

Ráðstefna Vistfræðifélags Íslands 2021

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Icelandic Ecological Society 2021



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ÁGRIP / ABSTRACTS

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PLENARY

Arctic terrestrial ecology: past, present and future challenges

Ingibjörg Svala Jónsdóttir, University of Iceland.

During the last four decades, research in Arctic terrestrial ecology has developed from being of rather local concern to being one of the globally most important research fields of today. The driving factor behind this development was first of all the increasing emphasis on research on climate change impacts on ecosystems starting in the early 1990s and later an increased understanding of the key role of high latitude ecosystems in the global carbon cycle. We are still trying to understand if and how climate change is affecting the carbon balance of the ecosystems and in which direction. To do that we need to disentangle the complex ecological processes behind. In this talk I will reflect on this fast development, with some examples from my own research, and identify some of the challenges ahead in Arctic terrestrial ecology, the importance of clear future vision and collaboration and, finally, the role of ecological societies such as Vistís and NSO.

SPECIAL ISSUE SEMINAR

INVASIVE PLANT SPECIES IN ICELANDIC TERRESTRIAL ECOSYSTEMS: CURRENT KNOWLEDGE AND FUTURE STEPS

A Future Planet of Weeds?

Daniel Simberloff, Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 37996, USA

In some habitats (e.g., grasslands and wetlands) a predicted homogeneous mass of dominant non-native plants is in the process of being realized. Although certain species have achieved widespread non-native distributions, the same ones are not always among the most common invaders in all regions to which they have been introduced. For forests, an “inertia” largely owing to the longevity of dominant native trees has retarded homogenization and may do so for another century or more. Shrublands, with their smaller and shorter-lived dominants, will be unlikely to impose such inertia. However, in the long run, virtually all plant communities will likely be transformed, as disturbances and seed dispersal provide increasing opportunities for non-natives to replace natives. New arrivals that change ecosystem properties, such as nitrogen-fixers and species that change fire cycles, can hasten the transformation. Without a substantial new relationship between humankind and natural habitats with their native biodiversity, as well as the continued development of promising new management tools, it is difficult to be optimistic that, within a millennium, all plant communities will not be dominated in many regions by non-native species.

Pulse dynamics in ecosystems under species invasion

Anke Jentsch, Bayreuth University in Germany

Human-induced environmental changes are often accompanied by the spread of invasive species, especially of invasive ecosystem engineers. Their impacts on plant communities and ecosystem functions are of growing interest, although the scientific debate around invasive species is fraught with paradoxes and dilemmas, as both positive and negative consequences arise. Estimating the likelihood of further spread of locally to globally invasive species under future climate change and the emergence novel ecosystems is a particular challenge. Evidence suggests that particularly legume ecosystem engineers will increase under future climate scenarios, thereby altering species composition, nutrient pools, recovery of native communities after weather extremes and ecosystem functioning. Eventually novel ecosystems might emerge. Accelerated pulse dynamics in ecosystems may give invasive species an additional advantage in competing for fluctuating resources. Thus, I would like to share with you our new theory of pulse dynamics and disturbance in ecology (Jentsch & White 2019). It contains four postulates: 1) 'Resource Dynamics' characterizing resource change including stoichiometric needs of organisms; 2) 'Energy Flux' characterizing resource assimilation rates across ecosystems; 3) 'Patch Dynamics' characterizing resource patches and resulting patterns of biotic diversity, ecosystem structure, and cross-scale feedbacks; and 4) 'Biotic Trait Diversity' characterizing the evolutionary responses to pulse dynamics and the way trait diversity affects ecosystem dynamics. Based on these postulates, the theory of pulse dynamics predicts i.e. disturbance magnitude, resource trajectory, rate of resource change, biotic trait diversification, and functional resilience. Ultimately, we aim at better understanding community dynamics, comprising resistance to invasion, adaptation and regime shift.

Non-native flora of Iceland: past, present and future

Pawel Wasowicz, Icelandic Institute of Natural History

During the talk I will give a comprehensive overview of the problem of non-native flora of Iceland and I will put it in a wider pan-Arctic context. I will present the basic statistics of the Icelandic flora with special emphasis to non-native taxa. Starting from the times of Landnám (the Settlement of Iceland) I will present and discuss the impact of humans on Icelandic flora. I will show data on dynamics of non-native species immigration and discuss possible future scenarios for non-native flora of Iceland. During the talk I will discuss the dynamics of spread of two main invasive species: *Lupinus nootkatensis* and *Anthriscus sylvestris* their future expansion possibilities and the impact of climate change on their distribution. I will also present and briefly discuss examples of emerging invasive taxa: *Senecio pseudoarnica* and *Pinus contorta*.

Invasive alien species in paradise? Nootka lupin and soil erosion.

Kristín Svavarsdóttir, Soil Conservation Service of Iceland

Nootka lupin (*Lupinus nootkatensis*) is one of very few species classified as invasive alien species (IAS) in Iceland. It was introduced around the middle of last century for soil erosion control purposes. During the first decades it was planted at various sites, but first after the Soil Conservation Service of Iceland (SCSI) started seed production around 1990 began it to be established in large areas throughout the island. Furthermore, seed was freely available to municipalities, landowners, and the public for reclamation purposes upon request. The maximum amount of lupin seed sown by the SCSI was during the period 1995-1999, approx. 1,200 ha per year. In 2018, SCSI announced that no alien species would be used in its activities, thus lupin was used by SCSI for reclamation purposes 1991-2018. Lupin research by SCSI and collaborators can be divided into two periods, the first from 1970s to 1990s consisting of studies on how to cultivate lupin and enhance its use, and the second starting in 1990s and still ongoing consisting of ecological studies including mapping approaches, and how to manage and eradicate the plant where it has invaded new areas. IAS are related to ecological restoration in two ways. Firstly, the need of a careful selection of species used in restoration to avoid the risk of it later becoming invasive and secondly restoration of ecosystems that have been invaded by IAS. In Iceland, lupin applies to both as a well-meant species introduction for soil erosion control went wrong.

Vegetation succession in *Lupinus nootkatensis* patches in East Iceland

Guðrún Óskarsdóttir, East Iceland Nature Research Centre

The introduced nootka lupin (*Lupinus nootkatensis*) has been used extensively for land reclamation in Iceland. It is classified as invasive and once colonized, it strongly influences ecological succession. For over 30 years, the Icelandic Institute of Natural History (NÍ) has monitored vegetation succession at lupin sites in North and South Iceland. Long-term vegetation changes have differed between regions and the variation has been linked to climate differences. In East Iceland, lupin has recently colonized new areas. A study like NÍ's, could increase understanding on the long-term effects of lupin in the region and help predict future succession at newly established lupin sites. Using NÍ's methodology, in 2020, we established eight sites in East Iceland. According to our results, the sites showed similarities with sites from both North and South Iceland. Vascular plant species richness and diversity decreased with increasing lupin cover. Lupin cover increased quickly in the first few years after establishment but varied greatly as it got older, presenting different successional trajectories. Where lupin had retreated, it had either been partly replaced by *Anthriscus sylvestris* or died off, possibly due to harsh environmental conditions. In the latter case, soil organic matter was low, but species richness high. Our results suggest that vegetation composition of lupin sites in East Iceland is at least partly influenced by climate, but future monitoring is needed to determine its effect on long-term succession in lupin patches.

TALKS

E1

Population regulation in fox sanctuaries: a new experience for the management of a native apex predator

Ester Rut Unnsteinsdóttir, Icelandic Institute of Natural History

The Arctic fox is the only native terrestrial mammal in Iceland and is protected according to the 1994 wildlife act (earlier foxes were not protected). Nevertheless, the Arctic fox is still hunted, as allowed by the 1994 wildlife act, and the main justification is aimed to prevent stated damage to livestock. The Arctic fox population declined 1958-1980 to a minimum of 1,200 individuals. Then increased to a peak of 9,000 individuals in 2008. This variation in population dynamics occurred despite a relatively stable hunting effort, indicating that hunting did not regulate population size. Den occupancy rate is an indicator on breeding pairs and can be used to monitor population dynamics. Arctic fox dens in two Icelandic sanctuaries have been visited regularly to gather information on occupancy. The occupancy rate of dens for the sanctuaries were compared before and after the reserves were established. These indices were compared with occupancy rate of dens between protected and hunted areas. Interestingly, den occupancy rate has since protection remained stable on both sanctuaries but has increased in hunted areas at the same time. This suggests that protecting the Arctic foxes within the sanctuaries did not increase population growth in those areas as feared by some. On the sanctuaries fox populations became stabilized and probably regulated through natural processes and carrying capacity. These results strongly suggest that wildlife management should focus less on hunting to regulate the fox population, particularly in national parks and nature reserves where livestock is not at risk.

E2

Mapping herbivore studies in the Arctic – how robust are the conclusions we can draw from our current knowledge?

E. M. Soininen, UiT–the Arctic University of Norway

I.C. Barrio, Agricultural University of Iceland

J. D. M. Speed, Norwegian University of Science and Technology

HN Systematic Map Team

Herbivores modify tundra ecosystems, but their effects vary across the Arctic and depend on where and when herbivory happens. The results of individual studies on herbivory depend on their local conditions, i.e. their ecological context. To assess the ability of these studies to produce generalizable conclusions on the effects of herbivores on tundra vegetation we need to understand how well they cover the underlying environmental conditions across the Arctic. We created a systematic map that identifies the ecological contexts in which herbivore impacts on vegetation have been studied in the Arctic. We searched for relevant literature in online databases, search engines and specialist websites, and identified 315 relevant studies with 678 evidence points (representing e.g. different ecological contexts or experiments within the same study). Our results indicate a clear geographical bias in the distribution of herbivore studies in the Arctic, with most studies conducted in northern Scandinavia. Vertebrate herbivory was addressed seven times more frequently than invertebrate herbivory, and most studies were conducted in warmer and wetter parts of the Arctic and in regions that are showing moderate responses to climate change. This uneven coverage of environmental gradients across the Arctic suggests that the current evidence base might not be sufficient to understand the effects of herbivores throughout the region. In particular, the uneven coverage of climatic contexts, with an alarming lack of studies in areas changing the most or the least in response to climate change, prevents robust generalizations about the effects of herbivores under different climatic scenarios.

E3

Long-term monitoring reveals topographical features and vegetation explain winter habitat use of an Arctic rodent

Xaver von Beckerath, University of Freiburg

Gita Benadi, University of Freiburg

Olivier Gilg, Université de Bourgogne Franche-Comté

Benoît Sittler, University of Freiburg

Glenn Yannic, Université Savoie Mont Blanc

Alexandra-Maria Klein, University of Freiburg

Bernhard Eitzinger, University of Freiburg

The quality of wintering habitats, such as depth of snow cover, plays a key role in sustaining population dynamics of arctic lemmings. However, few studies so far investigated habitat use during the arctic winter. Here, we used a unique long-term time series to test whether lemmings are associated with topographical and vegetational habitat features for their winter refugium. We examined yearly numbers and distribution of 22,769 winter nests of the collared lemming *Dicrostonyx groenlandicus* (Traill, 1823) from an ongoing long-term research on Traill Island, Northeast Greenland, collected between 1989 and 2019, and correlated this information with data on dominant vegetation types, elevation and slope. We found that the number of lemming nests was highest in areas with a high proportion of *Dryas* heath, but also correlated with other vegetation types which suggest some flexibility in resource use of wintering lemmings. Conversely, they showed a distinct preference for sloped terrain, probably as it enhances the formation of deep snow drifts which increases the insulative characteristics of the snowpack and protection from predators. With global warming, prime lemming winter habitats may become scarce through alteration of snow physical properties, potentially resulting in negative consequences for the whole community of terrestrial vertebrates.

E4

Surveying salmonid spawning grounds in Thingvallavatn: A crucial step in evaluating the effects of a changing climate

Lieke Ponsioen, University of Iceland

Benjamin D. Hennig, University of Iceland

Jónína H. Ólafsdóttir, Marine and Freshwater Research Institute

Marcos G. Lagunas, University of Iceland

Sigurður S. Snorrason, University of Iceland

Kalina H. Kapralova, University of Iceland

Climate regimes are expected to change more dramatically at higher latitudes over the next few decades and this will undoubtedly affect Iceland. The surface temperature of Thingvallavatn has been rising since the 1960s and the lake has further been impacted by various anthropogenic factors (e.g. influx of tourism). Two salmonid species, Arctic charr (*Salvelinus alpinus*) and brown trout (*Salmo trutta*), reside in the lake. Both species require not only stable low temperatures for their successful embryonic development, but also a flow of oxygen-rich surface or groundwater and specific substrate characteristics that limit the number of available spawning sites. Locating, monitoring and preserving these salmonid spawning areas are thus essential for their very existence. The spawning grounds are often located in streams and shallow areas of lakes which make them detectable from the air. Here, we mapped the well-studied Arctic charr spawning grounds within the boundaries of the Thingvellir National Park (Ólafsdráttur) using an UAV (drone) and a remote sensing protocol. We then verified that these were indeed spawning grounds by performing an exploratory dive, collecting embryos and genotyping them using a ddRADseq method. By comparing data from the embryos with ddRADseq data from samples of adult brown trout and Arctic charr it was confirmed that the collected embryos belonged to Arctic charr. The remote sensing protocol we developed can now be used without any further verification steps to map and monitor salmonid spawning grounds. Furthermore, it can be applied anywhere and by everyone using commercially available and affordable UAVs.

E5

Changes in salmonid communities of Lake Thingvallavatn – how stable and resilient are they?

Sigurður S. Snorrason, Háskóla Íslands

Fia Finn, Háskóla Íslands

Finnur Ingimarsson, Náttúrufræðistofu Kópavogs

Haraldur R. Ingvason, Náttúrufræðistofu Kópavogs

Han Xiao, Háskóla Íslands

Kalina H. Kapralova, Háskóla Íslands

Lieke Ponsioen, Háskóla Íslands

Marcos Lagunas, Háskóla Íslands

Stefán M. Stefánsson, Náttúrufræðistofu Kópavogs

Lake Thingvallavatn is renowned for its salmonids, the four morphs of Arctic charr and the iconic brown trout that can grow rapidly to a very large size. How stable and resilient are these communities? While the physiochemical characteristics of the lake suggest stability of the ecological underpinnings of the fish communities, various written and oral records of catches by farmers and anglers suggest that the fish communities might be dynamic. Catch records only cover adult trout and two of the four charr morphs. To get a better overview of changes in the status of the salmonid community we need comprehensive monitoring of juveniles and adults of trout and all four morphs of Arctic charr. Here we compare data of habitat-wide surveys of adult and juvenile salmonids from 1984 and 2019. The data show that the trout population has made a dramatic recovery. In 1984 only 2 trout were found in a sample of 2417 fish (0.08%) caught in the benthic habitats. In 2019 313 trout were found in a sample of 1227 fish (25.5%). Most of these trout (211) were juveniles and caught at one station near the outflow of the river Ölfusvatnsá, indicating their native origin from spawners in that river. The reasons for the resurrection of the trout and the possible effects on the different charr morphs are not known but will be discussed with respect to the new survey data. The comparison of surveys clearly illustrates how monitoring surveys must cover both temporal and regional aspects of variation in fish density.

E6

Re-assessing Iceland's Biodiversity

Anthony James Schultz, Icelandic Museum of Natural History

Ester Rut Unnsteinsdóttir, Icelandic Institute of Natural History

Tomas Grétar Gunnarsson, University of Iceland Research Centres

Filipa Samarra, University of Iceland Research Centres

Camille Leblanc, Hólar University

Bjarni Kristófer Kristjánsson, Hólar University

Hilmar Malmquist, Icelandic Museum of Natural History

Skúli Skúlason, Hólar University and Icelandic Museum of Natural History

Here we will introduce a new large-scale research project led by the Icelandic Museum of Natural History in collaboration with other institutions.

Icelandic habitats and biodiversity are unique, due to the location and climatic, geological, and biological history of the island. The combination of relatively low species diversity with steep habitat gradients allows for novel ecological opportunity – the availability of ecological resources which may promote rapid organismal evolution and adaptations. This may drive increased intraspecific phenotypic and genetic variation within Icelandic species. Such processes are not unique to Iceland and may be found in regions which drive the creation and maintenance of species diversity and are thus important for biodiversity conservation. Furthermore, intraspecific variation can contribute to ecosystem function as much as species diversity. However, intraspecific variation is typically overlooked in the educational system and policy regarding biodiversity conservation and resource use. It is important to provide accurate, comprehensive education on biodiversity concepts to the public, and provide relevant information for policymakers to develop effective conservation/resource utilisation policy. The overarching objective of this project is to gather, analyse, and present the existing scientific knowledge of biological diversity in Iceland, using a process-driven lens, in a way that can be understood and applied to education and policy. This includes a systematic review of the degree/kind of intraspecific variation within Icelandic species (starting with vertebrates as a first step), and a meta-analytic approach to investigate whether common patterns exist between environmental characteristics and intraspecific diversity levels across Icelandic taxa.

E7

Community structure in tundra ponds in central Iceland

Gísli Már Gíslason, Institute of Life and Environmental Sciences, University of Iceland, Reykjavik, Iceland

Udo Halbach, Zoological Institute, Johann Wolfgang von Goete Univeristät, Frankfurt am Main, Germany

Günter Flechtner, Zoological Institute, Johann Wolfgang von Goete Univeristät, Frankfurt am Main, Germany

Tundra ponds in Thjórsarver oasis, central Iceland, 600 m a.s.l. were studied in 1972 and 1974.. They are small, < 1 m deep in wetlands, with extensive permafrost palza mounts. They were ice covered, or frozen solid, from October to May. Communities differed in barren moraine ponds near the glacier from those in vegetated wetlands (*Carex* spp.). Species diversity was lower than in lowland ponds in Iceland. Trophic structure was simple. Aquatic vegetation was dominated by sedges and mosses, plankton communities were dominated by calanoid copepods and cladocerans and benthic fauna by midges, annelids, subarctic caddis larvae, *Lepidurus arcticus* and several other invertebrate groups.

E8

Spatial temperature and precipitation gradients predict ten year shift in community trait composition

Ragnhild Gya, Department of Biological Sciences and the Bjercknes Center of Climate Research, University of Bergen, Norway

Brian J. Enquist, Ecology and Evolutionary Biology, University of Arizona, USA

Francesca Jaroszynska, Department of Biological Sciences and the Bjercknes Center of Climate Research, University of Bergen, Norway

Kari Klanderud, Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Ås, Norway

Vigdis Vandvik, Department of Biological Sciences and the Bjercknes Center of Climate Research, University of Bergen, Norway

With climate change we are already observing shifts in biodiversity, ecosystem functioning and services. Functional traits can give a mechanistic understanding of how plant communities change with climate change. To understand how alpine and boreal grasslands respond to climate change we surveyed functional traits across temperature (6.5 to 10.5°C summer temperature) and precipitation (600-3000 mm per year) gradients, and species composition change over 10 years. We used the trait driver theory, with community weighted means and skewness of traits linked to the leaf economic and size spectrum to understand shifts along the climate gradients and in time. Our results mirror global patterns distributing community traits in the leaf economic and size spectrum. Our analyses show that most traits shift with both temperature and precipitation, but these patterns are context dependent. We find the tallest plant communities in warm and dry climates and resource conservative plant communities in cold and wet climates. With a warmer climate we expect a shift to taller, larger-leaved plant communities with more resource acquisitive leaves. However, in areas of high precipitation, further increases in precipitation could act as a stressor, which results in a shift towards resource conservative leaves. Over the ten-year period we observed few significant trait shifts, but most temporal trait shifts were in the same direction as the spatial trait shifts. The traits that show the most shift in time also have the largest skewness, indicating an ongoing shift from one optimum to another. Our results indicate these grasslands are already shifting, slowly.

E9

Unveiling the myrmecofauna (Hymenoptera: Formicidae) of Iceland. A survey of invasive ant species diversity and distribution

Marco Mancini, University of Iceland

Almost the entire Icelandic fauna had to colonize Iceland after the last glacial period, and its location and climate do not make it particularly conducive for colonization. The increased travel and international trade in the last century opened the floodgates for alien species to settle on the island. The research seeks to explore the diversity and distribution of the alien myrmecofauna that have settled in Iceland in the last decades, both outdoors and indoors, with particular emphasis on the Greater Reykjavík area. Several ant species are among the most harmful invasive organisms and may have devastating impacts on the environments in which they are introduced. A few ant species have been recently found in Iceland, but knowledge about their distribution is incomplete. We analyzed data previously collected by the Icelandic Institute of Natural History. Besides, by raising public awareness and implementing protocols for citizen science and pest control agents that operate in the Greater Reykjavík area, we collected new data and specimens and shed light on the dispersion of alien ant species around Reykjavík. The research forms an indispensable contribution towards understanding the spread of invasive ants in a subarctic environment.

E10

Promoting greater awareness and understanding of biodiversity in Iceland

Skúli Skúlason, Department of Aquaculture and Fish Biology, Hólar University and Icelandic Museum of Natural History

Christophe Pampoulie, Marine and Freshwater Research Institute

In October 2020 a group of biologists participated in an online workshop organized by the European Molecular Biology Laboratory (EMBL) in order to explore collaboration opportunities. One of the conclusions from this meeting was that Iceland has important properties to serve as a case study for the world for the generation, management and conservation of biological diversity. This motivated the participants to stay in touch and develop what now has become a network of scientists and institutions in Iceland with the common goal of promoting research, greater awareness and understanding of biodiversity in Iceland. This objective reflects the growing need to meet the global challenges of the massive loss of biodiversity worldwide and associated ecosystem degradation. The network has agreed on a joint statement that identifies three main pillars targeting 1) research, 2) the transfer of knowledge to education and policy for conservation and management, and 3) capacity building. Here, we will introduce and explain this initiative and invite others to join the network.

SHORT TALKS

S1

Machine learning for entomological discovery

Thomas Y. Chen, The Academy for Mathematics, Science, and Engineering

Many technical methods have been used to gain insights into insects over time, but recently, machine learning, deep learning, computer vision, and data mining have increasingly been utilized to obtain novel results. For example, machine learning-based sensor technology enables organism classification opportunities. Computational entomology has already yielded many results that would have been impossible without big data analysis techniques, and this emerging field has great potential in the future. These methods can be leveraged to assess populations in an accurate and efficient manner, leading to more effective conservation practices. In this talk, we explore recent work in this burgeoning field. Specifically, the author delves into his work regarding a novel imagery dataset for computer vision classification of monarch butterflies. As the populations of this species declines, it is crucial that AI methods are in place to track trends.

S2

Morphological and molecular characterization of adult hairworms (Phylum Nematomorpha) from Iceland and the Faroe Islands, and documentation of their non-adult stages and hosts

Christina Anaya, University of Nebraska-Lincoln

Kurt E. Galbreath, Northern Michigan University

Matthew G. Bolek, Oklahoma State University

No species of freshwater Nematomorpha have been described from Iceland, but they have been identified anecdotally. Recent surveys in Iceland using freshwater gastropods as biodiversity indicators resulted in the collection of adult freeliving hairworms and their non-adult stages including cysts in snail paratenic hosts and juvenile worms in ground beetle definitive hosts. Additionally, specimens acquired from the Icelandic Institute of Natural History indicate nematomorphs are common in Iceland. A single specimen from the Faroe Islands National Museum represents a new species record. Our morphological and molecular characterization indicated all the samples belong to the species *Gordionus wolterstorffii*, a common nematomorph found throughout Europe. Also, we provide the first descriptions of the cyst stage for the genus *Gordionus*. Molecular phylogenetic analysis based on 10 species of *Gordionus* and one species of the closely related genus *Parachordodes* indicates that *Gordionus* is not monophyletic. Combining our morphological and phylogenetic investigations, we discuss the lack of clarity in diagnostic morphological characters and the need for additional global collections to clarify the taxonomy of *Gordionus*.

S3

Migration and non-breeding distribution of Icelandic Oystercatcher *Haematopus ostralegus* as revealed by ringing recoveries and colour-ring sightings.

Sölvi Rúnar Vignisson, Suðurnes Science and Learning Center and University of Iceland

Böðvar Þórisson, The University of Iceland's Research Centre in South Iceland

Verónica Méndez, University Centre of the Westfjords

Jose Alves, University of Aveiro

Jennifer Gill, University of East Anglia

Jörundur Svavarsson, University of Iceland

Tómas Grétar Gunnarsson, The University of Iceland's Research Centre in South Iceland

In order to understand the demographic causes and consequences of migration on individuals across populations, information on the migration and wintering distribution has to be established. Factors such as winter site quality and conditions or distance from breeding ground can have an effect on fitness and timing of laying during breeding [Carneiro2021;Anderson2019]. Individual marking is the traditional and go to method for studying individual movement and gathering information on migratory routes and wintering sites of animals. This method is still used and provides invaluable data on bird migration despite its well-known biases in re-encounter probabilities [Thorup2014]. The first metal ring recovery of a Oystercatcher *Haematopus ostralegus* marked in Iceland was in Wales 1935 but a systematic analysis of both metal and colour-ring recoveries and sightings of Icelandic Oystercatchers abroad has not previously been undertaken. The Icelandic Oystercatcher is of the subspecies *ostralegus* that occurs on the coastal areas from the Wadden Sea to Brittany, as well as Iceland and few sites in the Mediterranean [VandeKam2004]. The Icelandic population is estimated at 13 000 breeding pairs [Skarphedinsson2016] or, based on juvenile survival, 37 000 individuals in mid-winter [Þorisson2018]. The population is partially migratory where a third are residents in Iceland during winter and two thirds are thought to migrate to western Europe [Þorisson2018]. This is the first formal account of ring recoveries and sightings of Icelandic Oystercatchers outside of Iceland.

S4

Serenade of a whimbrel: using acoustic monitoring to investigate display behaviour

Maite Cerezo-Araujo, South Iceland Research Centre, University of Iceland, Laugarvatn, Iceland.

Gunnar Þór Hallgrímsson, Institute of Biology, University of Iceland.

Böðvar Þórisson, South Iceland Research Centre, Laugarvatn, Iceland.

José Alves, Department of Biology, CESAM, University of Aveiro, Aveiro, Portugal. South Iceland Research Centre, University of Iceland, Laugarvatn, Iceland.

Tómas G. Gunnarsson, South Iceland Research Centre, University of Iceland, Laugarvatn, Iceland.

Animal sounds contain important information used in intra- and inter-species communication that may entail cues on an individual's fitness. Display calls emitted during the breeding season have traditionally been associated with two functions: repelling rivals and attracting mates. The distinction between the two strategies relies among other factors, on the frequency at which display calls occur given local densities of the species emitting these signals, and the time of the breeding season on which they occur. Most waders exhibit elaborate displays consisting of energetically expensive aerial flights accompanied by a call, therefore indicating the behavioural strategy for communicating is honest and does not function to trick conspecifics. Here we investigate the frequency of display calls in Icelandic whimbrels across varying breeding densities in order to test which of these two functions is better supported by patterns of display behaviour. To do so, we surveyed 12 study sites located in the lowland plains of south Iceland using automatic sound recorders and field point-counts where the number of display calls was recorded. Preliminary results from the field seasons 2019 and 2020 indicate a higher frequency of display calls at low whimbrel densities, suggesting this behavioural strategy is likely used for mate attraction rather than for territorial defence.

S5

Cortisol and toxin levels in stranded Long-finned pilot whales (*Globicephala melas*) in Iceland

Nicholai Xuereb, Faculty of Life- and Environmental Sciences, University of Iceland

Edda Elísabet Magnúsdóttir, Department of Life- and Environmental Sciences, University of Iceland

Kristín Ólafsdóttir, Faculty of Medicine, University of Iceland

Filipa Samarra, University of Iceland's Research Centre in the Westman Islands

Gísli Víkingsson, Marine and Freshwater Research Institute

Jörundur Svavarsson, Faculty of Life- and Environmental Sciences, University of Iceland

Long-finned pilot whales (*Globicephala melas*) are the most commonly stranded cetaceans in the world. However, the predominant drivers of these events are still poorly understood. Previous study on smaller stranded odontocetes has shown a correlation between cortisol levels and morphometric indices (mass/length²) where whales in worse body condition had higher cortisol levels on average. Thus, cortisol levels may indicate the animal's health prior to stranding. Cortisol is a steroid hormone produced diurnally and is highly elevated during acute and prolonged stressful conditions. This hormone is partially deposited into the blubber layers where it accumulates longer than in the circulatory system. Quantification of cortisol in both free-living and stranded *G. melas* has not been published before. This study aims to quantify blubber cortisol levels in stranded pilot whales from NE-Iceland and compare them to physical factors and levels of accumulated toxins in their blubber. Hormones were extracted from the full blubber layer and the cortisol levels quantified using an enzyme-linked immunosorbent assay. Preliminary results indicate highly elevated cortisol concentrations for the pilot whales which is up to sixfold the average amount measured from free swimming individuals. Body length, age group, and total blubber thickness did not seem to have any effects on the cortisol levels while there are indications of sex differences. There is a clear evidence of a cortisol concentration gradient within the blubber layers, with highest levels in the bottom layers. Further toxicology analysis will be implemented and compared with cortisol levels. The study can, thus, provide deeper insight into whether cortisol levels could be used as a tool to assess the health of stranded and free ranging pilot whales.

POSTERS

P1

Ecological genomics predict climate vulnerability in a lichen symbiosis.

Denis Warshan, University of Iceland

Philipp Resl, University of Munich

Hörður Gudmundsson, University of Iceland

Zophonías O. Jónsson, University of Iceland

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Warming in the Arctic is nearly twice the global rate and has already altered Arctic living communities with feedbacks on ecosystem functioning. Yet, we lack understanding on the potential for climatic adaptation in organisms that are driving Arctic's carbon and nutrient dynamics. Lichens play a key role in cold biomes where dinitrogen fixation by their cyanobacterial partner can contribute greatly to ecosystem productivity. For symbiotic species such as tripartite lichens formed by a fungus, a green alga and a cyanobacterium, the spatial genetic heterogeneity of each partners can shape the ability of the lichen to respond to rapid climate change. Here, we use ecological genomics to assess the genetic potential for adaptation to rising global temperature and precipitation changes for each of three symbiotic partners forming the widespread lichen *Peltigera leucophlebia* in Iceland. Using genotyping by sequencing, we assessed genetic variation in populations across Iceland. We found that patterns of genetic variation are better explained by environmental than geographic distances, and that the lichen partners seem to show a co-evolutionary response to climatic conditions. The spatial patterns of genetic variation of the fungal host were most strongly associated with precipitation, in contrast to the cyanobacteria where genetic variation was mostly correlated with differences in temperature. Genome-wide association analyses detected links between climate-associated genotypes and specific genes in each of the partners, indicating some degree of local functional adaptation to climate. Our results suggest that the three partners may respond differently to climate change and call for management of this species.

P2

Rhizosphere influence on soil microbial biomass and enzyme activity in banj oak, chir pine and banj oak regeneration forests in the central Himalaya

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Rhizosphere plays a significant regulatory role in soil microbial biomass, enzyme activity, nutrients and varies with tree species. Most studies focus on soil nutrients in central Himalaya. However, little is known about belowground processes associated with rhizosphere soil, like soil microbial intact nutrients, SOC, and nutrients in the rhizosphere of broadleaf (banj oak), conifers (chir pine) and naturally regenerated of banj oak tree species. Fumigation extraction method was used to estimate soil microbial biomass. Principal Component Analysis (PCA) was performed to obtain the rhizosphere soil microbial index (RSMI). Rhizosphere soil has significantly ($p < 0.05$) higher soil microbial biomass, enzyme activity and nutrients over the bulk soil. Rhizosphere soil microbial biomass and nutrients differed significantly with the forest types. Among the studied forest banj oak forest has higher rhizosphere magnitude of soil microbial biomass followed by chir pine and minimum in banj oak regeneration forest. RSMI values indicate soil biological properties were important to evaluate rhizosphere soil quality. Root that exudates organic compounds may stimulate the growth of soil microbes. Banj oak forest with high soil nutrients and fine root biomass exerts more rhizosphere effect than the chir pine and banj oak regeneration which has less nutrients. Regeneration of banj oak in chir pine improves the soil properties through the enhancement of moisture, SOC, nutrients and soil microbial biomass.

P3

Mapping alien plant species in urban areas: an example of open green spaces in Reykjavik, Iceland

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Invasive species threaten urban biodiversity and cities can become hubs for alien species invasions, therefore, highlighting the need to monitor urban biodiversity and alien species. In Reykjavik, Iceland, identifying and mapping invasive species is a part of the city's biodiversity strategy. Cow parsley (Skógarkerfill = *Anthriscus sylvestris*) and sweet cicely (Spánarkerfill = *Myrrhis odorata*) are alien plants spreading in Iceland and becoming a concern in urban areas, but their distribution in Reykjavik has not been mapped before. This study aimed to map the distribution of cow parsley and sweet cicely in open green spaces of Reykjavik. We conducted summer surveys from 2017-2019 using AllTrailsPro and ArcGIS mobile applications. Overall, cow parsley covered 0,51% (139,5 ha) and sweet cicely 0,02% (5,4 ha) of the total land cover of the city (273 km²). A total of 2026 cow parsley communities were identified in Reykjavik, varying in size from <1 m² land cover (1-3 plants) to a significantly large 12,9 ha sized community with thick density of the plant species. Cow parsley was most abundant near pathways, riversides, lakes, and streams. Sweet cicely was less prevalent, with 212 records, and covering ≤1 ha in all study areas and with the largest distribution in Laugarnes. The plant species were seldom recorded growing in close vicinity of each other. Long-term monitoring as well as testing and adopting multi-approach techniques via adaptive management is recommended to manage their distribution and that of other invasive species.

P4

Nitrogen fixation and bacterial communities associated with *Racomitrium* mosses during primary succession in the Fláajökull glacier forefield

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Mosses are among the first colonizing organisms after glacier retreat and can develop into thick moss mats during later successional stages. They are key players in nitrogen fixation through their microbiome, which is an important process for nutrient build-up during primary succession. How these moss-microbe interactions develop during succession is not well-studied and is relevant in the light of climate change and increased glacier retreat. We examined the bacterial communities of two moss species of the genus *Racomitrium* and the underlying substrate along a successional gradient in the glacier forefield of Fláajökull in southeast Iceland. In addition, we measured N₂-fixation rates and nitrogen fixing bacterial abundance and moss characteristics, such as carbon (TC) and nitrogen content (TN). We found that moss TC increased with soil age, while moss TN and N₂-fixation rates did not show any trends with soil age. N₂-fixation rates were affected by changes in the moss-associated bacterial community composition and nifH gene abundance. Soil age and moss C:N ratio accounted for variation in the soil bacterial community. The moss bacterial community however was more strongly affected by soil age and additionally by moisture content. Our results suggest that the successional stage influences the bacterial communities of mosses and underlying soils. In addition, moss traits can influence the bacterial community composition of the moss itself, but also the bacterial community composition of the underlying soil. N₂-fixation rates seem to be dependent on the bacterial community composition, rather than TN content of the moss.

P5

Impacts of dioecious woolly willow on soil processes

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An ecosystem engineer is a species that causes changes in the biotic or abiotic environment, modulating habitats and resource availability for other species, often in a beneficial way. In grasslands and heathlands, isolated shrubs alter microclimate and light conditions, and their fungal symbionts are capable of modifying soil environments. We have examined ways in which woolly willow (*Salix lanata*, loðvíðir), a medium-sized deciduous and dioecious shrub and one of Iceland's most widespread woody species, may act as an ecological engineer. Here we report on its impact on belowground processes. A standardised approach (Tea Bag index) was used to measure decay rates and stabilisation of organic soil material around woolly willow shrubs during the 2019 and 2020 growing seasons. Two contrasting field sites were selected; the early successional outwash plain Skeiðarársandur (80 m a.s.l.) and a moss-rich willow heathland on Skaftafellsheiði (380 m a.s.l.). Teabags were buried along a gradient from each individual: at their centre, at 20 and 50 cm away from their perimeter and at control points >2 m away from any visible shrub. Decomposition and stabilisation factors declined with increasing distances from the willow bushes at both sites, with significant drops when leaving the influence of the rhizosphere. Interestingly, even though female shrubs were on average smaller than males, they were associated with higher decomposition rates at both sites, possibly suggesting increased microbial activity around female willows.

P6

Vegetation as an indicator of long term water level in four drained wetland sites

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Wetlands provide a variety of ecological services. They are f.e. important habitats for many bird species and store a large amount of organic carbon in soil. Wetlands in Iceland have been drained extensively, in particular between 1942 and 1993 when around 33 000 km of ditches were dug. Following drainage, and the subsequent lowering of the water table, properties and functions of the ecosystems are also altered. The vegetation composition commonly changes and the cover of dryland species generally increases at the expense of wetland species over time. Wetland vegetation is known to be largely controlled by water level which itself is a good indicator of other ecosystem functions. In our study vegetation was mapped at four drained sites in S-, W- and N-Iceland. At the sites vegetation composition was measured and water level was monitored manually in permanent monitoring plots for two years. Overall, vegetation seems to be a good predictor of the sites long term water level.

P7

Characterizing carbon dynamics in degraded tundra soils

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Tundra rangelands in Iceland have experienced extensive degradation and ecosystem collapse. The main driver is land use combined with volcanic activity, andosol features and a subarctic climate, that make the ecosystems vulnerable to overgrazing by livestock. The most obvious sign of degradation is reduced plant productivity, but less is known about soil dynamics, such as microbial community composition and its potential functional response to change in soil organic carbon stock and other nutrient substrates. In this study, soil properties and microbial communities were investigated in two different stages of degradation in tundra landscapes grazed by sheep in summer, a *Betula nana* heath and a highly degraded stage, a gravel desert. We investigated grazing exclusion experiments at two comparable geographical sites in the highlands, Þeistareykir and Auðkúluheiði, inside and outside the active volcanic zone. All measured soil properties (SOM, C/N ratios and CO₂ fluxes) were significantly lower in the gravel desert than in the *Betula nana* heath at both sites. For the *Betula nana* heath all variables were significantly higher inside the active volcanic zone. Four to five years of sheep grazing exclusion did not affect any soil parameters. The next step is to investigate if and how variation in soil properties is related to soil microbial communities and the relative abundances of functionally important genes related to carbon flow in soil systems. To analyze the microbial communities and their carbon related functionality we use high throughput shotgun metagenomic sequencing (work in progress).

P8**Lífsögbreytur hjá ólíkum vaxtarformum birkis***Benedikt Traustason, Háskóli Íslands*

Breytileiki í vaxtarformi íslensks birkis (*Betula pubescens*) spannar allt frá beinvöxnum einstofna trjám til kræklótttra, margstofna runna. Rannsóknir hafa sýnt að vaxtarhraði trjá-birkis er almennt hærri en kræklubirkis en lítið er annars vitað um hvort eða hvernig vaxtarformin endurspeglast í ólíkum lífsögbreytum. Markmið þessarar rannsóknar er að bera saman stofn- og æxlunarlíffræði þriggja birkistofna sem vaxa í svipuðu loftslagi en á ólíku undirlendi (hæð yfir sjó og elsta tré í úrtaki í sviga): 1) ungur beinvaxinn stofn í grýttri fjallshlíð vestan við Núpsstað (50-80 m, 22 ára), 2) eldri stofn kræklubirkis á hrauni við Leiðvöll (40-60 m, 41 árs) og 3) ungur beinvaxinn stofn á jökulaurum á Skeiðarársandi (70-80 m, 27 ára). Hér verður greint frá frumniðurstöðum fyrir stofnana við Núpsstað og Leiðvöll. Ársvöxtur (2018-2020) var mældur á lengsta sprota, mesta hæð og lengd mæld, og fjöldi rekla og stofna talinn á 25 tilviljanakennt völdum trjám á hvoru svæði. Trén voru felld, lífmassi ofanjarðar metinn sem þurrvigt trjákenndra vefja og aldur ákvarðaður með talningu áhringja við rótarhál. Þrátt fyrir hærri meðalaldur stofnins við Leiðvöll, var ofanjarðarlífmassi meiri við Núpsstað (562 ± 162 g, Leiðvöllur = 222 ± 40 g; $\bar{x} \pm$ staðalskekka meðaltals). Ársprotavöxtur við Núpsstað ($12,9 \pm 0,8$ cm/ári) var hár miðað við birt meðaltöl fyrir íslenskt birki en þau eru frá síðustu öld. Birkið við Núpsstað óx mun hraðar en Leiðvallarbirkíð ($8,9 \pm 0,8$ cm/ári). Á Leiðvelli var marktækt neikvætt samband milli vaxtar og fjölda rekla sem við túlkum sem fórnarskipti milli nýtingar auðlinda til vaxtar vs æxlunar. Það kom hins vegar á óvart að þetta samband var jákvætt hjá Núpsstað.

P9**The beetle fauna of the island of Koltur and a new record for the Faroe Islands***Agnes-Katharina Kreiling, Faroe Islands National Museum**Leivur Janus Hansen, Faroe Islands National Museum*

Koltur is a small (2.5 km²) island located in the central part of the archipelago of the Faroe Islands. Apart from its two permanent inhabitants and the currently 160 sheep grazing on the island, there is relatively little human influence. Despite its small size, a variety of habitats occur on Koltur, such as steep mountain slopes, wetlands, grasslands, sea bird colonies, rocky shores, and a unique beach with a high proportion of shell sand. Extensive pitfall trap sampling on Koltur conducted in June/July 2019 and 2020 revealed at least 42 species of Coleoptera, which represents around 23% of the known beetle fauna of the whole country. The majority of them belong to the beetle families Carabidae and Staphylinidae. The most abundant species were *Loricera pilicornis*, *Patrobus septentrionis* (both Carabidae), *Tachinus rufipes*, and *Quedius nitipennis* (both Staphylinidae). Also widespread but less numerous were *Nebria salina*, *Notiophilus biguttatus*, *Trechus obtusus* (all Carabidae), *Stenus brunripes*, *Othius angustus*, and *Cypha laeviuscula* (all Staphylinidae). Species were not evenly distributed over the island, but their distributions reflected different habitat types and altitudes in line with their reported ecology. Among the beetles collected in Koltur was a new record for the Faroe Islands, the dung beetle *Aphodius borealis* (Scarabaeidae, Aphodiinae). Fifteen individuals of *A. borealis* were collected from sheep dung in 2019 and the species was given the Faroese name Norðurtøðklukka.

TALKS

E11

Is mitogenomic variation in White-tailed eagles maintained due to selection on sex chromosomes?

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A clear phylogeographic pattern has been observed in White-tailed eagles throughout the species' range from Greenland, across Europe and Asia, based on the variable control region in mitochondria. In Iceland and Greenland two haplotypes were found, one common in NW-Europe and the other, separated by a single base pair mutation, was endemic to the islands. In a recent study on variation of the whole mitochondria from Greenland, Iceland, Norway, Denmark and Estonia we obtained similar patterns. However, two distinct lineages were observed within countries despite small population sizes and haploid genomes of the mitochondria. As bird mitochondria are transmitted with the W-chromosome, any form of balancing selection including inbreeding avoidance, which could maintain variation on the W, e.g. due to certain genotypes Z_i/W_j in the females having high fitness could contribute to the maintenance of the mitochondria lineages. Such selection could act on genotypes at the pseudoautosomal regions (PAR) or in the homologous non-recombining regions in W. Such a linked effect is predicted to be more likely in smaller populations, such as in raptors, due to lower recombination rates. Analysis of phylogenetic trees of Z- and W-chromosomes show similar dichotomy within countries as the mtDNA, but differ from the tree based on the autosomal chromosomes, where time to common ancestors within countries are short. Population patterns based on non- or low recombining regions should be interpreted with caution as such markers can be affected by selection at linked loci and there is a need to consider independent markers.

E12

Unleashing of cryptic genetic variation by environmental challenges and genetic assimilation studied at level of gene expression

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Variation in environment can influence development and destabilize phenotypes. This exposes cryptic genetic variation upon which natural selection can act and potentially lead to assimilation of environmentally exposed phenotypes. This theory rests on work by Waddington and Patton, which applied heat-shock to fly pupae that developed into adults with wings that crossvein defects. They showed that artificial selection can increase the frequency of crossveinless phenotypes in populations and that it could be genetically assimilated. We ask what are the molecular basis of these phenomena? And does selection alter expression in other tissues during development? A wild-type population of *Drosophila melanogaster* was subjected to heat-shock during development, and populations selected, either for or against crossveins. Replicate populations underwent artificial selection on these phenotypes, for 20 generations. Transcriptome libraries were prepared from wing-discs and brains of 3rd instar larvae, sequenced on Illumina HiSeq2500 platform, mapped and counted with Kallisto and analyzed with DEseq2.

In the wing disc, about 100 genes were differently expressed between the crossveinless and control groups. There was notable expression overlap between the crossveinless populations and assimilated lineages. We report on the expression divergence in the larval brain also. In conclusion, environmental perturbation and artificial selection exposed cryptic genetic variation in wild populations, that while overlapping also differ substantially between replicates. This has relevance for our understanding of how natural populations respond to abiotic and biotic environmental changes and insults.

E13

Molecular signatures of canalisation unravel Arctic charr evolution

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Populations adapting to novel ecological niches (like fish diverging between benthic and pelagic feeding habitats) experience a loss of phenotypic variability, a double-edged sword that enables the evolution of adaptive traits at the cost of missing ecological opportunities. This suppression of variability is often the result of canalisation, the buffering of developmental mechanisms, which remains poorly understood. By uncovering phenotypes that cannot be observed with traditional approaches, gene expression studies now provide new insights into canalisation and its ecological implications. We investigated whether variability in gene expression (signatures of canalisation) differs between populations subjected to contrasting selective regimes, such as habitats with more or less stable environmental conditions. We conducted a common garden experiment to study gene expression during embryonic development in a benthic and a pelagic Arctic charr morph (*Salvelinus alpinus*) from lake Thingvallavatn. We expected the offspring of the two morphs to differ in gene expression variability at major stages of head shape development. While we did not observe differences between morphs in the overall variability of gene expression, we discovered numerous clusters of genes with conserved expression or with less expression variability in one morph or the other (e.g. underlying more constrained ossification in the benthic morph or less variable endothelial development in the pelagic morph). This study provides a complex picture in which canalisation levels may be trait specific rather than a general characteristic of organisms.

E14

Intraspecific variation in brain size and shape in Arctic charr (*Salvelinus alpinus*) juveniles from streams or lakes

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In a range of taxa, larger brains have been associated with higher cognitive capacity. In fishes, some evidence have been found that variation in brain size and morphology is associated with environmental complexity and/or diet. Here we tested the hypothesis that brain shape and size of juvenile Arctic charr differ among divergent populations of Arctic charr. We studied five populations having different reproductive strategies, two spawning in streams (an anadromous population and the silver morph of Lake Vatnshlíðarvatn) and three spawning within lakes (large benthic and pelagic morphs from Þingvallavatn, and brown morph from Vatnshlíðarvatn). Fish from known parents were raised individually in common garden for a year. Geometric morphometrics were used to characterise shape variation of the left half of the brain of 160 individuals. The results showed considerable variation in size and shape of brain and different allometric relationships between brain size and fish size among populations. Fish in streams had larger brains and retained an allometric relationship between fish size and brain size. Stream fish had more elongated brain with more streamlined frontal area and cerebellum, but a larger rounded optic tectum, in comparison to fish emerging in lake. Although size, morphs and family significantly affected brain shape, a large amount of variation in shape was not explained by any of these factors. The extent of intraspecific genetic variation in brain size and shape in this study likely reflects the evolutionary history of polymorphic Arctic charr, and local genetic adaptation to contrasting niches (habitat and/or diet).

E15

DNA methylation in Arctic charr: Epigenetics to explain resource polymorphism

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Arctic charr (*Salvelinus alpinus*) is a polymorphic cold-water fish species belonging to the Salmonidæ family. In Iceland, *Salvelinus alpinus* is found in many places, but in Lake Thingvallavatn it displays remarkable morphological variation, in particular in terms of head and trophic apparatus development. Our group has been working on understanding the reasons behind these morphological differences for years, and recently interesting gene expression differences were found between phenotypically different populations. To study the developmental roots of phenotypic diversity and add a new dimension to the studies of Arctic charr differentiation, the aim of this project was to study DNA methylation differences between the 4 morphs present in Thingvallavatn.: Small Benthic (SB), Large Benthic (LB), Planktivorous (PL) and Piscivorous (PI). DNA methylation between 4 early developmental stages was also investigated. Our results show a clear difference in DNA methylome between time point and between morphs, mainly between the limnetic and benthic ones. qPCR analysis was performed to investigate the expression of genes located close to those differentially methylated regions (DMR) and correlations between methylation and expression were drawn. Surprisingly, DMRs showed an enrichment in functional RNA sequences, mainly tRNA and rRNA which shows a possible methylation-based regulation of those molecules in this model.

E16

The dynamic ontogenetic patterns of adaptive divergence and sexual dimorphism in Arctic charr

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Polymorphic and sexually dimorphic populations can be the outcome of natural, sexual and/or ecological sexual selection acting on available phenotypic variation. Although recent adaptive radiations have served the literature to understand the origins of polymorphic populations, the interplay between adaptive and sexual traits and their dynamics during ontogeny have been overlooked.

In this study, we aimed to determine the factors driving genetically-based variation of morphological traits associated with sexual dimorphism and adaptations to benthic-limnetic ecological niche utilisation. To achieve this, we focused on two of the four morphs of Arctic charr in Thingvallavatn, an iconic example of resource polymorphism along the benthic-limnetic axis. In a common-garden setup, crosses of the small benthic and the planktivorous (limnetic) morphs and their reciprocal hybrids were studied with geometric morphometrics tools across ontogeny, including the onset of sexual maturation.

We found that growth is the main driver of shape variation across time and provided evidence of a genetically-controlled ontogenetic shift that gives rise to the limnetic morph. Additionally, our results indicate that the onset of sexual maturation triggers differences in both sex ontogenetic trajectories and static shape variation at different time points, likely dissipating the canalisation of traits traditionally associated with benthic-limnetic adaptation. The interplay between traits linked to benthic-limnetic adaptation and sexual dimorphism seems to be complex and dynamic during ontogeny.

E17

Correspondence of morphological divergence across genotypes in response to diet follows evolutionary divergence of ecologically specialized morphs

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High degree of developmental plasticity has been hypothesized to enable certain species to radiate into multiple subpopulations or ecomorphs. Arctic charr (*Salvelinus alpinus*) is a widespread, highly plastic and polymorphic organism displaying significant diversity in body size, morphology, diet, life history, and behaviour throughout its range. Following the arrival of Arctic charr in Iceland approximately 10,000 years ago, anadromous charr radiated into a variety of morphological forms, ecological roles, and habitats. Plasticity is expected to be reduced in specialized forms and vary by traits, but it is unknown if it behaves as a recessive, additive or dominant trait. Morphological diversity can be experimentally induced in Arctic charr, allowing study of plasticity within and across morphs in response to environmental stimuli. Using a common-garden rearing experiment, we assessed morphological response to differing diet treatments, in particular investigating divergence of developmental plasticity of specialized morphs from anadromous populations (representing ancestral types) and the genetics of plasticity. Results from growth and head morphology show strong morphological divergence across morphs and diet treatments. We find high correspondence of morphological change in response to diet type across genotypes with evolutionary divergence of specialized morphs. The impact of variation and plasticity during development on phenotypic traits in subsequent life stages can shed light on the interaction of development, environment, and evolution to produce a range of individual phenotypes with different ecological functions.

E19

Genetic diversity, population structure, and relationships in a downy birch (*Betula pubescens*) across Iceland revealed by genotyping-by-sequencing (GBS)

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Birch woodlands are the only native forest in Iceland and conservation of the remaining birch woodlands is a recognized priority. Since settlement, the former continuous forest has been reduced from 25.000-30.000 km² to 1.200 km² of fragmented patches. Furthermore, genetic studies on chloroplast variation have indicated widespread hybridization with dwarf birch. In this study, we assessed the genetic variation within and among remains of old birch forests across Iceland. The samples (N=96) were collected from the following forests: Westfjords; Teigsskógur and Heydalur; NW-Iceland; Fagrahlíð Austurdal; NE-Iceland; Meiðavallaskógur, Vaglaskógur, and Hlíðardalur; E-Iceland: Hallormsstaðaskógur; S-Iceland; Skógarhraun, Þórsmörk, and SE-Iceland: Bæjarstaðaskógur.

For the genetic analysis, we used GBS (LGC, Germany), a method of choice for high throughput discovery of SNPs and simultaneous genotyping in multiple DNA samples. It combines restriction enzyme-mediated complexity reduction (PstI-ApeKI) with the high-throughput sequencing capacity of Illumina NovaSeq SP, to score random markers across an entire genome. The results consisted of 3 million reads per individual providing a total of 219.847 SNPs, and 24.585 SNPs, with the lower allele frequency > 5%.

The analysis showed similar diversity within forests, suggesting that the fragmentation and hybridization have had a limited effect on the genetic variation within sites. A clear genetic divergence was found among forests from the different regions, that may reflect historic isolation. Fewer differences were observed among adjacent forests within regions possibly reflecting geneflow over shorter geographic distances. In order to retain the genetic entity of each area, birch woodland reforestation should be organized with seed collection and dispersal according to location.

E20

Correlates of annual growth fluctuations in a colonizing birch population

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Since the 1990s, *Betula pubescens* has expanded fast on Skeiðarársandur, SE Iceland. Given the exposed setting of the apparently homogenous plain, we postulated that 1) tree growth rates would be low compared to established birch forests, 2) temporal variations would be significant and related to annual fluctuations in temperature and precipitation but that, 3) spatial variation among sites would contribute more than temporal patterns to growth. Our goal in this project is to elucidate the factors influencing tree growth rates and their environmental correlates.

Trees were randomly selected at the westernmost margin of the birch distribution (S1), the presumed oldest (S3) and highest-density site (S4). Growth was measured as tree-ring widths in dominant stems ($N=48 \geq 140\text{cm}$) and as annual increments of the leading shoot (2016-2018, $N=227$). Tree age was determined by counting annual tree-rings in basal section ($N=132 \geq 20\text{cm}$ length). Climatic data were obtained from Skaftafell meteorological station.

Tree-ring widths (1999-2018) were weakly positively correlated with temperature and negative to precipitation. The strongest correlation was with $DD \geq 5^\circ\text{C}$ in June+July ($r=0.46$). Two negative pointer years were identified, 2011 (Grímsvötn eruption) and 2018. Although mean tree age did not differ between sites, growth rates (radial and longitudinal) and mean tree lengths were significantly greatest in S4. Growth rates on Skeiðarársandur are not low to previous estimates for Icelandic birch in established forests.

We conclude that multifaceted growth patterns in seemingly a uniform environment attest to spatial rather than temporal variation and underline importance of non-climatic growth factors.

E21

High seed quantity and seedling survival of *Betula pubescens* can counteract poor seed quality

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Most trees are characterized by a Type III survivorship curve, with very high losses at early stages of the life cycle. Some seeds are lost to predation and most seeds that enter the soil seed bank never germinate. Of those that do, a fraction typically survives beyond the seedling stage. Here, we report on a four-year study of a tree population that deviates from this general model.

The first generation of *Betula pubescens* on Skeiðarársandur outwash plain recently reached reproductive maturity. Estimates of seed rain (50-2,300 seed/m²) and the soil seed bank (250-2,200 seed/m²) at two sites reflect its high fecundity and prolific seed production. However, potential population growth rates are first modified by the 15-50% of seeds lost annually to *Semudobia betulae* larvae and second by low germination rates (0.3-17%), mostly explained by apparently healthy seeds that inexplicably lack a live embryo. Counteracting the very poor seed quality was an unexpected high seedling survival: of 550 marked seedlings, 72% and 55% were alive at the end of the 1st and 2nd growing seasons, respectively. Microhabitat mapping of 1,300 seedlings revealed that most seedlings appeared in thin moss (<2 cm), a significantly higher proportion than expected given its spatial share of ten habitat types.

The birch population on Skeiðarársandur has grown extremely rapidly in the last 20 years, from scattered plants in a few patches to >35 km². A significant contribution to its successful establishment appears to be the very favourable environmental conditions on this sparsely vegetated outwash plain.

E22

Tiny changes – how do soil fungal communities change during downy birch (*Betula pubescens*) succession?

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Succession is one of the oldest concepts in ecology, but our knowledge and understanding of belowground successional processes are still limited. Soil microbes play a key role in nutrient cycling and mycorrhizal fungi are important for plants in nutrient poor soils. The arrival of tree species into an early successional low-stature vegetation may initiate marked ecosystem changes, e.g. through their higher biomass, greatly increased litter input, distinct leaf and wood chemistry and the simultaneous establishment of their ectomycorrhizal partner.

Here we present our findings on how soil fungal communities change during natural colonization of mountain birch (*Betula pubescens*) on Skeiðarársandur, an outwash plain in southeast Iceland. We sampled microbial communities at a series of successional sites ranging from very sparsely vegetated (no birch), through three sites with increasing densities and height of birch trees. These were compared with three local birch forests and woodlands. Using DNA metabarcoding and statistical methods, we identified fungal taxa which were assigned potential ecological roles based on whether they appeared, disappeared or were indifferent to the successional stages of birch.

We identified 1.274 fungal taxa, of which 35 were associated with birch colonization and 21 retreated after birch colonization. Fungal taxa that retreated from birch were mostly saprotrophs while co-colonizing fungi had higher amount of symbiotrophic fungi. Different sets of fungi were associated with different successional stages and generally there was little overlap between fungi associated with colonizing birch and mature forests.

E23

Allelopathic capacity by dominating species in degraded rangelands

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Empetrum nigrum and *Racomitrium lanuginosum* are common unpalatable species in Iceland and are particularly dominating in degraded rangelands. Earlier studies from Scandinavia have shown that *Empetrum nigrum* and some bryophytes show allelopathic effects on competing vascular plants, by inhibiting germination, growth, and survival. The aim of this study is to investigate if this is also the case in Iceland and to assess variation in the strength of the allelopathic effects of *Empetrum nigrum* and *Racomitrium* spp. Plant and soil material was collected at two sites in the Icelandic highlands. We ran bioassays on the germination of two common vascular plants, *Festuca richardsonii* and *Bistorta vivipara*, in response to *Empetrum nigrum* leaves and the soil underneath *Empetrum nigrum* or *Racomitrium* spp. Both leaves and soil underneath *Empetrum nigrum* had a negative effect on the germination of the two vascular plants. The negative effect of *Racomitrium* soil on germination of both species likely indicates allelopathic effects but requires further evaluation. The present study supports potential allelopathy of both *Empetrum nigrum* and *Racomitrium* spp in the Icelandic highlands and presents a possible explanation for the dominance of these species in degraded ecosystems.

E24

Pseudomonas syringae in non- agricultural environments in Iceland. Are lichens non-host reservoirs?

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Pseudomonas syringae is a widely spread plant pathogen, causing epidemics in almost all economically important crops. In recent years, an increase in occurrence of this plant pathogen has been noticed. Monteil et al. 2013, suggest that different reservoirs in non-agricultural environments of *P. syringae* could influence the virulence by lateral gene transfer.

In this project, the natural reservoirs of *P. syringae* are studied with a special emphasis on lichens. Lichens were screened for *P. syringae* presence and genetic characterisation. We also characterised *P. syringae* in wild plants and moss surrounding the lichens for a better understanding of *P. syringae* distribution and ecology. Iceland is suited for plant pathogen studies due to lack of disruptions such as human activity or cropping and for its abundance and diversity of lichens, with more than 750 species found in Iceland so far.

To our best knowledge, this is the first time that *P. syringae* is found and isolated from lichens. Interestingly, results so far indicate that *P. syringae* presence in lichens is limited to the genus *Peltigera*, and all four *Peltigera* species studied to date have yielded detectable levels of *P. syringae*. Isolates from the samples have been identified showing tendencies in strain type or abundance depending on the type of organism (lichen, moss, or plant), habitat or, inner-outer part of the lichen in our case. Surprisingly, the second most abundant *P. syringae* phylotype observed in the present study is most similar to pathovar tomato which could indicate a present risk for tomato crops in Iceland. Further studies are needed to understand *P. syringae* ecology and habitat preference.

E25

Spatial distribution of grazing pressure in the Icelandic highlands

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Tundra herbivores provide important ecosystem services to northern communities, as many Arctic herbivores are hunted (e.g. geese, ptarmigan, reindeer) or farmed (e.g. sheep). A better understanding of how the effects of multiple herbivores combine to influence plant communities will help guide grazing management in natural rangelands. The Icelandic highlands provide good settings to address this question because the number of vertebrate herbivore species is relatively low but has increased since the settlement eleven hundred years ago through the introduction of livestock and later of reindeer. In recent years, the increase in the number of migratory geese and reindeer has notably raised concerns by sheep farmers as they are thought to reduce forage availability to sheep.

In this study, we are compiling census and habitat preference data for the main herbivore species frequenting the Icelandic highlands. These data are combined using metabolic biomass estimates to evaluate the additive grazing pressure of wild and domesticated herbivores across the landscape. To date, a series of maps was prepared to visualize the grazing footprint of sheep, reindeer and ptarmigans, individually and in combination. These maps can be used to target management actions and raw data could be extracted to evaluate the link between grazing pressure and different environmental variables. A pilot study has demonstrated how we can link reindeer grazing pressure to vegetation productivity measured through remote sensing analyses. This allows the identification of potentially vulnerable areas where vegetation productivity is low and grazing pressure is high.

E26

Vistfræði náttúruverndar á Íslandi [Ecology of nature conservation in Iceland]

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Í erindinu verður rætt um fjögur álitamál sem varða náttúruvernd hérlandis: fyrirkomulag friðlýsinga, umsjón verndarsvæða, flokkun verndarsvæða og tengsl náttúruverndar við önnur megin svið umhverfismála. Á Íslandi eru nú ríflega 100 náttúruverndarsvæði, af mismunandi stærð og toga. Talsvert hefur fjölgað í þessum hópi á síðustu misserum, eftir langt tímabil stöðnunnar í friðlýsingum. Núgildandi lög um náttúruvernd (nr. 60/2013) lögðu grunn að nýrri hugsun um náttúruvernd og einnig að nýju fyrirkomulagi friðlýsinga. Þetta var jafnframt í annað sinn frá aldamótum sem því fyrirkomulagi var breytt. Arfur fyrri tíma, þ.e. svæða sem sett voru á upphaflega náttúruminjaskrá og/eða á náttúruverndaráætlun, lifir enn en óljóst er þó hvernig farið verður með þessi svæði sem tilnefnd voru á grunni annars fyrirkomulags en nú er við lýði. Umsjón verndarsvæði á Íslandi er í einkum í höndum þriggja aðila: Umhverfisstofnunar, Þjóðgarðsins á Þingvöllum og Vatnajökulsþjóðgarðs. Þessir aðilar eru óháðir hver öðrum og áform um að fella allt verndarstarf undir eina stofnun (nú síðast Þjóðgarðastofnun) hafa ekki gengið eftir. Friðlýst svæði á Íslandi dreifast mjög ójafnt á milli einstakra verndarflokka; nýlega (2020) voru fyrstu svæði friðlýst á grundvelli landslagsverndar en ekkert svæði hefur enn verið friðlýst vegna óbyggðra víðerna. Náttúruvernd á sér ekki stað í tómarúmi, hugmyndafræði hennar er – eða ætti að vera – í stöðugri þróun og tekur þá um leið mið af þróun á öðrum sviðum umhverfismála, ýmist þá í jákvæðu eða neikvæðu samhengi. Aðgerðir gegn hamfarahlýnun geta rekist á markmið náttúruverndar og öfugt. Það sama gildir um samspil náttúruverndar við sjálfbæra þróun og verndun líffræðilegrar fjölbreytni.

E27

Long-term warming manipulations reveal complex decomposition responses across different tundra vegetation types

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Decomposition of plant litter is a process regulated by substrate quality and environmental conditions. In a rapidly warming tundra, ecosystems will undergo major environmental changes which are predicted to significantly alter below-ground processes. Making use of International Tundra Experiment sites (ITEX), established approximately two decades ago, we examined long-term impacts of warming on decomposition. We used the Tea Bag Index (TBI) methodology to measure the annual mass loss (%) of two tea types as a proxy for potential decomposition rates, across five tundra vegetation types. Direct effects of warming were assessed by comparing mass loss within and outside warming manipulations. Indirect effects of warming, such as those caused by warming-induced changes in plant community composition, were assessed through the relationship between mass loss of tea and biotic and abiotic local conditions. We found positive effects of warming on decomposition, although the responses varied between vegetation and tea types. Interestingly, we found support for the indirect influence of long-term warming on decomposition through warming-induced changes in the composition of plant communities. Our findings demonstrate the complexity in decomposition responses to warming across different vegetation types and highlight the importance of long-term legacies of warming in decomposition responses across the Arctic.

E28

Warm air temperatures alter longevity and oviposition of Subarctic summer-emerging chironomids

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Climate change is predicted to warm Arctic and Subarctic temperatures at twice the rate of lower latitudes. In Iceland, chironomids emerge from streams throughout the summer and winter. Studies of longevity of adult chironomids collected in lower latitudes demonstrate warming air temperatures decrease lifespan and alter timing of oviposition for winter-emerging taxa. Many of the same taxa that emerge during winter in lower latitudes emerge year-round in Iceland. Thus, warming air temperatures may alter similar aspects of life history for Icelandic chironomids emerging in summer. The goal of this project was to quantify the impact of warm air temperatures on longevity and timing of oviposition for adult summer-emerging chironomids in Iceland. Studies were conducted in 2018 and 2019. Chironomids were collected daily from emergence traps on 2 streams in 2018 and 4 streams in 2019 in the Hengladalir alpine geothermal valleys. Streams had differing water temperatures, averaging from 6°C to 20°C. Adult chironomids were incubated at 6 and 20°C in the laboratory post-collection and observed daily until dead. Longevity was significantly reduced in the warm treatment irrespective of stream site for both 2018 and 2019 and adults oviposited significantly earlier at 20°C compared to adults held at 6°C in 2019. Additionally, more egg masses hatched at 20°C than at 6°C in 2019. We found that chironomids emerging from both cold and warm springs in Iceland are equally susceptible to warming air temperature and may progress more rapidly through the adult phase of their life cycles.

E29

The Evolution of Ecosystem Management in Framengjar Wetlands, Lake Mývatn NE Iceland; A Story Told by Trolls, Placenames, Historical Documents and Biodiversity

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The Mývatn area in northeast Iceland has been occupied by farming communities since the arrival of Viking Age settlers in the late ninth century. Despite its inland location and relatively high elevation, this lake basin was affected by continuous human occupation through multiple disturbances, such as periods of harsh climate, volcanic eruptions, and soil erosion. Mývatn's residents have sustained themselves through the centuries by managing the natural resources of the lake itself and by sheep farming. Until the late 1960's the outfield hay gathered within the Framengjar wetlands was the single most important resource for Mývatn's farmers, and historical documents indicate that without these wetlands, the human habitation in the region would have been unsustainable. Documents on the management of these wetlands from 1700 to present day indicate furthermore, that erosion forces were a constant threat to the existence of these wetlands, the management of which needed to constantly be adapted and the conservation of which was considered the most difficult annual task by the farmers. These challenges are reflected by the myth of the troll woman Kráka, who cursed the farmers with this enormous task. The evolution of the ecosystem management of Framengjar wetlands in the 19th and 20th centuries was also fuelled by socioeconomic changes with its story being told in part by the creation of new place names and by the biodiversity of sedges within individual fields.

E30

Primary carbon sources in the coastal fish assemblage of Breiðafjörður

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Macroalgae-dominated rocky shores in Iceland provide important habitats and nursery grounds for a diverse fish community. The primary carbon sources of the food web in these habitats are considered to derive from both benthic and pelagic materials. Pelagic derived materials are transported into the coastal waters, where they are consumed and assimilated by benthic primary consumers and then transferred to higher trophic levels. Accordingly, the coastal fish assemblage does strongly rely on the exchange of trophic resources among and within ecosystems as a consequence of oceanographic forces. Here we used stable isotopes to examine the relative contribution of pelagic and benthic materials to the primary carbon source of the coastal fish community in Breiðafjörður, an area with strong water mixing resulting from tidal currents. We sampled primary producers and fish from three different sites within Breiðafjörður and determined their $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotopic values. As representatives for the benthic- and pelagic-derived carbon we used tissues from grazers and filter feeders, respectively. We found strong divergence of $\delta^{13}\text{C}$ isotopic values between pelagic and benthic carbon sources. The results suggest that the primary carbon sources of the fish assemblage in the shallow coastal waters are significantly subsidized by pelagic-derived materials.

E31

Spatial patterns in genetic and phenotypic variation in the common whelk (*Buccinum undatum*) reveal population and migration patterns in Breiðafjörður, Iceland

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Reconstruction of spatial genetic structure can provide valuable insight into the demographic processes affecting species, such as population genetic structuring, migration, and selection. Across the North Atlantic, repeated glacial cycles have significantly influenced modern-day marine invertebrate phylogeography. During the last glacial maximum many species, survived in glacial refugia, undergoing genetic bottlenecks that resulted in signatures of low genetic diversity in recently expanded populations. Here we present a study of spatial genetic structure in the common whelk, *Buccinum undatum*, within the Breiðafjörður (Iceland). The common whelk is a commercially significant gastropod distributed throughout the North Atlantic; however, Breiðafjörður's populations are particularly interesting from an ecological and evolutionary perspective as they display the greatest degree of spatial genetic and phenotypic structuring known for the species. Spatial patterns in genetic variation and their relation to phenotypic gradients in Breiðafjörður are discussed, as are trends in gene flow and migration. Finally, our studies will be discussed within the context of ongoing and future *B. undatum* research in Iceland.

E32

Transient dynamics of spatially structured fluctuations in a threespine stickleback population

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Uncovering the demographic basis of population fluctuations is challenging for spatially structured populations, because this requires disentangling synchrony in demographic rates from coupling via dispersal. In this study, we fit a stage-structured metapopulation model to a 29-year times series of population density estimates of threespine stickleback in the heterogeneous and productive Lake Mývatn, Iceland. The lake comprises two basins (north and south) connected by a channel, through which the stickleback disperse. The model includes time-varying demographic rates, allowing us to disentangle the contributions of recruitment and survival, spatial coupling via dispersal, and transient dynamics to the population's large fluctuations in abundance. Our analyses indicate that recruitment is largely unsynchronized between the two basins, whereas survival probability of adults is highly synchronized, contributing to cyclic fluctuations in the lake-wide population with a period of approximately 6 years. The analyses further show that the two basins are strongly coupled through dispersal, with the north basin subsidizing the south basin and playing a dominant role in driving the lake-wide dynamics. Moreover, transience due to non-equilibrium distributions of individuals across demographic states results in large short-term changes in abundance that partially obscure the cyclic nature of the dynamics. Our results show that cyclic fluctuations can arise through both spatial coupling and synchronization of demographic rates, and they highlight the importance of accounting for transience in analyses of population dynamics.

E33

Comparison of the gut microbiota in the groundwater amphipod *Crangonyx islandicus* to biofilms in its spring-source habitat

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Crangonyx islandicus Svavarsson and Kristjánsson, 2006 is an endemic groundwater amphipod in Iceland, restricted to spring sources at edges of lava fields in the volcanic active zone. Genetic analysis indicate that the amphipods have survived in subglacial refugia in the groundwater in Iceland during Ice Age. In this study we investigated the gut bacteria of *C. islandicus* and compared them with the bacterial diversity identified in biofilms from its habitat. The diversity of both uncultivated and cultivated bacteria was analyzed using partial 16S rRNA gene sequences. The results show that iron-oxidizing bacteria such as *Sideroxydans* and *Gallionella* and the methanotroph *Methylobacter* are common in the biofilm but absent from the gut samples. *Thiomonas* was common in both the biofilm and the gut samples. The cultivation of gut bacteria revealed that most of the taxa could be affiliated with terrestrial soil and/or freshwater habitat. This indicates that the food source for the amphipods is partly of terrestrial origin. The presence of primary producers in the subsurface habitat of *C. islandicus* indicate that microbial chemolithotrophic activity might fuel the system at least partly and thus explain the amphipod survival in the subsurface of Iceland during repeated glaciation for the past 5 Myrs.

E34

Diel activity and growth of three sympatric species of stream Salmonids

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Diel activity, the way animals partition the 24h cycle towards feeding activity and resting, is important as it can influence individual fitness through susceptibility to predation, expenditure of energy, and feeding potential. Differences in diel activity can also shed light on how related species compete for and share habitats and resources through time. We tested if diel activity patterns and growth rates differed among sympatric juvenile Arctic charr (*Salvelinus alpinus*), brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*) in an Icelandic stream. More specifically, we individually tagged a total of 72 fish (24 of each species) and monitored their behavior over 18 days in 12 stream enclosures, at high and low water current velocities. Activity levels were highly variable between species. Arctic Charr showed the highest activity rates and were actively feeding 89% of the time, compared to brown trout and Atlantic Salmon, which were only active 17% and 15% of the time, respectively. Activity levels did not differ between high and low water current velocity, either across species or within species. Overall, the three species were slightly more active during the day rather than at night. Growth rates did not differ, either among the three species, or between high and low water current velocity. These results show that diel activity is highly variable among these related species but that this variability may not translate into different growth rates, at least over short periods of time.

E35

Patterns of genetic divergence and diversity among populations of Arctic charr and Brown trout in Iceland.

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Ecological opportunities, chance and migration rates are expected to shape the history and relatedness of populations during colonization and adaptation to new habitats. The salmonid species, Arctic charr (*Salvelinus alpinus*) and Brown trout (*Salmo trutta*) exhibit extensive variability in life history and exist as anadromous or resident populations, many of which are land locked in lakes and rivers. Both species are presumed to have colonized Iceland roughly 10.000 years ago at the end of the ice-age. As the ice retreated many populations became isolated as impassable waterfalls formed. This system, with two species, extensively variable habitats and different degrees of genetic isolation offer great opportunities to address questions of adaptive divergence, concerning e.g. the role of ecological opportunity, history and chance in forming and maintaining diversity. Our group has amassed SNP genotype data from both species using a ddRADseq approach from a large number of both anadromous and resident populations. In this talk the current status of analyses will be summarized and the parallels and differences between the population structures of the two species highlighted. As expected the major axis of genetic variation in both species reflects geography but interesting differences can be seen in the patterns of subdivision, and degree of relatedness between groups and outgroups. Sound knowledge on genetic divergence, relatedness and gene flow opens avenues for more focused studies of adaptive divergence, e.g. tests of parallelism. Furthermore, understanding the population structure of both species is important for informed decisions on stock management and habitat protection as it is important to maintain genetic diversity and local adaptations when possible.

E36

The correlation between personality and partial migration in Atlantic cod (*Gadus morhua*)

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Many studies have demonstrated individual differences in movement. Partial migration, where not all individuals from a population migrate, is an extreme example of this. Dispersing individuals seem to be a non-random subset of the population and show high repeatability in their movement behavior while experiencing (initially) similar environmental conditions. This gives rise to ideas about the role of phenotypic traits underlying movement, that may be triggered by both environmental and genetic factors. One of the traits influencing animal movement might be personality. Evidence is mounting that personality acting on movement, can largely influence population dynamics.

In a first approach to unravel the correlation between personality and movement, 102 Atlantic cod (*Gadus morhua*) juveniles were caught at three different locations around the Westfjords in Iceland, in an attempt to collect equal numbers of migratory and resident genotypes (determined by polymorphisms in the pantophysin gene (PanI-locus)). After transportation to the lab, these juveniles were subjected to inter- (2) and intramonth (3) shelter tests, open field tests, novel object tests, mirror tests, and fear tests, supplemented with measurements of activity in home tank and morphometrics during eight months. Here, the preliminary results of this work are presented.

E37

Would rising temperatures affect the spawning behaviour of salmonids?

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Climate change will undoubtedly impact salmonids, large ectotherms inhabiting the northern hemisphere. Although there is great inter- and intra-specific variation in salmonids' thermal tolerance, they are overall highly vulnerable when exposed to elevated temperatures. Here we sought to study the dynamics at the spawning grounds of the large benthic morph of Arctic charr in Thingvallavatn. By using male densities, aggression and courtship behaviours as proxies of spawning site selection, we were able to detect spatial heterogeneity in behaviour associated with the location of the redds (salmonid nests). We determined that the majority of the redds were located in the shallow areas of the spawning grounds. We also detected increased aggression and courting behaviours among males occupying shallow redds. The greater competition among males for females at lower depth indicates that prime spawning sites may be located in the shallow areas - which are fed by groundwater springs insuring a low and stable temperature all year around. While the temperature at the shallow and deeper redds did not differ significantly during the spawning time, the long term trend showed that redds located in deeper areas were consistently warmer during the period encompassing the charr's embryonic development.

This will inadvertently affect the rate of development, the timing of emergence and even have lasting effects throughout adult life. Our findings suggest that rising temperatures will not only lead to increased metabolic costs and influence salmonids' activity as previously described in the literature but will also influence their breeding efforts.

E38

First insight into Arctic Charr (*Salvelinus alpinus*) cognition and personality: impact of environmental factors and eco-evolutionary context.

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The CharrCo multidisciplinary project aims at studying the evolution of spatial cognition and personality in the Arctic Charr (*Salvelinus alpinus*, AC) and how it is shaped by the environment. In a first step, we investigated the effects of environmental enrichment on personality in juvenile of aquaculture strains, its interplay with brain morphology and growth performance. Growth and behaviour were followed over time on different batches of AC raised in enriched versus plain environments. At the end of the experiments fish were euthanized for brain morphology measurements. The second step of the project hypothesized that cognition and personality are impacted by the degree of divergence along an evolutionary and ecological gradient and that it is associated with brain morphology and molecular markers. We focused on an anadromous population (supposedly close to the ancestral population) and two pairs of sympatric lake morphs varying along a gradient of genetic and phenotypic divergence. Fish were raised in common garden and placed in enriched versus plain environment conditions after hatching. All populations undergo individual behavioural tests: boldness; attractiveness of different ecologically meaningful stimuli; spatial cognition abilities and preferred strategies were tested in a “conflict paradigm” in which fish had to learn the path to exit the maze and get a reward, either by performing a specific turn or by following a landmark. At the end of the experiments, fish were sacrificed, and brains collected to compare morphology and gene transcription between groups. Here we give an overview of the ongoing project steps with preliminary results.

E39

Effect of physical environmental factor on personality expression, brain development and their interaction in Arctic charr (*Salvelinus alpinus*)

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Animal personality has been reported as among – individual variation in average behaviour across time and context. Personality traits are complex and shaped by both genetic and environmental factors. The contribution of each as well as the underlying mechanisms remain largely unknown. The environment animal is exposed to at early stage of development could affect dramatically the expression of personality traits. Physical enrichment is known to influence brain morphology through developmental plasticity or even throughout the lifetime to a lesser extent but the effect on the interaction between brain morphology and personality has not yet been studied. In this study, we investigated how environmental factor led to brain personality trait expression and their interaction in an arctic freshwater species Arctic charr (*Salvelinus alpinus*). We predicted long term behavioural consistency in enriched environment along with a link between behaviour and brain region volume. Boldness was assessed three times in an Open Field Test with Shelter (OFTS) at 298, 310 and 373 dph. Fish heads were dissected at 470 dph and brain photographed in dorsal and lateral views to measure the volume of each brain region. Environmental enrichment induced among – individual variation consistency across long term period (i.e., personality trait expression) as well as a positive correlation between boldness and the olfactory bulbs volume. This brings new insights into the effect of environmental factors on personality traits expression and in turn how brain morphology can be affected.

E40

Characterization and influence of the rearing environment on spatial cognitive abilities in offspring of wild-caught Arctic charr (*Salvelinus alpinus*).

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Current human-driven disturbances in nature apply constant pressures on wildlife to adapt to rapid modifications of the environment. Spatial cognition, i.e. mental processes by which individuals orient in space, might be a key animal ability to respond to environmental changes. Indeed, every individual depends on spatial cognition to locate food, retrieve reproductive grounds, avoid high predation-risk zones, etc. Hence, determining spatial cognitive abilities in threatened species is an important step to assess their adaptability to habitat changes, and implement adapted conservation policies. The Arctic charr (*Salvelinus alpinus*, AC) is an emblematic species in Icelandic freshwaters, displaying a precious intraspecific diversity long recognized as in need for conservation. This study is the very first attempt to assess cognitive characteristics in this species. We used offspring of a wild-caught AC population, the Large Benthic morph from lake Thingvallavatn, and determined their spatial learning abilities and orientation strategies thanks to a specially-developed T-maze. In order to characterize the effect of the environment on the development of spatial cognition, fish were separated in two treatments from hatching: either in plain tanks or in tanks enriched with rocks and plants. Contrary to our expectations, enriched-tanks fish were slower learners compared to plain-tanks fish. Also, fish from both treatments used self-centered motor responses to orient, rather than using landmarks. This environmentally-driven development of spatial cognition might indicate AC adaptability. Nevertheless, those results might be morph-dependent and we need further comparison with other AC populations.

SHORT TALKS

S6

Evidence of density-dependent growth in juvenile Atlantic salmon (*Salmo salar*) in an Icelandic river

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Density dependence is a key process in population ecology and provide a mechanism for population regulation by affecting mortality rates, emigrations/immigrations rates and individual growth rates. Stream salmonids are ideal for studying density related factors because of their territorial behaviour during juvenile stages. In Iceland, many populations of stream salmonids are monitored yearly for parameters necessary to establish stock recruitment relationships, and to promote the conservation of salmon stocks and management for the sport-fisheries. In some of these rivers monitoring spans over 30 years and quantitative long-term data are available. We used 21 years of consecutive sampling data to explore if density dependent growth occurs in a population of Atlantic salmon juveniles in River Vatnsdalsá in NW-Iceland. More specifically, we examined the relationship between average fork length and population density of three cohorts (YOY, one- and two years old) in eight electrofishing sites within the river. In short, preliminary results revealed a significant negative relationship between density and average fork length of YOY in four out of eight sampling sites. This is the first attempt to predict such a relationship in Icelandic stream-dwelling salmonids and we will apply the same procedure to more Icelandic rivers where long-term datasets exist.

S7

Impact of enriched environment on brain morphology and link with boldness in the Arctic charr large benthic morph of Thingvallavatn

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Arctic charr colonized lakes and rivers in the northern hemisphere after the last glaciation period and since then undergo rapid diversifying evolution, forming resource-based morphs. The Arctic charr from the Icelandic lake Thingvallavatn is an extreme case of such divergence that resulted in the emergence of four morphs occupying different habitats. Here we focus on one morph only, the large benthic from Thingvallavatn that is known to be highly diverged from an ancestral anadromous population. In this study, we examined how the enriched rearing condition affects the brain morphology i.e., weight, volume and shape in the Arctic charr and how it can be linked to boldness. We used a batch of 450 fish that we raised in enriched versus plain environment (75 in each) from hatching. Boldness was measured twice at 300 DPH in an Open-field test with shelter with a 1-week interval in between. Fish were sacrificed at 420 DPH and head preserved in 1% PBS until brain extraction. We first weighted each brain. Then, we assessed the length, width and height from photos of dorsal and ventral views to calculate the volume of the brains with the ellipsoid formula. Finally, we assessed the shape of the brains using geometrics morphometrics on dorsal views photos. Here we present the preliminary results of this study.

S8

Effect of physical enrichment on brain morphology in juvenile Arctic charr

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Fish brain is known to be partly shaped by the environment through developmental plasticity but also throughout the lifetime to a lesser extent. Previous studies showed that enriched environment have an impact on the brain morphology of several salmonids such as Atlantic salmon or rainbow trout. In this study, we examined how the enriched rearing condition affects the brain morphology i.e. weight, volume and shape in the Arctic charr.

We used a batch of 180 fish from an aquaculture strain at early stage of development that we raised in enriched versus plain environment (90 in each) from first feeding (73 DPH) to 470 DPH. Fish were sacrificed and head preserved in 1% PBS until brain extraction. We first weighted each brain. Then, we assessed the length, width and height from photos of dorsal and lateral views to calculate the volume of the brains with the ellipsoid formula. Finally, we assessed the shape of the brains using geometrics morphometrics on dorsal views photos.

We found significantly bigger whole brain and telencephalon volumes in the fish reared in plain environment and a significant difference in the brain shape according to the two reared conditions. These results could be explained by different links with behaviour between the two environments.

S9

The social aspects of biological invasions – involving stakeholders in research on the European flounder (*Platichthys flesus*) in Iceland

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Biological invasions and the induced impacts on invaded environments have attracted attention of scientists since the 1960s. Mostly, invasion science has focused solely on biological and ecological perspectives, vastly ignoring potential anthropogenic factors. Considerations of human and social perspectives have recently gained increased attention. Involving these components enables scientists to understand how biological invasions inflict changes beyond biological levels but it also offers the opportunity to gather data directly from the people impacted by invasions. In the current case study, stakeholders were involved in research on the establishment of the European flounder (*Platichthys flesus*) in Iceland. The objective was to understand how they perceive *P. flesus* and if they could contribute further data on its distribution. *P. flesus* is a flatfish species that has been reported in Icelandic waters since 1999 and can currently be found in most parts of Iceland. Considering that *P. flesus* can co-occur with highly valuable salmonids in freshwater habitats, recreational fishermen and managing parties selling licenses were identified as important stakeholders. Using anonymous online surveys, stakeholders were approached and asked to answer questions about their knowledge and previous experiences with *P. flesus*. To investigate their perception, they were asked to rank their agreement on various statements concerning *P. flesus*. Additionally, semi-structured interviews were held to gain a more in-depth understanding of what drives people's perception. Preliminary results show a prevalent and highly negative perception of *P. flesus* among the recreational fishing sector. Furthermore, involving stakeholders has greatly expanded the official knowledge on the distribution.

S10

What reward for spatial cognition tests in Arctic charr (*Salvelinus alpinus*) ? Comparison of different ecologically meaningful stimulus between two morphs

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Arctic charr (AC) is an emblematic species in Iceland, which makes it a preservation priority. Indeed, it occupies extremely variable ecological niches and shows a huge adaptative polymorphism. For example, the large benthivorous morphs (LB) are permanently living in shallow environment, whereas the anadromous (AN) migrate annually to the sea.

Among other phenotypic traits, spatial cognition can be impacted by the degree of divergence along an evolutionary and ecological gradient. Cognition experimentation is based on learning tasks requiring a proper reward which is species- and even population-specific. This study focuses on the AN AC from Fljótaá river in Iceland, considered the population closest to the ancestral form, compared to the LB morph from lake Thingvallavatn. Four ecologically relevant stimuli were tested as potential rewards through preference tests on AN and LB: a shelter, a mirror, congeners, and dark background. Fish were raised under plain versus enriched treatment, then 150 fish were tested in an arena with the different stimuli (one group of 30 fish per stimulus). Time spent near the stimulus and other kinematic variables were recorded with the Ethovision videotracking software, and the results compared between groups in a population x treatment factorial design. Here, we will present the preliminary results of this study comparing the two morphs.

S11

Environmental enrichment influences behavioural syndrome and relation between behaviour and growth in juvenile Arctic charr (*Salvelinus alpinus*)

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Behaviour research might give important insights into understanding more about how the Arctic Charr interacts with its environment and develops its among individual differences i.e. personality traits. In the current study, we assessed the personality traits boldness and activity and the correlation between both (i.e., behavioural syndrome) in juvenile Arctic Charr raised since hatching in a plain versus enriched environment. Besides that, growth was measured as a fitness indicator to assess how it links to behaviour and environment. To answer these questions, we used an open field test with shelter to assess boldness and a circular open field test to assess activity. We found that boldness and activity were repeatable over time and can therefore be counted as personality traits and that a tendency for a behavioural syndrome exists for the fish in the enriched environment while there was none in the plain environment. Neither the growth nor the personality seemed to be affected by the addition of physical enrichment, but the growth was positively correlated to boldness. We suggest the environment the fish are exposed to at early stage of development to play an important role in the development of consistent behavioural traits i.e., personality. Social structure is thought to be an explanatory mechanism in the development of personality traits and how it links with growth.

POSTERS

P10

Inferring movement patterns of northern bottlenose whales (*Hyperoodon ampullatus*) from photographic information and long-term passive acoustics

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The northern bottlenose whale (andarnefja) is a beaked whale currently listed as “data-deficient” on the red lists of the International Union for Conservation of Nature and the Icelandic Institute of Natural History. Commercial exploitation of the species throughout its range in the 19th and 20th centuries almost certainly depleted its numbers and likely continues to provide challenges for its recovery. However, population assessments are severely hampered by a general lack of understanding about stock structure, migration patterns, critical habitat and potential threats. Here, we present the first results of HYPMO, a research project on *Hyperoodon ampullatus*’ movement ecology and vulnerability to man-made noise exposure. Photographic materials collected by researchers and naturalists in the Jan Mayen-Iceland-Faroe Islands region since 2013 were analysed to establish a catalogue of individuals, collate their sighting histories, and assign individuals to age-sex classes. In addition, two deep-sea moored hydrophones were deployed at 2500 m depth in an area with steep bathymetry east of Iceland. Preliminary analysis of the acoustic data revealed the occurrence of echolocating northern bottlenose whales in the area. Temporal patterns in the acoustic occurrences over these Feb-Aug 2020 deployments were consistent with information from satellite tags, stranding patterns and passive acoustics suggesting seasonal migrations of northern bottlenose whales in the northeast Atlantic, including between Jan Mayen and Iceland. Future research within the HYPMO project will be discussed.

P11

Interspecific interactions between pilot whales and killer whales in Iceland

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Interspecific interactions between marine mammals are little understood but may become increasingly important due to changing distribution patterns driven by climate change. Long-finned pilot whales (*Globicephala melas*) are regularly seen harassing killer whales (*Orcinus orca*) in Vestmannaeyjar, South Iceland since 2014. Similar interactions have been observed in Norway and Spain. These interactions are unusual because killer whales are known predators of pilot whales and not vice versa. It has been suggested that pilot whales are approaching killer whales to compete for food or as a mobbing, anti-predator behaviour but it remains unclear what drives these interactions. We show preliminary results of land- and boat-based observations, indicating that pilot whales were not common visitors to the waters around Vestmannaeyjar in the past but that sightings have increased in recent years, with a corresponding increase in interactions with killer whales. Our observations indicate that the interactions may be more complex than previously described and can include avoidance by killer whales to high speed chases by pilot whales. We will investigate these interactions in more detail in future studies, including the role that acoustic cues may play in such interactions. The results will have broader applications to other species and human disturbance.

P12

Notkun GPS staðsetningatækja til að kanna atferli sauðfjár í sumarhögum

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Stór hluti Íslands er nýttur til sauðfjárbeitar yfir sumartímann og þekkt er að beit hefur í gegnum tíðina haft áhrif á gróður- og jarðvegsauðlindir landsins. Til að nýta beitarlönd á sjálfbærari hátt og draga úr neikvæðum áhrifum beitar er nauðsynlegt að skilja hvar sauðfé heldur sig og hvernig það nýtir landið. Árið 2018 hófst verkefni þar sem fylgst með ferðum sauðfjár yfir sumartímann til að safna upplýsingum um staðsetningu þeirra, m.a. um hvers konar land sauðfé sækir í og hversu stórt svæði hver ær nýtir.

Árlega frá sumrinu 2018 hafa um 10 bændur víðsvegar um landið tekið þátt í verkefninu. Á hverjum bæ fengu 10 lambær GPS-hálsólar sem sendu staðsetningarupplýsingar á 6 klst fresti frá því að lambánnum var sleppt og þar til þeim var smalað að hausti. Staðsetningarupplýsingarnar voru síðan nýttar til að sjá hvaða gróðurlendi ærnar héldu sig á og til að reikna út heimasvæði (það svæði sem hver kind heldur sig mest á) kindanna.

Frumniðurstöður fyrstu þriggja ára liggja fyrir. Sauðfé heldur sig einna helst í mólendi en einnig í votlendi, graslendi og moslendi. Lítil breytileiki er á gróðurlendavali á milli ára en mikill breytileiki á milli bæja, sem byggir líklega á ólíkum landssvæðum og því hvaða gróðurlendi standa til boða á hverjum stað. Heimasvæði er bæði breytilegt á milli einstaklinga af sama bæ og á milli svæða.

P13

Assessing the degree of maerl habitat fragmentation affecting fish species richness and abundance

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Maerl beds are a type of habitat that consists of calcified red algae (Corallinales sp.). The biodiversity of maerl beds is not adequately documented despite maerl being a threatened habitat in many regions. Juvenile Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) utilize nursery grounds to recruit adulthood demersal fish populations, which are essential for fishing industries. In the current study, the abundance, and species richness of fish within fragmented maerl beds were investigated in Ísafjörður, NW Iceland. We used SCUBA diving surveys to estimate the abundance of fish and a Starfish 452F side-scan sonar system was used to map the maerl habitat. Finally, we used an imaging sonar, Gemini 720im SeaTec, to test if it could be used to estimate fish abundance and size. Juvenile gadoid fish were more frequent at maerl beds than at an adjacent gravel site. Moreover, the outer edges of maerl patches had less fish than the interior. The results confirm that gadoid fish use maerl beds as nursery grounds and suggest that this role can be adversely affected by fragmentation.

P14

How to study spatial cognition in the Arctic charr (*Salvelinus alpinus*)?

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Spatial navigation refers to the processes allowing one to follow a route or maintain a trajectory towards a targeted location. Spatial cognition research explores how animals acquire and use different kinds of information to determine where they are and where are locations important for their survival. Spatial strategies are known to be affected both by current (e.g. level of stress, motivation) and long term intrinsic factors (e.g. species ecology). To conduct learning-based experiments and assess spatial strategies, differently-shaped mazes and procedures are described in the literature. Using a standardized procedure in a non-conventional animal model might lead to serious drawbacks: acute stress responses induced by experimental conditions and the lack of a species-specific reward can impair learning abilities. It is important to provide appropriate environmental conditions allowing tested individuals to express enough motivation to perform their task. Cognition has never been investigated so far in the Arctic charr, hence it is crucial to design a new apparatus and a new protocol to successfully assess its learning abilities. We built up a new type of maze where individuals are raised in one part of it. This living area is used as the reward per se during training (i.e., combination of shelter, dark background and food). The procedure follows three successive steps: the acclimation period, the training (to study learning rates) and conflict tests (to determine the strategy used to solve the maze). Here, we present both the apparatus and the procedure designed to evaluate spatial cognitive abilities in Arctic charr.

P15

Diversity in the internal functional feeding elements of Arctic charr, *Salvelinus alpinus*, morphs in Lake Thingvallavatn, Iceland

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Feeding structures of fishes are among the most variable and fastest evolving traits in the animal kingdom. This offers a great system to investigate the role of ecological specialization, developmental plasticity and integration and allometry on emergence of adaptive traits. Arctic charr, *Salvelinus alpinus*, is freshwater fish species known for extensive phenotypic variation throughout its distribution, both with sympatric morphs and specializations by habitats. In Lake Thingvallavatn four different morphs of Arctic charr coexist: large benthivorous (LB) and small benthivorous (SB), planktivorous (PL) and piscivorous (PI) charr. They are characterized by large differences in head shape and feeding morphology which relate to distinct feeding habits and habitat selection. It was hypothesized that the internal functional feeding elements also reflect morphological adaptations and one prior study found evidence of differences in specific structures between the morphs. The research question of this project are the following. (1) Which functional feeding elements vary among the morphs? (2) How independent/integrated are traits in different bones/sections of the feeding apparatus? (3) Have some traits changed in the 20 years since the first study? Adult individuals of the four morphs in Lake Thingvallavatn will be gathered, weighed and measured in length to study and control for allometric relationships. The heads will be boiled to retrieve the bones and the structure of the bone examined, by photographing, placing landmarks and geometric morphometrics. The results are expected to provide understanding of the anatomical and developmental origins of rapid evolution in feeding morphology.

P16

Study of Arctic charr brain gene expression linked with behavior

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Spatial cognitive abilities have an impact on animals' fitness and are consequently subject to natural selection. The Arctic charr (*Salvelinus alpinus*) occupies different habitats and several morphs, ranging from anadromous to benthic and pelagic lake-resident morphs can be found in sympatry. Cognitive abilities and behavior of the Arctic charr may be shaped according to evolutionary history and current ecological factors implying differential expression patterns of genes linked with spatial cognition variation between populations. The overall goal of this project is to study the gene expression differences in several brain structures of Arctic charr morphs raised under enriched versus plain conditions. Here we used different tissues (brain, muscle, liver and hatch) to optimize the method that will be implemented for the different populations. To do so, the expression of 14 genes and their paralogs expressed in the Arctic charr brain and directly or indirectly involved in neurogenesis and neural plasticity will be studied by qPCR approach. After the dissection of brains, RNA is extracted and reverse transcribed. Then, the relative expression of genes will be monitored by qPCR. Pairs of primers were designed based on literature research and available genome sequence. They were chosen based on melting temperature, the length of the final product and the absence of amplification of unexpected products. To avoid genomic DNA contamination, primers are designed on an exon-exon junction or for the presence of an intron in the amplified sequence. This contamination is tested when the efficiency of primers is checked.

P17

Arctic charr and Brown trout movement in Lake Thingvallavatn

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The aim of our study is to collect movement data over three years from Arctic charr and the Brown Trout in Lake Thingvallavatn using acoustic telemetry. We will surgically implant a tag in the abdominal cavity of the animal that actively transmits acoustic signals every 120 seconds, with information about I.D. of the individual as well as temperature and specific position, to fixed receivers placed strategically in its habitat.

In year one we are tagging 20 individuals of each morph as well as 20 brown trout. The small benthic and the planctivorous morph will be fitted with VEMCOs V7, 18mm, tag weighing only 0.7 grams in water. The large benthic and the piscivorous morphs will be fitted with the V9 (26,1mm, 2,0g). For the Brown trout we will use the larger V13 (46mm, 6,3g) and V16 (71mm, 11,7). Projected battery life for the tags range from 220 days for the V7s to 3650 days for the V16s. 40 receivers will be placed in an even grid throughout the lake to collect presence/absence data. Using the results from the first year we will focus in on the feeding grounds and 3-D position the individuals and thereby track individual behaviour on a finer scale. The third year we will put the same focus on the spawning grounds.

This data will be organized in a database with accessibility for other research groups and institutions to address ecological, evolutionary and conservational questions.