

# BROWN BEAR PREDATION ON DOMESTIC SHEEP REGISTERED WITH MORTALITY TRANSMITTERS

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**Abstract:** During 1989, 291 lambs in 3 herds of domestic sheep were tagged with silent mortality transmitters prior to release onto open, coniferous forest range in southeast Norway. Twenty-six lamb carcasses were recovered. Lamb mortality was attributed to disease (19%), accidents (22%), and predation (59%). In addition to the dead lambs, the carcasses of 21 ewes were also recovered. Of these, 20 were attributed to predation. Brown bear (*Ursus arctos*) was the sole predator implicated. Use of silent mortality transmitters was found to be highly effective in the prompt recovery of sheep carcasses in rugged, densely vegetated terrain.

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**Key words:** domestic sheep, brown bear, predation, Norway, *Ursus arctos*.

Norway is the northernmost part of the Eurasian continent, with warm ocean currents and heavy precipitation along the coast. The country is characterized by rugged mountains, stretches of forests, and little agricultural lands. Production based on grass in outlying areas is therefore important, and grazing with sheep has long traditions in the economy of rural societies in these parts of Europe (Mysterud, unpubl. data.). Use of local resources is important both politically and strategically in maintaining Norway's scattered settlement (Mysterud and Warren 1991a). At present, 2.3 million sheep range freely on open range during the summer, tended at regular or irregular intervals (Mysterud and Warren 1991a). Several loss factors prevail, including accidents, predators, disease, husbandry practices, and poaching. The total annual loss is estimated at 100,000 individuals, mostly lambs. The official management authority in Norway (Directorate for Nature Management) attributes 5–10% of the total loss to carnivores. This figure is based on compensation claims for sheep killed by protected carnivores (wolf [*Canis lupus*], bear, wolverine [*Gulo gulo*], and golden eagle [*Aquila chrysaetos*]). Lynx (*Lynx lynx*) was added to the list of protected species in 1992, now lynx kills also will qualify for compensation.

Supposedly, only 5–10% of 100,000 sheep lost are killed; the rest are accredited to other causes. The causes of these remaining losses are, however, not at all clear, and have long been debated. How much is actually attributed to different loss factors? Is it possible to combine a viable population of brown bears with extensive sheep ranging? What will the actual loss rates involve? Bear predation today is found only within the bears' range; their range is limited. The percentage of the total loss attributed to bears is also limited. Locally, however, the damage can be considerable.

To generally and systematically investigate the losses, a mortality transmitter fitted for sheep was developed in

1987 (Mysterud and Warren 1991b), and in 1988 a long-term investigation of sheep mortality began (Mysterud and Warren 1991b, 1992). During 1989, the project worked inside the bears' range in Hedmark in southern Norway. This resulted in the first combined study of mortality transmitter efficiency and predatory behavior of bears on a forested sheep range.

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## STUDY AREA

The study area was Lutnes–Landsjøåsen in Trysil municipality, Hedmark county, Norway (LLT-area). LLT-area is situated in the southeast corner of Trysil close to the Swedish boarder and comprises an area of about 120 km<sup>2</sup>. The landscape is dominated by gently elevated formations around the Trysil River Valley surrounded by large stretches of coniferous forest. Elevation varies between 300 and 700 m. The topography is hilly and in some areas large boulders are found. There are few lakes and some bogs. The LLT-area has a typical inland climate with cold winters, warm summers, and moderate annual precipitation. Annual average precipitation for the Plassen weather station is 720 mm. Forests are dominated by mixed conifers, Norway spruce (*Picea abies*), and Scots pine (*Pinus sylvestris*) intermingled with birch

(*Betula odorata*). There has been considerable logging in the area, and a network of forestry roads is well developed.

## MATERIALS AND METHODS

A total of 316 lambs were fitted with mortality transmitters in 3 herds comprising a total of 266 ewes and 437 lambs (Table 1). In addition 9 ewes, 5 in herd A and 2 each in herds B and C were collared with activity transmitters to study home range use. At the end of the grazing season, an additional 25 ewes were monitored with mortality transmitters.

The main objective was to study herds that had experienced high and poorly documented losses in the past, so-called hidden losses (Mysterud and Warren 1991b). Large herds with enough lambs to absorb a sufficient number of transmitters were selected, 2 of which had experienced bear attacks in the previous years. The herds had to be close to each other to minimize transportation costs, and there had to be a network of forestry roads to facilitate detailed telemetry surveillance.

Transmitters were silent while the animal was active, but they transmitted after animals were motionless for 2 to 3 hours. The transmitters were adapted from American equipment and principles developed by Kolz (1975) and manufactured by the Swedish firm Televilt AB (Storå). Another type, based on the same principle, has been used in an extensive Swedish study of reindeer (*Rangifer tarandus*) calf mortality (Björvall and Frazén 1981, Björvall et al. 1990, Frazén and Björvall 1980).

The mortality transmitters were built on 4 different frequencies and attached to expanding plastic and rubber collars. The rubber part expanded and was made of elastic bands of different length, the outermost the shortest, the innermost the longest. When the outermost rubber band weathered and disintegrated, the collar expanded. When the radiotransmitter was activated, the signal was

picked up by a receiver and a directional Yagi antenna. The direction of the mortality signal was determined and transmitter location pinpointed. Tracking was mainly by car, with bearings taken from several fixed points. The telemetry equipment is standard, and is described in greater detail elsewhere (Mysterud and Warren 1992).

In selecting lambs to be monitored, the general procedure was to select lambs with low survival expectancy (i.e., lambs having the lowest daily weight gain from birth to release on the summer range). Though non-random selection can complicate interpretation, it presumably increases the number of carcasses recovered. In this initial study, documenting as many cases and causes of mortality as possible was important, due to the tentative nature of the study. As a dead lamb was recovered, its transmitter was transferred to a lamb selected at random. All carcasses recovered, both radiocollared and others, were investigated according to routine veterinary and necropsy procedures. Carnivore kill sites were closely searched for signs and tracks to give indication as to the kill behavior and eating patterns. Bite and blows together with any sign of hemorrhage, edema, and trauma were documented through photographs of carcasses and were plotted on body diagrams.

## RESULTS

Of the 291 lambs initially fitted with transmitters, 25 lost their collars during the grazing season (8.9%). They fell off throughout the grazing season, but most were lost from 6 June to 1 July. These were subsequently placed on new lambs (Table 2). Losses of collared and uncollared animals totaled 34 ewes (12.8%) and 38 lambs (8.8%) giving a total loss of 10.3% from the herds (Table 2). Of these, 49 were recovered and examined. Six of the 49 (12.2%) died of disease, 6 (12.2%) were killed in accidents (3 of these were induced by the project), the cause of death in 1 case was unknown, and 36 (73.5%) were

**Table 1. Summary of 3 sheep herds monitored during loss research in the Lutnes–Landsjøåsen study area, Trysil, Norway 1989.**

Herd	Ewe	Lamb	Released on the range		Breed
			Total	Lamb to Ewe Ratio	
A	102	169	271	1.66	Dala, Spel, Dala x Spel
B	52	89	141	1.71	Spel
C	112	179	291	1.60	Spel
Total	266	437	703		

**Table 2. Lost, radiocollared, and noncollared animals in herds A–C in the Lutnes–Landsjøåsen study area, Trysil, Norway 1989.**

Herd	Number of radiocollared animals		Number of collared animals lost		Number of noncollared animals		Number of noncollared animals lost		Total number		Total loss		Loss percent		
	Ewe	Lamb	Ewe	Lamb	Ewe	Lamb	Ewe	Lamb	Ewe	Lamb	Ewe	Lamb	Ewe	Lamb	Total
A	25	135	1	11	77	34	13	4	102	169	14	15	13.7	8.9	10.7
B	0	59	0	3	52	30	8	3	52	89	8	6	15.4	6.7	9.9
C	0	97	0	12	112	82	12	5	112	179	12	17	10.7	9.5	10.0
Total	25	291 <sup>a</sup>	1	26	241	146	33	12	260	437	34	38	12.8	8.8	10.3

<sup>a</sup> In addition to these 291 lambs, 25 more lambs were collared during the summer with transmitters, that had either fallen off or been recovered from dead animals, for a total of 316 radiocollared lambs.

killed by brown bears (Table 3). One lamb fell in to a muddy ditch made by a heavy forest machine, and 2 drowned in water holes. Five lambs were recovered with one leg caught in the collar. Two of these were dead, a third was subsequently slaughtered, and 2 survived with insignificant wounds. These study-induced accidents were 11.1% of the total loss of radiocollared animals. Of the 6 disease losses, 3 lambs died early in the season of coccidiosis and pasteurellosis and one lamb died from tympanites. One ewe had acute mastitis. This animal

was removed from the range and subsequently slaughtered.

On 1 August, the first bear-killed lamb in herd A was located newly killed and eaten. The bear crossed the border from Sweden into Norway on 1 August, as confirmed by track observations on a forest road in the border zone. Its presence had not been noted earlier during the season. On 16 August, the first bear-killed lamb from herd B was located, and on 23 August, in herd C. Predation in all 3 areas was detected by the transmitters, and

**Table 3. Cause of death for recovered ewes (Ewe) and lambs (Lamb) with transmitters (Collared) and without (Noncollared) mortality transmitters in the LLT-area, Trysil, Norway, 1989. Disease-related deaths were in several cases more complex than noted.**

Cause of death	Collared		Noncollared		Total (%)
	Ewe	Lamb	Ewe	Lamb	
<b>Disease</b>					
Thoracic inflammation		3			3
Intestinal infection		1			1
Tympanites		1			1
Mastitis			1		1
Total disease					6 (12.2)
<b>Accidents</b>					
Drowning		2			2
Stuck in muddy ditch		1			1
Equipment related		3			3
Total accidents					6 (12.2)
<b>Carnivores</b>					
Brown bears	1	15	19	1	36
Total Carnivore					36 (73.5)
<b>Unknown</b>					
Decayed carcass				1	1
Total Unknown					1 (2.0)
Total	1	26	20	2	49

apparently nervous and agitated (tightly flocked, highly vigilant) sheep were observed in herd B.

Brown bear preyed on sheep from all 3 herds in the LLT-area during the rest of the grazing season for a total loss of 10.7%, 9.9% and 10.0%, from herds A, B, and C respectively (Table 2). Loss to other predators was not documented, although carcasses were also used by red fox (*Vulpes vulpes*) and raven (*Corvus corvus*). Consumption of the carcasses was in a majority of cases considerable. Large quantities of meat were quickly consumed. In a few cases, only small parts of the animal were eaten or the animal was cached more or less untouched. The total loss attributed to bears was 20 ewes and 16 lambs. Cause of mortality was unknown for 12 ewes and 12 lambs. By assuming the same distribution of mortality factors among known and unknown losses, bear are estimated to have removed a total of 29 ewes and 25 lambs from the herds. This constituted 10.9% and 5.8% of the total number of ewes and lambs, respectively. Further, bear killed twice as many male as female lambs, despite herd sex ratios which were approximately 50/50.

Most lambs were killed by bites to the neck and head. The killing pattern was more or less stereotypical, implicating a single bear. An exception was an incident August 24 on Borveggen, where the killing technique was the same for the 3 animals, but was distinct from the rest. The kills were made in a variety of forested habitats, and carcasses were often dragged a considerable distance to cover. At many of the kill sites there were resting beds made by bear, and signs indicating different bedding, feeding and marking behavior.

The use of mortality transmitters to locate fresh kills and hence bear positions was so efficient that sheep owners were asked by project leaders not to carry rifles when assisting project personnel during surveillance with mortality transmitters. This was to prevent possible conflicts of interest between the study and herd owners if a bear happened to be sighted near a carcass.

In several cases bears, red foxes or ravens prevented transmitter activation by pulling or moving carcasses. This made it difficult to judge the age of carcass and whether the amount eaten by bears was consumed during >1 visit to the kill.

## DISCUSSION

The silent mortality transmitting technique (SMTT) proved to be a highly efficient method in locating freshly killed carcasses. Experience from a series of earlier Norwegian studies has shown that carcasses are often found only as old remains, which provide poor qualitative in-

formation (Mysterud and Warren 1991b). As demonstrated here, early kill site inspection, while the signs of activity are still fresh and readable, was important for the study of bear behavior. We thus recommend SMTT to allow efficient documentation of losses and carnivore activity in any area where bear predation occurs and where there is disagreement about loss characteristics.

Predation by brown bear was the cause of death for a majority of the carcasses recovered, especially during the latter half of the season. Because of the study's non-random selection procedure, it is uncertain whether mortality due to predation, and other factors, has been representatively estimated. It may be reasonable to assume that mortality and its respective causes were overestimated, since (presumably) weaker lambs were collared. The predation pressure by bears, however, is greatest on larger lambs and on ewes (Mysterud 1975, Warren and Mysterud 1995). Thus, while accident and disease-related mortality is probably more likely among weaker animals, it is possible that bear-related mortality is not, and has therefore not been overestimated in this study. The strategy of selecting small lambs, or only lambs, for radiomonitoring should be avoided where bears are the main predator; instead lambs should be selected at random, and ewes should be monitored to estimate loss of adult animals. Our SMTT-monitoring of ewes in the LLT-area was undertaken too late in the season to give a representative loss sample, though bears commonly take a higher proportion of ewes than lambs (Mysterud 1975), which was the case in the LLT-area. Although nothing should be generalized from the LLT-area survey alone, bear displayed a very persistent and efficient use of the sheep as a food resource. This is despite healthy populations of moose (*Alces alces*) and other potential natural food species in the area.

The loss to bears in this study is comparable to recent high losses reported from domestic reindeer in a Swedish SMTT study (Björvall et al. 1990). In this study, losses to carnivores, mainly lynx and wolverine, comprised 50-75% of the total mortality. The LLT-sheep loss percentage is also comparable to losses in wild ungulate populations attributed (mainly) to wolves and bears (Linnell et al. 1995). The LLT-survey might provide a first indication that claims from sheep herders of high losses to bears in some areas are correct.

There seems to be no simple relationship between loss size (damage pressure) and overall density of bear populations; there are so far no data from Norway to document this. Loss size seems to vary with several factors, and extreme food selection and surplus killing have been reported from some areas (Mysterud 1975, 1979, 1980),

whereby few bears may lead to considerable losses of sheep. Damage pressure, however, is an important sociological factor. In Norway, when damage pressure increases calls for problem bear removal quickly become politically acute (Mysterud 1977).

Densities calculated on the basis of recent Norwegian population figures (Kolstad et al. 1986) for some of the largest, presumably high-quality bear areas (i.e., areas which are ecologically equivalent to those in Sweden which support high densities) indicate that bear densities in Norway are among the lowest densities documented. Whether this is due to underestimation of populations, actually poorer habitat, or to illegal killing is not known (Mysterud and Muus Falck 1989). Lack of habitat is not viewed as a key factor for bear population development in Norway, however (Kvam et al. 1990), and it is unlikely that food shortage is a limiting factor. In some smaller areas, however, such as Vassfaret, Elgmork (1978) argued that human disturbance through extensive logging, road building, and large-scale tourism with the construction of holiday cabins has been detrimental to bear habitat and has affected the local bear population.

The low bear density in Norway stands in contrast to that in ecologically comparable habitat on the Swedish side of the border. The density of domestic sheep in Sweden is, however, considerably lower than in Norway. Sweden has only 400,000 sheep, and they are not free-ranging. We suggest that it is the loss pattern (i.e., damage pressure on domestic sheep and reindeer) in Norway that is responsible for the low bear population density. When predation pressure becomes severe and legal removal of bears is not undertaken according to law allowing defense of life and property or during official hunts, covert and illegal removal of bears may result. Populations are therefore not allowed to increase on the Norwegian side of the border. Damage pressure provides a constant, sociopolitical population sink. Surviving individuals are extremely shy, and covert removal in what has been termed populist management is very difficult to detect and investigate (Mysterud 1992). Even persons that actually shoot bears legally may not openly admit it due to harassment from the mass media or by conservationists. Several persons that have recently shot bears or wolves in Norway have been seriously threatened. Conflicting views in many local bear areas on loss size and characteristics is of utmost importance for bear survival. Local people claim to experience much more to elucidate circumstances surrounding such losses (Mysterud 1992). Detailed insight is also necessary to evaluate whether viable population of bears and extensive sheep ranging can be combined under present Norwegian conditions.

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