



4th
International conference in
ARCTIC FOX BIOLOGY
2013 | Westfjords | ICELAND

abstracts

October 11-13th 2013

Hótel Nupur

The Westfjords of ICELAND





International conference in
ARCTIC FOX BIOLOGY

Hotel Nupur, Westfjords, Iceland
October 11-13th 2013

Program, abstracts and list of participants

Unnsteinsdóttir, E.R. & Lai, S. (eds)

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Welcome Word

We are pleased to welcome you in the Westfjords of Iceland for the 4th International Arctic Fox Conference. This conference is bringing together researchers, conservation managers, tour operators and volunteers interested in the biology and the issues regarding this polar species. While the knowledge about the arctic fox has been growing steadily since the 80's, from physiology, genetics, winter behavior, demography to community interactions, many aspects of its biology are still unknown. Conservation issues continue to be a cause for concern for many arctic fox populations throughout its circumpolar range, especially in Fennoscandia and the Bering Sea islands. Knowledge of the population ecology of the species is certainly as important as ever before. The location of Iceland, the isolation of the arctic fox population and the global interest in the effects of climate changes on Nordic wildlife makes the Icelandic arctic fox population important in comparative studies. Picking up from the last arctic fox conference held in Vålådalen, Sweden in 2009, the 4th International Arctic Fox Conference will present a collection of plenaries, science sessions, posters and films reflecting the new knowledge gathered over the past years.

Iceland is home to the Arctic Fox Centre, a non-profit research and exhibition center. Born from an idea of late prof. Páll Hersteinsson (1951-2011), it is the only institution in the world especially dedicated to the arctic fox. The last day of this conference will be dedicated to Dr. Páll Hersteinsson, in his memory and the work he has done on the biology of the arctic fox. We hope that you will enjoy your stay and your participation in the conference !

Ester Rut Unnsteinsdóttir, Iceland
Sandra Lai, Canada

Anders Angerbjörn, Sweden
Bodil Elmhagen, Sweden
Dominique Berteaux, Canada
Eva Fuglei, Norway
Karin Norén, Sweden
Nina Eide, Norway

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Program

Thursday 10 October

Pre-tour (Borea Adventures) - Arctic Fox Centre and the foxes of Hornstrandir Nature Reserve

Friday 11 October

09:00-10:00 **Registration and conference handouts**

10:00-10:15 **Welcome word**

10:15-11:00 **Plenary I**

An ecosystem approach for monitoring and management of the Arctic fox.

Killengreen, S.T., Henden, J.A., Hamel, S., Ehrich, D., Yoccoz, Y. and Ims, R.

11:00-12:00 **Population perspectives I**

11:00-11:20 *Stable arctic foxes in a changing ecosystem in the southern tundra of Yamal, Russia*

Ehrich, D., Sokolov, A.A., Sokolova, N.A., Fuglei, E., Rodnikova, A.Y., Ims, R.A., Yoccoz, N.G. and Sokolov, V.A.

11:20-11:40 *Ecology of the arctic fox in Svalbard: a synthesis based on long-term monitoring data*

Fuglei, E., Pedersen, Å.Ø. and Ims, R.A.

11:40-12:00 *Arctic fox dens 40 years survey in Yamal peninsula, Russia*

Sokolov, A., Shtro, V., Ehrich, D. and Sokolova, N.

12:00-13:15 **Lunch Break**

13:15-14:00 **Plenary II**

Where do arctic foxes go in winter? A 6-year study using satellite telemetry on Bylot Island, Canada

Lai, S., Bêty, J. and Berteaux, D.

14:00-15:00 **Population perspectives II**

14:00-14:20 *Social organization in arctic foxes, pattern and processes*

Angerbjörn, A., Elmhagen, B., Godoy, E., Hersteinsson, P., Meijer, T., Norén, K. and Wagenius, S.

14:20-14:40 *Demography of the Mednyi arctic fox (*Vulpes lagopus semenovi*)*

Doronina, L.O., Bocharova, N.A., Nanova, O.G., Kruchenkova, E.P., Sergeev, S.S., Shienok, A.N., Volodin, I.A. and Goltsman, M.E.

14:40-15:00 *Fluctuations in arctic fox (*Vulpes lagopus*) juvenile survival in a cyclic environment. Effects of maternal experience, fox juvenile body measurements and habitat primary productivity.*

Erlandsson, R., Angerbjörn, A. and Meijer, T.

15:00-15:30 **Coffee break**

15:30-16:30 **Interaction with other species and humans**

15:30-15:50 *Foxes, lemmings and voles*

Elmhagen, B., Meijer, T., Hellström, P., Norén, K., Dahlgren, J.P., Eide, N. and Angerbjörn, A.

15:50-16:10 *Food subsidies rather than climate warming may explain the twentieth century red fox expansion into the Canadian Arctic*

Gallant, D., Lecomte, N. and Berteaux, D.

16:10-16:30 *Arctic fox as an Eco-tourism attraction*

Gardfall, E.

16:30-17:30 **Poster session**

19:00- **Dinner**

20:00-22:30 **Social visit to the Arctic Fox Centre (optional)**

Saturday 12 October

10:00-10:45	Plenary III <i>Sea ice, lemmings and other foxes - context-dependent genetic structuring in the arctic fox</i> Norén, K.
11:00-11:40	Physiology and genetics
11:00-11:20	<i>Variability in stress, parasites, and diet in arctic fox.</i> Roth, J.D., Friesen, O.C. and McDonald, R.M.
11:20-11:40	<i>Kin encounter rate and inbreeding avoidance in canids</i> Geffen, E., Kam, M., Hefner, R., Hersteinsson, P., Angerbjörn, A., Dalèn, L., Fuglei, E., Norén, K., Adams, J.R., Vucetich, J., Meier, T.J., Mech, D.L., Vonholdt, B.M., Stahler, D.R. and Wayne, R.K.
12:00-13:15	Lunch Break
13:15-14:00	Plenary IV <i>The fox tax - a brief overview of Conservation and management in Iceland</i> Unnsteinsdóttir, E.R.
14:00-15:00	Conservation and management
14:00-14:20	<i>Management of the arctic fox in Norway – history and status</i> Bolstad, J.P.
14:20-14:40	<i>Arctic fox Skandinavia 2013 – status and conservation actions</i> Eide, N.
14:40-15:00	<i>Success of the endangered arctic fox captive breeding programme</i> Landa, A., Tovmo, M., Ulvund, K., Meås, R., Eide, N.E., Flagstad, Ø. and Andersen, R.
15:00-15:30	Coffee break and poster session
15:30-17:00	Conservation and management
15:30-15:50	<i>Arctic foxes in Hornstrandir Nature Reserve - status on conservation and research</i> Unnsteinsdóttir, E.R. and Hersteinsson, P.
15:50-16:10	<i>Felles Fjellrev – a Norwegian-Swedish InterReg/EU project on Arctic foxes in the Scandinavian Mountains</i> Ericson, M.
16:10-16:30	<i>Fieldwork in the Scandinavian Arctic fox project, Felles Fjellrev</i> Solstad, T., Liljemark, L., Berglund, H., Johansen, T. and Blad, N.
16:30-16:50	<i>Conservation Status of the Pribilof Fox <i>Alopex lagopus pribilofensis</i></i> White, P.A.
17:30-18:00	A visit into agent world, original home of the early 1900's
19:00-	Banquet - Dinner and toast to our good friend PH

Sunday 13 October : Páll Hersteinsson memorial day

10:00-12:00 **An overview of Hersteinsson studies in Iceland**
Greetings from former collaborators and mentors
Ester Rut Unnsteinsdóttir
Collaboration with PH in Sweden:
Anders Angerbjörn
Collaboration with PH in Norway:
Eva Fuglei, Rolf Ims, Nina Eide
Collaboration with PH in Westfjords:
Þorleifur Eiríksson
Collaboration with PH in Iceland/UNI
Skarphéðinn Þórisson

12:00-13:15 **Lunch Break**

13:20-15:00 **Slideshow of late Páll's work**

Film Introductions

The Arctic Foxes of Hornstrandir - Ljósop, introduction and trailer, Iceland
ICELAND by Tobias Mennle, from the series "Wild Scandinavia", Germany
Skolliales by Haukur Sigurdsson, MSc project in visual anthropology, Norway/Iceland
Storm & Tinde - introduction and trailer. A film about the future of the Arctic Fox in Scandinavia by The InterReg/EU-project Felles Fjellrev
Frumbygginn (e. The Settler). A documentary film by Snorri Þórisson. Following Páll Hersteinsson in his field studies in Ófeigsfjörður during 1980's, Iceland

15:00-15:30 **Coffee break**

15:30-16:15 **Concluding remarks and future steps**

16:30-17:00 **Ending of the conference "Salute"**

List of Abstracts



Plenary I

An ecosystem approach for monitoring and management of the Arctic fox

Killengreen, S.T., Henden, J.A., Hamel, S., Ehrich, D., Yoccoz, Y. and Ims, R.

University of Tromsø

The arctic fox population has during the last century retracted from the southern edge of its circumpolar range. The cause for this apparent range-retraction has been attributed both to the greening of the arctic, accompanied by a range shift of the red fox and dampening or collapse of the small rodent cycle.

On Varanger Peninsula, located in the sub-arctic climate zone, a long-term study assessing the causes of the decline in the Fennoscandian arctic fox population has been conducted. To be able to assess the importance of the different hypotheses the project has taken an ecosystem approach. We found lemmings to be the most important prey species and more susceptible to climate change than other species of small rodent. Even though the probability of re-colonization of a small population of arctic fox was affected by peak lemming densities, the presence of red fox constituted the most limiting factor for re-colonization of arctic fox in Varanger. Moreover, our study has shown that the apparent expansion of red fox in Finnmark is probably to be due to increased access to reindeer carcass subsidies, rather than a “greening of the arctic”. Availability of these subsidies is likely to have contributed to the intensifying of competition between the two fox species. The increasing availability of reindeer carcasses is utilized by the entire scavenger guild and increases the presence of all scavenger species, which in turn may affect the tundra food web in different ways.

Our research highlights the need for an ecosystem approach to properly discriminate between competing ecological hypotheses for the decline of Fennoscandian arctic fox.

Siw T. Killengreen, e-mail siw.killengreen@uit.no

Session I: Population Perspectives I

Stable arctic foxes in a changing ecosystem in the southern tundra of Yamal, Russia

Dorothee Ehrich¹, Aleksandr A. Sokolov², Natalya A. Sokolova², Eva Fuglei³, Anna Y. Rodnikova⁴, Rolf A. Ims¹, Nigel G. Yoccoz¹, Vasily A. Sokolov⁵

¹University of Tromsø, Tromsø, Norway; ²Ecological Research Station of Institute of Plant and Animal Ecology RAS, Labytnangi, Russia; ³Norwegian Polar Institute, Tromsø, Norway; ⁴Lomonosov Moscow State University, Moscow, Russia; ⁵Institute of Plant and Animal Ecology RAS, Ekaterinburg, Russia.

The decline of arctic fox populations in Fennoscandia has been attributed to two, non-exclusive, causes: the scarcity of lemming peak years in the last decades, which has been linked to climate change, and the increase of the competitively superior red fox. However, in most of the wide Russian tundra regions arctic foxes are still common. We investigate the state of a population in the southern Arctic, the tundra zone which is particularly exposed to climate-induced changes and influences from more southern biome. Seven years of den survey at Erkuta tundra monitoring site in southern Yamal (N 68.2°, E 69.2°; bioclimatic subzone E) show that arctic foxes are reproducing nearly every year. The number of occupied dens does not change much and is not strongly correlated to the small rodent dynamics, which are characterized by low amplitude fluctuations in a community dominated by voles. In addition to small rodents, a rich guild of medium sized herbivores comprising hare, willow grouse and muskrat, as well as numerous waterfowl may provide enough resources for arctic fox breeding. Instead of behaving as “lemming foxes” typical for the Siberian tundra, we hypothesize that this population is a relatively stable inland population relying on a wide variety of prey. Red foxes are present in the study area, but in much lower numbers than arctic foxes. Using an ecosystem based approach we aim at describing the state of this arctic fox population in a changing ecosystem, and want to understand how stable the present state is.

Dorothee Ehrich, e-mail Dorothee.ehrich@uit.no

Ecology of the arctic fox in Svalbard: a synthesis based on long-term monitoring data

Eva Fuglei¹, Åshild Ønvik Pedersen¹ and Rolf Anker Ims²

¹Norwegian Polar Institute, Tromsø, Norway; ²University of Tromsø, Tromsø, Norway

The arctic foxes in Svalbard live in an ecosystem that largely defines them as the coastal ecotype. Long-term monitoring, since early 1990, with den surveys giving information on breeding population, and trapping statistics giving information on demography has been conducted in two locations in Svalbard. In the presentation we will give a synthesis of recent results that have been obtained based on this monitoring data.

Eva Fuglei, e-mail eva.fuglei@npolar.no

Arctic fox dens 40 years survey in Yamal peninsula, Russia.

Sokolov¹, V. Shtro¹, D. Ehrich² and N. Sokolova¹

¹Ecological Research Station of Institute of Plant and Animal Ecology RAS, Labytnangi, Russia; ²University of Tromsø, Tromsø, Norway

The number of entrances is an important feature of arctic fox dens. Previous evidence suggests that larger dens with more entrances are occupied more often by reproducing pairs, and that the number of pups may be higher in larger dens. Arctic fox dens are easily detectable in the tundra zone of Yamal peninsula (Russia). Most dens are in sandy soils, and it is easy to count the number of entrances for each den. Here we present results of a comparison of the number of entrances in arctic fox dens which were first described in the 1980s, and visited again in 2005-2013. The study included sites in all bioclimatic subzones of the Yamal peninsula (from the low arctic shrub tundra to high arctic tundra). We discuss whether the number of entrances in dens can be used as a proxy for the state of an arctic fox population.

Aleksandr Sokolov, e-mail sokhol@yandex.ru

Plenary II

Where do arctic foxes go in winter? A 6-year study using satellite telemetry on Bylot Island, Canada

Sandra Lai, Joël Bêty and Dominique Berteaux

Chaire de recherche du Canada en biodiversité nordique, Centre d'Études Nordiques and Université du Québec à Rimouski, Rimouski, Québec, Canada

Spatio-temporal resource dynamics is a major driver of population movement patterns. The High Arctic has a very marked seasonality, with many migrant species breeding in summer and food resources becoming scarcer during the cold season. The temporary sea ice also provides a habitat for species, such as the arctic fox (*Vulpes lagopus*), that can use it as a bridge or as a hunting platform. This study aims to investigate movement patterns of arctic foxes from Bylot Island (Nunavut, Canada) during winter and spring in order to 1) determine their population-level movement pattern and 2) investigate the influence of resource dynamics on individual movement strategies. From 2007 to 2012, 97 Argos satellite telemetry collars were used to track adult arctic foxes during the sea ice period (25 October–31 May). Intra-population variation in fox movement patterns was observed. The majority of the population (mean proportion \pm SD : 78.3 \pm 21.2%) displays varying degree of range residency, with resident foxes making commuting trips to the neighbouring fast ice. A small proportion of individuals undertakes a breeding dispersal (mean proportion \pm SD : 16.6 \pm 14.5%; 18 cases) and only a few individuals make a long-distance movement before returning to their previous home range for breeding (mean proportion \pm SD : 5.1 \pm 8.6%; 4 cases). Foxes with home ranges outside of the goose colony or away from the coastline were more likely to become nomads (disperse or temporarily leave), while resident foxes outside the goose colony increase the frequency of their trips to the sea ice when lemming abundance is lower.

Sandra Lai, e-mail laisandra@gmail.com

Session II: Population Perspectives II

Social organization in arctic foxes, pattern and processes

Angerbjörn, A., Elmhagen, B., Isaksson, J, Hersteinsson, P., Meijer, T., Norén, K. and Wagenius, S.

Department of Zoology, Stockholm University

The standard description of the social organization for arctic foxes is that they are monogamous and pair-living. There are however many exceptions to this basic pattern. In some populations more complex families are fairly common but in others they are rare. Extra pair paternity varies in a similar way. Extra adults in the more complex families are offspring from earlier litters and in some cases younger females have even been breeding together with their mother in the same den. But both extra females and males can contribute to the rearing of juvenile arctic foxes by providing food and by guarding at the den. We argue that the pattern of social organization can be explained by a combination of low cost to include more adults in a territory during high resource availability and by the benefit in terms of territorial defiance against predation.

Anders Angerbjörn, e-mail anders.angerbjorn@zoologi.su.se

Demography of the Mednyi arctic fox (*Vulpes lagopus semenovi*)

L.O.Doronina^{1,2}, N.A.Bocharova¹, O.G.Nanova¹, E.P.Kruchenkova¹, S.S.Sergeev¹, A.N.Shienok¹,
I.A.Volodin¹ and M.E.Goltsman¹

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Experimental Pathology and Molecular Neurobiology, Muenster, Germany

The endemic population of the Mednyi arctic fox has been isolated for several tens of thousands of years on the small island in the North Pacific (Geptner, Naumov, 1967). Apparently, it is the most ancient island population of canids now.

In 1994, the long-term individual-oriented field study of arctic foxes on Mednyi Island commenced. Annually, arctic fox cubs are marked with plastic ear-tags and the population number, family composition and spatial distribution are examined (Goltsman et al., 2005, Kruchenkova et al., 2009).

Annual fluctuations of the population size were low (CV = 15%). It is essentially lower than in the isolated mainland populations with nearly the same size in Fennoscandia (Angerbjorn et al., 1995). We did not find any long-term trends in the Mednyi population number which was observed in Iceland (Hersteinsson, 1992). The mortality of animals under the age of one was 72.3% (95%CI=65.81-78.81), the mortality of animals between the ages of one and three was observed at an approximately constant rate of 31.4% (95%CI=26.00-37.63), the mortality of animals at the age of four was 43.6% (95%CI=25.01–62.19), and it increased for animals when they reached 5 to 79.2% (95%CI=65.99–92.34). The life expectancy in the age class 0 was 1.03 years for males ($n_0=309$) and 1.44 years for females ($n_0=311$) and was greater for females of all ages. The intergenerational time interval (the mean age of breeding females) in the Mednyi fox population was relatively short ($M=2.67$ years, 95%CI=2.39-2.95).

The surveys were financed by grants of the Russian Foundation of Basic Sciences.

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Liliya Doronina, e-mail doronina@uni-muenster.de

Fluctuations in arctic fox (*Vulpes lagopus*) juvenile survival in a cyclic environment. Effects of maternal experience, fox juvenile body measurements and habitat primary productivity.

Rasmus Erlandsson, Anders Angerbjörn and Tomas Meijer

Zoologiska institutionen, Stockholms universitet

I have studied differences in juvenile summer survival in the endangered Fennoscandian arctic fox population in order to determine the effect of a) maternal experience, b) fox juvenile body measurements and c) habitat primary productivity on juvenile survival. Habitat primary productivity was assessed for different territories using near-IR colour aerial photos. Arctic fox Juvenile summer survival varied between years and litters depending on small rodent phase, maternal experience, juvenile body size and habitat primary productivity. Survival rate of juveniles of inexperienced females was lower during small rodent decrease phase, and significantly higher during peak phase. Juveniles of experienced females were not significantly affected by rodent phase. Size was positively related to survival and relative juvenile body size of experienced females was larger than for inexperienced females. Survival was negatively related to habitat productivity. No signs of starvation were found and the lower juvenile survival associated with inexperienced females is likely an effect of a lower ability to cope with the increased predation pressure from red fox (*Vulpes vulpes*) and Golden eagle (*Aquila chrysaetos*) associated with small rodent decrease.

Rasmus Erlandsson, e-mail rasmus.erlandsson@zoologi.su.se

Session III: Interaction with other species and humans

Foxes, lemmings and voles

Bodil Elmhagen¹, Tomas Meijer¹, Peter Hellström¹, Karin Norén¹, Johan P. Dahlgren², Nina Eide³ and Anders Angerbjörn¹

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²Dept. of Ecology, Environment & Plant Sciences, Stockholm Univ., 10691 Stockholm, Sweden

³Norwegian Institute for Nature Research, N-7845 Trondheim, Norway

Inland arctic foxes prey primarily on cyclic small rodents. In the 20th century, there were extended periods without high-amplitude rodent peaks in Fennoscandia. The regional dynamics of arctic and red fox populations in Sweden suggests there were similar patterns of change in the dynamics of tundra lemmings and boreal voles, supporting the hypothesis that a large-scale driver such as climate is the ultimate cause of non-stationary dynamics in small rodents. How might changes in the dynamics of small rodents impact the arctic fox in Fennoscandia? Arctic fox females produce larger litters than expected given food abundance in the increase phase of the rodent cycle. This may be explained by a high reproductive value of offspring born in the increase phase. Thus, the reproductive strategy of the arctic fox appears to be adapted to the rodent cycle. However, current arctic fox population trends in Fennoscandia cannot be explained by the rodent cycle alone, but other factors such as red fox competition must also be taken into account.

Bodil Elmhagen, e-mail bodil.elmhagen@zoologi.su.se

Food subsidies rather than climate warming may explain the twentieth century red fox expansion into the Canadian Arctic

Daniel Gallant¹, Nicolas Lecomte^{1,2} and Dominique Berteaux¹

¹Chaire de recherche du Canada en biodiversité nordique and Centre d'Études Nordiques, Université du Québec à Rimouski, Rimouski, Québec, Canada

²Department of Environment, Government of Nunavut, Igloolik, Nunavut, Canada

In his most influential paper (Oikos 64:505-515, 1992), Pall Hersteinsson introduced, with David W Macdonald, original ideas about interspecific competition and the geographical distributions of red and arctic foxes. In the early 20th century, the red fox expanded its distribution over thousands of kilometers in the Arctic. The fate of the arctic fox in many parts of the Arctic depends on whether the dominant red fox continues to increase its presence there, so it is important to understand factors involved in its expansion. We assembled and analysed historical fur harvest data, and considered three hypotheses based on Hersteinsson and Macdonald's idea that food availability historically limited red fox presence in the Arctic: 1) warming summers caused the expansion by increasing ecosystem productivity, 2) warming winters caused the expansion by alleviating thermal stress and thus energy requirements, and 3) the appearance of sedentary human populations caused the expansion by creating food subsidies on the tundra. We compared statistical models to identify important factors describing temporal trends in the importance of red fox relative to arctic fox in fur harvests. Summer and winter climate variables performed poorly. The most important factor was human presence, as represented by the number of community-years counted around trading posts. Our study does not support Hersteinsson and Macdonald's climate-based hypothesis but it may have not existed without their paper, which framed our research objectives. Original ideas published ahead of their time are valued and those who publish them, like Pall Hersteinsson, are influential on their field.

Daniel Gallant, e-mail beru9664@hotmail.com

Arctic fox as an Eco-tourism attraction

Erik Gardfall

Swedish Touristassociation (STF), Manager/Guide at STF Helags Mountainstation

In the core of Sweden's richest Arctic fox area lays Helags STF Mountain Station. It's like a small hotel in out the mountains, 12km from the nearest road at the foot of the Helagsmountain. We offer cozy accommodation in our cottages and good food and beverages in our restaurant. We offer service, guided tours and information to hikers who wants to experience the mountain area. Helags is Sweden's highest peak south of the Arctic Circle and Swedens southernmost glacier you can find here.

We are especially proud to have the opportunity to offer our guests a chance to enjoy watching Arctic foxes in their natural environment. Guests can join our Arctic fox guide to an inhabited den. It is mandatory that every guest sign a contract declaring that he/she understand that information of the location of the den may not be disclosed to any third party in any way.

In addition to the chance to really see a Arctic fox, we provide basic information about the Arctic fox, the important conservation measures and other things worth knowing about the mountain area, such as tourism and reindeer herding. It often becomes a memorable experience and the guests get to go home with a better understanding and knowledge for the mountains and the Arctic fox.

The tours is an important part of conservation efforts for the Arctic fox in a concrete way. 100% of the fee for the tour goes to the purchase of dogfood for feeding the Arctic foxes. The donation size covers a large part of the annual consumption of dogfood.

Erik Gardfall, e-mail: erik.gardfall@stfturist.se

Plenary III

Sea ice, lemmings and other foxes - context-dependent genetic structuring in the arctic fox

Karin Norén

Department of Zoology, Stockholm University, Stockholm, Sweden

The genetic composition in a population is determined by the interplay between environmental conditions, historical and ongoing processes. In this presentation, the impact of ecological variation across the Arctic fox distribution range in relation to microevolutionary processes and subsequent genetic structure at different scales and time spans will be summarized.

The origin of present Arctic fox populations is according to genetic evidence highly influenced by the lack of capacity to track climate-induced habitat shifts through dispersal. Globally, present connectivity is determined by access to sea ice and distance between populations, generating high genetic homogeneity between all populations connected by sea ice. Lemming cycles can trigger long-distance dispersal pulses between the ecotypes, which produce phase-related and seasonal shifts in genetic composition. However, as arctic ecosystems are modified in pace with the changing climate, opportunities for dispersal decrease due to habitat fragmentation and another question is what genetic consequences this brings. Populations isolated from immigration through year-round open water have evolved independently and are biologically and genetically divergent. Moreover, as exemplified by the Scandinavian conservation situation, inbreeding is an important factor forming the distribution of genetic variation and individual success for survival and reproduction in small and isolated populations. The effect of inbreeding on individual fitness is however strongly influenced by the lemming cycle, creating a phase-dependent difference between inbred individuals.

In conclusion, a vast array of studies based on neutral genetic evidence entails that dispersal, or the lack thereof, in combination with the ecological context is a key process determining genetic structure. During the last decade, development of genetic methodology has accelerated and there is now ample opportunities for testing functional genetic divergence between populations and individuals. This, in combination with detailed ecological knowledge carries high potential for future genetic research and can shed light over questions that remain unanswered.

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Session IV: Physiology and genetics

Variability in stress, parasites, and diet in arctic fox

James D. Roth, Olwyn C. Friesen, and Ryan M. McDonald

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Challenges to an organism such as low food availability or increased parasite loads can provoke a stress response that over time can inhibit reproduction and immunity and increase mortality. Arctic fox populations can experience dramatic variation in food availability that strongly affect their population dynamics, which may be reflected in their physiological response to changing environmental conditions. To examine the relationship between stress, parasites, and diet in arctic foxes near the southern edge of their distribution in Canada we measured cortisol concentrations in hair samples collected from arctic foxes harvested near Churchill, Manitoba. We also identified and enumerated endoparasites from fox carcasses, and measured their stable isotope ratios as a reflection of diet. Cortisol concentrations tended to be higher in animals with lower body condition, but cortisol and condition were unrelated to sex or age. Stable carbon isotope ratios were positively related to cortisol concentration and negatively related to condition, suggesting foxes may benefit from consuming rodents over alternative prey. We found a high prevalence and abundance of both cestodes and nematodes, but neither cortisol concentration nor body condition were related to parasite abundance. These results suggest that high parasite burdens may have little effect on arctic fox populations and illustrate the physiological mechanisms relating the population response to changing prey availability.

James D. Roth, e-mail jim.roth@umanitoba.ca

Kin encounter rate and inbreeding avoidance in canids

Eli Geffen^{*}, Michael Kam[†], Reuven Hefner[‡], Pall Hersteinsson[§], Anders Angerbjörn[∖], Love Dalèn^{**}, Eva Fuglei^{††}, Karin Norèn[∖], Jennifer R. Adams^{‡‡}, John Vucetich^{§§}, Thomas J. Meier^{∖∖}, L. Dave Mech^{***}, Bridgett M. Vonholdt^{†††}, Daniel R. Stahler^{‡‡‡}, Robert K. Wayne^{§§§}

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Mating with close kin can lead to inbreeding depression through the expression of recessive deleterious alleles and loss of heterozygosity. Mate selection may be affected by kin encounter rate, and inbreeding avoidance may not be uniform but associated with age and social system. Specifically, selection for kin recognition and inbreeding avoidance may be more developed in species that live in family groups or breed cooperatively. To test this hypothesis, we compared kin encounter rate and the proportion of related breeding pairs in noninbred and highly inbred canid populations. The chance of randomly encountering a full sib ranged between 1–8% and 20–22% in noninbred and inbred canid populations, respectively. We show that regardless of encounter rate, outside natal groups mates were selected independent of relatedness. Within natal groups, there was a significant avoidance of mating with a relative. Lack of discrimination against mating with close relatives outside packs suggests that the rate of inbreeding in canids is related to the proximity of close relatives, which could explain the high degree of inbreeding depression observed in some populations. The idea that kin encounter rate and social organization can explain the lack of inbreeding avoidance in some species is intriguing and may have implications for the management of populations at risk.

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Plenary IV

The fox tax - a brief overview of Conservation and management of arctic foxes in Iceland

Unnsteinsdóttir, ER

The Arctic Fox Centre, The Icelandic Institute of Natural History

Already at the first human settlement during the 10th century, another mammal, the arctic fox, had established in all regions of the island. The settlers brought sheep and other farm animals and the native fox was soon regarded a threat to livestock. The first law written 1295 included provisions for killing arctic foxes, or to pay "The fox tax". In the 1950's the law was changed from management into destruction. The Icelandic Wildlife Management Unit (WMU) was established 1958. Dr. Pall Hersteinsson (PH) became the director of WMU 1984. In his first years at WMU, PH conducted various studies on arctic foxes, in collaborations with colleagues at UNI and wider. PH gained a position as a professor in mammal ecology at UNI in 1995 and continued collecting data and studying arctic foxes for as long as he lived. According to PH's estimates, arctic fox numbers were extremely low in the late 1960's, below 1000 individuals. The population grew substantially ever since and is now believed to exceed 10.000 individuals in fall. The current law, stipulating protection of arctic foxes in Nature Reserves and National parks, were set 1994. According to the law from 1994 and following provisions, the Icelandic arctic fox population should be kept healthy and sustainable. Since 1995 over 80.000 individual foxes have been killed at the cost of over 1.6 billion ISK [2012]. The location of Iceland, the isolation of the arctic fox population and the global interest in the effects of climate changes on Nordic wildlife makes the Icelandic arctic fox population important in comparative studies. Knowledge of the population ecology of the species has never been as important. Fortunately the monitoring program has found a safe "home" at The Icelandic Institute of Natural History. Data sampling is still based on good collaboration with foxhunters. Future remarks will be to encourage the authorities to include scientific results in decision making. By continuing PH's work we can contribute to the future management conservation planning on the behalf of the only native terrestrial mammal in Iceland.

Ester Rut Unnsteinsdóttir, e-mail ester@ni.is

Session V: Conservation and management

Management of the arctic fox in Norway – history and status

Jan Paul Bolstad

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In 2003 the former Directorate for nature management (DN), now Norwegian Environment Agency, presented an action plan for saving the arctic fox. This was the first official action plan on any endangered species in Norway. The plan contains a review of historic data on former arctic fox distribution also including hypotheses for the decline and non-recovery of arctic fox, and recommended actions to save the arctic fox from extinction in Norway.

The Norwegian arctic fox is part of a common population shared by several countries (Sweden, Finland, and Russia), hence cross-border co-operation, especially with Sweden, was also emphasised in the plan. Based on recommendations in the action plan we started four programmes, both to enhance the knowledge of the arctic fox and to increase the arctic fox population in Norway. In co-operating with research institutes in Norway, we started 1) a captive breeding and reintroduction programme, 2) a programme to evaluate the effect of red fox control as a conservation strategy for the arctic fox, 3) gathering regional monitoring initiatives to a national arctic fox monitoring programme with genetics as an important part, and 4) an arctic fox project in co-operation with the County Administrative Board of Jämtland in Sweden financed by Interreg/EU.

Results from these programmes, based primarily on the Norwegian action plan, have been crucial for the observed increase in the arctic fox population in Norway the latest years.

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Arctic fox Skandinavia 2013 – status and conservation actions

Nina Eide

Norwegian institute for nature research (NINA), Trondheim, Norway

Nina Eide, e-mail: nina@nina.no

Success of the endangered arctic fox captive breeding programme

Arild Landa, Mari Tovmo, Kristine Ulvund, Roger Meås, Nina E. Eide, Øystein Flagstad and Roy Andersen

Norwegian institute for nature research (NINA), Trondheim, Norway

The Arctic fox captive breeding programme was established in its current form in 2005, when the breeding station at Sæterfjellet (Oppdal) was opened. Breeding facilities consists of large enclosures in natural arctic fox habitat. The breeders are founded on 16 wild captured cubs, representing the remaining Scandinavian genetic variation. During 2006–2013 46 litters and totally 298 cubs have been born in captivity. Of these 213 have been released and 37 will be released during the coming winter. 21 cubs have been included in the breeding stock and 27 have died due to various causes of mortality. All release sites are prepared with artificial dens and feeding stations for supplemental feeding.

The release areas have been Saltfjellet/Junkern, Northern Norway, Dovrefjell (Snøhetta and Knutshø), Central Norway, Finse, Southern Norway and Sylan, Eastern central Norway. In Dovrefjell, Finse and Sylan the arctic fox was extinct for a period before the breeding programme started re-introducing foxes to these areas. In Saltfjellet/Junkern the release of cubs is carried out to support the remaining small and scattered population. We estimated the minimum survival after the first winter from recapture rates, using DNA from scats and registrators at the feeding stations. Minimum survival varied between 15-71%. True survivalis probably underestimated due to emigration of foxes and insufficient recapture methodology. In total, the animals released have been involved in minimum 41 litters in the wild in Norway and minimum 12 in Sweden. In 2013 released individuals or foxes from the F2 generation born in the wild were responsible for 19 of the 24 recorded litters in Norway. There were 15 litters in Dovrefjell and four litters in Finse. During the project period the Arctic fox population at Dovrefjell has gone from extinct to being the largest population in Norway.

Arild Landa, e-mail arild.landa@nina.no

Arctic foxes in Hornstrandir Nature Reserve - status on conservation and research

Unnsteinsdóttir, E. R. and Hersteinsson, P.

The Arctic Fox Centre, The Icelandic Institute of Natural History, The University of Iceland

In Iceland, the arctic fox is the only native terrestrial mammal, found in all regions of the island. Rough estimate of the Icelandic population is around 11000 individuals in the fall. Bounty hunting of around 5000-6000 individuals, killed annually in all seasons takes place over most of the country. A legislation stipulating protection of the arctic fox in Nature Reserves and National Parks, was instituted by law in 1994 in Iceland. Hornstrandir Nature Reserve (HNS) is a 580km² remote peninsula in Northwest Iceland and the most important sanctuary for arctic foxes in the country. Due to the protection, the foxes of HNS have become famously tame to people. The Nature Reserve hosts around 40-50 breeding fox pairs and two of the largest sea-bird cliffs in Westfjords. According to a new proposal to the law, foxes should not be protected anywhere in Iceland so that the future of the tame and dense population of HNS is uncertain. Hornstrandir Nature Reserve has become extremely popular as a hiking area and most visitors expect to spot the arctic foxes while travelling there. The importance of the foxes in tourism is increasing but it is not clear if the increasing pressure affects the lifetime success of the local population. Knowledge on the arctic fox population in this area is especially vital for conservation and management of the species in the country. Together with late Pall Hersteinsson and other colleagues, data on den occupancy and social behaviour of the Hornstrandir population has been collected since 1989. Comparative studies on the population ecology of the arctic foxes within the nature reserve versus non-protected areas with similar food resources and denning facilities can become an important contribution to future conservation and management of the arctic fox population in Iceland.

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Felles Fjellrev – a Norwegian-Swedish InterReg/EU project on Arctic foxes in the Scandinavian mountains

Mats Ericson

Felles Fjellrev and Taiga Nature & Photo

The InterReg project Felles Fjellrev is an Arctic fox conservation project, where 50% of the funding comes from the EU. The project owners are the Norwegian Environment Agency and the County Administrative Board of Jämtland, Sweden. The project focuses on measures to help the Arctic fox in Trøndelag and the county of Jämtland, and is conducted in close cooperation with the Norwegian Institute for Nature Research (NINA) and the Department of Zoology at Stockholm University.

One target is to use supporting measures to benefit the Arctic fox in “stepping stone” areas, i.e. mountain areas between the Arctic fox’s three core areas in Trøndelag and the county of Jämtland – Helags/Sylarna, Børgefjell/Borgafjäll and Dovrefjell. We hope that this will help the Arctic fox to spread over considerably larger areas, where Arctic foxes used to live.

Our presentation will cover actions taken during the 2010-2013 project period and the results so far. These results, and the actions taken from 2000, demonstrate that areas in which supporting measures are provided are home to Arctic foxes that can breed during good rodent years. However, in areas where no supporting measures have been carried out, few or no pups were born, even during good rodent years – quite simply, there were too few Arctic foxes.

Mats Ericson, e-mail mats@taigaphoto.se

Fieldwork in the Scandinavian Arctic fox project, Felles Fjellrev

Tore Solstad, Lars Liljemark, Håkan Berglund, Tom Johansen and Nicklas Blad

Arctic fox fieldworkers from the Norwegian Environment Agency and the County Administrative Board of Jämtland, Sweden.

Slide show presenting the work carried out in the mountains where Felles Fjellrev operates.

Tore Solstad, Lars Liljemark et al., e-mail tore.solstad@miljodir.no / lars.liljemark@lansstyrelsen.se

Conservation Status of the Pribilof Fox *Alopex lagopus pribilofensis*

Paula A. White

Center for Tropical Research, Institute of the Environment and Sustainability
University of California Los Angeles, USA

The Pribilof fox, *Alopex lagopus pribilofensis*, is an endemic subspecies of arctic fox restricted to three small islands in the middle of the Bering Sea, Alaska. Pribilof foxes are morphologically and genetically distinct, and exhibit complex social organization rarely seen in this species. Despite their uniqueness, Pribilof fox populations have undergone dramatic declines due to a variety of factors that threaten their long-term survival. Threats include significant reduction in food resources, increased exposure to diseases and toxins, and unsustainable levels of direct human persecution. Additionally, the decline in sea ice has likely led to increased genetic isolation. The current status of the Pribilof fox populations will be discussed. Recommendations towards improved management that may provide more effective conservation measures for *A.l. pribilofensis* will be presented.

Paula A. White, e-mail paw@carnivoreconservation.com

Poster Session

Poster 1

Spatial distribution of Norwegian lemming in Swedish tundra

Le Vaillant Maryline, Elmhagen Bodil, Erlandsson Rasmus and Angerbjörn Anders

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The dynamics of arctic foxes and many others arctic specialist predators are strongly dependent on small rodent abundance. Indeed, the cyclic dynamics of the latter affects their predators through a bottom-up effect. Whereas the cyclicity of lemmings in Scandinavia was first described in 1924, its causes and mechanisms remain unexplained. Hypotheses developed to explain the cycle suggest that lemmings are regulated both by food availability, i.e. the vegetation, and specialist predators, including arctic foxes. Using species distribution modeling on Norwegian lemming (*Lemmus lemmus*) in Swedish tundra over 8 years, we investigated which environmental components predict lemming presence in different cycle phases. We showed that in the increase phase lemming presence was linked to vegetation type (fresh heath and meadow) while during the peak phases, lemmings were associated with primary productivity which correlated to presence of grass. Moreover lemming presence only during the increase phase was also explained by topographical characteristics of the habitat (elevation and characteristic of the slope). These specific field characteristics should permit greater snow accumulation and offer lemming a habitat with better isolation against cold and long winter, and also a protection against predators, whereas during the peak phases, lemming might be more exposed to their predators. Our findings support the hypothesis that the lemming population is regulated both by vegetation, their predators and snow condition, where lemmings become less habitat specific during the peak phase when their search for food in a wider range of habitats exposes them to an increased predation risk.

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Presenter : Anders Angerbjörn, e-mail anders.angerbjorn@zoologi.su.se

Spatial and temporal distribution of red and arctic foxes in southern Yamal in early spring.

A.Sokolov¹, D.Ehrich², R.Ims², N.Lecomte², A.Rodnikova³, V.Shtro¹, N.Sokolova¹, V.Sokolov⁴ and N.Yoccoz²

¹Ecological Research Station of Institute of Plant and Animal Ecology RAS, Labytnangi, Russia; ²University of Tromsø, Tromsø, Norway; ³Lomonosov Moscow State University, Moscow, Russia; ⁴Institute of Plant and Animal Ecology RAS, Ekaterinburg, Russia

The expansion of the red fox (*Vulpes vulpes*) and the retraction of the arctic fox (*Vulpes lagopus*) are one of the most widely known changes in distribution of arctic mammals. At present the distribution of the two species overlaps in large areas of the southern tundra. Here we present results from four years of camera trapping in the south-western part of Yamal Peninsula (68.13N, 69.09E, Russia). We run a transect of 10 camera stations perpendicular to sea shore in March-April (2008-2011). Distance between stations was 5 km. Each station was equipped with an automatic camera which took a picture every 10 min, and baited with slaughtering remains of reindeer.

During the summer seasons (2007-2011), we conduct rodents trapping sessions in the same area. Our study period covered a complete small rodent cycle with an intermediate year in 2007, low year in 2008, growing populations in 2009, peak densities in 2010, and decreasing populations in 2011. In total more than 135 000 pictures were obtained from the automatic cameras. Arctic foxes dominated at all stations in all years. In each year, the number of pictures with arctic foxes increased during the season. Red foxes were considerably less present on the pictures. A single picture of a red fox was recorded in 2008, and the species was not recorded at all in 2009 and 2011. In 2010, however, red foxes were present at frequencies comparable with that of arctic foxes. They were recorded only at the two most inland stations.

Aleksandr Sokolov, e-mail sokhol@yandex.ru

Spatial winter dynamics in arctic fox pairs at Bylot Island

Marie-Jeanne Rioux, Sandra Lai, Joël Bêty and Dominique Berteaux

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The arctic fox is a socially monogamous species. Simultaneity of pair activity depends largely on the strength of the pair-bond and the need to coordinate activities such as feeding, breeding and territory defense. During winter in the High Arctic, food resources are scarcer due to the departure of the migratory birds and the additional difficulty of catching lemmings under the snow cover. The sea ice can also offer additional food resources such as seal carcasses. Arctic foxes have been reported to mate for life, however their degree of social proximity during winter is unknown. Arctic foxes may have to make compromises between keeping their home range and pair-mate, and foraging on sea ice. This study is the first to focus on the spatial winter dynamics of arctic fox pairs. The objectives are to determine: 1) if arctic fox pairs are faithful to their summer home range during winter, 2) if extraterritorial movements towards the sea ice are simultaneous between pair-mates and 3) the spatial proximity between mates when extraterritorial movements are simultaneous. To meet those objectives, between 2007 and 2011, 21 arctic fox pairs from Bylot Island (Nunavut, Canada) were tracked using Argos satellite collars. Results show that arctic foxes from Bylot Island are faithful to their summer home ranges during winter (*Fidelity index*: $73.85 \pm 24.20\%$). Extraterritorial movements are short-termed (2.44 ± 8.34 days) with a low simultaneity between pair-mates (*Simultaneity index*: $14.16 \pm 14.04\%$). Results also show that pair-mates usually move alone during simultaneous extraterritorial movements. Overall, these results show that pair-mates stay close within their home ranges even during winter, but forage independently on the sea ice.

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Presenter : Sandra Lai, e-mail laisandra@gmail.com

Dietary specialization of Mednyi Island Arctic fox (*Vulpes lagopus semenovi*)

Alexander Shienok

M.V. Lomonosov Moscow State University, Faculty of Biology, Moscow, Russian Federation

On Mednyi Island (Commander Islands, North Pacific), arctic fox population have access to different types of foraging resources, such as sea birds colonies and fur seal rookeries. We have studied the dietary and reproductive response of arctic fox to the varying abundance of different types of prey. We discuss whether Mednyi arctic fox tends more specialistic or opportunistic foraging strategy.

Alexander N. Shienok, e-mail anshienok@gmail.com

Estimation of lamb (*Ovis aries*) mortality during summer in Iceland, a step towards estimating costs and benefits of arctic fox (*Vulpes lagopus*) culling

Helgason¹ Hálfván, Ancin F. Javier² & Unnsteinsdóttir Ester^{1,3}

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² University of Tromsø

³ Náttúrufræðistofnun Íslands / The Icelandic Institute of Natural History

The Icelandic Arctic fox (*Vulpes lagopus*) population has been in a continuous growth phase since the late 1970's and was last estimated to be 7000 - 14000 individuals in autumn 2007, (Hersteinsson 2010). The Icelandic legislation establishes fox culling a.o.t. to prevent livestock loss due to predation. These measures resulted in 6832 foxes reported shot by hunters in 2007 at a cost of approximately 100 million ISK [2012] according to data from the environment agency of Iceland. The potential effect of Arctic foxes on lamb survival has however never been quantified, nor has lamb mortality during summer been published. We used data from the Icelandic farmers association's registry, Fjárvis, to estimate lamb mortality, between releasing to grazing grounds in spring and herding in autumn. This is a necessary baseline from which to assess the costs and benefits of the culling efforts. Fates were obtained for 3.616.149 lambs of 12 cohorts (2000-2011) within 48 areas generally following municipality administrative lines. Of these, 93% were classified as having been released in to grazing grounds in spring and 91% as having been retrieved in the following autumn. Using a general linear modeling (GLM) approach we tested the data for annual and regional differences in mortality, using year and regions as predictor variables. Lamb mortality probabilities in summer grounds for the total sample were estimated to be 0.0283 (0.0281 - 0.0285 [95% CI]). Results show an overall increase in mortality from 2.2% in 2000 to 3.7% in 2011 and differences of average mortality probabilities ranging from 2.2% to 3.4% between regions. These changes were, however, not significant, neither between years nor individual regions. The non-significant increase in lamb mortality over a period of a steady increase in the fox population casts doubts on the notion that predation by foxes severely affects lamb mortality on a large scale.

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Reproductive success of arctic fox (*Alopex lagopus*) and various factors including rodent population fluctuations: An experimental enclosure approach

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Norwegian Inst. of Nature Research, Trondheim Norway

Little is known about the actual mechanisms limiting reproduction in the critically endangered Norwegian population of the arctic fox. It had been proposed that this lemming ecotype arctic fox is dependent on peak rodent cycles for production of large litters and produce few or no litters in the low phase of the rodent cycle. We have studied the contribution of various traits and factors on male and female fertility including genetic lineage, wild or captive born, age, previous reproductive output and small rodent density using an experimental approach in captivity. All breeding attempts (n= 49) in the captive breeding program for 2007-2013 at Sæterfjellet breedingstation, Oppdal, Norway have been included in the study. Foxes are kept in breeding pairs year-round in large natural habitat enclosures with unlimited access to food resources. The chainlinked fencing allows small rodents such as lemming and vole to freely pass in and out of the fox enclosures. Litter size varied between 0-14 pups (mean=5.86, median=6). Mean female fecundity between years was 6.06 (range, 4.56-8.63) and mean yearly fecundity between individual females was 5.31 (range, 3.25-8.334). We found that female age and previous reproductive output had the strongest influence on litter size. Peak rodent density does seem to have a positive effect on litter size ($p=0.152$) but is not necessary for successful breeding to occur in a captive population. We hypothesis that exposure to rodents encourages ovulation and/or fetus implantation, perhaps by direct hormone stimulus or by increasing appetite or general contentment in captivity. We conclude that it is possible for Fennoscandian lemming ecotype foxes, to have yearly, medium to large size litters regardless of cyclic rodent density phase provided that subsidy food is provided.

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Inter-annual variation in arctic fox pup emergence date as determined by automatic cameras

Camille Morin, Sandra Lai and Dominique Berteaux

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Arctic foxes give birth inside dens in spring and pups will emerge later during the summer. On Bylot Island (Nunavut, Canada), we monitored arctic fox reproduction by camera traps from 2008 to 2013. Cameras were placed at reproductive dens from the end of May to early August. We analyzed pictures to determine 1) the date of emergence of fox litters and 2) the variation in the mean emergence date in relation to the abundance of lemmings. By providing a continuous monitoring of reproductive dens, cameras placed at dens provide very valuable informations on foxes' reproductive output.

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Presenter : Sandra Lai, e-mail laisandra@gmail.com

Tourist effects on denning arctic foxes - code of conducts for tour operators and visitors

^{1,2} Borgný Katrínardóttir, ² Chloe Nater and ^{1,2} Ester Rut Unnsteinsdóttir

²The Arctic Fox Centre, ¹The Icelandic Institute of Natural History

Wildlife tourism is a growing industry world wide, with ever increasing number of tourists seeking to observe and interact with wild animals in their natural surroundings. Wildlife tourism can in some ways positively contribute to conservation but there are also possible negative effects that need to be recognised in order to minimise them. In Iceland, arctic foxes have been heavily hunted throughout the centuries but in the remote Hornstrandir Nature Reserve, they have been protected since 1994. The foxes of Hornstrandir have become relatively tame and increasingly popular among visitors and there are even special tours designated to observe and photograph them. It is however not known to what extent the presence of tourists affects the behaviour and reproductive success of the foxes.

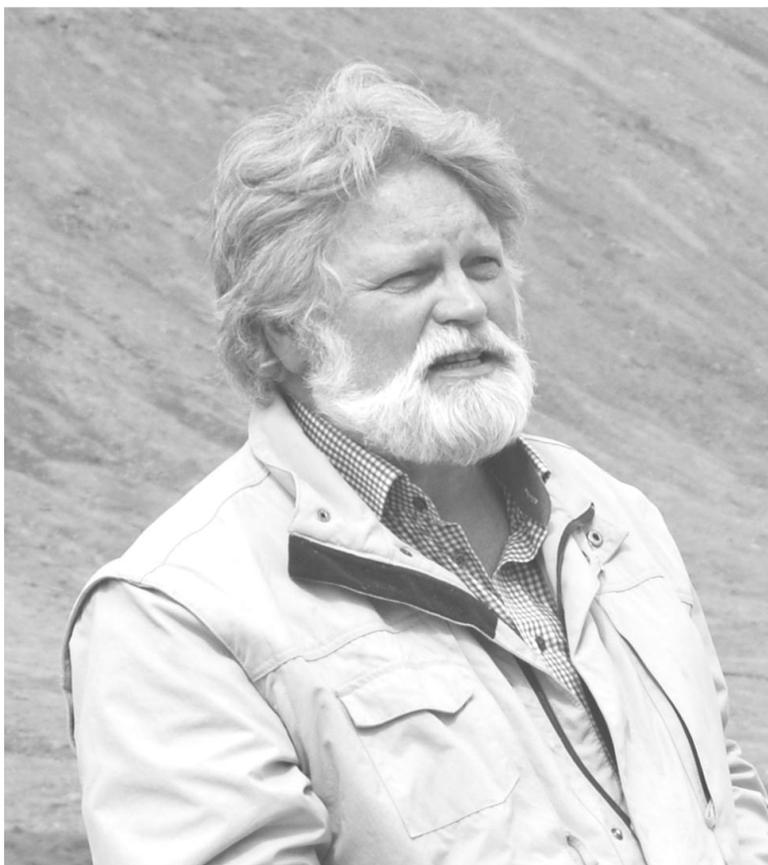
In order to assess these effects, a monitoring program was established in Hornstrandir in 2008 and several dens have been observed monthly every summer since. All activity at the dens is timed and registered, with special attention paid on effects of tourists on frequency and duration of behavioral activities.

Here we present preliminary results from monitoring in 2008 and 2012-13 and suggestions for a code of conduct for tour operators and visitors.

Borgný Katrínardóttir, e-mail borgny@ni.is

Memorial Words

† Páll Hersteinsson (22.3. 1951 – 13.10. 2011)



In the memory of a great scientist

Prof. Pall Hersteinsson passed away, after short but severe illness, at The University Hospital of Iceland on October 13th 2011. The 4th Arctic Fox Conference will be held in his memory.

Pall was a respected and efficient scientist, both in Iceland and worldwide. His studies on the arctic fox since the late 70's have resulted in valuable information on the biology and population ecology of the species in Iceland and worldwide. Pall's work was based on long-term hunting statistics and dissections on carcasses from foxhunters in the past 32 years. This collaboration between hunters and a scientist has gained attention out of Icelandic shores as extremely important and practical.

We have lost an outstanding partner, colleague and friend. We will keep up his spirit and continue studies on the arctic foxes, with global respect to one another's contribution.

By continuing and extending our work we will keep up the memory of late Páll's lifetime work and contribute to the future management conservation planning on the arctic foxes all around the world.

From David

Pall Hersteinsson was my close friend throughout my professional life, and my treasure trove of memories spans 24 hour vigils of Arctic foxes watched from the cliffs of Ofeigsfjurdur to equally long nights with a whisky bottle in Krakow during a somewhat variable conference. However, the memory that stands out in my mind, and is actually the oldest, was the occasion in the mid-Seventies when a knock on my office door in Oxford's Animal Behaviour Research Group, announced Pall's arrival. I was in the final year of writing my doctoral thesis on red foxes, so it was a surprise when this good-looking Icelander with a charming smile announced that he had come to persuade me to supervise his doctorate! My astonishment deepened when he explained that he was older than me, and already advancing through a doctorate in Cambridge, which he proposed to abandon in order to join me. If you sense some measure of impulsiveness behind this story, then you are correct! Pall told me that his doctorate was on the clasp reflex of the *Xenopus* toad, and while clasping each other might excite toads, it did not excite Pall. I had recently made a BBC TV documentary (The Night of the Fox) using, for the first time in broadcast history, infra-red images of animal behaviour at night. Happily the film had enjoyed some acclaim, and propelled me into the role of Finalist for that year's BAFTA Awards. Pall announced that he had seen the film, realised in a Damascus road moment that his destiny lay in trying to do similar work with Arctic foxes, and so there he was, in my office, and determined. Flabbergasted, I told him it was both crazy and impossible, and so we set about making it happen, and it did! So, the long nights spent together in Ofeigsfjurdur, a lifetime of shared obsession with the joys of the Resource Dispersion Hypothesis and the intricacies of fox colour phases and delight in the indigestible trophies in their scats – all tackled by Pall with a level of ingenuity and clarity of thought and intellectual agility that made it obvious that he would soon be a distinguished Professor. Pall always expressed gratitude that I took a risk on him at that first meeting, but that is nothing in comparison to the enormity of the compliment he paid me by trusting that together we could deliver his dream: that trust lives on in my treasure trove of lifetime memories.

David W. Macdonald

From Ester

The summer after my third year I got so lucky to be able to work closely with Páll in a collaborative study of UNI and NAVE. I was hired by Þorleifur Eiríksson to stay along with Páll and Hólmfríður Sigbórsdóttir in Hornstrandir the whole summer of 1998. Hólmfríður and I got to know different sites of our teacher than our class-mates at UNI. He introduced us into the world of the arctic foxes that he knew so well, their behaviour and role in the ecosystem. Hólmfríður and I share a lot of precious memories from that summer. The days that we were out monitoring foxes, the nights in the old house Búðabær where Páll told us everlasting and exciting stories. After two summers of field work with Páll, I helped him around with his lab work, boiling heads and autopsies. When I thought of a graduate project, the arctic fox was my dream but he offered a wood mouse study. I have to admit that I became offended, at least a bit, but now I know how clever it was of him. With the mice we would get a lot of data in an easy and achievable way. Besides, I would get wider experience with field work and data analysis. I remember the first field tours to my study area; he made sure that I would become skilled in micro tagging the tiny mice with the huge pin. One of the most memorable moment was when we were radio collaring the mice. It was probably hilarious to see us together out there, holding the mouse together and stretching the tiny radio collar around its neck. Páll was a great teacher, always giving time for discussions, always creative and open for new ideas, suggesting new solutions. Páll turned out to become more than my teacher and a mentor, he also became a good friend. Losing my father before twenty I guess he became my father image. He certainly backed me up in my personal life as well as professionally, probably without ever realizing it. The humour was always close by; when I had finished a „waterfall“ of the problems of being a teenage girl mom, he looked at me glancing and said: „have you thought of writing a book?“. When Páll asked me to attain a tourism conference in Westfjords in April 2005 in his absence, I didn't hesitate. We worked on the presentation together and in that process, he really allowed himself to brainstorm. This was the introduction of the idea of The Arctic Fox Centre. I'm not sure if either of us realized what this meant for my future. To be short, I went to Westfjords, gave the talk and everyone knows the rest: I now live in Westfjords and the Arctic Fox Centre was opened in June 2010. Páll became the official guardian of the centre and it was amazing to see him give a speech at the opening. Despite my work at the centre, I promised Páll to finish my PhD and he did his best to help me in that process. Páll himself was always working on many things at the same time and was the most efficient and intelligent person I will ever meet.

One would think that a person like him wouldn't have time for family and hobbies. Not Páll, he took really good care of his family and I know that he had some good old friends that he met regularly. He also loved travelling and I still read his blogs, just for fun. Gardening was his joy and he spent many days planting trees at the family's summerhouse. The last years he and Ásta became honey bee farmers. It was awesome to listen to him talk about the honeybees, his eyes glowed and it was obvious that he had found something that he loved taking care of. That was the real Páll, nourishing and taking care of living creatures. Páll was so happy when he became a grandfather and I'm glad that he managed to experience that in his life. I can picture him holding his little granddaughters arms, showing her all the trees he had planted around the summer house. She will live with the memories of her precious moments with him. For her and all the rest of us, the memory of Páll's kindness and great personality will live forever. I consider myself lucky to have been able to get to know him and I will do my best to keep up his memory.

Ester Rut Unnsteinsdóttir

From Westfjords

In the summer of 1998 a year-long collaboration was established between the Westfjords Natural History institute and Pall Hersteinsson, on behalf of The University of Iceland. The first project was a thorough study on arctic fox behaviour in Hornstrandir Nature Reserve, where the arctic fox had been protected by law in 1995. The institutes hired two biology students, Ester Rut Unnsteinsdóttir and Hólmfríður Sigbórsdóttir. Their main job was to monitor two arctic fox dens and record all behavioural activity seen. The pups were "trap trained" so that they would willingly enter traps when they were large enough to carry transmitters for dispersal studies. The next summer, another expedition was conducted to Hornstrandir, this time on the old sailboat Neisti with Captain Guðmundur Jakobsson. That summer was used for visiting all known den sites within Hornstrandir Nature Reserve to see if they were occupied. Jón Oddsson, a former foxhunter of Hornstrandir, was on the boat and explained the locations of the dens, remembering all details and never failed, he was more than 80 years old. After these two summers, several other projects were conducted and friendship was formed between the people involved. Ester Rut kept on working on arctic fox projects in collaboration with both institutes and it was always Pall who was the scientific consultant of the projects. During the summers 2002-2007 an international study was conducted on the arctic foxes in Hornstrandir. This project was a collaboration between Israel (Dr. Eli Geffen), Sweden (Dr. Anders Angerbjorn), Norway (Dr. Eva Fuglei) and Iceland (Dr. Pall Hersteinsson). The major aims of the studies were to estimate the cost of reproduction and the proportional time each parent spent rearing pups and bringing food. Studies on the arctic fox status in the Nature Reserve have continued and others began. Pall leaves a gap in the group that will not be filled up again. His insight and knowledge was amazing and it will be a challenge for the rest of us to continue his important work for over 30 years.

On behalf of The Arctic Fox Centre and the Westfjords Natural History institute, shareholders, staff and board members,

Porleifur Eiríksson

From Daniel

Unfortunately, I did not get the chance to meet Dr. Páll Hersteinsson, but our research has been heavily influenced by his work. More than 20 years ago, by presenting very original ideas that involved the biogeography of arctic and red foxes, the competition between these species, and climate, Dr. Hersteinsson, together with Dr. David Macdonald, framed our research project well in advance. He set a path for us, and defined the angle from which we undertook the study of the expansion of the red fox in the Canadian Arctic. By climbing on his shoulders, we were able to inch forward, and bring forth our own contribution to improve our understanding of this major change in a species' distribution. Dr. Hersteinsson dared to propose new and original ideas. His work reminds us that we really should be doing the same at every opportunity. After all, ideas are like the mainstay that secures our scientific progress. Ideas constitute the material that we work with; we put them to the test to gain new insights. For that, we are especially thankful to Páll, because we, in the scientific community, continue to inherit from his work.

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