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Notes on the Marine Algae of the Bermudas. 8. Further Additions to the Flora, Including *Griffithsia aestivana* sp. nov. (Ceramiaceae, Rhodophyta) and an Update on the Alien *Cystoseira compressa* (Sargassaceae, Heterokontophyta)

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Notes on the marine algae of the Bermudas. 8. Further additions to the flora, including *Griffithsia aestivana* sp. nov. (Ceramiaceae, Rhodophyta) and an update on the alien *Cystoseira compressa* (Sargassaceae, Heterokontophyta)

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Abstract

Griffithsia aestivana sp. nov. is described as an endemic from Bermuda. Vegetatively, it is most similar to *G. capitata* from the eastern Atlantic Ocean, but the two differ in overall size and in the tetrasporic state. Eleven other marine algal taxa are reported from Bermuda for the first time: *Anadyomene howei, Struvea elegans, Cladophoropsis macromeres, Derbesia turbinata, Caulerpa racemosa* var. *lamourouxii, Halimeda discoidea, Chrysymenia nodulosa, Gloiocladia iyoensis, Dasya caraibica, Chondrophycus iridescens* and *Polysiphonia scopulorum*. All except *D. turbinata* represent new northern limits of distribution in the North Atlantic Ocean. In addition, recent Bermuda collections of the alien Mediterranean *Cystoseira compressa* and the rarely found *Womersleyella setacea* are detailed.

Keywords: alien species; Bermuda; *Cystoseira compressa*; *Gloiocladia iyoensis*; *Griffithsia aestivana* sp. nov.

Introduction

When Collins and Hervey published their 1917 Bermuda marine algal flora, they stated that "while future additions are of course to be expected, we think that the main characters of the algal flora are likely settled, and the greater part of the species determined." Little did they anticipate the great number of species that had eluded them in their island collections. Since the appearance of a checklist of Bermuda marine algae which included more than 30 species that had been added to the flora from our specimens (Schneider 2003), recent collections have continued to add taxa to those known at the time the list was published (Schneider 2004, Schneider and Lane 2005, Saunders et al. 2006, Schneider et al. 2006). In this paper, 12 new additions to the Bermuda flora are reported, including the new species *Griffithsia aestivana* C.W. Schneider *et* C.E. Lane, a summer inhabitant of Walsingham Pond. A few species poorly known in Bermuda have been re-collected and established as members of the flora. One, *Cystoseria compressa* (Esper) Gerloff *et* Nizamuddin, an alien Mediterranean species that was introduced to the islands in the 1960s (Taylor 1961), has established a sizable population on the south shore of Bermuda Island.

Materials and methods

Underwater collections were made by snorkeling or scuba, and specimens were pressed fresh onto herbarium paper with fragments preserved in 5% formalin-sea water. Recent site coordinates were determined using a Garmin™ GPS III Plus (Olathe, Kansas, USA), earlier ones being translated from LORAN-C signals. Photomicrographs were taken using a Carl Zeiss microscope (Oberkochen, Germany) equipped with a model 4.2 Spot InSight QE digital camera (Diagnostic Instruments, Sterling Heights, USA), and herbarium specimens were scanned on an HP 2175 scanner (Hewlett-Packard Company, Palo Alto, USA) at a resolution of 300×300 dpi. The digital images were composed in Adobe Photoshop™ 7.0 (Adobe Systems, San Jose, USA). Line drawings were made with a Carl Zeiss camera lucida. Voucher specimens are deposited in the senior author's personal herbarium, with duplicates of most sent to MICH, MSM, NY, the Bermuda Natural History Museum (BAMZ), and some to C, DUKE, GALW and US. When listed, herbarium abbreviations follow Holmgren et al. (1990) and standard author initials are from Brummitt and Powell (1992).

Observations and discussion

Ulvophyceae: Cladophorales, Anadyomenaceae

Anadyomene howei D.S. Littler *et* Littler 1991, p. 103, figs 1–5 (Figure 1)

Type locality Great Ragged Island, Bahamas, western Atlantic Ocean.

Collections Bermuda: *C.W. Schneider (CWS)/R.B. Searles (RBS)* 85-10-23, 8 June 1985, Northeast Breakers, 32°30.5′ N, 64°39.4′ W, depth 29 m on dead coral; *CWS/C.E. Lane (CEL)* 06-8-36, 20 June 2006, west of Eastern Blue Cut channel marker, 32°23′22.1″ N, 64°53′23.0″ W, depth 12 m.

Remarks This record of *Anadyomene howei* represents the first since its description and report from the

Bahamas and Caicos Islands (Littler and Littler 1991). Although it was reported from the intertidal and shallow subtidal zones in the protologue, *A. howei* has not been found thus far in our numerous inshore collections in Bermuda beginning in 1992. The deep-water plants from Bermuda are small and somewhat incomplete blades, as interstitial cells do not totally fill in all of the spaces between veins (Figure 1). The specimens are reminiscent of those illustrated by Littler and Littler (1991) and have areas where the outer margin is becoming bordered by elongate cells as typical for the species but are most similar to the immature specimen Littler and Littler (1991, fig. 1) depicted. *Anadyomene howei* is most comparable to *A. saldanhae* A.B. Joly *et* E.C. Oliveira in the western Atlantic Ocean, including Bermuda (Schneider 2003), but the former is prostrate and has interstitial cells two or more times the size of the more common and larger alga (Littler and Littler 1991).

Collection Bermuda: *CWS/CEL* 06-8-21, 20 June 2006, west of Eastern Blue Cut channel marker, 32°23′22.1″ N, 64°53′23.0″ W, depth 12 m.

Remarks This species was considered a possible resident of Bermuda (Schneider 2003) after a report of *Struvea anastomosans* var. *caracasana* (Grunow *ex* Murray *et* Boodle) Collins by Frederick (1963) in his unpublished dissertation and a note on the MICH herbarium sheet that this specimen may be *S. elegans*. In any event, recent offshore specimens verify the presence of *S. elegans* in the flora. Our young plants show the early blade development (Figure 4) prior to segregate cell division (Figure 2), a character now prominent in separating *Struvea* Sonder from *Phyllodictyon* J.E. Gray (Kraft *et* Wynne 1996). This collection represents a new northern limit of distribution for *S. elegans* in the Atlantic Ocean.

Boodleaceae

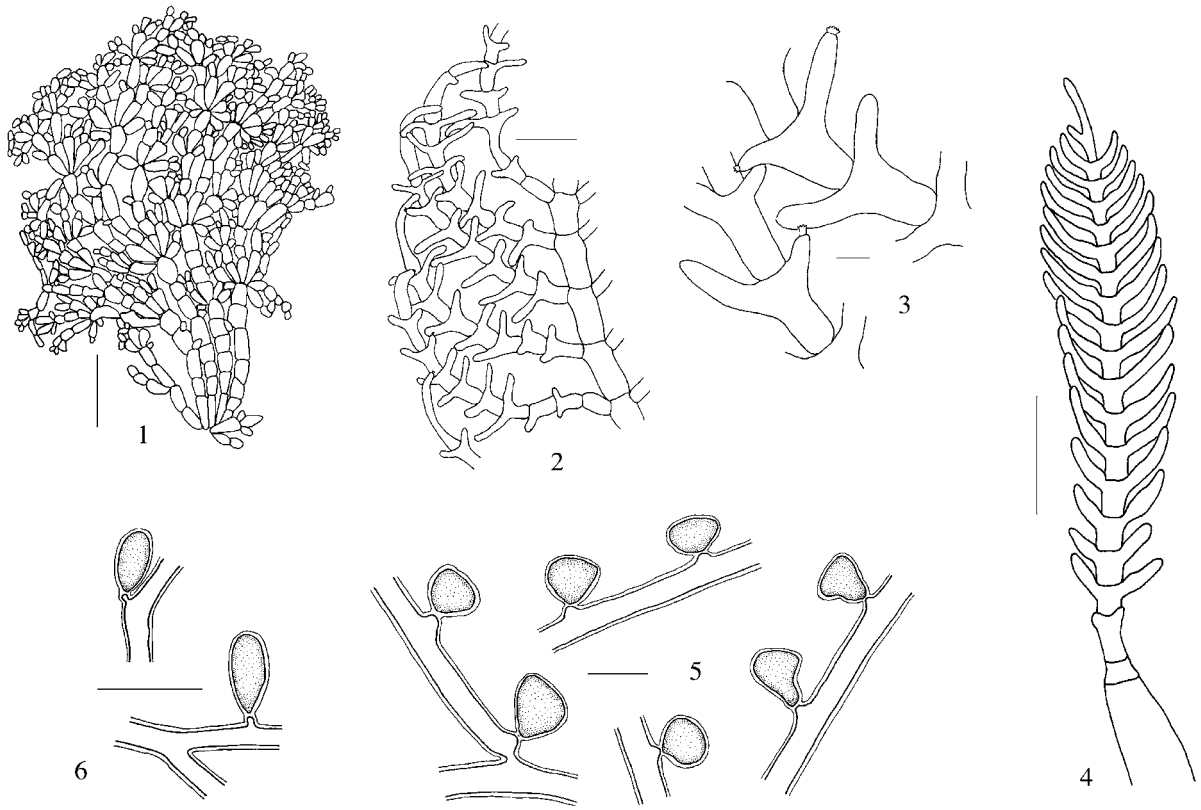
***Struvea elegans* Børgesen 1912, p. 264, figs 13, 14 (Figures 2–4, 7)**

Lectotype locality Off America Hill, St Jan, Virgin Islands, Caribbean Sea.

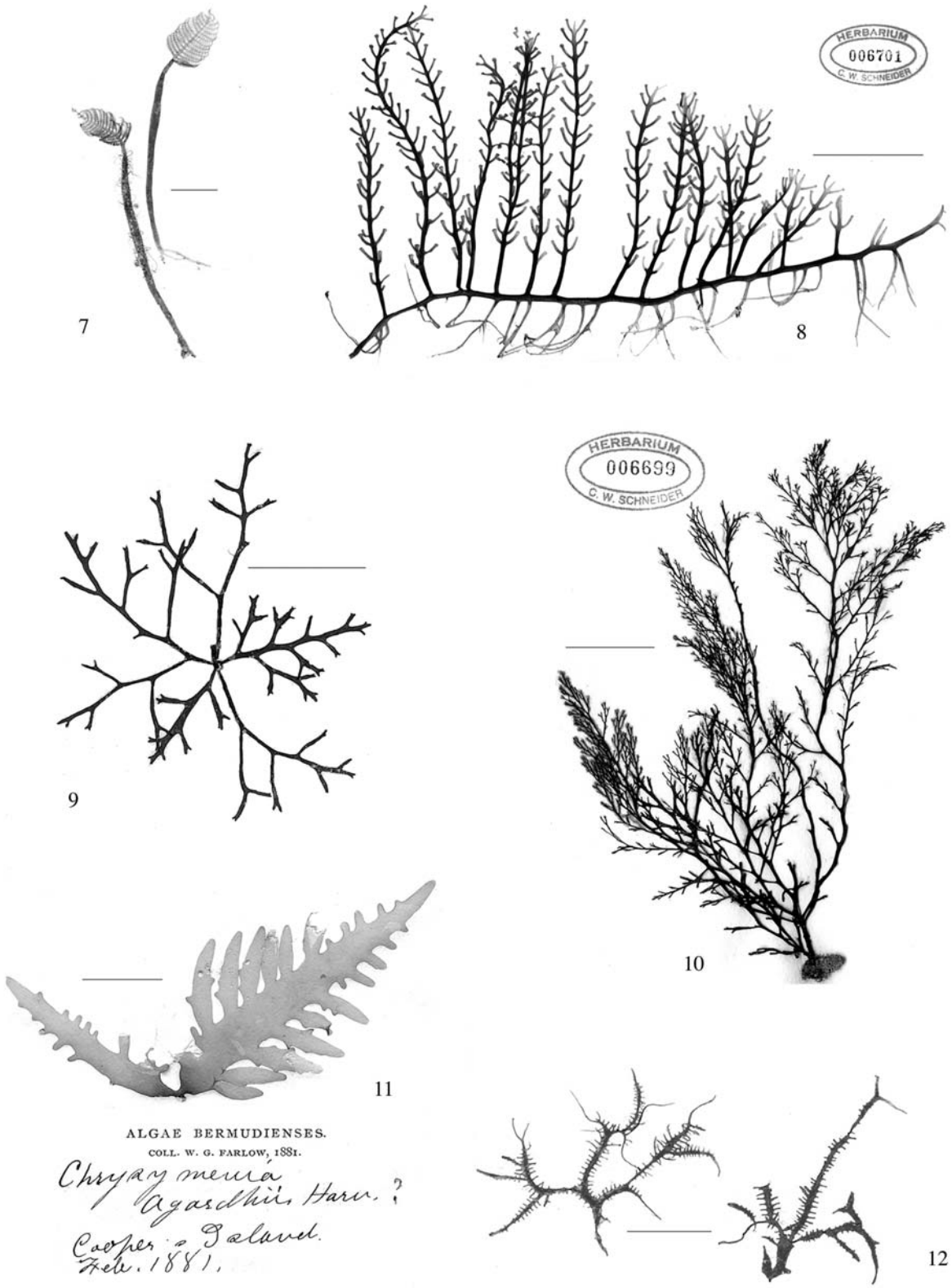
Siphonocladaceae

***Cladophoropsis macromeres* W.R. Taylor 1928, p. 64, pl. 4 figs 15, 16**

Type locality Fort Jefferson, Dry Tortugas, Florida, Gulf of Mexico, western Atlantic Ocean.



Figures 1–6 Bermuda chlorophytes.
(1) *Anadyomene howei* (*CWS/RBS* 85-10-23), scale 1 mm. (2–4) *Struvea elegans* (*CWS/CEL* 06-8-21): (2) detail of blade branching pattern, scale 1 mm; (3) detail of branch cells with tenacular attaching cells, scale 200 μm; (4) Young plant habit prior to segregate cell division, scale 2.5 mm. (5) *Derbesia turbinata* sporangia (*CWS/CEL* 06-17-10), scale 200 μm. (6) *Derbesia marina* sporangia, (*CWS/CEL* 02-13-19), scale 200 μm.



Figures 7–12 Bermuda seaweed wholemounts.
(7) *Struvea elegans* (*CWS/CEL* 06-8-21), scale 1 cm. (8) *Caulerpa racemosa* var. *lamourouxii* (*CWS/CEL* 06-16-1), scale 5 cm. (9–10) *Cystoseira compressa*: (9) offshore specimen in rosette stage (*CWS/CEL* 06-8-17), scale 2 cm; (10) intertidal upright plant (*CWS/CEL* 06-15-5), scale 3 cm. (11) *Chrysymenia nodulosa*, W.G. Farlow collection, Feb. 1881 (FH), scale 2 cm. (12) *Gloiocladia iyoensis* (*CWS/RBS* 85-16-10), scale 1 cm.

Collection Bermuda: *CWS/CEL* 05-9-6, 19 July 2005, Cliff Pool, Walsingham Park, Bermuda Island, 32°20.8′ N, 64°42.6′ W, depth 1–2 m.

Remarks Although this species was listed for Bermuda in Taylor (1960), vouchers for that report have not been located in MICH where Taylor deposited his collections. A world monograph of *Cladophoropsis* by Leliaert and Coppejans (2006), including specimens from NY and MICH, did not include Bermuda in the biogeographic distribution of *C. macromeres*. A recent collection of this species, however, establishes this taxon in the islands. It was collected in a protected inland collapsed cave pool, a "quiet" set of conditions similar to that of the Florida type locality described in the protologue of Taylor (1928). Proximal portions of axes of Bermuda specimens reach 500 μm in diameter, and specimens match the protologue as well as the recent description by Leliaert and Coppejans (2006). This report represents a new northern limit of distribution for the species.

Caulerpales, Bryopsidaceae

***Derbesia turbinata* M. Howe *et* Hoyt 1916, p. 106, pl. II figs 10–16 (Figure 5)**

Type locality Offshore from Beaufort in Onslow Bay, North Carolina, western Atlantic Ocean.

Collection Bermuda: *CWS/CEL* 06-17-10, 22 June 2006, Walsingham Pond, Bermuda Island, 32°20.7′ N, 64°42.6′ W, depth 3–5 m.

Remarks This species was found growing entangled with *Dasya caraibica* Børgesen in a sinkhole salt-pond with a subterranean connection to Walsingham Bay. The plants have siphons ranging from 50–100 μm in diameter; these diameters overlap those of the siphons of *Derbesia turbinata* reported in North Carolina (16–100 μm, Hoyt 1920). At maturity, the sporangia are turbinate to obpyriform and transverse elliptical, 110–170 μm in diameter and 120–160 μm long, and these are borne on short pedicels (Figure 5), similar to those in the protologue, 104–156 μm in diameter and 112–182 μm long (Howe and Hoyt 1916). In siphon, habit and sporangial dimensions, *D. turbinata* is twice the size of *D. marina* (Lyngbye) Solier, a species more common in Bermuda with obovoid to elongate sporangia (Figure 6; *CWS/CEL* 02-13-19, Ferry Reach cove, St George's Island, 32°22.1′ N, 64°41.8′ W, depth 1–2 m). Interestingly, the other *Derbesia* species known from Bermuda, *D. osterhoutii* (L.R. Blinks *et* A.C.H. Blinks) J.R.Z. Page, is known only as its gametophytic *"Halicystis"* stage throughout its range in Bermuda, Florida, the Bahamas and the Caribbean Sea.

Aside from North Carolina and Bermuda, *Derbesia turbinata* has been found in the western Atlantic Ocean off Georgia (Searles 1987) and the western Caribbean Sea (Littler and Littler 2000). It has also been reported from the eastern Atlantic Ocean off Senegal (Sourie 1954), Pacific Panama (Wysor 2004) and India (Silva et al. 1996). These disjunct localities suggest that *D. turbinata* is possibly more widespread in warm temperate to tropical seas, being overlooked due to its small stature and indistinguishable features when lacking sporangia.

Caulerpaceae

***Caulerpa racemosa* var. *lamourouxii* (Turner) Weber-van Bosse 1898, p. 368, pl. 32 figs 1–4, pl. 33 fig. 15 (Figure 8)**

Basionym *Fucus lamourouxii* Turner 1811–1818, p. 79, pl. 229.

Type locality Red Sea.

Collections Bermuda: *CWS/CEL* 05-9-1, 19 July 2005, Cliff Pool, Walsingham Park, Bermuda Island, 32°20.8′ N, 64°42.6′ W, depth 1–2 m; *CWS/CEL* 06-16-1, 22 June 2006, Cliff Pool, *loc. cit.*

Remarks During the summer months, an extensive population of this variety is found in Cliff Pool, a protected collapsed cave in Walsingham National Park. This taxon joins four other varieties of *Caulerpa racemosa* (Forsskål) J. Agardh already reported from Bermuda (Schneider 2003, p. 338). Its distichous habit, cylindrical axes and branchlets, and large overall size (Turner 1811) are in conformity with the concept of var. *lamourouxii* as used in the Caribbean (Børgesen 1907, Taylor 1960, Littler and Littler 2000). The salt-pool environment is subjected to low light intensities due to nearly complete shading by the park's tree canopy, as well as a 10 m cliff on the northwestern side of the sinkhole. The striking bilateral arrangement of branchlets on upright axes noted in most of our Bermuda specimens (Figure 8) matches the morphology artificially induced for *C. racemosa* var. *lamourouxii* specimens at very low-light intensities by Peterson (1972), but some plants have only a unilateral row of branchlets. Indeed, Peterson (1972) found that all of the many varieties of *C. racemosa* were environmentally created habits, rather than genetically based taxa, and thus, he referred to them as "ecophenes". In Guam, Peterson (1972) found *C. racemosa* var. *lamourouxii* in shaded areas within reef flat depressions, where the plants were "protected from breaking waves, high-light intensity and low-tide exposure," conditions similar to those in the highly protected Cliff Pool. In contrast, South Pacific plants attributed to this variety by Littler and Littler (2003) from reef rim and fore-reef slope to 30 m bear no resemblance to the Atlantic specimens reported here or, for that matter, those they have depicted from the Caribbean Sea (Littler and Littler 2000), a fact noted by the authors in their own account (Littler and Littler 2003, p. 293). Børgesen's (1907) plants were all collected from deep water off the Virgin Islands, and thus represent light-limited specimens, although the limitation was from light attenuation at depth rather than direct shading of shallow-water specimens as in Bermuda. Whether all of the Atlantic specimens attributed to *C. racemosa* var. *lamourouxii* are exposed to similar low-light intensities of Cliff Pool and/or are of the same genetic stock requires molecular investigation.

Caulerpales, Halimedaceae

***Halimeda discoidea* Decaisne 1842, p. 102**

Type locality Unknown (see Silva et al. 1996).

Collections Bermuda: *CWS/CEL* 05-25-3, 23 July 2005, Cocoa Bay, Smith's Sound, St David's Island, 32°21.8′ N, 64°39.7′ W, depth 0–1 m; *CWS/CEL* 06-20-1, 23 June 2006, eastern side of ferry dock, Great Bay, St David's Island, 32°22′03.1″ N, 64°39′25.6″ W, intertidal zone to 1 m.

Remarks Widespread populations of this large-plated alga were found in silt-covered Cocoa Bay amongst the extensive grass beds (mostly *Thalassia testudinum* König *et* Sims), and even more dense populations outcompeting seagrasses in Great Bay. Plants to 23 cm tall, with plates to 2 cm wide, were found attached to mud flats, rock, submerged tree limbs and private docks. Subutricles in the population, to 180 μm in diameter, are greatly inflated relative to other Bermuda *Halimeda* species. Although Taylor and Bernatowicz (1969) mention making collections of other species from the numerous bays on the north side of St David's Island, they never reported this presently abundant species here. Considering its present dominance in this area of Bermuda, this seems odd, unless *H. discoidea* is a recent introduction to the islands, whether natural or anthropogenic.

Phaeophyceae: Fucales, Sargassaceae

***Cystoseira compressa* (Esper) Gerloff *et* Nizamuddin 1975, p. 342 (Figures 9, 10)**

Basionym *Fucus compressus* Esper 1799: 152, pl. LXXVII.

Type locality Adriatic Sea.

Collections Bermuda: *CWS/CEL* 06-8-17, 20 June 2006, west of Eastern Blue Cut channel marker, 32°23′22.1″ N, 64°53′23.0″ W, depth 12 m; *CWS/CEL* 06-15-5, 22 June 2006, rocky point south of beach at Capt. Williams' Bay, Bermuda Island, 32°18′08.5″ N, 64°44′17.7″ W, on intertidal rock.

Remarks This alga was first reported in Bermuda as a putative invader from southern Europe, although "not necessarily one destined to persist" [Taylor 1961, as *Cystoseira fimbriata* (Desfontaines) Bory]. In fact, it has persisted and even thrived. Bermuda remains the sole location of this alien species in the western Atlantic Ocean, whereas in the eastern Atlantic Ocean it ranges from the Azores (Neto 1994, as *C. fimbriata*), Atlantic Portugal (Ardré 1970) and Spain (Gómez Garetta 2001), Atlantic Morocco (Benhissoune et al. 2002), the Mediterranean and Adriatic Seas (Ribera et al. 1992, Furnari et al. 1999), Madeira, the Salvage Islands, and the Canaries (John et al. 2004). Taylor originally found all of his specimens in the drift on the north side of Bermuda at Shelly Bay, an area distant from those supporting anchorages of transatlantic ships. Later, Taylor and Bernatowicz (1969, as *C. fimbriata*) reported an attached collection by I.M. Lamb on a jetty in the Great Sound off Somerset Island, an area adjacent to a transatlantic dockyard on the bay side of Ireland Island North. One further collecting site was discovered in 1970 by Taylor after his last published report of *Cystoseira* in Bermuda (Taylor and Bernatowicz 1969), that from Castle Harbour at the southwestern end of Kindley Airfield (now Bermuda International Airport), St David's Island. Since then, the only reports of *C. compressa* have been infrequent drift collections (Cavaliere 1986, as *C. fimbriata*; Cavaliere 1994).

A recent collection from Capt. Williams' Bay was made from an extensive attached population in a high energy surf intertidal environment as well as thalli in less exposed tidal pools. According to locals (C. Flook personal communication), this population has been well-established here on the south shore for decades and may have remained undiscovered due to its location on private property, which would be inaccessible by boat or water due to intense surf most days. This population could possibly have originated from the one discovered by Taylor near the airfield. Castle Harbour has open connections to both the north and south shores, and waters flow south out of the harbor as the tide ebbs, distributing spores, gametes and even whole drift organisms to the south shore of Bermuda. Clearly, however, after nearly a half century in the islands, *Cystoseira compressa* has not become a widespread invasive species here, surviving only in restricted locations.

The specimens recently discovered at Capt. Williams' Bay perfectly match the description provided by Taylor (1961), as well as a photograph of the species from Mediterranean France by Feldmann [1937, pl. 17, as *C. abrotanifolia* (L.) C. Agardh], the worker who identified the original Bermuda specimens for Taylor (1961). We made a second collection offshore at 12 m depth on the outer barrier reef due north of Daniel's Head (north shore). This single specimen was a rosette of alternately pinnate branches flat against the coral on which it grew (Figure 9), yet still contained receptacles. The intertidal specimens also grow as widespreading rosettes prior to sending up a large number of 30 cm tall upright branches with floats and receptacles making the thalli appear bushy (Figure 10).

Rhodophyceae: Rhodymeniales, Rhodymeniaceae

***Chrysymenia nodulosa* J.N. Norris *et* D.L. Ballantine 1995, p. 159, figs 2a, 2b, 4, 5, 7, 8a, 8b, 9 (Figure 11)**

Type locality Media Luna reef, La Parguera, Puerto Rico, Greater Antilles, Caribbean Sea.

Collection Bermuda: *W.G. Farlow,* Feb. 1881, Cooper's Island (as *Chrysymenia agardhii* Harv.) (FH, MICH).

Remarks Although we have not found recent collections to corroborate that this species is still extant in the Bermuda marine flora, a specimen that represents *Chrysymenia nodulosa* (Figure 11), collected and identified by W.G. Farlow as *C. agardhii* over a century ago from Cooper's Island, was discovered in an examination of island specimens in FH. A second specimen from the same col-

lection was later discovered in MICH. Since the 19th century, Cooper's Island has changed dramatically. When Kindley Airfield was built in Bermuda from 1941–1943 as part of a wartime U.S. army airbase, landfill was added to connect Cooper's Island to increase the length of St David's Island (Murphy and Mowbray 1951), thus giving the military (now civilian) runways greater length for safer operation. Whether the landfill covered the 1881 collection site at Cooper's Island of *C. nodulosa* is unknown, but no modern collections have been made to date.

Littler and Littler (2000) report *Chrysymenia nodulosa* only from the Greater Antilles in general, and specimens collected in Puerto Rico by David Ballantine (Herb. CWS#005731) compare favorably with the flattened pinnate Bermuda specimens from 1881.

Faucheaceae

***Gloiocladia iyoensis* (Okamura) R.E. Norris 1991, p. 587, figs 14–23 (Figure 12)**

Basionym *Gloioderma iyoense* Okamura 1934, p. 27 (English text), pl. 315 figs 11–16.

Type locality Otateba, Ehima Prefecture, Japan.

Collections Bermuda: collections previously reported as *Gloiocladia atlantica* (Searles) R.E. Norris *sensu* Schneider and Searles (1998b); *CWS/RBS* 85-16-10, 13 June 1985, northeast of Great Head, St David's Island, 32°22.8′ N, 64°36.4′ W, depth 18–24 m; *CWS/CEL* 03-31-11, cystocarpic, 3 April 2003, Tobacco Bay, St George's Island, 32°23.3′ N, 64°40.7′ W, depth 3 m; *CWS/CEL* 05-10-24, 20 July 2005, North Rock, north of Bailey Bay Flats, 32°28.3′ N, 64°46.1′ W, depth 18 m; *CWS/CEL* 06-14-34, ⊕, 21 June 2006, outer reef off Frick's Beach, Bermuda Island, 32°19.9′ N, 64°40.3′ W, depth 10 m on *Dictyota humifusa* Hörnig, Schnetter *et* Coppejans.

Remarks A deep-water collection from North Rock and a recently discovered collection made on a past R/V *Seahawk* cruise yielded the largest specimens of *Gloiocladia* we have found in Bermuda, all previous collections coming from deep offshore reefs as well. These specimens call into question the determination of the several small and fragmentary samples previously reported from Bermuda as *G. atlantica* (Searles) R.E. Norris, despite narrower axes than the North Carolina type (Schneider and Searles 1998b). The new materials are plants spreading to 3 cm, but the major axes remain narrow (1 mm or less in diameter), not becoming broader as is the case for *G. atlantica* (2 mm in diameter, Searles 1972). Only some of the axes of these specimens are flattened, and all axes have fine, terete, finger-like, closely set pinnate branches (Figure 12), unlike those for *G. atlantica*. In fact, the large offshore specimens match the illustrations found in the protologue of *G. iyoensis* (Okamura 1934) with narrowly pinnate axes and occasional ultimate branching out of the mostly two-dimensional plane of the axes. Furthermore, the specimens listed above are seen simply as larger versions of the fragmentary material collected in the past from 15–29 m in Bermuda and reported as *G. atlantica* (Schneider and Searles 1998b). Therefore, we remove *G. atlantica* from the local flora and insert as its replacement *G. iyoensis*, a species with an Atlantic distribution that now includes Bermuda along with Brazil (Yoneshigue 1985).

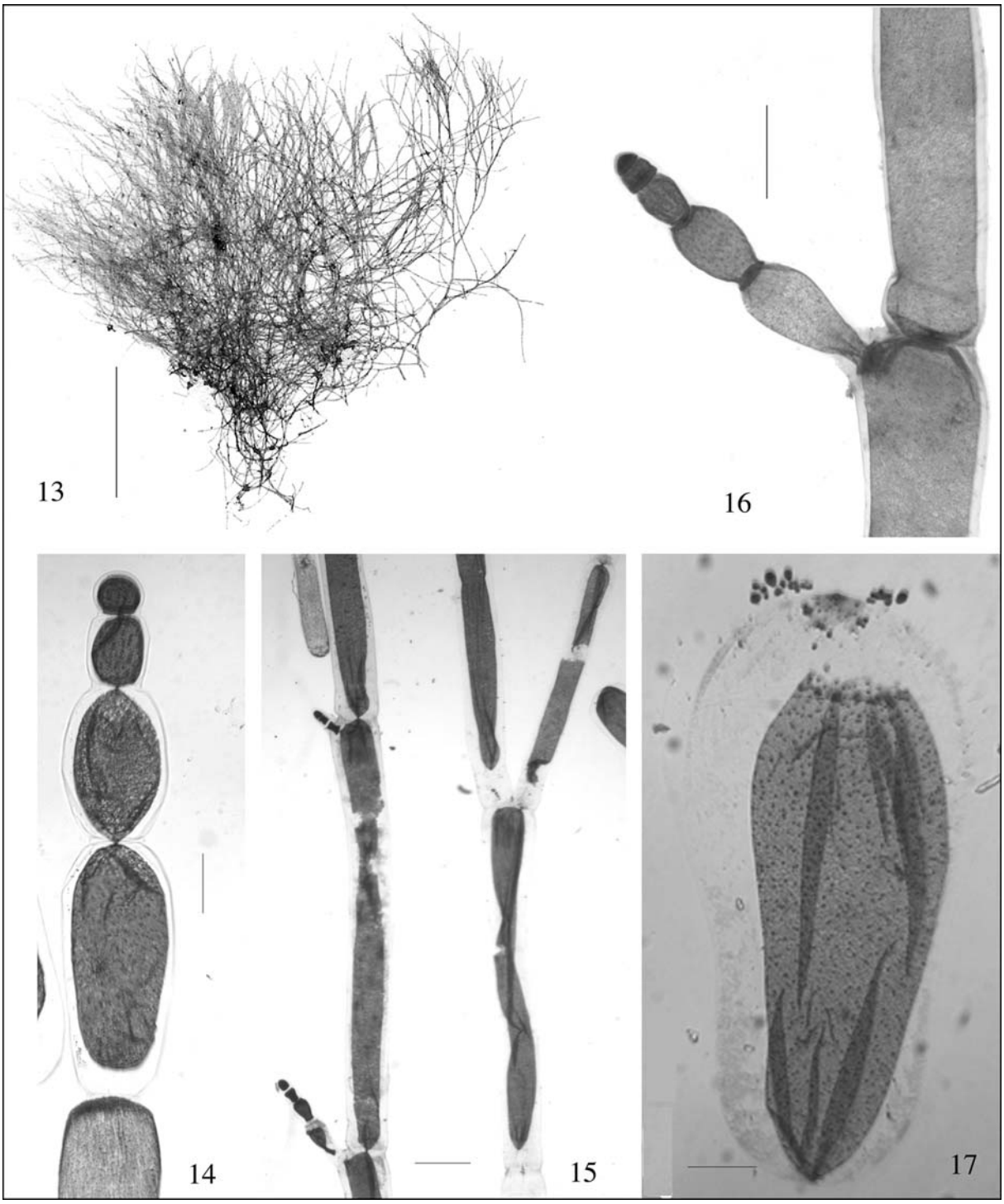
Norris (1991) suggested that *Gloiocladia atlantica* and *G. iyoensis* might be conspecific. A molecular comparison is needed to determine if in fact these two species should be maintained. At this time, type material of *G. atlantica* (Herb. CWS # 003619) and the many Bermuda specimens herein reported as *G. iyoensis* are easily separable on morphological grounds alone.

Ceramiales, Ceramiaceae

***Griffithsia aestivana* C.W. Schneider *et* C.E. Lane, sp. nov. (Figure 13–22)**

Diagnosis *Plantae epiphyticae vel saxicolae, erectae et ramosae late, 3–6 cm altae, roseolae, rhizoideis ramosis multicellulosis cellula basalari efferentibus affixae, rhizoidea secundaria multicellulosa cellulis axialibus interdum efferentia affixae, ramos adjacentes vel algas alias cingentia; rami laterales ad extrema distales cellularum axialium distantium apicibus prodientes, brachyblasti abbreviati cellulares atque primum cresentes, ad longitudinibus apicum vel longiorum quam axes e producientibus postea evoluti, dichotomi primum cresentes ubi aequales; cellulae cylindratae, saepe clavescentes apprime in cellulis ramosis, sed cellulae sine ramis generatim solum parum latiores in regionibus distalibus quam ad extrema proximales; cellulae axiales 245–285 μm diametro ad basim, 300–400 μm et 2.0–2.5 mm longitudine in medio, ad cellulas ultimas brevi-cylindratae vel ovoideae ad sphaericas et 80–180 μm diametro contractae; tetrasporangia sphaerica, ad 390 μm diametro, extrema distalia cellularum subapicalium ad cellulas in medio cingentia, tres in ramis unicellularibus plerumque portata, cum trichoblastis adjacentibus consociata sed involucri destituta; gametangia ignota*.

Description Plants epiphytic or saxicolous, erect and loosely branched, 3–6 cm tall, light rosy-red, attached by branched multicellular rhizoids issued from the basal cell, secondary multicellular rhizoids issued from occasional axial cells, encircling adjacent branches or other algae; branching lateral several cells distant from the apex at the distal ends of axis cells, appearing as short-celled dwarf shoots in early stages, later developing to reach the tips or even overtake the axes from which they were produced, when equal in length appearing as dichotomous; cells cylindrical, often becoming club-shaped especially in cells where branching occurs, but cells without branches generally only slightly wider in distal regions than at the proximal ends; axial cells 245–285 μm in diameter near the base, reaching 300–400 μm in diameter and 2.0–2.5 mm long in median positions, tapering to ultimate cells that are short-cylindrical or ovoid to spherical and 80–180 μm in diameter; tetrasporangia globose, to 390 μm in diameter, encircling distal ends of subapical to median cells, usually three borne on one-



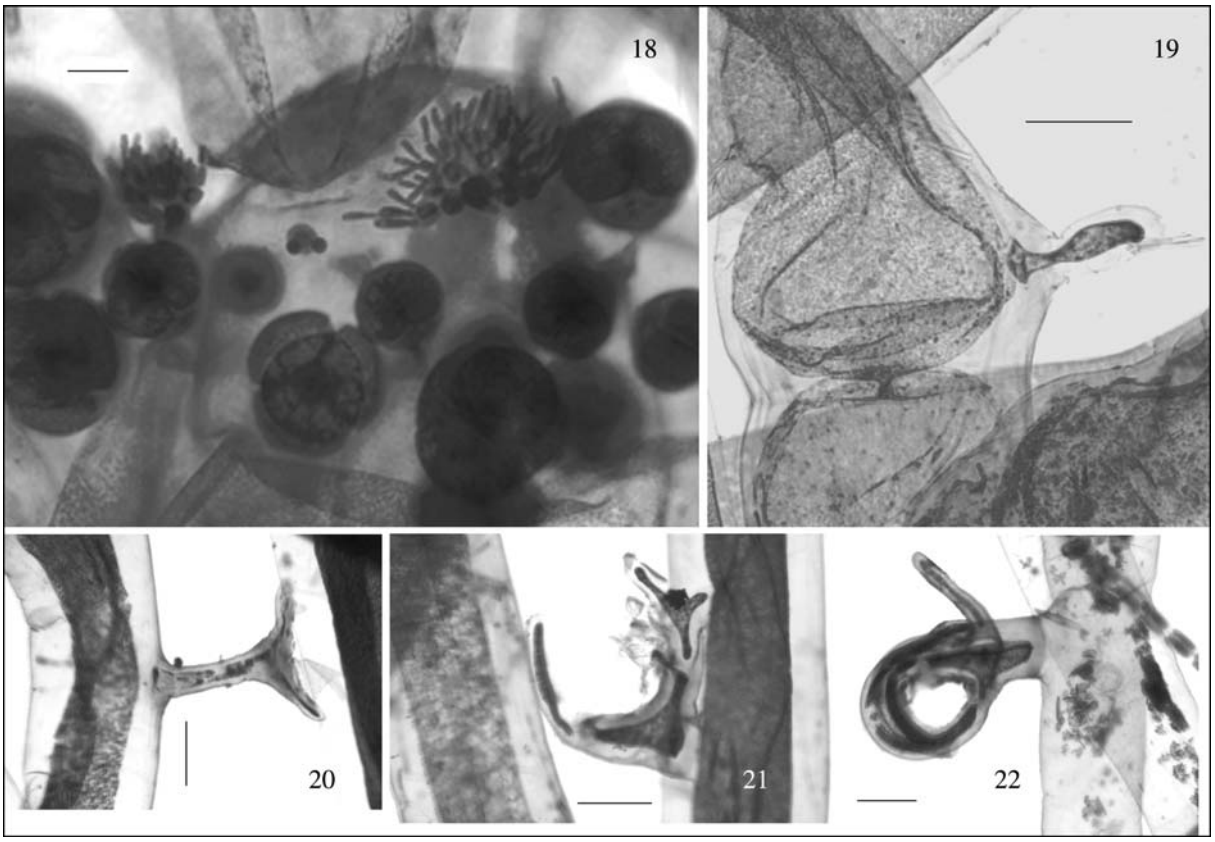
Figures 13–17 *Griffithsia aestivana* sp. nov.
(13) Habit (CWS/CEL 06-17-1), scale 2 mm. (14–16) Holotype (CWS/CEL 96-9-10): (14) apex of branch with axial cells beginning to elongate, scale 100 μm; (15) dwarf shoots developing from distal ends of axial cells, scale 100 μm; (16) dwarf shoot, scale 200 μm. (17) Early development of tetrasporangia at distal end of axial cell, scale 100 μm (isotype).

celled branches, associated with adjacent trichoblasts, but lacking involucral branches; gametangia unknown.

Holotype (designated here) MICH (isotypes Herb. CWS, MSM, NY, US).

Type collection/locality *CWS* 96-9-10, ⊕, 5 July 1996, Walsingham Pond, Hamilton Parish, Bermuda Island, 32°20.7′ N, 64°42.8′ W, depth 1–4 m on mangrove roots and entagled with other algae on vertical ledges.

Additional collections Bermuda: *CWS*/*CEL* 99-17-12, 23 July 1999, Walsingham Pond, *loc. cit.*; *CWS*/*CEL* 05-8-4, 19 July 2005, Walsingham Pond, *loc. cit.*; *CWS*/*CEL* 06-17-1, 22 June 2006, Walsingham Pond, *loc. cit.*, depth 3–5 m.



Figures 18–22 *Griffithsia aestivana* sp. nov. (holotype).
(18) Mature tetrasporangia and associated trichoblasts, scale 25 μm. (19–22) Rhizoid production from axial cells, early uniseriate development to encircling, multicellular processes, scales 100 μm.

Etymology Named for Bermuda which was, during the 17th century, temporarily renamed the Somer Islands (*Aestivae Insulae* on period navigational maps) upon the death of Sir George Somers there in 1610, after he inadvertently brought the first colonists to the islands in 1609. The epithet can be regarded as a double-entendre, as it has been collected in Bermuda only during the summer months.

Remarks Abundant plants all collected from Walsingham Pond over the last decade are herein described as a distinct new species despite the lack of gametangial specimens. *Griffithsia aestivana* is most similar to *G. capitata* Børgesen, a species of the eastern Atlantic Ocean from the Canary Islands (Haroun et al. 2002) and Madeira (Levring 1974), but has features with which to distinguish it, despite not having gametangial features known at present. The Bermuda plants are loosely branched to 6 cm tall (Figure 13), twice the size of *G. capitata* described in the protologue as growing in "tufts 2–3 cm high" (Børgesen 1930, p. 34). Levring's (1974) specimens were only about 1 cm tall, smaller than those from the Canaries.

Only seven of the 39 current species of *Griffithsia* (Guiry and Guiry 2007) lack vegetative involucral cells which surround tetrasporangial clusters at the distal ends of axial cells. Although both *G. aestivana* and *G. capitata* produce typical whorls of tetrasporangia clustered on small stalk cells at the distal ends of axial cells and lack involucral cells, in *G. capitata* the whorls are produced on the two swollen penultimate cells at the tips, whereas in *G. aestivana* they are found on long cylindrical cells from several cells below the apices down to median portions of the axes (Figures 17, 18). Associated with the sporangia in the Bermuda specimens are di-, tri-chotomous trichoblasts emanating from swollen spherical basal cells (Figure 18), referred to by Børgesen (1930) as "dwarf shoots," a feature that he did not find developing in *G. capitata*.

Of the known *Griffithsia* species lacking tetrasporangial involucral cells, several are small, dichotomously or pseudodichotomously branched species with prostrate spreading axes giving rise to uprights that produce moniliform swollen spherical cells at branch apices. None of these could be confused with the loose erect, laterally branched axes and cylindrical subterminal cells of *G. aestivana* (Figures 14–16). These include one widespread tropical to subtropical species recently reported from Bermuda, *G. heteromorpha* Kützing (Schneider 2004), *G. rhizophora* Grunow *ex* Weber-van Bosse from the Indian and Pacific Oceans (Guiry and Guiry 2007), *G. coacta* Okamura from Japan (Okamura 1930) and *G. weber-van-bosseae* from the Indian Ocean (Børgesen 1942). The two remaining species, *G. radicans* Kützing and *G. teges* Harvey, lack tetrasporangial involucres and have elongate cylindrical cells, but are also easily distinguished from *G. aestivana*. *Griffithsia radicans* is known from Brazil (Taylor 1960), Caribbean Mexico (Aguilar Rosas et al. 1998) and

the Canaries (Haroun et al. 2002). It is a repent, spreading species with irregular branching and cell lengths only three times the cell diameters (Kützing 1862, Taylor 1960), *versus* ten times in the new species. On the other hand, *G. teges* from Australia has stiff, erect branches with greater overall and cellular dimensions, and axes that taper to acute apices (Baldock 1976, 1998).

Although easily distinguished from the new species by the production of tetrasporangial involucres, a few taxa bear some vegetative resemblance to *Griffithsia aestivana*. Two large erect Pacific species, *G. subcylindrica* Okamura and *G. heteroclada* Yamada *et* Hasegawa, are similar in having long cylindrical axial cells. Along with tetrasporangial involucres, *G. subcylindrica* is larger (to 10 cm tall; Okamura 1930) than the new species, whereas *G. heteroclada* has short unilateral to opposite branches giving the plants a dense branching appearance (Hasegawa 1949). *Griffithsia caribaea* Feldmann-Mazoyer is smaller (to 2.5 cm) and spreading, but has long clavate cells that might give the appearance of *G. aestivana* in the vegetative condition (Feldmann 1947).

A special feature of *Griffithsia aestivana* that differentiates it from others in the genus is the production of multicellular rhizoids that often encircle, and apparently do not firmly affix to adjacent branches of itself or other algae. These encircling rhizoids start out as uniseriate rhizoids (Figure 19) and upon contact with another filament, divide and branch (Figures 20, 21), ultimately encircling the adjacent filament or branch (Figure 22). We were able to loosen the "attached" branch out of some of these "looping" rhizoids in wet samples (Figure 22). Some rhizoids that have not made contact with another branch or algal filament continue to extend more than 1 mm and remain unbranched. This apparently unusual form of secondary attachment in the new species resembles another red alga, *Lomentaria amplexans* R.E. Norris (1987) from South Africa, but that species has entire axes twining around a host "support" species rather than the encircling rhizoids of *G. aestivana*.

It is unclear whether the 1–3 inch (3–8 cm) specimens Howe (1918, p. 526) reported as possible *Griffithsia globulifera* Harvey *ex* Kützing from Bermuda are actually *G. aestivana*, but we have yet to collect the former in more than two decades of work in the islands. Howe's (1918) description does list characteristics that would best fit *G. globulifera* including pseudodictomous branching, yet he lists male and female features after reporting only tetrasporic specimens from Bermuda, thus making us wonder what portions of the description actually came from his local collections. We have looked at the only representative of his material that we could find [*M.A. Howe* 205, on rocks in shallow water, Castle Harbour, Bermuda 23.vi.1900 (NY)], and it could be *G. aestivana* based on lateral branching and cell size, but without tetrasporangia, we are reluctant to ascribe his local concept of *G. globulifera* to the new species.

This species' habitat, Walsingham Pond, is the type locality of several other Bermuda taxa, including the recently described *Chondracanthus saundersii* C.W. Schneider *et* C.E. Lane (Schneider and Lane 2005) and *Crassitegula walsinghamii* C.W. Schneider, C.E. Lane *et* G.W. Saunders (Schneider et al. 2006).

Dasyaceae

***Dasya caraibica* Børgesen 1919, p. 319, figs 322, 323 (Figure 23)**

Type locality Between St. John and St. Thomas, Virgin Islands, Greater Antilles, Caribbean Sea.

Collection Bermuda: *CWS/CEL* 06-17-3, immature ⊕, 22 June 2006, Walsingham Pond, Bermuda Island, 32°20.7′ N, 64°42.6′ W, depth 3–5 m.

Remarks At the apices of branches, this species is reminiscent of *Dasya rigidula* (Kützing) Ardissone, also found in Bermuda, but achieves a much larger size and becomes corticated by rhizoids below the apices. In all respects, the specimens from Bermuda match the protologue of *D. caraibica* from the Virgin Islands (Børgesen 1919), as well as other published reports from the Caribbean Sea (Taylor 1960). In the eastern Atlantic Ocean, this species has been reported in the Canary Islands (Haroun et al. 2002), Madeira (Cruz-Reyes et al. 2002) and with a query from Mauritania (Marcot-Coqueugniot 1991).

Rhodomelaceae

***Chondrophycus iridescens* (M.J. Wynne *et* D.L. Ballantine) Garbary *et* J.T. Harper 1998, p. 195**

Basionym *Laurencia iridescens* M.J. Wynne *et* D.L. Ballantine 1991, p. 395, figs 1–11.

Type locality Les Alizes, Guadeloupe, Lesser Antilles, Caribbean Sea.

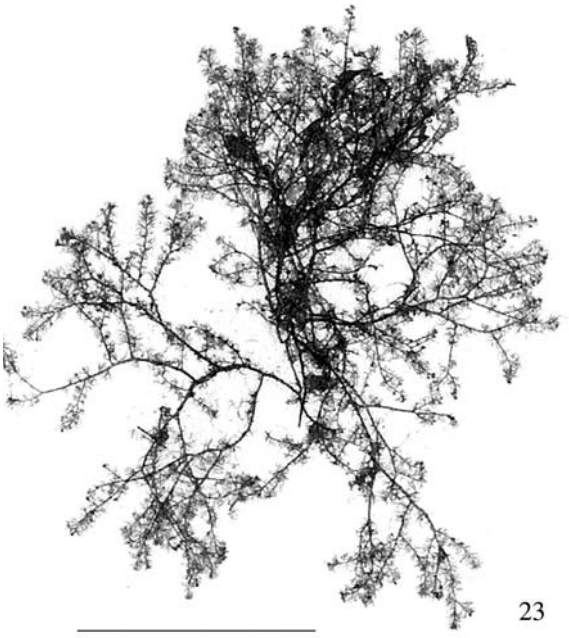


Figure 23 *Dasya caraibica,* wholemount (*CWS/CEL* 06-17-3), scale 2 cm.

Collections Bermuda: *CWS/CEL* 01-20-1, ⊕, 15 Nov. 2001, West Whale Bay, Southampton, Bermuda Island, 32°15.3′ N, 64°52.5′ W, on coral "boilers" from 1-2 m; *CWS/CEL* 03-36-6, ⊕, 3 Oct. 2004, West Whale Bay, *loc. cit.,* depth 1–3 m; *CWS/CEL* 03-37-2, 3 Oct. 2003, Horseshoe Bay, Bermuda Island, 32°15.0′ N, 64°49.2′ W, depth 1–4 m; *CWS/CEL* 06-4-8, 18 June 2006, West Whale Bay, *loc. cit.,* depth 2 m.

Remarks The specimens from Bermuda are similar in all respects to those in the protologue (Wynne and Ballantine 1991, as *Laurencia iridescens*) and were found as small iridescent and concrescent clumps in the shallow subtidal of high-energy coral "boiler" environments during the fall season. Since its original report from Guadeloupe, Littler and Littler (2000) have reported *Chondrophycus iridescens* from Florida and the Gulf of Mexico, as well as throughout the Caribbean Sea. The report from Bermuda represents a new northern distributional limit for this species.

Recently, Nam (2006) presented justification for the elevation of Yamada's (1931) Section Palisada of *Laurencia* to generic level, and *Chondrophycus iridescens* was to be one of the species included in that newly delineated genus. However, in light of the fact that Nam did not properly validate that proposal (G. Furnari personal communication; ICBN Art. 33.3, Greuter et al. 2000), we are leaving our collections as *C. iridescens* until Nam's proposals are validated.

***Polysiphonia scopulorum* Harvey 1854, p. 540, var. *scopulorum* (Figure 24)**

Type locality Fremantle, Western Australia, Indian Ocean.

Collection Bermuda: *CWS/CEL* 06-22-7, 23 June 2006, junction of Horseshoe and Higgs Islands at Town Cut, St. George's Harbour, 32°22′37.7″ N, 64°39′48.8″ W, depth 0–1 m, on *Dasycladus vermicularis* (Scopoli) Krasser.

Remarks This is the first report of the nominate variety in Bermuda, although two other varieties have been previously reported from Bermuda. *Polysiphonia scopulorum* var. *villum* (J. Agardh) Hollenberg and *P. scopulorum* var. *minima* Hollenberg were both discovered as part of a probable syntype collection [F.S. Collins no. 7779 (NY)] of *Lophosiphonia bermudensis* Collins *et* Hervey [Oliveira and Cordeiro-Marino 1970; see discussion of *Womersleyella setacea* (Hollenberg) R.E. Norris below, and refer to Schneider 2003, p. 310]. *Polysiphonia scopulorum* var. *scopulorum* has been reported in the western Atlantic Ocean from Belize (Littler and Littler 1997, Littler et al. 2000), Mexico (Aguilar Rosas et al. 1998) and Brazil (Guimarães et al. 2004).

The new Bermudian specimens are twice the size (to 140 μm in diameter) of the narrower *Polysiphonia scopulorum* var. *villum* [decumbent axes 40–60 (-70) μm in diameter] that we often find around the islands. Prostrate segments are mostly 1.0–1.5 times as long as broad, and from these issue centrally a large number of mostly digitate rhizoids in open connection with a ventral pericentral cell. Trichoblasts are abundant on erect, mostly unbranched, axes early in development (Figure 24), but are deciduous at maturity. Our collection consists of only vegetative specimens.

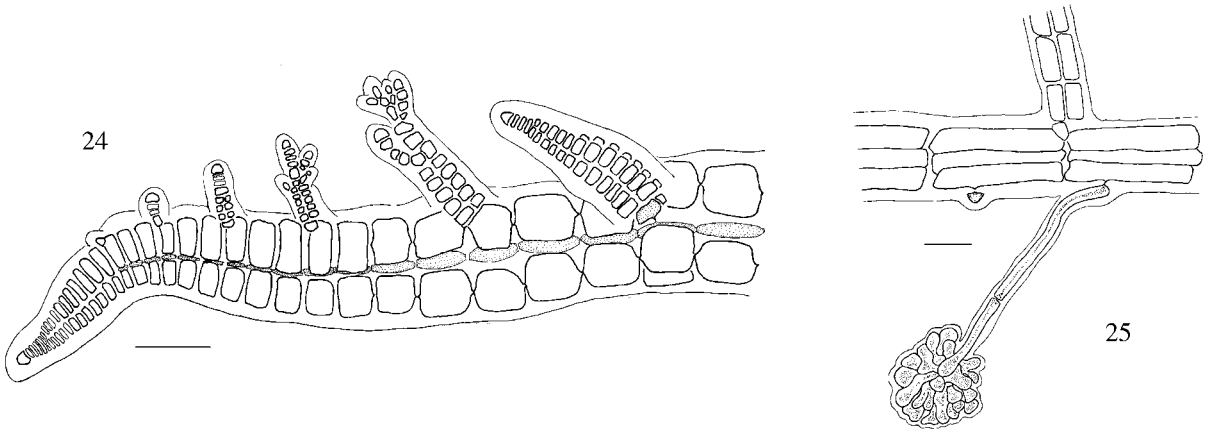
***Womersleyella setacea* (Hollenberg) R.E. Norris 1992, p. 70 (Figure 25)**

Basionym *Polysiphonia setacea* Hollenberg 1968, p. 85, figs 5A–C.

Type locality Koko Head, Oahu, Hawaiian Islands, central Pacific Ocean.

Collection Bermuda: *CWS/CEL* 01-14-23, immature ⊕, 12 Nov. 2001, Walsingham Pond, Bermuda Island, 32°20.7′ N, 64°42.6′ W, from 4 m on a shaded vertical ledge at the western end of the salt pond.

Remarks A tentative report of this species from Bermuda was made by Oliveira and Cordeiro-Marino (1970,



Figures 24–25 Bermuda rhodophytes.
(24) *Polysiphonia scopulorum* var. *scopulorum,* detail of apex of prostrate axis, with upright branches developing trichoblast initials (*CWS/CEL* 06-22-7), scale 50 μm. (25) *Womersleyella setacea,* detail of the origin and development of multicellular rhizoids from ventral pericentrals on a prostrate axis (*CWS/CEL* 01-14-23), scale 50 μm.

as *Polysiphonia setacea*), when they found it as part of the probable syntype collections of *Lophosiphonia bermudensis* Collins *et* Hervey [=*Dipterosiphonia rigens* (Schousboe *ex* C. Agardh) Falkenberg and *Polysiphonia scopulorum* Harv. vars] in the F.S. Collins Herbarium (presently housed in NY). The putative *Womersleyella setacea* was mixed in with *D. rigens* in one of the Bermudian Collins collections [no. 7626 (NY)], and Oliveira and Cordeiro-Marino (1970) described the specimens as coarse plants with prostrate axes 71–114 μm in diameter and segments 1.0–1.5 as long as broad. The axes they observed had reduced trichoblasts that were spirally disposed and quickly deciduous, and rhizoids were cut off from the distal ends of pericentral cells.

In the 2 cm specimens reported here, trichoblasts are not present and scar cells few, ecorticate prostrate axes are 80–120 μm in diameter, segments are 1.0–1.5 times as long as broad, pericentral cell end walls are often oblique, and rhizoids issue from the distal ends of prostrate axial segments (Figure 25). The distal ends of rhizoids become multicellular and digitate (Figure 25) upon contact with a substratum. Long, erect branches in the Bermudian specimens are issued cicatrigenously and only rarely branch. Tetrasporangia form in long series in apical segments, only slightly spiraling and therefore appearing to form in a straight line. All of these characters, except for a lack of trichoblasts, are in conformity with the protologue (Hollenberg 1968, as *Polysiphonia setacea*). The multicellular tips on rhizoids in this species of *Womersleyella* separate it from the many similar species of *Polysiphonia* and *Neosiphonia* with four pericentral cells in Bermuda (Schneider 2003), except for a tentative report of *P. poko* Hollenberg from the islands (Hollenberg 1968). Although *P. poko* is described as producing unicellular rhizoids, a historical collection from Bailey's Bay with multicellular rhizoids was considered this species by Hollenberg (1968, p. 71). An evaluation of the Bailey's Bay specimens (*A.J. Bernatowicz* 53-358) is necessary to tell whether these are more correctly determined as *W. setacea*.

Conclusion

Due to its position relative to the north-flowing and warm Gulf Stream, Bermuda is a northernmost outpost for a great number of species in the Caribbean tropical flora (Schneider and Searles 1998a). Except for the new species, *Griffithsia aestivana*, all of the species reported from Bermuda for the first time are known from the Caribbean Sea and most are widely distributed in the western Atlantic Ocean. Of the 11 new records in the flora, ten represent new northern limits of distribution in the North Atlantic Ocean, with only *Derbesia turbinata* being known at a higher latitude in North Carolina to the east (Schneider and Searles 1991).

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