

## **Herbivory Network meeting 2019**

The Herbivory Network (HN) meeting 2019 was held between 19 and 24 September 2019 in the town of Labytnangi, Yamal, Russia. The meeting was hosted at the brand new research facilities of the Arctic Research Station of the Institute of Plant and Animal Ecology of the Ural Branch, Russian Academy of Sciences, and was organized by Aleksandr Sokolov, Natalya Sokolova, Svetlana Sokovnina, Eeva Soininen, Dorothee Ehrich, Nicolas Lecomte and Isabel C Barrio. The aim of the meeting was to finalize ongoing HN projects and to discuss new research ideas amongst HN members. Altogether, 20 researchers from 8 countries participated in the network meeting (see List of participants at the end of this document). During the days of the meeting participants were invited by the Mayor of Labytnangi to enjoy a cultural performance by local artists in the town concert hall. A special post-meeting excursion was organised for participants to discover the main museum of Yamal as well as the sightings of Yamal's capital city, Salekhard. We acknowledge the administrative support received from the Yamal Government for organizing special invitations for visa applications.

### **Opening of the meeting and anthropological view on reindeer herding in Yamal**

On 19 September 9:15 am, Aleksandr Sokolov welcomed the participants at the Arctic Research Station (ARS) in Labytnangi. Meeting participants were also addressed by Ms. Marina Treskova, mayor of Labytnangi, who warmly welcomed meeting attendants to the town of Labytnangi.

The first presentation at the meeting was given by Alexandr Volkovitskii from ARS. Alexandr presented an anthropological project, where during one of the expeditions he and his colleague Aleksandra Terekhina lived with Nenets family for an entire year to study their culture and land-use traditions. The presentation highlighted historical land management practices on Yamal, as well as long-term and recent developments of human and reindeer populations. The presentation also exemplified the migratory patterns of different families and the size of their reindeer herds. Yamal is estimated to currently harbour approximately 700 000 reindeer with an exponential increase in stock numbers, mainly due to better medical supply and state support, and previous vegetation assessments indicate that reindeer stocks may have surpassed the carrying capacity of the land. On the other hand, many Nenets families have suffered from significant reindeer losses in recent years. As an example, approximately 80 000 reindeer died as a result of rain on snow events during winter 2014. The presentation raised the necessity to acquire better estimates of the pastures' carrying capacities on Yamal and to study the potential impacts of climate changes on vegetation and reindeer. Altogether, the information presented was crucial for the meeting participants in order to discuss the impact of grazing in socio-ecological systems of Yamal and to develop new research ideas.

After the presentation, HN members introduced ongoing activities and discussed potential workshop ideas.

### **Overview of ongoing work and suggestions for parallel workshops**

Several meeting participants presented ongoing HN activities and suggested parallel workshops, in order to proceed or to finalize different projects. Each presentation lasted for approximately 15 min. By the end of this session meeting participants identified seven topics for the parallel workshops.

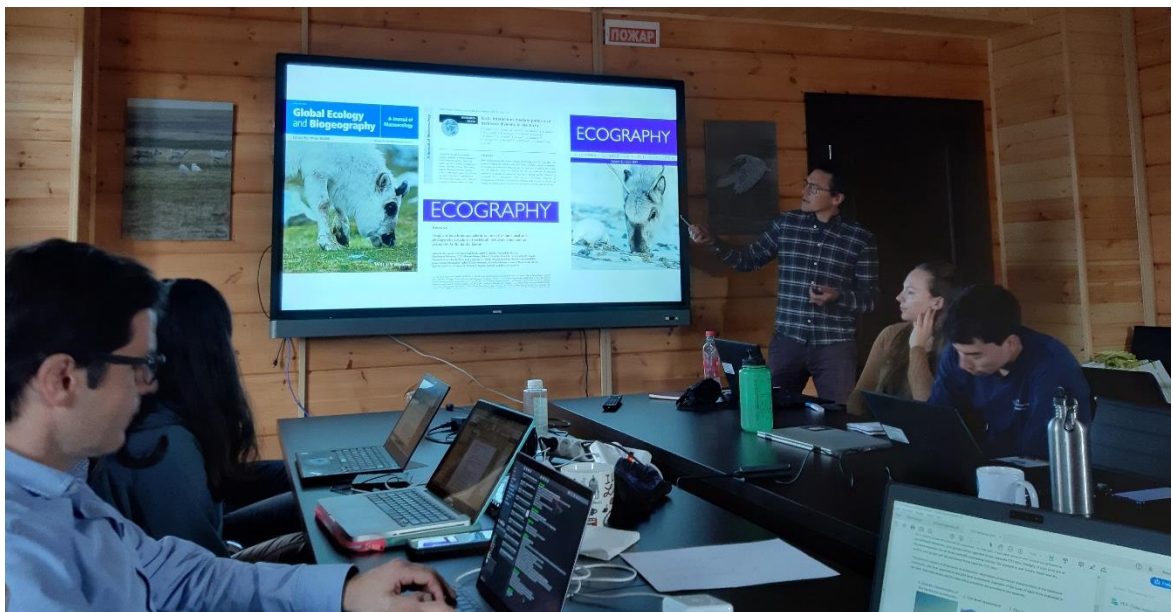
- Svetlana Sokovnina presented results from the Yamal enclosure experiment, where enclosures for three different groups of herbivores were established within three tundra habitats. These habitats were either characterized by i) xeric conditions with a dominance of *Fabaceae* species, ii) mesic conditions with a dominance of graminoids and sedges, and iii) moist conditions with a dominance of willow thickets and forbs. Current results from the study indicate that plant biomass is higher within

exclosures, especially in the *Fabaceae* habitat. Further interpretation of the results and development of manuscript ideas was suggested as one of the parallel workshops.

- Dorothee Ehrich elaborated further on the Yamal herbivory studies. Her focus was on how to integrate different spatial scales of assessments and more specifically; how to extrapolate findings from Yamal exclosures to the landscape scale. Herbivore effects were studied via drone imagery and related to the movement of willow thickets. How to extrapolate from small exclosure to landscape scale, which is relevant for management strategies, was suggested as one of the parallel workshops.
- Violetta Filippova presented her findings from an internship at the Institute of Plant and Animal Ecology (RAS). She gave further insight into the Yamal grazing studies and showed how drone images from different tundra types might relate to changes in climate and grazing pressure.
- Megha Verma presented the outcome of her MSc thesis, which she conducted at Imperial College London. She studied how changes in climate and herbivory might have driven the vegetation distribution in Yamal over the last 32 years. She used Landsat imagery and connected trends in NDVI to greening and shrub cover. Since no changes in those parameters were found, the group elaborated on scale issues and how to improve assessments in vegetation changes on landscape scale in response to grazing.
- Katariina Vuorinen presented a dendroecology dataset, which she will use to study climate and herbivory effects for the Arctic. She established a database of tree ring increments from different *Betula* and *Salix* species, which were gathered from various sites throughout the Arctic. Growth increments will be related to trends in climate and changes in herbivore pressure. However, a current issue is to disentangle the effects of both drivers and to make data comparable.
- Eeva Soininen presented the current standing of the systematic map of herbivory in the Arctic. The initiation of this project was a workshop held during the 2016 HN meeting in Reykjavik. Since then, Eeva secured funding from the FRAM Centre for a small group of authors to develop a protocol for the systematic map, which was published in the journal *Environmental Evidence* (Soininen et al. 2018, DOI: 10.1186/s13750-018-0135-1). Using this published protocol, the aim is to map all existing evidence of herbivore studies in the Arctic and to identify context dependencies. Several issues, such as the spatial extent of gathered information still needed to be clarified and information from many articles still needs to be coded. Some of these tasks were conducted during one of the parallel workshops of this meeting.
- Isabel Barrio presented the current standings of the International Tundra Experiment (ITEX) herbivory protocol. Since the initiation of the HN, one of the aims has been to develop standardized protocols to assess herbivory within tundra. One of the first protocols was developed within the ITEX experimental set up. The protocol includes assessments at several hierarchical spatial scales and some field trials were conducted in summer 2014. Site assessments were conducted based on dropping counts along transects. At the plot level, researchers recorded herbivore signs, such as chewing marks. Transect data was presented from several Arctic sites, some without experimental warming treatments. Plot data was presented for experimentally warmed plots (OTCs) *versus* controls. The current results are aimed to be published in a special issue on the ITEX network of the journal *Arctic Science*. However, the exact storyline, especially whether to present both site and plot assessments, was still to be discussed in one of the parallel workshops.
- Guillermo Bueno presented current activities of the Soil Working Group. The aim of this working group is to identify impacts of herbivory on the soil. Herbivore activities through vegetation removal, but also through trampling and waste deposition, can have strong impacts on physical, chemical and biological properties of the pedosphere. However, as demonstrated by a dataset from Audkúluheidi

(Iceland), those effects may be site and soil-trait dependent. Such context dependencies, in combination with strong variability of herbivore effects in space and time, currently pose special challenges to develop unified protocols.

- James Speed introduced recently published, and ongoing studies of Arctic vertebrate herbivore diversity. Two scientific articles on that subject were published by HN group members recently (Barrio et al. 2016 DOI: 10.1111/geb.12470; Speed et al. 2019 DOI: 10.1111/ecog.04347), highlighting driving forces and the spatial patterns of vertebrate herbivore species richness, functional- and phylogenetic diversity throughout the arctic tundra. James Speed presented current activities to proceed on that topic, and also suggested to expand pattern analyses towards boreal ecosystems or to investigate herbivore diversity patterns in space and time (see e.g. Speed et al. 2019 DOI: 10.1371/journal.pone.0217166). He also presented ideas to link knowledge from this research to other outcomes of HN research, such as the Systematic Map.



Herbivory Network meeting in Labytnangi. James Speed presented two recently published HN papers, which featured two journal covers!

## Workshops

Altogether, seven workshop sessions were held during the meeting. Some of these workshops were aiming to initiate new projects amongst HN participants, whereas others were follow up activities of ongoing projects.

### Workshop: Herbivore exclosures at Erkuta

**Contact persons:** Svetlana Sokovkina ([sokovkina\\_su@ipae.uran.ru](mailto:sokovkina_su@ipae.uran.ru)) and Dorothee Ehrich ([dorothee.ehrich@uit.no](mailto:dorothee.ehrich@uit.no))

Svetlana Sokovkina started the workshop with a presentation of the design of the exclosure experiment, including some preliminary results. The exclosures were built to separate the effect of three different groups of herbivores on tundra vegetation. A large 2.5 x 2.5 fence excludes reindeer. Within each large exclosure there are 6 small 50x50 cm plots. Two of them allow grazing by medium and small herbivores (only reindeer excluded), two exclude also medium sized herbivores, such as ptarmigan and hare, and two of them exclude all herbivores, including small rodents. Exclosures were set up in three different habitats: *Fabaceae* tops (FT; exposed sites with little snow and flowering *Fabaceae* vegetation in summer), mesic tundra (MT; was chosen as one of the most widespread habitats in the study area) and moist willow meadows (WM). The exclosures were established in 2014, and biomass was measured on all plots in 2014, 2015 and 2018. Workshop participants

discussed several aspects of the study, relating to the interpretation of results and the storyline for a scientific paper:

An issue was the interpretation of differences in treatment (exclosures) response between habitat types, especially in FT habitat. The exclosures in the wind exposed *Fabaceae* habitat might e.g. induce a reduction of nutrient input from feces, but due to runoff during the melting period, feces from the surroundings may sometimes accumulate in the fences and increase nutrient input locally. Similar artefacts of the fence treatment may be related to the accumulation of plant litter. This process should be accounted for, since litter accumulation affects shrub growth on Yamal, as found by a PhD student of Marc Macias-Fauria at Oxford University. Litter decomposition experiments or special bags, which collect litter, could be used to investigate those effects.

Contrasting response between years was also observed in 2015 and 2018 in the FT habitat, suggesting that vegetation might be negatively affected in dry years and positively affected by early onset of growing season in other years. Melt out timing and onset of phenological events generally happens latest in the WM habitat. Here late melt out in certain years, such as in 2018, may cause plant biomass to be so low that herbivory effects may not even be detectable. Trampling during fieldwork may also have strong effects in this fragile habitat. Vegetation in WM and MT responded in one way to the differences in phenology, but FT responded differently. This seems a bit strange and it would be interesting to see which species actually caused these differences in overall biomass.

Suggestions to account for herbivore abundance during data analyses were further brought up, which could be achieved by incorporating dropping count data, which were gathered twice per year. The results of the exclosures could also be more specifically related to the diet of different herbivore species. This could be done by combining these data with data from feces metabarcoding, which was done a couple of years ago. The genetic diet data could be used to define what is palatable. Focusing on palatable/low palatable plants, or even on palatability on a community level, would give an interesting twist to the paper.

Another idea was to make ordination plots to look at shifts in community composition between the years and treatments, or to apply topic modelling, which would allow to assess changing community patterns.

### **Workshop: Integrating across scales: herbivory, willow thickets and remote sensing on Yamal**

**Contact person:** Dorothee Ehrich ([dorothee.ehrich@uit.no](mailto:dorothee.ehrich@uit.no))

In this workshop participants started by exchanging information on scaling issues. The discussion happened mainly between Marc Macias-Fauria and his group, and the Yamal-Tromsø group. Three master students presented their theses. Markus Spiegel used satellite images to look at the correlation between climatic parameters and NDVI using Modis images over the whole of Yamal. Places where this correlation was weaker were interpreted as potentially more affected by reindeer grazing. These localities were discussed with A. Volkovitsky regarding how likely this interpretation was according to his knowledge of reindeer herding routes. Megha Verma looked at changes in the extent of willow thickets in the Erkuta study area since 1982 based on classification of Landsat images. Her results did not show any significant trend for increase or decrease of willow thicket cover, and were interpreted as possibly reflecting the simultaneous impact of two opposite drivers, climate warming and reindeer grazing. Violetta Filippova will assess willow thicket configuration based on high resolution satellite images and drone pictures, as well as by looking at willow recruits on the ground.

These presentations were followed by a discussion – mainly brainstorming about what one could do to improve measurements and bridge between the scales. Different methods to assess vegetation structure from drone pictures were discussed. One suggestion for common projects was to connect the correlation identified by Markus, with the willow thicket area changes, which Violetta will produce for the Erkuta study area, and to consider the question whether one and/or the other reflect grazing pressure in summer.

**Workshop: Disentangling climate and herbivory effects on arctic shrub growth**

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In this workshop, participants discussed the current state of the dendroecological database compiled within the DISENTANGLE project, which aims at determining relative importance of large vertebrate herbivores and climate factors on shrub growth across the Arctic. Herbivore information in this database differs in quality between sites and is either based on enclosures, exclosures, or rough estimates of animal numbers. The group elaborated on potential approaches for dealing with such data quality issues in statistical analyses. The idea was to follow a two-step approach, where sites with experimental manipulations are analyzed separately from sites with contrasts in animal densities. Sites with estimated animal numbers may be further divided according to seasonality of grazing and classes of animal densities. Furthermore, additional data sources to be included into the database were identified. The data analyses can thus proceed in the weeks following the meeting.

**Workshop: ITEX protocol final version and manuscript**

**Contact person:** Isabel C Barrio ([isabel@lbhi.is](mailto:isabel@lbhi.is))

The HN itself was initiated during a meeting of the International Tundra Experiment (ITEX). The starting group aimed for developing unified protocols to assess herbivory in arctic and alpine tundra, especially in ITEX sites. A protocol was designed in 2014, and was trialed in the field during 2014 and 2015. Herbivore assessments were either done on a site level through dropping counts along transects, or on a plot level including temperature manipulations *via* Open Top Chambers (OTCs) and their controls. However, not all data that was gathered over the last years was from ITEX sites, and some sites conducted plot level assessments without associated OTC application.

Isabel Barrio presented the outcome of the collected data assessments and the group discussed whether to include both, site level and plot level assessments, into a manuscript. The question was also whether to present the outcome of herbivore assessments in form of a methodological study or as original research. A first realization was that there is no validation of the applied methods, but still some recommendations can be made. Furthermore, the integration of site and plot level assessments seems problematic, since the former were mostly influenced by vertebrate herbivores, and the latter by invertebrates.

After further discussion, the group decided to incorporate all available site and plot level assessments into the manuscript. Further assessments by other groups using a modified version of the site-level assessment of the ITEX protocol were also identified and will be included within the next months. In an ordination diagram, all research sites will be grouped based on the presence of herbivore species and abundances. ITEX sites will be highlighted in the diagram. Repeated site assessments were done in some places and a figure of variation throughout the years will be included for those sites in an appendix. The MS will also show plot level assessments and the effect of OTCs on herbivory for the ITEX sites.

The focus of the study will be to visualize the herbivory context of different arctic sites and serve as a platform to allocate ITEX sites according to their context of herbivory. A rough outline of the MS was noted by Amanda Kolz during the workshop.

**Workshop: Systematic map of herbivore effects in the Arctic**

**Contact person:** Eeva Soininen ([eeva.soininen@uit.no](mailto:eeva.soininen@uit.no))

Eeva Soininen presented the work for the Systematic Map. Workshop participants were split into groups: One group coded scientific publications according to the systematic map approach. Russian or French speaking workshop participants identified literature evidence in their native language and started to code the respective articles. The systematic map approach will require ongoing effort, including many more participants than those

present at the meeting. The coding work should be completed by the end of November 2019, followed by drafting the manuscript.

Some of the workshop participants (James Speed, Guillermo Bueno, Martin Mörsdorf) tried visualizing different contexts of herbivore studies, based on the literature that has been coded so far. It was thereby possible to visualize different context dependencies of herbivory studies using standard plotting functions in R. Some examples were presented by James Speed.

### **Workshop: Invertebrate Herbivory protocol**

**Contact person:** Isabel Barrio ([isabel@lbhi.is](mailto:isabel@lbhi.is))

There is an ongoing effort together with the Network of Arthropods of the Tundra (NeAT) to develop a protocol to measure invertebrate herbivory in tundra. After two multi-authored published papers on the patterns of background invertebrate herbivory in tundra (Barrio et al 2017 Polar Biology DOI 10.1007/s00300-017-2139-7; Rheubottom et al 2019 Polar Biology <https://doi.org/10.1007/s00300-019-02568-3>), and an ongoing effort to quantify spatial and temporal variation at a finer scale, we are now in a better position to recommend some guidelines for a common protocol. However, based on the previous experience some questions still remain, and some of the points were discussed during the meeting. These common protocols, to be implemented across a vast and remote area like the Arctic, need to be simple enough and repeatable by different observers. As well, many researchers implementing the protocol may not necessarily be interested in invertebrate herbivory and may just implement the protocol as an add-on to their ongoing field measurements, so the requirements in terms of time and effort should be kept to a minimum. In this sense, more detailed measurements at the community level (like in Rheubottom et al 2019), although interesting and allowing for comparisons at the community level, may be too laborious to implement at a wider scale. It was discussed then if to recommend monitoring a single plant species across the Arctic (but that would exclude many sites where this species is not abundant) or if to focus on the most abundant plant. A question would then be if to decide targeting a functional group (e.g. deciduous shrubs) and select the most abundant species within that functional group at each site. Since the idea is to monitor changes in invertebrate herbivory over time, even if different sites focus on different species, data (changes over time) would still be comparable.

This topic will be followed up at the NeAT meeting in Aarhus at the end of October 2019, and the idea is a potential contribution to a special issue on polar entomology in the journal *Insects* (deadline December 2019).

### **Workshop: Approaches to assess herbivory in space and time**

**Contact person:** Martin Mörsdorf ([martin.moersdorf@biologie.uni-freiburg.de](mailto:martin.moersdorf@biologie.uni-freiburg.de))

A workshop on how to assess historical effects of herbivory was led by Martin Mörsdorf during the HN meeting 2016 in Reykjavik. Since ecosystems have different resilience towards disturbances, the impacts of past herbivory may still be affecting the ecosystem characteristics today. Workshop participants in 2016 discussed different proxies for assessing herbivory, all of which relate to different temporal and spatial scales. Furthermore, the collection of those proxies will lead to different quality of data, with some being purely qualitative and some quantitative assessments.

So far, it was unclear how to proceed with the outcomes of the workshop. One possibility was to found a new HN working group, which would draft protocols for assessing the history of herbivory in the field. During the Yamal workshop, some participants discussed the proceeding of the project, and concluded that most of the gathered methods will presumably not be implemented by researchers, as long as there is no budget or time specifically allocated to these tasks. The following conclusion was to proceed with a review article. Here, contributors of the study will organize different proxies of assessing herbivory according to the spatial and temporal scale of the rendered data. Proxies will also be organized according to the quality of data. The result will be an overview of possibilities for the individual researchers to assess herbivory specifically with respect to

space and time. The application of each proxy will be demonstrated by a list of previous studies where those were applied.

The meeting at ARS in Labytnangi ended on Saturday 21<sup>st</sup> September.

### **Field excursion to Erkuta**

Most meeting participants joined a field excursion to the research site in Erkuta for the next two days. Erkuta is a long-term field site of the Arctic Research Station, situated 220 km north of Labytnangi in the south of Yamal Peninsula, in the low Arctic shrub tundra. Erkuta has a rather lush vegetation with highly productive willow thickets and different typical tundra types. It is also the home of a diverse community of herbivores, including domestic reindeer that are herded in the traditional way by the Nenets people living close by. Ecological research has been carried out at the site for more than 20 years. Meeting participants visited the field experiment with size-selective exclosures that was presented by Svetlana during the meeting, and visited a Nenets family in their summer camp. Discussions of some of the topics presented at the meeting were followed up during the field visit.

Participants left from Salekhard on 24<sup>th</sup> September 2019.

## List of participants

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