Research Article

EURASIAN LYNX DEPREDATION ON SHEEP IN NORWAY: SUMMARIZING 20 YEARS OF RESEARCH

John Linnell*, Jenny Mattisson, Vincenzo Gervasi, John Odden

Norwegian Institute for Nature Research, PO Box 5685 Sluppen, NO-7485 Trondheim, Norway

Large carnivores were effectively exterminated from much of Norway during the early to mid-20th century. In their absence, a form of sheep husbandry developed which involved releasing up to 2 million sheep into forest and tundra grazing areas throughout the country without fencing or protection. Supervision is limited to the occasional patrolling of the grazing area that has no protective effect. The sheep do not flock and disperse over large areas. Sheep are normally free-grazed from June to September, spending autumn and early spring on fenced fields close to the farm and winter in barns. The system requires low labour inputs and many sheep farmers have alternative employment outside the farm.

Since the 1980's populations of Eurasian lynx, wolverine, brown bear and wolf have been recovering in Norway. There are currently between 300 and 400 lynx in Norway, spread thinly across most of the country. The population is maintained at this level through the use of an annual quota regulated harvest. Parallel with this recovery has been an increase in the mortality of sheep while free grazing in summer. There has been considerable uncertainty about the causes of this mortality because the extensive nature of the grazing system, the complex terrain in which the sheep graze, and the low level of supervision do not facilitate the timely discovery of carcasses in a state that permits necropsy. A series of early studies using radio-telemetry of sheep documented that large carnivores were killing substantial numbers. As a result a practice evolved where compensation was paid for most missing sheep above a level that was regarded as a pre-carnivore recovery "normal" loss. This has reached the stage where currently less than 10% of paid compensation is based on a carcass that has been subject to field inspection. The rest is based on a somewhat subjective evaluation by administrators in the various county environmental affairs departments.

*Corresponding author: john.linnell@nina.no

What is actually happening to the sheep?

Eurasian lynx are the most widespread of the large carnivores in Norway, and their entire distribution overlaps with sheep farming areas. Although there is plenty of evidence that lynx depredate on free-grazing sheep from necrospy of carcasses, there is considerable uncertainty about how many are killed. Lynx killed sheep are particularly hard to detect, because they tend to kill single sheep, and often consume and/or bury the carcass. In recent years, almost 10,000 sheep have been compensated as lynx kills annually in Norway.

In order to shed light onto the actual extent of lynx depredation the Scandlynx project began studying livestock depredation among radio-collared lynx in 1995. Since then we have been studying depredation in both southern and northern Norway. Although the development of technology (from VHF to GPS collars) has changed our way of working, the essential work involves following individual lynx to quantify their kill rates (number of animals killed per unit time) on wild and domestic prey under different environmental conditions. The major difference between southern and northern Norway lies in the availability of alternative prey. In the south roe deer, followed by red deer, are the most common wild prey. In the north there are no wild herbivores of a size that lynx can readily kill, so domestic reindeer represent their most common prey (Fig. 1). A total of 78 individual lynx with access to free-ranging sheep during summer have been studied so far.

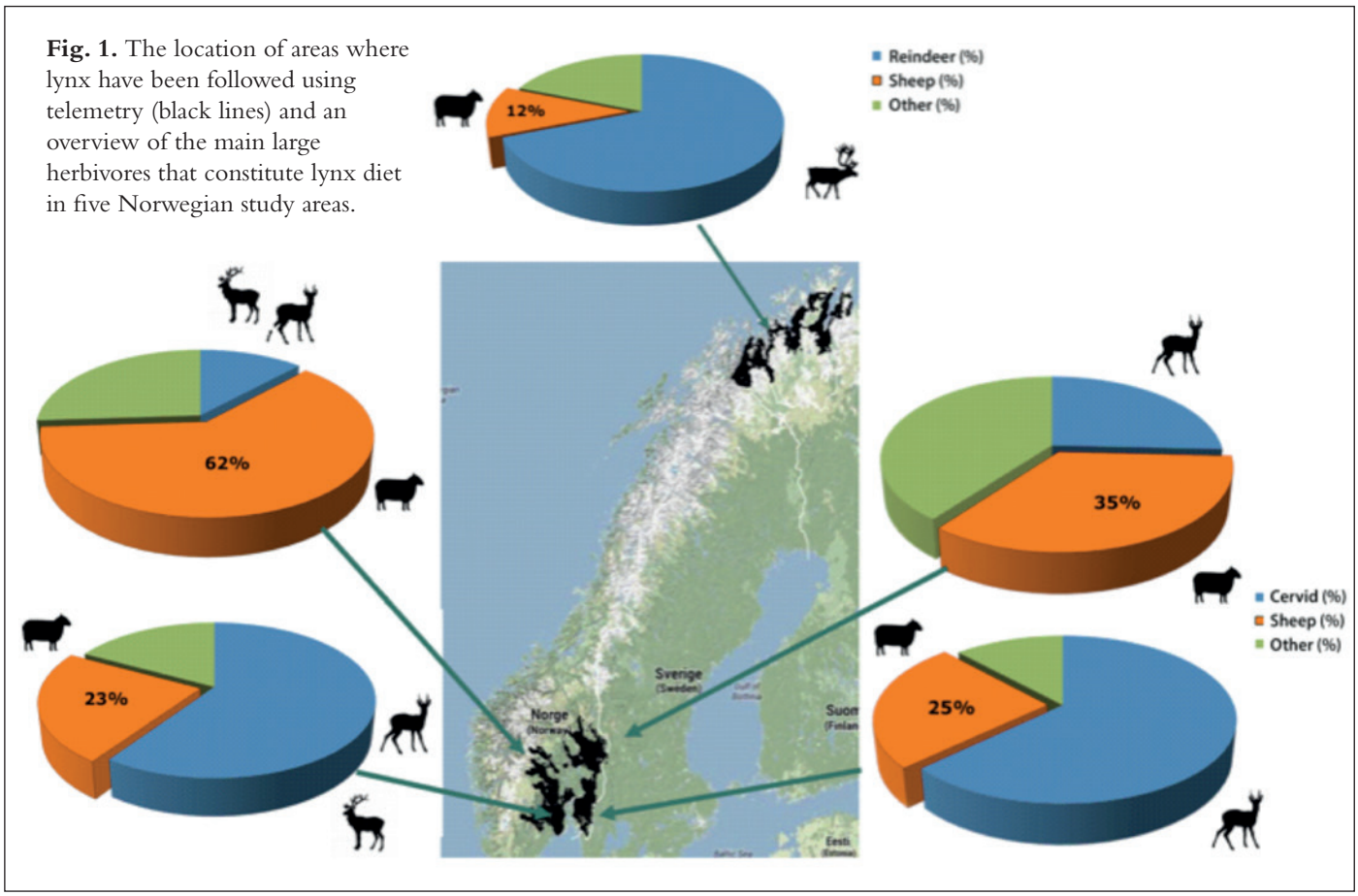

Fig. 1. The location of areas where lynx have been followed using telemetry (black lines) and an overview of the main large herbivores that constitute lynx diet in five Norwegian study areas.

Who kills sheep and where?

Our most intensive study area in the area west of Oslo (Østafjells) provided good insight into the factors explaining variation in the probability of lynx killed sheep (Table 1). Roe deer and red deer were the main winter prey for all lynx. In summer, solitary female lynx killed comparatively few sheep, whereas females with dependent young and adult males were four and five times more likely to kill a sheep. When looking at individual variation it was clear that both the density of roe deer and sheep influenced patterns of prey selection. Males were always more likely to kill sheep

Table 1. Seasonal composition of the prey species killed by solitary females, females with kittens, and male lynx in Buskerud, Telemark, and Oppland counties, southern Norway, 2006-2011. Numbers in parentheses indicate the total number of kills for a given lynx category and season.

Prey type	Solitary Females (%)		Females with kittens (%)		Males (%)	
	Summer (16)	Winter (64)	Summer (73)	Winter (87)	Summer (188)	Winter (64)
Beaver (*Castor fiber*)	0	0	0	0	0	0.5
Goat (*Capra aegragus*)	0	0	0	0	0.5	0
Hare (*Lepus timidus*)	10.5	12.5	13.7	16.5	12.9	4.3
Moose (*Alces alces*)	0	0	0	0	0	1.2
Red deer (*Cervus elaphus*)	5.4	7.8	2.7	6.2	1.1	22.6
Red fox (*Vulpes vulpes*)	0	1.5	0	0	0	1.8
Reindeer (*Rangifer tarandus*)	0	0	0	0	0.5	0.6
Roe deer (*Capreolus capreolus*)	52.6	67.2	24.7	67.0	23.1	56.7
Sheep (*Ovis aries*)	10.5	0	45.2	3.1	55.4	12.3
Squirrel (*Sciurus vulgaris*)	0	0	0	1.0	0	0
Tetraonids	10.5	9.4	12.3	6.2	3.8	0
Other birds	10.5	1.6	1.4	0	2.7	0

than females, and kill rates on sheep were highest in areas with more sheep and fewer roe deer, and lowest in areas with more roe deer and fewer sheep (Fig. 2). When looking at the occurrence of sheep in lynx diet across the range of study sites, the main finding was that sheep were rarely the major part of the diet, apart from areas with few roe deer and with very high sheep densities.

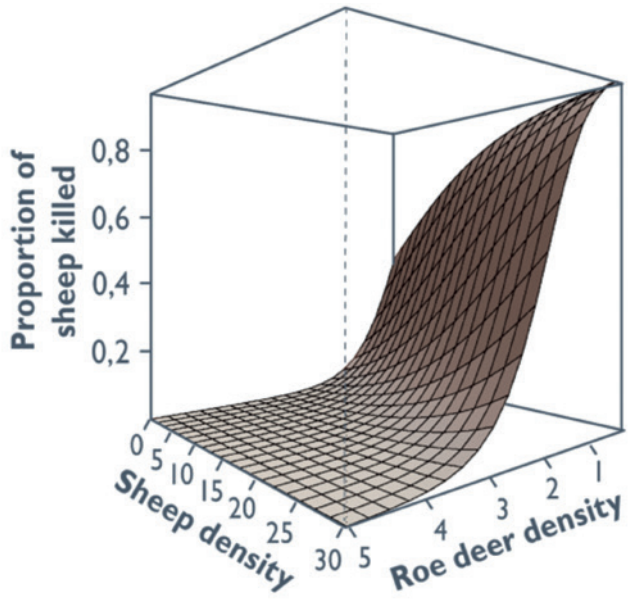

Fig. 2. Relationship between lynx prey selection for sheep and densities of roe deer and sheep.

How often do lynx kill sheep?

During our studies we found that most of the collared lynx killed sheep at one time or another (75% of males and 33% of females) during the weeks that we followed them. This finding led us to quickly reject the idea that there were just a few sheep-specialist problem-individuals in the lynx population. However, there was considerable variation in the rates at which lynx killed sheep. The main difference was between males

Table 2. Seasonal composition of the prey species killed by solitary females, females with kittens, and male lynx in Buskerud, Telemark, and Oppland counties, southern Norway, 2006-2011. Numbers in parentheses indicate the total number of kills for a given lynx category and season.

Area	Sex	Lynx*season	Proportion (%) of lynx involved in depredation (n)	Average lambs per km^2	Average roe deer per km^2	Sheep killed per 30 days
Region 5	M	9	83% (6)	1.3 (±2.6)	0.2 (±0.2)	7.9 (±8.6)
	F	14	8% (12)	1.0 (±1.1)	1.1 (±1.3)	0.2 (±0.7)
Region 4	M	5	25% (4)	1.8 (±2.5)	3.5 (±1.8)	0.4 (±1.8)
	F	3	33% (3)	1.9 (±2.4)	2.2 (±1.1)	0.8 (±1.4)
Region 2 - north	M	8	100% (8)	3.2 (±1.8)	0.6 (±0.4)	5.9 (±3.1)
	F	7	83% (6)	5.2 (±3.0)	0.4 (±0.3)	2.4 (±1.8)
Region 2 - south	M	6	67% (6)	1.1 (±0.7)	3.2 (±1.4)	1.9 (±1.6)
	F	3	33% (3)	1.5 (±0.9)	2.7 (±2.1)	0.9 (±1.6)
Region 8	M	16	50% (6)	8.5 (±3.8)	12.3 (±5.4	0.9 (±0.4
	F	23	55% (11)	8.1 (±5.7)	11.1 (±4.6)	1.5 (±0.4)

and females (Table 2). In most study areas males killed sheep far more frequently than females. In addition, males were responsible for all cases of multiple killing. Kill rates for all lynx classes varied from 0.2 to 8 sheep per month. An overall analysis revealed that kill rates on sheep decreased with increasing roe deer density and that the relative kill rates were lower at lower sheep density (Fig. 3).

Based on these analyses we believe that sheep killing behavior by lynx is mainly a result of encounter rates between lynx and sheep. In areas with high sheep densities there are more encounters between lynx and sheep, leading to more sheep kills. However, this may well be modified by the availability of alternative prey, seeing as the chances of killing a sheep was also higher in the areas with extremely low roe deer density. In support of the encounter rate model is the observation that of 15 lynx in southeastern Norway who had access to sheep grazed on fenced (mainly simple sheep fencing) pastures – there was not a single case of depredation documented.

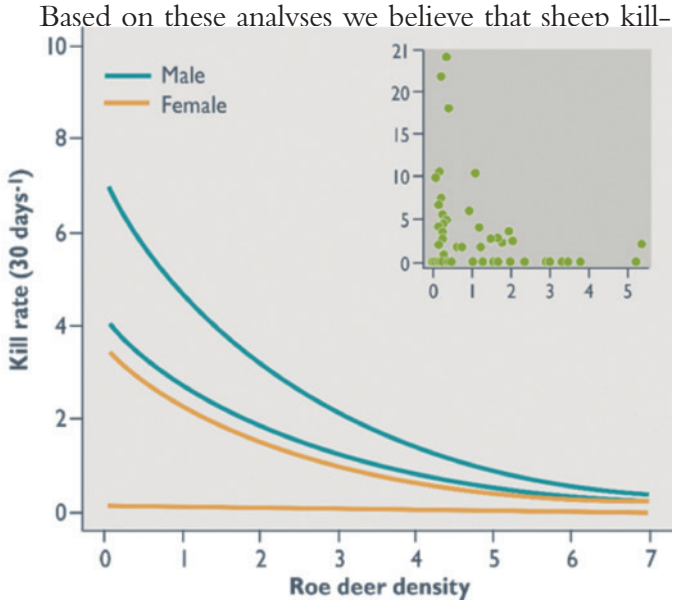

Fig. 3. The impact of roe deer density and sex of lynx on sheep kill rate at high (upper lines) and low (lower lines) sheep density.

Are too many sheep being compensated?

Given a per capita estimate of kill rate and combining it with the annual population census that estimates the size of the lynx population it is possible to estimate the number of sheep killed by lynx each year. We performed the calculation for four of the carnivore management regions where we had collected field data on lynx. For three of the management regions we estimated that on average over the last 18 years managers had paid out compensation for an average of between 2 and 5 times more lynx than we estimated even when using maximum kill rate estimates. In some years the payments were up to 8 times higher than what we esti-

mated as being likely. Only one region appeared to have been making realistic payments. Clearly, lynx have in general been blamed for more depredations than they are responsible for. So, if the sheep are not being killed by lynx, what is killing them? The simple answer is that nobody really knows. In some areas, it could be other large carnivores like wolverines or bears, although this can be excluded in at least one of the regions. The problem is that the original estimates of "normal" loss come from 30 to 40 years ago and much has changed in that period. Red foxes have returned to Norwegian nature after being decimated during the 1980's during a scabies epidemic. The climate is changing, leading to an expansion of tick distribution. A variety of diseases (e.g. Anaplasmosis), poisoning (photosensitivity caused by eating certain plants), and accidents can also kill significant numbers of sheep. If lynx are not killing so many sheep as thought, there is a real need to find out what is happening to free-grazing sheep from both animal welfare and economic points of view. In Norway every summer approximately 130,000 sheep disappear while summer grazing. Even with the large numbers (30,000) being compensated as carnivore kills each year there are still 100,000 deaths that need to be accounted for. The main problem in assigning cause of death is that most dead sheep simply disappear as the husbandry system does not permit the rapid finding and necropsy of animals.

How to limit lynx depredation?

Although our study indicates that lynx depredation is over-estimated there are still substantial numbers (thousands) of sheep being killed by lynx. The current strategy to deal with this has involved using sports hunting to regulate the size of the lynx population. This strategy has succeeded to the point that it has prevented the lynx population from growing and has kept a limit on the numbers of sheep killed, but it has done nothing to reduce the per capita depredation rates (Fig. 4) which is by all estimates unacceptably high.

Any reduction in per capita impact implies that either the sheep will need to be better protected (fencing is the only realistic option in Norway given high labor costs that exclude shepherding) or else there will need to be more effective zoning to separate sheep and lynx.

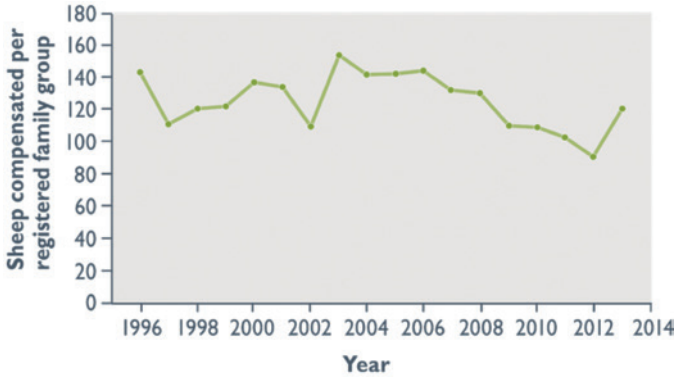

Fig. 4. Annual numbers of sheep for which compensation has been paid relative to the size of the lynx population as measured by number of annual reproductions (family groups).

Zoning is already used in Norway as a central management strategy. On one level it works as it has been used to exclude lynx from the southwestern counties with the highest sheep densities. However, on a finer scale it has not worked because regional managers have not been able to adapt policy to the massive home ranges of Norwegian lynx (from 300 to 2,000 km^2) and have tried to create a too fine scaled mosaic of zones.

A final measure that is needed is to restructure the compensation system. The fact that despite current efforts it is impossible to confirm the cause of death for 90% of the missing sheep indicates that any such ex-post facto compensation system can never produce results with any degree of confidence. Rather than trying to refine the present system we believe that it would be better to move to an incentive based system that removes all requirement to document losses and simply pays an amount scaled to a level that corresponds to what the lynx population in a given area is believed to be responsible for killing. In such a system, the herder who manages to adapt his husbandry and minimize losses will gain a double payment, from both the sale of more lambs to slaughter and from the incentive payment. The present system does not provide any economic incentive to change the form of husbandry.

All of these measures will require a willingness to change on the part of sheep farmers and massive amounts of economic, logistical and technical assistance from the state. At present, there are a lot of funds available for assistance, although most of it is being used on unsuitable measures and is tied up in compensation. However, the willingness to change appears to be absent, at least judging from media reports of statements from the agricultural organisations. However, the consequence of not doing anything is both an unacceptable rate of sheep losses and unsustainable levels of social conflict that are likely to continue indefinitely.

Publications on which this summary is based

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This lynx has been immobilized to equip it with a GPS collar in connection with studies to document rates of depredation on livestock.
Photo: Thomas Strømseth.