

***Taonia abbottiana* sp. nov. (Dictyotales, Phaeophyceae) from the Tropical Western Atlantic¹**

Diane S. LITTLER^{a, b*} & Mark M. LITTLER^b

^aDivision of Marine Science, Harbor Branch Oceanographic Institution, 5600 U.S.
1 North, Fort Pierce, Florida 34946, USA.

^bNational Museum of Natural History, Department of Botany, NHB-166, P.O.
Box 37012, Smithsonian Institution, Washington, D.C. 20013-7012, USA.

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Abstract — A new species of brown algae, *Taonia abbottiana* D.S. Littler et M.M. Littler, is described from the tropical western Atlantic. To date, this is the only member of the genus reported from the region. *Taonia abbottiana* differs from other species of the genus in having (1) sporangia raised above the surface layer on a stalk composed of two cells, and (2) in addition having a surface cortical layer of differentiated cells that are smaller than those of the medullary layers. *Taonia abbottiana* has often been confused with *Stypodium zonale*, but the two differ anatomically in the development of cells directly behind the growing margin and, when living at similar depths, *T. abbottiana* consistently has light colored concentric lines, while *S. zonale* has dark concentric lines.

Caribbean / Dictyotales / marine algae / Phaeophyceae / *Taonia abbottiana* sp. nov. / *Taonia* / taxonomy / tropical western Atlantic

Résumé — *Taonia abbottiana* (Dictyotales, Phaeophyceae) de l'Atlantique tropical occidental. Une nouvelle espèce d'algue brune, *Taonia abbottiana* D.S. Littler et M.M. Littler, est décrite de l'Atlantique tropical occidental. A ce jour, c'est le seul taxon du genre présent dans cette région. *Taonia abbottiana* diffère des autres espèces du genre par (1) des sporanges élevés au dessus de la surface par un pédicelle composé de deux cellules et (2) par une couche corticale de surface composée de cellules différenciées, plus petites que celles des couches médullaires. *Taonia abbottiana* a souvent été confondu avec *Stypodium zonale*, mais ces deux taxons diffèrent anatomiquement par le développement des cellules directement derrière la zone de croissance marginale ; de plus, lorsque les deux espèces vivent à des profondeurs semblables, *T. abbottiana* a logiquement des lignes concentriques brillamment colorées, tandis que *S. zonale* a des lignes concentriques sombres.

Algues marines / Atlantique occidental tropical / Caraïbes / Dictyotales / Phaeophyceae / *Taonia* / *Taonia abbottiana* sp. nov. / taxinomie

1. Dedicated to Prof. Isabella Aiona Abbott on her 85th birthday.

* Reprints and correspondence: littlerd@si.edu

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INTRODUCTION

The genus *Taonia* J. Agardh (1848: 101) [Dictyotaceae, Dictyotales] is characterized by a blade-like thallus that is fan-shaped to highly divided, with plain or toothed (in one species) margins, and without a midrib (see also: Abbott, 1977; Womersley, 1987). The medulla consists of 2-6 layers of large colorless cells and the surface cortex is generally a single layer of smaller darkly pigmented cells. Growth of the blade margin in *Taonia* is initiated by a solitary meristematic marginal cell that divides longitudinally to produce the first 2 cell layers of the medullary tissue. At about 100 μm to 1 mm behind the margin, the cells divide again; this feature is consistently present but highly variable. The cells of the medulla gradually increase from two layers to four layers, in some species up to six layers, in older tissue. With the addition of the new species *T. abbottiana* described herein, the genus *Taonia* at present consists of six known species worldwide, including *T. atomaria* (Woodward) J. Agardh (1848), *T. australasica* Agardh (1894), *T. lacheana* Cormaci, G. Furnari et Pizzuto (1994), *T. lennebackerae* J. Agardh (1894) and *T. pseudociliata* (Lamouroux) Nizamuddin et Godeh (1993).

MATERIALS AND METHODS

Specimens were preserved in 10% Formalin-seawater. Air-dried herbarium collections, liquid-preserved materials and living algae were examined microscopically after portions were prepared on glass microscope slides for anatomical study. Thallus sections were made by hand using single-edge razor blades (in the field) or by freezing microtome. Microscopic preparations were stained with 1% aniline blue and mounted in 20% corn syrup (Karo[®] Syrup, Corn Products, Inc.) solution in distilled water containing a trace of phenol (Tsuda & Abbott, 1985). All anatomical drawings were made with a camera lucida on a Zeiss Universal Microscope to ensure accuracy; internal measurements were made with a calibrated ocular micrometer. The holotype (Fig. 1) and paratype specimens studied are deposited in the Algal Collection of the U.S. National Herbarium (US), National Museum of Natural History, Smithsonian Institution, Washington, D.C. Herbarium abbreviations follow Holmgren *et al.* (1990).

RESULTS

Taonia abbottiana D. Littler et M. Littler, *sp. nov.* (Figs 1-7)

Taonia sp. *sensu* Littler and Littler, 2000: 278-279, Figs 1-5, color plate.

Styopodium zonale sensu Littler *et al.*, 1989: 113 (*pro parte*; color plate) [non *S. zonale* (Lamouroux) Papenfuss, 1940: 205].

Latin Diagnosis: *Species* Taoniae australiacae anatomia et structura similes, sed cum crassioribus laminibus, nudis pedunculatisque (2 cellulas) sporangiis et deversus corticeus.

1



Liquid Material Preserved In
Vial # 14576 Jar # 1294

**Marine Algae of
JAMAICA**

Dictyotaceae

Taonia abbottiana D.S. Littler & M.M. Littler

HOLOTYPE

2 miles W of Discovery Bay.

18°29.071'N 77°30.154'W

D.S. Littler D&ML 51849

2 Jun 1996

M. M. Littler, B. L. Brooks & S. A. Reed

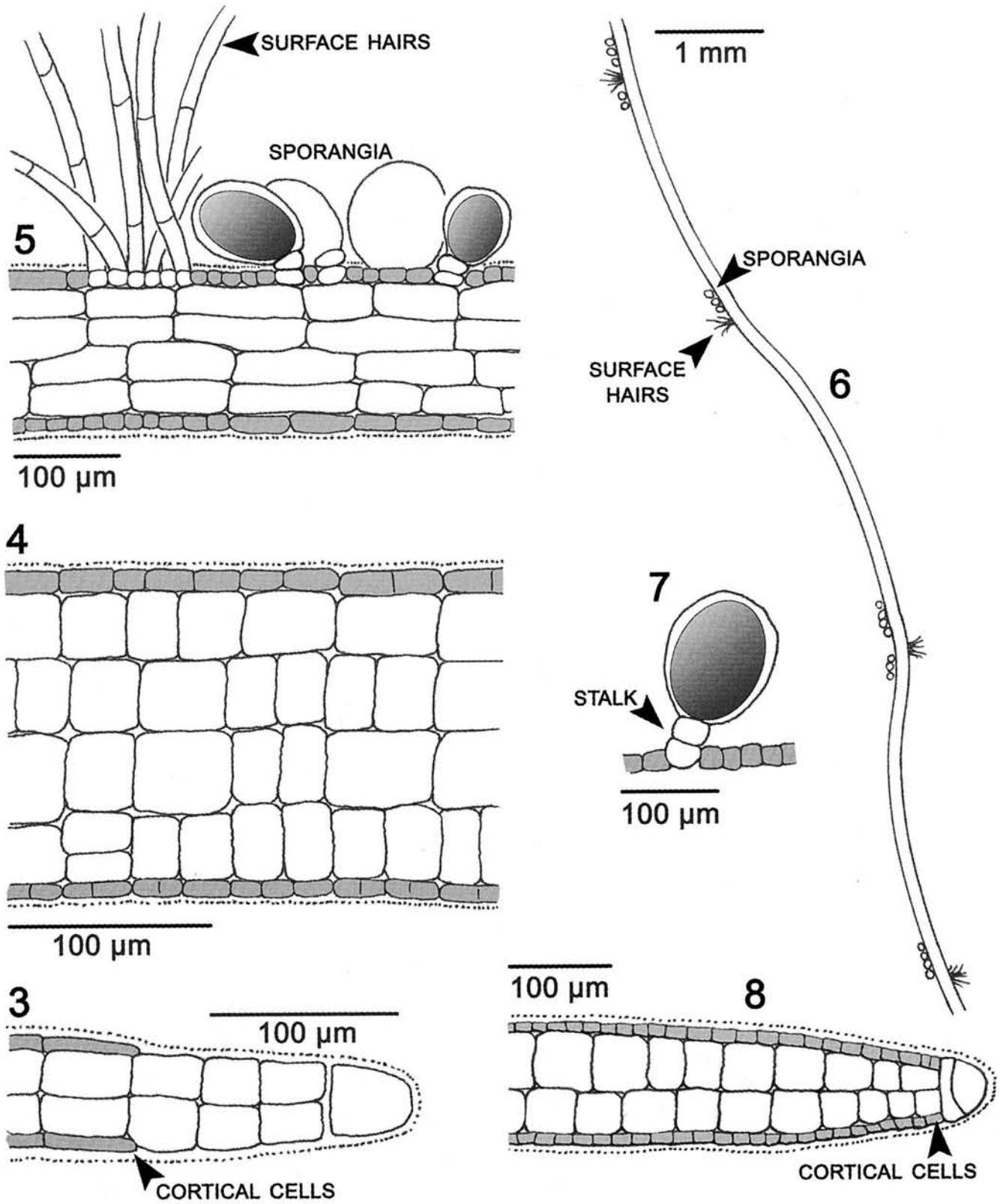
Collected off the R/V *Sea Diver* with support from the
National Science Foundation and Harbor Branch Oceanographic Institution

Fig. 1. Holotype of *Taonia abbottiana* sp. nov. (#US Alg. Coll.-208962).



Fig. 2. *In situ* underwater photograph of young thalli of *Taonia abbottiana* sp. nov., showing the characteristic light-colored concentric lines on the fan-shaped blades.

Description: The thallus appears as an erect cluster of iridescent yellow-brown, fan-shaped blades (Fig. 2) growing up to 20 cm high. Blades may reach up to 15 cm wide, and are 180–210 μm thick. Older blades can split and become ragged and somewhat strap-shaped (Fig. 1). The margins are smooth, but often become irregular due to uneven growth or splitting. Distinct light-colored concentric lines are formed by narrow bands of surface hairs, easily observed in living material (Fig. 2); but when pressed and air-dried, the light bands turn dark and thus this feature does not aid in identification (Fig. 1). These lines of surface hairs are approximately 1–3 mm apart near the margins, and 6–8 mm apart near the base; thus, the surface hair lines become progressively further apart as the blade matures, and in older blades may occasionally form isolated, short, irregular lines rather than the smooth concentric lines found in younger portions of the blade. In longitudinal section, the medulla consists of two layers of cells in younger tissue, within 2 mm of the growing margin (Fig. 3), and four medullary layers in older areas, beyond 4 mm from the growing margin (Figs 4, 5). Cells of the medulla are roughly square in transverse section (Fig. 4) and generally rectangular in longitudinal section (Fig. 5), ranging from 50–125 μm in length, 30–60 μm in thickness, and arranged in irregular rows. Surface cells are irregularly rectangular in surface view, growing to 15 μm in width, 20 μm in length and 20–30 μm in thickness. Surface hairs (Fig. 5) occur in transverse narrow bands, alternating irregularly from ventral to dorsal sides of the blade (Fig. 6); however, they are most commonly found on the dorsal side of the blade.



Figs 3-8. Anatomical comparisons of *Taonia abbottiana* sp. nov. (3-7) and *Stypopodium zonale* (8). 3-7: *Taonia abbottiana* sp. nov. (#D&M Littler-51849). 3: Longitudinal section of the growing margin showing the thinner cortical cells developing on the fourth medullary cell from the initial meristematic marginal cell. 4: Transverse section of the lower portion of the blade with a four layered medulla covered on the top and bottom by the smaller, thinner, heavily pigmented surface cells. 5: Longitudinal section of a blade showing surface hairs and a sporangial cluster. 6: Longitudinal profile of a blade showing the zones of surface hairs and sporangia alternating irregularly on the ventral and dorsal sides of the blade surface. 7: Sporangium raised above the blade surface on a two-celled stalk. 8: *Stypopodium zonale*, a longitudinal section of growing margin of showing the 4 cell layers developing immediately behind the lead marginal meristematic cell (or 2 cells at most).

Sporangial sori closely border and run parallel to the hair bands (Figs 5, 6) and are generally most abundant on the ventral side of the blade. However, these sori occur intermittently and are not always present. The sporangia are spherical to oval (Figs 5, 7), 80-100 μm in diameter, and are formed on a short, two-celled stalk up to 30 μm in diameter (Fig. 7), which elevates the sporangium proper well above the surface of the blade (Figs 5-7).

Etymology: This species is named in honor of Isabella Aiona Abbott whose systematic and floristic research and enthusiastic teaching over the years have helped shape the careers of numerous phycologists.

Holotype: #US Alg. Coll.-208962, coll. D.S. Littler, M.M. Littler, B.L. Brooks and S.A. Reed, #*D&M Littler-51849*, 2 Jun. 1996 (Fig. 1).

Type locality: Jamaica: two miles west of Discovery Bay [$18^{\circ}29.071'N$; $77^{\circ}30.154'W$]; growing in a mixed community on hard substrate, 10–20 m deep.

Distribution: Bahamas, Florida, Jamaica, México, Puerto Rico, Saba.

Habitat: On rock or coral fragments in sandy areas or on solid substrates; up to 40 m deep, most commonly occurring less than 15 m deep.

Paratype specimens studied: **Bahamas – Great Abaco Is.:** Sandy Cay [$26^{\circ}24'N$; $77^{\circ}00'W$], near reef on sheltered bottom, coll. “field class of E.I. Friedmann,” *s.n.*, 8 Feb 70 (#US Alg. Coll.-21251). **U.S.A. – Florida:** Sombrero Key, Monroe County, Florida Keys, coll. “unknown”, #*K-71-19*, 22 Mar 71 (#US Alg. Coll.-21240). **México – Quintana Roo:** Tanchah, Yucatan Peninsula, along shore, rocky and with surf, coll. “Schmitt Party”, *s.n.*, 2 Apr 60 (#US Alg. Coll.-50080). **Greater Antilles – Puerto Rico:** Isla Monito [$18^{\circ}09.50'N$; $67^{\circ}56.69'W$] (northwest of Isla de Mona), attached to small pebbles on sand plain off west side of Is. Monito, 40 m deep, coll. D.S. Littler, M.M. Littler, B.L. Brooks & S.A. Reed, #*D&M Littler-17025*, 14 May 89 (#US Alg. Coll.-161869). **Lesser Antilles – Saba:** Diamont Rots [$17^{\circ}39.20'N$; $63^{\circ}15.25'W$], on vertical wall of the pinnacle rock, 27 m deep, coll. D.S. Littler, M.M. Littler, B.L. Brooks & S.A. Reed, #*D&M Littler-17267a*, 14 May 89 (#US Alg. Coll.-161866).

DISCUSSION

In the tropical western Atlantic, *Taonia abbottiana* can be confused with *Styopodium zonale* (Lamouroux) Papenfuss (1940: 205). Abbott (1977) astutely was the first to point out that *Taonia* is distinguished from *Styopodium* Kützting (1843: 341) by the early formation of cells adjacent to and just behind the growing margin of the blade (cf. Abbott, 1977: fig. 1A). Unlike the development in *Taonia*, *Styopodium zonale* splits into 4 cell layers immediately behind the leading margin of the meristematic cell or cells (2 at most), and always less than 50 μm from the growing margin (Fig. 8); whereas *Taonia* divides into only 2 cell layers immediately behind the marginal meristematic cell (Fig. 3), and later (from 100 μm to 2 mm in distance from the growth margin) develops additional layers (Figs 4, 5). In *T. abbottiana*, the next cell layer to develop is the cortical layer (Fig. 3), a surface layer of differentiated cells that are smaller, thinner and more darkly pigmented than the much larger central or medullary cells (Figs 4, 5). This differentiated surface layer is present in only three other species of *Taonia* (see: Table 1), i.e., *T. lacheana* Cormaci, Furnari et Pizzuto (1994: 463), *T. lennebackerae* J. Agardh (1894: 30; see Mathieson, 1966) and *T. pseudociliata* (Lamouroux)

Table 1. Comparison of the morphological and anatomical characteristics of species of *Taonia*.

<i>Species</i>	<i>Habit</i>	<i>Sporangia</i>	<i>Margins</i>	<i>Thickness (near the base)</i>	<i>Surface cells similarity to medullary cells</i>	<i>Number of cells in sporangial stalk</i>	<i>Distribution</i>
<i>T. abbottiana</i>	Flabellate	External	Entire	180–210 µm	Differentiated	2	Tropical Western Atlantic
<i>T. atomaria</i> (Generitype)	Flabellate	Partially embedded	Entire	150 µm	Similar to medullary cells	0	Europe, Mediterranean, West Africa & Pakistan
<i>T. australasica</i>	Flabellate	External	Entire	110–160 µm	Similar to medullary cells	3	Australia & New Zealand
<i>T. lacheana</i>	Pseudo-dichotomous	Partially embedded	Entire	350–400 µm	Differentiated	1	Mediterranean
<i>T. lennebackerae</i>	Flabellate	Partially embedded	Entire	130–180 µm	Differentiated	1	Western Pacific (North and Central America)
<i>T. pseudociliata</i>	Pseudo-dichotomous	Partially embedded	Dentate	150–240 µm	Differentiated	1	Mediterranean

Nizamuddin *et al.* (1993: 202). While these three species have a similar blade structure to *T. abbottiana*, their reproductive structures differ considerably. The sporangia of these three *Taonia* are partially embedded within the surface layer of cells and develop on single celled stalks; whereas *T. abbottiana* has sporangia external to the surface layer, i.e., raised well above the blade surface (Figs 5, 6), on 2-celled stalks (Figs 5, 7). The generitype, *Taonia atomaria* (Woodward) J. Agardh (1894: 30), with the broadest distribution (Table 1: Europe, Mediterranean, West Africa and Pakistan; see Guiry & Nic Dhonncha, 2004), is the least similar species to *T. abbottiana*. It has a partially embedded sporangium that develops without a stalk, and an undifferentiated surface layer, i.e., the cortical cells are very similar to the medullary cells in size and thickness, but possess more pigmentation.

The species most similar to *T. abbottiana* is *T. australasica* J. Agardh (1894: 30). However, the latter has external sporangia developing on a 3-celled stalk (Allender & Kraft, 1983; Womersley, 1987), compared to the 2-celled stalk of *T. abbottiana*. The drawing of Womersley (1987: 239, fig. 84D) shows a much elevated sporangium; whereas, the drawing of Allender & Kraft (1983: 92, fig. 9I) depicts a sunken stalk topped by a mostly exposed sporangium. Whether exposed or slightly embedded, all sporangia reported from *T. australasica* have 3-celled stalks. The two also differ dramatically in the blade structure with *T. australasica* lacking a differentiated cortical layer and having a thinner blade (110-160 µm vs 180-210 µm thick in *T. abbottiana*). Furthermore, the surface cells of *T. australasica* are approximately the same size and thickness as the medullary cells, whereas in *T. abbottiana*, the surface cells are much smaller and thinner than the medullary cells (Figs 3-5).

Gerwick *et al.* (1985) found that shallow water *Styopodium zonale* from Belize and Florida were thick (up to 480 µm) and produced similar secondary metabolites from year to year; whereas the deep-water form of “*S. zonale*” was chemically and anatomically distinct; with two additional, unique metabolites, and much thinner blades, only 165 µm thick. These latter specimens may also be *Taonia abbottiana* (J.N. Norris, personal communication). However, both species

contain natural products that strongly deter herbivore grazing (for *S. zonale* see: Norris & Fenical, 1982; Gerwick *et al.*, 1985; and *T. abbottiana*: V. Paul, personal communication).

In the Caribbean, *Taonia abbottiana* and *Styopodium zonale* are often found growing in the same habitats of medium to high herbivory. Where growing sympatrically, field identification is possible with *T. abbottiana* having light colored concentric lines (Fig. 2; Littler *et al.*, 1989: 113, color plate, as '*S. zonale*'), while *S. zonale* has dark concentric lines (Littler & Littler, 2000: 279, color plate).

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REFERENCES

- ABBOTT I.A., 1977 — On the identity of *Zonaria hawaiiensis* (Phaeophyta, Dictyotales). *Bulletin of the Japanese Society of Phycology* 25, Supplement: 1-8.
- AGARDH J.G., 1848 — *Species genera et ordines algarum, seu descriptiones succinctae specierum, generum et ordinum, quibus algarum regnum constituitur*. Vol. I: Algas Fucoideas complectens. Lund, C.W.K. Gleerup, [iii]+viii+1-363 p.
- AGARDH J.G., 1894 — *Analecta algologica. Continuatio I. Lunds Universitets Års-skrift, Andra Afdelningen, Kongliga Fysiografiska Sällskapets i Lund Handlingar* 29(9): 1-144, 2 pls.
- ALLENDER B.M. & KRAFT G.T., 1983 — The marine algae of Lord Howe Island (New South Wales): The Dictyotales and Cutleriales (Phaeophyta). *Brunonia* 6: 73-130.
- CORMACI M., FURNARI G. & PIZZUTO F., 1994 — *Taonia lacheana* sp. nov. (Dictyotales, Phaeophyta), from the Mediterranean Sea. *Nordic Journal of Botany* 14: 463-466.
- GERWICK W.H., FENICAL W. & NORRIS J.N., 1985 — Chemical variation in the tropical seaweed *Styopodium zonale* (Dictyotaceae). *Phytochemistry* 24: 1279-1283.
- GUIRY M.D. & NIC DHONNCHA E., 2004 — *AlgaeBase version 2.1*. Galway, National University of Ireland, world-wide web electronic publication, <http://www.algae-base.org> [searched on 11 May 2004.]
- HOLMGREN P.K., HOLMGREN H.H. & BARNETT L.C. (eds.), 1990 — *Index Herbariorum, Part I. The Herbaria of the World*. Bronx, New York, New York Botanical Garden, x+693 p. [*Regnum vegetabile* vol. 120].
- KÜTZING F.T., 1843 — *Phycologia generalis oder Anatomie, Physiologie und Systemkunde der Tange ...* Leipzig, F.A. Brockhaus. xxxii+1-458, [459] p.
- LITTLER D.S., LITTLER M.M., BUCHER K.E. & NORRIS J.N., 1989 — *Marine Plants of the Caribbean: A Field Guide from Florida to Brazil*. Washington, D.C., Smithsonian Institution Press, viii+263 p.
- LITTLER D.S. & LITTLER M.M., 2000 — *Caribbean Reef Plants*. Washington, D.C., OffShore Graphics, Inc., 542 p.
- MATHIESON A.C., 1966 — Morphological studies of the marine brown alga *Taonia lennebackerae* Farlow ex J. Agardh, I: Sporophytes, abnormal gametophytes and vegetative reproduction. *Nova Hedwigia* 12: 65-79, pls. 11-14.
- NIZAMUDDIN M. & GODEH M., 1993 — Observations on *Taonia atomaria* f. *ciliatae* (Lamour.) Nizamuddin. *Pakistan Journal of Botany* 25: 199-207.

- NORRIS J.N. & FENICAL W., 1982 — Chemical defense in tropical marine algae. *In*: RÜTZLER K. & MACINTYRE I.G. (eds.), *The Atlantic Barrier Reef Ecosystem at Carrie Bow Cay, Belize, 1: Structure and communities. Smithsonian Contributions to the Marine Sciences* 12: 417-431.
- PAPENFUSS G.F., 1940 — Notes on South African marine algae, I. *Botaniska Notiser* 1940: 200-226.
- TSUDA R.T. & ABBOTT I.A., 1985 — Collecting, handling, preservation, and logistics. *In*: LITTLER M.M. & LITTLER D.S. (eds.), *Handbook of Phycological Methods, Vol. IV. Ecological Field Methods: Macroalgae*. Cambridge/New York, Cambridge University Press, pp. 67-86.
- WOMERSLEY H.B.S., 1987 — *The Marine Benthic Flora of Southern Australia, Part II*. Adelaide, South Australian Government Printing Division, 484 p.