

First Record of *Gonimophyllum buffhamii* Batters (Delesseriaceae, Rhodophyta), a Marine Red Algal Parasite of *Acrosorium polyneurum* Okamura from Japan

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Abstract An unusual red alga, *Gonimophyllum buffhamii* Batters (Delesseriaceae, Ceramiales, Rhodophyta) was collected from the Boso Peninsula, Chiba Prefecture, Japan. This species, which has been known as an adelphoparasitic alga living in relation to the several genera of the family Delesseriaceae, was found firstly on the thalli of a red alga *Acrosorium polyneurum* Okamura (Delesseriaceae) in the coast of Japan. Male gametophyte plants and female gametophyte plants of the species were observed, while no tetrasporophyte plants were collected in this research. This is the first record of this genus from Asia, and also the first report on this species from the Pacific Ocean.

Key words: *Acrosorium polyneurum*, algal parasite, Delesseriaceae, *Gonimophyllum buffhamii*, Japan, Rhodophyta.

In the end of the 19th century, the marine red algal genus *Gonimophyllum* (Cryptopleureae, Delesseriaceae, Ceramiales, Rhodophyta) was established by Batters (1892) on the basis of *Gonimophyllum buffhamii* Batters (type species), which was found on the thalli of “*Nitophyllum laceratum* (S.G.Gmelin) Greville” (= *Cryptopleura ramosa* (Hudson) L.Newton) by T. H. Buffham in England. This genus includes four algal parasitic species distributed mainly to the Atlantic Ocean: *G. africanum* M.T.Martine et M.A.Pocock, 1953 (South Africa, Uruguay and Brazil), *G. buffhamii* Batters, 1892 (Europe), *G. insulare* Wagner, 1954 (New Zealand and Argentina), *G. skottsbergii* Setchell, 1923 (Washington to California) (Silva *et al.*, 1996; Gallardo and Escudero, 2011; Guiry and Guiry 2018). These species are adelphoparasites, or algae living in association with hosts belonged to the same tribe or family (Goff, 1982). All of their hosts belonged to the tribe Cryptopleureae, which was

established by Wynne (2001) as a suprageneric taxon below the family Delesseriaceae including *Cryptopleura* Kützing (type genus), *Acrosorium* Zanardini, *Botryoglossum* Kützing, *Hymenena* Greville, and *Gonimophyllum* Batters: the hosts of *G. africanum* are *Acrosorium maculatum* (Sonder ex Kützing) Papenfuss, *Botryoglossum platycarpum* (Turner) Kützing and *Neuroglossum binderianum* Kützing and *Botryocarpa prolifera* Greville; the hosts of *G. buffhamii* are *Acrosorium ciliolatum* (Harvey) Kylin and *Cryptopleura ramosa*; the hosts of *G. insulare* are *Hymenena semicostata* (J.Agardh) Kylin and *H. falklandica* Kylin; the hosts of *G. skottsbergii* are *Botryoglossum farlowianum* (J.Agardh) De Toni, *Hymenena flabelligera* (J.Agardh) Kylin and *Cryptopleura ruprechtiana* (J.Agardh) Kylin (Wagner, 1954; Gallardo and Escudero, 2011). None of these host algae was recorded from Japan and any species of the genus *Gonimophyllum* were not reported from Asia so far.

There is no record of the genus *Gonimophyllum* from Japan so far (Yoshida *et al.*, 2015; Guiry and Guiry 2018), and probably no report of any species from Asia. In the Pacific Ocean only *G. skottsbergii* was described from the west coasts of North America, from the northern Washington to the southern California, U.S.A. (Setchell, 1923; Smith, 1944; Abbott and Hollenberg, 1976). Marine algal flora of the southern Japan is influenced strongly by the Kuroshio Current, which flows along the coasts of the east side of Asia from Philippines to the southern Japan, terminating at off the Boso Peninsula. Therefore, it is indispensable to research the marine algae in the Boso Peninsula for estimating the range of biogeographical influence of the Kuroshio Current to the northward. In this study, to confirm the identity of present alga found on the Japanese algal host, *Acrosorium polyneurum* Okamura, the author made anatomical observations on the material from the Boso Peninsula, Japan, using microscopes.

Material and Methods

The red algal material referable to the genus *Gonimophyllum* was collected on the thalli of a red alga *Acrosorium polyneurum* Okamura cast away on the coast of the Tangaura Bay, Ohara, Isumi City, the Boso Peninsula, Chiba Pref., Japan (35°14'15"N, 140°24'21"E) on 16 June 2018. For preservation, the material was fixed in 10% formalin-seawater. Anatomical observations were made on the material using microscopes. Slides were prepared by hand sectioning and mounted in glycerine jelly after staining by 1% aniline blue solution. Voucher specimens were deposited in the algal herbarium of the National Museum of Nature and Science (TNS).

Results

Class Florideophyceae Cronquist, 1960

Order Ceramiales Oltmanns, 1904

Family Delesseriaceae Bory, 1828

Tribe Cryptopleureae Wynne, 2001

Gonimophyllum buffhamii Batters

J. Bot., British and Foreign 30: 67. pl. 319 (1892).

[Figs. 1–14]

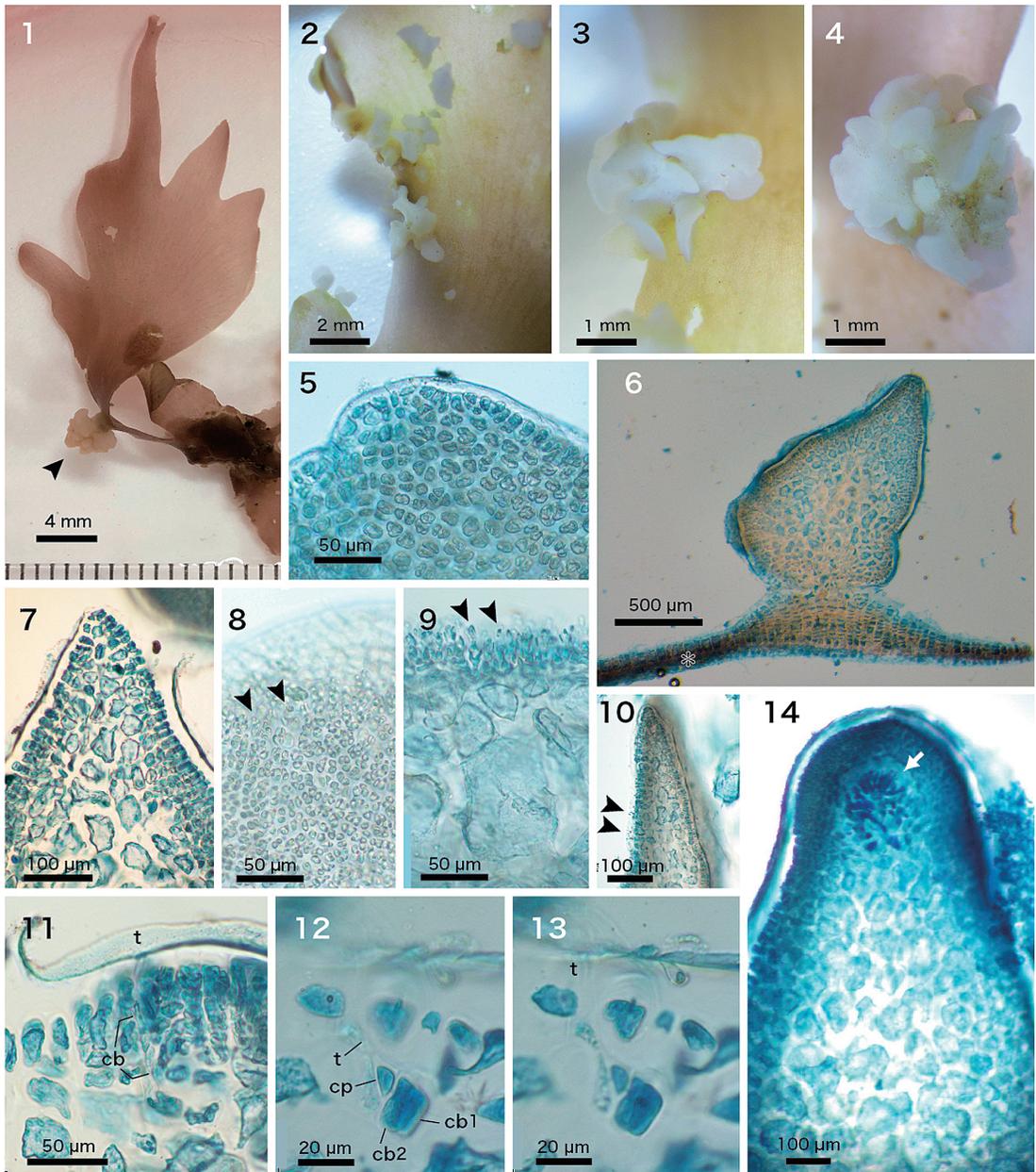
[Lectotype locality: Deal, Kent, England. Lectotype: BM, microscope slide 8746 (Maggs and Hommersand, 1993).]

Habitat: Parasitic on *Acrosorium polyneurum* Okamura (Cryptopleureae, Delesseriaceae).

Vegetative morphology: Plants are small, globose, 0.2–4 mm in diameter, arising on both surfaces of host alga, *Acrosorium polyneurum* (Fig. 1 arrowhead; Fig. 2). Thalli are globular clusters of compressed, flattened to swollen, or irregular blades, attached on hosts by a basal cushion-like pad (Figs. 3, 4). Blades are erect, up to 1 mm in height, rounded, lobed or reniform, up to 700 μ m in thickness, with a smooth margin (Fig. 5). Tissues are composed of a cortical layer of small cells and a medullary layer of large cells (Figs. 6 and 7). Cortical cells are cubic or cylindrical, 8–20 μ m in diameter. Medullary cells are circle to oval, 35–110 μ m in diameter.

Reproductive morphology: Plants are dioecious. Male gametophytic plants have thinner blades with curved margins (Figs. 2, 3). Spermatangial sori are formed covering both sides of blades (Figs. 8–10). Spermatangia (Figs. 8–10, arrowheads) are spherical, 2–4 μ m in diameter. Female gametophytic plants have thick blades with rounded margins (Fig. 4). Carpogonial branches (cb) are more or less curved, two-celled, bearing a carpogonium (cp) with a trychogone (t) (Figs. 11–13). Cystocarps are spherical, located on the margin of the blades (Fig. 14, arrow). Tetrasporophytic plants were not detected.

Specimens examined: Tangaura Bay, Ohara, the Boso Peninsula, Chiba Pref. Japan



Figs. 1–14. *Gonimophyllum buffhamii* Batters from Ohara, the Boso Peninsula, Japan (cast ashore). 1. Habit showing a parasitic thallus (arrowhead) on the host alga *Acrosorium polyneurum* Okamura. 2. Crowd of male plants on *A. polyneurum* (TNS-AL 209449). 3. Male plant. 4. Female plant. 5. Margine of young plant. 6. Transverse section of young plant with host algal thallus of *A. polyneurum* (asterisk) (TNS-AL 209450). 7. Transverse section of margine of young blade. 8. Surface view of male plant with a spermatangial sorus showing spermatangia (arrowheads). 9. Transverse section of male plant showing spermatangia (arrowheads) (TNS-AL 209451). 10. Transverse section of male blade showing spermatangia (arrowheads). 11. Transverse section of female plant showing a carpogonial branch (cb) showing a trichogine (t). 12–13. Two images with different focus of transverse section of female plant showing a carpogonial branch composed of two cells of carpogonial branch (cb1, cb2) and a carpogonium (cp) with a trichogine (t) (TNS-AL 209452). 14. Transverse section of female plant showing a cystocarp (arrow) (TNS-AL 209453).

(35°14'15"N, 140°24'21"E), 16 June 2018 (cast ashore at low tide), leg. T. Kitayama (TNS-AL 209449–209454).

Japanese name: Sujiusuba-yadori (nov.).

Distribution: England (type locality), Scotland, Ireland, Channel Isls. (Maggs and Hommersand, 1993), Spain (Escudero and Gallardo, 2011). New to Japan (the Boso Peninsula, the present study).

Discussion

The present alga collected from the Boso Peninsula, Chiba Pref., Japan is similar to both species of *Gonimophyllum buffhamii* Batters (type species) and *G. africanum* M.T.Martine et M.A.Pocock in habit and morphology. Among the four species of the adelphoparasitic genus *Gonimophyllum*, whose hosts are restricted to the algae in the tribe Cryptopleureae (family Delesseriaceae), *G. buffhamii* and *G. africanum* use the genus *Acrosorium* [e.g., *A. ciliolatum* (Harvey) Kylin] as hosts, while the other species, *G. insulare* Wagner and *G. skottsbergii* Setchell, do not use *Acrosorium* (instead, *Botryoglossum* and *Hymenena*). The host alga of the present alga from Japan is *Acrosorium polyneurum* Okamura, which is the Pacific species endemic to Asia. Similarity in hosts is also regarded as important characteristic for identification of species or genera in taxonomy of parasites. However, it is not so useful for species identification because of that *A. polyneurum* has not been known as a host of *Gonimophyllum* so far, and taxonomic position of *A. polyneurum* is probably not defined yet because its procarps have structure similar to the ones of *Hymenena*, not *Acrosorium* (Mikami, 1974; Yoshida, 1998, p. 960).

Gonimophyllum buffhamii and *G. africanum* are also similar to each other in morphology. In size of individuals these two species are smaller than the other species: diameters of the thalli are 1–4.6 mm in *G. buffhamii* (Maggs and Hommersand, 1993), and “a few” mm in *G. africanum* (Stegenga *et al.*, 1997), while diameters of thalli are 5–12 mm in *G. insulare* (Wagner, 1954), and

1.5 cm in *G. skottsbergii* (Abbott and Hollenberg, 1976). Microscopic veins near the base of the blades are absent in *G. buffhamii* and *G. africanum*, while microscopic veins near the base of the blades are present in *G. insulare* (Wagner, 1954) and *G. skottsbergii* (Abbott and Hollenberg, 1976). Numbers of cystocarps per blade are 1–4 in *G. buffhamii* (Maggs and Hommersand, 1993), and one to several in *G. africanum* (Stegenga *et al.*, 1997), while numbers of cystocarps per blade diameters are numerous in *G. insulare* (Wagner, 1954), and several in *G. skottsbergii* (Abbott and Hollenberg, 1976).

Therefore, the present alga is considered as *G. buffhamii* or *G. africanum*. It is not easy, however, to identify the species name because morphological differences between *G. buffhamii* and *G. africanum* are not defined so well. When Martine and Pocock (1953) published *G. africanum* from South Africa as a new species, they described a few differences of their new species from *G. buffhamii*, the type species of *Gonimophyllum* from England: “the less flattened and leaf-like female” and “different locality and hosts”. However, these differences are not enough for identification for the plants in the Pacific Oceans having various blades and a host alga different from both of the Atlantic species.

As a result, the author identifies temporarily the alga from the Boso Peninsula as *Gonimophyllum buffhamii* Batters, suspending a treatment of *G. africanum* as a synonym of *G. buffhamii* because there is also a possibility that the alga may be a third species different from the two known species preferring *Acrosorium* as host algae. To define the range and distribution of this species and to clarify a relationship between *G. buffhamii* and *G. africanum*, both molecular analyses and further anatomical observations are required.

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