CONFERENCE ABSTRACT BOOK

the 15th International Arctic Ungulate Conference

Jokkmokk, Sweden 12-16 August 2019

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SCIENTIFIC COMMITTEÉ

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FUNDING

Economic support for the conference has been obtained from Nordforsk through the Nordic Centre of Excellence Reindeer Husbandry in a Globalizing North (ReiGN) and from the Swedish research counsil FORMAS

ORGANIZING COMMITTEÉ

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PREFACE

The Arctic Ungulate Conferences originate in an initiative by Jack Luick, David Klein and Robert White, who organized the First International Reindeer/Caribou Symposium, held at Fairbanks, Alaska, in 1972. Then seven years went by until the Second Int. Reindeer/Caribou Symposium was held at Røros, Norway, in 1979. Thereafter Int. Reindeer/Caribou Symposia were organized on a tri-annual basis, in Saariselkä, Finland (1982), Whitehorse, Canada (1985), and Arvidsjaur, Sweden (1988). Parallel to this, the First International Muskox Symposium was held at Fairbanks, Alaska in 1984, followed by a second in Saskatoon, Canada, in 1987. The Sixth Reindeer/Caribou Symposia was due to be held at Nuuk, Greenland, in 1991. At this time it was realized that there was not enough new research to go around for both tri-annual reindeer/caribou and muskox symposia, since both meetings were pretty much catering for the same group of people. It was therefore decided that a conference dealing with all arctic ungulates should be held every four years, and the Nuuk meeting in 1991 therefore became the First International Arctic Ungulate Conference (AUC). The Second AUC was held in due time at Fairbanks, Alaska, in 1995. At the time for the third conference it had become clear that the terminology, based on three different series of conferences, was confusing and it was therefore decided that the next meeting at Tromsø, Norway, 1999, would become the 10th International Arctic Ungulate Conference. At the meeting in Tromsø, a proposal by A.S. Blix, led to the inauguration of the “Arctic Ungulate Society”, which primarily is a body to decide on the selection of venue and aid in the organization of upcoming conferences (http://www.arcticungulate.org/). Thereafter four AUC conferences have been arranged in Saariselkä, Finland (2003), Yakutsk, Russia (2007), Yellowknife, Canada (2011), and Røros, Norway (2015).

The present meeting is the 15th in this series of conferences, and we are proud and happy to welcome the participants to Jokkmokk, in the middle of the reindeer herding area in Sweden, a centre for Sámi culture and a traditional meeting place for reindeer herders and other members of the Sámi people.

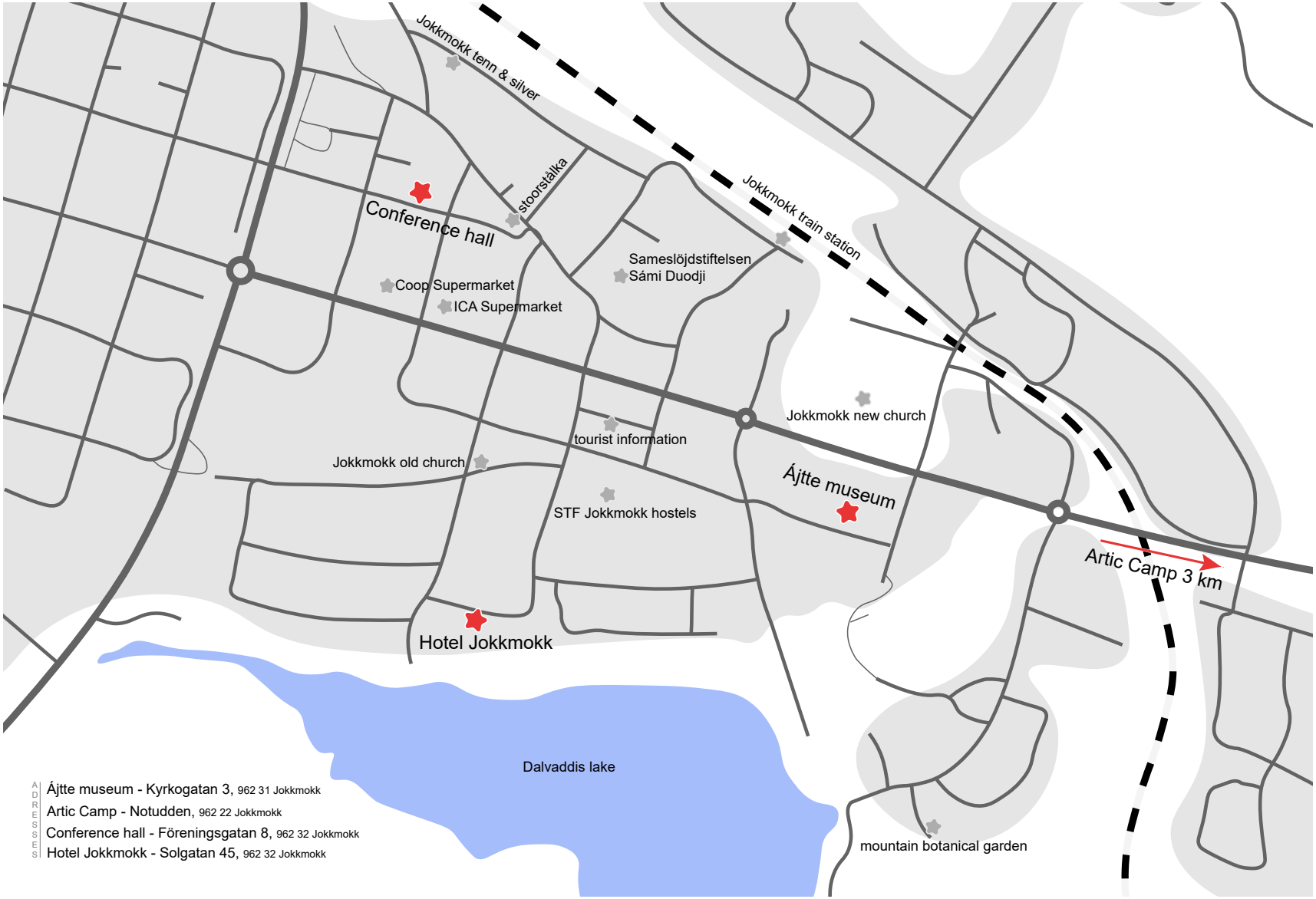
We wish everyone an enjoyable and fruitful 15th International Arctic Ungulate Conference and a plesant stay in Jokkmokk.

Birgitta Åhman
President of AUS

LIST OF CONTENT

PRACTICAL INFORMATION

MAP OVER JOKKMOKK



VENUE

Jokkmokk/Jåhkåmåhkke is situated just north of the polar circle and an important heart of reindeer husbandry in the Swedish part of Sapmi. It has been the meeting place for Sami people and others for at least 400 years. Each year in beginning of February Jokkmokk holds one of the world's oldest winter markets.

The conference will be held in Jokkmokk Community Hall (Folkets hus). Registration for the conference is outside the meeting room. We will have coffee breaks at the conference hall. Lunch and dinner will take place at Hotel Jokkmokk by lake Dalvaddis, a 10 min walk from the conference hall. The opening reception on Monday evening will take place at Ajtte museum a 10 min walk from Hotel Jokkmokk or the conference hall.

Accommodation is either at Hotel Jokkmokk or at the Arctic Camp 3 km east of Jokkmokk centre. Breakfast, lunch and dinner takes place at Hotell Jokkmokk, regardless of whether your accommodation is at Hotel Jokkmokk or Arctic Camp. For those of you staying at the Arctic Camp there will be a shuttle bus to and from the Jokkmokk centre/Hotel Jokkmokk in the morning and in the late afternoon/evening.

Check-in at Hotel Jokkmokk and Arctic Camp Jokkmokk can be done 15:00. The hotel reception is open from 07:00 to 00:00 and upon arrival after closing time the keys are left with a name-tag in a mailbox outside the hotel. Arctic Camp Jokkmokk has a separate reception and the keys are collected there. There is possibility to leave luggage in the luggage room at community hall and at Hotel Jokkmokk. Check-out must be done before 12:00 at both the hotel and the Arctic Camp.

The hotel as well as the Arctic Camp has plenty of parking spots. If taxi service is required, Jokkmokks Taxi is available at 0971-55120.

If there is anything else you may need help with, please don't hesitate to contact the organizing committee or Sabina consulting:

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EXCURSION

Excursion by bus to Stora sjöfallet/Stuor Muorkke, 140 km northwest from Jokkmokk, will bring you to the Laponia World Heritage area and the visitors centre Naturum Laponia. On our way to the centre we will pass through ancient Sámi land where a spectacular landscape compete with large-scale hydropower development. Naturum Laponia Visitor Centre is the portal to four national parks, two nature reserves and nine Sámi communities. The total size of Laponia World Heritage area is 9,400 km². Lunch and coffee will be serverd during the day and we recommend that you bring comfortable shoes, mosquito repellent and a camera.

CONFERENCE AGENDA

Monday 12 August

09:00	**09:30**	**Conference Opening**			
		Session 1: Human - animal relations (Chair: Anna Skarin)			
09:30	**10:15**	**Keynote lecture**	**1**	**David Anderson**	**Beyond wild and tame**
10:15	**10:45**	**COFFEE**			
10:45	**12:00**	**Oral presentations**	**2**	Max Pospisil	Towards a Cross-Cultural Ethics for Human-Caribou Engagement in North-Central Saskatchewan
			3	Päivi Soppela	Domestication in Action – Multiple dimensions of using reindeer as a draught animal
			4	Mathilde van den Berg	Defining the osteological markers of castration in reindeer bones for tracing reindeer domestication ..
			5	Anna Skarin (Åhman)	The role of supplementary feeding in reindeer husbandry
			6	Annette Löf	Supplementary feeding in Sami reindeer herding – an adaptation to climate change or …
12:00	**13:30**	**LUNCH**			
		Session 2A: Taxonomy and genetics (Chair: Øystein Holand)			
13:30	**14:10**	**Keynote lecture**	**7**	**Knut Røed**	**Taxonomy and origin of reindeer and caribou, domestication and history of reindeer husbandry**
14:15	**14:45**	**Oral presentations**	**8**	Bart Peeters	Population genetics and sea ice connectivity across the distribution range of Svalbard reindeer
			9	Micheline Manseau	A genomic refinement of A.W.F. Banfield's Rangifer classification for North America
14:45	**15:05**	**Speedtalk presentations of posters, session I (9 posters)**			
15:05	**16:00**	**COFFEE & Poster session I**			
16:00	**16:30**	**Oral presentations**	**10**	Vasiliy Goncharov	Relationship berween wild and domestic reindeer populations in tundra and taiga
			11	Samantha McFarlane	Density estimates and breeding patterns in mountain and boreal caribou …
18:00	**20:00**	**RECEPTION at Ájtte Museum**			

		Session 2B: Predators and predation (Chair: Robert Weladji)			
14:15	**14:45**	**Oral presentations**	**12**	Ilpo Kojola	Large carnivores and calf production in semi-domesticated reindeer herds in Finland
			13	Vasiliy Goncharov	Impact of predators on domestic reindeer husbandry on the Taymyr Peninsula
16:00	**17:00**	**Oral presentations**	**14**	Antt-Juhani Pekkarinen	Predation costs and compensations in Fennoscandian reindeer herding
			15	Jenny Mattisson	Predation or scavenging? Reindeer body condition influences decision-making in the wolverine …
			16	Jenny Mattisson (Walton et al.)	The cost of migratory prey …
			17	Joëlle Taillon	Backtracking wolves equipped with GPS collars: a novel approach to estimate winter predation …

Tuesday 13 August

		Session 3: Populations, climate, pastures, nutrition (Chair: Steeve Côté)			
08:30	**09:10**	**Keynote lecture**	**18**	**Chris Johnson**	**Theory to practice: Application of the declining- and small-population paradigms to the rapid decline and hoped-for recovery of caribou across Canada**
09:10	**09:40**	**Oral presentations**	**19**	Bart Peters (Hansen et al.)	Reduced extinction risk by worsening climate and increased harvest: the role of internal regulation …
			20	Christine Cuyler	Catastrophic weather as principle suspect, if caribou abundance in central West Greenland crashes …
09:40	**10:30**	**COFFEE**			
10:30	**11:30**	**Oral presentations**	**21**	Larissa Beumer	From sea to summit: behavioural responses to increasingly severe winter feeding conditions in…
			22	Stine Højlund Pedersen	The effect of snow characterstics on movement and foraging behaviors of Alaska caribou
			23	Katherine Parker	As Landscapes Change, So Do Foodscapes
			24	Larissa Beumer	Linking behavioural states of free-ranging muskoxen to environmental conditions
11:30	**13:00**	**LUNCH**			
		Session 3A: Populations, climate, pastures, nutrition, physiology (Chair: Manuela Panzacchi)			
13:00	**13:45**	**Oral presentations**	**25**	Tamara Hiltunen	Inter-annual variation and long-term changes in the winter diets of Svalbard reindeer …
			26	Amélie Paoli	Response of reindeer breeding time to climatic variability in the Kutuharju herd, northern Finland
			27	Larissa Beumer (Græsli et al.)	Seasonal hypometabolism in free-ranging moose
		Session 4: Human-animal interactions (Chair: Manuela Panzacchi)			
13:50	**14:35**	**Oral presentations**	**34**	Sindre Eftestøl	Do reindeer avoid areas in-view of wind turbines?
			35	Skarin Anna	Out of sight of wind turbines—Reindeer response to wind farms in operation
			36	Christian Fohringer	Are reindeer the new canaries? - How extractive industries facilitate multiple pressures …
14:35	**15:00**	**Speedtalk presentations of posters, session II (11 posters)**			
15:00	**16:00**	**COFFEE & Poster session II**			
		Session 4: Human-animal interactions (Chair: Birgitta Åhman)			
16:00	**16:45**	**Oral presentations**	**37**	Steve Côté (Plante et al.)	Human disturbance effects on behavior and survival of migratory caribou …
			38	Manuela Panzacchi	Assessing the functionality of reindeer ranges, and the cumulative impact of anthropogenic activities
			39	Skarin Anna	Actions for mitigation of cumulative impact - from a reindeer husbandry perspective
16:45	**17:30**	**Intro excursion**			Presentation on Laponia World Heritage and practical information
18:00		**DINNER**			

		Session 3B: Knowledge and communication (Chair: Mia Landauer)			
13:00	**14:30**	**Oral presentations**	**28**	Andrea Hanke	Moving East? Documented traditional knowledge from Kugluktuk and Ekaluktutiak …
			29	Per Sandström	Creative solutions to describe the need for connectivity in reindeer pasture land
			30	Camilla Risvoll	Maps and stories in the creation of richer accounts of change in Pastoral Landscapes in…
			31	Kajsa Kuoljok	GPS tracking in husbandry – the value of knowledge
			32	Marianne Singsaas	Research projects as bridging organisations in nature management
			33	Mia Landauer (Sarkki et al)	Matching knowledge demand, research funding and knowledge supply …

Wednesday 14 August

08:00	**18:00**	**Excursion to Stora Sjöfallet (includes lunch and coffee)**			
18:00		**DINNER**			
19:00		**MOXNET meeting** (place to be announced)			

Thursday 15 August

		Session 5: Historical land use, development of reindeer herding (Chair: Jon Moen)			
08:30	**09:10**	**Keynote lecture**	**40**	**Ingela Bergman**	**Sami cultural landscapes**
09:10	**10:00**	**Oral presentations**	**41**	Sari Stark	Centennial legacies of historical reindeer herding on tundra ecosystem processes in Staloluokta, Sweden
			42	Kjell-Åke Aronsson	Historical and climatical aspects on the development of reindeer herding in Fennoscandia
			43	Malin Brännström	Indigenous legal traditions as a part of sustainable decision making.
10:00	**10:30**	**COFFEE**			
		Session 6A: Animal conservation and population demography (Chair: Christine Cuyler)			
10:30	**11:30**	**Oral presentations**	**44**	Timothy Fullman	Migration patterns and fidelity in a partially-migratory caribou herd in Arctic Alaska
			45	Milla Niemi	Wild forest reindeer returns to its historical range - soft releases as the first step
			46	Vincent Brodeur	Post-calving photographic surveys of the George River Herd between 2010 and 2018
			47	Mathilde Le Moullec	A century of recovery from overharvest in a warming high Arctic
11:30	**13:00**	**LUNCH**		**(AUS board meeting)**	
		Session 6A: Animal conservation and population demography (Chair: Mathieu Leblond)			
13:00	**14:40**	**Oral presentations**	**48**	Skarphéðinn Þórisson	Reindeer hunting in Iceland – monitoring and management – a successful system?
			49	Rán Þórarinsdóttir	Explaining population dynamics in a small reindeer sub-heard in East Iceland 2002-2018
			51	Shirow Tatsuzawa	Instability and confluence of three reindeer populations in the eastern Siberia
			52	Christine Cuyler	Too many, or too few: Kangerlussuaq muskoxen in central West Greenland?
			53	Patricia Reynolds	Group dynamics in a reestablished population of muskoxen in northern Alaska, 1983-2006
			54	Vincent Brodeur	Monitoring and management of an expanding introduced muskox population in Northern Québec, Canada.

		Session 6B: Reindeer herders day (Chair: Annette Löf)			
10:30	**10:40**	**Opening of the day**		Annette Löf	
10:40	**11:00**	**Introduction**	**59**	Åsa Larsson Blind	Forskning och framtid ur renskötselns perspektiv (Research and future from a reindeer herder perspective)
11:00	**11:30**	**Interactive session**			
11:30	**13:00**	**LUNCH**			
13:00	**17:00**	**Session 6B: Reindeer herders day - Interactive session** (including coffee at 15:00)			

14:40	**15:00**	**Speedtalk presentations of posters, session III (9 posters)**			
15:00	**16:00**	**COFFEE & Poster session III**			
		Session 6A: Animal conservation and population demography (Chair: Alessia Uboni)			
16:00	**16:30**	**Oral presentations**	**56**	Alexis Brodeur	Potential for competition between eastern migratory caribou and muskoxen in Nunavik
			57	Nuka Møller Lund	Adaptive management of muskoxen in Greenland
18:30		**CONFERENCE DINNER**			

Friday 16 August

		Session 7: Health and diseases (Chair: Morten Tryland)			
08:30	**09:10**	**Keynote lecture**	**60**	**Susan Kutz**	**Wildlife health and disease in a changing climate**
09:10	**10:00**	**Oral presentations**	**61**	Morten Tryland	Infectious disease outbreak associated with supplementary feeding of semi-domesticated reindeer
			62	Sauli Laaksonen	Transmission and distribution of emerging vector-born filaroid nematodes in Finnish cervids
			63	Asgrim Opdal	Chronic Wasting Disease (CWD) appearance - a threat to our livelihood
10:00	**10:30**	**COFFEE**			
10:30	**11:30**	**Oral presentations**	**64**	Jørn Våge	Chronic Wasting Disease in Norway: An update on surveillance, research and disease development
			65	Mariella Güere	Chronic wasting disease associated to prion protein (PRNP) gene variation in Norwegian wild reindeer…
			66	Marina Kholodova	Different prevalence of prion protein genotype associated with resistance to CWD …
			67	Ulrika Rockström	Improving herders' competence regarding reindeer health and diseases
11:30		**Closing the conference**			
12:00	**13:00**	**LUNCH**			

LIST OF POSTERS

POSTER SESSION I - 12 AUG

1	Krutikova et al.	Polymorphism of th growth hormone gene in reindeer
2	Moravčíková et al.	Genetic variation of family Cervidae based on cross-species SNPs genotyping
3	Radovan et al.	Gene flow and diversity in local red deer populations
4	Nikitkina et al.	Assessment of cryopreserved semen in reindeer (Rangifer tarandus)
5	Kumpula et al.	Changes on winter pastures in the reindeer management area of Finland
6	Carter et al.	Impact of Muskox Herbivory on Vegetation Composition and Biomass
7	Aastrup & Raundrup	Do arctic and other ungulates postpone a greener Greenland?
8	Horstkotte et al.	Supplementary feeding in reindeer husbandry across Fennoscandia – a participatory study
9	Vinblad & Muuttoranta	Regional differences in using the dogs in reindeer herding work

POSTER SESSION II - 13 AUG

~~**10**~~	~~Sipko et al.~~	~~Musk-Ox Translocation to Zavyalova Island (Magadan region, sea of Okhotsk)~~
11	Agustsdottir & Þorisson	Spying on reindeer cows in Iceland – What do their home ranges tell us?
12	Rönnegård et al.	Spatial modelling of reindeer pellet group counts using the hglm package in R
13	Leblond et al.	Habitat selection by migratory caribou along spring and fall migration routes in northern Quebec and Labrador
14	Puoskari et al.	Calving site selection criteria of wild forest reindeer (Rangifer tarandus fennicus) in Kainuu, Finland – Implications for habitat conservation
15	Tsegaye et al.	Methods of evaluating effects of varying levels of disturbance on reindeer movements and area use
16	Valente et al.	Attacked from two fronts: combined effects of anthropogenic and biotic disturbances generate complex movement patterns
17	Moudud et al.	Estimating zones of influence of windfarm on reindeer habitat selection
18	Niebur et al.	Connectivity conservation in face of rapid anthropogenic changes: tropical case studies using expert knowledge
19	Wagner et al.	Evaluation of possible technological solutions against reindeer-train-collinsions
20	Helldin	Effectiveness of road and railway bridges for reindeer and wildlife movements – an ongoing project

POSTER SESSION III - 15 AUG

21	Timofeeva et al.	Assessment of the elemental status of reindeer males by the chemical composition of the hair
22	Filippova et al.	The reindeer rumen microbiome regional differences in the Russian Arctic regions
23	Ilina et al.	The relationship between the epizootic situation and the composition of the reindeer's rumen microbial community in the herds of the Russian Arctic regions
24	Kynkäänniemi et al.	Relationship between the deer ked Lipoptena cervi and the reindeer Rangifer tarandus tarandus in Finland
25	Pyziel & Höglund	Dictyocaulus cervi (Nematoda: Trichostrongyloidea), a new causative agent of parasitic bronchitis in red deer, Cervus elaphus
~~**26**~~	~~Rauset et al.~~	~~A multi-disciplinary approach to investigations of supplementary salt-licks as transmission hot-spots for CWD and endoparasites in Norway~~
~~**27**~~	~~Hovelsrud & Risvoll~~	~~Reindeer Husbandry, Societal Infrastructure, and Climate Sensitive Infections: Are there Linkages?~~
28	Muutoranta et al.	Animal welfare at reindeer abattoir pens in Finland
29	Paulsen et al.	Animal welfare in Sámi reindeer husbandry – the double-edged sword of supplementary feeding

Session 1: Human – animal relations

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1. Keynote lecture: Beyond wild and tame

David Anderson

University of Aberdeen, Scotland, Anderson, david.anderson@abdn.ac.uk

In my talk I will examine the social sensibilities that unite hunters, followers, and herders of Rangifer in both North America and Eurasia. Citing archaeological and ethnographic work, I will test the established boundaries between the understanding of wild and tame populations and suggest a relational theory for understanding this circumpolar species.

2. Towards a cross-cultural ethics for human-caribou engagement in North-Central Saskatchewan

Max Pospisil

University of Saskatchewan, Canada, max.pospisil@usask.ca

Due to sharply decreasing populations, woodland caribou (Rangifer tarandus caribou) are a species of concern for global, Canadian, and Indigenous governments and communities. In northern Saskatchewan, Indigenous and non-Indigenous researchers, wildlife managers, hunters, communities, and industry have faced multiple challenges in working together to manage and conserve woodland caribou. Some of these challenges are due to the vastly different ways that Euro-Western and Indigenous cultures know and understand the world, generally, and nonhuman animals in particular. The language of ethics and values may provide a working platform for cross-cultural conversations about wildlife engagement that answers these concerns. Drawing on multicultural and multi-species understandings of human-nonhuman animal relations, I ask, “How do we build community-driven ethical approaches for human-caribou engagement that are comprehensible and applicable to Indigenous and Euro-Canadian peoples, and consider more-than-human voices and agencies?” Using multi-species ethnographic and participatory community-based research methodologies, this study aims to document the traditional ethical conventions and values that structure how primarily-Indigenous (Cree and Métis) communities around La Ronge, SK propose to engage and manage caribou. I will analyze my results with respect to both prior research and management plans and current goals, and return them to the communities for verification. The final product, a cross-cultural and cross-species ethical model, will be used to provide a practical means to partner with Indigenous, Euro-Canadian, and more-than-human ways of knowing to gain better understandings of human-caribou relations and to develop recommendations for co-management. This work will be important to international sustainability goals of both biological and cultural conservation.

3. Domestication in Action – Multiple dimensions of using reindeer as a draught animal

Päivi Soppela[1,2], S Kynkäänniemi[2] and H Wallen[1,2]

[1]Arctic Centre, University of Lapland, Finland, [2]Department of Archeology, University of Oulu, Finland, paivi.soppela@ulapland.fi

This project is part of the wider interdisciplinary research project the aim of which is to create new methodology for identification and interpretation of past and present animal domestication. As a novel approach, the project will focus on interactional events between humans and animals as indications of domestication. The project will use methods aimed at identifying interactional events such as draught use and feeding, between the reindeer and humans. The methodology includes archaeological bone research combined with reconstruction of physical activity of draught reindeer, stable isotope analysis to assess feeding, and participatory methods to conceptualize past understandings of human-domesticate relationships. Our part in this project is to examine current understanding of personhood and agency of domesticated reindeer by conducting participatory observation and interviews among reindeer herders. In this presentation we will focus in outlining our work package of the project and presenting preliminary findings from the field work starting in April 2019. Current understanding of reindeer personhood and agency will be examined by conducting interviews and participatory research among reindeer herders in northern Finland. Nowadays reindeer are trained to pull a load and to some extend to carry it. The interviews will focus on reindeer herders who train draught and race reindeer, as well as on herders working with reindeer in tourism industry. We are interested in interactions related to train reindeer for draught and racing use. The results will illustrate how animal personhood and human-animal interaction shape current reindeer herding practice and draught reindeer raising in modern animal husbandry practice and help to conceptualize human-domesticate interaction and mutuality in past domestication processes. The results will also contribute to the wider discussion on the social, economic, and ethical implications of animal domestication.

4. Defining the osteological markers of castration in reindeer bones for tracing reindeer domestication in Fennoscandia

Mathilde van den Berg, Henri Wallen and A-K Salmi

University of Oulu, Finland, mathilde.vandenberg@oulu.fi

Knowledge of the processes surrounding reindeer (Rangifer tarandus) domestication can give insight in the history of many past and contemporary circumpolar cultures. However, the time and origin of reindeer domestication remain hotly debated today. Determining the domestication status of reindeer in archaeological bone assemblages poses a problem because wild and semi-domesticated reindeer are morphologically very similar. It is argued by many that castration played an important role in the reindeer domestication process, and it is said that castrated males were probably the key to reindeer domestication. Although the importance of castrates and their part in incipient reindeer domestication is widely recognized, no methods exist that can discern a reindeer gelding from a reindeer bull. Focusing on the use of castrated reindeer and defining the osteological manifestations of reindeer castration can be a powerful novel approach to document human intervention in the population structure of this species. The premise of this method is that longitudinal growth of the bones is linked to epiphyseal fusion. For several studied species (e.g. sheep and goat), castrates show a clear pattern of delayed epiphyseal fusion relative to both males and females, which allows the elongation of the bones, and the long-bones in particular. This study focuses on reindeer domestication in Fennoscandia in particular, but the results can gain insight into the reindeer domestication process of other areas as well. For this study three ecotypes of reindeer that were extant in Fennoscandia until the 19th century were analyzed. These are the wild mountain reindeer (R.t. tarandus), wild forest reindeer (R.t. fennicus), and semi-domestic reindeer (R.t. tarandus). Skeletons of known age, sex, castration status, and subspecies were analyzed to plot the osteometric differences between castrates and full males. In this presentation the results of this study are presented. The outcomes of this research aid in evaluating a novel method of tracing (incipient) domestication also for other species.

5. The role of supplementary feeding in Fennoscandian reindeer husbandry

Birgitta Åhman

Swedish University of Agricultural Sciences, Sweden, birgitta.ahman@slu.se

Reindeer herding represents a nature-based, pastoral system that has been practiced by Sami people in Fennoscandia during several hundred years. The semi-domesticated reindeer generally graze freely on natural pastures, and herding practices are adapted to the natural migration and foraging behavior of the animals. Present-day husbandry suffers from fragmentation and loss of land because of national borders, infrastructure, industrial activities and forestry removing the lichen pastures. This has reduced the flexibility and possibility to adapt land use to seasons and variation in weather. Reduction of suitable land has led to increased animal densities on the remaining pastures, sometimes resulting in too intense grazing and reduced lichen productivity. Loss of old forest with arboreal lichens has removed a crucial alternative food source for reindeer in winters with icing or difficult snow conditions when forage on the ground becomes inaccessible. In many regions in Norway, Sweden and Finland there was a drop in reindeer numbers after several severe winters with difficult snow conditions in the mid 1960s. This promoted increased use of hay to reindeer (especially in Finland), and grain-based feeds for reindeer started to be tested and developed. Supplementary feeding, that had previously been restricted to animals used for transportation, thus became an increasingly common practice within reindeer herding. Feeding is most wide-spread in Finland, were many herders routinely feed their reindeer during mid and late winter. In Sweden and Norway, feeding is often used in connection to migration and gathering, but otherwise mostly restricted to winters with exceptionally poor grazing conditions. Easy access to supplementary feeds for reindeer is probably a main explanation to relatively high and stable reindeer populations in Fennoscandia during the last decades. This presentation links to the ongoing discussions regarding regulation of population size within reindeer husbandry and the paradox related to remaining population sizes in spite of large loss of available grazing resources.

6. Supplementary feeding in Sami reindeer herding – an adaptation to climate change or yet another threat to an Indigenous livelihood?

Annette Löf and T Horstkotte

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In Sápmi, the land of the Sami people, climate change is no longer a distant threat but a lived reality. Sami reindeer herders are among the most affected. Concern over how weather and land is changing coupled with increasingly limited flexibility in land use and restricted access to grazing resources – due to climatic, ecological and sociopolitical factors – put herders in a difficult situation. The winter 2017/18 grazing conditions in Swedish Sápmi were extreme; more herding communities than ever before applied for emergency funds to be able to afford supplementary feeding. Supplementary feeding – in contrast to traditional free-grazing land use – is, from a policy perspective, the adaptation option of choice. Our analysis shows, however, that reindeer herders view supplementary feeding quite differently; as a forced maladaptation and expression of continued cultural colonization. Using the case of supplementary feeding in reindeer herding, this presentation demonstrates the multilayered and political complexity of so called “adaptation options”. It shows how the supplementary feeding-discourse is closely intertwined with a weak implementation of Sami indigenous rights, both to land and self-determination. Our presentation draws on several years of qualitative research working with climate related issues in reindeer herding, complemented with the findings from a recent case study and a series of focused workshops with reindeer herding communities drawing on fuzzy logic mapping. Our paper stresses the importance of addressing adaptation critically and in the context of the lived reality of those affected.


Session 2A: Taxonomy & genetics
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7. Keynote lecture: Taxonomy and origin of reindeer and caribou, domestication and history of reindeer husbandry

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Reindeer and caribou (Rangifer tarandus) are distributed throughout the northern Holarctic region. The species dates back to the early Pleistocene glaciation period (~ 2 million years ago), which is characterised by intensive climatic fluctuations resulting in niches where Rangifer evolved. The last glacial period period, which ended about 12,000 years ago, was particularly influential for the origin and evolution of present genetic lineages. At that time, large parts of both northern Eurasia and America were covered by ice while polar deserts and tundra characterized large parts of Siberia and central Eurasia. During the last glacial maximum Rangifer lived south of the ice sheet in both Eurasia and North America, as well as in Beringia, an area encompassing most of Siberia as well as the Bering land bridge including parts of Yukon and Alaska. As the climate got warmer, the ice retreated and the herds isolated south of the large ice sheets in both Eurasia and North America then colonized towards the north, while the Euro-Beringian genetic lineage could expand both west into northwest Europe and east towards most of northern Canada. Accordingly, three main genetically groups are detected in contemporary Rangifer, each characterized by DNA patterns typically seen in woodland caribou (R.t.caribou), Fennoscandia domestic reindeer (R.t. tarandus), and a wide subnetwork with all subspecies represented. Many key questions related to the origins, spread and intensification of reindeer domestication remain poorly understood. Convincing evidence implies millennial use of domestic reindeer by indigenous people for transport, as decoy animals, and in some places for milking. However, what is commonly described as 'the pastoral transition' documents a type of large-scale, extensive reindeer husbandry which is thought to represent one of the most fundamental social transformations to ever take place in Eurasian Arctic. Screening of genetic markers of wild and domestic reindeer herds across Eurasia suggests separate origin of the domestic reindeer in Fennoscandia and Russia. For both regions, analyses of ancient maternal markers revealed significant genetic changes since medieval times associated with the emergence of more extensive reindeer husbandry. For both areas, and independent of each other, the emergence and spread of reindeer pastoralism involved the translocation and breeding and of a special type of animal with a partly non-native and independent origin.

8. Population genetics and sea ice connectivity across the distribution range of Svalbard reindeer

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Concerns have been raised that sea ice loss will have dramatic consequences for the persistence of wildlife species across polar ecosystems. In this study, we show how metapopulation genetics in the endemic, high-arctic Svalbard reindeer (Rangifer tarandus platyrhynchus) are shaped by the interactive effects of sea ice cover and extinction-colonization dynamics linked to past overexploitation. We genotyped 411 wild reindeer sampled across the entire subspecies' range at 19 microsatellite loci. Bayesian clustering analysis revealed a distinct hierarchical structure with three main clusters and six subclusters across the Svalbard archipelago. Genetic differentiation among populations was high (mean FST = 0.21). We found low levels of allelic richness (AR = 2.07-2.58) and observed heterozygosity (H¬O = 0.23-0.43) at the population level. Individual heterozygosity decreased strongly towards the outer distribution range, where populations showed significant levels of inbreeding. Coalescent estimates of effective population sizes and migration rates revealed strong evolutionary source-sink dynamics with the central population as the main source. Geographically distinct subpopulations of Svalbard reindeer were isolated by distance (Mantel's r = 0.48), but more strongly isolated by resistance (r = 0.70) due to barrier effects of glaciers and open water, and the strong connectivity across sea ice. Observed deviations from these isolation patterns could be explained by past harvest-induced extinctions and subsequent reintroduction programs, combined with low gene flow due to a recent lack of sea ice. These results suggest that past and current anthropogenic drivers of global change may have interactive effects on large-scale ecological and evolutionary processes. Continued loss of sea ice as a dispersal corridor within and between island systems is expected to increase the genetic isolation of populations, and even subspecies, and thus threaten the evolutionary potential and persistence of Arctic wildlife.

9. A genomic refinement of A.W.F. Banfield's Rangifer classification for North America

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Banfield's taxonomic revision of Rangifer based primarily on adult skull measurements is an invaluable resource for understanding the evolution and diversity of the species. In order to validate this work published in 1961, we analyzed the whole-genome sequencing of representative caribou subspecies and ecotypes, coupled with a comprehensive mitochondrial DNA survey across North America. We found striking concordance in the two evolutionary reconstructions. Genomic demographic reconstruction indicated a major expansion of caribou during the glacial interstitial stage of a largely ice-free North America 120 kya with subsequent differential population trajectories of emerging subspecies. Timing of subspecies divergence was concordant for barren-ground caribou (R. tarandus groenlandicus, R. t. granti), woodland caribou (R. t. caribou), and the diversification of Peary caribou (R. t. pearyi) and Greenland caribou (R. t. (eo)groenlandicus). Some revisions were notable between Banfield and our genomic reconstruction. Mountain caribou in western Canada have a more complex evolutionary history beyond ecotypic characterization within the woodland subspecies, including northern mountain caribou populations being of Beringian origin. Convergent evolution of ecotypes was observed within Beringian derived lineages evolving a boreal ecotype independent of the woodland caribou origin where it is currently placed. Genomic characterization also detected admixture among lineages in many instances, and while Banfield described intergradation among caribou forms, introgression among lineages is consistent with the recent findings of many mammalian species in that introgression is a more important evolutionary driver than previously thought. Overall, the similarity of Banfield's revision captured the main patterns of caribou evolution; however, our genomic results provide a more accurate characterization of introgression and more complex ecotypic divergence relevant to the delineation of conservation units.

10. Relationship between wild and domestic reindeer populations (Rangifer tarandus L.) in tundra and taiga

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Studies were conducted in Taimyr (tundra zone) and Evenkia (northern taiga) in order to obtain data on the effects of contacts between wild and domestic reindeer on possible offspring. The reindeer herding in specified areas is based on two breeds of domestic reindeer – Nenets and Evenk respectively. This Arctic territory is also home to a population of wild reindeer. At the same time, the number of wild reindeer in Taimyr decreased from 1 million in 2001 to 400 thousand animals in 2018, but the number of domestic animals increased from 60 to 120 thousand during the same period. In Evenkia the opposite tendency is observed: the number of forest wild reindeer has grown from 48 to 58 thousand; domestic - has decreased from 11 to 3 thousand animals. The problem of relations between wild and domestic reindeer has always existed. It is still relevant today. Due to intensive use and subsequent degradation of pastures, the routes of autumn and spring migrations of wild reindeer in Taimyr have changed and shifted to the East from the places of traditional domestic reindeer herding. However, on the migration routes wild reindeer come into contact with domestic animals. As a result, in autumn, during the rut, males of wild reindeer cover domesticated females, sometimes taken them away from the herd. The analysis of the obtained data shows that hybrids from such mating have some differences: they are born with increased viability and exceed their peers in live weight at birth by 300 g; the suit of calves from 6 months of age is lighter with a gray tint; the behavior since birth is more active than that of peers in the domestic herd; growing calves often leave the pasture, and it takes time to find them. Domestic reindeer of Evenk and Nenets breeds differ markedly: forest animals are higher in the withers, mainly of brown color, with lager carrying capacity. Wild reindeer exceed their domestic relatives in height and live weight. Because of the selection, the necessary characteristics of domestic reindeer are obtained: good meat productivity and high working qualities, which is reflected in their exterior features. Experimental data indicate the heteromorphism of domestic reindeer and their wild relatives. The coexistence of two forms of reindeer and their contacts contributes to the conservation of the species and its rational use by the indigenous peoples of the Arctic and Siberia.

11. Density estimates and breeding patterns in mountain and boreal caribou: applications of genetic methods

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Numerous wildlife species of conservation interest are elusive and found in low densities in remote areas, making the monitoring of these populations challenging. The use of non-invasive genetic sampling is offering new possibilities, including detailed population parameters and information about genetic variability. Non-invasively collected genetic samples can be used to directly study genetic diversity and familial relationships between individuals based on genotypes. Microsatellite markers are well-suited for the study of familial relationships, as they provide highly polymorphic, heritable genetic identity data for individuals. Parentage information from direct field observation is often limited to females, but non-invasive genetic studies using molecular markers are a powerful tool for inferring paternity. We used non-invasively collected genetic samples from two mountain caribou populations in the west-central Alberta Rockies and one boreal caribou population on the eastern slopes of the Rockies in Alberta, Canada, to infer parentage and sibling relationships among individuals, identify population genetic structure, and obtain genetic diversity estimates and fitness measures derived from pedigree networks. We used spatially-explicit capture-recapture (SCR) to determine sex-specific density estimates of caribou populations. The SCR results confirmed low caribou densities and the pedigree network confirmed limited interbreeding among populations and varied fitness levels in both males and females. The limited interbreeding among populations indicates low levels of gene flow between caribou populations, increasing susceptibility to the effects of low genetic diversity and inbreeding. In some populations, the varying reproductive fitness observed amongst males and females was significant and should be considered in future population management efforts. Improved connectivity among and with neighbouring subpopulations should also be considered to sustain or enhance genetic diversity. Density patterns emerging from the analysis of the mountain caribou populations are being compared to several boreal caribou populations across western Canada.


Session 2B: Predators & predation
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12. Large carnivores and calf production in semi-domesticated reindeer herds in Finland

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Calf/female ratios showed a decreasing trend during 1991 through 2015 almost half (48%) of 54 reindeer herding cooperatives in Finland and the trend had a clear geographic pattern. With a few exceptions the cooperatives with negative trend were located south of the 66th latitude. Calf/female ratios were significantly related to the reported predation rate by one of the four large carnivore species (brown bear, grey wolf, wolverine, Eurasian lynx) in 24 reindeer herding cooperatives. The wolf differed from the other three carnivores because it bred only occasionally in the reindeer husbandry area of Finland. The damages were mostly caused by young wolves that had recently moved from outside reindeer husbandry area and many of them from Finnish packs hosting territories near southern boundary of the reindeer area. Increasing carnivore densities in regions within and nearby reindeer husbandry region caused distinctively increased damages due to predation but calf/female ratios declined in 44% of herding cooperatives without relationship to predation by carnivores. In these cooperatives reindeer are often kept in corrals near human residences over winter months. This practice is apt to decrease predation by carnivores but come expensive to reindeer herding due to feeding costs and might also increase expose to disease and parasite transmissions.

13. Impact of predators on domestic reindeer husbandry on the Taymyr Peninsula

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The aim of the research was to study consequences of predators' attacks on domestic reindeer in the tundra of Taimyr. A visual method was used to assess the behavior of reindeer during various predators' attacks. We took into account the number of attacks, periods of activity and methods of predators' attacks, various methods for protecting reindeer. Predators attack reindeer throughout the year, but the greatest activity of predators is observed in the spring during the calving period. During this period not only large predators such as wolf (Canis lupus), brown bear (Ursus arctos), wolverine (Gulo gulo), but also small – arctic fox (Vulpes lagopus), fox (Vulpes vulpes), as well as birds – white-tailed eagle (Haliaeetus albicilla) and crow (Corvus corax) may attack reindeer. The appearance of predator causes anxiety in the herd, especially among females. There have been cases when young females had left their calves. The habits of the attacks of the different predators vary greatly. Bears attack reindeer in spring and autumn, and rarely in summer. The bear usually sneaks up secretly from ravines and bushes. In the calving period a hungry bear may kill up to 5 calves for the day. After killing large reindeer, a bear hides the remains, burying them under the moss and turf. Unlike a wolf, a bear, having got a reindeer, does not pursue other animals. Wolves are more careful. They are most active in autumn, when they teach the grown puppies to the craft of hunting. The greatest harm to the herd is caused in the spring by arctic foxes. Newborn calves become easy prey for them. A group of predatory killers (3-4 foxes) surrounds the female with a calf. One animal of the group aggressively distracts the female, and as soon as she runs after him, the other foxes pounce on the calf. Crows attack in the same way as foxes, in a group, and beaks inflict deadly blows to the head and eyes. White-tailed eagle is able to abduct a few calves in the calving period. During the year, predators kill about 20 reindeer in one herd, 60% of them are calves during calving, more than 50% of the loss falls on arctic foxes and bears. Russia does not pay compensation to reindeer herders for the losses of reindeer. Reindeer herders need to take special preventive measures against predators and birds, which will reduce the loss of reindeers and save the livestock.

14. Predation costs and compensations in Fennoscandian reindeer herding

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Conflicts often arise when large predators and free-ranging livestock share a common area. Various compensation schemes are used to attempt solving these conflicts, but the costs of predation to suffering stakeholders are often unknown. Semi-domesticated reindeer (Rangifer tarandus L.) herding and large carnivores form one such system, where conflicts between predator conservation and the traditional livelihood are common. We apply an age- and sex-structured reindeer-lichen model to examine the effects of predation on reindeer management. We specify age- and sex-class-specific mortalities due to various predators, and use the model to study optimal reindeer herding under predation pressure and the costs of predation. We show that adaptation to predation pressure includes increasing the size of the reindeer population in winter and changing the slaughtering age of males towards younger age classes. The costs of predation highly depend on the age-class-specific killing rates of reindeer by various predator species, but not on interest rate or pasture conditions. Regarding species that also kill adult reindeer in addition to calves, the total predation costs are clearly higher than the net slaughtering value of the predated animals. Our solutions corresponding to a territorial compensation system show that the decrease in steady-state yearly net income is nearly 25 000€ per gray wolf (Canis lupus L.), but lower for other predator species. However, if herders have not adapted to the predation pressure, and are assumed to search for the predated reindeer to gain compensations, the total predation costs are approximately 40 000€ per gray wolf. Our results suggest that combining a viable gray wolf population and profitable reindeer management in the same area is not possible in most cases.

15. Predation or scavenging? Reindeer body condition influences decision-making in the wolverine, a facultative predator.

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The interaction between predators and their prey is a key factor driving population dynamics and shaping wildlife communities. Most predators will scavenge in addition to killing their own prey, which alters predation effects and implies that one cannot treat these as independent processes. However, the relative importance of predation vs. scavenging and the mechanisms driving variation of such are relatively unstudied in ecological research on predator–prey relationships. Foraging decisions in facultative predators are likely to respond to environmental conditions (e.g., seasonality) and inter-or intraspecific interactions (e.g., prey availability, presence of top predators, scavenging competition). Using data on 41 GPS-collared wolverines (Gulo gulo) during 2401 monitoring days, in four study sites in Scandinavia, we studied variation in diet and feeding strategies (predation vs. scavenging), along a gradient of environmental productivity, seasonality, density, and body mass of their main prey, semi-domestic reindeer (Rangifer tarandus). The most important factor affecting the relative extent of predation and scavenging was mean prey body mass. Predation on semi-domestic reindeer was more pronounced in summer, when vulnerable calves are abundant, and individual kill rates were negatively related to local reindeer body mass. This relationship was absent in winter. The probability of scavenging was higher in winter and increased with decreasing local reindeer body mass, likely as a response to increased carrion supply. Wolverine feeding strategy was further influenced by predictable anthropogenic food resources (e.g., slaughter remains from hunted ungulates) and the presence of a top predator, Eurasian lynx (Lynx lynx), which provided a continuous carrion supply promoting scavenging. Our results suggest that wolverine feeding strategies are flexible and strongly influenced by seasonally dependent responses to reindeer body condition in combination with carrion supply. This study demonstrates that large-scale environmental variation can result in contrasting predator feeding strategies, strongly affecting trophic interactions and potentially shaping the dynamics of ecological communities and the extent of human – wildlife conflicts in regards of wolverine depredation on semi-domesticated reindeer.

16. The cost of migratory prey: seasonal changes in semi-domestic reindeer distribution influences breeding success of Eurasian lynx in northern Norway

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Migratory prey is a widespread phenomenon that has implications for predator–prey interactions. By creating large temporal variation in resource availability between seasons it becomes challenging for carnivores to secure a regular year-round supply of food. Some predators may respond by following their migratory prey, however, most predators are sedentary and experience strong seasonal variation in resource availability. Increased predation on alternative prey may dampen such seasonal resource fluctuations, but reduced reproduction rates in predators is a predicted consequence of migratory primary prey behavior that has received little empirical attention. We used data from 23 GPS collared Eurasian lynx Lynx lynx monitored during 2007–2013 in northern Norway, to examine how spatio-temporal variation in the migratory behavior of semi-domestic reindeer Rangifer tarandus influences lynx spatial organization and reproductive success using estimates of seasonal home range overlap and breeding success. We found that lynx of both sexes maintained seasonally stable home ranges and exhibited site fidelity across years, independent of whether they had access to reindeer throughout the year or experienced a scarcity of reindeer in winter due to migration. However, lynx without access to reindeer in winter showed a decreased probability of reproducing and a tendency for lowered kitten survival into their first winter, when compared to female lynx with reindeer available year around. This supports the hypothesis that sedentary predators experience demographic costs in systems with migratory primary prey. Changes in the migratory behavior of ungulates, including disrupted migrations, is therefore likely to have bottom–up effects on the population dynamics of sedentary predators as well as the previously documented consequences for ungulate population dynamics.

17. Backtracking wolves equipped with GPS collars: a novel approach to estimate winter predation rate on migratory caribou

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The study of predator-prey relationships is key for understanding variations in the abundance of arctic ungulate populations. Accurate predation rates, however, are difficult to obtain for large carnivores in remote areas. In recent decades, the use of GPS collars allowed to develop new approaches. It has been proposed to use clusters of a predator's GPS collar locations to determine predation sites of large prey. We applied this technique to wolves (Canis lupus) predating on migratory caribou (Rangifer tarandus caribou) in northern Quebec during winter, but obtained poor results. Indeed, we could rarely confirm the presence of caribou carcasses at clusters of wolves' locations, either because there was no carcass or we could not detect it. We concluded that our ability to visit the cluster sites soon after they were used by wolves greatly limited the effectiveness of that technique in remote areas. In this study, we developed a new approach to assess winter predation rates of wolves on migratory caribou, that we call the backtracking technique, where we used an helicopter to visit all the locations of GPS collared wolves that were recorded <72 h before the survey. We carefully searched for caribou carcasses in a 150-m radius around each wolf location, and noted other signs of wolf presence or activity (ex., bedding sites, tracks). Because locations of wolves were spaced 3-h apart, which is shorter than the time required by a wolf pack to handle a large prey, we assumed that we had very few chances of missing a kill. We determined the environmental characteristics (ex. habitat category, elevation, slope) in a 150-m buffer around each wolf location to develop a model discriminating kill sites from bedding sites, the two most frequent activities displayed by wolves at clusters. We also investigated the movement pattern of wolves between each location (ex., directionality, movement rate, turning angle). Future steps will be to validate the model and apply it to other wolves equipped with GPS collars to assess their predation rate. These results, combined with the investigation of movement patterns, space use and seasonal diet of wolf, will help determining the role of this primary predator on the dynamics of migratory caribou, especially that predation by wolf is currently one of the primary natural limiting factors of this arctic ungulate in Northern Quebec.


Session 3: Populations, climate, pastures & nutrition
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18. Keynote lecture: Theory to practice: Application of the declining- and small-population paradigms to the rapid decline and hoped-for recovery of caribou across Canada

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Across Canada, populations of Rangifer tarandus are classified as one of 11 evolutionarily significant conservation units. Following recent assessments, 9 of those units are now recognized nationally as Endangered or Threatened. These are challenging times for ecologists tasked with the management and now recovery of one of Canada's most iconic species. Despite several decades of intensive study, we are struggling to maintain woodland caribou across Canada's forested ecosystems and to return barren-ground caribou to numbers that will support the cultural and subsistence needs of Aboriginal communities. Corresponding with the declines of caribou, we are witnessing an unprecedented growth in research focused on better understanding the ecology of the species. The findings of those studies reveal some of the mechanisms that dictate declines and illuminate incomplete or flawed approaches for monitoring and maintaining caribou. More generally, those experiences provide a foundation from which we can look back as well as to the future in an effort to identify more effective approaches for addressing Canada's unfolding caribou crisis. Caughley's (1994) review of the declining- and small-population paradigm is an excellent framework for assessing our response to the management and recovery of caribou. Population ecologists focused on the declining-population paradigm are interested in understanding how deterministic factors cause an abundant population to decline rapidly. In the case of caribou, that decline can result in management actions that restrict or prevent harvest. Alternatively, the small-population paradigm is focused on populations that are nearing extirpation as a product of environmental, demographic and genetic stochasticity. Here, the emphasis is not management, but persistence. Caughley concluded, "The declining-population paradigm is urgently in need of more theory. The small-population paradigm needs more practice." Our recent experience with managing and conserving Canada's barren-ground and woodland caribou provides some insights on theory and many examples of successful and failed practice. Over the past 30 years, barren-ground caribou in Canada have declined by >56%. This is not the first decline witnessed by scientists and Aboriginal people, but the precise causes remain unclear. Complicating our understanding of that decline, and hoped-for recovery, are emerging determinants of population change. This includes unsustainable harvest following a density regulated decline, expanding industrial development, and a rapidly changing Arctic climate. Unlike the cyclical dynamics observed in the past, there is much concern that herds may remain at low abundance for longer periods. Historically, woodland caribou persisted at low densities across much of their Canadian range with a gradual trend of northerly contraction through the 19th and 20th centuries. In the past 25 years, these caribou have entered a new phase of more rapid decline and contraction that has resulted in population extirpation. That decline is the result of human activities that degrade habitat and alter multi-species predator-prey dynamics. As with barren-ground caribou, those dynamics are not linear or easily predicted and the mechanisms of decline are evolving. Conservation professionals are applying the full suite of intensive and expensive recovery tools to stave off further extirpation and boost small populations of mountain and boreal caribou. These efforts are challenged by the conflict between habitat protection and the trillions of dollars in revenue generated by the natural resource industries that co-occur with caribou and their predators. As Caughley noted, we cannot recover declining and small populations without first understanding and addressing the mechanisms underlying those observed patterns. However, the causes of decline for Rangifer are not static and in many ways present a growing and unclear spectrum of new challenges. An expanding human footprint in the Arctic and quickening of climate change suggests that monitoring will be key for anticipating emerging causes of population decline. For Canada's woodland caribou, the challenges will be in finding recovery solutions that are effective over the short and long term and that are compatible with other values and land uses. Caughley did not hesitate to discuss the scientific challenges and missteps of managing and recovering declining and small populations; however, he did not address the trials of a changing world and the constraints imposed by socioecological systems. Governments need to invest in monitoring to avoid unanticipated population declines, such as we are now observing. Adaptive experimentation is necessary to identify the conservation actions that will provide the greatest likelihood of persistence of small populations of woodland caribou. Finally, we need to identify solutions that address the conflict between the 'simple' determinants of population change and the cultural and economic needs of Canadians.

19. Reduced extinction risk by worsening climate and increased harvest: the role of internal regulation in long-term population dynamics

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Extreme climate events may cause population crashes but are difficult to account for in population-dynamic studies. Especially in long-lived animals like reindeer and caribou, density dependence and fluctuations in demographic structure may induce lagged impacts of environmental perturbations, such as extremely severe winters, on population growth. In the Arctic, several recent observations of ungulate population crashes have been linked to extreme rain-on-snow events and 'ice-locked' pastures. A perhaps intuitive, yet naïve extrapolation of such single or rare events is that increasingly frequent rainy winters would destabilize the population dynamics and increase the extinction risk. Here, using empirically parameterized, stochastic population models for High-Arctic wild reindeer in Svalbard, we show that more frequent winters with extreme rain-on-snow actually reduce extinction risk and stabilize the population dynamics due to interactions with age structure and density dependence. Extreme rain-on-snow events and ice-locked tundra mainly suppress vital rates of vulnerable ages, i.e. calves and old animals, and mainly at high population densities. A resultant population crash generates a new population state characterized by resilient ages and a long-term reduction in population sensitivity to subsequent icy winters. Thus, observed responses to single or rare extreme events are poor predictors of Rangifer population dynamics and persistence because internal density-dependent feedbacks will act as buffer against more frequent events. By simulating different harvest regimes (constant, proportional, and threshold harvest) and levels we also show how an adaptive management strategy can reduce long-term extinction risk under a range of winter climate change scenarios.

20. Catastrophic weather as principle suspect, if caribou abundance in central West Greenland crashes in near future.

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Since 1721, there have been two cycles of abrupt caribou abundance and crash in central West Greenland. The intervening periods of few caribou persisted for about a century, although large predators are absent. The assumed cause of both crashes was human overexploitation. Today, we know that central West Greenland contains several distinct caribou populations that exhibit high fecundity and recruitment. The current, third, and longest recorded ca. 45-year period of relatively stable high abundance continues, despite the recent two decades of intensive modern hunting, both commercial and recreational. Since 2000, harvest management aimed at aligning caribou density with the vegetation's regenerative capacity appears successful. Human exploitation likely played a minor role, if any, in precipitating the previous two crashes, ca 1750 and 1850. Alternatively, catastrophic weather events, specifically in winter, may bear the major responsibility. With 'islands' of terrain juxtaposed between the year round ice-free seacoast and the Greenland Ice Cap, severe storms occur regularly in central West Greenland. With ca 170 years since the last caribou crash, central West Greenland is 'overdue' for catastrophic weather events. Climate change raises the risk of excessive winter snow depths and severe icing events. Weather events will likely be the principle cause of the next, third, caribou abundance crash in central West Greenland.

21. From sea to summit: behavioural responses to increasingly severe winter feeding conditions in high-Arctic Svalbard reindeer

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The interaction between predators and their prey is a key factor driving population dynamics and shaping wildlife communities. Most predators will scavenge in addition to killing their own prey, which alters predation effects and implies that one cannot treat these as independent processes. However, the relative importance of predation vs. scavenging and the mechanisms driving variation of such are relatively unstudied in ecological research on predator–prey relationships. Foraging decisions in facultative predators are likely to respond to environmental conditions (e.g., seasonality) and inter-or intraspecific interactions (e.g., prey availability, presence of top predators, scavenging competition). Using data on 41 GPS-collared wolverines (Gulo gulo) during 2401 monitoring days, in four study sites in Scandinavia, we studied variation in diet and feeding strategies (predation vs. scavenging), along a gradient of environmental productivity, seasonality, density, and body mass of their main prey, semi-domestic reindeer (Rangifer tarandus). The most important factor affecting the relative extent of predation and scavenging was mean prey body mass. Predation on semi-domestic reindeer was more pronounced in summer, when vulnerable calves are abundant, and individual kill rates were negatively related to local reindeer body mass. This relationship was absent in winter. The probability of scavenging was higher in winter and increased with decreasing local reindeer body mass, likely as a response to increased carrion supply. Wolverine feeding strategy was further influenced by predictable anthropogenic food resources (e.g., slaughter remains from hunted ungulates) and the presence of a top predator, Eurasian lynx (Lynx lynx), which provided a continuous carrion supply promoting scavenging. Our results suggest that wolverine feeding strategies are flexible and strongly influenced by seasonally dependent responses to reindeer body condition in combination with carrion supply. This study demonstrates that large-scale environmental variation can result in contrasting predator feeding strategies, strongly affecting trophic interactions and potentially shaping the dynamics of ecological communities and the extent of human – wildlife conflicts in regards of wolverine depredation on semi-domesticated reindeer.

22. The effect of snow characteristics on movement and foraging behaviors of Alaska caribou

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Winter foraging and movement behaviors of caribou (Rangifer tarandus) are affected by physical snowpack properties. Across tundra and boreal forest landscapes, snow properties such as depth, density, layering, strength, and hardness are highly variable in both space and time. This variability is largely controlled by snowfall, snow redistribution by wind, mid-winter melting and rain-on-snow events, which are strongly dependent on terrain, vegetation, and the weather and climate dominating the region. Snow properties of particular importance to caribou in Arctic Alaska are snow hardness and depth, which affect caribou access to forage and locomotive energy costs. In addition, spatial and temporal variation in snow distribution may affect selection among multiple possible migration corridors connecting the summer habitat in tundra and the wintering habitats in the mountains and foothills. We conducted field surveys of snow properties in late-winter 2018 and 2019 across the range of the Central Arctic Caribou Herd (CACH) between interior Alaska and Alaska's Arctic coast. Our field measurements included detailed snow-pit observations, vertical snowpack hardness profiles, and extensive snow depth transects. These observations were combined with spatially and temporally explicit snow-modeling toolkit (SnowModel) outputs to develop high-resolution (30-m, daily) quantitative measures of snow property distributions and evolution throughout the fall, winter, and spring. The resulting snow information, in combination with caribou GPS location data, allows us to evaluate the influence of within- and between-year variations in snow properties, distribution, and timing on CACH daily and seasonal movement patterns and foraging ecology. Insight into these relationships improves our understanding of how snow properties influence caribou energy budget, nutritional condition, and distribution.

23. As landscapes change, so do foodscapes

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As climate and anthropogenic disturbance alter landscapes, Rangifer are being subjected to changing nutritional conditions and changing physiological and ecological costs. Questions regarding the extent to which food quantity and quality on the landscape influence health and productivity of Rangifer populations are largely unanswered. Summer nutrition is especially important because the majority of key life processes occur in summer and autumn (lactation, juvenile growth, breeding) and body reserves acquired in summer affect overwinter survival and subsequent calving. Even small differences in nutrient supplies can have multiplier effects on population productivity. For tundra and woodland caribou, we used findings from large-scale movements in relation to forage quality and quantity (as measured by remote sensing and ground observations); small-scale selection of diets and nutrient contents (from tame and free-ranging animals); and models of protein and energy gain from forage in relation to nutritional requirements to better understand habitat values. We show how scaling up from individual forage selection and forage quality allows us to map foodscapes. We discuss the challenges and need for mapping foodscapes, which influence distribution of caribou and their ability to be productive. Foodscapes are a tool to better understand the vulnerability of caribou to changing landscapes. In particular, mapping foodscapes allows us to more explicitly examine how adaptive capacity can be strengthened, which is essential to reduce vulnerability in the face of climate change and human disturbance.

24. Linking behavioural states of free-ranging muskoxen to environmental conditions

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An animal's behaviour is both the result of its physiological condition as well as a manifestation of its response to the environment. Appropriate behavioural responses to the environment will increase fitness and hence positively influence the demographic processes of survival and reproduction. Assessing animals' behaviour-based habitat use and how this is shaped by environmental conditions is thus a central question in ecology. Simultaneously to improvements in biologging and tracking technologies, behaviour-based modelling approaches have evolved over the last years, designed to detect different behaviours (e.g. foraging, resting, relocating) from remotely collected movement and activity time-series data. We present the results of a study investigating how behavioural states in muskoxen (Ovibos moschatus) are related to environmental conditions, with a focus on the snow-covered period. Applying a Hidden Markov model, we infer likely behavioural states (i.e. foraging, resting, relocating) from step length and turning angles between hourly positions from more than 30 GPS-collared female muskoxen tracked over the past 5 years in northeast Greenland. To assess how duration of behavioural states and state-switching probabilities are influenced by the small-scale environmental conditions encountered by muskoxen, we make use of a high-resolution snow model developed for the study region. Exploring drivers and plasticity of behaviour-based habitat use under varying environmental conditions, the presented results increase our understanding of this high-Arctic key herbivore's spatiotemporal winter behaviour. Muskoxen are particularly interesting in this context, as they are highly adapted to a cold and dry climate while major temperature and precipitation regime shifts are predicted for the Arctic. Thus, climate change will affect the biotic and/or abiotic conditions of the Arctic environment, which may lead to constraints on the natural behaviour of muskox individuals (e.g. heat stress, altered movement and habitat use patterns). Constrained behaviour can in turn affect energy acquisition (e.g. reduced foraging success) and energy expenditure (e.g. increased costs of movement), thereby altering the energy budget of individuals and ultimately the demographics of populations.

Session 3A: Populations, climate, pastures, nutrition & physiology

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25. Inter-annual variation and long-term changes in the winter diets of Svalbard reindeer based on serum δ13C and δ15N values

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Svalbard reindeer (Rangifer tarandus platyrhynchus) are found on an archipelago in the High Arctic between 74° and 81° north, a region that is undergoing significant changes in winter and summer climates. These climate change impacts range from negative effects on winter foraging such as ice locked pastures as a result of rain on snow (ROS) events to the positive effects of warmer summers and greater forage productivity. These complex interactions between stochastic or extreme climatic events and vegetation dynamics may impact on fecundity, individual survival and even long-term population sustainability. The winter diets of these herbivores are still uncertain as are any changes associated with climate change. In this study, we collected serum samples from adult, female reindeer at the end of winter over a 15 year period between 1995 and 2012. Serum samples were then analysed for δ13C and δ15N values as the combination of these isotopes may reflect variation in the species or functional groups that the reindeer have consumed and assimilated during the prior 1-3 months. These serum isotope values and those of forage collected during winter will be used in Bayesian mixing models to ascertain diets between years and over the decade and a half of our study. Over the entirety of the study one main trend is an enrichment in the δ15N values and a simultaneous depletion in δ13C values. These concurrent changes in serum isotope values, indicate that the winter diets have shifted to include more nutrient rich grasses. The increased proportions of graminoids in the diet vary annually and between the valleys, in response to ROS events and increased summer plant productivity. Although Svalbard Reindeer are unique, the findings of this study are applicable to the management of semi-domesticated reindeer herds especially as these extreme events are likely to increase in frequency in the future.

26. Response of reindeer breeding time to climatic variability in the Kutuharju herd, northern Finland

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The breeding time of many taxa has changed over the past two to three decades in response to climate change. In order to predict how climate change will affect reindeer husbandry and given the cultural and socioeconomic importance of Rangifer for northern peoples, it is crucial to understand how reindeer base their reproductive efforts on environmental cues since breeding time is a key reproductive trait affecting the individuals' reproductive success and therefore the population's recruitment rate. We addressed those questions using long-term datasets of 45 years of birth dates, as well as mating behaviors and copulation dates recorded since 1996 from a semi-domesticated reindeer population in Kaamanen, North Finland. We found an advancement of calving season by ~ 7 days between 1970 and 2016, of males' mating time by 10 days over 16 years, and of females' copulation dates by 11 days over 18 years. The advancement of those phenological events were found to follow the climatic changes reported in the study area since (1) earlier calving dates were associated with lower snowfalls and a reduced snow cover in April and warmer temperatures in April-May, (2) males began to display mating behaviors earlier with a higher amount of precipitation in May and (3) observed copulation dates also occurred earlier following a warmer weather in April. An improved physical condition of individuals in response to better climatic conditions in early spring, facilitating availability of late winter food and early green-up of vegetation probably accounted for the observed advance in reindeer breeding time. More importantly, reported trends for heavier calves, calves with a higher first-summer survival and an overall higher number of newborn calves following better climatic conditions in spring make us believe that the plastic response of breeding time to climatic conditions in spring will most likely allow reindeer to adapt to climate change in Finnish Lapland. As such, reindeer populations may be more resilient to climate change than previously acknowledged.

27. Seasonal hypometabolism in free-ranging moose

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Migratory prey is a widespread phenomenon that has implications for predator–prey interactions. By creating large temporal variation in resource availability between seasons it becomes challenging for carnivores to secure a regular year-round supply of food. Some predators may respond by following their migratory prey, however, most predators are sedentary and experience strong seasonal variation in resource availability. Increased predation on alternative prey may dampen such seasonal resource fluctuations, but reduced reproduction rates in predators is a predicted consequence of migratory primary prey behavior that has received little empirical attention. We used data from 23 GPS collared Eurasian lynx Lynx lynx monitored during 2007–2013 in northern Norway, to examine how spatio-temporal variation in the migratory behavior of semi-domestic reindeer Rangifer tarandus influences lynx spatial organization and reproductive success using estimates of seasonal home range overlap and breeding success. We found that lynx of both sexes maintained seasonally stable home ranges and exhibited site fidelity across years, independent of whether they had access to reindeer throughout the year or experienced a scarcity of reindeer in winter due to migration. However, lynx without access to reindeer in winter showed a decreased probability of reproducing and a tendency for lowered kitten survival into their first winter, when compared to female lynx with reindeer available year around. This supports the hypothesis that sedentary predators experience demographic costs in systems with migratory primary prey. Changes in the migratory behavior of ungulates, including disrupted migrations, is therefore likely to have bottom–up effects on the population dynamics of sedentary predators as well as the previously documented consequences for ungulate population dynamics.


Session 3B: Knowledge & communication
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28. Moving East? Traditional knowledge documents a distribution shift in the Dolphin and Union caribou herd in 2003

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The Dolphin and Union caribou herd (Rangifer tarandus groenlandicus x pearyi), or tuktu, is a migratory caribou population of northern Canada found on Victoria Island that characteristically migrates to and from the adjacent mainland. Dolphin and Union caribou are ecologically, economically and culturally important, yet little information about the herd is available for co-management decisions. In 2003, the Government of Nunavut conducted 30 structured interviews with experienced hunters, elders and wildlife officers in Kugluktuk and Cambridge Bay (Ekaluktutiak). Subsequently, the University of Calgary thematically analyzed the transcripts per community, under critical realism and with NVivo. Each resulting theme and associated metric(s) are part of a cycle where they were influenced by, and exerted pressure on, the other themes and metrics. The themes and metrics are non-exhaustive and limited by the information in the interviews and the study's methodology and methods. The five cyclical themes (and metrics) are: land-based survival in the Arctic (the specificity, sensitivity and accuracy of information); interdependence between humans, animals and the land (predator abundance); caribou culture (caribou population cycles, abundance, health and body condition); caribou autonomy (caribou use of the land, location changes, and behaviour choice); Inuit spatial intimacy (caribou migrations and movement) and environmental deviations (trends in weather, freezing rain, caribou drownings, and sea ice conditions). Separating the analysis by community has allowed insight into asynchronous observations of population trends, health statuses and spatial ranges. When interpreted together, the themes and metrics suggest a distribution shift of the Dolphin and Union caribou herd.

29. Creative solutions to describe the need for connectivity in reindeer pasture land

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The functionality of landscapes for reindeer husbandry in Sweden and elsewhere are under immense threats from a numerous other land use forms. Reindeer herder's observations, as well as research results, indicate that many reindeer herding communities (RHC) have reached a tipping-point where hinders and barriers in the landscape seriously threaten the traditional form of reindeer husbandry. We have reached a point where actions to restore landscapes and their connectivity is necessary. In this project we contribute to the planning of a new high-speed train line paralleling the main highway (E4) cutting through the winter range of the reindeer husbandry area. Without mitigating efforts the train line in combination with the existing highway would form a complete barrier eliminating access to large areas of key winter grazing areas. At present, the highway is already a major obstacle to reindeer crossings even though unknown to the Swedish Transport Administration (STA) responsible for highways and train lines. The planning process of the train line offered us the opportunity to explain reindeer husbandry's complex needs of connected landscapes and to address the specific problems caused by the highway as a barrier to reindeer movement. We combined knowledge from reindeer herders with scientific tools and methods to explain the needs for restoration and to identify solutions. We co-produced information and mapped and designed a system of reindeer overpasses as solutions to landscape level barriers. Furthermore, we examined methods to communicate needs and solutions to the STA. In our search for most effective communication methods we tried several methods, tools and media sources. This included creation of traditional reports and custom-made maps using a participatory GIS. Furthermore, we equipped reindeer herders with a drone to document a reindeer herd's dramatic crossing of the E4 highway. Footage from the drone unfolding specific problems during the crossing became the communication form that finally led to the full insight of the problem for STA personnel. As a result, the STA have placed a work-order for an initial wide, vegetation covered highway overpass. Further plans are underway to link this overpass with a series of overpasses over the new train line. Additionally, the STA has started an educational program for their personnel about how to incorporate the needs of reindeer husbandry in their overall planning process.

30. Maps and stories in the creation of richer accounts of change in Pastoral Landscapes in Nordland County

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Maps are powerful but always and necessarily partial accounts of the world. They establish a particular way of seeing the world that emphasizes the spatial properties of well-defined elements. In the other hand, the practices of traditional reindeer herding shapes a way of seeing the landscape that differs from the way of seeing that maps creates. In this article we use a case in Nordland to exemplify some of these mismatches and discuss the implications for governance. Rather than taking mapping as a tool for description, in this article we explore the possibilities of maps as a practice of inquiry that may promote insights into how different ways of inhabiting and seeing the world can establish a dialogue in how best to intervene and manage landscapes. Our results show that existing governmental land-use maps for Sámi reindeer pastoral landscapes in Northern Norway can be misleading in terms of the size, ecological and temporal dynamics of areas. We devised and implemented an iterative participatory mapping dialogue with reindeer herders to illustrate how herders' knowledges can contribute to understanding the dynamics of actual pasture access, key migration passage points and other features of landscape. Our analysis show how the cumulative effects of processes of change and development create a multitude of stressors that affect pasture access, grazing behaviour and reduce both reindeers' and herders' flexibility and adaptability to weather variability and climate change impacts. Further our approach provided the platform to elicit how herders are adapting to encroachment and that their adaptation strategies have both intended and unintended and unforeseen effects. We conclude by discussing implications of mapping and the dilemmas this entails for dealing with changes in pastoral access and flexibility within reindeer husbandry in Nordland County, northern Norway.

31. GPS tracking in husbandry – the value of knowledge

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Generations of reindeer herders have built up a traditional Sámi knowledge, about reindeer, the landscape and the environment. The Sámi culture and reindeer husbandry have been in constant change and never static which has been decisive for their continuing existence. The demand to integrate new technologies into husbandry has intensified in the last decades. This presentation brings together reindeer husbandry grounded in traditional Sámi knowledge and the use of the tool: GPS (global positional systems) transmitters on reindeer, so-called GPS collars. This technology has changes every-day herding practices among the interviewed herders. The GPS transmitters are attached to the reindeers' necks, and generate the reindeer movement data, which is sent to the reindeer herders via satellite or telephone. This illustrates a shift from "believing" to "knowing" and the GPS collar has an impact on herders' ability to feel they have control through the transmitted data. The GPS system enables data to be transferred from multiple locations into one place, where herders can gain an overall view. The data also enables herders to talk about the reindeer flows in communication with external actors. During the last decade, industrial investments have increased the pressure on reindeer grazing lands. In discussions with stakeholders, it is important for the Sámi community to be able to visualize and communicate reindeer husbandry's use of the area. Here, the GPS maps become an important tool with power.

32. Research projects as bridging organisations in nature management

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Uncoordinated planning between sectors and a plethora of plans for the same territory is a major challenge in managing natural resources in Norway. With the low level of national policy integration, there is a growing realisation of the need for cross-sectoral cooperation in nature management. Management of natural resources must therfore take into account the competing interests and interdependencies of various stakeholders at different levels and in different sectors. This paper assesses the GPS collaring research projects in the Hardangervidda wild reindeer area in Norway, as a bridging organisation, providing an arena for trust-building, collaboration, knowledge building and learning between stakeholders. This paper draws on two strands of literature - institutional capacity – and - social capital - to investigate the contributions of the GPS collaring research projects in building institutional capacity in Hardangervidda, focusing on knowledge, networks and agents of change. Based on written material from 2001 – 2018, and interviews with key informants, the paper shows a development from an initial focus on GPS-data collection, to a growing awareness of the "side effect" of the project as an arena for coordination and mediation, awareness raising and behaviour change. The paper claims that the role of the GPS collaring research project has been decisive for building institutional capacity in Hardangervidda. However, the paper also point to important obstacles in the implementation of the outputs into outcomes in terms of joint action.

33. Matching knowledge demand, research funding and knowledge supply: Trends and scenarios around reindeer herding in Finland

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Matching knowledge demand, research funding, and knowledge supply (DFS) is important to enhance societally and policy relevant research, to target funding appropriately and to enhance connectivity between science, policy and society. The DFS field around reindeer herding in Finland offers a fertile case study to examine interconnected and complex trends and relations between herders' and policy makers' knowledge demand, ministerial funding and independent supply of knowledge by science. We identify matches and mismatches between the DFS around reindeer herding across ten inductively identified themes and in time scales of 2000-2009 and 2010-2018. We apply an ex-post scenario approach to identify five alternative and legitimate ways to match the DFS. This goes beyond simplistic arguments according to which research must always follow policy needs or societal concerns should always define the scope of research and its funding. In more general terms, the present paper implies that currently booming "reversely linear approach" (D → F → S) is appropriate in some situations, but the whole DFS fields must not rely on a single strategy. The identified five scenarios fit to varying situations and can inform alternative ways to match the DFS around reindeer herding applicable also in other contexts.


Session 4: Human – animal interactions
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34. Do reindeer avoid areas in-view of wind turbines?

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Knowledge on distinct disturbance stimuli from wind power plants, such as visibility of turbines, human activity or noise, and how they affect reindeer (in isolation or in synergy) is limited. We also lack an understanding of why reindeer seemingly behave differently in different study sites. Based on feedback from local herdsmen, and using two years of "before" and five years "after" data from GPS-tagged female reindeer, we test the area use of reindeer in relation to visibility of wind turbines in the Raggovidda wind power plant, Finnmark, northern Norway. Using visibility maps and BBMM, we compare changes in area use during the calving period in relation to visibility and/or distance from turbines. We also aim to include how area use relates to daily herder activities, habitat quality and spatiotemporal variation. Although wind turbines have been shown to disturb reindeer, uncertainty remains whether visibility of turbines at different distances influences this response, or whether level of human activities within a wind farm drives reindeer reactions. In order to understand and improve land management for multiple user groups, more multi-scale and multi-year, before-during-after studies such as this are necessary

35. Out of sight of wind turbines — Reindeer response to wind farms in operation

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To meet the expanding land use required for wind energy development, a better understanding of the effects on terrestrial animals' responses to such development is required. Using GPS-data from 50 freely ranging female reindeer (Rangifer tarandus) in the Malå reindeer herding community, Sweden, we determined reindeer calving sites and estimated reindeer habitat selection using resource selection functions (RSF). RSFs were estimated at both second- (selection of home range) and third-order (selection within home range) scale in relation to environmental variables, wind farm (WF) development phase (before construction, construction, and operation), distance to the WFs and at the second-order scale whether the wind turbines were in or out of sight of the reindeer. We found that the distance between reindeer calving site and WFs increased during the operation phase, compared to before construction. At both scales of selection, we found a significant decrease in habitat selection of areas in proximity of the WFs, in the same comparison. The results also revealed a shift in home range selection away from habitats where wind turbines became visible to- ward habitats where the wind turbines were obscured by topography (increase in use by 79% at 5 km). We interpret the reindeer shift in home range selection as an effect of the wind turbines per se. Using topography and land cover information together with the positions of wind turbines could therefore help identify sensitive habitats for reindeer and improve the planning and placement of WFs. In addition, we found that operation phase of these WFs had a stronger adverse impact on reindeer habitat selection than the construction phase. Thus, the continuous running of the wind tur- bines making a sound both day and night seemed to have disturbed the reindeer more than the sudden sounds and increased human activity during construction work.

36. Are reindeer the new canaries? - How extractive industries facilitate multiple pressures on an Arctic pastoral ecosystem

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In this study, we show how extractive industries, especially large-scale mining, facilitate a cascade of land conversions which are affecting animal populations and pastoralists' behavior in northern Sweden. By incorporating herder knowledge, reindeer movements and public data on socio-economic variables combined with geospatial tools, we illustrate how the reindeer herding system functions as a proxy for ecosystem vulnerability in the Arctic. Environmental changes and their consequences on pastoral lifestyles and biodiversity are known to have far reaching effects on the resilience of animals and associated livelihoods around the world. To avoid further loss of favorable habitat and mobility, as well as negative demographic and economic effects on pastoralism, it is important to understand the socio- ecological baselines which can be used for future planning and adaptation. Our approach and results provide new insights for scientifically robust cumulative impact assessments of extractive industries by creating a baseline via historical data of trends and extents of human activity and infrastructural developments over the last century.

37. Human disturbance effects on behavior and survival of migratory caribou of Northern Québec and Labrador, Canada.

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As human development intensifies in northern ecosystems, concerns are raised regarding the potential negative impacts on wildlife. Human disturbances have been suggested as a potential cause for the decline of many caribou and reindeer (Rangifer tarandus) populations, and disturbance effects on caribou have often been investigated. Few studies, however, have quantified the area avoided by wildlife around human disturbances, evaluated the cumulative habitat loss resulting from the avoidance of disturbances and assessed the impact of disturbance exposure on survival. Here, we evaluated the effects of human disturbances on two migratory caribou herds in northern Québec and Labrador, the Rivière-aux-Feuilles herd (RFH) and the Rivière-George herd (RGH). We quantified the zones of influence (ZOI) of human disturbances. We also evaluated the effects of roads on caribou movement and accessibility to seasonal ranges. We estimated cumulative habitat loss caused by avoidance behavior. We finally assessed the effect of repeated exposure to disturbances on longevity and seasonal survival, and the instantaneous effect of proximity to disturbances on daily survival. Between 2009 and 2015, we equipped 510 caribou with GPS collars and evaluated their habitat use in areas surrounding roads, mines, mining exploration sites, human settlements and power lines. We found that caribou avoided human disturbances, either by using seasonal areas that excluded disturbances, or by reducing their use within a ZOI of a few kilometers up to 23 km from disturbances. Caribou also doubled their movement rate when crossing a road. We demonstrated that a road limited the access of the RFH caribou to a portion of their summer range. Avoidance of disturbances translated into cumulative habitat loss reaching as much as 30% of seasonal ranges and 37% of high-quality habitats for caribou. Although we found broad negative effects of human disturbances on caribou behavior, the impact on survival appears limited at the current level of development in northern Québec and Labrador. We found that longevity in the RGH was reduced for individuals more exposed to disturbances, but for the RFH and for other scales of analysis for the RGH, survival was mainly explained by non-anthropogenic factors. We conclude that space use in migratory caribou is more affected than survival by human disturbances.

38. Assessing the functionality of reindeer ranges, and the cumulative impact of anthropogenic activities

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Human activities and infrastructures present major challenges for reindeer management and conservation, globally, as they cause both habitat loss and fragmentation. Traditionally, studies quantified the impact of anthropogenic activities either in terms of habitat loss, or on landscape fragmentation, using methods derived from different theoretical backgrounds. However, most often habitat loss and habitat fragmentation occur together and their total, cumulative impact depends on their interaction. In other words, cumulative impacts are determined to a large degree by the type of infrastructures, and by their location with respect to other anthropogenic activities and to crucial areas for reindeer. Hence, traditional approaches to quantify habitat loss and fragmentation, separately, are not ideally suited to draw strong conclusions on cumulative impacts. We developed a methodological framework that integrates and extends recent advances in habitat modelling, connectivity modelling, movement ecology and computer science. The output is a metric - Habitat Functionality, HF - that synthesizes simultaneously the importance of each landscape unit (pixel) both in terms of habitat quality and movement-based connectivity, calculated based upon the species' specific movement patterns. In other words, HF synthesises how functional each landscape unit is for the focal species. This metric can therefore be used to quantify cumulative impacts of existing infrastructures, to make scenario analyses (e.g. to assess the total impact of planned infrastructures or climate change), to identify the most crucial movement corridors, and to support management in the identification of priority areas for conservation or restoration. The metric is based upon advanced algorithms, and can be used on large landscapes. We apply this approach to a large number of GPS-monitored reindeer covering a range of ecosystems across Norway, and we demonstrate how this metric can be used to quantify functional habitat, cumulative impacts and to predict the impact of planned mitigation measures, in a scenario approach.

39. Actions for mitigation of cumulative impact – from a reindeer husbandry perspective

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In the Arctic, there is a growing concern over the cumulative impacts of multiple land uses on landscape functionality. Sami reindeer husbandry often bears the brunt of these impacts since it relies on interconnected landscapes where the reindeer can move, by itself or facilitated by the herders during both smaller and larger migrations. Barriers and obstacles caused by human activities may result in making important grazing lands inaccessible or with the reindeer ending up in the wrong grazing area at the wrong time. Most often, the only source of knowledge on these impacts are the herders themselves, i.e. those who experience and navigate the consequences in their everyday lives. However, while recent years have seen growing interest, globally, in how indigenous communities can lead impact assessments on their own lands little research has yet explored how cumulative effects assessment can be undertaken based on the knowledge of Sami reindeer herders. In fact, impact assessment, especially in the European North, remains one of the arenas most entrenched in colonial practices that privilege 'foreign' and expert led research, invariably silencing herders' knowledge. In this paper, we present insights from a long-term study in Sirges and Vilhelmina Norra Sami reindeer herding communities in northern Sweden, where herders with support from researchers have developed their own approach to cumulative effects assessment. The question we ask is how an impact assessment would look if conducted with genuine Sami leadership and how the results would differ from those generated by standard impact assessments. The assessment combined a wealth of both qualitative and quantitative methods but were all based on herders' knowledge about their current and historical land use in. Moreover, we compiled current and historic geographical data on all other land use activities to show the progression of land use development. With this design, it provided novel understanding of the impacts of piecemeal developments both in space and in time on reindeer grazing ranges. It also allowed the herders to propose plans to improve the conditions and to remove known bottlenecks in the landscape, i.e. to repair old or enhance existing migration routes. Discussing these findings and methods, the study allows us to reflect on the role of research partnerships for the future development of cumulative effects assessment.

Session 5: Historical land use & development of reindeer herding

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40. Keynote lecture: Sami cultural landscapes

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When pioneer communities established in northern Sweden soon after the latest deglaciation, reindeer already formed an integral part of subsistence and livelihood. At the earliest settlement site, dating to 9 800 BP, reindeer bones formed 90% of the osteological material. From then on, the close relationship between humans and reindeer runs all through the prehistorical and historical times to the present day. Hunting techniques and methods developed aiming at an increasingly larger scale presupposing the collaboration on a community level. Eventually, the significance of reindeer changed from prey to property with great implications not only to the economy, but to social structures, religious concepts, inter-cultural relations and, not least, to landscape management. The time, cause and course of the transition from reindeer hunting to herding, is much discussed among archaeologists and historians. The complex dynamics involved in the development of reindeer herding/pastoralism requires inter-disciplinary research strategies, including the humanities as well as the natural sciences. During the past 20 years, the Silvermuseet in Arjeplog, has initiated a number of research projects focussing on the inter-relationship between socio-economic processes, landscape formation and long-term ecosystem changes in alpine and boreal environments. Research teams included archaeologists, ecologists, forest historians and soil scientists. Results show that the transition to reindeer pastoralism during the first millennium AD involved gradual changes in land use strategies and the active management of forest and grazing resources. The longitudinal analyses have produced new knowledge of traditional Sami land use and landscape affiliation adding new perspectives on todays´ disputes over land and resources.

41. Centennial legacies of historical reindeer herding on tundra ecosystem processes in Staloluokta, northern Sweden

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It is commonly known that ungulates exert important effects on ecosystem processes, such as microbially mediated soil carbon and nutrient cycling, rates across ecosystems. The indirect effect of ungulate grazing on soil microbial activity feedback on plant species composition, ecosystem productivity and carbon stocks. To date, little is known on how long-lasting changes in soil processes are following ungulate grazing. We investigated the legacies of past reindeer herding on plant and soil processes in Staloluokta, northern Sweden by analyzing soil microbial processes and nutrient concentrations at historical sites, where reindeer herding induced a vegetation transition from deciduous shrubs or dwarf shrubs to graminoids several centuries earlier but where grazing ceased already a century ago. The results demonstrated a strong legacy of grazing on tundra soil processes even after grazing had long ended. Different plant- and soil-driven processes influenced by herbivory had different response times, revealing a temporal discrepancy in the effects of grazing on carbon decomposition and nutrient mineralization. The differences in plant and soil processes between them seem to have counteracted each other, leading to no change in soil carbon storage capacity even at multicentennial timescales. Sites with demonstrated historical ecosystem transitions could provide a powerful tool for testing ecological predictions on the long-term consequences of ecosystem change across long timescales and improving understanding on their main drivers.

42. Historical and climatic aspects on the development of reindeer herding in Fennoscandia

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The introduction of reindeer herding and development of nomadism has been very much debated in Fennoscandia. An intensive international debate about the origin of reindeer herding started already one hundred years ago. One theory was that reindeer herding was diffused from centre in Siberia. The dominating view in Scandinavia has however been that the different forms of reindeer herding in Eurasia are the result of independent evolution in different cultural environments. In a long term perspective archaeological, genetic and palaeoecological investigations may give new aspects on reindeer domestication and the development of reindeer herding among the Sami in Fennoscandia. Climatic factors may also have been of importance when reindeer herding expanded earlier than usually presumed. Established hypothesis must be reconsidered in the light of investigations during the last decade. Some old frameworks in theory must also be questioned. These problems will be discussed in relation to actual archaeological, genetic and palaeoecological research

43. Indigenous legal traditions as a part of sustainable decisionmaking

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Laws arise whenever human interactions create expectations about proper conduct. Indigenous legal traditions have developed in this fashion and they are based on the customs and practices of the Indigenous peoples. Each group´s norms vary according to its history, material circumstances and social structure. Indigenous legal traditions are often recorded in oral form and they are best understood through the lens of customary law. However, these laws have often been ignored and overruled by non-indigenous laws. Thus, their influence has often been eroded within indigenous communities. Common and civil law has often been applied to separate indigenous people from their lands and environments. Within international indigenous law the importance to respect legal traditions is emphasized. This requires a translation process that identifies relevant customs and practices. However, in this case the powers of interpretation and judgement should not be vested in non-indigenous legislators and judges. Instead indigenous participation is a prerequisite for the proper interpretation of legal traditions. This translation process can also lead to the development of internal dispute resolutions. Within the Swedish legal system Sami land rights are primarily explained and described from a traditional Swedish legal perspective, with an emphasis on written sources such as the Reindeer Herding Act. Yet, within groups of Sami reindeer herders there are obvious legal traditions that guide how individuals and groups should behave in relation to each other and the nature. For instance, there are various local traditions about allocation of resources and grazing lands. These legal traditions are often inconsistent with rules in the Reindeer Herding Act. Nevertheless, they direct behavior and internal decisions within the group. Until now, Sami legal traditions have, to a great extent, been disregarded and they have not been in focus of research. This presentation argues that it is necessary to study and identify legal traditions among Sami reindeer herders to obtain a more sustainable decision-making both within reindeer herding and the public administrations. Furthermore, it is argued that the identification of Sami legal traditions can be a first step to develop internal processes for dispute resolution.


Session 6A: Animal conservation & population demography
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44. Migration patterns and fidelity in a partially-migratory caribou herd in Arctic Alaska

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Migration is common across the globe, yet shows great variability in distance and duration, fidelity to particular routes, and the proportion of populations that migrate. We examined migration dynamics in the Teshekpuk Caribou Herd (TCH) of northwestern Alaska, which displays a variety of migratory behaviors. Most of the herd overwinters within the summer range on the tundra of the northern coastal plain, while other individuals migrate hundreds of kilometers to spend the winter in foothills and mountains. GPS collar data from 79 adult female caribou between 2004-2016 were used to identify migration behavior and timing using First-Passage Time and Net-Squared Displacement. The percentage of migrants varied annually from 41-100%, but without a consistent trend over time. Multiple years of observations for 53% of caribou allowed analysis of behavioral fidelity over time. While most individuals migrated in a given year, they varied their strategies employed (i.e., short- vs long-distance migration) and their destination. The probability of returning to the same wintering area was less than 40% for all winter areas other than the western coastal plain, for which it was 57%. We then used mixed effects models to regress the probability of using coastal plain versus mountain winter areas, as well as patterns of migration timing and duration, against both intrinsic (e.g., age, parturition status) and extrinsic (e.g., vegetation productivity, temperature) factors. Migration destination was influenced by both intrinsic and extrinsic factors, with older caribou and those that were pregnant less likely to migrate to the mountains, while those that experienced higher summer vegetation productivity and population size more likely to migrate away from the coastal plain. In contrast, migration timing seemed only to be affected by extrinsic factors. Migration destination strongly influenced start and end dates of both fall and spring migration, while other factors like temperature, precipitation, and vegetation productivity varied between spring and fall migration. The Arctic is undergoing rapid climate change as well as experiencing increasing human activity and development. Our findings provide a baseline for exploring how migration behavior of a key subsistence species responds to rapidly changing environments in northern Alaska.

45. Wild forest reindeer returns to its historical range - soft releases as the first step

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The Finnish wild forest reindeer (WFR) Rangifer tarandus fennicus occurred almost throughout the boreal Finland in the 16th century but was gradually hunted to nationwide extinction by the 1920s. The subspecies remained across the border in Russia and started to re-establish in Finland in the 1950s. Nowadays, about 2300 WFR inhabits three areas; the original subpopulation lives in the NE Finland, whereas the two occurring in central parts of the country originate from reintroductions made in the 1980s and 90s. The original subpopulation has been declining recently, mostly because of poor breeding success following excessive predation by large carnivores. The total world population of ssp. fennicus in Finland and Russia together is about 4000 - 4500 individuals. In 2016, Finland and the EU started a seven-year conservation project (WildForestReindeerLIFE), which tackles the WFR conservation from various angles. One of the core actions is a new reintroduction into two areas in the subspecies' historical range. This will be carried out through captive breeding and soft releases. Enclosures were constructed into two National Parks in 2017 and together they now (January 2019) host 21 individuals. The founders were both from ex situ population and from the wild. In spring 2018, five calves were born in enclosures. More founders will be taken in, and eventually, all offspring will be released directly from the enclosures at the age of 16-20 months in 2019-2022. The short-term objective is that after the captive breeding and releases, about 30-40 WFR are living near both enclosures, and that both of these populations are steadily growing

46. Post-calving photographic surveys of the George River Herd between 2010 and 2018: Documentation of the precipitous decline of an iconic Canadian migratory caribou herd

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Formerly one of the world's largest caribou (Rangifer tarandus caribou) herds estimated at over 800,000 in the early 1990's, the George River herd (GRH) has crashed to fewer than 5,500 in just 25 years; at currently less than 1% of its peak abundance. As of 2010, with the population then at 74,000, post-calving surveys during the summer aggregation have been conducted at two year intervals through to 2018. In addition to these five surveys, annual fall composition surveys and continuous monitoring of female survival rates have generated a thorough demographic assessment of the herd. During this period, in recognition of the severity of the situation, graduated conservation actions were enacted by the Provinces of Newfoundland and Labrador, and Québec. This began with the elimination of the sport hunt and was followed by a complete ban on all hunting in Labrador and a voluntary moratorium by aboriginal groups in Québec. The significance of these management actions highlights the complexity of the situation and the high burden of scientific proof placed on the respective provincial wildlife management agencies. The post-calving survey results are widely regarded by all stakeholders as the most compelling evidence supporting conservation measures. A recent meta-analyses of post-calving surveys conducted on western Canadian caribou herds showed how sample size of marked animals, sampling effort, aggregation indices and calculation methods can have a significant effect on the survey results and their validity. We address these themes specifically for the GRH post-calving surveys and demonstrate why the Rivest estimator was useful in 2001 and 2010 but was replaced with the Lincoln-Petersen estimator as the population declined while the sample of marked animals provided improved knowledge of the herd's distribution at time of survey. Sex specific heterogeneity of the summer behavior also contributed to the selection of the calculation method. The series of five successful post-calving surveys conducted on the GRH offers opportunity to assess method assumptions as the survey parameters evolve along a continuous gradient of declining abundance.

47. A century of recovery from overharvest in a warming high Arctic: the successful conservation story of the endemic Svalbard reindeer

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Caribou and reindeer (Rangifer tarandus) have experienced recent severe population declines, often attributed to anthropogenic stressors such as harvesting, landscape fragmentation and climate change. The wild reindeer subspecies R. tarandus platyrhynchus, endemic to the high-arctic Svalbard archipelago was protected in 1925, after most subpopulations had been eradicated by hunting. While direct pressure from hunting has ceased, indirect anthropogenic stressors from environmental changes have increased in this climate change 'hot-spot'. An assessment of the current distribution and abundance is urgently needed. We combine distance sampling (300 km transects, n = 493 reindeer groups) and total counts (1350 km², n = 1349 groups) on foot to estimate the Svalbard reindeer distribution and abundance across its entire range, which we compared with historical data from the literature and radiocarbon-dated bones. Reindeer have now recolonised nearly all non-glaciated land (i.e. areas occupied prior to human presence), with spatial variation in abundance tracking vegetation productivity. However, independent of vegetation productivity, recently recolonised areas show lower reindeer densities than areas not subject to past extinction. This suggests that recovery from past overharvesting is still in progress. Because of such ongoing recolonisation, combined with 'greening' effects of warming, our status estimate of reindeer abundance is more than twice the previous estimate based on opportunistic counts. Thus, while our study demonstrates the successful outcome of strict harvesting controls implemented a century ago, current and future population trajectories are likely shaped by another anthropogenic impact, i.e. climate change.

48. Reindeer hunting in Iceland – monitoring and management – a successful system?

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In 1787, 35 domestic reindeer (Rangifer tarandus) were introduced to Northeast Iceland from Norway and have roamed wild since then. They multiplied and dispersed in the 19th century but in 1939 the population was near to extinction with only about 100 animals left in the highlands of East Iceland. Successful action was taken by the government to save them and thereafter the herd increased and dispersed all over East Iceland. During the last two decades the population has more than doubled, from 3000 to 7000 animals. Reindeer in Iceland have been hunted since 1790 with a 38-year period of protection in the early 20th century. Different systems and different governing institutes have been involved in monitoring the stock and managing the hunting. Through experience and expertise, a successful hunting quota system has been developed. A Reindeer Council was established in 1992 to take charge of the hunting. From 2000 East Iceland Nature Research Centre has been responsible for the monitoring and research of reindeer population in Iceland and to propose annual hunting quota. Hunters are now obliged to hire a professional hunting guide who is responsible for the welfare of animals during the hunting and also for reporting various information about the condition of shot reindeer. The Environmental Agency of Iceland is responsible for management and surveillance of the actual hunting. With the current management system over 95% of the annual hunting quota is met and majority of hunting guides deliver valuable and important input to the monitoring system. And not at least the present management is in harmony with landowners. Present monitoring of the reindeer population and the management strategy fulfils the goal of maintaining a sustainable reindeer population in Iceland. In the future, the aim should be to improve data collection from hunting and monitor changes in environmental factors connected to climate change, especially in relation to grazing and health of the reindeer. One should bear in mind that low genetic diversity in the Icelandic population could limit adaptability to rapid ecosystem changes and emerging pathogens.

49. Explaining population dynamics in a small reindeer sub-heard in East Iceland 2002-2018

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In times of severe international Reindeer and Caribou population decline, knowing what causes fluctuations in animal numbers may be of vital importance to future preservation of the species. Because of low biodiversity in Iceland, and relative simplicity of arctic island ecology, distinguishing the causes of population fluctuations should be viable. Reindeer were introduced successfully from Finmark in Norway to East-Iceland in 1787. Except from livestock, reindeer are the only large mammalian herbivore in Iceland. With no predation, few parasites and hardly any competition for forage, there are few natural constrains to population growth other than harsh weather so far. As vegetational resistance against grazing is low under such isolated circumstances, reindeer densities have always been kept low and the distribution is restricted to East - Iceland to keep certain sheep diseases at bay. This is implemented with state-controlled hunting. The Fljótsdalsheiði sub-herd has been monitored since 1940 with annual summer population counts and hunting records. Hunting is expected to cause more than half of all mortality in most years, but the fluctuations are mainly caused by changes in recruitment rates which correlate with the North Atlantic Oscillation Index (NAO). Monitoring is ongoing.

50. Current status of wild reindeer (Rangifer tarandus) populations in the Eastern part of Russian Arctic (Republic Sakha, Yakutia)

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Republic of Sakha (Yakutia) is the largest region of Russia in territorial and economic terms, within which the largest populations of the tundra wild reindeer have inhabited for centuries. Reindeer hunting is still the main traditional livelihood of the indigenous peoples in the region. The mainland tundra of Yakutia is inhabited by three major populations (herds) of wild tundra reindeer: the Yana-Indigirka, Lena-Olenek (Bulun) and Sundrun (Indigirka-Kolyma). The Lena-Olenek population of wild tundra reindeer inhabits in the Western Yakutia, in the Lena-Anabar inter-rivers region. The Sundrun population is in the East, between Indigirka and Kolyma rivers. The Yana-Indigirka population inhabits an intermediate position between the first two populations, between the Yana and Indigirka rivers. To estimate their population and population structure, aerial survey (by airplane or helicopter) have been carried out by Yakutian scientists from the 1960s to the present. Recent aerial surveys were conducted in 2012 and 2018. From 2010, the Russian-made radio-collars "PULSAR" operating with Argos and GLONASS satellite system are used to monitor the annual seasonal migrations of wild reindeer. From results of these surveys, the total decrease in the tundra wild reindeer number from the late 1990s to the present time has been revealed. The catastrophic decline has occurred in the Yana-Indigirka population: 140,000 individuals in the late 1990s, 34,000 individuals in 2002 and 2,500 individuals in 2012, It can be assumed that this population had virtually ceased to exist. A steady decreasing trend is observed in Sundrun (Indigirka-Kolyma) population, which now has about 27,000 individuals (2012). The number of the Lena-Olenek population is also decreased from 95,000 (2009) to 84,000 (2018). In addition, in the Lena-Olenek and Sundrun populations, some unfavorable trends in the demographic structure towards a reduction, e.g. decreasing of large productive males, which seems to be the result of high hunting pressure. Another factor that had a negative impact on the overall condition of the wild reindeer is the industrial development (diamond, oil and gas mining) of their habitats. All of these are further exacerbated by global warming.

CANCELLED

51. Instability and confluence of three reindeer populations in the eastern Siberia

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Once in East Siberia, two large herds (Taymyr, Lena-Olenek) of wild tundra (migratory) reindeer have been recognized between the Yenisey river and the Lena river. However, they have showed significant changes in their population and distribution in 21th century; a drastic crash of Taymyr herd and local increase in the west part of Lena-Olenek herd. (In our view, the two old herds have declined and a new one emerged in the middle.) Although the causes of these changes are not known, they make it difficult for local/indigenous people to maintain their traditional livelihoods (domesticated reindeer herding/wild reindeer hunting). Therefore, we have been conducting satellite tracking surveys intensively on this "third herd" to clarify its migration range and relationship with two old herds. From 2009, we have tracked about 50 animals by using of satellite radio transmitters (Argos-Argos, GLONASS/GPS-Argos) in the middle area of the Olenek river and others. From results of these tracking, the followings were found: a) Their migration routes have been shifted to the south, and utilization of tundra area was decreasing compared with about 30 years ago. ; b) Although they are dispersed in several summer ranges, their wintering ranges tends to concentrate on the Mirnynskiy region of the Republic. ; c) Their current migration ranges are restricted to "reindeer lichen habitats", and they are faced with a conflict (competition) with the local industry for the use of wintering areas. These results show that the tundra reindeer population may be further exacerbated by decline of reindeer lichen due to global warming and artificial developments, and the third herd's shrinkage might mean a fatal disappearance of wild tundra (migratory) reindeer in this vast area (about 20% of the total distribution range in the world). Adaptation measures are needed to balance its conservation (especially protection of wintering areas) and the securing of local/indigenous people's livelihood.

52. Too many, or too few: Kangerlussuaq muskoxen in central West Greenland?

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Historically, muskoxen never naturally colonized central West Greenland, where all current populations are the result of translocations. The Kangerlussuaq population of the Angujaartorfiup Nunaa area is the result of the absolute first translocation in 1960's. Muskoxen became firmly established and since 2000 have provided the basis for expanding commercial interests within meat harvest, trophy hunting and qiviut production, specifically the latter two since 2010. In the period 2000-2006, winter ground-counts observed minimums of 4,000-5,000 muskoxen, and only covered areas favoured by muskoxen and accessible to hunters. Count number dropped in 2010, and again in 2014, albeit area coverage was smaller. In 2017, concerned with perceived low muskox abundance, locals suggested complete closure of the winter muskox harvest. In March 2018, and following the winter hunting season, for the first time, the entire Angujaartorfiup Nunaa area was aerial surveyed using distance sampling. Estimated abundance was ca. 20,334 muskoxen. Density was ca. 2.6 per km², relative to the entire Angujaartorfiup Nunaa (7,853 km²). The majority of muskoxen, however, occupied a small subarea inaccessible to hunters, and relatively unused by muskoxen in 2000-2006. Prolonged use at high animal density of what likely constitutes poor habitat may negatively influence survival and reproduction. Continuous use by muskoxen of the small areas inaccessible to hunters may be incompatible with maintaining the large abundance estimated in 2018.

53. Group dynamics in a reestablished population of muskoxen in northern Alaska, 1983-2006

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Group living is an important element in the ecology and behavior of arctic ungulates. From 1983 through 2006, we recorded the type, size, and presence of radio-collared animals in groups of muskoxen in northern Alaska during annual pre-calving surveys in early April, composition counts in late June, and radio-relocation flights throughout the year. We analyzed observations of mixed groups of muskoxen with one or more radio-collared animals seen during April to determine changes in group membership in consecutive years from 1983 through 2006. Muskoxen were either solitary, in mixed groups of 2 or more adult females, subadults, and often adult males, or in male groups of 2 or more male muskoxen. Single females comprised <1% of all single and groups of muskoxen observed. By contrast, 11% were single males. In all years and seasons, mixed groups had a mean size of 19.3 (SD = 12.491), with a median of 17, and ranged in size from 2 to 109 muskoxen. Fifty-five percent of mixed groups had 7 - 21 muskoxen. During the same period, male groups averaged 2.7 (SD =2.2) and ranged in size from 2-12 with a median of 2 males. Mean size of muskox groups was significantly larger in winter than during the growing and breeding seasons. Mixed groups containing radio-collared muskoxen were not stable units. Over 80% of 216 mixed groups increased or decreased in size by at least 20% in consecutive years. Similarly, 58% of mixed groups either lost and/or gained marked individuals from one year to the next. Changes in mean group size and the number of groups over time contributed to understanding changes in population size and distribution.

54. Monitoring and management of an expanding introduced muskox population in Northern Québec, Canada

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The wild muskox (Ovibos moschatus) population found throughout Nunavik originates from planned releases of 55 farmed individuals by the Government of Québec between 1973 and 1983, during a failed qiviut industry attempt. With a harvest moratorium in place, the species expanded from the release sites and is now well established in the vicinity of six Inuit communities located along the Ungava Bay and the Hudson Bay coasts. The muskox is now legally recognized as a wild species in Québec. Their increasing numbers garner mixed opinions from the Inuit, particularly as migratory caribou (Rangifer tarandus caribou) populations decline. Some communities are interested in developing a local muskox outfitting industry to obtain financial benefits, while reducing muskox numbers. Inuit hunters are increasingly harvesting muskoxen, either as a reliable food source or to eradicate an introduced species that they understand displaces caribou. Seventy muskoxen have been collared throughout the range since 2017 to study the relation between muskoxen and the sympatric Rivière-aux-Feuilles migratory caribou population. The study of habitat selection and behavior also serves to plan the monitoring of their population dynamics and study the effects of muskoxen on habitat quality. A thorough health assessment of these animals showed no muskox-associated zoonotic pathogens of concern for subsistence hunters, nor of significant risk for the health of muskoxen or caribou. However, antibodies for Erysipelothrix sp., an emerging pathogen in this species, were detected in a high proportion of tested animals. The relatively high seroprevalence of Besnoitia tarandi and Fascioloides magna suggest that habitat overlap with migratory caribou influences the muskox parasitic diversity. A transect survey covering over 23,000 km² and a detailed classification were conducted in March 2019 along the Ungava Bay to estimate the abundance of muskoxen. Previous monitoring efforts in Nunavik have been irregular and limited to the surroundings of the release sites. The 2019 survey provided the first demographic portrait of the expanding muskox population, at a scale that may represent one of two subpopulations of muskoxen in Québec. Classification results were used to simulate sustainable harvest scenarios specific to Inuit and sport hunters. Inspired by the MOXNET management template, our objective is to develop muskox harvest management strategies at the Inuit community-level.

55. Annual habitat use of reintroduced muskox in the eastern part of the Russian Arctic (Yakutia)

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The re-introduction of the muskox in Yakutia began in 1996. Animals were brought from the Taimyr Peninsula and have been introduced in four geographically different areas of the tundra zone of Yakutia. Their current situation is different from each other. Therefore, to know their daily activity, satellite tracking survey was carried out using GPS/GLONASS transmitters (PULSAR) mounted on collars. Female muskoxen with these collars were released in the Lena river mouth in 2012 and in the Indigirka river mouth in 2013. Processing of the tracking data was performed using the mapping program OziExplorer and ArcGIS 10.1. From tracking data, 259 daily movement distances in Lena area and 462 daily movement distances in Indigirka area. The Seasonal change pattern of daily movement distance in the two areas showed the same trend. It was the largest in October and then declined as the temperature dropped. At the Lena River, it became the smallest at the end of February, then increased with the rise in the temperature. In April, a sharp decrease in the daily movement distance was occurred. At this time, muskoxen prefered more sheltered places and becomes relatively inactive, as if they avoided strong winds and crusts. The current total number of these 4 populations is about 3,000 and they are occupying only about 6% of the total area suitable for the habitat of this species in Yakutia. As there are much potential habitats and rare competitors, these populations will expand and further reintroduction may be done. Therefore, further surveys on their habitat use and competition with reindeer are necessary.

CANCELLED

56. Potential for competition between eastern migratory caribou and muskoxen in Nunavik

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Several caribou and reindeer (Rangifer tarandus) populations are declining across arctic and subarctic regions, in part due to climate change and anthropogenic disturbance. In northern Quebec, the Rivière-aux-Feuilles (RAF) herd has declined >70% during the past 20 years. Conversely, muskox populations (Ovibos moschatus) have increased considerably since their introduction in northern Quebec in the 1960's. This prompted local Inuit communities and scientists to question the potential role of muskox in caribou declines. Our objectives were to assess the potential for competition between caribou and muskox, particularly in regards to space use, habitat selection and diet overlap. In 2017, 44 muskoxen were fitted with GPS collars in the RAF herd range, where >100 caribou were already equipped with telemetry collars as part of an ongoing long term study. We used resource selection functions (RSF) to characterize muskox and caribou habitat selection by season, and more specifically in spring and summer when spatial overlap was at its highest. Moreover, 190 fecal samples were collected and analysed using DNA metabarcoding to estimate diet overlap. In spring, preliminary results suggested that muskox were found at higher elevation, habitat ruggedness and slope than caribou. Muskoxen also strongly selected habitat closer to the coast, which led to lower co-occurrence probabilities with caribou. In summer, less than 10% of caribou locations overlapped with the muskox range on the coast of Ungava Bay. Muskox and caribou similarly selected herbaceous tundra with prostrate shrubs. Wetlands and erect-shrub tundra were selected by muskox and avoided by caribou. Muskox were also found at lower elevation and higher habitat ruggedness than caribou. Furthermore, spring diet analysis showed that Ericaceae and Salicaceae were the most commonly found plant families for both species. We conclude that while spatial overlap is limited, the two species may compete for habitat and diet composition during part of the year.

57. Adaptive management of muskoxen in Greenland

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The original muskoxen from North-East Greenland was introduced to West Greenland in the 1960's, when 27 muskoxen were moved to Angujaartorfik Land in Kangerlussuaq, where their numbers grew rapidly during the following decades with the fastest growth-rate ever. Hunting of the muskoxen began in 1992, when Greenlandic hunters from Maniitsoq and Sisimiut started hunting limited quotas using dog-sledges and snowmobiles in the area east from Kangerlussuaq called Kuussuaq. The muskoxen are valuable and sought after for their skin, wool, horn and meat. Hunting the muskoxen in Kangerlussuaq today has developed into an important business for many hunters on the West Coast of Greenland. The numbers of muskoxen taken during the winter-hunt each year are increasing. The muskoxen populations in Ittoqqortoormiit area in East-Greenland and other places in West Greenland, where the wild muskoxen, has been introduced, are also of increasing importance for socio-economic and commercial purposes, including tourism activity. The muskoxen populations are also very important in terms of trophy-hunting and the area around Kangerlussuaq is one of the most sought after worldwide. Each year Trophy-hunters from around the world travel to Kangerlussuaq to catch the muskox of their dreams using long-rifles or bow and arrow. But, how are the muskoxen adapting to the increasing human activities, such as hunting and the increasing use of motorized vehicles in the area. How are we using Adaptive Management to manage hunting-periods, hunting-areas and quotas in co-operation with the hunters and local communities? What are the challenges and opportunities for a sound adaptive management of wild muskoxen populations?

58. Restoration of reindeer in the Nizhny Novgorod region, Russia

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Since the 18th century, the reindeer have been known as a common species on the territory of Nizhny Novgorod region, north of the Volga river valley. However, by the 1920s the reindeer died out there. To restore the population of reindeer in the region the Nature Reserve “Kerzhensky” was selected for the reintroduction. Genetic studies of reindeer fossil remnants in that area found genetic similarity with the reindeer survived now in the North of the Russian plain. Trapping wild reindeer took place in the Krasnoborsky district, South of Arkhangelsk Oblast. In that area reindeer live in conditions similar with the conditions of the Nature Reserve “Kerzhensky”, they do not make long migrations. In addition, some reindeer of the Moscow Zoo having ancestors from Karelia were brought at the reserve. Totally 10 (4 females \ 6 males) reindeer have been used for the reintroduction. Unfortunately, two females and one male died from stress during transportation. In 2016, the first calf was born in an enclosure of the reserve. To this moment four calves were born. At present, there are 3 reindeer females and 8 males in the reserve. The project will be continued.

CANCELLED


Session 6B: Reindeer herder’s day
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59. Research and future from a reindeer herder perspective

Åsa Larsson Blind

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This talk is an introduction to the Reindeer herders' day, where herders from Sweden, Norway and Finland will get the opportunity to meet scientists from various research areas and discuss matters of importance for reindeer and reindeer herders with scientist and among each other. Herders will also get the opportunity to define research topics that are important for them in the future - where are the knowledge gaps and what questions needs to be investigated further?


Session 7: Health & diseases
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60. Keynote lecture: Wildlife health and disease in a changing climate

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The unprecedented rate of climate change in the Arctic is having profound impacts on this sensitive ecosystem and threatening the very future of uniquely adapted arctic wildlife species. Wildlife conservation requires that our monitoring and managements systems are sensitive to detect wildlife population health changes and nimble in response. By bridging local, traditional and scientific knowledge we can improve wildlife health surveillance and response in the Arctic. Data on indicators of population health can and should be informed by three complementary approaches: targeted scientific studies, hunter-based sampling, and systematic documentation of local and traditional knowledge. Implementation of this multi-faceted process will ensure early detection of changes in population health, thus allowing more timely adaptive responses.

61. Infectious disease outbreak associated with supplementary feeding of semi-domesticated reindeer

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Due to reindeer pasture fragmentation and climatic conditions supplementary winter feeding of semi-domesticated reindeer (Rangifer tarandus tarandus) has become more common in Sweden and Norway. With increased corralling and feeding, often associated with animal stress, an altered range of infectious diseases and health challenges may emerge. A simultaneous outbreak of three different infectious diseases appeared in a reindeer herd in Norrbotten County, Sweden. The animals were corralled and fed silage. Several animals in poor body condition stopped eating, were drooling and displayed discoloration of the hair coat around the mouth. They had large, black, necrotic lesions in the tongue and gingiva, or holes perforating the chin, indicating oral necrobacillosis caused by Fusobacterium spp. Simultaneously, animals were seen with proliferative lesions in the oral mucosa and on the lips, characteristic of contagious ecthyma caused by Orf virus (ORFV). Further, three animals had eye infections, suggesting exposure to Cervid herpesvirus 2 (CvHV2) and secondary bacterial infections. DNA specific for Fusobacterium necrophorum was detected in tissue and swab samples from mucosal lesions. DNA specific for ORFV was detected in a tissue sample. Antibodies against CvHV2 were detected in ten of 13 diseased and in four of 11 apparently healthy reindeer. Gathering, translocation, corralling and transport of reindeer is often associated with stress, increased animal-to-animal contact and sometimes poor hygienic conditions, contributing to a heightened disease risk, which is challenging the animal welfare and the herder`s economy. Reindeer herders are increasingly being offered economical compensation to conduct feeding when pasture land is used for other purposes, such as building infrastructure. These health risk factors may be underestimated when replacing natural grazing with feeding.

62. Transmission and distribution of emerging vector-born filaroid nematodes in Finnish cervids

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Vector-borne filarial nematodoses with major public health importance include lymphatic filariosis and onchocercosis, while those with major animal health hazards and economic implications are e.g. dirofilariosis, setariosis and onchocercosis. Recent studies have revealed that species of several filarial genera are circulating in northern latitudes. The nematodes Setaria tundra, Onchocerca spp. and Rumenfilaria andersoni appear to have emerged in Fennoscandian reindeer during the latter half of the 20th century. Geographic shifts linked to climate warming and recent host colonization to reindeer from local to intercontinental sources in white-tailed deer, roe deer and red deer have structured this fauna, serving as precursors and drivers of emerging disease. Thousands of reindeer died in 1973 during emergence of S. tundra followed by recurrent outbreaks in 2003–06 and 2014 leading to condemnations during reindeer slaughter. Concurrently, chronic tarsitis and necrotic granulomas in liver and muscles, caused by Onchocerca spp., were increasingly common in reindeer. In 2004-06, R. andersoni, previously unrecognized in Eurasia, was found in the lymphatic vessels of reindeer with a local prevalence up to 95 %. As it is found in all the four cervid species examined in Finland, it can be expected to spread further into new areas in Eurasia. Filarioid nematode faunas now recognized in Fennoscandia are a mosaic assemblage from disparate sources, over extended or recent time frames, through anthropogenic introduction, establishment and processes of environmentally driven geographic expansion. All outbreaks and incidences in Fennoscandia have been connected to warm weather. The topic is highly timely, since the predicted change in temperatures indicates a particularly strong warming trend at the high latitudes, directly influencing ecological sustainability in northern systems, reviewed as Stockholm paradigm.

63. Chronic Wasting Disease (CWD) appearance - a threat to our livelihood

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In March 2016 the first CWD case outside NA appeared in a wild reindeer population, Nordfjella (NF), Southern Norway. As leader and herder in Filefjell Herding Company, bordering NF, I was informed through unofficial channels before the press release from the Norwegian Food and Safety Authority in April. The potential risk for spreading into our herd dawned. The first report from the Norwegian Scientific Committee for Food Safety in June 2016 focused mainly on the low zoonotic risk. As several incidents appeared, a hectic meeting activity followed and the scientific community recommended extermination of the NF population. Together with the Reindeer Herders Association, we expressed our deep concern, lobbying for extermination of the NF population. The politicians hesitated and no action was taken. We started controlling the border and we were licensed to cull animals from the NF population entering our pasture. A following-up scientific report in April 2017 recommended immediately culling of the NF population. Several mitigation actions were recommended; elimination of potential “hotspots” for transmission (supplementary salt-licks) and construction of a fence between our summer pastures and NF. A decision to exterminate the whole population, which also border wild populations to the south, was announced May 2017. Actions were taken to minimize the risk of spreading until the extermination could be executed. Sheep saltlicks were shield for reindeer entering and we intensified the border patrolling, as the fence was not completed before the end of August 2017. The winter 2018 the NF population was successfully exterminated. 18 CWD positive reindeer were diagnosed in NF, luckily non in our herd. The CWD appeared unexpectedly and had directly consequences for our activity. We had to allocate resources and labor for gathering information, take part in meetings and tackle the media. We started worrying about our future, knowing that if only one incident was diagnosed in our herd the whole herd would be exterminated. All possible mitigation actions were taken; gear were cleaned, border controls intensified, slaughtering practice strengthen and samples collected. The ambiguous situation drained us for energy and we are still recovering from the mental pressure. It is essential that the authorities keep up surveying the situation. Unclear responsibilities among different agencies and hesitating politicians slowed down the action and put our future in jeopardy.

64. Chronic Wasting Disease in Norway: An update on surveillance, research and disease development

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Chronic Wasting Disease (CWD) is an invariably fatal neurodegenerative disease of cervids, belonging to the group of transmissible spongiform encephalopathies. The disease is endemic in North America, with natural infection in different cervid species. Prior to 2016, CWD had never been reported outside North America, except in captive deer in South Korea introduced by import of CWD-infected animals. The surveillance for CWD in Europe has been limited. In Norway, approximately 2 100 cervids were tested for CWD in the period 2004-2015. Less than 20 of these were free-ranging reindeer (Rangifer tarandus tarandus). Norway is the last refugium for wild tundra reindeer in Europe that live in fragmented sub-populations in remote alpine regions of South Norway. In March 2016, a young adult female wild reindeer was diagnosed with CWD, representing the first detection of CWD in Europe and the first case of natural infection in reindeer worldwide. Since 2016, through enhanced surveillance, 19 free-ranging reindeer have been diagnosed in Norway along with four cases in moose (Alces alces), and one case in red deer (Cervus elaphus atlanticus) from a total of 74 060 cervids tested. Diagnostic molecular analysis cannot differentiate the CWD-prions detected in reindeer from findings in North America, while prions found in Norwegian moose and red deer have an atypical character. This raises important questions concerning the disease itself (origin, pathogenesis and transmissibility) as well as its future management. CWD research conducted at the Norwegian Veterinary Institute is currently focusing on disease progression and pathogenesis, diagnostics, epidemiology and genetics. We will present and update on the surveillance and disease status three years post discovery, along with future perspectives and a brief overview of the current research projects.

65. Chronic wasting disease associated to prion protein (PRNP) gene variation in Norwegian wild reindeer (*Rangifer tarandus)*

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The first case of Chronic Wasting Disease (CWD) in Europe was in a reindeer (Rangifer tarandus) from the wild population in Nordfjella, in southern Norway in 2016. CWD is a fatal neurodegenerative disease that affects cervids and has until 2016 been confined to North America and the Republic of Korea. The Norwegian case was the first natural case of CWD in reindeer. The subsequent active nationwide CWD surveillance in Norway revealed several new cases among reindeer, all restricted to the northern part of Nordfjella mountain area. In addition, four moose (Alces alces) and one red deer (Cervus elaphus) have tested positive for CWD. Owing to the risk of CWD spread, the entire northern Nordfjella population of about 2500 reindeer was eradicated and tested for CWD. In total, 19 animals tested positive for CWD. The disease involves a misfolded variant of a normal protein as the infectious agent. The cellular prion protein (PrPC) undergoes structural changes resulting in a resistant isoform known as disease-associated prion (PrPSc). PrPSc mediates prion diseases or transmissible spongiform encephalopathies (TSEs), like CWD. A common feature of TSEs is the neurodegeneration induced by the PrPSc aggregates. For most species, the disease modulation relates to variations in the prion protein (PRNP) gene, which encodes PrPC in the host DNA. Our study aimed to identify the variants of the PRNP gene in reindeer affected and non-affected with CWD, and to evaluate possible associations between these PRNP variants and CWD status. DNA was isolated and analysed from the 19 CWD cases and 105 negative controls matched on gender and age category. We amplified the open reading frame of PRNP gene (771 bp) by PCR, followed by sequence analyses. The study population (n=124) showed variance at seven positions in PRNP. Six of them served as markers to infer the PRNP gene variants (alleles) that translate into unique proteins. In total, five PRNP alleles combined into 14 genotypes were identified. The overall alleles and genotypes frequency distribution between cases and controls were significantly different. Our data show that two genotypes increase the probability of being CWD affected, which supports the association between PRNP gene variants and CWD occurrence in reindeer.

66. Different prevalence of prion protein genotype associated with resistance to chronic wasting disease in domestic and wild reindeer from the European North of Russia

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Chronic wasting disease (CWD) a deadly prion disease of the Cervidae family until recently was only observed among deer species in NorthAmerica. It has now appeared in Europe: CWD was reported from moose and wild reindeer in Norway (2016), and from moose in Finland (2018). Given the high mobility of ungulates, as well as the possibility of interspecific transmission of CWD and prolonged conservation of prions in the environment, currently there is a real danger of the spread of CWD to NorthWest Russia. For reindeer from Russia the composition of alleles of the prion protein (PRP) was studied based on the determination of the nucleotide sequence of the PRNP gene. For the wild reindeer of the European part of Russia (N=27) and the Novaya Zemlya archipelago (N=23), and for domestic reindeer from Kolguev island (N=19) and Komi Republic (N=16) 7 single polymorphisms (SNPs) in the PRNP gene were described, associated with 6 amino acid substitutions of PRP. Certain differences in the allele composition of the PRP were found between populations between domestic and wild reindeer. In the analysis, special attention was paid to amino acid substitutions related to genetic resistance/predisposition of Reindeer to CWD. As previously shown for reindeer the asparagine (N) at position 138 in the amino acid sequence of the PRP is associated with a higher resistance to CWD, and serine (S) - with an increased predisposition to this infection. We found that allele 138S was more common in all groups of reindeer. Homozygotes 138SS ranged from about 53-63% in domestic herds to 85-91% in wild populations. The percentage of 138N alleles varied accordingly. The proportion of homozygotes 138NN in wild reindeer populations was about 9-11%, in domestic 19-32%, and heterozygotes 138SN approximately 4% and 16-19%, respectively. Some differences between the studied populations were also found in PRP alleles at positions 2(V/M), 129(G/S), 169 (V/M), 176(N/D), 225 (S/Y), especially noticeable between domestic and wild reindeer. Our preliminary results show a higher potential resistance to CWD of domestic reindeer compared to wild ones from the European North of Russia. The need for widespread of genotyping of reindeer in Russia to determine their resistance to CWD, the development of special measures for the protection of domestic and wild deer from the spread of CWD is underlined. This study was funded by the Presidium of the Russian academy of sciences, Program № 41.

67. Improving herders' competence regarding reindeer health and diseases

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It is not uncommon that reindeer herders, by tradition, do not chose to contact a veterinarian in case of disease and death among their reindeer. The reasons for this are many, and one may be that there is a low confidence in veterinarians, that often has limited knowledge about reindeer herding and reindeer diseases. The reason can also be practical, for example difficulty to obtain a veterinarian in remote areas. Sometimes it might also be a reluctance to admit disease problems among your animals. If no veterinarian is being contacted, and no post mortem of dead animals is being performed, it will have negative consequences for both reindeer, herder and the industry. In addition, it means that the competence regarding reindeer health and disease will remain neglected and poor among both herders and veterinarians. For this reason the authors initiated a number of trainings courses for interested reindeer herders. Since 2017, we held six one-day, one two-day and six three-day courses. The three-day courses were directed towards herders who wanted to deepen their knowledge and get a title as ”reindeer health specialist”. The three-day courses included two theoretical days about reindeer health, common diseases, control of infections, sampling, treatment and clinical investigation of sick animals. One day was practical, when all participants were trained to perform a post mortem of a dead reindeer. All “reindeer health specialists” have the opportunity to join a closed Facebook group, for internal discussions about different health problems in reindeer. We are convinced that these courses have been a great success in terms of increasing both interest and knowledge about reindeer health. There is a great demand for more courses being organized in the future. With more knowledge among herders it is also more likely that a veterinarian is contacted when needed. The herder will also be able to give more exact details about symptoms and post mortem findings to the veterinarian, which will lead to a better description of the problem, and to better advice. This can enable the herder to take necessary measures and work preventively.


Poster session I
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P1. Polymorphisms of the growth hormone gene in reindeer

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The genetic structure of the growth hormone (GH) gene has been studied for a wide range of species due to its functional importance. GH is a hormone synthesized in and secreted by the pituitary gland and plays an important role in metabolism in mammals by regulating somatic growth and various aspects of the metabolism. The aim of this study was to identify GH gene polymorphisms in both wild and domestic reindeer (Rangifer tarandus) from the northern parts of Eurasia. Reindeer is the main representative of the fauna in the Far North and constitute a vital biological resource for the indigenous peoples inhabiting these territories. For this study, we analyzed domestic reindeer from Russia (Taimyr, Yakuts, Evenkia, Chucotka, and Kolguev Island) and Finland (Kaamanen) as well as wild reindeer from Russia (Taimyr) and Norway (Snøhetta and Svalbard). By analyzing 179 individuals for a 382 bp long fragment (covering exon 2 and 3) of the GH gene, four, single nucleotide substitutions; C12T, C72T, A122G, A235G was identified. Two of these were synonymous (C12T and C72T), and two were nonsynonymous (A122G and A235G), i.e. results in a change in the amino acid composition of the protein, and possibly its functional features. Overall, we found low levels of variation in the two island populations (Kolguev and Svalbard), while the remaining populations showed relatively high levels of variation, especially in Taimyr and Evenkia. The C12T position showed least variation, and with the homozygote CC genotype as the most common variant. At this position, we also found the wild Snøhetta population and the two domestic populations from Chucotka and Kaamanen to be fixed for the CC homozygote genotype. The Svalbard population was fixed for the rare homozygote genotype TT. We found high levels of variation in the C72T position, except on Svalbard which also at this position was fixed for the TT genotype. The two positions A122G and A235G showed much variation in all populations, except on Kolguev and Svalbard, which was fixed for the homozygote genotype GG in both positions. Our results show differences in GH gene variation within and between populations of wild and domestic reindeer, as well as between mainland and island populations. This may indicate bottleneck effects and/or selection, however, more analyzes need to be conducted to be able to distinguish between these processes.

P2. Genetic variation of family Cervidae based on cross-species SNPs genotyping

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The aim of this study was to analyse the genetic variation and relationships within three tribes from family Cervidae represented by species: reindeer (tribe Rangiferini), moose (tribe Alceini), red deer, wapiti and sika deer (tribe Cervini). The database of genetic information included 60 animals that were genotyped by using Illumina BovineSNP50 BeadChip. Due to the cross-species genotyping of SNPs significant decrease of call rate across samples were obtained (62.28%). Even if the quality control of data showed that only 46.23% of SNPs on the chip were successfully genotyped in at least 90% of animals overall 1374 loci were identified as polymorphic (MAF>0.01). To assess the genetic background of analysed species as well as to estimate the genetic variation on intra and interspecific levels following approaches were used; analysis of molecular variance (AMOVA), discriminant analysis of principal components (DAPC), Wright's F statistics, and Nei's genetic distances. The AMOVA analysis revealed that the genetic variation among species accounted for 82%, while across individuals was distributed only 13% of variations. The remaining proportion of variance (5%) was explained by differences among individuals within each species. The Wright's FIS index pointed out to relatively low level of heterozygosity within each species (0.29±0.01). The subsequent DAPC analysis clearly validated a strong genetic distinction among analysed species at the tribe levels. As expected due to their phylogeny origin the frequency of alleles varied continuously across three main genetic clusters composed from genus Cervus, Rangifer, and Alces. The most proportion of variance was conserved within first six principal components and first two discriminant function (94.1%). Both, the Wright's FST index and Nei's genetic distances revealed the closest genetic affinity between the species from genus Cervus, whereas the highest genetic distance were found between genera Cervus and Alceini. With respect to reindeer the highest genetic similarity showed moose (NA=0.69) and lowest sika deer (0.71). Obtained results showed that the application of cross-species SNPs genotyping can be regarded as valuable tool to clarify the proportion of genetic variance conserved within family Cervidae and can be also use to assess the proportion of admixture among closely related species. This study was supported by the Slovak Research and Development Agency (APVV-14-0054 and APVV-17-0060).

P3. Gene flow and diversity in local red deer populations

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The objective of this study was to estimate the state of genetic diversity and migration rate within and across seven local populations of red deer based on microsatellite markers. The genomic DNA were collected for overall 572 animals originating from Hungarian (42), New Zealand (36), Polish (327), Latvian (23), German (36), Slovak (33), and Czech (48) deer farms. A panel of 11 microsatellites (OarFCB5, T156, BM888, RT1, RT13, T501, T26, RM188, IOBT965, BM1818, and ETH225) were used for animals' genotyping. The mean number of alleles varied significantly across populations; from 7.63±0.62 (New Zealand) to 18.27±2.33 (Poland). A certain decrease of genetic variability within New Zealand population compared to others populations under consideration confirmed also the effective number of alleles (4.26±0.46 to 6.42±0.85) and Shannon's information index (1.59±0.11 to 2.09±0.11). Even if the observed heterozygosity (0.71±0.01) as well as gene diversity (0.78±0.01) indicated relatively good proportion of heterozygotes across populations the positive values of Wright's FIS index pointed out to certain increase of homozygosity within each population (FIS=0.09±0.03). The strongest impact of inbreeding was found in German population (FIS=0.17±0.04). The FST index (0.06±0.01) showed that in general the genetic differentiation across analysed population was low. But subsequent Bayesian assignment analysis revealed that the average log-likelihood was maximized at K=7, which means that each population created genetically separated clusters. The highest genetic similarity (FST=0.01) as well as proportion of admixed individuals was found between Polish and German populations. Analysis of relative migration rate showed mostly consisted results with patterns of population differentiation. The strongest gene flow was found between Polish and German (0.29±0.02), Slovak and Hungarian (0.28±0.02), and New Zealand and Polish populations (0.28±0.02). Obtained results clearly confirmed that alongside genealogical or morphological data the microsatellites or genetic markers in general provide good basis for the development of conservations strategies and breeding programmes not only in classical livestock species. This study was supported by the Slovak Research and Development Agency (APVV-14-0054 and APVV-17-0060).

P4. Assessment of cryopreserved semen in reindeer (*Rangifer tarandus*)

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Reindeer husbandry is a traditional land use with profound importance for the cultural identities of the indigenous people. Reindeer husbandry is facing the major challenges related to social changes, climate, globalization and industrial developments. Deep freeze storage of wild and domestic reindeer sperm will preserve the gene pool of a population. Comprehensive assessment of changes in the sperm under the influence of low temperatures is a scientific basis for the development of reindeer semen freezing technology, that will preserve the biological resources of the Arctic. The aim of the study was to evaluate cryopreserved semen in reindeer (Rangifer tarandus). Semen was collected in Taimyr and at private Zoo in St.Petersburg in autumn 2017, 2018. We involved a team of reindeer herders with a 1.5-thousand herd on the right bank of the Yenisei River in 2018. It is important to note that over the last 50 years this is the first herd of domestic reindeer, who came to the pasture on the right bank of the Yenisei River. Males were fixed by rope on the legs and horns. A total of 25 samples from 11 adult males were collected by electroejaculation. After analyzing sperm motility and concentration, semen was extended to a final concentration of 100 million sperms/ml, loaded into 0.25 ml straws and equilibrated in a cold room to +5 °C for 120 min. Straws were frozen in liquid nitrogen vapour for 12 minutes and stored in a liquid nitrogen tank. Post-thaw total and progressive motility, morphology and membrane integrity were measured by CASA (computer-assisted semen analysis). Total and progressive sperm motility had high variability from 0 to 64 % (23,2 ± 5,25 % mean ±SD) and from 0 to 45 % (16,3 ± 3.46%), respectively. There was no significant increase in cells with damaged acrosome (2.5 ± 0.35% with variability from 0.6 to 8.3%). The number of cells with injuries in the tail was 11.9 ± 1.31% before freezing and 15.5 ± 1.15% after freezing. There were 21.8 ± 4.44% of cells with damaged membrane integrity (from 3.5 to 53.3%). Such large variability is due to the different cryostability of semen from different males and individual ejaculates. It requires further investigation.

P5. Changes on winter pastures in the reindeer management area of Finland

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The reindeer management area covers one third of the land area of Finland. Its parts differ from each other's in climate conditions, landscape types, vegetation and reindeer herding systems as well as in land users, colonization and livelihoods. Therefore, also the state and usability value of reindeer pastures are affected by several of these factors. Various land use and livelihoods interests are also facing in the pasture environment causing conflicts between reindeer herding and other operators. This sets great challenges on the research examining the state of reindeer pasture environment. The research should be able to clarify the amount, quality and usability value of various pasture resources as well as changes taken place in these resources. Besides this, especially effects of different kinds of factors on the state of pasture should be found out. In 1995-1997 and 2005-2008 Finnish Game and Fisheries Research Institute (presently Luke) performed reindeer pasture inventories, where the amount, location and condition of the most important winter pastures (especially ground and arboreal lichen pastures) in the reindeer management area were mapped (Kumpula et al. 1997 and 2009). Different kinds of pastures were located in each co-operative area by satellite remote sensing. In the second inventory the coverage and disturbance areas of various land use forms were mapped. In both of these inventories 625 field sites located on lichen pastures in the 20 northernmost districts were studied. Effects of different factors on the condition of lichen pastures were then analyzed. The results of inventories showed that the co-operative areas differ considerably from each other in the amount and condition of ground and arboreal lichen pastures, general age structure of forests, as well as on the extents of land use forms and their disturbance areas. Forest harvesting and different land use forms had very remarkable effects on the state and usability value of pastures especially in the middle and southern management area. Condition of ground lichen pastures was dependent on long-term reindeer density and grazing system as well as on age structure of coniferous forests and the proportion of old growth forests. Luke together with Syke has made the third reindeer pasture inventory in 2016-2018, published in April 2019. We will find out changes and cause of change on the amount, condition and usability values of winter pastures after the second inventory.

P6. Impact of Muskox Herbivory on Vegetation Composition and Biomass

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Muskox were reintroduced in Alaska in the 20th century and have recently established breeding groups eastward into the Yukon's North Slope and the Richardson Mountains of the Northwest Territories. Community members in Aklavik and Inuvik have expressed concerns about the impact this reintroduced muskox population may have on caribou; citing concerns about muskox herbivory and its effect on vegetation. The objective of this project is to characterize the impact of muskox herbivory on vegetation composition and biomass. From 2015 to the spring of 2018, 20 satellite collars were distributed amongst muskox groups in the region such that most groups have at least one individual whose location can be precisely determined. In the summer of 2018 and 2019, sites of high density muskox usage and sites with no detected muskox presence were visited. At these sites, vegetation composition and height were characterized along with environmental variables. I report findings on the differences in vegetation at sites occupied and unoccupied by muskox.

P7. Do arctic and other ungulates postpone a greener Greenland?

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Most of Greenland is arctic or high arctic with parts of south Greenland being subarctic exceptions, that have the potential to expand because of climate change. A recent study predicts a greener Greenland because of increased temperatures as a consequence of climate change. The study highlights areas around Nuuk, Kangerlussuaq in west Greenland, and Jameson Land in east Greenland, as candidates to become suitable for many more tree and shrub species in the future including species of Larix and Picea, that were common in Greenland in earlier warm periods. The study concludes that future expansions are strongly limited by dispersal, soil development and other disequilibrium dynamics, with dispersal by humans having potentially large impacts on spread rates. The study mentions herbivory, but do not discuss the effect of it further. Other studies indicate, however, that shrubification is hindered by grazing sheep and caribou. Caribou, reindeer, muskoxen, sheep, and even cattle in the south graze various parts of the west coast of Greenland. From exclosure studies in south and west Greenland, we have seen that vegetation is affected by grazing. With predicted climate change, a larger part of Greenland may become subarctic giving new options for agriculture and farming of sheep and perhaps other ungulates. If Greenland wants also to take advantage of the potential for subarctic forests or plantations, we argue that it is essential to designate specific areas as non-ungulate territory.

P8. Supplementary feeding in reindeer husbandry across Fennoscandia – a participatory study

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Due to multiple forces of change, supplementary feeding has increasingly become a necessary strategy for reindeer husbandry communities across Finland, Sweden and Norway to buffer lacking grazing resources during the critical winter period. The application of and experience with supplementary feeding varies considerably in the Fennoscandian reindeer husbandry area. Hence, we gathered reindeer herders and a multidisciplinary group of researchers from the three countries to a workshop in Kiruna, Sweden in March 2018 to facilitate the exchange of experiences and knowledge related to supplementary feeding. Following this participatory setting, we developed an iterative knowledge coproduction process to compare the potential barriers and opportunities with supplementary feeding. Here, we present challenges and opportunities concerning supplementary feeding as perceived by herders, and their concerns on the way this strategy affects their husbandry practices, and the land in which their livelihoods depends. Issues related to reindeer health and behavioral changes, economic and work-related burdens, fodder quality and accessibility, as well as threats to traditional knowledge and land use access and rights emerged as key issues of concern. Positive effects were mainly related to reindeer survival, including reduced losses to predators, and a better control over the herd. Knowledge gaps that need to be addressed include the restoration of lost grazing grounds, unconscious breeding effects and a diverse array of socio-cultural consequences. Herders from all countries emphasized that supplementary feeding is rather avoided as long as possible. However, changing environments and socio-economic changes in society mean that herders are often left without other options. Sharing experiences and learning about feeding practices is therefore seen as an important commitment for the reindeer herders. Herders therefore emphasized the need for better communication between and within the countries as a valuable learning opportunity.

P9. Regional differences in using the dogs in reindeer herding work

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Dogs are an important part of reindeer herding work in Finland. In the vast reindeer herding area, the reindeer herding work varies depending on the landscape and usable resources for reindeer herding. The role of dogs also varies accordingly. In this study, we compared two regions of the Finnish reindeer herding area to demonstrate the diversity of using the dogs in reindeer herding. We interviewed reindeer herders (N=10) on how they utilise their dogs in their reindeer herding work and how important they find the role of their dogs. The studies areas were i) the north-west part of reindeer herding area, and ii) the southern part of Finnish reindeer herding area. In the north-western area, the dogs were part of herders' everyday work. During winter, the herders tend reindeer within and between pasture areas and move along the animals with snow scooters. The dogs worked in order to move to reindeer and to keep the animals in a herd when needed. The culture and tradition on using the dogs in reindeer herding was strong and the dog had an important role besides the herder. In the southern part of the area, most of the reindeer were close to herders' premises during wintertime, and they got extra feed. The use of natural pastures was less common and in winter, the herders seldom moved the animals as a herd. The most important time to herd the reindeer was autumn, when the animals were gathered for round-ups. The herding dogs could help in this task, yet there were often only a couple herders using working dogs in a herding district. In many districts, more herders could use dogs to ease the working burden. However, the herders in South think that the dogs were the best tool to move the reindeer from the unfenced agricultural land, where reindeer must not graze. In South, the dogs' position as a working partner may not be as strong as it has been before the motorisation of reindeer herding. Despite the differences in the dogs' role in reindeer herding, they were considered effective tools and can help the herders, in particular on the regions where the number of herders participating in the work is limited. In the modern reindeer herding society the working dog have many tasks, last but not least being the (wo)man's best friend.


Poster session II
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P10. Muskox translocation to Zavyalova Island, Magadan region, sea of Okhotsk

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The aim of this project is the creation of self-sustaining viable Musk-Ox population on Zavyalova Island (N 59.05°, E 150.62°) for environmental education and recreational use, and, in long term, for the resettlement of young animals into the territory of Magadan region. Zavyalova island is located on the same latitude with the island of Nunivak Island, where they live for a long time and has similar environmental conditions. In August 2018 on the Begichev island, located in Hatangskom Bay, we captured 25 (13 females and 12 males) calves. The animals were caught from 6 different groups. The animals were moved to the island of Zavyalova by plane and helicopter. Until mid-November animals kept in enclosures. In the next phase of the project on 2 males were tagged with GPS-Argos collars and we opened the fence of the enclosure to allow the animals freely move in and out. The first 19 days of the musk ox were located near the enclosure. Then the animals divided into two groups, which disperse to the opposite side of the island. A month later, after leaving the enclosures, both groups settled on elevations in different parts of the island.

CANCELLED

P11. Spying on reindeer cows in Iceland – What do their home ranges tell us?

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Reindeer (*Rangifer tarandus*) have roamed wild in East Iceland since 35 domesticated animals from Finnmark were introduced in 1787. The animals are in good shape and the population has more than doubled from the turn of the century. Seventeen reindeer cows in different herds have been followed with GPS collars in two different periods, from 2009 to 2011 and from 2018 and ongoing. We analyzed, defined and compared individual home ranges, habitat selection and movement patterns to body mass, available resources and possible disturbance. Size of home ranges and body condition has in previous studies for example been linked with human disturbance and quality of resources. The home ranges of our cows differed in size, shape, time and space but were similar to the sizes of home ranges of reindeer in West - Greenland. They were smallest during the calving period and largest during the hunting season. Quality of available vegetation seemed to affect the size of the home ranges for the different herds. Travelling speed is comparable with both Swedish and Norwegian reindeer, except in summer when Icelandic reindeer move 20% less than reindeer on Hardangervidda. The study is underway.

P12. Spatial modelling of reindeer pellet group counts using the hglm package in R

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The need for spatial modelling in ecology has increased over the years and user-friendly statistical tools for analyzing spatially correlated data are required. We utilize the non-Bayesian R package hglm, publically available on CRAN, to develop a procedure for fitting spatial random effects with a Matérn covariance structure in generalized linear mixed models (GLMM). The computational efficiency can be dramatically increased by constraining the smoothing parameter in the Matérn covariance function to a reasonable subset of values. This is an approximate method that increases computational speed and is expected to give very little loss in accuracy of the estimated spatial correlation. The method is tested and applied on a data set of reindeer pellet group counts from a survey in northern Sweden, studying the effect of wind power development of reindeer habitat use. The survey data was collected in a forested mountain region of Storliden using a point transect design with plots of 15m2. There were nine transects, each approximately 3 km in length. The distance between each transect was 300 m and the distance between each plot on each transect was 100 m. The data was collected between 3 and 8 June 2009 and 28 May and 1 June 2010. A Poisson GLMM was fitted including several explanatory variables fitted as fixed effects (including elevation and distance to power lines), and each plot fitted as a spatial random effect. The data from the two years were analyzed separately. Our results show that the spatial correlations could be accurately estimated with low computational cost. Furthermore, both the estimates and standard errors of the fixed effects are substantially affected by considering the spatial covariance of the data but the results are not sensitive to misspecifications of the smoothing parameter. In conclusion, the developed R function is useful for fitting GLMMs with a Matérn spatial covariance structure. Future work includes additional analyses of data collected in the years 2011 to 2015, and we also plan to include our new function in a future revision of the hglm package.

P13. Habitat selection by migratory caribou along spring and fall migration routes in northern Quebec and Labrador

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Migratory caribou (North America) and reindeer (Eurasia) travel hundreds, sometimes thousands of kilometers each year between their wintering grounds to the south and calving grounds to the north, where females can find safer, more productive summer ranges for their calves. The large Rivière-aux-Feuilles and Rivière-George herds in northern Quebec and Labrador, Canada, have sharply declined in recent years, and the causes of these declines are still not well understood. Climate change and anthropogenic disturbance could have a major impact on the quality of resources available to migratory caribou during migration. For example, early snowmelt in spring or abundant snow precipitations in fall could deteriorate snow conditions, increasing the energetic costs of movements. Changes in plant availability and quality associated with climate change could also affect patterns of migration. This project aimed at identifying factors involved in the habitat selection of migratory caribou during migration. Using GPS telemetry data collected on more than 400 individuals during 11 years, we defined migratory corridors used by the majority of the herds, and assessed variations in migration routes through time according to environmental changes. Preliminary results based on step selection functions indicated that caribou avoided lakes and rivers as well as rugged terrain during spring and fall migrations, possibly to limit the costs of movements. Moreover, individuals selected for vegetation associations dominated by shrubs and lichens during fall. Additional work will further evaluate how variations through time, e.g., caused by changes in climate and human use, influenced the migratory patterns observed during the last decade. The identification of frequently used migratory routes, as well as the collection of evidence-based knowledge about the factors determining the behavior of caribou during these critical periods of their life cycles, are essential in order to direct conservation efforts towards the most critical areas.

P14. Calving site selection criteria of wild forest reindeer (Rangifer tarandus fennicus) in Kainuu, Finland – Implications for habitat conservation

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Placement of individuals into different habitats depends on multiple things: resource selection, predator avoidance and anthropogenic disturbance. Habitat selection can be studied with resource selection functions (RSF) showing preferred and avoided environmental characteristics. RSF's are thus useful tools when planning the conservation of species. Here we study the calving site placement of wild forest reindeer (Rangifer tarandus fennicus), which is a near threatened species living in two populations in Finland. Our results show the clear environmental criteria of calving site selection of forest reindeer in the Kainuu population. As predicted, the forest reindeer preferred old forest areas for calving. They strongly avoided gravel roads, whereas the vicinity of water areas (particularly the islands of lakes) and, to some degree, paved roads were preferred. Results are mainly similar to the extensive studies of the North American woodland caribou, which favors undisturbed forest areas as calving sites. The most important threats for Finnish forest reindeer are forestry and wind energy building, which reduce old forest areas and produce new gravel roads. Therefore the results of this study are particularly important when planning the land use actions and conservation of the forest reindeer.

P15. Methods of evaluating effects of varying levels of disturbance on reindeer movements and area use

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Most research has investigated broad-scale effects of infrastructure on the space use of reindeer without understanding the mechanisms behind negative responses, and how negative effects can be mitigated. We present an ongoing study that combines different methods of simultaneously monitoring human disturbance and effects on reindeer, including GPS-tracking and surveillance cameras. In addition to GPS-data for reindeer, we also registered vehicle activity in wind farms equipped with GPS. This allows a differentiation between sub-periods and areas with more and less human activity. We also mounted cameras at strategic places along wind farm roads and power lines to register reindeer activity and weather conditions. Cameras also register the visual footprint of the infrastructure by comparing periods with good visibility and less visibility. Management, reindeer husbandry and developers need specific knowledge on how infrastructure affects the animals, possibly enabling mitigating measures aimed at reducing or eliminating existing and future conflicts with reindeer and reindeer husbandry.

P16. Attacked from two fronts: combined effects of anthropogenic and biotic disturbances generate complex movement patterns

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Currently, disturbances generated by human activities are nearly ubiquitous and they have the potential to interact with biotic disturbances in generating cumulative impacts on animal movement. However, that interaction has yet to be investigated thoroughly. Our study aims to fill this knowledge gap by assessing the combined effects of a human activity, i.e. military exercises, and a biotic disturbance, i.e. insect harassment, on movement rates of free-ranging semi-domesticated reindeer (Rangifer tarandus). From 2010 to 2012, we collected location data from GPS-collared female reindeer in the largest European military test range, situated in northern Sweden. Subsequently, we estimated movement rates and related them to presence/absence of military exercises, indices of insect harassment, and their interaction. We determined that military exercises and insect harassment indeed interacted in affecting reindeer movement. This result suggests that the effect of anthropogenic disturbances may be underestimated if not considered in combination with biotic factors. Insect harassment will likely increase in the future as a consequence of the predicted climate warming, especially pronounced in the arctic regions. Thus, evaluating its interaction with human activities is imperative, especially because of the growing interest toward natural resources and other land uses in northern ecosystems.

P17. Estimating zones of influence of windfarm on reindeer habitat selection

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In environmental impact assessment, it is often of interest to estimate the zones of influence of some possible disturbances (e.g. establishment of wind farms, mining sites, etc.) on local animal species. In estimating zones of influence the concept of ecological threshold (Holling, 1973), and analytical procedures developed therein are applied (Boulanger et al., 2012). Under this framework, the zones of influence is estimated by fitting some kind of piecewise regression model where the effect threshold is identified through grid-search. In this work, we formulate the problem of identifying ecological threshold as a variable selection problem, in a piece wise linear regression model. A computational challenge involved with this approach is that some columns of model matrix become highly correlated, due to model specification. Therefore we need to use a variable selection method which is robust against multicollinearity. Unlike the ordinary variable selection problem, here we have an important prior knowledge that the effects of the disturbances have to diminish with increasing distance from the source, and they must disappear at some long distance. We utilize the prior information both in adaptive Lasso, and hierarchical generalized linear models (HGLM; Lee, et al., 2017) approach for model selection and estimation. We compare the performances of the two approaches, via simulation study. We apply the HGLM method to identify the zone of influence of wind farm and road on reindeer habitat preference using GPS positioning data from north of Sweden.

P18. Connectivity conservation in face of rapid anthropogenic changes: tropical case studies using expert knowledge

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Populations of all species have been facing continuous challenges because of rapid anthropogenic changes all over the world. Modifications that exert more intensive pressure over populations include agriculture, livestock, and urban growth, forest logging, mining, and the expansion of energy production and transportation infrastructures – mainly roads, in the latter. Beyond reducing the amount of available habitat, these activities produce land use changes that alter animal behavior and movement and tend to decrease the connectivity between populations. In this context, it is critical to assess the potential damages of human structures over landscape connectivity and provide solutions to conserve and restore the connectivity between populations. Here we provide three case studies from the tropical Atlantic Forests of South America, a highly fragmented biodiversity hotspot. The Atlantic Forest shelters 120 million people, most in urban areas, and have been facing centuries of human impact. First, we assess the effects of roads on genetic connectivity of a small forest primate, the Golden Lion Tamarin (Leontopithecus rosalia). We simulate ecological corridors and compare them with road crossing and occurrence data, as a guideline to restore forests and build wildlife road passages to connect populations. Second, we combine land use data with the urban zoning plan of a historical Brazilian city, Ouro Preto, to simulate ecological corridors for several bird species. By considering the urban zoning as a proxy of potential future changes, we can include species perception and behavior to plan for connectivity conservation in the context of urban growth. Finally, we show the potential of corridor simulations to measure how the connectivity for multiple species and ecological processes are damaged by large scale mining environmental disasters, specifically the disruption of mining dams. In all three studies, expert knowledge is used to fill a gap on species movement knowledge in the literature. Although these studies are located in the tropics, they may have similarities with situations of anthropogenic impacts in the Arctic and in other regions of the world. Therefore, we believe they can offer insights on connectivity conservation beyond the tropical boundaries.

P19. Evaluation of possible technological solutions against reindeer-train-collisions

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Reindeer-train-collisions (RTC) are a challenge for Norwegian reindeer herders and Bane NOR. We identified peak times and places for RTCs and evaluated putative technological solutions. Most collisions occur with female reindeer on Saltfjellet during the arctic winter. Reindeer herders struggle to find animals damaged in RTCs and thus are rarely compensated. No single system will avoid RTCs, but a variety of technological tools is available. While lack of scientific evaluation of mitigation measures is a global problem, Bane NOR's database is of outstanding value for research. We categorize technological mitigation measures into systems that

1) physically separate animals from the railway tracks,
2) warn or scare animals away from the tracks
3) warn the train drivers to reduce speed due to animals near the track.

The only electronic fencing system on the market has been shown to have no effect on reindeer in its current form (Jørgensen & Eilertsen 2012 & 2014). The effect of warning / scaring sounds & lights on reindeer is questionable. Semidomesticated reindeer are used or even attracted to human activities. Reindeer also aim for the highest landmark point if scared, often resulting into them jumping onto the tracks. Furthermore, artificial light or loudspeaker systems may be ineffective in deep snow or strong winds. Real-time animal detection systems warn train drivers to reduce speed. Due to high maintenance costs of railway instrumentation with such systems (IR & laser beam-break systems, thermal sensors, microwave, radar, geophones etc), we recommend research & development projects covering short distances around tunnels or sections used as corridors by wildlife. Alternatively, instrumentation of female reindeer (collars & ear tags) in combination with geofences gives specific animal position data and results in less false positives. Energy supply, system reliability and durability under arctic conditions (wind, snow, low temperatures, humidity, darkness) are a challenge for all systems. Development and testing will require close collaboration between Bane NOR, Statens vegvesen and reindeer herders. We strongly recommend that system performance is documented and made publicly available and hope our report will be of use in the efforts to reduce reindeer-train-collisions in future.

P20. Effectiveness of road and railway bridges for reindeer and wildlife movements – an ongoing project

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Large roads and railways act as barriers for ungulates, with potential impact on individual fitness, population demography, and genetic diversity. Such barriers to movements are particularly problematic in areas where ungulates conduct seasonal migrations, such as in northern Scandinavia. For semi-domestic reindeer, as for wild migratory ungulates, fenced roads and railways may effectively block animals from reaching crucial seasonal areas and resources. For the reindeer husbandry, roads and railways with fences or high traffic volumes tend to create severe obstacles during driving of large herds, require extra efforts to retrieve animals from the "wrong" side, and result in loss of odd individual animals to neighbor districts or unknown fates. In order to minimize the barrier effects, the Swedish Transport Administration (STA) aims at providing safe passages for reindeer and other large mammals where major transport infrastructures intersect with important animal migration routes and movement corridors – i.e., at conflict points between grey and green infrastructure. However, it remains unknown how such passages should be designed to fulfil the ecological and practical requirements in the most cost-efficient way. Therefore, we have started a project to monitor how reindeer and wildlife use existing bridges over and under roads and railways. The bridges monitored vary in dimensions and design; some are constructed specifically for reindeer while others are bridges for roads or streams. The data collection includes camera trapping within and around the bridges, and camera images will be analysed for number, behavior and categories of animals. The project includes the development of effectiveness criteria towards which the use of individual bridges can be evaluated. The project is planned to run 2018-2020, and to work in close cooperation between university, STA and five reindeer husbandry districts ranging from mountain to forest and lowland (consession) districts, within Norrbotten County, Sweden. Some preliminary results will be presented.


Poster session III
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P21. Assessment of the elemental status of reindeer males by the chemical composition of the wool

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Providing the organism with minerals is one of the indicators of its health. This is especially important in the difficult environmental conditions of the north. The chemical composition of hair is a good indicator of income and accumulation of trace elements in the body. Wool is readily available biomaterial, and it is obtained without causing stress in the animal. A low or excess concentration of macro - and microelements had a negative impact on reproductive health of animals. A number of researchers revealed the relationship of the content of chemical elements in the hair with the volume and quality of the semen in horses. The aim of the work was to study the using of the chemical composition of wool as a marker for assessing the elemental status and reproductive qualities of reindeer. The experimental animals were males with horns and with cutting velvet antlers. We take into account chemical composition of wool and the efficiency of semen collection and erection. Wool samples were taken from the neck and examined for 25 chemical elements by mass spectrometry. Sperm were collected by electroejaculator (Minitube). The elemental composition of wool was analyzed by cluster analysis. As a result, the reindeers were divided into 2 groups. 1 group - males with antlers (G1), 2 group - males without antlers (G2).The group G1 was characterized by low content of essential elements: chromium (0.11±0.002 µg/g), iron (59.94±13.5 µg/g) and manganese (3.1±0.5 µg/g). In the G2, the content of essential elements was exceeded (Cr-0.38 ±0.08 µg / g, Fe-400.7 ±60mcg/g, Mn – 18.9 ±2.2 µg /g). The males in G1 had good erection was and the volume of ejaculate reached 2 ml. The males in G2 had no erection and the volume of the ejaculate did not exceed 0.5 ml. Therefore, the elemental composition of wool reindeer can be used as a marker of reproductive health. Authors acknowledge financial support from Russian Science Foundation. Grant number :17-16-01023

P22. The reindeer rumen microbiome regional differences in the Russian Arctic regions

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Studying of reindeer rumen microbiome formation is an important task because it allows us to expand the understanding of the physiological adaptations of reindeer, which allow them to use the poor nutritional resources of tundra and forest-tundra for feeding. Rumen content and feed samples was carried out in three Arctic regions of Russia in the summer-autumn period, which are included in various climatic zones. Samples of rumen liquid were collected from the reindeer in the Yamalo-Nenets Autonomous District (Kharp, forest-tundra climatic zone), the Nenets Autonomous District (Nelmin-Nos, tundra climatic zone) and the Murmansk region (Lopar, tundra climatic zone). Using the NGS, the influence of a number of factors on the composition of rumen microbiomes was analyzed: gender, age, regional habitat conditions, and feed features. The presence of dominant phylums of Firmicutes, Bacteroidetes, Proteobacteria, Actinobacteria, Tenericutes, Fusobacteria, Cyanobacteria was revealed in all reindeer. According to modern concepts, representatives of Firmicutes, Bacteroidetes, Proteobacteria constitute a large part of the microbial community of the intestines of various mammals, which suggests an important ecological role of these microorganisms, probably due to their wide metabolic potential and adaptation to habitats in the gastrointestinal tract of animals. In total, representatives of 27 phylum have been identified, including 25 - bacterial, 2 - archeotic. The total amount of Firmicutes and Bacteroidetes ranged from 79.06 to 90.18%, Proteobacteria - no more than 5%, Cyanobacteria, Spirochaetes, Verrucomicrobia - no more than 3%, the rest - in a minor amount. It was found that regional factor were the main determinant for all components of the microbial community of the reindeer rumen, while other studied factors (gender, age) were less significant, but made a certain contribution to the ratio of microorganisms in the rumen. Presumably, the observed patterns are due to differences in the composition of the pasture herd diet, since the meteorological parameters in the studied regions were similar. The smallest similarity with other regions was found for samples from the Murmansk region, which is probably due to differences in reindeer pasture diets in this region: differences in vegetation composition and lower nutritional values. The research was carried out with the support of the grant of the Russian Science Foundation (RSCF) № 17-76-20026

P23. The relationship between the epizootic situation and the composition of the reindeer's rumen microbial community in the herds of the Russian Arctic regions

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In the period of August-September 2017 year a number of expeditions were organized to various regions of the Russian Arctic for sampling the rumen content of reindeer. Also, information on morbidity and mortality of reindeer was collected in the summer – autumn of 2017 in the Murmansk region, the Yamalo-Nenets Autonomous District and Nenets Autonomous District. Laminitis was observed at all territories. The amount of animal with laminitis was 14% - in the Nenets Autonomous District, 10% - in the Yamalo-Nenets Autonomous District, and 7% - in the Murmansk region. As a result of the disease 9-16% of the number of diseased animals died in the Nenets Autonomous District, 8-15% died in the Yamalo-Nenets Autonomous District and 4% died in the Murmansk region. For reindeer's herding the problem of reindeer's laminitis in the summer-autumn period is one of the most significant among other diseases, since it brings the most significant damage to the economic activity of the regions of the Arctic. The results of the studies confirmed the presence in reindeer herds of the Yamalo-Nenets Autonomous District another infectious diseases - brucellosis (0.8%), pasteurellosis (0.1%) also. As a result of pasteurellosis, the death rate was 0.1% of the total number of animals. The microbial community of the reindeer's rumen was analyzed using next generation sequencing. A general decrease of rumen biodiversity was observed in animals with clinical manifestations of laminitis. In the rumen of reindeer with symptoms of laminitis the increasing of the phylum Fusobacteria - causative agents of laminitis, order Pasteurellales - causative agents of pasteurellosis and family Enterobacteriaceae - causative agents of gastroenteritis was observed. The rumen microbial community of clinically healthy animals differed from animals with laminitis not only by fewer pathogens but a high content of bacteria of the order Bacteroidales, an archaea of the order Methanobacteriales and a smaller amount of bacteria of the order Lactobacillales (including the family Streptococcaceae) and the family Veillonellaceae also. Thus in the rumen of animals with symptoms of the laminitis the pathogens number increasing was observed, including not only widely known phylum Fusobacteria but pathogens from order Pasteurellales and family Enterobacteriaceae also. The research was carried out with the support of the grant of the Russian Science Foundation (RSCF) № 17-76-20026

P24. Relationship between the deer ked Lipoptena cervi and the reindeer Rangifer tarandus tarandus in Finland

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The deer ked is an ectoparasitic lousefly (Hippoboscidae, Diptera L.) and in Finland its principle host is the moose (Alces alces). Observations on the deer ked-infested reindeer in the southern part of the reindeer herding area increased after 2006 and it became necessary to study the deer ked – reindeer relationship. The aim was to gain information about the impacts of the deer ked on the health and welfare of reindeer and about this parasitic relationship. Two sub-projects were performed: an experimental infection and a field observation. The first experiment was conducted by the permission of the Committee on Animal Experiments of the University at the Biological Research Facility of the University of Oulu between May and December 2007. The experimental animals were 18 adult reindeer divided into three groups (Infection group, Infection & Medication group and Control group). The reindeer in the Infection and Infection & Medication groups were infested with 300 deer keds/reindeer. In the field observations reindeer (24) with natural deer ked infestation were observed (with conventional and infrared cameras) and pupae were collected from the sleeping sites (in winter 2010 – 2011;Halla cooperative). The experimental infestation induced restless behaviour and fur damages to the reindeer. At the end of the experimental infestation (December), only dead keds were found in the pelts of Infection & Medication group, indicating that ivermectin would be efficient against deer keds. However, very few keds (N=6(+/-)) survived in the Infection group. Based on the result of the experimental infestation, it is plausible that the reindeer is able to resist deer ked infection based on the low survival of the parasites. However, field observations on naturally infested reindeer indicate that the deer ked is able to remain on reindeer over winter causing expanding areas of hair loss, and also to reproduce on reindeer as the pupae were collected from the sleeping sites of the reindeer in March. The areas with hair loss had higher maximum skin temperatures suggesting heat loss during winter months. Based on our results, deer ked infestation decreases the welfare of reindeer. It is important to examine relationship between the deer ked and the reindeer in Fennoscandia, in order to reliably detect patterns of hair damage among reindeer, to estimate the reproduction success of the deer ked on reindeer and to predict possible adaptation between the host and the parasite.

P25. Dictyocaulus cervi (Nematoda: Trichostrongyloidea), a new causative agent of parasitic bronchitis in red deer, Cervus elaphus

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The large lungworms of the genus Dictyocaulus are causative agents of parasitic bronchitis in various ungulate hosts, including red deer. Recently, a red deer-derived lungworm Dictyocaulus cervi was described, which is genetically distinct from D. eckerti (Pyziel et al. 2017). The result of a multiplex PCR test (Pyziel et al. 2015) provided the first evidence of a novel genotype of a large lungworm infecting red deer both in Sweden and Poland and moose in Sweden. It was then shown by sequencing of 134 specimens of this novel lungworm isolated from red deer from Northeast Poland, that it diverged from D. eckerti (0.06 %) both in the conserved SSU rDNA, and more variable ITS2 (13.35 %) regions. Moreover, nucleotide sequence variation of mitochondrial cox1 between the NCBI reference sequence of D. eckerti (GenBank NC_019809) and a novel genotype of D. cervi was 8.49 %, whereas at the amino acid level it was 0.96 %. Subsequent morphological investigation revealed that D. cervi can be distinguished from D. eckerti on the basis of the absence of cervical papillae, the occurrence of a single ring of 4 symmetrical submedian cephalic papillae, length of the tail in females, morphometry of the female reproductive system and measurements of gubernacula in males (Pyziel et al. 2017). Furthermore, D. cervi infection was associated with various degrees of lung pathology, including interstitial pneumonia, bronchitis and bronchiolitis with an influx of eosinophils, lymphocytes, plasma cells and macrophages; massive hyperplasia of lymphoid follicles within bronchiolar tissue, and hyperplasia of the bronchial and bronchiolar epithelium. In conclusion, the examined population of free-roaming red deer could supposedly suffer from clinical signs of parasitic bronchitis caused by D. cervi (Pyziel et al. 2018).

P26. A multi-disciplinary approach to investigations of supplementary salt-licks as transmission hot-spots for CWD and endoparasites in Norway

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"Classic" chronic wasting disease (CWD) has recently been diagnosed in the Nordfjella subpopulation of wild reindeer in Norway. To avoid spread of the disease, the subpopulation has been depopulated and the area will be let fallow for a long period before reintroduction of a new herd. Even so, infectious prions may still persist in the environment. This presents a risk of spread to surrounding wild ungulate populations, semi-domesticated reindeer, and free-ranging domesticated sheep. Most importantly it poses a potential reinfection risk for reintroduced reindeer. Salt-lick stones are used by farmers and reindeer herders both for supplemental nutrition and as a gathering point for easier monitoring and/or collection of their animals. However, these sites are also used intensively by wild ungulates, and represent potential hot-spots for disease transmission, both directly between animals and indirectly through environmental contamination. This presentation will describe our multi-disciplinary project which aims to define the importance of salt-licks for disease transmission in Norway. The study is taking place in three Norwegian reindeer areas, one of which is the CWD-infected Nordfjella. We use camera traps on salt-lick areas to monitor visits at the stones. Using both camera data and current/historic data from GPS collared animals, we will determine the frequency and duration of animal visits to these sites and how this may vary spatially and temporally. Soil samples are collected from both sites with a stone present and sites where the stone has been removed to analyse for presence of prions. We will also analyse these samples for the presence and intensity of endoparasites. These parasites are common pathogens of ungulates and, thus, could be used as a proxy for prion transmission. In addition, these soil samples will be analysed for mineral content, which may indicate how attractive these areas are even after salt-lick stone removal. To perform this project, we have gathered a team of researchers with expertise on a range of topics, including veterinary science, parasitology, prions, soil science and general and spatial ecology of ungulates. Disease transmission in the wild is a multi-faceted problem, and we believe such a multi-disciplinary approach is vital to produce scientific insights to these problems.

P27. Reindeer husbandry, societal infrastructure, and climate sensitive infections: Are there linkages?

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As the climate changes, vegetation and animals respond by moving northward and to higher elevations. This shift leads to the introduction of new species and to different co-existence of species in new places. Climate change is already having an impact on the geographical distribution and epidemiology of infections such as zoonoses – infections that are transmitted between animals and humans, and that can likely be labelled climate sensitive infections - CSIs. Many northern societies depend on animal husbandry, such as reindeer herding and sheep farming for their livelihoods. In the ongoing Nordic Centre of Excellence, CLINF: Climate-change effects on the epidemiology of infectious diseases and the impacts on Northern societies, we are studying how the spread of climate sensitive infections (CSIs) will affect societal and individual well-being, ontological security, and adaptive capacity in animal husbandry in the north. We expect to see an increase in CSIs in parallel with increasing temperatures, which in turn will have consequences for livelihoods, socio-economic conditions, values, culture, identity and worldviews. Societal infrastructure is expected to influence the spreading of such CSIs in the northern region. This paper outlines five categories of societal infrastructure, including EU policy and institutional agreements that intersect with five societal processes such as mobility and kinship. Together these are being investigated for their potential impacts on spreading or reducing CSIs in reindeer husbandry. An initial analysis of the available data reveals a range of cascading effects and complex interactions between societal infrastructure, social organization, and current adaptation strategies to multiple stressors.

P28. Animal welfare at reindeer abattoir pens in Finland

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In Finland, over 75% of reindeer are slaughtered in reindeer-specialised abattoirs. Produced meat is considered as an ethical choice for many consumers as marketing of reindeer meat relies on the image of the free-roaming animals that live in clean nature. The critical pre-slaughter points for animal welfare are transportation, handling and stunning of these semi-domesticated animals. In reindeer herding year 2017 – 2018, we audited 16 of 18 reindeer abattoirs for pre-slaughter welfare of the reindeer. In these abattoirs the reindeer herders performed the slaughter work themselves. In this sub-study, we focus on the welfare of reindeer in abattoir before slaughter. Welfare legislation regulates the treatment of animals in the slaughterhouse. For example, the animals must have access to water or clean snow and they must not see the by-products of slaughter. At all audited abattoirs, the animals had access to water or snow, and at three abattoirs there were heated watering systems. In 14 abattoirs the reindeer were given time to rest after round-up before they were slaughtered. The lairage time prior to slaughter was often over 12 hours in the abattoir pens. Loading and unloading of the transported animals can cause stress for animals. To 12 abattoirs the animals were transported by lorries or vans. At four abattoirs the animals were able to walk to the abattoir pen, and at two of those, majority of reindeer were handled in a round-up corral close to the abattoir. Most of the abattoir pens had either gravel surface or wood chips to cover the bottom of the pens. This kind of material helps to keep the animals clean and dry despite the weather, as the pens had no roof. From the animal welfare and food hygiene point of view, clean snow is the best bottom for pens. During the auditing, at all 16 abattoirs, the pens were spacious related to the number of animals. Reindeer form a hierarchical structure in a group, and enough room enables the subordinate animals to retreat from the dominant ones with little need of social conflicts. Most the reindeer herders were aware of the need of space in the pens. Although in our study, the welfare of reindeer during slaughter and connected activities filled the Finnish legislative demands for minimum level, differences between abattoirs were detected, emphasizing that there still is room for improvement and further research in required.

P29. Animal welfare in Sámi reindeer husbandry – the double-edged sword of supplementary feeding

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Reindeer herding is radically different from traditional farming. The reindeer are semi-domesticated and most of the year they run free, in the wild, where they can behave naturally in an environment they are genetically adapted to, while their herders try to protect them from harm. This freedom enables the animals to behave "natural" but at the same time this increases the risk of food shortage, predatory attacks and exposure to harsh climate. Unstable winter weather, with freezing and thawing periods lead to a buildup of ice cover above the reindeer lichen during the winter. These Ice covers are potentially too thick for the reindeer to dig through. This condition is called "locked pasture" and can lead to starvation and death if the reindeer are unable to find food elsewhere. The combination of locked pasture, pasture regulations, encroachment and an increasingly growing population of predatory animals pose a huge challenge for many herders. To the extent where it is right to say that current day Sámi reindeer herding is located within a contested field where multiple interests compete over limited resources forcing reindeer herders and reindeer across Sápmi to adapt or perish. Increased use of supplementary feeding is one adaptive measure. Supplementary feeding can seem like a good solution to many problems the reindeer husbandry face. But the implication of increased use of supplementary feeding is unknown. Together with increased winter survival rates and increase the control over the herd, supplementary feeding can change reindeer husbandry practices, the reindeer ability to fend for them and increase the risk of disease outbreaks. Supplementary feeding may seem like a good adaptive measure, yet it is imperative that the implementation of this is in occurrence with the knowledge and the husbandry practices in present day reindeer husbandry.

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