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The Identity of the Endozoic Red Alga *Rhodochortonopsis spongicola* Yamada (Acrochaetiales, Rhodophyta)

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Abstract The identity and status of the unusual endozoic red alga, *Rhodochortonopsis spongicola* Yamada (Acrochaetiales, Rhodophyta) was reassessed, by reexamining the type specimens (TNS). This species was originally described as the only representative of the monospecific genus *Rhodochortonopsis* by Yamada (1944), based on material collected by the Emperor Showa. Yamada (1944) observed single stichidia (specialized branches bearing tetrasporangia) and considered them as the discriminant character to distinguish this genus from all the members of the order Acrochaetiales. This study shows that these specimens are actually belonging to the species *Acrochaetium spongicola* Weber-van Bosse. The presence of "stichidia" is actually an artifact, due to a cover of sponge spicules, forming bundles originally mistaken as part of the alga. Consequently, the genus *Rhodochortonopsis* has no entity.

Key words: Acrochaetiales, *Acrochaetium spongicola*, endozoic red alga, *Rhodochortonopsis spongicola*, Rhodophyta.

Introduction

Epizoic and endozoic marine algae (i.e. living on or inside animal bodies) have been little studied. This is inherent to the difficulties of collecting, isolating from the animal host (especially for endozoic algae) and making voucher specimens for further reexamination. More than half a century ago, the unusual endozoic red alga, *Rhodochortonopsis spongicola* (Acrochaetiales, Rhodophyta), was described by Yamada (1944), for which he created a new genus. The diagnoses of the species and the genus were based on the microscopic plants within the tubes of polychaete worms, which were collected by the Emperor Showa (1901–1989) in the sea off Hayama, Sagami Bay, Japan. The main characteristic of the genus *Rhodochortonopsis* lies in the "very peculiar stichidia" harbouring many zonately divided tetrasporangia (Fig. 1). After the original description, however, this alga has not been collected again in Japan. Only Norris (1991) recorded a similar algal species from Natal (South Africa) and suggested a possible relationship of *Rhodochortonopsis* to the order Gigartinales (and not Acrochaetiales) because of the cystocarpic structures of the female plants and the presence of a structure similar to Yamada's "stichidia". In this research the identity of this species is reassessed by examination of the type specimens.

Materials and Methods

Type material of *Rhodochortonopsis spongicola* Yamada stored in the herbarium of the Showa Memorial Institute, the National Museum of Nature and Science (TNS), Tsukuba, Japan was reexamined. The fragments from the materials were immersed in glycerin or stained using 1% acidified aniline blue and observed using a microscope.

Observations and Discussion

ORDER ACROCHAETIALES Feldmann 1953: 12

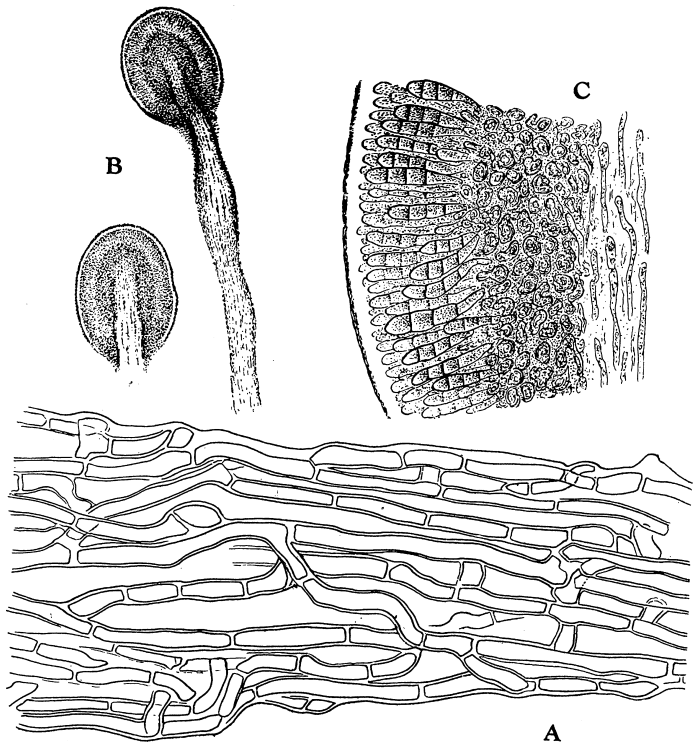


Fig. 1. Illustrations of "*Rhodochortonopsis spongicola*" Yamada in the original description.
A. A part of the frond. ca. ×470. B. Stichidia. ca. ×40. C. Cross-section of a stichidium. ca. ×330 (after Yamada 1944, p. 24, f. 8).

Family Acrochaetiaceae Fritsch ex Taylor 1957: 209, 210, nom. cons.

Acrochaetium spongicola Weber-van Bosse 1921: 195 (as "*Acrochaetium spongiocolum*"). (Figs. 2–8)

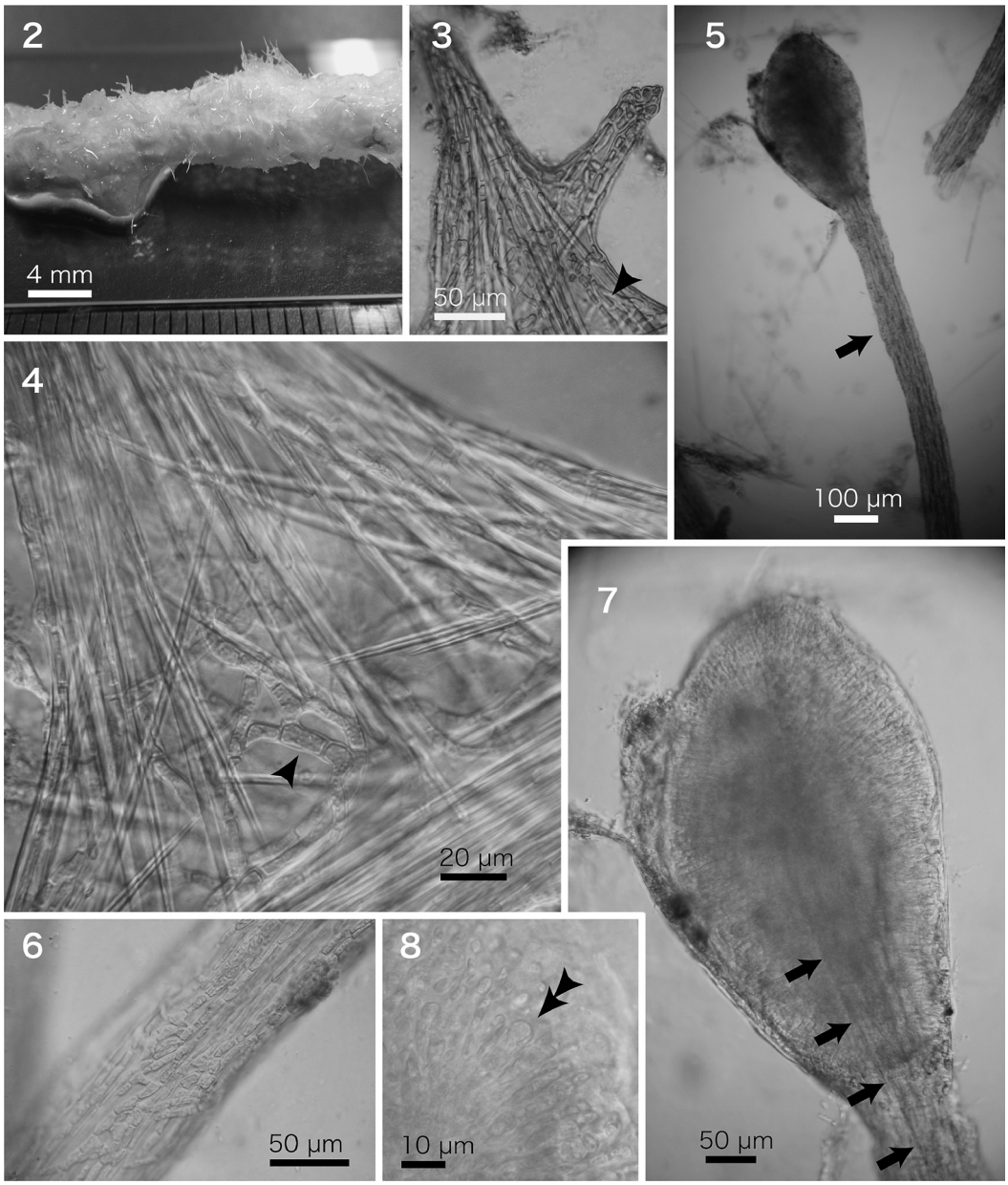
Synonyms: *Audouinella spongicola* (Weber-van Bosse) Stegenga 1985: 314, fig. 18 (as "*Audouinella spongiocola*").

Colaconemam spongiocolum (Weber-van Bosse) Woelkerling 1971: 41A–F. 195.

Rhodochortonopsis spongicola Yamada 1944: 23, figs 7, 8.

Specimens examined: Off Sashima (Hayama), Sagami Prov. (Kanagawa Pref.), Japan (15 Aug. 1939), Coll. Showa Tenno, TNS-AL-R L-212 (y. no. 1859, holotype of *Rhodochortonopsis spongicola*).

The type material is composed of several tubes of polychaete worms, mainly made of sponge spicules (Fig. 2). Pseudoparenchymatous structures consisting of algal vegetative filaments were observed (Fig. 3, arrowhead). The filaments are uniseriate, irregularly branched, *Colaconema*-like in shape (Fig. 4, arrowhead). Vegetative cells are cylindrical, 4–7 μm in diameter and 8–38 μm in length, irregularly branched and forming a network on the surface of bundles of sponge spiclues. In addition the filaments are covering a stem-like structure made of sponge spicules. The accumulation of the filaments often makes a crustose on the terminal portion of the stalk (Figs. 5 and 6). As a result, this structure appears to be the same as the "stichidium" reported in the original description of the species (Yamada, 1944, f. 8b) (Figs. 1 and 5). The stalks of the "stichidia"-structures are cylindrical, 70–95 μm in diameter. A number of erect filaments are rising from the surface of the crustose having an



Figs. 2–8. "*Rhodochortonopsis spongicola*" Yamada (TNS-AL-R 212, holotype). 2. Parasitized polychaete tube, made of sponge spicules. 3, 4. View of vegetative filaments (arrowhead) growing between the spicules (surface view of the polychaete tube). 5. "Stichidium" with a long stipe (arrow). 6. Surface of stipe of "stichidium" showing covered with vegetative filaments. 7. Terminal portion of the "stichidium"-structure showing a bundle of sponge spicules inside the structure (arrows). 8. Surface of the terminal portion of the "stichidium"-structure showing a putative monosporangia (double arrow).

axis of sponge skeletons inside (Fig. 7, arrows). Erect filaments often have a putative monosporangium on their terminals (Fig. 8, double arrow).

Stichidia (*sing.* Stichidium) are specialized branches bearing tetrasporangia in Rhodophyta,

usually enlarged over the vegetative axes (Bold and Wynne, 1985). Yamada (1944) described the "stichidia" in the alga as an important feature for the genus *Rhodochortonopsis*. The "stichidium" illustrated in his description (f. 8B) coincides with the structures observed in the type specimens (long cylindrical stalk, 75–125 μm in diameter) (Fig. 1). However, the "stichidium"-structure observed in the type specimens of *Rhodochortonopsis spongicola* Yamada is not part of the macroalgal thallus but is in fact consisting of "axes" of sponge spicules and covered by vegetative filaments of *Audouinella* or *Acrochaetium* on their surface. It is considered that the constant diameters of the stalks (i.e. the spicules) are the result of a selection by the polychaete during the elaboration of the tube. Therefore, the algal fraction of the type material is considered as *Acrochaetium spongicola* Weber-van Bosse or *Audouinella spongicola* (Weber-van Bosse) Stegenga, and in either case it is suggested that *Rhodochortonopsis spongicola* Yamada is not a separate species and its monotypic genera *Rhodochortonopsis* has no entity.

The generic taxonomy of Acrochaetioid algae (Acrochaetiales) including several genera, *Acrochaetium*, *Audouinella*, *Colaconema*, *Kylinia*, *Rhodochorton*, etc. is continuing to be confused and many classification schemes have been proposed by many authors (e.g., Drew, 1928; Woelkerling, 1983; Garbary and Gabrielson, 1987; Lee and Lee, 1988) depending on criteria used for defining genera. For example, Silva *et al.* (1996) treated all acrochaetioid algae reported from the Indian Ocean as *Acrochaetium*, following Feldmann's proposal that *Acrochaetium* includes species in which each cell has a single chloroplast, whether it be stellate or laminate, axile or parietal (Feldmann, 1962). However, most of the authors did not make any mention of the genus, *Rhodochortonopsis*, including even a recent molecular investigation on Acrochaetiales using DNA sequence data of *Acrochaetium*, *Audouinella*, *Colaconema*, *Rhodochorton* (Harper and Saunders, 2002). Probably it was largely a result of Yamada's statement, "very peculiar stichidia" and noted that "owing to lack of cystocarps it is impossible to determine the systematic position of the new genus" in his original description (Yamada, 1944, p. 25). Kylin (1956) and Silva *et al.* (1996) treated this genus as the one of genera of uncertain position in Rhodophyceae (Rhodophyta). Only Yoshida (1998) and Yoshida *et al.* (2005) listed this genera in Acrochaetiaceae (Acrochaetiales) with an additional comment about indeterminacy of its taxonomic position.

Norris (1991), who made the only recorded of *Rhodochortonopsis spongicola* after the Yamada's original description, observed the female plants and cystocarpic plants collected from Natal, South Africa in 1990. He suggested the possibility that this unusual alga, *Rhodochortonopsis spongicola*, has a relationship with the Gigartinales, based on the combination of the advanced type of cystocarpic structures on or with the female gametophytes from South Africa and zonate tetrasporangia on the Japanese tetrasporophytes described in the original description. As he noted, however, it cannot be unequivocally established that his female and cystocarpic plants belong to the same entity as the tetrasporophytic plants described by Yamada (1944). Thus, since Norris (1991) avoided deciding its final position in the Rhodophyta, this problem has been pending for a long time. In this research, it was revealed that the "stichidia" described in the Yamada's original description were made of sponge spicules covered with vegetative filaments and a crustose arising numerous erect filaments (with probably monosporangia) on the terminal. The Japanese plants are identified as *Acrochaetium spongicola* Weber-van Bosse in the morphology of vegetative filaments forming network on the sponge skeletons and putative monosporangia on the crustose. Although the identity of the South African plants with cystocarps is unknown, I consider that the name of *Rhodochortonopsis spongicola* should be synonymized under *Acrochaetium spongicola* (or *Audouinella spongicola*), which has been recorded so far from only south hemisphere: Indonesia

(type locality: Aru Isls., Weber-van Bosse, 1921) and South Africa (Stegenga, 1985), southern Australia (Woelkerling and Womersley, 1994), while there is no record of the species from the north hemisphere.

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