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Vulcanochloris (Trebouxiales, Trebouxiophyceae), a new genus of lichen photobiont from La Palma, Canary Islands, Spain

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Abstract

This paper describes a new genus of lichen photobionts, *Vulcanochloris*, with three newly proposed species, *V. canariensis*, *V. guanchorum* and *V. symbiotica*. These algae have been discovered as photobionts of lichen *Stereocaulon vesuvianum* growing on slopes of volcanos and lava fields on La Palma, Canary Islands, Spain. Particular species, as well as the newly proposed genus, are delimited based on ITS rDNA, 18S rDNA and *rbcL* sequences, chloroplast morphology, and ultrastructural features. Phylogenetic analyses infer the genus *Vulcanochloris* as a member of Trebouxiophycean order Trebouxiales, in a sister relationship with the genus *Asterochloris*. Our data point to the similar lifestyle and morphology of these two genera; however, *Vulcanochloris* can be well distinguished by a unique formation of spherical incisions within the pyrenoid. Mycobiont specificity and geographical distribution of the newly proposed genus is further discussed.

Introduction

The class Trebouxiophyceae, originally circumscribed by ultrastructural features as Pleurastrophyceae, is currently defined phylogenetically, predominantly by a similarity in 18S rDNA sequence data. As presently conceived, the class comprises single-celled, colonial and multicellular algae living mainly in freshwater or terrestrial habitats (Leliaert *et al*. 2012). Many members of this class are able to make symbiotic relationships. For example, species of genera *Elliptochloris* Tschermak-Woess (1980b: 71) and *Chlorella* Beyerinck (1890: 758) have been reported as symbionts of invertebrates (Letsch *et al*. 2009, Hoshina *et al*. 2010). The class is generally known to comprise the majority of eukaryotic lichen symbionts, *i.e*., the phycobionts. The genera *Trebouxia* Puymaly (1924: 109), *Asterochloris* Tschermak-Woess (1980a: 291), *Coccomyxa* Schmidle (1901: 23) and *Myrmecia* Printz (1921: 13) are among the most common photobionts worldwide (Friedl & Büdel 2008, Tschermak-Woess 1988). However, due to a simple morphology and small cell sizes, diversity of Trebouxiophycean algae is still poorly understood. Indeed, a number of new species and genera are still being discovered (Hoshina *et al*. 2010, Neustupa *et al*. 2011, 2013, Gaysina *et al*. 2013). Many findings of new taxa could be expected also among lichen photobionts, mainly among "*Chlorella*-like" lichenized algae (Friedl & Bhattacharya 2002, Nyati *et al*. 2007, Thüs *et al*. 2011).

The Canary Islands are famous for their extraordinary diversity of vascular plants. Among the free-living algae attention was almost exclusively paid to marine representatives (Bouza *et al*. 2006, García-Jiménez *et al*. 2008, Cassano *et al*. 2012). The diversity of lichenized algae has been studied only marginally, as a part of the studies investigating the photobiont diversity of *Tephromela atra* (Hudson 1762: 445) Hafellner (1983: No. 297) (Muggia *et al*. 2010), *Ramalina farinacea* (Linnaeus 1753: 1146) Acharius (1810: 606) (Casano *et al*. 2011, Campo *et al*. 2013), *Lecanora rupicola* (Linnaeus 1767: 132) Zahlbruckner (1928: 525), *L. carpinea* (Linnaeus 1753: 1141) Vainio (1888: 23) (Blaha *et al*. 2006) and *Parmotrema pseudotinctorum* (Abbayes 1951: 973) Hale (1974: 338) (Molins *et al*. 2013). The Canary Islands are known to host a high diversity of lichens and lichenicolous organisms. The most recent checklist lists more than 1600 species for an area of just 7447 km^2 (Hernández Padrón & Pérez-Vargas 2010). One of the most abundant lichens of Canary Islands, *Stereocaulon vesuvianum* Persoon (1810: 19), has been subjected to a study investigating its role in rock weathering processes (Stretch & Viles 2002). However, no study has been performed to explore the photobiont diversity in this remarkable lichen species, so far.

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