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How diverse are coccoid cyanobacteria? A case study of terrestrial habitats from the Atlantic Rainforest (São Paulo, Brazil)

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Abstract

The present study analyzed 267 samples of terrestrial habitats from different fragmented areas of the Atlantic Rainforest located in São Paulo State (southeastern Brazil), finding 61 taxa of coccoid cyanobacteria, 21 of which we were only capable of identifying at the generic level. The samples were examined using light microscopy and populations were morphometrically separated and taxonomically identified. Among the identified taxa, we propose the elevation of *Chroococcus turgidus* var. *subviolaceus* to *Chroococcus subviolaceus comb. et stat. nov.* Due to the high species richness found, we assume that the Atlantic Rainforest is a 'hotspot' of coccoid cyanobacterial diversity and should be better studied, in addition to other tropical ecosystems and terrestrial habitats, which have been shown to be suitable places for cyanobacterial diversity establishment.

Key Words: Brazilian forest, Chroococcales, cyanobacterial biodiversity, *combinatio nova*, *status novus*

Introduction

Coccoid cyanobacteria have historically been understood as presenting the 'simplest' morphology among cyanobacteria, since they cannot form 'true' filaments or specialized cells (heterocytes and/or akinetes). However, this idea underestimates these organisms, whose complexity extends beyond simple spherical or elongated cells and colonies. Despite their inability to form true filaments, these bacteria vary widely in colonial shape and they also have a complex process of cell division, such as asymmetrical, multiple and binary fission in different planes (Kováčik 1988, Komárek & Anagnostidis 1998). In addition, many taxa have complex life cycles, with different morphotypes, which can overlap in distinct genera/species, leading to misinterpretations (e.g. *Asterocapsa*/*Gloeocapsa*/*Gloeocapsopsis*) (Komárek 1993). These points, together with the difficulty in recognizing diacritical features are obstacles in identifying coccoid cyanobacteria. Moreover, the greatest variability of coccoid shapes and morphotypes are not found in aquatic sites, but mainly in terrestrial environments, which remain poorly investigated. This leads to a gap in the knowledge of these organisms, and hinders reconstructing true biogeographic and systematic scenarios. In terrestrial environments, cyanobacteria are widespread and play a crucial role as primary producers and pioneers, preparing the soil for subsequent colonization and biofilm establishment (Gorbushina 2007). Coccoid cyanobacteria are frequently dominant, compressing and sedimenting particles, mainly due to their excessive mucilage production (Golubic & Abed 2010). There is still a paucity of studies on tropical biodiversity, since most studies have been undertaken in temperate zones. Researchers have demonstrated over the past century the vast richness of coccoid species in the tropical zone (Fritsch 1907, Wille 1914, Printz 1921, Gardner 1927, Skuja 1949). Interestingly, a recent metagenomic study showed that unicellular and colonial cyanobacteria are abundant in tropical biofilms (Gaylarde *et al.* 2012), and they also dominate these habitats more frequently in tropical Latin America than in continental Europe (Gaylarde & Gaylarde 2005).

Among tropical and subtropical zones, the Atlantic Rainforest is highlighted as one of the most diverse biomes on Earth, considered a hotspot for biodiversity and should be conserved (Myers *et al.* 2000). The wide variability of distinct and particular landscapes in this ecosystem can explain the high number of endemic organisms, which is also true for microorganisms, including cyanobacteria. Twenty-two articles containing three new genera, 43 new species,

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