Report on Field Activities of the Czech Research Group in the Central Part of the Svalbard Archipelago (Isfjorden, Billefjorden, Petuniabukta) During the Summer 2009

Research was conducted under the auspices of the "Biological and climate diversity of the central part of the Svalbard Arctic archipelago" project sponsored by the Ministry of Education, Youth & Sport of the Czech Republic, INGO - LA 341 (2007 - 2010). It is an interdisciplinary (biology and climatology) research project; which is a member of the Network for ARCtic Climate and Biological DIVersity Studies (ARCDIV), an international multidisciplinary research initiative. This initiative was prepared under the auspices of the International Polar Year (IPY 2007 - 2008). From June 29 to August 20, 2009 seventeen researchers from four Czech and Belgian institutions (University of South Bohemia in České Budějovice - Josef Elster, Oleg Ditrich, Oldřich Říčan, Tomáš Tyml, Andrea Bednářová, Alena Bartošová and Martin Hais; Institute of Botany, Academy of Sciences of the Czech Republic - Tomáš Hájek, Karel Prach, Alexandra Bernardová, Jana Kvíderová, Otakar Strunecký, Alexeii Redchenko; Masaryk University in Brno - Kamil Láska, Miloš Barták, and Olga Bohuslavová; and University in Liege, Belgium - Zorigto Namsaraev) conducted the field research (Fig. 1 and 2).

Fig. 1

Fig. 2

In the same manner as in the 2008 season, the Czech research activities covered the following disciplines:

1. botany (phycology, lichenology, bryology and phanerology, as well as plant ecology-physiology)
2. zoology (parasitology)
3. climatology

The fieldwork conducted in 2009 (vegetation mapping - spatial distribution of the species diversity of algae-cyanobacteria, mosses, and vascular plants - on both the broad and fine scale) was conducted by various specific research programmes.

Botany

Phylogenetic and molecular diversity of Phormidium (cyanobacteria)

The different geographical populations belonging to taxa Phormidium were collected for detailed taxonomic study. Eleven samples of cyanobacterial mats were collected at the locality of the Austenfjorden, forty-three samples were collected at the Petuniabukta locality, and six in the Longyearbyen area (Fig. 3). The settlements of Pyramiden and Longyearbyen were sampled with respect to possible human introductions of non-indigenous species. Cyanobacterial samples were identified by optical microscopy (Fig. 4) at the Petuniabukta station. Samples of Phormidium were immediately inoculated onto agar plates. At present, these unialgal strains are being cultivated at the Algology Center of the Czech Academy of Science, and prepared for sequencing.

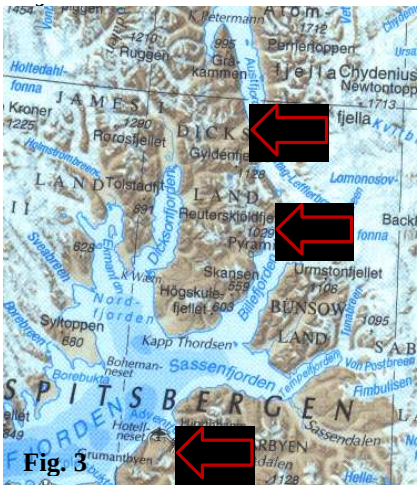


Fig. 3

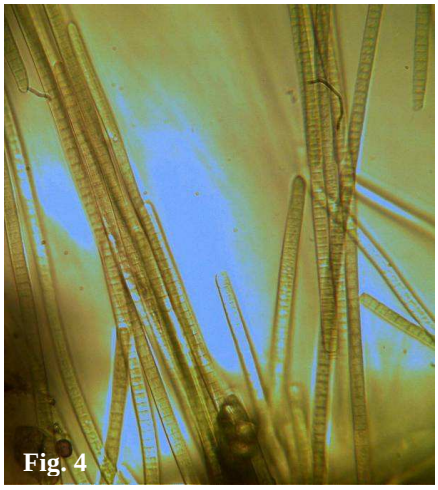


Fig. 4

Hummock tundra - ecophysiology of cyanobacteria and mosses - Open Top Chambers experiment

Wetted hummock tundra is the most productive ecosystem in the high Arctic (Fig. 5). The plant community is mainly composed of mosses and to a lesser extent by vascular plants. Macroscopic cyanobacterial colonies of Nostoc are an important part of this plant community (Fig. 6). During the snow melt period, the hummock tundra is watered by melting water from the surrounding snow fields. At that time, the wet hummock tundra has the character of


Fig. 5


Fig. 6

shallow wetlands. However, during the summer period, the hummock tundra slowly dries up. Three Open Top Chambers (OTC), together with three control boxes (CB), were installed in the hummock tundra (Fig. 7). In these treatments, temperature and water content are permanently monitored at the edges and tops of hummocks (Fig. 8). Simultaneously, in the OTC and CB, the photosynthetic rate of mosses and Nostoc (Fig. 9) are measured, together with the rates of decomposition and moss growth. Because it is known that in these habitats nitrogen is frequently the limiting factor of plant community growth, we measured in the macroscopic Nostoc colonies the rates of nitrogen fixation. During the experimental season, we observed a decrease of photosynthetic activity of the Nostoc. This decrease is connected with the desiccation of the Nostoc colonies. For experimentation, we collected Nostoc colonies in the field and transported them to the field laboratory. There, we slowly desiccated the Nostoc colonies while simultaneously measuring the rate of photosynthesis (Fig. 10) as well as the rate of nitrogen fixation. With respect to nitrogen cycling in the hummock tundra community, we also measured the content of mineral nitrogen in the water coming from the snow melt. The results of this experiment should help us to understand which ecological changes in the wet hummock tundra we can expect, with respect to climate changes currently occurring in the Arctic.

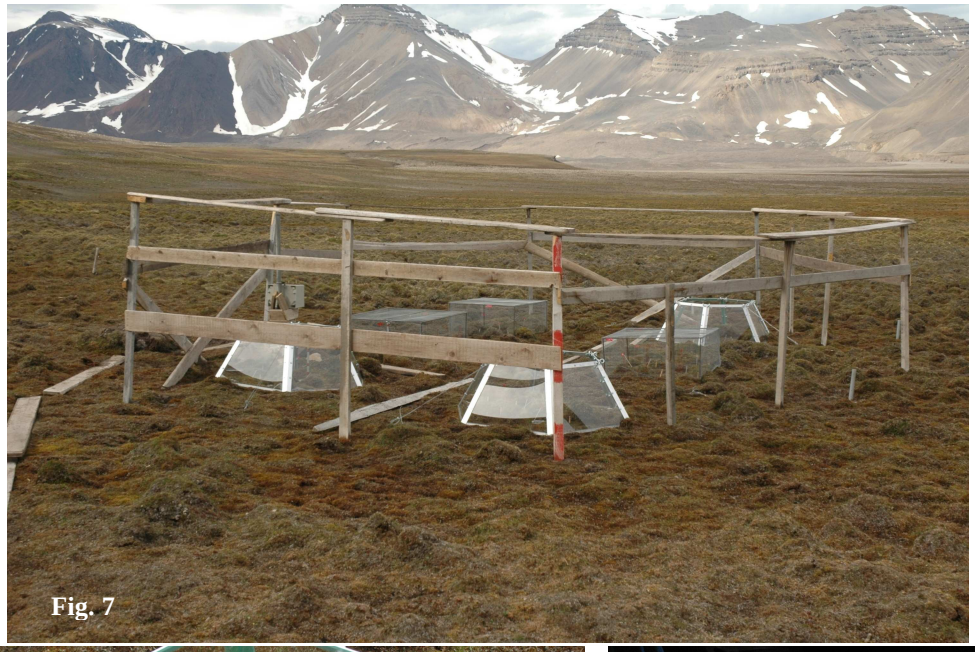


Fig. 7

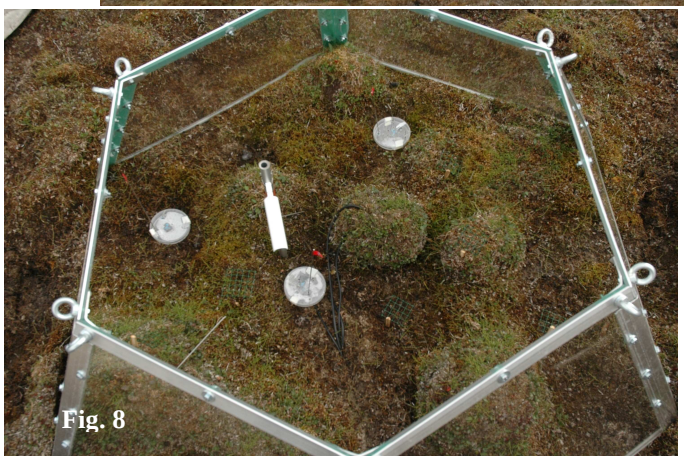


Fig. 8

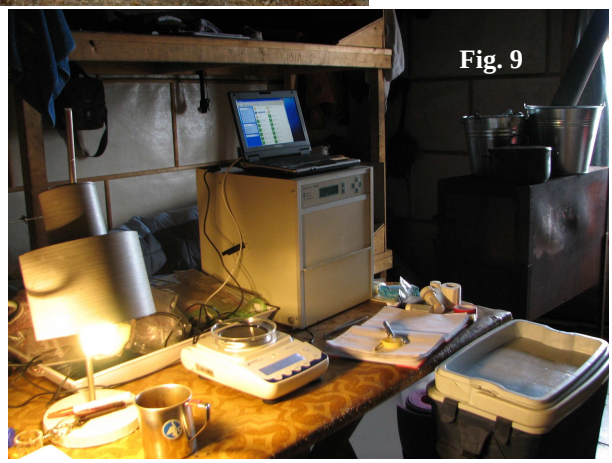


Fig. 9

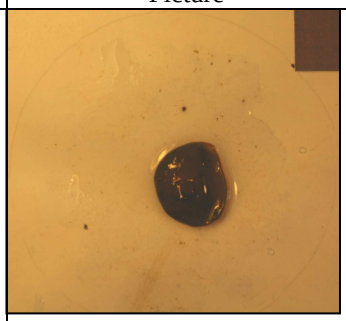
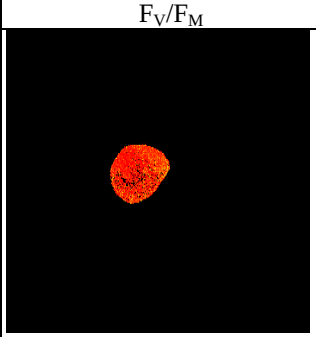
Fig. 10	Picture	F_V/F_M	Parametrs
Fully hydrated colony of *Nostoc*			FV/FM 0.46 Φ_{PSII} 0.18 NPQ 0.43 Qp 0.45

Fig. 10. Example of measured photochemical processes of *Nostoc* colonies. F_V/F_M – maximum quantum yield, Φ_{PSII} – actual quantum yield under irradiance of 100 μmol m^{-2} s^{-1}, NPQ – nonphotochemical quenching, Q_p – photochemical quenching.

Succession of vegetation after retreat of glaciers

Sixty-four vegetation records were performed at different distances from the head of four glaciers (Ferdinand, Hornby, Ragnar, and Ebba). All vascular plants were recorded, together with an estimation of their cover. The distance from the glaciers and the coordinates were measured. Nowadays, location of all sampling sites is made in cooperation with Polish geomorphologists, who have measured, in detail, the rate of retreat of the glaciers (Rachlewitz *et al.* 2007). This enables exact dating of the successional age. The data will be processed using uni- and multivariate (ordination) statistics.

Detailed analyses of vegetation patterns along transects, with particular attention to ecology of Dryas octopetala and Braya purpurascens

The location of one study transect was chosen near the newly established open-top-chamber experiment (see Fig. 7), stretching from the lowest maritime terrace up slope to the nearby hill. This site was selected as one of the most diverse and variable, in regard to vegetation types. The length of this transect was 780m, and was permanently fixed. Along the length of the transect, three vegetation samples (108, 5x5m in size) were recorded at distances of 20m. The distance between the samples was also 20m. All vascular plants were recorded, their cover estimated, along with the total cover of mosses and lichens. The following main vegetation types were recorded along the altitude gradient: the thufur communities, with the dominant species *Equisetum arvense* and *Carex subspatacea*, over more or less permanent tundra (*Cassiope tetragona*, *Dryas octopetala*, *Carex rupestris*, *Salix polaris*, *Saxifraga opossitifolia*), to communities of debris with an herb layer cover of only about 5% (*Saxifraga opossitifolia*, *Salix polaris*, *Draba* sp.). Vegetation patterns will be evaluated by multivariate analyses (ordinations) during the winter. Growth characteristics of *Dryas octopetala*, in relationship to landforms types, altitude, cover of the herb layer, cover of *Dryas* itself, etc. will be evaluated, based on the samples and other measurements of annual increase of shoots and rings. Samples for tree-ring analysis were taken, and will be described during the winter. In the case of *Brayra purpurascens*, a transect 30m in length was established at a site where this species is abundant. All specimens occurring along the transect, up to 10cm distant, were recorded, and their phenological status was evaluated (*i.e.*, small rosettes, large rosettes, flowering plants, plants with young fruits, plants with dry and mature fruits). The same

analysis will be repeated in the next year(s) in order to understand the population dynamics of the species. There is an assumption that this species is not able to finish its cycle in one season, and may postpone the ripening of seeds until the next season(s).

Plaeoecological records

The objective of the palaeoecological study is to obtain data for a reconstruction of prior vegetation cover and its development over time. Earlier vegetation on Svalbard has predominantly been studied by pollen analysis (*e.g.* the studies of van der Knaap). Macrofossil analysis has only been conducted in a few cases (*e.g.* Birks 1991). Thus, samples were collected in amounts suitable for analyses of both pollen and macro-remains. Palaeoecology research was primarily focused on terrain prospecting, finding suitable peat layers for analysis, and also on collecting plants and seeds for the reference collection. Five cores were eventually extracted for palaeoecological analysis. The cores were dug out with a spade, until the gravel terrace was reached. The profile was sampled directly from the core-side into the plastic bags, after 3cm. The volume of each sample was approximately 200ml. Around each sampling place, a list of recent vegetation was also made. First, three cores were recovered in the eastern part of Petuniabukta from consecutive marine terraces (4m a.s.l., 19m a.s.l., and 27m a.s.l.) where the vegetation types vary from waterlogged hummock moss tundra with *Carex subspatacea, Cx. paralela, Equisetum variegatum, Eriophorum triste, E. scheuchzerii*, to "mature tundra" with *Cassiope tetragona, Dryas octopetala, Carex rupestris, Cx. nardina, Cx. misandra*. The fourth core, 72cm long, was extracted in wet moss tundra near Brucebien on a flat terrace. The last core, 27cm long, is lacustrine sediment from a small periodic lake, extracted near the Polish research station, Scottehyta, in the eastern part of Petuniabukta. From each sample, 10ml of sediment was left for pollen analysis, As a reserve for other analysis (*e.g.* ICP, stable isotopes), the remainder of the sediments were soaked in water, wet-sieved through a 0.25mm mesh sieve with water, and dried at room temperature. The processing of the pollen samples and macro-fossil analysis will be conducted in a laboratory during the 2009/2010 season. Due to the fact that Petuniabukta was not completely glaciated during the "Little Ice Age", it is possible to assume that the palaeoecology record could cover the entire period, since the area was deglaciated in the early Holocene. From the results of the palaeoecology research we would like to deal with these problems and find answers for the following questions: How was the vegetation formed since the retreat of the glacier? Is there any significant change in its floristic composition? Are there any significant events in the record? How was the vegetation affected during the "Little Ice Age"? Are we able to reconstruct past environmental conditions from the palaeoecological record?

Plant physiology

Within the Svalbard 2009 expedition, researchers from Masaryk University, Brno carried out long-term comparative measurements of primary photosynthetic processes in three species of vascular plants. The measuring instruments were installed in the vicinity of the Petunia hut, located in the Petunia Bay. A fluorometric device, using the method of repeated saturation with light pulses was applied, to measure daily courses of the photosynthetic processes. The pulses were applied in the actual physiological state of a plant, *i.e.* in the light-adapted state, reflecting the actual amount of incident photosynthetically active radiation. In this way, the quantum yield of photosynthetic processes in photosystem II (effective quantum yield: Φ_{PSII}) was measured. The measuring apparatus consisted of three monitoring fluorometric probes

linked to a controlling unit (Moni-DA data acquisition system, Heinz Walz, Germany), as well as data storage unit (Moni-PAM data logger, Heinz Walz, Germany). The entire measuring apparatus was supplied by a high-capacity gel accumulator and a voltage converter. Light pulses were applied to the leaves of the experimental plant species in a semiautomatic regime, in 5 minute intervals. The three selected species were dominant in the vegetation cover of the tundra at Petunia bukta, Svalbard: *Silene acaulis*, *Dryas octopetala*, and *Salix polaris*. Simultaneously with the fluorometric parameters of the three plant species, ecophysiological data on (1) leaf temperature, and (2) relative leaf irradiance were recorded. In addition, measurements of the absolute values of incident photosynthetically active radiation (PAR) were taken by an EMS-12 radiometer and a Minikin (EMS Brno, ČR) datalogger. Simultaneous measurements of PAR and Φ_{PSII} enabled the calculation of the electron transport rate through the chloroplastic photosynthetic apparatus (ETR). In the period June 29th to July 9th, 2009, a total of 11 daily courses of ETR were taken. All the data obtained were processed recently. Simultaneously, a manuscript is being prepared for submission to an ISI-excerpted scientific journal. Preliminary data analysis has shown that within the above-specified period, diurnals of photosynthesis were recorded for three basic weather types: (a) fully overcast day, (b) partly cloudy day, and (c) fully sunny day. From a microclimate point of view, the data on leaf temperature for the three different species are interesting. The leaf temperature reached a minimum of -2.3^{o}C and a maximum of 16.1^{o}C.

PAR and Φ_{PSII} related to the physiological properties of particular plant species; as well as peculiarities in spatial leaf arrangements; particularly the self-shading phenomenon, and the Sun elevation angle.

Climatology

The meteorological measurements and climate research activities were carried out in the coastal zone of Petuniabukta (north-western branch of Billefjorden) from June 30 to July 19, 2009. The main aim of these field work activities were the maintenance and technical service of the meteorological stations, and their respective permanent study plots. In case of measuring sensor failures, the replacement of damage components with a new one was done immediately. At present, four automatic weather stations (AWS) are operated along the northern coast of Petuniabukta in the following locations:

- AWS1 - old marine terrace at an altitude of 15 m a.s.l.
- AWS2 - old marine terrace at 25 m a.s.l.
- AWS3 - mountain ridge of Mumien Peak at 469 m a.s.l.
- AWS4 - head of Hørbye Glacier at 66 m a.s.l.

The above-mentioned stations are equipped with an identical set of sensors to measure air temperature and relative air humidity at a height of 2 m, as well as the soil temperature and soil moisture (volumetric water content) at depths of 5 and 15 cm. Apart from basic meteorological data, an extended monitoring program is carried out at the main AWS1, located on the south-eastern slope at an altitude of 15 m. It consists of sensors for the measurement of shortwave radiation, both downward and upward, PAR, air pressure, air temperature and humidity, surface temperature of the vegetation cover, and the wind speed and direction. In addition, soil temperature sensors at depths of 2, 5, 15, 30, 50, 75, 100, and 150 cm are installed near the AWS1 location. All AWS are set to operate at a sampling frequency of 30 minutes; instantaneous values except for wind speed (cumulative values). Only radiation data are sampled at intervals of 10 seconds; after which 30 min means are stored. In summer 2009, the researchers from Masaryk University built a new microclimatological station, equipped with sensors used for measurements of the air temperature at a height of 30 cm above the ground, soil moisture (volumetric water content) at

a depth of 2 cm, and soil temperatures at depths of 2, 5, 15, 30, and 50 cm. This monitoring system (AWS5) provided basic data on the spatiotemporal variations of microclimate at the tundra ecosystem formed by the thufur field (cryogenic hummocks). The thufurs are located in the wetland coastal zone at an altitude of 8 m. The shape of the thufurs form conical rounded objects, less than 30 cm in diameter and up to 20 cm in height. Near surface temperatures of both upper and lower parts of the thufurs are measured by a set of thermocouples with a special needle-like construction. The last meteorological station (AWS6) was built at the top of Pyramiden Peak (935 m a.s.l.) with the assistance of researchers from the University of South Bohemia. This station is dedicated to the measurement of air temperature and relative air humidity, enabling calculation of hypsometric gradients.

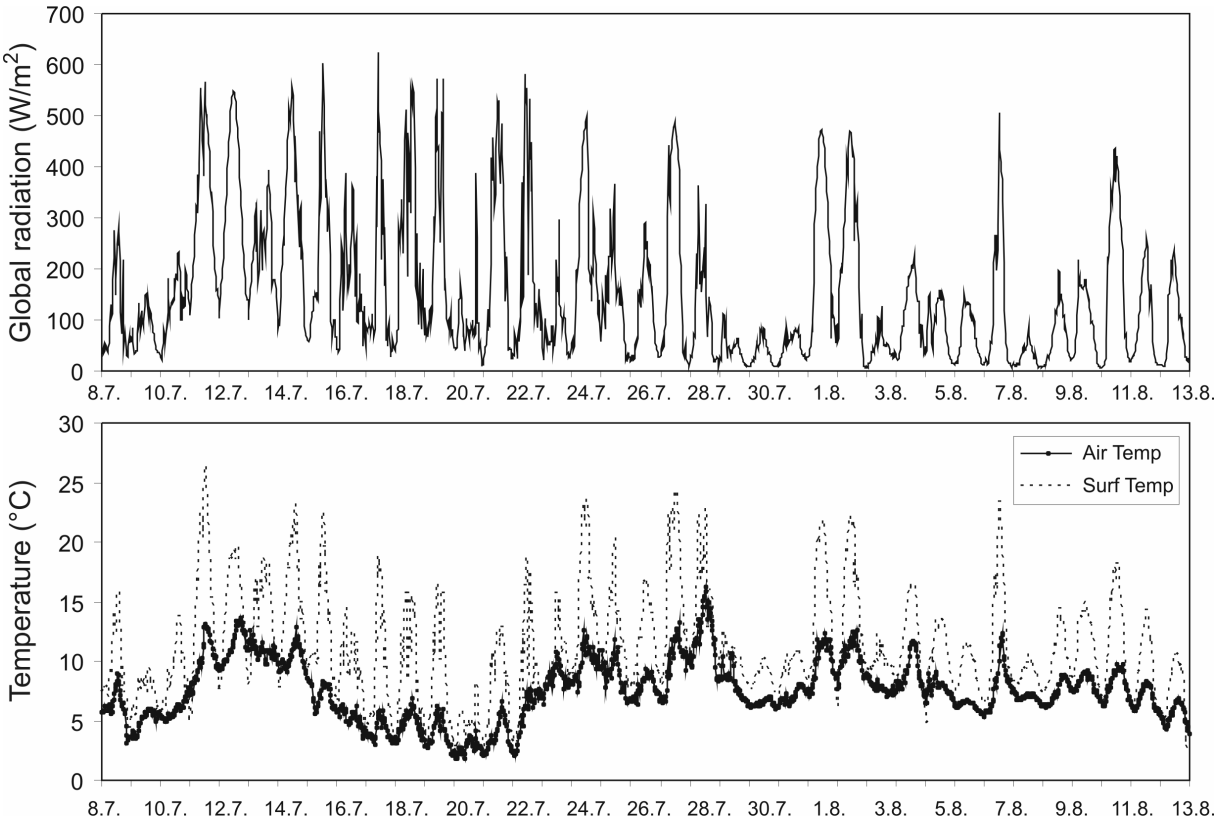


Fig. 11. Daily variability of global solar radiation, air temperature, and surface temperature of tundra vegetation at Petuniabukta in the period of 8 July - 13 August 2009.

On the basis of preliminary data analysis, it can be concluded that the climate conditions in Petuniabukta differed slightly from the rest of the Svalbard archipelago, Isfjorden in particular (Fig. 11). In the period of July 21, 2008 to August 13, 2009, the mean air temperature at Petuniabukta (AWS1) was -4.5°C. The air temperature reached an absolute minimum of -32.6°C and a maximum of 16.2°C. Mean global shortwave radiation was 85.9 W/m^2. However, daily maximum intensity of the global radiation can reach as high as 360 W/m^2. In the summer of 2009 (8 July - 13 August, 2009), the mean air temperature was 7.5°C; while the mean surface temperature of tundra vegetation reached 10.8°C, with the absolute maximum of 26.5°C. The prevailing winds at Petuniabukta corresponded to the orographic conditions of the north-western part of Billefjorden and surrounding glaciers. Therefore, winds from the south (34%) and northeast (18%) occurred frequently. Moreover, summer mean wind speed was 3.4 m/s.

Zoology - parasitology

The aims of the parasitological research

The parasitological part of the project is aimed toward the study of the littoral biocenoses and host - parasite relationships. According to the time schedule, the following partial goals were planned for 2009:

1. The study of life cycle of trematods from the family Opecoelidae, occurring in gastropods *Buccinum* spp. and the family Gymnophalidae from bivalves *Hiatella arctica*.
2. Study of other helminths found in fish and selected invertebrate hosts.
3. Examination of tissues and organs if selected vertebrate and invertebrate hosts with the aim of histological studies of parasites from the groups Myxozoa, Microsporidia, Ciliata, and the isolation of amphizoic amoebas.
4. Continuation of mapping of the biodiversity of litoral biocenoses.

Sampling

1. The localities in Petunia Bay were reached using a Zodiac boat. Scuba diving was utilized for sampling (the team members have special open water diving, as well as advanced open water diving licenses).
2. The fish were captured using drift nets and during diving.
3. The invertebrates were sampled both individually during diving (to max. 30 m depth) and by sieving of bottom sediments. Special attention was paid to molluscs, specifically *Buccinum* spp. and *Hiatella arctica*.

Parasitological examination:

The fish (and birds accidentally captured to the fish net) were dissected parasitologically, with special attention to flukes and tapeworms. The tissue samples from selected organs were sampled for histological examinations. The molluscs were dissected using the compression method, like invertebrates from other taxonomical groups. The numbers of animals dissected are in Tab. 1 and 2.

Tab. 1. Ivertebrates dissected.

Hiatella arctica	58
Buccinum undatum	162
Buccinum spp.	11
Euspira pallida	26
Margarites olivaceus	23
Seripes groenlandicus	18
Chlamys islandica	12
Tonicella marmorea	12
Astarte sulcata	10
Dendronotus robusta	4
Clione limacina	2

Gammarus wilkitzkii	36
Hyas araneus	26
Euchone sp.	14
Pagurus pubescens	10
Marthasterias glacialis	4
Strongylocentrotus sp.	4
Sclerocrangon boreas	3
Total	435

Tab. 2. Fish dissected.

Myoxocephalus scorpius	96
Icelus bicornis	31
Pollachius virens	13
Lumpenus lampretaeformis	11
Clupea harengus	9
Hippoglossoides platessoides	4
Sebastes mentella	4
Boreogadus saida	1
Salmo salar	1
Lycodes vahlii	1
Total	171

The trematodes of the family Opecoelidae were represented by *Myoxocephalus scorpius* and *Icelus bicornis*; probably adults corresponding to cercaria and metacercaria found in *Buccinum* spp. (specimens were fixed for DNA isolation, that will resolve species identification). Distinct seasonal dynamics has been observed in the life cycle of trematodes of the family Opecoelidae and Gymnophalidae. Experimental stimulation of cercariae release has been not successful. Developmental stages of opecoelid trematodes from *Buccinum* spp. and gymnophalid trematodes from *Hiatella arctica* were described in detail. For the completion of the life-cycle of gymnophalid trematodes, it would be extremely useful to dissect predators of bivalves: *Somateria mollissima.*

Fig. 12. Cercaria from the family Opecoelidae from *Buccinum undatum*.

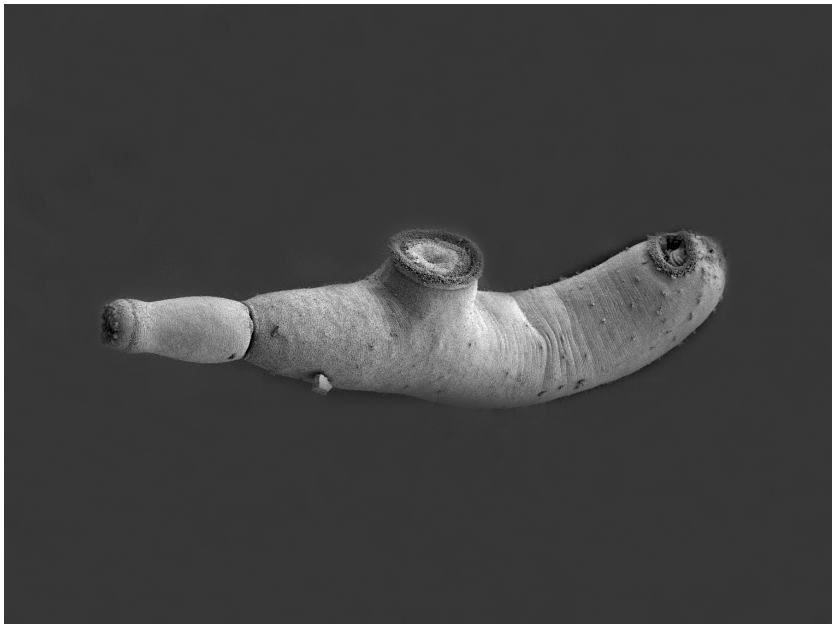


Fig. 13. Metacercaria from the family Gymnophalidae from *Hiatella arctica*.

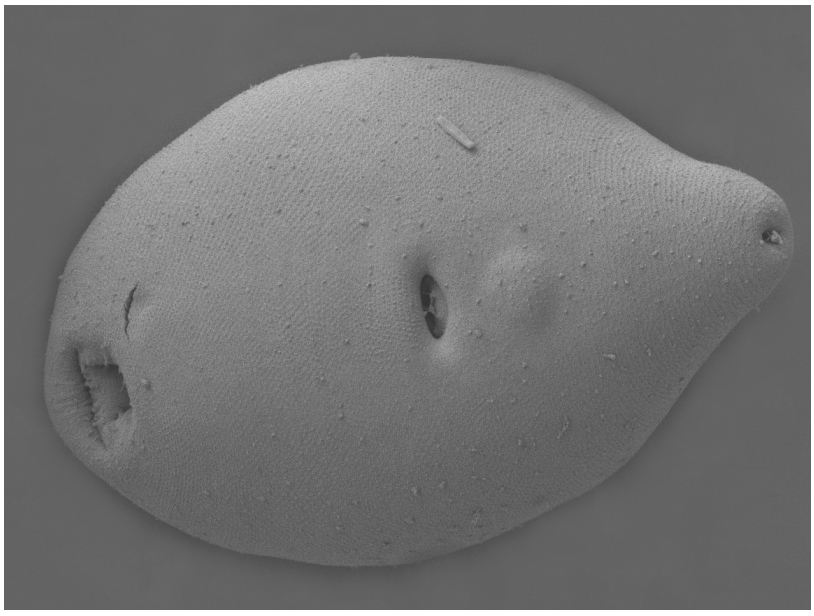


Fig. 14. Cercaria from the family Gymnophalidae in the hepatopancreas of *Hiatella arctica*.

The gills of *Myoxocephalus scorpius* were infected with at a high frequency with unicellular parasites of the genus *Ichthyophonus* (Mesomycetozoa), the causative agent of ichthyophoniasis, cutaneous ulcers, and cysts in most body organs.

Fig. 15. Cyst of *Ichthyophonus* sp. in the gill of *Myoxocephalus scorpius*

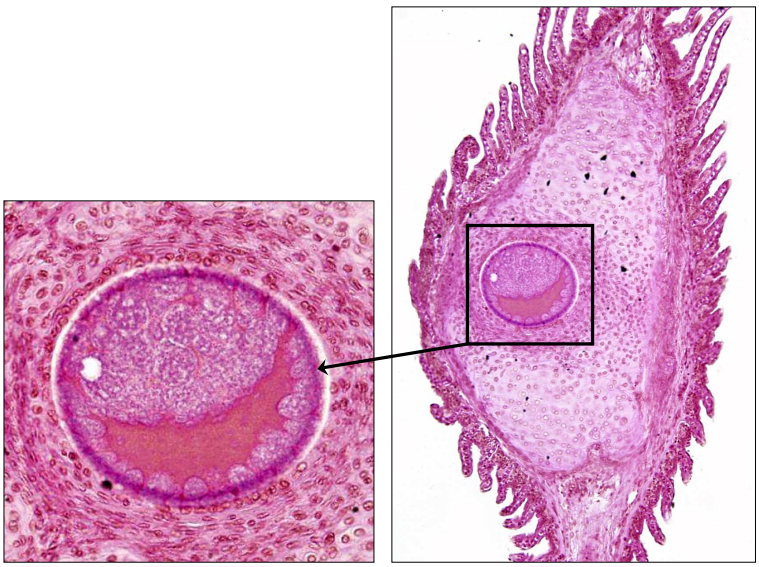


Fig. 16. Myxozoa and microsporidia from gall bladders and urinary bladders of *M. scorpius, I. bicornis* and *L. vahlii*

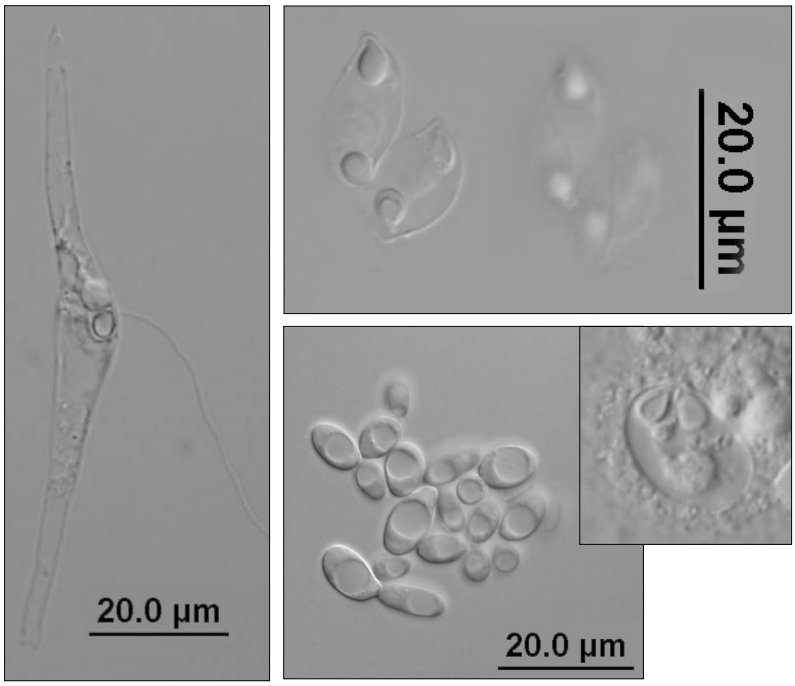


Fig. 17. Kidney of *M. scorpius* containing myxozoa.

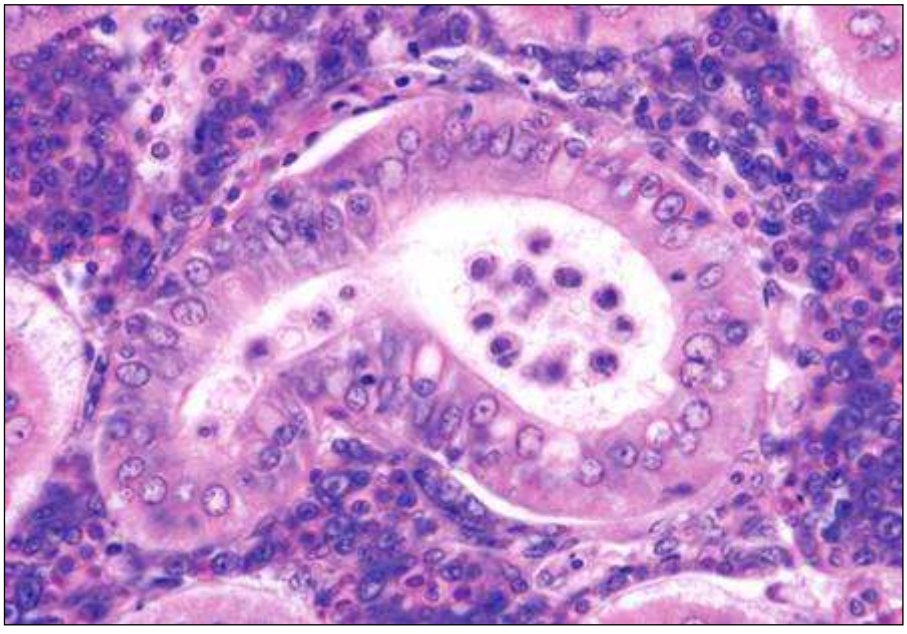


Fig. 18. *Trichodina* sp. (Ciliophora) in the gills of *M. scorpius.*

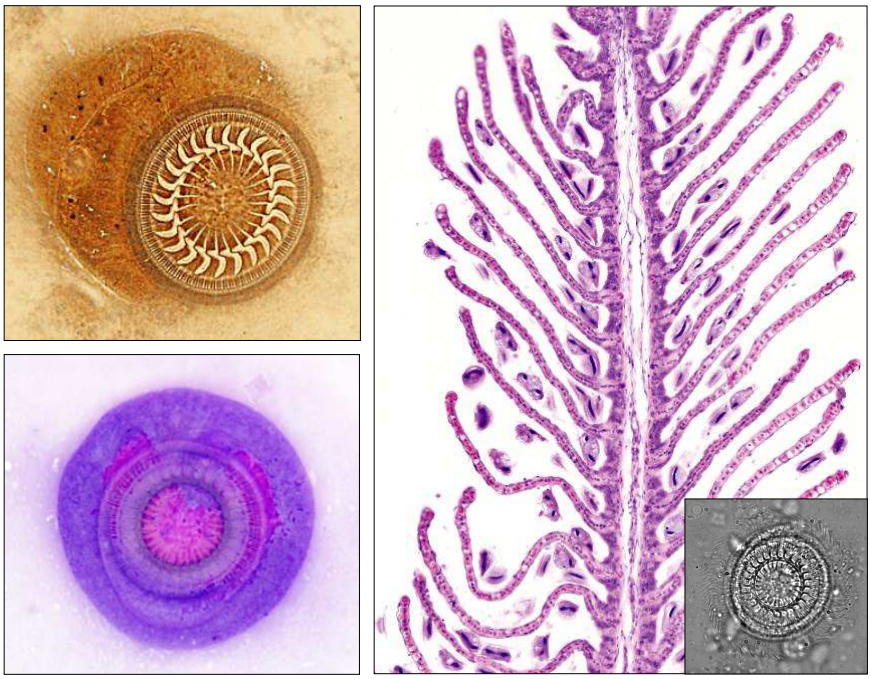


Fig. 19. *Ichthyobodo* sp. in the gill of *M. scorpius* and its TEM micrograph from culture.