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Notes



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本学会では日本植物学会第46回大会の関連集会として，講演会・懇親会を下記の通り開催しますのでご出席戴きたくご案内申し上げます。

1. 日　　時：昭和56年10月5日（月）17：00～20：00
2. 場　　所：岐阜大学教育学部
3. 演　　題：シドニーの国際植物学会議に出席して
   (1) シンポジウムを中心に（秋山　優氏，島根大学教育学部生物学教室）
   (2) エクスカーションを中心に（横浜康継氏，筑波大学下田臨海実験センター）
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Jap. J. Phycol. (Sôrui) 29: 73-78. June 20, 1981

# Ultrastructure of a red tide chloromonadophycean alga, *Chattonella* sp., from Kagoshima Bay, Japan

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NORO, T. and NOZAWA, K. 1981. Ultrastructure of a red tide chloromonadophycean alga, *Chattonella* sp., from Kagoshima Bay, Japan. Jap. J. Phycol. 29: 73-78.

A chloromonad associated with red tides in Kagoshima Bay, Japan was isolated. Cells measure 47.0±4.0 $\mu$m long and 24.8±1.2 $\mu$m wide ($\bar{x}$±95% C.I.). A gullet is seen to be present at the ultrastructural level. Two flagella, one of which possesses hairs, are attached at the base of the gullet and are associated with the nucleus by a rhizoplast. The cell lacks a wall. A large number of vacuoles, lipid bodies, and chloroplasts occupy the peripheral layer of the cytoplasm. The chloroplasts contain lamellae of 3 thylakoids, lipid droplets, and pyrenoids. The nucleus contains 1-4 nucleoli and scattered chromatin. Golgi bodies and mitochondria occur arcund the nucleus, but no contractile vacuoles, eyespots, trichocysts or mucocysts are present. It is suggested that this organism is a speries of *Chattonella*.

*Key Index Words*: Chattonella; *Chloromonadophyceae*; *chloroplast*; *flagellum*; *Kagoshima Bay*; *lipid body*; *red tide*; *rhizoplast*; *ultrastructure*.

From June to August, 1977, and again during the same months in 1978, blooms of a chloromonadophycean alga were observed in Kagoshima Bay. This marine chloromonad is the most common red tide alga causing mortality of yellow tail fish in the coastal areas of Japan. ADACHI (1974) identified it as *Hornellia* SUBRAHMANYAN (1954). HOLLANDE *et al.* (1956) considered *Hornellia marina* SUBRAHMANYAN to be the synonym of *Chattonella subsalsa* BIECHELER (1936) and this opinion seems to be accepted by most taxonomists.

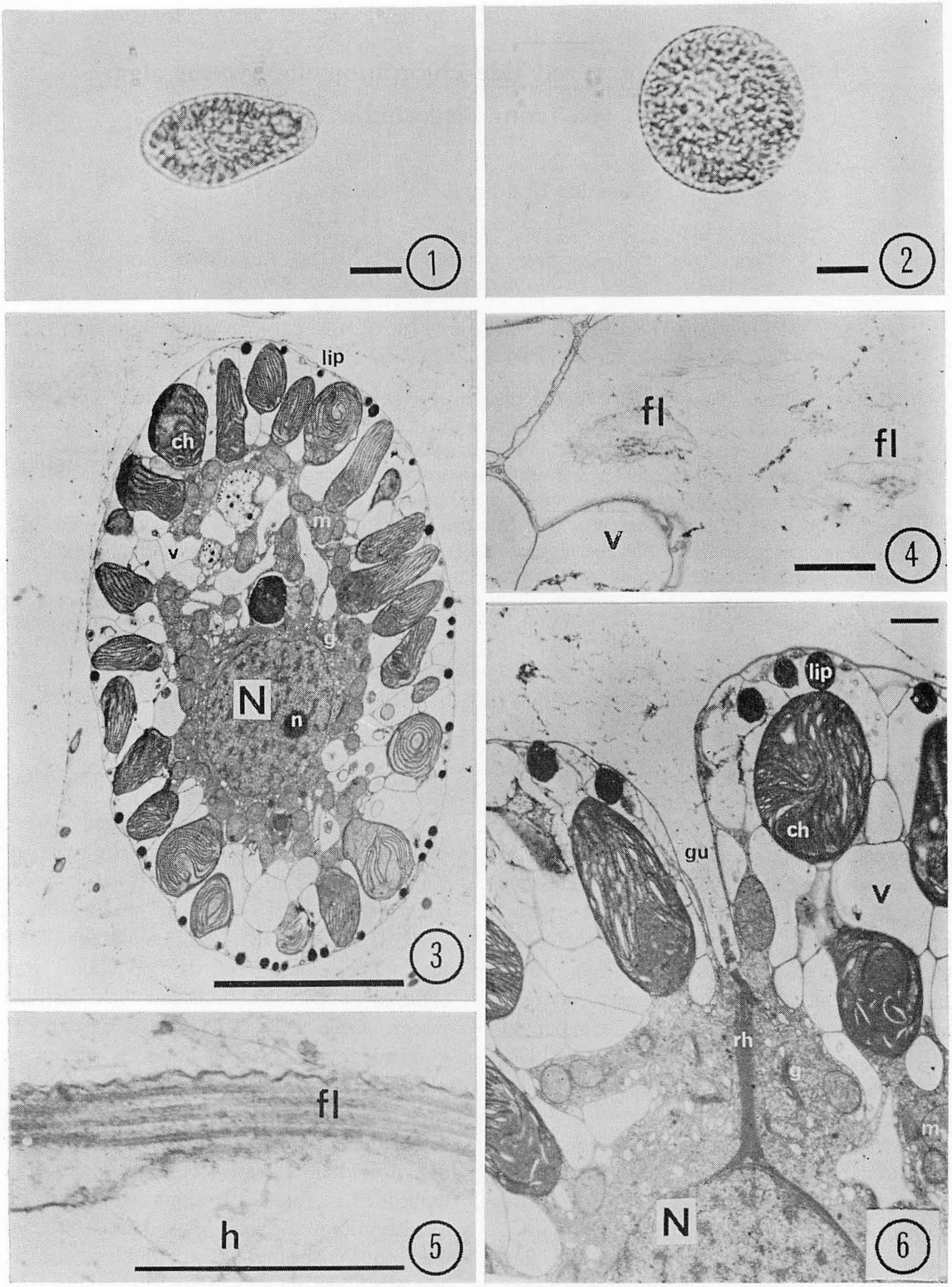
*Chattonella* ultrastructure has been studied by MIGNOT (1976) (on *C. subsalsa* BIECHELER) and LOEBLICH *et al.* (1977) [on *C. japonica* (=*Fibrocapsa japonica*) LOEBLICH *et al.*]. LEADBEATER (1969) also studied the fine structure of *Olisthodiscus luteus* CARTER that was subsequently transfered to *Chattonella* by LOEBLICH *et al.* (1977). The purpose of this paper is to present a general description of *Chattonella* sp. from Kagoshima Bay.

## Materials and Methods

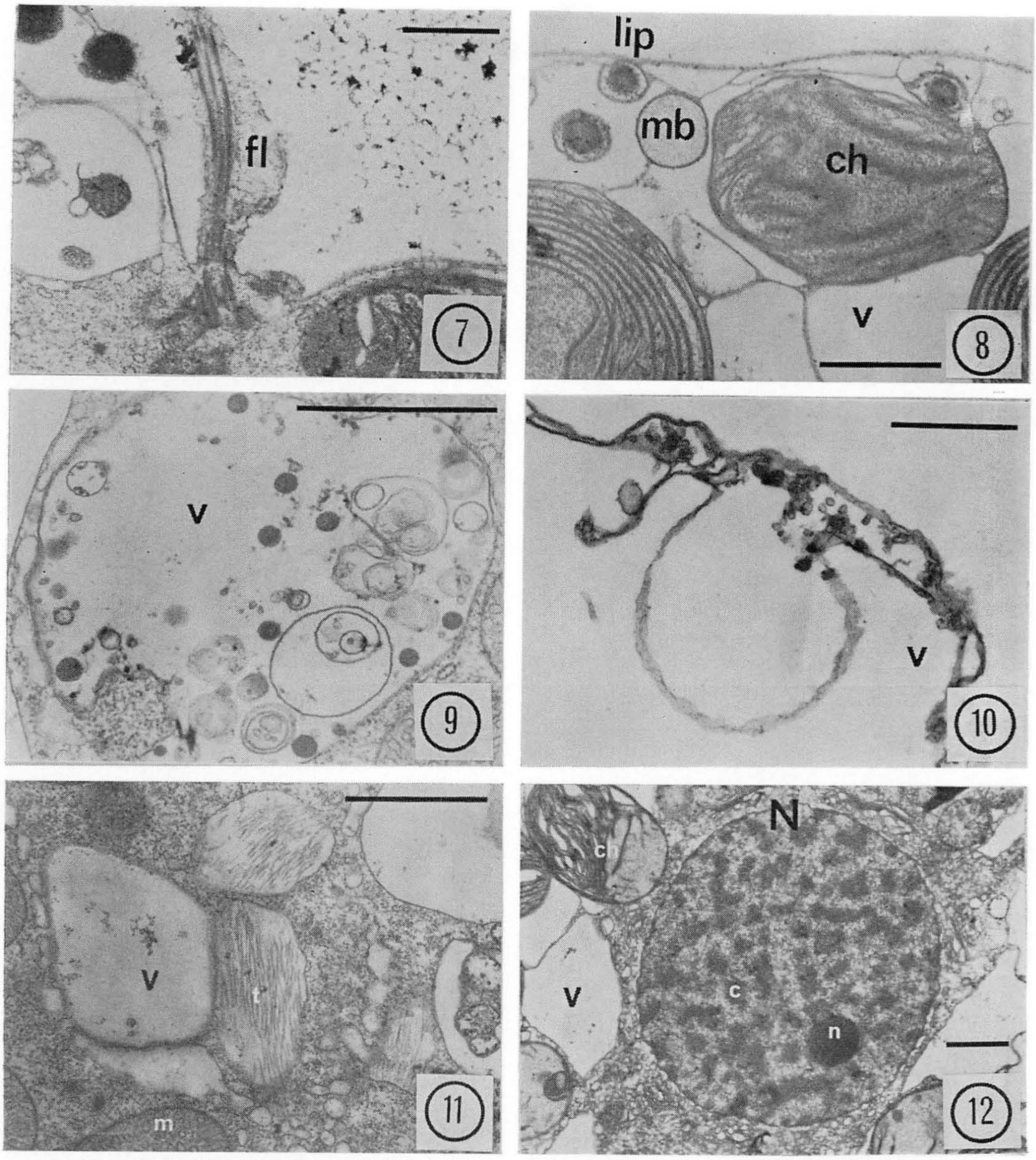
Specimens utilized for this study were collected in July, 1978, from the port of Kagoshima. The unialgal isolates were grown in 2% ESP enriched sea water at 20-23°C under a 12: 12 LD cycle (ca. 4,000 lux). The salinity of the medium was lowered to 25‰ by dilution with distilled water. Cells were fixed for 1.5 hrs. in 2% glutaraldehyde with Milloning's buffer at pH 7.5. After several washes in the buffer, they were postfixed in buffered 1% osmium tetroxide. All cells were subsequently dehydrated in a graded ethanol series and embedded in Epon. Sections were cut on an ultramicrotome using glass knives, stained with aqueous uranyl acetate and lead citrate, and examined using a H-300 Hitachi electron microscope.

## Observations

*Light microscopy.* Motile cells of the

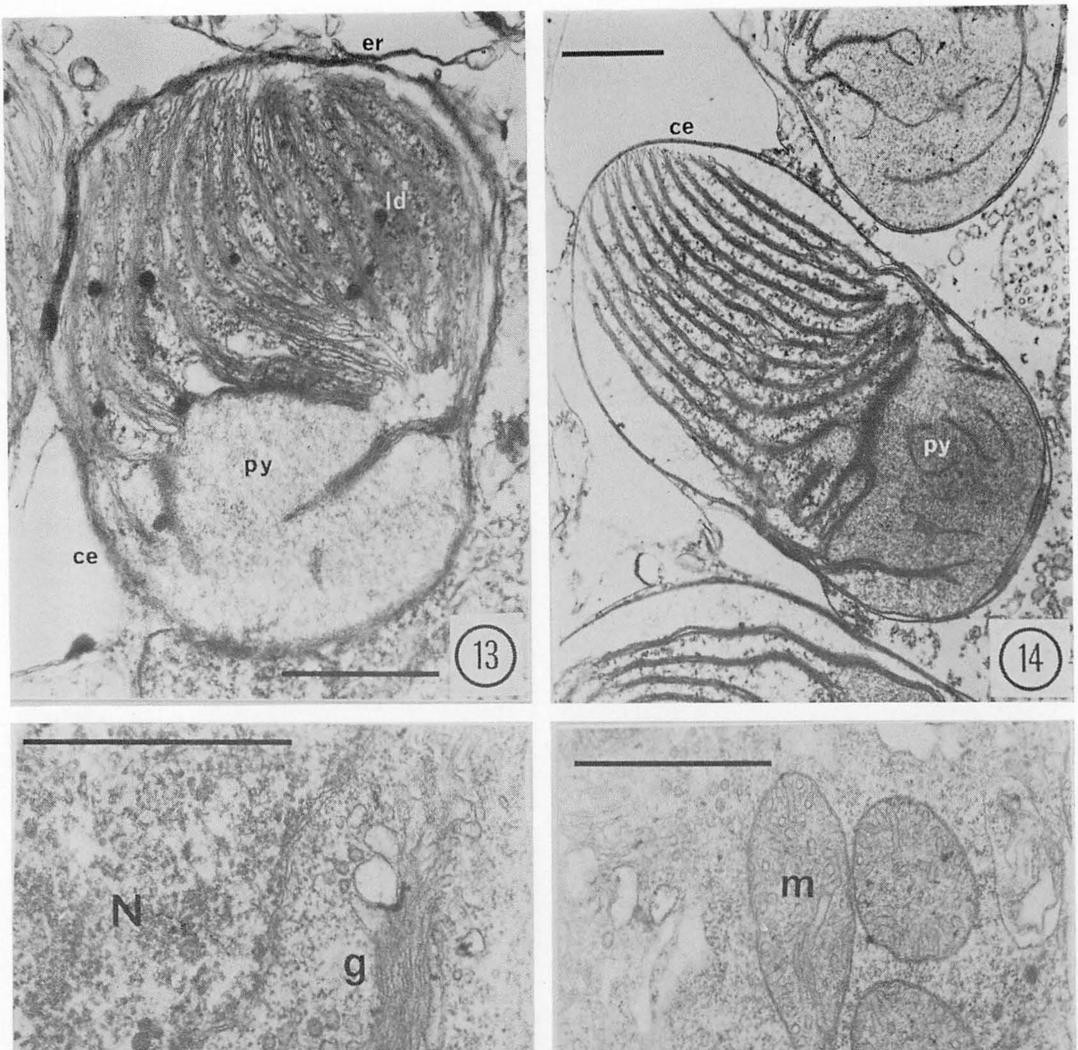



Figs. 1–2. Light micrographs of living cells of *Chattonella* sp. 1. Lateral view of elongated cell showing chloroplasts. No trichocyst rods are seen. Scale=10 μm; 2. Round cell produced under unfavorable conditions as viewed with the light microscope. The flagella are detached from the cell. Scale=10 μm.




Figs. 3-6. Electron micrographs of *Chattonella* sp. Scale = 1 $\mu$m. 3. Longitudinal section of *Chattonella* sp. showing chloroplasts (ch), vacuoles (v), and lipid bodies (lip) in large numbers, and dense cytoplasmic layer surrounding nucleus (N). Also note nucleolus (n), mitochondria (m), and Golgi bodies (g). The flagellar apparatus is not present in this section; 4. Transverse section of two flagella (fl); 5. Longitudinal section of posterior flagellum showing the hairs (h); 6. Gullet (gu) and rhizoplast (rh) which runs directly from the basal bodies of flagella to the nucleus.

Figs. 7-12. Electron micrographs of *Chattonella* sp. 7. Longitudinal section through the base and transition zone of flagellum; 8. The vesiclar cortex containing chloroplast (ch), lipid bodies (lip), and microbody (mb); 9. Thin section of vacuole containing material; 10. Envelope of lipid body after discharge of material; 11. Cytoplasmic region where numerous vesicles occur with tubular contents (t). The tubules are thought to be stored flagellar hairs; 12. A typical interphase nucleus. The nucleus is bound by a double nuclear envelope and contains a nucleolus (n) and scattered chromatin (c).




Figs. 13–16. Electron micrographs of *Chattonella* sp. 13. Chloroplast fixed in glutaraldehyde and osmium tetroxide. External to girdle band is the chloroplast envelope (ce) and endoplasmic reticulum (er). Chloroplast stroma contains large numbers of lipid droplets (ld). Simple internal pyrenoids show a lamella passing into the pyrenoid (py); 14. Chloroplast with 3 thylakoid lamellae fixed in osmium tetroxide; 15. Vertical section through the Golgi body. Note the swollen ends of the cisternae and the adjacent Golgi vesicles. The Golgi body is situated above the nucleus; 16. Mitochondria showing a two-membrane envelope and tubular cristae. The elongated mitochondrion is dividing.

organism are pear-shaped with two flagella arising in a gullet. The cells are 47.0±4.0 μm long and 24.8±1.2 μm wide ($\bar{x}$±95% C. I.) (Fig. 1). Under unfavorable conditions, these cells altered to a spherical shape (Fig. 2). The periplast is thin and flexible, and in some instances numerous discoid chloroplasts and cytoplasmic refractive bodies, assumed to be lipid globules, are located just beneath the cell membrane. The species lacks an eyespot. Although chloromonadophycean algae are generally bright green in color, this organism forms golden yellow colored blooms.

*Electron microscopy.* Fig. 3. is a longitudinal section of the organism showing profiles of most of the organelles except the flagella. The cell is bounded only by a cytoplasmic membrane, without a cell wall or scales. Two flagella extend from the base of a gullet (Fig. 4). The axonemes appear to have the typical 9+2 microtubular arrangement (Figs. 4, 5, 7). One of the flagella has a row of fine hairs (Fig. 5). There is a broad, striated flagellar root which runs directly from the basal bodies to the nucleus where it appears to be attached to the nuclear envelope (Fig. 6). Many earlier workers termed this type of root a rhizoplast, and it has been found in *Chattonella subsalsa* (MIGNOT 1976) as well as in *Olisthodiscus luteus* (LEADBEATER 1969). Vesicles containing fibrous material occur in the protoplast, and this type of vesicle has been previously reported in *C. subsalsa* (MIGNOT 1976) and *C. japonica* (LOEBLICH and FINE 1977). The fibrous material appears to be an early stage in development of the flagellar hairs. Large numbers of vacuoles and chloroplasts occupy most of the region between the cell membrane and the layer of cytoplasm surrounding the nucleus (Fig. 3, 8). The vacuoles are easily broken in the fixative solution, especially under low osmotic conditions. Sometimes the vacuoles contain digested materials or lipid bodies (Fig. 9). The arrangement of lipid bodies beneath the surface of the cell membrane can be seen in Fig. 8. Each sphere is enclosed in a vesicle surrounded by a single membrane (Fig. 10). Chloroplasts are 2.4-2.5 μm long× 1.5-3.3 μm wide and generally disc-shaped (Figs. 13, 14). The lamellae are arranged approximately parallel to the longitudinal axis of the chloroplasts, each band consisting of 3 thylakoids (Fig. 14). The chloroplast stroma contains large amounts of small electron dense materials which are assumed to be lipid droplets (Fig. 13). Large pyrenoids penetrated by lamellae are present in the chloroplast. External to the girdle band is the chlorplast envelope which is bound by endoplasmic reticulum. This endoplasmic reticulum may be involved in maintaining the chloroplast in position, but a direct continuity between the nuclear envelope and the endoplasmic reticulum is not present. The nucleus is also surrounded by a two-membrane envelope (Fig. 12). The nuclei possess 1-4 nucleoli and distinct chromatin which is evenly distributed within the nucleoplasm. This type of densely granular chromatin is called heterochromatin by DODGE (1973 p. 143). Several Golgi bodies are situated around the nucleus (Fig. 15). Each of the Golgi bodies consists of a stack of 4 or 5 cisternae. Numerous mitochondria are also found around the nucleus (Fig. 16). They are elongate and ovoid in shape. The inner mitochondrial membrane forms tubular cristae which have slightly constricted bases.

## Discussion

Our observations on this chloromonad are partly in agreement with those on *C. subsalsa* (MIGNOT 1976) in the following ways: 1) at the anterior end of the cell there is a narrow canal-like gullet; 2) two flagella, nearly the same in length, arise close to each other from the base of a gullet; 3) only the anterior flagellum bears hairs or mastigonemes; 4) there is a rhizoplast; 5) the nucleus is filled with dense chromatin; 6) the vesicular cortex contains many chloroplasts with basal pyrenoids and lipid bodies. We noted, however, that the color of the cells differed in our chloromonad from that of *C. subsalsa*. Cells of *Chattonella* sp. were golden yellow, whereas those of *C. subsalsa* were green. Little variation in cell dimensions occurred within these species. We have never observed mucocysts in this chloromonad, but they have been seen in *C. subsalsa*. In *C. subsalsa* no lamellae enter the pyrenoid, while several lamellae pass through the pyrenoid in *Chattonella* sp.. This suggests that this chloromonad and *C. subsalsa* are not the same species, but they have many similarities and may be closely related.

Detailed ultrastructural descriptions were given by LEADBEATER (1969) for *C. luteus* (as *Olisthodiscus luteus*) and LOEBLICH *et al.* (1977) for *C. japonica*. There are no detailed observations on *C. akashiwo* (=*Heterosigma akashiwo*, see LOEBLICH *et al.* 1977) using the electron microscope. Nevertheless, all of these organisms greatly differ from *Chattonella* sp. in cell dimensions, plastid number, situation of the groove, and presence of mucocysts.

Some morphological differences, especially in cell length and width, were observed between the specimens of *Chattonella* collected from Maizuru Bay, Seto Inland Sea and Yatsushiro Bay (ONO *et al.* 1979). One of these three strains may be *Chattonella subsalsa* BIECHELER, but additional studies are needed to answer this question. In this paper we apply the name *Chattonella* sp. to the chloromonad from Kagoshima Bay.

## Acknowledgements

Our sincere thanks are due to Mr. T. ARAMAKI, Kagoshima Prefectural Fisheries Station, for supplying the culture of *Chattonella* sp.. We thank Prof. R. E. NORRIS, Univ. of Washigton, for reading the manuscript, and Prof. M. CHIHARA and Dr. Y. HARA, Univ. of Tsukuba, for their kind suggestions.

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**野呂忠秀・野沢洽治：鹿児島湾産緑色鞭毛藻 *Chattonella* sp. の微細構造について**

鹿児島湾で1978年に発生した赤潮鞭毛藻 *Chattonella* sp. は長さ 47.0±4.0 μm, 幅 24.8±1.2 μm で，前方の溝から二本の鞭毛を前後に伸出しており，内一本は羽型であった。この鞭毛の基部は，リゾプラストによって核膜と結ばれていた。さらに本藻は細胞壁を欠き，多数の液胞，脂肪球，葉緑体が細胞の表層を占めていた。葉緑体内部には，三層からなる多数のチラコイドバンド，油滴やチラコイドの陥入したピレノイドがみられた。核の中には1～4個の核小体と多数のクロマチンがあり，ゴルジ体やミトコンドリアが核周辺に散在していた。しかし収縮胞，眼点，刺胞，粘液胞は観察されなかった。以上の結果から本種は緑色鞭毛藻 *Chattonella* 属の一種であることが確かめられた。(890 鹿児島市下荒田 4-50-20, 鹿児島大学水産学部)

Jap. J. Phycol. (Sôrui) 29: 79-80. June 20, 1981

# A sex chromosome in *Cymathaere japonica* MIYABE et NAGAI

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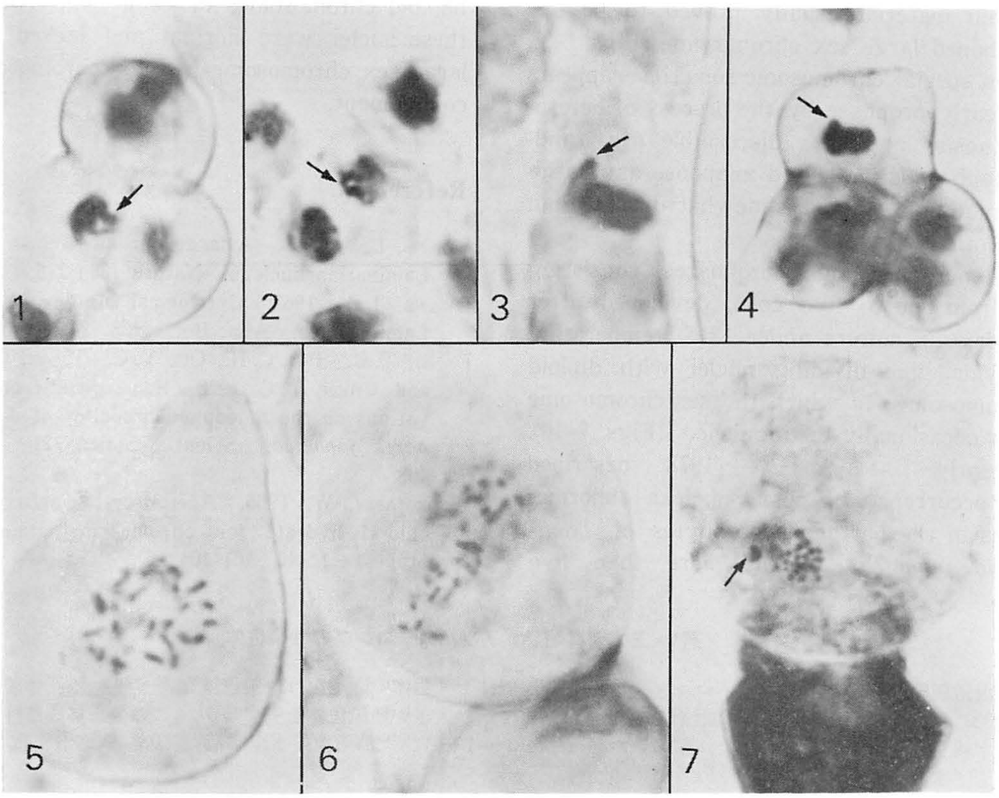
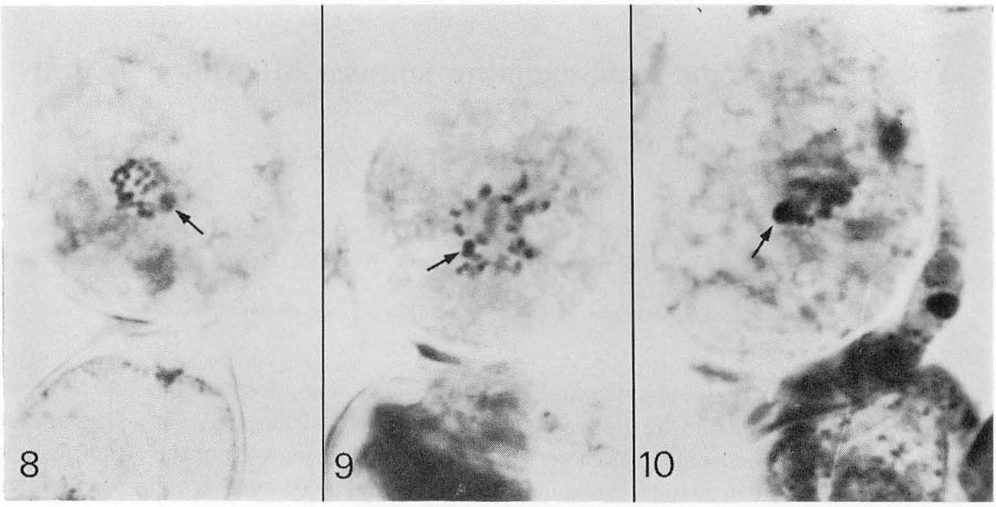
*Key Index Words*: Cymathaere japonica; *Phaeophyta*; *sex chromosome*.

The gametophytes and sporophytes used in culture were obtained from fertile fronds of *Cymathaere japonica* collected in 10 meters depth at Kyoeicho, Rausu in eastern Hokkaido on September 26, 1980. The fronds were fixed with acetic alcohol (1 : 3) and stained by the method recommended by Wittmann (1965) for cytological observations. The haploid chromosome number ranged from 28-34 in the cells of female gametophytes (Fig. 5) and a reliable number seems to be 33, as shown in Table 1. The presence of a large chromosome has been reported by Evans (1963, 1965) in several Laminariaceous species from the Atlantic, among which *Saccorhiza polyschides* was shown to

Table 1. Chromosome count in fifty cells of female gametophytes of *Cymathaere japonica*.

| Number of chromosome (n) | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
|---|---|---|---|---|---|---|---|
| Number of cell | 4 | 3 | 6 | 7 | 9 | 14 | 7 |






Figs. 1-10. Mitosis in the gametophytes and sporophytes of *Cymathaere japonica* Miyabe et Nagai. 1-4. Sex chromosome (arrows) at metaphase in the cell of male gametophytes; 5. Chromosomes in the cell of female gametophyte; 6. Metaphase (2n) in the sporophyte at one-celled stage; 7-10. Sex chromosome (arrows) at metaphase in the sporophytes of one-celled stage. Magnification; All figures, ×2,300.

have a markedly large X-chromosome in the female gametophyte. The well defined metaphase figure in the male gametophytes in our material usually proved to be one U-shaped large sex chromosome (Figs. 1-3). This special chromosome sometimes appears by early prophase by the process of heteropyknosis and is discernible in mid-metaphase (Fig. 4) and anaphase as a large chromosome stained somewhat deeper than the other chromosomes.

Numerous young sporophytes, consisting of from one to five cells, developed after 14 days in culture under 13°C temperature provided fine dividing nuclei with diploid chromosomes in which the sex chromosome was occasionally distinguished (Figs. 7-10). Recently FANG *et al.* (1978) described the occurrence of some nuclear abnormalities in the parthenosporophytes of *Laminaria japonica*. Among more than five hundred sporophytes with dividing nuclei observed we could see nine parthenosporophytes at the two-celled stage with haploid chromosomes in each cell. All of these nuclei were normal and lacked the large sex chromosome in their chromosome complement.

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**籔　凞*・三本菅善昭**：アツバスジコンブの性染色体**

北海道羅臼で採集したアツバスコンブを培養し，配偶体と芽胞体の固定を行い染色体を調べた。雌性体では n ＝約33の染色体数が得られた。雄性体と芽胞体は通常１ケの大きい性染色体を有するが，この染色体は雄性体ではU字状を呈することを確かめた。(*041 函館市港町３―１―１ 北海道大学水産学部 **085 釧路市桂恋 116 北海道区水産研究所)

Jap. J. Phycol. (Sôrui) 29: 81-84. June 20, 1981

# Pollutant levels in the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL

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SIVALINGAM P. M. 1981. Pollutant levels in the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL. Jap J. Phycol. 29: 81-84.

Investigations on the seasonal variation of the following trace metal pollutants, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb and Zn, in the abundantly found Malaysian sea lettuce, *Ulva reticulata* Forsskal, indicated the presence of amounts below detectable levels of Cd, Co, Cr and Cu the year through while Fe, Hg, Mn, Ni, Pb and Zn had three peaks between the months of January-March, May-July and September-December. These fluctuations correspond well to the peak productivity periods of the alga.

Contaminants of persistent pesticide residues of pp'DDE, $\alpha$-, $\beta$-, $\gamma$- BHC and aldrin in this algal species fluctuated between $9.6\pm0.05$, $0.089\pm0.012$, $1.03\pm0.015$, $0.48\pm0.04$ and $606.8\pm0.53$ ppbs, respectively. PCBs (KC-400), on the other hand, ranged between $16.6\pm0.015$ ppb.

From the viewpoint of environmental contaminants this algal species appears to be within the safety levels for human consumption.

*Key Index Words*: *environmental pollution*; *PCBs*; *persistent pesticides*; *trace metals*; Ulva.

Marine pollution studies, in the Malaysian context, are very scarce (SIVALINGAM *et al.* 1978, 1979a, 1980a). Trace metals pollutant levels in some marketed shellfish have been reported by LEE and LOW (1976), while PCBs and persistent pesticide residues in cultured cockles, *Anadara granosa*, were studied by SIVALINGAM *et al.* (1980b). Related studies on solid and liquid shrimp paste have also been conducted (SIVALINGAM *et al.* 1980c). Elaborate laboratory studies on the modes of bioaccumulation of trace metals in the local green mussel, *Perna viridis* L., and the rock oyster, *Saccostrea cucullata* BORN, have also been carried out (SIVALINGAM and BHASKARAN 1980; SIVALINGAM 1979b). The Consumers Association of PENANG (1976) reported extensive pollution of the Juru River and its detrimental effects on the adjacent fishing communities A study on the Hg content of human hair in fishing communities in the State of Penang verified these findings (SIVALINGAM and AZURA bt. SANI 1980).

Studies (SIVALINGAM 1977, 1978a) on marine algae and their succession patterns had indicated the existence of 3 species of Cyanophyta, 21 species of Rhodophyta, 8 species of Phaeophyta and 12 species of Chlorophyta along the shores of Penang Island. Analyses of biodeposited trace metals and minerals in Penang Island marine algae have also been reported (SIVALINGAM 1978b, 1979b). At this location the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL, is the dominent species and its biochemical evaluation as a potential human food source (SIVALINGAM 1979c) and the effects of high concentration stresses

Abbreviations: $\gamma$-BHC, $\gamma$-benzene hexachloride; pp'DDE, pp'l, 1-di-chloro-2, 2-bis (p-chlorophenyl) ethylene; PCB, polychlorinated biphenyls.

of trace metals on the mode of biodeposition have been reported (SIVALINGAM 1978c).

Following this line of investigation the author has endeavoured to make a detailed study on the seasonal fluctuation of trace metals, PCBs and persistent pesticide residues content in *Ulva reticulata* FORSSKÅL prior to utilization of it as a significant food source.

## Materials and Methods

*Ulva reticulata* FORSSKÅL was harvested during low tides periodically between January 1977-December 1978 at the Marine Depot, Penang. The fronds were cleaned of epiphytes and other contaminants by washing with filtered sea water and then with distilled water. The clean thalli were dried at 90°C for about 72 hr and pulverized using a pestle and mortar before processing for analysis.

The presence of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn were determined by predigesting 500 mg of dried sea lettuce overnight in 10 ml of a mixture of hypochloric and nitric acid (1 : 2) before digestion on an electrothermal heater in a Kjeldahl flask. The digest was filtered and diluted to 100 ml before analysis using a Varian Techtron AA 120 atomic absorption spectrophotometer.

The total Hg content of the dried thalli was determined using a Coleman Mercury Analyzer MAS-50 according to the method of STANLEY *et al.* (1971).

PCBs and persistent pesticide residues were extracted from 5 gm of powdered thalli with n-hexane. The extract was dehydrated in $Na_2SO_4$ column, adsorbed on a silica gel column and eluted with 100 ml of n-hexane and 15% ether in n-hexane as eluates 1 and 2 for PCBs and DDE and other pesticide residues, respectively. The two eluates were then concentrated separately in a Kuderna-Danish concentrator and subjected to gas chromatographic analysis. GC-analysis was performed under the following conditions; column packing-OV 17/1.5% chromosorb W, detector and column temperature-210 and 190°C, respectively, $N_2$ flow-30 ml/min., chart speed-10 mm/min., range-$10^2 \times 8$ and an electron capture detector of $^{63}Ni$. Identification and quantification of the PCBs and pesticide residues were done through comparison with gas chromatograms of authentic samples.

## Results and Discussion

Table 1 shows the seasonal variation in trace metal contents of *Ulva reticulata* FORSSKÅL. It is obvious that the trace metals Fe, Hg, Mn, Ni, Pb and Zn are fairly low in content as compared with amounts reported for other algal species of Penang Island (SIVALINGAM 1978b) or the seaweeds of Goa, India, Öresund Area, Sweden and Vostok Bay, Sea of Japan (AGADI *et al.* 1978; HAGEHALL 1973; SAENKO *et al.* 1976). The quantity of these trace metals however, appears to vary corresponding with the three maximal productivity periods which fall between the months of January-March, May-July and September-December (SIVALINGAM 1979c).

Table 1. Seasonal variations in trace metal content in the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL.

| Month | Concentrations (ppm $g^{-1}$ dry wt.) Fe | Hg | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|
| Jan. | 810 | 0.0625 | 29 | 94 | BDL+ | 46 |
| Feb. | 1,980 | 0.0632 | 138 | 60 | 128 | 60 |
| Mar. | 1,470 | 0.0619 | 66 | 46 | 100 | 133 |
| Apr. | 960 | 0.0628 | 62 | 11 | 113 | 357 |
| May. | 2,660 | 0.0615 | 130 | 34 | BDL | 128 |
| Jun. | 1,570 | 0.0625 | 154 | 11 | 56 | 77 |
| Jul. | 2,960 | 0.0598 | 63 | 24 | 95 | 47 |
| Aug. | 1,290 | 0.0628 | 62 | BDL | 56 | 36 |
| Sep. | 1,560 | 0.0640 | 67 | 12 | BDL | 40 |
| Oct. | 1,060 | 0.0604 | 173 | BDL | 53 | 50 |
| Nov. | 1,000 | 0.0624 | 32 | 268 | BDL | 89 |
| Dec. | 400 | 0.0654 | 29 | 20 | 91 | 91 |

+ BDL: below detectable levels. Also take note that the contents of Cd, Co, Cr and Cu were undetectable the whole year through except for Cu which had a value of 34 ppm in November.

Table 2. Mean PCBs and persistent pesticide residues content in *Ulva reticulata* FORSSKÅL.

| Contaminant | Concentration (ppb $g^{-1}$ dry wt.) |
|---|---|
| PCB (KC 400) | 16.6±0.15 |
| DDE | 9.6±0.05 |
| α-BHC | 0.089±0.012 |
| β-BHC | 1.03±0.015 |
| γ-BHC | 0.48±0.04 |
| Aldrin | 606.8±0.53 |

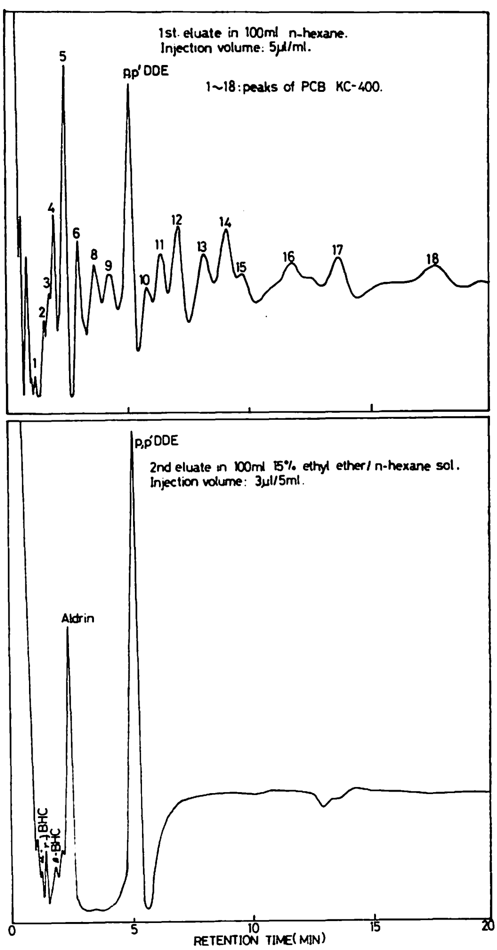


Fig. 1. Gas chromatograms of PCBs and persistent pesticides of 1st and 2nd eluates.

Table 2 shows the mean contents of PCBs and persistent pesticide residues in the fronds of *U. reticulata,* while Figure 1 is the gas chromatogram of eluates 1 and 2 obtained from silica gel. As compared to the levels found in a liter of sea water around the Island of Penang (1980a) these are lower by exponential 3731 times for DDE, 449-1798 times for α-BHC, exponential-1749 times for β-BHC, 318-2849 times for γ-BHC and 3.2-30 times for aldrin. However, although no amounts of PCBs were detectable in 1 liter sea water samples from Penang Island, a contaminant amount is detectable at 16.6 ppb $g^{-1}$ dried thalli. This quantity does not seem detrimental to human health and is comparable to those reported by AMICO *et al.* (1979) for seaweeds of the East Coast of Sicily.

Based on the present data, it is concluded that the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL, is safe to be considered as a possible human food source from the viewpoint of environmental contaminants.

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## P. M. シバリンガム：マレーシア産 *Ulva reticulata* FORSSKÅL における環境汚染物質量

多量に見出されるマレーシア産の *Ulva reticulata* 中の Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn などの環境汚染微量金属の季節的変動を調査した。その結果，Cd, Co, Cr, Cu は年間を通してもその存在量は検知能以下であったが，Fe, Hg, Mn, Ni, Pb, Zn は一年の間の1～3月，5～7月，および9～12月の3回に増加のピークがみられた。この変動はこの藻の最大現存量とよく一致する。

この藻体中の持続性農薬残溜物である pp' DDE は 9.6±0.05 ppb, α-BHC は 0.089±0.012 ppb, β-BHC は 1.03±0.015 ppb, γ-BHC は 0.48±0.04 ppb, そしてアルドリンは 606.8±0.53 ppb の変動を示した。PCBs (KC-400) は 16.6±0.015 ppb の変動幅であった。

環境汚染物質の点からみれば，*U. reticulata* は人間の利用消費にも安全な範囲にあると思われる。

Jap. J. Phycol. (Sôrui) 29: 85-93. June 20, 1981

# Taxonomic studies on *Scenedesmus* in Japan 1. On *Scenedesmus acuminatus* (LAG.) CHOD. and its varieties and *S. javanensis* CHOD.

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OOSHIMA, K. 1981. Taxonomic studies on *Scenedesmus* in Japan 1. On *Scenedesmus acuminatus* (LAG.) CHOD. and its varieties and *S. javanensis* CHOD. Jap. J. Phycol. 29: 85-93.

In order to determine the circumscription of *Scenedesmus acuminatus* and its closely related taxa, a number of morphological features and their variations were examined based upon sixteen isolates cultured in seven kinds of media. Consequently, it was confirmed that the following characters were apparently stable: 1) the shape of cells: lunate or sigmoid, 2) the arrangement of cells in the 4- and 8-celled coenobia: linear, alternate or zigzag, 3) the form of colonies: flat, curved or twisted. On the basis of these features, *S. acuminatus* var. *acuminatus*, *S. acuminatus* var. *falcatus*, *S. acuminatus* var. *tortuosus*, and *S. javanensis* were recognized as distinct taxa.

*Key index words*: *Green algae; Chlorococcales; Chlorophyceae;* Scenedesmus; S. acuminatus; S. javanensis; *taxonomy*.

Since MEYEN (1829) established the genus *Scenedesmus*, four monographs have been published by CHODAT (1913, 1926), G. M. SMITH (1916) and UHERKOVICH (1966). Numerous species and infraspecific taxa belonging to *Scenedesmus* have been described based only on a few samples from natural collections. Consequently, the taxonomy of the genus, which contains more than 100 species, is currently in confusion.

On the other hand, TRAINOR and co-workers have investigated many strains of polymorphic *Scenedesmus* and obtained excellent results, especially on morphological variability and the control of unicell formation (TRAINOR 1966, 1967, 1969, 1979; TRAINOR and ROSKOSKY 1967; TRAINOR and ROWLAND 1968; TRAINOR and SHUBERT 1974; SHUBERT and TRAINOR 1974; TRAINOR *et al.* 1976). SHUBERT (1975) has made a new attempt to describe a polymorphic species on the basis of morphological and physiological characteristics observed in the cultures. The use of culture methods is today of primary importance to taxonomic studies of *Scenedesmus*. In order to determine the circumscription of the individual species and infraspecific taxa, it is necessary to obtain as many cultures as possible and to examine the stability and flexibility of related characteristics.

The present paper constitutes the first of a series of taxonomic studies on *Scenedesmus* in Japan, and deals with the morphology and taxonomy of *S. acuminatus* (LAG.) CHOD. and several closely related taxa, maintained in unialgal cultures.

## Materials and Methods

The unialgal cultures used for this study were originally isolated from the algal habitats summarized in Table 1. All the cultures were immediately established from a 4- or 8-celled coenobium by using PRINGSHEIM's micropipette-washing method (STEIN

Table 1. Source of unialgal cultures investigated.

| Strain No. | Localities | Dates | Cell No./colony |
|---|---|---|---|
| 421 | Senzokuike pond, Tokyo | Dec. 10, '75 | 4 |
| 452 | Sanaruko-lake, Shizuoka | May 12, '76 | 4 |
| 459 | Sanaruko-lake, Shizuoka | May 12, '76 | 4 |
| 462 | Sanaruko-lake, Shizuoka | May 12, '76 | 4 |
| 473 | Sanaruko-lake, Shizuoka | May 17, '76 | 8 |
| 492 | Ashigaike pond, Aichi | May 18, '76 | 4 |
| 495 | Ashigaike pond, Aichi | May 18, '76 | 4 |
| 501 | a small pond, Okayama | Oct. 16, '75 | 8 |
| 505 | a small pond, Okayama | Oct. 16, '75 | 8 |
| 510 | a small pond, Okayama | Oct. 16, '75 | 4 |
| 539 | Ashigaike pond, Aichi | Aug. 24, '76 | 8 |
| 555 | a small pond, Aichi | Aug. 25, '76 | 8 |
| 562 | Ashigaike pond, Aichi | Aug. 25, '76 | 4 |
| 630 | a small pond, Ibaraki | May 30, '77 | 8 |
| 699 | a small pond, Saitama | May 12, '78 | 4 |
| 703 | a moat around the castle, Shimane | Aug. 21, '78 | 8 |

Table 2. Composition of media (mg/$l$).

| Constituent \ Medium | A | B | C | D10 | D200 | F | AWB |
|---|---|---|---|---|---|---|---|
| $KNO_3$ | 300 | 300 | 300 | 30 | 1.5 | 300 | 300 |
| $NH_4NO_3$ | 200 | 200 | 200 | 20 | 1 | 200 | 200 |
| $KH_2PO_4$ | 30 | — | 20 | 2 | 0.1 | 20 | 20 |
| $K_2HPO_4$ | — | 30 | 10 | 1 | 0.05 | 10 | 10 |
| $MgSO_47H_2O$ | 50 | 50 | 50 | 5 | 2.5 | 50 | 50 |
| $NaHCO_3$ | 20 | 20 | 20 | 2 | 0.1 | 20 | 20 |
| Fe-citrate | — | — | — | — | — | 0.5 | 0.1 |
| Soil Extract | — | — | — | — | — | — | 10 m$l$ |
| pH | 4.6 ~ 4.8 | 8.2 ~ 8.4 | 6.8 ~ 7.0 (C–AWB) | | | | |

1973), and were maintained at 20°C under fluorescent lights of ca. 3000 lux intensity with a 12/12 hr light-dark cycle.

Four weeks after the beginning of incubation, a drop of the original cultures was suspended by shaking and was transferred into a series of test tubes containing the seven kinds of media shown in Table 2. Medium A, B and C were different in acidity. Medium D10 and D200 were made by diluting medium C and were the same in acidity. Medium F was also made by adding ferric citrate to medium C. Medium AWB with 0.6% agar was employed as an agar medium for the agar-water biphasic culture medium, which was composed of two phases, a solid phase of agar and a liquid phase of water (OOSHIMA 1975). This medium was also employed for isolation. The others were used as liquid media. All the media were sterilized by autoclaving. These series of test tubes inoculated were kept under the same culture conditions mentioned above and were gently shaken every other day.

After two to four weeks, a total of 200–300 individual organisms in each of the test tubes was examined; the percentages of coenobial types were recorded, and the shape, size and arrangement of cells and the form of coenobia were observed under high magnification. The length of the cells was measured and recorded as that of the longitudinal axes of the cells.

## Results and Discussion

*Scenedesmus acuminatus* (LAG.) CHOD. and the related taxa have been classified based on the following characters: the shape and size of cells, the arrangement of cells in each colony, and the form of the 4- and 8-celled coenobia. Concerning the stability and flexibility of these characters, the results obtained in the present investigation examining each strain in various media provides useful information.

*Unicells*: The strains used in this study frequently produced a high percentage of unicells in medium B, and seldom in the others. In the older cultures of medium B, there was a tendency toward a higher percentage of unicells. These formed colonies when transferred into fresh media. The colonies were also similar in shape and size to the original cell. These results suggest that the unicells observed are quite different from those in the polymorphic strains of spiny *Scenedesmus*, reviewed by TRAINOR *et al.* (1976).

*Cell shape and size*: The culture conditions employed in the present investigation produced little abnormal change in the shape of cells in all the vigorous cultures. Cells from newly released colonies were more or less lunate or sigmoid, tapering to a point. They increased gradually in dimension with age. When the cells matured, the proportions between length and width had changed to some degree. They were about one and half times as long as the young cells, and about twice in width. However, they retained the lunate or sigmoid shape. Consequently, the shape of cells proved to be one of the stable characteristics for all strains examined.

On the other hand, the size of cells was variable at each stage of the cultures, especially in the mature condition. The bigger mature cells had a strong tendency to produce 8-celled coenobia.

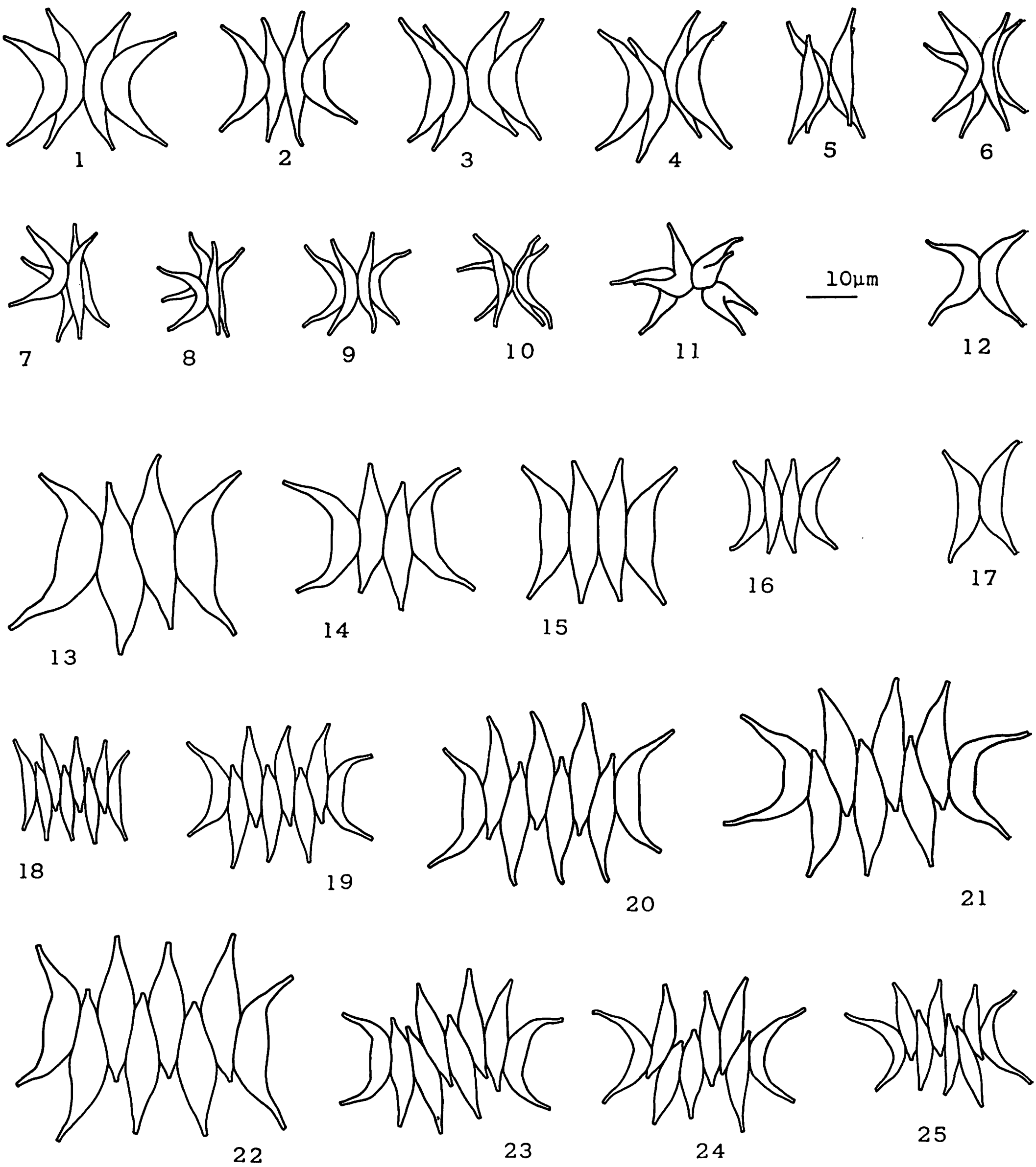
*Cell arrangement*: The cells were regularly arranged in the 4- and 8-celled coenobia in the front view. All the cultures of strains 501, 505 and 510 constantly showed a unique zigzag arrangement of cells in the 4- and 8-celled coenobia (Figs. 40, 43). In the other strains, the cells were arranged either in a linear series or in an alternate series, and never in such a double series as *S. costulatus* CHOD. or *S. ecornis* var. *disciformis* CHOD. The alternate arrangement was more conspicuous in the 8-celled coenobia (Figs. 18–22). This character was stable in each strain examined.

*Colony form*: In vertical view, we can clearly observe the form of colonies in which the cells join one another just like a raft. Each strain kept the form of 4- and 8-celled coenobia constant. The fifteen strains produced either the flat or curved coenobia, while strain 492 distinctively produced the twisted coenobia (Figs. 26–31). The form of the 2-celled coenobia, however, showed strikingly similarity for all strains observed (Figs. 12, 17, 37). According, the form of the 4- and 8-celled coenobia proved to

Table 3. Comparisons of four taxa investigated in the present study.

| Taxa | Cell Shape T : M | | Cell Size T : M | Cell arrangement 4-C | Cell arrangement 8-C | Form of 4-C & 8-C |
|---|---|---|---|---|---|---|
| *S. acuminatus* var. *acuminatus* | L | L | ≑ | 1-a | — | curved |
| var. *falcatus* | L | L | > | 1-a | a | flat |
| var. *tortuosus* | L | L | ≑ | 1-a | a | twisted |
| *S. javanensis* | L | S | > | z | z | flat |

* T, terminal cells; M, median cells; L, lunate; S, sigmoid; 4-C, 4-celled coenobia; 8-C, 8-celled coenobia; a, alternate series; 1, linear series; z, zigzag series.




Figs. 1-12. *S. acuminatus* var. *acuminatus*. 1-5. 4-celled mature coenobia; 6-10. 4-celled young coenobia; 6-8. side view of 4-celled coenobia; 11. vertical view; 12. 2-celled coenobium.

Figs. 13-25. *S. acuminatus* var. *falcatus*. 13-15. 4-celled mature coenobia; 16. 4-celled young coenobium; 17. 2-celled coenobium; 18. 8-celled young coenobium; 21 and 22. 8-celled mature coenobia; 23-25. irregular arrangement of cells in 8-celled coenobia.

be one of the stable characteristics.

On the basis of the stable characters described above, the sixteen strains examined were grouped into four taxa, as summarized in Table 3.

**1. *Scenedesmus acuminatus*** (LAG.) CHOD. var. ***acuminatus*** MAT. Fl. Crypt. Suiss. **1**(**3**): 211. *fig*. 88. 1902.

——**Figs. 1-12**

In Table 4, the percentages of coenobial types observed in the 2-week-old cultures are given for strain 452. The number of cells forming colonies was always two or four in all the media, and the 8-celled coenobia were never found during this investigation. Unicells appeared only in medium B. The 4-week-old cultures of medium B, which produced 29% unicells, were no longer vigorous, and the cells in these cultures were brownish in color and abnormal in shape. Similar results were obtained with strains 421, 459, 539 and 562.

Each cell forming a coenobium was little different in shape and size. The cells in the young coenobia were 19-21 $\mu$m long and 2-2.5 $\mu$m broad, while the largest cells in the mature coenobia were up to 34.5 $\mu$m long and 5.5 $\mu$m broad. The dimensions of the mature cells were approximately equal to those in some descriptions (LAGERHEIM 1882; CHODAT 1902, 1926; SMITH 1920). The shape of the cells was more or less lunate. The terminal cells in the 4-celled coenobia were somewhat more curved than the median cells (Figs. 6-8).

The cells of the 4-celled coenobia were never arranged in a plane. The coenobia were always curved and sometimes semicircular in vertical view (Fig. 11). Although it changed to some degree with age, the curvature of the 4-celled coenobia was constant in all the vigorous cultures. In the front view of the coenobia, on the other hand, the cells were arranged in a linear series (Figs. 1, 2), and sometimes in an alternate series (Figs. 3-5).

From the results of the present investigation, the five strains examined were definitely identified with *S. acuminatus* (LAG.) CHOD. (1902). These results, moreover, supported the opinion of LAGERHEIM (1882), CHODAT (1902, 1926) and SMITH (1916, 1920) that the curvature of the 4-celled coenobia was one of the important characteristics for this species. Accordingly, this taxon can be clearly distinguished from the others.

**2. *S. acuminatus*** var. ***falcatus*** (CHOD.) OOSHIMA nov. comb.

***S. falcatus*** CHOD. Rev. Hydrol. **3:** 146-147. *figs.* 36-37. 1926. ——**Figs. 13-25**

The results obtained from strain 462 are shown in Table 5. The 4-week-old cultures of the strain were not vigorous in medium B and D200. High percentages of the 8-celled coenobia were recorded especially in medium AWB and D10. Unicells were always produced in medium B, and they were rarely found in the others, *e.g.* in medium AWB (strain 462) and in medium C (strain 473). Similar results were obtained with strains 473, 495, 555, 630, 699 and 703.

In each of the 4- and 8-celled coenobia, the terminal cells were different from the median cells in shape and size. The shape of the median cells was slightly lunate, while the terminal cells showed the characteristic curved shape. In most cases, curving was more conspicuous in mature coenobia (Figs. 21, 22) than in young ones (Fig. 18). The terminal cells were longer than the median cells, and were about the same in width. In the largest of the 8-celled coenobia, the terminal cells were up

Table 4. Percentages of unicells and coenobia produced in seven kinds of media (strain 452: *S. acuminatus* var. *acuminatus*).

| 2 w. | AWB | A | B | C | D10 | D200 | F |
|---|---|---|---|---|---|---|---|
| unicells | 0% | — | 1% | 0% | 0% | 0% | 0% |
| 2-celled | 6 | — | 15 | 31 | 52 | 67 | 42 |
| 4-celled | 94 | — | 84 | 69 | 48 | 33 | 58 |
| 8-called | 0 | — | 0 | 0 | 0 | 0 | 0 |

*A : dead

Table 5. Percentages of unicells and coenobia produced in seven kinds of media (strain 462: *S. acuminatus* var. *falcatus*).

| 2 w. | AWB | A | B | C | D10 | D200 | F |
|---|---|---|---|---|---|---|---|
| unicells | 0% | — | 1% | 0% | 0% | 0% | 0% |
| 2-celled | 0 | — | 3 | 0 | 0 | 0 | 0 |
| 4-celled | 12 | — | 84 | 51 | 43 | 79 | 50 |
| 8-celled | 88 | — | 12 | 49 | 57 | 21 | 50 |

*A : dead

to 35.5 $\mu$m long and 7 $\mu$m broad, and the median cells were up to 32.5 $\mu$m long and 7 $\mu$m broad. In the 4-celled coenobia, the terminal cells were up to 42 $\mu$m long and 8.5 $\mu$m broad, and the median cells were up to 34 $\mu$m long and 9 $\mu$m broad.

The form of the 4- and 8-celled coenobia was flat and rarely curved in some degree. The cells in the 8-celled coenobia were always arranged in a markedly alternate series and never in a linear series (Figs. 18–22). In some of the coenobia, however, they were arranged in irregular series (Figs. 23–25). The percentage of the irregularly arranged coenobia was about 6% in strain 462. In the 4-celled coenobia, on the other hand, the arrangement of the cells was variable, from linear (Figs. 15, 16) to strikingly alternate (Figs. 13, 14).

The seven strains examined were clearly identified with *S. falcatus* CHOD. (1926). Although many authors have regarded it as synonymous with *S. acuminatus*, the abovementioned results give good grounds for the recognition of this taxon. *S. falcatus* differs from *S. acuminatus* in the form of 4-celled coenobia, but closely resembles it in other respects: the shape of cells and the arrangement of cells in 4- and 8-celled coenobia. Taking the similarities into consideration, it would be more natural to consider this taxon as a variety and to name *S. acuminatus* var. *falcatus* (CHOD.) OOSHIMA.

Some of the 8-celled coenobia observed in the vigorous cultures (Fig. 20) were similar to those of *S. acuminatus* f. *gyoparosiensis* (KISS) UHERK. (1966), which was originally described based only upon the 8-celled coenobia. It seems open to doubt whether the characteristic structure of the 8-celled coenobia, which has been used as the only criterion for characterizing the taxon, is stable.

**3. *S. acuminatus*** var. ***tortuosus*** (SKUJA) OOSHIMA nov. comb.

***S. falcatus*** f. ***tortuosa*** SKUJA Act a Hort. Bot. Univ. Latv. **2:** 83. *fig.* 4. 1927.

***S. acuminatus*** f. ***tortuosus*** (SKUJA) UHERK. *Scenedesmus*-Art. Ung. 43. *figs.* 71–78. 1966.
——**Figs. 26–37**

The percentages of coenobial types recorded for strain 492 are presented in Table 6. The 4-celled coenobia were always dominant in all the media, while the 8-celled coenobia were found only in medium C and F.

The form of the 4- and 8-celled coenobia was distinctively twisted. Viewing them from different angles, the 4-celled coenobia varied in appearance (Figs. 26–30, 32–36). The twisted form was more conspicuous in the side or vertical view (Figs. 26, 29). The cells in the 4-celled coenobia were arranged in a linear or slightly alternate series, and the 8-celled coenobia showed a strikingly alternate arrangement of the cells which was quite similar to that of the var. *falcatus* (Fig. 31).

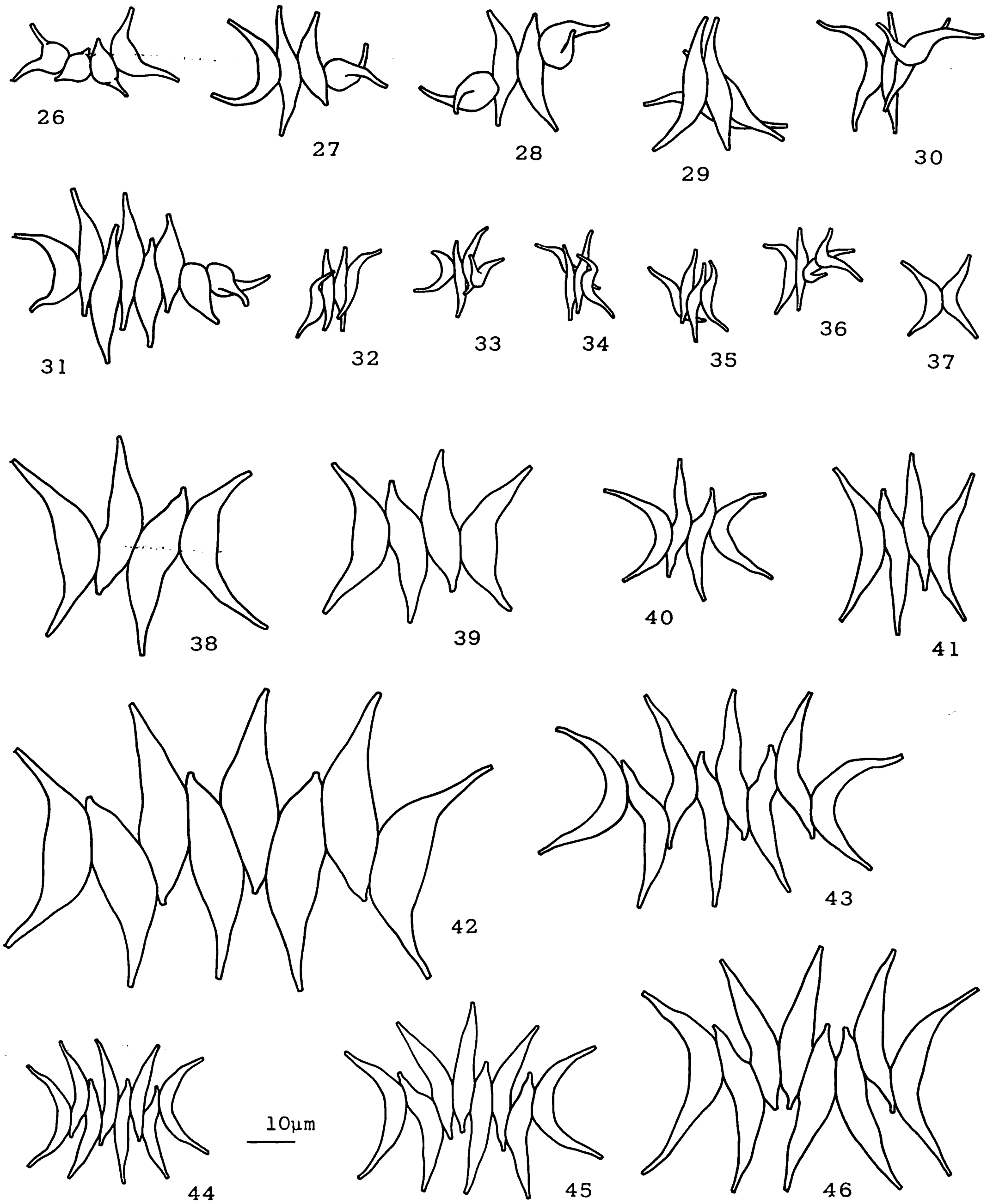
The cells of each colony were usually alike both in shape and size. Most of them were approximately the same in length and width though the terminal cells were sometimes a little longer than the median cells. The large cells in the mature coenobia were up to 35.5 $\mu$m long and 6.5 $\mu$m broad. The dimensions measured in strain 492 were smaller than those in SKUJA's description (1927). The shape of the cells was lunate and sometimes looked sigmoid or $\alpha$-shaped in appearance because of the twist of each colony.

Strain 492 was identified with *S. acuminatus* f. *tortuosus* (SKUJA) UHERK. The results of the present investigation confirmed

Table 6. Percentages of unicells and coenobia produced in seven kinds of media (strain 492: *S. acuminatus* var. *tortuosus*).

| 2 w. | AWB | A | B | C | D10 | D200 | F |
|---|---|---|---|---|---|---|---|
| unicells | 0% | — | 30% | 0% | 0% | 0% | 0% |
| 2-celled | 2 | — | 17 | 0 | 2 | 5 | 0 |
| 4-celled | 96 | — | 53 | 90 | 98 | 05 | 93 |
| 8-called | 0 | — | 0 | 10 | 0 | 0 | 7 |

*A: dead




Figs. 26–37. *S. acuminatus* var. *tortuosus*. 26–30. 4-celled mature coenobia; 31. 8-celled mature coenobium; 32–36. 4-celled young coenobia; 37. 2-celled coenobium.

Figs. 38–46. *S. javanensis*. 38 and 39. 4-celled mature coenobia; 40 and 41. 4-celled young coenobia; 42. 8-celled mature coenobium; 44. 8-celled young coenobium; 45 and 46. irregular arrangement of cells in 8-celled coenobia.

the original description of SKUJA (1927) and clarified the circumscription of this taxon, which has been misunderstood because of the too fragmentary description. On the basis of the characteristic features mentioned above, especially the unique form of colonies, the taxon should be raised to the higher rank and named *S. acuminatus* var. *tortuosus* (SKUJA) OOSHIMA.

**4. *S. javanensis*** CHOD. Rev. Hydrol. **3:** 157. *fig.* 47. 1926. ——**Figs. 38-46**

In strain 510, the 8-celled coenobia were always dominant in all the vigorous cultures, while the 2- and 4-celled coenobia were sometimes observed in the older cultures. As shown in Table 7, the 4-week-old cultures of medium B produced not only three types of coenobia but also 5% unicells which were brownish in color and abnormal in shape. Similar results were obtained with strains 501 and 505.

In the 4- and 8-celled coenobia, the terminal cells were lunate in shape and the median cells were sigmoid. The sigmoid shape was more unusual in the median cells of the younger coenobia than in those of the mature coenobia. As they matured, the median cells showed a tendency to become lunate in appearance (Fig. 42). Strains 501, 505 and 510 all possessed this feature.

Cells in the 4- and 8-celled coenobia were about the same in width, but the terminal cell was always longer than the median cells. The terminal cells in the 4-celled coenobia were up to 55 $\mu$m long and 11 $\mu$m broad, and the median cells were up to 46.5 $\mu$m long and 11.5 $\mu$m broad. In the 8-celled coenobia, on the other hand, the terminal cells were up to 43 $\mu$m long and 8.5 $\mu$m broad, and the median cells were up to 36 $\mu$m long and 8.5 $\mu$m broad. These dimensions are much larger than those in CHODAT's description (1926).

Table 7. Percentages of unicells and coenobia produced in seven kinds of media (strain 510: *S. javanensis*)

| 4 w. | AWB | A | B | C | D10 | D200 | F |
|---|---|---|---|---|---|---|---|
| unicells | 0% | — | 5% | 0% | 0% | — | 0% |
| 2-celled | 0 | — | 1 | 0 | 0 | — | 0 |
| 4-celled | 26 | — | 6 | 0 | 0 | — | 2 |
| 8-celled | 74 | — | 88 | 100 | 100 | — | 98 |

*A and D200: dead

The form of the 4- and 8-celled coenobia was flat and rarely curved a little. In some cases, however, the terminal cells were at an angle to the whole coenobium. The arrangement of the cells was very characteristic and it proved to be a stable, species-specific feature. The two median cells in the 4-celled coenobia and in the center of the 8-celled coenobia were in contact with each other only at the middle, and were joined with the outer cells by their apices. As a result, the cells were distinctively arranged in a unique zigzag series (Figs. 40, 43).

The irregular arrangement of the cells in the 8-celled coenobia was observed in the vigorous cultures (Figs. 45, 46). In the 2-week-old cultures of strain 501, the percentage of the irregularly arranged coenobia was on the average about 7% and at most 15% in medium F.

The three strains examined were definitely identified with *S. javanensis* CHOD. (1926). The original description is quite similar to the young coenobia observed in these cultures. Considering the above-mentioned features, especially the distinctive zigzag arrangement of cells and the sigmoid shape of median cells, this taxon should be recognized as a distinct species.

This species bears some resemblance to *S. bernardii* SMITH (1916) in the zigzag arrangement of cells, but is quite different from it in the shape and size of cells. Based on these characters, *S. bernardii* is similar to *S. acutus* MEYEN (1829) rather than to *S. javanensis*.

**Acknowledgements**

The author would like to express his appreciation to Dr. H. KOBAYASI of the Tokyo Gakugei University for his suggestions and encouragement. His thanks are also due to Dr. S. KOMIYA and Mr. T. NAGUMO of the Nippon Dental University and Dr. S. KATO of the Tokyo Metropolitan

University for their generous aid in collecting some of the original samples.

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**大島海一：日本産セネデスムス属の分類学的研究 1. *Scenedesmus acuminatus* とその変種および *S. javanensis* について**

7種類の培地を用いて *S. acuminatus* に類似する16株について単藻培養実験を行ない，その形態的特徴の安定性および変異を調べた。その結果，次の三形質は安定していることが明らかになった。1) 細胞の形：三日月形あるいはS字形。2)定数群体内における細胞の配列パターン：直線的配列，交互配列あるいはジグザグ配列。3) 定数群体全体の形：平面的か，湾曲しているかあるいはねじれ面を形成しているか。これらの諸形質に基づいて，*S. acuminatus* var. *acuminatus*, *S. acuminatus* var. *falcatus*, *S. acuminatus* var. *tortuosus*, *S. javanensis* の4分類群が明確に識別された。(252 藤沢市亀井野1866 日本大学農獣医学部生物学研究室)

## (続) 中華人民共和国における藻類学研究業積論文リストの紹介

前号に引き続き，中華人民共和国藻類学研究業績論文リストの紹介を行います。リストの内容に関する詳細は，第29巻第1号の p 22を参照して下さい。 〔編集委員会〕

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*94. Fang, T.C., J.J. Li and B.Y. Jiang: Further studies on the comprehensive utilization of *Laminaria japonica* ARESCH. (See: Studia Marina Sinica, No. 3)

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—100頁へ続く—

Jap. J. Phycol. (Sôrui) **29**: 95-99. June 20, 1981

# *Berkeleya sparsa* sp. nov., a tube-dwelling diatom from Hokkaido, Japan*

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MIZUNO, M. 1981. *Berkeleya sparsa* sp. nov., a tube-dwelling diatom from Hokkaido, Japan. Jap. J. Phycol. **29**: 95-99.

A new marine tube-dwelling diatom, *Berkeleya sparsa* MIZUNO sp. nov., has been collected from Point Nosappu, Nemuro City, Hokkaido, Japan and is described in detail. Colonies are found on rocks in the littoral zone and form tubular tufts, up to 2 cm in length. Valves are narrowly elliptical, being 19-37 μm in length and 5-8 μm in width. Striae are transverse in the middle part of the valve and radiating to the ends. There are 18-22 striae in 10 μm. The ratio values of the distance between the central raphe endings to the valve length are 15-21% for a valve length of 20 μm, 18-26% for 27 μm and 23-31% for 35 μm, respectively.

*Key Index Words*: *Bacillariophyceae*: Berkeleya sparsa *sp. nov.*; *frustule*; *taxonomy*; *tube-dwelling diatom*; *valve.*

The author collected a tube-dwelling diatom at the Point Nosappu, Hokkaido in April 15, 1975. After morphological observations, the author has come to the conclusion that the present diatom is a new species of the genus *Berkeleya* and has named it *Berkeleya sparsa*. A description of *B. sparsa* will be given below.

## Material and Methods

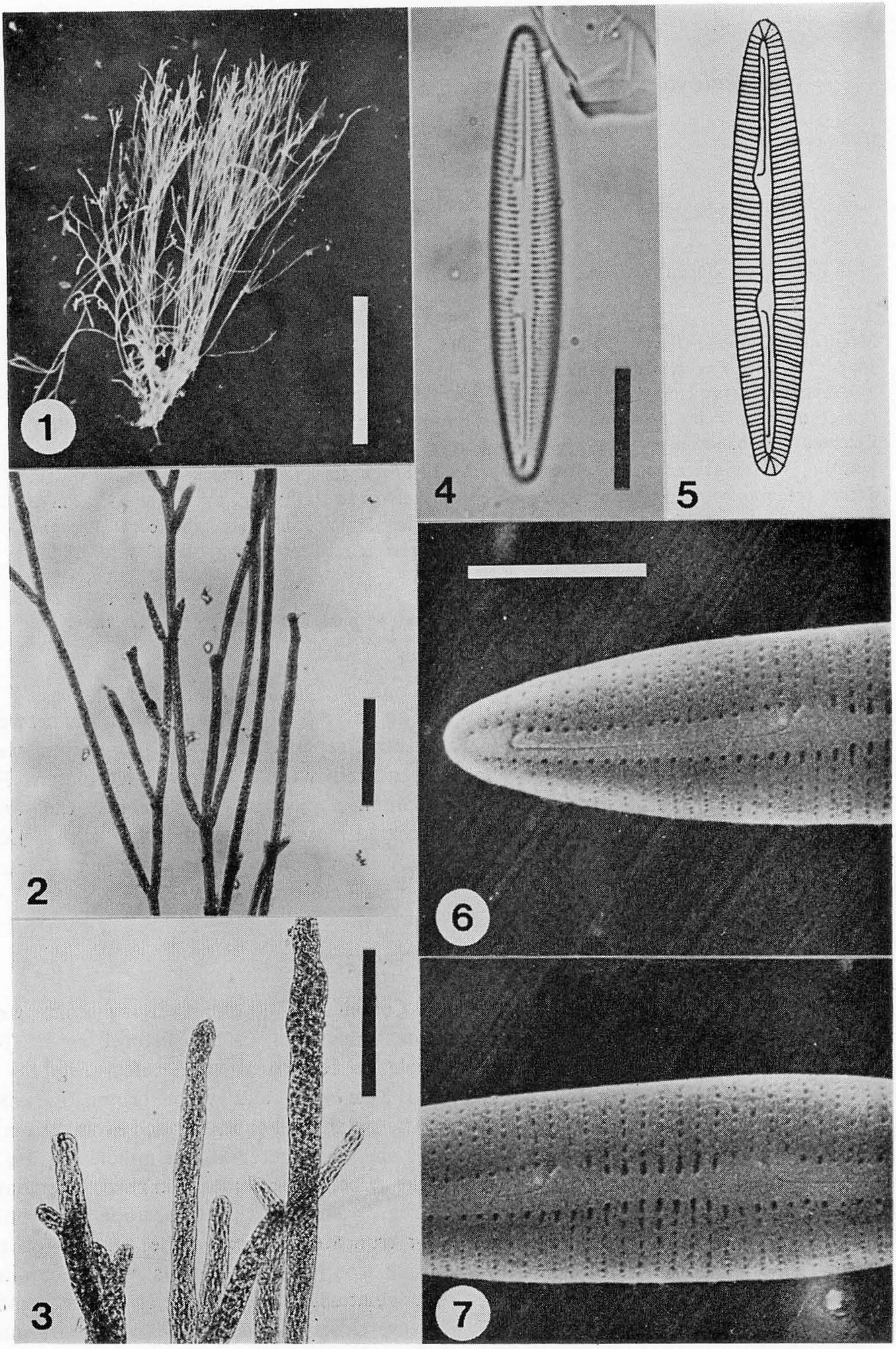
Material was collected at Point Nosappu, Nemuro City, Hokkaido in April 15, 1975. It was preserved in 3% formalin seawater and formalin sample was used for observations of tube morphology. Part of the material was cleaned by concentrated nitric acid and distilled water, and was mounted in Pleurax for the observations of valve structures. The number of striae in 10 μm in the middle part of 50 valves was counted. The valve length and the distance between central raphe endings of 119 valves were measured with a screw micrometer. For scanning electron microscopy, the acid-treated material was observed with a JXA-50A X-ray microanalizer (Japan Electron Optics Lab. Co., Ltd.).

## Observations

Colonies of the present diatom were found on rocks in the littoral zone. The colonies formed tubular tufts (Fig. 1), up to 2 cm long and were brown in color. The gelatinous tubes ranged from 27 μm to 66 μm in diameter at the middle portion of the tube. The tube branched irregularly (Fig. 2) and the tip of the tube was obtuse or truncate (Fig. 3). The texture of the tube was rigid. The cells were contained in gelatinous tubes in which a vast number were closely or loosely packed in irregular files (Fig. 3).

The frustules were narrowly elliptical in valve view (Figs. 4, 5, 8A-B). In girdle

* This study was undertaken mainly at the Institute of Algological Research, Faculty of Science, Hokkaido University at Muroran, Hokkaido, Japan.




Figs. 1-7. *Berkeleya sparsa* sp. nov. 1. A colony; 2. Light micrograph showing the branching of the tube; 3. Light micrograph showing the apices of the tube; 4. Light micrograph of valve view; 5. Sketch of Fig. 4; 6. Scanning electron micrograph of outer

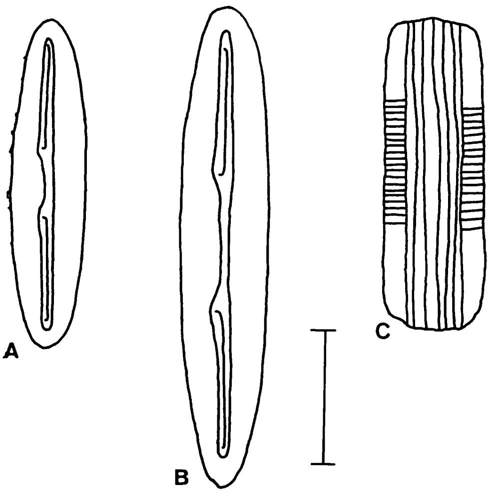



Fig. 8. *Berkeleya sparsa* sp. nov. A-B: Valve view; C: Girdle view. Scale 10 $\mu$m.

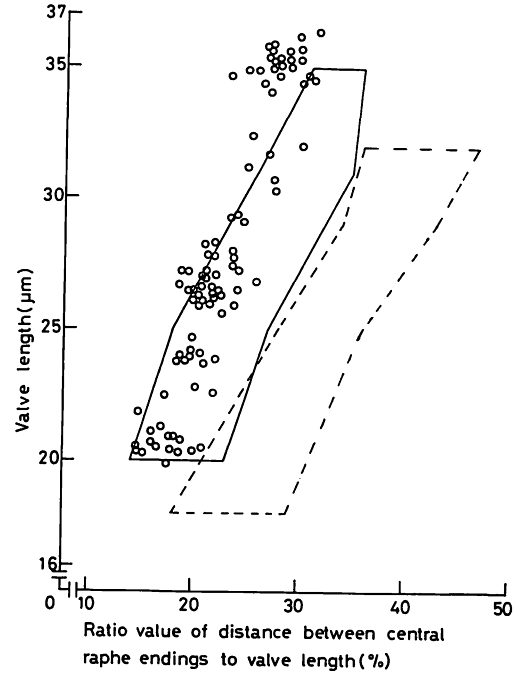



Fig. 9. Correlation between the valve length and the ratio value of the distance between central raphe endings to the valve length of *Berkeleya sparsa* sp. nov. (○). The area surrounded by broken line shows that of *B. rutilans* (MIZUNO 1977) and the area surrounded by solid line shows that of *B. obtusa* (MIZUNO 1979).

view, frustules with girdle bands were rectangular (Fig. 8C). The valves measured 19-37 $\mu$m in length, 5-8 $\mu$m in width. By light microscopy, two parts of the axial area expanded in the same direction as the bending direction of raphe endings and resulted in asymmetry (Figs. 4, 5, 8A-B). Scanning electron micrographs of the outer surface clearly showed that the central raphe endings bent to the expanded axial area and also the polar raphe endings bent to the same side (Figs. 6, 7). The valve surface was sparsely covered with striate (Figs. 4, 5). The striae were transverse in the middle part of the valve and radiated over the end (Figs. 4, 5). The striation density was 18-22 in 10 $\mu$m in the middle of the valve and 20 striae in 10 $\mu$m were frequently observed. By scanning electron microscopy, each stria consisted of a single row of pores and the pores next to the central area were transversely elongated (Fig. 7). Central raphe endings were widely separated (Figs. 4, 5, 7). The ratio value of "the distance between central raphe endings to the valve length" was shown in Fig. 9. The ratio values (percentage) in each class of the valve length were as follows; 15-21% for a valve length of 20 $\mu$m, 18-26% for 27 $\mu$m and 23-31% for 35 $\mu$m. The ratio value increased in proportion to the valve length.

## Discussion

Recently COX (1975a) showed that the genus *Amphipleura* sensu CLEVE was comprised of a heterogenous group of species on the basis of a detailed study using light and electron microscopes and she transferred the marine tube-dwelling species of the genus *Amphipleura* to the genus *Berkeleya* GREV. emend. COX. The characteristics of the genus *Berkeleya* emended by her are as follows; (1) plants live in brackish or marine conditions, (2) cells are usually

← surface of the valve apex; 7. Scanning electron micrograph of outer surface of the middle of the valve. Scale in 1 represents 3 mm; scale in 2 represents 300 $\mu$m; scale in 3 represents 200 $\mu$m; scale in 4 for 4-5 represents 10 $\mu$m; scale in 6 for 6-7 represents 5 $\mu$m.

enclosed in gelatinous tubes, (3) the frustule has many girdle bands, and (4) central raphe endings are distant.

Because of its tube-dwelling habit, frustule morphology and marine habitat, the present diatom apparently belongs to the genus *Berkeleya* GREV. emend. COX. Of the previously described species of the genera *Berkeleya* and *Amphipleura*, *B. capensis* GIFFEN, *B. hyalina* (ROUND et BROOKS) COX, *B. obtusa* (GREV.) GRUN., *B. rutilans* (TRENT.) GRUN., *A. arctica* PATRICK et FREESE, and *A. pumila** SCHUMANN are similar to the present diatom in valve size. GIFFEN (1970) described *B. capensis* as having following characteristics: transapical striae were 15 in 10 μm in the middle and about 20 in 10 μm towards the ends, in girdle view short pseudosepta were seen at the ends of the valve, girdle segments (girdle bands) were 2-3 and punctate along the margin. Such structures as the presence of pseudosepta and punctae of girdle band are not seen in the present diatom. The striation density of *B. hyalina* is more than 40 in 10 μm (ROUND and BROOKS 1973, COX 1975b), which is twice the density of the present diatom. The striation density of *A. arctica* is 24-32 in 10 μm and the ratio value of "the distance between central raphe endings to the valve length" is 53% in 34 μm of valve length, measuring from the figure given by PATRICK and FREESE (1960, Pl. I, Fig. 14). *A. arctica* is distinguished from the present diatom by these two characteristics. The valve of *Amphipleura pumila**, collected at Königsberg (present name Kaliningrad) facing the Baltic Sea, is $7\text{-}9\times10^{-3}$ "pariser Linie" (15.8-20.3 μm**) in length and striation density is 42 in $10^{-2}$ "pariser Linie" (18.6 in 10 μm) (SCHUMANN 1869). These characteristics of valve of *A. pumila** are similar to those of the present diatom. However, SCHUMANN (1869) doubted whether *A. pumila** would belong to the genus *Amphipleura* or not and he added an question mark after the genus name. Examination of SCHUMANN's figure (SCHUMANN 1869, Taf. II, Fig. 7) does not clearly reveal the genus of *A. pumila**. DE-TONI (1891) suggested that *A. pumila** SCHUMANN belongs to the genus *Navicula*. Further, in the reports on the diatoms of Europe, especially of the Baltic Sea (HUSTEDT 1937, CLEVE-EULER 1952), a species having such features as those of *A. pumila** is not found in the genus *Amphipleura* or *Berkeleya*. From these, *A. pumila** seems to belong to neither the genus *Amphipleura* nor to *Berkeleya*. The curvature of raphe endings and the shape of pores adjacent to the central area of the present diatom are morphologically similar to those of *B. obtusa* and *B. rutilans* (COX 1975b, MIZUNO 1979). However, the striation densities of *B. obtusa* and *B. rutilans* were 24-32 and 24-36 in 10 μm, respectively (MIZUNO 1977, 1979). Furthermore, as shown in Fig. 9, *B. obtusa* and *B. rutilans* differed from the present diatom in the ratio value of "the distance between central raphe endings to the valve length" in the range of the large valve and in the whole range of valve length, respectively.

From the above mentioned characters, it is concluded that the present diatom is a new species of the genus *Berkeleya* GREV. emend. COX and it is named *B. sparsa* by sparse striation density.

## Description

*Berkeleya sparsa* MIZUNO sp. nov.

Colonies tubular, gelatinous, branched irregularly, with obtuse or truncate apices, up to 2 cm long, 27-66 μm diameter, consisting of many cells. Valves narrowly elliptical, 19-37 μm long 5-8 μm wide; two parts of axial area expanded in one direction, resulting in asymmetrical axial area; central and polar raphe endings bent to same expanded direction of axial area;

* *Amphileura? pumila*, according to SCHUMANN (1869)

** One "pariser Linie" was turned 2.256 mm (Brockhaus Enzyklopädie 1970).

ratios of distance between central raphe endings to valve length 15-21% for a valve length of 20 $\mu$m 18-26% for 27 $\mu$m and 23-31% for 35 $\mu$m; transapical striae parallel in middle portion, radiating over end, sparsely, 18-22 in 10 $\mu$m, consisting of single row of pores; adjoining pores to central area elongate in transapical direction. Girdle bands numerous.

Habitat: In the littoral zone.

Coloniae tubulares, gelatinosae, irregulariter ramosae, apicibus obtusis vel truncatis, usque 2 cm altae, 27-66 $\mu$m latae, constantes ex cellulis multis. Valvae anguste ellipticae, 19-37 $\mu$m longae, 5-8 $\mu$m latae; duae partes areae axialis expansae ad unam directionem, itaque area axialis asymmetrica; fines centrales et polares raphium obstipae ad directionem expansam areae axialis; rationes distintiarum inter fines centrales raphium pro longis valvarum 15-21% in valvam 20 $\mu$m longam, 18-26% in valvam 27 $\mu$m longam et 23-31% in valvam 35 $\mu$m longam; striae transapicales parallelae in partem mediam et radiantes in partem apicalem, sparsae, 18-22 in 10 $\mu$m, constantes ex poris seriatis singulis; pori contigui areae centrali transverse elongati. Fasciae zonarum multae.

Habitat: In saxis inter aestus accessum et recessum locatis.

Holotypus: Point Nosappu, Nemuro City, Hokkaido, Japan, M. MIZUNO No. 1008, 15 April 1975 in National Science Museum in Tokyo (TNS).

Iconotypus: Figs. 4, 5.

## Acknowledgements

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**水野　真：海産樹枝状群体珪藻の一新種 *Berkeleya sparsa* MIZUNO**

北海道根室市納沙布岬産の珪藻 *Berkeleya* 属の一種を新種 *B. sparsa* として報告する。本種は潮間帯の岩上に着生し，高さ約 2 cm の樹枝状群体を形成する。殻は狭い楕円形で，殻長 19-37 $\mu$m，殻幅 5-8 $\mu$m である。条線は 10 $\mu$m 中に18-22本あり，中央部ではほぼ平行であり，殻端近くでは放射状である。殻長に対する縦溝の中心孔間の距離の比は，殻長が 20 $\mu$m の時15-21%，殻長が 27 $\mu$m の時18-26%，殻長が 35 $\mu$m の時23-31%である。(094 北海道紋別市落石町 7 丁目　道都大学社会福祉学部)

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# Observations on *Chnoospora minima* (HERING) PAPENFUSS (Phaeophyta, Scytosiphonales) in the field and in culture

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FOTOS, Sandra S. 1981. Observations on *Chnoospora minima* (HERING) PAPENFUSS (Phaeophyta, Scytosiphonales) in the field and in culture. Jap J. Phycol. 29: 101-108.

Examination of the brown alga *Chnoospora minima* (HERING) PAPENFUSS from Hawaii, provides cytological evidence for its placement in the Scytosiphonales. Cortical cells possess one large plastid and a single pyrenoid, and the erect blades bear only plurilocular sporangia. The thallus structure is similar to that of the other genera within the Scytosiphonales. However, the blade shape and subapical meristem are characteristic features of the alga. *C. minima* is perennial; although a seasonal decline of large thalli occurs in areas exposed to autumn and winter wave action, small thalli persist throughout the year.

Culture study reveals the presence of a discoid phase, which can independently reproduce itself for generations, in the vegetative development of the erect thallus.

*Key Index Words*: *brown alga*; Chnoospora; *cytology*; *morphology*; *phaeophycean life history*; *Phaeophyta*; *Scytosiphonales*.

In 1949 FELDMANN proposed a new phaeophycean order, the Scytosiphonales, to accomodate genera in the Scytosiphonaceae, Chnoosporaceae and the Phaeosaccionaceae (since transferred to the Chrysophyceae). The order was circumscribed using the following features: production of only plurilocular sporangia on the erect blade, the presence of a single large plastid and a single pyrenoid in the cortical cells, and an isomorphic life history. However, it is now well established (TAKEWAKI 1966, WYNNE 1968, NAKAMURA and TATEWAKI 1975, CLAYTON 1979) that crustose or filamentous microthalli alternate with the erect blade in Scytosiphonalean species. Nonetheless, FELDMANN's cytological criteria are still valid (COLE 1970).

The genus *Chnoospora* J. AGARDH is a tropical alga, with compressed, elongated, dichotomously branched fronds arising from a basal disc. It was placed in its own family, the Chnoosporaceae, by SETCHELL and GARDNER (1925). These authors also suggested that *Chnoospora* represented an evolutionary development of cylindrical thalli. Placement of the Chnoosporaceae in the Scytosiphonales (FELDMANN 1949) was based only on morphological features. Cytological evidence of a single plastid and pyrenoid was not available.

This study was conducted to obtain cytological information on one of the species found in Hawaii, *Chnoospora minima* (HERING) PAPENFUSS, to confirm its placement within the Scytosiphonales. The morphology of the thallus was examined and its habitat investigated. A culture study of the life history of *C. minima* was undertaken to determine the presence of a crustose stage.

## Materials and Methods

Thalli of *Chnoospora minima* were collected from three sites on Oahu island, Hawaii, over a period of two years, from 1976-1978. The inclination of the substratum slope at each site was measured with a protractor. Thalli used for culture were washed in sterile seawater, trimmed 4 cm from the blade apex, soaked in an antibiotic mixture (GUILLARD 1973) and placed in petri dishes containing seawater-algal agar. Petri dishes contained tips from a single thallus only. All cultures were maintained at 18–26°C (ambient temperature) under a 16 hour light regime at 600 foot candles, using cool white flourescent tubes. Thalli obtained through culture were kept in covered culture dishes containing 250 m*l* of filtered seawater to which PROVASOLI's Enriched Medium (McLACHLAN 1973) was added. Groups of immature $F_2$ and $F_3$ thalli were kept in a growth chamber at 20°C with 10 hours of light. Germanium dioxide (LEWIN 1966) and the antibiotic mixture were added during the weekly medium change to surpress contaminants. Culture dishes were agitated at 100 RPM on rotary shakers.

Material for cytological examination was sectioned on a freezing microtome and stained with analine blue. Material examined for nuclear dimensions was fixed with alcohol-acetic acid and stained with aceto-carmine.

A dense field population at Kaloko, Oahu was surveyed monthly from August, 1977 through January, 1978. A sampling ring $0.18^2$ M was placed in the densest portion and all visible thalli were harvested, counted and measured. Dry weights of each sample were recorded. Three size range categories were established for thalli harvested: small, less than 2.5 cm; medium, from 2.6 to 5.5 cm; and large, over 5.6 cm.

## Results

*Ecology*: *Chnoospora minima* is a common intertidal alga in Hawaii, growing in tufts on low angled (less than 50°) wave washed shorelines protected from strong waves except during winter storms or southwesterly winds. The species is restricted to a belt in the upper littoral zone. Although the thalli are exposed to air at low tide, and may be submerged for only a few hours a day during high tide, they are continually wetted by wave action. None are found above the zone of constant surge. The lower limits are also sharply defined. The second species, *C. implexa*, also occurs in Hawaii, but is subtidal and has a round, cushion-like habit.

*C. minima* is perennial. However, field populations were observed during this study to decline sharply from September, with large and medium length thalli found only in sheltered locations. However, small thalli and discs with blade initials were present at all sites throughout the year. In April, field populations again became conspicuous, with medium and large thalli in abundance.

*Morphology and cytology*: Mature thalli occur in clumps, consisting of a large, irregular basal crust, composed of coalesced discs and erect fronds which arise from the discs (Fig. 1) Young thalli are often found singly. Blades may grow to a maximum of 16 cm. Although each blade usually branches dichotomously several times, specimens have been collected with 4 or 5 blades emerging from a single junction. Regeneration of blades from basal crusts as well as from eroded blade tips is common.

Both blade and holdfast consist of a cortex of small, pigmented cells and a medulla of large colorless cells. Cortical cells are oval, averaging $10\times15\ \mu$m and contain a single, large, irregularly shaped plastid lying against the portion facing the blade periphery (Fig. 2). Below the plastid is a round nucleus, averaging 5 $\mu$m in diameter. A single large pyrenoid is embedded in or adjacent to the plastid (Fig. 3).

Young medullary cells are circular, becoming distorted and ovoid with age, the largest averaging $34\times70\ \mu$m. Cell walls of both cortical and medullary cells are thick and irregular, with lamellate regions.

Growth takes place through divisions of a subapical meristem consisting of a layer

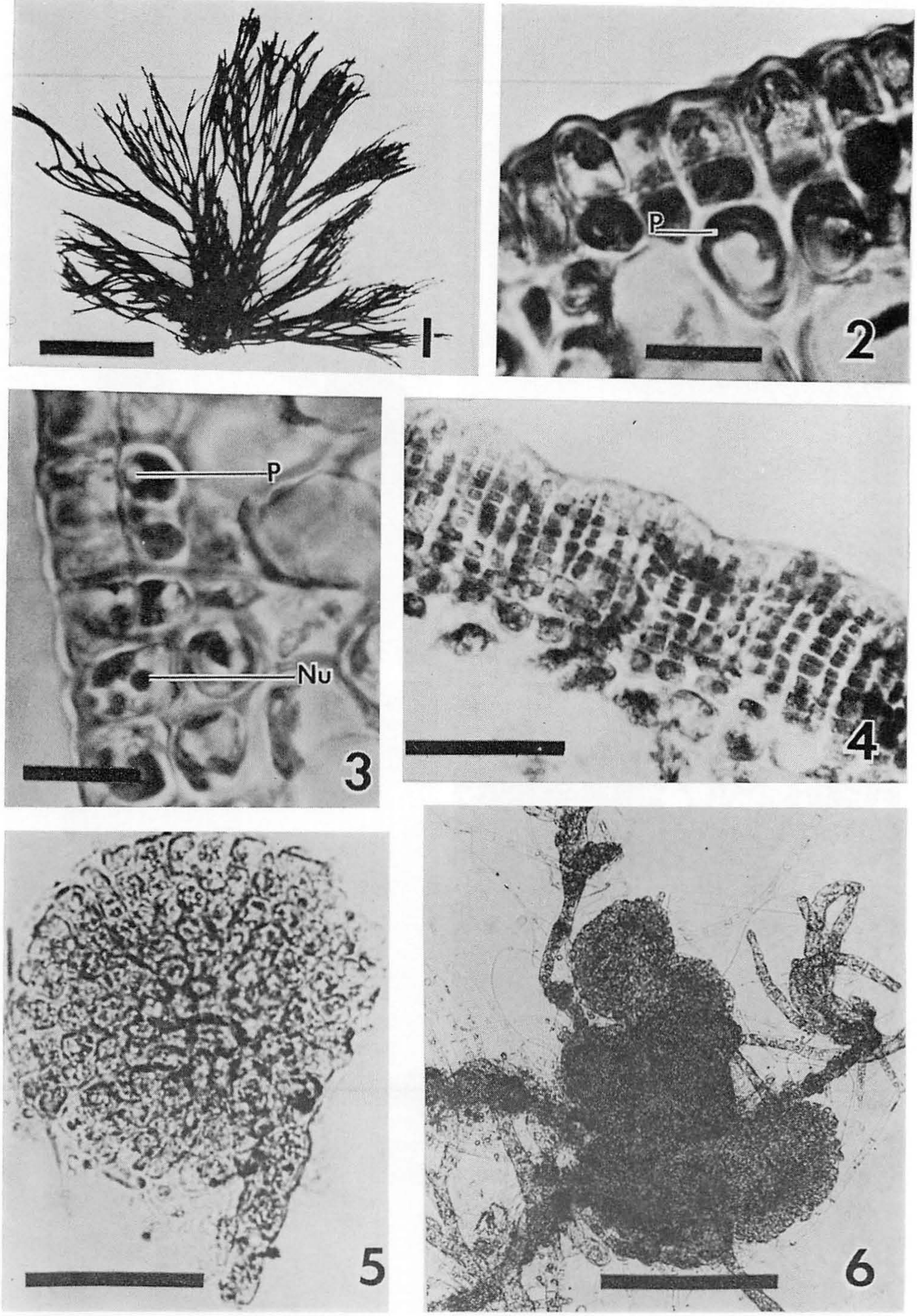
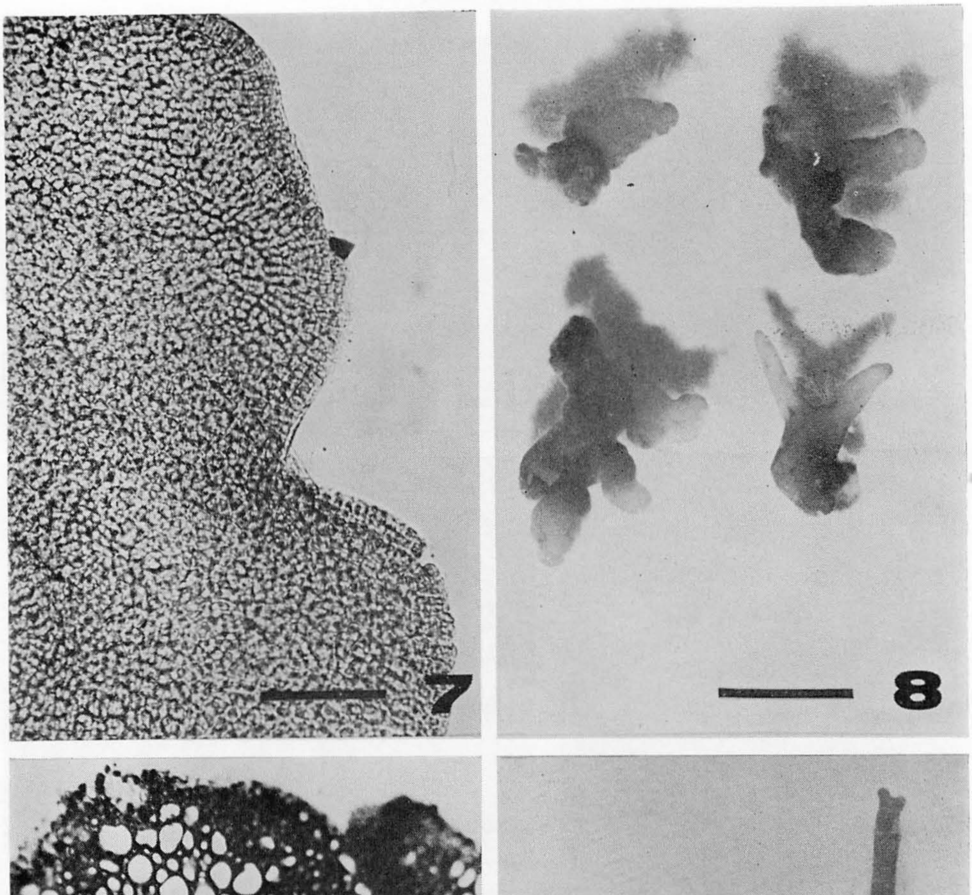



Fig. 1. Herbarium specimen of mature thallus of *Chnoospora minima*. Scale equals 4 cm.
Figs. 2-6. Light micrographs of *Chnoospora minima*. 2. Cortical cells, showing large, single plastid (p) lying against upper cell surface. Scale equals 25 μm; 3. Cortical cells, each possessing a single nucleus (nu) and pyrenoid (p). Scale equals 25 μm; 4. Cross section 1 cm from blade apex, showing plurilocular reproductive organs. Scale equals 100 μm; 5. Young disc with pluriseriate section of knot filament arising from it. Scale equals 100 μm; 6. Mature disc with sterile hairs and knot filaments. Scale equals 150 μm.




Figs. 7 and 9. Light micrographs of *Chnoospora minima*. Figs. 8 and 10. Live thalli of *Chnoospora minima*. 7. Surface view of blade apex at zone of developing dichotomy. Scale equals 100 $\mu$m ; 8. Erect fronds arising from mature $F_2$ discs. Scale equals 1 cm ; 9. Oblique section through the center of mature disc initiating blade. Scale equals 150 $\mu$m ; 10. Thallus of *C. minima* obtained from $F_3$ disc. Scale equals 1 cm.

of small rectangular cells lying beneath the top cortical cell layer.

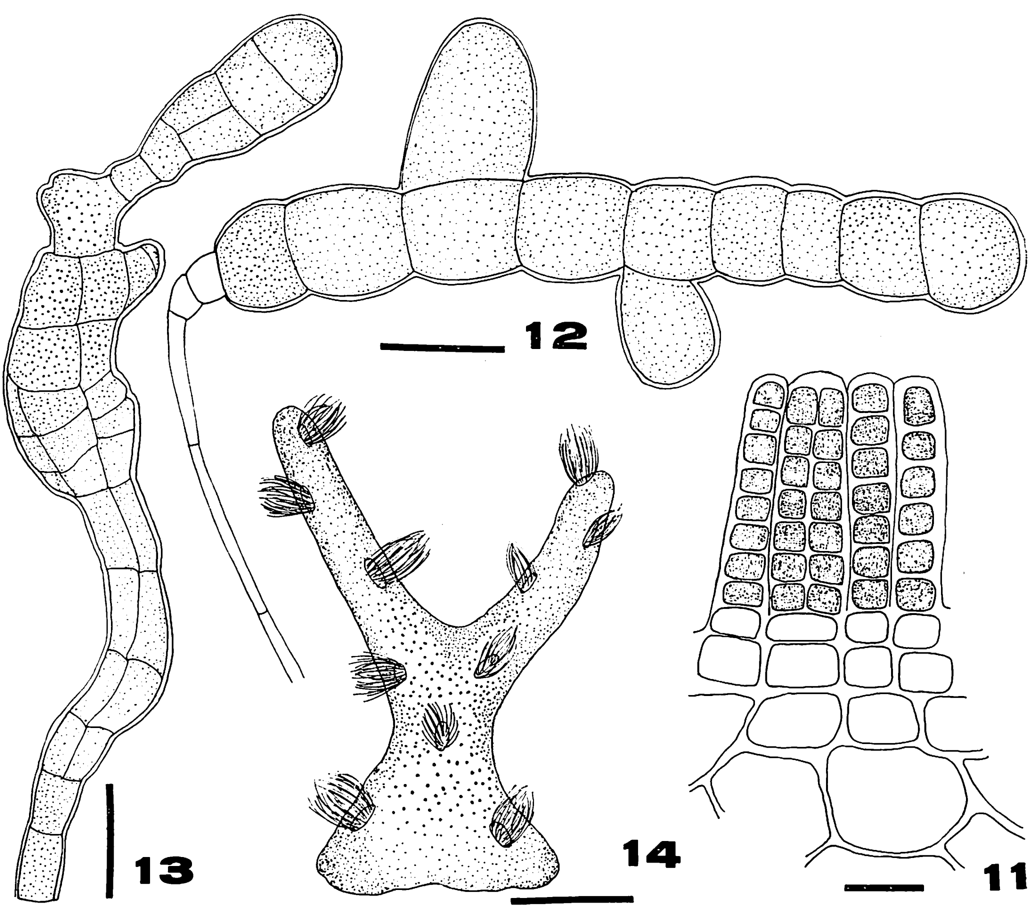
Cells derived from periclinal divisions become medullary cells. Anticlinal divisions of the subapical meristem produce the blade dichotomy (Fig. 7) and the meristoderm layer. This layer increases blade length and width through both periclinal and anticlinal divisions.

The entire thallus bears pits containing uniseriate unbranched colorless hairs with elongated cells. Hair production varies with the degree of exposure to air, thalli growing at the uppermost limits often producing copious hairs.

Blades were observed to produce only plurilocular reproductive organs. These are uni-or biseriate (Fig. 4) and average 38 $\mu$m in length. Individual locules (Fig. 11) have an average length of 6 $\mu$m, with a width of 8 $\mu$m. There are from 5 to 8 locules in a uniseriate plurilocular organ.

The plurilocular organs are derived from the top layer of cortical cells and are produced basipetally. Sometimes their development along one blade face preceeds that along the other, but mature organs occur in dense layers over the entire surface of the blade.

After the discharge of swarmers, the




Figs. 11-14. Line drawings. 11. Plurilocular organs of *C. minima*, showing uni- and biseriate forms. Scale equals 10 $\mu$m; 12. 7-10 day old germling. Scale equals 10 $\mu$m; 13. Knot filament (detail from Fig. 6), showing multiseriate section. Scale equals 15 $\mu$m; 14. Young *C. minima* thallus, obtained from $F_2$ disc. Scale equals 2.5 mm.

plurilocular organs and the cortical cells from which they are derived erode away, exposing layers of medullary cells. The eroded apex then drops off, leaving a blade stub several cm in length. Regeneration of a new blade from the stub often occurs.

Actively swimming, biflagellate swarmers, bearing one plastid and an eyespot, were observed in culture dishes containing field thalli as well as in those holding cultured material. They were 8-10 $\mu$m in length and 3-4 $\mu$m in width. The releasing process of swarmers from the plurilocular organs was unfortunately not confirmed. Fusion of swarmers in culture dishes was not encountered, probably because dishes contained thalli derived only from one parent. It was not possible during this study to collect swarmers from different thalli and mix them, to test for mating strains and obtain zygotes.

*Observations on the life life cycle in culture*: Swarmers from the plurilocular organs of field thalli germinated parthenogenetically into uniseriate filaments of 5-10 rounded cells (Fig. 12). Lateral branches developed which coalesced, producing discs, 1-2 mm in diameter and 0.5 mm thick (Fig. 5). After two weeks the discs produced long colorless hairs as well as short branches of limited length containing both uni- and multiseriate sections of darkly staining cells (Fig. 6). These branches are termed knot filaments because of apparent morphological similarities with knot filaments borne on Ralfsioid discs of *Petalonia* type thalli (EDELSTEIN *et al.* 1970) in culture. Knot filaments were also observed on the basal discs of field material of less than 2.5 cm in length.

Swarmers identical to those previously described were observed in culture dishes containing discs with knot filaments and in dishes containing only knot filaments. Although the release of swarmers from knot filament cells was not directly confirmed, it is likely that portions of the knot filament (Fig. 13) function as reproductive organs. No unilocular or plurilocular reproductive organs were observed on the discs or the knot filaments at any [time during this study.

Several days after the development of knot filaments a new generation of discs appeared in culture. The pattern of growth of the $F_2$ discs was identical to that of the $F_1$ thalli. Several generations of discs were produced in this manner.

Two weeks after the development of knot filaments approximately 80% of all discs gave direct rise to fronds identical in appearance to field thalli of *C. minima* (Figs. 8, 14). An oblique section through a mature disc giving rise to a blade (Fig. 9) shows differentiation into cortex and medulla in the blade initial. The small, round, elongated medullary cells of the emerging blade contrast with the large, irregular medulla of the disc. Blade initiation occurs when the cell layer lying beneath the top cortical cell layer becomes meristematic. A meristoderm layer is produced and its divisions increase blade length and width.

After 1½ months, the blades reached 2.5 cm in length (Fig. 10) and developed plurilocular reproductive organs. After two weeks a new generation of discs appeared around the base of the mature thalli. These discs also showed a direct return to the blade. Development of neither knot filaments nor blades occurred among approximately 20% of cultured discs. Cultures grown under lower temperatures and shorter day length developed identically to those at regular culture conditions.

**Conclusions**

Early morphological studies of *Chnoospora* (BARTON 1898, SETCHELL and GARDNER 1925, KUCKUCK 1929) described its flattened, dichotomous blade, subapical meristem, pits of hairs and dense rows of plurilocular sporangia. Whereas the former two features are distinctive to the genus, the distribution of pits and plurilocular sporangia were found to be similar to that of *Colpomenia* DERBES and SOLIERS (BARTON 1898, SETCHELL and GARDNER 1925, FELDMANN 1949). The specimens of *C. minima* examined show the general morphological and cytological features characterizing the members of the order Scytosiphonales. The erect blades bear only plurilocular reproductive organs and the cortical cells possess a single plastid with a conspicuous pyrenoid. These features support the accomodation of *Chnoospora* within the Scytosiphonales.

However, although dimorphism in the absence of a sexual cycle has been well demonstrated (HSIAO 1969, WYNNE 1969, WYNNE and LOISEAUX 1976) for members of the Scytosiphonaceae, it has been linked to enviromental conditions. The present observations show that decreases in the photoperiod and temperature, conforming to the minimum range of the Hawaiian climate, did not inhibit blade development in *C. minima*. The apparent seasonal decline of large and medium length thalli in the field was not due to surpression of blade development. Large and medium thalli were present throughout the year in sheltered locations and discs with blade initials were found at all sites throughout the year. It is suggested that the decline is due to removal by the mechanical action of autumn and winter storms. Discs and small thalli are less suseptible to removal by wave action and persist.

The occurance of a plethysmothalloid discoid phase which perpetuates itself before producing the erect blade is an unusual finding. However, the existance of knot filaments arising from the microthallus has been recorded for another member of the Scytosiphonales (EDELSTEIN *et al.* 1970) Blades of the genus *Petalonia* were produced by Ralfsioid discs which also bore knot filaments. However, only unilocular reproductive organs were produced on the discs and knot filaments. The erect blades produced only plurilocular organs.

The microthalli of *C. minima* did not produce unilocular organs. This observation differs from other recent findings regarding both haploid and diploid microthalli of other genera in the Scytosiphonales (NAKAMURA and TATEWAKI 1975, CLAYTON 1979). This is possibly due to unfavorable culture conditions, and future work with the genus may show the production of unilocular organs on the discoid phase.

The parthenogenetic development of gametes is common in other Scytosiphonalean genera (see WYNNE and LOISEAUX 1979 for a review), and production of zygotes has been shown in some species to be limited to certain seasons of the year (CLAYTON 1979, 1980). This may be the case with *C. minima* as well. The present study demonstrates the parthenogenetic development of swarmers. Future work with *Chnoospora* species may reveal a heteromorphic alternation of haploid blades with diploid discs, a sexual life history described (NAKAMURA and TATEWAKI 1975, CLAYTON 1979, 1980) for a number of genera in the Scytosiphonales.

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## S. S. フォトス：ボウガタムラチドリの野外観察および培養

ほとんど研究が行なわれていない褐藻のムラチドリ属 *Chnoospora* J. Agardh の一種，ハワイ産のボウガタムラチドリ *Chnoosoora minima* (Hering) Papenfuss を詳しく調べたところ，本種がカヤモノリ目に帰属すべきものであることの細胞学的な根拠が得られた。皮膚細胞は1個の大きな葉緑体と1個のピレノイドをもち直立葉片は複（室胞）子嚢のみを有する。葉状体の構造はカヤモノリ目の他の属のそれと同様である。しかしながら葉片の形態と亜頂端の表皮層は *C. minima* に特徴的である。本藻は多年性である。大きな葉状部は秋や冬に波の影響で季節的衰退を示すが，小さな葉状部は年間を通じて存在する。

直立葉状体の栄養的発達過程における一世代として，独立の生殖能力を有する盤状体の相が存在することが培養実験によって示された。(305 茨城県新治郡桜村天王台 1-1-1，筑波大学生物科学系)

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# Holocene history of the diatom assemblages of the sediments from the mouth of the Samondo-gawa river along the northern coast of the Osaka Bay

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KUMANO, S. and MIYAHARA, S. 1981. Holocene history of the diatom assemblages of the sediments from the mouth of the Samondo-gawa river along the northen coast of the Osaha Bay. Jap. J. Phycol. 29: 109-115.

The sediments collected by Dr. MAEDA from a caisson at the mouth of the Samondo-gawa river were studied to clarify the sedimentary environment by diatom assemblage analysis. 1. The Osaka Bay Formation can be divided into the Nanko Bed and the Umeda Bed, which is subdivided into three units. 2. Based upon the ecological categories of diatoms, the sediments are classified in three diatom zones named A to C in ascending order. Diatom Zone A roughly corresponds to the Nanko Bed and is dominated by fresh-water assemblages of diatoms. From the fact that marine species increase in number downwards in Diatom Zone A, it can be assumed that the raising of the sea level occurred toward the period about 30,000 years BP at the Samondo-gawa site. 3. Diatom Zone $B_1$ corresponds to Molluscan Assemblage I reported by MAEDA (1978). An intertidal assemblage of diatoms appears prior to that of mollusca in the progress of Holocene transgression. Because Diatom Zone $B_1$ is dominated by *Nitzschia granulata*, the sea was very shallow at the horizons between $-24$ m and $-21.8$ m. 4. Diatom Zone $B_2$ ($-21.8$ m to $-11.5$ m) corresponds to Molluscan Assemblage II by MAEDA. Because littoral or neritic diatoms appear, it appears that sea became deeper at this horizon. 5. Diatom Zone C ($-11.5$ m to $-9.5$ m) corresponds to Molluscan Assemblage III. The change from the sub-intertidal assemblage to the intertidal one was caused by the regression of sea level at the period between 2,500 and 1,500 years BP.

*Key Index Words*: *diatom zone*; *freshwater species*; *holocene transgression*; *marine species*; *molluscan assemblage*; *Osaka Bay*; *Samondo-gawa*; *sedimentary environment.*

The past environmental changes are reconstructed mainly from the information obtained by geomorphological, the biological and the chronological investigations. ISEKI (1976) reviewed the investigations for the geomorphological environment, for the fluctuation of sea level and for the development of landforms during the Holocene period. MATSUSHIMA and OHSHIMA (1974) and MATSUSHIMA (1978) studied the littoral molluscan assemblages during the Holocene transgression along the Tokyo Bay and the Sagami Bay. MAEDA (1976, 1978) also determined the past sea level changes based upon the molluscan assemblages along the northern coast of the Osaka Bay.

The Mizoro-ga-ike Research Group (1976) investigated a history of the Mizoro-ga-ike in the Kyoto Basin based upon pollen and diatom analyses. The diatom assemblages were analysed by HASEGAWA (1968) in the Kanto Plain and UTASHIRO *et al.* (1975) in Kurashiki City in order to ascertain the sea level changes and the highest sea

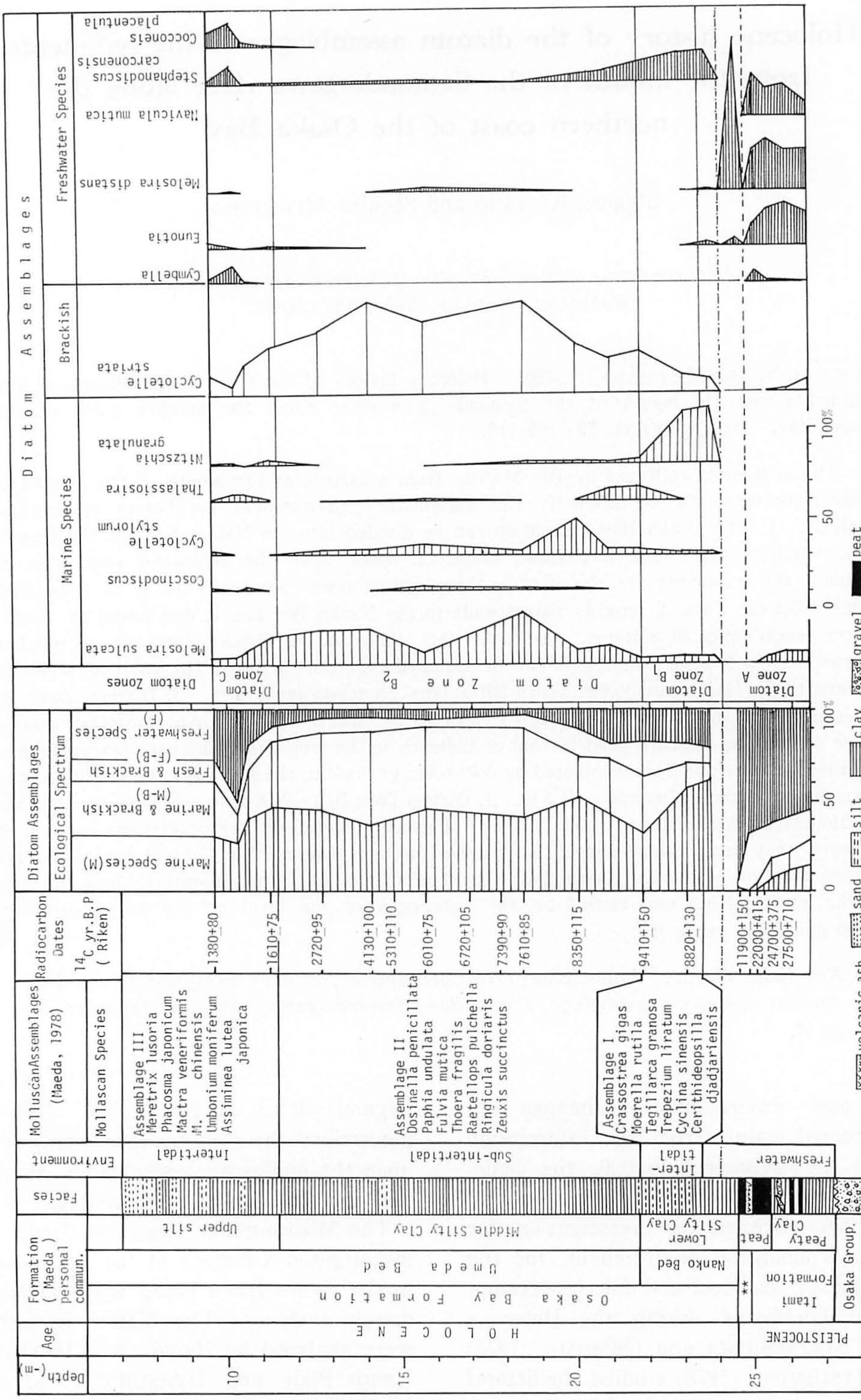


Fig. 1. Stratigraphy, columnar section, molluscan assemblages, radiocarbon dates and diatom diagrams of the sediments from the Samondo-gawa river along the northern coast of Osaka Bay.

level of Holocene transgression. YASUDA (1978) investigated the history of environmental changes and human activities around the Uriudo site in Osaka Prefecture. He reconstructed the paleo-geographical sequence from the Paleo-Kawachi Bay, via the Paleo-Kawachi Lagoon toward the lagoonal lowland based upon the geomorphological, the archaeogeological and the palynological evidences. MORI and HORIE (1975) studied the diatoms in a 200 meters core sample from Lake Biwa-ko.

The present work forms a part of studies to reconstruct the paleoenvironment during the Holocene along the coast of Osaka Bay. In the present paper the diatom assemblages were analysed in order to ascertain the sedimentary environment already reconstructed by evidence of molluscan assemblages (MAEDA 1978).

## Materials and Methods

The sediments were collected by Dr. Maeda from a caisson used to build the foundation of bridge piers of the Tatsumi-bashi from February to June in 1972. The Tatsumi-bashi is situated near the mouth of the Samondo-gawa river along the northern coast of the Osaka Bay in Japan. For the diatom analysis, samples of approximately 1 g were taken at proper intervals of sediment, boiled with 15% hydroperoxide, and treated with conc. hydrochloric acid. A suitable amount of the cleaned and washed materials was dried and mounted with pleurax. The identification of diatoms was made by means of photomicrographs. About two hundred frustules of diatoms were counted in each sample, along a transect chosen at random and the relative abundance of each taxon is shown as a percentage of the total.

## Stratigraphy

The stratigraphy of the sediments at the Samondo-gawa site is shown briefly in the 2 nd to 4 th columns of Fig. 1 and was described by MAEDA (personal communication) as follows:

The lowermost unit of this sediment belongs to the Osaka Group, composed of blue sand and gravel.

The Itami Formation is divided into two units:

a) blue green sand, clay and dark brown peaty clay about 2 cm thick.

b) dark brown peat; lower peat 40 cm thick, middle volcanic ash 50 cm thick and upper peat 20 cm thick. The upper part of this bed may be separated from the Itami Formation on the basis of the radiocarbon dates described below.

The Osaka Bay Formation can be divided into three units.

a) lower silty clay (Nanko Bed); the lower part consists of humaceous silty clay containing *Phragmites* sp. and freshwater sediments; the upper part consists of laminated dark brown clay containing many marine shells such as *Crassostrea gigas* and *Cerithideopsilla djadjariensis*, which imply the beginning of Holocene transgression at this site.

b) middle silty clay (the lower part of Umeda Bed); all consist of marine silty clay containing abundant marine shells indicating the sediments typically formed in an inner bay.

c) upper silt (the upper part of Umeda Bed); the lower part consists of silty clay and fine sandy silt upward, containing marine shells indicating an inner bay sediments.

## Radiocarbon Dates

Seventeen samples from the Samondo-gawa site have been dated by Dr. HAMADA. Sixteen of them are shown in the 6 th column of Fig. 1. The other one is of −9.7 m and shows a radiocarbon age of 1370±80. The radiocarbon dates suggest that the upper peat of the Itami Formation shows a radiocarbon age of 22,000±415 years BP* and the upper continuation of the same peat bed shows an age of 11,900±150 years BP. Dr. MAEDA has not yet given

* BP=before present=before 1950

any name for the bed younger than Itami Formation and older than 10,000 years BP. Consequently, the authors consider that there is an unnominated bed between the Nanko Bed above and the Itami Formation below.

**Molluscan Assemblages**

The molluscan fossils from the Umeda Bed at the Samondo-gawa site are studied and summarized by MAEDA (1978) as shown in the 5 th column of Fig. 1. MAEDA's description for the molluscan assemblages are as follows in ascending order. Assemblage I has characteristics indicating the environment of the intertidal zone of an inner bay. He pointed out that it shows the beginning of Holocene transgression at this site. Assemblage II has characteristics indicating the center of an inner bay. This assemblage is considered to have been formed at the period of the high level of the sea. Assemblage III indicated the sandy area of an inner bay. Such an assemblage was found in two horizons at this site, one at a depth of −22 m and the other at about −10 m below the present sea level. The assemblage at −22 m is confined in a very thin stratum indicating a short period in the rise of sea level. Another assemblage of −10 m imbedded in a sandy stratum indicating the leading edge of a coastal delta, which shows that sea was very shallow at that time at this site.

**Diatom Assemblages**

According to the results provided by many authors (HUSTEDT 1930, 1959, 1961-1966; PATRICK and REIMER 1966, 1975), most taxa of diatoms are able to be grouped into categories of salinity, i.e. marine species (M), marine and/or brackish (M-B), fresh and/or brackish (F-B) and freshwater species (F). Based upon these categories the diatoms found in the sediments at the Samondo-gawa site can be classified in three Diatom Zones which named A to C in ascending order. Diatom Zone B is divided into Subzones based on an occurrence of *Nitzschia granulata*.

In Diatom Zone A (−27 m to −24 m), being dominating by *Melosira distans*, *Navicula mutica*, *Eunotia* spp. and *Cymbella* spp., the ratio of freshwater species is more than 50% and increases up to 93% at −24.5 m depth.

In Diatom Zone B (−24 m to −11.5 m) freshwater species are dominated by *Stephanodiscus carconensis* and its ratio is less than 20%. On the other hand, marine species increase up to about 50% and the ratio of marine (M), marine and/or brackish (M-B) reaches nearly 85% at around −15 m depth. Diatom Zone B is divided into Diatom Subzone $B_1$ (−24 m to −21.8 m) and Diatom Subzone $B_2$ (−21.8 m to −11.5 m). In Diatom Subzone $B_1$, diatoms are dominated by a marine species *Nitzschia granulata* and a freshwater species *Stephanodiscus carconensis*. Diatom Subzone $B_1$ is roughly correlated with Molluscan Assemblage I and Diatom Subzone $B_2$ with Molluscan Assemblage II reported by MAEDA (1978).

In Diatom Zone C (−11.5 m to −9.5 m), being dominated by *Cocconeis placentula*, *Stephanodiscus carconensis* and *Cymbella* spp., the ratio of freshwater species is about 50%. Diatom Zone C roughly corresponds to Molluscan Assemblage III by MAEDA (1978).

**Discussion**

The radiocarbon dates suggest that the lowermost part of the sediments at the Samondo-gawa site shows an age of about 30,000 years BP. From the fact that marine species increase in number downwards in Diatom Zone A, it can be assumed that the rising of the sea level occurred toward the period about 30,000 years BP. Pollen analysis tells us that mean annual temperature at the period between 33,000 and 29,000 years BP was about 3-4°C lower than that of the present in northern Japan (NAKAMURA *et al.* 1960). This warm period was immediately followed by a cold glacial period around

2,0000 years BP, when the mean annual temperature was 7-8°C lower than that of the present. Corresponding to this warm temperature a high sea level around 30,000 years BP has been expected in the coastal area in Japan. YASUDA (1978) points out that a series of radiocarbon dates places this warm period in the Würm glacial age between 33,000 and 29,000 years BP, suggesting the possibility that it corresponds to the Denekamp Interstadial (HAMMEN *et al.* 1971) in the Netherlands.

The genus *Eunotia* is commonly found in stagnant waters and *Melosira distans* is characteristic of more or less humaceous lakes. From the fact that Diatom Zone A is dominated by the above mentioned taxa, *Eunotia* and *Melosira distans*, it can be considered that there were many lowland freshwater marshes around the Samondo-gawa site and the sea level was very low at the period around 10,000 years BP.

According to MAEDA (1978) the beginning of the Holocene transgression, confirmed by the intertidal assemblage of mollusca, starts at −23.4 m, which horizon shows an age of 8,820 years BP. In the present paper, only four frustules of diatoms were detected at −24.0 m, as if some remarkable events or environmental changes took place. Many marine species of diatoms appeared at −23.8 m, which horizon consists chiefly of humaceous silty clay containing *Phragmites* sp. but no marine molluscs and belongs to the lower part of lower silty clay of the Nanko Bed. From the above mentioned evidence, it can be assumed that an intertidal assemblage of diatoms appears prior to that of molluscs in the progress of Holocene transgression.

It is considered that sea was very shallow at the horizon between —24 m and —21.8 m, because Diatom Zone $B_1$ is dominated by *Nitzschia granulata*, which is frequent on sandy shores in England (HENDY 1964). This consideration agrees with the opinion that sea level rose slowly at the period between 8,800 and 8,000 years BP (MAEDA 1978).

On the other hand, Diatom Zone $B_1$ is dominated by *Stephanodiscus carconensis*, which is one of the most noticeable phytoplankers in the Lake Biwa-ko ever since the last 250,000 years (MORI and HORIE 1975) and at present time (NEGORO 1960). MORI and HORIE (1975) stated that *Stephanodiscus carconensis* decreased at Sc. 1 Point of a 200 meter core sample from the Lake Biwa-ko and referred the period after Sc. 1 Point to the post-glacial time. From the above mentioned facts, *Stephanodiscus carconensis* found in Diatom Zone $B_1$ at the Samondo-gawa site is regarded as a phytoplankter which drifted from the Lake Biwa-ko, so that this site was connected with the Lake Biwa-ko through the Paleo-Yodo-gawa at this period.

In Diatom Zone $B_2$, the dominant species of marine diatoms changes from *Nitzschia granulata* in a sandy shore habitat, via *Cyclotelle stylorum* in a littoral habitat, to *Melosira sulcata* in a littoral or in neritic habitat in accordance with the changes of the molluscan assemblages, from intertidal to sub-intertidal zones reported by MAEDA (1978).

In Diatom Zone C (—11.5 m to −9.5 m), a decrease of *Melosira sulcata* of littoral or neritic species and an apperance of *Nitzschia granulata* on sandy shore habitat as well as an apperance of the intertidal assemblage of mollusca are found. It is assumed that these changes were caused by the regression of sea level at this period between 2,500 and 1,500 years BP. On the other hand, the ratio of freshwater species increases up to 50%, being dominated by an alkaliphilic species *Cocconeis placentula*, and a planktonic spcies *Stephanodiscus carconensis* which drifted from the Lake Biwa-ko. From these facts, it can be considered that the Samondo-gawa site was located near the fringe of the lobated delta of the Paleo-Yodo-gawa.

**Acknowledgements**

The authors wish to express their sincere thanks to Dr. H. HIROSE, Professor Emeritus of Kobe University and Dr. A. SUGIMURA of Kobe University for their critical readings of the manuscript. Grateful acknowledgement is expressed to Dr. Y. MAEDA of Kobe City Institute for Educational Research for the collection of the sediments and for his valuable suggestions. The authors wish to express their thanks to Dr. A. L. BLOOM of Cornell University for helpful discussion. Heartfelt thanks are also expressed to Dr. I. KOIZUMI of Osaka University, Dr. Y. NOGUCHI of Osaka Kyoiku University and Prof. T. ZORIKI of Osaka Seikei Women's College for the identification of diatoms and Dr. C. HANADA of Institute of Physical and Chemical Research (Riken) for the imformation on radiocarbon dating used in this study.

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**熊野　茂・宮原幸子：大阪湾左門殿川口における完新世珪藻遺骸群集の変遷**

左門殿川川口の潜函より前田（1978）の採取した堆積物の珪藻分析を行なった。
大阪湾累層は南港層と梅田層に，梅田層は更に2層に細分される。堆積物の珪藻遺骸群集の特徴より，大阪湾累層は下部より上部へ A, B, C の珪藻遺骸群集帯に分けられる。
珪藻群集帯Aでは淡水性珪藻が優占し，南港層にほぼ対応する。珪藻群集亜帯 $B_1$ は浅い海または潴に生育する潮間帯群集を含み，前田（1978）の貝類群集Iに対応する。完新世海進に伴って珪藻群集の変化は貝類群集の変化に先行する。珪藻群集亜帯 $B_2$ では浅海性珪藻の比率が増加し，前田の潮間帯下貝類群集IIに対応する。珪藻群集帯Cは潮間帯貝類群集IIIに対応し，淡水性珪藻が増加し再び海が浅くなったことを示す。（657 兵庫県神戸市灘区六甲台町1－1　神戸大学理学部生物学教室）

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## 案　内

### 第1回国際藻学会議 First International Phycological Congress

第1回国際藻学会議が1982年8月8-14日にカナダ東海岸のニューファウンドランドの St. John's にあるニューファウンドランド・メモリアル大学 Memorial University of Newfoundland で開催される。

海藻・淡水藻，大形藻・微細藻，およそ藻と名のつくものを研究するすべての人々の参加が期待される国際会議の第一回で，特別講演として次の3つ，シンポジウムとして次の12のテーマが取上げられる予定。

**特別講演：**

- 8月9日　1. R.T. Wilce: Arctic benthic phycology: Where we have been and where we have to go. 2. O. Moestrup: Algal phylogeny from the ultrastructural viewpoint. 3. K. Lüning: Photoperiodism in algae.

**シンポジウム：**

- 8月10日　1. Algal hormones. Convenor: R.C. Starr, 2. Freshwater Algae and Water Quality. Convenor: L.R. Mur, 3. Species Relationships and Distribution Patterns in the Phaeophyta. Convenor: A.R.O. Chapman, 4. The Dinoflagellate Cell Covering. Convenor: J.D. Dodge,
- 8月12日　1. Intra- and Intercellular Transport in Algae. Convenor: J. Willenbrink, 2. Algae-grazer Interactions. Convenor: T.A. Norton, 3. Life Histories and Taxonomy of Rhodophyta. Convenor: M. Guiry, 4. Nuclear and Cell Division from an Ultrastructural Viewpoint. Convenor: G. Leedale,
- 8月13日　1. Osmoregulation in Algae. Convenor: J. Hellebust, 2. Polymorphism and Taxonomy of Desmids. Convenor: C.E.M. Bicudo, 3. Genetics of Macro-Algae. Convenor: J.P. Van der Meer, 4. Plastids and the Cell Cycle. Convenor: Mme. Lefort-Tran.

ファーストサーキュラー入手希望者は下記に申込むこと。

The Secretariat, First International Phycological Congress, c/o Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland, Canada AIB 3X9

なおこのファーストサーキュラーには申込用紙がついているので，これに必要事項を記入して8月31日まで事務局に送ると，セカンドサーキュラーを10月頃受取ることができる。

（千原　光雄）

**井上 勳・堀口健雄：微細藻類ノート (3). *Bipedinomonas rotunda* CARTER（プラシノ藻綱）. Isao INOUYE and Takeo HORIGUCHI: Notes on micro-algae in Japan (3). *Bipedinomonas rotunda* CARTER (Prasinophyceae).**

PARKE & GREEN (1976) の分類系に従うと本種はプラシノ藻綱 (Prasinophyceae)，プテロスペルマ目 (Pterospermatales) ネフロセルミス科 (Nephroselmidaceae) に所属する藻である。大きさ 4～6 μm の浮遊性鞭毛藻であり，通常のネットによる採集は不可能である。多くの場合試料水中に存在していても個体数が少なく，確認は容易でない。本種の採取には先にのべた方法（井上，1981）が効果的である。

藻体は円形に近い偏平な細胞で，やや不等長の2本の鞭毛を側面の小さなくぼみからのばす。葉緑体はカップ状で，やや黄がかった緑色を呈する。側壁に沿って2枚の片葉に分かれ，リング状のよく目立つデンプンに包まれたピレノイドが鞭毛の反対側に位置する。眼点は葉緑体片葉の先端にあり，短鞭毛に近接して存在する。核は眼点と反対側の鞭毛基部近くにある。すばやく回転しながら，短鞭毛を前方に，長鞭毛を後方に引いて泳ぐ。しばらく遊泳すると，唐突に停止し，図1のように長鞭毛を接線方向にのばし，また短鞭毛は細胞外膜を包みこむような様子を示すが，再び唐突に遊泳をはじめる。このような特徴的な運動をくりかえすので，生材料を用いれば低倍率でも属の同定は比較的容易である。運動を停止したときのこの特徴的な鞭毛の様子は固定試料では保存されない。

細胞表面は1辺約 45 nm の正方形の鱗片と大小2層の星状の鱗片が密におおう。これらの鱗片は微小で，電子顕微鏡でのみ確認が可能である（図2）。

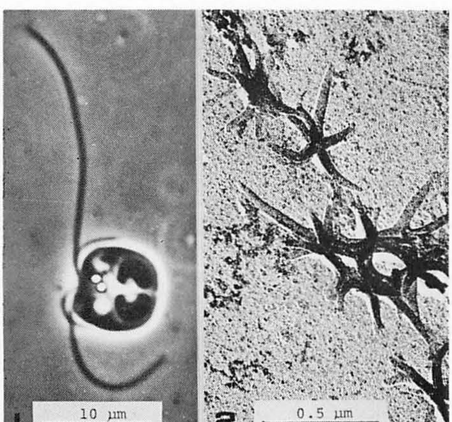


Fig. 1. A cell under phase contrast microy.
Fig. 2. Shadowcast field of large stellate scales.

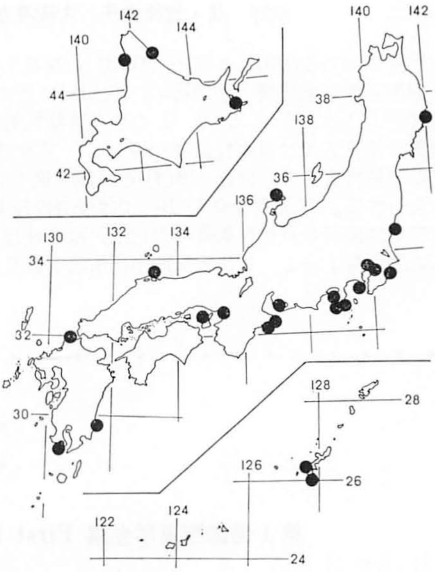


Fig. 3. Map showing localities where specimens of *B. rotunda* were collected.

この藻の光顕的特徴は CARTER (1937) の記載によく一致し，また鱗片の形質は MANTON *et al* (1965) の報告によく一致する。

本種は港湾，河口域の水サンプルや海浜の砂サンプルからしばしば分離されるので，比較的幅広い環境条件のもとで生息していると思われる。現在までに確認したわが国における本種の分布を図3に示す。地理的分布は北海道から沖縄までの広範囲におよび，極めて普遍の種であるらしい。

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（筑波大・生物）

藻類 Jap. J. Phycol. 29: 117-120. June 20, 1981

# 優占種，多様性指数および純率からみた多摩川の流下藻の生態

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YOSHITAKE, S. 1981. Drifting algae in the River Tama in view of dominant species, diversity index and MOTOMURA's index. Jap. J. Phycol. 29: 117-120.

Drifting algae were investigated at 8 stations in the middle and lower reaches of the River Tama, central Japan. The materials were collected in August and October 1973, and in January 1974. When an abrupt increase of algal density was found in the main course of the river, the first and second dominant species were composed of planktonic species or attached algae which were capable of living also as plankton. In this case, the diversity indices based on SHANNON's formula were generally low because the drifting algal communities were confined to several species. Such an abrupt increase of the algal density with a low value of diversity suggest that the dominant species might derive from proliferating planktonic algae rather than removal of attached algae.

Compared with the average cell density in Japanese rivers, higher values were found at a few stations of the tributary streams. The first and the second dominant species at these stations consisted of attached algae which have a tolerance for water pollution and in addition, the diversity indices were low (1.10−2.62) excluding one exceptional high value, 3.54. Negative correlation was recognized between the diversity index and MOTOMURA's index (MOTOMURA 1943), which is the cell number of the first dominant species divided by the total cell number, and between the dominance index (MCNAUGHTON 1967) and the diversity index. So, it is more time-saving to employ MOTOMURA's index than the diversity index which requires much time to calculate. High values of MOTOMURA's index were recognized at such stations where drifting algae profusely increased or the waters were polluted.

*Key Index Words*: *diversity index*; *dominant species*; *drifting algae*; MOTOMURA's *Index*.

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1973年8月，10月および1974年1月の3回にわたって多摩川の中，下流部の本流5，支流3地点，計8地点の流下藻を採集した。これら流下藻の各調査水域における優占種と多様性指数から，多摩川の流下藻の生態を考察してみた。また，計算の複雑な多様性指数にかわるものとして元村の純率の応用を検討してみた。

## 材料と方法

流下藻の採集は，川の流れの中央部で行ない，表層水 250 m*l* を採水し，ホルマリン固定を行なった。試料は一昼夜静置した後，上澄液を捨て，この操作を数回繰返して濃縮し，この一定量を採り検鏡を行なった。定量に際しては300個体を目標に，出現した藻類を計数した。

## 結　　果

多摩川の流下藻の現存量を Table 1 にまとめた。これによると多摩川本流では1973年8月には st. 1 より st. 2 までは $5\times10$〜$5\times10^2$ 細胞であるが，st. 3 では $2\times10^3$ 細胞以上と高い現存量を示し，それより下流も同様に高い値を示している。上流の地点に比べて高い現存量がみられる st. 3, 4 の第一優占種には，それぞれ *Cyclotella* sp. が出現しており，第二優占種は *Chlamydomonas* sp. *Merismopedia* sp. が出現している。(Table 2)。

10月の調査結果では st. 2 までは数十細胞であった

Table 1. Cell number (cell/m*l*) and index values in the samples of drifting algae from the River Tama.

| station | cell number/m*l* | | | diversity index | | | Motomura's index | | | dominance index | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aug. | Oct. | Jan. | Aug. | Oct. | Jan. | Aug. | Oct. | Jan. | Aug. | Oct. | Jan. |
| 1 | 58 | 14 | 425 | 2.62 | 2.88 | 3.24 | 44.8 | 57.1 | 27.8 | 60.3 | 78.5 | 44.5 |
| 2 | 539 | 30 | 1312 | 3.15 | 2.66 | 2.69 | 28.9 | 30.0 | 47.6 | 46.0 | 56.5 | 63.4 |
| 3 | 2117 | 376 | 1024 | 2.48 | 1.96 | 2.83 | 50.6 | 69.4 | 32.8 | 62.1 | 76.3 | 65.8 |
| 4 | 9368 | 1069 | 383 | 2.37 | 1.84 | 3.39 | 53.2 | 64.5 | 26.9 | 69.6 | 81.6 | 61.9 |
| 5 | 3836 | 871 | 311 | 2.98 | 2.28 | 3.07 | 26.7 | 44.7 | 32.8 | 47.1 | 70.6 | 55.9 |
| 6 | 36 | 8 | 763 | 2.49 | 2.16 | 3.54 | 38.9 | 37.5 | 25.4 | 58.3 | 62.5 | 36.8 |
| 7 | 2010 | 396 | 2371 | 2.36 | 3.54 | 2.62 | 47.2 | 22.0 | 38.8 | 69.2 | 42.4 | 66.3 |
| 8 | 19198 | 590 | 214 | 1.42 | 1.10 | 1.82 | 61.2 | 80.7 | 47.7 | 86.8 | 89.0 | 82.7 |

Table 2. Dominant species of drifting algae in the River Tama.

| station | date | the first dominant species | the second dominant species |
|---|---|---|---|
| st. 1 | Aug. '73 | *Synedra ulna* var. *oxyrhynchus* | *Cymbella turgidula* var. *nipponica* |
| | Oct. '73 | *Ceratoneis arcus* var. *vaucheriae* | *Navicula* gregaria |
| | Jan. '74 | *Nitzschia dissipata* | *Cymbella ventricosa* |
| st. 2 | Aug. | *Nitzschia palea* | *Chlamydomonas* sp. |
| | Oct. | *Cyclotella* sp. | *Navicula gregaria* |
| | Jan. | *Chlamydomonas* sp. | *Nitzschia palea* |
| st. 3 | Aug. | *Cyclotella* sp. | *Chlamydomonas* sp. |
| | Oct. | *Cyclotella* sp. | *Melosira varians* |
| | Jan. | *Chlamydomonas* sp. | *Stigeoclonium* sp. |
| st. 4 | Aug. | *Cyclotella* sp. | *Merismopedia* sp. |
| | Oct. | *Cyclotella* sp. | *Merismopedia* sp. |
| | Jan. | *Nitzschia palea* | *Euglena sp.* |
| st. 5 | Aug. | *Merismopedia* sp. | *Cyclotella sp.* |
| | Oct. | *Cyclotella* sp. | *Anabaenopsis* sp. |
| | Jan. | *Euglena* sp. | |
| st. 6 | Aug. | *Nitzschia paleacea* | *Nitzschia palea* |
| | Oct. | *Achnanthes* sp. | *Cocconeis placentula* |
| | Jan. | *Cymbella ventricosa* | *Gomphonema tetrastigmatum* |
| st. 7 | Aug. | *Synedra ulna* | *Nitzschia palea* |
| | Oct. | *Nitzschia palea* | *Stigeoclonium* sp. |
| | Jan. | *Nitzschia palea* | *Stigeoclonium* sp. |
| st. 8 | Aug. | *Nitzschia palea* | *Stigeoclonium* sp. |
| | Oct. | *Nitzschia palea* | *Cyclotella* sp. |
| | Jan. | *Anabaenopsis* sp. | *Stigeoclonium* sp. |

のが，st. 3 では $3\times10^2$ 細胞以上となり現存量が急に高くなっている。st. 3 と St. 4 の第一優占種は *Cyclotella* sp. で，第二優占種はそれぞれ *Melosira varians*, *Merismopedia* sp. になっている。

1月には st. 1 で約 $4\times10^2$ 細胞あったが，st. 2 で値がかなり大きくなり $10^3$ 細胞以上となっている。st. 2 の第一優占種は *Chlamydomonas* sp. で，第二優占種は *Nitzschia palea* になっている。

以上より多摩川本流で流下藻個体数が急に高い値を示す時は，第一および第二優占種はいずれも浮遊生活可能な種で構成されている（例，8月 st. 3, st. 4, 10月 st. 3, st. 4）。一方，上流の調査地点に比べてかなり高い現存量を示していても，その増加率がさほど高くない地点では，第一優占種は浮遊生活可能な種であるが，第二優占種は付着性種となっている（例，1月 st. 2）。これら上流の地点に対して，個体数増加の著しい地点の多様性指数（SHANNON and WEAVER 1963）は概して小さい値で，1.84より2.69の間の値を示している（Table 1）。

支流においても日本の平均値（数十〜数百細胞/m*l*,

福島1971)に比べて現存量の高い場合が時々みられる。それらは，8月の st. 7 と st. 8 で，第一優占種はそれぞれ *Synedra ulna*, *Nitzschia palea*, 第二優占種は *Nitzschia palea*, *Stigeoclonium* sp. である。10月も同じ2地点で，第一優占種はいずれも *Nitzschia palea*, 第二優占種は *Stigeoclonium* sp., *Cyclotella* sp. である。1月では，st. 7 で *Nitzschia polea*, *Stigeoclonium* sp. が，優占種になっている (Table 2)。

以上より，これらの支流で流下藻の多い場合は，いずれも主として付着藻によるもので，これらの藻の有機汚濁耐性は大変強いのが普通である。この場合の多様性指数は，かけ離れた値の3.54を除くと1.10〜2.62と小さい値をとっている (Table 1)。

## 考　　察

日本の河川の流下藻は，上流にダム湖がない限りは，一般には付近の石礫に付着している種や，上流の付着性藻類の種が剝離流下してきたものである。従って，藻類の塊が入らない限り，種類は多いがどの種も個体数が少ない。このような場合は多様性指数が大きくなる。しかし本調査では，次のような条件下では流下藻でも低い値の多様性指数を示している。

1) 調査水域付近で流下藻が多量に増殖している場合。この例は本流における数地点で既に記した。

2) 流域のかなり広い範囲が汚濁している場合，。また小さい支流等では，源流部付近から汚濁の著しい場合にも多様性指数は小さくなり，st. 8, 野川がこの例にはいる。

3) 何らかの理由で付着藻類が多量に混入した場合。10月に st. 1 で，*Ceratoneis arcus* var. *vaucheriae* が多量に出現したのがこの例である。

どのような理由によって多様性指数が低い値を示しているのかは，優占種の生態によって推定が可能である。優占種がいわゆる浮遊性種である場合は 1) に相当する事が多く，汚濁耐性の大変強い種である場合は 2) と推定でき，上記以外の生態を示す種の場合は 3) と一応考える事が妥当である。即ち，優占種の生活型や汚濁耐性などの生態的特性が，流下藻群集の成因，由来を推定するには重要である。

流下藻群集の由来を推定するには，優占種の生態的特性及び多様性指数を検討する必要があることを既に記

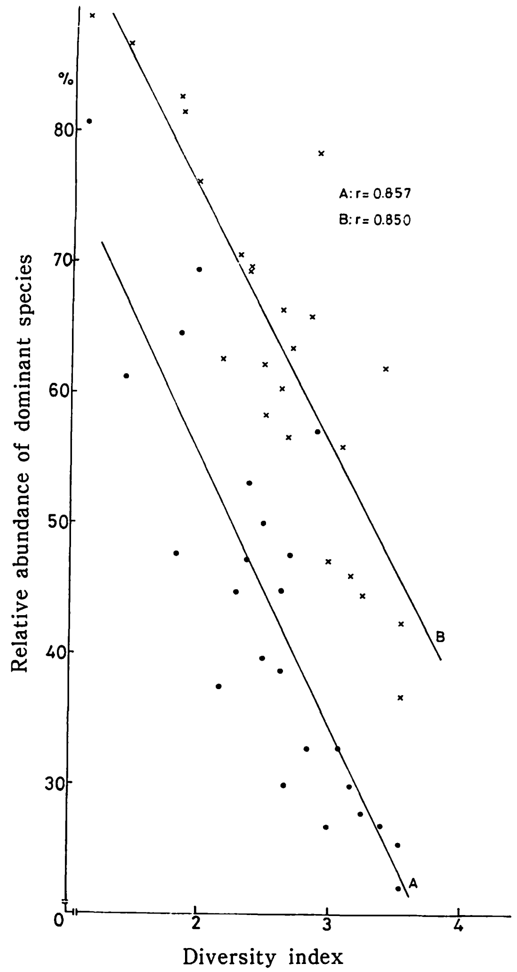


Fig. 2. Relationship between dominance (as percentage of cell number contributed by the most dominant species: line A and that of total cell number contributed by two most dominant species: line B) and diversity index of the River Tama in three seasons. ●……relationship between MOTOMURA's index and diversity index. ×……relationship between dominance index and diversity index.

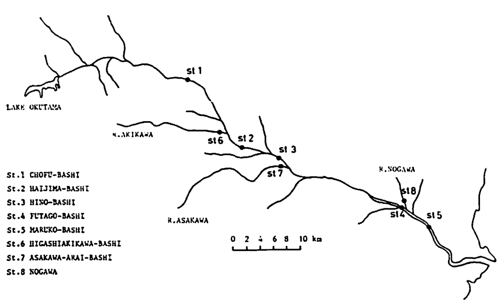


Fig. 1. Location of sampling stations in the River Tama.

したが，多様性指数の算出は簡単ではないので，この方法にかわるもっとも簡単な方法として純率を考えてみた。純率は元村（1943）によると群集に出現する種類のうち，最大の個体数を有する種類，即ち優占種の個体数を，出現した藻類の総個体数で割った値である（Table 1)。等比級数の法則に従う群集では，純率のみから等比級数の公比を推算する事が可能である。従って，優占順位第一位の種類の純率は，きわめて重要な意味をもち，この種の示す生態が流下藻群集の成因，由来を推定するのに重要となってくる。そこで，多摩川の流下藻の純率と SHANNON and WEAVER の多様性指数の相関関係を Fig. 2 の直線Aに示した。その相関係数は r=0.857 で信頼度95%，99%ともに負の相関関係を認める事ができ，回帰式は y=−20.85x+96.59 である。これは上記の元村（1943）によると当然の事である。

次に McNAUGHTON (1967) によると優占度指数 (dominance index) が種多様性と負の相関関係を認める事ができるとしている。

この優占度指数は，個体数のもっとも多い種とその次の種の個体数，即ち上位2種の個体数の和をその群落の総個体数で割った値を言う (Table 1)。優占度指数は SHANNON and WEAVER の多様性指数とも相関関係が成立するはずで，両者の関係も Fig. 2 の直線Bに示す。相関係数 r=0.850 で，信頼度95%，99%共，負の相関関係が成立し，回帰式 y=−19.08x+113.25である。

上記のような事から群集構造の解析に簡便法として，純率および優占度指数共に有効であるが，純率の方がその計算がより簡単であるので，これを利用する方が便利である。

多摩川本流で，流下藻の増殖していると考えられる地点の純率は，8月の st. 3 の50.6, st. 4 の53.2，10月の st. 3 の69.4， st. 4 の64.5，1月の st. 2 の47.6であり，その値は47.6〜69.4と大きい値を示している。支流においては，47.6以上を示すのは8月，10月，1月の st. 8 だけである。

以上より推定すると，流下藻の純率の大きい値を示すのは，河水中で浮遊性の流下藻が夥しく増殖したときか，著しく汚濁した河水の場合であると考えられる。

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# 淡水産中心類ケイソウ *Aulacosira ambigua* (GRUN.) SIM. の微細構造について

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KOBAYASI, H. and NOZAWA, M. 1981. Fine structure of the fresh water centric diatom *Aulacosira ambigua* (GRUN.) SIM. Jap. J. Phycol. 29: 121-128.

Nine samples of *Aulacosira ambigua* (=*Melosira ambigua* (GRUN.) O. MUELL.) collected from different habitats in Japan were examined using the scanning electron microscope. The ring-costa, termed "Ringleiste" in German, was revealed to be a canal running around the inside of the valve mantle near the edge. On the inside slope of the internal wall of the ring-costa opposite to the large rectangular opening of the external surface one weakly developed labiate process usually appeared. However, specimens with two labiate processes were infrequently noticed.

Both the separation valves with tapering solid marginal spines and the connecting valves with interlocking bifid marginal spines were found in a single chain. These two types of valves were clearly distinguished by the presence of marginal costa at the junction of the valve face and mantle of the separation valve. Each loculus was closed inside by a cribrum and a framework composed of circular and radially developed stick-like costae.

*Key Index Words*: Aulacosira ambigua; Melosira ambigua; *centric diatom*; *plankton*; *SEM fine structure*.

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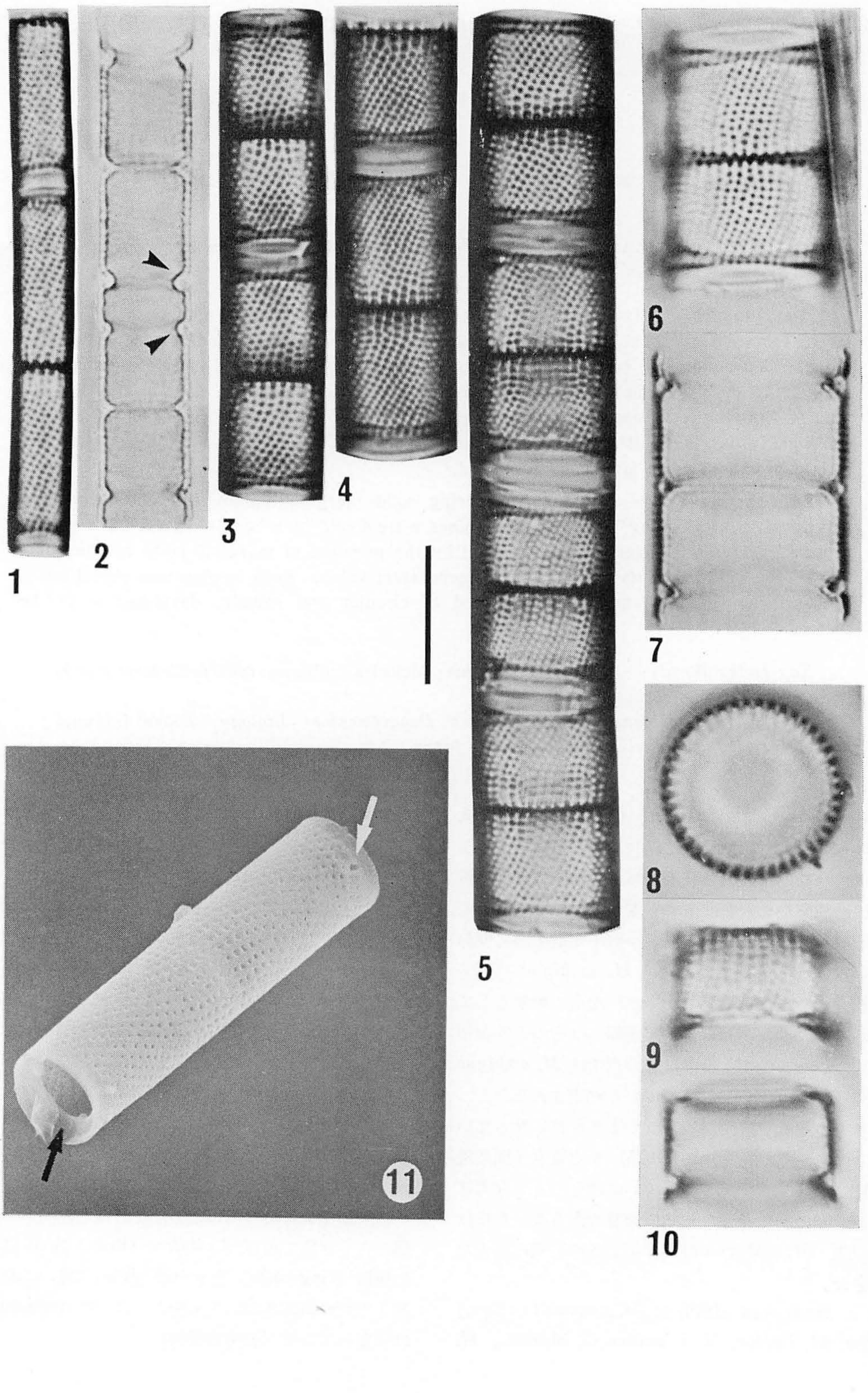
*Melosira ambigua* (GRUN.) O. MUELL と *M. italica* (EHR.) KUETZ. は，共に淡水産プランクトン性ケイソウの代表的な種類である。珪藻フロラの研究では，周知のように欧米でも本邦でも，種の同定には HUSTEDT (1930) の著名な小冊子が最も多く使われている。ところがここでは，*M. ambigua* は深くて明瞭な溝からなる輪溝 (sulcus) をもつ種類として描かれている。しかしながら，実際にはそのような個体は得られないので，輪溝以外の点では *M. ambigua* と考えられる個体が *M. italica* と同定されるなど，なお多くの混乱と疑問が残されたまま今日に至っている。しかし，CRAWFORD (1975) が走査電子顕微鏡 (SEM) を用いて，*M. ambigua* にはそのような溝はなく，それは輪になった管状の構造であることを指摘して以来，*M. ambigua* の実体がようやく明らかとなってきた。

また，SIMONSEN (1979) は *M. granulata* (EHR.) RALFS, *M. italica*, *M. islandica* O. MUELL., *M. distans* (EHR.) KUETZ. など代表的なプランクトン種が，すべて結合棘で連結すること，外側に開口をもち内側が師板 (cribrum) で閉ざされた胞紋 (areola) をもつこと，殻縁に1個の唇状突起 (labiate process) をもつことなどの共通点を重視し，これらをまとめて *Aulacosira* 属に移しかえを行なった。

筆者らが，*M. ambigua* もしくは *M. italica* と同定されてきた本邦産の試料を光学顕微鏡ならびに SEM を用いて観察したところ，それらのほとんどすべてが，*Aulacosira ambigua* (GRUN.) SIM. と同定されるべきものであることが判明した。

この種の微細構造について，またこの種を *Aulacosira* 属に移しかえることの妥当性についていくつかの新知見を得たので報告したい。なお，*Aulacosira* 属のタイプ種である *A. italica* (EHR.) SIM. は中実の横輪 (ring-costa) をもつが (Fig. 23)，これは胞紋その他の構造においても明らかに *A. ambigua* とは異なっている（未発表資料)。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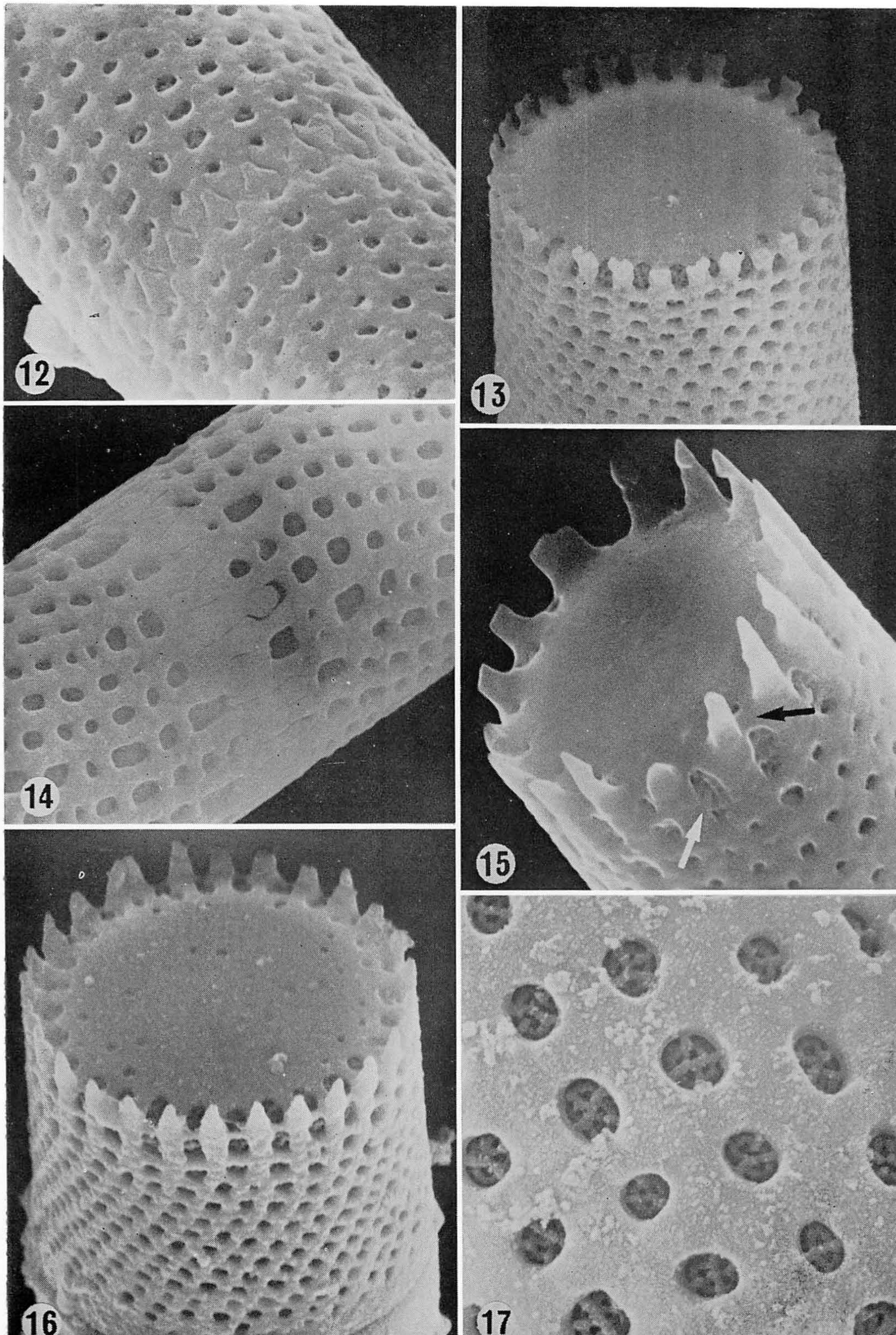
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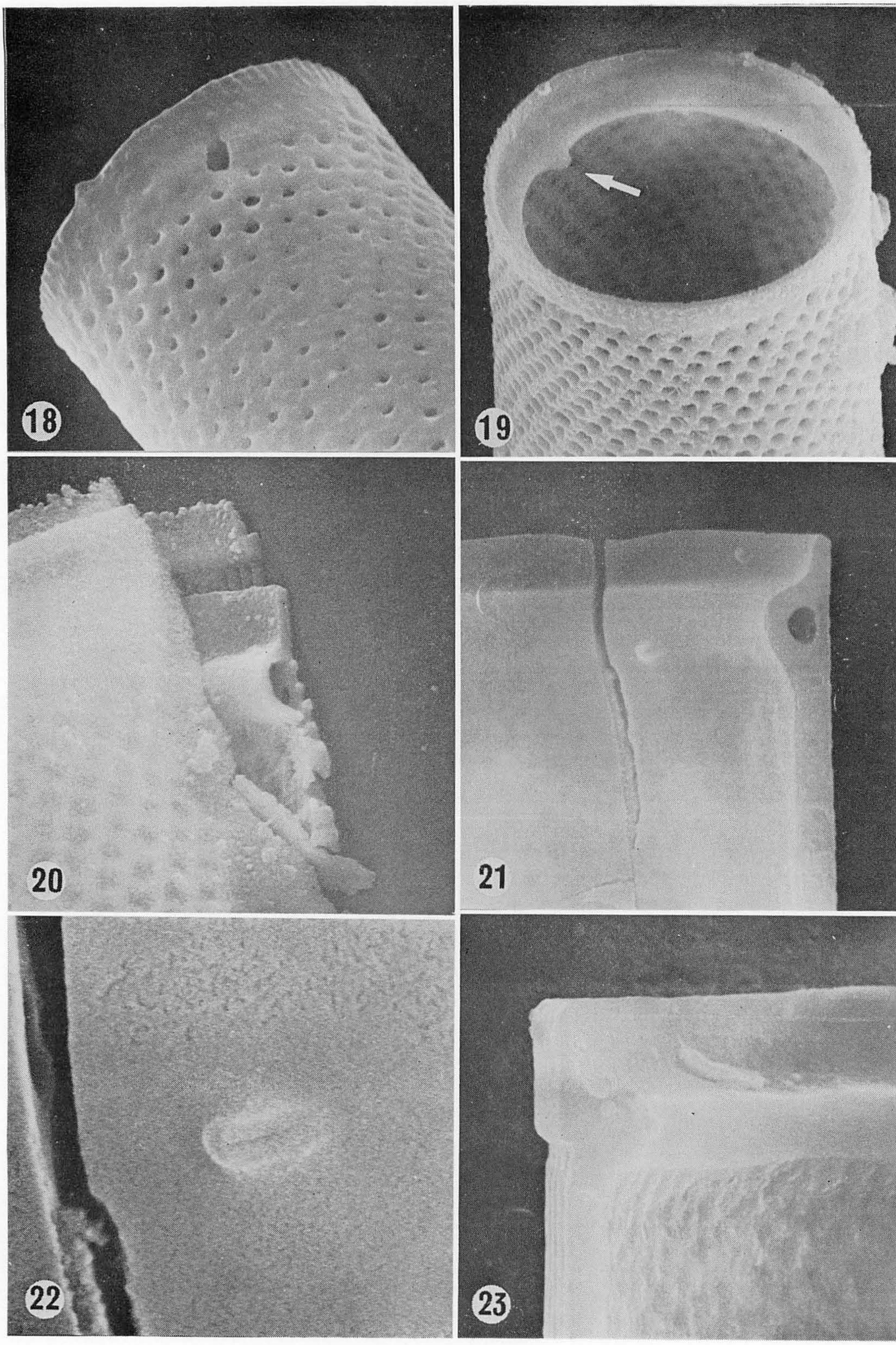
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## 材料と方法

観察に使用した試料は，次の9地点から採集されたものである。

青森・大沼 (55.4.29 プランクトン),
茨城・北浦 (54.4.29 プランクトン),
群馬・大峰沼 (47.6.11 植物付着),
同・尾瀬沼 (53.5.3 底泥),
埼玉・仙女ヶ池 (40.10.3 植物付着),
同・武蔵丘稜森林公園 (47.4.29 底泥),
東京・三宝寺池 (54.11.30 底泥),
静岡・一碧湖 (55.5.5 プランクトン),
滋賀・琵琶湖 (47.4.17 プランクトン)

どの試料も，硫酸・塩酸・過酸化水素水の順に各々熱処理を行なった後，蒸留水による十分な洗浄を繰り返した。光顕観察のためのプレパラートは，試料をPleurax または Eukitt で封入して作成した。また同一殻の殻面と帯面を比較するためには，ゆるくといたPleurax 中で試料を動かしながら観察した。SEM による観察には，カバーグラス上に目的とする殻をマイクロピペットで単離し，自然乾燥させた後，白金パラジウムで蒸着したものを用いた。SEM 観察には，日立 S-550 型，日本電子 JSM-F15 型を使用した。

## 結果と考察

国内各地で採集された試料の光顕観察によれば (Figs. 1, 3-5, 6, 9)，殻套面の点紋列は多少不規則ではあるが貫殻軸に対してやや傾きをもったラセン状に配列し，点紋列を構成する点紋は殻面に近づくほど大きくなる。殻の大きさに関しては，その変異の幅は大きく，殻径は 4-13 μm，殻高は 4-16 μm であった。点紋列は 10 μm 中に14-20本の範囲にあったが18本のものが最も多く，点紋は 10 μm 中に14-22個を数えることができた。殻面には，縁に沿って1列の点紋列が見られた (Fig. 8)。以上のことは，HUSTEDT (1930)

Figs. 1-10. Light micrographs showing variation in breadth of filaments of *Aulacosira ambigua*. Scale=10 μm. 1. Narrow filament mounted in Pleurax. Bottom sediment from Sanpoji-ike pond; 2. Mid-focused filament showing the specialized inward folds called sulci (arrow heads). Epiphyte from Oomine-numa pond; 3. Narrower filament composed of four connecting valves. Bottom sediment from Shinrin Park; 4. Middle size filament composed of a separation valve with tapering marginal spines and two connecting valves. Plankton from Biwa-ko lake; 5. Middle size filament composed of eight connecting valves. Plankton from Biwa-ko lake; 6, 7. Up and middle focused girdle view of the same filament mounted in Eukitt showing the hollow-costae (Ringleiste in German). Plankton from Biwa-ko lake; 8-10. Valve face, up and mid-focused girdle view of the same valve mounted in Pleurax. Bottom sediment from Oze-numa pond.

Fig. 11. Scanning electron micrograph showing two sibling valves linked together by interlocking spines. External opening of the labiate process (white arrow) and internal view of annular ring-costa (black arrow) are visible. ×3000.

Figs. 12-17. Scanning electron micrographs showing fine structure of *Aulacosira ambigua*. 12. Detail of the interlocking spines of the connecting valves. ×11500; 13. Valve face of the connecting valve showing areolae located at the junction of the valve face and mantle. ×6500; 14. Detail of the alternately inserted tapering spines of the separation valves. ×8000; 15. Oblique view of a separation valve showing the tapering spines, the terminal large areolae of the curved striae (white arrow), marginal costa (black arrow) and marginal areolae on the valve face. ×11500; 16. Separation valves collected from Biwa-ko lake with small areolae on valve faces in addition to the marginal large areolae. ×6400; 17. Detail of each areola on the valve mantle showing frame work composed of stick-like circular and radial costae of the inner layer. ×24000.

Figs. 18-22. Scanning electron micrographs showing fine structure of *Aulacosira ambigua*. 18. Mantle edge of a valve showing large external opening of labiate process. Note absence of sulcus near the mantle edge. ×11500; 19. Internal view of valve end showing ring-costa with one labiate process (arrow). ×6400; 20. Inside view of fructured hollow ring-costa showing thin internal wall and perforated external wall. ×10000; 21. Inside view of fractured hollow ring-costa with thick internal wall. Lips of labiate process are seen on inside slope of the ring-costa. ×8000; 22. Detail of lips and longitudinal slit of the labiate process. ×30000; 23. *Aulacosira italica*. Inside view of fractured mantle edge showing solid ring-costa. ×8000.

の記載ともよく一致した。

群体は殻面の縁にある棘 (spine) どうしの結合によって形成され，それらは強固にかみ合っているため，酸処理を行なっても分離せず，そのほとんどが細胞中央部ではずれ，無紋域の頸部 (hals) を末端として観察された (Fig. 11)。このような結合殻 (connecting valve) の結合棘は，間条線 (interstria) の延長上に1本ずつ見られ (Fig. 12)，先端が浅く二裂している。棘は根元よりも先の方が広いヘラ形であるため，物理的な圧力が加わらない限りはずれることはないように思われる。HELMCKE and KRIEGER (1952) は透過電子顕微鏡による観察に基いて，この種の殻の構造模式を発表しているが，棘の形態については筆者らのものとよく一致した。さらにこのような結合様式は，*A. granulata* (EHR.) SIM. (FLORIN 1970) および *A. baikalensis* (K. MEYER) SIM. (CRAWFOLD 1979) にも見られている。通常，殻面の中央部は平坦で，殻肩には棘の間に縦長の胞紋が1個ずつ存在する。(Fig. 13)。しかしながら，琵琶湖および森林公園内山田大沼 (KOBAYASI and ANDO 1977) から得た試料では，殻套の胞紋よりもはるかに小さな胞紋 (約1/4－1/10) が，殻面に不規則に同心円状に点在する場合も見られた。(Fig. 16)。

FLORIN (1970) は，*A. granulata* では群体を形成する中間部の殻の棘はヘラ形で，これらがジッパー状にかみ合ってはずれないのに対し，先細の棘のみが差し込み合った分離殻 (separation valve) が群体の途中に現われると，群体はその部分で2つに分かれると述べている。同様の構造は筆者らによって *A. ambigua* でも観察された (Figs. 14-16)。しかし，CLEVE-EULER (1951) は *A. ambigua* にはこのような末端細胞 (Endzellen) が形成されないので，群体の分離は娘殻を包んで残存する母殻の殻帯 (Gürtelband) がはがれた時にのみ起こると述べている。

分離殻の棘は，先細で結合殻のそれよりもやや長いが，同じく間条線の延長上に1本ずつ見られる (Fig. 14)。また，分離殻の胞紋列も結合殻とは異なっている。すなわち，殻套部の最も殻面に近い胞紋は他のものより2-3倍大きく (Fig. 15)，したがって，この部分の点紋列も 10 $\mu$m 中に12-14本と粗くなり，数本おきに1本の挿入条線が加わる。光顕像でも，殻肩の棘列とこれに接する大きくまばらな点紋，および挿入条線の存在から，分離殻を区別することは可能である (Fig. 4 の最上殻)。殻面の縁に沿って見られる1列の胞紋列は，棘と棘の間に1個ずつ存在しているが，分離殻では殻肩部に肥厚した肋骨状構造があり (Figs. 15, 16)，殻套部の胞紋とはこのために切り離されている。

殻套上の胞紋 (Fig. 17) の形は，円形またはややだ円形で孔の中には棒状体が周囲の壁から突き出て樹枝状の構造を作っている。OKUNO (1964) は *A. granulata* の胞紋構造について，内側は細い支柱で支えられた網目状の師板で閉ざされ，外側に向かって不規則に開口していると述べ，その詳細な図を示している。筆者らの観察した *A. ambigua* でも，よい像が得られなかったが，いくつかの殻の断面像から判断したところでは，基本的には OKUNO の示した模式図と一致するように思われる。このように殻の外側へと開口している胞紋構造は，*Melosira varians* C. A. AG. (CRAWFORD 1971)，*M. nummuloids* (DILLW.) C. A. AG. (CRAWFORD 1973)，*M. moniliformis* (O. MUELL.) C. A. AG. (CRAWFORD 1977) のそれとは異なっている。これらの殻壁構造は外側に師皮 (rica) をもつ偽小箱 (pseudoloculus) と呼ばれる (ROSS *et al.* 1979) ものである。これに対し，*A. ambigua* では外側の師皮は見られない。

HUSTEDT (1927) がこの種について，横輪と呼べる内側への肥厚部は存在せず，幅広な輪溝のみをもつと記載しているように，古くからこの種を特徴づける最も重要な形質は，深くて平らな底をもつ輪溝にあるとされてきた。確かに光顕では，屈折率の低い封入剤中で観察した場合，全ての個体にこの溝状ともとれる構造を見ることができた (Figs. 2, 7, 10)。しかし，殻表面に焦点を合わせたものではそのような溝は見られず，また SEM による観察でも輪溝に該当する構造は見られなかった (Figs. 11, 18, 19)。一方，殻の内面観ではこの部分に梁状に肥厚した横輪が見られるが (Fig. 19)，その断面観から肥厚部は中空の管状であることが判明した (Figs. 20, 21)。管の内壁は，出現水域の違いにより薄いものから非常に厚いものまで見られた。HELMCKE and KRIEGER (1952) の模式図では中実のものが描かれており，管状の横輪を推測したのは CRAWFORD (1975) が初めてであるが，断面を示してはいない。この点に関して古い記録を調べたところでは，GRUNOW (1882 in VAN HEURCK)，MÜLLER (1903) のどちらも完全にくびれた輪溝を描いてはいない。HUSTEDT (1927, 1930) になって，明瞭な溝をもつというやや誇張した表現がなされたように思われる。

殻縁部 (殻套の末端部) の表面には ほぼ長方形を

した目立った開口が1個存在する (Figs. 11, 18) が，ごく稀には2個のものも見られた。すでにCRAWFORD (1975) はこれを，唇状突起 (labiate process) の外部への開口であろうと述べているが，今回の調査で，横輪上の殻面よりの縁に内部への突出部が存在することがわかり (Figs. 19, 21, 22)，この開口がまぎれもなく唇状突起の外部への開口であることを確かめることができた。

以上のように，①円柱形の殻の殻肩に顕著な結合棘をもつこと，②胞紋が偽小箱構造であること，③殻縁部に少なくとも1個の唇状突起をもつこと，の3点によって，この種はSIMONSON (1979)の提唱するように，*M. nummuloides* をタイプ種とする *Melosira* 属から，*A. italica* をタイプ種とする *Aulacosira* 属に移しかえられてよいものと思われる。但し，*Aulacosira* 属を Thalassiosira 科と Melosira 科のどちらに帰属させるかは，今後なお検討を要する問題であろう。

また，殻が細長いために *M. italica* var. *tenuissima* (GRUN.) O. MUELL と同定されていた殻径 3-5 μm の個体についても，光顕・SEM による観察を行なったところ，*A. ambigua* との構造的な相異は認められなかった (Fig. 1)。*A. granulata* var. *angustissima* (O. MUELL) SIM. については，培養実験と SEM による観察の結果から，これらが承名変種の種内変異の範囲に含まれるべきであるとする報告が見られる (KILHAM and KILHAM 1975)。今回の調査でも，殻径 5 μm 以下のもののみが出現する水域が見当らず，また同一の試料中では出現する個体の殻径の変異は連続的であった。これらの結果と考え合わせ，*A. ambigua* でも，細くて長い個体を別の分類群として分ける必要はないものと思われる。

本研究に際し，琵琶湖の試料を提供下さった京都大学附属大津臨湖実験所の中西正己博士，SEM 使用の便宜を与えられた日本歯科大学の南雲保氏に深く感謝申し上げる。

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1933年に東京文理科大学附属臨海実験所として開設されて以来，戦後の学制改革に伴い，東京教育大学理学部附属臨海実験所と改称され，さらに東京教育大学の閉学と筑波大学の開学に伴って，1976年に筑波大学下田臨海実験センターと改称された。

伊豆半島の南端近くに位置する下田湾の一部をなす小さな入江である鍋田湾を前にした 18,200 $m^2$ の敷地に，延べ面積 1,185 $m^2$ の3階建ての第1研究棟，183 $m^2$ の平屋の実習棟，624 $m^2$ の2階建ての第2研究棟，91 $m^2$ の平屋の海洋観測棟，986 $m^2$ の一部2階，一部3階建ての宿泊棟などが建っている。

実習室は第2研究棟内にもあるので，30名程度の実習を2つ同時に行なうこともできる。船舶は 18t で定員30名の「つくば」，0.8t で定員5名の「みさご」の他，船外機付ボート1，和船2がある。実習用備品としては，双眼顕微鏡（ニコン CL-1）および双眼実体顕微鏡（オリンパス X-2）各40台，光合成呼吸測定装置（プロダクトメーター）6台，海藻標本乾燥器（永田式）3台など，研究用備品としては，電子顕微鏡（日立 HS-9），分離用超遠心分離機（日立 65P）ブラウン管オシロスコープ（日本光電）分光光量子計（QSM-2500），生産酸素計 YSI，水中スターラー付溶存酸素計 YSI，ダブルビーム自記分光光度計（島津 UV-200）などがある。

臨海実習は筑波大学の生物関係，地球科学関係だけでも10前後を数え，その他に東京学芸大学，東京都立大学，静岡大学，群馬大学，山梨大学，愛知教育大学，信州大学，秋田大学なども利用している。その他，研究者，大学院生，あるいは卒論生等による利用も多く，年間の延べ利用者数は7千人を超えている。

鍋田湾の両岸は共に磯で海藻の採集に適しているが，特に左岸の広い波食棚には多種多様の海藻がみられる。潮間帯には上部の方からマルバアマノリ，ヒトエグサハナフノリ，フクロフノリ，イワヒゲ，イシゲ，イロロ，マツノリ，イボツノマタ，イカノアシ，ウミトラノオ，ヒジキ，ネジモクなどが生え，タイドプール中には，オキツノリ，オゴノリ，ピリヒバ，ウスカワカニノテ，アミモヨウなどがみらする。漸深帯や下位のタイドプールには，カバノリ，ウミウチワ，マメダワラ，ヤツマタモク，アカモク，ノコギリモク，オオバモク，ホンダワラ，ハハキモク，イソモクなどが多く，また波のよく当る場所にはオオシコロ，暗い岩陰にはミドリゲなどが生えている。

下田へは東京から直通の特急で2時間40分，急行で3時間10分ほどで着き，関西方面からなら熱海で乗り換えると，それから1時間30分ほどで着く。終点の伊豆下田駅からはタクシーなら5分ほどでセンターへ着く。食事は日曜祭日は提供できないが，センター周辺には喫茶点やレストランが数軒あるため不自由はないであろう。また市街は徒歩で10分ほどの距離にある。

筑波大学の実習は春休みと夏休みに集中し，他大学の実習は4月中旬から5月にかけて多いが，実習中も団体でなければ利用可能である。利用申込は所定の用紙によって，〒305 茨城県新治郡桜村，筑波大学学務第2課管理係（電話 0298-53-2206）または〒415 静岡県下田市 5-10-1，筑波大学下田臨海実験センター（電話 05582-2-1317）へ。利用目的を充分達成するために，利用に先立って情報の必要な方は，藻類関係なら横浜まで連絡いただきたい。

（筑波大学下田臨海実験センター）

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# アミジグサとコモングサの培養と細胞学的研究

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YABU, H., NOTOYA, M. and SUGIMOTO, K. 1981. Culture and cytological observations on *Dictyota dichotoma* (HUDSON) LAMOUROUX and *Spatoglossum pacificum* YENDO. Jap. J. Phycol. **29**: 129-134.

Culture conditions of 20°C, 2000 and 4000 lux light intensities and 12 h dark and 12 h light photoperiodicity, using modified Grund medium obtained the complete life cycle of *Dictyota dichotoma* and *Spatoglossum pacificum* from their tetraspores. Under the above conditions, male or female reproductive organs were produced on plantlets 8-10 mm height of *Dictyota dichotoma* after one month culture, and on plantlets about 10 mm height of *Spatoglossum pacificum* after three months culture. The life cycle was completed in two months for *Dictyota dichotoma* and in seven months for *Spatoglossum pacificum*. The chromosomes of *Dictyota dichotoma* in the cells of young gametophyte and in the cells of antheridia had the haploid number of from 25-30. Cytological observations on the tetrasporangia of *Spatoglossum pacificum* indicated the following: 1) In early prophase, chromatin threads form loops at one corner of the nuclear cavity. 2) Occasionally a chromophilous spherule was found in the nuclear cavity at prophase I. 3) The nuclear membrane was clearly visible even at metaphase.

*Key Index Words*: *culture*; *cytology*; *Dictyotales*; Dictyota dichotoma; Spatoglossum pacificum.

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アミジグサ (*Dictyota dichotoma* (HUDSON) LAMOUROUX) については欧州では古くから THURET (1855), WILLIAMS (1897 a, b, 1898, 1903, 1904 a, b, 1905) MOTTIER (1900), WENDEROTH (1933), SCHREIBER (1935) 等により活発に研究が行われ，四分胞子体と雌雄配偶体の生殖器官形成，胞子の発生，あるいは核分裂について詳しく報告されている。このアミジグサは我が国では北海道から沖縄に至るまで日本海と太平洋の両沿岸に春から秋にかけてごく普通に見られるが，通常四分胞子体のみが得られて，今迄配偶体についての報告は岡村 (1903) が雌性体並びにその卵細胞群を図示したものと，松永 (1966) が九州で雄性体を採集し，その造精器について観察したこの2例があるにすぎない。

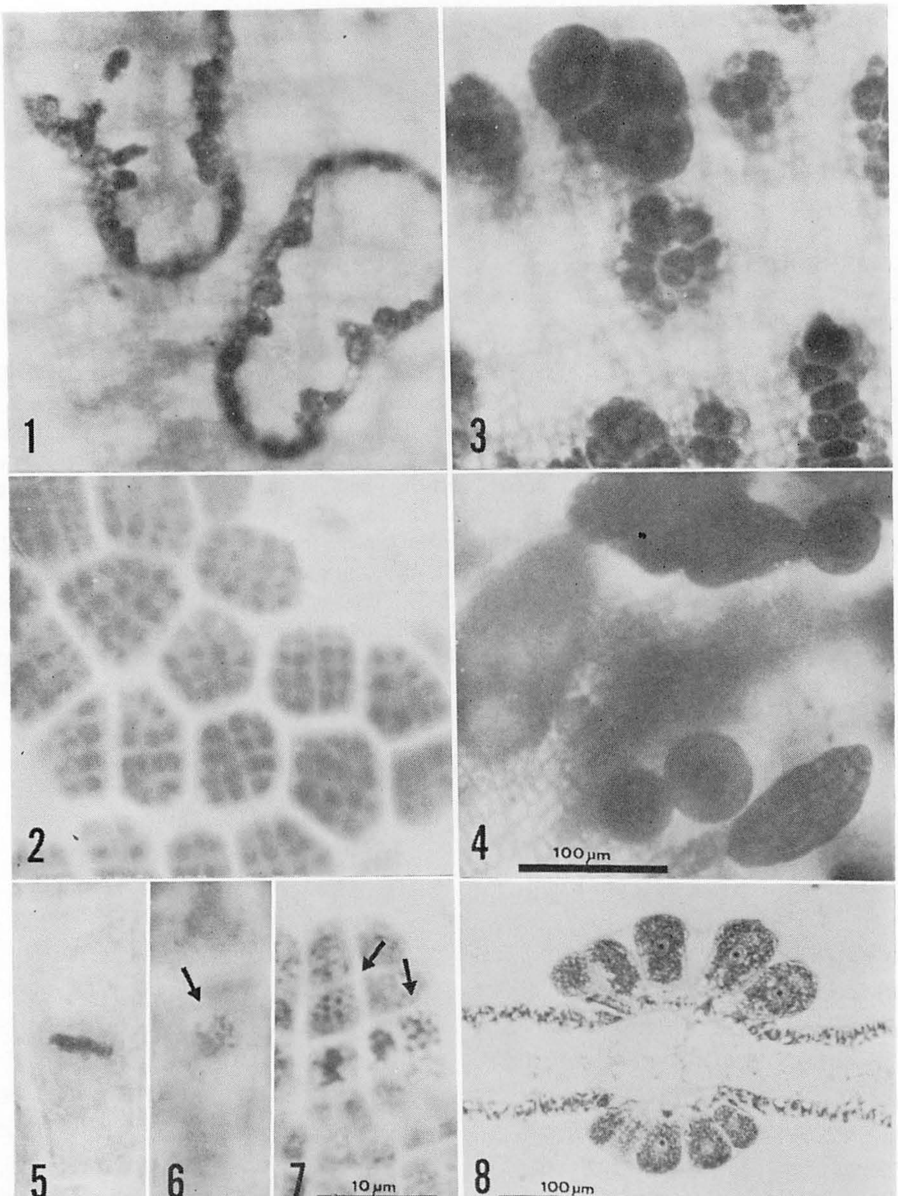
一方，同じアミジグサ目に属するコモングサ (*Spatoglossum pacificum* YENDO) は1902年 YENDO がこれを新種として発表した際，雌性配偶体の卵形成を見ているが，未だ雄性体が得られた記録はない。

そこで筆者らは函館に産するアミジグサとコモングサの四分胞子を培養し，その発生体について観察を続けていたところ，両種ともに少数のものから雌雄の配偶体を得ることができた。又，本培養を行うに際して採集したアミジグサの多数の四分胞子体に混じってごく少数の雌性体を見出した。アミジグサでは培養中の発芽体で，コモングサでは採集した四分胞子体の胞子形成部分で核分裂についても二三の観察を行った。

## 材料と方法

材料として使用したアミジグサは1979年8月11日，コモングサは1979年10月18日にいずれも函館市内の銭亀沢で採集した四分胞子体である。

アミジグサの四分胞子はまず予備実験として温度10, 15, 20, 25°C，照度を 500, 1000, 2000, 4000, 8000 lux，光周期は12時間明期，12時間暗期で10日間培養を行った結果，温度は 20°C，照度は 2000 lux と 4000




Figs. 1-8. *Dictyota dichotoma* Lamouroux. 1-4. Tetraspore germling in culture: 1. Part of a male gametophyte bearing fully matured antheridial sori in 30 day culture; 2. Part of a matured male gemetophyte bearing young antheridial sori in 35 day culture; 3. Part of a female gametophyte bearing eggs in 10 day culture; 4. Part of a female gametophyte bearing eggs and young sporophytes developed from the eggs, in 45 day culture; 5-7. Nuclear divisions in tetraspore germlings: 5. Side view of metaphase in a cell of germling in 35 day culture; 6. Metaphase (arrow) in a cell of germling in 35 day culture; 7. Metaphase (arrows) in the cells of antheridia of male gametophyte in 35 day culture; 8. Cross section of a female gametophyte collected at Zenigamezawa in Hakodate on August 11, 1979. Fig. 4 scale to right of Figs. 1-3. Fig. 7 scale to right of Figs. 5-6.

lux で生育状態が良かったので，アミジグサとコモングサはともにこの温度と照度で培養した。培養液には modified Grund medium (McLachlan 1973) を用い，一週間に一度，液の全量を換水した。

アミジグサの四分胞子発芽体で成熟中の雄性配偶体を酢酸・アルコール (1: 3) の液で固定し，酢酸・鉄ヘマトキシリン・抱水クロラール液 (Wittmann 1965) で染色した。コモングサでは採集した四分胞子体の一部を田原氏 (1929) の液（2%オスミウム酸・7 cc, 2%クロム酸・70 cc，氷酢酸・2.5 cc，海水・30 cc）とホルマリンを 3: 1 の割合で使用直前に混ぜた液で固定し，パラフィン法により厚さ 8μ の切片を作製し，ハイデンハイン氏鉄ヘマトキシリンで染色した。

## 観察と結果

### 1. アミジグサ

**培養結果**：培養した四分胞子は1ヶ月後に体長8-10 mm となったが，このときごく少数（約10%）の発生体に雌性又は雄性の生殖器官が形成された (Figs. 1-4)。雄性体では体の中央部付近より成熟が始まり，造精器が形成されてくる。雌性体では造卵器は初め数個ずつ群をなして現われるが，その 4-5 日後に成熟した卵（径 65-70 μm）が放出された。卵形成が始まったばかりの雌性体を1個体ずつ小型シャーレに移し入れて培養し，卵の単為発生について観察を行った。この場合には卵は発芽して 2-3 個細胞の体になるが発芽後 5-8 日経つと色素体が褪色して，そのまま枯死する。受精した卵は順調に生育し，四分胞子発芽体と同じ発生経過をたどる。しかし，仮根を形成しないまま生長する体も観察された。卵の発芽体は1ヶ月後に四分胞子体（体長約 10 mm）となり，この体から得た四分胞子を培養すると天然の四分胞子体から得た四分胞子発芽体の場合と異なり，すべての体が1ヶ月後には成熟して雌雄の配偶体（体長約 9 mm）となる。この雌性体より放出された卵からは1ヶ月後に再び成熟した四分胞子体（体長約 10 mm）が得られた。

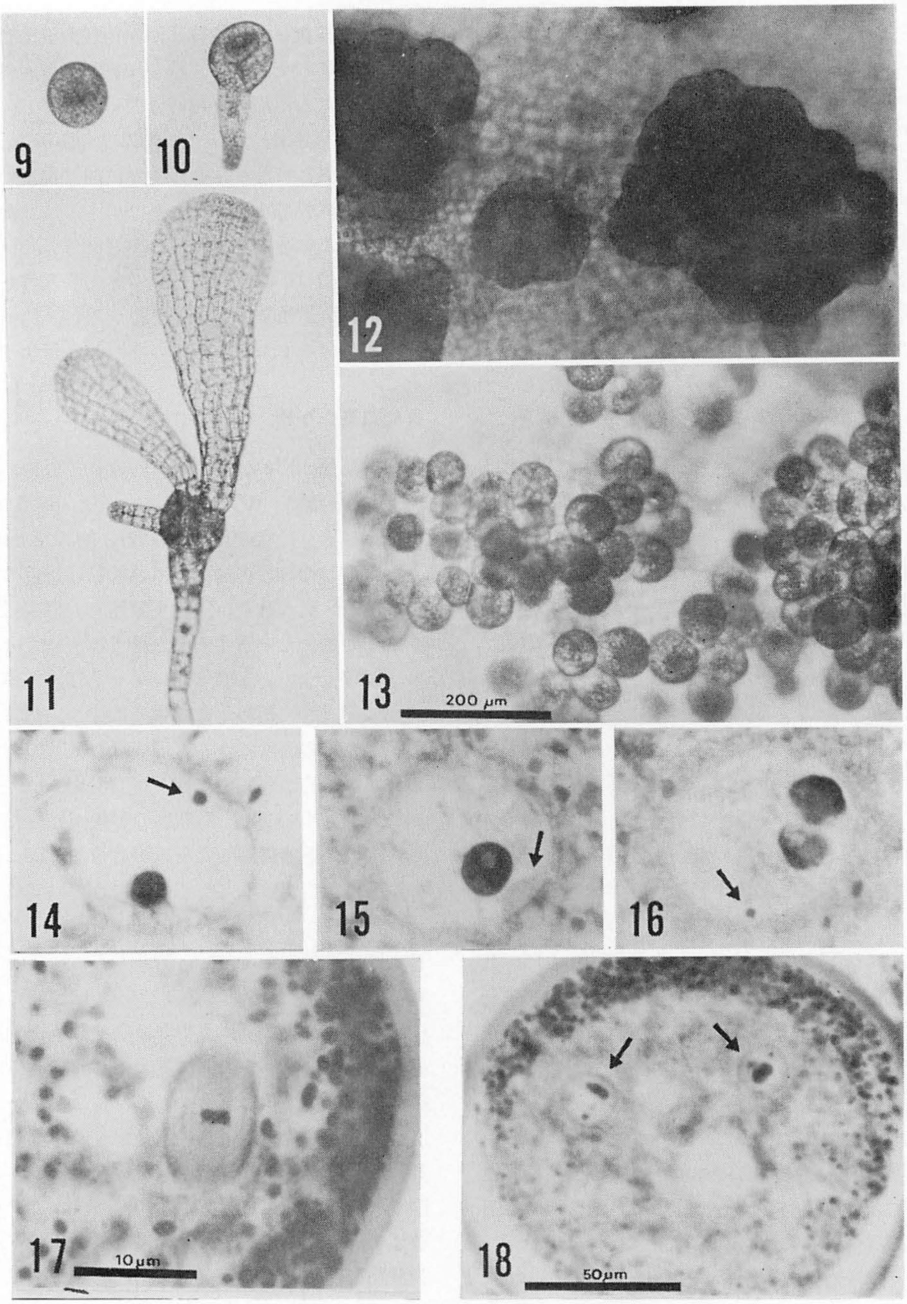
**核分裂**：四分胞子放出後3週間経て体長約 6 mm に達したもの5個体と，その後更に2週間経った成熟中の雄性配偶体10個を固定，染色して調べた。未熟体では体の先端付近の細胞のなかに核分裂中期の像 (Figs. 5, 6) が得られたが，その多くは側面観で，染色体を数え得る像はごく少数しか見ることができなかった。そのうちの3個の像ではそれぞれ25, 27, 29の染色体数を認めた。雄性配偶体では造精器内で分裂像 (Fig. 7) を多数観察できたが ここでも 25-30 の染色体数が得られた。

**天然で採集した雌性体**：函館市銭亀沢で1979年8月11日に採集したアミジグサを研究室に持ち帰り整理していたところ，約 300 の四分胞子体に混じって3個体の雌性体を見出した。この時の四分胞子体は体長 3-5 cm で群生しており，6月中旬に同じ場所で得た四分胞子体（体長約 10 cm）よりは小さく，二次的に発生して成熟したものと思われた。3個体の雌性体はいずれも体長約 10 cm で四分胞子体よりは著しく大きく外観は四分胞子体よりも幾分色が濃い。Fig. 8 はそれらの雌性体のうちの1個体の横断面を示す。

### 2. コモングサ

**培養結果**：Figs. 9-11 は四分胞子の初期発芽体を示す。四分胞子（径 70-94 μm，平均 86.5 μm）は培養開始後3ヶ月目に長さ約 1 cm，幅 2.5 mm に生長し，この時約10%の発芽体に雌性又は雄性の生殖器官の形成が見られた。雄性生殖器官の形成経過はアミジグサの場合と一致するが，精子嚢班は幾分アミジグサよりは大きい。雄性器官 (Fig. 12) は葉状体の中央部に形成され始め，成熟するに従がい体表面全体に散在してくるようになる。卵 (Fig. 13) の形成が認められてから約2週間後に卵（径 74-84 μm，平均 80.3 μm）が放出された。造卵器の形成が始ったばかりの雌性体を分離培養して卵を放出させると，この未受精卵は仮根を生ずることなく数日のうちにアミジグサの場合と同様に枯死した。受精卵は四分胞子の発芽の場合と同様の発生を行ない，約4ヶ月後に体長 1-2 cm，幅 3-5 mm となり四分胞子を形成した。この頃には中肋の隆起が認められるようになった。四分胞子嚢は体の下部の中肋部の両側に認められるようになり，次第に体の中央部に形成されてくる。

**核分裂**：体の表層細胞が四分胞子嚢母細胞となり，これが分裂を行い若い四分胞子嚢を生ずる。この四分胞子嚢はその大きさを増すと同時に核も大きくなり，核径が約 25 μm になった時核分裂を開始する。核分裂前期の初めには染色糸は核内の一隅に偏在し (Fig. 14)，次いで極めて繊維な糸状となって核内に拡がりやがて染色体となる。核分裂前期の初めでは約20%の核に色素によく染まる "chromophilous spherule" (Figs. 14, 16) が，約10%の核内には核膜に接してレンズ状のうすく染まる物体が見られる。仁は通常1個であるが稀に2個 (Fig. 16) 存在する。核分裂中期でも核膜は消失せず且つ紡錘体は明瞭に観察できる (Fig. 17)。核分裂の方向は細胞の軸に平行の方向




Figs. 9–18. *Spatoglossum pacificum* Yendo. 9–13. Tetraspore germling in culture: 9. Liberated tetraspore; 10. Tetraspore germling in one day culture: 11. Tetraspore germling in 4 day culture; 12. Part of male gametophyte bearing anthridia in 95 day culture; 13. Part of female gametophyte bearing eggs in 120 day culture. 14–18. Nuclear divisions in the tetrasporangia; 14–16. Early prophase. Chromophilous spherule in Figs. 14 and 16 and crescent lens body in Fig. 15 are indicated by arrow; 17. Side view of metaphase I; 18. Metaphase II (arrows). Fig. 13 scale to right of Figs. 9–12. Fig. 17 scale to right of Figs. 14–16.

のものが多いが斜め又は水平の方向のものもある。第2分裂では核径は 8-10 $\mu$m となり，第1分裂の核よりは可成り小さくなる。第2分裂を終え細胞内に4核が形成された後，細胞に隔膜が生じ4つの胞子が出来上る。

## 考　察

前述のごとく今までにアミジグサでは岡村 (1907) が雌性体を，松永 (1966) が雄性体を記述しているが，コモングサでは雄性体は報告されていない。本研究を行うに際して函館市銭亀沢沿岸でアミジグサとコモングサ両種の雌雄配偶体を探すべく努力したが，アミジグサでは約300個体の四分胞子体に混じって3個体の雌性体を見出すことができた。しかし，コモングサでは配偶体は見出すことはできなかった。

アミジグサ科植物の四分胞子の培養は現在までに COHN (1865), REINKE (1878), THURET and BORNET (1878), WILLIAMS (1904), PEIRCE and RANDOLPH (1905), CARTER (1927), ROBINSON (1932), INOH (1936), 西林・猪野 (1966) 等により行われたがいずれもその観察は初期発生にとどまり，未だ生活史を培養によって完結させた記録はない。

今回筆者らの行った培養では，アミジグサとコモングサはともに四分胞子発芽体の約10%が成熟して雌雄の配偶体となった。そして雌性体から放出された卵を培養したところ，すべて四分胞子体に成長し，アミジグサでは約2ケ月で，コモングサでは約7ケ月で生活史を完結させることができた。アミジグサでは更に2ケ月間培養を行ない2世代の生活史を得たが，この結果からみるとアミジグサは比較的水温が高くて栄養塩類の豊富な南方の沿岸においては雌雄の配偶体が存在し，且つ4ケ月位の短期間の間に2世代の生活史が繰り返されている可能性があるものと推定される。

アミジグサの染色体数については既に欧州産の材料で MOTTIER (1900) と WILLIAMS (1904) がいずれも n=16, 本邦産の材料で籔 (1958) と KUMAGAE, INOH and NISHIBAYASHI (1960) がいずれも n=32 と報告しているが，本研究で函館産アミジグサの四分胞子発芽体の細胞内と雄性体の造精器の細胞で見た染色体数は n=25−30 で，この単数染色体数と KUMAGAE ら (1960) が見た染色体数と類似している。

今回の培養でコモングサの雄性体が初めて得られたが，精子形成の過程はアミジグサの場合と同様であった。

コモングサの四分胞子嚢内核分裂では核分裂前期の初めに色素に極めてよく染まる "chromophilous spherule" が約20%の核に存在した。邦産の籔 (1958) によるアミジグサとエゾヤハズ，KUMAGAE, INOH and NISHIBAYASHI (1960) によるアミジグサとオキナウチワ，熊谷・猪野 (1966) によるエゾヤハズについての研究では，この "chromophilous spherule" なる小体はエゾヤハズとオキナウチワでは観察されているが，アミジグサでは認められていない。

コモングサの四分胞子嚢内核分裂中期では核膜は消失することなくそのまま残存した。この時期における核膜はアミジグサとオキナウチワでは消失するが，エゾヤハズでは存在することが籔 (1958) KUMAGAE, INOH and NISHIBAYASHI (1960) と熊谷・猪野 (1966) により報告されている。以上コモングサの四分胞子嚢内核分裂の観察結果より見るとコモングサはアミジグサよりもエゾヤハズに近いものと考えられる。

コモングサの染色体数については本研究では確認することはできなかったので，この件については今後更に研究を進めたい。

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藻類 Jap. J. Phycol. 29: 135-141. June 20, 1981

# 兵庫県明石地方の一溜池，皿池の植物性プランクトンの遷移

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IMAZU, T. 1981. The succession of phytoplankton communities in the Sara-ike irrigation pond in the Akashi District of Hyogo Prefecture. Jap. J. Phycol. 29: 135-141.

The present study deals with the annual changes in phytoplankton communities in the Sara-ike irrigation pond which lies in the western area of Akashi City in Hyogo Prefecture. The collections and investigations were carried out a total of six times, in the years 1959, 1960, 1964, 1967, 1973 and 1977.

The total number of phytoplankton species in each year fluctuates narrowly between 42 and 47. However, the number of desmids dropped sharply from 27 forms in 1959 to 10 forms in 1977. The number of Chlorophycean taxa excluding desmids, increased, though the total number of Chlorophycean taxa decreased. Year by year, the number of Cyanophyceae increased, as did the Euglenophyceae and the Bacillariophyceae. Those species which appeared or disappeared in each year are listed.

In 1967 there was a great change in the species composition, with many species disappearing, and new ones taking their place. New taxa in 1967 totaled 16 forms and those which disappeared totaled 14 forms. The change in the number of taxa showed a close correlation with the degree of eutrophication of the ponds. The period of species change coincided with a new housing development being constructed near the ponds. The number of species which continuously appeared during the period from 1959 to 1977 were 12. Those species appeared to tolerate the increased water pollution.

The process of phytoplankton succession is summarized as follows. Over time we observed the gradual decrease of desmids, the gradual increase of Chlorophyceae, excluding desmids, and the gradual increase of Cyanophyceae and Bacillariophyceae, though the total number of algal species at any one period was almost invariable.

Both simple and compound quotients of the pond were calculated for each period when collections were carried out. These calculated values show the clear progress of the eutrophication of the Sara-ike pond.

*Key Index Words: eutrophication; phytoplankton community; succession.*
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明石市西部地域（Fig. 1）は特に溜池の密集した地域である。これらの溜池は西は加古川，東は明石川，北は美濃川に及ぶ高位と中位の段丘からなる段丘上に散在している。これらの溜池群のうち同市大久保町を中心とする13溜池（Fig. 1内の A-M）の植物性プランクトンについて1959年より1977年迄の間に計６回の調査を重ねてきた。これらの溜池の経年調査の結果から植物性プラヴクトン相の遷移が特に著しかった皿池（Fig. 1 内のL）について通計18年間における植物性プランクトン相の遷移の模様を報告する。採集調査は，1959, 1960, 1964, 1967, 1973, 1977年それぞれの年の６～９月の間に実施した。

## 溜池の概況と調査方法

大久保町西南の溜池群（皿池を含む）は低位の段丘である大久保台地（海抜 50～100 m）上にあり，高位の台地より水利はよく，溜池の構築年代も新しく（1700～1800年代），灌漑用として作られたものである。広い割合に概して浅く，平均水深 1.2 m～2.0 m 程度である。皿池は直径約 500 m，水深 2～3 m で田畑に囲まれ，一部道路に面する溜池である。調査方法は西条（1957）に従った。調査に当っては各溜池とも２定

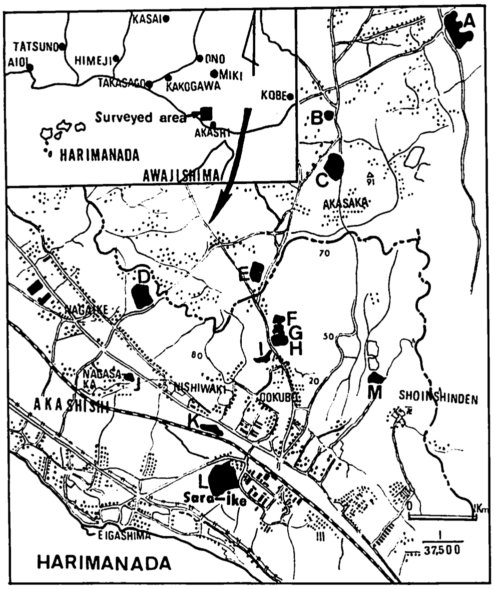


Fig. 1. Map showing the distribution of ponds in the western area of Akashi-Shi. A: Kotorikui-ike B: Hasu-ike C: Akasakahokubu-ike D: Nagaikehokuto-ike E: Juichigo-ike F: Shimomachi-ike G: Naka-ike H: Katabuchi-ike I: Yasojima-ike J: Shimo-ike K: Nishiwakinanbu-ike L: Sara-ike M: Shindenhokusei-ike.

Table 1. Water quality in each year in Sara-ike pond.

| Year | pH | D.O(%) | Water color* |
|---|---|---|---|
| 1959 | 6.2 | 137 | 7 |
| 1960 | 6.0 | 138 | 7 |
| 1964 | 6.2 | 127 | 8 |
| 1967 | 5.8 | 115 | 9 |
| 1973 | 5.6 | 108 | 9 |
| 1977 | 5.4 | 120 | 8 |
| Mean | 5.9 | 124 | 8 |

*Number of Forel's water color standard.

点を定め，採集にはミュラーガーゼ No. 25 のプランクトンネットを用いたが，水草のしぼり液をもあわせ採取した。標品は3～5％ホルマリンで固定した。調査項目としては，pH，温度，溶存酸素量，水色（フォレル氏水色計）の他に水生顕花植物の分布をも調べた。1959年の採集時には部分的にヨシが群生しており水中にジュンサイ，トチカガミ，ヒルムシロなどが僅かに生育していたが，1964年採集時にはそれらの間にヒシが出現しはじめ，1967年には混生状況となり，1973年頃よりヒシが優占種となった。水質は Table 1 に示すとおり弱酸性（pH 5.4～6.2）であり，溶存酸素量は表層部で108～138％を示した。また，水色はフォレル氏水色計 No. 7～No. 9 の範囲で淡黄緑色を呈し中

Table 2. Number of phytoplankton species in all ponds surveyed (A—M).

| Ponds surveyed | Cyano-phyceae | Chryso-phyceae | Dino-phyceae | Eugleno-phyceae | Bacillario-phyceae | Chlorophyceae Desmids | Chlorophyceae excl. Desmids | Total |
|---|---|---|---|---|---|---|---|---|
| A. Kotorikui-ike | 1 | 0 | 0 | 3 | 4 | 4 | 7 | 19 |
| B. Hasu-ike | 1 | 0 | 0 | 1 | 3 | 1 | 5 | 11 |
| C. Akasakahokubu-ike | 1 | 0 | 1 | 0 | 2 | 0 | 1 | 5 |
| D. Nagaikehokuto-ike | 1 | 0 | 0 | 0 | 5 | 0 | 1 | 7 |
| E. Juichigo-ike | 2 | 0 | 0 | 0 | 8 | 0 | 1 | 11 |
| F. Shimonomachi-ike | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 4 |
| G. Naka-ike | 1 | 0 | 0 | 1 | 6 | 5 | 6 | 19 |
| H. Katabuchi-ike | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 5 |
| I. Yasojima-ike | 1 | 0 | 0 | 0 | 5 | 1 | 3 | 10 |
| J. Shimo-ike | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 4 |
| K. Nishiwakinanbu-ike | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 |
| L. Sara-ike | 3 | 1 | 0 | 1 | 5 | 27 | 7 | 44 |
| M. Shindenhokusei-ike | 2 | 0 | 1 | 1 | 3 | 0 | 1 | 8 |

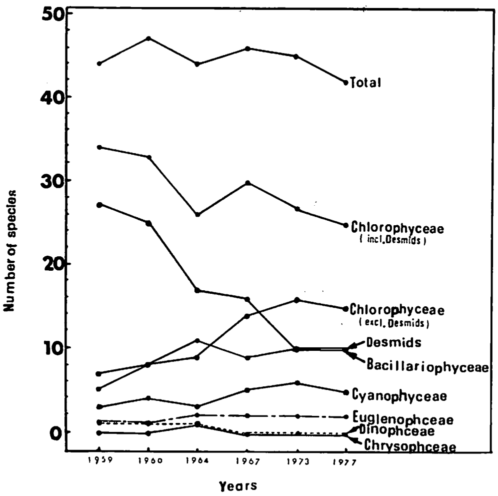


Fig. 2. Changes in number of species which appeared in Sara-ike pond, from 1959 to 1977.

栄養的であった。Table 2 に示すとおり調査した13溜池中皿池は植物性プランクトンの種類数および量が最も多く，1959年の調査時には，21属44種で，これらのうち鼓藻類が27種を占めていた。

## 植物性プランクトンの遷移

出現種数は採集年度によって多少相違している。1959年は，21属44種，1960年は，23属47種，1964年は，25属44種，1967年は，29属46種，1973年は，32属45種，1977年は，33属42種と変動し，42種から46種の間であり，種類数の極端な増減はなかった。しかし緑藻類中鼓藻類の減少が目立っており，1959年の27種から1977年の10種に減少している。また，鼓藻類以外の緑藻類の増加数は，鼓藻類の減少数よりも少いので緑藻類全体としては減少している (Fig. 2, Table 3)。年と共に増加しているのは，鼓藻類以外の緑藻類，珪藻類，藍藻類である。ミドリムシ藻類，黄色鞭毛藻類，渦鞭毛藻類では種類数の増減はほとんど見られない (Table 3)。総出現種について各調査年度別にその遷移状況（新出現種，消滅種，固定種など）および出現 taxa 数を示したものが Table 3 である。さらに新出現種と消滅種との比較は，Table 4 に示すとおりである。Table 4 に示されたように種類数の変化を調査年度の順に述べれば，1960年には新出現種７種，消滅種４種，1964年には新出現種10種，消滅種14種であり，次いで1967年の新出現種16種，消滅種14種，1973年の新出現種12種，消滅種13種，1977年には新出現種６種，消滅種７種である。これらの種類変動は溜池の水質変化と密接な関係のあるものと思われる。特に1964年から1973年にかけ宅地造成が著しかったため池水の富栄養化が著しく進んだものと考えられる。なお，1959年以来1977年までの18年間で調査時に常に出現をみた種即ち固定化された種は，11属12種である。これらの種は水質の多少の変化にも耐え得る広適応性種と考えられる。これらに対し消滅種は水質に敏感で適応性の狭い種と考えられる (Table 3, Table 4)。採集時の溜池の優占属は，Table 5 に示すとおりである。優占属の遷移状況をみると，1959年，1960年には鼓藻類が優占し，1964年には，鼓藻類以外の緑藻類と鼓藻類とよりなり，1967年には緑藻類だけの増加が著しく認められ，1973年には，藍藻類と緑藻類とが優占し，1977年には，鼓藻類以外の緑藻類と珪藻類が優占属となった。また，新出現種では，Table 4 に示すとおり年代の推移とともに鼓藻類以外の緑藻類，藍藻類，珪藻類などが増加してきている。逆に消滅種では鼓藻類が目立ち，1959年 (27種)，1960年 (25種)，1964年 (17種)，1967年 (16種)，1973年 (10種)，1977年 (10種) と次第に減少している。(Fig. 2, Table 3)。

## 溜池の栄養度

藻類の種類数に基づく池の栄養度を表わす方法として，単純商$\left(\frac{\text{緑藻類}}{\text{鼓藻類}}\right)$……THUNMARK (1945) や複合商

$$\left(\frac{\text{藍藻類}+\text{緑藻類}+\text{中心目珪藻類}+\text{ミドリムシ藻類}}{\text{鼓藻類}}\right)$$

……NYGAARD (1949) などがあるが，単純商は，特に緑藻類の多い水域では信頼度が薄く，複合商の方がはるかに妥当するとのことであるので単純商，複合商両方の値を求めてみた。その結果は Table 6 に示すとおりである。

それらの単純商，複合商の求め方については水野 (1960)に負うところが多い。これらの結果は複合商の場合，値が1.0より小なら貧栄養，1.0～2.5なら中栄養，2.5より大なら富栄養とされている。1977年の皿池についての単純商は，2.4で複合商は3.2であるから富栄養型であることがわかる。また，Table 6 に示す如く年代の推移とともに値が大きくなり富栄養化が大きくなっている。1964年から1973年にかけてその値が著しく増加しているのは，この年代の間に富栄養化が著しく進んだことを示している。

## 考　　察

明石市の西部地域並びにその近傍の環境のよく

Table 3. Abundancy of qhytoplankton in Sara-ike pond

| Species | Abundancy | | | | | |
|---|---|---|---|---|---|---|
| | 1959 | 1960 | 1964 | 1967 | 1973 | 1977 |
| CYANOPHYCEAE | | | | | | |
| *Gloeotrichia echinulata* | 1 | 2 | 2 | | | |
| *Lyngbya dignetii* | 3 | 1 | | | 1 | |
| *Oscillatoria tenuis* | 2 | 1 | | | 2 | 2 |
| *Gloeocapsa aeruginosa* | | 1 | 1 | 2 | 1 | 2 |
| *Anabaena affinis* | | | 2 | 1 | 1 | |
| *Chroococcus limneticus* | | | | 2 | 2 | 1 |
| *Microcystis aeruginosa* | | | | 2 | 4 | 2 |
| *Aphanocapsa grevillei* | | | | | 2 | 2 |
| CHRYSOPHYCEAE | | | | | | |
| *Dinobryon divergens* | 2 | 1 | 1 | | | |
| DINOPHYCEAE | | | | | | |
| *Ceratium hirundinella* | | | 1 | | | |
| EUGLENOPHYCEAE | | | | | | |
| *Phacus curvicauda* | 1 | | | 1 | 2 | 2 |
| *P. orbicularis* | | 1 | 2 | | | |
| *P. pleuronectis* | | | 1 | 1 | 1 | 1 |
| *Euglena deses* | | | | | | 2 |
| BACILLARIOPHYCEAE | | | | | | |
| *Cymbella gracillis* | 2 | 2 | 2 | 1 | 2 | 1 |
| *C. constrictum* | | | | | | 1 |
| *C. lanceolata* | 1 | 1 | 1 | | | |
| *C. tumida* | | | 1 | 2 | 2 | 2 |
| *Fragilaria construens* | 2 | 1 | 1 | 1 | 2 | 2 |
| *Frustulia romboides* | 2 | 1 | 1 | | | |
| *Gomphonema angustatum* | | 1 | 1 | 2 | 2 | 2 |
| *G. constrictum* | 1 | 1 | 2 | 1 | | |
| *Eunotia lunaris* | | 1 | | | 1 | |
| *E. pectinals* | | | 1 | | 1 | |
| *Melosira varians* | | | 2 | 2 | 2 | 3 |
| *Navicula cryptocephala* | | | | | | 1 |
| *N. exigua* | | | 1 | 1 | 1 | |
| *N. placentula* | | | | | | |
| *Surirella robusta* | | | 1 | 1 | 1 | 1 |
| *Tabellaria fenestrata* | | | | 1 | 1 | 1 |
| CHLOROPHYCEAE | | | | | | |
| *Golenkinia radiata* | 2 | 1 | 1 | 2 | 2 | 1 |
| *Oedogonium* sp. | 2 | 2 | 2 | 2 | 2 | 2 |
| *Spirogyra* sp. | 2 | 2 | 1 | 2 | 2 | 2 |
| *Pediastrum araneosum* | 1 | 1 | 1 | | | |
| *P. boryanum* | 2 | 1 | 2 | 2 | 2 | 1 |
| *P. duplex* | 2 | 1 | 3 | 2 | 2 | 2 |
| *P. duplex* var. *clathratum* | 1 | 1 | 2 | 1 | | |
| *P. tetras* | | 1 | 2 | 2 | 2 | 2 |
| *P. tetras* var. *tetraodon* | | | 2 | 2 | 1 | |
| *Bulbochaete* sp. | | | | 2 | 2 | 1 |
| *Coelastrum microporum* | | | | 2 | 1 | 2 |
| *Scenedesmus gracile* | | | | 2 | 3 | 3 |
| *S. quadricauda* | | | | 2 | 3 | 3 |
| *Ankistrodesmus falcatus* | | | | | 2 | 2 |
| *Kirchneriella lunaris* | | | | | 2 | 2 |
| *Gloeocystis gigas* | | | | | 2 | 2 |
| *Volvox globator* | | | | 4 | 2 | 2 |
| *Zygnema* sp. | | | | 2 | 2 | 2 |
| DESMIDIACEAE | | | | | | |
| *Closterium cornu* | 2 | 1 | 2 | 1 | | |
| *C. dianae* | 1 | 2 | 2 | 2 | 2 | 1 |
| *C. dianae* var. *minus* | | | 1 | 1 | | |
| *C. parvulum* | 1 | 2 | 2 | 1 | | |
| *C. toxon* | 1 | 2 | 2 | 1 | | 1 |
| *Cosmarium amoenum* | | | | | 1 | |
| *C. binum* | 2 | 2 | 1 | | | |
| *C. circulare* | 3 | 3 | | 1 | | |
| *C. contractum* | | | | | 2 | |
| *C. contractum* var. *ellipsoideum* | 2 | 2 | | 2 | | |
| *C. furcatospermum* | 2 | 3 | | | | |
| *C. jenneri* | | | 1 | 1 | | |
| *C. lundellii* | | | 1 | 1 | | |
| *C. pachydermum* | 2 | 2 | | | | |
| *C. sublatere-undatum* | 2 | 2 | | | 1 | 2 |
| *C. subortogonum* | 2 | 2 | 1 | | 1 | 2 |
| *Euastrum ansatum* | 2 | 2 | | 2 | | 1 |
| *E. bidentatum* | 1 | | | | | |
| *E. glaberrimum* | 1 | | | | | |
| *Hyalotheca indica* | 3 | 3 | 3 | 1 | 2 | 2 |
| *H. dissiliens* | | | | | 3 | |
| *Micrasterias alata* | 2 | 2 | | 1 | 2 | 2 |
| *M. crux-melitensis* | 1 | 1 | 1 | | | |
| *M. foliacea* | 2 | 1 | | 1 | | |
| *M. lux* | 2 | 1 | | | | |
| *M. mahabuleshwarensis* | 2 | 2 | 2 | | | |
| *M. pinnatifida* | 2 | 2 | 2 | 2 | 1 | 1 |
| *Netrium digitus* var. *naegelii* | 2 | 1 | 2 | 1 | 1 | 1 |
| *N. digitus* var. *lamellosum* | 2 | 1 | 1 | | | |
| *Pleurotaenium nodosum* | 2 | 2 | 1 | 1 | 1 | 1 |
| *Staurastrum gracile* | 2 | | | | | |
| *S. iotanum* | 1 | 2 | 1 | | | |
| *S. johnsonii* | 2 | 1 | | | | |
| *S. paradoxum* | | 1 | | | | |

Note: Numerical figures mean the abundancy of the appearance
(1 : rare, 2 : few, 3 : common, 4 : abundant, 5 : extremely abundant)

Table 4. Comparison of newly appeared species with that of disappeared species.

| | | 1960 | 1964 | 1967 | 1973 | 1977 |
|---|---|---|---|---|---|---|
| Species appeared | *Cyanophyceae* | *Gloeocapsa aeruginosa* | *Anabaena affinis* | *Chroococcus limneticus*<br>*Microcystis aerginosa*<br>*Lyngbya diguetii* | *Aphanocapsa grevillel*<br>*Oscillatoria tenuis* | |
| | *Euglenophyceae* | *Phacus orbicularis* | *Phacus pleuronectes* | *Phacus curvicauda* | | *Euglena deses* |
| | *Dinophyceae* | | *Ceratium hirundinella* | | | |
| | *Bacillariophyceae* | *Cymbella tumida*<br>*Gomphonema angustatum*<br>*Eunotia lunaris* | *Merosira varians*<br>*Navicula exigua*<br>*Surirella robusta*<br>*Eunotia pectinalis* | *Tabellaria fenestrata* | *Eunotia lunaris*<br>*E. pectinalis* | *Cymbella constrictum*<br>*Navicula cryptocephala*<br>*N. placentula* |
| | *Chlorophyceae* | *Pediastrum tetras* | | *Volvox globator*<br>*Bulbochaete* sp.<br>*Coelastrum microporum*<br>*Scenedesmus gracile*<br>*S. quadricauda* | *Gloeocystis gigas*<br>*Ankistrodesmus falcatus*<br>*Kirchneriella lunaris* | |
| | *Desmidiaceae* | *Staurastrum paradoxum* | *Closterium dianae*<br>*Cosmarium jenneri*<br>*C. lundelli* | *Cosmarium circulare*<br>*C. contractum*<br>*Euastrum ansatum*<br>*Micrasterias alata*<br>*M. foliaceae*<br>*Zygnema* sp. | *Cosmarium amoenum*<br>*C. contractum*<br>*C. sublater-undatum*<br>*C. subortogonium*<br>*Hyalotheca dissiliens* | *Cosmarium toxon*<br>*Euastrum ansatum* |
| | | Total 7 | Total 10 | Total 16 | Total 12 | Total 6 |
| Species disappeared | *Cyanophyceae* | | *Lyngbya diguetti*<br>*Oscillatoria tenuis* | *Gloeotrichia echinulata* | *Lyngbya diguetii* | *Anabaena affinis* |
| | *Chrysophyceae* | | | *Dinobryon divergens* | | |
| | *Euglenophyceae* | *Phacus curvicauda* | | *Phacus orbicularis* | | |
| | *Dinophyceae* | | | *Ceratium hirundinella* | | |
| | *Bacillariophyceae* | | *Eunotia lunaris* | *Cymbella lanceolata*<br>*Eunotia pectinalis*<br>*Frustulia rhomboides* | *Gomphonema constrictum* | *Eunotia lunaris*<br>*E. pectinalis*<br>*Navicula exigua* |
| | *Chlorophyceae* | | | *Pediastrum araneosum* | *Pediastrum duplex* | *Pediastrum tetra* |
| | *Desmidiaceae* | *Euastrum bidentatum*<br>*E. glaberrium*<br>*Staurastrum gracile* | *Cosmarium circulare*<br>*C. contractum*<br>*C. furcatospermum*<br>*C. pachydermum*<br>*C. subratere-undatum*<br>*Euastrum ansatum*<br>*Micrasterias alata*<br>*M. foliacea*<br>*M. lux*<br>*Staurastrum johosonii*<br>*S. paradoxium* | *Cosmarium binum*<br>*C. Subortogonium*<br>*Micrasterias cruxmelitensis*<br>*M. mahabuleshwarensis*<br>*Netrium digitus (Ehrb.)*<br>*Staurastrum iotanum* | *Closterium cornu*<br>*C. dianae Ehrb.*<br>*C. parvulum*<br>*C. toxon*<br>*C. circulare*<br>*C. cotractum*<br>*C. jenneri*<br>*C. lundellii*<br>*Euastrum ansatum*<br>*Micrasterias foliacea* | *Cosmarium amoenum*<br>*Hyalotheca dissiliens* |
| | | Total 4 | Total 14 | Total 14 | Total 13 | Total 7 |

Table 5. Changes in dominant genera of Sara-ike pond from 1959 to 1977.

| Year | 1959 | 1960 | 1964 | 1967 | 1973 | 1977 |
|---|---|---|---|---|---|---|
| Dominant genera | *Cosmarium* | *Cosmarium* | *Pediastrum* | *Volvox* | *Microcystis* | *Scenedesmus* |
| | *Micrasterias* | *Closterium* | *Closterium* | *Pediastrum* | *Scendesmus* | *Melosira* |

Table 6. Values of simple quotient and compound quotient of Sara-ike pond from 1959 to 1977.

| | 1959 | 1960 | 1964 | 1967 | 1973 | 1977 |
|---|---|---|---|---|---|---|
| Simple quotient | $1.3\left(\frac{34}{27}\right)$, | $1.3\left(\frac{32}{25}\right)$, | $1.5\left(\frac{25}{17}\right)$, | $1.9\left(\frac{30}{16}\right)$, | $2.5\left(\frac{27}{11}\right)$, | $2.4\left(\frac{24}{10}\right)$ |
| Compound quotient | $1.4\left(\frac{38}{27}\right)$, | $1.5\left(\frac{37}{25}\right)$, | $1.8\left(\frac{31}{17}\right)$, | $3.4\left(\frac{55}{16}\right)$, | $3.2\left(\frac{35}{11}\right)$, | $3.2\left(\frac{32}{10}\right)$ |

似た13溜池中に生息する植物性プランクトンの組成を比較してみると，出現種の種類 (Table 2) において相違がみられる。これは環境の変化によるためであることは言うまでもないが，特に近年宅地造成などの影響が大きかったものと思われる。大久保町西南の皿池は田畑に囲まれた溜池で一部道路に面しているが汚水，排水などの混入の少ない溜池であり，1959年，1960年の調査時には水色も青緑色を呈し，貧栄養的な溜池に見受けられたが，植物性プランクトンとしては鼓藻類が多く，*Micrasterias, Euastrum, Staurastrum, Cosmarium* などの大型種が目立っていた。1964年，1967年には新出現種，消滅種が急激に増加するとともに各属とも小型化してきている (Table 4)。これらの種の遷移は宅地造成その他の影響による環境水質の変化によるものと考えられる。また，Fig. 2 に示すとおり，1959年，1960年には鼓藻類の出現が比較的多くみられたが，1964年には鼓藻類が減少し，1967年には鼓藻類以外の緑藻類の増加がみられる。1973年には鼓藻類以外の緑藻類や藍藻類が主となり，1977年には種類数が一様に減少する傾向がみられるが，これらの種類数の減少は，溜池の水質が中栄養から富栄養へと推移した結果によるものと考えられる。溜池は天然池と異なり，必要に応じて放水するので天然池に比較すれば水の交代が烈しく，従って腐植質の推積量も比較的少ないので富栄養化しにくいと思われる。溜池は一般に池が浅く底が平板状であり，水草の繁茂し易い条件をそなえているのでそれらの腐植によって逆に富栄養化し易いという面もある。従って溜池の特徴としては，水質の変動が大きく，出現種や出現量の変動が大きいことが考えられる。しかし常に調査時に出現をみる固定化した種もありそれらの種は水質の多少の変化にも耐え得る程に適応性の強い種と考えられる。それらの種は皿池だけでなく当地方の他の溜池においても固定化されてよく出現する。

それらの種は大久保町南西の皿池においては鼓藻類の *Closterium dianae* EHRB., *Hyalotheca indica* TURN., *Micrasterias pinnatifida* (KÜTZ.) RALFS, *Netrium digitius* (EHRB.) ITZIG. var. *naegellii* (BRÉB.) KRIEG., *Pleurotaenium nodosum* (BAILEY) NAEG. 鼓藻類以外の緑藻類では *Golenkinia radiata* CHOD., *Oedogonium* sp., *Pediastrum boryanum* (TURP.) MENEGH., *Pediastrum duplex* MEYEN, *Cymbella gracilis* (RACIB.) CI., *Fragilaria construens* (EHRB.) DE TONI などで皿池のみならず一般的に広く出現をみる種類である。

Desmids の同定に当っては特に平野 (1955-60, 1956-1974)，藍藻に関しては広瀬 (1937, 1959, 1977) 珪藻に関しては渡辺 (1962) を参照した。また，チリモ類の遷移に関しては伊藤 (1967) に負うところが多い。終りにあたり，本稿のご指導とご校閲を賜わった神戸大学名誉教授広瀬弘幸博士に心から謝意を表します。

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—100頁から続く—

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*141. Zhang, C.F. (Chang, C.F.) and B.M. Xia: Studies on some marine red algae of the Xisha Islands, Guangdong Province, China II. (See: Studia Marina Sinica, No. 15)

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*143. Jiang, B.Y. and Zh. J. Tang: Mature sporophytes cultured from the male gametophytes of *Laminaria japonica* ARESCH. (in Chinese)

*144. Jiang, B.Y. and Zh. J. Tang: Induction of auxins in male gametophytes of *Laminaria japonica* ARESCH. (in Chinese).

〔以 上〕

# 金子 孝: C. WRIGHT 採集の日本産 *Laminaria saccharina* は *L. japonica* である

Takashi KANEKO: HARVEY's *Laminaria saccharina* collected by C. WRIGHT from Japan is *L. japonica*

著者は先に北海道稚内市声問でカナダ，サイモンフレーザー (Simon Fraser) 大学の L. DRUEHL 教授と共にカラフトコンブ *Laminaria saccharina* f. *linearis* J. AGARDH *sensu* TOKIDA を採集し，本種が日本に産することを報告した (DRUEHL and KANEKO 1973)。しかし，その後 C. WRIGHT が North Pacific Exploring Expedition (1853-56) の際に日本で採集した海藻標本の中に HARVEY によって *L. saccharina* (L.) LAMOUROUX と同定された標本があることを DAWSON (1959) によって編纂された HARVEY の未発表の原稿 "William H. HARVEY's report on the marine algae of the United States North Pacific Exploring Expedition of 1853-1856" で知った。この論文の p. 11 に36番目の種として，*L. saccharina* (Lx.) J. Ag. Sp. Alg. 1. p. 132. Harv. Phyc. Brit. t. Turn. Hist. t. 163. Hakodadi, Japan. Three varieties are in the Herbarium. の記述がある。もしこの同定が正しければ，著者らの報告より以前に，すでに北海道から *L. saccharina* 採集されていることになる。またこのことは本種の分布の面からも興味深い資料ともなるので，原標本をぜひ観察したいと思っていた。1978年に Smithonian Institution を訪ねた際，著者は同標本庫の *L. saccharina*, アジアの部に C. WRIGHT の採集による 3 葉の腊葉を見つけ出した。旅の途中でもあり標本を写真に収めて帰国した。その後，同館の Dr. J. NORRIS の御好意で標本を借り出し，詳しく観察する機会を得たので，その概要を報告したい。

3 個体の腊葉標本のうち，2 個体は完全な体であるが，1 個体は葉の一部分だけである。腊葉台紙は No. 01476と No. 01477 の 2 枚に分かれ，前者の台紙には 1 個体，後者の台紙には 2 個体の標本があり，ともにラベルには U.S. North Pacific Exploring Expedition under Commanders RINGGOLD and RODGERS, 1853-56. *Laminaria saccharina*, C. WRIGHT coll. Japan. と書かれている。また特に No. 01476 の腊葉紙にはペン書きで，Hakodadi Bay, dredged by Mr. SHIMPSON とある。

No. 01476 の標本は図 1 にみられるように幼体で，葉部は高さ 15 cm，幅 4 cm，2 列の龍紋状の凹凸を有する。茎部は長さ 6.0 mm，茎径は 1.0 mm に達しない。茎部に粘液腔道を有する。根は縦列し，比較的太い。本標本は龍紋があること，基部が比較的張っている点から *L. saccharina* や，チヂミコンブ *L. cichorioides* の若い体に類似するが，茎部に粘液腔道を有することから前者とは異なり，縦列する比較的太い根を持つことから後者とも区別される (MIYABE 1902)。茎部に粘液腔道をもつこと，採集地が函館湾であること，さらにコンブ属植物は幼時には龍紋が観察されることが多いなどを考慮すると，本標本をマコンブ *Laminaria japonica* ARESHOUG の幼体と同定する方が良いと思われる。No. 01477 の台紙上の 2 個体の標本 (Fig. 2) のうち，1 個体は葉部の高さ62.5 cm，幅 7.5 cm，茎部は長さ 2.5 cm，茎径 3.4 mm × 5.0 mm で，根は葉部の基部から 1.5 cm のところから縦列する。茎部には明らかな粘液腔道が観察される (Fig. 3)。他の 1 個体は長さ 30 cm，幅 6.5 cm の葉部のみの標本である (Fig. 2)。この標本の一部を切り取り，海水に浸したところ，葉部の幅は 9.0 cm に拡がり，幅 3.7 cm からなる明らかな中帯部を持ち，中帯部が葉幅に占める割合は 2/5 である。また葉の厚さは中帯部で 1530 $\mu$m，縁辺部で 510 $\mu$m である。

以上のように C. WRIGHT によって採集され，HARVEY によって *L. saccharina* と同定された標本は，MIYABE (1902) および岡村 (1936) の *L. japonica* の記載と，体が小さい点を除けば，ほぼ一致する。No. 01477 の標本には *Hakodadi* との記述が見あたらないが No. 01476 と同じ場所で採集されたものと思われる。北海道沿岸のコンブ属植物の分布から考えても，これらの標本を *L. japonica* ARESCHOUG と同定してさしつかえないと思われる。

HARVEY (DAWSON 1959) によれば "Three varie-

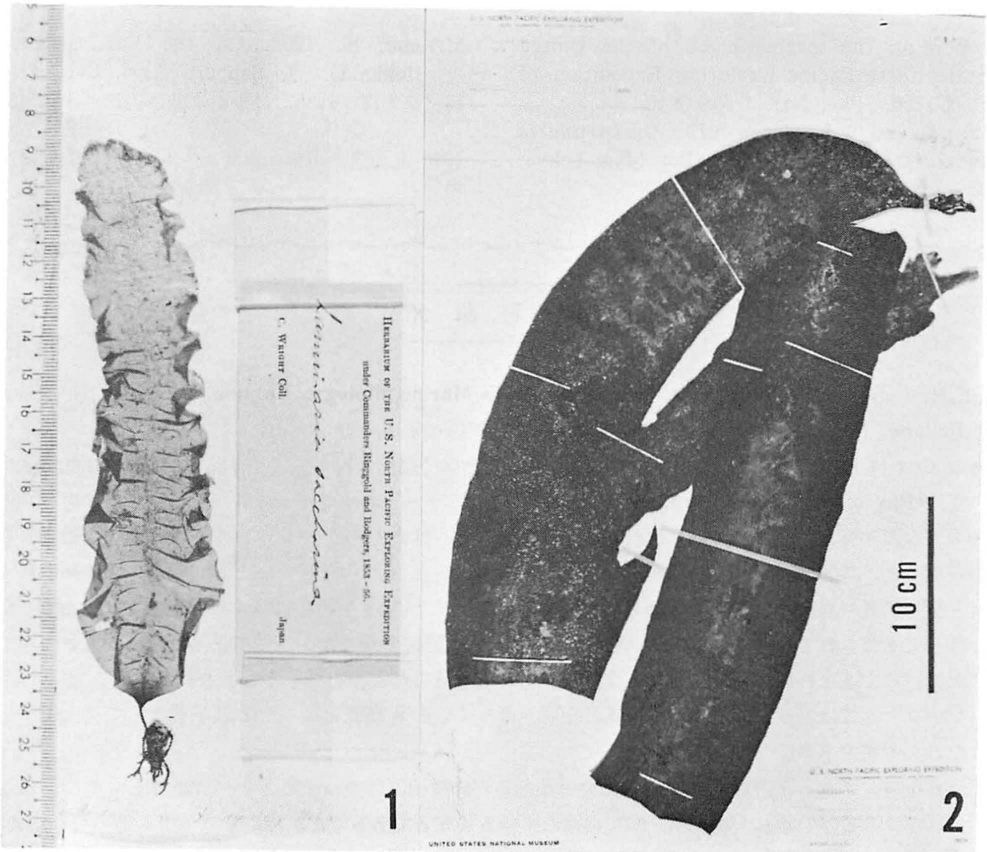


図1および2 C. Wright によって北海道から採集された *Laminaria saccharina* (L.) Lamouroux. 図1は No. 01476 の標本（スケールの単位は cm)。図2は No. 01477 の標本。

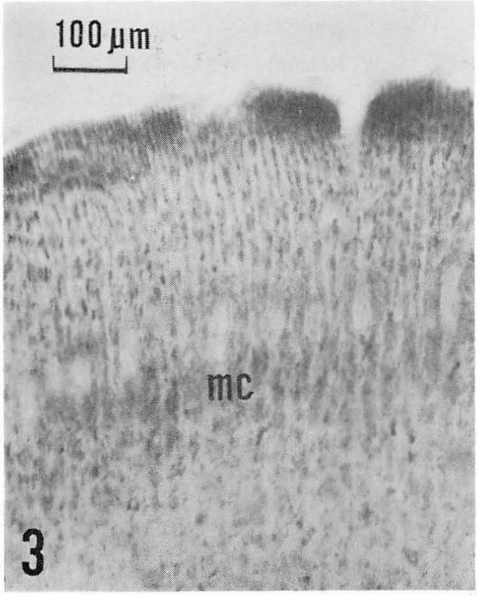


図 3. No. 01477 の標本の茎部の横断面，粘液腔導 (mc) を示す。

ties are in the herbarium" とあるが，前述のようにラベルには *Laminaria saccharina* としかなく，three varieties の実体については今も不明である。

なお茎部における粘液腔道の有無は種を分ける際の基準になり難いとの報告 (Burrows 1964 ; Chapman 1975) があるが，ここでは旧来の基準に従って同定を行った。

おわりに貴重な標本の閲覧ならびに借し出しの労をとられた Smithonian Institution の Dr. J. Norris に感謝の意を表します。

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## 新 刊 紹 介

COX, E. R. (ed): **Phytoflagellates. Developments in Marine Biology. Volume 2.** ix+474 pp. Elsevier/North-Holland. New York, Amsterdam, Oxford. 邦価約 ¥16,400

編者の Cox 博士の序文によれば, 1978年にジョージア大学で開催されたアメリカ藻類学会の Annual meeting において, "Phytoflagellates: Form and Function" というテーマのシンポジウムが開かれ, この会合がきっかけとなって本書作製の企画がすすめられたということである。すなわち, シンポジウムでは全ての鞭毛藻群を扱えなかったこと, 時間に制約があり, 十分な討議ができなかったこと, そしてなによりも, 鞭毛藻類の研究は藻類学者と動物学者の双方によってすすめられているために, これらの生物群に関する研究論文はさまざまな研究誌に分散して掲載されており, 一般に, 研究の現状を十分に把握することが困難であるとの声が大きく, このような状況を打開するために, 研究の現状と文献を豊富に盛り込んだ書物をつくることが決定されたという。そして, シンポジウムではカバーできなかった藻群を取り扱っている研究者を新らたに執筆者として迎えたうえでつくられたのが本書である。

目次に目を通してみると, 多様性に富んだ鞭毛藻あるいは微細藻群のほとんどすべてが網羅されていること, しかも各群の執筆者はいずれも現在第一線で活躍している研究者であることがわかる。編者が述べているように, 確かにこれまで本書に類似した書物はなかったといえる。従来の書物の多くは鞭毛藻類に関する章を比較的簡単に概略的に扱う場合が多く, また各群を詳細にそりあげている書物, 例えば Bourrelly の "Les algues d'eau douce", あるいは Fott の "Algenkunde" などのすぐれた書物でも, 急速に進展している研究の現状をフォローするには必ずしも十分ではなかった。これに対して, 本書はそれぞれの藻群の研究者に豊富な情報を提供することができるだけの内容をもっており, その点で出版の意義は大きいといえる。本書で取り上げられている藻群と著者をあげると以下のようである: 単細胞緑藻 (C. A. Lembi), 氷雪藻 (R. W. Hoham), プラシノ藻 (R. E. Norris), 群体性緑藻 (R. C. Starr), ミドリムシ藻 (P. L. Walne), 黄金色藻 (R. N. Pienaar), 黄緑藻 (D. J. Hibberd) ハプト藻 (D. J. Hibberd), 真正眼点藻 (D. J. Hibberd), 珪殻鞭毛藻 (S. D. Van Valkenburg), ラフィド藻 (P. Heywood), クリプト藻 (E. Gantt), 渦鞭毛藻 (K. Steinger and E. R. Cox).

各章の内容は極めて具体的であり, それぞれの藻群についての研究の現状が紹介されている。執筆者の違いによって, 各章それぞれに特徴があり, 研究の現状を解説的に記しているものや, 論文としての色彩のつよいものなどさまざまであるが, いずれにしても相当に専門的であり, 多くの章は近年の電子顕微鏡を用いた形態学的および細胞学的研究の成果や生化学的知見を詳細に紹介した総説となっており, またそれらに基いて分類や系統が論じられている。そのために, これからその藻群についての一般的な知識を得たいという, いわば初心者にとっては, この種の書物としては図や写真が少ないこともあって, かえって理解しにくい複雑な内容となっている。そのような場合には, 例えば, H. C. Bold and M. J. Wynne (1978) の "Introduction to the algae", (Prentice-Hall, New Jersey) や Van den Hoek (1978) "Algen" (Einführung in die Phykologie, Georg Thieme Verlag, Stuttgart) などのすぐれた教科書である程度の基礎知識を仕入れてから読めばよいように思われる。

本書はむしろ専門家向けのものだといえる。現在既に取り扱っている藻群に関する情報を整理された形で読みたいというむきには, あるいは, 新刊の雑誌に掲載されている鞭毛藻に関する論文の論点の理解をたすけるための専門的な基礎知識を求めているむきには, これまでそのような要望に答て得るものがなかっただけに, よい手引きとなるだろうと思われる。また, 各章ごとにつけられている豊富な引用文献も有益なものである。さらに,

多くの章には，Needed Research という項目が末尾に設けられており，研究のこれから進むであろう方向についての示唆がなされていて参考になるだろう。

近年，電子顕微鏡による鞭毛藻の研究は著しく進展し，一般構造に加えて，細胞分裂などの動的な現象に関する微細構造の知識が蓄積されてきた。本書の最後の章では，それ以前の章において記述されているいろいろな藻群についてのこのような知見に基いて，鞭毛藻の祖先はどのような特徴をもっていたか，各藻群は互いにどのような関統にあるかといった興味ある問題について，鞭毛藻類の系統という題で，K. D. Stewart and K. Mattox による論が展開されている。このテーマは，鞭毛藻に限らず，大型の藻類や高等植物をも含めた系統という問題につながるものであり，現在，この章の筆者らを中心に活発な研究が展開されている分野でもあるので，進化・系統というようなテーマに関心のあるむきには一読の価値があると思われる。

最後に本の体裁について触れると，本書はタイプ印刷であるためか，一行抜けたり，一行余分だったりという編集校正上のミスが目立つ（例えば p. 15 の16-17行，p. 137 の15-16の間の行は行抜け，p. 137 の32行目は余分である)。第二版では訂正を期待したい。 （井上　勲）

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# ――学 会 録 事――

## 1. 日本藻類学会第5回春孝大会

昭和56年3月31日と4月1日の両日，筑波大学第2学群において第5回春季大会が開催された。大会準備委員会は当初地理的な不便さによる参加者の減少を危惧したが，実際に受付を開始してみるとその不安は一掃され，最終的には参加者125名(当日参加者を含む)，一般講演49題におよんだ。また，J.A. WEST 教授(カリフォルニア大学・バークレー) の特別講演が本大会をさらに一層盛大なものにした。大会第1日，昭和56年総会に引続き開かれた懇親会は参加者101名となり，春季大会始って以来の大規模なものとなった。学会活動の隆盛を喜びたい。しかし，参加者や講演題数がこれ以上増えた場合には大会準備や日定，プログラム編集など従来の規模では処理できなくなるので，その対策を考えなければならないといった新たな問題がおきてきた。

大会，総会並びに懇親会の開催に協力をいただいた筑波大学生物科学系長市村俊英教授と大悟法滋講師並びに大学院学生諸氏に感謝申し上げる。また特別講演を引き受けて下さったJ.A. WEST 教授と特別講演の企画準備に助力をいただいた北海道大学理学部植物学教室の黒木宗尚教授及び同教室の方々に御礼申し上げる。

大会参加者：赤星りか，秋岡英承，秋山　優，鰺坂哲朗，荒木　繁，有賀祐勝，安藤一男，猪川倫好，石川依久子，石橋勇人，出井雅彦，井上　勲，岩崎英雄 J.A. West，臼田康子，大島海一，太田雅隆，大谷修司，岡崎恵視，岡部作一，奥田武男，長田敬五，納田美也，垣内政宏，加崎英男，梶村光男，加藤久美子，加藤季大，加藤　孝，金沢昭人，金子　孝，川井浩史 姜　悌源，喜田和四郎，木村敦子，木村いずみ，楠元守，工藤純子，熊野　茂，黒木宗尚，高原隆明，後藤敏一，小林艶子，小林　弘，今野敏徳，斎藤英三，斎藤昭二，斎藤　実，沢地なおみ，清水　哲，須貝敏英 鈴木健策，関谷公範，瀬戸良三，造力武彦，高木勝行 高田英夫，高野秀昭，高橋京子，高橋宗弘，田尻純仁 田中次郎，千原光雄，千葉尚二，塚田善也，鶴岡英作 寺尾公子，当真　武，中里広幸，中庭正人，中野武登 中村　武，中村義輝，長島秀行，南雲　保，西澤一俊 二宮早由子，野崎久義，野沢美智子，野呂忠秀，長谷井稔，畑田太美子，畑野智司，服部　彩，浜田真実，原　慶明，半田信司，坂東忠司，平山知子，S.S. Fotos，福島　博，福田明芳，福田育二郎，藤井修平 藤井美奈子，藤田大助，舟橋説往，堀　輝三，堀口健雄，前川行幸，正置富太郎，増田道夫，松山恵二，真山茂樹，丸山　晃，万谷司郎，右田清治，水野　真，宮地和幸，森　宏枝，諸星裕夫，Dirce Yano，山岸高旺，山田家正，山嵜　登，横地洋之，横浜康継，吉崎　誠，吉田忠生，吉武佐紀子，渡辺　信，渡辺　信 渡辺真之，渡辺恒雄

## 2. 評議員会報告

第5回春季大会前日3月30日 (17：30～19：30)，筑波研修センターで評議員会が開催され，昭和56年度総会に提出される報告事項および議題について審議された。審議内容は総会報告の項と重複するので，その項を参照されたい。

出席者：千原光雄会長，加崎英男，小林　弘，西澤一俊，山岸高旺，喜田和四郎，秋山　優，奥田武男，右田清治，各評議員，原　慶明，横浜康継，井上　勲，堀　輝三，渡辺真之，各幹事。

## 3. 編集委員会報告

3月30日，評議員会に先だち (15：30～17：30)，筑波研修センターで編集委員会が開かれた。その内容は評議員会で審議され総会で報告されたので，総会の項に詳しい。

出席者：千原光雄会長，堀輝三編集委員長，秋山　優，岩崎英雄，黒木宗尚，小林　弘，正置富太郎，右田清治，西澤一俊，吉田忠生，各編集委員，渡辺真之編集幹事，井上勲会計幹事

## 4. 昭和56年度総会

昭和56年3月31日，春季大会第1日 (17：30～18：30)，筑波大学において昭和56年度日本藻類学会総会が開催された。千原光雄会長の挨拶に引き続き，議長に山岸高旺氏（日本大学）を選出し，審議に入った。その内容は下記のようである。

I　報告事項

1. 庶務関係

(1) 会員状況 (56. 3.29現在)　名誉会員1名。普通会員472名。学生会員52名。団体会員40件。賛助会員14件。外国会員63名。

(2) 昭和55年度文部省科学研究費補助金「研究成果刊行費」70万円を受けた。

(3) 日本学会事務センターに学会業務の一部を委託する契約が締結され，昭和56年1月1日より，下記のように業務内容が振り分けられた。

○学会事務局の業務

〔会計関係〕

ア）学会刊行物の販売

(1) 学会誌の販売，但し外国の定期販売は除く。

(2) 学会出版物（コンブ論文集，日米セミナー，山田追悼号）の販売。

イ）論文別刷代，論文頁数超過負担金，広告代の徴収。

ウ）山田幸男博士記念事業基金の管理。

エ）会計監査。

〔庶務関係〕

ア）総会，評議員会，編集委員会，春季大会等の準備。

イ）学会刊行物の管理。

ウ）論文別刷の発送。

エ）選挙業務。

オ）文部省科学研究費補助金「研究成果刊行費」の申請。

カ）寄贈・交換文献の管理。

〔編集関係〕

ア）編集一般の業務

○日本学会事務センター委託業務

〔会計関係〕

ア）学会費の徴収

(1) 普通，学生，団体，外国，名誉会員を扱う。

(2) 学会費納入は郵便振替または銀行振り込みに限る。

(3) 年3回学会費納入請求が行なわれる。

〔庶務関係〕

ア）会員業務

(1) 会員原簿の管理。

(2) 新入会，退会，住所変更の手続。

イ）会誌の発送

(1) 会員および寄贈，交換，販売のための会誌を発送する。但し国内の定期販売は除く。

(4) 日本植物学会第46回大会開催時（岐阜：岐阜大学）に講演会および懇親会を行なう計画で，中部地区会員の渡辺信氏（富山大，教養）と協議中である。

2. 会計関係

(1) 昭和55年度および昭和56年度の会員納入状況が報告された。

(55年度納入状況) 普通会員81％，学生会員96％，団体会員75％，外国会員82％，賛助会員76％，(56年度納入状況) 2月28日現在，普通会員，学生会員とも60％を越えている。

(2) 昭和56年1月1日より会費の納入先が学会事務局から日本学会事務センターは変更になったこと，それにともなって納入方法も改訂された旨報告された。

3. 編集関係

学会誌の発行状況と投稿論文数について報告された。29巻1号は本年3月10日に刊行され，現在29巻2号を6月20日発行を予定し編集中である。現在未審査のものを含め，欧文15編，和文7編の原著論文が投稿されている（29巻2号の掲載予定論文を含む)。

4. 評議員会関係

総会に提出された議題の他に以下のことが審議された。

(1) 山田基金の使途について

山田基金の使途については100万円に到達した時点で具体化する方針が決められてあった。55年末に山田基金が100万円を越えた（表-2参照）ので，学会費，特別出版物，研究助成等の具体案が提出され審議が行われた。しかし最終結論を出すにはさらに充分な審議を要すること，およびその期間に基金を増やす方向で努力することが確認された。

(2) 編集委員会

① 学会誌の編集方針として，欧文ページと和文ページが半々になるように努力する。

② 英文原稿で編集委員から英文の書き直しが指示された場合，外国人を紹介するよう（謝礼は著者負担）努力する。

③ 和文原稿の abstract の英文は予算の許す範囲で謝礼を支払い外国人に校閲してもらう。

④ 学会誌の体裁を損わない程度で広告を掲載する。

(3) 春季大会補助金の件

従来春季大会の補助金として6万円が計上さ

れていたが，その額を10万円まで引きあげる。

(4) 日本植物学会第46回大会のシンポジウムの件

日本分類学会会長加崎英男氏より，日本植物学会のシンポジウムを共催したい旨の要請があった。

Ⅱ 議題

1. 55年度一般会計決算報告・同監査報告

55年度決算については本年1月17日会計監事川端清策・三上日出夫両氏の監査を受け，表-1 のとおり報告承認された。

2. 55年度山田幸男博士記念事業基金特別会計決算報告・同監査報告

一般会計と同様に，表-2 のとおり報告承認された。

3. 56年度一般会計予算案

原案に一部修正を加え，表-3 のとおり承認された。

4. 56，57年度事業計画案

以下のように承認された。

(1) 56年10月岐阜大学で開催予定の日本植物学会の折に講演会と懇親会を開く。

(2) 57年春季大会および総会を筑波大学で開催する予定。

5. 中村義輝先生名誉会員推薦の件

学会長を経験し，満70才になられた会員は本会名誉会員の有資格者となり，会の承認を得て名誉会員になることができる。今回，中村義輝先生が時田旬先生についで2人目の名誉会員に推薦され承認された。

6. 学会誌への投稿規定一部改訂の件

以下のように承認された。

(1) 印刷経費の高騰に伴ない，実状に合わせて超過頁負担金を現在の1頁7千円から1万円に改める。

(2) 投稿論文の図版・写真は原則として原寸大とし，図版にかぎり印刷頁の2倍以内の大きさまで認める。

(3) 不備原稿などの返送にかかる費用は投稿者負担とする。

7. 春季大会参加費の件

春季大会は参加者数，講演題数が年々増加しそれにつれて大会開催費用が膨張してきたため，従来の参加費1,500円を2,000円に改めることが提案され承認された。

表-1 昭和55年度 一般会計決算報告　　日本藻類学会

| 収入の部 | | (円) | 支出の部 | | (円) |
|---|---|---|---|---|---|
| 会費 | | 2,426,398 | 印刷費 | | 3,291,150 |
| 普通会員 | 370件 | 1,564,000 | 28巻1～4号 | | 3,055,800 |
| 学生会員 | 47件 | 116,000 | 別刷 | | 235,350 |
| 外国会員 | 51件 | 366,398 | 発送費 | | 215,910 |
| 団体会員 | 30件 | 130,000 | 28巻1～4号 | | 173,740 |
| 賛助会員 | 10件 | 250,000 | 別刷 | | 42,170 |
| 販売 | | 324,250 | 通信費 | | 42,620 |
| 定期販売 | (28巻33口) | 198,000 | 編集費 | | 62,367 |
| バックナンバー | | 126,250 | 論文審査料 | 24件 | 24,000 |
| 別刷代 | | 255,550 | 通信費 | | 38,367 |
| 論文頁数超過負担金 | | 329,000 | 庶務費 | | 179,466 |
| 預金利息 | | 61,287 | 事務用品等 | | 2,716 |
| 広告代 | | 155,000 | 会議費 | | 25,500 |
| 文部省科学研究費 | | 700,000 | 事務整理補助 | | 71,750 |
| | | | 印刷費 | | 28,500 |
| | | | 学会事務センター委託カード作成 | | 51,000 |

| | | | |
|---|---|---|---|
| | | 送換金手数料 | 18,150 |
| | | 幹事手当（5名） | 60,000 |
| | | 春季大会運営補助 | 59,569 |
| | | 幹事旅費補助 | 100,000 |
| | | （札幌－東京　2回<br>総会出席，学会事務センター打合せ） | |
| | | 選挙費用 | 74,450 |
| | | （通信費 | 28,850） |
| | | （印刷 | 45,600） |
| | | 学会事務センター初年度経費 | 0 |
| 小計 | 4,251,485 | 小計 | 4,103,682 |
| 前年度繰越金 | 1,446,292 | 予備費 | 1,594,095 |
| 合計 | 5,697,777 | | 5,697,777 |

昭和56年1月17日　　日本藻類学会　会長　黒木宗尚 ㊞

会計幹事　山田家正 ㊞

本決算報告は適正であることを認める

昭和56年1月17日

会計監査　川端清策 ㊞

会計監査　三上日出夫 ㊞

表-2　昭和55年度　山田幸男博士記念事業基金特別会計決算報告　　日本藻類学会

| 収入の部 | (円) | 支出の部 | (円) |
|---|---|---|---|
| 山田追悼号売上金（6冊） | 33,500 | | |
| 学会出版物売上金 | 43,300 | | |
| （コンブ論文集（19冊） | 13,300） | | |
| （日米セミナー（10冊） | 30,000） | | |
| 預金利息 | 46,178 | | |
| 寄附金（7件） | 130,000 | | |
| 小計 | 252,978 | | |
| 前年度繰越金 | 753,418 | 次年度へ繰越 | 1,006,396 |
| 合計 | 1,006,396 | 合計 | 1,006,396 |

昭和56年1月17日　　日本藻類学会　会長　黒木宗尚 ㊞

会計幹事　山田家正 ㊞

本決算報告は適正であることを認める

昭和56年1月17日

会計監査　川端清策 ㊞

会計監査　三上日出夫 ㊞

表-3　昭和56年度　一般会計予算案　　日本藻類学会

| 収入の部 | (円) | 支出の部 | (円) |
|---|---|---|---|
| 会費 | 2,705,000 | 印刷費 | 3,540,000 |
| 普通会員　480件 | 1,920,000 | 29巻1～4号 | 3,140,000 |
| 学生会員　50件 | 125,000 | 別刷 | 400,000 |
| 外国会員　50件 | 250,000 | 学会事務センター業務委託費 | 1,105,000 |
| 団体会員　40件 | 200,000 | 経常経費 | 745,000 |
| 賛助会員　14件 | 210,000 | 初年度経費 | 360,000 |
| 販売 | 712,000 | 発送費 | 107,000 |
| 定期販売　(29巻52口) | 312,000 | 販売発送 | 52,000 |
| バックナンバー | 400,000 | 別刷発送 | 55,000 |
| 別刷代 | 455,000 | 編集費 | 220,000 |
| 論文頁数超過負担金 | 200,000 | 論文審査料　(40件) | 40,000 |
| 広告代 | 250,000 | 通信費 | 84,000 |
| 預金利息 | 25,000 | 編集整理補助 | 96,000 |
| 春季大会プログラム代 | 20,000 | 庶務費 | 180,000 |
| 文部省科学研究費 | 700,000 | 事務用品費 | 70,000 |
| | | 会議費 | 30,000 |
| | | 事務整理補助 | 40,000 |
| | | 雑印刷 | 40,000 |
| | | 送換金手数料 | 6,250 |
| | | 幹事手当 | 60,000 |
| | | 幹事旅費補助 | 26,400 |
| | | 春季大会補助 | 100,000 |
| | | 春季大会プログラム印刷代 | 20,000 |
| 小計 | 5,067,000 | 小計 | 5,364,650 |
| 前年度繰越金 | 1,594,095 | 予備費 | 1,296,445 |
| | 6,661,095 | | 6,661,095 |

日本藻類学会第5回春季大会 (56. 3.31～ 4.1) 会計決算報告　　日本藻類学会 春季大会準備委員会

| 収入の部 | (円) | 支出の部 | (円) |
|---|---|---|---|
| 大会参加費　(126件) | 189,000 | 宿泊代 | 297,400 |
| 懇親会費　(101件) | 202,000 | 筑波研修センター | 278,400 |
| 宿泊費　(118泊) | 283,200 | 筑波大学大学会館 | 5,100 |
| 寄附　(2件) | 40,000 | キャンセル分 | 13,900 |
| 学会補助金 | 100,000 | 懇親会会食代 | 205,000 |
| | | 学会会場費 | 13,125 |
| | | 会場使用料 | 6,881 |
| | | 光熱費 | 6,241 |
| | | 印刷代 | 36,500 |
| | | プログラム別刷代 | 20,000 |
| | | 名札・振替用紙印刷 | 16,500 |
| | | アルバイト代 | 185,500 |
| | | 雑費 | 33,536 |
| | | 学会補助金返却分 | 43,139 |
| 合計 | 814,200 | | 814,200 |

## 学 会 出 版 物

下記の出版物をご希望の方に頒布致しますので，学会事務局までお申し込み下さい。(価格は送料を含む)

**1. 「藻類」バックナンバー** 価格，会員は各号1,000円，非会員には各号1,500円，欠号：1巻1-2号，5巻1号，6巻1-3号，7巻1-3号，8巻1-3号，9巻1-3号.

**2. 「藻類」索引** 1-10巻，価格，会員1,000円，非会員1,500円．11-20巻，会員1,500円，非会員2,000円.

**3. 山田幸男先生追悼号** 藻類25巻増補，1977．A5版，xxviii+418頁．山田先生の遺影・経歴・業績一覧・追悼文及び内外の藻類学者より寄稿された論文50編（英文26，和文24）を掲載．価格5,500円.

**4. 日本科学セミナー記録** Contributions to the systematics of the benthic marine algae of the North Pacific. I. A. ABBOTT・黒木宗尚共編，1972．B5版，xiv+280頁，6図版．昭和46年8月に札幌で開催された北太平洋産海藻に関する日米科学セミナーの記録で，20編の研究報告（英文）を掲載．価格3,000円.

**5. 北海道周辺のコンブ類と最近の増養殖学的研究** 1977．B5版，65頁．昭和49年9月，札幌で行なわれた日本藻類学会主催「コンブに関する講演会」の記録．4論文と討論の要旨．価格700円.

## Publications of the Society

Inquiries concerning copies of the following publications should be sent to the Japanese Society of Phycology, c/o **Institute of Biological Sciences, The University of Tsukuba, Sakura-mura, Ibaraki-ken, 305 Japan.**

**1. Back numbers of the Japanese Journal of Phycology** (Vols. 1-28, Bulletin of Japanese Society of Phycology). Price, 1,250 Yen per issue for members, or 1,800 Yen per issue for non member. Lack: Vol. 1, Nos. 1-2; Vol. 5, No. 1-2; Vol. 6, Nos. 1-3; Vol. 7, Nos. 1-3; Vol. 8, Nos. 1-3; Vol. 9, Nos. 1-3. (incl. postage, surface mail)

**2. Index of the Bulletin of Japanese Society of Phycology.** Vol. 1 (1953)-Vol. 10 (1962), Price 1,500 Yen for member, 2,000 Yen for non member, Vol. 11 (1963)-Vol. 20 (1972). Price 2,000 Yen for member, 2,500 Yen for non member. (incl. postage, surface mail)

**3. A Memorial Issue Honouring the late Professor Yukio YAMADA** (Supplement to Volume 25, the Bulletin of Japanese Society of Phycology). 1977, xxviii+418 pages. This issue includes 50 articles (26 in English, 24 in Japanese with English summary) on phycology, with photographies and list of publications of the late Professor Yukio YAMADA. Price, 6,000 Yen. (incl. postage, surface mail)

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

**5. Recent Studies on the Cultivation of *Laminaria* in Hokkaido** (in Japanese). 1977, 65 pages. Four papers followed by discussions are included, which were presented in a symposium on *Laminaria*, sponsored by the Society, held in Sapporo, September 1974. Price 700 Yen. (incl. postage, surface mail)


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# 藻 類

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ノート



日 本 藻 類 学 会