BOTRYOCLADIA GANESANII SP. NOV. (RHODOPHYTA, RHODYMENIALES) FROM THE CARIBBEAN COAST OF VENEZUELA

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ABSTRACT. — A new subtidal species of the genus *Botryocladia* Kylin, *B. ganesanii* Aponte Díaz sp. nov. is described from the upwelling areas of eastern Venezuela. *B. ganesanii* is the eight member of the genus from the Caribbean Sea. In some respects, the newly described species closely resembles *B. guineensis* John, but differs in the (i) number and shape of vesicles, (ii) vesicle structure, (iii) dimensions of gland cells, tetrasporangia and cystocarps, (iv) presence of a tela arachnoidea in the cystocarps and (v) monoecious sexual plants.

RÉSUMÉ. — Une nouvelle espèce du genre *Botryocladia* Kylin, *B. ganesanii* Aponte Díaz sp. nov. est décrite d'une zone à upwelling de l'est du Vénézuela. *B. ganesanii* est la huitième espèce de ce genre dans les Caraïbes. Par certains caractères cette nouvelle espèce présente des similitudes avec *B. guineensis* John, mais elle en diffère par 1) le nombre et la forme des vésicules; 2) la structure des vésicules; 3) les dimensions des cellules secrétrices, des tétrasporocystes et des cystocarpes; 4) la présence d'une tela arachnoidea dans les cystocarpes; 5) sa monoécie. (traduit par la rédaction).

KEY WORDS : *Botryocladia, Botryocladia ganesanii* sp. nov., marine algae, Rhodymeniales, Rhodophyta, Venezuela.

INTRODUCTION

The genus *Botryocladia* Kylin (Rhodophyta, Rhodymeniales) generally a deep water marine alga of the tropical, subtropical and warm temperate seas, is characterized by one to several hollow vesicles borne on a simple or variously branched erect axis. Structurally the vesicle consists of 2-3 or more layers of cells, and the inner most medullary cells in most species produce groups of secretory cells. As a result of these features it is one of the easily recognized genera of marine red algae. Seven species of *Botryocladia* are currently known from the Caribbean Sea (Ballantine, 1985) and the genus so far contains 30 described species (Brodie & Guiry, 1988). While studying the marine algal flora of eastern

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Venezuela, especially in the upwelling areas of the island of Margarita (11°00' N - 63°47'30" W), a species of *Botryocladia* was collected, which proved to be different from the other described species of the genus.

MATERIALS AND METHODS

All specimens studied were cast ashore, indicating a subtidal habitat. Material was preserved in 4 % formalin seawater and dried as herbarium sheets. Both whole mounts and sectioned material were studied. Sections (30 µm) thick were cut with a freezing microtome. A 1 % aqueous aniline blue solution, to which a few drops of 1 % HCl were added was used as stain. Stained material was mounted in 50 % Karo Syrup. Herbarium specimens and slides have been deposited in the Herbarium, Department of Marine Biology, Institute of Oceanography, Cumaná, Venezuela. Duplicate specimens are also deposited in the Herbarium, University of California, Berkeley, U.S.A., and Muséum National d'Histoire Naturelle, Paris, France. For comparative studies, herbarium specimens of *Botryocladia guineensis* John, were kindly sent on loan from the British Museum (Natural History), London. In describing the shape of the vesicles and the secretory cells, the glossary of phycological terms of marine macroalgae by Hine (1977) was used.

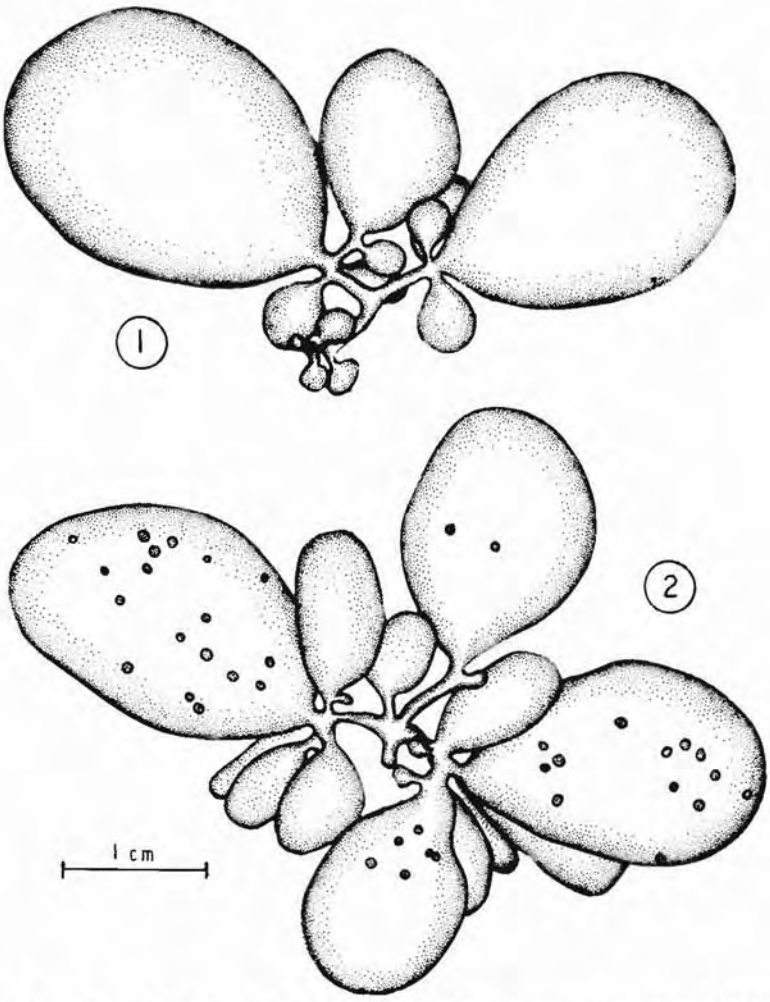
DIAGNOSIS AND OBSERVATIONS

Diagnosis

Botryocladia ganesanii Aponte Diaz sp. nov.

Plantae subtidalae 30-35 mm altae; erectus axis cylindricus 1 mm diam., 2-7mm longus, 7-20 vesiculis ovatis, 10-18 mm diam., 20-25 mm longis; paries vesicularum 129-171 µm crassa, a tribus stratis cellularum constituta est; externum stratum parvis cellulis subsphaericis, sparse dispositis 4-7 (-10) µm diam., intermedium stratum irregulariter compositum, cellulis 8-60 µm diam., et internum stratum polyhaedricis cellulis, 60-300 µm diam., 358-366 µm longum; cellulae glandulosae 6-12(15) conglobatae, ovatae-pyriformae, 5-9 µm diam., 6-10 µm longae, tetrasporangia generaliter ovata, 20 µm diam., 24 (-28) µm longa, irregulariter et indistincte divisa; plantae monoicae; cystocarpia matura sphaerica 700-900 µm diam., moderate projectati; ***tela arachnoidea*** *in cystocarpii juvenis; spermatangia 1-2 µ m diam., in soris irregularibus leviter elevatis super stratum externum vesicularum.*

Holotypus : (monoecious), Pampatar (11° 00' N - 63° 47'30" W), Margarita Island, Venezuela. (MA-BV. 45a; 25.ii.1983), in Herbarium Institute of Oceanography, University ~~the~~ of Oriente, Cumaná, Venezuela; isotypi : deposited in the Herbarium, Department of Botany, Berkeley, California, U.S.A. (UC) and Muséum National d'Histoire Naturelle, Paris, France (PC).

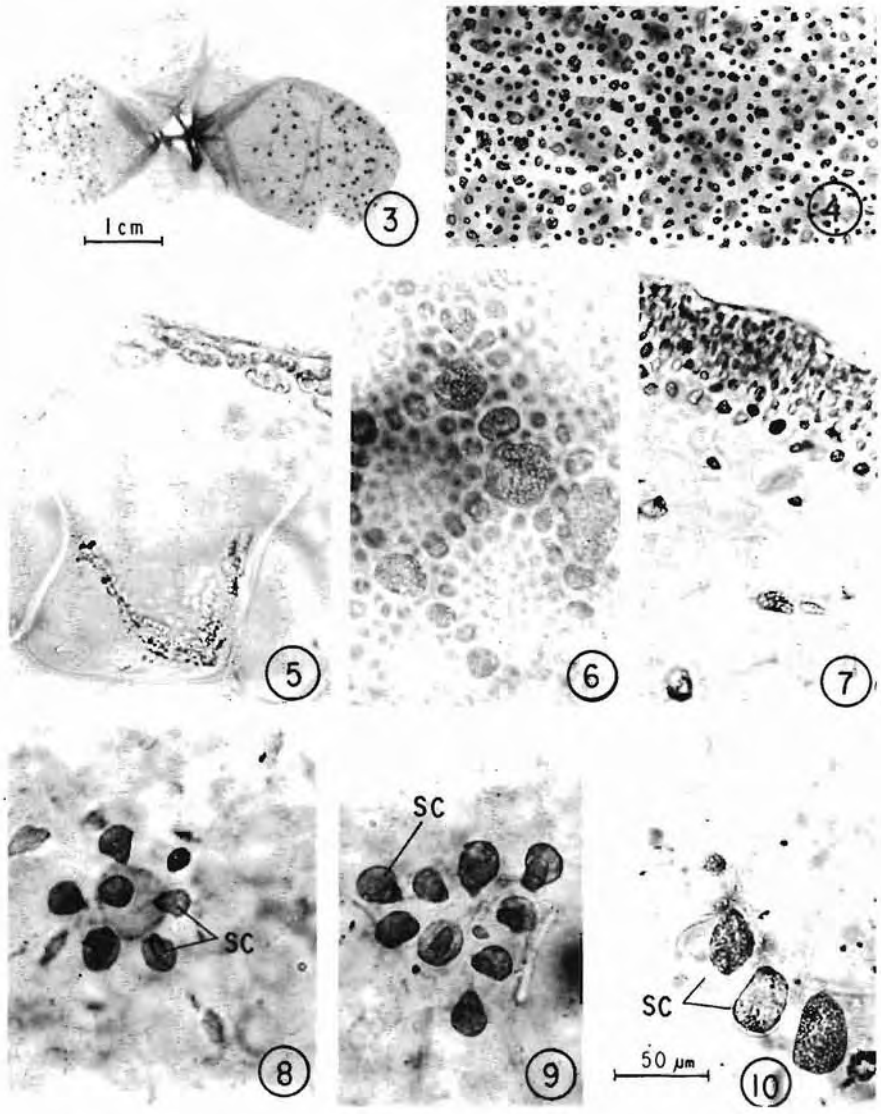


Figs. 1-2. — *Botryocladia ganesanii* sp. nov. 1. Habit of a tetrasporic plant. 2. Habit of a monoecious gametophytic plant.

Observations

Botryocladia ganesanii sp. nov.

Plants of *B. ganesanii* were to 30-35 mm long; each plant consisted of a small discoid base, a short cylindrical erect axis (1 mm broad and 2-7 mm long), which may be divided oppositely, tri- or polychotomously. Each branchlet ended in one to several vesicles of different ages. The number of young and old vesicles varied

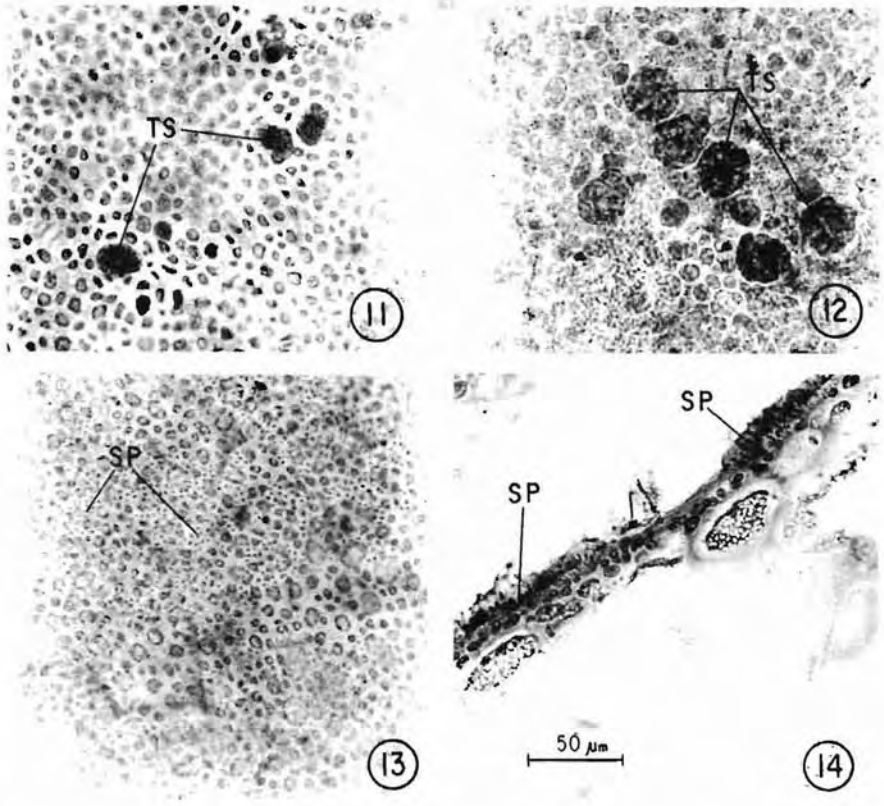


Figs. 3-10. — *Botryocladia ganesanii* sp. nov. 3. Holotype. 4. Surface view of cortical layer in a young vesicle. 5. Section of a mature vesicle. 6. Surface view at the basal part of an old vesicle. The net-like layer of large cells is the intermediate layer, while the cortical layer of small cells is slightly out of focus. 7. Section of an erect axis. 8. Secretory cells from a young vesicle. Note that the medullary cell bearing the secretory cells, stains readily. 9. Secretory cells from an old vesicle. Note the medullary cell does not stain readily. 10. Section of a vesicle showing the secretory cells borne directly on the medullary cell. SC : Secretory cells. Scale fig. 10 also applies to Figs. 4-9.

from 7-20 per plant. Young developing vesicles were spherical while fully developed vesicles were ovoid, 10-18 mm broad and 20-25 mm long (Figs. 1 and 2).

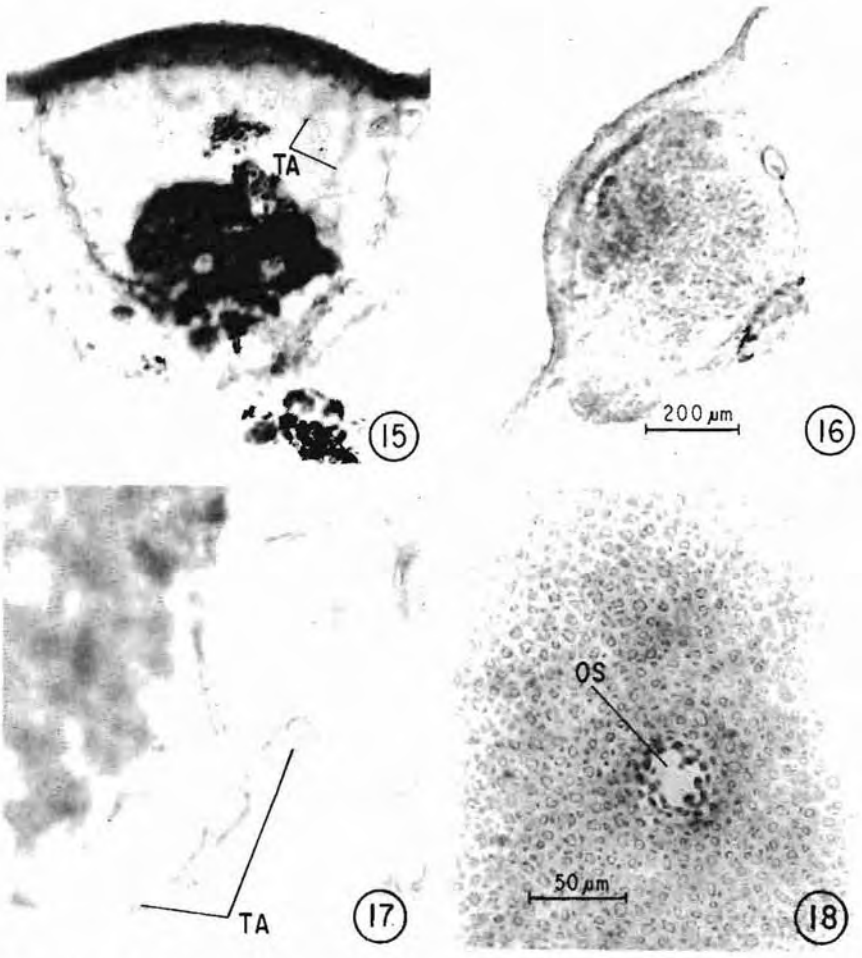
Structurally the erect axis consisted of a narrow peripheral zone of several layers of small subspherical cells and a large central medullary zone of big colourless cells (Fig. 7). Between the large colourless cells, groups of small cells were found interspersed (Fig. 7).

The vesicle consisted of 3 layers of cells both in the young and old vesicles, indicating that the number of layers did not increase with age. The outermost layer constituting the cortex is continuous and is made up of small subspherical pigmented cells, 4-7 (10) μm broad. The disposition of this layer in surface view



Figs. 11, 13, 14. — *Botryocladia ganesanii* sp. nov. 11. Surface view of a tetrasporic plant showing the disposition of tetrasporangia. 13. Surface view of a spermatangial area. 14. Transverse section of a spermatangial area. Note the slightly raised nature of spermatangial area. 12. *B. guineensis* John. Surface view of tetrasporic plant showing the disposition of tetrasporangia. TS: tetrasporangia. SP: spermatangia. Scale in Fig. 14 also applies to Figs. 11-13.

in a young vesicle (3 mm broad) and an old vesicle (12 mm broad) are shown in Figs. 4 and 6, respectively. Formation of hairs from the cortical cells was not observed. The intermediate or middle layer was discontinuous (Fig. 6) and was constituted of polygonal cells 8-60 μm in diameter. The innermost layer con-



Figs. 15-18. — *Botryocladia ganesanii* sp. nov. 15. Transverse section of a developing cystocarp showing its immersed nature and the presence of tela arachnoidea filaments. 16. Transverse section of a mature cystocarp. Note the most part of cystocarp is projecting into the vesicular cavity. 17. Part of a cystocarp enlarged to show the nature of tela arachnoidea filaments. 18. Surface view of an empty cystocarp showing a prominent ostiole. TA : tela arachnoidea. OS : ostiole. Scale in Fig. 16 applies to Fig. 15 and scale in Fig. 18 to Fig. 17.

sisted of a single continuous layer of large colourless cells 60-300 μm in diameter (Figs. 5 and 14). Thickness of the wall of the vesicle varied from 100-200 μm. Groups of secretory cells were commonly observed directly on the face of some medullary cells. In young vesicles, the medullary cells bearing the secretory cells were intensely stained with aniline blue (Fig. 8), but in later stages they were indistinguishable from the surrounding cells (Fig. 9). In the numerous groups of gland cells observed, a subtending or bearing cell was not observed (Fig. 10). Each group consisted of 6-12 (15) pyriform or ovoid secretory cells. Individual gland cells measured (25) 30-45 (50) μm long and 20-35 μm broad.

Tetrasporangia were found scattered in the cortical layer (Fig. 11) in an irregular manner. Division of the contents of mature tetrasporangia was irregular and indistinct. Tetrasporangia were generally ovate, 24-28 μm long and 20 μm broad.

Sexual plants were monoecious (Figs. 2 and 3). Spermatangial areas occurred in the form of small or extensive patches (Fig. 13) among the cortical layer. In section (Fig. 14) the spermatangial layer was slightly raised in the form of an irregular sorus from the adjacent sterile cells. Each spermatangial mother cell produced 1-2 small spermatangia.

Numerous cystocarps occurred scattered irregularly on the vesicle walls (Figs. 2 and 3). There was no regular pattern in their distribution, since they occurred not only a few mm below the apex of the vesicle, but also at the extreme base of the vesicle a few mm above the stipe. In section they measured 700-900 μm broad and 580-800 μm high. In surface view, they reached up to 1 mm in diameter. The cystocarp generally projected more inside the vesicular cavity than outside (Figs. 15 and 16). In young developing cystocarps a tela arachnoidea made up of elongated, loosely packed filaments inside the vesicular cavity was observed (Figs. 15 and 17). Tela arachnoidea filaments were however not abundant. In mature cystocarps, they were not easily distinguishable. Some empty cystocarps showed a distinct ostiole in surface view (Fig. 18).

Holotype : (monoecious), Pampatar (11° 00' N - 63° 47' 30" W), Margarita Island, Venezuela (MA-BV. 45a; 25.ii.1983), in Herbarium Institute Oceanography, University of Oriente, Cumaná, Venezuela; isotypi : deposited in the Herbarium, Department of Botany, Berkeley, California, U.S.A. (UC) and Muséum National d'Histoire naturelle, Paris, France (PC).

The specific name honours Dr. E.K. Ganesan in recognition of his contributions to the knowledge of the Venezuelan marine algal flora.

DISCUSSION

While describing *Botryocladia ardreana* as new species from Portugal, Brodie & Guiry (1988) recognized 30 species in the genus (including *B. ardreana*). They also evaluated several criteria for the identification of species of the genus and provided a comparative table summarizing the vegetative and reproductive

features of the 30 species. Of these, seven species i. e., *B. monoica* Schnetter (1978), *B. occidentalis* (Børgesen) Kylin (Taylor, 1960), *B. papenfussiana* Ganesan et Lemus (1972), *B. pyriformis* (Børgesen) Kylin (Taylor, 1960), *B. shanksii* Dawson (1962), *B. spinulifera* W.R. Taylor et Abbott (1973) and *B. wynnei* Ballantine (1985) are known to occur in the Caribbean Sea (Wynne, 1986). The vegetative and reproductive characteristics of the Caribbean species were summarized by Ballantine (1985).

Botryocladia ganesanii sp. nov. is different from the seven Caribbean members in the following features. *B. monoica* and *B. papenfussiana* have incomplete cortication of the vesicles, while *B. occidentalis* and *B. shanksii* are large plants (70-200 mm long) with numerous small vesicles that range in size from 2,5-5 mm in diameter. *B. spinulifera* is unique in possessing spinous projections on the surface of the vesicles. *B. pyriformis* has vesicles that are generally 4-9 mm in length (rarely up to 50 mm) with only 2 layers of cells and is presumed to be dioecious, since only one male plant had been reported so far (Ballantine, 1985, p. 202).

Among the non-Caribbean species, *B. ganesanii* sp. nov. showed a very close similarity in external appearance to *B. guineensis* John (1972) described from tropical west Africa (Ghana). However, structurally and reproductively, there are several differences, which merit recognition of the Venezuelan plants as a new species. *Botryocladia guineensis* has 2-6 (10) spherical to elongate pyriform vesicles, while *B. ganesanii* has 7-20 ovoid vesicles. Brodie and Guiry (1988) showed that the vesicle shape may vary with reproductive state and under certain environmental conditions like temperature and irradiance, but that the number of layers in the vesicle is a constant feature and is apparently of specific value. *B. guineensis* has 3-5 layers (John, 1972) or 4 layers (Lawson & John, 1982). But *B. ganesanii* has only 3 layers both in the young and old vesicles. This prominent structural difference is due to the fact that *B. guineensis* has 2 layers of large colourless medullary cells (John, 1972, fig. 4), while in *B. ganesanii* the medulla is made up of only a single layer of large colourless cells (Figs. 5 and 14).

According to Brodie & Guiry (1988), the number, size and position of secretory cells are of principal importance in the species distinction of the genus *Botryocladia*. *Botryocladia guineensis* has 4-8 (12) spherical to pyriform gland cells, generally 11-33 μm in length (average 20 μm) and 10-25 μm broad. *B. ganesanii* has 6-12 (15) ovoid - pyriform secretory cells, which are (25) 30-45 (50) μm long and 20-35 μm broad. In both species, they arise directly on the medullary cells without a bearing cell. However, in *B. ganesanii*, the medullary cells bearing developing secretory cells stain more readily in the early stages of development (Fig. 8) and stand out distinctly from the surrounding cells. In later stages however, their identity is lost (Fig. 9).

In both *B. guineensis* and *B. ganesanii* the cortical layer is complete. But the arrangement and cell size are different both in the sterile and reproductive areas in the two species. In *B. guineensis* cortical cells are large and closely

packed (Fig. 12), while in *B. ganesanii* they are small and loosely arranged (Fig. 11). Tetrasporangia of *B. guineensis* are ovoid 22-33 μm long and 16-22 μm broad (John, 1972), while those of *B. ganesanii* are ovate but smaller, up to 24 (28) μm long and 20 μm broad. Fig. 11, 12 which respectively show cortical cell arrangement and tetrasporangia in *B. ganesanii* and *B. guineensis*, have the same magnification.

The Venezuelan plants are monoecious, while *B. guineensis* is presumed to be dioecious, since only female plants have been reported (John, 1972). I also carefully examined some type female plants of *B. guineensis* and these did not show any spermatangial areas. It should however be pointed out that in some species like *B. wynnei*, male and female reproductive structures do not develop at the same time, the cystocarps developing first (Ballantine, 1985). Additional collections and study of *B. guineensis* are necessary to clarify whether this species is dioecious or behaves like *B. wynnei*. A tela arachnoidea was present in *B. ganesanii*, but such a feature was not described for *B. guineensis*. Brodie & Guiry (1988) described the presence of a tela arachnoidea for the first time in *B. ardreana*, considering it anomalous. These authors stated that other species of *Botryocladia* should be examined for the presence of a tela arachnoidea. In the Venezuelan material it was especially evident in developing cystocarps and indistinguishable in mature cystocarps.

Attention should also be called to the fact that in certain species of *Botryocladia* specific delimitations are still not clear, particularly in species occurring on the two sides of the warm waters of the Atlantic. Dr. Paul Silva and Dr. Richard Moe (pers. comm.) pointed out that in *Botryocladia* there exist vicarious pairs, which include *B. papenfussiana* and *B. lawsonii, B. occidentalis* and *B. botryoides, B. senegalensis* and *B. monoica* and perhaps *B. guineensis* and *B. ganesanii*. The differences between these vicarious pairs, according to them, might be the result of geographically correlated modifications. Until comparative critical culture studies are made on these vicarious pairs to know how stable these differences represent specifically, it is uncertain if the latter names of these pairs represent true species or only varieties or even less taxonomically.

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