Gradient of algal and cyanobacterial assemblages in a temporary lake with melting water at Solorina Valley, James Ross Island, Antarctica

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Abstract

The aim of presented study is to contribute to species list of algae, cyanobacteria and diatoms from moist localities of James Ross Island, Solorina Valley (63° 53' S, 57° 48' W) in particular. In 2012, samples of microbiological mats were taken from a bottom of shallow depression close to a seashore line. The sampling site has been filled with melting water from glacier for some weeks preceding the collection. On collection date, however it was dried out. The samples were analysed using optical microscopy approach after the transport of samples to Czech Republic (Masaryk University, Brno). Algal and cyanobacterial taxa forming the microbiological mats were determined according to their morphological characteristics and the frequencies of individual taxa occurrence evaluated. Species richness differed between individual sampling sites located across a shallow depression suggesting an ecological role of duration of stagnant water for biodiversity in temporary freshwater ponds. Altogether, 37 algal and cyanobacterial taxa were found. While 23 taxa present in the centre of the depression, only 10 taxa were found close to the margin where the dry period was the longest.

Key words: James Ross Island, mats, temporary pond, algae, cyanobacteria

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Introduction

Within last decades, species diversity in microbiological mats from Antarctic habitats represents an important aspect of field and laboratory studies. It is because endemism of Antarctic autotrophic microorganisms, cyanobacteria in particular, is still an open question (Vincent 2000). That is why a great number of studies use molecular biology tools to determine species forming microbiological mats in different Antarctic habitats, such as *e.g.* dry valleys lakes (Taton et al. 2003).

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Terrestrial freshwater algae and cyanobacteria are quite abundant in maritime Antarctica, especially along the South Shetland Islands and western coast of Trinity peninsula. James Ross Island, located east of the Antarctic peninsula, however, represents a location typical by both maritime and continental climate. Therefore, species typical for maritime Antarctica could be expected to a less extent than on the western coast of the Antarctic peninsula. Species richness of algae and cyanobacteria has been studied at the James Ross Island since 1990ies by *e.g.* Elster et al. 2013, Komárek et Elster 2008, Komárek et Komárek 2010, Komárek et al. 2008, 2012, 2014. Specifically for diatoms, numerous studies has been devoted to their taxonomy and occurrence at the James Ross Island (*e.g.* Kopalová et al. 2002, 2013, Van de Vijver et al. 2011, Zidarova et al. 2014). In these studies, collection sites were mainly lakes, streams, seepages, and wet rock surfaces. Less attention has been devoted to temporary freshwater ponds.

Temporary freshwater ponds represent quite frequent niche in Arctic (*e.g.* Elster et al. 1997) and Antarctic regions during summer season. Typically, they hold liquid water for a few weeks or months. Different aspects of biology of such ponds has been studied covering *e.g.* freshwater fauna biodiversity (Filgueiras et al. 2007), predation of pelagic microorganisms (Bertilsson et al. 2003), cyanobacterial toxicity (Hitzfeld et al. 2000, Kleinteich et al. 2014) *etc*. Dynamics of freshwater algae biodiversity in temporary polar ponds has been studied in Northern hemisphere (*e.g.* Jang-Seu et al. 2006), however, only few studies are available from Antarctica (Jungblut et al. 2005). In spite of numerous studies of diatoms and cyanobacteria that have been taken at different localities of James Ross Island (mainly seepages, streams, ponds and lakes), Solorina Valley has not yet been investigated. Therefore, we focused on a small-area temporary pond from the above-specified site to describe species richness and differences in community composition as related to the radial gradient from pond centre to the margin. We hypothesized that differences in species composition would be found and related to the length of the period for which water was available before the pond got dry.

Material and Methods

Sampling site description

Samples of microbiological mats were collected from Solorina Valley (63° 53' S, 57° 48' W, 60 m a.s.l.), James Ross Island, Antarctica – *see* Fig. 1. Sampling site was located 150 m from a seashore. It was a shallow depression that had been filled with stagnant water for some weeks preceding the collection. On collection date, however, it was dried out. The sample No. 1 were taken from a margin part of the former shallow pond followed by the other ones (No. 2 to 5) taken at regular intervals towards the centre of depression (*see* Fig. 2). The samples were then delivered to J. G. Mendel Czech Antarctic station, where dried under natural conditions and stored in dried state in a refrigerator (5 ^{o}C).

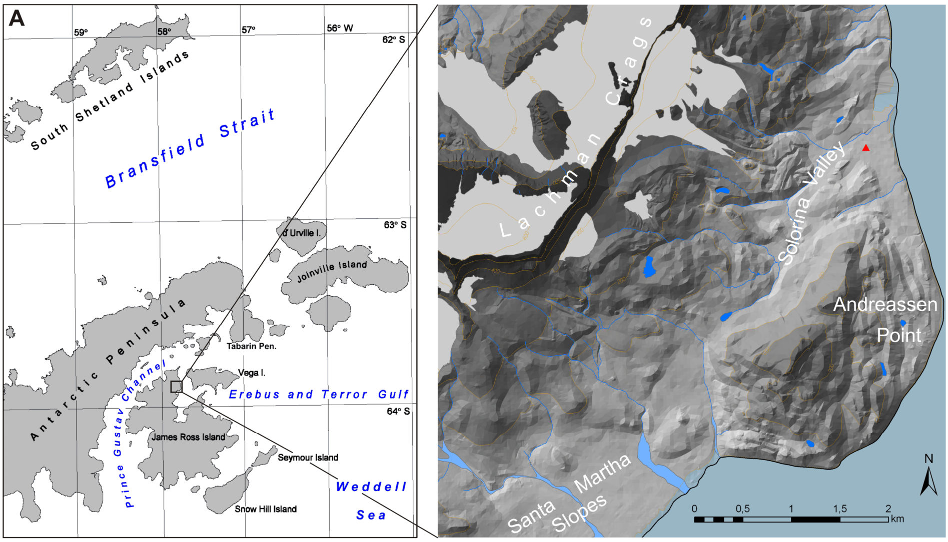

Fig. 1. Map of the northern part James Ross Island. Red point indicates the studied area. Adopted from Czech Geological Survey, 2009.

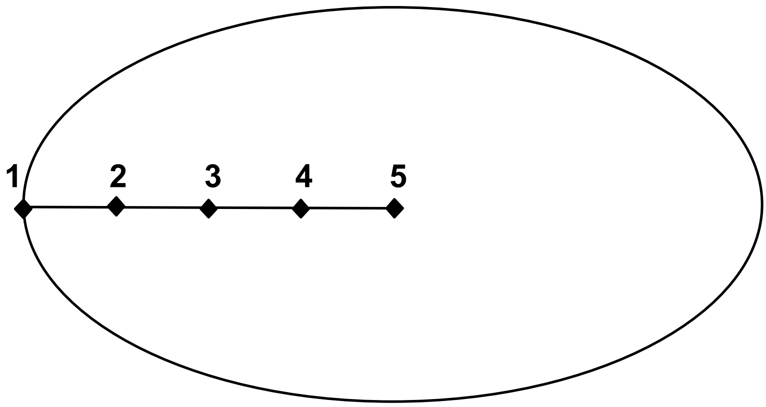

Fig. 2. Scheme of temporary pond at Solorina Valley with marked sampling sites from a margin part (No. 1) to the centre (No. 5).

Optical microscopy

Dried samples of microbiological mats were transported to Brno (Czech Republic) for analysis. After transfer, the samples were rewetted and biodiversity of autotrophic organisms determined as dependent on the distance of samples from depression centre. We hypothesized that biodiversity as well as abundance of the species would be dependent on the time of liquid water availability which was longest in the depression centre.

Algal and cyanobacterial species were observed in microbiological mats from individual sampling sites (No. 1 to 5). Each of crust were (re)hydrated and analysed by an optical microscopy (Olympus BX50, Japan). Digital photographs of algal and cyanobacterial species found in the mats were taken by Sony SLT-A35. Throughout all samples, more than 1000 microphotographs were taken and analysed, so that individual mat-forming species could be distinguished. Morphologic approach was used to determine particular algal and cyanobacterial species. Relative frequencies of species were calculated for each sample.

Results

In all studied samples from Solorina Valley are cyanobacteria predominating taxonomic group. During this research, living cells of Bacillariophyceae were not present, only their single empty frustules in microbiological mats from sampling sites number 2, 3, 4 and 5. Because of this fact, we assume the studied site has been colonised by them but they were not found on soil surface in a dry period which took place here at the time of collection (being hidden in deeper soil layers).

In the examined samples of microbiological mats, total number of 37 algal and cyanobacterial taxa were found. Number of species, however, differed between sampling sites (*see* Table 1). The highest biodiversity was found in the central part of the depression (23) and species richness declined toward to margins. Sampling site No. 1 was distinctly dominated with cyanobacterium *Microcoleus* sp. morphotype 1 (Fig. 3A) which has a strong sheath protecting against desiccations. Following samples (sites No. 2 and No. 3, closer toward the centre) were dominated with *Nostoc* sp. (Figs. 3B, F) and *Leptolyngbya* sp. (thick grey filaments with granulations). At site No. 4 were the most abundant some species of Xanthophyta (Fig. 3G) and cyanobacterium *Leptolyngbya erebi*. *L. erebi* dominated also in central part of the locality (site No. 5).

Discussion

Our results indicate that the community structure of microbiological mats differed between sampling sites (from water holding central part of the temporary pond towards marginal part lacking water for a longer period during austral summer season). This could be documented both for total number of taxa found in central (23) compared to marginal part (10), as well as for specificity of species composition. While quantity of Streptophytes and Bacillariophytes was found to increase toward the central part, they were not found in the marginal part.

Cyanobacteria were present in all sampling sites. In the central part, the most abundant group of cyanobacteria were *Oscillatoriales* (Figs. 3A, D), however, *Nostocales* (*e.g. Hydrocoryne quesadae* – Fig. 3C) and *Chroococcales* (*e.g. Coelomoron chroococcoideum* – Fig. 3H) also occurred there. In the marginal part, cyanobacterial taxa with mucilaginous envelopes (*e.g. Nostoc* sp. – Figs. 3B, F, *Microcoleus* sp. morphotype 1 – Fig. 3A) or with encrusted sheaths (*Calothrix* sp. – Fig. 3E) were more abundant.

	site 1	site 2	site 3	site 4	site 5
Cyanobacteria					
Aphanocapsa sp.	+				+
Calothrix sp.	+ +	+	+		
Coelomoron chroococcoideum (West & West) Komárek 2013		+	+	+	+ +
Dactylothamnos antarcticus Fiore, Genuário & Komárek 2014	+	+	+	+	+
Geitlerinema sp.			+	+ +	
Hassalia andreassenii Komárek, Nedbalová & Hauer 2012	+		+		
Hydrocoryne quesadae Komárek & Genuário 2014	+	+ +	+	+ +	+ +
Chroococcus sp.			+		
Leptolyngbya erebi (West & West) Anagnostidis & Komárek 1988	+ +	+ +	+	+ + +	+ + +
Leptolyngbya sp.		+ + +	+ + +		
Microcoleus sp. (morphotype 1)	+ + +	+	+		
Microcoleus sp. (morphotype 2)		+ +			
Nodularia quadrata Fritsch 1929		+		+	+ +
Nostoc sp.	+ +	+ + +	+ + +	+	
Oscillatoria sp. (morphotype 1)	+		+ +		
Oscillatoria sp. (morphotype 2)		+			
Oscillatoria sp. (morphotype 3)			+ + +	+ +	
Phormidium sp. (morphotype 1)		+ +			
Phormidium sp. (morphotype 2)		+	+		+ +
Phormidium sp. (morphotype 3)			+ +	+ +	+ +
Pseudanabaena sp.					+ +
Chlorophyta					
Ulothrix sp.		+	+		
Streptophyta					
Actinotaenium sp.		+ +	+		+
Cosmarium sp.			+		
Klebsormidium sp.				+	+
Staurastrum sp.				+	+
Zygnema sp.				+	+
Bacillariophyta					
Hantzschia sp.			+	+	+
Luticola sp.				+	
Neidium sp.				+	+
Nitzschia sp.					+
Stauroneis sp.				+	
Chlorophyta (spherical cells)		+	+	+	+
Xanthophyta	+	+	+	+ + +	+
Phormidiales (hormogonia)				+	+ +
coccal green elipsoid cells				+	+
other pennate diatoms		+	+		
tiny green spherical cells			+	+ +	+

Table 1. Occurrence of algal and cyanobacterial taxa in sampling sites of the temporary pond (Solorina Valley, Antarctica). + + + frequent taxa, + + medium taxa, + rare occurring taxa.

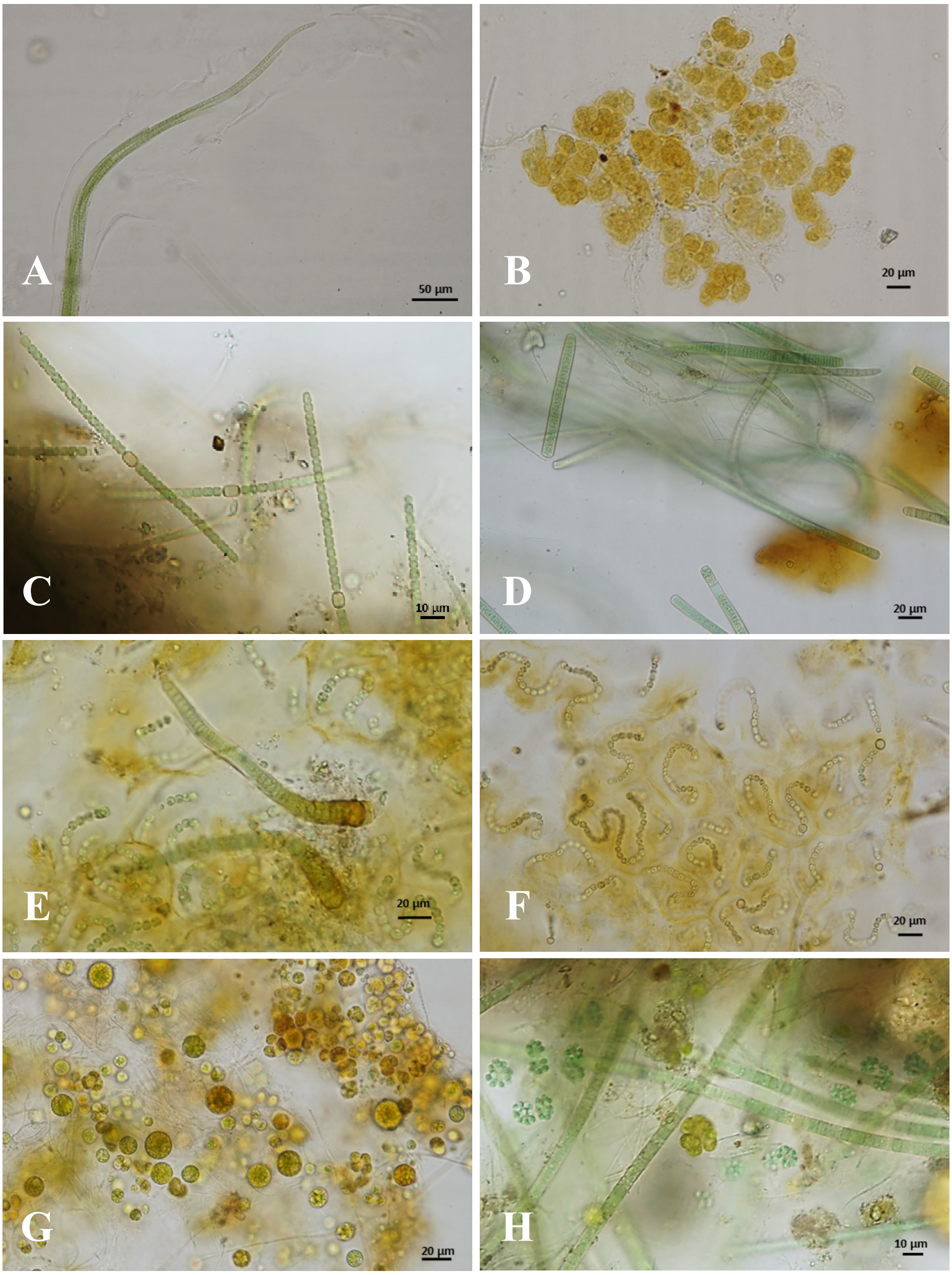

Fig. 3. Cyanobacteria and algae of James Ross Island - Solorina Valley. A – *Microcoleus* sp. (morphotype 1) from sampling site No. 1, B – initial stage of *Nostoc* sp. (site No. 1), C – *Hydrocoryne quesadae* (site No. 2), D – *Oscillatoriales* (site No. 3), E – *Calothrix* sp. (site No. 3), F – *Nostoc* sp. (site No. 3), G – *Eustigmatophyceae* (site No. 4), H – *Coelomoron chroococcoideum* (site No. 5). Photos by K. Skácelová.

Our study represents a contribution to biodiversity of freshwater algae, cyanobacteria and diatoms on the James Ross Island. Within last few years, several sites have been sampled on the island and numerous taxa was determined (*see* e.g. Skácelová et al. 2013). In some selected species, photosynthetic parameters were studied under laboratory conditions in response to light, temperature (Barták et al. 2013), and osmotic stress (Vilumbrales et al. 2013). However, research on biodiversity is far from being completed because of tens to hundreds of sites that have never been sampled at deglaciated part of James Ross Island.

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