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New Records of Marine Algae From the Philippines

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Abstract—Five species of marine algae, *Acrothamnion preissii* (Sonder) Wollaston (Rhodophyceae, Ceramiales), *Caulacanthus ustulatus* (Mert.) Kütz. (Rhodophyceae, Gigartinales), *Ochrosphaera verrucosa* Schussnig (Prymnesiophyceae, Coccosphaerales), *Ostreobium quekettii* Bornet et Flahault (Chlorophyceae, Bryopsidales), and *Rhodosorus marinus* Geitler (Rhodophyceae, Porphyridiales) are recorded for the first time in the Philippines. The sporophytic stage of *Derbesia marina* (Lyngbye) Solier is also reported. *Caulacanthus indicus* Weber-van Bosse and *C. okamurae* Yamada are synonymized with *C. ustulatus* based on morphological and anatomical comparisons of type material with field and culture specimens and successful cross-breeding of Philippine and Australian isolates in culture.

Introduction

In 1987 and 1988 the authors collected benthic marine algae on several islands in the Philippines. Among the collections of benthic marine algae from these areas were several specimens of unreported species. The plants were collected by hand, from different depths and habitats as indicated. Part of these collections were placed in culture following the methods of West & Calumpong (1988). Sections were made by hand with razor blades. Squash sections were made by first softening the tissue with saturated chloral hydrate solution for 2-5 minutes. These sections were then stained with 0.4% aniline blue-black in 0.1% acetic acid (5% formalin was added to prevent fungal growth in the mounting medium) and mounted in 50% Karo^{R} syrup. Coverslips were sealed with clear fingernail varnish. All sections were examined under light microscopy. Type specimens were used for comparison when available. Voucher specimens are deposited in the University Herbarium of the University of California at Berkeley (UC), California, U.S.A. and the Silliman University Herbarium (DGT) at Dumaguete City, Philippines. Voucher cultures are deposited with the Culture Collection of Algae, Department of Botany, University of Texas, Austin TX 78713-7640 U.S.A. Classification follows that of Silva, Meñez & Moe (1987).

Class RHODOPHYCEAE
Order PORPHYRIDIALES
Family PORPHYRIDIACEAE
Rhodosorus marinus Geitler

Rhodosorus marinus Geitler, 1930: 615–636.

This unicellular red was isolated from a culture of *Laurencia patentiramea* (Montagne) Kützing collected by H. Calumpong from Cang-alwang, Siquijor I., Central Visa-

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yas, 10 May 1987 (culture 2789A). The cells are about 5 μm diam and contain numerous starch granules. The chloroplast usually has 3-4 parietal lobes and a central pyrenoid evident in light microscopy. A 3-μm polysaccharide halo surrounds each cell.

The distribution record of *Rhodosorus marinus* is patchy. It was described originally in the Canary Islands (Geitler 1930) and subsequently recorded in France (Giraud 1958), Italy and the Florida Keys (Ott 1967) and Hawaii (West 1969). We believe that the alga is more ubiquitous than records indicate. It may be overlooked in collections because of its very small size.

Order GIGARTINALES
Family RHABDONIACEAE
Caulacanthus ustulatus (Turner) Kützing

Fucus acicularis Wulfen var. *ustulatus* Turner, 1809: 143, 144. Type: Cádiz, Spain, collected by S. de R. Clemete (BM!). (Lectotypified by Searles, 43: 46, pl. 10a. 1968.)

Caulacanthus ustulatus (Turner) Kützing, 1843: 395.

TAXONOMIC SYNONYMS:

Caulacanthus indicus Weber-van Bosse, 1921: 222–223, fig. 67. Type: Dongala (Paloe Bay), Celebes (Siboga Stat. 86), 18–19 June 1899 (L 939.69 . . . 794!). (Lectotypified herein).

Caulacanthus okamurai ("okamurae") Yamada 1933: 277–285, pls. 10–13. Type: Prov. Mikawa, Japan, collected by K. Okamura, 11 June 1899 (SAP!). (Lectotypified at SAP and confirmed herein.)

Taxonomic synonyms as proposed by Searles 1968:

Laurencia divaricata Suhr., 1840: 265. Type: "Kaffernküste," South Africa (Holotype: LD 34144!).

Caulacanthus divaricatus (Suhr.) Papenfuss, 1943: 86–87.

Rhodomela? spinella J. Hooker et Harvey, 1845: 534–535. Type: New Zealand, #236, collected by Colenso (BM!). (Lectotypified herein.)

Caulacanthus spinellus (J. Hooker et Harvey) Kützing, 1849: 753.

Misapplied name (*fide* Papenfuss, 1943: 86): *Rhodomela botryocarpa*.

CHARACTERISTICS: Field plants growing together with *Murrayella periclados* (C. Ag.) Schmitz, sterile, consisting of long stolons and uniformly positioned upright axes. Branching pectinate or irregularly pectinate, main branches 145–155 μm diam. No rhizoidal discs seen.

SPECIMENS STUDIED: Culture-2920: Jampason, Initao, Misamis Oriental. 14 May 1988. Collected by Wilfredo Uy.

CULTURE STUDIES: A long stolon from the field collection was cleaned of epiphytes and placed in a deep storage dish in sterile seawater. In less than a month, cut ends regenerated new axes from the medulla. The single apical cell of each branch divided obliquely to form the main axial filament, each cell of which in turn formed two lateral filaments as described by Searles (1968). Rhizoidal discs appeared at points that came into contact with the glass substrate. In two months, the plant produced zonately divided tetrasporangia measuring 55-60 μm diam. Spore germination followed the pattern typical of the order. Gametophytes became reproductive after two months. Female gametophytes were more densely and irregularly branched compared to the males and tetrasporophytes.

Carpogonial branches were typically 3-celled and straight and were embedded in the thallus. Carposporophytes released carpospores that germinated readily.

The Philippine material was cross-bred with *Caulacanthus indicus* Weber-van Bosse (culture 2831) collected from Alma Bay, Magnetic Island, North Queensland, Australia on 6 June 1987 from drift. The Australian plants differed slightly from the Philippine material in size and frequency of branching and rhizoidal discs. The Australian isolate has smaller thalli (125-133 μm diam) that are more densely and irregularly branched (at about 1 mm interval) and have numerous rhizoidal discs (at about 0.35 mm interval). In cross-section, the two have a similar pattern with a large colorless thick-walled central axial cell, two layers of round medullary cells and a layer of subquadrate cortical cells. This is a little different from *C. ustulatus* from Mauritius as described by Børgesen (1950) whereby the cortical cells are more elongated.

Results of the cross showed the two isolates to be interfertile although out-crosses produced fewer cystocarps than self-crosses. In the 2831 self-cross, carpospore formation and release took 17 days. The hybids released carpospores in 25 days.

Another isolate from Korea, 2596 was collected by In Kyu Lee and identified as *Caulacanthus okamurae* Yamada. This was compared with the other two isolates. *Caulacanthus okamurae* has been grown in 10-12°C since 14 Jan 1982 and has remained vegetative even when exposed to bright light (80 μmol $m^{-2} s^{-1}$) and higher temperature (25°C). The axes are the same diameter as the Philippine isolate (140-155 μm). The cross section resembles the Mauritius plants (Børgesen, 1950) more than the Philippine or the Australian isolates.

DISCUSSION. The characters used to separate *Caulancanthus indicus* and *C. okamurae* from *C. ustulatus:* diameter of axes, frequency and density of branching, frequency and density of rhizoidal discs, and dimorphism of sterile and reproductive plants appear to be variable as revealed by culture investigations and may not be reliable. Reproductive female gametophytes assume a more irregular and dense branching as compared with the male gametophyte and tetrasporophytes.

King (1981) lists *Caulacanthus okamurae* for Queensland, Ngan & Price (1979) list *C. ustulatus* for Townsville, and Cribb (1983) lists *C. indicus* for the Great Barrier Reef. All of this indicates a great deal of uncertainty about the species limits. Successful cross-breeding of the Philippine and Australian isolates leads one to conclude that these three are conspecific.

Based on the variability and thereby unreliability of characters separating these three taxa and the fact that the two isolates interbreed in culture, we believe that we are dealing with only one taxon here which under the rules of priority take on the name of *Caulacanthus ustulatus* (Turner) Kützing.

Also in comparing the type specimens of *Caulacanthus indicus* Weber-van Bosse with *C. ustulatus* (Turner) Kützing which were both sterile, no significant morphological and anatomical differences were found. The same is true with *C. okamurae* Yamada *Laurencia divaricata* Suhr, and *Rhodomela spinella* J. Hooker et Harvey.

In considering other closely-related genera, we have compared the vegetative and reproductive anatomy of *Feldmannophycus rayssiae* (J. et G. Feldmann) Augier et Boudouresque with that of *Caulacanthus ustulatus*. The principal features considered by Augier & Boudouresque (1971) and by Feldmann & Feldmann (1961) are sufficiently distinct to warrant the continued separation of the genera.

Caulacanthus ustulatus has a tropical to subtropical distribution extending from Japan (Yamada 1933) to Australia (Cribb 1983, King 1981, Ngan & Price 1979), and New Zealand (Searles, 1968) across the Pacific in Baja California (Dawson 1961), in Europe (Italy, Spain: Searles 1968) and Africa (Senegal, South West Africa, South Africa: Searles 1968; Mauritius: Børgesen 1950; Somalia: Sartoni 1986; and Tanzania: Jaasund 1976, Lawson 1980), India (Dixit 1966, Searles 1968). This report represents the first record in the Philippines.

Order CERAMIALES
Family CERAMICEAE
Acrothamnion preissii (Sonder) Wollaston

Callithamnion preissii Sonder 1845: 52. Type: Western Australia (Holotype: MEL 10260).
Antithamnion preissii (Sonder) De Toni, 1903: 1414–1415.
Taxonomic synonyms as proposed by Wollaston, 1977:
Callithamnion pulchellum Harvey, 1855: 561. Syntype localities: Rottnest and Cape Riche, Western Australia.
Acrothamnion pulchellum J. Ag., 1892: 25, pl. I. figs. 6-10.

CHARACTERISTICS. Field plants sterile, branching opposite. Main axes 25-30 μm diam, lateral branches of the same diameter as the main axes, generally with terminal gland cell. Axial cells 4 times as long as wide.

SPECIMENS STUDIED. Collected by H. Calumpong from Talisoy, Virac, Catanduanes Island, eastern Philippines, 14 May 1988 (culture 2885). The plants were growing on shaded limestone in the mouth of a semicave, mixed with other small filamentous reds: *Gymnothamnion elegans* (Schousboe ex C. Ag.) J. Ag., *Haloplegma duperreyi* Montagno and *Dasyphila plumarioides* Yendo.

DISCUSSION. Basson, Silva & Moe (unpubl.) point out that Wollaston failed to indicate the type locality of *Callithamnion pulchellum* when she lectotypified it. They further indicate that *C. pulchellum* Harvey is a later homonym of *C. pulchellum* C. Ag. (1828: 175), hence not priorable, and treat *Acrothamnion pulchellum* as a *nomen novum*.

Acrothamnion preissii is found in Western Australia (Wollaston 1977), South Africa (Norris & Aken 1985), Japan (Itono 1977), the Mediterranean (Cinelli & Sartoni 1969) and, now, the Philippines.

Class CHOLOROPHYCEAE
Order BRYOPSIDALES
Family OSTREOBIACEAE
Ostreobium quekettii Bornet et Flahault

Ostreobium quekettii Bornet et Flahault, 1889: CLXI, pl. IX, fig. 5-8. Type: Luc (Calvados), France, collected by P. A. Dangeard (P!). (Lectotypified herein).
Taxonomic synonym as proposed by Lukas, 1974:
Ostreobium reineckei Bornet in Reinbold, 1896: 269. Type locality: Samoa.

CHARACTERISTICS. Vegetative filaments 3-4 μm minimum diam, extensively branched with many short, often irregularly shaped laterals. Chloroplasts very small, discoid to elongate, (2-7 μm), appearing yellow-green, lacking pyrenoids and resembling those of the Xanthophyceae, without starch granules, although small (<0.5 μm) granules that do not stain with IKI are present in the cytoplasm. Colorless, refractive lipid bodies

also common. Small coccoid bacteria are abundant in the vacuoles of filaments. Reproduction is by zoospores and by fragmentation of vegetative filaments. Sporangia arising from apices or short lateral branches, initially appearing subspherical, 25-40 μm diam, becoming multilobed with what may be discharge tubes as they enlarge.

SPECIMENS STUDIED: Isolated from specimens of *Acrothamnion preissii* (culture 2885) collected on 14 May 1988, by H. Calumpong on shaded limestone at the mouth of a semicave at Talisoy, Virac, Catanduanes Island, eastern Philippines (culture 2924).

DISCUSSION. The above observations were made from plants grown in the laboratory in the absence of calcium carbonate substrate (culture 2824). The small coccoid bacteria which were abundant in the vacuoles of filaments are probably endosymbionts generally common in siphonous greens (Burr & West 1970).

Ostreobium usually is "endolithic" in corals, shells and coralline algae so the appearance of free living plants is of interest. The species has been investigated in culture by Kornmann & Sahling (1980). Lukas (1974) recognizes five species and our isolate appears closest to *O. quekettii* Bornet et Flahault. The "type" material of *O. quekettii* is deposited at the Muséum National d'Histoire Naturelle Laboratorie de Cryptogamie at Paris (P) but Bornet & Flahault (1889) did not specify from which of the three oyster shells in that collection they obtained the sample on which they based their description. From the Muséum we received three separate samples of bivalve shell fragments labeled: Le Croisic (September 1887), Brest (October 1886) and Luc (no date—collected by P. A. Dangeard) labeled *Gomontia polyrhiza* Bornet et Flahault. After careful examination of these samples under the steromicroscope pale green 0.5 mm fragments were excised and immersed for 1 hr in 1% HCl for decalcification. Under the compound microscope the green filaments observed were extensively branched, septate and 5-12 μm diam. These appear to be *Ostreobium quekettii* and with reservations we designate the Luc material as the lectotype.

Although Jeffrey (1968) has identified chlorophyll a and b in *Ostreobium quekettii* from the brain coral *Favia,* this should be reaffirmed with this isolate as well.

Ostreobium quekettii is widely distributed in North America (Taylor 1957; Florida Keys: Lukas 1974), Europe (British Isles: Lyle 1929, Wilkinson & Burrows 1972; France: Bornet & Flahault 1889; Netherlands: van den Hoek 1958; North, Baltic, Black and Red Seas: Nadson 1927), the Atlantic (Bermuda: Schroeder 1972), Caribbean (Lukas 1974), Pacific (Caroline and Marshall Islands: Lukas 1973; Samoa: Bornet 1896, Setchell 1924), Indian Ocean (India: Dixit 1966, Krishnamurthy & Joshi 1970, Untawale *et al.* 1983; Maldives: Hackett 1977; Faeröes Islands: Børgesen 1908), and Australia (De Toni & Forti 1923, Lewis 1987).

Class PRYMNESIOPHYCEAE
Order COCCOSPHAERALES
Family HYMENOMONADACEAE
Ochrosphaera verrucosa Schussnig

Ochrosphaera verrucosa Schussnig, 1940: 317–330.

Ochrosphaera verrucosa is widely distributed in the Philippines and occurs in nearly all cultures of macroalgae that we have isolated from there. Because it reproduces so rapidly it is often difficult to eliminate and can be classified as a "pest species." The same

frequency is evident in collections from Hawaii (West 1969), Japan (Inouye & Chihara 1980), Indonesia (Inouye 1988), Australia, Brazil, Mexico, Puerto Rico, Samoa, Guam, Truk, Seychelles, Comoros, Maldives, (West, unpublished). We have isolated one strain from a collection of *Laurencia concinna* Montagne (culture 2773) collected by H. Calumpong from White Beach near the town of Mahatao, Batan Island, Batanes, 22 April 1987. The specimens in culture correspond in size and cytological detail to those described in West (1969) and Inouye & Chihara (1980).

Order BRYOPSIDALES
Family DERBESIACEAE
Derbesia marina (Lyngbye) Solier

Vaucheria marina Lyngbye, 1819: 79, pl. 22A. Type locality: Kvivig, Strømø, Faeröes.
Derbesia marina (Lyngbye) Solier, 1846: 453.
Taxonomic synonyms:
Gastridium ovale Lyngbye, 1819: 72, pl. 18B. Syntype localities: various in Faeröes.
Halicystis ovalis (Lyngbye) J. Areschoug, 1850: 447.

Only gametophytes (*Halicystis ovalis* stage) of *Derbesia marina* (Lyngbye) Solier were reported in the Philippines (Domantay 1962, Reyes 1978, Saraya & Trono 1980). In a collection of *Laurencia* from Cang-alwang, Siquijor Island, Central Visayas, 8 May 1987, by H. Calumpong (culture 2791D), reproductive filaments of the sporophyte (*Derbesia marina* stage) were seen. The filaments measured 15-30 μm in diameter. Spores germinated into irregular spheres.

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