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On *Gloeophycus koreanum* I. K. Lee & Yoo (Rhodophyta, Gloiosiphoniaceae) in Hokkaido

Takashi Kaneko*, Keiji Matsuyama*
and Iemasa Yamada**[1)]

* *Hokkaido Central Fisheries Experimental Station, Yoichi, Hokkaido, 046 Japan*

** *Department of Botany, Faculty of Science, Hokkaido University, Sapporo, 060 Japan*

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The plant identified as *Gloeophycus koreanum* I. K. Lee & Yoo (1979), recently described as a new monotypic genus of the Gloiosiphoniaceae from Korea, has been collected from the subtidal zone on the coasts of north-western Hokkaido. The morphology and the distribution are described. Our observation of the post-fertilization development differs from the original description. In the plant from Hokkaido, the fertilized carpogonium divides a connecting cell which fuses with the auxiliary cell, whereas in the Korean plant the fertilized carpogonium fuses directly with the auxiliary cell.

Key Index Words: *distribution*; Gloeophycus; *Gloiosiphoniaceae*; *morphology*; *post-fertilization development*; *Rhodophyta*.

Recently, Lee & Yoo (1979) reported a new monotypic genus, *Gloeophycus* (*G. koreanum*), belonging to the Gloiosiphoniaceae from the west coast of Korea. According to them, this plant is characterized in having the uniaxial thallus structure, the procarp provided with 3-celled carpogonial branch and 2-celled auxiliary cell branch borne on the same supporting cell, and the fertilized carpogonium fusing directly with the auxiliary cell.

During the last several years, we have collected a characteristic fragile red alga from the subtidal zone of different places on the north-western coasts of Hokkaido. From the morphological observation of the alga we had prepared the establishment of a new genus in the Gloiosiphoniaceae to this alga, but we knew a new monotypic genus, *Gloeophycus* I. K. Lee and Yoo by the personal communication of Lee to I. Yamada. By their description, we judged that our plant can be referred to *G. koreanum* by the striking similarities in the vegetative and reproductive structures. However, we found that our plant differs from the Korean plant described by Lee and Yoo only in having a connecting cell formed by the division of a fertilized carpogonium in the post-fertilization development.

The development of the female reproductive structure as well as the vegetative structure and the distribution of our plant are described here.

Materials and Methods

Materials examined were collected by dredging or SCUBA diving at the following nine stations in Hokkaido (Fig. 1). They were found growing solitarily or rarely gregariously on rocks, pebbles, and sometimes on scallop shells.

1) Present address: Biological Laboratory, Otaru University of Commerce, Otaru, 047 Japan

Specimens collected: Japan Sea coast of Hokkaido, from south to north: Shimamaki, June 11, 1975 (at a depth of 6 m, leg. K. MATSUYAMA); Bikuni, July 15, 1975 (11 m, leg. K. MATSUYAMA); Oshoro, Aug. 16, 1976 (10 m, leg. K. MATSUYAMA); Shukuzu, Otaru, Aug. 4, 1970 (10 m, leg. I. YAMADA), Aug. 8, 1975 (10–13 m, leg. K. MATSUYAMA); Atsuta, July 25, 26, 1974, July 7, 1975 (7–12 m, leg. K. MATSUYAMA); Hamamasu, July 24, 1974 (10 m, leg. K. MATSUYAMA); Mashike, July 4, 1973 (18 m, leg. T. KANEKO); Haboro, Aug. 7, 1976 (14 m, leg. T. KANEKO). Okhotsk Sea coast: Hama-Onishibetsu, Sept. 18, 1971 (20 m, leg. N. TAZAWA), Aug. 23, 1973 (18 m, leg. K. TOMITA), Aug. 18, 1974 (18 m, leg. T. HAYASHI), Aug. 16, 1976 (20 m, leg. T. KANEKO).

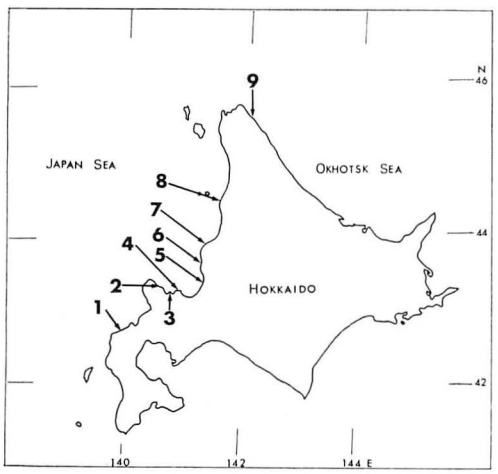


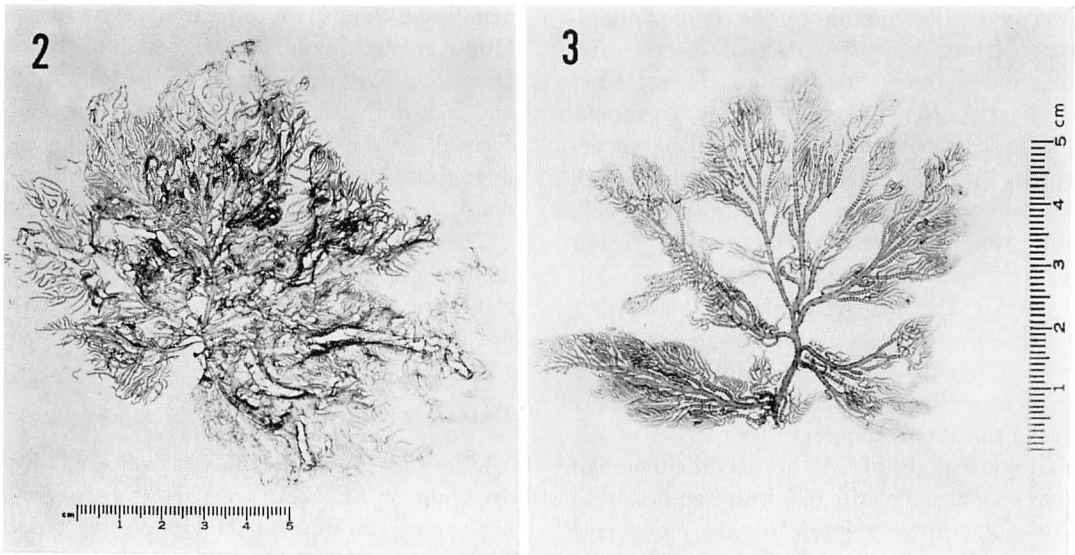
Fig. 1. Map showing nine localities for the plants collected. Numerals: 1, Shimamaki; 2, Bikuni; 3, Oshoro; 4, Shukuzu; 5, Atsuta; 6, Hamamasu; 7, Mashike; 8, Haboro; 9, Hama-Onishibetsu.

Materials for microscopic study were fixed with 5% formalin sea-water, stained with 1% aniline blue acidified with 1 N HCl and mounted in 50% solution of glucose syrup. All drawings were made with the aid of a camera lucida.

Specimens used in this study are deposited in the Herbaria of the Faculty of Science, Hokkaido University (SAP); Faculty of Fisheries, Hokkaido University, Hakodate; and the Hokkaido Central Fisheries Experimental Station, Yoichi.

Observations

Thallus habit: Thallus (Figs. 2, 3) erect, up to 15 cm tall, 1.7 mm thick in the lower,



Figs. 2–3. *Gloeophycus koreanum* collected from Hokkaido.

2. Mature plant collected from Shukuzu, Otaru, at a depth of 10 m on Aug. 4, 1970 by I. YAMADA. 3. A young plant collected from Hama-Onishibetsu at a depth of 20 m on Aug. 16, 1976 by T. KANEKO.

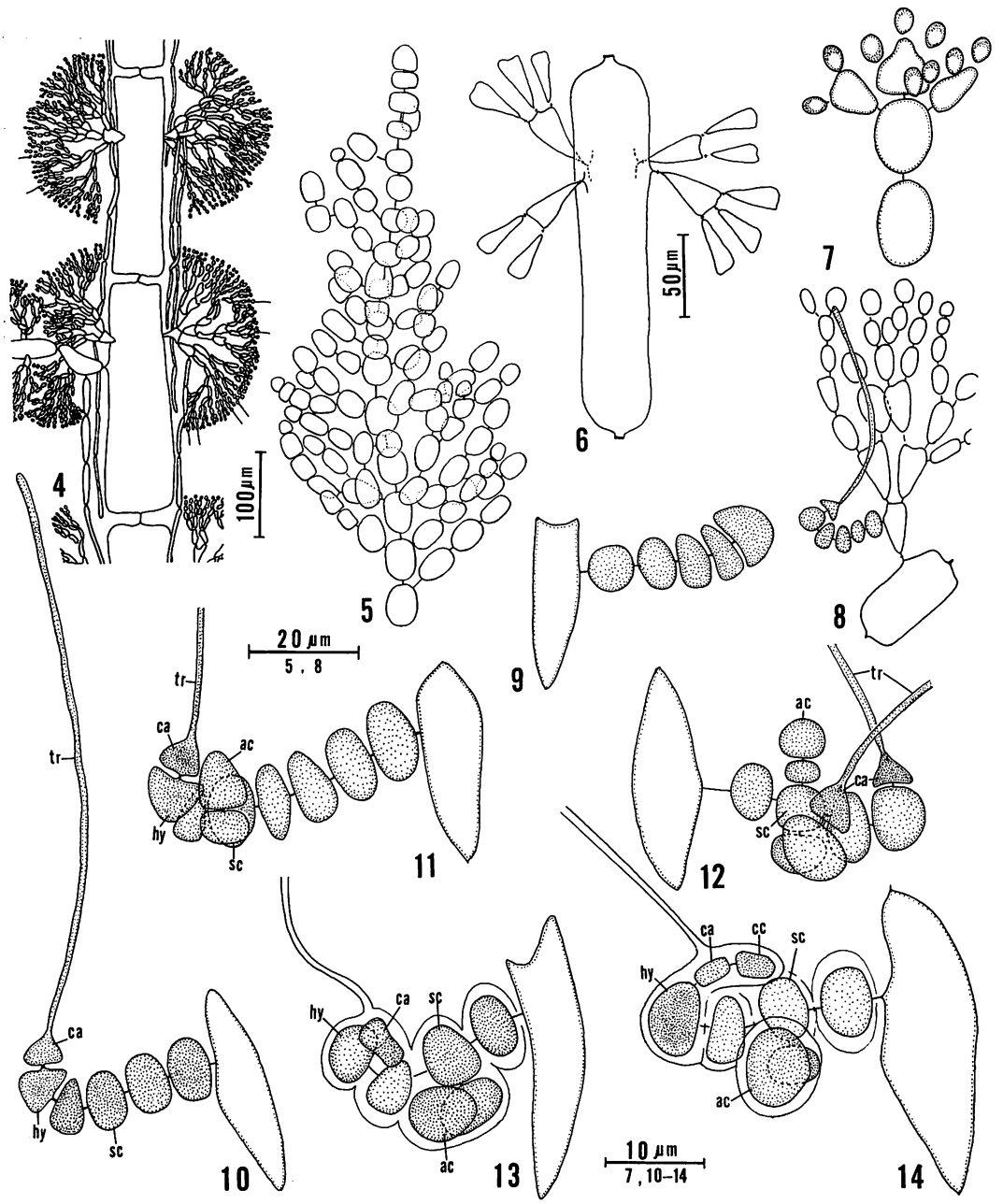
provided with terete, branched axes and branchlets possessing macroscopic nodal bands. There are 2 to 4 orders of branching. The main axis branches irregularly, sometimes alternately into several tapering branches which give off numerous branchlets unilaterally or pinnately, sometimes alternately. The stipe is short, usually tapering at the base. The base is small and discoid holdfast attached to the substratum. The thallus is soft, fragile and strongly mucilaginous in substance, and rosy to faint red in color.

Thallus structure: Thallus is uniaxial, composed of uniseriate axial cells and 4-whorl laterals of limited growth (Figs. 4, 6). The thallus develops by means of transverse division of an apical cell which cuts off segments to form axial cell row (Figs. 5, 22). Axial cells are 3–12 times as long as broad, tapering upward, measuring 140.4× 23.4 μm in length and breadth in the upper portion, 719.6×74.1 μm in the middle, and up to 940×200 μm in the lower, and are surrounded by simple or branched rhizoidal filaments descending from the lower cells of whorl laterals, especially thickly in the lower portion of thallus (Fig. 4). Whorl laterals arise from the upper portion of axial cells excepting at the extreme tip of the thallus (Figs. 5, 6), and branch 5–8 times dichotomously. Cells of whorl laterals are progressively smaller outward, oblong to spherical in shape. Superficial cells of whorl laterals measure 8.5×4.9 μm in length and breadth, and each may bear a deciduous unicellular hair, up to 130 μm in length, swollen slightly at the tip (Figs. 4, 24). These whorl laterals form macroscopic nodal bands except for the rhizoidally thick lower portion of the main axis. Vegetative cells are all uninucleate. Mature thalli observed are all monoecious. Tetrasporophytes are not known.

Development of female fertile branch: Female fertile branches are specially formed from the lower, first to fifth cells of whorl laterals nearly all over the thallus except for the lower portion (Figs. 8, 24). The supporting cell, the second to fifth of the cells in this branch from the point of its attachment, produces apically a 3-celled carpogonial branch, and laterally a 2-celled auxiliary cell branch at maturity but before fertilization. The apical cell of the carpogonial branch is the carpogonium with a long trichogyne. The hypogynous cell is a little larger than other cells and takes a shape so as to bend the branch adaxially. The terminal cell of the auxiliary cell branch is the auxiliary cell which is larger than the lower cell and rich in contents, staining deeply with aniline blue (Figs. 9–11, 25). A sterile filament composed of two to four cells rarely develops from a cell below the supporting cell. Rarely two carpogonial branches are formed from the same supporting cell (Fig. 12).

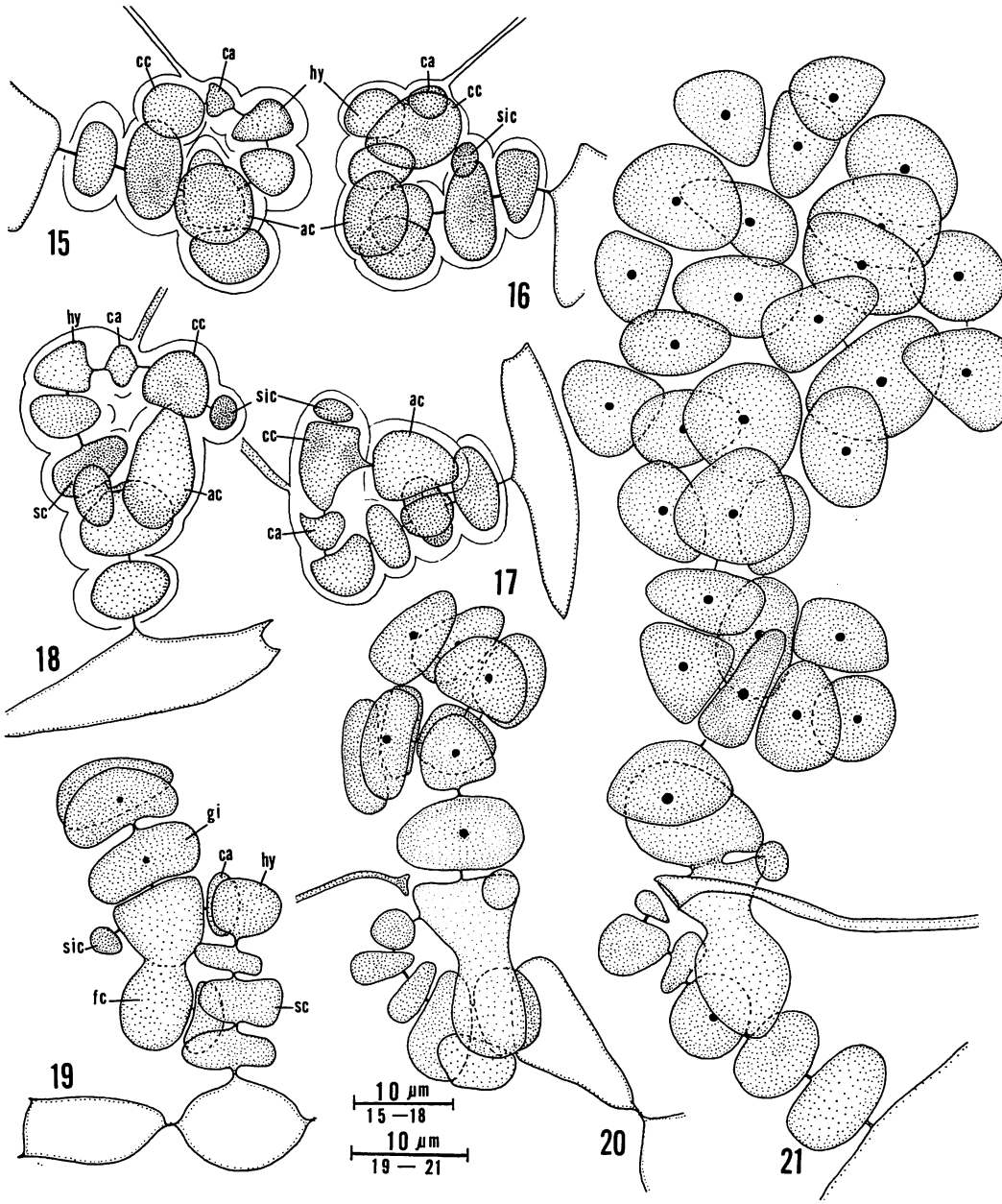
Development of gonimoblast: After fertilization the carpogonium becomes larger and bends toward the auxiliary cell (Fig. 13), and then divides transversely into two cells (Fig. 14) of which the upper cell becomes larger (Fig. 15) and divides again a small sister cell* (Figs. 16, 26). The carpogonium is thus divided into three cells of which the middle one becomes a connecting cell. The connecting cell fuses with the auxiliary cell to form a relatively large fusion cell (Figs. 17, 18, 27). The fusion cell does not fuse with any other cells of the carpogonial branch. The fusion cell cuts off a gonimoblast initial not from the side of the auxiliary cell itself but from the side of the connecting cell (Figs. 19, 28). Prior to the fusion, the auxiliary cell becomes larger and is stained deeply with aniline blue. The gonimoblast develops outwardly into a single or double lobes of large cells (Figs. 20, 21, 29), most of which become subspherical carposporangia. Carpospores liberated are (16.8–) 20.8–23.2 (–23.8) μm in diameter. Mature cystocarps are spherical, up to 150 μm in diameter, with no involucres, immersed among the whorl laterals. The junction between the fusion

* The term "sister cell" is used after ABBOTT (1961, her Fig. 6).



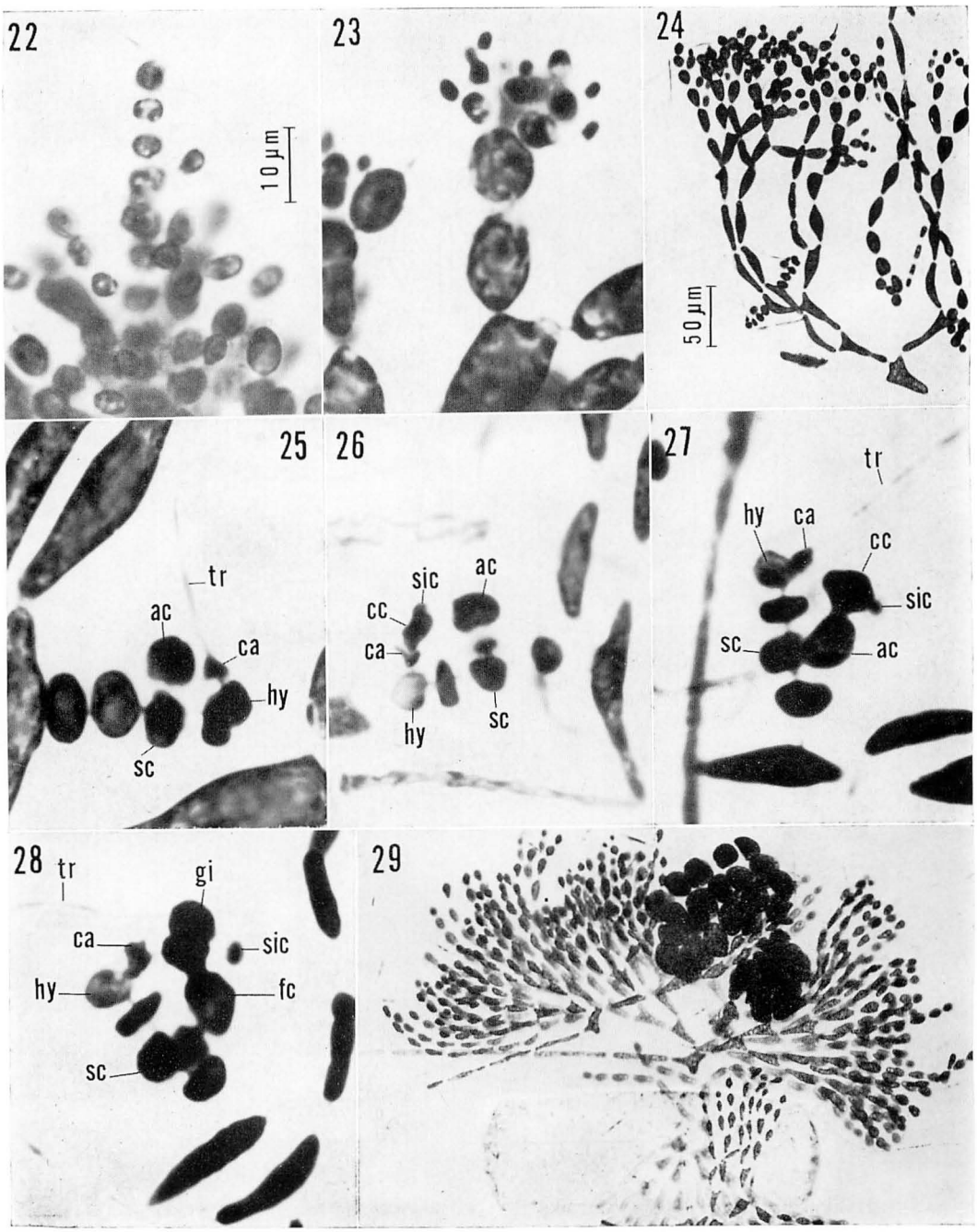
Figs. 4–21. *Gloeophycus koreanum* collected from

4. Thallus structure, showing axial cells with 4-whorl laterals, and rhizoidal filaments. 5. Apical portion of a branch, showing transverse cell division at the apex. 6. An axial cell with lower cells of 4-whorl laterals. 7. Spermatangia formed from superficial cells. 8. Situation of female fertile branch arising from the basal cell of a lateral. 9. A young 5-celled female fertile branch. 10. A 6-celled female fertile branch, showing carpogonium (ca) with a long trichogyne (tr), hypogynous cell (hy), and supporting cell (sc). 11. A female fertile branch, showing 2-celled auxiliary cell branch arised laterally from sup-



Hokkaido, camera lucida drawings.

porting cell, and terminal auxiliary cell (ac). 12. A female fertile branch, showing two carpogonial branches and an auxiliary cell branch borne on the same supporting cell. 13–16. Successive early stages of post-fertilization, showing connecting cell (cc) and sister cell (sic) cut off from carpogonium. 17–18. Fusion between connecting cell and auxiliary cell. 19–21. Successive stages of the development of gonimoblast, showing gonimoblast initial (gi) cut off from the fusion cell (fc) at the side of connecting cell (Fig. 19).



Figs. 22–29. *Gloeophycus koreanum* collected from Hokkaido, photomicrographs, materials were stained deeply with acidified aniline blue. Scales for Figs. 23 & 25–28 shown in Fig. 22, and scale for 29 shown in Fig. 24.

22. Apical portion of a branch, showing transverse cell division at the apex. 23. Spermatangial clusters on an apical portion of laterals. 24. A whorl lateral, showing vegetative cells, unicellular hairs, and the situation of female fertile branches. 25. A female fertile branch just prior to fertilization (cf. Fig. 11). 26–28. Successive stages of the developments of post-fertilization. 26. The connecting cell (cc) and the sister cell (sic) cut off from the carpogonium (ca). 27. Fusion between connecting cell and auxiliary cell (ac). 28. Gonimoblast initial (gi) cut off from the fusion cell (fc) at the side of connecting cell. 29. Mature gonimoblast with two lobes of carposporangia.

cell and the gonimoblast initial becomes somewhat broadened in later stages when the trichogyne and the sister cell still remain, showing no decrease in size (Fig. 21).

Spermatangia: The spermatangia are formed on the tips of whorl laterals nearly all over the thallus. The spermatangial mother cells are cut off from the upper cells of the whorl laterals and each produces three to six spermatangia in a single layer. The spermatangia (Figs. 7, 23) are ellipsoidal in shape, 2.8×2.1 μm in size.

Discussion

LEE & YOO (1979) established a new genus *Gloeophycus*, monotypic with *G. koreanum*, belonging to the Gloiosiphoniaceae on the basis of the uniaxial vegetative structure and the female reproductive structure consisting of 3-celled carpogonial branch and 2-celled auxiliary cell branch borne on the same supporting cell.

Judging from the description and figure by LEE & YOO (1979, fig. 30), our plant agrees well with *G. koreanum* in the vegetative structure, although the former is taller and is seemingly provided with many more delicate branchlets than the latter. Our plant is also similar to *G. koreanum* in the female reproductive structure, but the former differs from the latter in the post-fertilization development. Our plant has the connecting cell which is formed by the division of a fertilized carpogonium and fuses with the auxiliary cell to form a fusion cell. According to LEE & YOO (1979), the fertilized carpogonium is described to fuse directly with the auxiliary cell. However, there remains a little doubt to the direct fusion described by LEE & YOO. A figure by them (1979, fig. 7) seems not to show the exact direct fusion. The shape of the auxiliary cell in the figure seems as if there were a certain cell fusing with auxiliary cell other than the carpogonium. Further verification of the direct fusion in the Korean plant is expected. As far as we have observed, the plant producing no connecting cell has never been encountered. In *Thuretella schousboei* of the Gloiosiphoniaceae, as also discussed by LEE & YOO (1979), the fertilized carpogonium usually fuses directly with the auxiliary cell, but sometimes produces a connecting cell (HASSENKAMP 1902; KYLIN 1930).

As pointed out by LEE & YOO (1979), *Gloeophycus* resembles *Thuretella* in the vegetative structure, but differs in the female reproductive structure. Our plant, on the other hand, rather resembles *Schimmelmannia* in the development of the female reproductive structure by the occurrence of the connecting cell. The connecting cell formation of our plant is also similar to that in *Schimmelmannia*, of which fertilized carpogonium divides twice successively and the resulting middle cell becomes the connecting cell (KYLIN 1930; SEGAWA 1938; ABBOTT 1961; UMEZAKI 1967; ACLETO 1972). It is noticed that the connecting cell of our plant becomes larger before fusing with the auxiliary cell comparing to that of *Schimmelmannia*.

Japanese name: Otohime-mozuku (n. n.)

Acknowledgements

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金子　孝*・松山恵二*・山田家正：北海道産オトヒメモズク（新称）*Gloeophycus koreanum* I. K. LEE & YOO（紅藻，イトフノリ科）について**

北海道北西岸の亜潮間帯から採集された紅藻が，最近，韓国西岸から新属新種として報告された*Gloeophycus koreanum* I. K. LEE et YOO 1979（イトフノリ科，オトヒメモズク）に同定された。分布，体構造，生殖器官について述べ，原記載と異なる点について考察した。即ち，原記載では受精した造果器が直接助細胞と癒合するとされているが，北海道産の材料では受精した造果器は分裂し connecting cell を作り，それが助細胞と癒合する点で異なる。(*046 余市郡余市町浜中町　北海道立中央水産試験場・**060 札幌市北区北10条西8丁目　北大理学部植物学教室・**現住所；047 小樽市緑3-5-21　小樽商大)

Addendum

In reading the proof of this paper, we have received a personal communication from Dr. I. K. LEE. He reexamined the original material of *Gloeophycus koreanum* I. K. LEE et YOO in response to our results informed to him, and he recognized the occurrence of the connecting cell and sister cell in the post-fertilization development as seen in our material. This additional note was written by the proposition of Dr. I. K. LEE.

Accordingly, our material is no doubt identified as *Gloeophycus koreanum*.