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Roholtiella, gen. nov. (Nostocales, Cyanobacteria)—a tapering and branching cyanobacteria of the family Nostocaceae

MARKÉTA BOHUNICKÁ[1,2,*], NICOLE PIETRASIAK[3], JEFFREY R. JOHANSEN[1,3], ESTHER BERRENDERO GÓMEZ[1], TOMÁŠ HAUER[1,2], LIRA A. GAYSINA[4] & ALENA LUKEŠOVÁ[5]

[1]*Faculty of Science, University of South Bohemia, Branišovská 31, České Budějovice 370 05, Czech Republic*
[2]*Institute of Botany of the Czech Academy of Sciences, Dukelská 135, Třeboň, 379 82, Czech Republic*
[3]*Department of Biology, John Carroll University, University Heights, 1 John Carroll Blvd., Ohio 44118, USA*
[4]*Department of Bioecology and Biological Education, M. Akmullah Bashkir State Pedagogical University, 450000 Ufa, Okt'yabrskoi revolucii 3a, Russian Federation*
[5]*Institute of Soil Biology of the Czech Academy of Sciences, Na Sádkách 7, České Budějovice 370 05, Czech Republic*
**Corresponding author (bohunicka@centrum.cz)*

Abstract

A total of 16 strains phylogenetically placed within the Nostocaceae were found to possess morphological features of the Rivulariaceae and Tolypothrichaceae (tapering trichomes and single false branching, respectively) in addition to their typical Nostocacean features (production of arthrospores in series). These strains formed a strongly supported clade separate from other strains that are phylogenetically and morphologically close. We describe four new species within the genus *Roholtiella gen. nov.* The four species include three distinguishable morphotypes. *Roholtiella mojaviensis* and *R. edaphica* are morphologically distinct from each other and from the other two species, *R. fluviatilis* and *R. bashkiriorum*. *Roholtiella fluviatilis* and *R. bashkiriorum* are cryptic species with respect to each other. All four species are easily distinguished based on the sequence of the 16S-23S ITS regions, in particular the flanking regions to the conserved Box-B and V3 helices. The species are further established by the elevated p-distance between species that is much reduced among strains within the same species. *Calochaete cimrmanii,* a recently described tapering species from tropical biomes, is the most likely sister taxon to *Roholtiella.*

Key words: 16S rRNA gene, 16S-23S ITS, cryptic species, morphology, new genus, Nostocophycideae, polyphasic approach, taxonomy

Introduction

With the advent of molecular sequencing and the polyphasic approach to cyanobacterial taxonomy, there has recently been considerable advance made in the systematics and taxonomy of cyanobacteria, including the description of numerous cyanobacterial genera and species. The first genera to be described with a combination of morphological and molecular methods appeared in 2002 (Abed *et al.* 2002, Flechtner *et al.* 2002, Suda *et al.* 2002). Since that time, over 40 genera have been described using a polyphasic approach that includes both morphology and molecular sequence data.

The heterocytous taxa have proven difficult to characterize and numerous morphologically well-defined genera have been found to be polyphyletic based on molecular phylogenetic analyses. Over the past century, characteristics such as tapering and false branching were thought to have evolved very seldom, and so most filaments that tapered were identified as *Calothrix* Agardh *ex* Bornet & Flahault (1886: 345) or *Rivularia* Agardh *ex* Bornet & Flahault (1887: 345), and false branching forms were commonly placed in either *Tolypothrix* Kützing ex Bornet & Flahault (1888a: 118) or *Scytonema* Agardh *ex* Bornet & Flahault (1888a: 85). When strains that were incorrectly assigned to these genera began to be sequenced (Rajaniemi *et al.* 2005), it created a good deal of taxonomic confusion, some of which persists to the present (Hauer *et al.* 2014).

The Nostocaceae have traditionally consisted of the heterocytous taxa that do not possess false branching or tapering (Geitler 1932, Komárek 2013). They form arthrospores that are solitary, or in series and are produced

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as more extensive taxon sampling to resolve the genera that likely exist within the clade. By describing *Roholtiella* using a polyphasic approach, we hope to have made progress towards this end.

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