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Notes on marine algae in the International Biosphere Reserve Seaflower, Caribbean Colombia, VII: Additions to the benthic flora of San Andrés Island

Notas sobre las algas marinas de la Reserva Internacional de Biosfera Seaflower, Caribe Colombiano, VII: adiciones a la flora bentónica de la isla de San Andrés

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ABSTRACT
Ten species of red macroalgae are newly reported for the Seaflower International Biosphere Reserve in the Caribbean Sea. Of these taxa, four have been previously reported for the Colombian Caribbean: *Dohrniella antillarum, Halydictyon mirabile, Taenioma nanum*, and *Aglaothamnion cordatum*. The remaining six species are new records for the country: *Callithamniella tingitana, Frikkiella searlesii, Lejolisia exposita, Melanothamnus gorgoniae, Monosporus indicus*, and *Wrangelia gordoniae*. The algal material was collected in coral reef habitats (9–17 m depth), and all species but one are diminutive algae growing mostly on coral rubble or as epiphytes on larger algae. Their morphological features are discussed.

Key Words. Caribbean, Colombia, *Frikkiella*, red algae, *Wrangelia, Callithamniella, Lejolisia, Melanothamnus, Monosporus*.

RESUMEN
Se presentan diez nuevos reportes de especies de macroalgas rojas para la Reserva Internacional de la Biosfera Seaflower en el Mar Caribe. Cuatro taxones fueron previamente citados para el Caribe colombiano: *Dohrniella antillarum, Halydictyon mirabile, Taenioma nanum* y *Aglaothamnion cordatum*. Las restantes seis especies son nuevos registros para el país: *Callithamniella tingitana, Frikkiella searlesii, Lejolisia exposita, Melanothamnus gorgoniae, Monosporus indicus* y *Wrangelia gordoniae*. Todas las algas fueron colectadas en hábitat de arrecife coralino (9–17 m de profundidad), y todas las especies menos una son algas de tamaño diminuto, creciendo principalmente sobre coral muerto o como epifitas de algas más grandes. Se discuten las características morfológicas y reproductivas de cada especie, así como las novedades de su distribución.

Palabras Clave. Algas rojas, Caribe, Colombia, *Frikkiella, Wrangelia, Callithamniella, Lejolisia, Melanothamnus, Monosporus*.

INTRODUCTION

San Andres Island is part of the International Biosphere Reserve Seaflower, one of the largest marine reserves in the world (CORALINA-INVEMAR 2012); however, the marine flora of the island has historically received little attention (Albis-Salas and Gavio 2011). Recently, collections of macroalgae have been undertaken in the whole archipelago, revealing a flora much more diverse than previously appreciated (Albis-Salas and Gavio 2011, Ortiz and Gavio 2012, Reyes-Gómez *et al*. 2013, Gavio *et al*. 2013, Barrera *et al*. 2016, Reyes-Gómez and Gavio 2017).

In 2003, Díaz-Pulido and Díaz-Ruiz presented an updated list of macroalgae for the Caribbean coast of Colombia, including a total of 565 taxa, 201 of which were reported for the Archipelago of San Andres, Old Providence, and Santa Catalina. From 2011 to date, phycological studies have been resumed in the archipelago: Albis-Salas and Gavio (2011) included six new records of red epiphytic algae, growing over *Thalassia testudinum* K.D. Koenig. Ortíz and Gavio (2012) listed 80 macroalgae species, reporting 23 as new records, 17 for the archipelago and six for Colombia. Reyes-Gómez *et al*. (2013) recorded seven species of Cyanobacteria, of which five were new records for Colombia. Additionally, Gavio *et al*. (2013) described a new species for science, *Crouania pumila* B. Gavio, V.P. Reyes-Gómez & M.J. Wynne, which was found in samples taken at different coastal ecosystems of the archipelago. Rincón-Díaz *et al*. (2014) reported a new record of the red alga for Colombia, *Ceramium bisporum* D.L. Ballantine, exhibiting variation in reproductive structures from the original description.

Vega-Sequeda *et al*. (2015) explored the northernmost ocean reef complex of Colombian Caribbean: Bajo Alicia cay (Joint Regime Area between Colombia and Jamaica) and Serranilla cay, where they made rapid ecological evaluations to determine the composition and abundance of the most representative groups of marine biota. For the macroalgae, they recorded 16 species of brown algae, 22 of green algae, and 23 of red algae, and several cyanobacterial morphotypes. Their results included seven new records for Colombia and for the International Reserve Seaflower: *Caulerpa lanuginosa* J. Agardh, *Caulerpa paspaloides* var. *laxa* Weber-van Bosse, *Jania cubensis* Montagne ex Kützing, *Gracilaria cornea* J. Agardh, *Chamaedoris peniculum* (J. Ellis and Solander) Kuntze, *Cladophora prolifera* (Roth) Kützing, and *Hydrolithon chamaedoris* (Foslie and M. Howe) M.J. Wynne.

Gavio *et al*. (2015) published a list of species collected in the northern key of the archipelago, specifically at Quitasueño, also known as Queena Reef. A total of 75 taxa were listed: 14 were new records for Colombia and nine new records for the archipelago. Albis-Salas and Gavio (2015) reported nine species as new records for the Archipelago, all found growing as epiphytes on *Thalassia testudinum*.

Rincón-Díaz *et al*. (2016) found as a new record for the Western Atlantic the species *Griffithsia capitata* Børgesen, originally reported exclusively from Macaronesia. Barrera *et al*. (2016), exploring the intertidal rocky shore habitats associated with the mollusk *Cittarium pica* (Linneaus, 1758) on San Andrés Island, reported 25 new records, 16 for Colombia and nine for the Archipelago. Finally, Reyes-Gómez and Gavio (2017) reported two new records of brown algae for Old Providence Island.

To date, the list of species of seaweed registered for the archipelago includes a total of 303 taxa. Most of these species are small filaments or filiform in morphology and difficult to detect and to identify, although they appear abundant and are epiphytes of

larger algae or seagrasses. These findings reveal the high diversity of benthic flora in the Archipelago and the need to continue exploring for them.

To complete the biodiversity study of the International Biosphere Reserve Seaflower, we discuss our recent findings on 10 species, four of which are new records for the Archipelago and the other six new for the Colombian Caribbean.

MATERIALS AND METHODS

San Andrés (12°28' North; 81°40' West) is an oceanic island of coral origin located in the southwestern Caribbean, Colombia (Fig. 1). The island has, on the eastern side, a barrier reef running parallel to the coast, which encloses a shallow lagoon. The western side is characterized by two submerged terraces, parallel to the coastline: one terrace is shallow (4–10 m depth), while the second is deeper (10–20 m depth) (Chaves-Fonnegra *et al*. 2007). All the specimens were collected randomly by SCUBA diving over the coral reef formations on the western side of the island, at the localities "Wild Life" (12°30'30" North; 81°43'45" West) and "Green Moon" (12°29'07" North; 81°44'01" West), at depths ranging from 9–17 m. This sector is characterized by a reef terrace with coral mat formations starting at a depth of 9 m, characterized by high species diversity of corals, sponges, octocorals, and algae (Díaz *et al*. 2000).

Sampling was carried out during the rainy (from November 2012 to January 2013 and June 2013 to August 2013) and dry season (from February 2013 to May 2013). The algae were collected by hand and then preserved in a 4 % formalin/seawater solution. In the laboratory, algae were identified using an OLYMPUS BX51 optical microscope (Olympus, Tokyo, Japan) with specific literature for species identification such as Taylor (1960), Littler and Littler 2000, and Dawes and Mathieson 2008). Slide material was mounted in 50 % glycerin, with previous staining in aniline-blue solution. All specimens were deposited in COL, the Herbarium of the Universidad Nacional de Colombia. Information on type localities and nomenclature was obtained from Dr. Paul C. Silva's Index Nominum Algarum (Silva c2017) and AlgaeBase (Guiry and Guiry c2017).

Figure 1. San Andrés Island with sampling sites. Wild Life (12°30'30" North; 81°43'45" West). Green Moon (12°29 07" North; 81°44′01" West).

RESULTS AND DISCUSSION

We listed and commented on a total of 10 new records of red algae found attached to coral rubble or epiphytic on larger algae. *Callithamniella tingitana, Frikkiella searlesii, Lejolisia exposita, Melanothamnus gorgoniae, Monosporus indicus,* and *Wrangelia gordoniae* are new records for Colombia (**). *Dohrniella antillarum, Halydictyon mirabile, Taenioma nanum*, and

Aglaothamnion cordatum are new records for the archipelago (*).

RHODOPHYTA

Order Ceramiales
Family Callithamniaceae
Aglaothamnion cordatum* (Børgesen) Feldmann-Mazoyer **Figs 2a-b**
Type locality: Virgin Islands, Caribbean Sea.

Specimens observed: San Andrés Island: Wild Life: 02/IX/2012, depth 13 m; 22/I/2013, depth 17 m; 4/IV/2013, depth 13 m; 7/VI/2013, depth 10 m; 09/VIII/2013, depth 10 m. Green Moon: 6/II/2013, depth 12 m; 2/IV/2013, depth 9 m. All specimens were in a vegetative stage. Specimen collected at Green Moon, 6/II/2013, deposited at COL (COL 602242).

Thallus filamentous, erect, delicate (Fig. 2a), up to 5 cm high; uniseriate main axes ecorticate throughout, attached to the substrate by descending multicellular rhizoidal filaments (Fig. 2b). Main axis 50–110 μm in diameter, tapering distally; cells 180–250 μm long (Fig. 2a). Branchlets alternate and radial, composed of cells 15–20 μm in diameter and up to 125 μm long. Apical cells of secondary branchlets are longer and obtuse, 4 μm in diameter and 7.5 μm in length, and basal cell 50 μm diameter and 120 μm in length. Basal portion formed by multicellular rhizoids with haptera (Fig. 2b). No reproductive structures were observed. All specimens were found growing as epiphytes on *Canistrocarpus cervicornis* (Kützing) De Paula et De Clerck, *Dictyota pulchella* Hörnig et Schnetter, *Lobophora variegata* (J.V. Lamouroux) Womersley ex E.C. Oliveira, and *Halimeda opuntia* (Linnaeus) J.V. Lamouroux.

Remarks: To date, there are 28 species of *Aglaothamnion* taxonomically accepted (Guiry and Guiry c2017). Most species are

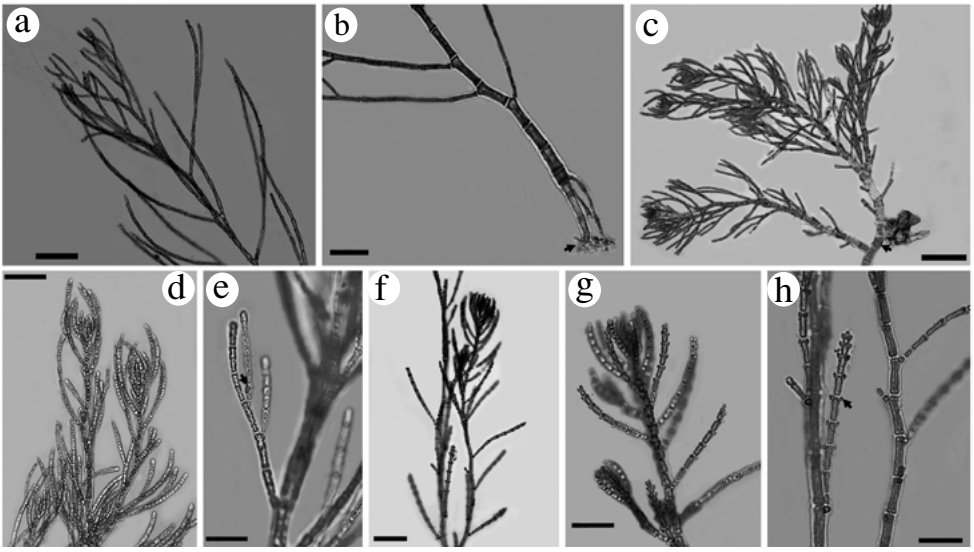


Figure 2. Habit of species reported from the International Biosphere Reserve Seaflower. ***Aglaothamnion cordatum*: a.** Principal branches, **b.** Detail of rhizoids with haptera (arrowhead). ***Callithamniella tingitana*: c.** Habit with detail of prostrate axis and multicellular rhizoids (arrowhead). **d.** Erect and alternate branches bearing glandular cells, **e.** Detail of glandular cells (arrowhead) located in the last dichotomy of the branches. ***Dohrniella antillarum***: **f.** Habit and detail of erect axes, **g.** Main branch bear alternately decumbent branchlets with papilliform cells (arrowhead). **h.** Detail of basal cells of branches and papilliform cells. Scale bar: a, b, c and f = 200 μm; d, g and h= 100 μm; e= 50 μm.

differentiated by the presence or absence of rhizoidal cortication, the branchlet disposition and the shape of carposporophytes. In the tropical and subtropical Western Atlantic, there are 11 recognized species of *Aglaothamnion* (Wynne 2017). *Aglaothamnion collinsii* Aponte, Ballantine & Norris, *A. felipponei* Aponte, Ballantine & Norris, *A. herveyi* (Howe) Aponte, Ballantine & Norris and *A. priceanum* Maggs, Guiry & Rueness are easily distinguishable from our specimen because they are corticated. *A. gallicum, A. halliae* (Collins) Aponte, Ballantine & Norris, *A. roseum* (Roth) Maggs & L'Hardy-Halos and *A. uruguayense* (W. R. Taylor) N. E. Aponte, D. L. Ballantine & J. N. Norris have distichous branching, while our specimen has radially distributed branchlets. We can also discard *A. boergesenii* (Aponte & Ballantine) L'Hardy-Halos & Rueness because of its coarser habit: according to the original description (Aponte and Ballantine 1990, as *Callithamnion boergesenii*) the main axis is 160–220 μm in diameter, while our specimens are in the range of 50–110 μm in diameter.

The remaining species, *A. cordatum* and *A. flexibile* (Collins) Aponte, Ballantine & Norris share many characters. However, they are easily distinguishable by the shape of carposporophytes, and the overall shape of the apices, which are distinctly flat topped in *A. flexibile* and pyramidal in *A. cordatum*. In the absence of reproductive structures, the apex outline in our specimens fits the description of *A. cordatum*. The species has been previously reported for the continental coast of Colombia, for the National Natural Park Tayrona (near the town of Santa Marta) and for the Darien region, close to the border with Panama.

Family Ceramiaceae
Callithamniella tingitana** (Schousboe ex Bornet) Feldmann-Mazoyer **Figs 2c-e**
Type locality: Tangier, Morocco.

Specimens observed: San Andrés Island: Green Moon: 12/VIII/2013, depth 12 m, vegetative specimen.

Very small algae (up to 1 mm), epiphytic on *Halimeda tuna* (J. Ellis & Solander) J.V Lamouroux. Branched thallus with prostrate and erect uniseriate axes (Fig. 2c). Prostrate axis consisting of cells that are 70–80 μm in diameter and 110–135 μm in length. From these cells originate either a rhizoid or an erect axis. Rhizoids are multicellular, with lobate haptera. The axial cells in the middle thallus are about 68 μm in diameter and 80 μm in length. Apical cells are 15–25 μm in diameter and 30–60 μm in length. Determinate erect axis with 1–2 orders of branches made up of cylindrical cells of 20 μm diameter at the base, and 50 μm long; these branches have dichotomous to pseudodichotomous divisions. Cells of the erect branches with 15 μm diameter at the apex and 25 μm long. Divisions of branches have small basal cells of 15 μm in diameter and 15 μm in length near the apex; these cells have a 6.5 μm diameter and a 7.5 μm in length (Fig. 2d). The specimens observed had few inconspicuous glandular cells that are usually located in the last dichotomy of the branches. These gland cells are 5–7 μm in diameter, are located at one end of the cells and are in contact with just one cell of the branch (Fig. 2e). No reproductive structures were observed.

Remarks: The genus *Callithamniella* was described by Feldmann-Mazoyer (1938), based on the species *Callithamnion tingitana* Schousboe ex Bornet (1892). Later, Feldmann-Mazoyer (1941) provided a more detailed description, depicting the creeping axes giving rise to erect axes, on which pedicellate tetrasporangia were produced. Accounts of this species have also been given by Schneider and Searles (1991) and by Dawes and Mathieson (2008) for material

occurring on the coasts of North Carolina and Florida, respectively. More recently, Secilla (2012) has described material of this species from the coast of Spain. In the specimens collected, the branches are simple or with a pseudo-dichotomy in the second or third cell from the base, do not exceed 500 µm and are composed of up to 20 cells, while for *Callithamniella flexilis* Baardseth, the thallus has simple branches, up to 1000 µm and composed of up to 30 cells.

Dohrniella antillarum* (W.R. Taylor) Feldmann-Mazoyer **Figs 2f-h**
Type locality: Baie Anglais, Aquin, Haiti.

Specimens observed: San Andrés Island: Green Moon: 2/IV/2012, depth 9 m, vegetative specimen.

Thallus delicate (2.5–3 mm high) attached to the substrate by multicellular rhizoids (Fig. 2f). Main branch erect, uniseriate, with basal cells up to 65 µm diameter, 130 µm long, tapering towards the apex (Fig. 2g). Cells in the middle part of the axis 34 µm in diameter, 62 µm in length, and at the apex, 25–30 µm in diameter, 30 µm in length. The main axis bears alternately decumbent branchlets, which are 500 to 600 µm long and have 1-2 elliptical papilliform cells (12 x 18 µm) located at distal cells of each branch (Fig. 2h). No reproductive structures were observed. Specimens epiphytic on *Dictyota* spp.

Remarks: the genus *Dohrniella* includes only three species: *D. neapolitana* Funk, *Dohrniella nana* Mayhoub, which are restricted to the Mediterranean basin, and *D. antillarum*, described from Haiti, in the Caribbean Sea, and reported for the tropical Western Atlantic and the Atlantic coast of Africa (Guiry and Guiry c2017). These algae are characterized by their small size, and the presence of papilliform cells, which is considered a characteristic of the genus (Mayhoub 1975). Our specimen can be easily distinguished from *D. nana* by the absence of unicellular rhizoids and from *D. neapolitana* by the absence of secretory cells (Mayhoub 1975). Due to its small size, it is easily overlooked. For the continental coast of Colombia, it has been previously reported for National Natural Park Tayrona and the Darien region (Díaz-Pulido and Díaz-Ruiz 2003).

Family Dasyaceae
Halydictyon mirabile* Zanardini **Figs. 3a-b.**
Type locality: Adriatic Sea.

Specimens observed: San Andrés Island: Green Moon: 6/II/2013, depth 12 m. 12/VIII/2013, depth 12 m. These were vegetative specimens. Specimen collected at Green Moon, 12/VIII/2013, deposited at COL (COL 602241).

Thallus soft, forming turfs like a mesh. Light-pink to pale-red branches. Uniseriate axes formed of cylindrical cells, branched, with branches fusing to form a mesh. The branchlets are 170 µm in diameter, cells up to 700 µm in length (Fig. 3a). The main axis is indistinct. At the apex, cells are rounded to semi-acute (Fig. 3b). Growing on *Canistrocarpus cervicornis* and *Halimeda tuna* (J. Ellis et Solander) J.V. Lamouroux, and attaching by small rhizoids.

Family Delesseriaceae
Frikkiella searlesii ** M.J. Wynne et C.W. Schneider **Figs. 3c-e.**
Type locality: Mona Island, Playa Carabinaro, Puerto Rico, Greater Antilles.

Specimens observed: San Andrés Island: Wild Life: Tetrasporic specimen, 4/IV/2013, depth 13 m; Spermatangial and tetrasporic specimens, 09/VIII/2013, depth 14 m; Cystocarpic specimens, 4/IV/2013, depth 13 m. Green Moon: Spermatangial specimen, 12/VIII/2013, depth 12 m. Specimens collected

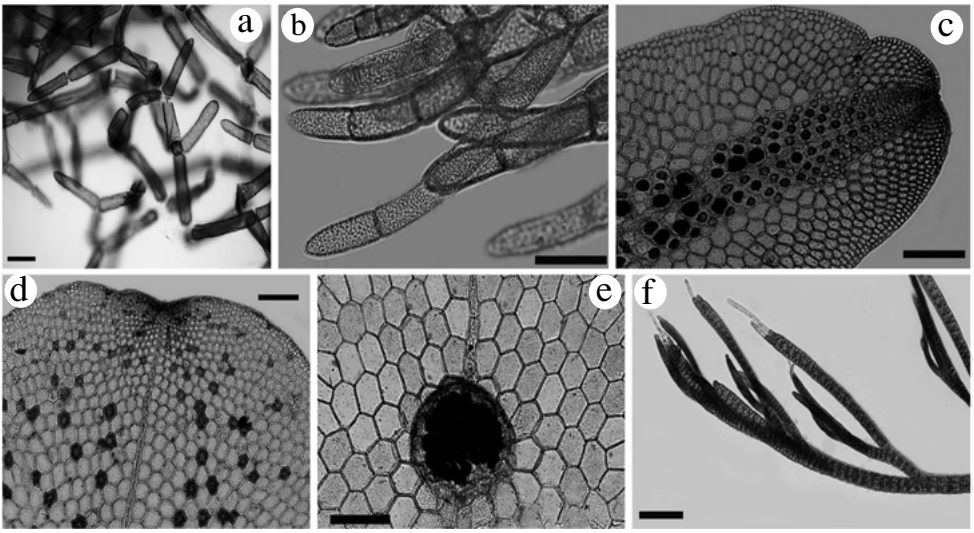


Figure 3. Habit of species reported from the International Biosphere Reserve Seaflower. ***Halydictyon mirabile*: a.** Filament branching in the center of thallus, **b.** Detail of filaments apex. ***Frikkiella searlesii:* c**. Blade with central tetrasporangial sori, **d**. Blade bearing spermatangial sori, **e.** Blade bearing a cystocarp. ***Taenioma nanum:* f.** Upper portion of blades with two monosiphonous "hairs" at apex. Scale bar: a, c, d, e and f= 200 µm; b = 100 µm.

at Wild Life, 09/VIII/2013, deposited at COL (COL 602237 and COL 602240).

Blades primarily monostromatic, 2–3 mm long and 1.5–2 mm wide. Cells of mature blades have pentagonal or hexagonal shapes in surface view (Fig. 3c), the blade arising from a short rhizoidal holdfast, and also exhibiting marginal multicellular rhizoids in some portions of the blades. Third-order rows of cells produced only from outer cells of second-order rows. Narrow tetrasporangial sorus in the center and distal region of the blade (Fig. 3c). Tetrasporangial tetrahedrally divided and to 70 µm diameter. Spermatangial sori scattered over the surface of blades (Fig. 3d). Cystocarps on the mid-line of 370–400 µm in diameter and 380–400 µm in length, with a ostiole measuring up to 100 µm in diameter (Fig. 3e).

Remarks: The genus *Frikkiella* was described by Wynne and Schneider (1996) based upon specimens from Bermuda and the Caribbean Sea (Bahamas, Puerto Rico and Martinique). It comprises two species: *Frikkiella searlesii* and *F. pseudoprostrata* (D.L. Ballantine and M.J. Wynne) M.J. Wynne and C.W. Schneider. They are easily distinguishable from one another by the arrangement of the tetrasporangial sori. Our tetrasporangial specimen fits well the description of *F. searlesii*. In the Caribbean Sea, this is the southernmost record of the species.

Taenioma nanum* (Kützing) Papenfuss
Fig. 3f
Type locality: Naples, Italy.

Specimens observed: San Andrés Island: Wild Life: 22/I/2013, depth 17 m; 4/IV/2013, depth 13 m; 07/VI/2013, depth 14 m. Green Moon: 6/II/2013, depth 12 m; 02/IV/2013, depth 9 m; 12/VIII/2013, depth 12 m. All the specimens were vegetative.

Thalli to 1 mm, creeping, observed growing over larger algae such as *Amphiroa tribulus*

(J. Ellis et Solander) J.V. Lamouroux, *Canistocarpus cervicornis, Lobophora variegata, Halimeda* spp., *Sphacelaria* sp., and the cyanophyte *Phormidium* sp. Often found as part of turf mats. Polysiphonous prostrate axes, with four pericentral cells; axes 60–80 µm in width, with uniseriate rhizoids of 13–20 µm in width. The apices of erect thalli have one apical cell or two apical hairs (Fig. 3f). No reproductive structures were observed.

Remarks: To date, there are only two recognized species of *Taenioma: Taenioma nanum* and *T. perpusillum* (J. Agardh) J. Agardh. The first species was described from the Mediterranean Sea and has been reported in most oceans, thus with a cosmopolitan distribution. In the Caribbean Sea, Taylor (1960) reported it as *T. macrourum*, which was later put in synonymy with *T. nanum. Taenioma perpusillum*, the type species, whose type locality is the Pacific coast of Mexico, has a cosmopolitan distribution similar to the former taxon, including the Caribbean Sea. The main characters to differentiate the two species is the number of hairs at the apex of the erect axes, which are one or two in *T. nanum* and three or more in *T. perpusillum*, and the number of segments of erect determinate branches, which range from eight to 20 in *T. nanum* and from 20 to 30 in *T. perpusillum*. Despite that some authors in the past have considered *T. nanum* and *T. perpusillum* to be conspecific (Hollenberg 1967, cited in Womersley 2003), at present the two taxa are recognized as separate. Our specimen fits well the description of *Taenioma nanum*.

Family Rhodomelaceae
Melanothamnus gorgoniae** (Harvey) Díaz-Tapia et Maggs **Figs 4a-d**
Type locality: Key West, Florida, USA.

Specimens observed: San Andrés Island: Wild Life: Cystocarpic, spermatangial, tetrasporic and vegetative specimens, 22/I/2013, depth 17 m; Cystocarpic specimens, 04/IV/2013, depth 13 m; Cystocarpic specimens, 7/VI/2013, depth 14 m; Cystocarpic specimens, 09/VIII/2013, depth 14 m. Green Moon: Tetrasporic specimens, 7/XII/2012, depth 10 m; Vegetative specimens and cystocarpic specimens, 6/II/2013, depth 12 m; Vegetative, tetrasporic and cystocarpic specimens, 2/IV/2013, depth 9 m; Cystocarpic and vegetative specimens, 05/VI/2013, depth 10 m; Vegetative specimens and cystocarpic specimens, 12/VIII/2013, depth 12 m. Cystocarpic specimen collected at Green Moon, 02/IV/2013, deposited at COL (COL 602236).

Epiphytic and erect plant up to 3 cm high, found growing on *Hypnea spinella* (C. Agardh) *Kützing, Dictyota* spp., *Coelothrix irregularis* (Harvey) Børgesen, *Halimeda tuna* and *Riphocephalus phoenix* f. *longifolius* A. Gepp et E. Gepp. Thalli with ecorticate segments and four pericentral cells. Main axes 135–150 µm in diameter comprised of segments 150–160 µm in length, fixed by a basal disc with unicellular rhizoids 450 µm length (Fig. 4a).Branchlets of 110 µm diameter and 120 µm length narrowed towards the apex. Scar cells occur one per segment. Apex with hair-like filaments dichotomously divided. Apical and spherical tetrasporangia spirally arranged up to 100 µm in diameter (Fig. 4b). Spermatangial branches up to 100 µm width and 300 µm long, with sterile cell at apex (Fig. 4c). Numerous dichotomically divided trichoblasts, up to 800 µm in length, of up to 10 cells in length, of 1–4 for each dichotomy. Cystocarps ovoid 250 µm in width, and 250 µm in length. Ostiole up to 130 µm long. Carpospores ovoid to 55–60 µm length and 25 µm with in the widest dimension (Fig. 4d).

Remarks: *Melanothanmus gorgoniae* was originally described as *Polysiphonia gorgoniae* (Harvey, 1853), with a type locality of Key West, Florida (USA). It was later transferred to *Neosiphonia* by

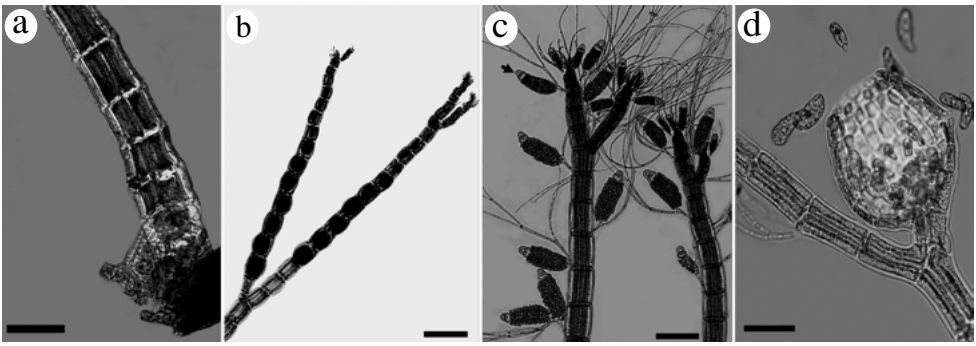


Figure 4. Habit of species reported from the International Biosphere Reserve Seaflower. ***Melanothamnus gorgoniae:*** **a.** Basal region of thallus on *Dictyota* sp., showing a disc of fixation with rhizoids, **b.** Tetrasporangial branches, **c.** Spermatangial branchlets having sterile cell at apex (arrowhead), and with many trichoblasts, **d.** Detail of cystocarp showing ostiole and carpospores. Scale bar: a, b and c = 200 µm; d = 100 µm.

Guimarães and Fujii (in Guimarães *et al*. 2004). Most recently, it was transferred to *Melanothamnus* by Díaz-Tapia and Maggs (in Díaz-Tapia *et al*. 2017), who provided both molecular and morphological evidence for their treatment.

This species is easily recognizable because it is the only entirely erect species of Polysiphonia-group in the area. Two other species of erect "*Polysiphonia*" are listed for the Caribbean Sea: *Polysiphonia binneyi* Harvey and *Melanothamus harveyi* Bailey Díaz-Tapia et Maggs. However, *Polysiphonia binneyi* differs from our species in that the branches arise in the axil of trichoblasts, while in *M. gorgoniae* they replace the trichoblasts (Schneider and Searles 1991); *M. harveyi* is corticated at the base, while our specimen is completely ecorticated. At this time, it is the only erect species in this "*Polysiphonia* complex" for the Archipiélago.

Family Wrangeliaceae

Lejolisia exposita** C.W. Schneider et Searles **Figs 5a, b**

Type locality: Onslow Bay, North Carolina, USA.

Specimens observed: San Andrés Island: Wild Life: Tetrasporic and vegetative specimens, 2/XI/2012, depth 13 m. Tetrasporic specimen collected at Wild Life, 02/XI/2012, deposited at COL (COL 602239).

Epiphytic plant, pinkish-red, spreading, with prostrate axes attached to the substrate by short unicellular rhizoids, with digitate ends, 20 µm long (Fig. 5a) placed distally in the cells of prostrate exes. Prostrate axes 20 µm in width, formed of rectangular cells in surface view, to 100 µm long. Erect axes scattered unbranched, to 1.5 mm high, placed in the middle of prostrate cells, 15–20 µm in width, cells to 55 µm long in the basal portion of the axis. Erect axes slightly tapering, apical cell 12.5 µm in diameter. Tetrasporangia ovoid, 40–45 µm in diameter, tetrahedrally divided, borne laterally on erect axes, or short lateral branches, 1–5 cells long (Fig. 5b). Gametangia not observed.

Remarks: Díaz-Pulido and Bula-Meyer (1997) reported *Lejolisia mediterranea* Bornet for the Archipelago of San Andres based on vegetative material. Although we lack cystocarpic material, the tetrasporangial specimens fit the description of *L. exposita* better than *L. mediterranea*. In his description, Bornet (1859) reported that tetrasporangia are formed only on the basal cell of the erect filaments for *L. mediterranea*

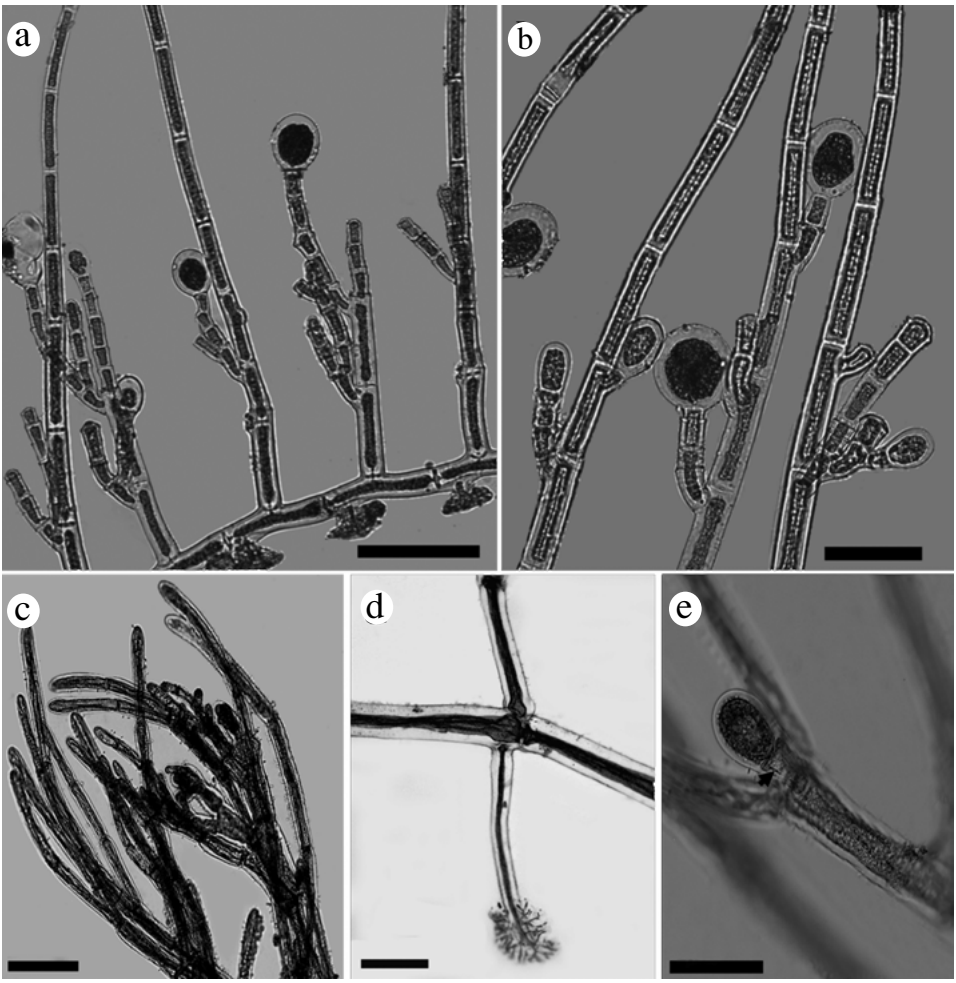


Figure 5. Habit of species reported from the International Biosphere Reserve *Seaflower*. ***Lejolisia exposita:*** **a.** Habit with ovoid tetrasporangia, tetrahedrally divided, borne laterally or terminally on erect axes, **b.** Detail of lateral tetrasporangia. ***Monosporus indicus:*** **c.** Detail of distal branchlets portion, **d.** Prostrate axis and unicellular rhizoid, **e.** Oval one-celled propagules attached by triangular pedicel (arrowhead). Scale bar: a and e = 100 µm; b = 50 µm; c and d = 200 µm.

and are borne on a one-cell pedicel (Bornet 1859, plate 1), while in *L. exposita* they are located in the basal and middle part of the erect filament (Searles and Schneider 1989), borne terminally on 1–4 cell branches (Searles and Schneider 1989, Figs 5a, b). Our specimen has terminal tetrasporangia on 1–5 celled branches, which may grow in the basal through middle part of the erect filaments (Fig. 5b). Considering that a previous report of *L. mediterranea* was based on vegetative material (Díaz-Pulido and Díaz-Ruíz 2003), we contend that the record of this species for Colombia is doubtful and propose to eliminate it from the Colombian marine flora.

Monosporus indicus** Børgesen **Figs 5c-e**
Type locality: Bombay, India.

Specimens observed: San Andrés Island: Wild Life: Vegetative specimen; 4/IV/2013, depth 13 m; Vegetative specimen, 7/VI/2013,

depth 14 m; Tetrasporic and vegetative specimen, 9/VIII/2013, depth 14 m. Green Moon: Vegetative specimen, 05/VI/2013, depth 10 m; Vegetative specimen, 12/VIII/2013, depth 12 m. Specimen collected at Wild Life, 09/VIII/2013, deposited at COL (COL 602238).

Thalli filamentous to 1 mm high, with prostrate and erect axes. Principal axes to 55–60 µm in diameter, and 400–450 µm in length, secondary axes 120–150 µm in diameter, and 550–600 µm in length (Fig. 5c). Unicellular rhizoids, up to 650 µm long, one per node, and with clawlike ends (Fig. 5d). Branched dorsally bearing erect axes with subdichotomously division at every node, up to 800–900 µm high, cells 50–150 µm in diameter, to 400 µm in length. Apical cells broadly rounded (Fig. 5c). Oval one-celled propagules to 100 µm in length and 30–60 µm in breadth attached by a triangular pedicel (Fig. 5e). No gametophytes observed.

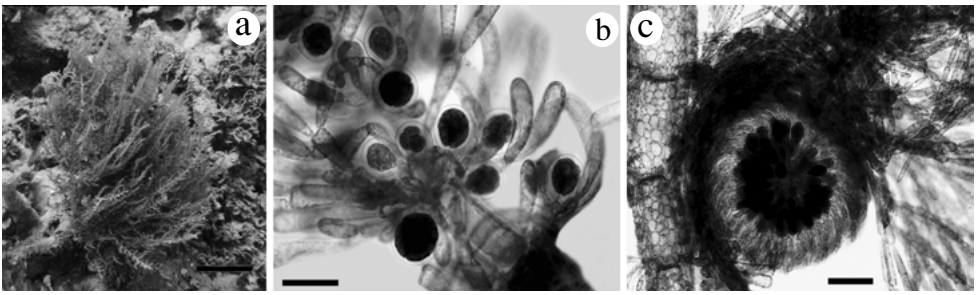
Remarks: *Monosporus* is a genus of red algae that produces one-celled propagules, and to date it accommodates five species (Guiry and Guiry c2017): *Monosporus belangeri* (Montagne) De Toni, *M. herpesticus* Vickers, *M. indicus, M. inkyui* G.H. Kim et D.-S. Choi, and *M. pedicellatus* (Smith) Solier. Three of these species are currently reported for the Caribbean Sea (Wynne 2017): *M. belangeri, M. herpesticus* and *M. indicus*. While the first two taxa have their type locality in the Caribbean basin (Martinique and Barbados, respectively), the latter was originally described by Børgesen (1931) from the Indian Ocean and was later reported from Australia (Huisman and Kraft 1982), the Caribbean (Bucher and Norris 1995, Ballantine and Aponte 1997, Delnatte and Wynne 2016) and Florida (Ballantine 1996). It is a widespread species reported for the Indian Ocean, the Western and Central Pacific Ocean (Abbott 1999, Lee and Kang 2001). It is also now known from the Mediterranean Sea, where it has been recently introduced (Hoffman and Wynne 2016). Our specimen fits well the description of the species. Similar to the situation for other species recently observed from Colombia (e.g. *Griffithsia capitata*, Rincon-Díaz *et al*. 2016), due to its small size, it is difficult to state if this taxon has always been part of the benthic flora of the Archipelago or if it is a recent introduction, either from other regions of the Caribbean Sea or elsewhere.

Wrangelia gordoniae** K.E. Bucher, D.L. Ballantine, C. Lozada-Troche and J.N. Norris **Figs 6a-c**

Type locality: on North Pinnacle, of a "seamount" off N end of San Salvador Is., Bahamas.

Specimens observed: San Andrés Island: Wild Life: Vegetative, female and tetrasporic specimens, 7/XI/2013, depth 14 m. Specimen collected at Wild Life, 07/XI/2013, deposited at COL (COL 602243).

Large erect alga, approximately 10–15 cm high (Fig. 6a). In its natural habitat it is red to pink and was found growing mainly on coral rubble. The main axis is completely corticated, 800 µm to 1 mm in diameter, and segments are 1.6 mm in length. Main axis bearing alternately corticated branches with 450–500 µm diameter, becoming smaller towards the apex. Each axial segment has alternate branches bearing whorled branchlets from the holdfast; these branchlets are not corticated and have dichotomous divisions, with rounded apical cells. Branchlets approximately 1–1.5 mm long; at the base, cells are 100 µm in length, and 20–25 µm in diameter; the apex is 170 µm long and 20 µm in diameter. Principal axis has 4–5 periaxial cells at the nodes. Tetrahedrally divided tetrasporangia occur in some of the branchlets, up to 50 µm diameter including the cell wall; these



Figures 6. Habit of species reported from the International Biosphere Reserve Seaflower. ***Wrangelia gordoniae:*** **a.** Habit *in situ*, **b.** Whorl branchlets bearing clusters of tetraedric tetrasporangia. **c.** Mature cystocarp. Scale bar: a = 4 cm; b = 100 μm; c = 200 μm.

sporangia were found usually surrounded by involucral cells (Fig. 6b). Apex of the alternate branches have cells with partial and external cortication, different as observed in the principal axis. Cortical cells of mature portions have varied and irregular forms with a diameter of 30–70 μm, and superimposed over and around cells of inner cortical layer, these cells with 150–170 μm diameter.

Some specimens were found with cystocarps (650–800 μm in diameter, Fig. 6c) terminating the branchlets. Carpospores are 80–100 μm in length, and 60–70 μm in diameter. Spermatangia were not observed.

Remarks: Our specimens of *Wrangelia gordoniae* fit well the description and can be assigned to the species. It is a large alga, especially when compared to other species of *Wrangelia*, which normally are smaller and turf-like. It is also distinguishable from other species of the genus for its thick cortication, which is several cells in thickness. This taxon has been described relatively recently, from material of Puerto Rico (Bucher *et al.* 2014). The authors mentioned that it is a widely distributed species in the Caribbean and that it may be a possible introduction to the Caribbean Sea, due to the fact that herbarium specimens belonging to the species date from 1977 or later. We agree with the observation of the authors because it is a relatively large alga, at least for the Archipelago of San Andres, and it is very unlikely the species has been overlooked. Before the present work, we never observed the alga, but now it is widespread at several locations, and there are unpublished observations of it from the continental coast of Colombia (in Cartagena Bay, Rincón-Díaz, pers. obs.). We speculate that the alga might have been introduced from a region poorly explored from a phycological point of view and therefore never reported. Bucher *et al.* (2014) indicated that the species was confused with *Wrangelia penicillata* (C. Agardh) C. Agardh in the past. In the Archipelago *W. penicillata* is present, but it never reaches the size of *W. gordoniae* and is much less corticated. It would be worthwhile to determine if this alga is an introduction or not because in the past few years a number of species have been newly reported to the Caribbean Sea (e.g., Rincón-Díaz *et al.* 2016), but their status (autochtonous or allochtonous to the Caribbean basin) is yet to be determined.

CONCLUSIONS

Most of the species reported in the present work are small and epiphytic. Considering that the area has been poorly studied in the past, it is difficult to determine whether these algae have always been part of the marine flora or have been recently introduced. *Wrangelia gordoniae* is the only conspicuous

species that we found in this study, and native fishermen and divers have said that they do not remember seeing this alga before (Jorge Sanchez, pers. comm.). Therefore, its presence in the Archipelago before this study is doubtful. All the other species, which are largely distributed in the Caribbean basin, were possibly overlooked. Turf algae are increasing in abundance on coral reefs worldwide (Swierts and Vermeij 2016), and turf algal assemblages, with a relatively high richness, are more resilient to competition with corals (Cetz-Navarro *et al.* 2015). Monitoring the composition, distribution and cover of turf assemblages at these sites should be improved, to determine their interactions with coral.

AUTHOR´S CONTRIBUTION

MNRD sampling, data processing and analysis, writing; BG sampling design, data processing and analysis, writing; MJW data analysis and writing; ASM sampling design, data analysis and financial support.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests.

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LITERATURE CITED

Abbott IA. 1999. Marine red algae of the Hawaiian Islands. Honolulu, Hawaii: Bishop Museum Press.

Albis-Salas M, Gavio B. 2011. Notes on marine algae in the International Biosphere Reserve Seaflower, Caribbean Colombian I: new records of macroalgal epiphytes on the seagrass *Thalassia testudinum*. Bot. Mar. 54:537–543.

Albis-Salas M, Gavio B. 2015. Notes on the marine algae of the International Biosphere Reserve Seaflower, Caribbean Colombia IV: New records of macroalgal epiphytes on the seagrass *Thalassia testudinum.* Bol. Investig. Mar. Costeras 44(1):55–70.

Aponte N.E, Ballantine D.L. 1990. The life history in culture of *Callithamnion boergesenii* sp. nov. (Ceramiaceae, Rhodophyta) from the Caribbean. Phycologia 29 (2): 191-199.

Athanasiadis A. 1996. Morphology and classification of the Ceramiodeae (Rhodophyta) based on phylogenetic principles. Opera Bot. 128:1–216.

Ballantine DL. 1996. New records of benthic marine algae from Florida. Gulf Mex. Sci. 1996(1):11–15.

Ballantine DL, Aponte NE. 1997. Notes on the benthic marine algae of Puerto Rico. VI. Additions to the flora. Bot. Mar. 40:39–44.

Barrera JC, Gavio B, Mancera JE. 2016. Macroalgas asociadas al hábitat del gasterópodo *Cittarium pica* (Linnaeus, 1758), en la isla de San Andrés, Colombia. In: Campos NH, Acero A, editores. Contribuciones en Ciencias del Mar de la Universidad Nacional de Colombia-2016. Santa Marta: CECIMAR, Sede Caribe, Universidad Nacional de Colombia. p. 15–27.

Børgesen F. 1931. Some Indian Rhodophyceae especially from the shores of the Presidency of Bombay. Bull. Misc. Inf. /Royal Botanic Gardens, Kew 1931(1):1–24. doi: 10.2307/4102583.

Bornet É. 1859. Description d'un nouveau genre de Floridées des côtes de France. Ann. Sci. Nat., Bot. sér. 4, 11:88–92, pls I, II.

Bornet É. 1892. Les algues de P.-K.-A. Schousboe, récoltées au Maroc & dans le Méditeranée de 1815 à 1819. Mém. Soc. Natl. Sci. Nat. Cherbourg 28:165–373, 3 pls.

Bucher KE, Norris-J N. 1995. Marine algae new to the Lesser Antilles, including *Mazoyerella kraftii* sp. nov. (Ceramiales, Rhodophyta). Caribb. J. Sci. 31:1–24.

Bucher KE, Ballantine DL, Lozada-Troche C, Norris JN. 2014. *Wrangelia gordoniae*, a new species of Rhodophyta (Ceramiales, Wrangeliacee) from the tropical western Atlantic. Bot. Mar. 57:265–280.

Cetz-Navarro NP, Quan-Young LI, Espinoza-Avalos J. 2015. Morphological and community changes of turf algae in competition with corals. Sci. Rep. 5:12814. doi: 10.1038/srep12814.

Chaves-Fonnegra A, Zea S, Gómez M L. 2007. Abundance of the excavating sponge *Cliona delitrix* in relation to sewage discharge at San Andrés Island, SW Caribbean, Colombia. Bol. Investig. Mar. Costeras 36:63–78.

CORALINA-INVEMAR 2012. Atlas de la Reserva de Biósfera Seaflower. Archipiélago de San Andrés, Providencia y Santa Catalina. Instituto de Investigaciones Marinas y Costeras "José Benito Vives De Andréis" (INVEMAR) and Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina (CORALINA). Serie de Publicaciones Especiales de INVEMAR # 28. Santa Marta, Colombia.

Dawes CJ, Mathieson AC. 2008. The seaweeds of Florida. Gainesville, FL, USA: University Press of Florida.

Delnatte C, Wynne MJ. 2016. Revised checklist of marine algae and seagrasses of Martinique, French West Indies. Nova Hedwigia 103:415–449.

Díaz JM, Barrios LM, Cendales MH, Garzón-Ferreira J, Geister J, López-Victoria M, Ospina GH, Parra-Velandia F, Pinzón J, Vargas-Angel B, Zapata FA, Zea S. 2000. Áreas coralinas de Colombia. Serie Publicaciones Especiales No. 5. Santa Marta: INVEMAR

Díaz-Pulido G, Bula-Meyer G. 1997. Marine algae from oceanic atolls in the Southwestern Caribbean (Albuquerque Cays, Courtown Cays, Serrana Bank and Roncador Bank). Atoll Res. Bull. 448:1–18.

Díaz-Pulido G, Díaz-Ruíz M. 2003. Diversity of benthic marine algae of the Colombian Atlantic. Biota Colomb. 5:203–246.

Díaz-Tapia P, McIvor L, Freshwater DW, Verbruggen H, Wynne MJ, Maggs CA. 2017. The genera *Melanothamnus* Bornet and Falkenberg and *Vertebrata* S.F. Gray constitute well-defined clades of the red algal tribe Polysiphoniaeae (Rhodomelaceae, Ceramiales). Eur. J. Phycol. 52:1–30.

Feldmann-Mazoyer G. 1938. Sur un nouveau genre de Delesseriacées de la Méditerranée. Compt. Rend. Hébd. Séances Acad. Sci. 207:1119–1121.

Feldmann-Mazoyer G. 1941. Recherches sur les Céramiacées de la Méditerranées occidentales. Alger, Minerva.

Gavio B, Reyes-Gómez VP, Wynne MJ. 2013. *Crouania pumila* sp. nov. (Callithamniaceae, Rhodophyta), a new species of marine red alga from the International Biosphere Reserve Seaflower, Caribbean Colombia. Rev. Biol. Trop. 61(3):1015–1023.

Gavio B, Cifuentes-Ossa MA, Wynne MJ. 2015. Notes on the marine algae of the International Biosphere Reserve Seaflower, Caribbean Colombia V: First study of the algal flora of Quitasueño Bank. Bol. Investig. Mar. Costeras 44:117–126.

Guimarães SMPB, Fujii MT, Pupo MT, Yokoya NS. 2004. Reavaliação das características morfológicas e suas implicações taxonômicas no gênero *Polysiphonia sensu lato* (Ceramiales, Rhodophyta) do litoral dos Estados de São Paulo e Espírito Santo, Brasil. Rev. Brasil. Bot. 27:163–183.

Guiry MD, Guiry GM. c2017. AlgaeBase. Worldwide electronic publication, National University of Ireland, Galway. [last accessed: 30 Jan 2017]. http://www.algaebase.org

Harvey WH. 1853. *Nereis boreali-americana*; or, contributions towards a history of the marine algae of the Atlantic and Pacific coasts of North America. Part II. Rhodospermeae. Smiths. Contrib. Knowl. 5(5): [i-ii], [1]–258, pls XIII-XXXVI.

Hoffman R, Wynne MJ. 2016. Tetrasporangial plants of *Monosporus indicus* (Ceramiales, Rhodophyta): a new alien in the Mediterranean Sea. Eur. J. Phycol. 51:461–468.

Huisman JM, Kraft GT. 1982. *Deucalion* gen. nov. and *Anisoschizus* gen. nov. (Ceramiaceae, Ceramiales), two new propagule-forming red algae from southern Australia. J. Phycol. 18:177–192.

Lee Y, Kang S. 2001. A catalogue of the seaweeds of Korea. Cheju, South Korea: Cheju National University Press.

Littler DS, Littler MM. 2000. Caribbean reef plants. An identification guide to the reef plants of the Caribbean, Bahamas, Florida and Gulf of Mexico. Washington D.C., USA: OffShore Graphics, Inc.

Mayhoub H. 1975. Une nouvelle espèce de *Dohrniella* (Rhodophycées, Céramiacées) de Méditerranée orientale. Bulletin de la Société Phycologique de France 20:7–11.

Ortiz JF, Gavio B. 2012. Notes on the marine algae of the International Biosphere Reserve Seaflower, Caribbean Colombia II: diversity of drift algae in San Andres island, Caribbean Colombia. Caribb. J. Sci. 46:313–321.

Reyes-Gómez V, Gavio B, Velásquez H. 2013. Notes on the marine algae of the International Biosphere Reserve Seaflower, Caribbean Colombia III. New records of Cyanophyta. Nova Hedwigia 97:349–360.

Reyes-Gómez V, Gavio B. 2017. Notes on the marine algae of the International Biosphere Reserve Seaflower, Caribbean Colombia VI. New records of brown algae (Phaeophyceae). Acta Biol. Colomb. 22(2):138–141.

Rincón-Díaz MN, Gavio B, Santos-Martínez A. 2014. Occurrence of tetrasporangia in *Ceramium bisporum* (Ceramiales, Rhodophyta). Acta Biol. Colomb. 19:315–318.

Rincón-Díaz MN, Gavio B, Wynne MJ, Santos-Martínez A. 2016. First record of the red alga *Griffithsia capitata* (Ceramiales, Rhodophyta) in the southwestern Caribbean Sea, Western Atlantic. Mar. Biodivers. Rec. 9: 86. 5 pp.

Searles RB, Schneider CW. 1989. New genera and species of Ceramiaceae (Rhodophyta) from the southeastern United States. J. Phycol. 25:731–740.

Schneider CW, Searles RB. 1991. Seaweeds of the southeastern United States: Cape Hatteras to Cape Canaveral. Durham, N.C., USA: Duke University Press.

Secilla A. 2012. La familia Ceramiaceae *sensu lato* en la costa de Bizkaia. Guineana 18:1–369.

Silva PC. c2017. Index Nominium Algarum, University Herbarium. Berkeley: University of California. [last accessed: 20 Nov 2017]. http://ucjeps.berkeley.edu/INA.html

Swierts T, Vermeij MJA. 2016. Competitive interactions between corals and turf algae depend on coral colony form. PeerJ 4:e1984. doi: 10.7717/peerj.1984.

Taylor WR. 1960. Marine algae of the eastern tropical and subtropical coasts of the Americas. Toronto: The University of Michigan Press, Ann Arbor.

Vega-Sequeda J, Díaz-Sánchez C, Gómez-Campo K, López-Londoño T, Díaz-Ruíz M, Gómez-López D I. 2015. Biodiversidad marina en Bajo Nuevo, Bajo Alicia y Banco Serranilla, Reserva de Biosfera Seaflower. Bol. Investig. Mar. Costeras 44:199–224.

Womersley HBS. 2003. The marine benthic flora of southern Australia - Part IIID Ceramiales - Delesseriaceae, Sarcomeniaceae, Rhodomelaceae. pp. [1]-533. Canberra & Adelaide: Australian Biological Resources Study & State Herbarium of South Australia.

Wynne MJ. 2017. A checklist of benthic marine algae of the tropical and subtropical Western Atlantic: fourth revision. Nova Hedwigia, Beih. 145:1–202.

Wynne MJ, Schneider CW. 1996. *Frikkiella* gen. nov. (Delesseriaceae, Rhodophyta) from Bermuda and the Caribbean Sea. Syst. Bot. 21:77–84.

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