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Botryocladia bahamense sp. nov. (Rhodymeniaceae, Rhodophyta) from the Bahamas, western Atlantic

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Abstract — A new species, *Botryocladia bahamense* D.L. Ballantine et N.E. Aponte, from deep water in the Bahamian archipelago (tropical western Atlantic) is described. The new species is unique in having vesicles that initially are incompletely corticated with cortical cells arranged in a rosette pattern surrounding the margins of medullary cells; however, vesicles or portions of them may become entirely corticated with maturity. Algae are small, to 25 mm in height, with ovoid vesicles irregularly radially placed around the axis. Obovate gland cells are borne on medullary cells which either project into the vesicle cavity or not. The new species is monoecious and mature ostiolate cystocarps project equally inwardly and outwardly from the vesicle surface.

Bahamas / *Botryocladia bahamense* / deep-water marine algae / Rhodophyta / Rhodymeniaceae / western Atlantic

Résumé — *Botryocladia bahamense* sp. nov. (Rhodymeniaceae, Rhodophyta) des Bahamas, Atlantique ouest. Une nouvelle espèce, *Botryocladia bahamense* D.L. Ballantine et N.E. Aponte, est décrite des eaux profondes de l'archipel des Bahamas (Atlantique tropical occidental). La nouvelle espèce est la seule à avoir des vésicules initialement incomplètement cortiquées avec des cellules corticales disposées en rosette entourant les cellules médullaires ; cependant, à maturité, les vésicules ou des portions de celles-ci peuvent devenir complètement cortiquées. Les algues sont de petite taille, jusqu'à 25 mm de hauteur, avec des vésicules ovoïdes disposées irrégulièrement de façon radiale autour de l'axe principal. Des cellules glandulaires obovales naissent sur les cellules médullaires ; elles font ou non saillie dans la cavité de la vésicule. La nouvelle espèce est monoïque et les cystocarpes mûrs ont une ostiole ; ils font saillie autant à l'intérieur qu'à l'extérieur de la surface de la vésicule.

algues marines de profondeur / Atlantique occidental / Bahamas / *Botryocladia bahamense* / Rhodophyta / Rhodymeniaceae /

INTRODUCTION

The genus *Botryocladia* (J. Agardh) Kylin is morphologically distinctive with hollow saccate vesicles borne on a solid stipe. Species are distinguished on

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the basis of a number of characters including: size and shape of vesicles, degree of axial development, cortication, vesicle wall anatomy, whether or not a specialized gland supporting cell is present, whether the gametophytes are monoecious or dioecious, cystocarp development, and dimensions of tetrasporangia (Ballantine, 1985; Brodie & Guiry, 1988; Schneider & Lane, 2000). *Botryocladia* is now known to be comprised of some 35 species world-wide (Brodie & Guiry, 1988; Schneider & Lane, 2000) and is represented by eight species in the tropical and subtropical western Atlantic (Wynne, 1998). Examination of collections made from a research submersible at Lee Stocking Island, Bahamas has resulted in the recognition of a unique species of *Botryocladia* from deep-water habitats The new species is described herein.

MATERIALS AND METHODS

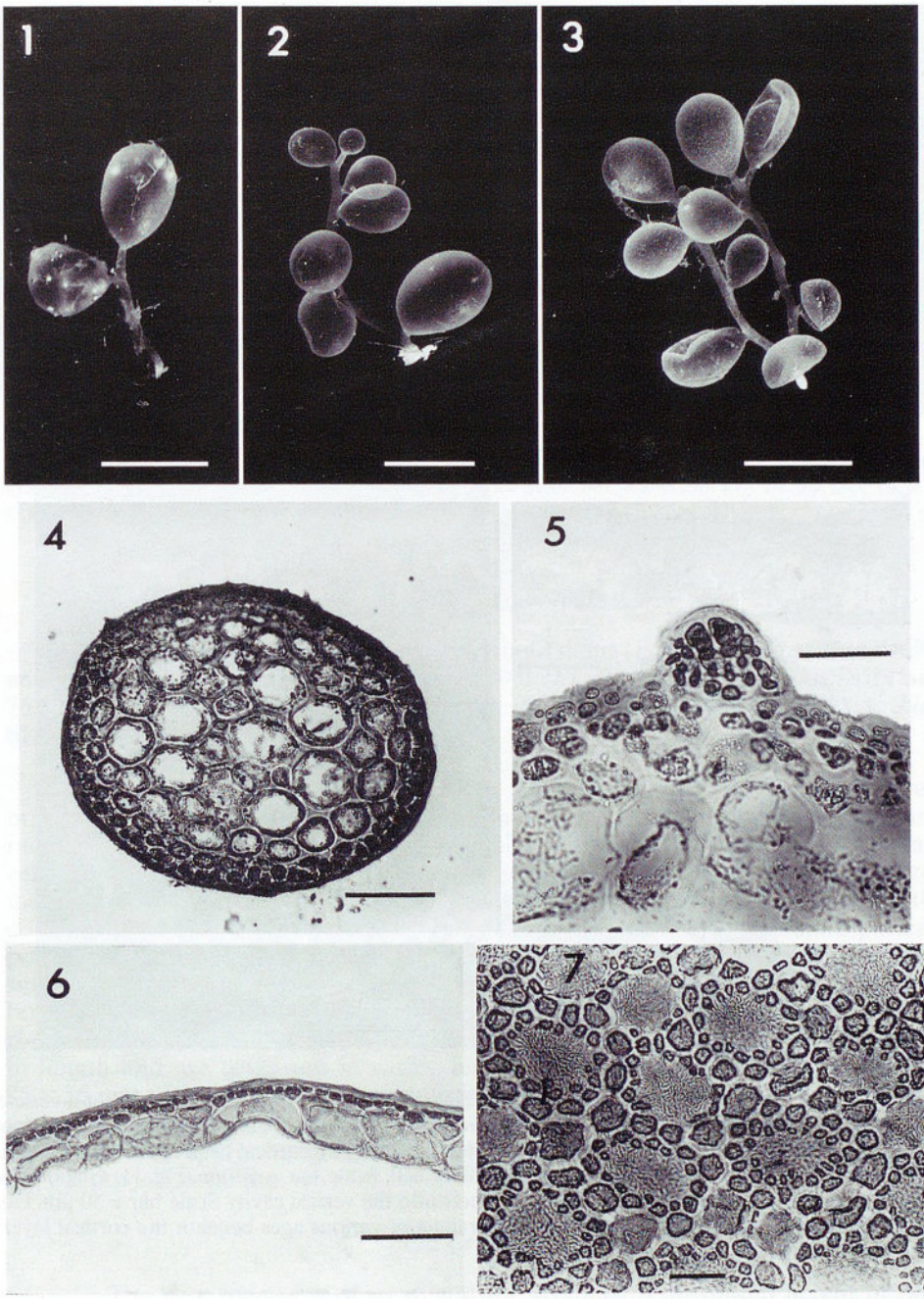
Plants were collected using the research submersible DSV *Nekton Gamma*, operated by the Caribbean Marine Research Center. Specimens were preserved in 10 % formalin-seawater. Transections (30 µm thick) were made using an American Optical Cryo-Cut freezing microtome. Microscopic preparations were stained in acidified 1% aniline blue and mounted in 60 % Karo® corn syrup on microscope slides. Photomicrographs using Kodak Technical Pan black and white film were taken through an Olympus BMAX light microscope. The holotype is deposited in US and isotypes in US, MICH, and MSM. Herbarium abbreviations follow Holmgren *et al.* (1990) and authority designations are according to Brummitt & Powell (1992). [Note: author's names were spelled in full by the Editor]

RESULTS

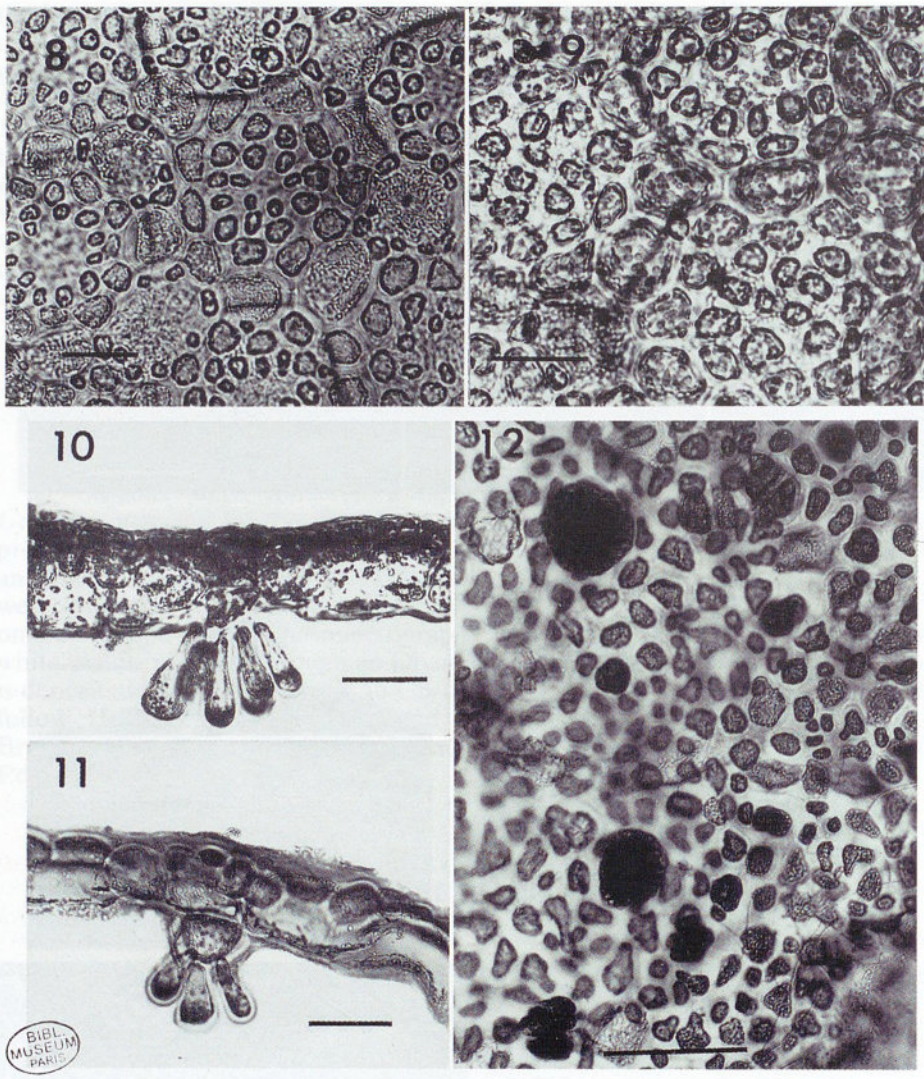
***Botryocladia bahamense* sp. nov. Figs 1-14**

Description

Algae altae 10-25 mm axibus usque ad 750 µm diametro, rare ramosae; vesiculae ovoideae, 3.5-7.0 mm longae × 2.5-4.0 mm latae, radiatim et irregulatim circum axem dispositae; paries vesicularum bistrati; cellulae medullosae intimae ad 100 µm latae et ad 42 µm altae, cellulis medullosis mediocribus 25-35 µm diametro inter cellulas medullosas intimas confertis; corticales cellulae margines cellularum medullosarum mediocrium magnarumque reticulatim circumcingentes, partes vesicularum vetustiorum aliquando omnino vel fere corticati; protuberationes parvae corticales saepe in vesicularum superficie; glandicellulae obovatae in cellulis medullosis maioribus vel in cellulis sustinentibus, quae in vesiculae cavitatem projectae, portatae; glandicellulae (2) 4-6 (8) in fasciculis factae, usque ad 48 um longae et usque ad 23 µm diametro; tetrasporangia ovata, cruciatim divisa, usque ad 25 × 56 µm; gametophyta monoecia; cystocarpia matura, usque ad 750 µm diametro, ostiolo vix elongato, in vesiculae cavitatem et e vesiculae superficie aequaliter projecta; massae spermatangiorum e vesiculae superficie elevatae; spermatangia 2.0-2.5 µm × 3.0-4.0 µm.

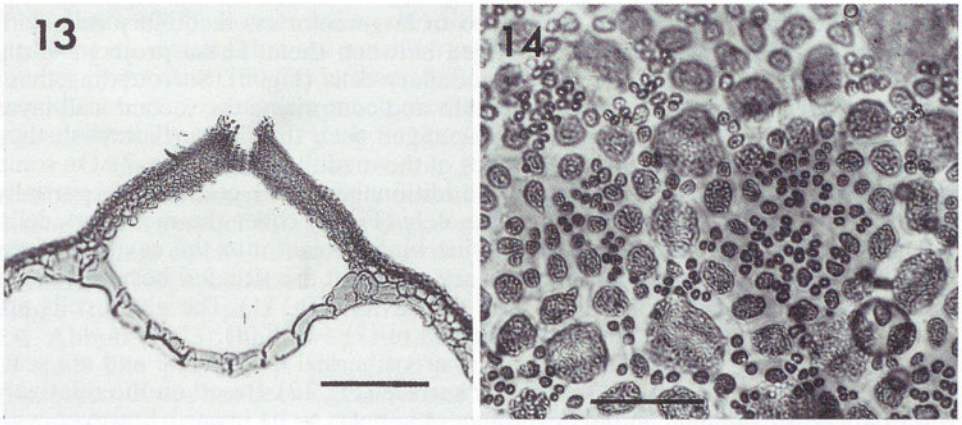


Figs 1-7. *Botryocladia bahamense* sp. nov. Fig. 1. Habit of plant with vesicles radially surrounding a single axis. Scale bar = 5 mm. Fig. 2. Habit of the holotype, gametophytic. Scale bar = 5 mm. Fig. 3. Habit of plant with a single branch. Scale bar = 5 mm. Fig. 4. Transection of solid axis. Scale bar = 100 µm. Fig. 5. Cortical outgrowth on surface of vesicle. Scale bar = 25 µm. Fig. 6. Transection through vesicle wall. Scale bar = 100 µm. Fig. 7. Surface view of outer cortical wall of a vesicle showing incomplete covering by cortical cells along the margins of medullary cells. Scale bar = 25 µm.



Figs 8-12. *Botryocladia bahamense* sp. nov. Fig. 8. Surface view of outer cortical wall of a vesicle showing near complete and incomplete cortical covering. Scale bar = 25 µm. Fig. 9. Surface view of outer cortical wall of a vesicle showing complete covering by cortical cells. Scale bar = 25 µm. Fig. 10. Gland cells produced from small medullary cell. Scale bar = 50 µm. Fig. 11. Gland cells produced from small medullary cell which projects into the vesicle cavity Scale bar = 50 µm. Fig. 12. Surface view showing dark-stained tetrasporangia of various ages beneath the cortical layer. Scale bar = 50 µm.

Holotype: *D.L. Ballantine 4904*, Lee Stocking Island (Exuma Chain), 23°46'78"N and 76°05'00" W, Bahamas, 61 m, 31.viii.1994 (Alg. Coll. # US-198086).



Figs 13-14. *Botryocladia bahamense* sp. nov. Fig. 13. Transection through vesicle showing a mature cystocarp (the section lacking the carposporophyte). Scale bar = 250 µm. Fig. 14. Surface view of vesicle surface showing spermatangia. Scale bar = 25 µm.

Isotypes: MICH; MSM; US.

Paratypes: *D.L.B. 4800*, Lee Stocking Island (Exuma Chain), 23°47'46"N and 76°05'85" W, Bahamas, 61 m; 22.ix.1993; *D.L.B. 4880*, *ibid.*, 23°46'78"N and 76°05'00" W, 76 m, 1.ix.1994; *D.L.B. 4932*, *ibid.*, 32 m, i.1995; D.L.B. 5084, *ibid.*, 61 m, 4.v.1995; *D.L.B. 5174*, 76 m, 4.v.1994.

Algae 10-25 mm in height with axes to 750 µm in diameter, rarely branched; vesicles ovoid in shape, 3.5-7.0 mm long × 2.5-4.0 mm wide, irregularly radially placed around the axis; vesicle walls of two layers, innermost medullary cells measure to 100 µm broad and 42 µm in height with intermediate-sized medullary cells, 25-35 µm in diameter wedged between; cortical cells surround the edges of the intermediate-sized and large medullary cells in a reticulate pattern, portions of older vesicles may become completely or nearly completely corticated; small cortical outgrowths frequently occur on vesicle surfaces; obovate gland cells borne on larger medullary cells or on supporting cells which project into the vesicle cavity; gland cells produced in clusters of (2) 4 to 6 (8) and measure to 48 µm in length and are to 23 µm in width; tetrasporangia ovate, cruciately divided, to 25 × 56 µm; gametophytes monoecious; mature cystocarps, to 750 µm in diameter with a slightly elongate ostiole, project equally into the vesicle cavity and from the vesicle surface; spermatangial masses elevated from the vesicle surface, spermatia 2.0-2.5 µm × 3.0-4.0 µm.

Observations

The new species is of small stature, attaining a maximum height of only 25 mm (Figs 1-3). Typically they contain a single leading axis (Figs 1, 2), which is rarely branched (Fig. 3). The axes (Fig. 4) bear up to 12 ovoid vesicles, but rarely only a single vesicle is present. The vesicles are irregularly radially placed around the axis. Vesicles rarely bear minute secondary vesicles; however, they frequently possess small cortical outgrowths (Fig. 5). Vesicle walls consist of two layers

(Fig. 6). The innermost layer is composed of large colorless medullary cells with intermediate-sized medullary cells wedged between them. These project slightly beyond the upper layer of the larger medullary cells (Fig. 6). Surrounding these large and intermediate-sized medullary cells and comprising the second wall layer are cortical cells. The cortical cells are arranged such that, in surface view, they form a reticulate pattern around the edges of the medullary cells (Fig. 7). On some mature vesicles, cortical cells produce additional cortical cells which partially (Fig. 8) or in some vesicle portions completely (Fig. 9) cover the medullary cells. Gland cells, which stain darkly with aniline blue, project into the cavity surface. These are borne on smaller-sized medullary cells that are situated between larger medullary cells (Fig. 10) or project into the cavity (Fig. 11). The gland cells are obovate in shape and are typically in clusters of (2) 4 to 6 (8).

Cruciately cleaved tetrasporangia are spherical to elongate and are scattered beneath cortical cells on the vesicle surface (Fig. 12). Based on the relatively few cystocarps examined, initial development appears to be inward; however, with maturity cystocarps project equally from the vesicle surface and into the vesicle cavity (Fig. 13). Mature cystocarps possess a slightly elongate ostiole (Fig. 13). Spermatangial mother cells are produced from surface cortical cells. Spermatangial masses (Fig. 14) become elevated from the vesicle surface and have a mucilaginous covering.

DISCUSSION

Feldmann (1945) divided the genus *Botryocladia* into two sections: Sect. Microphysae, which includes small-sized species with little-branched axes that bear only a small number of vesicles, and Sect. Botryoideae, which includes species with greater developed branched axes with more numerous vesicles. *Botryocladia bahamense* fits comfortably within the Microphysae section. For purposes of comparison, we find it necessary to consider *Botryocladia* species that are both completely and incompletely corticated. Nevertheless, we know of no other *Botryocladia* species which displays both partial and complete cortication. Complete cortication is presumably not a developmental feature in at least some of the species that possess it. For example in *B. ganesanii* M. Díaz (1988), both newly cut off vesicles and mature vesicles are completely corticated.

Schneider & Lane (2000) compared 10 species of *Botryocladia* Section Microphysae with incomplete cortication. Based on their table, *B. bahamense* can easily be distinguished from all of the partially corticated species. Of these only *B. wynnei* D.L. Ballantine and *B. monoica* Schnetter are monoecious although this character is questionable for *B. boergesenii* Feldmann, *B. senegalensis* Feldmann-Mazoyer *et* M. Bodard and *B. tenuissima* W.R. Taylor. As previously indicated, the new species may be distinguished from all of these (as well as presumably all other *Botryocladia* species in possessing secondarily acquired complete cortication. From *B. wynnei*, the new species differs in vesicle shape (elongate-obovate in *B. wynnei*), vesicle number (normally a single vesicle in *B. wynnei*), and gland cell supporting cell (sometimes stellate in *B. wynnei*) (Ballantine, 1985). *Botryocladia monoica* possesses much smaller vesicles (1.5-1.9 × 1.6-2.0 mm), has stellate gland bearing cells and substantially smaller cystocarps (to 350 μm) (Schnetter, 1978). The new species differs from *B. boergesenii* which possesses one to a few obovoid-shaped vesicles on a short stipe and also possesses stellate gland bearing cells

(Feldmann, 1941). *Botryocladia senegalensis* differs from the new species in having elongate vesicles that are much larger (40-60 mm) and in having substantially smaller cystocarps (100 µm in diameter). *Botryocladia tenuissima* differs from the new species in possessing a much shorter stipe (35-140 µm long) and in possessing substantially smaller tetrasporangia (20-24 µm) (Taylor, 1945).

Among Microphysae section *Botryocladia* species that are completely corticated, *B. bahamense* strongly resembles *B. ganesanii* at least superficially, particularly with respect to vesicle shape and the monoecious condition. The latter species differs chiefly in terms of cortication, having larger-sized vesicles (to 18 × 25 mm), lack of specialized gland bearing cells, and substantially smaller tetrasporangia (to 20 × 28 µm) (Aponte Diaz, 1988). From *B. spinulifera* W.R. Taylor et I.A. Abbott (1973), the new species differs in a number of respects including lack of spine-like projections from the outer vesicle wall. *Botryocladia pyriformis* (Børgesen) Kylin has been characterized as having cortication that is "more or less complete" (Børgesen, 1920). That species differs from *B. bahamense* by nature of its presumed dioecious condition (Ballantine, 1989), size and shape of vesicles as well as having pyriform gland cells produced from normal medullary cells (Børgesen, 1920). *Botryocladia botryoides* (Wulfen) Feldmann (1941) differs from the new species by nature of vesicle shape and by possessing spherical gland cells also produced from normal medullary cells.

Saunders *et al.* (1999) recently created the segregate genus *Irvinea* based on *Botryocladia adreana* J. Brodie et Guiry (1988). *Botryocladia bahamense* meets some of their criteria for that genus. Schneider & Lane (2000) indicated that there is a large degree of overlap in morphological characters between *Botryocladia* and *Irvinea*. Some of the character states assigned to *Irvinea* (including cortex arranged in rosettes surrounding medullary cells and secretory cells borne on modified inner faces of medullary cells), are not consistent in the new species. These inconsistencies include the possession of both cortication in a rosette pattern which sometimes gives way to complete cortication and gland cells that are either borne on specialized medullary cells cut off from an inner cell of the medullary layer or borne on a medullary cell from the medullary layer.

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REFERENCES

APONTE DÍAZ M., 1988 — *Botryocladia ganesanii* sp. nov. (Rhodophyta, Rhodymeniales) from the Caribbean coast of Venezuela. *Cryptogamie, Algologie* 9: 43-52.

BALLANTINE D.L., 1985 — *Botryocladia wynnei* sp. nov. and *B. spinulifera* (Rhodymeniales, Rhodophyta) Taylor & Abbott from Puerto Rico. *Phycologia* 24: 199-204.

BALLANTINE D.L., 1989 — Reproduction in Caribbean plants of *Botryocladia pyriformis* and *B. wynnei* (Rhodymeniales, Rhodophyta). *Phycologia* 28: 237-242.

BØRGESEN F., 1920 — The marine algae of the Danish West Indies III, Rhodophyceae, A. *Dansk Botanisk Arkiv* 3: 369-504.

BRODIE J. & GUIRY M.D., 1988 — Life history and reproduction of *Botryocladia adreana* sp. nov. (Rhodophyta, Rhodymeniales) from Portugal. *Phycologia* 27: 109-130.

BRUMMITT R.K. & POWELL C.E. (eds), 1992 — *Authors of Plant Names*. Royal Botanic Gardens, Kew. 732 p.

FELDMANN G., 1945 — Révision du genre *Botryocladia* Kylin (Rhodophycées-Rhodyméniacées). *Bulletin de la Société de l'Histoire Naturelle de l'Afrique du Nord* 35: 49-61.

FELDMANN J., 1941 — Les algues marines de la côte des Albères. IV. Rhodophycées (suite). *Revue Algologique* 12: 77-100.

HOLMGREN P.K., HOLMGREN H.H. & BARNETT L.C., 1990 — *Index Herbariorum, Part I. The Herbaria of the World*. Bronx, New York, New York Botanical Garden, x + 693 p. [*Regnum vegetabile* vol. 120].

SAUNDERS G.W., STRACHAN I.M. & KRAFT G.T., 1999 — The families of the order Rhodymeniales (Rhodophyta): a molecular-systematic investigation with a description of Faucheaceae fam. nov. *Phycologia* 38: 23-40.

SCHNEIDER C.W. & LANE C.E., 2000 — A new species of *Botryocladia* (Rhodymeniales, Rhodophyta) from the Galapagos Islands. *Cryptogamie, Algologie* 21: 167-175.

SCHNETTER R., 1978 — *Botryocladia monoica* (Rhodymeniales, Rhodophyceae), a new species from the Caribbean coast of Colombia. *Phycologia* 17: 13-15.

TAYLOR W.R., 1945 — Pacific marine algae of the Allan Hancock Expeditions to the Galápagos Islands. *Allan Hancock Pacific Expeditions* 12: 1-528.

TAYLOR W.R. & ABBOTT I.A., 1973 — A new species of *Botryocladia* from the West Indies *British Phycological Journal* 8: 409-412.

WYNNE M.J., 1998 — A checklist of benthic marine algae of the tropical and subtropical western Atlantic: first revision. *Nova Hedwigia* 116: 1-155.