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Short Communication

Descriptions of *Cottoniella fusiformis*, *Branchioglossum* cf. *minutum* and *Frikkiella searlesii* (Rhodophyta, Ceramiales) from the Brazilian continental shelf

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ABSTRACT

The diversity and distribution of marine macroalgae along the Brazilian coast have been investigated in detail. However, information about the deep-water macroalgal flora remains scarce, available mostly in scattered publications or gray literature. In this context, the aim of this study was to describe three specimens of Rhodophyta (*Cottoniella fusiformis*, *Frikkiella searlesii* and *Branchioglossum* cf. *minutum*) collected in the deep waters of the continental shelf off the coast of the state of Espírito Santo during expeditions of the program Evaluating the Potential of Living Resources in the Exclusive Economic Zone. The morphology and distribution of the collected species are detailed, and the taxonomic and biogeographic implications are discussed.

Key words: Deep waters, macroalgae, ReviZee, taxonomy

In the coastal waters of Brazil, there are 457 recognized taxa of Rhodophyta, belonging to 165 genera (Nunes *et al.* 2014). Part of this knowledge about algal biodiversity was generated from the program Evaluating the Potential of Living Resources in the Exclusive Economic Zone, in which oceanographic cruises were carried out between 1998 and 2002 in areas from the state of Bahia to the state of Rio de Janeiro (see Yoneshigue *et al.* 2006). During these expeditions, macroalgae samples were collected in deep waters with Van Veen dredges along the continental shelf off the coast of the state of Espírito Santo, at depths of 20-80 m (Lavrado 2006). All macroalgae collected were cleaned of sediment and fixed in a 4% formalin-seawater solution for subsequent identification analysis. Species identification followed: Børgesen (1919; 1920; 1930), Fritsch (1935; 1945), Taylor (1955), Schneider & Searles (1991), Wynne (2011) and Guiry & Guiry (2014). The identified species were deposited in the Herbarium of the Botany Department of the Federal University of Rio de Janeiro (code, RFA).

Although the occurrences of 228 species of macroalgae were recorded for deep waters off the coast of Brazil in the study carried out by Yoneshigue *et al.* (2006), those authors described only 10 taxa in detail. Therefore, the present study describes three species of Rhodophyta: *Cottoniella fusiformis* Børgesen (Sarcomeniaceae); *Frikkiella searlesii* Wynne & Schneider and *Branchioglossum* cf. *minutum* Schneider (Delesseriaceae). Diagnostic features of the species are presented below.

Key to the species

1. Filamentous plants consisting of polysiphonous basal parts and erect filaments with monosiphonous branches arranged in two rows along the upper part of convex side..... ***Cottoniella fusiformis***.

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1a. Laminar plants, delicate, with a evident midline ..... **2**.
2. Blade with third-order cells formed near the blade margin ..... ***Frikkiella searlesii***.
2a. Blade with third-order cells formed near the midline.....***Branchioglossum* cf. *minutum*.**

Class: FLORIDEOPHYCEAE
Order: CERAMIALES
Family: SARCOMENIACEAE

Cottoniella fusiformis Børgesen, Dansk Botanisk Arkiv 3: 369-504. 1920.
Fig. 1

Filamentous algae, with dorsiventral symmetry, up to 2.0 cm long. Basal parts consist of decumbent filaments 132 (180) 230 µm diam., in which several polysiphonous erect filaments arise from its dorsal region, and from ventral region numerous multicellular rhizoids 17 (30) 43 µm diam. with digitate holdfast. Polysiphonous erect filaments formed by a prominent apical cell 11 (13) 15 µm height and 3 (8) 9 µm diam. From these filaments, arise a series of monosiphonous branches that are arranged on the midline of the erect filaments in two rows localized along the same segment at the upper part of its convex side. From the fourth or sixth axial cell, the central cell gives rise to four pericentral cells, visible in the early stages of development, formation of flank cells and cortication occasionally occur in the later development stages. Monosiphonous branches formed in top of the thallus, disposed at acute angles with the straight filament composed of elongated cylindrical cells 38 (47) 60 µm long and 4.0 (5.6) 7.5 µm diam. These ramifications arise from quadratic cells, which are disposed between the pericentral cells. Polysiphonous branches arise from endogenous formation. Fertile individuals were not encountered.

Studied material: **BRAZIL. Espírito Santo:** São Mateus (18°52'47"S; 039°35'42"W), 28/02/1996, 23 m depth (RFA 36071).

Comments: Our material shows four pericentral cells (Fig. 1L-N), which differs from *Cottoniella sanguinea* described by Howe (1928), and later cited by Taylor (1960) for the state of Rio de Janeiro (Brazil), in which *C. sanguinea* is characterized by having five pericentral cells along the thallus. According to Cormaci *et al.* (1978), the variety *algeriensis* presents monosiphonous filaments emerging irregularly, differing from our specimen, which consisted of numerous filaments arranged regularly throughout the thallus (Fig. 1F-H). Our sample also differs from *C. arcuata* described by Børgesen (1919) due to the discontinuity of flank cell formation. In this context, the present specimen shows continuous development of flank cells throughout the thallus (Fig. 1E). Yoneshigue *et al.* (2006) reported this specimen as *Cottoniella filamentosa* var. *fusiformis* based on the dichotomous key proposed by Cormaci *et al.* (1978), assuming presence of two monosiphonous filaments in each segment as attribute of *Cottoniella filamentosa* var. *fusiformis* Cormaci & Furnari. However, Guiry & Guiry (2014) regards as a taxonomic synonym of *Cottoniella fusiformis* Børgesen. This species is considered rare, its distribution in the South Atlantic being restricted to Espírito Santo.

Order: CERAMIALES
Family: DELESSERIACEAE

Frikkiella searlesii Wynne & Schneider, System. Bot. 21:77-84. 1996.
Fig. 2

Plant laminar and delicate, rosy red, to 3.5 mm in length and 1.0 mm in width, short stipe, attached by rhizoidal mass. Blade becomes prostrated by rhizoids produced from margin. Growth by a prominent apical cell, axial cells gives rise to a midline region comprising three layers of overlapping cells (axial cells and two pericentral cells). Pericentral cells generate the second-order cell rows; and few outer cells of second-order bear the third-order cells near the blade margin. In surface view, hexagonal cells, elongated sori, occurring along the midline at apical region, sporangia tetrahedrally divided with 90-109 µm diam. No gametophytes were observed.

Studied material: **BRAZIL**. **Espírito Santo:** Aracruz (19°48'47"S; 037°56'33"W), 18/07/2001, 60 m depth (RFA 36043).

Comments: The two described species of *Frikkiella* (*F. pseudoprostrata* and *F. searlesii*) differ mainly in apical organization, the form of tetrasporangial sori and appearance of the cells of the alae. The morphological features, such as cell formation of third order near the blade margin (Fig. 2B), the hexagonal shape of the cells of the wing (Fig. 2C), and the layout and shape of tetrasporangial sori (Fig. 2C), corroborate the identification of our specimens as *Frikkiella searlesii* M.J. Wynne & Schneid C.W. Our specimens are smaller than the type species (23.0 mm) described for Puerto Rico, the Bahamas and Bermuda at depths of 20-61 m (Wynne & Schneider 1996). Although this rare species has been reported as endemic to the Caribbean Sea (Wynne & Schneider 1996), there is a record in Papua New Guinea (Coppejans & Millar 2000). Its distribution in the South Atlantic is currently restricted to Espírito Santo. The occurrence of *F. searlesii* at 60 m of depth corroborates the affinity of this species for deep waters.

Branchioglossum* cf. *minutum Schneider, Nova Hedw. 26: 83-103.1975.
Fig. 2

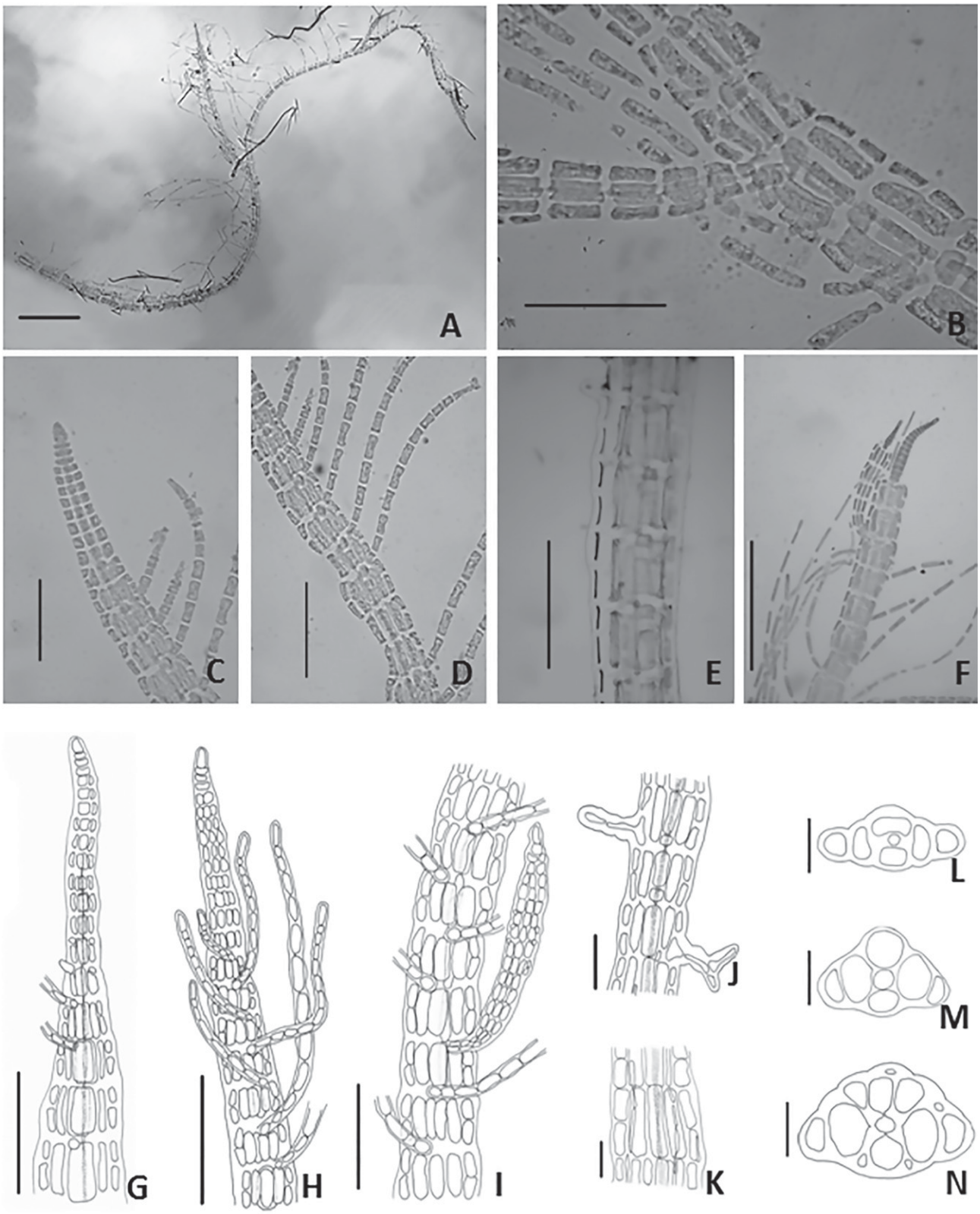

Figure 1. ***Cottoniella fusiformis*** **- A.** General aspect (50 μm); **B.** Endogenous polysiphonous branch (50 μm); **C.** Detail of apical organization (50 μm); **D.** Arrangement of monosiphonous filaments and formation of flank cells (50 μm); **E.** Cortication of thallus (200 μm); **F.** Thallus regeneration from the apical cell (200 μm); **G.** Detail of early formation of two monosiphonous filaments in each segment (100 μm); **H.** Acute arrangement of monosiphonous filaments (100 μm); **I.** Alternated monosiphonous filaments (100 μm); **J.** Lateral rhizoids with digitate holdfast (100 μm); **K.** Cortication of basal parts (100 μm); **L-N.** Transversal sections of thallus at different development stages (50 μm).

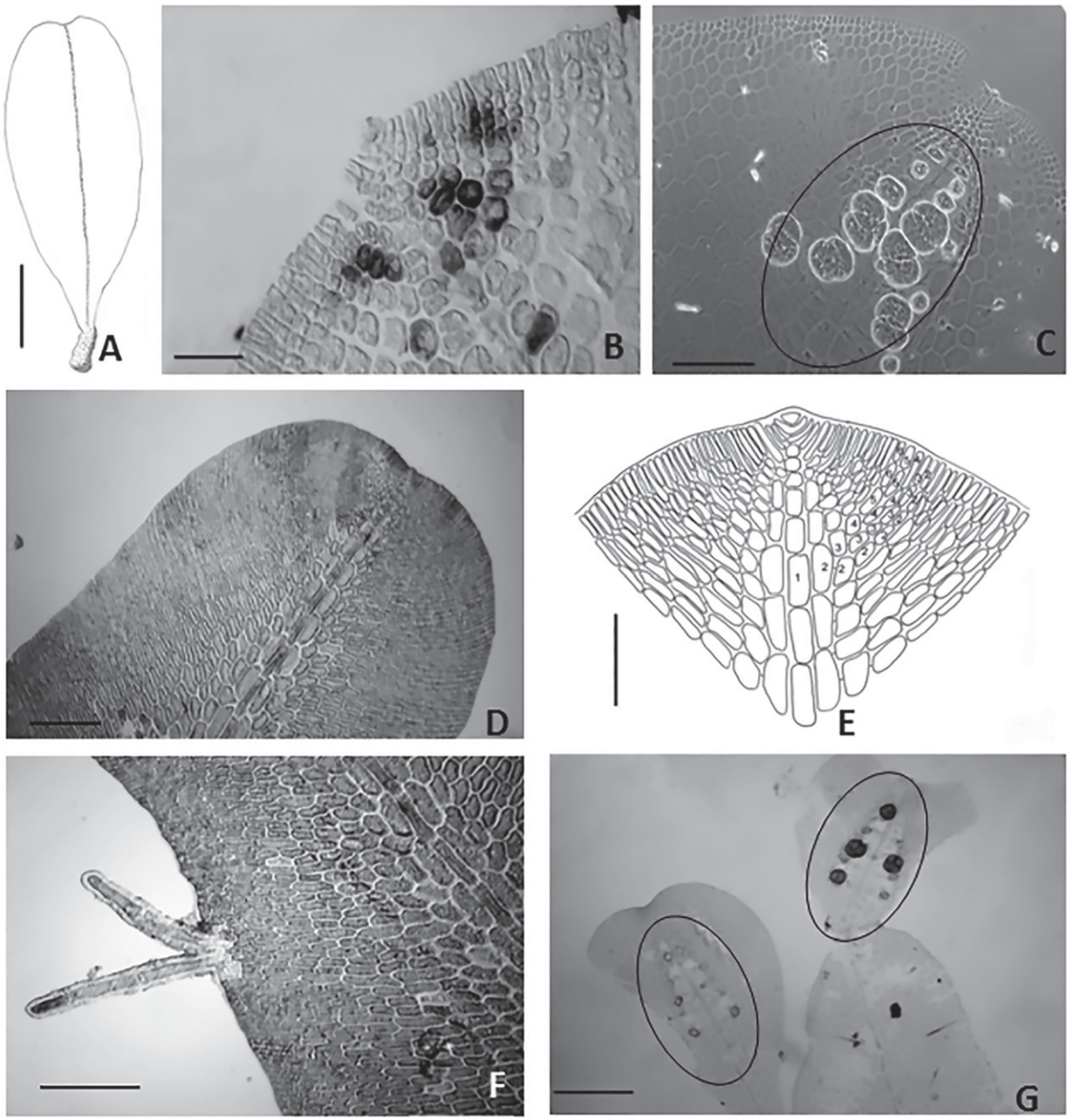

Figure 2. ***Frikkiella searlesii*** **- A.** Habit of blade (1 mm); **B.** Detail of the blade apex (25 µm); **D.** Sporangial sori (200 µm); ***Branchioglossum*** **cf.** ***minutum*****:** D. Surface view of blade (200 µm); **E.** Detail of the blade apex and cell organization (250 µm); **F.** multicellular and uniseriate marginal rhizoids (100 µm); **G.** Tetrasporangial sori ellipsoid (250 µm).

Plant delicate and laminar, red to rosy red, up to 0.3-2.3 mm in height and 0.3-0.7 mm in width, arising from a short rhizoidal holdfast. Secondary attachments by multicellular and uniseriate marginal rhizoids. Growth by a distinct apical cell 7.4 mm in length and 11.8 mm in diam. Monostromatic blade consisting mostly of rectangular cells, prominent multilayered midline, second-order cells rows give rise to rows of third-order cells near the midline region. Marginal branch originated from conversion of second-order cell into initial primary cells. Tetrasporangial sori ellipsoid 150-170 µm long and 90-95 µm wide, situated near the apical region and disposed symmetrically on both sides of the midline. Sporangia are tetrahedrally divided, arising from the pericentral cells 20-30 µm diam.

Studied material: **BRAZIL**. **Espírito Santo:** Aracruz (19°48'47"S; 037°56'33"W), 18/07/2001, 60 m depth (RFA 6093).

Comments: Our plants are smaller than plants from North Carolina/USA (<10.0 mm), collected at depths of 20-35 m (Schneider & Searles 1975), and specimens from

the Brazilian states of São Paulo and Santa Catarina (3.0-10.0 mm), collected at depths of 8-15 m (Horta & Oliveira 2001). Our specimens present ellipsoid tetrasporangial sori (Fig. 2G), differing from the circular or semicircular sori described for the type species (Schneider & Searles 1975) and for Brazilian specimens reported by Horta & Oliveira (2001). Although the ellipsoid tetrasporangial sori in one row on both sides of the midrib is a feature also present in *Branchioglossum nanum* Inagaki, our specimens differ in relation to the dichotomy of branches (Inagaki 1935). Our species shows morphological features similar to *Frikkiella pseudoprostrata* (Ballantine & Wynne) Wynne & Schneider, although not all *Frikkiella* second-order cell rows produce third-order rows (Wynne & Schneider 1996). In the absence of more specimens to confirm other vegetative and reproductive features, we have provisionally identified our material as *Branchioglossum* cf. *minutum* Schneider. Uncommon species with South Atlantic distribution as far south as the Brazilian states of Espírito Santo, São Paulo and Santa Catarina (Brazil), showing affinity for cold waters.

The characterization of these three species increases knowledge of the macroalgae of Brazil, underscoring the importance of deep-water studies. In this context, our description of these species furthers understanding of the biogeography and ecology of marine macroalgae.

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