European Journal of Wildlife Research (2021) 67: 52
https://doi.org/10.1007/s10344-021-01497-z

ORIGINAL ARTICLE

The context of an emerging predation problem: Nenets reindeer herders and Arctic foxes in Yamal

Alexandra Terekhina[1,2] · Alexander Volkovitskiy[1,2] · Natalia Sokolova[1] · Dorothee Ehrich[3] · Ivan Fufachev[1] · Aleksandr Sokolov[1]

Received: 18 June 2020 / Revised: 9 April 2021 / Accepted: 4 May 2021 / Published online: 12 May 2021

Abstract

Human-wildlife problems often arise when predators kill livestock. This can develop into serious conflicts between traditional pastoralists and other stakeholders, such as government officials and conservationists. In the Yamal Peninsula (Russia), nearly half of the indigenous Nenets people are reindeer herders. They have recently faced many challenges, such as high mortality of reindeer from pasture icing or disease outbreaks. In addition, predation of arctic fox on reindeer calves is perceived as an increasing problem. Here, we use an interdisciplinary approach to study this emerging predation problem. We present here results from semi-structured interviews with indigenous people, as well as from biological monitoring of fox populations. Our field data were obtained in Erkuta, in the south of Yamal and in Sabetta in the north, close to a newly built industrial settlement. We show how different factors may have come together to create a problematic situation. These factors include the abandonment of the fur trade in the 1990s, the building of huge industrial facilities providing possible resource subsidies and the increasing frequency of abnormal weather events leading to weak reindeer, high reindeer mortality and abundant carcasses as resources for predators. We discuss how each of these factors affects the abundance of predators as well as the understanding of the herders.

Keywords Human-wildlife conflict · Arctic fox · Reindeer herding · Arctic · Yamal · Nenets

✉ Alexandra Terekhina
terekhina.yamal@gmail.com

Alexander Volkovitskiy
vlk73@mail.ru

Natalia Sokolova
nasokolova@yandex.ru

Dorothee Ehrich
dorothee.ehrich@uit.no

Ivan Fufachev
fufa4ew@yandex.ru

Aleksandr Sokolov
sokhol@yandex.ru

[1] Arctic Research Station of Institute of Plant and Animal Ecology, Ural Branch, Russian Academy of Sciences, Zelenaya Gorka Str., 21, 629400 Labytnangi, Russia

[2] Centre of Arctic and Siberian Exploration Sociological Institute of the Federal Center of Theoretical and Applied Sociology RAS, St. Petersburg, Russia

[3] Department of Arctic and Marine Biology, UiT, The Arctic University of Norway, 9037 Tromsø, Norway

Introduction

Situations where wild animals cause problems for human activities have been studied as human-wildlife conflicts (HWC; e.g. Graham et al. 2005) in a wide range of cases: from depredation of livestock, for example, by leopards (*Panthera pardus*) or by wolves (*Canis lupus*; Mabille et al. 2015; Jamtsho and Katel 2019) to devastation of fish farms by fish-owls (*Ketupa flavipes*; Sun et al. 2004) and crop damage caused by rabbits (*Oryctolagus cuniculus*; Delibes-Mateos et al. 2014). Most of the HWC studies focus, however, on livestock predation by large carnivores and their economic impact on pastoralists (Lozano et al. 2019). These conflicts are often exacerbated by the fact that the predators involved are endangered and protected by law, while people continue to kill them for economic reasons, security or following traditions (Graham et al. 2005; Pooley et al. 2017). As pointed out by Redpath et al. (2015), the term wildlife coexistence problem is more appropriate to describe these situations. Coexistence problems consist of two different processes: the damage for humans and their

livestock caused by wildlife and the conflict between different human interests. As a rule, the ultimate cause of damage is the competition between humans and animals for limited resources, land in particular (Fernando et al. 2012). Conflict is a social concept that arises because several stakeholders view management options to deal with wildlife damage differently (Redpath et al. 2013). These stakeholders include pastoralists, conservationists, scientists, managers and decision makers at different levels. Each stakeholder is often inclined to pursue its own goals and avoid dialogue (White and Ward 2010). Depending on the socioeconomic situation of a country, various measures are taken to dampen HWC, such as compensatory payments for killed livestock, relocation of aggressive animal individuals, control of predator abundance, as well as changes in local environmental management regimes (Pedersen et al. 1999; Bangs and Shivik 2001; Mukesh et al. 2015).

Given this dual nature of problematic situations involving predators and livestock, interdisciplinary studies involving social scientists and ecologists are required to provide the knowledge needed to find constructive solutions and prevent conflicts from escalating (Aryal et al. 2014; Tveraa et al. 2014). Here, we present such an interdisciplinary study of arctic fox (*Vulpes lagopus*) predation on calves of domestic reindeer (*Rangifer tarandus*) on the Yamal Peninsula (located in the Yamalo-Nenets Autonomous Okrug (YNAO) of the Russian Arctic; Fig. 1). YNAO reindeer herding is unique in that nearly 18,000 people in indigenous communities, mostly Nenets, maintain a nomadic life in the tundra. Herders still perform year-round migrations as families together with their herds (family nomadism). More than 80% of the ca. 225,000 reindeer on the Yamal Peninsula belong to independent "private" households, whereas the remainder belong to municipal reindeer herding enterprises. Reindeer herding is the main source of livelihood for the Yamal nomads (Stammler 2005; Golovnev and Oscherenko 1999).

The Yamal reindeer herders have faced serious challenges in the 2010s (Volkovitskiy and Terekhina 2020). In the winter 2013–2014, heavy rain in November followed by strong frost formed a thick ice crust that blocked the pastures and caused the loss of thousands of reindeer that were unable to forage (Forbes et al. 2016; Sokolov et al. 2016). In summer 2016, an outbreak of anthrax not only killed many animals (Hueffer et al. 2020), but triggered controversial debates on a Nenets herding "crisis" revealing the concepts of overgrowth of herds and overgrazing (Golovnev 2017). These events are exacerbated by the lack of lichen winter pastures, critical for reindeer. Moreover, in the past few decades, industrial development has expanded significantly and reduced the area available for reindeer grazing (about 80% of Russian gas reserves are concentrated in YNAO), complicating the life of nomadic families (Kumpula et al. 2010).

Until the 1990s, the most dangerous predators for reindeer in Yamal were wolves. According to the indigenous people, wolves had almost disappeared from the Yamal Peninsula

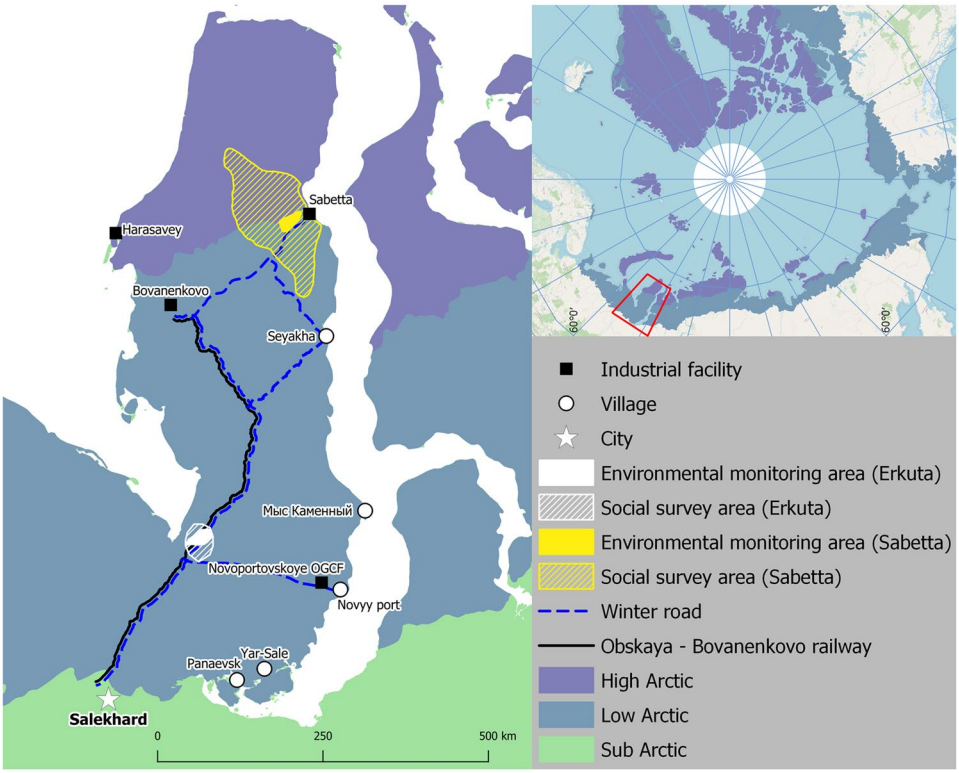

Fig. 1 Map showing the location of monitoring sites: white corresponds to the Erkuta research station, yellow corresponds to the Sabetta research station. Violet, blue and green indicate the delimitations of bioclimatic subzones. The high Arctic, low Arctic and Subarctic are drawn according to Walker et al. (2005). The infrastructure of YNAO is represented by settlements (white star is the capital of the YNAO, white circle-village, black square-industrial facility, black line-railway, dotted blue line-winter road)

by the end of the 1990s. This is because of the introduction of snowmobiles to Yamal at that time, which allowed herders to decimate predators unable to hide in the open tundra landscape, particularly given almost no restrictions on wolf hunting in Russia. In addition to wolves, reindeer calves can be attacked by wolverines (*Gulo gulo*), white-tailed eagles (*Haliaeetus albicilla*), golden eagles (*Aquila chrysaetos*), ravens (*Corvus corax*) and red foxes (*Vulpes vulpes*) in the south of the peninsula (Mukhachev and Salatkin 2008).

The Arctic fox is a common and widespread small predator in most of the Arctic (Berteaux et al. 2017) and one of the most common mammalian predators in Yamal. Throughout much of its range, the availability of small rodent prey, particularly cyclical lemming populations, is the main driver of arctic fox dynamics, and reproduction follows the rodent cycle (Elton 1924; Shtro 2009). Despite their preference for lemmings, arctic foxes can utilize a wide range of food resources such as birds and eggs (Lamarre et al. 2017; McKinnon et al. 2013), carcasses of ungulates (Eide et al. 2012; Ehrich et al. 2017) and marine resources (Nevai and van Gorder 2012). Moreover, they can quickly adapt to live close to humans and can subsidize their diets with human food refuse (Golovatin and Sokolov 2017; Savory et al. 2014).

The fur trade, for which the arctic fox was the main resource, has historically played a significant role for the tundra people and the development of the indigenous culture in Yamal. During the Tsarist colonial period, Nenets paid obligatory taxes in arctic fox pelts. In the Soviet times, many brigades of hunters were established on the Yamal Peninsula, and large-scale hunting of arctic foxes continued (Supplementary 1). After the collapse of the USSR in the 1990s, changes in the global fur market led to the cessation of large-scale fur hunting on Yamal. At present, the indigenous people only hunt arctic foxes for pelts to decorate traditional clothes.

While arctic foxes have been a valued resource for centuries, to the best of our knowledge, the only case where damage from arctic fox predation is considered a problem comes from Iceland. There the species has historically been viewed as a pest, predating on lambs and destroying nests of eiders; and a state-organized culling program has been in place since the middle ages (Hersteinsson et al. 1989). Arctic foxes have been reported to predate on reindeer calves on occasion in the Russian North (Skalon 1940; Sdobdikov 1935; Geptner et al. 1967), but they have been thought to scavenge mainly on reindeer carcasses and not to cause substantive economic damage to reindeer herding (Sdobnikov 1935: 22). In the area of Sámi reindeer herding in Fennoscandia, the population of arctic fox is extremely small, and no damage on reindeer has been recorded (Tveraa et al. 2003; Angerbjörn et al. 2013). In Yamal, however, predation of arctic foxes on reindeer calves has recently been perceived as a real problem by herders. Working among Nenets since 2008, we have observed growing tensions in different areas of Yamal and heard herders reporting massive attacks of these predators in the last 3 years. We started to pay special attention to the "arctic fox case" after reading an official letter sent to the Government of YNAO by the board of the Yamalskoye municipal reindeer herding enterprise after the calving period in 2018. The letter reported unprecedented predation of arctic foxes during calving in 2017–2018 in the northern part of the peninsula causing great damage to herds. The board argued for regulation of the population of these predators. Thus, the letter had formally stated the arctic fox predation as a problem.

Here, we aim to describe the context of an emerging predation problem. We take an interdisciplinary approach combining investigations of the context and understanding of the problem among reindeer herders carried out by social anthropologists with data about arctic fox populations resulting from ecological monitoring. Interviews with herders were used to obtain estimates of the importance of the problem. We also asked herders for their opinions on the causes of this increased predation and their perceptions of trends in arctic fox population size, as well as fox hunting activity levels. From an ecological point of view, increased predation may result from an increase in the predator population and/or from a change in resource use by predators. We assessed trends in arctic fox abundance (breeding density) as well as the dynamics of their most important resource, small rodents, in order to assess whether population growth could have caused increased predation on a new type of prey, or whether changes in the relationship between foxes and small rodents indicate use of new resources.

Methods

Study area and local population

This study was carried out in two areas located near the Erkuta and Sabetta field stations on the Yamal Peninsula (Fig. 1; hereafter Erkuta and Sabetta). Erkuta is located in the low Arctic tundra, in the lower reaches of the Yorkuta-Yakha river (68.2°N, 69.2°E). Local private reindeer herders (19 households with ca. 2000 reindeer in total) spend the winter and the calving period in a radius of 50 km from the research station, and in summer, some households gather all their reindeer and migrate westwards along the coast of the Baydaratskaya Bay to summer pastures. Others do not migrate, but stay for fishing in non-migrating *chums* (Nenets nomadic tents).

Sabetta (71.2°N, 71.5°E) is located in the northeastern part of the Yamal Peninsula on the border between the low and high Arctic. The station is adjacent to the Sabetta

industrial workers' settlement, sea port and liquid natural gas plant ("Yamal LNG" project). Approximately 50 households with a total of 8500 reindeer reside in the area radiating 100 km around the research station and migrate in different directions during the summer. Reindeer herders of northern Yamal have rather short circular migratory routes, uniting several households in summer. Arctic foxes are the most common mammalian predator in both study areas, and their primary prey are several species of small rodents including voles (*Microtus gregalis* and *M. middendorffii*) and lemmings (*Dicrostonyx torquatus* and *Lemmus sibiricus*) (Shtro 2009; Ehrich et al. 2017). Regarding other potential predators of reindeer calves, in Erkuta, red foxes and wolverines occur at low densities (Sokolov et al. 2016), and wolverines have also been observed in Sabetta. As mentioned above, wolves are currently nearly absent from the peninsula.

Interviews

The anthropological part of this research was designed as a qualitative study of the range of explanatory models of Nenets referring to their interactions with arctic foxes. The questions related to arctic foxes were a section of a broader survey that included topics such as climate change, observations of different animal species and the problems reindeer herders face in Yamal (Table 1). The interviews were conducted by two social anthropologists together (male and female) at both research sites: in Erkuta in March and June 2019 and in Sabetta in July–August 2019. All interviews were carried out in an informal setting, in the nomadic camps, as is preferable for Nenets. Given the logistical challenges, we were able to reach and interview 13 households in Erkuta (out of 19; the remaining families live in the southern part of the area, further away from the field station) and 32 in Sabetta (out of 50). All people we asked, and who were not busy with urgent work, accepted to take part in the survey.

Based on our long-term experience of ethnographic research of Yamal reindeer herders (Terekhina 2018; Terekhina and Volkovitskiy 2019; Volkovitskiy and Terekhina 2020), we chose a household (large family) as a survey unit. There is a clear gender division of responsibilities in the Nenets culture. Managing reindeer, guarding herds and other work with the animals are carried out by men; therefore, they may a priori be more aware of interactions with arctic foxes. However, in most cases, the interview was conducted in a chum in the presence of several family members (a couple, their children and other relatives living together) who answered alternately or in complement to each other. The age of the herders who answered the questions ranged from 23 to 72 years, and in a third of the households, three generations were represented (elderly people, middle-aged people and youngsters). In all cases, the groups reached consensus on the answers.

We used semi-structured interviews, a common method in social studies (Schensul and LeCompte 2013; Adams 2015). The researchers had a basic list of questions, but we talked with the herders following the flow of the discussion but making sure we covered all topics on the list. The order of the topics could thus vary in the course of the conversation, and we changed the wording if something was not clear to the informant. In such interviews, answers are given in a free and extensive form, which often leads to additional clarifying questions from the interviewer. The interview was conducted in Russian and in Nenets by two researchers together for better communication and quick recording of answers. All responses were written down in field diaries. In some cases, when the informants gave their consent, we recorded the answers with a digital recorder and transcribed them later. However, we did not rely on mandatory digital recording, since in our experience of fieldwork in Yamal, indicates that nomads may change their answers when they are recorded, considering social studies as part of State policy and control.

The answers to the questions about hunting depended on the degree of trust of the informants to the anthropologists and are presented here on condition of anonymity. There are indeed technical difficulties for many reindeer herders living far from villages to obtain and/or to renew firearms licenses, and thus some people have unregistered arms. The last question is not directly related to arctic fox predation on

Table 1 The list of questions that was developed by anthropologists and ecologists together, and formed the basis for the interviews. The questions were not asked in a given order

Questions
Do you think that the arctic fox population has increased, decreased or remained unchanged? Why do you think that this is happening?
Do arctic foxes attack calves and adult reindeer? Please, give examples
What percentage of calves in your herd are on average lost to arctic foxes?
How do you solve this predation problem? Did it exist earlier, and what did people do in such cases at that time?
How many arctic foxes have you hunted this year? How many have you hunted last year? If you don't hunt arctic foxes, why not?
How are arctic fox pelts used at present?
Have there been serious cases of reindeer losses (mortality) in your area during the last five years? If yes, when and what caused them?

reindeer. However, the information about reindeer mortality provided data regarding resource subsidies for predators (reindeer carcasses), potentially affecting their survival rate and abundance, and information about the recent development of the herd of the respondent.

The data obtained from the interviews were summarized, applying a thematic analysis based on coding (Braun and Clarke 2006). In each research area, qualitatively similar answers were grouped and their frequency was used to identify prevailing opinions.

Den survey

The ecological part of this research was based on den surveys, which constitute a standard method of monitoring arctic fox populations (Angerbjörn et al. 1995; Berteaux et al. 2017). We carried out annual den surveys in both study areas. In Erkuta, dens were monitored from 2007 to 2019 and the study area was gradually increased from 130 km^2 in 2007 to ca. 230 km^2 from 2015 to 2019. In Sabetta, we surveyed dens from 2014 to 2019 and the study area covered 130 km^2 in 2014 and ca. 170 km^2 in 2015–2019. We searched the study areas for dens and described all dens found. As far as possible, all known dens were visited each year between late-June and mid-July and inspected for breeding activity as described in Ehrich et al. (2017). A den was considered occupied when pups were seen, clearly heard or documented on an automatic camera with motion sensor. Because small rodents are the main driver of arctic fox populations in Yamal, small rodent populations were monitored by snap trapping on permanent plots in both study areas. For Erkuta, the trapping protocol is described in Ehrich et al. (2017). In Sabetta, a similar protocol was used (Supplementary 2).

Data from den surveys was summarized as the proportion of visited dens where breeding activity was detected. We tested for a temporal trend in the proportion of occupied dens with generalized linear mixed models (GLMM; using the function glmmTMB in R, R Core Team 2020) with the state of the den (breeding/non breeding) as a response variable, and a binomial error distribution. We restricted the analysis to dens that had been used for breeding at least once during the study period. In addition to year, we used small rodent abundance as a co-variable. An abundance index was estimated as the total number of small rodents (all species pooled) trapped in the first part of the summer per 100 trap nights. To compare the two study areas, we tested for a difference in density of breeding dens (number of breeding events per 100 km^2) using a *t* test.

As an indication of long-term population trends, we compared the density of all potential breeding dens present in the two study areas (dens with 4 entrances or more; Ehrich et al. 2017; with or without foxes present) to published historical data (Tsetsevinskiy 1940; Sosin et al. 1985; Shtro 2009). In the sandy landscape of Yamal, which is underlain by permafrost, arctic fox dens degrade in the course of a decade or two if they are not used. On the other hand, it is quite easy for foxes to dig new dens; therefore, it is likely that pronounced long-term changes in population size would change the density of dens in an area. Den densities were compared for the exact plots which had been visited in the past, as well as for the larger recent monitoring areas.

Results

Arctic fox predation on reindeer calves

All the households stated that arctic foxes have always hunted newborn calves on occasion. However, Erkuta and Sabetta Nenets identified 2017 as the onset of noticeably higher frequencies of arctic fox attacks on calves (the respondents mentioned this specific year or referred to "2–3 years ago"). All 32 households of Sabetta and 11 out of 13 households of Erkuta reported that arctic foxes were now hunting calves actively. The herders often started talking about arctic foxes themselves, even before we asked our questions: "*Arctic foxes have become shameless. They attack the calves*", "*Once they killed 20 calves. They attack in the dark*", "*We've pulled calves' legs out of the arctic fox's den*".

There are no valid statistics reflecting the losses during calving in privately owned herds; however, the herders are aware of the dynamics of their herd and can estimate the damage caused by predation. Sabetta herders perceived this predation problem more sharply and claimed that losses from arctic foxes amount to 10–30% of all offspring: "*From 100 females arctic foxes can eat one third of calves*", "*Last year the foxes attacked a lot. They are waiting for a blizzard and attack. Last year we had 30 calves together with our neighbours – only 10 of them survived*", "*Arctic fox steal calves. One third of the offspring in one season can be killed*". At the same time, most Nenets from Erkuta found it more difficult to estimate the losses of calves, and only four of the households included in the survey provided estimates, which amounted to ca. 10%.

Experienced herders noted that arctic foxes usually attacked at dusk or during blizzards, avoiding guards. The predators were rarely detected near a large herd because of their small size and white colour; moreover, reindeer do not react to their presence, as they reacted to wolves in the past. Sabetta reindeer herders revealed a narrative referring to collective hunting: "*They attack in groups: two of them distract the female, while the third pulls away the calf*", "*When the mother goes away to feed, they attack several together*". Nenets reported observations of 2–4 animals hunting together, some predators distracting the female reindeer,

while the others grabbed the calf. They claimed that calves born away from a herd become easy prey. During the process of birth, a female reindeer generally remains defenseless against predators: "*3–4 foxes wait until the female reindeer gives birth. Before the calf is completely born, the foxes start to bite it. The herder has to pull out the dead calf, which was bitten to death*".

The herders tried to take additional measures to protect the reindeer from predators during calving. They guarded the herd 24 h a day and constantly repelled arctic fox advances, circling the herd on a snowmobile, using scarecrows, and shooting approaching foxes. We were told that up to 50 arctic foxes could be killed while gathering around a calving herd (Sabetta). Rabies was mentioned as an additional problem related to arctic foxes by all our informants in both study areas. Nenets claimed that the increasing population of foxes in recent years has resulted in a larger number of attacks of rabid animals on reindeer as well as an increased number of cases among the herders' dogs. Herders as a rule terminate sick animals.

Drivers of arctic fox population trends: understanding of Nenets herders

Reindeer herders associated the increased frequency of attacks with an increased abundance of arctic foxes (Supplementary 3). All 32 households from Sabetta believed that in the last few years (the periods mentioned varied: 5, 10 years, "since the end of 90 s"), the arctic fox population had increased. Their estimations ranged from "*there have become more*" to "*a lot more*". About three-quarters of the Erkuta Nenets (8 out of 13) shared this view, but we also received opposite statements. Two households claimed that the number of arctic foxes had decreased; one said that the number had not changed, and two found it difficult to give an exact answer.

Regarding the causes of arctic fox population changes, most people who spoke about an increase associated it with the decline of fur hunting in Yamal in the 1990s: "*Previously, we specifically hunted them, 20–30 people gathered together, now they are needed only for collars*", "*It happened when we stopped hunting them, so there have been a lot of them. 18–20 cubs might be in a den*", "*There are lots of them, because nobody buys the furs anymore*". About a third of all the interviewed reindeer herders in both areas worked as hunters in the past; and they recalled their experience and observations from previous years. Since the 1990s, for the first time in several centuries, arctic foxes have become harvested only for the personal needs of the indigenous people, i.e. pelts for sewing traditional clothing. Pelts are used for edging of Nenets women's outerwear collars, winter hats and men's hoods. According to the informants' estimates and our assessment, based on years of personal experience living with nomadic Nenets, an average tundra family requires 2–4 winter pelts every 3 years for sewing.

Five households from the Sabetta area directly linked the increase of arctic fox abundance with the development of the large industrial settlement and the roads leading to it. They said that the rapid appearance of large numbers of workers has increased the amount of food waste available to scavengers: "*There are cabins for workers along the winter road where cars stop. Drivers eat there and throw away leftovers. Arctic foxes are not afraid of cars and people*". Despite strict requirements and compliance with international standards for the storage and disposal of garbage by Yamal LNG, many videos and photos can be found on the Internet showing shift workers feeding arctic foxes, and the animals themselves wandering around the facilities: "*The workers themselves feed them*". According to the Nenets, arctic foxes concentrate in large numbers near Sabetta from November to April, then move to the reindeer herds to hunt calves or scavenge dead ones while reindeer are calving in May.

One household in Erkuta stated that the abundance of arctic foxes has increased because of high winter mortality of reindeer and availability of carcasses in recent years. Another answer suggested that a decrease of the arctic fox population may be related to a decrease in lemming abundance. This opinion was expressed by a family whose main activity was fur hunting in the Erkuta region for many years in the past. However, this understanding may have resulted from communication and friendship with neighbouring biologists who were doing research on the impact of changing lemming dynamics on arctic predators. Five out of 13 households in Erkuta and 6 out of 32 households in Sabetta found it difficult to explain the reasons for changes in arctic fox abundance.

Recent cases of reindeer losses

Our informants in Erkuta and Sabetta described several cases of reindeer mortality in recent years (Supplementary 4). The herds in Sabetta were not harmed in 2013–2014 since there was no ice crust in the North of the peninsula. After the 2016 anthrax outbreak, a compulsory anti-anthrax vaccination was carried out in YNAO. The Sabetta herders argued that after this campaign, a large number of their reindeer died in autumn 2016 reacting to a "*wrong*" vaccine or to an "*incorrect*" method of vaccination. At the same time, our informants claimed that "*the calves born in 2017 and 2018* [that were not killed by arctic foxes] *had not survived*" and pregnant females had more miscarriages because reindeer were "*weak after the vaccine*". In 2018, the regional media reported that the local loss of 1000 reindeer caused by spring icing and lack of forage occurred in the north of Yamal, near the Sabetta area. Our interviews indicated that the scale of reindeer mortality in 2018 was underestimated.

Losses of reindeer occurred throughout the entire Yamal Peninsula, and many of the Nenets households are still affected by consequences of the disaster. Unlike in 2013, the ice in 2018 had appeared in the early spring and impacted both animals weakened by the winter and newborn calves. In Sabetta, local icing events also caused reindeer losses in late winter 2019. Some of the herders from Sabetta estimated their losses during the last decade as 20–50% of their herds and these figures (ca. 30% of losses) coincided with losses reported by herders from Erkuta.

Trends in the arctic fox breeding activity

Data from the den surveys show overall higher annual densities of dens with breeding in Sabetta (mean and standard deviation 5.8 ± 3.0 dens per 100 km^2) than in Erkuta (2.3 ± 1.7; t test: $t = 2.68$, $p = 0.03$). In both sites, there was considerable interannual variation in breeding activity. Over the 6 years of den survey in Sabetta, there was a close to significant trend of increase in the proportion of occupied dens when taking into account small rodent abundance (estimate on the logit scale 0.46, 95% confidence interval CI = −0.01–0.84, $p = 0.06$; Fig. 2; Supplementary 2). Not including small rodents into the model, there was no indication for an increase in the proportion of occupied dens (effect of time −0.16, CI = −0.38–0.07, $p = 0.17$). In Erkuta, during 13 years of den survey, there was no temporal trend in the proportion of dens with breeding foxes (−0.04, CI = −0.13–0.05, $p = 0.37$; Supplementary 5). There was a positive effect of small rodent abundance in Sabetta, but not in Erkuta.

Comparisons with historical data revealed a slight increase in the density of arctic fox dens excavated in both areas (Table 2; all dens with more than four entrances, both with and without foxes present in a particular year). In Sabetta, this was the case for the plot that had been visited in 1980, wherein two dens disappeared and three new dens were found in present time. For the larger study area, density was slightly lower, reflecting more varied habitat including more of the less productive tundra areas outside of the river valley. In Erkuta, an increase was observed independently of the part of the study area considered. However, for both study areas, the recent estimates resulted from many years of field work, whereas the old estimates were obtained during 1–2 seasons.

Discussion

The social part of the study revealed that the majority of Nenets households report an increase of arctic foxes predation on reindeer calves in recent years and express serious concern. These data are in agreement with information we obtained from herders in other parts of Yamal while working with other projects. The reindeer herders of Sabetta estimated the damage from predation at 10–30% of newborn calves. The Erkuta Nenets who provided an estimate assessed their losses at ~ 10%. Sabetta herders described in detail the hunting behaviour of arctic foxes, which they observed while guarding the herds. All the interviewed households in Sabetta and two-thirds of those in Erkuta attributed the increased predation to an increase in the arctic fox population, which they had observed. Most Nenets consider the cessation of large-scale fur hunting since the 1990s as a main reason for the increase of the arctic fox population.

However, interview data from our two field sites revealed that respondents perceived arctic fox predation and dynamics a little differently in the two areas. Around Sabetta,

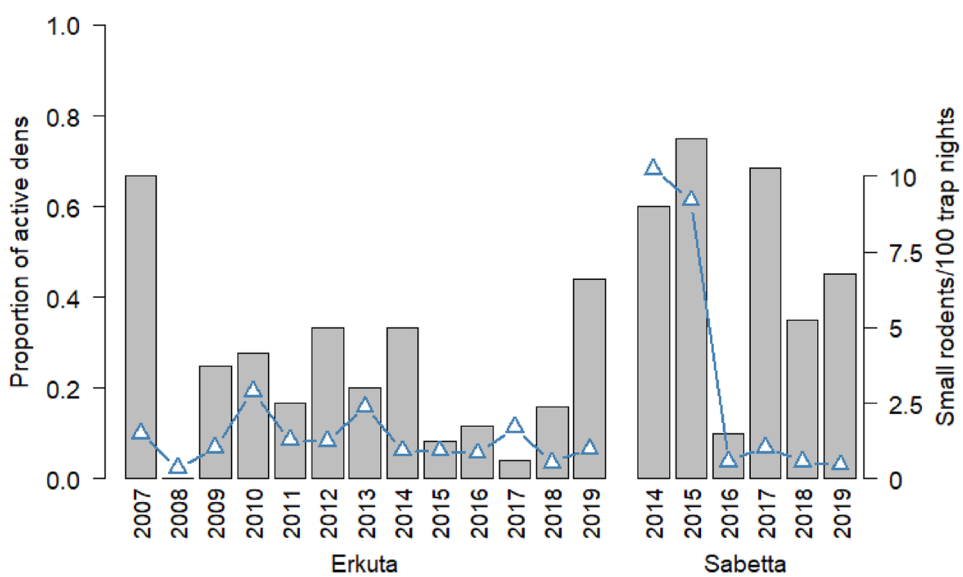

Fig. 2 Proportion of arctic fox dens with breeding activity (grey bars) among all visited dens, in which breeding has been recorded at least once during the study period, in the two study areas Erkuta and Sabetta on Yamal. Proportions were estimated based on 263 visits of 26 dens in Erkuta and 114 visits of 20 dens in Sabetta. Triangles show the total number of small rodents trapped per 100 trap nights in early summer

Table 2 Density of arctic fox dens in different time periods. Venuyeuoyakha is located 50 km from Sabetta. For Erkuta and Sabetta, densities were compared exactly on the plots surveyed in the past, as well as in the larger present day study areas

Survey years	Area km^2	Study area	Dens per 100 km^2	Source
1933–1934	Not reported	Venuyeuoyakha	13.3	Tsetsevinskiy (1940)
1980	55	Sabetta	16	Sosin et al. (1985)
2014–2019	55	Sabetta	18	Present study
2014–2019	169	Sabetta	14.2	Present study
1989	72	Erkuta	13.9	Report of IPAE (1990)
2007–2019	72	Erkuta	18	Present study
2007–2019	234	Erkuta	18.7	Present study

herders unanimously reported an increase of predation and of the arctic fox population, whereas the opinion of people at Erkuta varied. Observations of the herders agreed with the monitoring data, which revealed almost two fold higher densities of breeding arctic foxes around Sabetta compared to Erkuta, and thus indicated higher abundance. This contrast in perception of the problem may, however, also be related to different social and economic situations in the areas. Half of the households in Erkuta live separately from their herds, transferring their reindeer to migrating neighbours. Thus they did not see their herds for many months, including the calving period. In this regard, the owners were unable to estimate the number of lost calves from predation, since calves have also died from weather events in recent years. This also explains why Erkuta Nenets could not describe in detail the behaviour of arctic foxes hunting calves.

The monitoring data on breeding dens did not provide evidence for a recent increase in abundance of reproducing arctic foxes. The data from the den surveys in both areas spanned the onset of the perceived massive attacks on calves, but no increase in absolute breeding activity was detected; although in Sabetta, more foxes bred recently than expected given small rodent dynamics. On a longer time scale, we used the density of potential breeding dens excavated in the study area (including dens with or without foxes present in the particular year of survey) as a proxy for abundance to compare our data with historical data from the literature. In both study areas, more dens were found today than recorded in the past. More excavated dens might indicate higher fox densities in the area. It is, however, also likely that more dens were found in the study areas in the recent period because we spent more time searching for dens during multiannual monitoring compared to the short time historical studies.

Results presented here can be considered in terms of three lines of thought (Fig. 3).

1. *State and drivers of the arctic fox population*. Following the reindeer herders perception, arctic foxes attack calves more frequently due to the increase in arctic fox population size. The monitoring of dens did not suggest an increase in the breeding population. However, not all arctic foxes breed every year, and there may be a considerable number of young non-breeding individuals, which would not be included in our estimate. The perception of the herders reflects their observations during the whole year, in particular the calving period in May, and on a larger area than the monitoring plots. It is thus complementary to the information obtained from ecological monitoring in summer. Arctic foxes are very mobile animals, and migration may lead to different local dynamics in different seasons (Shtro 2009). For Sabetta, where the fox population increase was greater and fox attacks on reindeer were perceived as more serious, it is possible that the industrial settlement attracted foxes in winter, and led to higher fox densities in the larger area surrounding it also during the calving period in May. Expansion of the network of research sites using harmonized field protocols would certainly provide more information for understanding the ongoing processes (Berteaux et al. 2017).

From the Nenets point of view, the main reason for the perceived growth of the arctic fox population is the reduction of the fur trade during the 1980s and its cessation during the 1990s. Data from other parts of the Arctic do not reveal a uniform correlation between hunting and population trends in arctic foxes. Berteaux et al. (2017) reported trends for all monitored arctic fox populations, and the only population that was naturally increasing was that from Iceland, which was intensively hunted during the increase period (Carbonell Ellgutter et al. 2020). None of the monitored populations in North America showed increasing trends, despite reductions in hunting pressure there as well. However, monitoring focused usually on den surveys and thus on the breeding part of the population, and spanned rather short time periods. An increase in the abundance of non-breeding foxes or a potential slow long-term trend might thus have remained undetected.

Resource availability is a major driver of arctic fox dynamics. Thus, the long increase periods of the Icelandic population have been attributed to increasing prey populations (Pálsson et al. 2016; Carbonell Ellgutter et al. 2020). In Yamal, the main prey for arctic foxes are small rodents, in particular lemmings (Shtro 2009). In recent decades, however, the characteristic lemming peaks have been absent from the southern part of Yamal (Fufachev et al. 2019). The

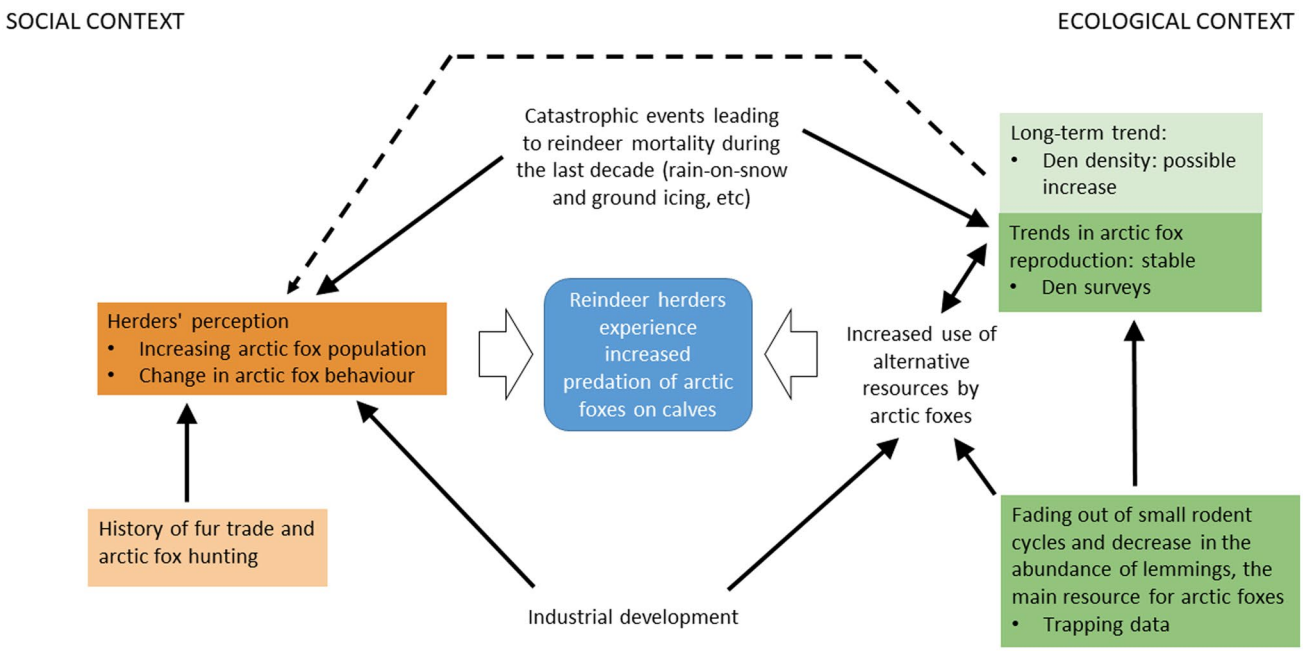

Fig. 3 Conceptual diagram illustrating the context of the arctic fox predation problem on reindeer calves in Yamal. The studied phenomenon (blue) is in the centre. Its components on both sides: social context (orange and light orange) and ecological context (green and light green). Additional factors that are taken into account in discussion of the results are not highlighted

breeding activity of arctic foxes in Erkuta is at present not significantly correlated to the small rodent abundance index, but responds both to vole density and to the availability of reindeer carcasses (Ehrich et al. 2017). Whereas an absence of lemming peaks would predict a decrease in arctic fox abundance (e.g. Ims et al. 2017), the increased availability of reindeer carcasses due to a series of catastrophic events during the last decade, which were reported in detail by our respondents (Supplementary 4), may represent a new resource that supports foxes during the harsh winter months. Indeed, reindeer carcasses have supported population growth of red foxes in northern Norway (Killengreen et al. 2011).

In Sabetta, anthropogenic subsidies from the workers' settlement may provide additional resources to the local population of arctic foxes, as has been described in Alaska (Lehner 2012). The high proportion of reproductive dens despite low small rodent abundance observed during recent years (and nearly significant increase when taking into account the small rodent numbers) suggest that foxes benefit from resource subsidies (Fig. 2). In general, a significant increase in human presence in the Yamal tundra was recorded in the past decade. Since 2010, several Russian flagship gas and oil industry projects have been launched. This has resulted in a large number of workers spread over the peninsula in dozens of industry settlements, permanent settlements, trade points and rail road stations. Supplies for all these workers are delivered by trucks on seasonal winter roads, the drivers of which live in their trucks for several days or weeks and also contribute to food waste.

In addition to industrial infrastructure, food subsidies for arctic foxes resulting from traditional land use activities, reindeer herding and fishing, may also have increased. Indeed, four large slaughter houses were built on the peninsula in the last decade, creating seasonal sources of huge amounts of slaughtering waste. Altogether, this increased resource availability may have resulted in higher winter survival of arctic foxes and could have contributed to a regional population increase. Supplemental feeding has indeed been shown to have a positive effect on arctic fox population productivity in Angerbjörn et al. (2013).

2. *Changes in arctic fox behaviour*. Another explanation for the frequent attacks on reindeer calves in recent years could be a functional response of arctic foxes to the changes in small rodent dynamics and community composition. Arctic foxes are indeed known to use a variety of alternative prey such as geese, waders, and marine resources when the lemming population is low (Bêty et al. 2002; Tarroux et al. 2012). In Svalbard, they are known to prey on new-born seal pups on the sea ice (Smith 1976). It is thus possible that in Yamal, they predate increasingly on reindeer calves as an alternative to the declining small rodent populations. Both in Sabetta and in Erkuta, the period of increased attention to the predation problem coincides with several years of low small rodent abundance. In Erkuta, however, the changes in small rodent dynamics already occurred 15 years ago (Fufachev et al. 2019); thus, an increase in damage on calves could have occurred earlier than in Sabetta. Moreover, it is possible that certain arctic foxes specialise on hunting

reindeer calves, maybe because of a bolder personality (Choi et al. 2019), something which may be supported by observations of the herders and could warrant further investigation. The development of such behaviour could have been facilitated by the poor condition of some reindeer after adverse winters and the birth of weak calves, which could provide easy prey for foxes.

The changes in arctic fox behaviour observed by the herders in Sabetta (foxes are bolder and hunt in groups) might be related to their use of anthropogenic resources in the settlement in winter. Indeed, when foraging at trash dumps or large amounts of slaughtering remains, arctic foxes can occur in groups of up to 10–20 animals. From their experience in the settlement, some of them may also lose to a certain degree their fear of humans.

3. *Perception of the reindeer herders*. Finally, it is possible that the frequency of dramatic events (both climatic and disease-related) together with a decreasing capacity of winter pastures, which all led to massive reindeer mortality (Bartsch et al. 2010; Forbes et al. 2016; Sokolov et al. 2016; Golovnev 2017), made the herders' perception of reindeer losses particularly sensitive (Perevalova 2015). Thus, their assessment of the scale of the problem of arctic fox attacks could be overestimated, as we know from other studies (e.g. Sun et al. 2004). In this case, we would witness a social phenomenon consisting of the appearance of a similar perception of danger by tundra inhabitants living at great distances from each other. Identifying the causes of the appearance of such similar impressions would warrant further specific social investigations.

To obtain additional evidence, it would be useful for researchers and/or the reindeer herders themselves document attacks of arctic foxes on calves with photos or videos, and possibly use mortality sensors (e.g. Nybakk et al. 2002). The herders could also document and count dead animals with clear signs of having been killed by the predators. Experience from Scandinavia, where conflict between reindeer herders and predator management has been ongoing for decades, shows that it is extremely important to obtain a solid knowledge base on the impact of predators (Tveraa et al. 2003; Norberg et al. 2006; Nieminen 2010).

Human-wildlife coexistence is often problematic because of misunderstandings and conflicts between stakeholders (Jacobsen and Linnell 2016). The case of arctic fox attacks on reindeers in Yamal does not include conservation concerns, since the arctic fox is not a protected species in Russia. However, we still witnessed misunderstandings and a lack of dialogue between the officials and reindeer herders. The letter from the reindeer enterprise informing the Yamal Government about the arctic fox problem and asking for help (mentioned above), was received very skeptically by some representatives of the Government, who informally expressed their distrust of the herders. They perceived the letter as a request for financial compensation by the herders on the basis of a problem that does not exist. Moreover, they did not even consider the theoretical possibility of such a phenomenon. Without investigating any further, they concluded that "*there is no way that the small arctic foxes are dangerous for reindeer*". No discussions about predation on reindeer calves were initiated between the Government and the reindeer herders. At present, the reindeer herding enterprise responsible for the letter no longer exists, and private herders are not declaring attacks by the predators and their losses of animals. This may be the result of a lack of well-established channels of communication with officials, and possibly because of the lack of response of decision makers to previous requests.

According to Nenets, they independently try to cope with predation by arctic foxes by guarding their herds during calving with guns and traps. However, in contrast to the successful liquidation of wolves in the open tundra using snowmobiles, the vehicles have been less effective against arctic foxes. Our informants recalled that earlier, when wolves attacked, reindeer always demonstrated fear behaviour, which was considered a sign requiring immediate reaction by the herders. The reaction of the herd to arctic foxes is different: the reindeer stay calm and do not express any fear, and do thus not warn the herders. It is also difficult for the herders to detect the small, well camouflaged predators, which often attack at dusk or in blizzards. This behaviour of the reindeer, apparently not fearing foxes, is consistent with the understanding that a serious threat from this predator is a recent phenomenon. Finally, low-income households complained about the lack of opportunities to buy cartridges (in addition to the legislative impediments) and modern snowmobiles to effectively guard reindeer during calving.

We believe that this problem of predation on reindeer should be addressed by establishing a constructive dialogue between stakeholders, including herders, management authorities, scientists and representatives of industrial companies. Scientists should provide solid data on trends for the whole arctic fox population and investigate the role of subsidies and their possible mitigations together with representatives from industry. Together with the herders, researchers should obtain quantitative estimates of the losses of reindeer calves due to predation. Based on these data, appropriate management actions can be developed. Local culling of arctic foxes by herders in the calving area prior to calving may be recommended as a measure to protect reindeer. Arctic fox fur use could be encouraged also for other purposes, such as for the production of souvenirs. Controlling management actions have to be followed up by careful monitoring to assess whether it has the desired effect and to adjust it in order to both protect the calving of the reindeer and avoid an unnecessarily large impact on the fox population. At the same time, we recommend that industrial companies and

other tundra entities, which may produce food subsidies for scavengers, organize more careful storage and disposal of waste and provide educational measures and penalties for shift workers to mitigate the problem.

Using an interdisciplinary approach to investigate the context of this emerging predation problem in the Arctic, we showed how different factors may have come together to create a problematic situation. The understanding of the reindeer herders that was communicated in the interview provided new information and suggested new avenues for continued research by ecologists. Thus, our study demonstrated the importance of including local knowledge in science related to nature management. Moreover, the case of the arctic foxes from Yamal highlights the necessity of taking into account points of view of the herders in order to address a problematic change in their environments. We hope that these findings will form the basis for future investigations and dialogues between stakeholders, and thus contribute to a solution for good future coexistences of reindeer, herders and arctic foxes.

Supplementary information The online version contains supplementary material available at https://doi.org/10.1007/s10344-021-01497-z.

Acknowledgements We thank "Gaspromtrans" company and NGO Russian Center of Development of the Arctic to logistic help. We are particularly grateful to the Community of the indigenous people "Ilebts" and its Head Roman Okotetto and to the all Yamal reindeer herders, with whom we were lucky to work. We also thank our colleagues Andrew Dixon and Peter Ungar for improving the language.

Funding This study was supported by the Russian Foundation for Basic Research through grant # 18–05-60261, "Arctic Fox project" of "Yamal LNG " company, project "Yamal EcoSystem" (362259) from the Terrestrial Flagship of the High North Research centre for Climate and the Environment (Fram Centre).

Declarations

Human and animal studies All applicable international, national and/or institutional guidelines for the social and animal studies were followed. This research was permitted by the Ethics Commission of Institute of Plant and Animal Ecology, Ural Branch, Russian Academy of Sciences (Ethics approval number 3, May 25, 2020).

Conflict of interest The authors declare no competing interests.

References

Adams WC (2015) Conducting Semi-Structured Interviews. In: Newcomer KE, Hatry HP, Wholey JS (eds) Handbook of Practical Program Evaluation, 4th edn. Jossey-Bass, Hoboken, NJ, pp 492–505

Angerbjörn A, Eide NE, Dalén L, Elmhagen B, Hellström P, Ims RA, Henttonen H (2013) Carnivore conservation in practice: replicated management actions on a large spatial scale. J Appl Ecol 50(1):59–67. https://doi.org/10.1111/1365-2664.12033

Angerbjörn A, Tannerfeldt M, Bjarvall A, Ericson M, From J, Noren E (1995) Dynamics of the Arctic fox population in Sweden Finnish Zoological and Botanical Publishing Board Dynamics of the arctic fox population in Sweden. Ann Zool Fenn 32(1):55–68

Aryal A, Brunton D, Ji W, Barraclough RK, Raubenheimer D (2014) Human-carnivore conflict: Ecological and economical sustainability of predation on livestock by snow leopard and other carnivores in the Himalaya. Sustainability Sci 9:321–329. https://doi.org/10.1007/s11625-014-0246-8

Bangs E, Shivik J (2001) Managing wolf conflict with livestock in the northwestern United States. Carnivore Damage Prevention News 3(July):1–5

Bartsch A, Kumpula T, Forbes BC, Stammler F (2010) Detection of snow surface thawing and refreezing in the Eurasian Arctic with QuikSCAT: Implications for reindeer herding. Ecol Appl 20(8):2346–2358. https://doi.org/10.1890/09-1927.1

Berteaux D, Thierry AM, Alisauskas R, Angerbjörn A, Buchel E, Doronina L, White PA (2017) Harmonizing circumpolar monitoring of Arctic fox: benefits, opportunities, challenges and recommendations. Polar Res 36(2). https://doi.org/10.1080/17518369.2017.1319602

Bêty J, Gauthier G, Korpimäki E, Giroux JF (2002) Shared predators and indirect trophic interactions: lemming cycles and arctic-nesting geese. J Anim Ecol 71(1):88–98. https://doi.org/10.1046/j.0021-8790.2001.00581.x

Braun V, Clarke V (2006) Using thematic analysis in psychology. Qual Res Psychol 3(2):77–101. https://doi.org/10.1191/1478088706qp063oa

Carbonell Ellgutter JA, Ehrich D, Killengreen ST, Ims RA, Unnsteinsdóttir ER (2020) Dietary variation in Icelandic arctic fox (*Vulpes lagopus*) over a period of 30 years assessed through stable isotopes. Oecologia 192(2):403–414. https://doi.org/10.1007/s00442-019-04580-0

Choi S, Grocutt E, Erlandsson R, Angerbjörn A (2019) Parent personality is linked to juvenile mortality and stress behavior in the arctic fox (*Vulpes lagopus*). Behav Ecol Sociobiol 73:162. https://doi.org/10.1007/s00265-019-2772-y

Delibes-Mateos M, Ferreira C, Rouco C, Villafuerte R, Barrio IC (2014) Conservationists, hunters and farmers: the European rabbit *Oryctolagus cuniculus* management conflict in the Iberian Peninsula. Mammal Rev 44(3–4):190–203. https://doi.org/10.1111/mam.12022

Ehrich D, Cerezo M, Rodnikova A, Sokolova N, Fuglei E, Shtro V, Sokolov A (2017) Vole abundance and reindeer carcasses determine breeding activity of Arctic foxes in low Arctic Yamal. Russia BMC Ecol 17(1):32. https://doi.org/10.1186/s12898-017-0142-z

Eide NE, Stien A, Prestrud P, Yoccoz NG, Fuglei E (2012) Reproductive responses to spatial and temporal prey availability in a coastal Arctic fox population. J Anim Ecol 81(3):640–648. https://doi.org/10.1111/j.1365-2656.2011.01936.x

Elton CS (1924) Periodic fluctuations in the numbers of animals: their causes and effects. J Exp Biol 2:119–163

Fernando P, Leimgruber P, Prasad T, Pastorini J (2012) Problem-elephant translocation: translocating the problem and the elephant? PLoS One 7(12):e50917. https://doi.org/10.1371/journal.pone.0050917

Forbes BC, Kumpula T, Meschtyb N, Laptander R, MacIas-Fauria M, Zetterberg P, Bartsch A (2016) Sea ice, rain-on-snow and tundra reindeer nomadism in Arctic Russia. Biol Lett 12(11):20160466. https://doi.org/10.1098/rsbl.2016.0466

Fufachev IA, Ehrich D, Sokolova NA, Sokolov VA, Sokolov AA (2019) Flexibility in a changing arctic food web: can rough-legged buzzards cope with changing small rodent communities? Glob Change Biol 25(11):3669–3679. https://doi.org/10.1111/gcb.14790

Geptner VG, Naumov NP, Yurgenson PB (1967) Mlekopitaushie Sovetskogo Soyuza [Mammals of the Soviet Union]. Moscow: High school 2(2):194–265

Golovatin MG, Sokolov VA (2017) Pesets na tekhnogennykh territoriiakh Iuzhnogo Iamala (Iamalo-Nenetskii avtonomnyi okrug) [Arctic Fox in technogenic territories of Southern Yamal (the Yamalo-Nenets Autonomous Okrug)]. Fauna of the Urals and Siberia 1:248–251

Golovnev AV (2017) Challenges to Arctic nomadism: Yamal Nenets facing climate change era calamities. Arct Anthropol 54(2):40–51. https://doi.org/10.3368/AA.54.2.40

Golovnev AV, Osherenko G (1999) Siberian survival: the Nenets and their story. Cornell University Press, Ithaca, NY

Graham K, Beckerman AP, Thirgood S (2005) Human-predator prey conflicts: ecological correlates, prey losses, and patterns of management. Biol Conserv 122(2):159–171. https://doi.org/10.1016/j.biocon.2004.06.006

Hersteinsson P, Angerbjörn A, Fradjord K, Kaikusalo A (1989) The Arctic fox in Fennoscandia and Iceland: management problems. Biol Conserv 49(1):67–81. https://doi.org/10.1016/0006-3207(89)90113-4t

Hueffer K, Drown D, Romanovsky V, Hennessy T (2020) Factors contributing to Anthrax outbreaks in the circumpolar north. EcoHealth 17(2):174–180. https://doi.org/10.1007/s10393-020-01474-z

Ims RA, Killengreen ST, Ehrich D, Flagstad Ø, Hamel S, Henden JA, … Yoccoz NG (2017). Ecosystem drivers of an Arctic fox population at the western fringe of the Eurasian Arctic. Polar Res 36(8). https://doi.org/10.1080/17518369.2017.1323621

Jacobsen KS, Linnell JDC (2016) Perceptions of environmental justice and the conflict surrounding large carnivore management in Norway – implications for conflict management. Biol Conserv 203:197–206. https://doi.org/10.1016/j.biocon.2016.08.041

Jamtsho Y, Katel O (2019) Livestock depredation by snow leopard and tibetan wolf: implications for herders' livelihoods in Wangchuck Centennial National Park, Bhutan. Pastoralism 9(1). https://doi.org/10.1186/s13570-018-0136-2

Killengreen ST, Lecomte N, Ehrich D, Schott T, Yoccoz NG, Ims RA (2011) The importance of marine vs. human-induced subsidies in the maintenance of an expanding mesocarnivore in the arctic tundra. J Anim Ecol 80(5):1049–1060. https://doi.org/10.1111/j.1365-2656.2011.01840.x

Kumpula T, Forbes BC, Stammler F (2010) Remote sensing and local knowledge of hydrocarbon exploitation: the case of Bovanenkovo, Yamal Peninsula, West Siberia, Russia. Arct 63(2):165–178. https://doi.org/10.14430/arctic972

Lamarre JF, Legagneux P, Gauthier G, Reed ET, Bêty J (2017) Predator-mediated negative effects of overabundant snow geese on arctic-nesting shorebirds. Ecosphere 8(5):e01788. https://doi.org/10.1002/ecs2.1788

Lehner NS (2012) Arctic fox winter movement and diet in relation to industrial development on Alaska's North slope. Master thesis, University of Alaska, Fairbanks

Lozano J, Olszańska A, Morales-Reyes Z, Castro AA, Malo AF, Moleón M, Martín-López B (2019) Human-carnivore relations: a systematic review. Biol Conserv 237:480–492. https://doi.org/10.1016/j.biocon.2019.07.002

Mabille G, Stien A, Tveraa T, Mysterud A, Brøseth H, Linnell JDC (2015) Sheep farming and large carnivores: what are the factors influencing claimed losses? Ecosphere 6(5):82. https://doi.org/10.1890/ES14-00444.1

Mckinnon L, Berteaux D, Gauthier G, Bêty J (2013) Predator-mediated interactions between preferred, alternative and incidental prey in the arctic tundra. Oikos 122(7):1042–1048. https://doi.org/10.1111/j.1600-0706.2012.20708.x

Mukesh, Sharma LK, Charoo SA, Sathyakumar S (2015) Conflict bear translocation: investigating population genetics and fate of bear translocation in Dachigam National Park, Jammu and Kashmir, India. PLoS One 10(8):e0132005. https://doi.org/10.1371/journal.pone.0132005

Mukhachev AD, Salatkin VG (2008) Fundamentals of reindeer herding, fur farming and hunt studies. Training manual. Vol. 1. [Osnovy olenevodstva, zverovodstva, okhotovedeniia]. Saint Petersburg: Enlightment

Nevai AL, van Gorder RA (2012) Effect of resource subsidies on predator–prey population dynamics: a mathematical model. J Biol Dyn 6(2):891–922. https://doi.org/10.1080/17513758.2012.677485

Nieminen M (2010) The impact of large carnivores on the mortality of semi-domesticated reindeer (*Rangifer tarandus tarandus L.*) calves in Kainuu, southeastern reindeer-herding region of Finland. Rangifer 30(1):79–88. https://doi.org/10.7557/2.30.1.1218

Norberg H, Kojola I, Aikio P, Nylund M (2006) Predation by golden eagle Aquila chrysaetos on semi-domesticated reindeer Rangifer tarandus calves in northeastern Finnish Lapland. Wildl Biol 12:393–402. https://doi.org/10.2981/0909-6396(2006)12[393:PBGEAC]2.0.CO;2

Nybakk K, Kjelvik O, Kvam T, Overskaug K, Sunde P (2002) Mortality of semi-domestic reindeer *Rangifer tarandus* in central Norway. Wildl Biol 8:63–68. https://doi.org/10.2981/wlb.2002.009

Pálsson S, Hersteinsson P, Unnsteinsdóttir ER, Nielsen ÓK (2016) Population limitation in a non-cyclic Arctic fox population in a changing climate. Oecologia 180(4):1147–1157. https://doi.org/10.1007/s00442-015-3536-7

Pedersen VA, Linnell JDC, Andersen R, Andrén H, Lindén M, Segerström P (1999) Winter *Lynx lynx* predation on semi-domestic reindeer Rangifer tarandus in northern Sweden. Wildl Biol 5(4):203–211. https://doi.org/10.2981/wlb.1999.025

Perevalova EV (2015) Interv'u s olenevodami Iamala o padezhe olenei i perspektivakh nenetskogo olenevodstva [A interview with Yamal reindeer herders about reindeer losses and the future of the Nenets reindeer herding]. Ural'skii Istoricheskii Vestnik [ural Historical Journal] 2(47):39–49

Pooley S, Barua M, Beinart W, Dickman A, Holmes G, Lorimer J, Milner-Gulland EJ (2017) An interdisciplinary review of current and future approaches to improving human-predator relations. Conserv Biol 31(3):513–523. https://doi.org/10.1111/cobi.12859

Redpath SM, Young J, Evely A, Adams WM, Sutherland WJ, Whitehouse A, Gutiérrez RJ (2013) Understanding and managing conservation conflicts. Trends Ecol Evol 28(2):100–109. https://doi.org/10.1016/j.tree.2012.08.021

Redpath SM, Bhatia S, Young J (2015) Tilting at wildlife: reconsidering human-wildlife conflict. Oryx 49(2):222–225. https://doi.org/10.1017/S0030605314000799

Report of IPAE (1990) Bassein reki Erkata-iakha [The basin of Yorkata-yakha River]: Research report. Labytnangi

R Core Team (2020) R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. https://www.R-project.org/

Savory GA, Hunter CM, Wooller MJ, O'Brien DM (2014) Anthropogenic food use and diet overlap between red foxes (*Vulpes vulpes*) and arctic foxes (*Vulpes lagopus*) in Prudhoe Bay. Alaska Can Journal Zool 92(8):657–663. https://doi.org/10.1139/cjz-2013-0283

Sdobnikov VN (1935) Vzaimootnosheniia severnogo olenia c zhivotnym mirom tundry i lesa [The relationship of reindeer with wildlife of tundra and forest]. Proceedings of the Arctic Institute 24

Schensul JJ, LeCompte MD (2013) Essential ethnographic methods: a mixed methods approach. AltaMira Press, Lanham

Shtro VG (2009) Pesets Iamala [Arctic Fox of Yamal]. Yekaterinburg: UB RAS

Skalon NV (1940) Zametki o rasprostranenii i biologii pestsa v Sibiri. [Notes on the distribution and biology of the Arctic fox in Siberia]. Nature 2:79–80

Smith TG (1976) Predation of ringed seal pups (*Phoca hispida*) by the arctic fox (Alopex lagopus). Can J Zool 54(10):1610–1616. https://doi.org/10.1139/z76-188

Sokolov AA, Sokolova NA, Ims RA, Brucker L, Ehrich D (2016). Emergent rainy winter warm spells may promote boreal predator expansion into the arctic. Arct 69(2): 121–129. https://doi.org/10.14430/arctic4559

Sosin VF, Paskhalnyi SP, Shtro VG (1985) Raspredelenie i chislennost′ nekotorykh vidov nazemnykh pozvonochnykh arkticheskoi tundry Iamala v letnii period [Distribution and abundance of some terrestrial vertebrates species of the Yamal Arctic tundra at summer]. In: Raspredelenie i chislennost' nazemnykh pozvonochnykh poluostrova Iamal [Distribution and abundance of terrestrial vertebrates of the Yamal Peninsula]. Sverdlovsk, pp 3–33

Stammler F (2005) Reindeer Nomads meet the market: culture, property and globalization at the "End of the Land." Lit-Verlag, Münster

Sun YH, Wu HJ, Wang Y (2004) Tawny fish-owl predation at fish farms in Taiwan. J Raptor Res 38(4):326–333

Tarroux A, Bêty J, Gauthier G, Berteaux D (2012) The marine side of a terrestrial carnivore: intra-population variation in use of allochthonous resources by Arctic foxes. PLoS One 7(8):e42427. https://doi.org/10.1371/2Fjournal.pone.0042427

Terekhina AN (2018) "Uchebnaia narta" i kerosinka, ili TundraSkills dlia kochevogo vospitatelia [A 'training sledge' and a kerosene lamp, or TundraSkills for the nomad kindergarten teacher]. Sib Hist Res 4:42–65. https://doi.org/10.17223/2312461X/22/3

Terekhina AN, Volkovitskiy AI (2019) The panty question in yamal: sawing, trading, discussing. J Sib Fed Univ – Humanit Soc Sci 12(8):1484–1505. https://doi.org/10.17516/199713700461

Tsetsevinskiy LM (1940) Materialy po ekologii pestsa Severnogo Iamala [Materials on the Arctic fox ecology of the Northern Yamal]. Zool J 19(1):183–191

Tveraa T, Fauchald P, Henaug C, Yoccoz NG (2003) An examination of a compensatory relationship between food limitation and predation in semi-domestic reindeer. Oecologia 137:370–376. https://doi.org/10.1007/s00442-003-1373-6

Tveraa T, Stien A, Brøseth H, Yoccoz NG (2014) The role of predation and food limitation on claims for compensation, reindeer demography and population dynamics. J Appl Ecol 51:1264–1272. https://doi.org/10.1111/1365-2664.12322

Volkovitskiy AI, Terekhina AN (2020) Sovremennye problemy iamal′skogo olenevodstva: diskussii i perspektivy [The contemporary issues of Yamal reindeer herding discussions and perspectives]. Etnogr 2(8):152–169. https://doi.org/10.31250/2618-8600-2020-2(8)-152-169

Walker DA, Raynolds MK, Daniels FJA, Einarsson E, Arve E, Gould WA, Kaitenin AE, Kholod SS, Markon CJ, Melnikov ES, Moskalenko NG, Talbot SS, Yurtsev BA (2005) The Circumpolar Arctic Vegetation map. J Veg Sci 16:267–282

White PCL, Ward AI (2010) Interdisciplinary approaches for the management of existing and emerging human–wildlife conflicts. Wildl Res 37:623–629. https://doi.org/10.1071/WR10191