

Caribbean Journal of Science, Vol. 35, No. 3-4, 286-295, 1999
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University of Puerto Rico, Mayagüez

First Reports of *Padina antillarum* and *P. glabra* (Phaeophyta-Dictyotaceae) from Florida, with a Key to the Western Atlantic Species of the Genus

MICHAEL J. WYNNE¹ AND OLIVIER DE CLERCK²

¹Department of Biology, University of Michigan, Ann Arbor, Michigan 48109.
mwynne@umich.edu

²Laboratory of Botany, University of Ghent, 9000 Ghent, Belgium.
Olivier.Declerck@rug.ac.be

ABSTRACT.—*Padina antillarum* (Kützinger) Piccone and *P. glabra* Gaillard are newly reported for Florida. The first species, which has been widely reported from the Indo-Pacific under the name *P. tetrastromatica* Hauck, has seldom been reported from the Western Atlantic. The type locality of *P. antillarum* is Trinidad in the Lesser Antilles, and there are reports of its occurrence from Venezuela and Colombia. Observations are provided on tetrasporangiate and oogonial plants collected from Brevard County, Florida. *Padina glabra*, first described from Senegal, northwest Africa, has been collected on three occasions from Anastasia Island, Saint Augustine, St. Johns County, Florida. The Florida material agrees in most respects with the original description of *P. glabra* except for the larger size of the Florida thalli and the fact the thalli bear plantules in addition to sporangia. A key to the Western Atlantic species of *Padina* is provided.

INTRODUCTION

Wynne (1998b) presented evidence that *Padina tetrastromatica* Hauck, a frequently reported species in the Indo-Pacific and tropical West Africa, and *P. antillarum* (Kützinger) Piccone, a poorly known taxon, are conspecific and that the latter name has priority. Collections of *P. antillarum* from P. Patrick Air Force beach, Brevard County, Florida, are herein reported and observations made on the vegetative and reproductive characteristics of this species of brown algae.

Up to now there have been reports of *Padina glabra* Gaillard only from the type locality in West Africa (Gaillard, 1966) and from southern India (Rengasamy & Anand, 1986). Thus, the identification of material from the northeast coast of Florida represents the first report of this species from the western Atlantic. A comparison with other species of the genus occurring in the western Atlantic with which *P. antillarum* and *P. glabra* might be confused is presented.

MATERIALS AND METHODS

The collection of *Padina antillarum* was made by Ted Klenk at P. Patrick Air Force Base beach (28° 13.9' N, 80° 36' W), 8 miles

south of Cocoa Beach, Brevard County, Florida, on 15.vii.1998. The specimens were found floating in the drift. The collection of several plants has been deposited in the Herbarium of the University of Michigan (MICH).

Collections made on three occasions from the same locality in Florida are herein identified as *Padina glabra* Gaillard.

Anastasia Island, St. Augustine, St. Johns County, Florida:

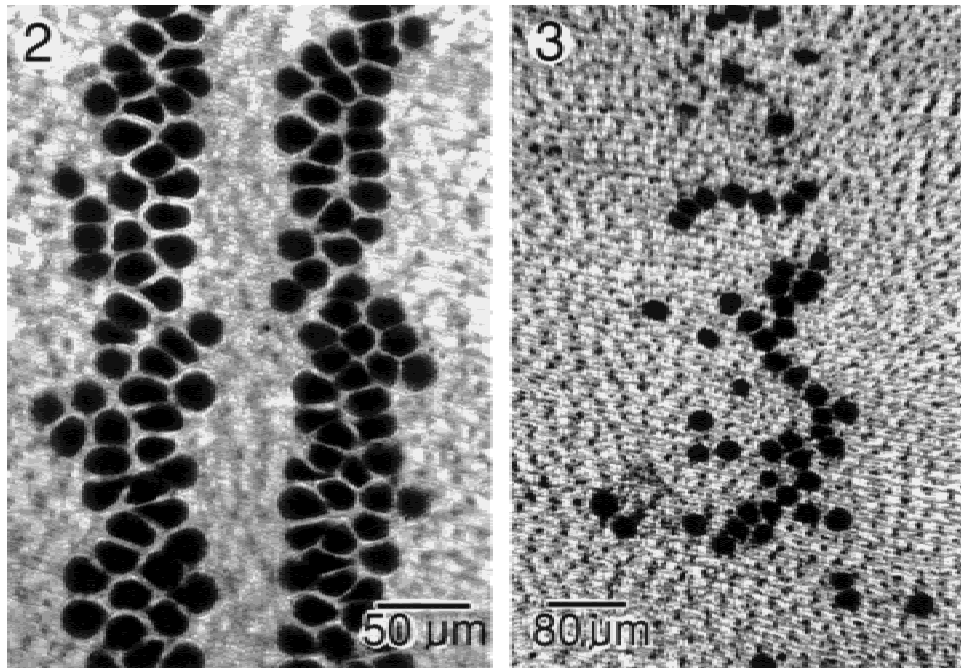
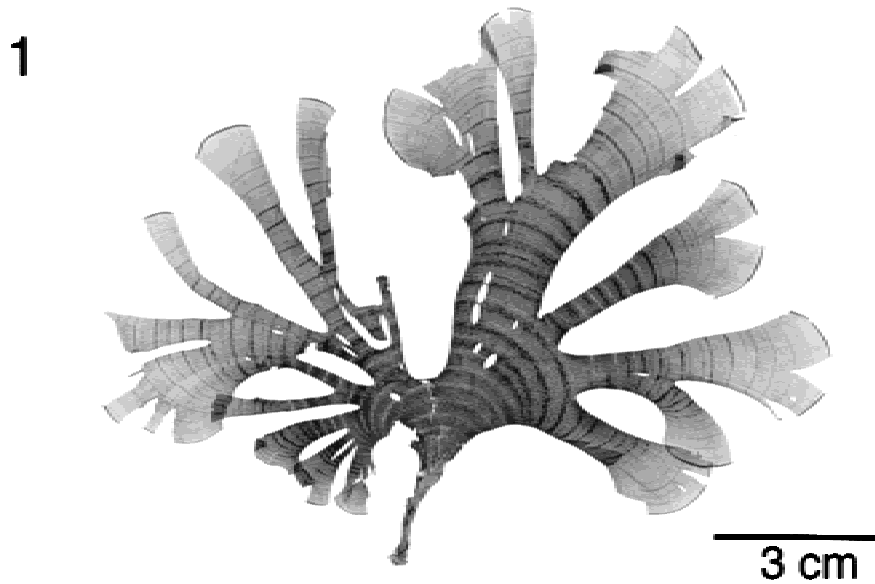
- 1) legit Mrs. G. A. Hall, 20.vii.1896, Phycotheca Boreali-Americana 580b (two sets in MICH).
- 2) legit Mary S. Snyder, ca. 1895-6 (MICH).
- 3) legit M. A. Howe no. 1189, 5.x.1902 (in NY); "on rocks of jetties at l. t. m. [= low tide mark] and below."

Specimens that had been identified by M. A. Howe as *Padina antillarum* (or as that species with a query) were borrowed from NY and US for re-examination.

RESULTS

Padina antillarum (Kützinger) Piccone (Figs. 1-10)

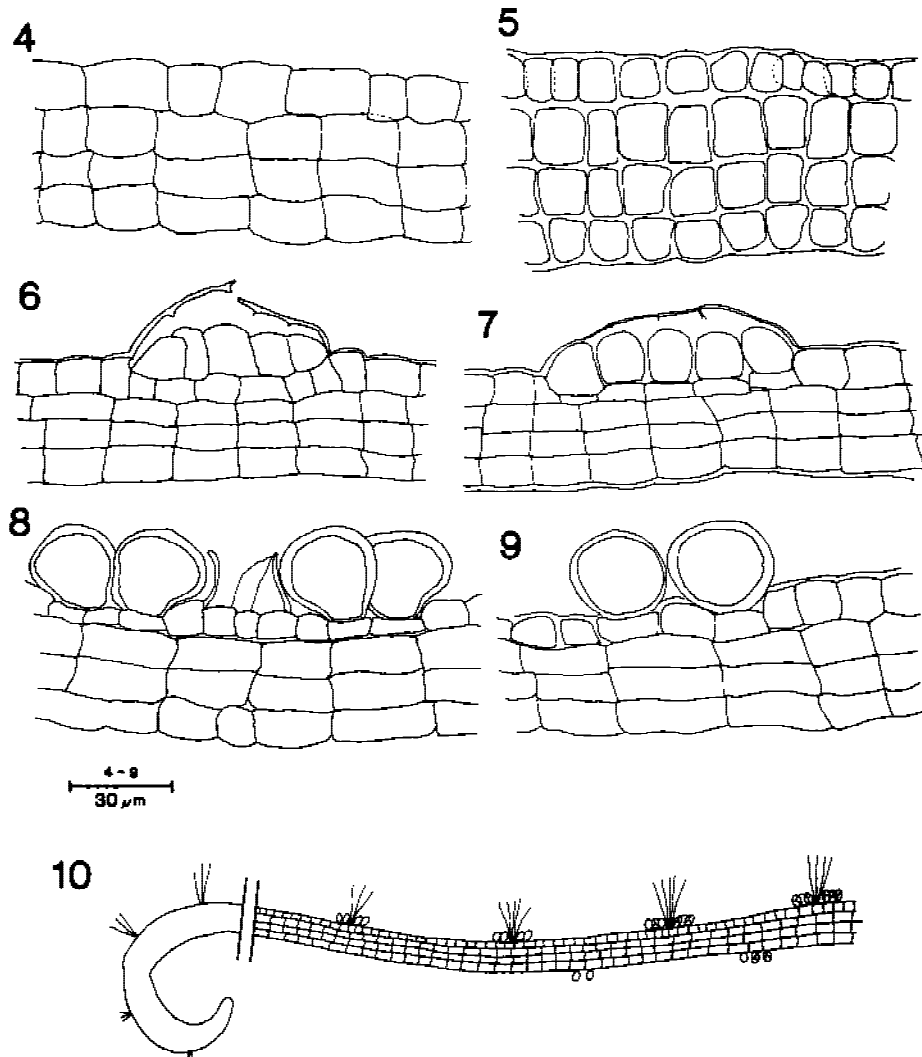
The Florida collection of *P. antillarum* contained tetrasporangial and oogonial



FIGS. 1-3. *Padina antillarum*. 1. Habit. 2. Surface view of inferior surface of tetrasporangial blade showing soral arrangement. 3. Surface view of superior surface of tetrasporangial blade showing scattered sporangia in the region between hair bands.

thalli. The largest thallus (Fig. 1) measured 10.5 cm in height and an overall breadth of 11.5 cm, although the thallus was deeply split into segments 0.5-2.0 cm in width. The

blades showed no calcification. Cross- and sagittal sections of the blades, both in mid-region and in more basal portions, showed a 4-layered organization (Figs. 4, 5). In tet-



FIGS. 4-10. *Padina antillarum*. 4. Sagittal-section in mid-region of blade. 5. Cross-section in basal region of blade. 6-7. Sagittal-sections of female blade with oogonial sorus. 8-9. Sagittal-section of blade bearing sporangia. 10. Schematic representation of soral pattern in relation to hair-lines.

rasporangial and oogonial plants, reproductive organs occurred as pairs of concentric bands, each pair closely abutting a common hair-line (Fig. 2). These soral bands were well developed on the blade surface away from the circinnately inrolled apex of the thallus, as is characteristic of the genus. This surface was referred to as the lower side by Trono (1969) and Womersley (1987) and the inferior surface by Gaillard (1967). Gaillard's terminology is followed in this paper. In sporangial plants, sporan-

gia were also sometimes present on the superior side, but they were loosely scattered in the mid-region between the soral bands on the opposite (inferior) side (Fig. 3). The sporangia were not associated with hair bands, contrary to Gaillard's (1967) observation that they may be associated with scattered hairs on the superior surface. Figure 10 represents a schematic view of a sectioned sporangial blade. In female thalli, an indusium covering the oogonia (Figs. 6, 7) is present, as depicted for this species by

Gaillard (1967). An indusium was not observed in tetrasporangial thalli (Figs. 8, 9).

Specimens in NY and US that had been assigned by M. A. Howe to *Padina antillarum* (sometimes with a "?") were re-examined. None was found to be *P. antillarum*, but they were re-determined as *P. boergesenii*, *P. haitiensis*, *P. sanctae-crucis*, and *P. boryana*.

Padina glabra Gaillard (Figs. 11-21)

In working over collections of *Padina* in NY, the first author found a collection of hairless blades from Florida. This collection consisted of numerous entangled specimens mounted on a single herbarium sheet. Individual thalli measure 10-12 cm in height. Most thalli are deeply divided, individual segments being 2-3 cm wide (Fig. 11). There is no evidence of calcification. In sectional view blades consist of 3 to 4 cell layers (Figs. 17, 21). Cells on the superior and inferior thallus face are 48-62 μm long, 24-30 μm broad, and 25-27 μm high (Fig. 19). The central row(s) of cells possess the same width and length as the other cells, but their height varies. If 3 cell layers are present, the middle layer is approximately 50 μm high; if 4 cell layers are present, the middle cell seems to be divided into 2 cells, each 25 μm high. Sporangia are borne mainly on the superior face of the blade; less frequently sporangia are borne on the inferior face, but they do not occur in dense concentric sori. The sori lack indusia, and the absence of hairs is noteworthy (Figs. 16, 18). The uppermost sori contain sporangia (Fig. 20), but in a proximal direction the sori contain plantules apparently by a direct germination of the tetrasporangial mother cells (Figs. 12-15). These plantules are sometimes arranged as a pair of closely placed concentric rows (Fig. 12). Toward the base of the blade there is a gradual increase in the size of the plantules.

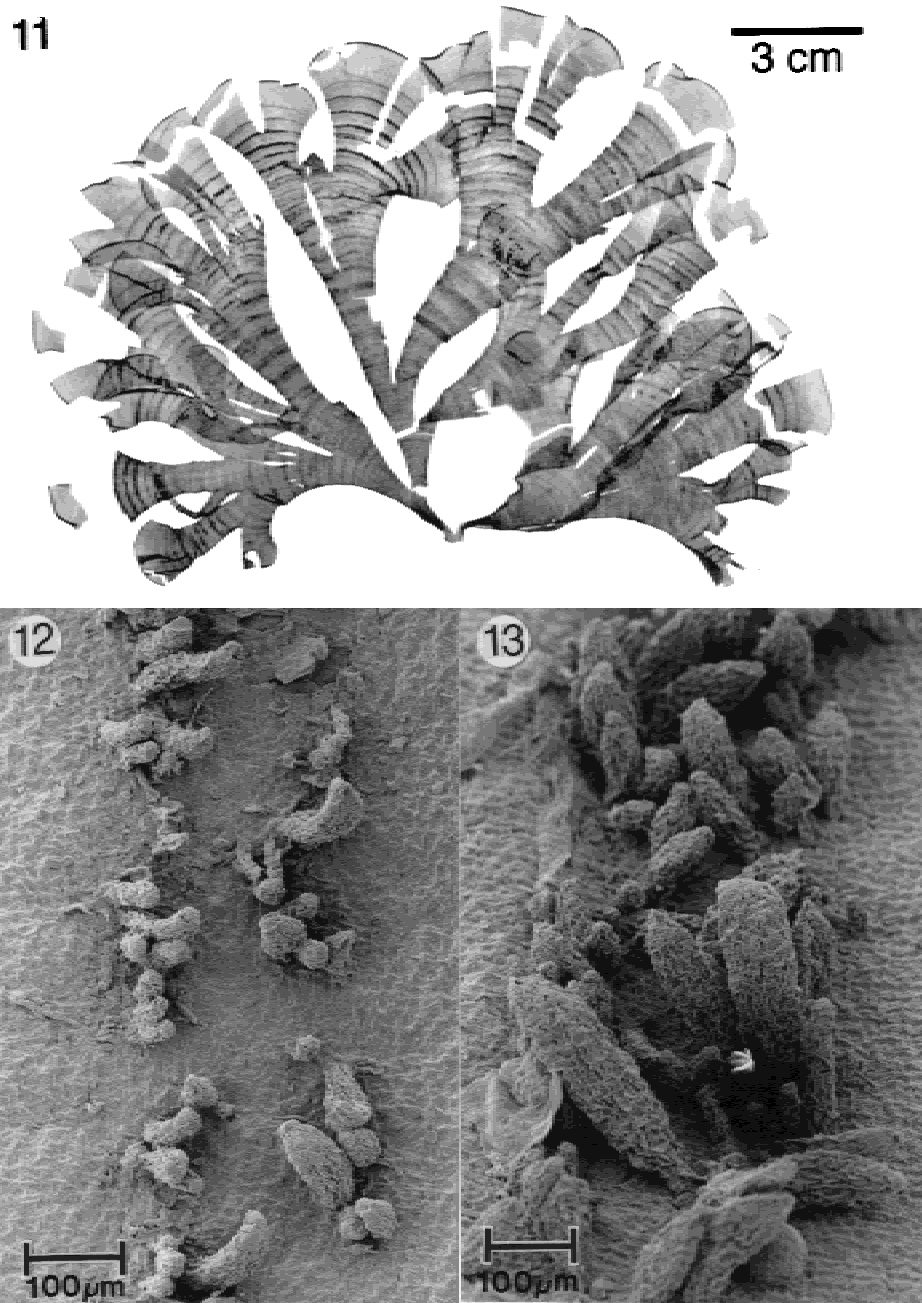
Our attention was drawn to Dangeard (1952) [see below] and the existence of a hairless *Padina* distributed as *Phycotheca Boreali-Americana* no. 580, specifically 580b, ("*Padina durvillaei* Bory"). In the two sets of PB-A 580b in MICH both specimens are hairless. These specimens (Fig. 11) bear

sporangia in the sori located in the uppermost portion of the blade, and there is a gradual transition to the production of plantules in the older sori, as observed in collections made some years later by Howe from the same locality. These sporangia and resultant plantules often occur in a pair of closely associated concentric rows. The lack of calcification, the deeply divided blades, and the blade thickness of 3-4 cell layers point to the identity of PB-A 580b as *P. glabra*.

DISCUSSION

Padina antillarum and *P. tetrastrumatica* were included in a recent checklist of benthic marine algae of the tropical and subtropical Western Atlantic (Wynne, 1998a). Gaillard (1967) published a detailed account of vegetative and reproductive observations on *P. tetrastrumatica*, based both on three specimens in the type collection in Leiden and on recent specimens from Dakar, Senegal, West Africa. Gaillard (1967, fig. 1) designated one of the three specimens as the lectotype of *P. tetrastrumatica*. The first account of *P. antillarum* was its description as *Zonaria antillarum* by Kützing (1859). Piccone (1886) transferred the species to *Padina*. The fact that Kützing did not provide information on its provenance may explain why Taylor (1960) did not include it in his marine benthic algal flora of the tropical western Atlantic. Wynne (1998b) examined the type specimen in MEL (National Herbarium of Victoria, Melbourne, Australia) and observed that the type locality was Trinidad in the Lesser Antilles, as the epithet "*antillarum*" suggests. Wynne also presented evidence that *P. antillarum* is taxonomically identical to *P. tetrastrumatica* Hauck (1887), with a type locality of Meith, Somalia.

Padina antillarum is widely distributed in the Indian Ocean (Silva et al., 1996, as *P. tetrastrumatica* as well as *P. antillarum*) and the tropical coast of West Africa (Lawson and John, 1987, as *P. tetrastrumatica*). After the original description of the species, the only reports of *P. antillarum* in the western Atlantic are those by Schnetter (1976) from

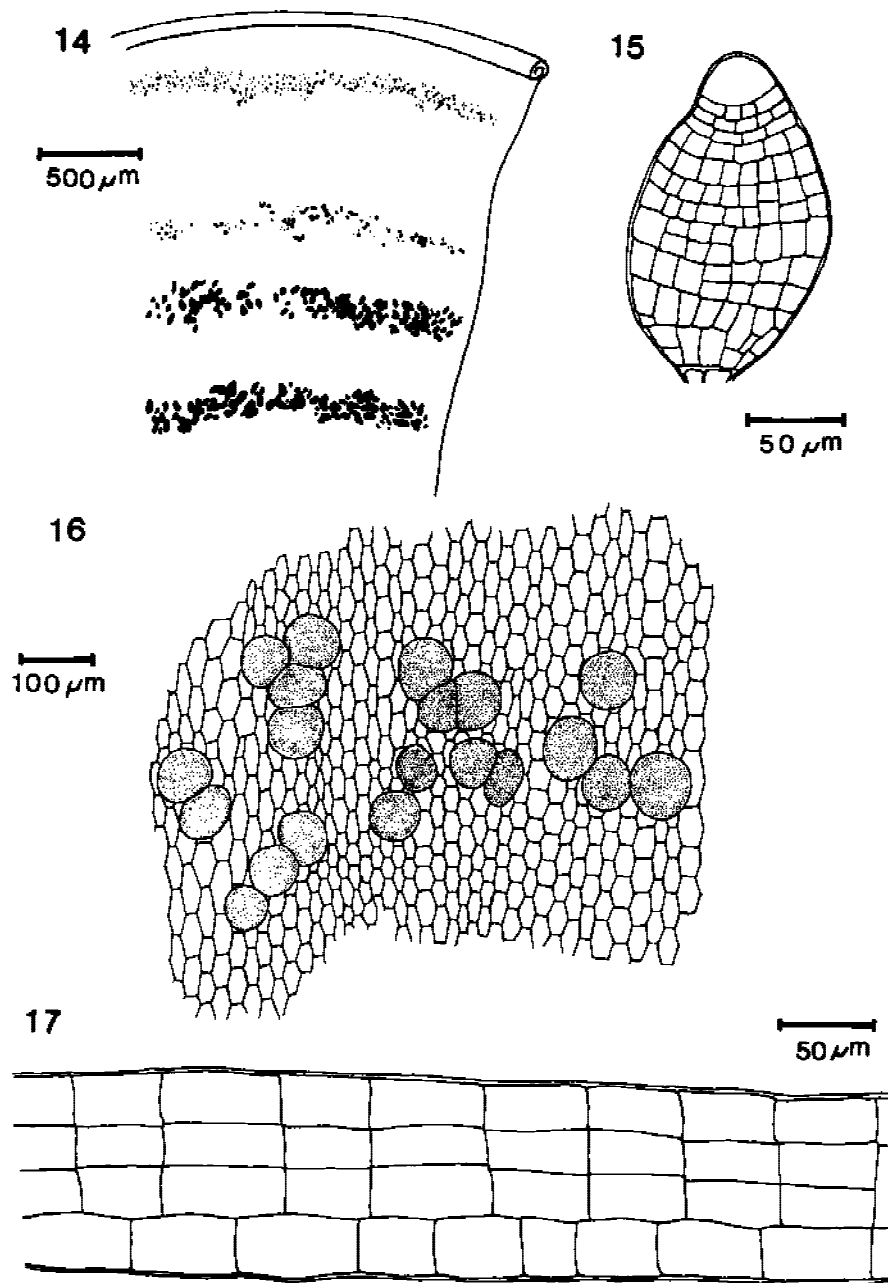


FIGS. 11-13. *Padina glabra*. 11. Habit of specimen, PB-A 580b (MICH). 12-13. Plantules on surface of blade (Howe no. 1189, NY).

Colombia and by Aponte and Ganesan cited by Ganesan (1990) from Venezuela (both records as *P. tetrastromatica*). According to Thivy (1945), the report of *P. tetrastromatica* by Setchell and Gardner (1930)

and repeated by González-González et al. (1996) from Pacific Mexico is most likely *P. crispata* Thivy in Taylor (1945).

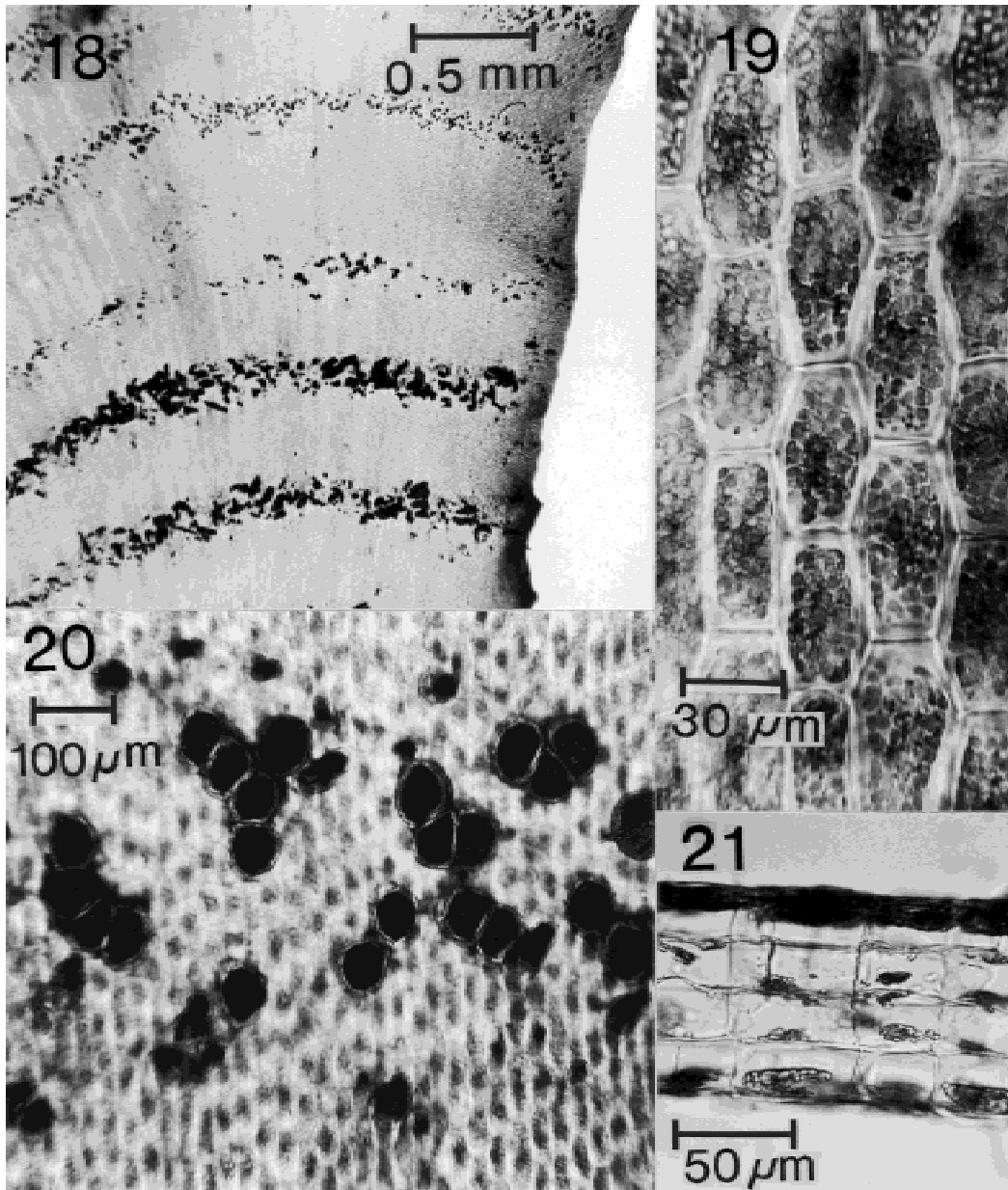
Padina glabra was described by Gaillard (1966) from Pointe de Fann, Dakar, Senegal,



FIGS. 14-17. *Padina glabra*. (These figures are based on Howe no. 1189). 14. Schematic depiction of transition from sporangia-bearing to plantule-bearing soral bands. 15. Individual plantule. 16. Schematic representation of sporangia in a sorus. 17. Sagittal section of blade.

northwest Africa. This is the only reported collection of this species from the west coast of Africa (Price et al., 1978). In a paper not mentioned by Gaillard (1966), Dange-

ard (1952) reported on various collections of *Padina* from Dakar, including some from Pointe de Fann (the type locality of *P. glabra*). He called attention to some specimens



FIGS. 18-21. *Padina glabra*. (These figures are based on Howe no. 1189). 18. Surface view of blade bearing sori but lacking hair bands. 19. Surface view of blade. 20. Region of sorus bearing sporangia. 21. Sagittal section of blade.

of *Padina* that were four cell layers thick, had sporangial sori arranged in concentric circles generally associated in pairs, and were hairless. According to Dangeard, J. Feldmann confirmed his observations and suggested that a new genus could be

erected for these specimens on the basis of the absence of hairs. Although Dangeard mentioned that the four-cell-layered construction suggested a relationship with *P. tetrastromatica* [= *P. antillarum*], he refrained from assigning a specific name. There is

little doubt that Dangeard was dealing with the species later described by Gaillard (1966) from the same location as *P. glabra*.

Dangeard (1952) called attention to the fact that a specimen of *Padina* that was distributed as *Phycotheca Boreali-Americana* no. 580, specifically 580b, ("*Padina durvillaei* Bory") was hairless. PB-A 580b was a collection made by Mrs. G. A. Hall, 20.vii.1896, from Anastasia Island, the identical location of the M. A. Howe collection. Another shared feature is that these specimens bear plantules; the printed label states "Both *a* and *b* bear tetraspores; in *b*, a large part of them have germinated in situ, on the frond." Collins and Hervey (1917) stated that PB-A 580b "should be referred to *P. variegata*", a name which was later replaced by *P. vickersiae* Howe (in Hoyt, 1920).

The Florida material being assigned to *P. glabra* agrees with Gaillard's (1966) account of this species in many aspects: the absence of hairs, the lack of calcification, the (3-4) cell-layered organization and the cell dimensions, and the non-indusiate nature of the sporangial sori. The material differs from Gaillard's (1966) account of *P. glabra* in the greater size of the blades (10-12 cm tall versus 1.0-1.5 cm for the type collection), the divided nature of the blades in contrast to entire blades, and the production of plantules. There is a report of *P. glabra* from Mandapam, southern India by Rengasamy and Anand (1986). Their observations minimize the apparent differences between Gaillard's account and our observations on the Florida material in that those authors noted that the blades were 4.0-5.0 cm tall, were divided down to the middle portion, and bore plantules. They also stress that this is the only species of *Padina* known to lack hairs, a feature shared by the Dakar, Indian, and Florida collections. Another point of agreement between the Florida and the Indian specimens is the presence of sporangia on the superior side of the thallus. Dangeard's (1952, fig. 7) depicted hairless "*Padina* sp." (from the type locality of *P. glabra* and most likely belonging to this species) as being 9 cm tall. Thus, the small stature reported in Gaillard's (1966) account of *P. glabra* would be at the low end of the possible range. The produc-

tion of plantules appears to be a variable feature in some species of *Padina* and in other Dictyotales. Thivy (1945) referred to these plantules as both brood buds and propagula, developing in the place of sporangia or from sporangia at a very young stage ("presumably before reduction divisions occurs"). She indicated their occurrence in *P. durvillaei* Bory and *P. distromatica* Hauck. These plantules have been noted also in *P. pavonica* by Bitter (1899) and Kuster (1899) and in *P. gymnospora* (Kütz.) Sonder by Hoyt (1920, as *P. vickersiae*). Hauck (1887), Gaillard (1967), and Lawson and John (1977) reported that thalli of *P. antillarum* (= *P. tetrastromatica*) sometimes bear plantules arising in the same position as the tetrasporangial sori. Feldmann (1937) observed that Mediterranean plants of *Dictyota* [*Dilophus*] *fasciola* (Roth) Lamouroux may bear plantules.

There is some similarity of the Florida *Padina glabra* to *P. profunda*, described by Earle (1969) from the Dry Tortugas of Florida, Gulf of Mexico, and also reported from offshore North Carolina (Schneider and Searles, 1973). According to Earle, blades of *P. profunda* are non-calcified and have faint piliferous zones with few hairs. Plants ranged in height from 10 to 25 cm. Blade thickness ranged from 2 cell layers near the margins to 3-4 cell layers in the mid-blade portion, and 3-6 cells layers at the base. Reproductive plants were not observed.

Padina gymnospora (Kütz.) Sonder has been the only species of the genus reported with confidence from the east coast of Florida (Moffler and Van Breedveld, 1979, as *P. vickersiae*; see Allender and Kraft, 1983). *Padina antillarum* can be distinguished from *P. gymnospora* by the latter species' thicker blades (6-8 layers in the basal region) and soral bands placed proximal to each successive hair zone.

Schneider and Searles (1998) reviewed the many reports of marine algae sharing a distribution in the eastern and western tropical or subtropical Atlantic. This first report of *Padina glabra* from the western Atlantic, thus significantly extending its range, is not surprising because many other algae have a similar distribution. The rarity

of this species is an interesting question. Whether this apparent rarity of *P. glabra* is real or merely the result of its being mistaken for other species remains unanswered.

Key to the species of *Padina* known for the Western Atlantic¹

1. Hairs and hair lines absent -- *P. glabra*
- 1'. Hairs and hair lines present (at times difficult to detect because they may have been shed or are poorly developed, but their formation is revealed by the presence of concentric lines)----- 2
2. Sporangial sori closely abutting the hair lines on both sides (the lower sporangial band often not well developed in *P. pavonica*)----- 3
- 2'. Sporangial sori not closely abutting the hairs lines----- 4
3. Blades 3 cell layers (3-4 in basal region); superior surface of blade heavily calcified, inferior surface moderately calcified; sporangial sori with persistent indusium; gametophytes bisexual ----- *P. pavonica*
- 3'. Blades 4 cell layers (3 in apical region; 6 in basal region); calcification absent or negligible; sporangial sori not indusiate; gametophytes unisexual ----- *P. antillarum*
4. Blades 4 cell layers in mid frond; 6-8 cell layers near base; sori present between successive hair bands (alternating fertile and sterile zones absent) ----- *P. gymnospora*
- 4'. Blades either 2 or 2-3 cell layers throughout; alternating fertile and sterile zones present----- 5
5. Blades 2 cell layers throughout----- 6
- 5'. Blades a mixture of 2 and 3 cell layers in same thalli ----- *P. boergesenii*

¹*Padina profunda* is excluded due to lack of knowledge of fertile specimens. *Padina crispata* Thivy in W.R. Taylor is also excluded; it ranges from Pacific Mexico to Pacific Colombia (Taylor, 1945; Schmetter and Bula Meyer, 1982), and its inclusion in Wynne's (1998a) checklist is an error.

6. Indusium not persistent; sporangial sori located in proximal region of fertile zone, just distal to hair lines ----- *P. sanctae-crucis*
- 6'. Indusium persistent; sporangial sori in mid-region of hair lines----- 7
7. Superior surface of blade heavily calcified and inferior surface very lightly calcified; surface cells of blade 25-38 μm wide; sporangia up to 120 μm in diameter --- *P. haitiensis*²
- 7'. Both blade surfaces moderately calcified except for zones of hair bands; surface cells of blade 30-50 μm wide; sporangia up to 170 μm in diameter ----- *P. perindusiata*

Acknowledgments.—We thank Mr. Ted Klenk of Orlando, Florida, for donating his collections to the senior author. We acknowledge William R. Buck of NY and Robert H. Sims of US for arranging the loan of specimens. We are grateful to Dr. Bruno de Reviere of PC for his assistance in trying to locate material of *P. glabra*.

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