INSULA Florianópolis Nº 36 07-20 2007

DASYA RIGIDULA (CERAMIALES, RHODOPHYTA) IN THE SOUTH AND SOUTHEASTERN BRAZILIAN COAST.

DASYA RIGIDULA (CERAMIALES, RHODOPHYTA) NO LITORAL SUL E SUDESTE DO BRASIL.

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RESUMO

Neste trabalho descrevemos a espécie *Dasya rigidula* (Kützing) Ardissone pela primeira vez referida para o sul e sudeste do Brasil. Os espécimes apresentaram ramificação irregular a subdicotômica; corticação variável ao longo do talo; ápice ocelado; e estiquídios com quatro tetrasporângios por segmento. Tradicionalmente as espécies deste gênero estão delimitadas de acordo com o padrão de ramificação, presença de ápice ocelado e grau de corticação. Variações tênues nestas características separam *Dasya brasiliensis, D. caraibica* e *Dasya rigidula*. Entretanto, estes diferentes aspectos morfológicos foram observados entre espécimes de uma mesma população por nós analisada. Atualmente, o número de tetrasporângios por segmento do estiquídio é considerado como característica diagnóstica para o gênero e todas as espécies listadas acima apresentam quatro, entre outras características em comum. Acreditamos que estas, no litoral brasileiro, representam uma mesma espécie e devam ser sinonimizadas com *Dasya rigidula*.

Palavras-chave: *Dasya*, Ceramiales, Rhodophyta, macroalgas, Brasil.

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ABSTRACT

This work describes, for the first time, *Dasya rigidula* (Kützing) Ardissone from the south and southeastern Brazil. The specimens presented irregular-subdichotomously branching; variable cortication along the thallus; ocellate apex; and stichidia with four tetrasporangia per segment. Traditionally, the species of this genus are diagnosed depending on the branching pattern, presence of ocellate apex and degree of cortication. Tenuous variations of these characteristics separate *Dasya brasiliensis, D. caraibica* and *Dasya rigidula,* and these variations have been observed among specimens of a single population analysed by us. Nowadays, the number of tetrasporangia per segment of stichidia is used to diagnose species and all the taxa listed above have four, among other common characteristics. We believe that, in the Brazilian coast, they represent the same species and should be sinomyzed with *Dasya rigidula*.

Key words - *Dasya*, Ceramiales, Rhodophyta, seaweed, Brazil

INTRODUCTION

Among the around 80 species of *Dasya* (Dasyaceae, Rhodophyta) listed to the world (Womersley, 1998), 19 are represented in the tropical American Atlantic (Wynne, 1998; Ballantine, 2000; López-Piñero & Ballantine, 2001a), and five in Brazil (Horta, 2000). This genus worldwide distributed, presents erect thallus, sympodial growth, branches and branchlets radially disposed, free subdichotomous monosiphonous filaments, tetrasporangia in stichidia and procarp without surrounding pericarp (Parsons, 1975).

Although the genus was well delimited, both molecularly and morphologically (Choi *et al.*, 2002; De Jong, 1997; De Jong *et al.*, 1998), confusions remain and erroneous determinations of some taxa in the world and especially in Brazil were made.

As discussed by Parsons (1975), the genus *Dasya* is a melting pot for all species possessing a polysiphonous, corticated or uncorticated axis, carrying monosiphonous pigmented filaments. Probably, this is the cause of so many confusions in the family and referred genus.

In this paper, we describe the morphology and some aspects of the reproduction of *Dasya rigidula* (Kützing) Ardissone, discussing the implications of these results for the taxonomy of the genus in Brazil. This is the first description of this species to the south and southern Brazilian coast, as well the first report of female reproductive structures.

MATERIALS AND METHODS

Specimens were collected in subtidal and intertidal zones in Rio de Janeiro, São Paulo and Santa Catarina states. In the field, the material was preserved in 4% formalin/seawater. Semipermanent slides were prepared by manual cuts using razor-blades, aniline blue 1%, HCl 1N and Karo (corn glucose) 50%. The photographs were taken using Olympus BH-2 microscope and Olympus C35AD camera. The material was deposited in the Federal University of Santa Catarina Herbarium (FLOR). Additional herbarium material from University of São Paulo (SPF) was also analyzed following the same methods.

RESULTS

Dasya rigidula (Kützing) Ardissone
Basinonym: *Eupogonium rigidulum* Kützing, Phycologia generalis, p.415, 1843.
Synonym: *Dasya squarrosa* Zanardini, *Dasya brasiliensis* Oliveira Filho & Braga;
Synonym to Brazilian citation: *D. caraibica* Børgesen.
Reference to Brazil: Oliveira Filho & Ugadim, 1976 (Atol das Rocas).

Analyzed material: **BRASIL. Rio de Janeiro**: Angra dos Reis, 01/I/1998, male gametophyte, *Horta PH169* (FLOR) tetrasporophyte, *PH 174*, (FLOR), tetrasporophyte *PH 182* (FLOR), female gametophyte., *PH239* (FLOR), tetrasporophyte, *PH266* (FLOR); **BRAZIL. Rio de Janeiro**: Arraial do Cabo, 03/V/2002, *Ritzmann, NR 1, NR 2, NR 3* (FLOR); **BRAZIL. Rio de Janeiro:** Marambaia, 5/XI/2001, *Pedrassoli, ZE 1, ZE 2* (FLOR), **BRAZIL. São Paulo**: Ubatuba, 15/IV/1999, tetrasporophyte, *PH 20* (FLOR); **BRAZIL. Santa Catarina**: Florianópolis, 20/IX/ 2001, *PH 4* (FLOR) .
Additional analyzed material:

Dasya brasiliensis Oliveira Filho & Braga – **BRAZIL, São Paulo**, Ubatuba, 07/XI/ 1968, holotypus, isotypus, *E.C.O. 2643, 1681* (SPF); São Sebastião, 20/V/1977, *E.J.P.& N.B.J. 54199* (SPF).
D. caraibica Børgesen – **BRAZIL, Espírito Santo**, no info., I/1973, *no info. 54978* (SPF).
D. corymbifera J. Agardh - **PUERTO RICO, Guánica**, Cayos de San Jacinto, 25/V/ 1963, *M. Díaz Pifer 8236* (SPF).
D. collinsiana M. Howe – **BERMUDA**, No info, *A.J.B. 4187* (SPF).
D. baillouviana (Gmelin) Montagne
Basinonym: *Fucus baillouviana* Gmelin, Hist. Fuc., p.165. 1768.
PUERTO RICO, ISABELA, SAN ANTONIO, 3/V/1977, M. DIAZ PIFENER 8235, 6327, 8466, 9861 (SPF), KNIGHT KEY, 31/XII/1975, *WYNNE 25178* (SPF); **U.S.A, FLORIDA,**

CRYSTAL BEACH, 30/III/ 1970, C. *AREGOOD 4524* (SPF); **BERMUDA**. NO INFO, III/ 1920, *A.B. HERVEY 6327* (SPF); **BRAZIL, ESPIRITO SANTO**, ILHA DO FRANCÊS, 17/IV/ 1975. *E.C.O. & Y. UGADIM 52371*(SPF).

Vegetative Structure- The plants are bushy, pinkish to red in color, 2 to 6 cm in height. Erect branches develop from a discoid base, giving rise to a subdichotomous to alternate branching pattern. Variable cortication was always present at the base. This cortication consists of a compact cortex built up from rhizoids growing down, between and over the pericentral cells. Axes are cylindrical with five pericentral cells in each segment that have approximately 540 μm in length and 450-570 μm in diameter. The axis growth is sympodial. The subapical cell or occasionally the cell below this one cuts off a lateral cell that grows out and forward, becoming the new apical cell and displacing the old one to the side. The old apical cell develops further into a pseudolateral. The pseudolaterals are monosiphonous, delicate and fragile branchlets, a feature that can cause their absence in the old parts of the plant. They possess a spiral disposition that forms an ocellated apex in successive segments. Growth of the pseudolateral is by apical cell division. The terminal cells of these pseudolaterals are 10-37 μm long and have 3-18 mm in diameter. The pseudolaterals arise in a basal cell with 50-98 μm in diameter. From this basal cell, adventitious polysiphonous branches arise, and can substitute these branchlets when these fall. (Fig. 1-6).

Reproductive Structures- Procarps develop from the polysiphonous segments from pericentral cells, located on the base of lateral branches. Because this pericentral cells are spirally arranged the procarps, that rise from them, have the same spiral arrangement. The four-celled carpogonial branch initiates from one pericentral cell that divides, its upper end rising the sterile group initial on its external side, while the residual cell becomes the supporting cell. After fertilization the fusion cell divides itself many times in gonimoblast filaments. These filaments are dichotomously branched, finishing in irregular carpospores 20-42 μm in diameter. The cystocarps are sessile and pyriform, with up to 780 μm in diameter and 1 mm high (Fig. 7-8).

Tetrasporangial stichidia developed from a pseudolateral simple branch. Pericentral cells usually become fertile. The fertile pericentral cell divides transversally, forming the tetrasporangia mother cell and then 3 cover cells that partially cover the tetrasporangia. These stichidia are borne in the second proximal subdichotomies of pseudolateral branches, are 1-3 cells pedicelated and have 37-84 μm in diameter at the base and 78-220 μm in lenght. It has 4 spheric, tetrahedrically divided tetrasporangia per segment, with 25-52 μm in diameter. Each stichidia presents 2-9 segments, sometimes with a long terminal point (Fig. 9-15).

Atypical spermatangial stichidia, found in a monoiceous specimen, developed from apical pseudolateral branchlets, that divide periclinally and anticlinally successively to form a single layer of many spermatangial mother cells surrounding

the central cell. The spermatangial stichidia have one pedicel but can also be sessile. We only found immature spermatangia 36-50 μm long and 6-12 μm in diameter.

Field observations- Specimens of *D. rigidula* located in deeper areas were smaller (height of up to 2 cm), less corticated, and showed lower frequency of reproductive structures, when compared to specimens found in more shallow areas (3-5 cm). Exemplars of the intertidal zone, showed larger sizes (up to 6 cm), abundant cortication and more abundant pseudolateral ramulli (Fig. 16-18). The size of plants of specimens located in the northern areas was bigger when compared to the ones found in similar rocky shore zones in southern areas.

DISCUSSION

Our exemplars fit the descriptions for the genus *Dasya* by the presence of erect and radially branched thallus; free monosiphonous, subdichotomous filaments, usually present on every segment; 5 vegetative pericentral cells; and without procarp surrounding pericarp initials (Maggs & Hommersand, 1993; Millar, 1996; de Jong *et al.*, 1998; Maggs, 1998). The specimens were diagnosed as *Dasya rigidula* by the possession of variable corticated axes; pseudolaterals spirally disposed, forming an ocellated apex; stichidia with whorls of 4 tetrasporangia and 3 post-sporangial cover cells that do not form a network filaments (Taylor, 1960; Schneider & Searles, 1991; Kajimura, 1998; Littler & Littler, 2000). This species has been reported from North Carolina, Bermuda, southern Florida, Gulf of Mexico, the Caribbean, the Mediterranean, British Isles to Portugal, Azores, Canary Islands and West Africa (Schneider & Searles, 1991). In Brazil, this species with this name, was just listed only from Rocas Atoll (Oliveira & Ugadim, 1976)

Among the species listed to the Atlantic Ocean, *Dasya collinsiana* possess corticated axes and pseudolaterals spirally disposed that form ocellated branch tips (Taylor, 1960), but presents an overlapping of the pericentral cells at the nodes (López-Piñero & Ballantine, 2001a), a characteristic not observed in our material.

Dasya ocellata (Grateloup) Harvey described from Bermuda possess heavily corticated axes, irregularly disposed branchlets with terminal ocelli, its distinguishing character being the 5 tetrasporangia per stichidial segment (Maggs & Hommersand, 1993).

There are two species, *Dasya brasiliensis* and *D. caraibica*, that have similar descriptions as *Dasya rigidula,* and we couldn't find any distinctive and diagnostic feature to separate them. They all have ocellated apex, four tetrasporangia per fertile segment of stichidia, one to three cells in the pedicels and a variable cortication along the thallus. The reproductive features, like tetrasporangium stichidia and cystocarp of these species do look the same. Light differences in their branching

pattern and degree of cortication (Tab. 1) can be observed, but many intermediate forms are present in a single population.

Oliveira-Filho & Braga (1971) and Yoneshigue (1985) think that there are some morphological similarities exhibited by *D. rigidula*, *D. caraibica* and *D. brasiliensis*. According to these authors the differences between these species are the density of the pseudolaterals, the size of the basal branchlets cells, degree of cortication and width of axial segment. Traditionally, these variations were used to separate species (Taylor 1960), nonetheless, recent studies with culture of *Dasya* species (Lopez-Piñero & Ballantine, 2001b; Maggs, 1998) revealed that these should not be used, because they are very variable.

Lopez-Piñero & Ballantine (2001) working with *Dasya caraibica* observed that there is a relationship between maturity and cortication. Maggs (1998), while studying *Dasya ocellata,* concluded that morphological variations can be attributed to ecological factors as wave action and predation. According to these authors, these variations can cause taxonomical misinterpretations.

In fact, these studies confirm our field observations that specimens located in deeper areas are smaller and less corticated, while exemplars from the intertidal region, showed larger sizes, abundant cortication and pseudolateral ramulli.

The analysis of the USP herbarium material reinforces the thought of the existence of an environmental plasticity in the referred genus. Exemplars of *D. brasiliensis* (that included the holotype and isotype), presented morphological differences in the degree of cortication, height, thallus' diameter, number of pseudolaterals and lateral ramifications. For instance, the isotype of *D. brasiliensis* presents more abundant ramifications than the holotypus, and there are differences in height that range from 4 to 15 cm, for example.

When comparing our exemplar of *Dasya rigidula* to *D. brasiliensis*, there were many similarities between these two species. It is noticeable that all present ocellated apex, same ramification pattern and disposition of the branchlets.

Dasya caraibica, another species present in this herbarium material, also has similar appearance as *D. brasiliensis's* holotypus and *D. rigidula,* but more abundant ocellated apex and monosiphonous branchlets and a height of 13 cm. We hypothesize that this specimen, that did not present reproductive structures, is representative of a different species from the one described traditionally as *D. caraibica* (Taylor, 1960).

Dasya corymbifera is a pyramidal species, with a repeatedly alternately branching pattern, variable cortication, with 4 tetrasporangia per stichidial segment, but non ocellated apex (Maggs & Hommersand, 1993). However, in the literature the description of a considerable morphologic plasticity is observed (Yoneshigue, 1985; Taylor, 1960). Yoneshigue (1985) presents as *D. corymbifera* specimens with an ocellated appearance what disagrees with the one proposed by Maggs & Hommersand (1993).

Yoneshigue (1985) highlights that the great similarity among *Dasya brasiliensis*, *D. caraibica* and *D ramosissima* could lead to the creation of a single complex designated as *D. ramosissima*. However, the latest descriptions for *D. ramosissima* are brief and reduced to the works of Taylor (1960) and Littler & Littler (2000), where important characteristics, as the number of tetrasporangia per stichidial segment or even dimensions of the pseudolateral basal cell, were not described. Considering the lack of information for *D. ramosissima*, in this work we opted for the non-inclusion of the referred species in the analyses.

In addition, *Dasya baillouviana* present in the SPF herbarium material, determined by Dr. Wynne, also showed enormous morphological variability concerning its height, thallus diameter, number and distribution of pseudolaterals and pattern of lateral ramifications. Sexual dimorphism was also seen for this species.

The founding of atypical spermatangial stichidia in a monoicious specimen is not in accordance with the commonly observed in the order Ceramiales. The same way, plants of this genus are traditionally dioecious. However, monoicious specimens are a common anomaly in Ceramiales (Maggs pers. com.).

Considering the variations explained above, we suggest that the morphological differences shown by the analyzed material designed to Brazil as *Dasya brasiliensis, D. caraibica* and *D. rigidula* (Tab. 1), could occur as a response to environmental conditions, representing in fact the same taxon, that should be designated as *D. rigidula*, the first to be described. It is recommended to check this synonymy through molecular analyses, using material from the respective type localities. This could ensure if this synonymy can be extrapolated to other localities, and certify if these characteristics actually used to diagnose this group are approprieted.

ACKNOWLEGMENTS

We extend our tanks to the CNPQ and CAPES for supporting this work and Dra. C. Maggs and Dr. Y. de Jong for their correspondence and suggestions.

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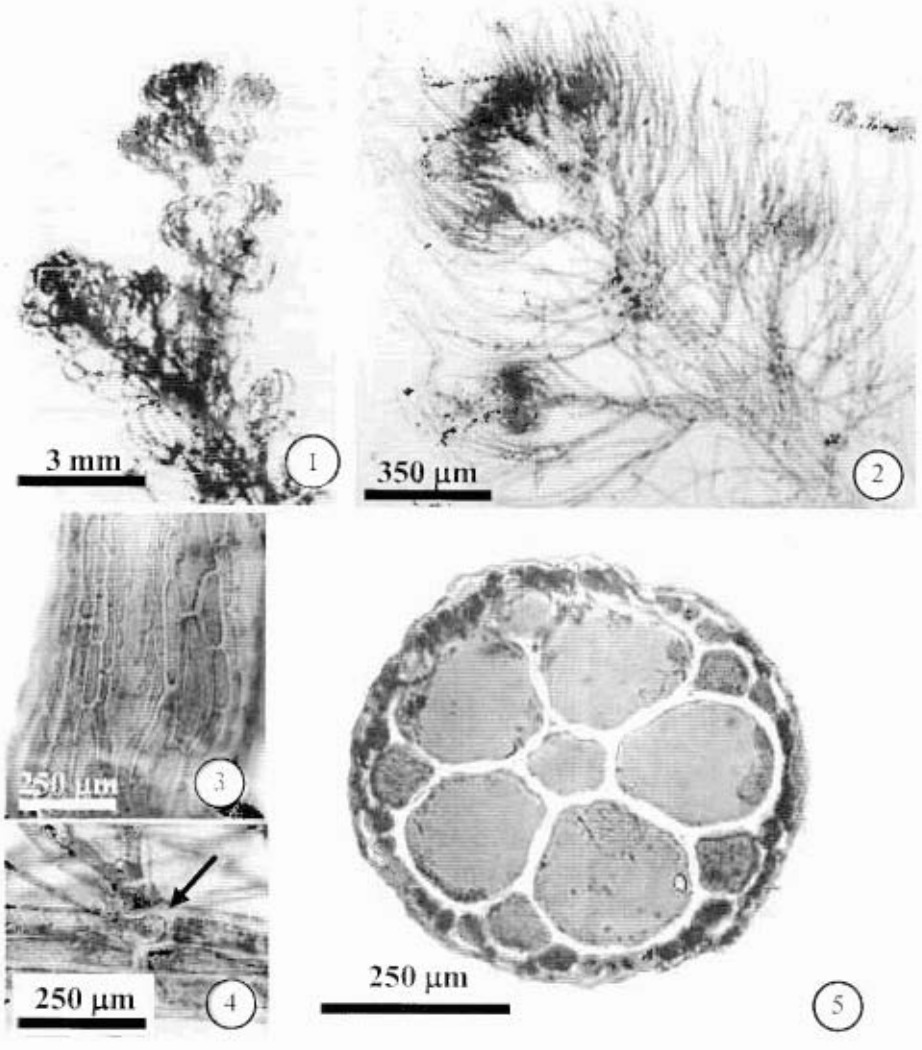
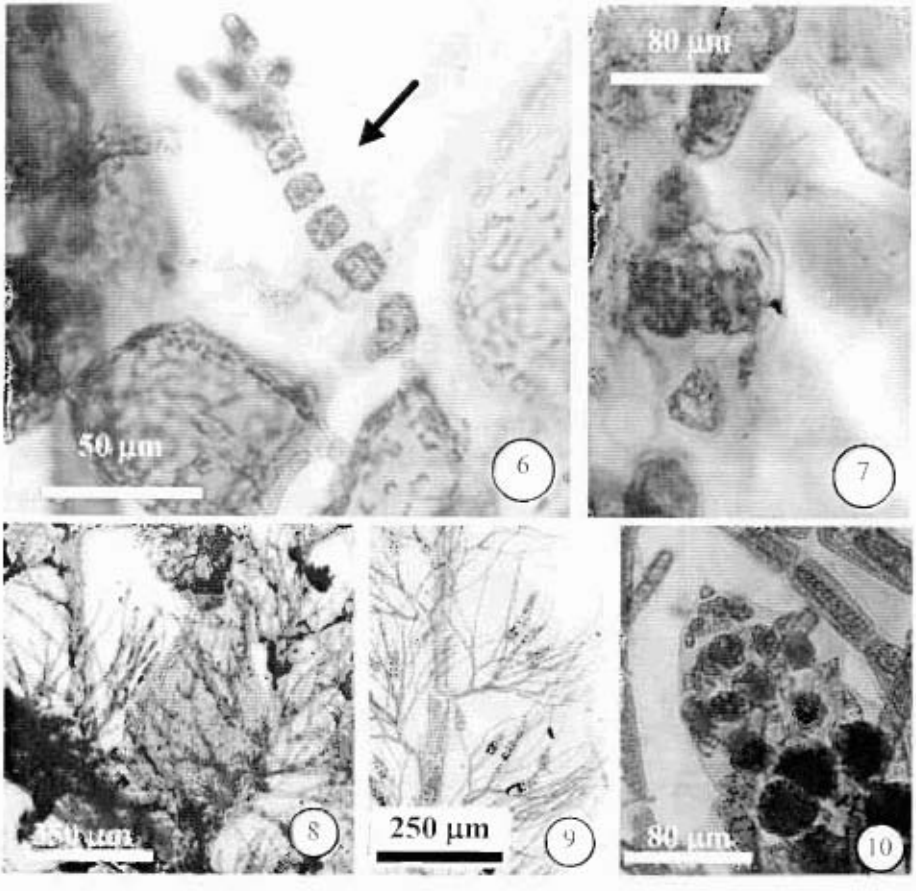
TABLE 1: Comparative analysis of different descriptions of *Dasya rigidula, D. brasiliensis* and *D. caraibica* (where: §=bushlike; D=pyramidal; sub=pyramidal; ¡=dichotomous; pseudo¡=pseudodichotomous; sub¡=subdichotomous; x=spiral; Â=irregularly alternate; d.= diameter; l.= length; += presence; - = no information available; (d)= diameter; (l)= length). [1]= species collected by us; [2]= Littler & Littler (2000); [3]= Yoneshigue (1985); [4]= Oliveira Filho & Braga (1971);[5]= López-Piñero & Ballantine (2001); [6]= Fredereq & Norris (1986).

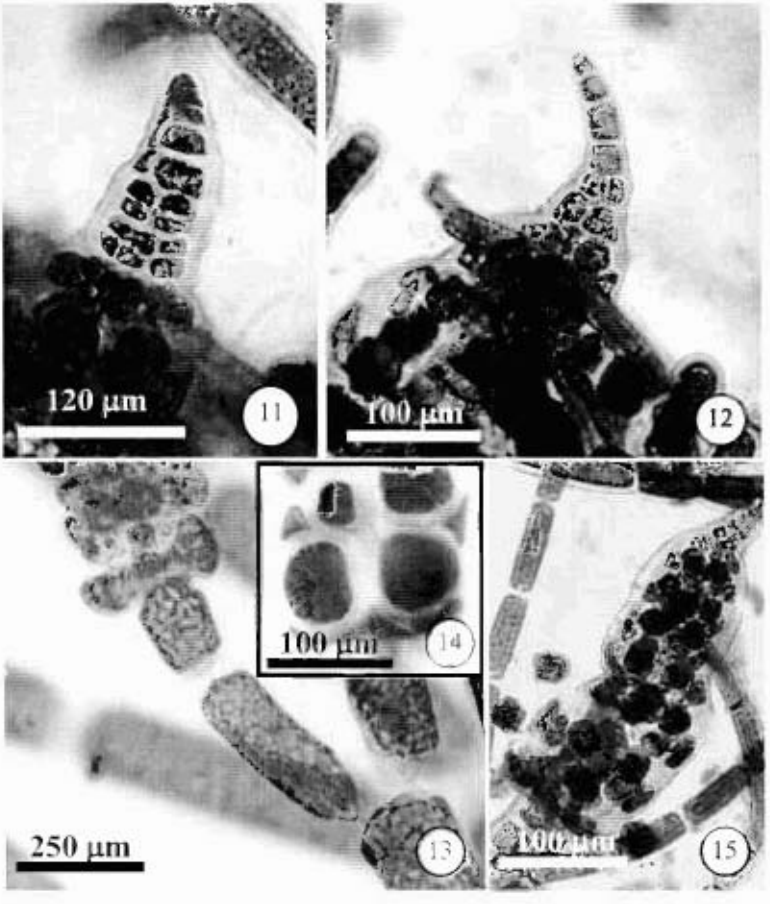
	D. rigidula [1]	*D. rigidula* [2]	*D. brasiliensis* [3]	*D. brasiliensis* [4]	*D. caraibica* [5, 6]
Thallus' shape	♣	_	Δ	♣	♣, subΔ
Degree of cortication	variable	variable	old branches	old branches	related to maturity
Branching pattern	subϒ to alternate	irregular	?	?	alternate
Disposition of ramulli	ξ	ξ	PseudosϒΥ	ϒ in ξ	ξ
Ocellate apex present	+	+	+	+	+
Height (cm)	3 – 5	1-8	<15	<15	<20
Pericentral cell	5	-	5	5	5
Pseudolateral basal cell (µm)	50-98 (d)	50-140 (d)	-	38-57 (l) l. 57-70	50 (d)
N° of pedicels	1-3	sessil or on one to three	1	1	2-3
Tetrasporangia diameter (µm)	22-68	20-50	27-42	-	40
N° tetrasporangia/segment	4	-	2-4	2-4	4
Tetrasporangial stichidia (µm)	37-84 (d) l. 78-220	120-170 (d) l. 40	30 – 108 (d) l. 78 – 333	78 – 105 (d) l.300-420	75-100 (d) l.350-950



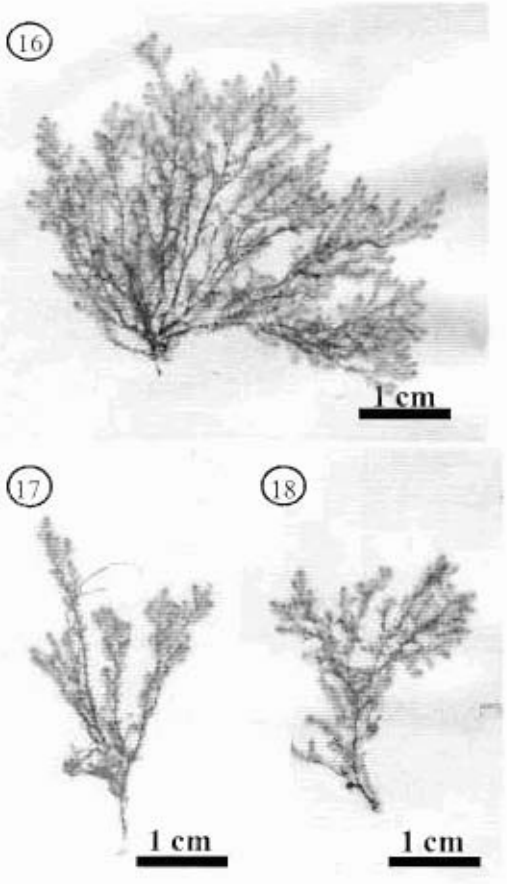
Figures 1-5: Some morphological and anatomical aspects of *Dasya rigidula* (Kützing) Ardissone. 1. and 2. Different aspects of ocellated apex; 3. Cortication in a thallus basal portion; 4. Basal cell of pseudolateral branches; 5. transversal section of a basal portion.



Figures 6-10: Some morphological and anatomical aspects of *Dasya rigidula* (Kützing) Ardissone. 6. Young adventitious branch; 7. Procarp initials; 8. mature cistocarp; 9. Tetrasporophyte general aspect; 10. Detail of tetrasporangial stichdial apex.



Figures 11-15: Some morphological and anatomical aspects of *Dasya rigidula* (Kützing) Ardissone. 10-12. Different aspects of tetrasporangial stichdial apex; 13. Stichdium with two pedicelar cells; 14. Detail of tetrasporangial segment; 15. Stichidium general aspect.



Figures 16-18: Some morphological variation of *Dasya rigidula* (Kützing) Ardissone from different depths and localities. 16 and 17. Specimens from 4 and 12 meters depth respectively, collected in Ubatuba, SP; 18. Specimen from 8 meters depth, from Arvoredo Island, Florianópolis, SC.