

An Updated and Annotated List of Marine Brown Algae (Phaeophyceae) of the Caribbean Coast of the Republic of Panama

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Thirty-six taxa of brown macroalgae (Phaeophyceae) are reported for the Caribbean coast of the Republic of Panama including 16 new records. Most of the species diversity is restricted to two families, Dictyotaceae and Sargassaceae. This updated list represents an increase in known algal diversity for Panama of approximately 80 %, but diversity is probably underestimated as revealed by comparison to the Colombian and Costa Rican floras which harbor many species not yet recorded in the marine flora of Panama. In total species diversity, Panama's brown algal flora is considerably less diverse than Caribbean Colombia but comparable to Caribbean Costa Rica. In addition to presenting a comprehensive species list, we propose the synonymy of *Dictyota pfaffii* Schnetter with *D. friabilis* Setchell and *D. jamaicensis* W. R. Taylor with *D. crenulata* J. Agardh and discuss other taxonomic problems regarding the Caribbean Dictyotales.

Introduction

The brown algae of the Republic of Panama have been poorly documented to date, primarily due to a paucity of floristic studies in the country. Historical collections are limited, and where available, they are generally poorly resolved taxonomically making estimates of species diversity difficult to ascertain from lists of archived specimens. Only 20 species of benthic brown algae have been recorded from Caribbean Panama (Earle 1972), whereas neighboring Costa Rica (Soto and Ballantine 1986) and Colombia (Schnetter 1976, Bula-Meyer 1998) host twice and three times the brown algal diversity, respectively.

In 1999, an intensive 10-month sampling program was undertaken to document macroalgal diversity for the Republic of Panama. Nearly 55 hours were logged for SCUBA-diving collections at depths down to 35 m, in addition to extensive snorkeling and wading excursions. As part of an ongoing series of papers on the marine flora of Panama we provide an annotated list of the brown macroalgae encountered in 1999, including 16 species previously undocumented in the Panamanian marine flora, taxonomic revisions in *Dictyota* and notes regarding unique or anomalous features of Panamanian specimens. We include previous records of marine algae documented for the country so that this list serves as a comprehensive list of all marine Phaeophyceae documented for the Republic of Panama.

Annotated Species List

Collection localities and methods are being published separately (Wysor and Kooistra unpublished). The list below follows the taxonomic scheme of Wynne (1998). New records for the Republic of Panama are denoted with an *. Unless otherwise noted, type locality was determined by reference to Silva *et al.* (1996).

Ectocarpales

Ectocarpaceae

Ectocarpus sp. Other Panamanian records: Earle (1972).

Chordariales

Chordariaceae

Cladosiphon occidentalis Kylin. Type locality: Dry Tortugas, Florida, USA. Other Panamanian records: Taylor (1942) as *Aegira zosterae* (Mohr) Fries; Taylor (1960) as above.

Ralfsiaceae

Ralfsia sp. Other Panamanian records: Earle (1972).

Scytosiphonales

Chnoosporaceae

Chnoospora minima (K. Hering) Papenfuss. Type locality: Durban [Port Natal], South Africa. Other

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Panamanian records: Taylor (1929, 1942) as *C. pacifica* J. Agardh; Taylor (1960) as above.

Scytosiphonaceae

Colpomenia sinuosa (Roth) Derbès et Solier. Type locality: near Cádiz, Spain. Other Panamanian records: Taylor (1942, 1960).

**Rosenvingea intricata* (J. Agardh) Børgesen. Type locality: Veracruz, Mexico. Collections: BW-01419 Cayos Zapatillas, ~10 m.

Sphacelariales

Sphacelariaceae

**Sphacelaria* sp. Collection: BW-01076 Isla Grande, tangled in *Digenea simplex* (Wulfen) C. Agardh from exposed bedrock along shoreline in breaking waves, < 1 m.

Dictyotales

Dictyotaceae

Dictyopteris delicatula Lamouroux. Type locality: Antilles, West Indies. Collections: BW-00024 Mainland, across from Isla Grande, reef slope, ~3–5 m, epizoid on coral and epiphytic on *Halimeda* sp.; BW-00041 ~11.4 km West of Portobelo, epiphytic on *Geli-diella* sp.; BW-00091 Fort Randolph, drifting over bottom, as a dense mat (~12 cm diameter), < 2 m; BW-00104 Sail Rock, unattached on bottom; BW-00164 Fort Randolph, unattached on bottom, ~1 m; BW-00939 Galeta E. lagoon and reef flat, unattached in sea grass bed; BW-01135 Long Bay Point; BW-01152 Long Bay Point. BW-01238 Long Bay Point, similar to BW-01152. Other Panamanian records: Taylor (1929) as *Neurocarpus delicatulus* (Lamouroux) Kuntze and *N. hauckianus* (Möbius) Kuntze; Taylor (1941, 1960) as above.

Dictyopteris delicatula is morphologically virtually identical to *D. repens* (Okamura) Børgesen, a species described from the western Pacific that lacks submarginal veins. The value of the submarginal vein as a distinguishing feature of *D. delicatula* has been questioned (Tsuda 1972, Allender and Kraft 1983, Phillips 2000, N'Yeurt 2001), and studies of Indian Ocean specimens (De Clerck, unpublished) of *D. delicatula* and *D. repens* reinforce the lack of distinction between these species. Pending further research including a detailed comparison of reproductive structures, both taxa are maintained as distinct species. Although *D. delicatula* and *D. repens* appear to be present in the Indian and Pacific Oceans, *D. repens* has not been reported from the Caribbean Sea (Wynne 1998).

Specimens of Panamanian *D. delicatula* are quite variable in morphology, ranging from mats of divaricately branched specimens with short internodal

lengths and broad branching angles (Figs 1–2) to larger, upright forms that are less bushy in appearance due to longer internodal distances and narrower branching angles (Figs 3–4). The type specimen (Fig. 5), housed in the Lamouroux Herbarium (CN C9F16), conforms to the small, divaricate growth form. Axis width of some specimens (BW-01152, BW-01238) collected in the Bocas del Toro province is very narrow; however, the range in axis width (< 1.0–1.5 [2.0] mm) is within the range of axis width (1.0–3.0 mm) exhibited in the more typical looking specimens. Most specimens examined from this collection exhibit marginal thickenings (Figs 6–10) and are therefore consistent with the type description for this species (Fig. 5), with the exception of BW-00164 which possesses either no medullary cells or a single medullary cell internal to the cortical layers (Figs 7–8). Marginal thickenings in the elongate forms (BW-01152, BW-01238) are striking in the thickness of the cell walls (Figs 9–10). Superficially, the marginal thickenings resemble the central vein and are continuous along the entire thallus (Fig. 11). The number of cells that make up the marginal thickenings is slightly greater (7–9) than was observed in typical forms.

**Dictyopteris jamaicensis* W. R. Taylor. Type locality: Hellshire Hills, St. Catherine Parish, Jamaica (Taylor 1960). Collection: BW-01359 Cayos Zapatillas, exposed side of reef.

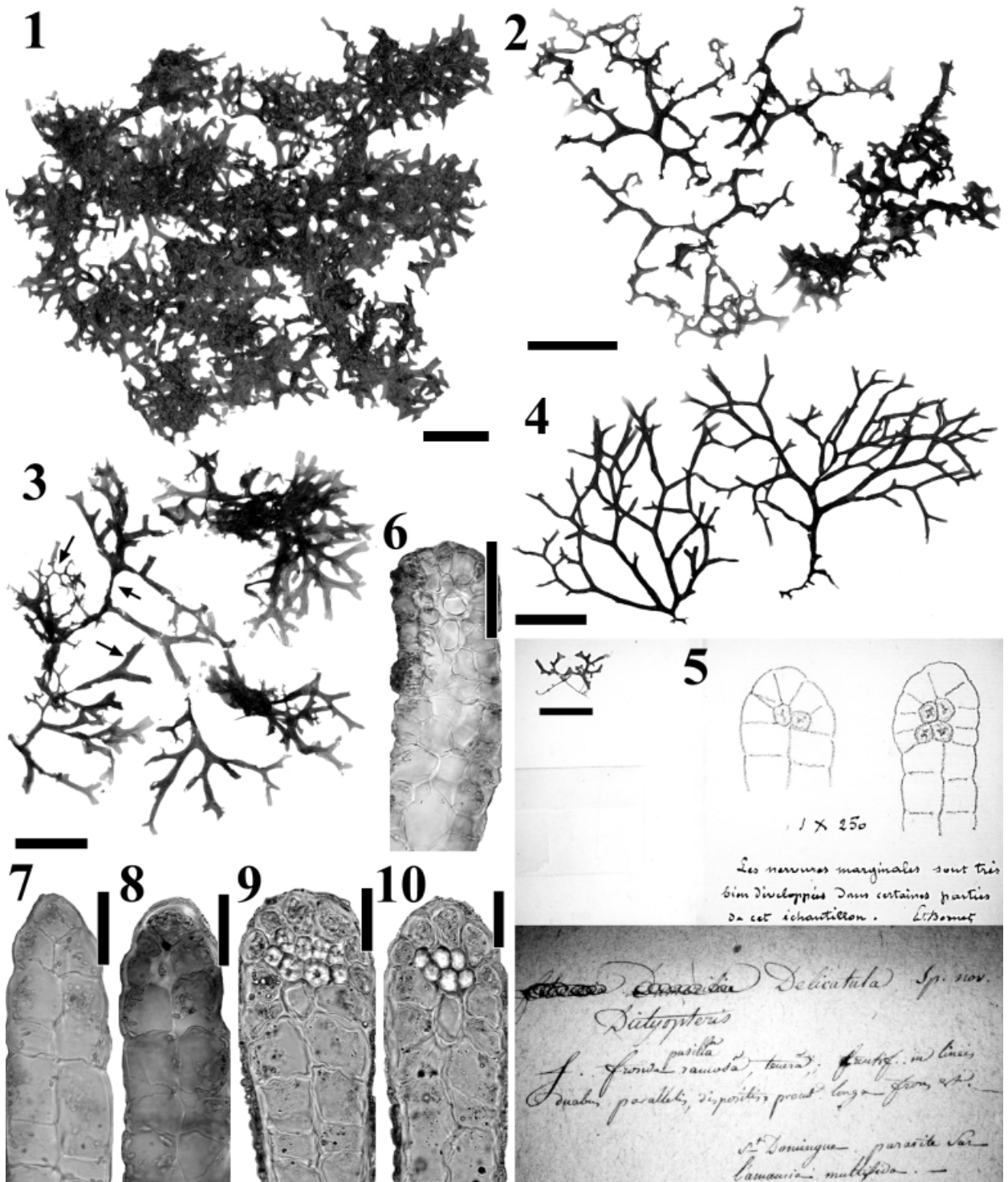
**Dictyopteris justii* Lamouroux. Type locality: Antilles (Index Nominum Algarum 2002). Collections: BW-01154 Long Bay Point, on hard substratum, ~10–12 m; BW-01184 Long Bay Point, on hard substratum, ~10–12 m; BW-01360 Cayos Zapatillas, exposed side of reef, 10–15 m.

Unlike other species of *Dictyopteris* collected in Panama, *D. justii* was often heavily epiphytized by encrusting and articulated coralline algae, as well as other turf-forming species. In some specimens, lush epiphytic growth almost entirely obscured the mid-vein.

Dictyopteris plagiogramma (Montagne) Vickers. Type locality: La Habana, Cuba. Other Panamanian records: Earle (1972) as '*D. plagiogrammus*' (Montagne) Vickers.

**Dictyopteris polypodioides* (de Candolle) Lamouroux. Type locality: "Mare Numidico" [Algeria]. Collections: BW-00283 Nautilus Dive Club, on coral, ~7 m; BW-01390 Cayos Zapatillas, on bay side of islets, on rock and coral rubble, ~1.5 m.

Dictyota bartayresiana Lamouroux. Type locality: Antilles, West Indies. Collections: BW-00147 Dog Island, on coral, ~5 m; BW-01112 near Knapps Hole, from sea grass bed near mangrove fringe; BW-01143 Long Bay Point; BW-01145 Long Bay Point, ~10–12 m; BW-01391 Cayos Zapatillas, on hard sub-



Figs 1–10. *Dictyopteris delicatula* Lamouroux.

Fig. 1. Matted morphology of specimen BW-00091 resulting from adventitious attachment of the lamina to each other. Fig. 2. Matted morphology of specimen BW-00041 that has been teased apart to show broad branching angles and relatively short internodes. Fig. 3. Specimen BW-00939 with longer internodes, narrower axes and more acute branch angles. Note the variability in axis width. Fig. 4. A narrow-bladed specimen with a very open branching system. Fig. 5. Type of *D. delicatula* from the Lamouroux Herbarium (CN C9F16) with illustrations of marginal thickenings. Fig. 6. Cross section through lamina margin of BW-00041 revealing a marginal thickening of 5 cells. Figs 7–8. Cross sections through lamina margin of BW-00164 showing no medullary cells (Fig. 7) or a single medullary cell (Fig. 8) between the cortical layers. Figs 9–10. Cross sections through lamina margin of BW-01238 revealing obvious marginal thickenings consisting of thick-walled cells very similar to those depicted by Lamouroux in his illustration of the type material (Fig. 5). Scale bars: Figs 1–5=2 cm; Figs 6–10=40 μ m.

stratum, < 2 m. Other Panamanian records: Taylor (1929, 1960) as *D. bartayresii* Lamouroux.

The taxonomic confusion between *D. bartayresiana* Lamouroux, *D. bartayresii* Lamouroux, *D.*

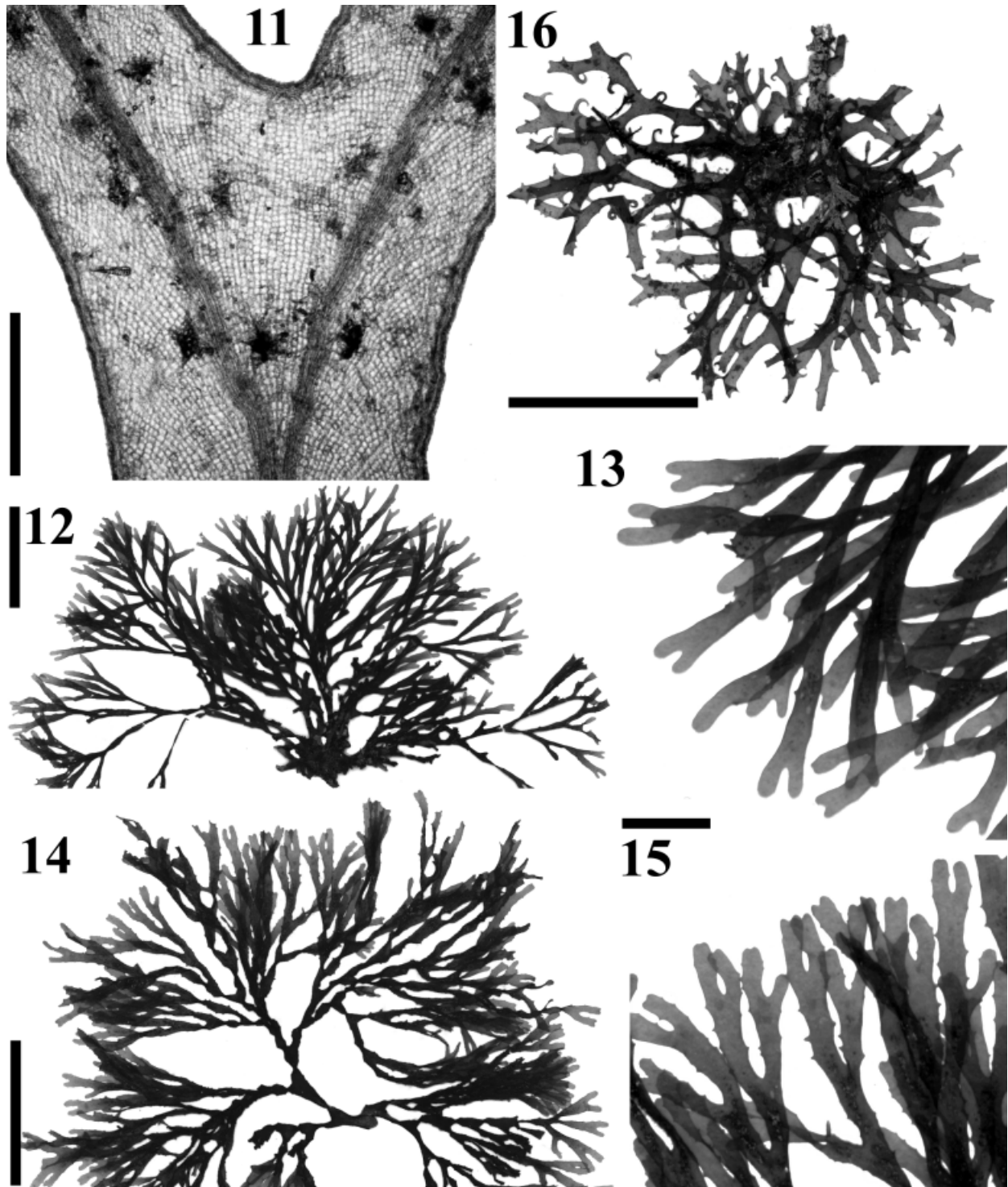


Fig. 11. *Dictyopteris delicatula* Lamouroux. Surface view of BW-01152 revealing obvious marginal thickenings that resemble the central vein in appearance (scale bar = 1 mm).

Figs 12–15. *Dictyota crenulata* J. Agardh.

Fig. 12–13. Habit (Fig. 12) and close up of branch tips (Fig. 13) of BW-00159 showing virtually no twisting in the axes and smooth margins that are rarely dentate. Fig. 14–15. Habit (Fig. 14) and close up of branch tips (Fig. 15) of BW-00160 showing highly twisted axes and dentate blade margins. The morphological distinction of these specimens is striking since they were growing in extremely close proximity (a few centimeters). Scale bars: Figs 12 and 14 = 2 cm; Figs 13 and 15 (same scale bar) = 0.5 cm.

Fig. 16. *Dictyota hamifera* Setchell (BW-01255). Habit of specimen showing characteristic hooks (scale bar = 2 cm).

crispata Lamouroux and *D. neglecta* Hörnig et Schnetter was resolved by De Clerck and Coppejans (1997). The initial concept of *Dictyota bartayresiana* Lamouroux (1809a,b), and also Taylor's (1960) concept, is that of a species with obtuse to rounded apices that lacks both surface proliferations and involucrate tetrasporangia. Specimens with apiculate apices, surface proliferations and involucrate sporangia, which in the past had often erroneously been named *D. bartayresiana* (Vickers 1908, Hörnig et al. 1992a,b) are referred to *D. crispata*.

**Dictyota caribaea* Hörnig et Schnetter. Type locality: Isla de San Andrés, Colombia (Hörnig et al. 1992b). Collections: BW-01354 Cayo Nancy Mangrove Key, 2–6 m; BW-01438 near Shepard Bank, on hard substratum, 10 m.

Easily confused with *D. cervicornis* Kützinger, this species lacks the involuclral cells guarding the sporangium. Although *D. cervicornis* may possess a wide divaricate branching angle (80–120°) in the distal parts of the thallus, branching is never 'cervicorn' in *D. caribaea*, rather the dichotomies are generally of equal length. Examination of the type material of *Dictyota cervicornis* f. *pseudobartayresii* W.R. Taylor (1928) in MICH (WRT989) showed that this taxon, which in a later publication by Taylor (1960) was relegated to synonymy with *D. bartayresiana*, is actually representative of *D. caribaea*. Despite the fact that the name *D. cervicornis* f. *pseudobartayresii* predates the description of *D. caribaea*, the existence of an earlier name of a different rank does not affect the proper usage of the latter (Greuter et al. 2000: art. 11.2).

The record *D. volubilis* sensu Vickers of Taylor (1929, 1960) is provisionally referred to *D. caribaea*. Hörnig et al. (1992b), in their revision of the genus *Dictyota* from the North Atlantic, stated that records of *D. caribaea* are most often referable to either *D. cervicornis* or *D. caribaea*. The descriptions and illustration of *D. volubilis* by Vickers (1908) are most representative of *D. caribaea*, hence (provisional) relegation of these records to the latter species.

Dictyota cervicornis Kützinger. Type locality: Key West, Florida, USA. Collections: BW-00027 Mainland, across from Isla Grande, on reef flat; BW-00028, Mainland, across from Isla Grande, on reef flat; BW-00042 ~11.4 km West of Portobelo; BW-00101 Sail Rock, on coral; BW-00148 Dog Island, on coral and in sand, ~10 m; BW-00149 Dog Island, on coral and in sand, ~10 m; BW-00165 Fort Randolph, in sand, ~3 m; BW-01111 near Knapps Hole, from sea grass bed along mangrove fringe.

Specimen BW-00027 has superficial (not marginal) proliferations and involucrate sporangia that are characteristic of the species *D. crispata* Lamouroux and *D. magneana* De Clerck et Coppejans. The three species are compared in detail by Coppejans et al. (2001). Other Panamanian records: Taylor (1929, 1942, 1960).

Dictyota ciliolata Sonder ex Kützinger. Type locality: La Guaira, Venezuela. Collections: BW-00026 Mainland, across from Isla Grande, on reef flat. BW-01144 Long Bay Point, on hard substratum, ~10–12 m; BW-01321 Barren Rock, on hard substratum.

Specimen BW-00026 lacks obvious marginal teeth typical of the species. Taylor (1960) notes, however, that particular scrutiny is needed to identify this species as marginal teeth are 'sometimes nearly completely absent.' Other Panamanian records: Taylor (1942, 1960).

**Dictyota crenulata* J. Agardh. Type locality: San Agustín, Oaxaca, Mexico. Collections: BW-00029 Mainland, across from Isla Grande, on reef crest in breaking waves; BW-00114 Sail Rock, on coral; BW-00143 Grass Island; BW-00159 Fort Randolph, on reef crest in breaking waves; BW-00159 Fort Randolph, on reef crest in breaking waves (Figs 12–13); BW-00160 Fort Randolph, on reef crest in breaking waves (Figs 14–15); BW-01140 Long Bay Point, on hard substratum, ~10–12 m.

The basis on which Taylor (1960) separated *D. jamaicensis* W. R. Taylor from *D. crenulata* has never been clear, and several authors have questioned the status of *D. jamaicensis* (Dawson 1962, Nizamuddin and Gerloff 1979, Hörnig et al. 1992b). Following the suggestion of these authors and after the examination of the respective type material in MICH and LD by the second author, *D. jamaicensis* W. R. Taylor is treated as a synonym of *D. crenulata*.

There seems to be tremendous variability with regard to dentition and twisting of the axes in the Panamanian material. Two specimens were especially noteworthy in this regard as they could be easily distinguished both in the field and in the laboratory. These specimens, BW-00159 (Figs 12–13) and BW-00160 (Figs 14–15), were found growing amongst each other in a dense patch on a reef crest. Specimen BW-00159 was originally identified as *D. ciliolata* var. *bermudensis* W. R. Taylor on the basis of its smoother margins (Fig. 13), slightly longer internodes and less twisted habit (Fig. 12). However, the distinction between *D. crenulata* and *D. ciliolata* var. *bermudensis* seems to be very obscure based on Taylor's (1960) description and illustrations. These taxa show clear overlap in many characters including 1–2 mm broad axes, dark color in the lower part of the axis, sparingly dentate margins and overall size (5–8 cm in *D. ciliolata* var. *bermudensis* vs. to 12 cm in *D. crenulata*).

In our opinion *D. ciliolata* var. *bermudensis* may represent a sparsely dentate growth form of *D. crenulata* rather than a growth form of *D. ciliolata*. Hörnig et al. (1992b) chose not to distinguish varieties in their key to the North Atlantic *Dictyota*, stating that there are very few instances in which a morphological variant is typical of a restricted region or environment, and in general variants are simply representative of the wide range of morphological variation

within species. Thus, the smooth margins of BW-00159 are arguably within the range of variability for this species. The differences between these two specimens could be considered marginal (i.e. insufficient to distinguish the specimens as distinct species), but given the proximity of the specimens (a few cm) the morphological distinction remains perplexing. Differences between BW-00160 and BW-00159 are not related to life history phase as both specimens are sporophytes with sporangia scattered across the blade surface. Despite close proximity, subtle factors such as the orientation of individuals relative to breaking waves (whether an individual is relatively more protected or more exposed) may explain differences in dentition or the degree of twisting in the axes. Age may also be a factor. Whether there is a genetic basis for the distinction of these taxa remains to be studied.

**Dictyota crispata* Lamouroux. Type locality: Antilles (Index Nominum Algarum 2002). Collections: BW-00085 epiphytic on *Udotea flabellum* (J. Ellis et Solander) Howe (BW-00082); BW-00195 Fort Randolph, on shell fragment over sand, 2–3 m.

Dictyota cuspidata Kützinger (1859), originally described from Vera Cruz, Mexico, is considered synonymous with *D. crispata*. The type specimen of the former (MEL 537267) represents a male gametophyte of which the paraphyses surrounding the antheridia are multicellular and pigmented. This character is highly diagnostic and has so far been observed only in *D. crispata* and the closely related *D. magneana* De Clerck et Coppejans (Coppejans et al. 2001).

**Dictyota friabilis* Setchell. Type locality: Tafaafu Point, Tahiti. Collection: BW-01309 Northeast of Canal de Bocas del Toro, on hard substrate, ~11–13 m.

This alga was generally known in the Caribbean Sea as *D. pfaffii* Schnetter (1972), which is here considered a synonym of *D. friabilis* Setchell. In the original description, and in a later publication, Schnetter (1972, 1976) stated that *D. pfaffii* is very similar to *D. friabilis* described from the Pacific Ocean, including the anastomosing habit, but that it differed with respect to rounded versus pointed apices and the lack versus presence of involucrate sporangia, hereby referring to Jaasund's (1970) description of *D. friabilis*. De Clerck and Coppejans (1999), however, showed that Jaasund's interpretation of the latter is erroneous after comparison to the type from Tahiti (UC 261252) and that the species referred to by Jaasund is actually *D. crispata*. Comparison of specimens from the Caribbean Sea and the Indo-Pacific, respectively, revealed no further differences that would allow the recognition of two separate species. Along with the conspecificity of *D. pfaffii* and *D. friabilis*, Bula-Meyer (1994) suggested that *D. humifusa* Hörnig, Schnetter et Coppejans and *D. pfaffii* are conspecific. This is

contradicted, however, by De Clerck (1999) and Schnetter (pers. comm.).

**Dictyota hamifera* Setchell. Type locality: Tahiti (Index Nominum Algarum 2002). Collection: BW-01255 Sail rock, ~8–10 m.

This specimen was collected as an unattached fragment, but the characteristic hooks leave no doubt as to its identification (Fig. 16).

Dictyota mertensii (Martius) Kützinger. Type locality: Brazil (Index Nominum Algarum 2002). Collections: BW-00285 Nautilus Dive Club, on coral, ~3–5 m; BW-00732 Galeta, epiphytic on red alga, ~5 m; BW-01141 Long Bay Point, on hard substratum, ~10–12 m; BW-01323 Barren Rock, on hard substratum. Other Panamanian records: Taylor (1929, 1942, 1960) as *D. dentata* Lamouroux.

**Dictyota pinnatifida* Kützinger. Type locality: Antigua, Leeward Islands. Collections: BW-00144 Grass Island; BW-00969 Las Farallones; BW-00976 between Pedro Pelada and Punta Cacique; BW-01074 Isla Grande, on exposed bedrock along shoreline in breaking waves, < 1 m.

Dictyota pulchella Hörnig et Schnetter. Type locality: Punta La Loma, Magdalena, Colombia. Collections: BW-00119 Sail Rock; BW-01137 Long Bay Point, in small tufts, ~10–12 m; BW-01237 Long Bay Point; BW-01278 Long Bay Point, ~15 m; BW-01325 Barren Rock, in small turfs; BW-01342 Cayo Nancy Mangrove Key, over seagrass, 1–4 m; BW-01424 Cayos Zapatillas, over sand, 10 m. Other Panamanian records: Taylor (1942, 1960) as *D. divaricata* Lamouroux.

Lobophora variegata (Lamouroux) Womersley ex E. C. Oliveira. Type locality: Antilles, West Indies. Collections: BW-00124 Grass Island, on coral, ~5 m; BW-00128 Grass Island, on coral, ~5 m; BW-00146 Dog Island, on coral, ~13 m; BW-00281 Nautilus Dive Club, on coral, 2–4 m; BW-00700 Pelican Island, on dead coral, ~5–7 m; BW-00722 Galeta, on coral, ~7 m; BW-00819 Galeta, on coral, ~6–8 m; BW-01087 Peninsula Valiente; BW-01149 Long Bay Point, on hard substratum, ~10–12 m; BW-01220 Long Bay Point, on hard substratum, ~8–10 m; BW-01234 Long Bay Point, on hard substratum, ~8–10 m. Other Panamanian records: Taylor (1929) as *Zonaria variegata* (Lamouroux) C. Agardh and in Taylor (1960) as *Pocockiella variegata* (Lamouroux) Papenfuss.

Padina boergesenii Allender et Kraft. Type locality: Virgin Islands. Collections: BW-00086 Fort Randolph, in sand; BW-00118 Sail Rock, in sand, < 0.5 m; BW-00196 Fort Randolph, epiphytic on *Halimeda opuntia* (Linnaeus) Lamouroux, ~2 m; BW-01392 Cayos Zapatillas, in drift near shoreline of center islet. Other Panamanian records: Taylor (1960) as *P. gymnospora* (Allender and Kraft 1983, Wynne 1998).

Padina gymnospora (Kützing) Sonder. Type locality: St. Thomas, Virgin Islands. Collection: BW-01316 Barren Rock, on rock, ~5 m.

This specimen is sterile, making it difficult to identify it with certainty. There are 6 cell layers at the base of the thallus and 3–4 in the mid-upper region, which is characteristic of both *P. gymnospora* and *P. antillarum* (Kützing) Piccone (Wynne and De Clerck 1999). The calcification, although minor, is heavier than is typical of *P. antillarum*. Other Panamanian records: Taylor (1942, 1960); Taylor (1929, 1942, 1960) also documented *P. vickersiae* Hoyt, which is considered conspecific with *P. gymnospora* (Allender and Kraft 1983, Wynne 1998).

**Padina sanctae-crucis* Børgesen. Type locality: St. Croix, Virgin Islands. Collections: BW-00025 Mainland, across from Isla Grande, on hard substratum buried in sand, amid seagrass on reef flat; BW-00051 Buena Ventura, in muddy sand; BW-00112 Sail Rock, in sand; BW-01073 Isla Grande, on exposed bedrock along shoreline, in breaking waves, < 1 m.

Spatoglossum schroederi (C. Agardh) Kützing. Type locality: Brazil. Collection: BW-00821 Galeta, on coral. BW-00957 Galeta, on dead coral, ~7–9 m; BW-01147 Long Bay Point, on hard substratum, ~10–12 m; BW-01168 Long Bay Point, on hard substratum, ~10–12 m. Other Panamanian records: Taylor (1929, 1960).

Styopodium zonale (Lamouroux) Papenfuss. Type locality: Dominican Republic. Collection: BW-00142 Grass Island, unattached over sand in 2 m water; BW-00282 Nautilus Dive Club, in drift; BW-00967 North of Pedro Pelada, attached to rock and in drift bank, ~10–15 m; BW-01066 Isla Grande, on dead coral, ~2 m. Other Panamanian records: Taylor (1929) as *Zonaria zonalis* (Lamouroux) Howe; Taylor (1960) as above.

Fucales

Sargassaceae

**Sargassum filipendula* C. Agardh. Type locality: West Indies. Collections: BW-00968 Between Pedro Pelada and Punta Cacique, on vertical face of rock, ~10–12 m; BW-00970 Las Farallones, on vertical face of rock, ~12–15 m; BW-01067 Isla Grande, drift material on sand shore of southwestern cove; BW-01241 Long Bay Point, drift material collected from open water near shore.

The distribution of this species is reportedly from Connecticut to the Florida Keys, and continuous to Tampa Bay in the Gulf of Mexico, where it is replaced by an endemic species, *S. mathiesonii* Kilar (N. Phillips, pers. comm.). Littler and Littler (2000) listed a much broader distribution throughout the Caribbean, and these records further support a broad distribution of this species.

Sargassum fluitans (Børgesen) Børgesen. Type locality: Sargasso Sea. Other Panamanian records: Taylor (1941, 1942, 1960).

**Sargassum hystrix* J. Agardh. Type locality: Campeche, Mexico (Index Nominum Algarum 2002). Collections: BW-00031 Mainland, across from Isla Grande, on reef crest in breaking waves; BW-00772 Galeta, on reef flat; BW-00949 Galeta, on reef flat in breaking waves.

**Sargassum platycarpum* Montagne. Type locality: Martinique (Index Nominum Algarum 2002). Collections: BW-00701 Pelican Island, in drift; BW-01444 off Porvenir Point, on dead coral, ~10 m.

Sargassum polyceratium Montagne. Type locality: La Havana, Cuba (Index Nominum Algarum 2002). Collections: BW-00079 Fort Randolph, on rocks in 0.5 m water at water's edge; BW-00080 Fort Randolph, on rocks in 0.5 m water at water's edge; BW-00138 Grass Island; BW-01139 Long Bay Point; BW-01155 Long Bay Point, on hard substratum, ~10–12 m. Other Panamanian records: Taylor (1941, 1942, 1960).

Sargassum sp. Collection: BW-01450 Hospital Bight mangrove fringe, on rock, < 1 m.

The identification of this specimen is questionable. Like much of the Panamanian *Sargassum*, the nearly complete lack of vesicles and reproductive receptacles hinders unequivocal determination. Blades bear an indistinct midrib and scattered cryptostomata and are further characterized by serrate margins, an asymmetrical base and slightly notched tips. These features, particularly the notched blade tips, and occasional spines on the primary axes and alternate branching are consistent with *S. vulgare* C. Agardh [an illegitimate taxon name (Silva *et al.* 1996)], but are also within the range of variability exhibited by *S. polyceratium*, one of the most highly polymorphic species of the genus (N. Phillips, pers. comm.). A Panamanian distribution for this species is not unexpected as it has been documented in nearby floras.

**Turbinaria turbinata* (Linnaeus) Kuntze. Type locality: Jamaica. Collections: BW-00030 Mainland, across from Isla Grande, from reef flat; BW-00139 Grass Island, in drift; BW-01068 Isla Grande, on exposed bedrock along shoreline, in breaking waves, < 1 m.

Discussion

Much of the brown algal diversity of the Caribbean coast of Panama has been overlooked historically. Earle (1972) listed 20 species of marine Phaeophyceae, and in the present list, 36 species are reported, 16 of which are new records for the country. The addition of these species represents an increase in known algal diversity of 80%. This increase can be attributed

to a variety of factors including poor historical documentation, intensive sampling over an extended period of time and the use of SCUBA diving to access subtidal habitats to depths of up to 35 m. The increase in known brown algal diversity is much less than that observed for the green algae of Caribbean Panama (~161%) (Wysor and Kooistra unpublished). Because collecting effort was the same for both groups, the difference is likely related to much lower diversity of tropical Phaeophyceae in general, and, in small part, also to the recognition of sub-specific diversity in the green algae.

While collections were made exhaustively from throughout the range of the Caribbean Panama coastline, they were limited to fairly discrete areas in

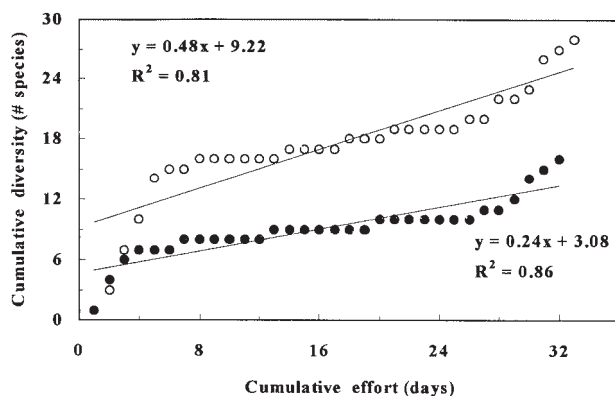


Fig. 17. Cumulative species count versus cumulative collecting effort. The number of brown algal species (filled circles) and the number of new brown algal species records for Panama (open circles) not previously encountered over the course of sampling is plotted against the cumulative collecting effort. The equation of a linear regression line through each data set reveals a mediocre fit ($R^2=0.81$ and 0.86 , respectively for species and new records). The slopes of the regression lines indicate that on each day of collection 0.48 species previously not encountered in our sampling were discovered and that half of these represented new records for Panama. The greater slope over the first and last four days of sampling reflects collecting in areas previously not visited.

which a number of different collection localities were sampled. Consequently, pockets of undiscovered macroalgal diversity may exist which can skew the current estimate of brown algal diversity. This scenario is revealed in Figure 17 in which cumulative species count is plotted against cumulative collecting effort. Unlike the relationship seen in the green algae of Caribbean Panama (Wysor and Kooistra unpublished), both the number of new brown algal species not previously encountered over the course of the sample period (filled circles) and the number of new brown algal records for Caribbean Panama (open circles) appeared to reach a threshold level until the final days of collecting. Collections made in the Bocas del Toro province are responsible for this surge in diversity. Thus, it appears that brown macroalgal diversity may be approaching a threshold value for central Panama but continued investigations throughout the rest of the country may continue to contribute new records.

Relatively few small species are recorded in this updated list, such as members of the Ectocarpales and Sphacelariales (for example), and Table I reveals that there are still many species known from nearby Caribbean marine floras that are not yet known for Panama's marine flora. In particular, neighboring Colombia hosts nearly twice as many brown algal species as reported here. While many of the unreported species are in fact smaller species (e.g. *Bachelotia*, *Feldmannia*, *Hinckesia*, *Ectocarpus*), there are also numerous larger-sized species such as *Padina pavonica* (Linnaeus) Thivy in W. R. Taylor, *Sargassum* spp., *Sporochnus pedunculatus* (Hudson) C. Agardh and *Turbinaria tricosata* (Linnaeus) Kuntze (among others) that are not recorded for the Caribbean flora of Panama. These larger species may be genuinely absent from the flora, or they may simply have failed to be detected. Future investigation of the marine flora of Panama will surely result in new additions, especially when seasonality in macroalgal distribution is considered and careful study of smaller species is undertaken.

Table I. Documented brown algal diversity of selected countries bordering the Caribbean Sea.

| Country | Number of Phaeophyceae | Number not represented in the flora of Panama | Source |
|-------------|------------------------|---|-----------------------------|
| Puerto Rico | 63 | 35 | Ballantine and Aponte 1997 |
| Colombia | 62 | No list available | Bula-Meyer 1998 |
| Costa Rica | 40 | 15 | Soto and Ballantine 1986 |
| Panama | 36 | — | This study |
| Belize | 23 | 8 | Littler and Littler 1997 |
| Honduras | 19 | 3 | Ogden 1998 |
| Nicaragua | 16 | 3 | Phillips <i>et al.</i> 1982 |

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