University of South Bohemia

Faculty of Science

Rock-inhabiting cyanoprokaryota of selected localities in the Czech Republic

Summary of the Ph.D. thesis

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České Budějovice
2007

The work was supported by grant of Ministry of Education of the Czech Republic FRVŠ 2221/2005 and Ministry of Environment of the Czech Republic programm Biosféra.

General introducion

Rock-inhabiting cyanobacteria are an interesting group of organisms. They live under very extreme conditions, which they have to be adapted to. The environment inhabited by epilithic aerophytic cyanobacteria is extreme, for a variety of reasons. The first of these must be the difficulty of settlement, especially on vertical rock walls. Next, an important factor is the great temperature extremes, which these organisms must often survive. For example, GEIGER in JAAG (1945) mentions a temperature of 71.5 °C (at a depth of 4 millimeters) under the rock surface during a sunny summer day. On the other hand, temperature lows below zero, particularly during winter (or in polar regions during the whole year) are quite usual. For example, FRIEDMANN et al. (1994) found the lower temperature limit for survival of cyanobacteria (at 50 % relative humidity) to be -24.5 °C. In some regions, the epilithic cyanobacteria are adapted for large temperature fluctuations between day and night (e.g. from -20 °C to + 40 °C in the Atacama Desert; WYNN-WILLIAMS 2000). Strong irradiation (BÜDEL 1999) and the mechanical impacts of rain or falling substrate (JAAG 1945, WYNN-WILLIAMS 2000), are the other environmental factors which epilithic organisms, in general, have to be adapted to. They also have to protect themselves against damage caused by rapid cycles of desiccation / rehydratation, and freezing / thawing. Additionally, the accessibility of liquid water, which is, according to some works, required by cyanobacteria, can also be a problem (BÜDEL & LANGE 1991; LANGE et al. 1993).

Epilithic aerophytic cyanobacteria are an important group of organisms in the environment. they colonize new, unsettled niches around the world, including both the extremely arid parts of Antarctica (BROADY 1981) and hot deserts. They also colonize new niches such as buildings, stone pits or lava fields. They settle into almost all kinds of rocky substrates including man-made concrete, mortar, and other such. The microrelief is important for settlement by cyanobacteria. Microscopic cracks and grains of substrate provide partial protection against solar irradiation, the mechanical protection against falling fractions of substrate or rain, and extend the availability of water due to their slowing evaporation (GOLUBIĆ 1967).

Epilithic cyanobacteria sometime actively crack the substrate and make the site accessible for other organisms. They are not only passive inhabitants, but sometimes actively modify the

substrate, e.g. euendolithic (GOLUBIĆ et al. 1981) cyanobacteria "boring" the substrate. The diversity of epilithic aerophytic cyanobacteria has been studied in several regions in the world, yet the knowledge is still quite poor. The classical published works are those by NOVÁČEK (1934), JAAG (1945) and GOLUBIĆ (1967) on the temperate zone. More recently, CASAMATTA et al. (2002) and PÓCS (2005) have also dealt with this topic. The state of knowledge of rock-inhabiting cyanobacteria in the Czech Republic (CR) is also very poor. Only the first part of the prospective (and at the time very modern) study by NOVÁČEK (1934) has been published about the cyanobacterial flora of serpentinic rocks in the Mohelenská hadcová step nature reserve. Another short study dealing with the same topic and on the same locality was published by KOVÁČIK (1998). Some information on cyanobacterial diversity upon rocky substrates is mentioned in PASCHER's (1903) and SCHORLER's (1915) studies.

Goals of the work

The main goal of the work was to discover diversity of rock-inhabiting cyanoprokaryota in the South Bohemia region, Podyjí National Park, Mohelenská hadcová step, Adršpašsko-Teplické skály and Broumovské stěny nature reserves and to improve the knowledge on their ecological demands, e.g. substrate specificity, moisture and light requirements.

General results

A total of 41 cyanobacterial morphotypes were found during the performance of this study: 62 % of coccoid, 14 % of simple trichal, and 24 % of heterocytous types (see Table 1). Five of these (*Chroococcus spelaeus, Gloeocapsa atrata, Gloeocapsa kuetzingiana, Gloeocapsa violascea*, and *Stigonema panniforme*) are new additions to the flora of the Czech Republic. The richest localities were those with calcareous substrates; on the other hand the poorest in diversity of cyanobacterial species were those sites with either sandstone or granitic rocks. In many cases, information on the substrate, where particular types occur, were complemented. Data obtained through this research showed that many types are not limited to one type of substrate.

In the South Bohemia region, 35 morphotypes in 30 localities with 11 types of substrate were found. Confirmation of the occurrences of some types that had been reported in the Šumava Mountains by PASCHER (1903) were not successful, but all types within other localities were found. Also, another occurrence locality for *Entophysalis atroviolacea*, described by

NOVÁČEK (1932), and reported the last time anywhere worldwide from the Mohelenská hadcová steppe by NOVÁČEK (1934), was found.

Species\Locality	A	B	C	M	P
Synechococcophycideae					
Aphanocapsa muscicola (MENEGHINI) WILLE	+		+	+	
Aphanocapsa parietina NÄGELI				+	
Chamaesiphon polonicus (ROSTAFIŃSKI) HANSGIRG			+		
Leptolyngbya sp.1 [short cells]	+		+	+	+
Leptolyngbya gracillima (ZOPF ex HANSGIRG) ANAGNOSTIDIS et KOMÁREK			+		
Pseudanabaena cf. *spelaea*			+		
Oscillatoriophycideae					
Aphanothece caldariorum RICHTER	+			+	
Aphanothece castagnei (BRÉBISSON) RABENHORST			+	+	
Aphanothece saxicola NÄGELI			+		+
Chlorogloea microcystoides GEITLER			+		
Chroococcus spelaeus ERCEGOVIĆ			+	+	
Chroococcus tenax (KIRCHNER) HIERONYMUS			+		
Chroococcus turgidus (KÜTZING) NÄGELI			+		
Chroococcus varius A. BRAUN in RABENHORST	+		+		
Cyanothece aeruginosa (NÄGELI) KOMÁREK	+	+			
Cyanosarcina sp.			+	+	+
Entophysalis atroviolacea NOVÁČEK			+	+	
Gloeocapsa alpina (NÄGELI) BRAND	+		+	+	
Gloeocapsa atrata KÜTZING			+		+
Gloeocapsa compacta KÜTZING				+	
Gloeocapsa kuetzingiana NÄGELI	+		+	+	
Gloeocapsa nigrescens NÄGELI in RABENHORST			+		
Gloeocapsa novacekii KOMÁREK et ANAGNOSTIDIS			+	+	+
Gloeocapsa violascea (CORDA) RABENHORST			+	+	
Gloeoecapsopsis chroococcoides (NOVÁČEK) KOMÁREK			+	+	+
Gloeocapsopsis dvorakii KOMÁREK et ANAGNOSTIDIS			+	+	+
Gloeocapsopsis pleurocapsoides (NOVÁČEK) KOMÁREK et ANAGNOSTIDIS			+	+	+
Gloeothece rupestris (LYNGBYE) BORNET in WITTROCK et NORDSTEDT	+		+		
Microcoleus vaginatus GOMONT ex GOMONT			+	+	
Phormidium vulgare KÜTZING		+			
Phormidium cf. *uncinatum*	+	+	+		
Pseudocapsa dubia ERCEGOVIĆ			+	+	
Nostocophycideae					
Calothrix parietina THURET			+		
Hassallia byssoidea HASSALL ex BORNET et FLAHAULT			+	+	+
Nostoc cf. *microscopicum*	+		+	+	+
Tolypothrix elenkinii HOLLERBACH			+	+	+
Tolypothrix cf. *distorta*			+	+	+
Scytonema crustaceum (C. AGARDH) BORNET et FLAHAULT			+	+	+
Stigonema minutum (C. AGARDH) HASSALL ex BORNET et FLAHAULT			+	+	
Stigonema panniforme (C. AGARDH) HASSALL ex BORNET et FLAHAULT			+	+	
Stigonema tomentosum (KÜTZING) HIERONYMUS				+	

Table 1: List of species found in the frame of this work. Localities **A** – Adršpašsko-Teplické skály nature reserve; **B** – Broumovské stěny nature reserve; **C** – South Bohemia region (all localities); **P** – Podyjí National park (all localities)

In the Podyjí National Park, 15 morphotypes in 10 localities were found. Except for three types, all were found within a single locality. This locality had superior moisture conditions than the others, and also differed in its substrates.

In the Moholenská hadcová steppe Nature reserve, 26 morphotypes were found. This is ten less than when compared with NOVÁČEK's (1934) work here. The area of the nature reserve may be divided in three distinct areas, according to moisture conditions. These areas have the typical composition of epilithic communities. The occurrence of *Entophysalis atroviolacea* (see above) was confirmed.

In two sandstone nature reserves Adršpašsko-Teplické skály and Broumovské stěny, a total of 11 morphotypes were found. Despite very good moisture conditions, both locations are very poor in rock-inhabiting cyanobacterial types. Three were found, however, on one man-made sandstone wall on which a calcareous mortar was used.

During the study, a strain of typical *Hassallia byssoidea* was isolated, and stored in the Culture Collection of Institute of Botany of AS CR, as strain No. CCALA 823. The sequence of 16S rRNA of this isolate was obtained and submitted to EMBL, with accession number AM905327 – this is the first sequence of *Hassallia* genus available in any database. The sequence was compared with sequences of other members of the family Microchaetaceae and genus *Scytonema*. The comparison in similarity matrix showed, that the similarity of *Hassallia* and *Tolypothrix* genera oscillates about the 93% level, below which it is surely possible to speak about two different genera (STACKEBRANDT & GOEBEL 1994). To confirm the validity and independence of *Hassallia* on *Tolypothrix* on the molecular level, it would be necessary to get and analyze more materials. In addition, the analyses confirmed, that inclusion of the genera *Hassallia* and *Tolypothrix* into the genus *Scytonema*, used by e.g. HOFFMANN (1986), is uncertain.

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Curriculum vitae

Tomáš Hauer, MSc.

Born: April 30th, 1979 in Sokolov

Education:

University of South Bohemia, Faculty of Biological Sciences/Faculty of Science

1997 – 2001 BSc. studies, Thesis A comparison of the phytoplankton of fishponds with field- and forest-catch basin in neighbourhood of Branišov [in Czech] – supervisor Prof. Jiří Komárek

2001 – 2003 MSc. studies, Thesis Cryopreservation of soil algae and cyanobacteria, experiment evaluation using digital imaging [in Czech] – supervisor Jan Kaštovský, PhD.

2003 – present PhD studies, Thesis Rock-inhabiting cyanoprokaryota of selected localities in the Czech Republic [in Czech] – supervisor Prof. Jiří Komárek

Scientific interests: rock-inhabiting cyanobacteria, digital imaging, image analysis

Scientific employers:

Since 2001 – Institute of Botany of the Czech Academy of Sciences, Section of plant ecology

Since 2001 – University of South Bohemia, Faculty of Faculty of Science/Faculty of Biological Sciences

International cooperation:

- 2002 – 2005 – European Commission Research Project (No. QLRT-2000-01645): The Conservation of a Vital European Scientific & Biotechnological Resource: MicroAlgae & Cyanobacteria.
- 2002 – 2006 – Archiv für Hydrobiologie/Algological Studies – technical editor
- Since 2002 – CyanoDB.cz – The on-line database of cyanobacterial genera
- September, October 2003 – Working stay at Johansen Lab, Department of Biology, John Carroll University, Cleveland, OH, U.S.A.

- Since 2005 – Member of organizing committee of Determination Course of Freshwater and Terrestrial Cyanobacteria

Grants:

- 2001- GA Acad. Sci. (No. A6005906): Vegetation of brambles – an example of coenogenesis of apomictic plants – co-worker
- 2002 – World database of cyanobacteria – co-worker (funded by NIES, Tsukuba, Japan)
- 2002 – 2005 – European Commission Research Project (No. QLRT-2000-01645): The Conservation of a Vital European Scientific & Biotechnological Resource: MicroAlgae & Cyanobacteria. – co-worker
- 2003 – FRVŠ 2003/1829: Educational web-site Sinice a řasy.cz – co-principal investigator
- 2003 – 2005 – GA Acad. Sci. (No. A6005308): Realtionships between molecular, phenotypic and ultrastructural properties of heterocytous cyanobacteria – co-worker
- 2005 – FRVŠ 2005/2221: Rock-inhabiting cyanoprokaryota in South Bohemia – principal investigator
- 2006 – 2007 – Ministry of industry and trade of the CR (IMPULS programme): Research and application of biotechnology of anti-erosion stabilization used during recultivation of slopes created by industrial activities – co-worker

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