Jpn. J. Phycol. (Sôrui) 37: 57–59, March 10, 1989

WANG Xiao Yang : Observations on pyrenoid ultrastructure of *Cladophora conchopheria* (Chlorophyceae)

Key Index Words: *Chlorophyceae*—Cladophora—*pyrenoid structure—ultrastructure.*
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Cladophora conchopheria SAKAI is classified among *Cladophora* species because it resembles them in external morphology (SAKAI 1964). Under cultural conditions, the species goes through a typical *Cladophora*-type life cycle and its number of chromosomes (2N=20–24) is similar to other species of *Cladophora* (WANG and SAKAI 1986). However, this species differs from the others in its intercuticular adventitious rhizoids, acropetal development of the reproductive segments (SAKAI 1964) and initial germination of spore by producing germ tubes (WANG and SAKAI 1986). All of these differences suggest the heterogeneous nature of *Cl. conchopheria* in the genus. In this paper, the ultrastructure of the pyrenoid of *Cl. conchopheria* is compared with those of several species of *Cladophora* and related algae to examine the taxonomic position of this species.

Cl. fascicularis (MERT.) KUETZING, *Cl. albida* (HUDS.) KUETZING, *Cl. opaca* SAKAI, *Cl. sakaii* ABBOTT, *Cl. rudolphiana* (C. AG.) HARVEY, *Cl. conchopheria* SAKAI, *Urospora penicilliformis* (ROTH) ARESCH. and *Spongomorpha* sp. were examined. They were from the stock culture in the Institute of Algological Research, Hokkaido University.

All species were cultured in PES medium (PROVASOLI 1966). Vegetative filaments were fixed in 1% glutaraldehyde, made up with PES medium, for 2–3 hr at 15°C. Specimens were post-fixed with 2% OsO_4 in seawater for 3 hr at the same temperature, *en bloc* stained with 2% uranyl acetate and dehydrated in a graded series of acetone. Finally, they were embedded in Spurr's epoxy resin. Sections were stained with uranyl acetate and lead citrate and observed with a Hitachi H-300 electron microscope.

Five species of *Cladophora*, except *Cl. conchopheria*, had the bilenticular-type of pyrenoid (Fig. 1). In this type of pyrenoid, the matrix was surrounded by a pair of hemispherical starch plates, and was traversed by a single thylakoid which continued into the thylakoid of the chloroplast proper. These results were consistant with the early studies about the ultrastructure of pyrenoids in Cladophoraceae (STRUGGER and PEVELING 1961; HORI and UEDA 1967; CHAN *et al.* 1978). In some sections of *Cl. fascicularis*, a pyrenoid which was traversed by two thylakoids that anastomosed in the matrix was seen.

A second type of pyrenoid is characterized by the presence of many fragmented starch plates on the surface of the pyrenoid matrix. However, differences in the structure of matrix were recognized in three species. In *Spongomorpha* sp. (Fig. 2), the matrix had a few tubular structures which might be related to the chloroplast thylakoids, and in *Urospora penicilliformis* (Fig. 3), more penetrating thylakoids appeared intermittently. By contrast, the pyrenoid of *Cl. conchopheria* (Fig. 4) is divided into many compartments by intrapyrenoidal undulating thylakoids. Pyrenoids seen in *Urospora penicilliformis* and *Spongomorpha* sp. have been reported (HORI and UEDA 1967, 1970; LOKHORST and TRASK 1981; BERGER-PERROT and THOMAS 1982). The pyrenoid of *Cl. conchopheria* is, however, distinctive. It is different from the bilenticular-type pyrenoid common to other *Cladophora* species.

The conservatism in pyrenoid structures is suggested by early ultrastructural studies of

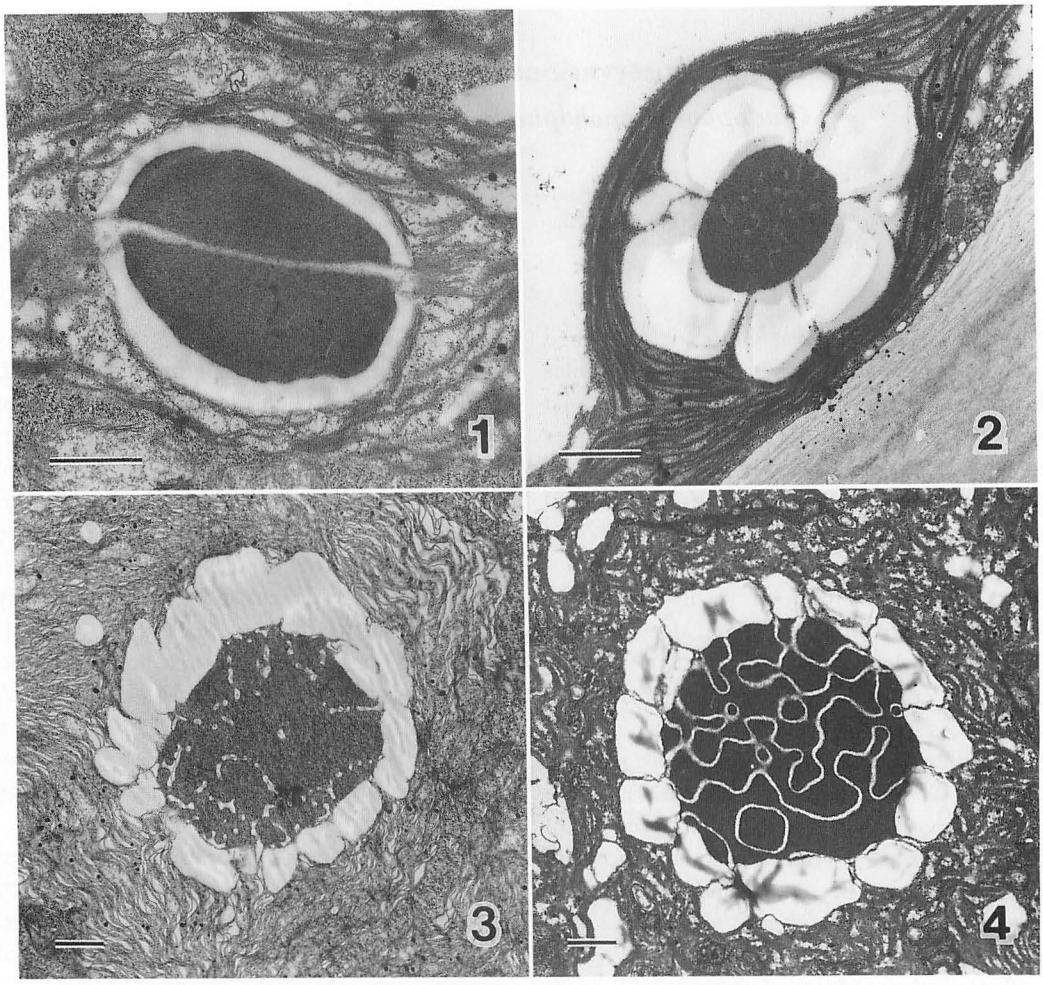

Fig. 1. Pyrenoid of *Cl. fascicularis*. Fig. 2. Pyrenoid of *Spongomorpha* sp. Fig. 3. Pyrenoid of *Urospora penicilliformis*. Fig. 4. Pyrenoid of *Cl. conchopheria*. Scale: 1 μm.

cladophoracean (STRUGGER and PEVELING 1961; GIBBS 1962; HORI and UEDA 1967; CHAN *et al.* 1978) and ulotrichalean pyrenoids (STEWART *et al.* 1973). The present study adds more examples for the view that the bilenticular-type pyrenoid is a common characteristic in the genus *Cladophora*. In the delimitation of the genus *Cladophora*, the pattern of life cycle, the constitution of cell wall, the structure of pyrenoid in chloroplast, the mode of cell division as well as morphological features have been considered to be important criteria (JÓNSSON 1962; VAN DEN HOEK 1963; ROUND 1971). The difference in pyrenoid structure was used when JÓNSSON (1962) established a new family, Acrosiphoniaceae, including *Urospora* and *Spongomorpha*. VAN DEN HOEK (1963) emphasized the structure of cell wall, pyrenoid and chloroplasts and the mode of cell division much more as the criteria for the separation of these three genera. The present results showed a remarkable difference between *Cl. conchopheria* and other *Cladophora* species. The characteristics of its pyrenoid make the inclusion of this species into genus *Cladophora* questionable as do other peculiar features (SAKAI 1964; WANG and SAKAI 1986). Thus, the taxonomic status of *Cl. conchopheria* should be reconsidered when more information is

accumulated.

I am indebted to anonymous reviewers for their constructive criticism.

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王 暁 陽：緑藻カイゴロモ(*Cladophora conchopheria*) のピレノイドについての電顕観察

シオグサ属1種，シリオミドロ属1種とモツレグサ属1種におけるピレノイドの微細構造を電子顕微鏡で観察した。その結果，シオグサ属5種，シリオミドロ，モツレグサ属の1種では今までの研究報告と一致したが，カイゴロモには顕著な違いが見られた。この種は典型的なシオグサタイプのピレノイドを持たず，シリオミドロやモツレグサに似るピレノイドを有する。つまり，ピレノイド基質の周りを数多くのデンプン粒が取り囲み，基質の中に多数のチラコイドが陥入する。この点とカイゴロモに見られる他の特徴的な性質とをあわせて考えると，この種の分類学的位置に関して，新たに検討する必要がある。(051 室蘭市母恋南町1－13 北海道大学理学部附属海藻研究施設)