University of South Bohemia in České Budějovice
Faculty of Science

# A peek into diversity of terrestrial cyanobacteria collected in San Gerardo de Rivas region, Costa Rica

**RNDr. Thesis**

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**Annotation:**

The presented thesis focuses on diversity of cyanobacteria collected from terrestrial habitats in the surroundings of San Gerardo de Rivas, Costa Rica. The first part of this thesis consists of a floristic survey performed on dried and subsequently revived samples using light microscopy. The second part introduces new cyanobacterial genus *Calochaete* (Microchaetaceae, Nostocales) with the type species *C. cimrmanii*.

**Declaration [in Czech]:**

Prohlašuji, že v souladu s § 47b zákona č. 111/1998 Sb. v platném znění souhlasím se zveřejněním své rigorózní práce a to v úpravě vzniklé vypuštěním vyznačených částí archivovaných Přírodovědeckou fakultou elektronickou cestou ve veřejně přístupné části databáze STAG provozované Jihočeskou univerzitou v Českých Budějovicích na jejích internetových stránkách, a to se zachováním mého autorského práva k odevzdanému textu této kvalifikační práce. Souhlasím dále s tím, aby toutéž elektronickou cestou byly v souladu s uvedeným ustanovením zákona č. 111/1998 Sb. zveřejněny posudky školitele a oponentů práce i záznam o průběhu a výsledku obhajoby kvalifikační práce. Rovněž souhlasím s porovnáním textu mé kvalifikační práce s databází kvalifikačních prací Theses.cz provozovanou Národním registrem vysokoškolských kvalifikačních prací a systémem na odhalování plagiátů.

V Českých Budějovicích dne 16. 3. 2017

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Radka Mühlsteinová

České Budějovice

16th March 2017

**Declaration of co-author:**

Hereby I declare, that Radka Mühlsteinová made a significant contribution to the following articles:

Mühlsteinová, R. & Hauer, T. 2013. Pilot survey of cyanobacterial diversity from the neighborhood of San Gerardo de Rivas, Costa Rica with a brief summary of current knowledge of terrestrial cyanobacteria in Central America. *Brazilian Journal of Botany* **36**: 299–307.

Hauer, T.**,** Bohunická, M. & Mühlsteinová, R. 2013. *Calochaete gen. nov.* (Cyanobacteria, Nostocales), a new cyanobacterial type from the "páramo" zone in Costa Rica. *Phytotaxa* **109**: 36–44.

I agree that the order of the article authors corresponds with the amount of work spent in its preparation. Radka Mühlsteinová analyzed the natural samples including photo documentation, isolated new cyanobacterial strains from them, wrote the most part of the first paper and contributed substantially to preparation of the second paper.

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Tomáš Hauer

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## 1. Introduction

In our latitudes cyanobacteria became famous particularly as the originators of obnoxious water blooms. The fact that they can not only inhabit much wider range of habitats but also play numerous key roles there remains usually noticed only by specialized scientists. Cyanobacteria living outside of the aquatic environments are often referred to as terrestrial and represent highly interesting group of organisms. They are able to withstand extreme living conditions including unpredictable water availability, severe changes in temperature during just a few hours, and often excessive dosage of light (Hoffmann, 1989, Gorbushina, 2007). Besides fascinating the scientific world by the ability to survive in such hostile and quickly changing conditions/circumstances, terrestrial cyanobacteria are appreciated due to numerous crucial roles by which they influence their surroundings. They serve as important first primary producers, influence nitrogen availability, facilitate further succession or participate in creating important ecological assemblages such as biological soil crusts (Hoffmann, 1989, Evans & Johansen, 1999, Freiberg, 1998, Büdel, 1999).

One of the areas where terrestrial cyanobacteria thrive is represented by Central America and adjacent Caribbean region. This area has been listed among the biodiversity hotspots due to the high endemism of plants and vertebrates (Myers *et al.*, 2000). Even though algae and cyanobacteria are much less conspicuous, studies performed so far seem to confirm considerable diversity also among these small organisms (Gardner, 1927). In Costa Rica the first studies noticing terrestrial cyanobacteria came from Kufferath (1929) and until the very end of the 20$^{th}$ century only a few works followed. With the exception of Drouet's (1938) brief notes on discovered organisms, the works focused mainly on physiological properties of studied cyanobacteria rather than on their diversity (Furnkranz *et al.*, 2008, Freiberg, 1998, Freiberg, 1999). We tried to change this situation by investigating cyanobacterial diversity in macroscopic mats collected from various terrestrial substrates such as rocks and soils using light microscopy (Mühlsteinová & Hauer, 2013). The paper with our results represents the first chapter of this thesis. The second chapter demonstrates that the cyanobacterial diversity in this area is definitely understudied, because even with the limited amount of available cyanobacterial cultures obtained from the floristic survey, we discovered genus and species new to science—*Calochaete cimrmanii* (Hauer *et al.*, 2013).

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# 2. Chapter 1

Pilot survey of cyanobacterial diversity from the neighborhood of San Gerardo de Rivas, Costa Rica with a brief summary of current knowledge of terrestrial cyanobacteria in Central America.

*The following part (9 pages) is a scientific work published in Brazilian Journal of Botany (DOI: 10.1007/s40415-013-0030-5) and is part only of the printed version of this RNDr. thesis (archived by the Faculty of Science, University of South Bohemia).*

# 3. Chapter 2

*Calochaete gen. nov.* (Cyanobacteria, Nostocales), a new cyanobacterial type from the "páramo" zone in Costa Rica.

## 4. Conclusion

Based on the state of knowledge and the determination literature available at the time when the collected samples were analyzed, large part of the cyanobacteria found during the floristic survey could be determined only to a genus level (Mühlsteinová & Hauer, 2013). Even though we suspected numerous taxa to represent new species, we were not able to obtain unicyanobacterial cultures and subsequently enough biomass for the DNA extraction to verify our assumptions. Therefore, only one strain could be subjected to more detailed study taking into account the morphological, ecological, and molecular data, which resulted in a description of a new genus defined around new species *Calochaete cimrmanii* (Hauer *et al.*, 2013).

With the development of new methods and approaches in past few years, the need for bigger amount of biomass for DNA extraction became less limiting. By applying the single-cell or single-filament PCR methods modified for very limited amount of initial biomass for the DNA extraction (Mareš *et al.*, 2015), determination and potentially description of taxa revealed during floristic studies will become less reliant on the need of cyanobacterial strains and cultures which are often impossible to obtain. Even though morphology plays crucial role in identifying cyanobacteria, it has been shown that morphology itself may not be sufficient for reliable delimitation of genera, let alone species (Mühlsteinová *et al.*, 2014). With diverse new molecular methods being evolved, allowing us to recover wide range of cyanobacterial community DNA from environmental samples, it is important to have the DNA sequences connected with reliable names and morphology. If we lack the ability to connect gained sequences to some other data, the acquired information is of rather limited use.

The fact that many of the organisms found during the floristic survey could not be reliably determined into species level based on the combined morphological traits and ecological information, further implies that the diversity of terrestrial cyanobacteria in tropical regions remains rather understudied in general and in the Central America especially. It was shown for the freshwater algae and cyanobacteria that tropics contain taxa different from the ones in temperate zone (Komárek, 1985, Komárek *et al.*, 1996). More recently similar conclusions were indicated by studies of cyanobacteria inhabiting alkaline marshes and water bodies (Rejmánková *et al.*, 2004, Tavera *et al.*, 2013) and collected from terrestrial habitats on the top of Mt. Roraima (Kaštovský *et al.*, 2011). Nevertheless, without combining all the available information and taking into account molecular data, we will not be able to reliably

answer the questions about cyanobacterial diversity in Central America and the geographical distribution of these tiny and morphologically simply organisms.

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