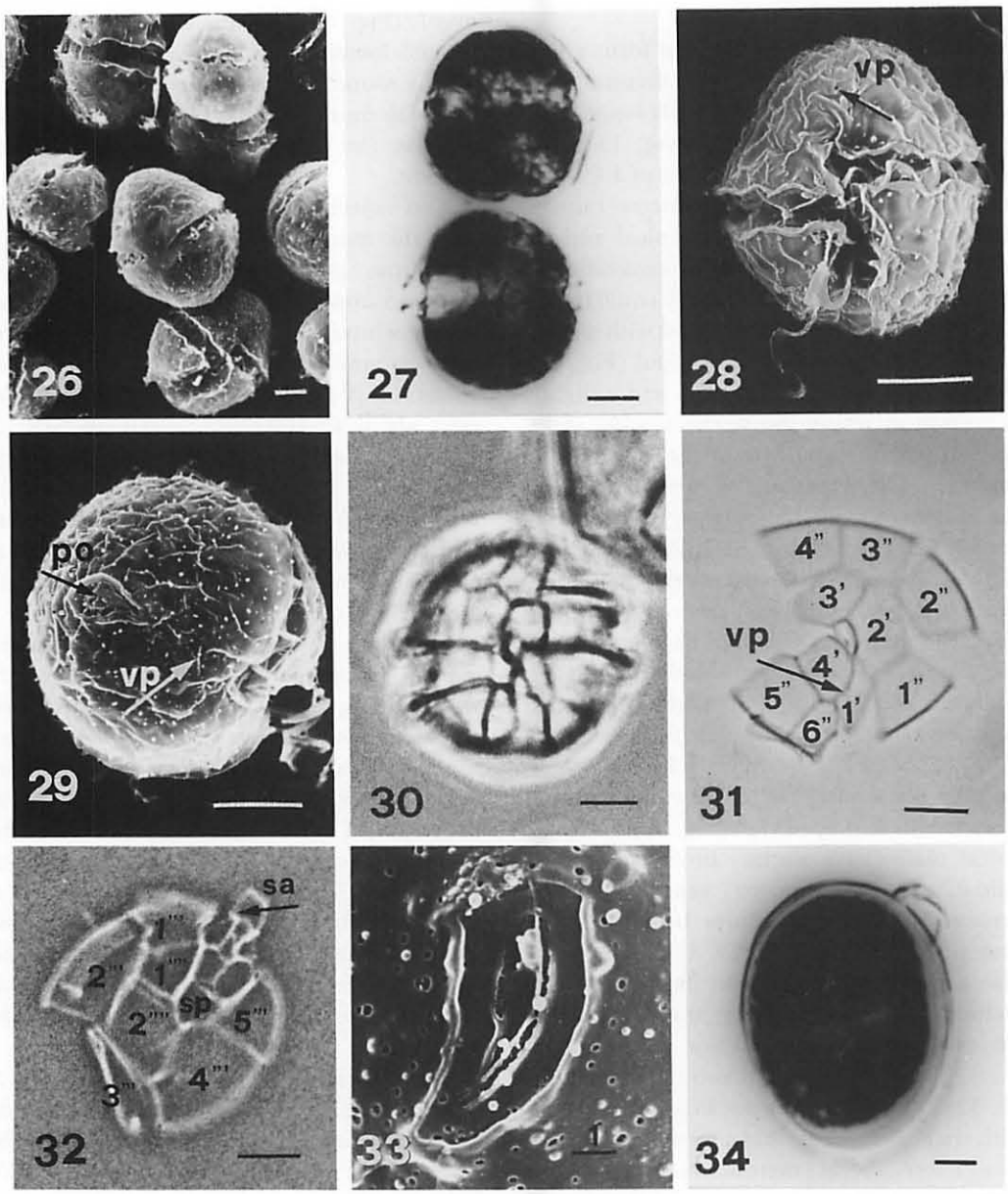
A. tamarense is a cosmopolitan alga occurred mainly in temperate coastal and estuary waters along the north part of the Atlantic and the Pacific Oceans (Taylor 1984) during summer time (Prakash 1963, Toriumi and Takano 1979). It also appeared in the tropical waters of Brazil and Venezuela along the west coast of the Atlantic Ocean (Balech 1971, Reyes-Vasquez *et al.* 1979). Recently, a nontoxic strain of this species was reported from Thailand coastal water (Fukuyo *et al.* 1989). This is the first record of toxic *A. tamarense* occurred in the tropical Pacific waters.

The intricate systematic problem of "Tamarensis" or "Catenella" group has been discussed (Loeblich and Loeblich 1975, 1979, Taylor 1975, 1979, 1984, Steidinger 1983, Fukuyo 1985). *Gonyaulax tamarensis, G.*

Fig. 14. *Gyrodinium instriatum*. Apical view. Showing the apical groove (ag) (SEM).

Figs. 15–22. *Pyrophacus horologium*. Fig. 15. Antapical view. Showing cytoplasm with numerous chloroplasts, and the thecae. Fig. 16. Dorsoventral view. Showing oblate shape. Fig. 17. Apical view. Showing apical pore plate (po) with its two slits and numerous trichocyst pores (tp) on the surface of the valve (SEM). Fig. 18. Antapical view. Showing the plate pattern and plain surface of the valve (SEM). Fig. 19. Phase contrast micrograph of the epitheca showing plates po, 5′, 9″. Fig. 20. The po, 6′, 10″ epitheca plates which different from those showing in Fig. 19. Fig. 21. Phase contrast micrograph of hypotheca. Showing plates 9‴, 1p, 3⁗ and sulcus platelets. Fig. 22. Antapical view. Showing two daughter cells inside the parental theca.

Figs. 23–25. *Gonyaluax verior*. Fig. 23. Ventral view. Showing the contour of the cell. Fig. 24. Ventral view. Showing the girdle, reticulate plate and two conspicuous spines (SEM). Fig. 25. Dorsal view. Showing the contour of the cell (SEM).



Figs. 26–34. *Alexandrium tamarense*. Fig. 26. The contour of the cell (SEM). Fig. 27. A two-cell chain. Fig. 28. Ventral view. Showing the displaced girdle, two flagella and a ventral pore (vp) (SEM). Fig. 29. Apical view. Showing the valve surface, po plate and ventral pore (vp) (SEM). Fig. 30. Ventral view. Showing the plate pattern. Fig. 31. Apical view. Showing the plates po, 4′, 6″ and ventral pore (vp). Fig. 32. Antapical view. Showing the plates 5‴, 2⁗, sulcal platelets. Fig. 33. Apical pore plate po. Showing trichocyst pores in single or in pair. Fig. 34. Hypnocyst.

tamarensis var. excavata, G. tamarensis var. tamarensis, G. excavata, Protogonyaulax tamarensis and *Alexandrium tamarense* are used to mention the same species. The morphological characteristics which have been used for identification of species are plate tabulation, cell shape, cell numbers of chain (Lebour 1925, Whedon and Kofoid 1936, Braarud 1945); lack or presence of ventral pore, toxicity and bioluminescence (Loeblich and Loeblich

1975); shape of cyst and sulcal platelets, contact of 1′ and Po plates (Taylor 1979, Fukuyo 1979, Balech 1985); the shape of apical pore plate, apical plate 1′ and sulcal posterior plate, and position of a posterior and an anterior attachment pore (Fukuyo 1985). But recently, the polymorphism of isozymes, DNA content and toxin spectrum have been used to help the identification of this group (Cembella and Taylor 1985). From the appearance of intermediate forms, and change of cell shape and cell numbers of chain in culture, Taylor (1984) suggested it may be more reasonable to put the "Tamarensis" group into intraspecific level. However, Balech (1985) thought some characteristics such as shape of apical pore, 1st apical plate 1′, sulcal anterior and posterior plate are conservative and can be used to distinguish different species.

Our specimens closely resemble *Alexandrium excavatum* (named as *G. tamarensis* var. *excavata* by Braarud) from Norway waters (Braarud 1945, Balech and Tangen 1985), *G. tamarensis* from Tamar estuary in England (173 strain in Loeblich and Loeblich 1975, Balech 1977) and *Protogonyaulax tamarensis* from Japanese coastal waters (Fukuyo 1985) in cell shape and plate tabulation. It also conforms to *G. tamarensis* var. *tamarensis* of Schmidt *et al.* (1978) in possession of a ventral pore and being toxic and nonbioluminescent. However, our alga differs from those reported from temperate waters in having ability to grow at very low salinity (3 ppt) and high temperatures (up to 33°C) in culture (Fig. 35A & B), and with smaller size (14–34 μm) (7 ppt and 25°C in Prakash 1967; 28–50 μm in Loeblich and Loeblich 1975). Although *Alexandrium tropicale* (Balech 1985) is a small sized and tropical species, and very similar to Tungkang strain of *Alexandrium tamarense* in cell shape, they still differ from each other in the position of nucleus (Balech 1971 Figs. 119, 120) and contact pattern of plate 1′ and po (Balech 1985 Fig. 7b). The contact pattern of plate 1′ and po was considered as a criterion for species (Loeblich and Loeblich 1979, Balech 1985), or for genus

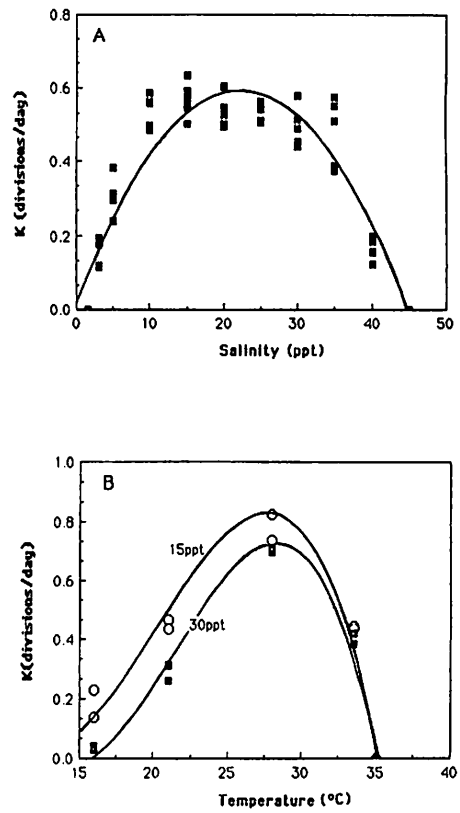


Fig. 35. The growth rates (K) of *Alexandrium tamarense* in various salinity (A) and temperature (B) under a 12 : 12LD cycle at 80 μE/m²/s light intensity.

(Taylor 1979). Because the contact is variable as that found in *A. excavatum* and *A. minimum* (Balech and Tangen 1985, Hallegraeff *et al.* 1988). We agree Balech's opinion that genus *Alexandrium* should include those species which have and have not the contact.

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蘇　恵美*・江　永棉：台湾南部の養殖池から採集した渦鞭毛藻

養殖した貝 (purple clam) の摂取による麻痺性貝中毒事故が発生し2人の死者がでた台湾南部の養殖池から採集した光合成を行なう渦鞭毛藻5種 (*Prorocentrum minimum, Gyrodinium instriatum, Pyrophacus horologium, Gonyaulax verior, Alexandrium tamarense*) について記載し，若干の分類学的検討を行なった。*A. tamarense* は，熱帯太平洋水域で単離された最初の有毒種であると報告されているが，著しい低塩分ならびに高温で成育し，サイズが小さい (11–34 μm) 点で温帯水域で報告されているものとは異なる。(台湾台北市 国立台湾大学海洋研究所；*現所属：台湾屏東県 台湾水産試験所東港分所)

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Photosynthetic capacity of various parts of the blade of *Laminaria longissima* Miyabe (Phaeophyta)*

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The rates of photosynthesis and dark respiration of discs cut from the basal, subbasal, middle, subdistal and distal parts of *Laminaria longissima* blades were measured once a month for a year. The photosynthetic rate at 10°C and 400 μE m^{-2} s^{-1} was generally highest near the midlength of the blade and lower in the basal and the distal parts. However, during the fertile period the photosynthetic rate was lowest in the sorus-bearing part of the blade and the respiratory rate was highest in the basal and sorus-bearing parts. The photosynthetic rates of discs cut from all parts of the blade showed almost identical seasonal trends, being generally highest during the colder season.

Key Index Words: blade—blade discs—intra-thallus variability—Laminaria longissima—*Phaeophyta—photosynthesis—respiration—seasonal variation.*

The brown alga *Laminaria longissima* Miyabe is distributed along the eastern Pacific coast of Hokkaido from Kushiro to Nemuro and usually grows subtidally between the low water mark and 5 m depth. This species is utilized as human food and its annual yield is the highest of all the edible species of *Laminaria* in Japan (Kawashima 1972, Torii and Tazawa 1987). Although intensive ecological studies concerning growth, reproduction, recruitment and mortality have been made on *L. longissima* (Sasaki 1969, 1973, Kawashima 1972), photosynthesis, which is the basis of growth, has scarcely been studied in this species.

In a previous paper (Sakanishi *et al.* 1990), we documented the photosynthesis-light relationships and seasonal changes of photosynthetic capacity in *L. longissima* by using blade discs cut from near the midlength of each plant as material. However, it is not clear whether the midlength region accurately represents the whole plant, and it is important to know whether there are differences in photosynthetic characteristics along the whole blade. The present study compares the photosynthetic capacity and the seasonal variation in photosynthetic capacity of various parts of the blade of *L. longissima*.

Material and Methods

Photosynthesis and respiration of *Laminaria longissima* were measured monthly from September 1987 to August 1988 using plants growing in the upper subtidal zone at Katsurakoi, Kushiro, Hokkaido. Sampling, preparation of blade discs and measurements of photosynthesis and respiration were performed as previously described (Sakanishi *et al.* 1990). Sample plants ranged from 1.88 to 7.12 m in blade length (Fig. 1). A single disc of 3.1 cm^2 was respectively cut out of the peripheral portion in the basal, the subbasal,

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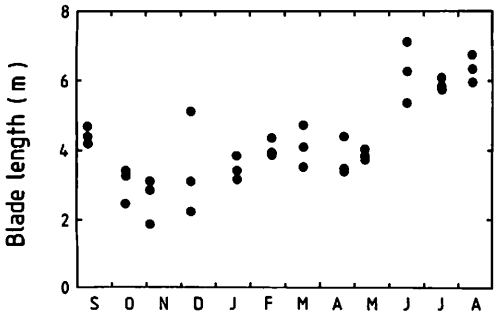

Fig. 1. *Laminaria longissima*. Seasonal change in the blade lengths of sample plants.

the middle, the subdistal and the distal parts of a blade (Fig. 2). Discs were cut out of three sample plants every month. From September 1987 to February 1988, approximately 30% of the discs obtained bore zoosporangial sori. Photosynthesis or respiration was measured with all discs held under constant conditions of 10°C and either 400 μE m^{-2} s^{-1} or darkness, respectively.

Results

Figure 3 shows for each month the net photosynthetic and respiratory rates measured for blade discs of *Laminaria longissima*. From September to February, when zoosporangial sori were present within the blades, the photosynthetic rate was generally lower in the basal and the sorus-bearing parts of the blades than in other parts, and showed no marked longitudinal pattern. From March to August, when the blades lacked zoosporangial sori, the photosynthetic rate increased from the basal part of the blade to reach a maximum at midlength and then declined toward the distal end. The longitudinal pattern of photosynthetic capacity was independent of blade length (cf. Fig. 1). The respiratory rate was relatively high in the basal part throughout the year except for September and November, and also in the sorus-bearing part during the fertile period.

The seasonal changes in the net photosynthetic and respiratory rates of discs from various parts of the blades are presented in Fig. 4. The photosynthetic rate of each part

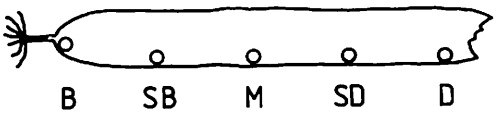

Fig. 2. *Laminaria longissima*. Sampling sites within a blade for measurements of photosynthesis and respiration. Discs were cut out of the basal (B), the subbasal (SB), the middle (M), the subdistal (SD) and the distal (D) parts.

showed an almost identical seasonal trend, being generally higher in the colder season. The photosynthetic rates were low in July–September, began to increase in October and reached their maxima (52–65 $\mu l\, O_2\, cm^{-2}\, h^{-1}$) in January or February. The photosynthetic rates declined in spring and reached a lower level in summer, the minima (3–30 $\mu l\, O_2\, cm^{-2}\, h^{-1}$) being obtained in July–September. During the period from June to August the photosynthetic rates of the basal and the distal parts of the blades were clearly lower than those of other parts.

The respiratory rates of various parts of the blade ranged from 2 to 13 $\mu l\, O_2\, cm^{-2}\, h^{-1}$. The respiratory rate of the basal part was at its highest from mid-winter to early spring. The respiratory rates of the subbasal, middle and subdistal parts were at their lowest from spring to early summer. The rate of the distal part of the blade showed no marked change throughout the year.

Discussion

The distribution pattern of photosynthetic capacity along the fronds has been reported for several species in the Laminariales: *Laminaria digitata* (King and Schramm 1976), *Laminaria solidungula* (Dunton and Jodwalis 1988), *Macrocystis pyrifera* (Sargent and Lantrip 1952, Clendenning 1964, Wheeler 1980), *Undaria pinnatifida* f. *distans* (Matsuyama 1983) and *Ecklonia cava* (Sakanishi *et al.* 1989). In those species, the photosynthetic rate increased with the age of the blade tissue until it reached a maximum and then decreased with further aging. Although the distribution of photosynthetic capacity along the blades of *Laminaria longissima* varied with

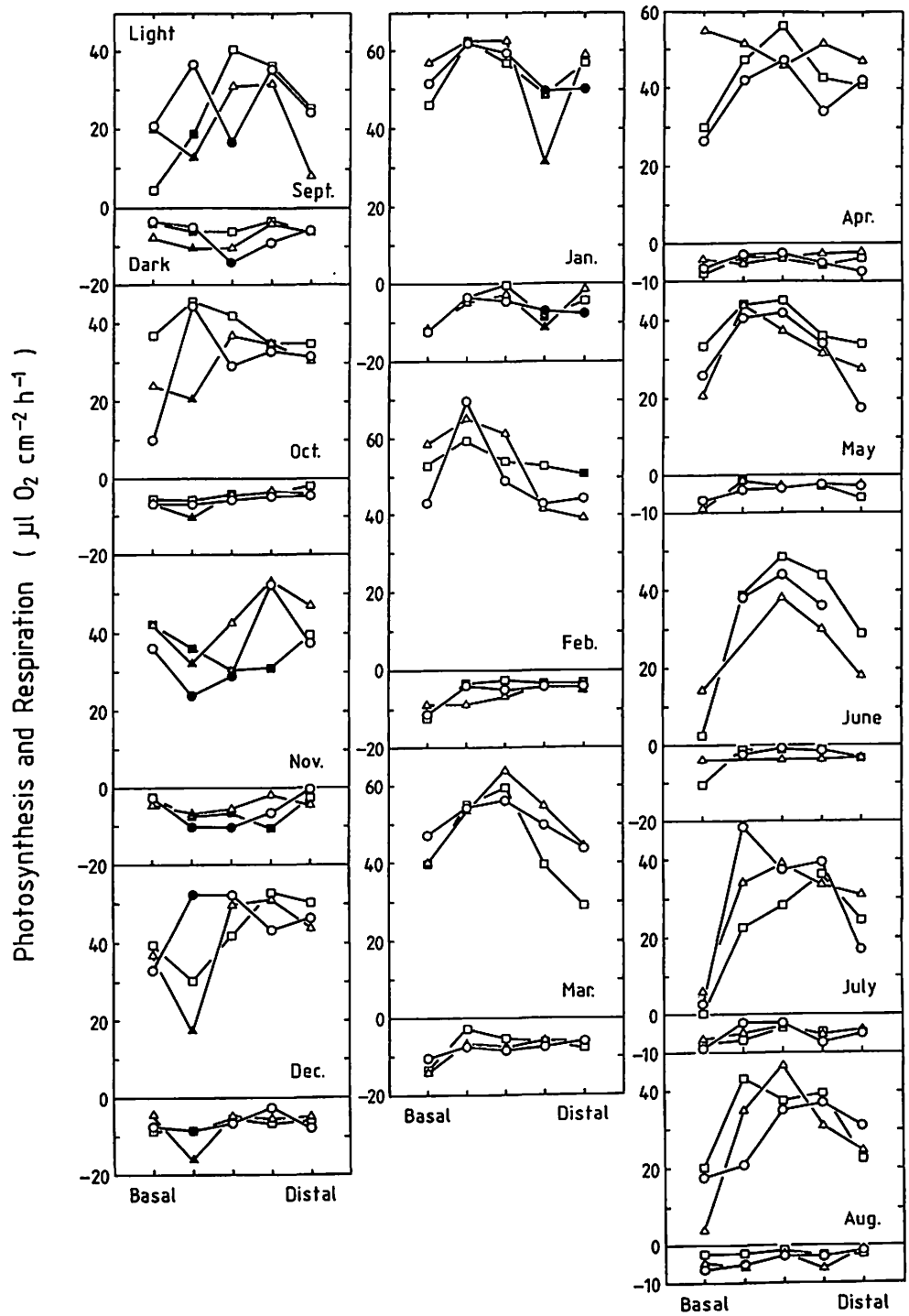

Fig. 3. *Laminaria longissima*. Comparisons of the net photosynthetic rates at 10°C and 400 μE m^{-2} s^{-1} and respiratory rates at 10°C and in darkness in different parts of the blade over 12 months. Each symbol shows a value obtained from a single plant. Closed symbols show values obtained with sample discs bearing zoosporangial sori.

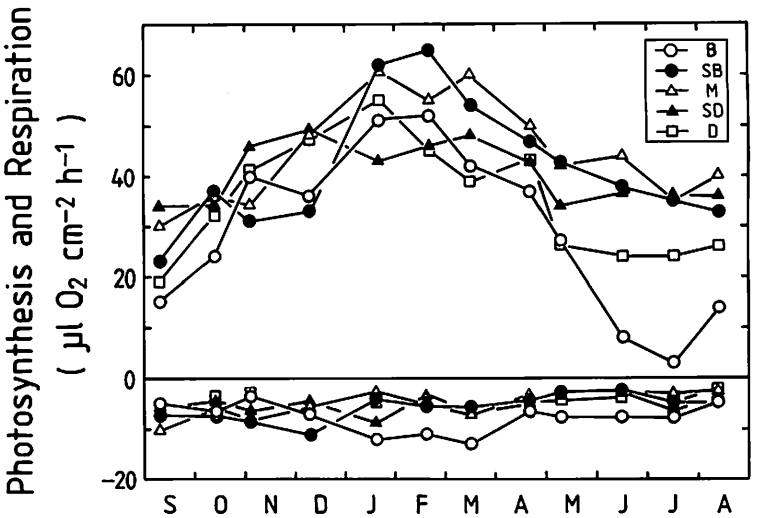

Fig. 4. *Laminaria longissima*. Seasonal changes of the net photosynthetic rates at 10°C and 400 μE m^{-2} s^{-1} and respiratory rates at 10°C and in darkness of discs from various parts of the blade, as indicated in the key by the abbreviations used in Fig. 2. Means for 2–3 replicates.

season (Fig. 3), the pattern was almost the same as that in other Laminariales except during the fertile period. The lower photosynthetic capacity of the sorus-bearing portion in *L. longissima* agrees with that reported by Aruga *et al.* (1990) in *Ecklonia cava*.

The seasonal changes in the photosynthetic rates of various parts along the blade of *L. longissima* (Fig. 4) suggest that the photosynthetic capacity of the whole blade is highest during the colder season. The seasonal trend in the photosynthetic capacity of the midlength region in blades of *L. longissima* reported by Sakanishi *et al.* (1990) represents that of the whole blade moderately well, since the photosynthetic capacity of various parts of the blade shows almost identical seasonal trends (Fig. 4).

Although the seasonal trends in the respiratory rates of the basal and the distal parts of the blade were different from those in other parts, the seasonal trend in the middle part can be assumed to represent that of the whole blade since the basal and distal parts with distinctive characteristics probably represent a small portion of the total blade area.

All the blade tissue of *L. longissima* used in January was at least as old as the blade tissue used at other times of the year, yet in January relatively high or even the highest photosynthetic rates throughout the year were observed (Fig. 4). These results suggest that the photosynthetic capacity of *L. longissima* is affected by seasonal changes in physiological state rather than by the aging of its blade tissue.

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坂西芳彦[1]・横浜康継[2]・有賀祐勝[3]：褐藻ナガコンブ藻体の種々の部位における光合成活性

ナガコンブ藻体の基部，中央，先端，ならびにこれらの中間の縁辺部から切り出した藻体片 (3.1 cm^2) を用い，9月から翌年8月まで毎月1回，10°C・400 $\mu E\ m^{-2}\ s^{-1}$ における光合成ならびに 10°C における暗呼吸を測定した。光合成活性は，一般に藻体の中央に近い部位で高く，基部および先端では低かったが，子嚢斑をもつ時期には光合成活性は子嚢斑部で最も低く，呼吸速度は基部ならびに子嚢斑部で最も高かった。光合成活性の季節変化は各部位ともほとんど同じ傾向を示し，一般に秋季に高まり始め，厳冬に極大に達した後低下し，夏季に極小に達することが明らかになった。([1] 085 北海道釧路市桂恋116　水産庁北海道区水産研究所；[2] 415 静岡県下田市5丁目10–1　筑波大学下田臨海実験センター；[3] 108 東京都港区港南4–5–7　東京水産大学藻類学研究室)

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Comparative photosynthetic capacities of different parts of *Sargassum horneri* (Phaeophyta)*

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Gao, K. 1991. Comparative photosynthetic capacities of different parts of *Sargassum horneri*. (Phaeophyta) Jpn. J. Phycol. 39: 245–252.

Net photosynthetic and dark respiratory rates measured with a differential gas-volumeter increased but chlorophyll content decreased with increasing leaf area ratio in leaves of *Sargassum horneri*. It was estimated that chlorophyll *a* increased 1.7–4.1%, while net photosynthetic and dark respiratory activities decreased 1.4–5.8% and 4.6–8.9%, respectively, as a leaf grew one day older. Vesicles were shown to possess high photosynthetic capacity in addition to supplying floatation. Photosynthetic activity was highest in leaves, intermediate in vesicles and lowest in the holdfast and primary laterals. It is shown that different parts of a *S. horneri* plant have different photosynthetic properties.

Key Index Words: *LAR—Phaeophyta—photosynthesis—respiration*—Sargassum horneri.

Studies of photosynthetic characteristics of *Sargassum* plants are fundamental to understanding their ecological properties. Diurnal photosynthetic performance was reported in *S. thunbergii* (Gao and Umezaki 1989a, b) and *S. horneri* (Gao 1990b) to show higher oxygen evolution rates in morning than in afternoon on fine days. Photosynthetic activity was reported to be higher in apical portion than in basal portion of *S. horneri, S. hemiphyllum* and *S. confusum* on a basis of chlorophyll *a* (Yokohama 1977). In studies on *S. horneri, S. serratifolium, S. autumnale, S. thunbergii* and *S. patens*, Gao and Umezaki (1988) reported that 'leaves' of the lower parts showed higher chlorophyll content but lower photosynthetic rate on a chlorophyll *a* basis, compared with the upper parts. Photosynthetic capacity of *S. thunbergii* was found to be obviously affected by nitrate and phosphate concentrations in seawater (Gao and Nakahara 1990). Diurnal photosynthetic rates were demonstrated to increase with PO_4^{3-} enrichment in pelagic *Sargassum* species, *S. natans* and *S. fluitans* (Lapointe 1986). Gao (submitted) showed that photosynthetic rate increased with increasing water current speed in adult *S. thunbergii* plants. It was also reported that *S. muticum* assimilated bicarbonate ion in photosynthesis (Thomas and Tregunna 1968).

Gao and Umezaki (1989c) reported that various parts of a *S. thunbergii* plant were differentiated with different photosynthetic properties, being comparable to the findings in *Laminaria* (Weidner and Kuppers 1973, Kuppers and Kremer 1978), *Fucus* (Küppers and Kremer 1978), *Macrocystis* (Wheeler 1980) and *Padina* (Yokohama 1977) plants. The present study gives different photosynthetic characteristics among various parts in *S. horneri*, which has been used as a food or a vegetable at some local places in Japan (Ikehara 1987). The seasonal variation of photosynthetic capacity of *S. horneri* was already reported (Gao 1990a) to show a similar patern to that of growth as previously reported (Umezaki 1984).

Materials and Methods

A *Sargassum horneri* plant (Fig. 1) consists of

* Partly presented at 3rd International Phycological Congress, 14–20 August 1988, Melbourne, Australia.

a holdfast, a primary lateral from which leaves and lateral branches are formed. The lateral branches produce both 'leaves' and vesicles and, during the mature season, receptacles. The species is distributed, from 1 m upto 20 m deep, along the coast of both the Sea of Japan and the Pacific Ocean throughout the Archipelago of Japan.

The experiments were carried out during the period from August to November 1986 and 1987 at the Fisheries Research Station of Kyoto University situated at the head of Maizuru Bay, one of the branch bays of Wakasa Bay facing the Sea of Japan. Samples of *S. horneri* were collected at Nagahama, Maizuru Bay, where the plant forms flourishing community at 1-3 m depth during the period from November to April next year and matures in May; juveniles appear in July.

Photosynthesis and dark respiration were measured at 20°C in the laboratory in the same way as previously reported (Gao and Umezaki 1989c, Gao 1990a) with a differential gas-volumeter, 'Productmeter', devised by Yokohama and Ichimura (1969) and improved by Yokohama *et al.* (1986). Light was supplied with an incandescent lamp (National, 110 V 150 W), and photosynthetically active radiation (PAR, 400-700 nm) of the supplied light was measured with an underwater quantum sensor (LICOR, LI-192S) linked with a recorder (Toa Electronics Ltd., FBR-253A). Water temperature in the water bath was controlled by using a Taiyo Coolnit (CL-30).

Chlorophylls were determined by freezing samples at −20°C, grinding in a mortar with quartz sand, extracting with 90% acetone, and filtering through absorbent cotton with 90% acetone. The absorbances of the acetone extract were measured at 750, 664, 647 and 630 nm with a spectrophotometer (Hitachi Ltd., Model 100-2). The concentrations of chlorophylls *a* and *c* were calculated by the formulae of Jeffrey and Humphrey (1975).

Fresh weight of samples was measured after blotting water drops from the thallus with tissue paper. Dry weight was determined after drying the samples at 85°C for 20-24 hours. Leaf area was determined by making a shade on a film, weighing the shaded part, and multiplying by the ratio of area to weight of the film. Leaf area ratio (LAR), the ratio of leaf area to leaf dry weight, was determined.

Leaf formation rate per day was determined by measuring the number of leaves at the beginning and at the end of a period (8 days, Aug. 17-25 1987), during which the plants (about 4 cm long) were maintained in the sea at their natural depth (1 m).

Daily relative change rates (CP) of chlorophyll, photosynthesis and respiration in a leaf were determined by the following formula:

$$CP=\frac{\ln Cb-\ln Ca}{(Lb-La)/Lf}\times 100,$$

where Cb and Ca represent chlorophyll content, net photosynthetic or respiratory rates of basal (or older) and apical (or younger) leaves, respectively; Lb and La, leaf order number counted from the apex for the basal and the apical leaves, respectively; Lf, leaf formation rate (the number of leaves formed per day).

The correlations of photosynthesis, dark respiration and chlorophyll content to LAR were analyzed by computer with a regression analysis program.

Results

Light-saturated net photosynthesis and dark respiration of the leaves produced from primary lateral increased parabolically, but chlorophyll *a* content decreased hyperbolically with increasing LAR, which increased from basal portion to apical portion of a *Sargassum horneri* plant (Fig. 1).

Figure 2 shows photosynthesis-light curves of apical and basal leaves on a chlorophyll *a* basis (A), on a leaf area basis (B) and on a dry weight basis (C). Dark respiration rate and net photosynthetic rate at above 100 μE m^{-2} s^{-1} was higher in the apical than in the basal leaves on any of the bases. Light compensation point was higher in the apical leaves compared to the basal leaves, with the former

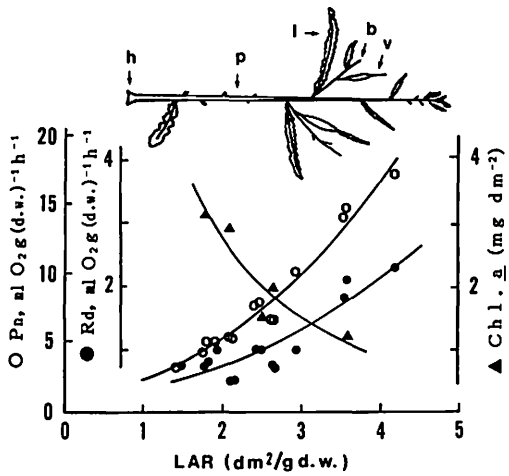

Fig. 1. Relationships of net photosynthesis (Pn), dark respiration (Rd) and chlorophyll (Chl.) *a* content to leaf area ratio (LAR) in a *Sargassum horneri* plant (h, holdfast; p, primary lateral; l, leaf; b, lateral branch; v, vesicle). Pn, Rd and Chl. *a* are expressed as functions of LAR (X) respectively as follows: $Pn=1.45+0.94X^2$ ($r^2=0.96$), $Rd=0.26+0.12X^2$ ($r^2=0.80$) and Chl. $a=1.02+7.46/X$ ($r^2=0.84$). Chlorophyll *a* content was the mean for 4–6 samples.

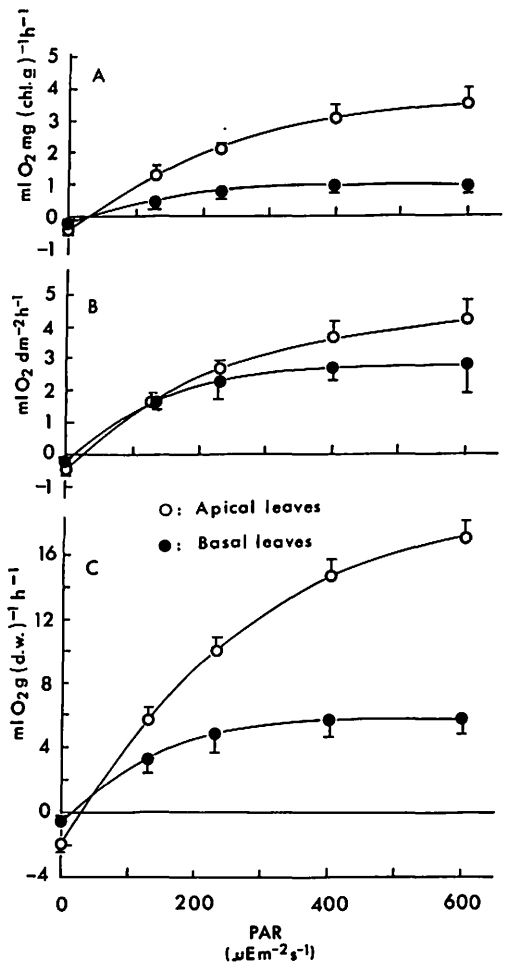

Fig. 2. Photosynthesis-light curves of the apical (○) and the basal (●) leaves of *Sargassum horneri* on a chlorophyll *a* basis (A), on a leaf area basis (B) and on a dry weight basis (C). The mean±S.E. for 5 plants (about 10 cm long) measured at 20°C in October 1987.

being 30 and 27 $\mu E\ m^{-2}\ s^{-1}$ and the latter 15 and 13 $\mu E\ m^{-2}\ s^{-1}$ on a dry weight basis and on a leaf area basis, respectively. On a chlorophyll *a* basis (A), light compensation point of the apical leaves was similar to that of the basal ones. Net photosynthesis was saturated at about 300 $\mu E\ m^{-2}\ s^{-1}$ in the basal leaves, but was not saturated until 600 $\mu E^{-2}\ s^{-1}$ in the apical leaves. Net photosynthetic rates at 600 $\mu E\ m^{-2}\ s^{-1}$ of the apical leaves were 3.5, 1.5 and 2.9 times, and dark respiration rates of the apical leaves were 2.0, 2.5 and 3.3 times as high as those of the basal leaves on a chlorophyll *a* basis, on a leaf area basis and on a dry weight basis, respectively.

Chlorphyll contents were compared among the leaves of different positions (Table 1). Data for the basal leaves obtained in 1986 (1987) were about 0.72 (0.76) times higher in chlorophyll *a* content and 1.13 (1.12) times higher in chlorophyll *c* content on a fresh weight basis, and were 1.12 (1.40) times higher in chlorophyll *a* content and 1.62 (1.91) times higher in chlorophyll *c* content on a leaf area basis, compared with those for the apical leaves. Chlorophyll *c* to *a* ratio was also higher in the basal than in the apical leaves. Chlorophylls *a* and *c* contents and chlorophyll *c* to *a* ratio of middle leaves were lower than those of basal leaves but higher than those of apical ones (Table 1, 1987). LAR of apical leaves was about 34% and 70% higher compared to middle leaves and basal leaves, respectively (Table 1).

Figure 3 compares a photosynthesis-light curve of vesicles with those of the basal and apical leaves in November. Net photosynthesis

Table 1. Comparisons of chlorophyll (Chl.) contents and leaf area ratio (LAR) among the apical, middle and basal leaves of *Sargassum horneri*.

Date: October 7, 1986

Leaf position	Chl. *a* (mg f.w.g^{-1})	Chl. *c* (mg f.w.g^{-1})	Chl. *a* (mg dm^{-2})	Chl. *c* (mg dm^{-2})	Chl. *c/a*	LAR (dm^2 d.w.g^{-1})	Samples (n)
Apical	0.812±0.014	0.112±0.001	1.472±0.104	0.203±0.012	0.138±0.002	2.446±0.437	6
Basal	1.396±0.096	0.238±0.017	3.125±0.205	0.532±0.033	0.170±0.004	1.785±0.414	6
	(1.719)*	(2.125)	(2.123)	(2.621)	(1.232)	(0.730)	

Date: October 10, 1987

Leaf position	Chl. *a* (mg f.w.g^{-1})	Chl. *c* (mg f.w.g^{-1})	Chl. *a* (mg dm^{-2})	Chl. *c* (mg dm^{-2})	Chl. *c/a*	LAR (dm^2 d.w.g^{-1})	Samples (n)
Apical	0.724±0.061	0.095±0.008	1.209±0.109	0.157±0.015	0.132±0.002	3.532±0.964	6
Middle	1.088±0.062	0.161±0.009	1.953±0.162	0.288±0.024	0.148±0.001	2.630±0.234	4
	(1.503)	(1.695)	(1.6159)	(1.834)	(1.121)	(0.745)	
Basal	1.275±0.056	0.201±0.006	2.899±0.378	0.457±0.052	0.158±0.002	2.075±0.272	4
	(1.761)	(2.116)	(2.398)	(2.911)	(1.197)	(0.587)	

* Figures in parentheses are values relative to those of apical leaves.

of vesicles was saturated at about 400 μE m^{-2} s^{-1}. Light-saturated net photosynthetic rate and dark respiration rate of vesicles were much lower compared to those of apical leaves but higher compared to those of basal ones.

Figure 4 compares a photosynthesis-light curve of primary laterals with that of leaves of juvenile plants. Dark respiratory and net photosynthetic rates were much higher in leaves than in primary laterals. Photosynthesis of primary laterals was saturated at about 250 μE m^{-2} s^{-1}. Light-saturated net photosynthetic rate and dark respiratory rate of leaves were respectively about 4 and 2 times as high as those of primary laterals.

Figure 5 illustrates relationships of pho-

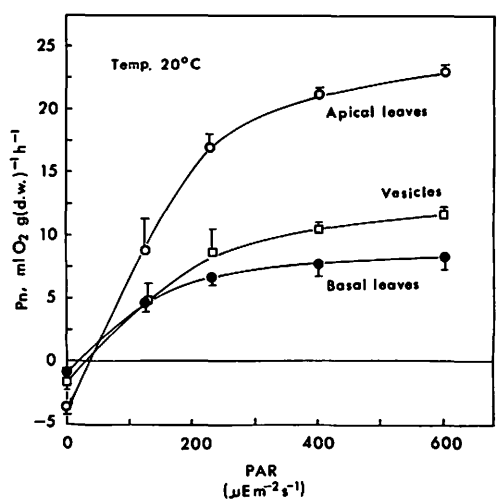

Fig. 3. Photosynthesis-light curve of vesicles compared to those of apical and basal leaves in *Sargassum horneri*. The mean±S.E. for 5 plants (about 25 cm long) measured in November 1987.

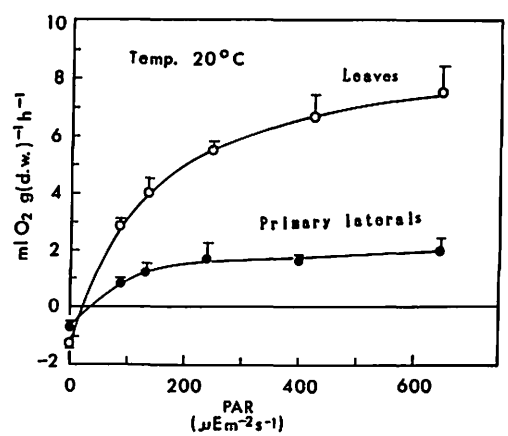

Fig. 4. Photosynthesis-light curve of primary laterals compared to that of leaves of juvenile plants of *Sargassum horneri*. The mean±S.E. for 12 plants (about 2.5 cm long) measured in August 1987.

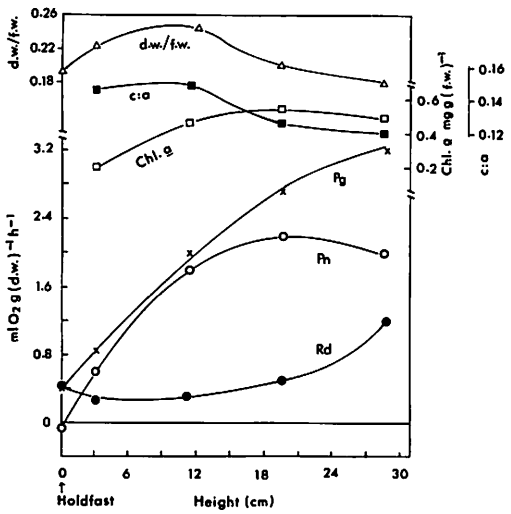

Fig. 5. Relationships of gross photosynthesis (Pg), net photosynthesis (Pn), dark respiration (Rd), chlorophyll *a* content (Chl. *a*), chlorophyll *c* to *a* ratio (c : a) and dry weight to fresh weight ratio (d.w./f.w.) to the hight of primary laterals of *Sargassum horneri*. Primary laterals of 4 plants were used. Measured at 20°C in November 1987.

tosynthesis, dark respiration, chlorophyll content and dry weight/fresh weight ratio to the height of primary laterals. Dark respiration showed a little higher values in holdfast compared to the basal part of primary laterals, and increased to show higher values in the apical part. It was clear that the holdfast also showed photosynthetic activity. Net photosynthesis increased from the holdfast to reach a maximum and then decreased owing to much higher dark respiration in the apical portion. Gross photosynthesis increased from the holdfast to the apex of primary lateral. Chlorophyll *a* content increased from the base to the apex of primary laterals, and chlorophyll *c* to *a* ratio was higher in the basal than in the apical portions of primary laterals. Ratio of dry weight to fresh weight increased from the holdfast to reach a maximum in the basal portion and then decreased until the apex of primary laterals.

As indicated in Table 2, a new leaf was formed every two days; i.e. neighbouring leaves were different in age by two days. The 4th to the 6th leaves and the 15th to the 17th leaves numbered from the apex were respectively considered as the apical and the basal leaves in October in the present study. Consequently, the difference in age between apical leaves and basal leaves was about 20 days. As chlorophyll contents increased (Table 1), but net photosynthesis and dark respiration decreased in leaves from the apical portion to the basal portion (Fig. 1), the daily relative chlorophyll increase rate, and the daily net photosynthesis and respiration decrease rates in a leaf were estimated in different positions of primary laterals (Table 3). Irrespective of bases, as a leaf grew one day older, chlorophylls *a* and *c* increased respectively 1.7-4.1% and 2.7-5.1%, and net photosynthetic capacity and dark respiratory activity decreased respectively 1.4-5.8% and 4.6-8.9%.

Table 2. Daily leaf formation rate (R, number day^{-1}) of *Sargassum horneri* in the sea.

Sample No.	1	2	3	4	5	6	7	8	9	10	Average±S.E.
R	0.5	0.5	0.4	0.5	0.4	0.4	0.3	0.8	0.5	0.3	0.5±1.1

Table 3. Estimated daily relative chlorophyll increase rate (RCIR), net photosynthesis decrease rate (RPDR) and dark respiration decrease rate (RRDR) in a leaf of *Sargassum horneri*.

	Leaf area basis		Dry weight basis		Chlorophyll *a* basis
RCIR (% day^{-1})	Chl. *a*	Chl. *c*	Chl. *a*	Chl. *c*	
	4.1	5.1	1.7	2.7	
RPDR (% day^{-1})	1.4		4.1		5.8
RRDR (% day^{-1})	4.6		7.2		8.9

Discussion

It is clear that light-saturated net photosynthetic rates and dark respiratory rates of leaves decreased on any of a dry weight, a leaf area and a chlorophyll bases, while chlorophyll content increased, from the apex to the base of a *Sargassum horneri* plant; i.e. the highest chlorophyll contents were confined in older leaves, but the highest photosynthetic activity was confined in younger leaves. However, light-saturated net photosynthetic rates of the apical leaves of *S. horneri* were lower (on a dry weight basis) or similar (on a chlorophyll basis) in June compared with those of the basal leaves as previously reported (Gao and Umezaki 1988). The difference may be related to the periods the photosynthetic measurements were carried out. In June, when *S. horneri* matured and then decayed away, net photosynthesis was much reduced while dark respiration was much increased in the apical leaves as demonstrated by Gao (1990a) in his seasonal studies of photosynthetic capacity of the species. Küppers and Kremer (1978), in their studies on *Laminaria digitata, L. hyperborea, L. saccharina, Fucus spiralis, F. vesiculosus* and *F. serratus*, showed that less pigments were contained in younger regions compared to older ones. Wheeler (1980) also showed that the meristem of *Macrocystis pyrifera* contained less pigments. *S. horneri* elongates apically, and its apical portion is younger than its basal portion. The results of the present study that chlorophyll contents were higher in older leaves than in younger leaves agree with those reported by the above authors.

There are several reports (Ramus *et al.* 1976a, b, 1977; Wheeler 1980; Wassman and Ramus 1973; Perez-Bermudez *et al.* 1981) to show that photosynthetic pigments in seaweeds incresed with water depth or the degree of shading. Basal leaves of *Sargassum* plants, near the bottom of the sea, get more or less reduced light because of light absorption by water column and shading by the upper parts of themselves. *S. horneri, S. thunbergii, S. serratifolium, S. patens* and *S. autumnale* were reported to show higher chlorophyll contents in basal leaves than in apical leaves (Gao and Umezaki 1988). Gao and Umezaki (1989c) also reported that chlorophyll contents of leaves and vesicles were higher in the basal portion than in the apical portion. Similar results were obtained in *S. horneri* in the present study. Increased chlorophyll contents in the basal leaves of *Sargassum* plants can be considered partially to be caused by an adaptation to the reduced light conditions. However, as demonstrated in the present study, chlorophyll contents increased as LAR decreased with aging of a leaf; and chlorophyll *a* content was estimated to increase 1.7-4.1% as a leaf grew one day older. In October *S. horneri* plants were about 10 cm long, and the differences of light reduction around leaves of different positions could be negligible. Therefore, it is reasonable to consider that light condition contributed little to the differences in photosynthetic pigment content among leaves of *S. horneri* during the experiment period.

Photosynthetic rates on a dry weight or on a leaf area bases decreased but contents of chlorophylls increased in the leaves as LAR decreased from the apex to the base of a *S. horneri* plant. Because LAR decreased with increasing d.w./f.w. ratio (Fig. 6), photosynthesis which increased with increasing LAR

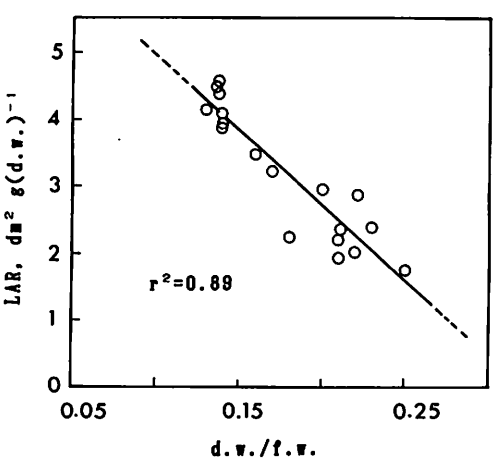

Fig. 6. Relationship between leaf area ratio (LAR) and dry weight to fresh weight ratio (d.w./f.w.) of leaves of *Sargassum horneri*. Measured in October 1987.

should decrease with increasing d.w./f.w. ratio in *S. horneri*. Photosynthesis of *S. thunbergii* was already reported to decrease with increasing d.w./f.w. ratio (Gao and Umezaki 1989c). The d.w./f.w. ratio (or LAR), which usually increases (or decreases) with aging, can be considered as a parameter engendering an aging effect on photosynthetic capacity in *S. horneri*. When the d.w./f.w. ratio increases or when LAR decreases, water content decreases, thereby the photolysis of water in photosynthesis can be slowed down, or the activities of some enzymes which directly or indirectly affect photosynthetic rate can be inhibited. For example, Küppers and Kremer (1978) demonstrated that the lower photosynthetic capacities in the older parts of *Fucus spiralis, F. serratus* and *F. vesiculosus* resulted from reduced activity of RuBP (ribulose-1,5-biphosphate) carboxylase.

S. thunbergii was shown to possess high photosynthetic capacity in vesicles, which contributed significantly to about 6% of the photosynthetic production of an adult plant from May to June (Gao and Umezaki 1989c). Vesicles of *S. horneri* were demonstrated to have high photosynthetic capacity in the present study. It was shown that vesicles occupied more and more percent in fresh weight as a plant grew larger, and it was estimated that photosynthetic production by vesicles in November and March accounted for 4% and 59%, respectively, while that by leaves about 90% and 34% of the hourly net photosynthetic production of a *S. horneri* plant under saturating solar radiation (Gao 1989). It is clear that vesicles of both *S. thunbergii* and *S. horneri* contribute considerably to their photosynthetic production in addition to supplying floatation. Photosynthetic production of a *Sargassum* plant seems to be done almost by leaves when it is young, and is contributed more and more by vesicles as it grows larger until maturation period.

Although the holdfast of *S. horneri* showed photosynthetic activity, its net photosynthetic rate (at 600 $\mu E\, m^{-2}\, s^{-1}$) was almost zero, which means that it contribute little to the growth. It is a problem to be studied whether there is any transporation of photosynthates from leaves to holdfast in *S. horneri*. Photosynthetic capacities were lowest in holdfast and primary lateral, intermediate in vesicles and highest in leaves in *S. horneri*. It can be concluded that *S. horneri* is also differentiated with differed photosynthetic properties in various parts as in *S. thunbergii* (Gao and Umezaki 1989c).

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高　坤山：褐藻アカモクの藻体部位別の光合成能

アカモク (*Sargassum horneri*) の葉，気胞，主枝，固着器の光合成と暗呼吸を差動式検容器を用いて測定した。葉では葉面積比の増加に伴い，純光合成と暗呼吸速度は増加したが，クロロフィル含量は減少した。葉が1日加齢するにつれてクロロフィル含量は1.7～4.1%増加し，純光合成および暗呼吸はそれぞれ1.4～5.8%，4.6～8.9%減少すると推定された。気胞は浮力を提供すると同時に高い光合成能をもつことが示された。光合成活性は葉，気胞，主枝，固着器の順で低下した。アカモク藻体の形態的分化は光合成特性の違いを伴っていることが明らかになった。(530 大阪市北区中崎西2丁目3番39号　関西総合環境センター)

Jpn. J. Phycol. (Sôrui) 39: 253–262, September 20, 1991

Chrysophytes in the southern part of Hyogo Prefecture, Japan (II). *Mallomonas*

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Seasonal occurrence of forty-three taxa of *Mallomonas* found in three ponds and a reservoir, Doro-ike Pond, Hoshino-ike Pond, Sengari Reservoir and Yasuba-ike Pond, situated in the southern part of Hyogo Prefecture, Japan is described. LM and EM descriptions are given for eleven taxa. Incorporating previously published data, it is suggested that twenty-nine taxa are widely distributed in Japan, whereas four other taxa, *M. striata, M. portae-ferreae, M. flora* and *M. splendens* occur in restricted regions.

Key Index Words: Chrysophytes—electron microscopy—Hyogo Prefecture—Mallomonas—*pond—reservoir.*

Several studies have been made on *Mallomonas* (Mallomonadaceae, Synurophyceae) in Japanese freshwater ponds and lakes, and forty-three taxa have been recorded: Takahashi (1959, 1977, 1978) reported thirty-five species, two varieties and three forms from about one hundred ponds and lakes, and Ito (1988) reported three species new to Japan from Lake Biwa, Shiga Prefecture. *Mallomonas* taxa so far recorded in Japan form thirty-one percent of one hundred and thirty-seven taxa which have previously been reported in the world (Asmund and Kristiansen 1986, Croome and Tyler 1986, Dürrschmidt 1986, Nicholls 1987a, 1987b, 1988a, 1989, Siver 1988, Wujek and Bland 1988, Cronberg 1989, Vigna and Kristiansen 1989). It suggests that many species have been overlooked in many floristic works so far undertaken, probably because the electron microscope was not used, and organisms are easily broken by fixation. In a previous paper, the present author reported chrysophyte flora including forty-three taxa of the genus *Mallomonas*, eight of which were reported as new to Japan from three ponds and a reservoir situated in the southern part of Hyogo Prefecture (Ito 1990). In this paper, seasonal occurrence of these taxa is given and eleven taxa which have not previously been described in Japan are described by transmission and scanning electron microscopy.

Materials and Methods

A detailed description of Doro-ike Pond, Hoshino-ike Pond, Sengari Reservoir and Yasuba-ike Pond, and procedures of sample collection, preparation and examination were given in a previous paper (Ito 1990).

Results and Discussion

Forty-three taxa of the genus *Mallomonas* found in Doro-ike Pond, Hoshino-ike Pond, Sengari Reservoir and Yasuba-ike Pond are listed below, as well as their previous records in Japan. Seasonal occurrence is shown in Table 1.

Sectio *Mallomonopsis* (Matvienko) Asmund et Kristiansen 1986

Series *Matvienkoanae* Asmund et Kristiansen 1986

Mallomonas matvienkoae (Matvienko) Asmund et Kristiansen 1986 in Opera Botanica 85: 1-128.

Basionym: *Mallomonopsis elliptica* Mat-

Table 1. Seasonal occurrence (Sp=March–May; Su=June–August; Au=September–November; Wi=December–February) of *Mallomonas* taxa collected from Doro-ike Pond, Hoshino-ike Pond, Sengari Reservoir and Yasuba-ike Pond in the southern part of Hyogo Prefecture, Japan.

Taxa	Doro-ike P.				Hoshino-ike P.				Sengari Res.				Yasuba-ike P.			
	Sp	Su	Au	Wi	Sp	Su	Au	Wi	Sp	Su	Au	Wi	Sp	Su	Au	Wi
**M. akrokomos*	●	●	●	●	●	○	○	●	●	●	●	●	●	○	●	●
**M. tonsurata*	○	●	●	●	●	○	●	●	●	○	●	○	●	●	●	○
**M. crassisquama*	●	●	●	●	●	○	○	●	○	○		○	○		○	○
**M. mangofera* f. *mangofera*	●	●	●	●	○	○	○	○	○	○		○	○	○	○	●
**M. punctifera*	●	○	●	●	●	○	●	●	○				○		●	○
**M. papillosa* var. *ellipsoidea*	○	○	●	○	○	○	○	○				○	○		○	○
**M. harrisiae*	●	○	●	●	●	○	○	●	○						○	○
M. striata	○	○	○	○	○	●	○	●	○				○			○
**M. parvula*	○	○	○	○	○				○			○	○		○	○
**M. pumilio*	●		●	●	○				○				○	●		●
M. splendens	○	●	○	○		○			●							○
**M. elongata*					○	○	○	●	○	○		○	●	○	○	●
**M. heterospina*					●	○	○	●	●			○	○		○	○
**M. matvienkoae*	○	○	○	○	○		○	○					○	○		○
M. sp. No. 2	○	●	●	○		○								○		
**M. lelymene*	●	●	○	●	○											
**M. multisetigera*	○	○	○	○	○											
**M. eoa*	●	○	○	●					○			○				
**M. recticostata*									○						○	
△M. pillura f. *valdiviana*				●									○		○	○
**M. areolata*									●	○		●	●		○	●
**M. annulata*									●		○	○	○			○
M. sp. No. 1									○	○		○	●	○	●	●
**M. mangofera* f. *foveata*	○		○												○	
**M. ouradion*	●	○	○	○												
**M. cristata*	○	●	○	○												
△M. ocellata	○	○	○	○												
**M. caudata*									●	○	●	●				
**M. alpina*									●		○					
**M. conspersa*									○			○				
**M. grata*										●		○				
△M. rasilis										○		○				
△M. calceolus									○							
M. flora									○							
△M. bangladeshica										○						
△M. retifera										○						
**M. paxillata*											○					
M. portae-ferreae											○					
△M. insignis													●	○	●	●
**M. alata*													○		○	○
△M. mangofera var. *sulcata*													○			
**M. peronoides*															○	
**M. guttata*															○	

●: Cells collected; ○ Scales collected.
△: Taxa reported as new to Japan in a previous paper (Ito 1990).
*: Tax widely distributed in Japan.

vienko 1941 in Trudy. Inst. Bot. Kharkov 4: 41-47.

Distribution: Hokkaido, Yamagata Pref., Fukushima Pref., Hyogo Pref., Shimane Pref., Ehime Pref. (Takahashi 1978).

Series *Ouradiotae* Asmund et Kristiansen 1986

Mallomonas parvula Dürrschmidt 1982 in Can. J. Bot. 60: 651-656.

Distribution: Yamagata Pref. (Takahashi 1978), Shiga Pref. (Ito 1988).

Mallomonas ouradion Harris et Bradley 1958 in J. gen. Microbiol. 18: 71-83.

Basionym: *Mallomonopsis ouradion* (Harris et Bradley) Harris 1966 in J. gen. Microbiol. 42: 175-184.

Distribution: Hokkaido (Takahashi 1978)

Series *Peronoides* Asmund et Kristiansen 1986

Mallomonas peronoides (Harris) Momeu et Péterfi 1979 in Contr. Bot. Cluji-Napoca 1979: 13-20.

Basionym: *Mallomonopsis peroneides* Harris 1966 in J. gen. Microbiol. 42: 175-184.

Distribution: Yamagata Pref. (Takahashi 1978).

Mallomonas bangladeshica (Takahashi et Hayakawa) Wujek et Timpano 1984 in Trans. Kansas Acad. Sci. 87: 73-82.

Basionym: *Mallomonopsis peroneides* Harris var. *bangladeshica* Takahashi et Hayakawa 1979 in Phykos 18: 129-147.

Cells oblong ellipsoidal, covered with smooth bristles and three kinds of scales: 1) apical scales with a thorn-like projection at distal end, 2) oval body scales, 3) obovate rear scales. Body scales with many papillae and a subcircular ornament which has 9-13 lobes along its edge and 1-3 pores on its surface at distal part (Figs. 1 & 2).

Sectio *Multisetigerae* Asmund et Kristiansen 1986

Mallomonas multisetigera Dürrschmidt 1982 in Arch. Hydrobiol. Suppl. 63/Algol. Stud. 31: 121-163.

Distribution: Yamagata Pref. (Takahashi 1978).

Sectio *Papillosae* Asmund et Kristiansen 1986

Mallomonas calceolus Bradley 1964 in J. gen. Microbiol. 37: 321-333.

Cells ovoid, covered with smooth bristles and scales. Scales oval or suboval with widely spaced, scattered papillae on the shield (Fig. 3).

Mallomonas conspersa Dürrschmidt in Kristiansen and Andersen 1986, Crysophytes, aspects and problems.

Distribution: Yamagata Pref. (Takahashi 1959).

Mallomonas paxillata (Bradley) Péterfi et Momeu 1976 in Nova Hedwigia 27: 353-392.

Basionym: *Mallomonopsis paxillata* Bradley 1966 in J. Protozool. 13: 143-154.

Distribution: Yamagata Pref., Tokushima Pref. (Takahashi 1978).

Mallomonas papillosa Harris et Bradley 1957 in J. Roy. Microscop. Soc. Ser. 3, 76: 37-46, var. *ellipsoidea* Harris 1967 in J. gen. Microbiol. 46: 185-191.

Distribution: Hokkaido, Yamagata Pref., Fukushima Pref., Hyogo Pref., Tokushima Pref., Ehime Pref. (Takahashi 1978).

Mallomonas rasilis Dürrschmidt 1983 in Nord. J. Bot. 3: 423-430.

Cells ellipsoidal, covered with serrated bristles and two kinds of scales, small apical scales and body scales. Scales suboval with many papillae on the shield and proximal border having internal radial struts (Figs. 4 & 5).

Mallomonas guttata Wujek 1984 in Brenesia 22: 309-313.

Distribution: Yamagata Pref. (Takahashi 1978).

Sectio *Planae* Momeu et Péterfi 1979

Series *Fastigatae* Momeu et Péterfi 1979

Mallomonas caudata Ivanov 1899 in Bull. Acad. Imp. Sci. St.-Petersbourg 11: 247-262, emend. Krieger 1930 in Bot. Arch. 29: 258-329.

Synonym: *Mallomonas fastigata* Zacharias 1903 in Forschubgsber. Biol. Stat. Plön 10: 223-289.

Distribution: Hokkaido (Hada 1959), Yamagata Pref., Fukushima Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Hyogo Pref. (Takahashi 1978), Shimane Pref. (Akiyama 1964, Takahashi 1978), Tokushi-

ma Pref. (Takahashi 1978).

Sectio *Insignes* Asmund et Kristiansen 1986

Mallomonas insignis Penard 1919 in Bull. Soc. Bot. Genève 2e. sér. 11: 122-128.

Cells obovoid to elongate-ellipsoidal, 30-96 × 14-25 μm, bluntly pointed anteriorly and tapering to a tail of varying length, with three kinds of scales: 1) apical scales with a stout hollow spine terminating in a bi- or trifurcate tip, 2) oval body scales without spines, 3) tail scales with a slender hollow spine terminating in a bifurcate tip. The shield of three kinds of scales is marked with internal honecomb pattern of ribs and with papillae on the outer layer (Figs. 6-9).

Sectio *Punctiferae* Asmund et Kristiansen 1986

Series *Punctiferae* Momeu et Péterfi 1979

Mallomonas punctifera Korshikov 1941 in Trudy Inst. Bot. Kharkov 4: 50-76.

Synonym: *Mallomonas reginae* Teiling 1946 in Bot. Notiser 1946: 61-88.

Distribution: Yamagata Pref., Fukushima Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Shimane Pref., Tokushima Pref. (Takahashi 1978).

Sectio *Heterospinae* Momeu et Péterfi 1979

Series *Heterospinae* Asmund et Kristiansen 1986

Mallomonas heterospina Lund 1942 in New Phytol. 41: 274-292.

Distribution: Yamagata Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Ehime Pref. (Takahashi 1978).

Mallomonas harrisiae Takahashi 1975 in Phycologia 14: 41-44.

Distribution: Yamagata Pref., Hyogo Pref., Ehime Pref. (Takahashi 1978).

Sectio *Akrokomae* Asmund et Kristiansen 1986

Mallomonas akrokomos Ruttner in Pascher 1913, Die Süβwasserflora Deutschlands, Österreichs und der Schweiz 2, p. 7-95.

Distribution: Yamagata Pref., Fukushima Pref., Gifu Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Okayama Pref., Tokushima Pref. (Takahashi 1978).

Sectio *Striatae* Asmund et Kristiansen 1986

Series *Striatae* Momeu et Péterfi 1979

Mallomonas striata Asmund 1959 in Dansk Bot. Ark. 18: 1-50.

Distribution: Shiga Pref. (Ito 1988).

Mallomonas retifera Dürrschmidt 1982 in Can. J. Bot. 60: 651-656.

Cells ovoid or ellipsoidal, covered with slender bristles and two kinds of scales, small apical scales with a wing-like structure and larger body scales. Scales suboval with papillae on the dome and the anterior flanges and reticulation on the shield (Figs. 10 & 11).

Mallomonas flora Harris et Bradley 1960 in J. gen. Microbiol. 22: 750-777.

Distribution: Gifu Pref. (Takahashi 1978).

Series *Actinolomae* Asmund et Kristiansen 1986

Mallomonas cristata Dürrschmidt 1981 in Phycologia 20: 298-302.

Distribution: Yamagata Pref. (Takahashi 1959).

Sectio *Mallomonas*

Series *Alpinae* Asmund et Kristiansen 1986

Mallomonas alpina Pascher et Ruttner in Pascher 1913, Die Süβwasserflora Deutschlands, Österreichs und der Schweiz 2, p. 7-95, emend. Asmund et Kristiansen 1986 in Opera Botanica 85: 1-128.

Synonym: *Mallomonas monograptus* Harris et Bradley 1960 in J. gen. Microbiol. 22: 750-777.

Distribution: Hokkaido, Fukushima Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Osaka Pref., Shimane Pref., Tokushima Pref., Ehime Pref. (Takahashi 1978).

Mallomonas areolata Nygaard 1949 in Kgl. Dan. Vid. Selsk. Biol. Skr. 7: 1-293.

Distribution: Yamagata Pref., Osaka Pref., Shimane Pref., Tokushima Pref., Ehime Pref. (Takahashi 1978).

Mallomonas elongata Reverdin 1919 in Arch. Sci. phys. nat. 1: 5-95.

Distribution: Yamagata Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Osaka Pref., Okayama Pref., Shimane Pref., Ehime Pref. (Takahashi 1978).

Series *Tonsuratae* Asmund et Kristiansen 1986

Mallomonas tonsurata Teiling 1912 in Svensk Bot. Tidskr. 4: 266-281, emend. Krieger 1930 in Bot. Arch. 29: 258-329.

Distribution: Hokkaido, Yamagata Pref.,

Fukushima Pref., Gifu Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Osaka Pref., Hyogo Pref., Okayama Pref., Shimane Pref., Tokushima Pref., Kumamoto Pref., Kagoshima Pref. (Takahashi 1978).

Series *Portaferreanae* Asmund et Kristiansen 1986

Mallomonas portae-ferreae Péterfi et Asmund 1972 in Stud. Univ. Babes-Bolyai Ser. Biol. 1: 11-18.

Distribution: Shiga Pref. (Ito 1988).

Series *Mallomonas*

Mallomonas crassisquama (Asmund) Fott 1962 in Preslia 34: 69-84.

Basionym: *Mallomonas acaroides* Perty 1851 emend. Ivanov 1899 var. *crassisquama* Asmund 1959 in Dansk Bot. Ark. 18: 1-50.

Distribution: Hokkaido, Yamagata Pref., Fukushima Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Hyogo Pref., Shimane Pref., Tokushima Pref., Ehime Pref. (Takahashi 1978).

Sectio *Pseudocoronatae* Asmund et Kristiansen 1986

Series *Lelymenae* Asmund et Kristiansen 1986

Mallomonas lelymene Harris et Bradley 1960 in J. gen. Microbiol. 22: 750-777.

Distribution: Fukushima Pref., Osaka Pref., Hyogo Pref. (Takahashi 1978).

Sectio *Annulatae* Asmund et Kristiansen 1986

Mallomonas pillura Harris 1967 in J. gen. Microbiol. 46: 185-191, f. *valdiviana* Dürrschmidt 1982 in Arch. Hydrobiol. Suppl. 63/Algol. Stud. 31: 121-163.

Cells spherical, $\pm 10\,\mu m$, covered with curved and delicate bristles and three kinds of scales: 1) apical scales with dome, 2) body scales with dome, 3) body scales without dome. The shield of three kinds of scales is marked with a reticulum of irregularly shaped meshes each enclosing a single pore or a group of few pores on the base plate (Figs. 12 & 13).

Mallomonas annulata (Bradley) Harris 1967 in J. gen. Microbiol. 46: 185-191.

Basionym: *Mallomonas papillosa* Harris et Bradley 1957 var. *annulata* Bradley 1966 in J. Protozool. 13: 143-154.

Distribution: Yamagata Pref. (Takahashi 1978), Shiga Pref. (Ito 1988), Ehime Pref. (Takahashi 1978).

Sectio *Torquatae* Momeu et Péterfi 1979

Series *Pumilae* Momeu et Péterfi 1979

Mallomonas pumilio Harris et Bradley 1957 in J. Roy. Microscop. Soc. Ser. 3, 76: 37-46, emend. Asmund, Cronberg et Dürrschmidt 1982 in Nord. J. Bot. 2: 383-395.

Distribution: Yamagata Pref., Shiga Pref., Ehime Pref. (Takahashi 1978).

Mallomonas alata Asmund, Cronberg et Dürrschmidt 1982 in Nord. J. Bot. 2: 383-395.

Distribution: Yamagata Pref. (Takahashi 1978).

Series *Eoae* Asmund et Kristiansen 1986

Mallomonas eoa Takahashi 1963 in Bull. Yamagata Univ., Agr. Sci. 4: 169-187.

Distribution: Yamagata Pref., Osaka Pref. (Takahashi 1978).

Mallomonas ocellata Dürrschmidt et Croome 1985 in Nord. J. Bot. 5: 285-298.

Cells ovoid or ellipsoidal covered with smooth bristles and three kinds of scales: 1) collar scales with dome, 2) rhombic body scales, 3) small rear scales. The shield of three kinds of scales is marked with more or less rounded pits. At the bottom of each pit the base plate is visible, centrally with a somewhat thickened area (Fig. 14).

Series *Mangoferae* Asmund et Kristiansen 1986

Mallomonas mangofera Harris et Bradley 1960 in J. gen. Microbiol. 22: 750-777, f. *mangofera*

Distribution: Yamagata Pref., Hyogo Pref., Shimane Pref., Tokushima Pref. (Takahashi 1978).

Mallomonas mangofera f. *foveata* Dürrschmidt 1983 in Pl. Syst. Evol. 143: 175-196.

Distribution: Yamagata Pref. (Takahashi 1978).

Mallomonas mangofera var. *sulcata* Dürrschmidt 1983 in Pl. Syst. Evol. 143: 175-196.

M. mangofera var. *sulcata* differs from *M. mangofera* var. *mangofera* in having grooves

running along the submarginal rib on the shield of scales (Fig. 15).

Mallomonas grata Takahashi 1963 in Bull. Yamagata Univ., Agri. Sci. 4: 169-187.

Distribution: Yamagata Pref. (Takahashi 1978).

Series *Doignonianae* Asmund et Kristiansen 1986

Mallomonas recticostata Takahashi 1972 in Bot. Mag. Tokyo 85: 293-302.

Distribution: Yamagata Pref., Shimane Pref. (Takahashi 1978).

Appendix

Mallomonas splendens (G. S. West) Playfair 1921 in Proc. Linn. Soc. N. S. Wales 46: 99-146, emend. Croome, Dürrschmidt et Tyler 1984 in Nova Hedwigia 41: 463-470.

Synonym: *Lagerheimia splendens* G. S. West 1909 in J. Linn. Soc. Bot. 39: 1-88.

Cells cylindrical, 25-28 × 8.5-11 μm, with four smooth spines at both ends and three kinds of scales: 1) oblong apical scales with dome, 2) rhomboidal body scales, 3) broadly ovate posterior scales with dome. Three kinds of scales with an outer minute papillose layer and an internal reticulum (Figs. 16 & 17).

Distribution: Shimane Pref. (Akiyama 1964).

Unidentified species

Mallomonas sp. No. 1

This species resembles *M. acaroides* Perty emend. Ivanov, but differs from it in having a wing-like structure of the anterior flange of scales (Fig. 18).

Mallomonas sp. No. 2

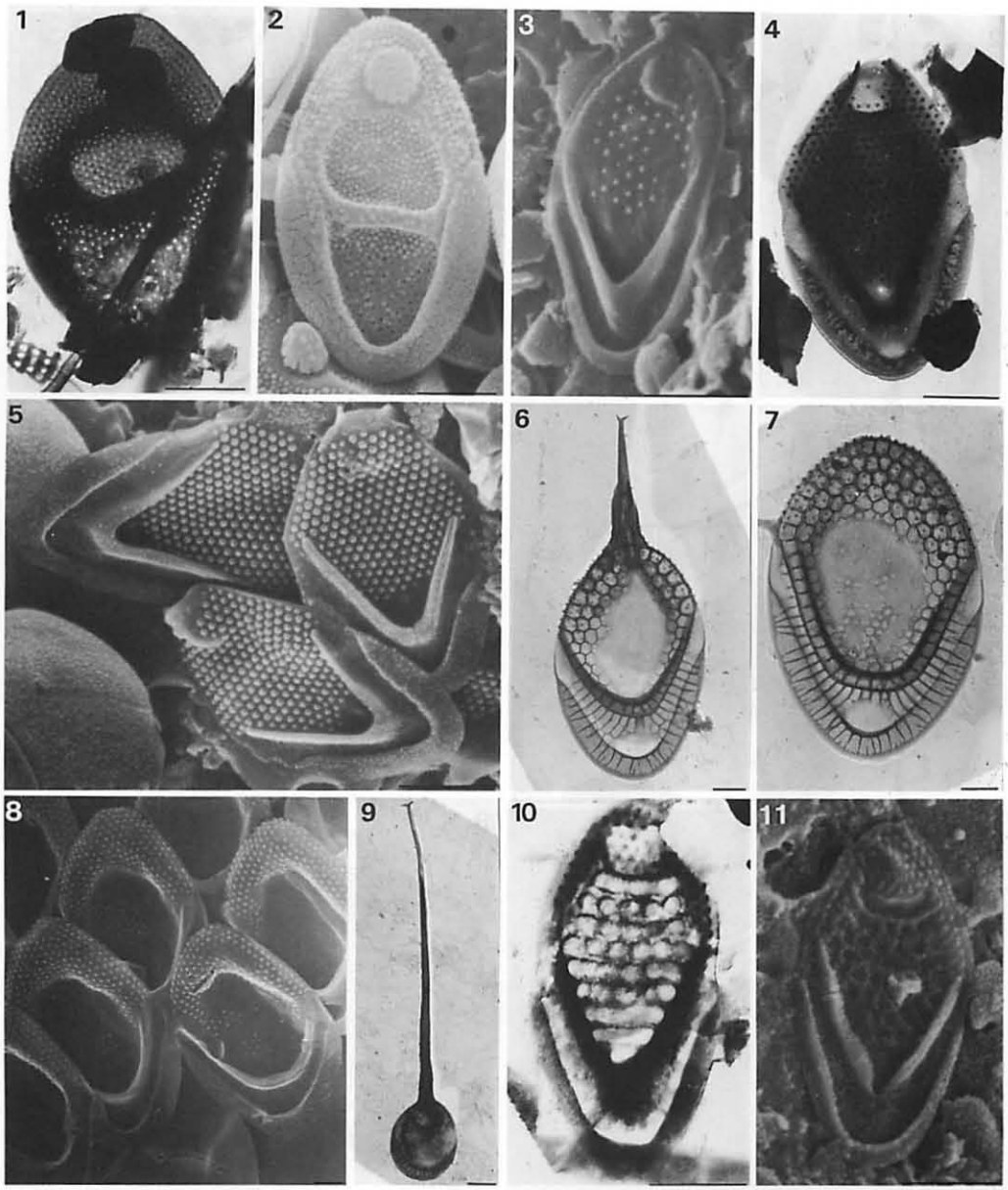
This species resembles *M. mangofera* f. *gracilis* Dürrschmidt, but differs from it in having circular or elongate pores on the shield of scales (Fig. 19).

Taking previously published data on the occurrence of *Mallomonas* taxa into account, twenty taxa recorded here are regarded as widely distributed in Japan (Takahashi 1978, Ito 1988). Studies have covered most districts of Japan, from Lake Ikeda in Kagoshima Prefecture to Lake Abashiri in Hokkaido. These taxa are indicated by asterisks in Table 1. Of these, *M. tonsurata, M. akrokomos* and *M. crassisquama* have been found in more than twenty ponds and lakes mainly in the Tohoku, Kinki, Chugoku and Shikoku districts. Water temperature and pH range during the occurrence of these three taxa have been reported: 0-31°C and 5.47-9.0 for *M. tonsurata*, 0.3-24°C and 3.8-8.5 for *M. akrokomos* and 0.3-27°C and 5.2-9.0 for *M. crassisquama* (Gutowski 1989, Hartmann and Steinberg 1989). *M. tonsurata* and *M. crassisquama* are classified as eurythermal and indifferent to pH (Takahashi 1978, Roijackers 1986). *M. akrokomos* is classified as eurythermal and acidophilious, although it also occurs in many alkaline lakes (Takahashi 1978, Hartmann and Steinberg 1989). It should be noted that these three taxa were collected in all sites as well as in almost all the sampling time (Table 1). The present author therefore agrees that these taxa are eurythermal, and this may be a major reason of their wide distribution.

M. peronoides, M. multisetigera, M. conspersa, M. guttata, M. cristata, M. alata, M. mangofera, f. *foveata* and *M. grata* have previously been found in one to three localities in Yamagata Prefecture and *M. ouradion* in one locality in Hokkaido (Takahashi 1978). These nine taxa (marked also by asterisks in Table 1) may be widely distributed in Japan because they also occur in Hyogo Prefecture (this study) and they have been collected from various types of ponds and lakes in other countries (Asmund and Kristiansen 1986, Dürrschmidt 1986, Hallförs and Hallförs 1988, Nicholls 1988b, Cronberg 1989).

Some species seem to show relatively narrow distribution and they occur in restricted regions: *M. striata* and *M. portae-ferreae* are distributed only in the Kinki districts, *M. flora* in the Chubu and Kinki districts, and *M. splendens* is distributed in the Kinki and Chugoku districts (Akiyama 1964, Takahashi 1978, Ito 1988, this paper).

Eight *Mallomonas* taxa recorded for the first time in Japan (Ito 1990) were found in one or two sites, and only scales were collected for six taxa except *M. insignis* and *M. pillura* f. *val-*

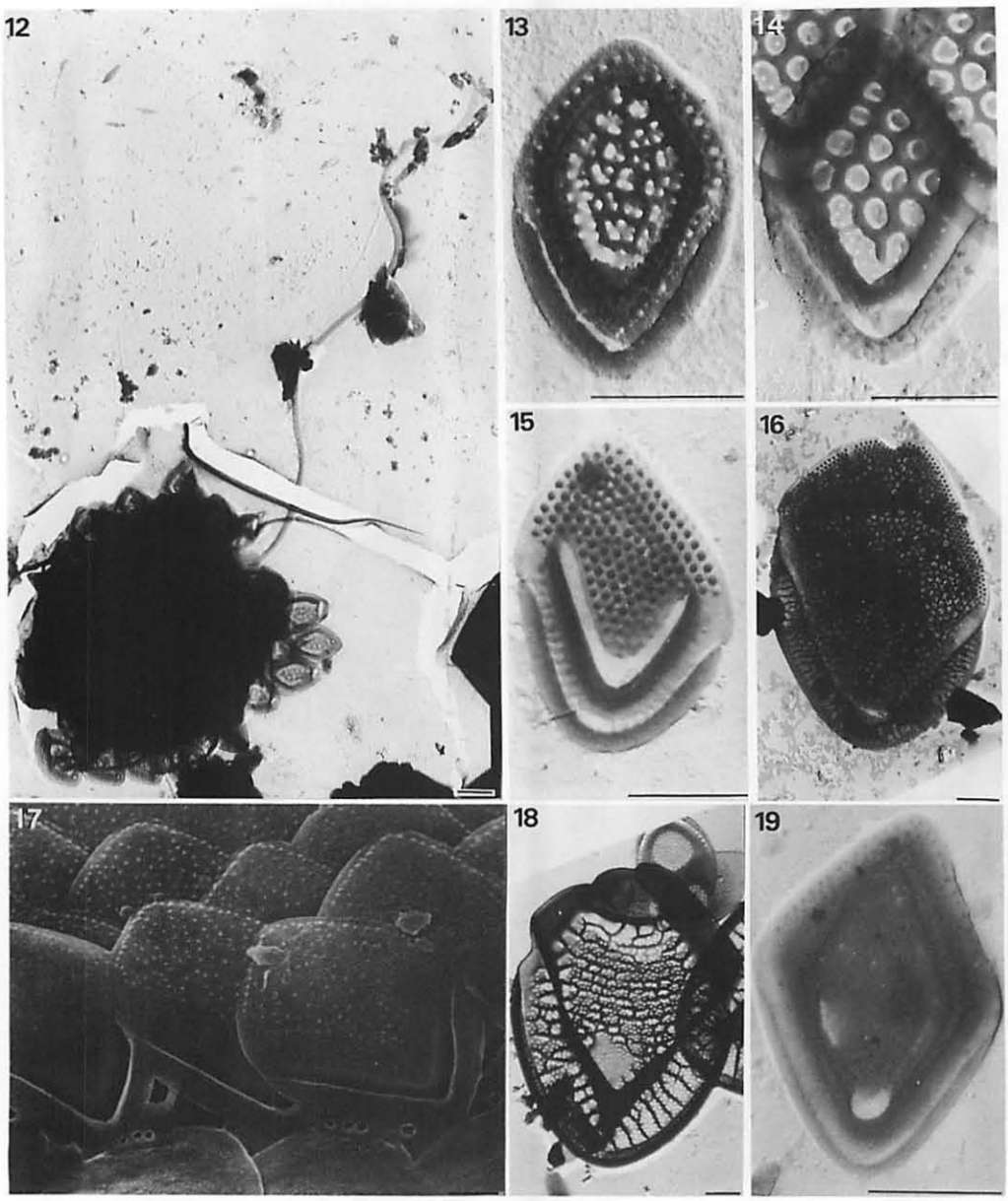


Figs. 1 & 2. *M. bangladeshica*; Fig. 1. a body scale (Transmission electron microscopy: TEM), Fig. 2. a body scale (Scanning electron microscopy: SEM). Fig. 3. *M. calceolus*, a scale (SEM). Figs. 4 & 5. *M. rasilis*; Fig. 4. a body scale (TEM), Fig. 5. body scales (SEM). Figs. 6–9. *M. insignis*; Fig. 6. an apical scale (TEM), Fig. 7. a body scale (TEM), Fig. 8. body scales (SEM), Fig. 9. a tail scale (TEM). Figs. 10 & 11. *M. retifera*; Fig. 10. a body scale (TEM), Fig. 11. a body scale (SEM). Scale bar=1 μm.

diviana (Table 1). The following six taxa have previously been reported from more than two continents as described below, and so they can be regarded as cosmopolitic species.

M. bangladeshica: North America, South America, Asia, Africa (Asmund and Kristiansen 1986, Cronberg 1989).

M. calceolus: Europe, North America, South America, Australia (Asmund and



Figs. 12 & 13. *M. pillura* f. *valdiviana*; Fig. 12. a whole mount cell (TEM), Fig. 13. a domeless body scale (TEM). Fig. 14. *M. ocellata*, a body scale (TEM). Fig. 15. *M. mangofera* var. *sulcata*, a body scale (TEM). Figs. 16 & 17. *M. splendens*; Fig. 16. a body scale (TEM), Fig. 17. body scales (SEM). Fig. 18. *Mallomonas* sp. No. 1, a scale (TEM). Fig. 19. *Mallomonas* sp. No. 2, a scale (TEM). Scale bar=1 μm.

Kristiansen 1986, Hallförs and Hallförs 1988, Cronberg 1989, Hartmann and Steinberg 1989).

M. rasilis: Europe, North America, South America, Asia, Australia, Africa (Asmund and Kristiansen 1986, Cronberg 1989, Hartmann and Steinberg 1989).

M. insignis: Europe, North America, Asia, Australia (Asmund and Kristiansen 1986, Croome and Tyler 1988, Kristiansen 1989).

M. retifera: Europe, South America (Asmund and Kristiansen 1986, Hartmann and

Steinberg 1989).

M. pillura f. *valdiviana*: Europe, North America, South America (Asmund and Kristiansen 1986, Hartmann and Steinberg 1989).

M. calceolus and *M. insignis* are eurythermal because they have been collected from subarctic, temperate and tropical regions. They could be widely distributed in Japan and further investigations treating many more ponds and lakes may confirm their common occurrence. *M. bangladeshica* has mostly been reported from the tropics with an exception of its occurrence in Kansas, U.S.A. (Wujek and Timpano 1984), suggesting that the species prefers warm water. In this study a few scales were collected only in August in Sengari Reservoir. *M. bangladeshica* may be found only in summer in Japanese ponds and lakes. The present author suggests that *M. ocellata* and *M. mangofera* var. *sulcata* are rare species. *M. ocellata* was described from a shallow pond in Malaysia (Dürrschmidt and Croome 1985) and *M. mangofera* var. *sulcata* was described from a meadow pond in Chile (Dürrschmidt 1983). They had not been collected ever since they were first described until the present author found them in Doro-ike Pond and Yasuba-ike Pond, respectively. The fact that only a single scale of *M. mangofera* var. *sulcata* and a few scales of *M. ocellata* were collected during the period of study may reflects their rare occurrence.

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伊藤裕之：兵庫県南部産黄金藻（II）．*Mallomonas* 属

兵庫県南部に位置する泥地，星野池，千苅貯水池，安場池から出現した43種類の *Mallomonas* 属について季節変化を調査した。また日本で以前に記載のなかった11種類について，電子顕微鏡を用いた記載を行った。本調査結果と従来の記録から，これらの種類の日本における分布を考察し，29種類は日本に広く分布するが，*M. striata, M. portae-ferreae, M. flora, M. splendens* の4種類は限られた地域に出現することを示唆した。（652 神戸市兵庫区楠谷町37–1　神戸市水道局水質試験所）

Jpn. J. Phycol. (Sôrui) 39: 263–269, September 20, 1991

Additions to the marine algal flora of Taiwan

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Huang, S.-F. 1991. Additions to the marine algal flora of Taiwan. Jpn. J. Phycol. 39: 263–269.

The occurrences of one species of Chlorophyceae and eight species of Rhodophyceae are newly reported in Taiwan: *Ventricaria ventricosa, Kallymenia perforata, Sebdenia agardhii, Botryocladia skottsbergii, Cryptarachne okamurai, Crouania minutissima, Griffithsia subcylindrica, Wrangelia tayloriana* and *Tolypiocladia glomerulata*. Annotations on their morphology, other features of taxonomic interest, habitat and world distribution are provided.

Key Index Words: Chlorophyceae—distribution—marine algae—new records—Rhodophyceae—Taiwan.

The algal flora of the main island of Taiwan has been well investigated (Yamada 1925a, b, 1938, Shen and Fan 1950, Chiang 1960, 1962, 1972, 1973a, b, Chou and Chiang 1981, Chiang and Chen 1982, Yang and Chiang 1982, Chiang and Wang 1987, Lewis and Norris 1987), but those of offshore islands are still insufficiently known. This paper deals with a collection of marine algae from Hsiao-Liuchiu island (120°21′55″E, 22°19′48″N), a small island located southwest of Taiwan (Fig. 1). Hsiao-Liuchiu island in an uplifted coral reef which is covered with recent soil, forming a plateau not higher than 70 m (Yang *et al.* 1975). Immersed in the clear warm water from the branching Kuroshio Current, Hsiao-Liuchiu has an annual average water temperature above 26°C, with yearly fluctuation within 60°C (Chu 1971, Yang *et al.* 1975). The salinity ranges between 32‰ to 34.5‰.

The algal flora of Hsiao-Liuchiu has been studied by Yamada (1950). He listed 49 species of marine algae (24 green and 25 brown algae). Since then no one has attempted to make a general study of the marine algae in this district. From March 1988 to September 1989, under the financial support of the National Science Council and the Taiwan Museum, the author made an extensive collection from the littoral zone to a depth of about 16 m around the island. It was found that a number of algal specimens were distinctly different from the previously recognized species in Taiwan. Data on the composition, distribution and seasonal succession of seaweeds of Hsiao-Liuchiu will be published in the future. In this paper, nine species of marine aglae are studied, including one species of Chlorophyceae and eight species of Rhodophyceae. These species have not been previously reported for Taiwan. *Ventricaria,*

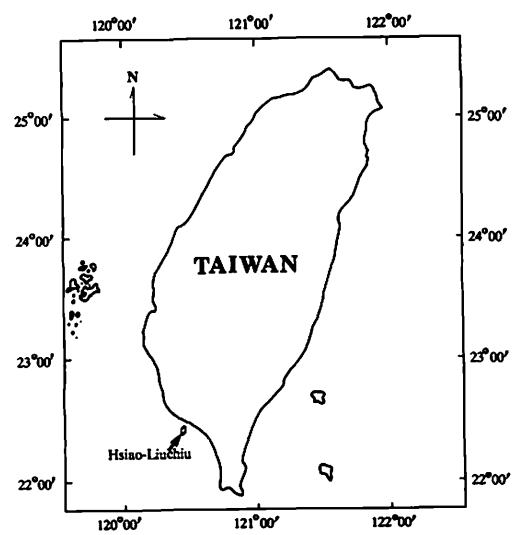


Fig. 1. Map of Taiwan, showing the location of Hsiao-Liuchiu island.

Kallymenia, Sebdenia, Botryocladia, Crouania, Wrangelia and *Tolypiocladia* are also new genera for Taiwan. All the specimens mentioned here are deposited in the herbarium of the Taiwan Museum.

List of species

Chlorophyta

Valoniaceae

***Ventricaria ventricosa* (J. Ag.) Olsen et West, Phycologia 27: 104, 1988.**

-*Valonia ventricosa* J. Ag., Algern. Syst. part 8: 96, 1887.

Collection: H-943 (May 21, 1988), H-1343 (March 10, 1989). The plants are found growing on coral fragments or the reef flat at the sublittoral zone.

Geographical distribution: This is a widely distributed species in tropical seas.

Rhodophyta

Kallymeniaceae

***Kallymenia perforata* J. Ag., Species Genera et Ordines Algarum 3: 219, 1876.**

Collection: H-1024 (Jan. 19, 1989). The specimens were all tetrasporophyte. They were found growing on rocks only in deep water (about 10-15 m).

Geographical distribution: Japan, Ceylon, West Indies, New Hollon (Irian Jaya), Tasmania.

Sebdeniaceae

***Sebdenia agardhii* (De Toni) Codomier in Tseng *et al.*, p. 66, 1980.**

-*Halymenia agardhii* De Toni, Syll. alg. part 4: 1542, 1905.

These tetrasporic specimens show the taller thallus (up to 45 cm) and roundness of the axilus as in *Sebdenia polydactyla* (Boergesen) Balakrishnan (Balakrishnan 1961) on one hand, and the blunt-ending ultimate branches as in *Sebdenia agardhii* (De Toni) Codomier on the other. Both species have several features common to each other and seem to be scarcely distinguishable (Tseng *et al.* 1980). The relationship between these two species needs further anatomical study.

Collection: H-684 (March 19, 1988), H-1514 (July 9, 1989). It was occasionally found growing on the rocks of sublittoral zone at the depths of 4–16 m. Tetrasporic plants have been gathered in March.

Geographical distribution: Japan, Hong Kong, Bermuda, North Carolina, Florida, West Indies (Guadeloupe, Tobago).

Rhodymeniaceae

***Botryocladia skottsbergii* (Boerg.) Levring, Meeresalgen der Juan Fernandez-Inseln, p. 645, 1941.**

-*Chrysymenia skottsbergii* Boerg., Mar. Alg. Easter Isl. p. 307, 1924.

-*Chrysymenia kuckuckii* W.v.B., Monogr. Siboga Exped. p. 446, 1928.

-*Botryocladia kuckuckii* (W.v.B.) Yamada et Tanaka, Sci. Pap. Inst. Algal. Res. Hokkaido Univ. 2: 77, 1938.

Collection: H-998 (Jan. 17, 1989). This plant appears to be rate and of erratic occurrence on the coast of Hsiano-Liuchiu, having only been found on two occasions, but then in abundance, growing on shaded sides of rocks or under surfaces of coral clumps in the calm area of the sublittoral zone 3-5 m deep. Plants with cystocarps were found in January.

Geographical distribution: Indonesia, Solomon Islands, Japan (Ryukyu Islands), China (Xisha Islands), Marshall Islands, Easter Island and Mauritius.

***Cryptarachne okamurai* (Yamada & Segawa) Zhang & Xia, Stud. Mar. Sinica 20: 133, 1983.**

-*Chrysymenia okamurai* Yamada & Segawa, Rec. Oceanogr. Works Japan 1: 110, 1953.

-*Chrysymenia kaernbachii* Okamura (non Grunow), Nippon Kaiso-si, p. 669, 1936.

Collection: H-1345 (March 10, 1989). It was found growing as a creeping mat on rocks or coral fragments at depths of 3-6 m.

Geographical distribution: Japan (Ryukyu Islands), China (Xisha Islands).

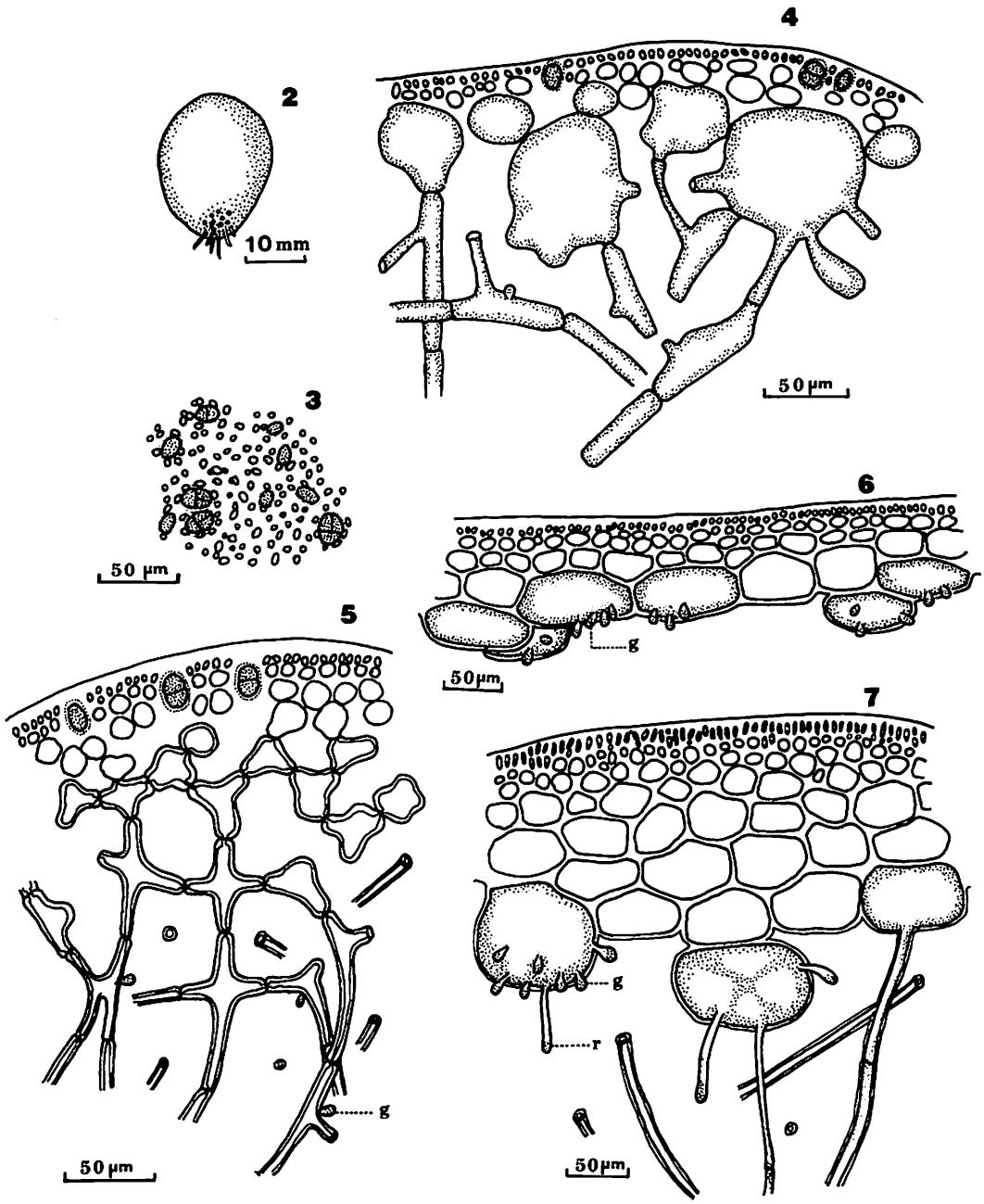


Fig. 2. Outline of *Ventricaria ventricosa*. Fig. 3. Surface view of *Kallymenia perforata*, showing tetrasporangia in the epidermal layer of thallus. Fig. 4. Transverse section of the thallus of *Kallymenia perforata*. Fig. 5. Transverse section of ultimate branch of *Sebdenia agardhii*, showing ramified filaments with glands (g). Fig. 6. Transverse section of the vesicle of *Botryocladia skottsbergii*, showing gland cells (g) grouping on the innermost layer of vesicle. Fig. 7. Transverse section of a sterile frond of *Cryptarachne okamurai*, showing gland cells (g) and rhizoid-like filament (r) from the innermost large cells.

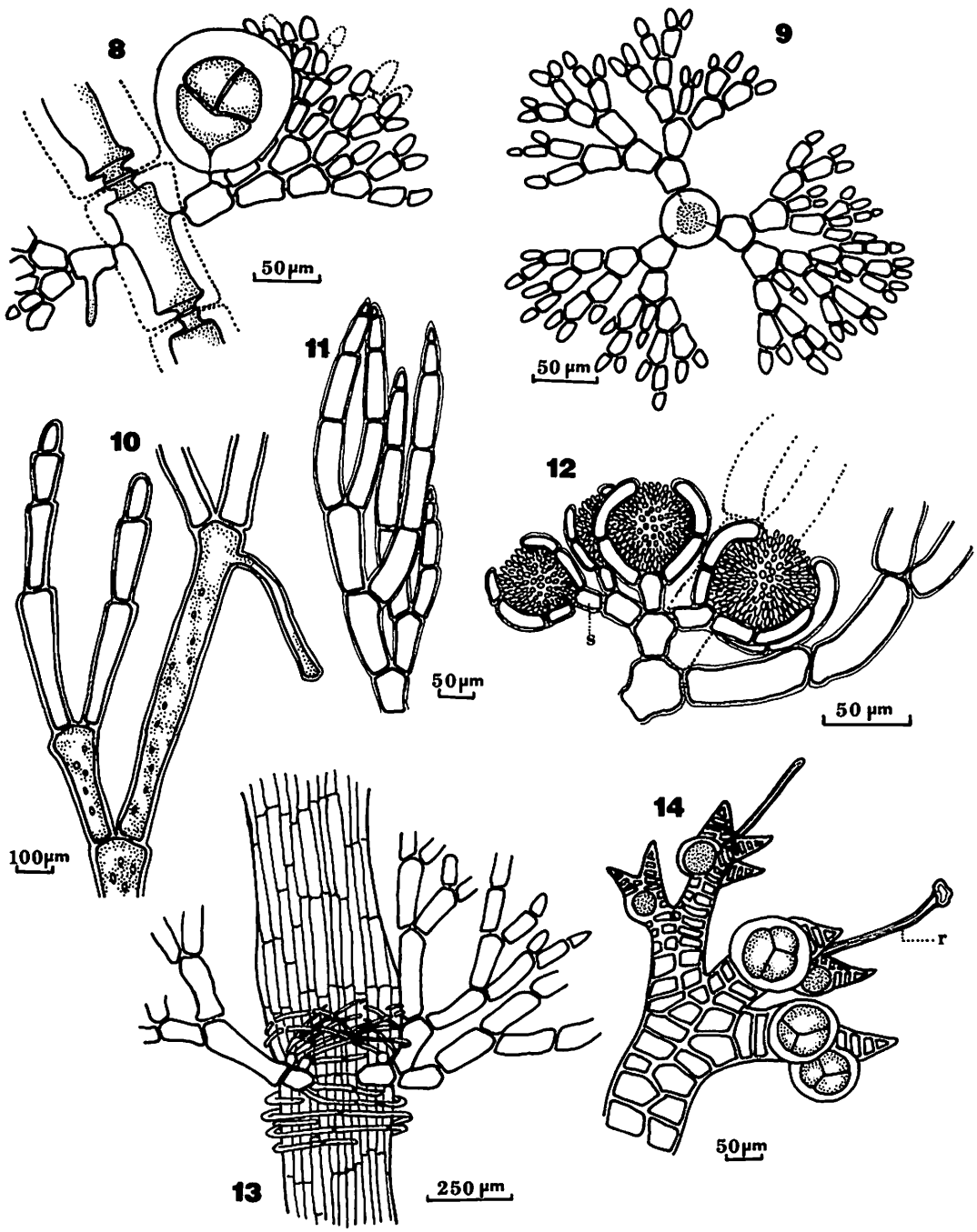
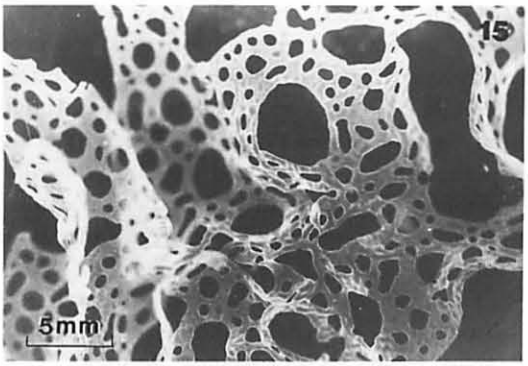


Fig. 8. Part of axis of *Crouania minutissima*, showing tetrasporangium on the basal segment of a determinate branch. Fig. 9. Cross section of *Crouania minutissima*, showing three determinate branch systems in whorl on axial cell. Fig. 10. Part of branches of *Griffithsia subcylindrica*. Fig. 11. Part of whorl-determinate branch of *Wrangelia tayloriana*. Fig. 12. *Wrangelia tayloriana*; a compact cluster of spermatangial head with involucral filaments and stalk cells (s). Fig. 13. Basal part of *Wrangelia tayloriana*. Fig. 14. A small upper part of *Tolypiocladia glomerulata*; note the rhizoid initials (r).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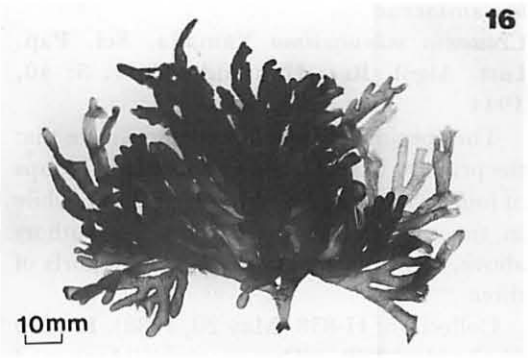
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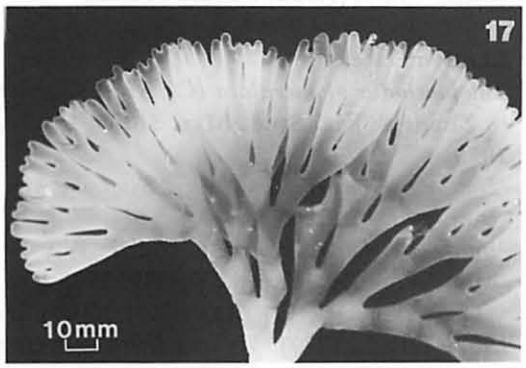
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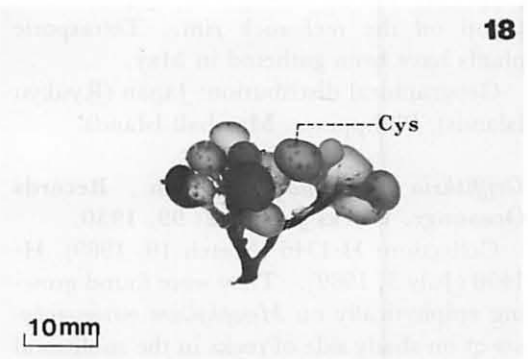
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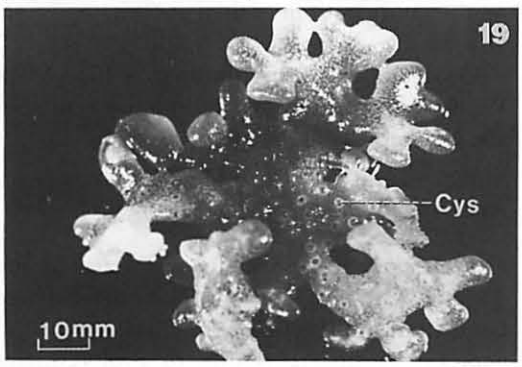
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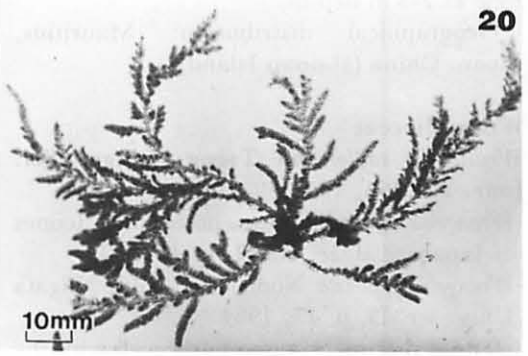
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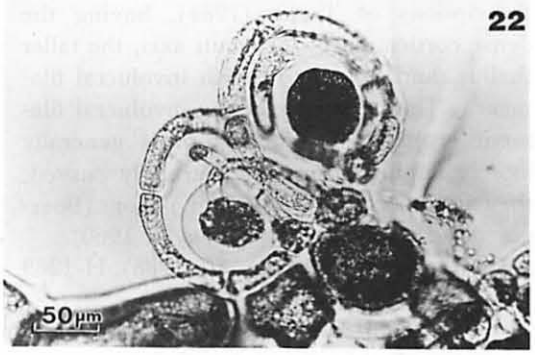
22
50µm

Ceramiaceae

***Crouania minutissima* Yamada, Sci. Pap. Inst. Algol. Res. Hokkaido Univ. 3: 40, 1944.**

The specimens appear to demonstrate that the primary branchlets do not occur in groups of four as described by Yamada (1944), while in the material reported by other authors above, the branch systems were in whorls of three.

Collection: H-858 (May 20, 1988), H-1609 (Sept. 11, 1989). These were epiphytic and found on the reef rock rim. Tetrasporic plants have been gathered in May.

Geographical distribution: Japan (Ryukyu Islands), Philippines, Marshall Islands.

***Griffithsia subcylindrica* Okam., Records Oceanogr. Works Japan, 2: 99, 1930.**

Collection: H-1346 (March 10, 1989), H-1498 (July 3, 1989). They were found growing epiphytically on *Mesophyllum mesomorphyum* or on shady side of rocks in the sublittoral zone at 2-3 m depths.

Geographical distribution: Mauritius, Japan, China (Hainan Island).

Wrangeliaceae

***Wrangelia tayloriana* Tseng, Lingn. Sci. Jour. 20: 264, 1942.**

-*Wrangelia argus* Okamura (non Mont), Icones of Japanese algae, vol. 7, p. 46, 1935.

-*Wrangelia japonica* Noda, Sci. Rep. Niigata Univ. ser. D, p. 17, 1964.

These specimens agree fairly well with the descriptions of Tseng (1984), having the dense cortication of the main axis, the taller thallus, and 2-3 cells in each involucral filament. The curvature of the involucral filament around the sporangium is generally loosely applied, sometimes strongly curved; they approach *W. argus* (Mont.) Mont (Boergesen 1916, Dawson 1954, Taylor 1960).

Collection: H-254 (Jan. 20, 1988), H-1289 (March 9, 1989), H-1400 (May 19, 1989). They were found growing on rocks covered with sand, in exposed places in the lower littoral zone. Plants occur commonly through the year in Hsiao-Liuchiu. Plants bearing spermatangia were found in March, whilst cystocarps were found in May. Tetrasporic plants were commonly found from January to July.

Geographical distribution: Malay Archipelago, Stevens Island, Philippines, Japan, China (Xisha Islands, Among).

Rhodomelaceae

***Tolypiocladia glomerulata* (C. Ag.) Schmitz in Zhang & Xia, Stud. Mar. Sinica 15: 38, 1979.**

-*Hutchinsia glomerulata* C. Ag., Systema Agarum, p. 158, 1824.

-*Roschera glomerulata* (C. Ag.) W.v.B., Monogr. Siboga Exped. 59: 359, 1923.

Collection: H-549 (March 17, 1988), H-1507 (July 5, 1989). It was found growing on the sandy bottom of tidal pools in the littoral zone.

Geographical distribution: Indo-West Pacific region, such as Philippines, Indonesia, Solomon Islands, etc.

Acknowledgements

This study was finacially supported by the Taiwan Museum and the National Science Council of the Republic of China. I wish to express my sincere thanks to Prof. Chiang Young-Meng, Institute of Oceanography, National Taiwan University, for his valuable criticism and allowing the author to make free use of his herbarium. I am also grateful to Mr. Tsai Mao-Hsiung, Manager of the Marine-Aquarium of Hsiao-Liuchiu, for his constant assistance in algal collections.

Fig. 15. Habit of *Kallymenia perforata*. Fig. 16. *Sebdenia agardhii*; a slightly reduced plant. Fig. 17. Flabellate-like branching of *Sebdenia agardhii*. Fig. 18. Habit of *Botryocladia skottsbergii*; note the vesicles with cystocarp (Cys). Fig. 19. Habit of carposporic plant of *Cryptarachne okamurai*. Fig. 20. Habit of *Wrangelia tayloriana*. Fig. 21. Vertical view of a cystocarp of *Wrangelia tayloriana*. Fig. 22. Tetrasporangia with involucral filaments on stalk cells.

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S.-F. Huang：台湾の海藻フロラへの追加

台湾本島の南西部沖に位置する Hsiao Liuchiu 島で採集した海藻の中から新たに次の９種（緑藻１種，紅藻８種）を台湾の海藻フロラに加えた，すなわち，オオバロニア *Ventricaria ventricosa*，ツカサアミ *Kallymenia perforata*，ヌラクサ *Sebdenia agardhii*，アツカワハナノエダ *Botryocladia skottsbergii, Cryptarachne okamurai*，ヒメヨツノサデ *Crouania minutissima*，キヌイトカザシグサ *Griffithsia subcylindrica*，ランゲリア *Wrangelia tayloriana*，イトクズグサ *Tolypiocladia glomerulata* である。これらの海藻について，その形態，分類的特徴，生育場所，世界における分布などについて説明を加えた。(Department of Botany, Taiwan Museum, No. 2, Siangyang Road, Taipei, Taiwan 10014, Republic of China)

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木崎湖および諏訪湖底泥中の溶藻性微生物の分布

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Yamamoto, Y., Kanno, N. and Hayashi, H. 1991. The distribution of alga-lysing microbes of sediments in Lake Kizaki and Lake Suwa. Jpn. J. Phycol. 39: 271-276.

Seasonal and vertical distributions of alga-lysing microbes and pigment contents (chlorophyll *a* and phaeophytin *a*) in the sediments of Lake Kizaki and Lake Suwa were determined. The number of alga-lysing microbes in the upper sediment (0-2 cm) was 10^3-10^4 cells·g^{-1} dry wt in Lake Kizaki and 10^4-10^6 cells·g^{-1} dry wt in Lake Suwa. The pigment contents were high in the upper layer and decreased rapidly with depth. In the upper sediments of both lakes higher proportions (40-70%) of the total carbon were estimated to have originated from phytoplankton. A close relationship between the microbial number and the carbon content originated from pigments was obtained in Lake Suwa.

Key Index Words: alga-lysing microbes—lake sediment—chlorophyll.
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湖沼の底は，湖水中の懸濁物が沈降し堆積する場であり，また，この堆積物を分解して栄養塩として水中に放出する役割を果たしているところでもある。富栄養化の進んだ諏訪湖や中栄養湖の木崎湖では湖内で生産された有機物の大半が植物プランクトンであり，湖水柱内での分解（植物プランクトンの5-22%が分解される，Matsunaga 1982，坂本・加藤1984）や湖外へ流出する量を除けば，沈降懸濁物のほとんどが植物プランクトンで，しかも富栄養化の進んだ湖ほどこのような堆積量が多いとされている(西条1956)。このような内生有機物の多くは主に従属栄養生物により分解されるが，湖水と底泥中に数多く存在する溶藻性微生物もその一つである。この微生物は湖水中では植物プランクトンの消長と深い関わりを持っている(Yamamoto 1981，山本1988)。本報告では，富栄養化のレベルの異なった木崎湖と諏訪湖の底泥における溶藻性微生物の分布を調べ，さらに，植物プランクトン起源の底泥有機物量と溶藻性微生物量との関わりについて検討を試みた。

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実験方法

木崎湖および諏訪湖の概要をTable 1に示す。調査した底泥試料は，両湖のほぼ湖心でコアサンプラーを用いて1988年4月から10月にかけて月1回の割合で採取した。採取試料は直ちに表層より2 cm間隔で分割し以下の分析を行った。

底泥中の溶藻性微生物数は，石と大型動物を除いたのち，ワーリングブレンダー（500ACD，マルサン製）を用い0.01 M トリス緩衝液 (pH 7.2) 中で均一分散 (16000 rpm, 3 min) させ希釈後，寒天重層法に従って計測した（山本1978）。嫌気培養は好気培養と同様に

Table 1. Characteristics of Lake Kizaki (Horie 1962) and Lake Suwa (Okino 1988).

	L. Kizaki	L. Suwa
Altitude (m)	764	759
Surface area (km^2)	1.4	13.3
Volume (m^3)	2.51×10^7	6.5×10^7
Depth (m) Maximum	29.5	6.8
Mean	17.9	4.7
Residence time (days)	186	38.8

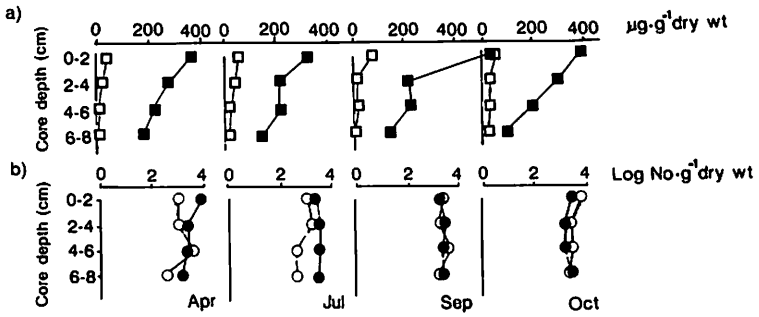

Fig. 1. Seasonal changes of the vertical distributions of chlorophyll *a* (□), pheophytin *a* (■) and aerobic (○) and anaerobic (●) alga-lysing microbes in the sediment of Lake Kizaki in 1988.

処理したのちガスパック内の暗所で25°C で3週間行い溶解斑を計測し，底乾土1gあたりの菌数として表した。

クロロフィルの定量は蛍光法（西条1975）で行った。抽出は湿底泥(0.1～0.5 g)から Whatman GF/C フィルターにより水分を十分除去したのち，90%アセトン 10 m*l* を加え，密栓して冷暗所に1昼夜おいて抽出し (Hansson 1988)，抽出液について日立蛍光分光光度計 F-4000 により 430 nm 励起の蛍光を 663 nm の波長で測定してクロロフィル *a* 量を求め，またこの抽出液に 1 N 塩酸を数滴加えて室温で5分間振盪したのち同じ波長で蛍光を測定し，フェオフィチン *a* 量を求めた。クロロフィル *a* 標準試薬には和光純薬の市販品 (*Spirulina*) を使用し，あらかじめ酸性係数を求めておき，この値を用いて底泥中のクロロフィル *a* とフェオフィチン *a* を算出した。

底泥中の全炭素および全窒素の分析は，住友製 NC-80 高感度炭素・窒素分析器により行なった。

結　果

木崎湖では，1988年には，1982年および1983年の初夏にみられた *Anabaena macrospora*（渡辺ら1985）はみられず，1987年秋から出現した *Peridinium bipes* の赤潮（朴ら1988）が1988年にも発生し，北部農具川河口部では表層水 (0 m) 中に最高 1 m*l* あたり 1.5×10^3 が計測された。諏訪湖では，春季には *Cyclotella* spp., *Fragilaria crotonensis, Melosira granulata, Navicula* sp. などの珪藻が優占し，夏季には *Microcystis* spp. が60–80%を占め，ここ数年来ほぼ同じ様な富栄養化状態を示す。沖野（1988および私信）によれば，諏訪湖では下水道設置（1979年11月）前に比べると *Microcystis* は後退し，*Anabaena* が多くなる傾向にあるという。

Fig. 1 に木崎湖底泥中のクロロフィル *a* とフェオフィチン *a* 量 (a) および溶藻性微生物数 (b) の鉛直分布を示す。クロロフィル *a* およびフェオフィチン *a* 量は，それぞれ 60–75 $\mu g\cdot g^{-1}$ および 200–550 $\mu g\cdot g^{-1}$ で，9月には最も高濃度に存在し，何れの季節でも 0–2 cm 以深で急激に減少している。湖水中の溶藻性微生物数は年間を通じて 1 m*l* あたり数個から十数個と少ないが，底泥 (0–12 cm) では 10^3～$10^4\cdot g^{-1}$ の値を示し，秋季には増加の傾向を示すが諏訪湖 (Fig. 4a; 10^4～$10^6\cdot g^{-1}$) のように大きな変動はみられない。嫌気性溶藻性微生物数は10月を除き好気性溶藻性微生物に比べてやや高い値を示した。

Fig. 2 に，木崎湖底泥中の全炭素と全窒素量および C/N 比の鉛直分布を示す。全炭素量は 4–5 $mg\cdot g^{-1}$，全窒素量は 0.2–0.45 $mg\cdot g^{-1}$，C/N 比は10–20であっ

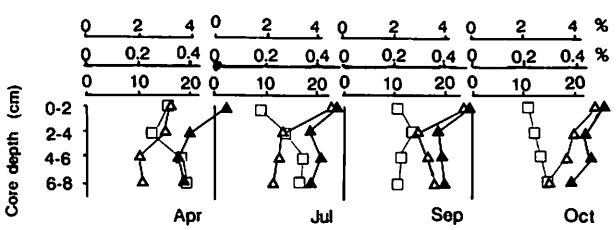

Fig. 2. Seasonal changes of the vertical distributions of total carbon (▲) and nitrogen (△) and C/N ratio (□) in the sediment of Lake Kizaki in 1988.

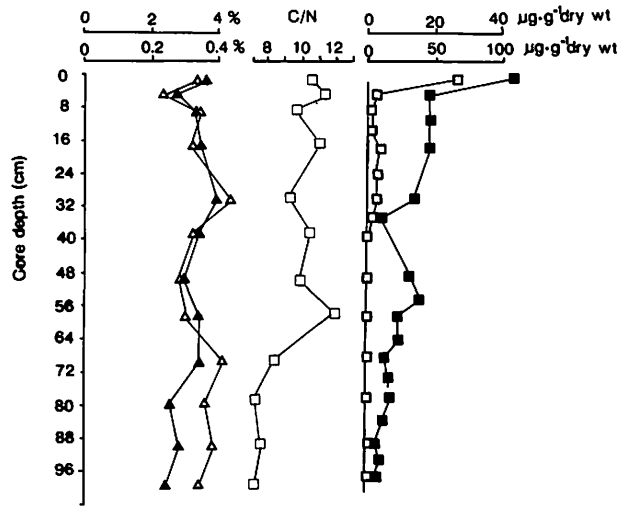

Fig. 3. Distributions of chlorophyll *a* (□), pheophytin *a* (■), total carbon (▲), nitrogen (△) and C/N ratio (□) in the sediment of Lake Suwa in September 1988.

た。全炭素および全窒素量とも 0–2 cm 層で最も高濃度で存在し，それ以深では急激に減少する。

Fig. 3 には1988年 9 月における諏訪湖底泥中の全炭素と全窒素量，C/N 比，クロロフィル *a* およびフェオフィチン *a* 量の鉛直分布を示す。全炭素と全窒素量および C/N 比はそれぞれ2.5–4%，0.2–0.4%，8–12であった。クロロフィル *a* 量は，表層では 30$\mu g \cdot g^{-1}$ で，深さにともなって急激に減少し，40 cm 以深では検出できなかった。フェオフィチン *a* 量は表層で 119 $\mu g \cdot g^{-1}$ で深さ 50 cm までは急激に減るが，55–60 cm 層でやや増え，それ以深では徐々に減少した。

Fig. 4 には諏訪湖底泥中の溶藻性微生物数の季節変動 (a) と鉛直分布 (b) を示す。溶藻性微生物数は表層 0–2 cm 層では 10^4～$10^6 \cdot g^{-1}$ で夏季から秋季にかけて高い値を示し，深さにともない減少し，1 m 層においては僅かに存在したに過ぎない。また諏訪湖における好気的溶藻性微生物数については，Fig. 5 に示すように光合成色素由来の炭素量と相関関係が認められた ($r=0.8507, n=9, p<0.005$)。しかし，木崎湖の底泥表層 (0–12 cm) においては，このような関係は認められなかった。

植物プランクトン中の光合成色素含有量は光や栄養

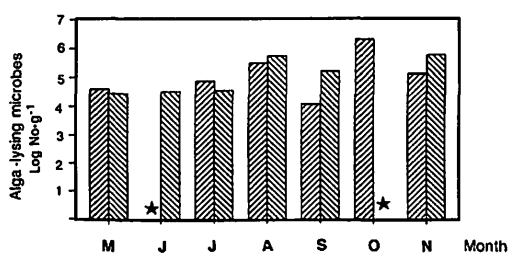

Fig. 4(a). Seasonal changes of alga-lysing microbes in the surface sediment (0–2 cm) at the center of Lake Suwa in 1984 (▨) and 1988 (▧). ★: not determined.

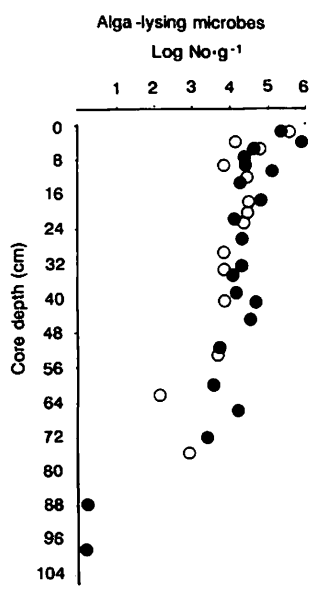

Fig. 4(b). Vertical distributions of alga-lysing microbes at the center of Lake Suwa in November 1984 (○) and September 1988 (●).

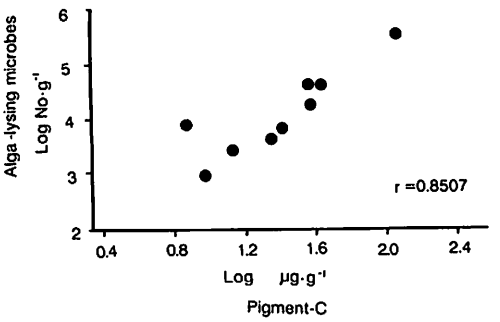

Fig. 5. Relationship between the number of alga-lysing microbes and the content of pigment-C in Lake Suwa in September 1988.

Table 2. Chlorophyll *a* content and carbon/Chl. *a* ratio of *Microcystis* spp. and Bacillariophyceae.

	Chl. *a* % dry weight		C/Chl. *a*
Microcystis spp. (Lake Suwa)	0.5		89.4
Asterionella formosa	0.68*	0.76 (mean)	52.63
Fragilaria crotonensis	0.74*		
Melosira granulata	0.87*		

* After Reynolds (1984).

塩濃度等の環境要因によって著しく変化するが，各湖に優占する藻株のクロロフィル*a*および全炭素量 (Table 2) から底泥における植物プランクトン起源の炭素量の推定を試みた。なお小山ら (1969) は諏訪湖底泥中の全炭素量のうちで無機態炭素の占める割合は2%にもならずその大部分が有機炭素であると報告しているので，有機炭素の値を全炭素の測定値をもって代用した。また両湖とも植物プランクトンの種組成は季節により変動するが，木崎湖では珪藻 *Asterionella, Fragiralia, Melosira* が，諏訪湖では *Microcystis* が，優占

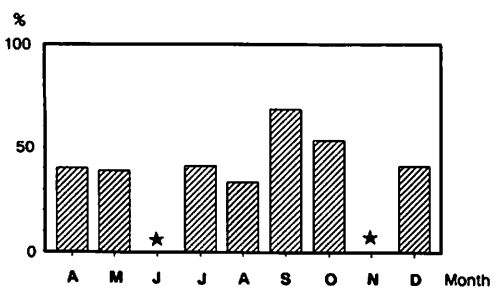

Fig. 6. Seasonal changes of the ratio of pigment-C to total organic carbon in the surface sediment (0–2 cm) of Lake Kizaki. ★: not determined.

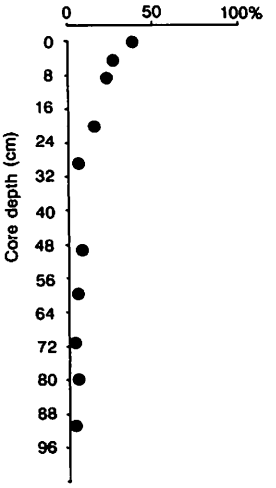

Fig. 7. Vertical changes of the ratio of pigment-C to total organic carbon in the sediment of Lake Suwa in September 1988.

していると仮定して，それぞれの植物プランクトン中に含まれるクロロフィル量の平均値から計算すると，木崎湖の底泥 (0–2 cm) では有機炭素量中の35–70% (Fig. 6) が，諏訪湖の底泥 (0–2 cm) では有機炭素中の40% (Fig. 7) が植物プランクトン由来の炭素となった。

考　察

Koyama *et al.* (1968) の1965年7月に行った木崎湖の調査によると，底泥中のクロロフィル*a*およびフェオフィチン*a*の量は底泥表層 (0–2 cm) で最も高く，深くなるにつれて急激に減少している。本報告の1988年の結果 (Fig. 1) も同様の傾向を示すが，各色素の含有量は Koyama *et al.* (1968) のおよそ1/2である。木崎湖は，1965年以降徐々にではあるが，富栄養化が進み湖水中のクロロフィル量も増大してきている（林ら1988)。それにもかかわらず1988年の底泥中のクロロフィル量が1965年より少いのは，湖水中の植物プランクトンの分解速度が1965年よりも上回り沈澱量が減少したか，あるいは測定法の違いが原因と考えられる。湖水中の植物プランクトンの分解速度が大きく変化したとは考えにくく（倉沢ら1976，坂本・加藤1984)，本報告と Koyama *et al.* (1968) とクロロフィル量の差は，測定法の違いによるものと考えられる。即ち，Koyama *et al.* (1968) は吸光法により測定しているが，吸光法は蛍光法に比べ，他成分の影響を受けた場合，著しく高い値を示す（Flovacek and Hannan 1977，芳竹ら1988，谷

野ら1988)。諏訪湖におけるクロロフィル(Fig. 3)も同様に吸光法により測定した値より小さくなっている(山本未発表)。また本報告で使用したアセトンによるクロロフィル抽出についても再検討する必要があるが，Mantoura and Llewellyn (1983) によればアセトン抽出法は他の方法に比べ良好な値を示す。

本報告で示したクロロフィル*a*およびフェオフィチン*a*量の年間の変動をみると，両湖とも夏季から秋季にかけて増加するが，木崎湖では年間を通じて諏訪湖より高い値を示している。諏訪湖における一次生産量は，1986年には651 g·C·m^{-2}·yr^{-1} (沖野1988)であったが，沖野（私信）によれば1988年もほぼこの値に近い。一方，木崎湖では一次生産量が0.2–0.23 g·C·m^{-2}·day^{-1}（坂本・加藤1984)と諏訪湖より小さいにもかかわらず，底泥中の色素含有量は高くなっている(Fig. 1)。木崎湖の沈澱量は諏訪湖に比べて大きいわけではない（西条1956)。木崎湖の水深約30 mの底泥は1年を通じて低温(5–6°C)で且つ酸素が不足しているため，一旦沈澱した植物プランクトンは容易に分解が進まない状態にあるのであろう。Sudo *et al.* (1978) および Ohtsuki and Hanya (1972a, b) は，嫌気的状態下での植物プランクトンの分解は好気状態に比べ極端に遅いことを報告している。Fig. 6, 7に示すように，両湖の底泥表層中の炭素は，植物プランクトン由来の炭素が大部分を占めている。この値は抽出されたクロロフィル*a*とフェオフィチン*a*から推定したものであり，未抽出のクロロフィル由来の色素を考慮に入れれば，底泥中の植物プランクトン由来の炭素量はさらに多くなると考えられる。

諏訪湖底泥中のクロロフィルおよびフェオフィチン色素，全炭素および全窒素量の鉛直分布(Fig. 3)では50–60 cmにピークがみられる。このピークは林(1984)の報告した有機態炭素と有機態窒素の鉛直分布，また渡辺ら(1982)による全リンの鉛直分布とも一致する。フェオフィチン*a*は，木崎湖の場合には表層(0–2 cm)に対して約10 cmの深度では50%以上が，諏訪湖の場合には表層に対して10 cmの深度では40%が，50 cmの深度では80%以上が分解されている。植物プランクトンの生産量の高い印旛沼においても同じように深さにともない色素の急激な減少がみられている（小林・宇田川1975)。

溶藻性微生物は，植物プランクトンやこれに由来する有機物を分解する微生物群であり，湖水中では植物プランクトン量と密接な関係があり(Yamamoto 1981, 山本ら1988)，夏季から秋季にかけて増えることが判明している（山本1988)。諏訪湖の底泥では，溶藻性微生物数と全炭素ならびに植物プランクトン由来の炭素との間に相互関係が認められたが，木崎湖ではこのような相関関係は認められなかった。この点に関しては，さらに検討をおこなっているが，諏訪湖底泥の溶藻性微生物はアメーバと細菌が大部分を占めているのに対し，木崎湖ではほとんどが細菌であった。

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Jpn. J. Phycol. (Sôrui) 39: 277–279, September 20, 1991

P. Ampili, M. V. N. Panikkar and V. D. Chauhan: Studies on spore germination and early growth in *Sarconema filiforme* (Sonder) Kylin (Rhodophyta, Gigartinales)

Key Index Words: *Gigartinales*—Sarconema filiforme—*spore germination.*
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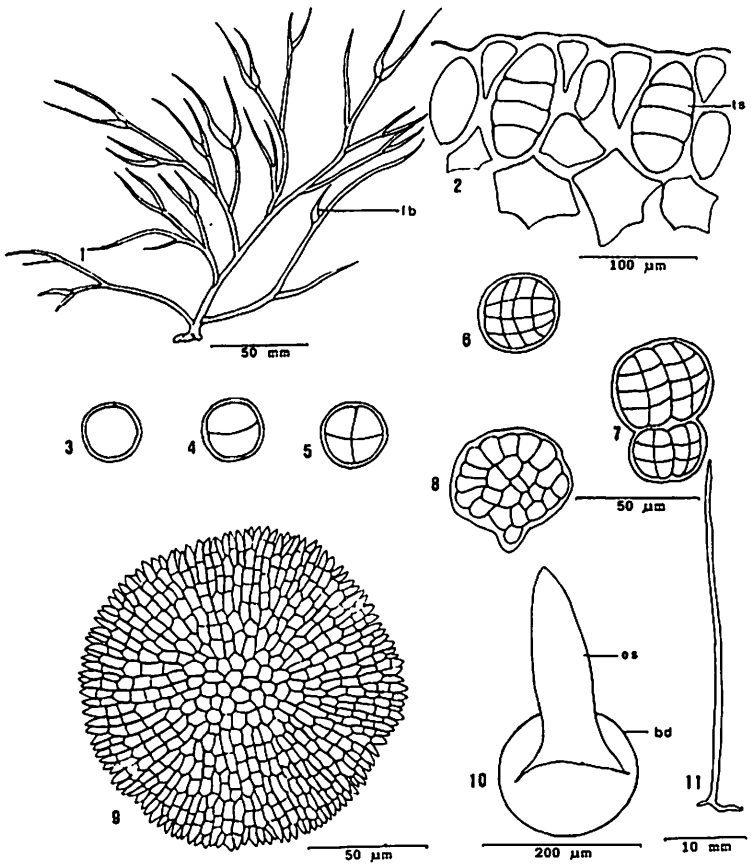
Sarconema filiforme (Sonder) Kylin belongs to the family Solieriaceae in the order Gigartinales. It is a tropical carrageenophyte found extensively on the coast of Red Sea (Ethiopia and Somalia), Indian Ocean, coasts of Africa (Kenya, Tanzania, Mozambique and Zanzibar), Arabian Sea (Karachi, Bombay and Cape Comerin) and also on the coasts of Australia (Bφrgesen 1937, 1938, Papenfuss and Edelstein 1977). From the order Gigartinales, spore germination has been studied in a number of species like *Chondrus crispus* (Darbishire 1902, Kylin 1917, Rosenvinge 1931, Chemin 1937, Burns and Mathieson 1972, Tveter and Mathieson 1976), *Gracilaria foliifera* (McLachlan and Edelstein 1977), *G. verrucosa* (Jones 1956, Oza and Krishnamurthy 1967), *Gigartina stellata* (Chen *et al.* 1974), *Hypnea musciformis* (Mshigeni and Lorri 1977).

In this paper we describe the spore germination pattern and early growth of *Sarconema filiforme* from Indian waters.

Tetrasporophytic plants of *Sarconema filiforme* was collected at Porbander on the western coast of India on December 12, 1982. The tetrasporangia were found in the swollen areas of the branchlets (Fig. 1). The pattern of division of the tetrasporangia was zonate (Fig. 2).

The plants collected were carried to the laboratory in seawater and kept overnight at 20°C. The fertile branches were excised and washed several times with sterilized seawater. The fertile pieces were spread over glass slides in Pertri dishes (10 cm diam.) containing 50 m*l* of sterilized seawater. The culture dishes were then placed in a constant temperature of 20±2°C with a light intensity of 1500 lux provided by fluorescent tubes and a photoregime of 14:$\overline{10}$ hours. Spore liberation occurred overnight and the spores settled onto glass slides. Following tetraspore liberation, the fertile pieces were removed and the glass slides were washed with a jet of sterilized seawater and placed into Petri dishes containing 50 m*l* of PES medium (Provasoli 1968). The medium was renewed at 2 day intervals for a week and thereafter at 7 day intervals. After attaining a length of 5 mm, the sporelings were detached from the slides and kept in crystallizing dishes (8 cm × 12 cm) containing 100 m*l* medium and unialgal cultures were maintained.

Tetraspore liberation was observed after 8–10 hr of incubation. The liberated spores were firmly attached to the glass slides by a sticky secretion. They are spherical and light-yellow in colour with a diameter of 16.5–22.5 μm (Fig. 3). They started germination without a resting period and the first division resulted in the formation of two cells of equal size (Fig. 4). On the second day a subsequent division occurred at right angles to the first, produced a four-celled sporeling (Fig. 5) and it turned reddish due to the development of more pigmentation. Further divisions produced a 16-32 celled sporeling with a diameter of 26.5-30.0 μm (Fig. 6). Some of its peripheral cells produced rhizoid like structures for firm attachment (Fig. 8). Additional divisions occurred in the peripheral cells and an expanded disc-like structure was formed with a diameter of 125-150 μm. The



Figs. 1–11. *Sarconema filiforme*. 1. A tetrasporic plant. 2. A part of the section of fertile branchlet. 3. Liberated tetraspore. 4. One-day old sporeling. 5. Two-day old sporeling. 6. Four-day old sporeling. 7. Two coalesced sporelings. 8. Sporeling with rhizoidal outgrowth. 9. Disc-like sporeling. 10. Fourteen-day old sporeling. 11. Forty-two-day old sporeling. bd, basal disc; es, erect shoot; fb, fertile branch; ts, tetrasporangium. Scale is common for all Figures 3–8.

central cells of the disc were oval or spherical in shape, while the peripheral cells were cylindrical with acute apices. From the central cells, a conical apex of the cylindrical shoot was produced. Within two weeks, an erect cylindrical shoot was produced with a group of apical cells (Fig. 10). The basal disc expanded as a circular holdfast for the developing shoot. The young upright shoot was terete and unbranched. Within 6 weeks of incubation the sporelings reached a length of 45 ± 5 mm (Fig. 11).

After 4 days of incubation the sporelings exhibited coalescence, resulting in the fusion of two or more sporelings and they were bounded by a common layer (Fig. 7).

The general pattern of spore germination of *Sarconema filiforme* was similar to that of the other members of the order Gigartinales. As in *Gracilaria verrucosa* (Oza and Krishnamurthy 1967), the tetraspore of *S. filiforme*, after repeated divisions, resulted a multicellular mass which produced rhizoids from the peripheral cells for firm attachment. A multicellular disc with radiating cells was observed which also gives a firm support for the developing shoot. Similar structure has also been observed in *Gracilaria* sp. (Bird *et al.* 1977) and *Chondrus crispus* (Tveter and Matheison 1976). In *S. filiforme* the disc was more conspicuous, radiating from a common centre with a large number of smaller cells. It seems

that coalescence of the sporelings is a common feature found during the germination of both carpospores and tetraspores in red algae (Jones 1956). The fusion of the developing sporelings of the intertidal algae may help in attaching them to the substratum in spite of mechanical disturbances.

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P. Ampili*·M. V. N. Panikkar·V. D. Chauhan*:** ***Sarconema filiforme*** **（紅藻スギノリ目）の胞子発芽と初期成長**

Sarconema filiforme はミリン科に属し、熱帯産のカラゲーナン原藻である。本報では、インド西岸の Porbander で採集した四分胞子体から四分胞子を採り、その発芽パターンと初期成長を観察した結果をまとめた。(*Marine Algae Discipline, Central Salt and Marine Chemicals Research Institute, Bhavnagar-364 002, Gujarat, India, **Department of Botany, S. N. College, Quilon-691 001, Kerala, India)

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Hiroshi Yabu: Occurrence of associated four minute chromosomes at meiotic metaphase I in the tetrasporangia of *Laurencia intricata* Lamouroux (Rhodophyta)

Key Index Words: chromosome—cytology—Laurencia intricata—*meiosis—Rhodophyta.*
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During the study of cytology on the materials of *Laurencia intricata* Lamouroux (Ceramiales, Rhodophyta) which is commonly grown in summer season on the flat shore of Moheji (near Hakodate, Hokkaido) and its vicinity, I recently noticed the presence of associated 4 minute chromosomes in the chromosome complements at meiotic metaphase I in the tetrasporangia. Therefore, the tetrasporic plants collected from Moheji in September 1989 were examined again to obtain the data for the chromosome complements, after fixed in aceto alcohol (1 : 3) and stained with aceto-iron-haematoxylin-chloral hydrate solution (Wittman 1965).

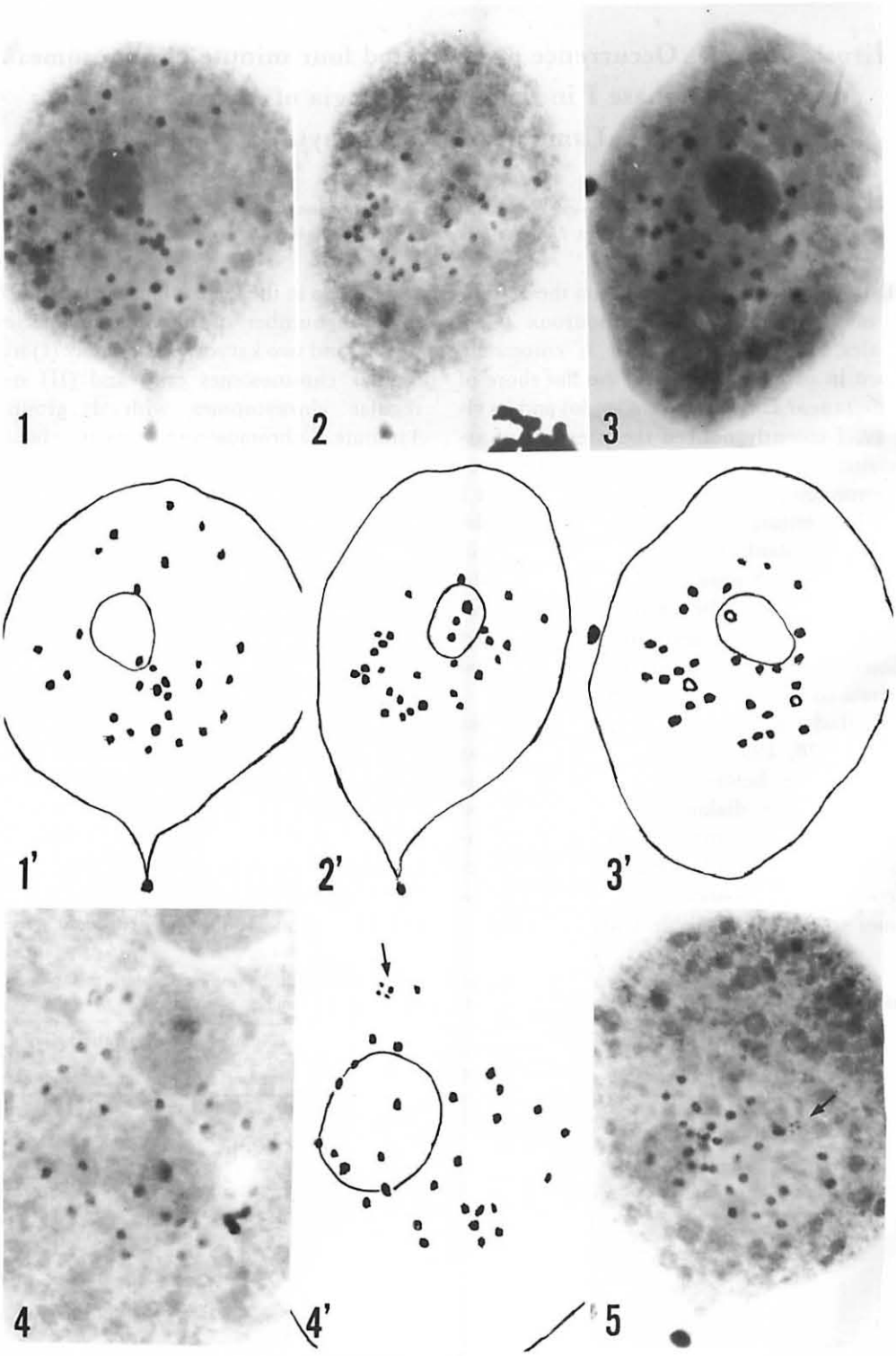
Similarly to the other *Laurencia* species (Yabu 1978, 1985), the present species has diffuse stage before diakinesis at meiosis I. Until late diakinesis, such associated 4 minute chromosomes could not be discernible. The count of chromosomes and occurrence of such associated 4 minute chromosomes are shown in Table 1 and Figs. 1-8.

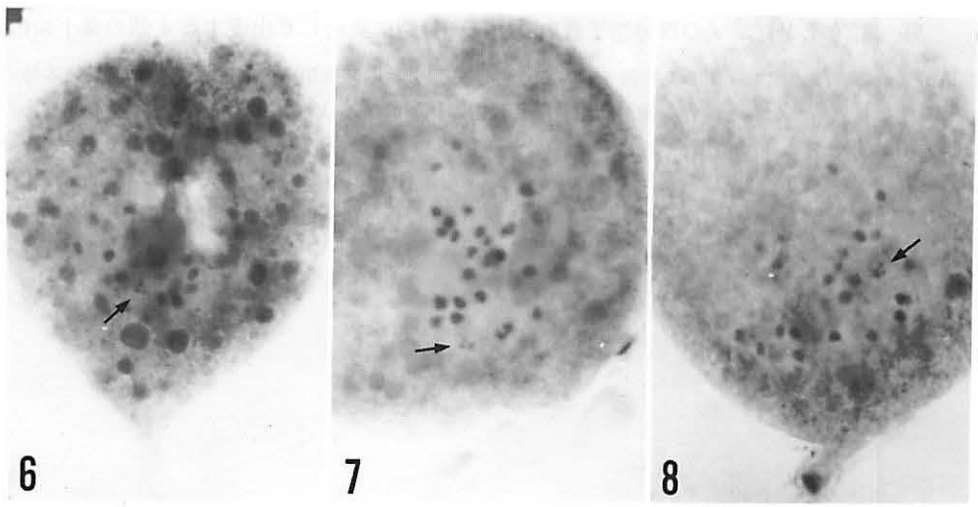
The data in the table indicates that the chromosome number of the present species is n=30, and two karyotypes, namely (I) n=30 regular chromosomes only and (II) n=29 regular chromosomes with 1 group of 4 minute chromosomes, exist in the tetrasporangia, and the tetrasporic plants comprise three varieties having tetrasporangia with karyotype (I) only, with karyotypes both (I) and (II), and with karyotype (II) only. From the above results, one of the regular chromosomes seems to have relation to the associated 4 minute chromosomes.

Up to the present time, the chromosome numbers in the genus *Laurencia* have been given for the following 10 species; *L. arbiscula* (n=29, Cordeiro-Marino *et al.* 1983), *L. catarinensis* (n=28, Cordeiro-Marino and Fujii 1985), *L. hybrida* (n=ca. 20 2n=ca. 40, Westbrook 1935), *L. nipponica* (n=28, Yabu 1978), *L. obtusa* var. *majuscula* (n=20 2n=40, Yabu and Kawamura 1959), *L. okamurai* (n=32, Yabu 1985), *L. papillosa* (n=20,

Table 1. Chromosome count and occurrence of associated 4 minute chromosomes at meiotic metaphase I in the tetrasporangia of *Laurencia intricata* collected at Moheji in September 1989.

Individual no.	Number of examined tetrasporangia	Number of tetrasporangia having 30 regular chromosomes	Number of tetrasporangia having 29 regular chromosomes together with associated 4 minute chromosomes
1	8	8	
2	9	9	
3	10	10	
4	8	8	
5	8	4	4
6	9	5	4
7	10		10
8	10		10
9	10		10
10	10		10


1
2
3
1'
2'
3'
4
4'
5



Figs. 1–8. Late diakinesis at meiosis I in the tetrasporangia of *Laurencia intricata* Lamouroux. ×1,280. 1–3. Sporangia having 30 regular chromosomes. 4–8. Sporangia having 29 regular chromosomes together with associated 4 minute chromosomes (arrow). In Figs. 6–8, one of the 4 minute chromosomes is out of focus. In Fig. 4, cells of trichobalst are seen mixed in a part of the squashed sporangia. 1′–4′. Drawings of Figs. 1–4, respectively.

2n=40, Yabu and Kawamura 1959; n=26, Cordeiro-Marino *et al.* 1974), *L. pinnata* (n=32, Yabu 1985), *L. pinnatifida* (n=ca. 20, Kylin 1929; n=15-16, Grubb 1925; n=ca. 20 2n=ca. 40, Westbrook 1928, 1935; n=29 2n=58, Austin 1956; n=29, Magne 1964) and *L. undulata* (n=30, Yabu 1985).

The chromosome number of n=30 counted in the present species is so far the same with that in *Laurencia undulata* among the above species.

Such a group of the associated minute chromosomes observed in the present species has never been reported in any of the above species.

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藪　熙：紅藻モツレソゾの四分胞子嚢内減数第一分裂に集合して出現する4個の微小染色体

北海道函館近郊の茂辺地で採集した紅藻モツレソゾの四分胞子嚢内減数第一分裂を観察した結果，本種の染色体数はn=30と見做された。その分裂像から四分胞子嚢内の核型には，(I) 30の正常な染色体を有するものと，(II) 29の正常な染色体と4個の微小染色体の一群を有するものとの2型があり，四分胞子体にはその四分胞子嚢に (I) 型のみ有するもの，(I) と (II) の型を有するもの，(II) の型のみを有するもの，以上3種類が存在することを認めた。このことから4個の微小染色体の1群は30の正常な染色体のうちの1個と関係があ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)

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藤田大介：無節サンゴモの属レベルの同定について —Woelkerling の検索表の紹介—

Daisuke Fujita: For the identification of genera of nongeniculate Corallinaceae —Introduction of Woelkerling's dichotomous key—

Key Index Words: Corallinaceae—dichotomous key—genera—identification—taxonomy.
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無節サンゴモは藻体に炭酸カルシウムを沈着し，化石として残り易いので系統進化学的に興味深いだけでなく，サンゴ礁や磯焼け等に関連する生物として生態学的にも重要な存在である（Littler 1972, Johansen 1981, 正置1984, Steneck 1986）。最近わが国でも様々な観点から無節サンゴモに興味を持つ人が増えてきているようで，その分類や性質について問い合わせを受けることが多くなった。

無節サンゴモについて諸実験を行おうとする際に大きな障害となるのは，種の同定が困難なことである。日本産無節サンゴモの同定には日本海藻誌（岡村1936）及び Masaki (1968) が大いに参考になるものの，未記載種や日本における未報告種もたくさんあるほか，タイプ標本との比較が十分に行われていないなどの理由で，種のレベルの分類には問題が多い。しかし，実際には種名とまでいかなくても，せめて属名がわかれば，それなりに研究成果を公表できる場合も多い。ところが，無節サンゴモの場合，これまでに設立された属が多過ぎ，各属の概念が曖昧で，研究者によっても捉え方がまちまちであったため，専門家でも悩むことが多かった。

このような状況の中で，最近オーストラリアの La Trobe 大学の Woelkerling 教授が中心となって，無節サンゴモの属レベルの本格的な見直し，特に各属の基準種のタイプ標本の詳細な観察に基づく大幅な整理統合が行われた。その成果は The Coralline Red Algae—An Analysis of the Genera and Subfamilies of Nongeniculate Corallinaceae— と題する労作 (Woelkerling 1988) に集大成され，一応の区切りがついた感がある。まだ未整理の部分（日本産のものではレプトフィツム属 *Leptophytum*）も残されているほか，属によっては基準種を中心とした少数種についてしか調べられていない場合もあるので，今後更に多くの種について知見を得ていく必要があるが，著書の中の亜科及び属レベルの検索表は現時点において非常に重宝なものである。ただ無節サンゴモの形態を表す用語には特殊なものが多く，私自身がこの類の研究を始めた頃，本誌に紹介された解説（千原1969）が大変参考になった経験もある。そこで，僭越ながら Woelkerling 教授に彼が作製した検索表を日本語で紹介させていただけるようにお願いしたところ快くお許し下さった。

この検索表は四分胞子体または二分胞子体の内部形態に基づくもので，成熟した胞子体が得られれば属レベルの同定は可能である。以前は内部構造の観察のために面倒な脱灰処理を経た切片作製を行わなければならなかった。最近では自然乾燥させた標本を走査型電子顕微鏡 (SEM) によって観察すれば良くなったので随分と楽になったものである。なお，Woelkerling 教授は無節サンゴモ類の内部構造を，これまで伝統的に用いられてきた組織の層（すなわち，基層，中層及び表層）としてではなく，細胞糸の集合体として理解することを提唱し，いくつかの用語を新たに導入して検索表にもこれらを用いている。ここでは検索表の理解に必要な最小限度の説明を加えるが，著書の中では豊富に写真が取り入れられ，こまめに引用されていて非常にわかりやすくなっているので，是非直接手にとって参照していただきたい。検索表の中で，チタノデルマ属 *Titanoderma*（＝ノリマキ属 *Dematolithon*）はその後 Campbell and Woelkerling (1990) によってイシゴロモ属 *Lithophyllum* の同物異名 (synonym) とされたのでここでは 4b の項を Woelkerling 教授に御教示いただいたとおりに修正し，それ以下の番号もずらしてある。

Woelkerling 教授が提案した用語の説明

1．背腹性のある藻体の内部構造について

①—組織性 (monomerous)

単一の擬柔組織系で，繰り返し分岐する細胞糸で構成され，各細胞糸は，藻体表面に多少とも平行に走っ

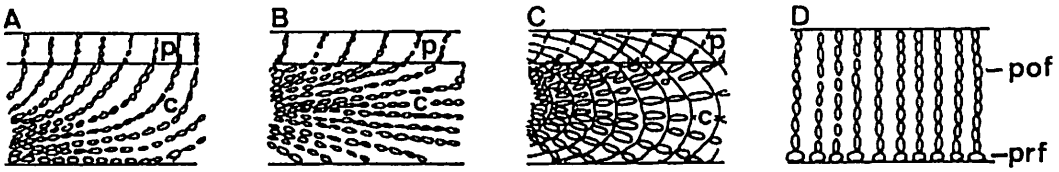

Fig. 1. Comparative diagram of monomerous and dimerous plants of nongeniculate Corallinaceae. A–C, monomerous plants; D, dimerous plants composed of primigenous (prf) and postigenous (pof) filaments. Cores of A, B and C are said to be unidirectional, plumose and coaxial, respectively. c, core; p, peripheral region.

て中核構造 (core) を形成した後，外側に屈曲して周縁部域を形成する。中核構造は細胞糸の配列状態によって羽状 (plumose)，単一方向性 (unidirectional) 及び共軸 (coaxial) の三様式が区別される (Fig. 1A–C)。

②二組織性 (dimerous)

互いに多少とも直角に配列する明瞭な二種類の細胞糸（すなわち初生的細胞糸及び後生的細胞糸）から成り，中核構造と周辺部域の区別はない (Fig. 1D)。

ほとんどの属では一組織性または二組織性のいずれか一方の性質を示すが，イシゴロモ属 *Lithophyllum* 及びスポンギテス属 *Spongites* では同一藻体の中で両方の性質を持ち合わせることがある。また突起 (protuberance) を生じる種では，本体が一組織性であっても二組織性であっても，突起の部分は常に一組織性となっている。

2．二組織性藻体の細胞糸について

①初生的細胞糸 (primigenous filament)

二組織性藻体を構成する細胞糸のうち，背腹性のある藻体の場合には藻体の最も腹側に位置する一細胞層（メタマストフォラ属 *Metamastophora* の老成体では体軸内部に埋まる），左右相称の藻体（テナレア属 *Tenarea*）の場合には中央の二細胞層を成す細胞糸群で，発芽中の胞子から直接生じると考えられる。いずれの場合も一つの平面を成して存在し，藻体の横方向あるいは縦軸方向の成長に寄与する。属によっては，初生的細胞糸を構成する全部あるいは一部の細胞が細長くなっていることがある。このような細胞は柵状細胞 (palisade cell) と呼ばれ，第一次原形質連絡孔を有する細胞壁が側壁よりもはるかに長く（通常 2–4 倍）なっている (Fig. 2)。

②後生的細胞糸 (postigenous filament)

二組織性藻体を構成する細胞糸のうち，初生的細胞糸の各細胞から二次的に多少とも直角に生じる細胞糸群で，藻体の厚さを増す方向の生長に寄与する。ふつう，初生的細胞糸の背側にのみ生じるが，メタマストフォラ属の老成体では腹側にも生じる。植物着生性の種ではあまり発達しない。

3．円柱状細胞 (columnar cell)

検索表の中には直接用いられていないが，藻体の大部分を構成する細長い細胞に対してこの名が付けられ

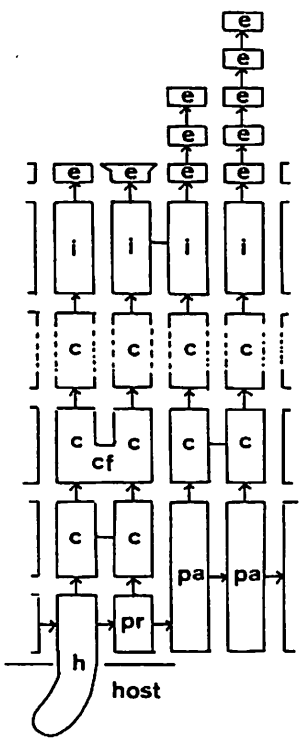

Fig. 2. Composite diagram of cells and filaments as seen in longitudinal sections/fractures of dimerous plants. No one species or genus contains all of these structures. c, columnar cell; cf, cell fusion; e, epithallial cell (single, with flared rim, and multilayered, respectively from the left); h, haustorium; i, vegetative initial; pa, palisade cell (elongated primigenous cell); pr, (usual) primigenous cell. Arrows show primary pit-connections, and lines between contiguous filaments, secondary pit-connections.

た。円柱状細胞は第一次原形質連絡孔を有する細胞壁よりも側壁の方がはるかに長く（通常2－4倍）なっているものである (Fig. 2)。円柱状細胞は細胞糸の伸びる方向に細長いのであり，初生的細胞糸に見られる柵状細胞とは細長くなる向きが異なる。

四分胞子体／二分胞子体に基づく無節サンゴモの亜科及び属レベルの検索表（これまでに日本に分布することが知られている属については属名の後ろに★印をつけた）

1a. 四分胞子／二分胞子生殖器巣は単孔の屋根 (Fig. 3A–C) をもつ
2a. 隣接細胞糸間では各細胞は主として第二次原形質連絡孔 (Fig. 2) によって連絡する (Lithophylloideae イシゴロモ亜科)
3a. 藻体は扁平な枝で構成されるが，枝の内部構造は左右相称で，その中央には柵状細胞 (Fig. 2) から成る2列の初生的細胞糸が存在する……*Tenarea* テナレア属
3b. 藻体は様々な形態をとるが，内部構造では細胞糸が背腹性 (dorsiventral) をもっているか，または放射状 (radial) に配列しており，中央に柵状細胞から成る2列の初生的細胞糸が存在することはない
4a. 吸根 (haustoria, Fig. 2) が存在し，細胞糸のうち最も腹側の層の細胞から生じて宿主細胞に侵入する；藻体は（色素を欠くために）白色；イシゴロモ属の種に「寄生」していると言われている；ふつう成熟個体は最大径でも1mm以下である……*Ezo* シズクイシゴロモ属★
4b. 吸根は存在しない；藻体は生時には（太陽光で色あせた標本を除き）ふつう色素を有する；植物体は独立栄養植物；ふつう成熟個体は最大径で2mm*以上になる……*Lithophyllum* イシゴロモ属★
2b. 隣接細胞糸間では各細胞は主として細胞融合 (cell fusion, Fig. 2) によって連絡するか，連絡構造を欠くように見える
5a. 各四分胞子嚢／二分胞子嚢は頂端栓 (apical plug, Fig. 3B) を有し，これらがまとまって胞子嚢放出前に生殖器巣孔を塞ぐ；生殖器巣の屋根は一層の細胞層から成る；細胞間の連絡構造を欠く (Choreonematoideae イシイボ亜科)……*Choreonema* イシイボ属★
5b. 四分胞子嚢／二分胞子嚢は頂端栓を欠く；生殖器巣の屋根は二層またはそれ以上の細胞層から成る；隣接細胞糸間では各細胞は細胞融合によって連絡する (Mastophoroideae イシノハナ亜科)
6a. 栄養組織は植物内生性で，表層細胞 (epithallial cell) を欠く；吸根を有する……*Lesueuria* レスエウリア属
6b. 栄養組織は基質着生性または非着生性で，(稀に例外はあるが) 表層細胞を有する；吸根を欠く
7a. 体全体にわたって柵状細胞から成る顕著な初生的細胞糸の層を有する (注1)
8a. 藻体は生殖器巣付近や分岐点のような特別な場合を除けばほとんど2－3(－5)層の細胞から成る；偏在または局在する細胞粘質物及び，または仮根によって基質に固着するか非着生性
9a. 四分胞子／二分胞子生殖器巣は中央部に小柱 (columella) を有し (Fig. 3C)，屋根は周縁部の細胞糸から形成される；胞子嚢は生殖器室の周縁部に限られて生じる……*Mastophora* イシノハナ属★
9b. 四分胞子／二分胞子生殖器巣は中央部の小柱を欠き，屋根は胞子嚢原基間に散在する細胞糸から形成される；胞子嚢は生殖器室の床全体に散らばって生じる……*Lithoporella* ウロコイシ属
8b. 藻体は少なくとも古くなった部分では多数の細胞層で構成される；限られた付着器によって一点で基質に固着し，明瞭な柄を生じる…*Metamastophora* メタマストフォラ属
7b. 体は柵状細胞から成る初生的細胞糸の層を欠くが，細長い細胞がパッチとなって局在することがある (注1)
10a. 藻体は多少とも体表面に平行に配列する細胞糸の共軸構造（弓なりに曲

* 原著では5mmとなっているが，小型種の多いチタノデルマ属が含まれたことにより2mmと訂正された。

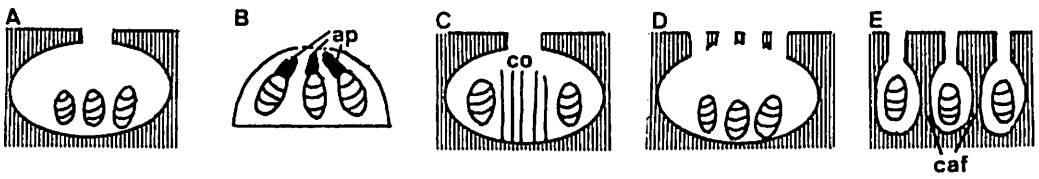

Fig. 3. Tetrasporangial/bisporangial conceptacles (representatively drawn as tetrasporangial here) of nongeniculate Corallinaceae. A–C, conceptacles with uniporate roofs; D–E, conceptacles with multiporate roofs. Note that tetrasporangia possessing apical plugs (ap) in B, existance of central columella (co) in C, and groups of clacified filaments (caf) in E.

がった細胞の層から成る部分，Fig. 1C）を有する

…*Neogoniolithon* イシノミモドキ属★

10b. 藻体は細胞糸の共軸構造を欠く

11a. 藻体の栄養組織はふつう表面から見える（注2）

12a. 発芽盤の中心要素は4細胞から成る；初生的細胞糸に毛生細胞(trichocyte)が存在する場合は細胞糸の末端に位置する

……*Fosliella* イボモカサ属★

12b. 発芽盤の中心要素は8細胞から成る；初生的細胞糸に毛生細胞が存在する場合，正常なものは細胞糸に介生的に生じる

……*Pneophyllum* モカサ属★

11b. 藻体の栄養組織は成熟時にはふつう10細胞層もしくはそれ以上厚くなる；細胞糸の腹側最下層は藻体縁辺部を除けば表面から見えない（注2）

……*Spongites* スポンギテス属★

1b. 四分胞子／二分胞子生殖器巣の屋根は多孔(Fig. 3D–E)である（Melobesioideae サビ亜科）

13a. 藻体は樹木状で扇型；平たく分岐したリボン状の上昇または直立する軸から成るが，この軸は明瞭な付着器，扁平もしくは偏圧した柄から生じる

……*Mastophoropsis* マストフォロプシス属

13b. 藻体は樹木状にも扇型にもならない；様々な形態を呈するが，分岐したリボン状の軸を生じることがなく，明瞭な付着器から立ち上がったり扁平もしくは偏圧した柄を持つこともない。ただし，付着柄(attachment stalk)を生じることがある

14a. 藻体構造は二組織性(Fig. 1D)；縦断面では初生的細胞糸の単一層があってこれから後生的細胞糸が背側へ向かって立ち上がるように見える ……*Melobesia* サビ属★

14b. 藻体構造は一組織性；縦断面では分岐した細胞糸の単一系から構成されているように見え，細胞糸のうちのある部分が中央あるいは腹側に位置する中核構造を形成し，残りの部分が藻体表面へ向かって外側に屈曲して周縁部を形成する

15a. 末端の表層細胞の外側の細胞壁は平らでフレア状の縁(flared rim, Fig. 2)をもつ

16a. 四分胞子／二分胞子生殖器巣は明らかに局在する；成熟した胞子嚢は1生殖器室あたり複数個生じ，永続性のある石灰化した細胞糸によって互いに仕切られることはない；細胞融合が存在する；第二次原形質連絡孔は知られていない

……*Lithothamnion* イシモ属★

16b. 四分胞子／二分胞子生殖器巣は散在する；生殖器室には胞子嚢の間に一群の石灰化した細胞糸(Fig. 3E)がある；細胞融合が優越して存在するが，第二次原形質連絡孔も存在する

……*Sporolithon* スポロリトン属★

15b. 末端の表層細胞の外側の細胞壁は丸くなるか平坦で，フレア状の縁をもつことはない。

17a. 吸根が存在し，基底の細胞糸層の細胞から生じて宿主の細胞に侵入する；藻体は色素が欠落しているために白い；植物体は他の無節サンゴモ上に「寄生」すると言われている；成熟個体はふつう最大径でも1 mm 以下…*Kvaleya* クヴァレヤ属

17b. 吸根はない；藻体はふつう生時には（太

陽光で色あせた標本を除き）色素を有する；植物体は独立栄養植物；成熟個体はふつう最大径で 5 mm 以上となる

18a. 藻体は細胞糸の共軸構造（弓なりに屈曲した細胞の層）が顕著である
……*Mesophyllum* エダウチイシモ属★

18b. 藻体は細胞糸の羽状 (plumose) 構造 (Fig. 1B) もしくは単一方向 (unidirectional) 構造 (Fig. 1A) が顕著である

19a. 細胞伸長は大部分が栄養分裂細胞 (vegetative initial, Fig. 2) 内で起こる（すなわち栄養分裂細胞が伸長してから分裂が起こる；このため栄養分裂細胞は通常これから直接生じた細胞と同じ長さであるか，これらよりも長くなっている）；生殖器巣原基 (conceptacle primordia) は表層細胞の下の栄養分裂細胞から直接生じる

20a. 中核構造の隣接細胞糸間では細胞の融合にはふつう隣接する細胞壁のほんの小部分だけが関与している；融合は藻体縦断面の走査電子顕微鏡観察では容易に認めることができるが，藻体縦断切片の光学顕微鏡観察では認めることが非常に難しい；細胞糸はふつう体表面で表層細胞を 1 個ずつ生じて終わっている（注 3）
……*Synarthrophyton*
シンアルトロフィトン属

20b. 中核構造の隣接細胞糸間では細胞の融合にはふつう隣接する細胞壁の大部分が関与している；融合は藻体縦断面／切片の走査電子顕微鏡及び光学顕微鏡のいずれの観察によっても認めることができる；ほとんどの種では各細胞糸はふつう体表面で 2 またはそれ以上の表層細胞を生じて終わっている（Fig. 2，注 3）
…*Clathromorphum* キタイシモ属★

19b. 細胞の伸長は大部分が栄養分裂細胞の下方で起こる（すなわち，栄養分裂細胞の分裂後に，これに由来する細胞が栄養分裂細胞よりも長くなる；このため栄養分裂細胞はこれから生じて伸長が起こった細胞よりも短い）；生殖器巣原基は通常の栄養細胞から不定に生じる
……*Phymatolithon*
フィマトリトン属★

（原注の要約）

注 1：スポンギテス属では初生的細胞糸を構成する柵状細胞の大きさや形に大きな変異が見られ，種によっては柵状細胞層が藻体全体に及んでいる場合もあるので，未記載の別属である可能性も踏まえて，今後さらに検討が必要である。

注 2：イボモカサ属とスポンギテス属，モカサ属とスポンギテス属の区別は今後さらに検討が必要である。特に藻体の厚さは変化に富むもので明瞭な境界はない。

注 3：キタイシモ属とシンアルトロフィトン属は必ずしも表層細胞の層数で区別できるとは限らないので，今後さらに検討が必要である。

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高　坤山：海水の流速が褐藻ホンダワラの光合成による酸素発生に及ぼす影響

Kunshan Gao: Effects of seawater current speed on the photosynthetic oxygen evolution of *Sargassum thunbergii* (Phaeophyta)

The photosynthetic oxygen evolution of *Sargassum thunbergii* adult plants was measured with changing seawater current speeds (0.5–1.2 cm s^{-1}) using a flow-through system. It was found that the rate of oxygen evolution increased with increasing seawater current speed. No significant difference between *S. thunbergii* adult and juvenile plants was found in light-saturated photosynthetic oxygen evolution rates at a constant seawater current speed (0.7 cm s^{-1}).

Key Index Words: diffusion boundary layer—Phaeophyta—photosynthesis—Sargassum thunbergii—*water current.*

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沿岸海域で一次生産者として重要な役割を果たしている海藻は，海水の流れにさらされている。そのような流れが海藻の一次生産の基礎となる光合成にどのような影響を及ぼすかは極めて興味深い問題である (Wheeler, 1980).

海水の流速は，海水が海藻の表面近くを通る際にその表面との摩擦抵抗によって藻体面に向かって低下し，境界層ができる。これは流速境界層と呼ばれる。一方，光合成の進行に伴う炭酸や栄養塩の取り込みと酸素の発生は，呼吸による酸素消費と CO_2 の発生を伴うが呼吸速度は同化速度より遙かに小さいので，藻体面に近づくにつれて炭酸濃度が低くなり酸素濃度が高くなるような拡散境界層が存在することになる (Fig. 1)。海水の流速と拡散境界層との関係は次のような式で表される。

$$\frac{\text{流速境界層の厚さ}}{\text{拡散境界層の厚さ}} = \text{Schmit 数}$$

Schmit 数は定数であるから，拡散境界層の厚さは流速境界層の厚さに比例し，流れが速くなればなるほど流速境界層が薄くなるので拡散境界層は薄くなる。したがって，海水の流れは炭酸や栄養塩の取り込みと酸素発生・消費に影響を及ぼすと思われる。淡水産ミズハコベでは，光合成時に CO_2 輸送抵抗の80%以上が境界層によるものと推定されている (Madsen 1984)。

本実験は1987年2月に舞鶴湾で採集したウミトラノオの生体（長さ 30–50 cm）の主枝を用いて行い，海水の流れが光合成による酸素発生速度に及ぼす影響を調べた。内径 3 cm，長さ 70 cm の同化パイプの中にサンプルを固定し，流入海水と流出海水の溶存酸素 (D.O.) 濃度の差から酸素発生速度 (P) を次式により求めた (Gao 1989)。

$$P = (A - B) \times F \times 60 \times 1/W$$

ここに，A と B はそれぞれ流出海水と流入海水の D.O. 濃度であり，F は流量 ($l\ min^{-1}$)，W はサンプルの乾燥重量（85°C，24時間）である。海水は舞鶴湾から汲み上げた天然海水を砂と活性炭で濾過したものを使用し，その水温は海と一致し 10°C であった。光合成による酸素発生は，960 $\mu E\ m^{-2}\ s^{-1}$ の光強度下（発熱電球，110 V，150 W）で測定した。ウミトラノオ

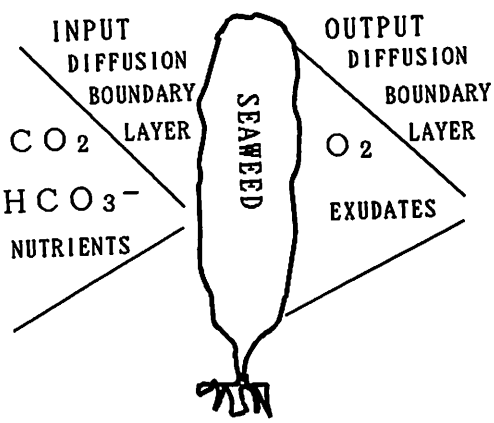

Fig. 1. Illustration of input and output diffusion boundary layers near the surface of seaweeds. The width between the oblique lines indicates the thickness of input or output diffusion boundary layer.

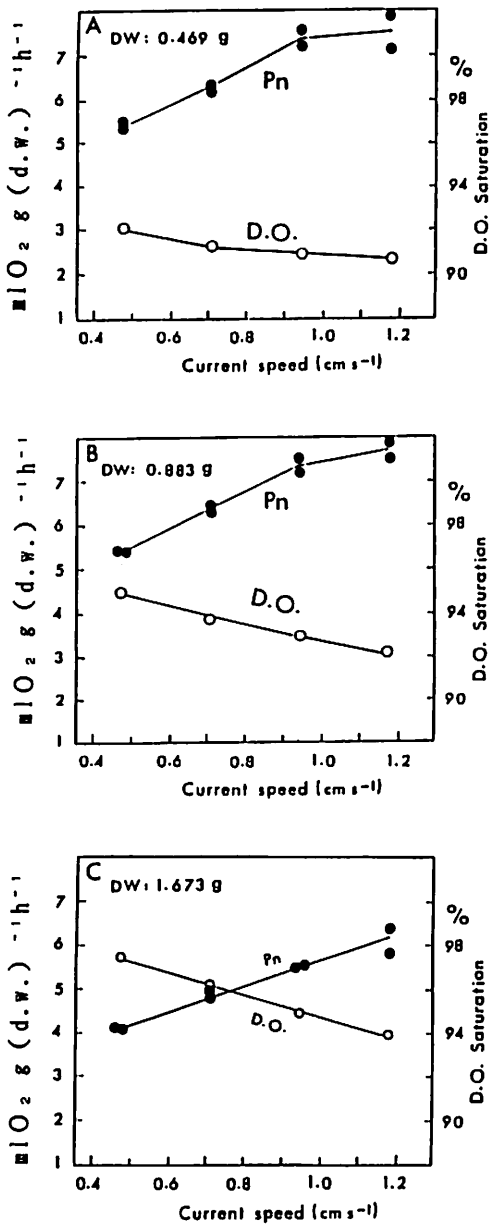

Fig. 2. Relationships of light-saturated photosynthetic oxygen evolution of *Sargassum thubergii* adult plants and D.O. saturation of outflowing seawater to the current speed in the pipe with different amounts (dry weight, D.W.) of samples (A: 4, B: 6, C: 8 plants). Measured on February 6, 1987.

の光合成は，この光強度下で飽和し，強光阻害は見られなかった (Gao 1989)。

Fig. 2 に示すように，流速 0.5～1.0 cm s^{-1} の範囲では流速の増加に伴って流出海水の酸素飽和度は直線的に低下したが，ウミトラノオの光飽和酸素発生速度はほぼ直線的に増加した。流速が 2 倍になると酸素発生速度は30～40%増加した。また，酸素発生速度はサンプルの量が少ない場合 (Fig. 2A, B) には 10 cm s^{-1} 以上の流速で飽和するような傾向がみられた。酸素飽和度並びに海水の流速の変化によるウミトラノオの酸素発生速度の変動について分散分析 (ANOVA) を行ったところ (Table 1, 2)，酸素発生速度に対する酸素飽和度の変化の有意な影響は認められなかったが，海水の流速の影響は有意であった ($P<0.05$)。

ウミトラノオの幼体と成体（主枝）について同じ時期（1987年 2 月）に同じ光源を用い，同じ測定手法（流速 0.7 cm s^{-1}）で測定した光飽和酸素発生速度を比較したところ (Table 3)，平均値では成体の主枝の方が

Table 1. Photosynthetic oxygen evolution [m*l* O_2 g (d.w.)$^{-1}h^{-1}$] at varied seawater current speeds and D.O. saturations in *S. thunbergii* adult plants.

Current speed (cm s^{-1})	D.O. saturation, %		
	91±1	94±1	98±1
0.47	5.45	5.40	5.55
0.71	6.25	6.35	6.26
0.94	7.40	6.43	6.48
1.18	7.60	6.10	6.73

Table 2. ANOVA of oxygen evolution as a function of seawater current speed (CS) and D.O. saturation.

Source	df	SS	MS	F
D.O.	2	0.773	0.387	2.38
CS	3	3.518	1.173	7.23*
Error	6	0.975	0.163	
Total	11	5.266		

* Significant at 0.05 level.

Table 3. Comparisons of light-saturated photosynthetic oxygen evolution rates [m*l* O_2 g (d.w.)$^{-1}h^{-1}$] between juvenile and adult plants of *Sargassum thubergii*.

Juvenile plants	Adults plants (main branch)
5.5±0.5	5.87±0.70
(n=3, Feb. 4)[a]	(n=6, Feb. 6)[b]

Dry weight of samples (a, 6; b, 18 individual plants) used in the pipe: a, 0.797 g; b, as indicated in Fig. 2.

幼体より高かったが，t-test の結果では有意差は認められなかった ($P>0.05$)。暗所での酸素消費速度についても比較したが（流速約 0.5 cm s^{-1}），幼体と成体の差は認められず，約 0.4 ml O_2 g (d.w.)$^{-1}$ h^{-1} であった。

Wheeler (1980) によれば，ジャイアントケルプ *Macrocystis pyrifera* の光合成による酸素発生速度は，密閉容器内の海水の回転速度の増加に伴って増加した。また，藻体の表面に乱流か層流が存在することによって境界層の厚さも大きく変化し，それによって光合成速度も変化することが指摘されている (Wheeler 1980)。藻体の表面に乱流か層流が形成されるのは，海水の流況だけでなく海藻の形態にも左右されると考えられる。前報 (Gao and Umezaki 1989) ではウミトラノオの幼体（10月）を用いて測定したが，本実験と同じ流速範囲では流速の変化に伴う酸素発生速度 (1000 μE m^{-2} s^{-1}, 16°C) の変化は認められなかった。ウミトラノオの幼体は広皮針形の初期葉を持つが，成体は線形の葉を主枝また側枝にいっぱい付けている。このような成体と幼体の形態的な違いによって海水の流れに差が生じ，それがウミトラノオの光合成による酸素発生速度に異なるインパクトを与えたものと考えられる。

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新 刊 紹 介

阪井興志雄：マリモの科学

202頁，北海道大学図書刊行会．1991．1854円．

本書の著者は，北海道大学理学部在学当時からマリモを含む緑藻シオグサ属の分類の研究を行ない，学位論文（1964年）で，マリモの分類と分布を明らかにした．その後も，マリモの生態の研究，マリモ調査団に加わるなど，生涯マリモに興味を持ち続けたマリモ研究の第一人者である．

本書は，古くから神秘な謎の多い植物とされてきたマリモを，著者の現在迄の幅広い知識と内外の学術論文，さらに一般に余り目に触れられない調査報告書を紐解いて，現在知られるマリモのすべてを平易に解説した一般向きの啓蒙書であるが，また，マリモ生物学を幅広く扱った内容が豊富で充実した学術書としても高く評価できる．

本書は，リンネ氏によってマリモの学名が付けられ(1753)てから，また日本の阿寒湖での発見と種名の同定（1894年）の経緯，マリモが北半球のみに分布するという地球上の分布，生育地の水質，生育状況，阿寒湖の垂直，水平及び場所毎の分布・生育状況，光合成，または比重からみたマリモの浮き沈みの現象，耐凍性が高いが，耐乾性の弱い性質など，その生理・生態が平易に説明されている．また，所謂マリモ球形体（ビロード状毬団）の他に種々な形状のマリモ糸状体が湖底に生育していること，その湖底のマット状に生育する糸状体から毬団への発達，逆に毬団の破損から種々な糸状体集団への生成の推定，糸状体が極性を変えることによって起こるマリモ毬団形成の西村真琴氏（1923年）の説，実験室の培養結果からマリモの直径と年齢との関係を計算し，直径15 cmのマリモが19年生（1式）または22年生（2式）と推定した著者ら（阪井・山田 1961年）の研究が紹介され，マリモの謎解の現状を知ることが出来る．日本の淡水産マリモはシオグサ属マリモ亜属に所属し，マリモとヒメマリモの2種があり，それぞれの品種の特性と分布がスケッチと写真で説明されている．最終章では，阿寒湖のマリモの被害と保護対策の現状を説明し，年毎の水質・底質の悪化と水位の底下，盗採などの被害を憂慮して，適切なる保護対策の必要を述べている．

著者が希望しているように，本書がマリモの研究・調査に役立てられるとともに，多くの愛読者がマリモの保護対策・保存に理解を示され，一層協力されて，この美しいマリモを永久に阿寒湖の宝として残したいものである．

（福井県小浜市飯盛128-6　梅崎　勇）

ニュース

第4回「有用海藻の分類学に関する国際ワークショップ」報告

有用海藻の分類学に関する国際ワークショップ Workshop on Taxonomy of Economic Seaweeds は Hawaii 大学の I. A. Abbott 教授が Convener として組織し，California Seagrant College Programの後援によって開催されている．太平洋を中心として有用海藻の種レベルでの分類を国際的に安定させ，他の分野で海藻の正しい名前を利用してもらえるようにすることを目的としている．各国の研究者が集まり，それぞれ標本と資料を持ち寄って検討するもので，ひじょうに実質的な討議とそれに基づく報告書ができる．最終的にはそれぞれの分類群の検索表と記載や図を伴って，種類を同定する手引きを作ることを目指している．

第1回のワークショップは1984年6月15-20日にGuam大学で開催され，ホンダワラ類，テングサ類，キリンサイ類，オゴノリ類が取り扱われた．日本からは北海道大学の山本弘敏氏と私が参加した．

第2回は1986年9月22-25日，中国青島市の中国科学院海洋研究所で行なわれ，ホンダワラ類，テングサ類，オゴノリ類，キリンサイ類，ソゾ類を対象とし，日本からは私一人の参加となった．報告書は少し遅れて印刷された（藻類37巻144ページ参照）．

第3回目は1989年8月7-11日に California, La Jolla の Scripps Institution of Oceanography で実施された．ホンダワラ類，テングサ類，オゴノリ類を対象とし，日本からの参加者は京都大学の鮫坂哲郎氏と私の2人で，ホンダワラのグループに入った．報告書は近く出版される予定で，印刷を急いでいる．

このとき，参加者から次回は札幌でという声が強く，私もそれを承諾せざるをえなかった．北大植物分類学講座に集積された資料を多くの人に利用してもらう機会でもある．そこで会期を1991年7月22-27日として準備に入った．このワークショップは旅費の一部と印刷費を California Seagrant College Program が負担し，開催を引き受けた地元機関が滞在費用などを負担する習慣なので，その点の困難があったが，多くの方々のご協力で実施することができた．

今回はこれまで続けてきたホンダワラ・テングサ・オゴノリのグループにオキツノリ類を加えた4グループとし，それぞれ日本側研究者に参加してもらうことにした．構成はつぎのとおりだった．

ホンダワラグループ

曽呈圭 Tseng, C. K.・陸保仁 Lu Baoren（中国），江永綿 Chiang, Y. M.（台湾），Gavino C. Trono (Philippines)

鮫坂哲朗・野呂忠秀・吉田忠生（日本）

テングサグループ

Bernabe Santelices (Chili)，李海福 Lee, H. B.（韓国）

安田昌彦（日本）

オゴノリグループ

Isabella I. Abbott (U.S.A.)，Khanjanapai Lewmanomont・Anong Chirapart (Thailand)，Phang Siew Moi (Malaysia)，夏邦美 Xia Bangmei（中国），Alan T. Critchley (South Africa)

大野正夫・山本弘敏（日本）

オキツノリグループ

Richard E. Norris (U.S.A.)，張俊甫 Zhang Junfu（中国）

増田道夫（日本）

オブザーバー

James J. Sullivan (U.S.A.)

馬場将輔・藤原秀一・岩田一幸・川久保明弘・今野猛彦・松本正喜・中嶋　泰・中瀬浩太・二宮早由子・太田雅隆・寺脇利信・山田俊郎・山本正之（日本）

期間を通じて各自持ち寄った標本と資料に加えて北大理学部標本室の標本も全面的に利用して問題点を検討し，連日活発な意見交換が続いた．特定の地域のみを対象とした個人的な研究では解決が難しい問題点について，共通な見解がえられた．グループ内に限定されず，さまざまな交流を通じて情報の交換も盛んだった．これらの結果は今後相互の密接な連係のもとで分担して纏められ，近い将来 Taxonomy of Economic Seaweeds Vol. 4として California Seagrant College Program から印刷公表の運びとなる．

このワークショップの実施にあたって，California Seagrant College Program, 北大国際交流事業基金，海外協力事業団，その他多くの企業と個人のご協力を得た．厚くお礼申し上げる．

（北海道大学理学部　吉田忠生）

—学 会 録 事—

—会 員 移 動—

新　入　会

住 所 変 更

日本学術会議だより　No.21

第14期最後の総会終わる

平成３年６月　日本学術会議広報委員会

日本学術会議は，去る５月29日から31日まで第111回総会を開催しました。今回の日本学術会議だよりでは，その総会で採択された勧告を中心に，同総会の議事内容等についてお知らせします。

日本学術会議第111回総会報告

日本学術会議第111回総会（第14期・第７回）は，平成３年５月29日～31日の３日間開催された。

総会冒頭に逝去された大谷茂盛，石原智男両会員の冥福を祈り黙禱を捧げた。会長からの経過報告の後各部・各委員会の報告があった。続いて規則の一部改正１件，国際対応委員会の設立等運営内規の改正１件，申し合わせ２件，勧告１件，要望１件，対外報告等３件，計９議案の提案があった。これらの議案については，同日午後の各部会での審議を経て，第２日目の午前に採決された。

なお，総会前日の午前には連合部会を開催し，これらの議案の説明，質疑を行った。また，総会に平行し，第１日目の夕方には第771回運営審議会が開催されて，これら議案についての各部の審議状況が報告された。

第２日目の午後は，「ポスト湾岸をめぐる諸問題」について自由討議が行われた。

第３日目の午前には各特別委員会が，午後には各常置委員会が開催された。

今回の総会では，「大学等における人文・社会科学系の研究基盤の整備について（勧告）」と「公文書館の拡充と公文書等の保存利用体制の確立について（要望）」が採択され，同日（30日）午後，内閣総理大臣に提出され，関係各省に送付された。

日本学術会議としての国際対応組織の問題は，前期からの懸案事項であったが，今期においてもこの問題は新たに増幅され，国際対応委員会を当分の間設立することが決まり，それに伴い運営内規の一部を改正することとなった。

対外報告としては，「人間活動と地球環境に関する日本学術会議の見解」を〔人間活動と地球環境に関する特別委員会〕が，『「医療技術と社会に関する特別委員会報告－脳死をめぐる問題に関するまとめ－」について』を〔医療技術と社会に関する特別委員会〕がまとめ採択された。また，会長提案のバイオテクノロジー国際科学委員会及び国際微生物学連合への加盟も採択された。

「ポスト湾岸をめぐる諸問題」についての自由討議は，大石泰彦副会長の司会で，はじめに話題提供として第２部の西原道雄部長，第２常置委員会の星野安三郎委員長，平和及び国際摩擦に関する特別委員会の川田　侃委員長がそれぞれ部・委員会の審議状況を報告した。それに基づき，会員間での意見交換が行われた。

大学等における人文・社会科学系の研究基盤の整備について（勧告）

国家・社会の健全な発展は，人文・社会科学と自然科学のバランスのとれた学術研究の成果が常にその土壌となっている。ところが，戦後の我が国では，自然科学の急速な進展に比して，人文・社会科学がそれに対応できない状況にある。それは，大学等における人文・社会科学系の研究基盤が整備されないまま放置されていたことに起因する。その上，これからの我が国は，国内的には広く生涯教育を推進し，国際的には各国との研究交流や留学生の受け入れなどを一層積極的に行うことを要請されている。すでに日本学術会議は，第13期において「大学等における学術予算の増額について（要望）」などを要望しており，これを踏まえて第14期では，さきに，主として自然科学系の「大学等における学術研究の推進について－研究設備等の高度化に関する緊急提言－(勧告)」の勧告をした。それに続いて，ここに人文・社会科学系の大学等における研究基盤を早急に改善し，整備するよう勧告する。

まず，人文・社会科学系の研究基盤を改善し，整備するためには，研究に関わる人的構成の強化を必要とする。したがって，なによりも研究者の増員が必要であり，それに関連して，特に若手研究者の養成と研究補助者の増員が求められる。今日，人文・社会科学も自然科学と同様に，研究分野が細分化されるとともに総合化も図られ，それに応じて新しい分野が開発され，それぞれの分野において総合的かつ多面的な研究方法が採られるようになったからである。

また，国内外でのフィールド・ワーク等の研究調査や外国人研究者の招へいなどがより活発に行われるためには，研究費の大幅な増額を必要とする。なお，国公立大学等における研究費の実験系と非実験系による区分は適正な基準により是正する必要がある。

さらに，人文・社会科学系の研究基盤の整備には，図書や資料の収集・保管など学術情報の充実が要求される。それを充たすには，それぞれの研究室における情報処理機器を整備・充実するとともに，図書館・情報センターなどの学術情報機関の拡充を図るべきである。その際，情報処理機器の購入と維持のために相対的に図書購入に当てる費用が圧迫されてはならず，図書費全体についても特段の増額が必要である。

以上のように人文・社会科学の人的・物的な研究基盤の速やかな整備が，国公私立大学のみならず，すべての研究機関において今日切実に要望されている。なお，大学等における研究基盤の整備に役立つ民間からの寄付等の援助には，それに対する包括的かつ柔軟な免税措置等が講じられるよう配慮すべきである。

公文書館の拡充と公文書等の保存利用体制の確立について(要望)〔要旨〕

わが国の公文書等の保存体制は，公文書館法が公布・施行されて大きく前進したが，その体制はなお国際的にみて大きく立ち遅れた状況にある。公文書等はきわめて重要な学術情報であり，かつ，国民共有の文化的・歴史的資産として貴重であることから，その保存・利用体制を確立するために以下の措置を早急に講じられるよう要望する。

1．国立公文書館の拡充とその権限の強化

現在の国立公文書館はその設備・人員等がきわめて貧弱であり，また，権限が著しく弱小である。国の公文書等の保存利用体制の確立のために，まず国立公文書館の権限を強化し，その設備・人員を大幅に拡充整備する必要がある。

2．地域文書館の設立・整備のための国の支援の強化

公文書館法の公布以後，地方公共団体において公文書館を設立する動きがあるが，まだ，その動きは限られている。設立を促進し機能を強化するために，国の財政的援助を拡充すると共に，地方公共団体の自主性を尊重しつつ国の技術的な指導・助言を強化する必要がある。あわせて，公文書等の保存に関して，文書館の権限を強化する必要がある。

3．公文書館専門職員養成制度と資料学・文書館学研究体制の整備

公文書館専門職員の養成・確保は緊急な課題であり，わが国にふさわしい専門職養成制度を早急に確立すべきである。この確立のためには，資料学・文書館学の研究者を確保し研究を推進するための体制を整備する必要がある。

4．公文書館法の整備

以上のような措置を講じる上で，現在の公文書館法は，公文書館の設置義務とその権限，専門職員の資格と地位，地域文書館への国の支援などについて不十分な点が多くみられるので，これを早急に整備して，公文書等の保存利用体制の確立を推進する必要がある。

人間活動と地球環境に関する日本学術会議の見解〔要旨〕

日本学術会議は，人間活動と地球環境に関する問題に強い関心を持ち，特別委員会や多数の研究連絡委員会において学術情報を集め，問題を総括し，研究体制の検討等を行ってきた。これらを基礎として見解を表明する。

日本はその自然環境の多様性や，近年の人間活動の急速な進展により環境問題に対して厳しい見方が必要である。この関連の研究は従来必ずしも十分ではなかった。国際協力の下に多岐にわたる学問分野がこれまでの枠を拡大し，多分野の学協会が融合化して活動し，新しい分野の研究活動の強力な推進を図るべきである。また，地球環境問題はグローバルな問題であるが，個々の人間の対応から出発する問題でもあるから教育や啓蒙活動が急務である。

わが国では多数の省庁が研究を行っているが，相互関係や全体を見渡した有機的・体系的な研究推進政策が必要である。日本学術会議はこれらのための助言，連絡，調整等にその組織と能力を生かして活動し努力する。

医療技術と社会に関する特別委員会報告 －脳死をめぐる問題に関するまとめ－

医療技術は不断に進歩するが，その進歩が著しければ著しい程，医療技術と人々のものの考え方や社会的な習慣との間に調和を欠く状況が生じている。脳死の取扱をめぐる問題はその一つである。今期の本特別委員会では「脳死は人の死か」についての直接的な審議は保留し，「もし脳死をもって人の死とすると，あるいは臓器移植を視点にいれると，何が問題になり，それを如何に考えるか」などについて論議した。本報告はその結果を整理したものである。（原文のまま，以下項目のみ）

1　脳死患者の医療上の取扱
2　意思の個別的確認について
3　死亡時刻の考え方に関して
4　医療提供側の問題点
5　医療費の取扱について

日本の学術研究環境－研究者の意識調査から－（第3常置委員会）刊行される

第3常置委員会は，第13期の「学術研究動向」調査を踏まえ，21世紀に向けて我が国の学術研究の中心的存在として活躍を期待される30歳代から40歳代の若手研究者（約2000人）を対照に，学術研究の基礎となる「研究環境」についてのアンケート調査（調査事項は，大別して「学術研究の組織・体制，研究者の養成・確保と国際化，研究費の調達・運用と研究設備，情報の収集・保存）を行い，その結果を基礎に報告書を作成した。なお，本書は日学資料として刊行している。

日本学術会議主催公開講演会「日本の学術研究環境は21世紀に対応できるか」開催される

「日本の学術研究環境」の刊行を記念し，平成3年6月6日（木）13時30分～17時00分に日本学術会議講堂において開催された。近藤会長の開会のあいさつの後，澤登第2部会員の司会により，①「日本の学術研究環境－研究者の意識調査から－」（森第7部会員）②純粋基礎研究は大学しかやらない（有馬第4部会員）③私立大学の立場から（松本第2部会員）④「産業の立場から」（内田第5部会員）の講演の後，総合討論を経て，渡邊第7部会員（第3常置委員会委員長）の閉会のあいさつをもって盛況のうちに終了した。なお，本公開講演会の内容は，追って日学双書で刊行する予定である。

平成3年1月以降，委員会等別の対外報告

部	1件	特別委員会	4件
常置委員会	1件	研究連絡委員会	23件

御意見・お問い合わせ等がありましたら，下記までお寄せください。

〒106 東京都港区六本木7－22－34
日本学術会議広報委員会　電話03(3403)6291

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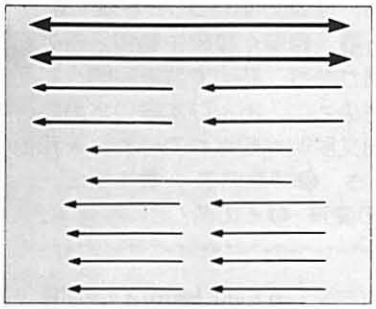

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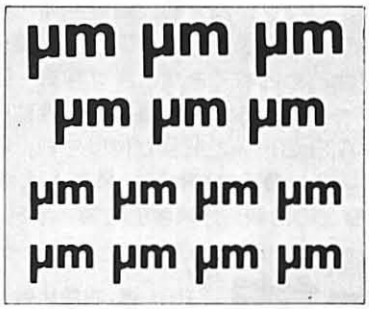

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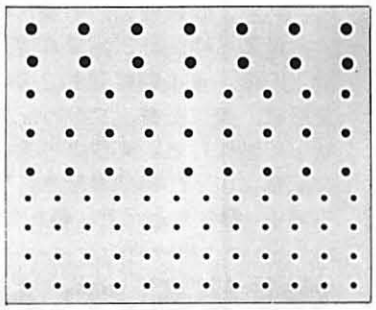

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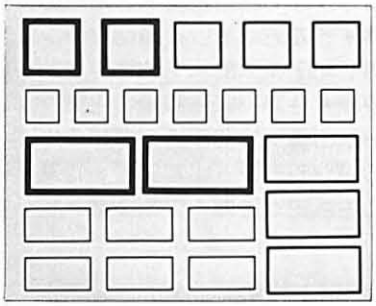

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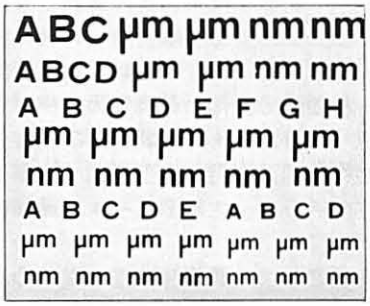

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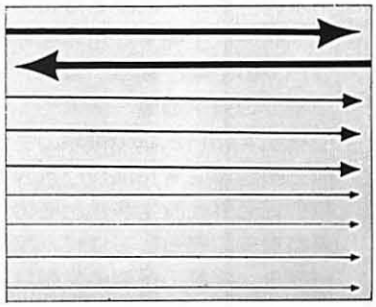

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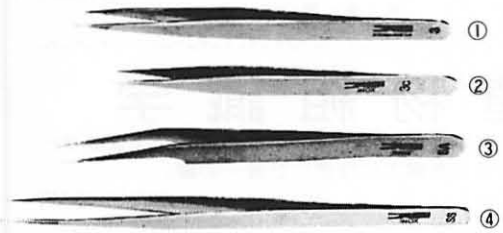

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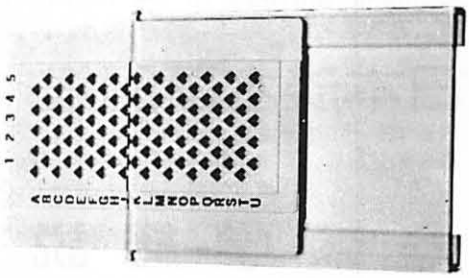

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日本の赤潮生物
—写真と解説—

福代康夫・高野秀昭
千原光雄・松岡数充　編

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赤潮の発生を防除するためには，赤潮の発生原因となる種をできるだけ正確に分類，同定する，ことが必要である。本書は，主に日本近海および日本の海水域に出現する200種の赤潮生物を収録したものであり，その貴重な顕微鏡写真，録画，解説，文献等と共に，赤潮生物の分類・同定に必携の書である。本書のえとなった「赤潮生物シート」(水産庁1979〜1984)は6年間にわたって集めたものを，今回改めて分類群別に編集し，近年の新知見を加えて現状にあう書とした。

〔特 色〕収録種は，藍藻8種，クリプト藻2種，渦鞭毛藻70種，珪藻80種，ラフィド藻9種，黄金色藻6種，ハプト藻4種，ユーグレナ藻8種，プラシノ藻5種，緑藻1種原生動物2種の計200種。★1種見開き2頁にまとめられており，まず写真・図があり，続いて写真説明，和文記載，英文記載，文献が記述されている。★写真は研究者秘蔵のもの，および本書のために新しく製作した。★写真・図はA,B,C……と記号が付けられ，和文説明が記されている。★和文記載は以下の特徴が記されている。❶細胞の性状，外形と大きさ　❷細胞構造　❸生殖法，生活史　❹生態と分布　❺類似種との比較，分類学的位置，学名の変遷　❻その他(呈内容見本)

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