Arctic Entomology under Climate Change: highlights from the NOVA PhD-course in Iceland 20-24 August 2018

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From August 20-24 a NOVA PhD course was organised by Prof. Gudmundur Halldorson with the title “Arctic Entomology under Climate Change”. The location of the course was at Gunnarsholt, the headquarters of the Soil Conservation Service of Iceland, Hella (S Iceland). Twelve international students participated and enjoyed the teaching of seven Nordic experts. The course is the second NOVA PhD course in the series “Climate Change Entomology in the North”, which focuses on the fundamental and drastic demands in agricultural entomology in the Nordic countries, associated with climate change. The course was also an activity of the UArctic Thematic Network “Sustainable Production and Foraging of Natural Products in the North”.

Climate change is occurring faster in the Arctic than elsewhere in the globe, and we are already witnessing its consequences in natural and agricultural systems in the North. Warmer temperatures could benefit agricultural production at high latitudes, but can also facilitate insect pests that will be able to expand from lower latitudes. These complex interactions need to be considered, when designing sustainable agricultural practices. In this course the consequences of ongoing and predicted environmental changes on Arctic entomofauna, from individual to community responses, and the implications to agriculture and forestry were discussed.

Course participants during a field trip to Sólheimajökull glacier in S-Iceland, to study how the ongoing climate warming has led to the glacier losing around 2.2 km^2 of its front part during the past century. The

speed of the retreat has been increasing as the climate has warmed, and in recent years the retreat has been equivalent to length of an Olympic swimming pool annually. Further point of interest at this site was the fast recovery of vegetation after volcanic eruption eight years ago. Photo by Bjarni Sigurðsson.

Below are listed some key points from the course contents, as extracted by the students and main teachers, including several points that can be interpreted as offering policy options for developing sustainable agriculture for the arctic and subarctic areas.

Applied entomology in the North

- Invertebrate herbivory in tundra ecosystems, especially in non-outbreak situations (i.e. background herbivory), has received too little attention
- Current levels of background herbivory are low but ubiquitous, and are likely to increase with ongoing climate warming in the Arctic
- Collaborative research approaches can help advance our knowledge on plant-insect interactions, and serve as a backdrop to evaluate future changes in the Arctic
- We know that pest species are expanding their ranges towards the poles, which also raises the question on how vulnerable Arctic areas are
- There is limited knowledge on arctic insects, but we know that many of them have unique adaptations to the extreme conditions in the north. This means that those species expanding their range, have to adjust their life cycle, as well as to adapt (e.g. physiology, behavior, life-history strategies) to the unique conditions in the north, unless climate changes radically
- We should pay attention to what extent humans 1) move a lot of pest species around, and 2) select pest species to become more invasive, particularly with our usage of pesticides and their sublethal effects
- Areas in northern latitudes have low numbers of pest species recorded, presumably due to cold winter temperatures, limited heat accumulation, few crop options, and isolated locations
- Insects and plants in the same location react differently to the warming climate, which leads to changes in pest pressure.
- Having sustainable agricultural industry in arctic areas requires the implementation of integrated pest management

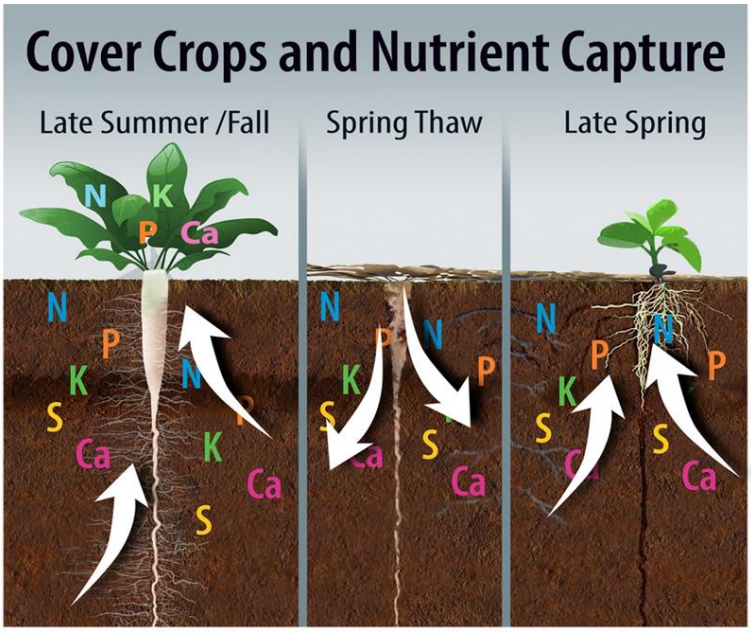
Crop pollinators in the North

- Dependence on native pollinators in crop production in the arctic and subarctic region is not well studied
- Diversity and abundance of native pollinators are important factors for successful pollination
- Changes in current agricultural systems have lowered the ability of the environment to support native pollinators, thus compromising the ecosystem service they provide
- To secure successful pollination it is not enough to focus only on arable land, but the areas surrounding it, and to see it as one functional system
- Flies are the key pollinators of the arctic: they are generalist species, their species richness is low but they are abundant. Most important families are: Muscidae,

Anthomyiidae, Syrphidae, Tachinidae, Calliphoridae, and Empididae. Fly abundances, however, are declining as Arctic is warming.

- The distribution of solitary bees is not well documented in the arctic
- Main challenges to pollinators under climate change arise because plant-pollinator interactions are disrupted in two ways: spatial (distributional) disruptions, and via changes in phenology. The timing of plant flowering and pollinator activity is found to be strongly affected by temperature. Mismatches in distribution of species changes the availability of mutualistic partners.
- Bumblebees are also important pollinators in arctic and subarctic regions
- The unique life history traits of bumblebees make them particularly well suited for pollination in colder climates
- Bumblebees have the potential to be used as a pollinator resource for both open field and agricultural systems in colder climates
- The warming of climate has wide reaching implications for a variety of bumblebee species

Northern agriculture in transition



Slide by Daniela Weber

- The arctic and the subarctic are characterized by very unique biological, climatic and geographic characteristics, which include unique light conditions, soil properties, and short growing seasons
- We need to find a way to promote agriculture in the north with respect to its identity/characteristics, and to use the unique conditions as a chance for niche marketing (super fruits)
- Crop diversity is more important than finding a single monoculture than can grow in this region.
- The need to increase food production by at least 50% globally by 2050 to feed the growing population, is this even possible in the Arctic region?
- Cultural/societal/environmental impact on the region from expanding agriculture in the arctic. What cost to this region is acceptable?
- We should focus on this issue as a global society rather than just dealing with ti regionally: a strength in numbers approach

- In order to intensify agriculture, we need to make sure of sustainability to avoid “agricultural deserts” and one factor is to preserve and enhance the soil quality (cover crops)

Sustainability is the goal

Slide by Brynja Hrafnkelsdóttir

- To ensure food security, countries strive to become self-sufficient in food production
- Food production should be sustainable. For this goal to be met, researchers must work together, and include farmers in their work
- Crop varieties adapted to the local climatic conditions, as well as local specialities, should be utilised more
- Food security is a very important factor for growing more locally. Iceland is an example of a country that has land, energy sources, and knowledge to grow much more locally
- Environmental reasons are critical. Public needs to be more informed about them, and how important they are. Labeling products (where it comes from, if it is local or not) is important
- Importat of vegetables and other plants opens pathways for new insect pests and pathogens to the area. Especially in the north, where there is lack of natural enemies
- Crop production in the arctic and subarctic region relies largely on the forage production.
- With climate change, longer and warmer growing season increases the winter forage biomass production, but also causes more extreme weather conditions such as drought and winter damage
- There is a potential of using Nootka lupine as a forage legume crop, but breeding activities regarding the toxic alkaloids are needed. Nootka lupine can also be used more as a green manure.
- The invasive Nootka lupine may threaten some food sources (natural flowering plants) of native pollinators
- For sustainable forage production under the arctic and subarctic conditions, we need to consider and balance the factors of genetics, environment and management.

Slide by Brynja Hrafnkelsdóttir

Arctic agriculture is without doubt unique in many ways and constitutes a challenge that can be met. The challenge should encompass technical issues such as season-extension techniques; improving soil fertilization; irrigation systems; and promoting research and development for suitable electricity in arctic areas to support horti- and agriculture. Climate change will pose new issues for sustainable agriculture in the North, with a change in abundance of pests, weeds, diseases, and invasive species. Identifying the potential invasive pest insects in arctic and subarctic areas for the next 50 years and assesing the risks for native ecosystems and horti- agriculture is needed to anticipate the change. Research for Integrated Pest Management should be promoted. Local products will be more expensive than imported products, therefore socioeconomic issues related to marketing, consumer preferences through education, and support for producers must be taken into account to reach sustainable agriculture