Report on Czech research activities
in Petuniabukta, Billefjorden, Svalbard,
performed in summer season 2015

RESEARCH ACTIVITIES SVALBARD 2015

Centre for Polar Ecology
University of South Bohemia in České Budějovice
Czech Republic

The research is supported by the grant of Czech Ministry of Education (MSMT) LM2010009 CzechPolar - Czech polar stations: Construction and logistic expenses.

Cover photo: Jan Kavan
Editors: Jana Kvíderová

1. Introduction

2015 was last year of the Project CzechPolar - Czech polar station: Construction and operational costs. Planed activities a) construction of field camp in Petunia Bay and b) construction or research motor-sailor were finished.

Field camp Nostoc consists four wooden houses (kitchen, laboratory and accommodation, Figs. 1.1. and 1.2.). The houses are connected with tent where lecture room and dining room are located. Filed camp is protected against polar bear attack by electronic system. Electric generator and bathroom are part of this system.

Fig. 1.1. The aerial view of the field camp Nostoc in the Petuniabukta, Svalbard.

Fig. 1.2. The interior of the field camp Nostoc in the Petuniabukta, Svalbard.

Research motor-sailor Clione (Fig. 1.3.)

- length 14.9 m
- width 4.0 m
- draught 1.9 m
- height above water level 16.5 m
- engine VD-DTA 66, 215 HP
- sail area 115 m^2
- load displacement, arrival 23 t, max. 26 t

Fig. 1.3. The research sailor Clione during tests at Slapy reservoir, Czech Republic.

More about research sailor (http://polar.prf.jcu.cz).

Fig. 1.3. The research sailor Clione (continued).

This year, the research activities were performed at two distinct places. Traditionally, we worked in Petuniabukta in Russian hunting hut at its west coast and the containers located in Pyramiden port facility served for storage. The research was also performed in Longyearbyen area.

Martina Pichrtová, who defended successfully her doctoral theses at Charles University in Prague (CZ) in 2014 has obtained the price "Česká Hlava" (Czech Brain) as the best junior scientist in the Czech Republic for 2014.

We had the pleasure to welcome Lauri Laanisto and Indrek Lannisto from the Estonian University of Life Sciences, Tartu, Estonia, co-operating with Petr Macek on vegetation research, and Andreas Holzinger from the University of Innsbruck, Austria, who participated in algal stress physiology research. The house in Longyearbyen served as a base for our long-term friends and colleagues from the University Adam Mickiewicz, Poland.

Josef Elster as representative of the Czech Republic in International Arctic Science Committee have been elected as Vice Chair of Terrestrial Working Group.

For more information visit polar.prf.jcu.cz, please.

2. Season 2015 Research Programme

The field research started on June 17, 2015, and was completed on September 23, 2015. The list of expedition participants and their periods of stay is summarized in Tab. 2.1.

Tab. 2.1. List of expedition participants with their affiliations and their periods of stay.

		Affiliation(s)	Field of research	Dates
Klára Ambrožová	S	MU	CLIMA	01-15/07/2015
Jan Blahůt	R	USMH	GEO	02-04/09/2015 21-23/09/2015
Přemysl Bobek	S	UK	BOTA	17/07-03/08/2015
Adam Borczyk		UAM	GEO	28-29/08/2015 14-16/09/2015
Marek Brož	RS	JU	ZOO	17/07-17/08/2015
Michalal Bryndová	RS	JU	ZOO	17/07/-17/08/2015
Tereza Coufalová	S	MU	CLIMA	01-15/07/2015
Jiří Černý	R	PARU	ZOO	01-15/07/2015
Miloslav Devetter	IR	ISB + JU	ZOO	17-29/06/2015 17/07-03/08/2015
Oleg Ditrich	IR	JU	ZOO	01/07-30/08/2015
Josef Elster	IR	JU + IBOT	MICRO	07-27/08/2015
Zbyněk Engel	IR	UK	GEO	01-15/07/2015
Jan Fiala	S	JU	MICRO	16-30/08/2015
Roman Gogolka	C	Archeva, spol. s r. o.		31/07-02/09/2015
Tomáš Hájek	IR	JU + IBOT	BOTA	17/07-03/08/2015
Klára Hajšmanová	R	JU	MICRO	31/07-30/08/2015
Martin Hanáček	IR	JU	GEO	01/07-17/08/2015
Filip Hartvich	R	USMH	GEO	02-04/09/2015 21-23/09/2015
Eva Hejduková	S	UK	HYDRO	16-30/08/2015
Andreas Holzinger	R	INU	MICRO	01-15/08/2015
Tereza Hromádková	R	UK + JU	ZOO	01-15/07/2015
Petra Hubová	R	CZU	BOTA	17-29/07/2015
Miloš Jahoda	C	JU		19/06-01/07/2015
Tomáš Jedlička	R	UHK	MICRO	16-30/08/2015
Jan Kavan	IR	MU + JU	HYDRO	03/07-09/09/2015
Kateřina Kopalová	IR	UK + IBOT	HYDRO	16-30/08/2015
Lidia Kozak	R	UAM	GEO	1-3/07/2015 30/07-01/08/2015
Tomasz Kurczaba	R	UAM	GEO	1-3/07/2015 12-13/09/2015
Jana Kvíderová	IR	IBOT + JU	MICRO	16-30/08/2015
Lauri Laanisto	R	ESTU	BOTA	31/07-07/08/2015
Indrek Laanisto	R	ESTU	BOTA	31/07-07/08/2015
Marek Lahoda	S	MU	CLIMA	01-15/07/2015
Veronika Langová	RS	JU	BOTA	17/07-17/08/2015
Kamil Láska	IR	MU	CLIMA	01-15/07/2015
Jiří Lehejček	R	CZU	BOTA	17/07-03/08/2015
Martin Lulák	RS	UK	MICRO	01/07/-09/09/2015
Petr Macek	IR	JU	BOTA	17/07-17/08/2015
Anna Mácová	SR	JU	ZOO	17/07/-17/08/2015
Jakub Małecki	R	UAM	GEO	28-29/08/2015 14-20/09/2015
Antonín Mikulka	C	Archeva, spol. s r. o.		31/07-02/09/2015
Eva Myšková	R	JU + PARU	ZOO	01/07-03/08/2015

Slavomír Nehyba	R	MU	CLIMA	01-18/07/2015
Przemysław Niedzielski	R	UAM	GEO	1-3/07/2015 30/07-01/08/2015
Daniel Nývlt	R	UK + MU	GEO	16-30/08/2015
Lenka Ondráčková	S	MU	HYDRO	16-30/08/2015
Jakub Ondruch	R	MU	GEO	25/06-10/09/2015
Daniel Paul	C	Archeva, spol. s r. o.		31/07-02/092015
Václav Pavel	IR	UPOL	ZOO	26/06-15/07/2015
Jan Petřík	S	MU	GEO	01-15/07/2015
Martina Pichrtová	R	UK	MICRO	01-15/08/2015
Vladimír Pískala	S	UK	CLIMA	01-15/07/2015
Petra Polická	R	JU	GEO	01/07-19/09/2015
Barbora Procházková	S	UK	GEO	01-15/07/2015
Grzegorz Rachlewicz	R	UAM	GEO	14-16/09/2015
Matěj Roman	S	UK	HYDRO	16-30/08/2015
Krzysztof Rymer	R	UAM	GEO	01-03/07/2015 30/07-01/08/2015 2-4/09/2015 14-20/09/2015
Michal Růžek	S	UK	MICRO	16-30/08/2015
Liliana Siekacz	R	UAM	GEO	14-20/09/2015
Zdeněk Stachoň	R	MU	GEO	01-15/07/2015
Lukáš Staněk	C	JU		19/06-01/07/2015
Josef Stemberk	R	USMH	GEO	02-04/09/2015 21-23/09/2015
Zdeněk Stachoň	R	MU	GEO	01-15/07/2015
Monika Stawska	R	AMU	GEO	16-20/09/2015
Jan Svrček	S	UK	MICRO	16-30/08/2015
Michaela Syrová	SR	JU	ZOO	02-25/08/2015
Václav Tejnický	R	CZU	BOTA	17-29/07/2015
Jiří Tomíček	S	UK	GEO	01-15/07/2015
Tomáš Tyml	IR	JU + MU	ZOO	01/07-09/09/2015
Pavel Váňa	C	Archeva, spol. s r. o.		31/07-02/09/2015
Ludmila Vlková	S	JU	ZOO	17/07-03/08/2015

Abbreviations:
Purpose of the stay: C – construction or management of the Svalbard infrastructure; I – instructor of the Polar Ecology course; R – research; S – student of the Polar Ecology course

Affiliations: CZU – Czech University of Life Sciences, Prague (CZ); ESTU – Estonian University of Life Sciences, Tartu (EE); IBOT – Institute of Botany CAS, Třeboň (CZ); INU – University of Innsbruck, Innsbruck (AT); ISB – Institute of Soil Biology, Biological Centre CAS, České Budějovice (CZ); JU – University of South Bohemia, České Budějovice (CZ); MU – Masaryk University, Brno (CZ); PARU – Institute of Parasitology, Biological Centre CAS, České Budějovice (CZ); UK – Charles University, Prague (CZ); UAM - University Adam Mickiewicz, Poznań (PL); UPOL – Palacký University, Olomouc (CZ); USMH - . Institute of Rock Structure and Mechanics CAS, Prague (CZ).

Field of research: BOTA - botany/plant physiology; CLIMA - climatology/glaciology; GEO - geology/geomorphology; HYDRO - hydrology/limnology; MICRO - microbiology/phycology; ZOO - zoology/parasitology.

3. Field work progress reports

3.1. Geology and Geomorphology

3.1.1. Initial soil development in the Nordenkiold glacier forefield, Svalbard: Physico-chemical and microbial trends in soil characteristics along deglaciated forelands with different bedrock

Petra Polická, Hana Šantrůčková & Martin Hanáček

Arctic ecosystems play a fundamental role in present frequently discussed global climate change. As a result of the climate change, glaciers in the Arctic, including Svalbard, are retreating at an accelerating rate. Rocks and minerals which are newly exposed to the surface conditions form a new habitat for microorganism that are fundamental for soil development, nutrient cycling and plant growth and provide possibility to examine an ecosystem evolution from a bare lifeless surface into a soil. The general trends of soil processes and plant succession after deglaciation are well documented mostly for Low Arctic and alpine glacier forelands. Nonetheless, an extrapolation of all the recorded initial process to the High Arctic environment seems to be problematic due to the extreme climatic conditions and isolation of these regions and thus many processes are still not well understood there.

The aim of the study is to investigate the rate of soil development in the first stages after deglaciation (100 years) in the presence of two chronosequences in Nordenskiold glacier forefield (Svalbard, High Arctic) with different bedrock mineral composition – one with predominantly siliceous rocks and one with a higher portion of calcium. Within these chronosequences the rate of changes in microbial community structure and in biotic properties of the initial soils will be examined. The main hypothesis is that the microorganisms prosper more in soils developing on the bedrock providing nutrients which are limited in the poor environment of the High Arctic. We assume, that with increasing age of soil, the effect of bedrock mineralogy will decrease and effect of organic matter will increase. Therefore, the similarity of soil development between two chronosequences on different bedrocks is gradually increasing.

To investigate our hypothesis, we collected soil samples from five zones with different age of deglaciation (0-25 yr, 25-44 yr, 45-79 yr, 79-107 yr, >107 yr) in the northern and southern forefield of the Nordenskiold glacier (Fig 3.2.1.). Dried soil samples were taken for analyses of mineralogical content, pH, cation exchange capacity, organic matter, total CNS content and potential respiration. Fresh samples were directly analyzed in Petunia for available nitrates, nitrites, and ammonium as well as for water extractable phosphorus. Samples for DNA analysis and enzyme activity were stabilized and together with acidified water extract for DOC and DON were sent to the labs of the Department of Ecosystems Biology. The rest of the fresh samples were used for microbial biomass determination.

Fig 3.1.1. The youngest zone of deglaciation (0-25 years), sampling site.

3.2. Climatology and Glaciology

3.2.1. Meteorology and climatology

Kamil Láska

The meteorological measurements and observations were performed in the coastal ice-free zone of Petuniabukta, northern branch of Billefjorden in July–August 2015. Eight automatic weather stations (hereafter AWS) have been operated along the western and northwestern coast of Petuniabukta (Fig. 3.2.1.) in the following locations:

- AWS1 – old marine terrace at the altitude of 15 m a. s. l. (operated since 2008)
- AWS2 – old marine terrace at 25 m a. s. l. (since 2008)
- AWS3 – foreland of Hørbyebreen at 67 m a. s. l (since 2008)
- AWS4 – mountain ridge of Mumien Peak at 475 m a. s. l. (since 2008)
- AWS5 – top of Mumien Peak at 770 m a. s. l. (since July 2013)
- AWS6 – top of Pyramiden Peak at 935 m a. s. l. (since 2009)
- AWS7 – Bertilbreen at 464 m a. s. l. (since 2011)
- AWS8 – Bertilbreen at 280 m a. s. l. (since 2014)

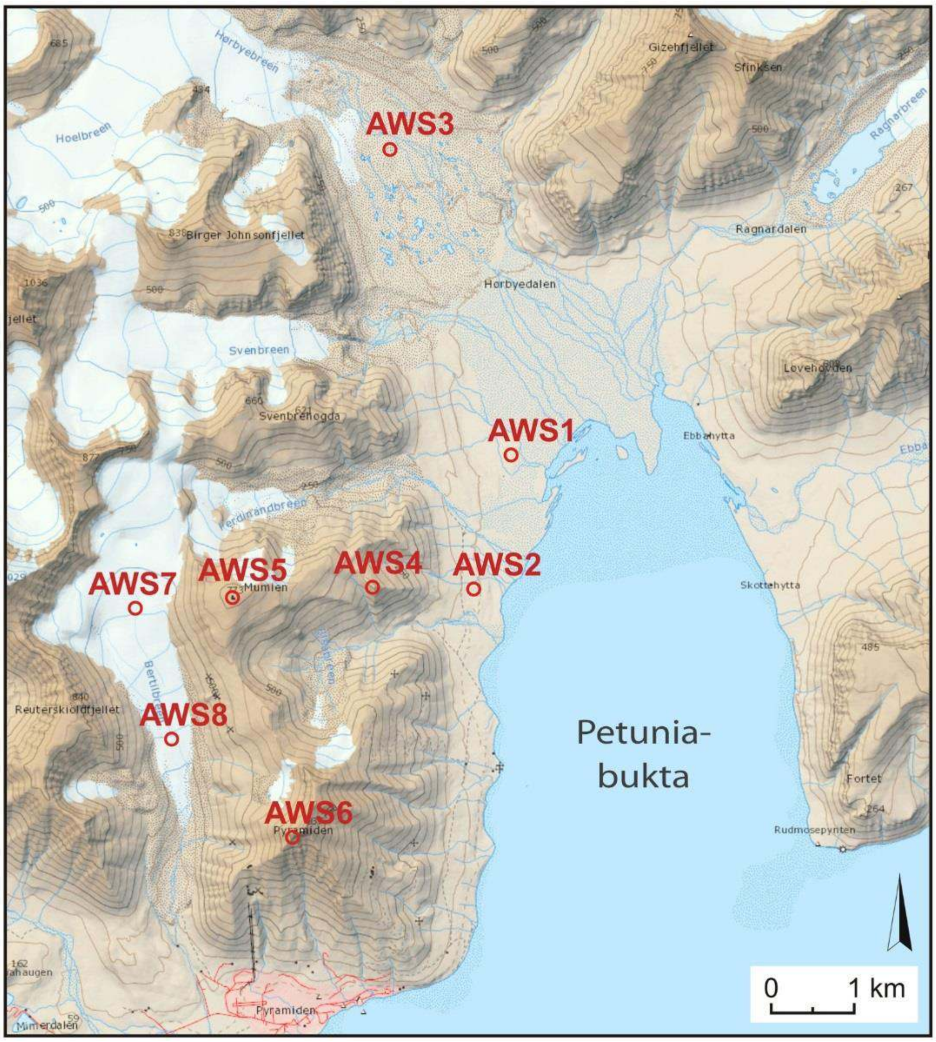

Fig. 3.2.1. Location of the automatic weather stations (AWS) in the vicinity of Petuniabukta (Billefjorden, central Spitsbergen) in July–August 2015. Credit: Svalbardkartet, Norwegian Polar Institute, 2015.

The main objectives of summer field campaign and research activities in Petuniabukta were:

- Observation of summer weather conditions and their evaluation in the context of large-scale atmospheric circulation over the Svalbard archipelago
- Microclimate monitoring of the tundra vegetation
- Investigation of glaciers and their spatial changes

In the study period, the atmospheric circulation and pressure pattern changed several times. From July 1 to 4, 2015, a cyclone centered to the northeast of Svalbard archipelago caused prevailing western to northwestern wind. At this time, the cloud types of *cirrus fibratus*, *altocumulus lenticularis*, *stratocumulus* and *stratus fractus* were observed in Petuniabukta area (Fig. 3.2.2.). In the period of July 5 to 7, Svalbard was under the influence of a low pressure trough situated southeastward from the archipelago. The clear sky and partly cloudy weather prevailed over the study area with occasional drizzle and wind gusts. Afterwards (July 8–13, 2015), an anticyclone was moving from northeast to southwest across the Svalbard archipelago. Very good visibility (more than 40 kilometers) with mostly high-level (*cirrus*, *cirrostratus*) and mid-level clouds (*altocumulus*) prevailed from July 8 to 10, 2015.

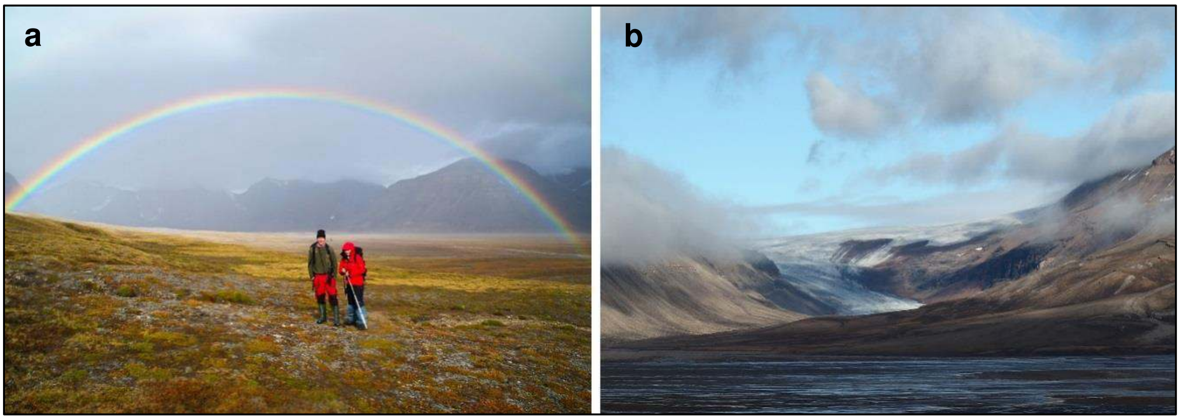

Fig. 3.2.2. (a) Primary and secondary rainbow on July 11, 2015 and **(b)** an example of low-level clouds of *stratus fractus* observed along the coast of Petuniabukta (photo Matěj Roman, Lenka Ondráčková).

They were, however, gradually substituted by a mist in the lowest 200 m of boundary layer, which later developed into a fog bank. In the last period (July 14–16, 2015), northeast cyclonic circulation resulted into prevailing overcast conditions with stratocumulus clouds. Changes in atmospheric circulation and local weather conditions were clearly seen in the variation of air temperature and surface wind speed measured at Petuniabukta (Fig. 3.2.3.). The mean daily air temperatures varied from 6 °C to 11 °C. On July 10 the daily maximum temperature reached 13.9 °C, while minimum temperature (2.9 °C) was observed on July 15.

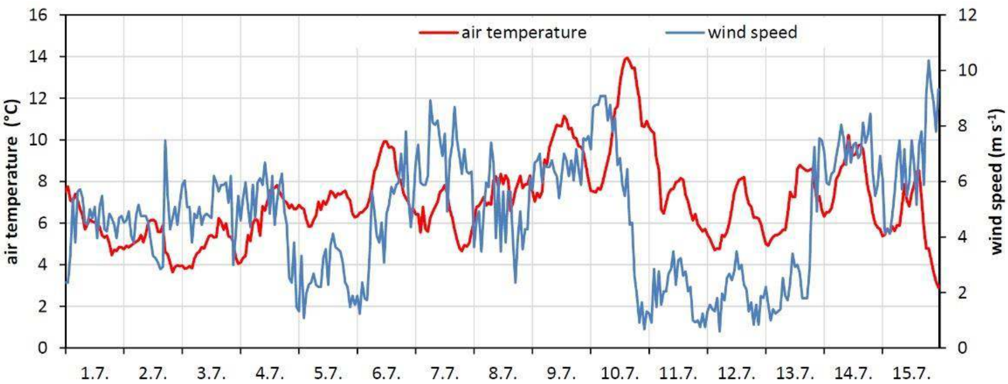

Fig. 3.2.3. Variation of air temperature and surface wind speed in the coastal zone of Petuniabukta from July 1 to 15, 2015.

Part of the fieldwork was devoted to studying of microclimatic conditions of tundra vegetation that was performed on the western coast of Petuniabukta. Measurements of radiation balance, surface temperature, and ground thermal and moisture conditions of the permafrost active layer were conducted in July-August 2015 and will be used to evaluate how vegetation cover influences the active layer thickness (Fig. 3.2.4.). The incoming global radiation data also served as an input into a GIS model which resulted into an initial map of insolation of Petuniabukta and its surroundings. The map will be further adjusted and recalculated in order to obtain accurate spatial data valid for all sky conditions and terrain complexity.

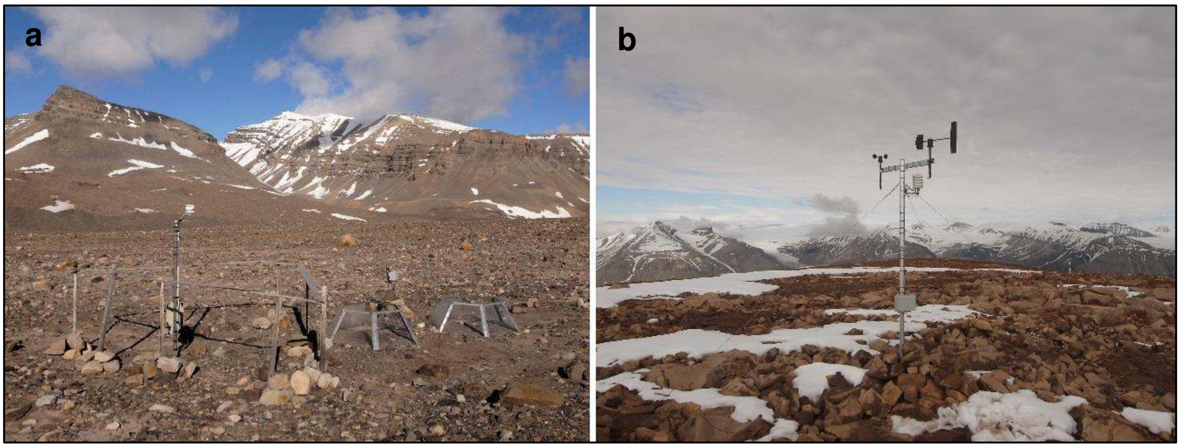

Fig. 3.2.4. (a) Automatic weather stations at the foreland of Hørbyebreen and **(b)** top of Mumien Peak (right) in the vicinity of Petuniabukta (photo Kamil Láska).

Glaciological survey was mainly focused on Bertilbreen and Ferdinandbreen glaciers. There were differential GNSS measurements of the glacier surface, as well as position and height measurements of ablation stakes installed in the previous years. Furthermore, ground penetrating radar (GPR) survey was conducted on Elsabreen and Nordenskiöldbreen during field campaign (Fig. 3.2.5.). The acquired data allow us to estimate areal and volumetric changes and thus monitoring these changes is an important task in the study of sensitivity of the glaciers to regional atmospheric warming.

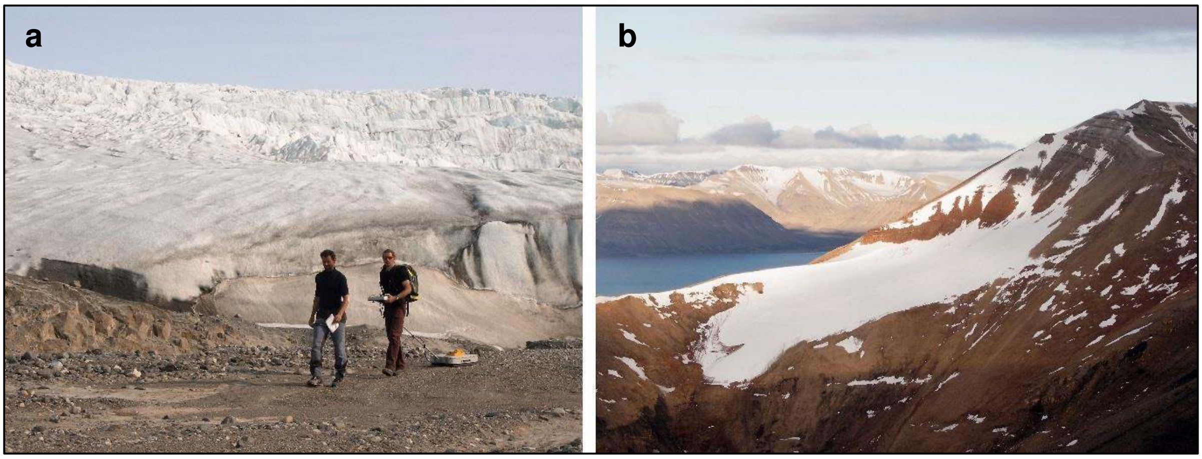

Fig. 3.2.5. Ground penetrating radar and geodetic measurements carried out **(a)** in the foreland of Nordenskiöldbreen and **(b)** Elsabreen glaciers, central Spitsbergen (photo Kamil Láska).

3.3. Hydrology and Limnology

3.3.1. Freshwater ecosystems monitoring in Billefjorden

Jan Kavan

Selected rivers and lakes were objects of a study as a part of a long-term project focused on monitoring both quantitative and qualitative parameters. Rivers with different glaciated proportion of their watershed were regularly monitored, also suspended and bedload sediments were sampled. Different methods of discharge measurement were tested – acoustic doppler current profiler, classical mechanical propeller and also using a tracer (fluorescent dye and salt; Fig. 3.3.1.). Network of dataloggers was maintained – both water level loggers and temperature loggers in lakes. Apart that, also biological samples were taken for further lab analyses and water samples for chemistry analyses were taken.

Snow monitoring system, that was running throughout the winter was maintained and records were downloaded and further processed. The same is true for the network of climatological stations located both in terrestrial and glacial environments, these were kept working during summer and prepared for overwintering.

Fig. 3.3.1. Discharge monitoring on Ferdinand using uranine dye tracer method.

3.4. Microbiology and Phycology

3.4.1. Paleoecology of diatom communities

Martin Lulák

Introduction: Diatoms are brown algae with unique cell walls made of silica (hydrated silicon dioxide) called a frustule. These frustules are exceptionally tough and are commonly preserved as fossils in fine marine and lake sediments. For the reason as the diatoms species are very sensitive to specific environment properties (e. g. water salinity, temperature, carrying capacity or sea ice concentrations), their fossil frustules are commonly used as indicators of paleoecologic conditions in a given area. The area of my field research lies in the High Arctic in the central part of Svalbard in Billefjorden fjord. In the last 110 000 years there were four major glacial periods in Svalbard which can be identified from sediments (the last one ended approx. 10 000 years ago). During these glacial periods the whole area of Billefjorden was covered by glaciers. Glaciers have huge mass and therefore they cause so-called glacial isostatic depression. After deglaciation the earth crust passes through the post-glacial rebound. This process caused an uplift of places which were situated locally even tens of meters below the sea level during the glacial period. Due to this process it is now possible to study sediments which were formed in marine conditions just after deglaciation.

Sites and on-field work: In sediments forming the uplifted marine terraces indicators of last four major glacial periods are preserved. Glacial periods are represented by extremely heterogeneous unsorted sediments, so-called tills. Just above these tills fine sediments are situated. These were formed right after the glacial period when the area was flooded by the rising sea and the earth crust had not yet responded through the post-glacial rebound. In various places in Billefjorden there are five main sites (Fig. 3.4.1.) correlated with those four major glacial periods which were identified by sedimentologists, including finegrained marine post-glacial sediments.

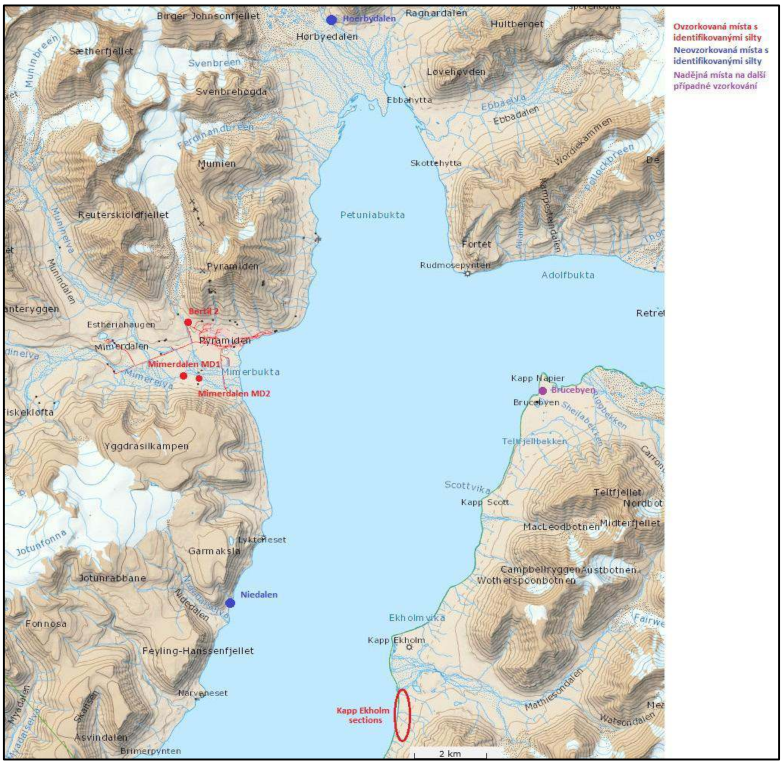

Fig. 3.4.1. Map of northern part of Billefjorden. In red are shown sites which were sampled (and are described and dated). In blue are sites which were not sampled (but they are described and dated) in it is planned to sample them in near future. In purple are sites which have the potential of future exploration (map was edited from toposvalbard.npolar.no).

Main focus was aimed to strata in Mimerdalen and Bertildalen near the Pyramiden town. These strata were not yet described and dated. Together with Martin Hanáček we worked whole summer on these old marine terraces in mainly in sedimentological and macropaleontolgical way (and the strata will be dated in near future). There were collected altogether five samples of silts, one on Bertil, three on MD1, one on MD2 (more in Fig. 3.4.1.). Bertil and Mimerdalen profiles contain record only from the Last Glacial Maximum before the beginning of the Holocene.

The most interesting area is formation of sections next to Kapp Ekholm (Fig. 3.4.2.) which lies near Mathiesondalen. There were identified by Mangerud and Svednsen (1992) altogether six sections with more or less complete strata from last four major glaciations. There we collected eight samples (Fig. 3.4.3.) from three sections. Samples contains all four beginnings of interglacials, some of them are moreover doubled.

Fig 3.4.2. Kapp Ekholm sections (I – VI). Samples are collected from sections II, IV and VI. Altogether eight samples from various horizons which represented different glacial-interglacial periods (courtesy of Martin Hanáček)

Another section with dated and described profiles is in Hoerbydalen (Fig. 3.4.1.). This site I would like to sample next year (there were no more time to do that this year). Moreover there is another interesting section near Brucebyen. It is not yet described and dated, but if there will be in the future more sedimentological work it can be sampled (if there will be silt part of the section).

Fig 3.4.3. Location of sample #8 in section VI (Holocene age, approx 9000 BP by Mangerud and Svendsen, 1992). The silt sample was collected cca 25 cm above tills just near the mollusk of *Mya truncata* in life position which indicates slow and calm marine sedimentological conditions right after glaciation.

Laboratory work: Laboratory processing begins in next month (November) and will be focused on determination and description of found frustules of diatoms. The method is not yet fully tested. It is a question of next few months.

Conclusion: By finding the paleoecology of the diatom communities from the fine-grained marine post-glacial sediments, the original sedimentological interpretation of the formation of marked sediments will be confirmed or completed. The outcome of this study will be complete knowledge of changes in the diatom biota during beginnings of the glacial periods in Billefjorden from the middle Pleistocene to the Early Holocene. This knowledge can provide yet unknown facts about evolution of climate and sedimentary conditions in area of central Svalbard through the Quaternary.

References:

Mangerud J., Svendsen J. I. (1992): The Last Interglacial-Glacial Period on Spitsbergen, Svalbard. Quaternary Science Reviews 11:633-664.

3.4.2. Research of distribution and life conditions of psychrophilic alga *Hydrurus foetidus* near Petuniabukta

Tomáš Jedlička

Fig. 3.4.4. Growth of *Hydrurus foetidus* in stream at Fortet.

Hydrurus foetidus is a genus of freshwater macrophyte belonging to Chrysophyceae, living in cold violent streams (Fig. 3.4.4.). Research was performed in the end of August 2015 in close vicinity of Czech Polar station in Petuniabukta. Field work was focused on two streams near Skansbukta and mountain Fortet. In both areas the *Hydrurus* was succesfully found. While in the stream at Fortet the alga was in great abundance creating over 20cm long hair-like threads, at Skansbukta *Hydrurus* was found mostly in its initial states as a brown slimy cover on rocks in the stream. That may have been caused by harsh weather conditions few days before visiting Skansbukta which caused the threads to be torn of the stones. At second visit of Fortet stream, abundance of *Hydrurus* was also much lower. It is possible that disturbance in form of harsh weather and debris movement limits the alga in growing into greater forms. Brief examination was also perfomed on a river Bjørndalen near Longyearbyen airport, where *Hydrurus* was also found in its hair-like form.

In all of the localities, measurements of water temperature were performed and samples of water taken as well. Those samples were subsequently measured for conductivity and pH and taken for laboratory analysis of nutrients. Also on the beginning and the end of Fortet stream were placed temperature dataloggers bound to two tall sticks, presumably to be found in winter conditions to examine how Hydrurus survives under snow (Fig. 3.4.5.).

Fig. 3.4.5. Placing a stick at the end of stream at Fortet to mark position of datalogger.

3.4.3. Diversity and ecology of Zygnema sp. and Zygnemopsis sp. populations

Martina Pichrtová & Andreas Holzinger

We spend two weeks on Svalbard in summer 2015. The main aim of our stay was to study diversity and ecology of *Zygnema* sp. and *Zygnemopsis* sp. populations around Billefjorden and within a day walk from Longyearbyen. Altogether, we sampled at 30 sites. Sexual reproduction and formation of zygopsores was observed only in one sample (Fig. 3.4.6.), which enabled us to determine the species according to the traditional morphological species concept. We determined it as *Zygnemopsis lamellata*. All cultures are now under investigations - we study their DNA sequence, morphology of chloroplasts and ecophysiological performance. These data will provide an insight into hidden diversity of this group in the Arctic, which is still unknown.

Fig. 3.4.6. Sexual reproduction and formation of zygopsores.

The other main aim of our field study was to collect biomass in different physiological state for further laboratory analyses. We selected two populations that were only few meters far away from each other and that produced high amounts of biomass. However, they differed strongly in cellular morphology and physiology (Fig. 3.4.7.). One of them consisted of typical vegetative cells while the other one contained mostly akinetes (mature cells with thick cell wall and accumulated lipids). Samples of both populations were frozen in liquid nitrogen and transported back for future metabolomic and transcriptomic analyses. This will help us to understand changes that the cells undergo during formation of akinetes that are important for survival of extreme Arctic conditions.

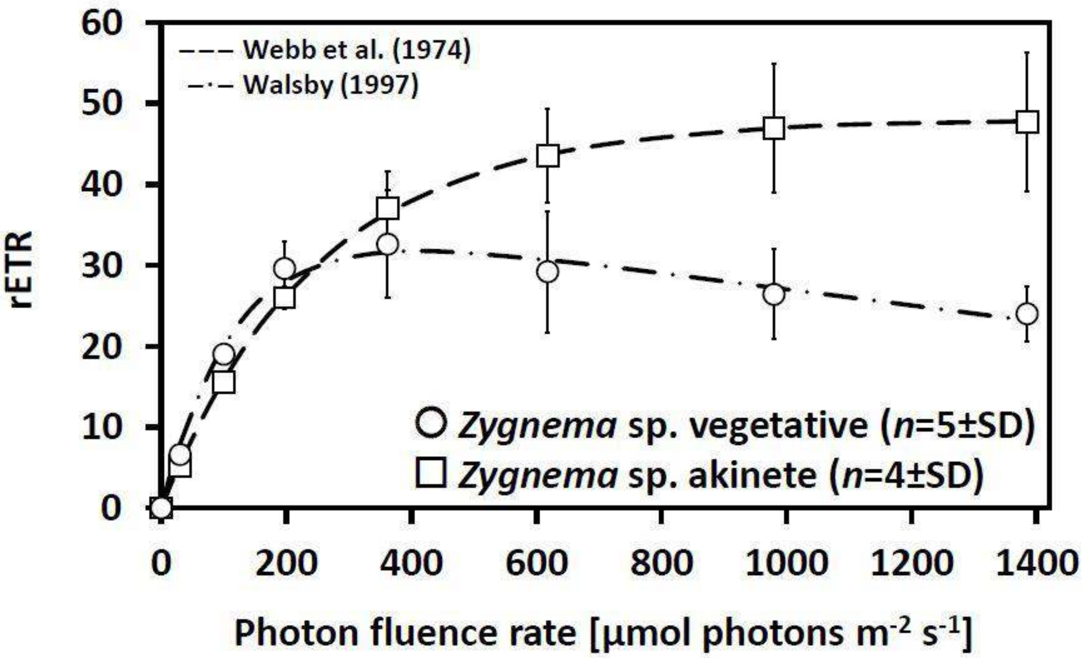

Fig. 3.4.7. The photosynthesis-irradiance curves of *Zygnema* sp. vegetative cells and akinetes.

3.4.4. Assessment of 3D structure of the *Nostoc* sp. colonies

Jana Kvíderová

Cyanobacterium *Nostoc* sp. is a significant primary producer in Svalbard where it provides important C and N inputs into the Arctic ecosystem. Physiological measurements proved that there are no physiological differences between the upper exposed surface and the lower shaded one, although the microclimatic conditions at each surface are different. The upper surface (i.e. air-colony interface) is exposed to more intense irradiation (VIS and UV) and drier conditions than the lower one (colony-soil interface). Since the thickness of the *Nostoc* sp. colonies may reach even 1 mm, it is possible that the inner structure (filament density, amount of extracellular matrix etc.) of both surface layers may differ.

Fig 3.4.8. 3D structure of the *Nostoc* sp. colonies obtained from microphotograph sequence.

In this study, the possibility of the observation of the 3D structure of the *Nostoc* sp. colonies was performed using light microscope microphotograph sequence in Petuniabukta, Svalbard. The images were processed using Fiji (ImageJ) image analysis software.

Despite of lower contrast between the cells and extracellular matrix, the microphotograph sequence was found useful to reveal the inner structure of the *Nostoc* sp. colony (Fig. 3.4.8.). The 3D imaging also revealed heterogeneity in the vertical profile of the *Nostoc* sp. colonies. The exposed surface is characterized by higher density of the filaments than the shaded one (Fig. 3.4.9.). The higher number of cells at the exposed surface may improve photon absorption the in low-light conditions and may participate in protection to excessive irradiance in the high-light ones.

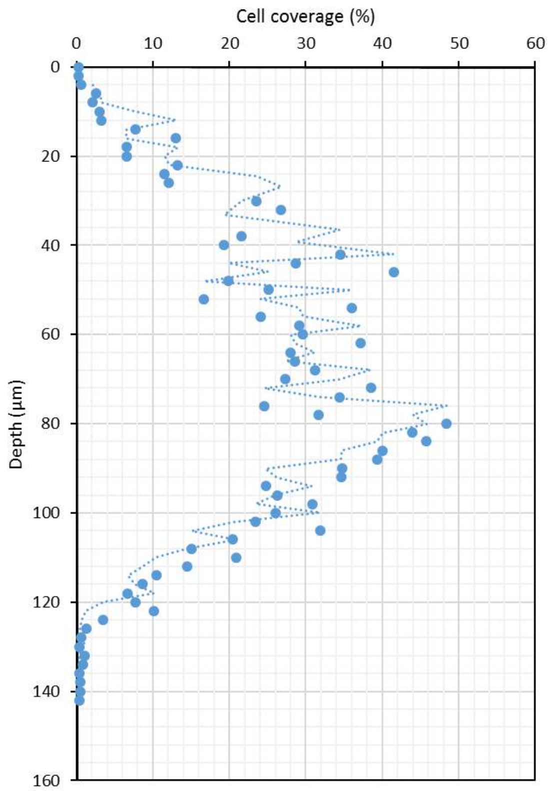

Fig 3.4.9. The vertical profile of the *Nostoc* sp. colony.

3.5. Botany and Plant Physiology

3.5.1. Plant ecology

Petr Macek, Veronika Langová & Lauri Laanisto

We focused on a project related to our long-term study at Svalbard, and we also participated on two international studies, one led by scientists from Norwegian Polar Institute and University of Tromsø, and the second one by scientists from Estonian University of Life Sciences, Tartu:

- How microclimate and herbivory affect plant-plant interactions in communities associated to cushion plant *Silene acaulis*: manipulative experiments.
- Herbivore densities in central Spitsbergen.
- A comparison of species ecology along a geographical gradient. Following is a brief description of each of the projects.

How microclimate and herbivory affect plant-plant interactions in communities associated to cushion plant Silene acaulis: experiment establishment

Plant-plant interactions between neighbouring species can range from negative (competition) to positive (facilitation) (Pugnaire & Luque 2001). Positive interactions are expected to increase with increasing environmental harshness (Michalet et al. 2006). Among plants known to facilitate significantly, cushion plants harbor diverse plant communities often of different species assembly as compared to the surrounding environment (Schöb et al. 2013). While in the alpine systems, cushion plants were frequently reported to provide benefits for other species, according to our previous measurements it does not seem to be true in harsh arctic environment (Fig. 3.5.1.).

Fig. 3.5.1. Cushions of *Silene acaulis*, **(a)** from the Alpine zone in Scandes, and **(b)** Arctic at Svalbard, host contrasting communities of subsidiary plants.

Whether this pattern holds under rapidly changing arctic environment remains to be tested. We therefore established a manipulative experiment with two factors, i.e. increase of temperature and preventing of herbivory. Using open-top chambers and herbivore exclusions we investigate how climate change influences the plant–plant interactions and how herbivore pressure interacts with this change. We further started investigating the effect of both treatments on plant traits in both, cushion (*Silene acaulis*) and subsidiary species. The two locations were river terrace close to Pyramiden and marine terraces at the end of Petuniabukta (Fig. 3.5.2.).

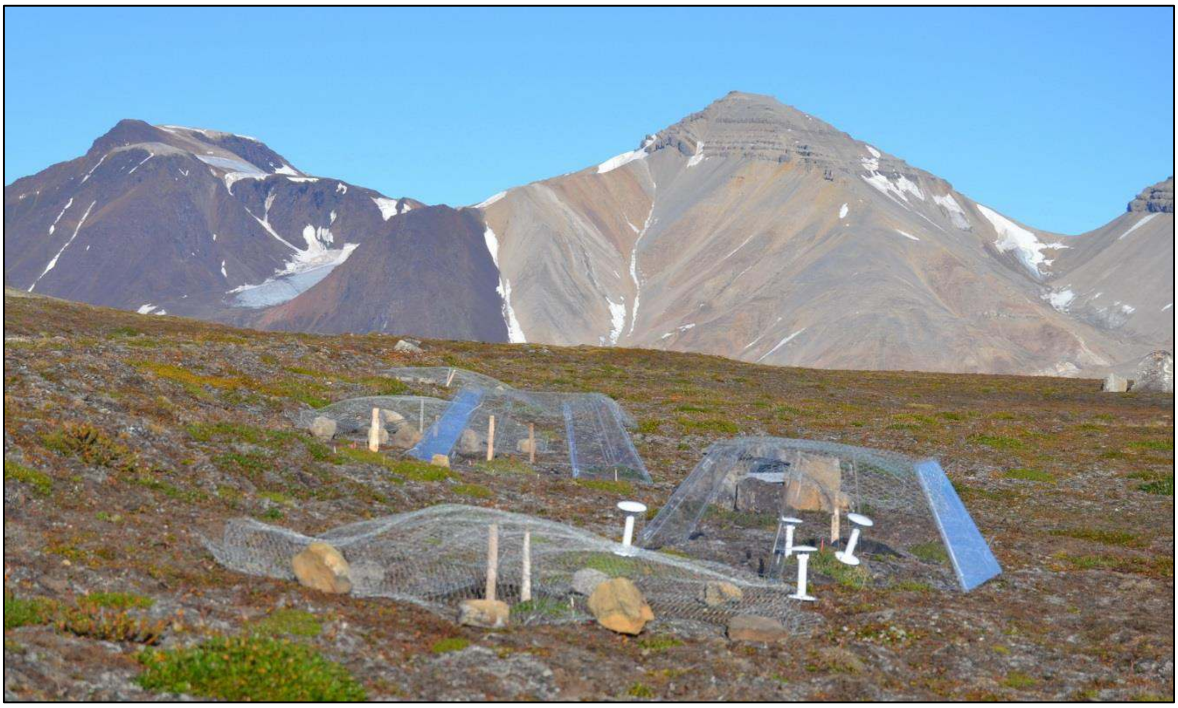

Fig. 3.5.2. A part of experimental plot in Petuniabukta, Svalbard, with open top chambers and herbivore exclusions.

Herbivore densities in central Spitsbergen: Common currency for "herbivore load" in tundra – a methodological study (Herbivory network, unpublished)

There are many existing field methods for quantification of herbivore load in tundra, using herbivore- and region-specific protocols. For obtaining common currencies that allow comparisons between tundra regions and sites within regions, methods need to be compared. A general protocol for vertebrate herbivore abundance is planned for within the Herbivory Network. The protocol is intended to serve as a tool in obtaining an estimate of herbivore abundance comparable between tundra areas and research and monitoring sites. The final protocol should give an area-representative estimate of herbivore abundance, independent of site-specific habitat classifications. As a step towards such a general protocol, we conduct this method study. The aim is to see how a general, area-representative herbivore load can be effectively assessed in tundra landscapes. Besides, the sampling will reveal the current herbivore load in different locations throughout Svalbard. (Fig. 3.5.3.).

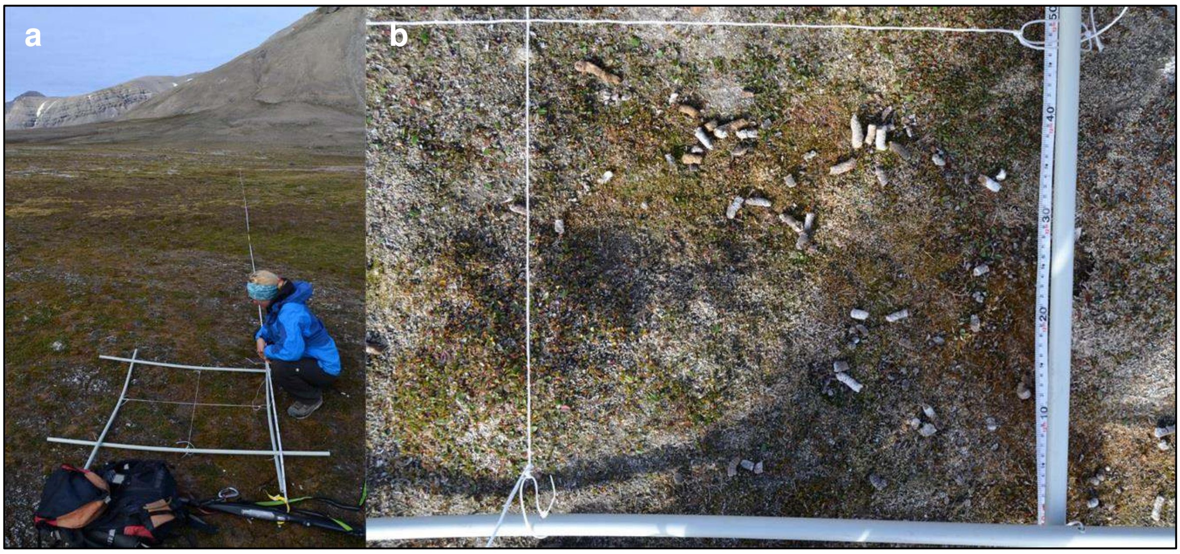

Fig. 3.5.3. A transect **(a)** counting of herbivore pellets at different scales, and **(b)** counting of geese droppings in tundra.

This study compares some of the most commonly used non-removal pellet count methods and other estimates of herbivore abundance (distance sampling or total counts, official statistics, or pellet removal plots). The study takes place in a set of tundra regions that include replicates within landscapes, and where we have existing information about herbivore abundance.

A comparison of species ecology along a geographical gradient

There are several species that are distributed both in Estonia and Svalbard. Mostly, these species are in their northern distribution border in Svalbard and in their southern distribution border in Estonia (Laanisto et al., unpublished). Some are common in Svalbard and rare in Estonia, or vice versa, or common or rare in both places. We aimed to compare the ecology and genetics of these species in their distribution borders.

References:

Laanisto, L., Melts, I., Lanno, K., Hutchings, M.J., Macek, P., Kull, T. Plant species persistence in range margins: there´s hardly room on the edge for margin of error. (Unpublished).

Michalet, R., Brooker, R.W., Cavieres, L.A., Kikvidze, Z., Lortie, C.J., Pugnaire, F.I., Valiente-Banuet, A. & Callaway, R.M. (2006) Do biotic interactions shape both sides of the humped-back model of species richness in plant communities? Ecology Letters 9, 767–773.

Pugnaire, F.I. & Luque, M.T. (2001) Changes in plant interactions along a gradient of environmental stress. Oikos 93, 42–49.

Schöb, C., Armas, C., Guler, M., Prieto, I. & Pugnaire, F.I. (2013) Variability in functional traits mediates plant interactions along stress gradients. Journal of Ecology 101, 753–762.,

3.5.2. Exudation of low molecular mass organic acids by arctic willow (Salix polaris) in different tundra habitats

Václav Tejnecký, Petra Hubová, Jiří Lehejček, Petra Polická, Tomáš Hájek, Filip Mercl & Ondřej Drábek

The exudation of low molecular mass organic acids (LMMOA) represents a strategy of plants for releasing nutrition and risk elements detoxification. Exudates are also sources of carbon and energy for microorganisms. The aim of this contribution is to evaluate LMMOA speciation in exudates of arctic willow (*Salix polaris*) growing in different habitats of high-arctic tundra in Petuniabukta (Billefjorden, Svalbard).

Willow plants were sampled on 4 localities with different vegetation covers (almost bare glacier forefield 25–69 years after deglaciation, partly vegetated (30%) tundra, fully vegetated dry tundra, and wet hummock-tundra). Five willow plants with roots and surrounding soil were collected on each locality. Plants were carefully removed from the soil and washed by deionised water. The exudation was carried out in deionised water for 2 h. Analysis of LMMOA and inorganic anions were done by ion chromatography. We also collected 5 individuals of *Salix polaris* (Fig. 3.5.4.) at each site for serial sectioning and consequently for dendrochronological dating. In glacier forefield the individuals were additionally collected with increasing distance from the glacier in order to support the results of chronosequence research (see section Polická et al.). Preliminary results show increasing age of the plants with the distance from the glacier. This clearly indicates we sampled the first generation of the population which is important finding for the plant soil interaction further used for chronosequence interpretation.

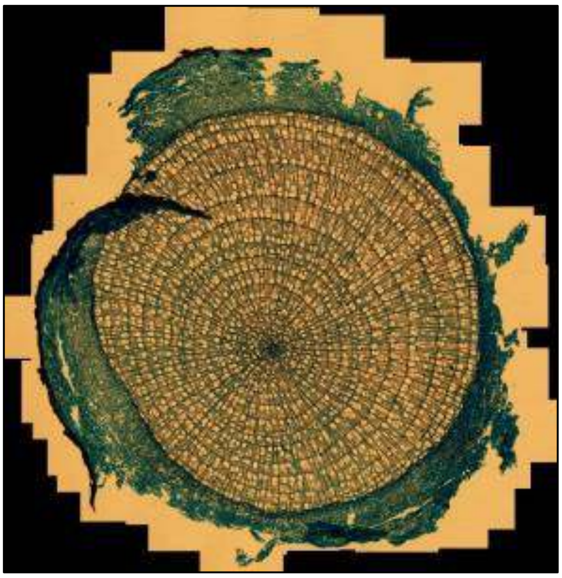

Fig. 3.5.4. Wood anatomy of *Salix polaris* from Nordenskiöldbreen forefield, Adolfbukta, Svalbard.

The most abundant species in willow exudates were lactate, acetate, formate, malate and citrate. Lower amount of pyruvate, quinate and oxalate were also determined (Fig. 3.5.5.). Nevertheless, there was a trend showing lower amount of totally exuded LMMOA under partly vegetated tundra in comparison to other stands. Moreover, there were significant differences between certain LMMOA species (e.g. lactate, formate and malate) between habitats. These differences could reflect the influence of habitat on exudation rate and exudate composition (e.g. increased lactate content under wet hummock-tundra reflects anoxic condition of stand). Expressed on carbon basis, the sum of exuded LMMOA tended to be lower in partly vegetated tundra (170 nmol C g^{-1} plant dry mass h^{-1}) in comparison to other habitats (291, 303 and 346 nmol C g^{-1} h^{-1} in glacier forefield, fully vegetated dry tundra and wet hummock-tundra, respectively). The study of plants exudation in arctic region is important for assessment of the vegetation influence on initial soil development.

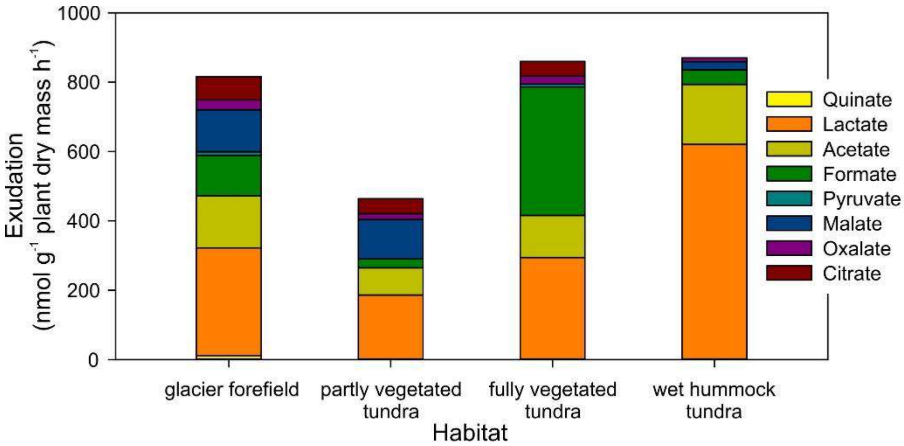

Fig. 3.5.5. Mean amount of LMMOA (nmol g^{-1} plant dry mass h^{-1}) exudates in different habitats.

3.6. Zoology and Parasitology

3.6.1. Ornithology

Václav Pavel & Tereza Hromádková

Breeding success of the Arctic tern (*Sterna paradisaea*) was monitored in the colony on the deglaciated island in front of Nordenskiöldbreen. We marked 87 nests and recorded survival of the nest during six days. In the colony we trapped 20 individuals of Artic terns and measured their body conditions (weight; length of wing, tail, tarsus, bill and distance between head and bill; high of bill by nostrils; Fig. 3.6.1.) and took samples with blood. Blood samples will be tested on parasites and stored for phylogeny analyses. All obtained data will be used in long-term study of life strategies of the Arctic tern.

Fig. 3.6.1. Measurement of body condition of the Arctic tern.

3.6.2. Parasitology

Oleg Ditrich & Tomáš Tyml

The main topic was devoted to studying of fish and marine invertebrates parasites. Apart from collecting and processing of all revealed parasites, we have concentrated on more detailed elucidation of life cycles of some, previously identified parasites.

<u>Number of dissected invertebrates</u>

Buccinum sp.	43 ex.
Buccinum glaciale	37 ex.
Circeis spirillum	30 ex.
Buccinum undatum	12 ex.

Buccinum polare	3 ex.
Mya truncata	3 ex.
Chlamys islandica	2 ex.
Colus kroyeri	2 ex.
Lunatia pallida	2 ex.
Buccinum truncatum	1 ex.
Mytilus edulis	1 ex.
Serripes groenlandicus	1 ex.

The record of *Mytilus edulis* in Petuniabukta is additional proof of the progressive comeback of this bivalve to the seashore of Svalbard.

Number of dissected fish

Amblyraja radiata	44 ex.
Gadus morhua	14 ex.
Hippoglossoides platessoides	14 ex.
Melanogrammus aeglefinus	13 ex.
Myoxocephalus scorpius	5 ex.
Gymnocanthus tricuspis	4 ex.
Anarhichas minor	1 ex.
Clupea harengus	1 ex
Polachius virens	1 ex.

Special attention has been paid to the parasites of Thorny Skate *Amblyraja radiata.* In their blood, *Haemogregarina delagei* was recorded in high prevalence, while in their gall blader myxosporeans of the genus *Chloromyxum* were present (Fig. 3.6.2.).

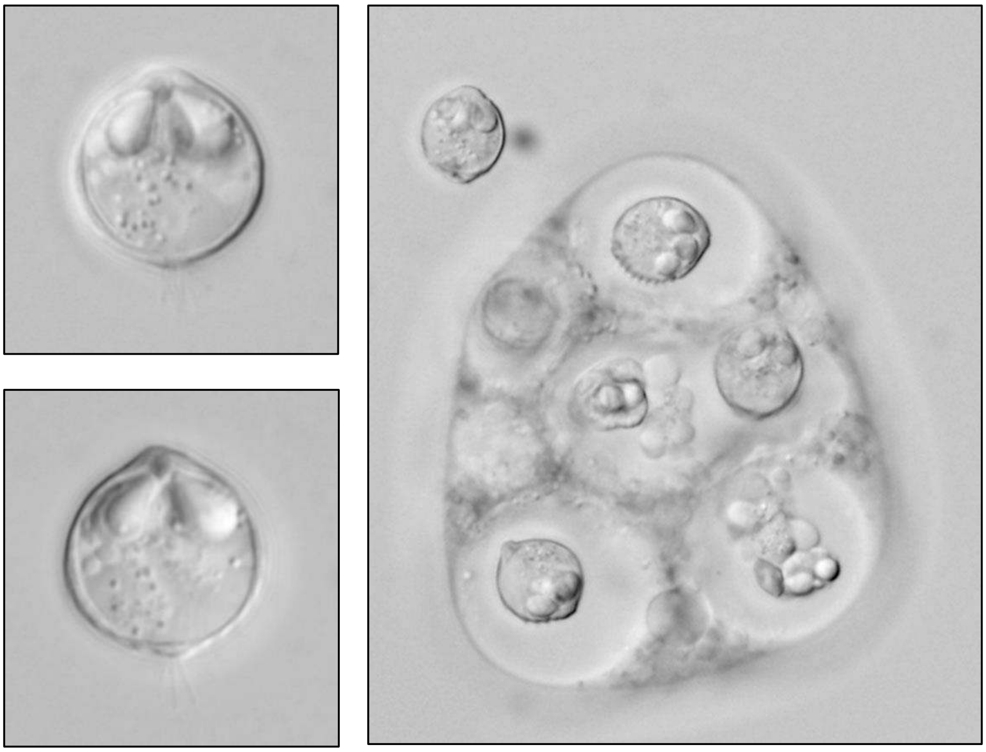

Fig. 3.6.2. *Chloromyxum* sp. from gall bladder of Thorny Skate (*Amblyraja radiata*).

Parasitological examination of terrestrial mammals has been focused to Arctic Fox (*Vulpes lagopus*) and Sibling Vole (*Microtus levis*). Samples of Polar Fox feces were collected mainly in the area of Petuniabukta in the central part of Svalbard (10 samples). Another samples (40 samples) were obtained in collaboration with Eva Fuglei from Norwegian Polar Institute. For analyses are used both microscopic and molecular methods focusing on the latter. The preliminary result indicate the presence of several intestinal parasites. For now the several different oocysts of coccidia and eggs of roundworm *Toxascaris leonina* were found. No finding of tapeworm *Echinococcus multilocularis* has been recorded yet.

Sibling voles were captured in the vicinity of dog yards and islandic horses stable (Fig. 3.6.3.). Till now, 52 Sibling Voles have been dissected and examined. In comparison with voles in continent, extremely low number of parasites was recorded. This fact is very probably a consequence of population bottleneck during vole introduction. For now intestinal *Cryptosporidium* (new, so far undescribed genotype) has been recorded in one specimen. No finding of *E. multilocularis* cysts has been recorded yet as well.

Fig. 3.6.3. Sibling Vole trapping.

3.6.3. Infection biology (Virology)

Jiří Černý

In 2015 we continued in collecting of samples for influenza virus screens. We collected oropharyngeal and cloacal swabs from blacklegged kittiwakes (*Rissa tridactyla*) and droppings from kittiwakes and barnacle geese (*Branta leucopsis*), Pink-footed geese (*Anser brachyrhynchus*), and common eiders (*Somateria mollissima*). We also continued in collection of mosquito samples for arbovirus focused screen in 2015. During this season we were able to collect over 3000 individuals from northern Billefjorden as well as from Adventsdalen which should be sufficient number for statistically meaningful epidemiological study. We also focused on characterization of meteorological conditions during which the mosquitoes attack people. Preliminary results show that local wind speed and precipitation occurrence but not temperature are driving factors for mosquito activity.

Laboratory analyses of blood samples collected in 2014 confirmed presence of anti-influenza antibodies in blood samples or kittiwakes on Svalbard. It means that these birds were infected by influenza virus but it does not say if it happened on their wintering sites or on Svalbard. No blood samples from 2015 were analyzed as we did not collect them this year. Preliminary results of PCR analyses of blood and swab samples from 2014 and 2015 showed some promising candidates which can show that influenza virus circulates also on Svalbard but these results have to be confirmed.

No arboviruses were detected in mosquito samples from 2014. Samples from 2015 have been analyzed just for Flaviviruses jet and all samples were also negative. These results indicate that Svalbard is most probably free for screened arboviruses now.

In 2016 we would like to continue in collection of samples suitable for influenza virus and arbovirus screens. Moreover, we would like to collect samples from domestic dogs which are kept on Svalbard in large packs for mushing and screen them for presence of canine viruses (canine parvovirus 2, distemper virus etc.) which appearance on Svalbard could pose an important veterinary threat to dog keepers and which spread could cause serious economical loses in local tourist industry.

3.6.4. Hydrobiology

Miloslav Devetter

In 2015, we have studied seasonal development of two different arctic lakes in the vicinity of Pyramiden and Petunia Bay. Deep arctic lakes have been studied in contrast to very shallow permanent ponds from the plankton development point of view and the effect of top-down regulation on each trophic level. Seasonal development of chemical characteristics (Fig. 3.6.4.). of the water, phytoplankton, zooplankton and *Lepidurus arcticus* as top predator was analyzed. Samples (Fig. 3.6.5.) for comparison of populations using molecular analysis of microsatelites were taken. However, phosphorus in deep lake did not strongly changed through the season, in shallow under

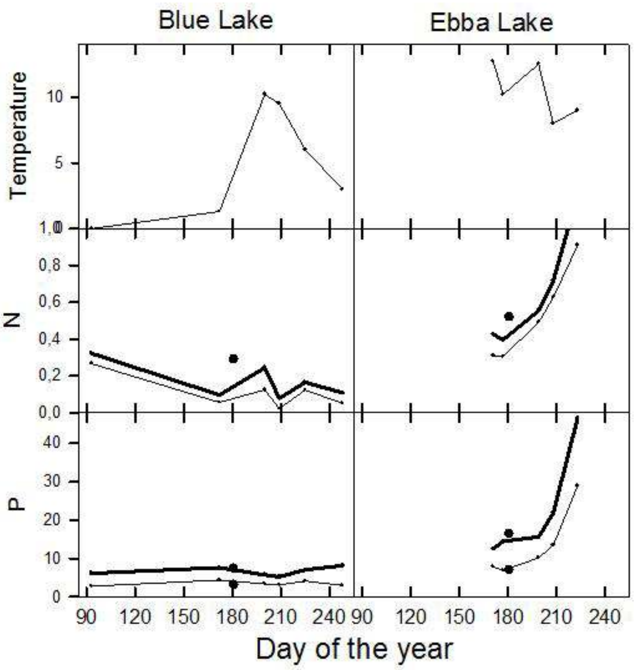

Fig. 3.6.4. Seasonal changes of temperature, nitrogen and phosphorus in two contrasting lakes (deep left and shallow right. Strong line is total, thin means dissolved.

strong grazing pressure it increases drastically.

Fig. 3.6.5. Collection of zooplankton samples on Blue Lake.