key words:
carnivores, depredation, grazing, losses, sheep

Losses of Sheep on Summer Range in Norway

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Abstract

The majority of two million Norwegian sheep graze on open mountain-range pastures during summer, and are neither fenced nor guarded. Each year about 125,000 ewes and lambs are lost on summer range. Mortality due to predation is increasing in many areas and wildlife administration pays about $12 million USD annually in compensation for sheep killed by protected large carnivores. Red fox, not a protected species, is also considered a main predator. In addition to predation, accidents, common diseases, and lack of micro-minerals increase the complexity of sheep mortality. In this study we have reanalyzed data from radio-telemetry-based mortality studies performed during the last 10 years, including 1170 lambs from 15 farms, with the object of documenting some characteristics of lambs killed by red fox, wolverine, and lynx specifically, and to find farm management factors which may be significant for reducing mortality on summer range. Results show that in a grazing area dominated by wolverine as the main cause of lamb losses, probability of survival was not influenced by the body mass of the lambs at release, whereas in areas dominated by lynx, survival increased significantly with increasing body mass at release. This link was even stronger within a red fox habitat. These results indicate that the "weaker" the predator, the more important the size of the prey. Mitigation measures are discussed.

Introduction

Around two million Norwegian sheep are grazing on unimproved mountain-range pastures during summer, and are neither fenced nor guarded. Each year about 125,000 ewes and lambs are lost on summer range. How many of these are taken by predators is uncertain and a subject of disagreement between farmers and the wildlife administration. The administration has annually paid between 61 and 77.5 million Norwegian kroner (approximately $12 million USD) in compensation for sheep killed by protected carnivores the last five years (www.rovbase.no).

The mortality rate during summer grazing in Norway has increased substantially the past 20 years. In 1990 2.3% of ewes and 4.8% of lambs from a total of 1.5 million sheep registered by the Norwegian Agricultural Authority were lost compared to 3.4% of ewes and 8.1% of lambs in 2010 (www.skogoglandskap.no/kart/beitestatistikk). There is large spatiotemporal variation in the magnitude of losses of sheep in Norway, both between areas, between herds within the same area, and within areas and herds across years. This variation in sheep losses is often speculated to mirror the geographical and temporal pattern in the abundance of predators, but remains to be verified in scientific investigations.

Radiotelemetry-based studies utilizing mortality transmitters have shown that increasing populations of large predators [lynx *(Lynx lynx)*, brown bear *(Ursus arctos)*, wolverine *(Gulo gulo)*, wolf *(Canis lupus)* and golden eagle *(Aguila chrysaëtos)*] are an increasingly important cause of sheep mortality in large parts of the country (Mysterud and Mysterud 1995; Sagør et al., 1997; Kvam and Jonsson, 1998; Nilsen et al., 2002; Andersen et al., 2003; Knarrum et al., 2006; Hansen, 2009). In coastal and lower altitude areas red fox *(Vulpes vulpes)* might

be the main predator, even killing lambs weighing more than 30 kilos (Hansen, 2006). Other studies indicate that causes of sheep death are complex and may be related to, e.g., lack of micro-minerals, tick-borne diseases, and the combination of carnivores and disease (Hansen, 2006; Grøva, 2010).

In this study we have reanalyzed data from four radiotelemetry-based mortality studies performed the last 10 years (Nilsen et al., 2002; Hansen, 2006; Hansen, 2007; Hansen et al., 2012), including 1170 lambs from 15 farms, to identify characteristics of lambs related to loss to red foxes, wolverines, and lynx specifically, and to find farm management factors which may be significant for the mortality on summer range.

Material and methods

A total of 963 lambs from four different years and areas were equipped with VHF radio transmitters in order to document the reason for mortality (Table 1, Figure 1). Individual birth weight, spring weight (when released on open summer range), sex, age of the dam, and litter size were registered for all lambs within each herd (N = 1170), in order to document whether the probability of survival was influenced by these predictors.

Every year field personnel monitored for carcasses every day throughout the grazing season from the beginning of June until mid-September. This included animals with and without mortality transmitters. Carcasses found were examined by experts in national wildlife service (Statens naturoppsyn). Carcasses that were not documented as killed by carnivores were sent to the Norwegian Veterinary Institute for further autopsy.

Statistics

Generalized linear models were used to scrutinize how body mass when released into the field, sex and litter size, and their interaction, influenced the probability of survival. Binominal distribution was assumed; hence a logit link was used in the models. As interactions and covariance complicated interpretation of single predictors, Akaikes Selection Criterion adjusted for small sample sizes (AICc) was used to select the most parsimonious models. AICc is a penalized likelihood based selection criterion, where precision and complexity of the model are balanced (Burnham and Anderson, 2002). As the youngest and oldest mothers had lower litter sizes than average, maternal age was excluded from the models to avoid

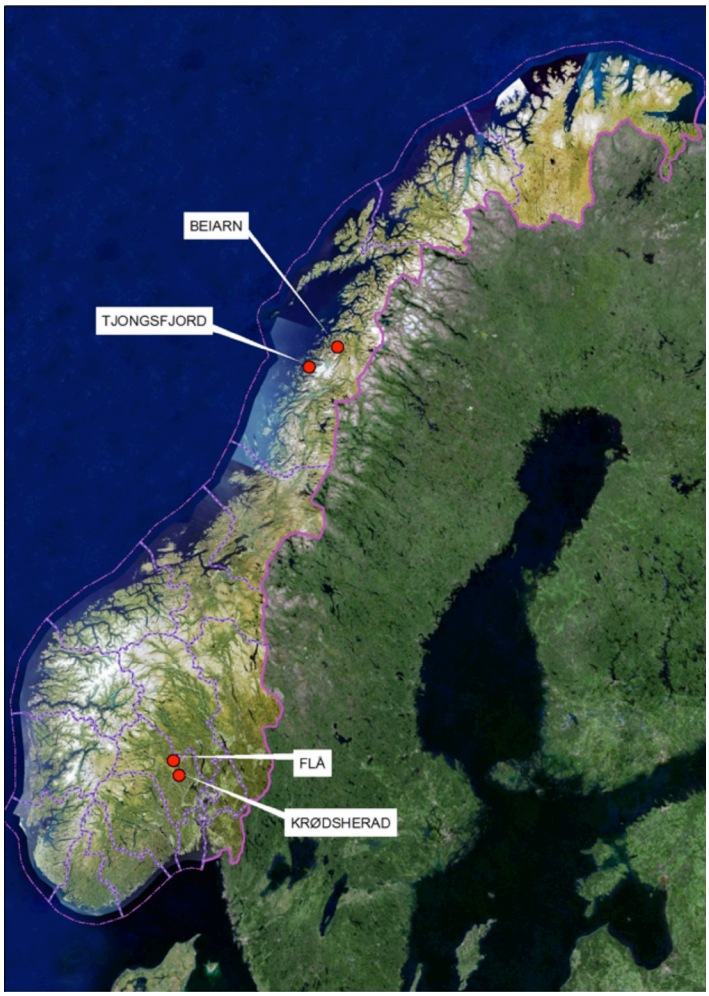

Figure 1. Map pointing out the four study areas.

Table 1. Flocks, animals, and locations of the four mortality studies performed.

Year	# of flocks	# of lambs with mortality transmitters vs. total # released on summer range	Area
2002	4	272 / 288	Beiarn, Nordland county
2006	6	277 / 277	Tjongsfjord, Nordland county
2007	3	182 / 182	Krødsherad, Buskerud county
2011	2	232 / 423	Flå, Buskerud county
In total	15	963 / 1,170	

unbalance. Predictors are referred to as significant if their 95% confidence interval (95% CI) does not include zero.

Results

Losses and causes of death within the different study areas

In Beiarn 84 lambs out of 272 lambs with mortality transmitters were lost (31%, Table 2), of which 53 carcasses were found. For eight of these we were unable to document the cause of death. Out of 45 lambs with known mortality cause, 38 lambs (84%) were killed by wolverine, one (2%) was killed by golden eagle, three (7%) died from disease/starvation, and three (7%) died in accidents. The probability of survival was not influenced by the body mass of the lamb at release or any other of the predictors (ΔAICc>0.59, Fig. 2).

In Tjongsfjord 62 out of 277 lambs with mortality transmitters were lost on summer range (22%, Table 2). Of these, 53 carcasses were found, of which the mortality of 28 was classified "unknown cause of death." Out of 25 lambs with a documented reason for mortality, 13 lambs (52%) were depredated by red fox, 10 (40%) died of illnesses, and two died in accidents (8%). The probability of survival increased strongly with increasing body mass at release (logit estimate: 0.17, 95% confidence interval [0.03,0.31], Fig. 2). None of the other predictors were included in the most parsimonious model (ΔAICc>1.13).

In Krødsherad 34 out of 182 lambs with mortality transmitters were lost on summer range (19%, Table 2). Five lambs had an unknown cause of death. Out of 29 lambs with a documented cause of mortality, 27 were killed by lynx (93%), one died of illness (3.5%) and one died in an accident (3.5%). Survival increased with increasing body mass at release (-0.78, 95%CI [0.22, 1.48], Fig. 2). However, the most parsimonious model included lower survival for males than females (-2.87, 95%CI [-6.29, 0.27]), as well as an interaction between litter size and sex (1.17, 95%CI [-0.27, 2.75]) and litter size and body mass (-0.35, 95%CI [-0.68, -0.08], ΔAICc>0.68).

In Flå 16 out of 232 lambs with mortality transmitters were lost on summer range (7%, Table 2). Out of 15 lambs with a known mortality cause, 13 (87%) were killed by lynx and two died in accidents (13%). There was no significant difference in losses on range between lambs with and without mortality transmitters. The results correspond to the findings in Krødsherad and document that lynx are the main reason for lamb mortality on range in these two areas.

Table 2. Lamb losses and mortality causes for radio-tracked lambs lost on summer range within the four study areas.

Study area	Lamb losses (%)	Causes of death (%)		
		Carnivores	Disease	Accidents
Beiarn	31	84 (wolverine) 2 (golden eagle)	7	7
Tjongsfjord	22	52 (red fox)	40	8
Krødsherad	19	93 (lynx)	3.5	3.5
Flå	7	87 (lynx)	0	13

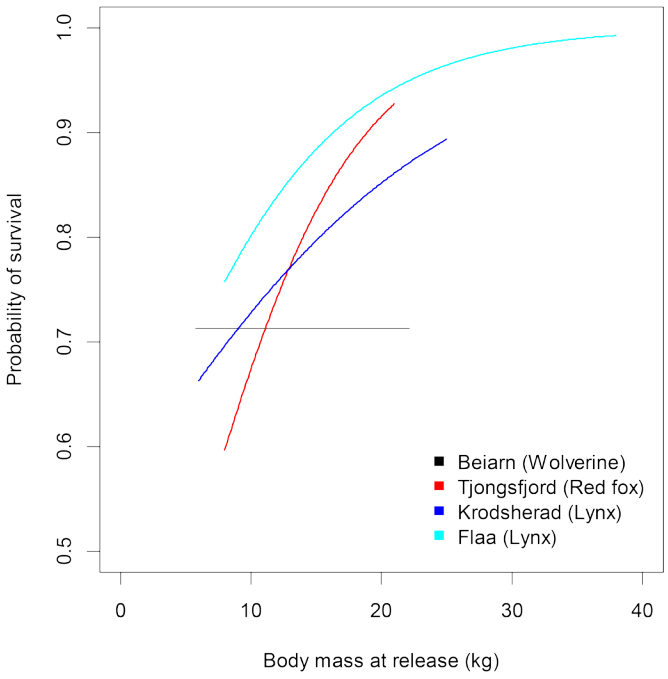

Figure 2. Probability of survival versus body mass of lambs at release for the four different areas. The main predators in these areas are indicated in brackets.

Survival increased with increasing body mass at release (0.13, 95%CI [0.04, 0.23], Fig. 2). No other predictor was included in the most parsimonious model (ΔAICc>0.79).

Characteristics of lambs killed by the different carnivore species

The wolverine most often kills by an effective and strong neck bite. Losses of lambs in Beiarn were relatively low in the beginning of the grazing season, but accelerated around August 25, mainly due to an increase in the number

of lambs killed by wolverines. This is typical for wolverines, which hoard prey during autumn for the winter.

The red fox has a less powerful bite than the wolverine; consequently, lambs killed by foxes have many bites around the neck region. The red fox, like the wolverine, may decapitate its prey. In Tjongsfjord, killings by red foxes and diseases [coccidiosis, micromineral deficiency (selenium, copper, cobalt), and poisoning by the plant called bog aspohodel *(Narthecium ossifragum)* causing kidney failure], were the dominating causes of death the first two months on summer range. However, a lamb weighing more than 35 kg was depredated by fox as late as September 18. Additionally, three other lambs above 20 kg were killed by foxes. A majority of the depredated lambs had coccidiosis and may have been weak at the time of attack. Two of the heaviest lambs killed by foxes had marginal Se-status, which might result in weak muscles and stiff legs.

The lynx kills its prey by a very precise and effective throat bite. Lambs were depredated by lynx in Krødsherad and Flå throughout the whole grazing season and the majority of these carcasses were located in the lower elevations (woods) of the grazing area.

Discussion

Throughout three of four areas in this study, mortality is linked to body mass of the lambs when released, indicating that the "weaker" the predator, the more important the size of the prey. We have also seen from these and other mortality studies that flocks that are well managed by farmers following best practices regarding preventive health care measures lose less animals due to disease. When such herds graze unprotected on free range in carnivore habitat, close to 100% of the losses might be caused by predation, as in Beiarn, Krødsherad, and Flå. In Tjongsfjord, the farmers did not always follow best practice, resulting in more diseases and deficiencies and which made some of the lambs easy prey, even for the small red fox. This was also indicated by the rapid increase in survival among heavier lambs. We recommend all sheep farmers join the Sheep Health Services (SHS) run by the Norwegian meat and poultry research center, Animalia (www.animalia.no). The SHS offers examination of the herds and management system and gives advice about feeding, management, animal welfare, and preventative health care.

Hunting during the ordinary hunting season is the most effective measure against red fox damages. Improving the condition of the lambs also increases the survival rate from attack by red fox. This measure may, however, be less likely for stronger predators.

As wolverine is a protected species, the best mitigation measure against wolverine predation is to take the sheep home from the mountain range a month earlier (in mid August) than usual, presupposing that there are lowland pastures available for the flock. In Norway only licensed hunting (motivated by the need for reduced damages) is allowed from September 10 until February 15. However, in the northern parts of Norway there are only a few hours of light during the day at this time of year, which makes hunting extremely difficult.

Trapping of lynx and wolverine is hard, since the regulation states that traps (wooden boxes) should be inspected physically twice a day. Red fox traps have to be examined once a day. Other types of trapping, like snaring, are not allowed. In management zones where increasing lynx population is a national goal, as in Buskerud, the best mitigation measure is to separate the sheep from the lynx by moving the herds from forest ranges up to mountain ranges. This will have a long-lasting effect on the losses due to lynx. To achieve reduced losses in lynx habitat there will be a need for grazing within enclosed pastures, with additional preventative support by electric fencing or by the use of guardian dogs. Licensed hunts of a specific number of lynx is taking place each year, hence this quota hunting may be an important stock regulating measure.

Conclusion

Mortality is linked to body mass of the lambs when released, indicating that the "weaker" the predator, the more important the size of the prey. Mortality caused by red foxes and diseases are factors the livestock farmers in some way can prevent, whereas mitigation measures against protected carnivores and accidents are harder to find. The most effective measures toward depredation are those that separate livestock and carnivores in time and space, like electric fencing or early gathering. However, these measures are in conflict with traditional sheep management in Norway based on free range summer grazing.

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