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Porolithon improcerum (Porolithoideae, Corallinaceae) and *Mesophyllum macroblastum* (Melobesioideae, Hapalidiaceae): new records of crustose coralline red algae for the Southwest Atlantic Ocean

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Abstract

Here we describe in detail two crustose coralline red algal (CCA) species newly reported for the southern Atlantic: *Porolithon improcerum* and *Mesophyllum macroblastum*. *Porolithon improcerum* was recorded on the remote oceanic island of Martim Vaz (ca. 1,200 km off the Brazilian Coast) and *M. macroblastum* on the Cagarras Archipelago (ca. 5 km off the coast of Rio de Janeiro city). Within the genus *Porolithon*, *P. improcerum* is characterized by thin vegetative thallus composed mostly of two cell layers and thalli forming several applanate branches overgrowing one another. Within the genus *Mesophyllum*, *M. macroblastum* is characterized by bearing volcano-like multiporate tetrasporangial conceptacles with a raised rim and sunken central pore plate in addition to pore canals of conceptacles being lined by cells that are similar in size and shape to other roof cells. While, *P. improcerum* has previously been reported for the northern Atlantic Ocean, this study represents the first report of *M. macroblastum* for the Atlantic Ocean.

Key words: Brazil, calcareous algae, Porolithoideae, Mastophoroideae, Melobesioideae, seaweed

Introduction

Crustose coralline red algae (Sporolithales and Corallinales, Rhodophyta: CCA) are considered benthic ecosystem engineers capable of modifying the physical characteristics of their environment and producing a habitat that can support a higher diversity and abundance of marine organisms in comparison with surrounding habitats (Nelson 2009, Nelson *et al.* 2012). Crustose coralline algae rank among the major reef builders as they are often the most abundant marine organisms on hard substrates within the photic zone (Steneck 1986, Littler and Littler 2011). They reinforce the structure of coral reefs by filling cracks and binding together much of the sand, dead coral and debris, creating a stable substrate less prone to erosion (see Nelson 2009 for a review). Despite their ubiquity and ecological importance, relatively little is known about reef and rocky shores attached CCA species composition and their taxonomy in the southwestern Atlantic. Up to now, most modern taxonomic studies on CCA in the southwestern Atlantic were devoted to rhodolith-forming species (e.g. Villas-Boas *et al.* 2009, Amado-Filho *et al.* 2010, Bahia *et al.* 2011) as the region is characterized by the highest concentration of rhodolith beds in the world (Foster *et al.* 2001, Amado-Filho *et al.* 2012). In order to better understand the ecological role of CCA at the species level in the southwestern Atlantic, a series of floristic surveys are being conducted on rocky shores and reefs of the Brazilian continental shelf and adjacent oceanic islands. Here we describe in detail two CCA species newly reported for the southern Atlantic: *Porolithon improcerum* (Foslie & Howe) Howe (1920: 587) and *Mesophyllum macroblastum* (Foslie) Adey (1970: 25). While *P. improcerum* has previously been reported for the northern Atlantic Ocean (see Townsend & Adey 1990, Ortega *et al.* 2001), this study represents the first record of *M. macroblastum* for the Atlantic Ocean.

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Material and methods

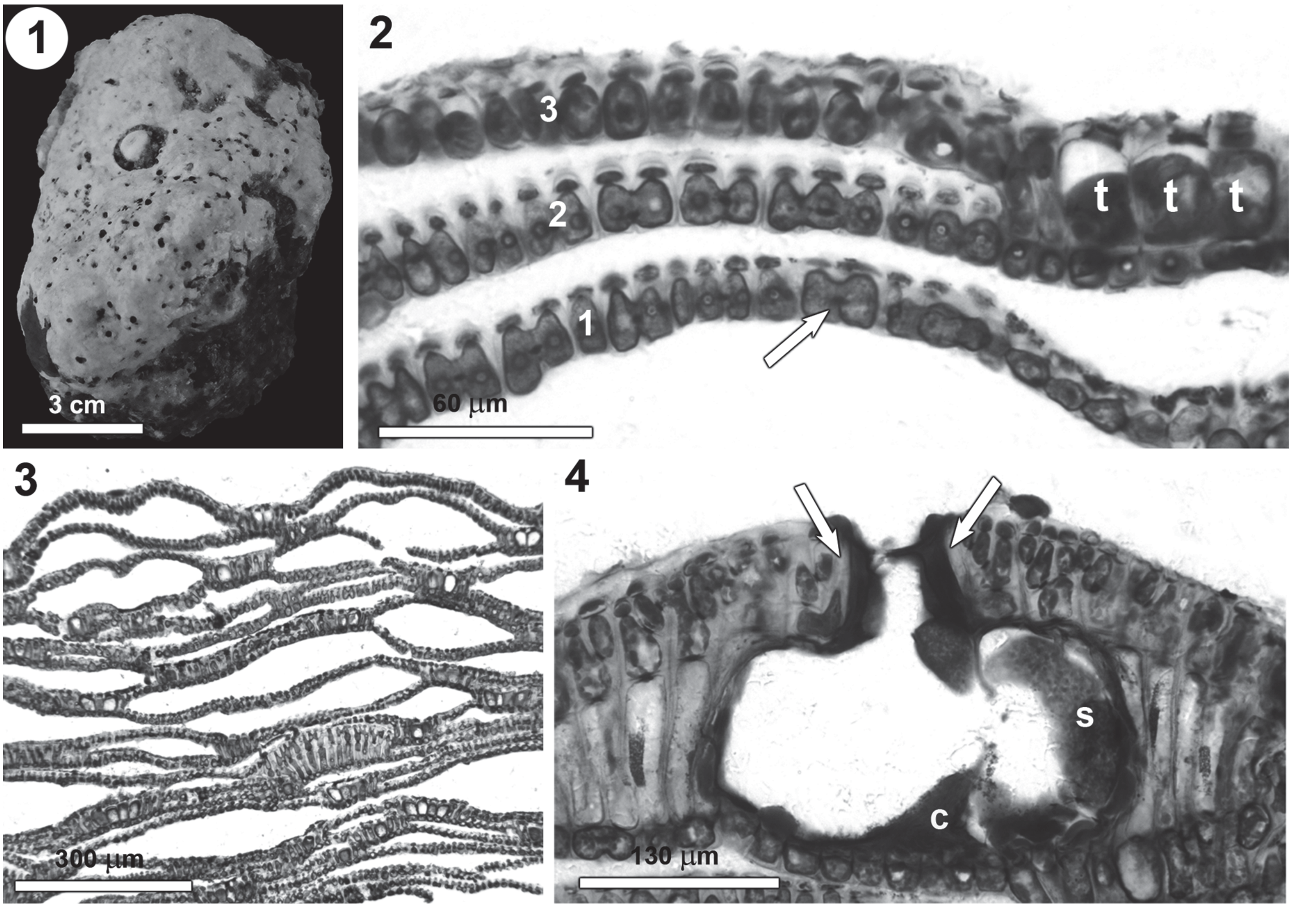
CCA were collected using SCUBA and a hammer and chisel from 15 m water depth along the rocky shores of the Brazilian oceanic island of Martim Vaz (20º28'05" S; 28º51'28" W) in March 2009 and from 3–15 m water depth off the coastal island of Palmas (23º02'16" S; 43º12'05" W), Cagarras Archipelago, Rio de Janeiro city in April 2012.

Samples for light microscopy analysis were prepared using the histological methods described by Maneveldt & van der Merwe (2012). For scanning electron microscopy (SEM) the procedure followed Bahia *et al.* (2010). For species descriptions, growth-form terminology follows Woelkerling *et al.* (1993) and thallus anatomical terminology follows Adey & Adey (1973). For cell length measurements, the distance between primary pit connections was considered while for cell diameters, the maximum cell lumen at right angles to the length was considered. Conceptacle measurements follow Adey & Adey (1973).

Results

Porolithon improcerum (Foslie & Howe) Howe (1920: 587)

Basionym:—*Goniolithon improcerum* Foslie & M.A.Howe in Foslie (1907: 24)
Homotypic synonym:—*Hydrolithon improcerum* (Foslie & M.A.Howe) Foslie (1909: 55)
Holotype: —TRH, A14-752 Montego Bay, Jamaica; Howe no. 4760b, date not indicated.
Material examined:—BRAZIL. Cadeia Vitória-Trindade, Ilha de Martim Vaz, 15 m depth, 20º28'05"S; 28º51'28"W, 22.iii.2009, *GM Amado Filho & RG Bahia*, RB 547497.



FIGURES 1–4. Vegetative and reproductive features of *Porolithon improcerum*. 1. General view of an encrusting and epilithic specimen. 2. Vertical section through thalli showing three applanate branches (1–3) overgrowing one another. Each branch is two cells thick consisting of a non-palisade, elongate basal cell and a dorsal rounded epithallial cell. Note the cell fusions (arrow) and trichocytes (t) occurring in horizontal fields. 3. Section showing multiple applanate branches overgrowing one another. 4. Longitudinal section through a uniporate tetrasporangial conceptacle showing the pore canal lined by enlarged cells (arrows) orientated perpendicularly to the roof surface. Note the presence of a small central columella (c) and a sporangium (s).

Habit and vegetative anatomy
Plants encrusting and smooth (Fig. 1), up to 800 µm thick, epilithic, occuring as applanate branches that overgrow one another (Figs. 2–3). Thallus pseudoparenchymatous, dorsiventral and dimerous (Fig. 2). Individual vegetative thalli mostly two cells thick, consisting of a single ventral (basal) layer of non-palisade cells and a single layer of epithallial cells arising dorsally (Fig. 2). Basal cells are rectangular to elongate and measure 10–28 µm in length and 6–18 µm in diameter. Epithallial cells are rounded to flattened and measure 4–6 in length and and 6–12 µm in diameter. Cell fusions between adjacent basal cells are abundant (Fig. 2); secondary pit connections were not seen. Trichocytes frequently occur singly or in small horizontal fields (up to six trichocytes per field) (Figs. 2–3).

Reproductive anatomy
Mature tetra/bisporangial conceptacles are uniporate and raised above the surrounding thallus surface. Their chambers measure 97–127 µm in height and 170–255 µm in diameter (Fig. 4). The conceptacle floor is usually flush with the surrounding thallus surface to 2 cells below it. The conceptacle roof at maturity is 30–40 µm thick (2–4 cells, incl. epithallial cell) and is formed from filaments peripheral to the fertile area as well as from filaments interspersed among the sporangial initials. A ring of enlarged, domed cells lines the base of the pore canal. These cells are oriented more or less perpendicularly to the roof surface and do not protrude into the pore canal. Zonately divided tetrasporangia that are 60–90 µm in length and 20–40 µm in diameter are peripherally arranged around a central columella. Gametangial conceptacles were not found.

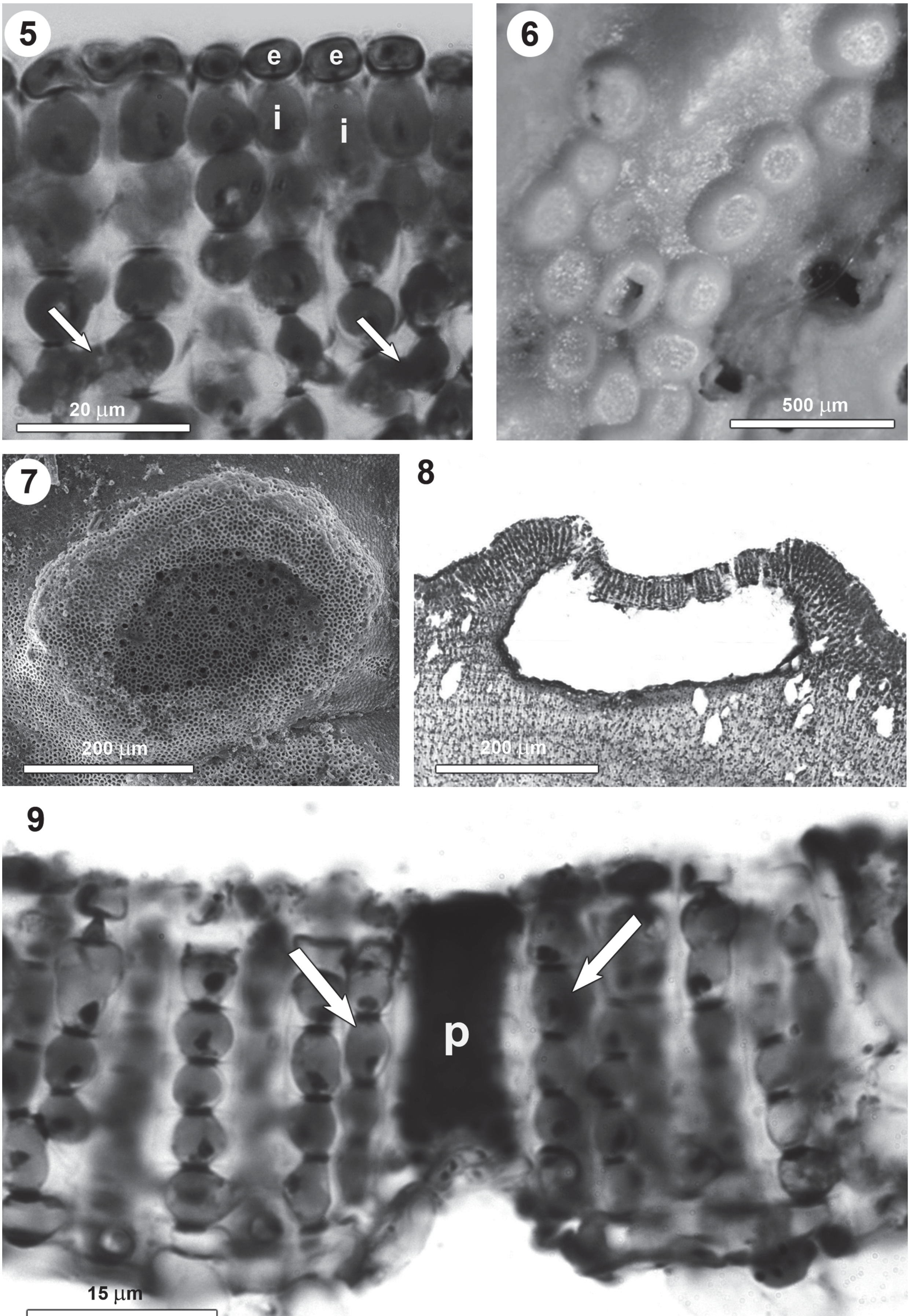
Mesophyllum macroblastum (Foslie) Adey (1970: 25)

Basionym:—*Lithothamnion macroblastum* Foslie (1897: 16)
Holotype:—TRH, B16-2435, includes slide 191 (Woelkerling 1998: 352), Gulf of Naples, Italy. Collector not indicated; date not indicated.
Material examined:—BRAZIL. Rio de Janeiro, Arquipélago das Cagarras, Ilha de Palmas, 3–15 m depth, 23º02'16'' S; 43º12'05'' W, 07.iv.2012, *GM Amado Filho*, RB 587613.

Habit and vegetative anatomy
Plants encrusting to warty, epilithic, 247–560 µm in thickness. Thallus pseudoparenchymatous, dorsiventral and monomerous. Medullary and cortical filaments composed of cells 6–15 µm in length and 5–13 µm in diameter. Subepithallial initials 9–14 µm in length and 7–9 µm in diameter, are as long as or longer than their immediate inward derivatives (Fig. 5). Flattened to rounded epithallial cells occur in a single layer, are 3–5 µm in length and 4–9 µm in diameter (Fig. 5), and are occasionally sloughed. Cells of medullary and cortical filaments are connected by cell fusions (Fig. 5); secondary pit connections were not seen.

Reproductive anatomy
Mature tetrasporangial conceptacles are multiporate and raised above the surrounding thallus surface (Figs. 6–8). Conceptacles are volcano-like in shape, differentiating into a peripheral rim and a central sunken pore plate (Figs. 6–8). Conceptacle chambers are 102–128 µm in height and 290–359 µm in diameter. Conceptacle roofs are mostly raised above or occasionally flush with the surrounding thallus surface (Fig. 8). Roof filaments are composed of 5–8 cells (incl. one epithallial cell) (Fig. 9). Cells of filaments lining the conceptacle pore canal are similar in size and shape to other roof cells (Fig. 9). Conceptacle floors are located 13–16 cell below the surrounding thallus surface. All conceptacles were empty and sporangia were not observed. However, the remains of apical pore plug were visible in some pore plates (Fig. 9). Gametangial conceptacles were not found.

FIGURES 5–9. Vegetative and reproductive features of *Mesophyllum macroblastum*. 5. Vertical section through the vegetative thallus showing a single layer of rounded epithallial cells (e), subepithallial initials (i) that are as long as or longer than their immediate inward derivatives, and cell fusions (arrows) between cells of adjacent filaments. 6. Magnified view of volcano-like multiporate tetrasporangial conceptacles in surface view. 7. SEM of a volcano-like multiporate tetrasporangial conceptacle in surface view showing the raised peripheral rim and central sunken pore plate. 8. Vertical section through a tetrasporangial conceptacle showing the raised peripheral rim and central sunken pore plate. Section through a tetrasporangial conceptacle roof showing a pore plug (p) and the cells lining the pore canal (arrows).


5
e
e
i
i
20 µm
6
500 µm
7
200 µm
8
200 µm
9
p
15 µm

Discussion

Samples from Martim Vaz Island examined in this study correspond to description of the type and to collections of *P. improcerum* from the Caribbean region (Townsend & Adey 1990, Maneveldt 2005, as *Hydrolithon improcerum*), southeastern Australia and New Zealand (Harvey *et al.* 2005, 2006, as *Hydrolithon improcerum*). This is the first record of the species for the southern Atlantic. According to Kato et al. (2011), the subfamily Porolithoideae (represented by the single genus *Porolithon*) is characterized by the following combination of feautures: 1) Thallus unsegmented; 2) secondary pit connections absent; 3) lateral fusions present; 4) basal layer without palisade cells; 5) trichocytes present in large tightly packed horizontal fields; 6) tetrasporangial conceptacles formed by filaments peripheral to the fertile area and interspersed among tetrasporangial initials, and 7) spermatangia developing on the floor of the male conceptacle. All the features found in the studied specimens match with the modern concept of *Porolithon* (Kato et al. 2011) listed above, except feature 7 that was not verified because no gametangial plants were found. The presence of very thin thalli occurring as successive applanate branches (secondary branching) is the main distinctive feature of *P. improcerum* within genus *Porolithon*. This same feature is known in two other species from other genera, namely: *Mastophora multistrata* Keats (2009: 413–417) and *Titanoderma prototypum* (Foslie) Woelkerling, Chamberlain & Silva (1985: 333). According to Keats *et al.* (2009: 415, Fig. 33) "secondary branching occurs when one or a few cells produce erect filaments that then generate a marginal terminal initial; growth of these branches over the surface of the existing thallus results in a new thallus layer forming on top of the original thallus. The repetition of these events and the tightly coherent nature of the layers produce a thallus that is many cells thick and solid". This same process presumably results in the characteristic applanate thalli observed in *H. improcerum*.

In addition to *P. improcerum*, only one other species of *Porolithon* is recorded for the southwestern Atlantic: *Porolithon pachydermum* (Foslie) Foslie (1909: 57) (Villas-Boas et al. 2005). The two species differ mainly by the occurrence of secondary branching in *P. improcerum* which is absent in *P. pachydermum*. Moreover, both species exhibit differences in vegetative thallus thickness. Individual vegetative thallus (in each branch) is always two cell layers in *P. improcerum* whereas *P. pachydermum* is often more than 10 cells thick.

Similarly, samples from Palmas Island, Cagarras Archipelago, Rio de Janeiro city identified as *Mesophyllum macroblastum* are in accordance with the type specimen from the Adriatic Sea described in detail by Woelkerling & Harvey (1993) as well as with collections described from southern and south-eastern Australia (Woelkerling & Harvey 1993, Harvey *et al.* 2003). According to Wynne (2011), there are eight other species of *Mesophyllum* reported for the Western Atlantic. However, among them, none shows the volcano-like mature multiporate tetrasporangial conceptacles with peripheral rim and sunken pore plate, which is a characteristic feature of *M. macroblastum*. Within the genus *Mesophyllum*, the characteristic volcano-like multiporate tetrasporangial conceptacle is only known to occur in *Mesophyllum printzianum* Woelkerling & Harvey (1993: 593–595), a species endemic in Australia. The two species can be distinguished from each other by the cells lining the pore canals of multiporate tetrasporangial conceptacles. In *M. macroblastum* they are similar in size and shape to other roof cells; in *M. printzianum* pore canal cells are more elongate, especially near the base of the pore canal, than other roof cells (Woelkerling & Harvey 1993).

In conclusion, this study represents the first record of *P. improcerum* for the southern Atlantic and the first record of *M. macroblastum* for the Atlantic Ocean. The latter species was previously found only in the Adriatic Sea, Australia and New Zealand (Woelkerling & Harvey 1993, Harvey *et al.* 2003, 2005). However, in the context of the modern CCA integrative taxonomic approach, the morpho-anatomical identification presented herein has to be confirmed in a near future by comparisons of species DNA sequences. Most of the easily accessible intertidal rocky shores and reefs off the main Brazilian coastal cities have never had their CCA flora documented. The discovery of *M. macroblastum* on the Cagarras Archipelago, a mere 5 km off the famous Ipanema Beach in Rio de Janeiro city, suggests that there are potentially many species of attached CCA as yet unrecorded and/or undescribed for the region.

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