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Observations on *Ceramium uruguayense* (Ceramiaceae, Rhodophyta): first occurrence in the Caribbean Sea

Observaciones sobre *Ceramium uruguayense* (Ceramiaceae, Rhodophyta): primer registro para el Mar Caribe

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ABSTRACT

The red algae *Ceramium uruguayense* is reported for the first time in the Caribbean Sea. The vegetative and reproductive morphology of this species are described. *Ceramium uruguayense* is compared with other similar Caribbean species. *Ceramium uruguayense* has clear diagnostic characters like 8-9 periaxial cell, presence of pseudoperiaxial cells, acropetal direction in nodal formation and basipetal growth from periaxial cell. A distribution analysis of the genus in the Caribbean is presented.

Key words: *Ceramium uruguayense*, Rhodophyta, Caribbean, morphology

RESUMEN

El alga roja *Ceramium uruguayense* es reportada por primera vez para el Mar Caribe. Se describe la morfología vegetativa y reproductiva de esta especie. *Ceramium uruguayense* es comparada con otras especies similares presentes en el Caribe. *Ceramium uruguayense* tiene caracteres diagnósticos claros como son 8-9 células periaxiales, presencia de células pseudoperiaxiales y formación del nudo con dirección acropétala así como crecimiento basipétalo desde la célula periaxial. Se presenta un análisis de la distribución geográfica del género para la región del Caribe.

Palabras clave: *Ceramium uruguayense,* Rhodophyta, Caribe, morfología

INTRODUCTION

The red algae genus *Ceramium* Roth is considered to be cosmopolitan with a broad distribution from pantropical coasts to the polar zones of both hemispheres. A total of 24 species, including one variety and one form have been reported to the Caribbean Sea (Table 2).

In Venezuela, the genus *Ceramium* is represented by 13 species: *Ceramium brasiliense* Joly (Ganesan, 1989), *C. brevizonatum* var. *caraibicum* H. E. Petersen et Børgesen (García & Vera, 2004), *C. cimbricum* H. E. Petersen *in* Rosenvinge (Ganesan, 1989), *C. comptum* Børgesen (Gómez, 1998), *C. dawsonii* A. B. Joly (Ganesan, 1989), *C. deslongchampsii* Chauvin ex Duby (Ganesan, 1989), *C. diaphanum* (Lightfoot) Roth (Ganesan, 1989), *C. floridanum* J. Agardh (Ganesan, 1989), *C. luetzelburgii* O. C. Schmidt (García & Gómez, 2005a), *C. nitens* (C. Agardh) J. Agardh (Ganesan, 1989), *C. tenerrimum* (G. Martens) Okamura (Gómez, 1998), *C. vagans* P. C. Silva (García & Gómez 2005b), and the currently reported *C. uruguayense* Taylor (Taylor, 1960).

Ceramium species are often difficult to identify since they are somewhat variable in morphology and some species have been inaccurately described.

During a review of the Evangelina marine algal collection of M. Díaz-Piferrer in the Herbarium MOBR, a specimen of *Ceramium uruguayense* from the north coast of the Margarita Island (Nueva Esparta State, Venezuela) was found and confirmed by comparison with the holotype.

MATERIALS AND METHODS

Specimens of *Ceramium uruguayense* were studied from the Evangelina collection deposited in the Herbarium MOBR of the Margarita Station of Marine Investigations from Fundación La Salle de Ciencias Naturales. Specimens were either pressed or preserved in 4% formalin sea water. The measurements of the nodes were made between fifth and sixth dichotomies starting from the apex. For the observation of axial and periaxial cells, cross section of the thallus was made through the upper part of the axial cell in the middle part of plant. The cortical band and cortication was studied based on the taxonomic criteria for the genus following Dixon (1960), Womersley (1978) and South and Skelton (2000). Acropetal and basipetal cortical cells measurements were made on the first cells near the periaxial cells. Microscope slide preparations were stained with 0.1% safranine and mounted in 15% fenolized corn syrup. Measurements were made using a Manostat vernier and micrometer for microscope to provide the (lowest), average, and (highest) measurement for the feature and the standard deviation is given in parentheses (SD). Abbreviations/symbols: ♀: female gametophyte, ♂: male gametophyte, ⊕: tetrasporophyte, v: vegetative. For distribution analysis of the genus in the Caribbean, a revision of the literature in the region was done.

RESULTS

Ceramium uruguayense W. R. Taylor (1960: 532 – 533, Pl. 65: Figs. 3, 4)

Type locality: Puerto La Paloma. Not specified: W. L. Schmitt; 6 December 1925; MICH Schmitt 277. (Fig. 1-9)

Vegetative morphoanatomy: Plants are erect, epiphytic, 5 cm in height and are attached by uniseriate unicellular and multicellular rhizoids that originate from periaxial cells only at the base of plant. The rhizoids are up to 287 µm long. The principal branching pattern is alternate in one plane and subdichotomous in the secondary branches which occurs every 5-6 nodes along the main axis. Adventitious branchlets of unlimited growth are present. The apices are slightly incurved. The branch tips may be convergent or divergent and up to 0.45 mm long and (94.3) 164.47 (266.5) (SD: 9.36) µm in diameter.

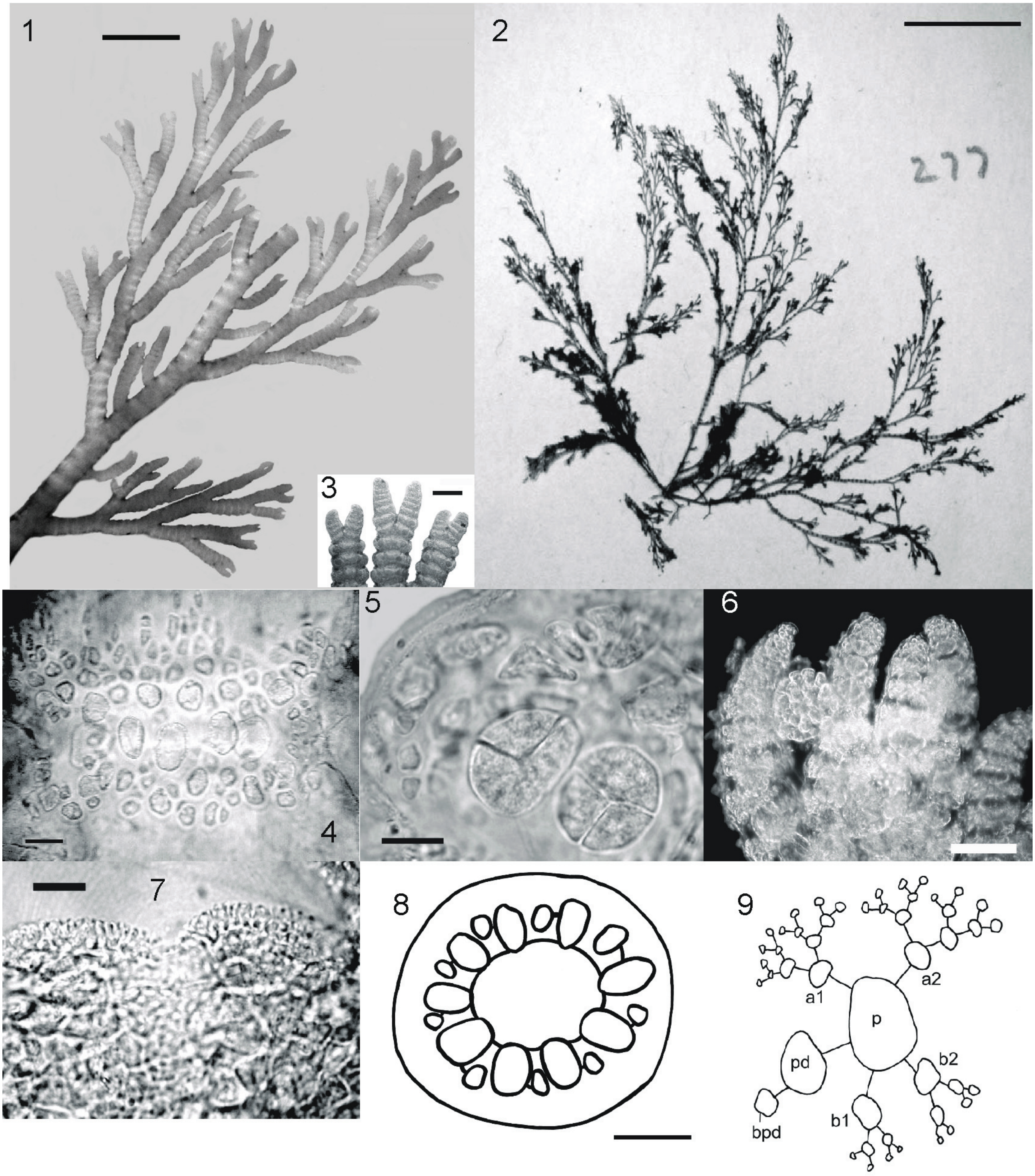
The axial cells are hyaline and in surface view (237.8) 253.79 (282.9) (SD: 13.45) µm wide x (262.4) 283.72 (303.4) (SD: 13.08) µm long. In the middle portion of the plant, the nodes are (254.2) 397.69 (550.8) (SD: 46.31) µm in diameter. The internodal distance measures (45.1) 131.6 (324) (SD: 71.1) µm. In the upper part of the plant, the cells are shorter bringing the nodes very close together. Cortication occurs only at the nodes. The cortical node length is (73.8)184.2 (237.8) (SD: 42.82) µm. The periaxial cells that develop the cortication are oval and number 8 to 9 per node. They occur in rows and are (12.3) 28.07 (41) (SD: 6.9) µm wide x (16.4) 40.61(57.4) (SD: 7.32) µm long in transversal cut.

Pseudoperiaxial cells are produced laterally from the periaxial cells in number eight to nine per node, (16.4) 21.67 (28.7) (SD: 3.9) µm wide x (36.9) 38.7 (41) (SD: 2) µm long. These pseudoperiaxial cells sometimes can divide to form one smaller pseudoperiaxial basipetal cell. The cortical bands consist of approximately five-six cell rows originating by the aggregation of four conspicuous corticated filaments. Each periaxial cell giving rise to four cells in two directions, two acropetally and two basipetally. The first acropetal cells are formed by dichotomic divisions of the first acropetal cells, so acropetal filaments are four to eight cells long, with four acropetal rows. Final divisions of acropetal filaments could be not dichotomic, just in one direction. Basipetal filaments are formed by dichotomic divisions of the first basipetal cells and are two to four cells long with two basipetal rows.

Reproductive morphoanatomy: Tetrasporangia emergent, tetrahedrical, pigmented and produced in whorls in the cortical bands. They are developing from the periaxial cells, are only on the branches of limited growth and (32.8) 78.38 (184.5) (SD: 59.1) µm in diameter. They are partially covered by cortical cells. Each fertile node is enlarged and contains one to four tetrasporangia.

Carpogonial branches develop at the apices of principal and secondary branches at the top of the plant. Gonymocarps are produced from the first periaxial cell and are three celled as described for the genus. The gonymocarp's cells are smaller than the trichogyne and are smaller when compared with the proximal cortical cell. The gonymocarps occurs 2-3 together on the abaxial side of the secondary branches and are surrounded by 5-6 sterile involucral branchlets, are spherical and terminal, and also projected above the surface of the branches. They appear to originate from periaxial cells. The gonymocarps are globulate and (61.5) 153.89 (243) (SD: 58.63) µm in diameter and (90.2) 157.1 (274.7) (SD: 93.86) in length. The carpospores are pyramidal, granulated in appearance, and (20.5) 29.11 (32.8) (SD: 4.08) µm long.

Spermatangia are globose, hyaline, and (4.1) 5.13 (6.15) (SD: 1.45) µm in diameter and (8.2) 9.6 (12.3) (SD: 2.37) µm in length. They develop from the cortical cells superficially and are dispersed over the nodes at young lateral branchlets and cover their nodes and the internodal zones but do not have defined borders.



Figures 1-9. *Ceramium uruguayense*. Fig. 1. Thallus showing branching (MOBR E-1802). Scale bar = 100 µm. Fig. 2. Habit of the holotype (MICH 17895). Scale bar = 1 cm. Fig. 3. Tetrasporangial branchtips (MOBR E-1802). Scale bar = 300 µm. Fig. 4. Superficial view of cortical node (MOBR E-1802). Scale bar = 50 µm. Fig. 5. Superficial view of tetrahedrical tetrasporangia (MOBR E-1802). Scale bar = 50 µm. Fig. 6. Apical branches with gonymocarps in high contrast. (MOBR E-1798). Scale bar = 100 µm. Fig. 7. Spermatangia covering cortical bands (MOBR E-9714). Scale bar = 20 µm. Fig. 8. Diagram of cross section of the node showing periaxial and pseudoperiaxial cells. Scale bar = 100 µm. Fig. 9. Diagram showing periaxial cell and its derivates. a = acropetal cell, b = basipetal cell, p = periaxial cell, pd = pseudoperiaxial cell, bpd = pseudo-basipetal cell. Scale bar = 100 µm

Table 1. Morphoanatomical differentiation between *Ceramium uruguayense* and the Caribbean species *C. brasiliense, C. floridanum, C. filicula* and *C. brevizonatum* var. *caraibicum.* Data based on this study, Taylor (1960), Ríos (1972), South and Skelton (2000), Barreto and Yoneshigue-Valentin (2001) and Barros-Barreto *et al.* (2006).

	C. uruguayense	*C. uruguayense* Holoytpe	*C. brasiliense*	*C. floridanum*	*C. fifficula*	*C. brevizonatum* var. *caraibicum*
	(means)	(means)	(means)	(means)	(means)	(means)
Thallus length (mm)	5.24	3.68	10	73	12	10.5
Branching pattern	altern-subdichotomous	altern	altern-subdichotomous	altern	subdichotomous	subdichotomous
Adventitious branch	yes	yes	yes	yes	yes	yes
Axial cell (width x length, µm)	253.8 x 283.7	257.1 x 193.3	80.7 x 126.9	368.5 x 321.3	95 x 143	138.5 x 231
Periaxial cell number	8-9	not observed	6-7	unknow	6-7	8-9
Periaxial cell (width x length, µm)	28.1 x 40.6	43.1 x 34.4	17.4 x 20.9	unknow	unknow	unknow
Pseudoperiaxial cell (number)	8-9	not observed	absent	unknow	absent	10-11
Pseudoperiaxial cell (width x length, µm)	21.6 x 38.7	not observed	absent	unknow	absent	unknow
Cortication rows	3-4 acropetal 1-2 basipetal	3-4 acropetal 1-2 basipetal	2 acropetal 2 basipetal	1-3 acropetal 1-3 basipetal	2 acropetal 2 basipetal	1-2 acropetal
Internodal distance (µm)	131.6	225.5	92.3	360	unknow	unknow
Cortical node in main axes (diameter x length, µm)	397.7 x 184.2	560 x 200	112.8 x 250.4	247 x 360	105.5 x 47.5	158 x 54
Tetrasporangia arrangement	whorled	not observed	whorled	whorled	whorled - bilateral	unilateral
Tetrasporangia (diameter, µm)	184.5	not observed	44.5	72.5	66	55
Gonymocarp (diameter x length, µm)	153.9 x 157.1	not observed	131.5	unknow	92.5	unknow
Spermatangia (diameter x length, µm)	5.1 x 9.6	not observed	4.36 x 8.8	unknow	unknow	unknow

Habitat: Commonly grows epiphytic on species of the genus *Corallina* L., *Bryothamnion* Kützing, *Grateloupia* C. Agardh, *Codium* Stackhouse and *Ulva* L.

Material examined: Uruguay: Holotype, puerto La Paloma, 6 December 1925, Schmitt 277, MICH 17895 (♀). These numbers are from MOBR, Venezuela: Margarita Island, Juangriego Beach, 12 Mach 1966, M. Díaz-Piferrer E-9714 (v); 12 March 1966, M. Díaz-Piferrer E-2041 (♀-♂); 12 March 1966, M. Díaz-Piferrer E-1798 (⊕-♂);Tolete Point, 23 April 1966, M. Díaz-Piferrer E-1800 (⊕,♀);Tacuantar Point, 23 April 1966, M. Díaz-Piferrer E-1799 (♀); El Paujil, La Guardia, 24 April 1966, M. Díaz-Piferrer E-1801 (v); Tacuantar Point, 8 June 1966, M. Díaz-Piferrer E-1802 (⊕,♀).

Aditional examined material: *Ceramium* brasiliense, numbers are from MOBR. Brazil: Saco de Ribeira Beach, Baía de Flamingo, Ubatuba, Estado de Sao Paulo, 16 November 1963, M. Díaz-Piferrer E-9639 (v); Parana Beach, Municipio de San Vicente, Estado de Sao Paulo, 29 November 1963, Díaz-Piferrer & A. Joly E-1684 (⊕-♀-♂); Saco de Ribeira Beach, Baía de Flamingo, Ubatuba, Estado de Sao Paulo, 29 November 1963, M. Díaz-Piferrer E-9812 (v).

Table 2. Distribution of taxa of genus *Ceramium* in the Caribbean.

Taxa	Ven	Mex.	Col	Great	Costa	Hon	Bel	Trin	Less	References
C. bisporum D. L. Ballantine				X						1
C. brasiliense	X			X						15,21
C. brevizonatum			X	X						3,21
var. caraibicum	X			X	X		X		X	12,17,18,20,21
C. cimbricum	X			X					X	11,18,21
f. flaccidum (H. E. Petersen) Furnari & Serio		X	X	X					X	2,4,22
C. codii (H. Richards) Mazoyer			X	X					X	4,21,22
C. comptum	X		X	X						6,15,22
C. corniculatum Montagne				X					X	17,22
C. cruciatum S. Collins & Hervey		X	X	X			X		X	2,3,7,17,18,21
C. dawsonii	X		X							4,11
C.deslongchampsii	X		X	X					X	2,9,16,21,22
C. diaphanum	X	X	X	X					X	2,4,5,11,21,22
C. dorsiventrale Hommersand								X		10
C. floridanum	X		X					X	X	16,19,21, 22
C. jolyi (Díaz-Piferrer) D. L. Ballantine & M. J. Wynne				X						2,8
C. leptozonum M. A. Howe				X						21
C. luetzelburgii	X		X							6,13
C. nitens	X	X	X	X	X	X	X		X	2,5,13,16,17,20,22
C. subtile J. Agardh		X		X	X				X	2,19,20,21,22
C. tenerrimum	X		X						X	4,15
C. tenuicorne (Kützing) Waern				X						22
C. uruguayense	X									(present study)
C. vagans	X			X						14,21
C.virgatum Roth		X		X						5,22

Ven: Venezuela, Mex: México, Col: Colombia, Great: Greater Antilles, Costa: Costa Rica, Hon: Honduras, Bel: Belize, Trin: Trinidad & Tobago, Less: Lesser Antilles.

References: 1=Ballantine (1990), 2=Ballantine and Aponte (2002), 3=Bula-Meyer (1986), 4=Bula-Meyer and Schnetter (1988), 5=Collado *et al.* (1998), 6=Díaz-Pulido and Díaz-Ruiz (2003), 7=Díaz *et al.* (1998), 8=Díaz-Piferrer (1968), 9=Díaz-Piferrer (1970), 10=Duncan and Lee (2006), 11=Ganesan (1989), 12=García and Vera (2004), 13=García and Gómez (2005a), 14=García and Gómez (2005b), 15=Gómez (1998), 16= Kapraun (1972), 17=Littler and Littler (1997), 18=Littler and Littler (2000), 19=Schnetter (1980), 20=Soto and Ballantine (1986), 21=Suárez (2005), 22=Taylor (1960).

Western Atlantic distribution (Taylor 1960): Brazil and Uruguay.

DISCUSSION

Comparative morphology. *Ceramium uruguayense* is described for the first time from the Caribbean. Based on morphoanatomical features, the Venezuelan specimens coincide with the taxonomic circumscription of the holotype specimen (table 1). *Ceramium uruguayense* was described by Taylor (1960) based in specimens from Punta del Este, Uruguay collected by Schmitt in 1925. In the diagnosis of *C. brasiliense* Taylor (*op. cit.*) commented that this plant could represent a "depauperate form of *C. uruguayense*".

Ceramium uruguayense has similitude with another Caribbean species like *C. brasiliense*, *C. floridanum* J. Agardh, *C. filicula* Harvey ex Womersley and *C. brevizonatum* var. *caraibicum* Petersen *et* Børgesen. The principal diagnostic character to separate *Ceramium uruguayense* and *C. brasiliense* is the presence of pseudoperiaxial cells; these are not present in *C. brasiliense* and the number of periaxial cells which are eight to nine in *C. uruguayense* and six in *C. brasiliense* (Barreto & Yoneshigue-Valentin, 2001; Barros-Barreto *et al.*, 2006). These aspects have been found to be valid diagnostic features for separating these species so the taxonomic status of both species in the western Atlantic is confirmed.

Ceramium floridanum is a little knows species, clear nodal cortication studies haven't been carried out to this species. *C. floridanum* is similar to *C. uruguayense* because is alternately branched and erect, but in contrast has nodes with cortication composed of 1-3 transversal series of cells, which extend equally up and down to the internodal zone and no pseudoperiaxial cell have been recorded for it (Taylor, 1960; Ríos,1972; Schneider & Searles, 1991).

Ceramium brevizonatum var. *caraibicum* is characterized by the presence pseudoperiaxial cells and eight to nine periaxial cells like *C. uruguayense* but differs from this, in the cortication with just one to two acropetal rows (Barros & Yoneshigue-Valentin, 2001; García & Vera, 2004; Barros-Barreto *et al.,* 2006) in contrast with three to four acropetal rows and two basipetal rows in *C. uruguayense*.

Ceramium uruguayense differs from *C. filicula* (Barros-Barreto *et al.*, 2006) in the presence of eight to nine periaxial cells, the presence of pseudoperiaxial cell and three to four acropetal rows.

Ceramium geographical distribution. Table 2 shows distribution of the *Ceramium* species in the Caribbean. More than 85% of the western Atlantic species are distributed in the Caribbean from the northern limit of the Yucatan Peninsula, Mexico, to the western coast of Venezuela. The main incidence per region occurs in the northern Caribbean with 18 species of *Ceramium*, 14 of which are reported for Cuba (Suárez, 2005). Also the genus has a good representation in the southern region specifically in Colombia, Lesser Antilles and Venezuela. The species with the in the Caribbean region is *C. nitens* in the entire Caribbean region (except in Trinidad and Tobago). *C. uruguayense* is restricted to the south western tropical Atlantic and *C. brasiliense* is reported in the Caribbean only for Cuba (Suárez, 2005) and Venezuela (Lemus, 1984).

Ceramium uruguayense is previously thought to be endemic to Uruguay in the subtropical western Atlantic. This temperate specie is now known that is present in the western region of Margarita Island, Venezuela. This species is not uncommon along this Venezuelan coastal area. Upwelling and cooler nutrient rich waters coincide with its occurrence.

The distribution of the sea surface temperature in the southern Caribbean is highly influenced by Trade Winds, currents and the continental shelf bathymetry that combine to induce the upwelling-generated foci of cooler water. The flow of high salinity waters from depth of 75 m to superficial layers near the coast in Margarita Island is more intense from January to July when the Trade Winds blow from the eastern and northeastern Venezuelan coast line causing the upwelling of cool deep ocean water and the Caribbean stream which carries the warm surface waters to the northern Caribbean (Ginés *et al.*, 1972; Castellanos *et al.*, 2002).

Díaz-Piferrer (1967) has noted the effect of this upwelling on the marine flora along the western coast of Venezuela and is more intense over the continental shelf of the north coast of Margarita Island (Juangriego Beach, Tacuantar Point) where surface temperatures of 19-23ºC give rise to a temperate zone enclave within which the benthic marine flora is markedly affected and where the temperate species of algae are commonly present during the first part of the year.

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