

Sexual reproductive structures and postfertilization in *Rhodochorton subimmersum* Setchell et Gardner

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In *Rhodochorton subimmersum* Setchell et Gardner, tetrasporangia have been the only reproductive structure known so far. In our investigation spermatangia and carpogonia were found in the same individual. Moreover, it was revealed that the tetrasporangia were formed on the gonimoblasts (carpotetrasporophytes) after fertilization of the carpogonia, and independent tetrasporophytes were lacking in the life cycle of this species in Hokkaido.

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Introduction

This endophytic species was first described by SETCHELL & GARDNER (1903). It was found growing in the thallus of *Grateloupia cutleriae* (Bind.) KÜTZING on the west coast of Whidbey Island, Washington. They recorded that this plant bore one or two tetrasporangia at the tip of an erect filament. DREW (1928) described the detail of this species from the Pacific coast of North America. NAKAMURA (1941) described this species with the material growing in *Grateloupia turuturu* YAMADA collected at Muroran, Hokkaido. However, none of them mentioned the sexual reproductive structures in this species. Thus, the "tetrasporophyte" is the only known phase. In the course of our study of Acrochaetiaceae in Hokkaido we found spermatangia and carpogonia in this species with field materials, and observed the postfertilization resulting in the formation of tetrasporangia.

Material

The materials observed were growing in *Grateloupia turuturu* and *G. flicina* (Lamour.) C. Agardh collected at both Oshoro

and Muroran, Hokkaido during November, 1977 to January, 1978. The detailed observation was done with the material in the former host, because it was easy to pick up the fragments owing to the abundant infection and to the soft and loose cortical tissue of the host.

Fixed materials in 5-10% formalin sea water were used for observation. Staining with cotton blue was done when it was needed. The voucher specimens in dry and in liquid and slide preparations are preserved in the Herbarium of our Department (SAP).

Observation

Plants are easily detected by the presence of dark red areas infected in the host thallus. The plant is composed of endophytic filaments and outer erect filaments projected on the host surface. In *Grateloupia turuturu* the endophytic filaments developed well and formed a network not only in the cortical layer but also on the surface of the host, and outer erect filaments also were luxuriant. While, in *G. flicina* the endophytic filaments did not grow on the host surface, and the outer erect filaments were few compared with those in *G. turuturu*. How-

ever, no endophytic filaments developed into the medullary layer of both the hosts.

Endophytic filaments develop parallel and slantwise to the host surface, and branch irregularly. The cells are cylindrical and tortuous in shape, and 3–6 μm wide and 20–60 μm long. The cell wall is very thin.

Erect filaments (Figs. 1–2) arise from the cells of endophytic filaments near the host surface, being usually simple or rarely issuing branches. Frequently forked branching is seen at the base of the erect filaments. Erect filaments are composed of 2–10 cells, 3–6 μm wide and 10–50 μm long, and slightly taper toward apex. The cells have nearly the same length as width or longer. The cell wall is somewhat thick (about 1 μm) compared with that of the endophytic filaments. Generally the development of the erect system is poorer than the prostrate system in the sterile stage, and the erect filaments show a tendency to appear after the fertilization of carpogonium.

A single parietal plastid lacking a pyrenoid is present in each cell (Fig. 3). The plastid is usually light in color in the carpogonium.

Spermatangia and carpogonia are borne on the cells of endophytic filaments growing near the host surface, sessile or stalked. Spermatangia (Figs. 4–7) are solitary on 1–3 or more celled stalks, and sometimes sessile. There are not formed well developed spermatangial clusters on erect filaments like those seen in *Rhodochorton purpureum* (Lightf.) Rosenvinge (WEST 1969). Spermatangia are nearly globular in shape, 3–4 μm in diameter, and light in color and equally stained with cotton blue to vegetative cells.

Carpogonia (Figs. 4–6) are sessile or on 1–2 celled stalks, and rarely lateral or intercalary on erect filaments, flask or conic shaped, and 3–4 μm wide and 5–10 μm long. Trichogynes are slightly constricted at the base, and 2–3 μm wide and up to 16 μm long. One or occasionally two spermatia (Fig. 8) attach on the apical portion of the trichogyne.

After fertilization the carpogonia enlarge upward to becoming elongated and obovoid

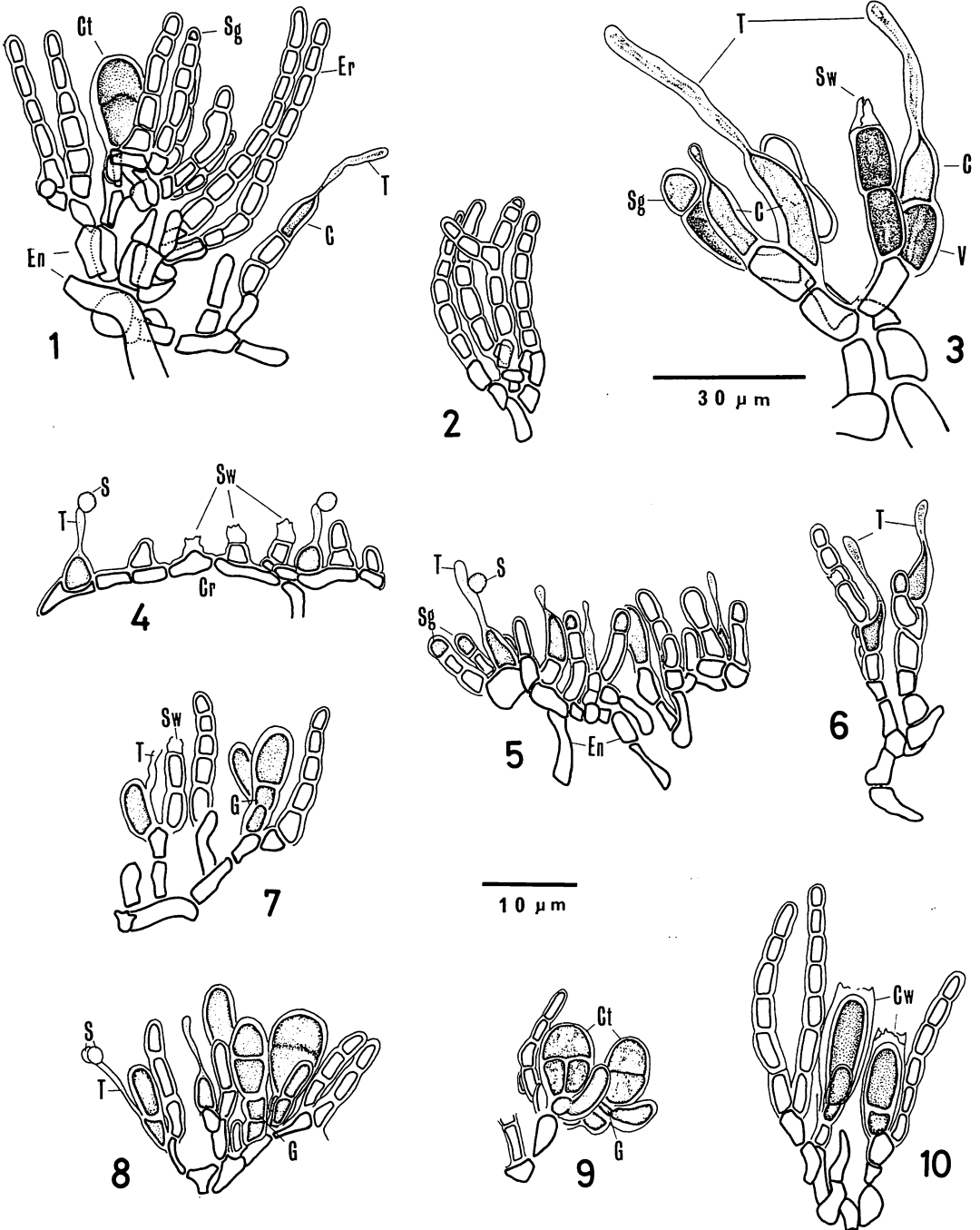
or club shaped (Fig. 7). By this stage and later trichogynes with empty spermatia frequently remain on the side of the enlarged carpogonia without disintegration. Then the carpogonia are divided into two cells of unequal size by a transverse wall (Fig. 8). The upper cell is larger than the lower one. The cell remains undivided or divided one to two times to form short gonimoblasts of 2–3 cells (Figs. 7–9). Sometimes the lower cell also issues 1–2 celled laterals. Thus there are formed very simple gonimoblasts, some of which are unbranched (2–3 celled) and others sparingly branched. The apical cells of the gonimoblasts are more enlarged and converted into tetrasporangia without being carposporangia as seen in the ordinary members of Florideophyceae. However, the apical cells of the laterals follow in maturation. Cells of the gonimoblast except for the apical cells are 5–6 μm wide and 3–6 μm long. When the tetrasporangia are formed, they appear to be terminal, solitary or paired on stalks as described by SETCHELL & GARDNER (1903), DREW (1928), and NAKAMURA (1941).

Tetrasporangia (Fig. 9) are obovoid to ellipsoid, cruciately divided, and 10–12 μm wide and 15–19 μm long. Regeneration of tetrasporangia in the empty ones occurs frequently (Fig. 10).

Monosporangia are absent. Hairs also are not found.

Discussion

From the above observations it is revealed that the male and female reproductive structures are produced in this species in Hokkaido and the fertilized carpogonia develop into very simple carposporophytes producing tetrasporangia instead of carposporangia. Such tetrasporangia and carposporophytes were named carpotetrasporangia and carpotetrasporophytes by BØRGESEN (1927) and BODARD (1971) respectively. The prior investigators (SETCHELL & GARDNER 1903, DREW 1928, NAKAMURA 1941) seem to have failed to find out the sexual reproductive



Figs. 1-10. *Rhodochorton subimmersum* Setchell et Gardner, part of endophytic filament (En) indicated with thick line, erect filament (Er), carpogonium (C) with trichogyne (T), spermatangium (Sg), spermatium (S) attached to trichogyne and development of fertilized carpogonium. 1-2; showing longer erect filaments, forked branching at the base and lateral branching on erect filament, 3; contents in vegetative (V) (dark) and reproductive (light) cells, 4-5; sessile or stalked carpogonia, spermatangia, empty spermatangia (Sw) and spermatia attached to trichogyne, 6; intercalary carpogonium in erect filament, 7-9; enlargement and first division by transverse wall in fertilized carpogonia, development of gonimoblast (G) with or without laterals and formation of carpotetrasporangia (Ct), 10; regeneration of carpotetrasporangia in empty sporangial walls (Cw). Use 10 μm scale for Figs. 1-2, 4-10.

structures owing to the occurrence in the early developmental stage of this plant and to have misunderstood the gonimoblast cells as the stalk cells of the tetrasporangia. The development of carpotetrasporophyte directly producing tetrasporangia from the gonimoblast cells is essentially the same as in *R. purpureum* (WEST 1969), although the rhizoids observed in *R. purpureum* by WEST are not issued and the growth of gonimoblasts is very reduced in this plant. Thus it is supposed in this plant that the ordinary carposporophytes as seen in the *Polysiphonia* type of the Florideophyceae and the independent tetrasporophytes are lacked in the life cycle, although the evidences by cultural experiment and cytological investigation are not given at present. The life cycle of this plants belongs to "Le cycle des Némaliales à carpotétraspores" (MAGNE 1972) or "The *Liagora tetrasporifera* type" (DIXON 1973, UMEZAKI 1977) as seen in *Liagora tetrasporifera* BØRGESSEN (1927), *Helminthocladia agardhiana* (C. Ag.) J. Ag. (FELDMANN 1939 as *H. hudsoni*), *Yamadaella coenomyce* (De-cais.) ABBOTT (1970), etc.

The nomenclatural problem of the genera belonging to Acrochaetiaceae (the *Rhodochorton-Acrochaetium* complex called by PAPPENFUSS 1945) has been discussed by a number of authors. Among them, DREW (1928) adopted one genus, *Rhodochorton*, in her review of the genera, *Chantransia*, *Rhodochorton* and *Acrochaetium*, because of the synonymy of rhodophycean *Chantransia* with *Batrachospermum* or *Lemanea* and the difficulty to separate *Rhodochorton* and *Acrochaetium*. NAKAMURA (1941, 1944) followed DREW's opinion in the nomenclatural treatment. KYLIN (1944, 1956) recognized six genera in the complex separated from one another by the differences of basal system, plastid morphology and reproductive structures. PAPPENFUSS (1945, 1947) also separated four genera according to the feature of plastids as the main criterion. In his paper *Rhodochorton subimmersum* was combined with *Acrochaetium* as *A. subimmersum*. FELDMANN (1962) distinguished the

complex into two families and eight genera based on the mode of the development of gonimoblasts and the character of plastids as well as the type of life cycle. WOELKERLING (1971, 1973) recognized two genera only, one is *Audouinella* (the oldest valid genus name of the complex) for the sexual taxa and the other *Colaçonema* for the asexual taxa. PARKE & DIXON (1976) and DIXON & IRVINE (1977) merged all the species of the complex into *Audouinella* according to the one genus concept of DREW (1928). Recently STEGENGA & VROMAN (1977) preliminarily reported that the complex was distinguishable into seven genera with the characters of the type of life cycle, the postfertilization development, the mode of spore germination and the plastid structure. According to the concepts of WOELKERLING, PARKE & DIXON and DIXON & IRVINE, this species, *Rhodochorton subimmersum*, may be also combined with *Audouinella*. At present, however, we prefer to use the original name for this species until further knowledge about the complex is accumulated.

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李 龍 弼・黒木宗尚: *Rhodochorton subimmersum* Setchell et Gardner の
有性生殖器官と受精後の発達

ムカデノリ属の藻体に内生する微小紅藻の *Rhodochorton subimmersum* の生殖器官はこれまで四分孢子囊だけが報告されていたが、藻体の若い時代に精子器、造果器の有性生殖器官が同一個体に形成されること、受精後に造果器から発達の貧弱な造胞糸が形成され、その先端細胞に果孢子囊でなく四分孢子囊が形成されることを明らかにした。このことから、本種には独立した四分孢子体はなく、*Liagora tetrasporifera* 型の生活環を示すものと想像される。(060 札幌市北区北10条西8丁目, 北大理学部植物学教室)