Bactrophora irregularis, a new brown alga from Australia

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(WITH PLATES 20, 21)

The genus *Bactrophora* was established by J. G. Agardh (1880, p. 22-24) who had in mind the resemblance of the peripheral assimilatory filaments of the plants to the crook or crosier of a bishop (Greek: *βάκτρον*, a staff, a rod, and *φορέω*, to bear).

Agardh included three species in the genus *Bactrophora*, all of them described from specimens brought from the southwestern and southeastern shores of Australia by William Henry Harvey,[1] who collected in that country between January 7, 1854 and June 15, 1855. *B. Filum* (Harvey) J. Agardh was found in King George's Sound, Western Australia by Harvey (1855) and briefly described by him as *Mesogloia filum;* it was later reported by Sonder (1880, p. 9) from Queenscliff, Victoria. *B. vermicularis* J. Agardh was collected at Port Fairy, Victoria by Harvey, and at Orford, Tasmania by Lady Meredith. The third species, *B. nigrescens* (Harvey) J. Agardh, was said to be often attached to *Zostera*, and the localities given are Georgetown, Tasmania, where it was collected by R. Gunn and by Harvey (1859, p. 292–293), Western Port, Victoria, by Harvey; and later reported 'at or near Port Phillip Heads and Western Port,' Victoria, by J. B. Wilson (1892, p. 163). Probably Wilson did not collect the alga but is merely referring to Harvey's collection.

From a study of the history of *Bactrophora*, it seems probable that few plants belonging to the genus have ever been collected, and that, aside from Agardh, who examined their morphological characters and described them, no one has done systematic or morphological work on the genus. No measurements have been given for the cells of the various parts of the frond. As far as is known to us, only two figures are in existence, one of *B. nigrescens* (as *Cladosiphon nigrescens* Harv.) shown by Kützing (1859, *pl. 1, fig. 2*) and one of *B. Filum* (the type species) by Agardh (1880, *pl. 1, fig. 4*). For these reasons the following account of what seems to be a fourth species may be of interest, especially to students of the Phaeophyceae.

The new species here proposed was collected by Miss Tilden at Basin Bay, Kiama, New South Wales, Australia, on September 24, 1912. The plants were found growing on rocks. They were of a light brown color and were soft and slimy to the touch.

[1] The three species of Agardh are based on Harvey's Alg. Austr. Exsic. nos. 91 D, 92, and 94.

A typical plant consists of an irregularly branched frond, attenuated toward the base, where it springs from a small flat disc-shaped holdfast. In the largest frond examined the width just above the holdfast was 0.5 microns and the greatest width was 2.5 microns, while the length was 13.5 cm. The branches arise from any point on the frond in no definite order. The largest branches measure 1 mm. in breadth and 5 cm. in length, and are slightly attenuated toward the tip. The lower younger branches are very short, slightly wider than the older ones, and are blunt or rounded off at the tip. Upon closer examination the frond is found to be composed of a colorless tubular jelly-like axis, covered with very short brown 'hairs,' which are more abundant in certain portions, thus giving to the frond varying shades of color.

MINUTE STRUCTURE OF THE FROND

No examination was made of the basal disc, as but one holdfast was found in the material at hand, and it was not deemed wise to mutilate the only perfect specimen in the collection.

The interior of the plant is composed of colorless, elongated, slightly branched and anastomosing multicellular filaments (pl. 20, figs. 5, 6) which take a longitudinal course through the frond. The central portion of the adult plant is practically hollow, the axial filaments forming a loosely connected layer surrounding the central cavity (fig. 8). From the exterior of this layer arise many stalked fascicles of peripheral assimilatory filaments (figs. 4, 10, 11) which grow out obliquely or at right angles to the longitudinal filaments.

The axial filaments are of three sizes (fig. 5), the broadest and middle-sized ones giving rise to the narrowest as branches. The cells of the broadest filaments (32–64×120–260 microns) are inflated at the middle and slightly contracted at the ends, where they are frequently joined to much narrower cells, thus giving an attenuated appearance to the filaments. The middle-sized filaments are more numerous than the broad ones and in these anastomosis most frequently occurs (fig. 6). They are composed of cells 24 microns wide and 120 microns long.

The smallest in size of the axial filaments are the most abundant. They arise as branches of the middle-sized filaments, and also from the base of the stalk of the fascicles of peripheral assimilatory filaments (figs. 2, 3, 4), at their point of attachment to the longitudinal parallel filaments. It is these smallest branches, whose cells range from 4–6 microns in diameter and from 100–115 microns in length, that grow downward in the frond and appear rhizoidal in character. They often depart from the tubular layer of filaments and make their way into the cavity in the center of the frond.

At the tip of the frond, or at the tip of a branch, these rhizoids, 120 microns or more in length, are seen in various stages of development.

The cells of the axial filaments contain little protoplasm, apparently, and practically no pigment material is present except in the outermost filaments from which the assimilatory threads arise.

In a transverse section through the frond (fig. 7), practically all of the axial filaments appear in cross section. Those near the periphery, however, are seen running lengthwise of the frond and terminating in assimilatory threads. The hollow interior is bordered by a layer made up chiefly of the largest of the filaments. The same structure can be made out in the longitudinal section (fig. 8). Here the axial filaments all appear running longitudinally and parallel to each other, on either side of the central cavity. Toward the exterior of the frond they turn outwards and give rise to peripheral filaments.

From observation of the axial filaments it might seem that the middle-sized were the primary filaments. Of course it is possible that they may increase in size, thus developing into the largest and oldest filaments, and in branching give rise to the smallest as well as to the peripheral filaments. This view is somewhat substantiated by an examination of the tips of the fronds, where there is found to be a large central cavity bounded by a few longitudinal, parallel, middle-sized filaments, which give rise to the peripheral fascicles and rizoidal branches.

The peripheral assimilatory filaments are borne in stalked fascicles (figs. 4, 11) and it is these that give to the frond its slightly hairy appearance. The average length of these fascicles from the top of the stalk to the apices of the branches is 200 microns. The branches grow out at about the same point on the stalk, and one cell may sometimes give rise to several branches. The peripheral filaments are attenuated toward the base, swollen or thickened and moniliform at the apex, and slightly incurved. They are composed of from 10 to 25 cells each. The apical cells have a greater diameter than the other cells of the filament. In some cases they are broader than long (20×12 microns) (fig. 9), while at other times they are longer than wide (12×16 microns) (fig. 11).

The cells in the middle of the filament are square in outline (8–12×8–12 microns), while the basal cells are oblong (4–6×8 microns). The apical cell is usually slightly larger than the cells below it. The swollen apical cells are divided usually but once, longitudinally or transversely (figs. 10, 12) (12–16×2–3 microns). Altogether, they resemble somewhat those described for *B. vermicularis*. The swollen cells, doubtless, add to the amount of curvature of the filaments. The moniliform appearance of the filaments

is more pronounced on the outer side of the curve, and here there sometimes occurs a one-celled branch.

The contents of the swollen cells are quite similar to the chromatophores in the other vegetative cells (fig. 9).

The peripheral assimilatory filaments appear as if inrolled upon themselves, as it were, so that they resemble, superficially, the circinate vernation of the fern leaf. This fact gave Agardh the opportunity of bestowing upon this genus a very fitting name, since the resemblance to a bishop's crosier is most striking (figs. 4, 10, 12).

In addition to the peripheral assimilatory filaments, a few long colorless hairs, or paraphyses, arise in the fascicles (fig. 4) and extend far out beyond the assimilatory threads. They are attenuated at the base and are composed of cells which vary in size (4×4 microns at the base; 8×32 microns at the top). They are usually broken off, leaving blunt ends.

REPRODUCTION

Agardh and others believed that the swollen cells of the assimilatory filaments contained reproductive bodies, and 'unilocular' and 'plurilocular sporangia' have been reported for the genus *Bactrophora*. Recent investigations lead us to believe that the gametophyte in the Chordariaceae is still to be discovered.

The plants studied are sporophytes. Unicellular ('unilocular') sporangia are borne at the bases of the peripheral assimilatory filaments where these arise from the stalk of the fascicle (figs. 4, 11, 13). The sporangia are sessile and are usually surrounded by peripheral filaments which curve around in such a manner as to enclose them partially. The sporangia are clavate to obovate in shape and the older ones are much swollen. They vary considerably in size, ranging from 8 to 40 microns in diameter and from 32 to 104 microns in length. The contents, for the most part, are finely granular and without definite arrangement within the hyaline sporangium wall, but occasionally there is an appearance as of small spheres closely packed together. The few empty sporangia seen were open at the apex and torn longitudinally (fig. 14). These structures in all probability are true sporangia, and the swollen terminal cells of the assimilatory filaments—the 'trichosporangia' of Agardh—are *not* plurilocular sporangia. The assimilatory filaments are purely vegetative structures.

GROWTH OF THE FROND

The mode of growth in the family Chordariaceae is known as subapical. The writers found no special region of growth in the axial filaments in any portion of the plant, except at the apex of a teased out branch, where the

presence of short cells seemed to indicate that growth occurs immediately below the apex of these filaments.

The growth of the peripheral filaments does not seem to be restricted to any particular portion, since both middle and apical cells were found in process of division. The rhizoidal filaments seem to grow basipetally, pushing downward in the frond. This is indicated by the presence of short, recently divided cells at their bases. The paraphyses, also, which occur among the peripheral assimilatory filaments, grow in length by division of cells at the base.

Bactrophora irregularis sp. nov. Fronde cylindracea, ramosa, ramis simplicibus, irregulariter egredientibus ex omni parte frondis; ramis longioribus parce attenuatis, brevioribus haud attenuatis, obtusis; filis axialibus majoribus 32–64μ diam., minoribus 4–6μ latis; filis periphericis ad 200μ longis; sporangiis 8–40μ diam., 32–104μ longis.

Hab. ad scopulos, Basin Bay, Kiama, New South Wales, Australia. 24 September 1912 (*Tilden 7093 B*).

Frond cylindrical, branched; branches simple, arising irregularly from any part of the frond; longer branches scarcely attenuated, shorter ones not at all attenuated, blunt at the apices; larger axial filaments 32–64μ in diameter, smaller ones 4–6μ in diameter; peripheral filaments up to 200μ in length; sporangia 8–40μ in diameter, 32–104μ in length.

CLASSIFICATION

Bactrophora irregularis is referable to the family Chordariaceae as described by J. G. Agardh, since the frond is composed of filaments which run through it in a longitudinal direction, giving off peripheral assimilatory branches. At this point Agardh and Kjellman differ in their classification. Agardh separates the genera according to the relation of the peripheral branches to the confining gelatin. Kjellman, on the other hand, uses the mode of growth as the distinguishing character in setting off the genera in the family. In the material studied it was impossible to determine either point. Kjellman (1893, p. 226) himself says, in describing the genus *Bactrophora*, 'Sprossaufbau nicht bekannt.' Omitting these two points, the plant corresponds in all other respects to the descriptions and keys leading to the genus *Bactrophora* in both classifications.

As stated above, Agardh included three species in the genus *Bactrophora*, and they have been retained by De Toni (1891, 1895). From *B. Filum* the new species differs in the fact that it has no distinct stipe; that it is much branched; that the basal cells of the peripheral filaments do not give off twin branches; that the peripheral filaments are less curved; and that the size and shape of the cells of these filaments do not at all correspond to those in Agardh's illustration. In the case of *B. vermicularis*, the

new species fails to correspond in the method of branching and in the number and shape of the branches. Nor does it resemble *B. nigrescens* in the method of branching or in the shape of the fertile peripheral filaments, according to Agardh's description and the drawing of Kützing.

All preparations for the study of the material were made by Miss Fessenden, as well as the drawings in the plates.

It is hoped that someone who has access to the herbarium material of W. H. Harvey may soon undertake a study of the entire genus *Bactrophora.*

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Explanation of plates 20, 21

PLATE 20

Fig. 1. Frond of *Bactrophora irregularis*.

Fig. 2. Stalks of peripheral assimilatory filaments branching from axial filaments. Rhizoidal branches growing down from end of stalk at the point from which the peripheral filaments arise.

Fig. 3. Detail of rhizoidal branches shown in figure 2.

Fig. 4. A fascicle of assimilatory filaments with stalk and rhizoidal branch and long colorless paraphyses.

Fig. 5. A group of axial filaments showing the variation in size.

Fig. 6. Anastomosing axial filaments.

Fig. 7. Part of a transverse section through a small frond, showing hollow center, cross cut longitudinal filaments, and peripheral filaments.

PLATE 21

Fig. 8. Longitudinal section through a small frond, showing hollow central region, axial filaments running longitudinally and parallel, and peripheral filaments arising obliquely.

Fig. 9. Apical cells of a peripheral assimilatory filament, showing protoplasmic contents.

Fig. 10. A fascicle of filaments showing longitudinal and transverse divisions of the apical cells.

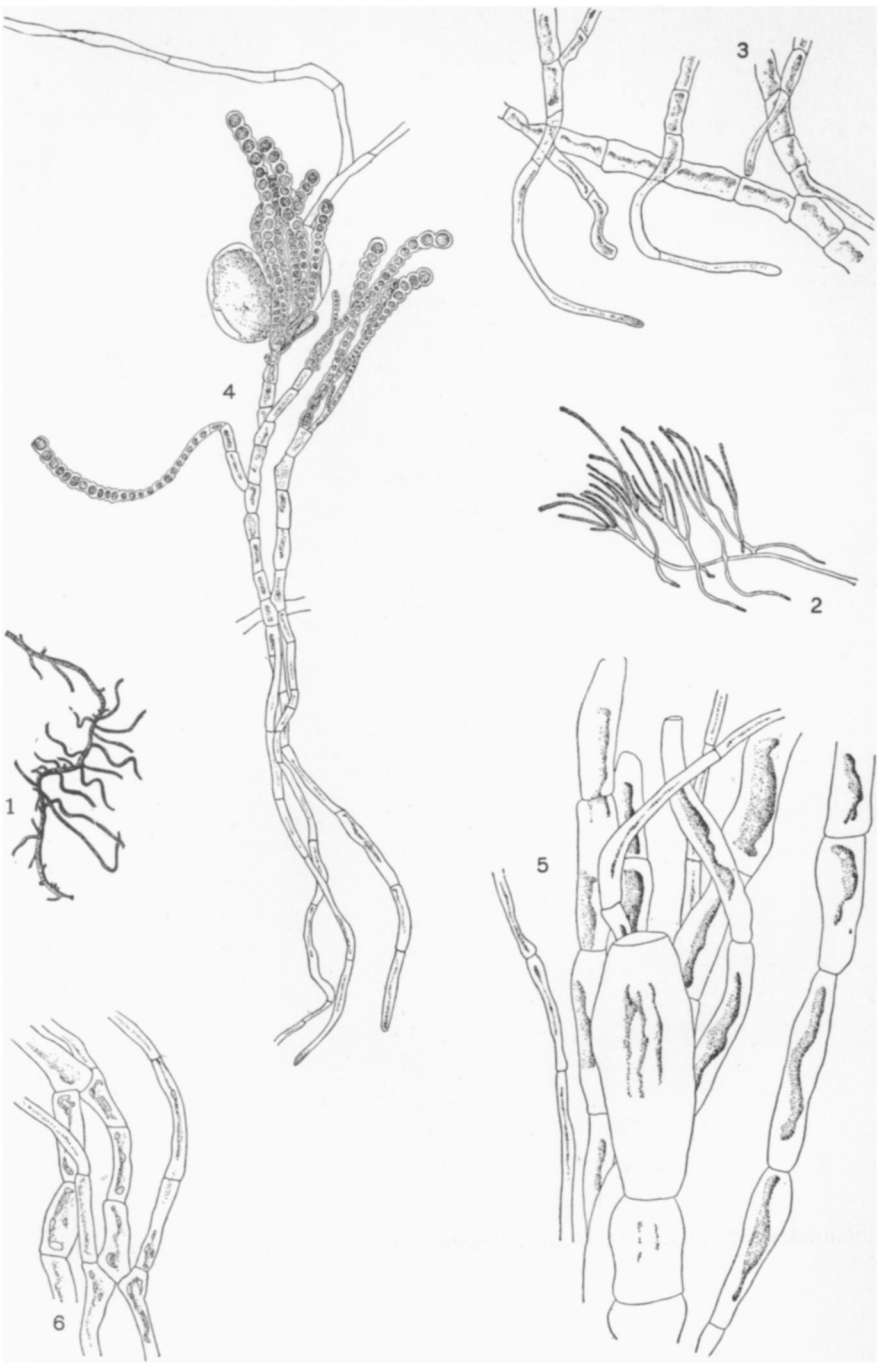
Fig. 11. A fascicle of curved assimilatory filaments showing one sporangium.

Fig. 12. A small, much curved assimilatory filament.

Fig. 13. Mature sporangia surrounded by short assimilatory filaments.

Fig. 14. Empty sporangia.

All drawings were made with the aid of the camera lucida.



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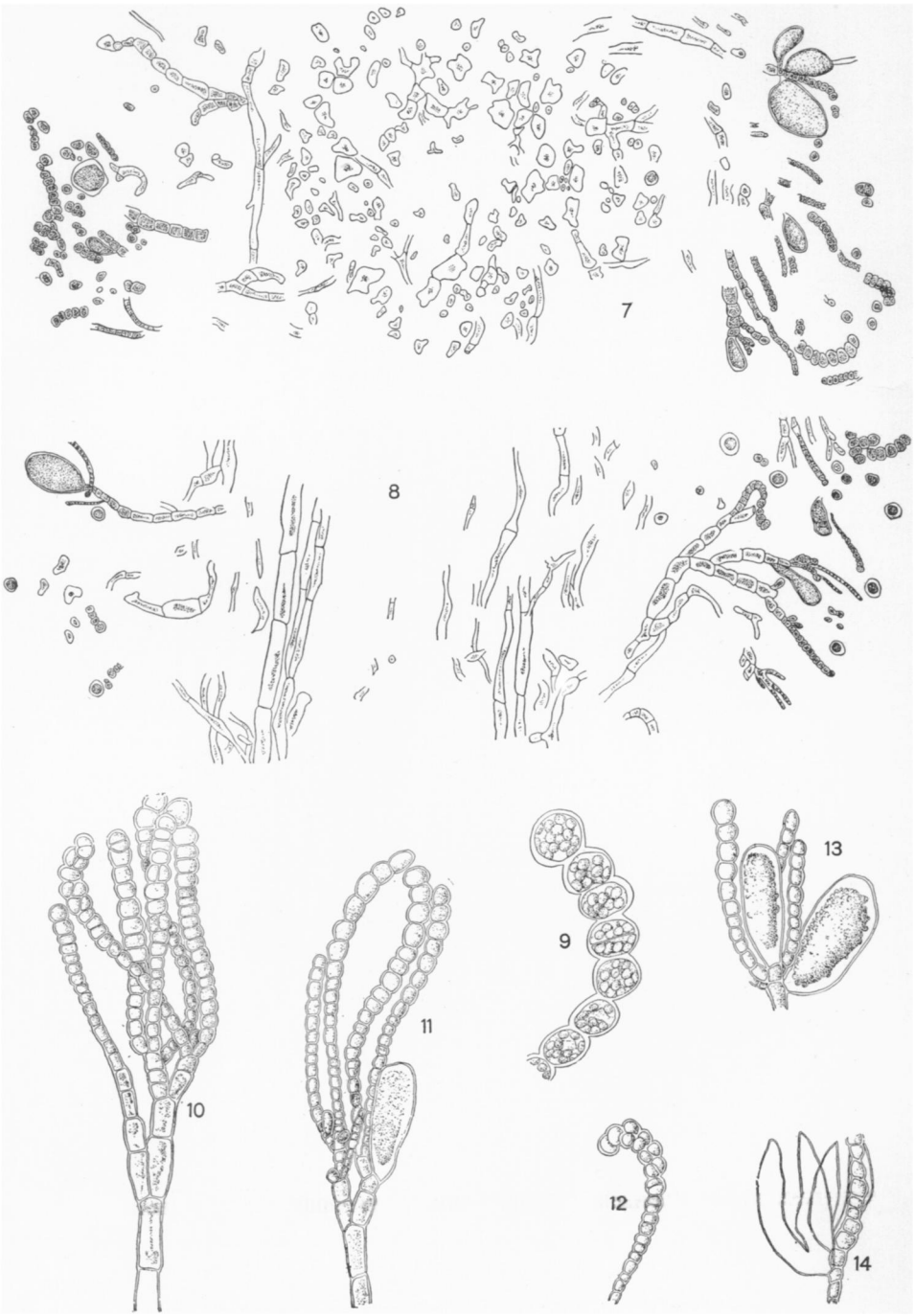

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