

The taxonomy of *Protectocarpus speciosus* (BØRGESEN) KORNMANN (Myrionemataceae, Phaeophyceae)

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Protectocarpus speciosus collected from Pacific coasts of northern Honshu was fully described and illustrated. This alga is characterized mainly by the unilaterally branched plurilocular reproductive organs and heterotrichous thallus. *Protectocarpus speciosus* was designated as the lectotype of this genus for the first time. Taxonomic relationship of the genus *Protectocarpus* in the Ectocarpaceae *sensu lato* was discussed. This is the first report for the occurrence of this genus and species in Japanese waters.

Key Index Words: Ectocarpaceae; Myrionemataceae; Phaeophyceae; *Protectocarpus speciosus*; taxonomy.

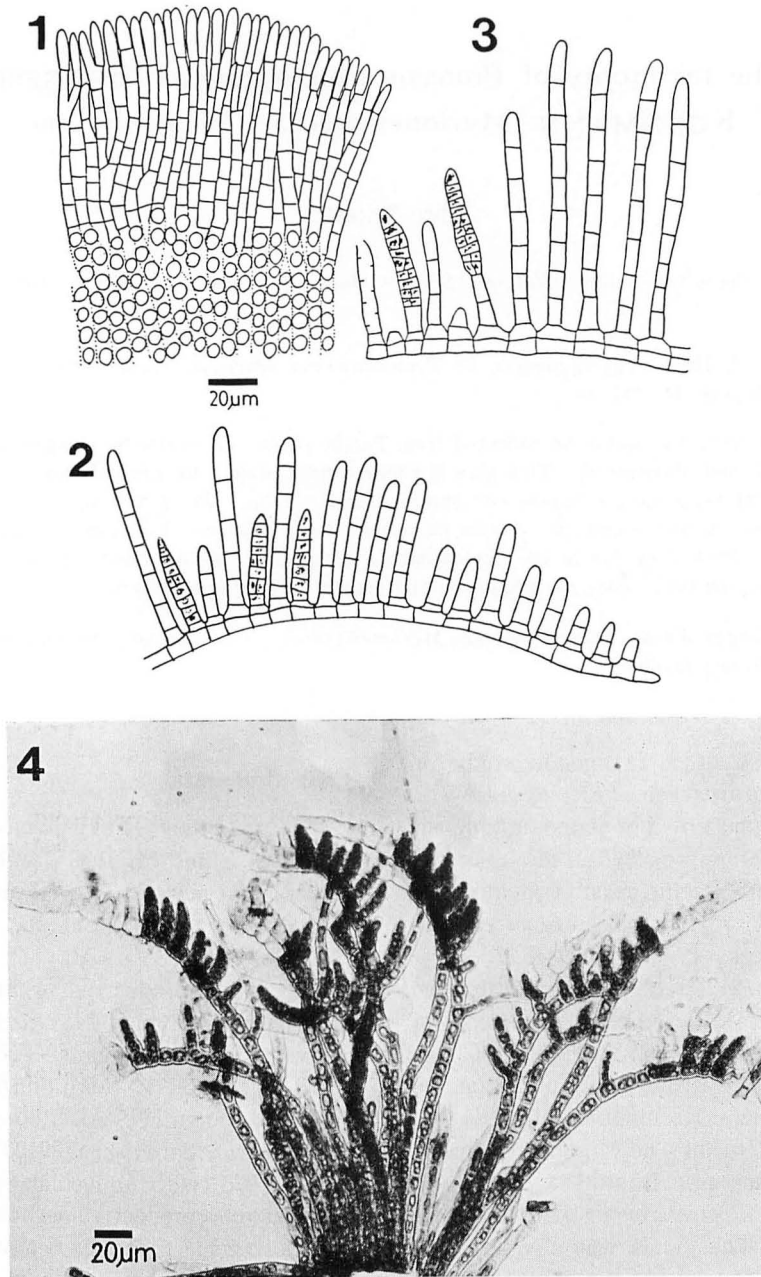
In the course of a taxonomic study on Japanese Ectocarpaceae, *Protectocarpus speciosus* was found growing abundantly on the marine spermatophyte *Phyllospadix iwatensis* along the north Pacific coast of Japan. The genus has not previously been reported from Japanese waters.

The genus *Protectocarpus* was established by KORNMANN (1955), chiefly on the basis of *Myrionema speciosum* BØRGESEN (1902), a species described from the Faeroes in the North Atlantic. Kornmann referred two other species to his new genus, namely, *Myrionema faeroense* BØRGESEN (1902) and a new species, *Protectocarpus hecatonemoides* KORNMANN. The genus was characterized as having heterotrichous thalli with unilaterally branched plurilocular reproductive organs.

The present paper describes in detail the morphological features of *Protectocarpus speciosus* collected in Japan, compares them with those of *P. speciosus* from Europe and the other species in the genus, and discusses the systematic position of the genus.

Collection Data

1. Cape Shioya, Fukushima-ken (37°00'N, 140°58'E), June 14, 1983 (with plurilocular reproductive organs) TNS-AL-5020 (in liquid).
2. Togawa, Choshi-shi, Chiba-ken (35°42'N, 140°52'E), May 2, 1981 (with plurilocular reproductive organs) TNS-AL-5166 (in liquid); June 14, 1980 (with plurilocular reproductive organs) TNS-AL-5167 (in liquid); June 5, 1977 (with plurilocular reproductive organs) TNS-AL-5166 (in liquid).
3. Ooarai, Ibaraki-ken (36°20'N, 140°38'E), Apr. 4, 1976 (with unilocular sporangia and plurilocular reproductive organs, mixed with *Giffordia sandriana* and *Ectocarpus confervoides*) TNS-AL-5173 (in liquid).
4. Akahama, Ootsuchi-cho, Iwate-ken (39°21'N, 141°55'E), March 19, 1985 (with plurilocular reproductive organs) TNS-AL-5235, 5240 (in liquid); March 1, 1986 (with plurilocular reproductive organs, mixed with *Rhodophysema* sp.) TNS-AL-5337.
5. Tanohama, Yamada-cho, Iwate-ken (39°24'N, 141°59'E), May 17, 1985 (with plurilocular reproductive organs) TNS-AL-



Figs. 1-4. *Protectocarpus speciosus*. Fig. 1. Surface view at the margin. Fig. 2. Vertical view, showing basal disc with one cell-layer and plurilocular reproductive organs directly upon basal filaments. Fig. 3. Vertical view, showing basal disc with two cell-layers. Fig. 4. Vertical view of thallus with mature and empty plurilocular reproductive organs.

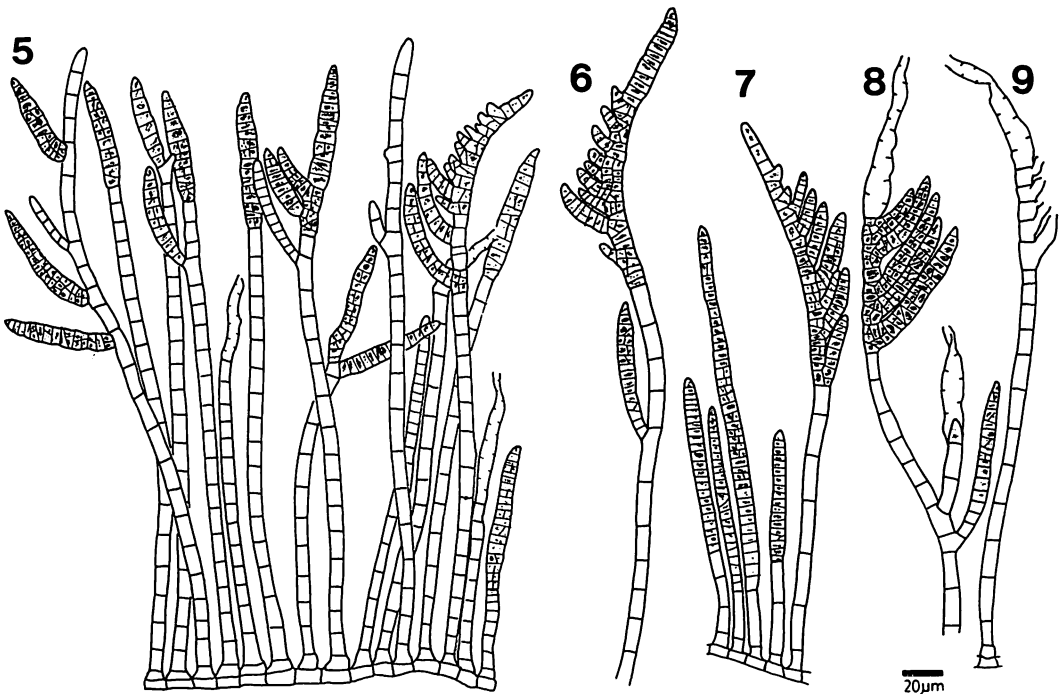
5267, 5271 (in liquid).

Description of *Protectocarpus speciosus* as found in Japan

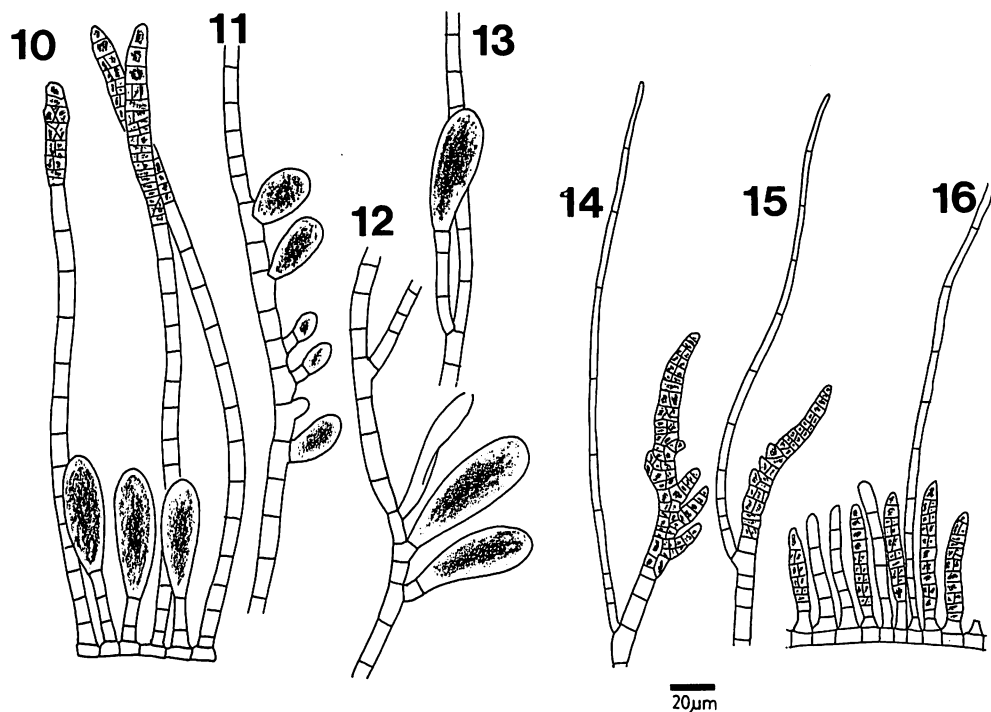
Thalli epiphytic on *Phyllospadix iwatensis*, dark brown, forming rounded patches 2–4 mm in diameter, sometimes overlying one another and becoming irregular in outline, showing marginal growth with a distinct marginal line, heterotrichous, consisting of a basal disc and erect filaments (Fig. 1); basal disc expanding over the surface of the substrate usually monostromatic but sometimes distromatic in the central part, composed of basal filaments (Figs. 2 and 3); basal filaments dichotomously branched, radiating from the center, sticking to one another to form a pseudoparenchymatous tissue; cells of basal filaments 5–10 μm high and 10–18 μm wide, apical cells at margin 15–20 μm long (Fig. 1).

Erect filaments 300–800 μm high, developed from center of basal disc and gradually decreasing in height to the margin, free from one another, usually unbranched but sometimes sparsely branched near the apex, each composed of 15–28 cells, the basal cell flattened, other cells 7.5–9 μm in diameter and 1–2.5 times as high as broad (Figs. 4 and 5).

Plurilocular reproductive organs and unilocular sporangia often borne on the same thallus of the materials from Ibaraki-ken. Plurilocular organs formed in four patterns: (1) directly upon basal filaments (Fig. 2); (2) terminally on short erect filaments (Figs. 3 and 7); (3) laterally from the upper portion of erect filaments (Figs. 6 and 8); and (4) terminally on upper part of erect filaments (Figs. 6 and 7). In the first to third cases, the organs cylindrical, 100–220 μm long and 10–12 μm in diameter, and in the fourth case, second with unilateral upwardly curved



Figs. 5–9. Vertical view of *Protectocarpus speciosus*. Fig. 5. Thallus with plurilocular reproductive organs. Fig. 6. A unilaterally branched plurilocular reproductive organ terminally on upper part of erect filaments, also showing laterally produced one. Fig. 7. Plurilocular reproductive organs terminally on short erect filaments and a unilaterally branched organ terminally on upper part of erect filament. Figs. 8 and 9. Empty plurilocular reproductive organs, showing apical pores.



Figs. 10-16. Vertical view of *Protocarpus speciosus*. Fig. 10. Unilocular sporangioborne terminally on short erect filaments associated with plurilocular reproductive organs. Fig. 11. Unilocular sporangia borne laterally on erect filament. Fig. 12. Unilocular sporangia with and without stalk, borne laterally on erect filament, also showing empty one with an apical pore. Fig. 13. Unilocular sporangium with stalk. Figs. 14 and 15. Hairs arising just below the plurilocular reproductive organs. Fig. 16. Hair arising on basal disc.

branches, 50-160 μm long and 40-60 μm wide (Figs. 6 and 7); swarmers releasing from a few apical pores in each organ (Figs. 4, 8-9).

Unilocular sporangia formed in several positions: (1) directly upon prostrate filaments; (2) terminally on short erect filaments (Fig. 10); (3) laterally on erect filaments with or without short stalk cells (Figs. 11-13), ellipsoidal, 17-23 $\mu\text{m} \times$ 50-75 μm ; swarmers releasing from an apical pore (Fig. 12).

Hairs arising from thallus in two positions: (1) laterally on erect filaments always just below plurilocular reproductive organs (Figs. 14 and 15); (2) directly upon the basal disc (Fig. 16), with or without a basal collar, 5-8 μm wide and 500-800 μm long, gradually attenuated to the apex, meristematic zone of hair situated just above the basal cell (Figs. 14-16).

Chloroplast plate-like, one or a few per cell, scant in hairs.

The present alga grows abundantly on old and often colorless leaves on *Phyllospadix iwatensis* in the lower tidal zones. It is distributed along the Pacific coast of northern Honshu (Chiba-ken, Ibaraki-ken, Fukushima-ken and Iwate-ken). The thallus is often mixed with many other algae; with Ectocarpaceae (*Giffordia sandriana* and *Ectocarpus confervoides*) in Ibaraki-ken and Fukushima-ken; with Myrionematæceae (*Myrionema* sp. and *Halothrix ambigua*), *Papenfusiella kuromo*, *Punctaria* sp. and crustose red algae (*Rhodophyseta* sp. and Corallinaceae) in Iwate-ken. Thalli from Iwate-ken are smaller than those from the other localities listed above and produce no unilocular sporangia, but produce many more hairs.

Discussion

BØRGESSEN (1902) described two new species, *Myrionema speciosum* and *M. faeroense*, from the Faeroes in the North Atlantic. Subsequently, these species were assigned to other genera in the Ectocarpaceae or the Myrionemataceae, namely, *Ectocarpus*, *Comptonema* and *Hecatonema*. In his handwritten manuscript, KUCKUCK (1955, published posthumously under the editorship of KORNMANN) recognized that these two species could form a particular group (which he called "Sectio X") of the Ectocarpaceae *sensu lato* because of their peculiarly shaped plurilocular reproductive organs. He added his new (but unpublished) species *Ecotcarpus hecatonemoides* to this group. KORNMANN, when publishing KUCKUCK's manuscript, established a new genus *Protectocarpus* for KUCKUCK's "Sectio X", including in it the three species mentioned above. (Kornmann incorrectly attributed the generic and specific names to Kuckuck, but they should be attributed directly to KORNMANN.) When Kornmann established this genus *Protectocarpus*, he did not indicate any of three species as the type. Now it is reasonable to designate *P. speciosus* as the lectotype of *Protectocarpus* because the generic definition of *Protectocarpus* had been made mostly by the characteristics of *P. speciosus*, as follows:

[*Protectocarpus* KORNMANN 1955, HELGOL.

wiss. Meeresunters. 29: 119. Lectotype: *P. speciosus*]

The present alga has the unilaterally branched plurilocular reproductive organs and heterotrichous habit characteristic of the genus *Protectocarpus*. In Table 1, morphological characteristics of plants from Japan are compared with those of *P. speciosus* from Europe and the other two species of the genus (*P. faeroensis* and *P. hecatonemoides*). This table shows that the Japanese alga is almost identical to *P. speciosus* as described from Europe, the slightly smaller diameter of the erect filaments in Japanese alga being considered a minor difference.

KUCKUCK (1955) did not mention the occurrence of a distromatic basal disc, but one of his illustrations (fig. 4B on p. 126) and my observation of Japanese material made clear that the center of the disc is partly distromatic in this species.

With regard to the systematic position of *Protectocarpus*, there remains still some uncertainty. CARDINAL (1964) included the genus in his monograph of the Ectocarpaceae. PARKE and DIXON (1976) stated that its systematic position was uncertain, but tentatively placed it in the Myrionemataceae. On the basis of presently observed features, it is concluded that *Protectocarpus* is more closely related to the Myrionemataceae than to the Ectocarpaceae *sensu stricto*. These features include (1) a heterotrichous thallus

Table 1. Morphological comparison among the present alga and three taxa of *Protectocarpus*.

	<i>P. speciosus</i> (BORG.) KORNM.	<i>P. faeroensis</i> (BORG.) KORNM.	<i>P. hecatonemoides</i> KORNM.	Present alga
Type locality	Faeroes, Denmark	Faeroes, Denmark	Helgoland, West Germany	
Height of thallus	600-800 μm	-500 μm	300-400 μm	300-800 μm
Diameter of erect filament	8-10 μm	9 μm	7-10 μm	7.5-9 μm
Plurilocular reproductive organs (width \times length)	much ramified 11 \times 40 μm max. 200 μm long	rarely ramified 11-15 \times 40-80 μm max. 150 μm long	rarely ramified 8-10 \times 50-80 μm	much ramified 10-12 \times 100-220 μm
Unilocular sporangia (width \times length)	20-25 \times 30-75 μm lateral & terminal	18 \times 50 μm lateral, rare		17-23 \times 50-75 μm lateral & terminal
Hairs	6-7 μm diam. lateral, rarely terminal		7-9 μm diam. terminal, rarely lateral	7-9 μm diam. lateral & terminal

with the prostrate system and the erect system developing to an equal degree; (2) slender erect filaments (7.5–9 μm in diameter); (3) plurilocular reproductive organs developing not only on erect filaments but also on prostrate filaments; (4) plurilocular reproductive organs in one or two rows; and (5) phaeophycean hairs arising abundantly on both prostrate filaments and erect filaments.

Protectocarpus speciosus occurs on the Pacific coast of Honshu north of Cape Inuboh, Chiba-ken. *Phyllospadix* occurs abundantly on the coast of the Izu Peninsula, which is influenced by the Kuroshio warm current, but *Protectocarpus* could not be found there. Judging from these Japanese distributional data and other data published for this species (CARDINAL 1964, JAASUND 1965, PARKE and DIXON 1976, KORNMANN and SAHLING 1977, YONESHIGUE and OLIVEIRA FIGUEIREDO 1984), *P. speciosus* may be considered a cool-temperate species.

NODA (1969) reported *Compsonea ramulosa* SENCHELL et GARDNER growing on *Pachydictyon coriaceum* or *Padina arborescens* from Sado Island off the middle part of the Japan Sea coast of Honshu. Judging from his description and illustration, his specimen is considered to be the same as the present material of *Protectocarpus speciosus*.

Acknowledgement

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田中次郎：日本産プロテクトカルプス属の1種（ミリオネマ科，褐藻類）の分類

本邦太平洋沿岸の親潮海域（関東—東北地方）より採集されたプロテクトカルプス属の1種 [*Protectocarpus speciosus* (BØRGESEN) KUCKUCK] について記載および分類学的考察を行った。現在までこの属にはタイプが指定されていない。この属に含まれるすべての種を形態的に比較した結果、本種は属の形質を最もよく表していることから、属のタイプとして指定した。本属、種は日本新産である。（160 東京都新宿区百人町 3-23-1 国立科学博物館植物研究部）