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Mortality Transmitters – New Instrument for Animal Loss Research on Norwegian Ranges

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Mysterud I. and J. T. Warren: Mortality transmitters – new instrument for animal loss research on Norwegian ranges. Acta vet. scand. 1991, 32, 415–424. – In 1988, 315 lambs from 4 sheep (*Ovis aries*) herds comprised of 1003 animals were marked with silent mortality transmitters in Gammeldalen in Hedmark County, southern Norway. The aim was to identify causes of death and the so-called "hidden loss" of lambs on summer range. A total of 22 animals, 19 lambs and 3 ewes were found dead. Of these, 18 lambs were marked with radio transmitters. A total of 10 animals died of disease (45.5 %) and 12 were killed by predators (54.5 %). Of the 18 radio-located lambs, 6 died of disease (33.3 %) and 12 due to predators (66.7 %). Various common lamb diseases were diagnosed, e.g. lung, thoracic and intestinal infections. Eleven lambs were killed by lynx (*Lynx lynx*), a 12th was found chased to exhaustion, presumably by a predator. Use of mortality transmitters is concluded to be useful in investigating sheep losses on Norwegian ranges.

sheep mortality; radiotelemetry; sheep summer range; predation on sheep; lynx (*Lynx lynx*).

Introduction

Domestic sheep (*Ovis aries*) are locally important to the rural economy in Norway. Each year approx. 2.2 million ewes and lambs are released onto open range. Grazing of small stock on open ranges invariably leads to losses, and a number of investigations into the causes of these losses have been carried out in the last 30 years (*Safford & Hoversland* 1960, *Balser* 1974, *Henne* 1977, *Nass et al.* 1984, *Scrivner et al.* 1985). Predation on sheep by large carnivores is the biggest problem in some areas in Norway (*Myrberget* 1969, *Mysterud* 1979). Areas in which wolf (*Canis lupus*), wolverine (*Gulo gulo*), bear (*Ursus arctos*), and lynx (*Lynx lynx*) kill sheep have all been studied (*Sørensen & Kvam* 1984). Such studies are sometimes widely reported in the media. Less is known about losses due to accidents, disease and poaching. Losses with unknown cause, so-called "hidden loss", constitute by far the largest part of the total loss, and are locally a serious problem.

Norwegian ranges are difficult to survey. They are rugged and often forested with a dense understory, making it difficult to locate carcasses in time for necropsy. Investigations have shown that losses increase with forest density and range ruggedness (*Dorrance* 1982, *Nass et al.* 1984). Sheep loss studies in open areas have shown that it is here most carcasses are found (*Klebenow & McAdoo* 1976). The critical phase in loss investigations is the efficiency with which dead animals are located (*Henne* 1977). Carcasses of most animals that die on the range are never found, however. Experience from a long series of Norwegian studies has shown that carcasses are often found only as old remains which do not provide qualitative information (*Aasberg* 1982, *Brøderud* 1982). Of 107 animals missing on a range in Sogn and Fjordane, causes of 81 deaths (75.7 %)

could not be determined (*Hustveit* 1981). In a more intensive investigation in Grane, Nordland County in 1984, the loss of 213 lambs of a total of 233 (91.8 %) was attributed to unknown causes (*Fylkesmannen i Nordland* 1985). A corresponding figure for 1985 was 70 of a total loss of 78 lambs (89.7 %) (*Sørvig* 1985).

"Hidden losses" in Norway have been a topic of discussion for many years. In 1988, a 3 year project was initiated which, through the use of radiotelemetry, was designed to reveal the causes of the "hidden losses" of free ranging lambs. A description of methods, choice of study area and the first results are presented here.

Materials and methods

During 1987, sheep-loss statistics for Hedmark County were studied to locate representative areas having substantial "hidden loss". Gammeldalen near Tynset in the northern part of Hedmark County was selected (Fig. 1). This area had an average lamb loss during the period 1983–87 of about 12 %.

Gammeldalen is a typical U-shaped valley with scattered grazing chalets. The grazing area of approx. 120 km^2 is characterized by great topographic variation. Altitude varies from 600 m on the valley floor to 1318 m at Storkletten. The study area has an inland climate with cold winters, mild summers and low annual precipitation (350–400 mm).

The flora in the lower parts of Gammeldalen is predominately Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) forest intermingled with birch (*Betula odorata*). At higher elevations, birch occurs in pure stands. The understory is dominated by blueberry (*Vaccinium myrtilus*) shrub, often with small fern species. In moist areas the vegetation can be luxuriant. Logging in some areas has been extensive, and on clearcuts and other open areas hairgrass (*Dechampsia flexuosa*) dominates the ground vegetation. Above the tree line crowberry (*Empetrum* spp.) dominates moister sites; lichens (*Cladonia* spp.) are common on drier sites.

Four herds, all of which have experienced considerable lamb loss in recent years were chosen. The herds consisted of a total of 1003 animals, 350 ewes and 653 lambs. Three hundred and fourteen lambs were fitted with silent mortality transmitters (Televilt, Storå, Sweden). This transmitter is silent while the animal is active, but transmits after 2 to 3 h of motionlessness (*Kolz* 1975).

Three hundred transmitters on 4 different frequencies were built and attached to plastic collars (Fig. 2). An expansion mechanism was developed, with elastic bands of different lengths, the outermost shortest, the innermost longest. As the outermost band weathers and disintegrates, the collar is meant to expand.

When the radio transmitter is activated the signal can be picked up using a receiver and a directional Yagi antenna. The direction of the signal source can be determined and transmitter location pinpointed. In addition to the lambs collared with mortality transmitters, 12 ewes were tagged with standard transmitters. This was done in order to follow the daily movements of the sheep throughout the area. Tracking was mainly be car, with bearings taken from several fixed points. The equipment used has been described in greater detail by *Mysterud & Warren* (1987).

In selecting lambs, we wished to single out those animals with the lowest survival expectancy. Mortality transmitters were thus attached to the 300 lambs having the lowest daily weight gain from birth to release onto summer range. As a dead lamb was recovered, its mortality transmitter was transferred to a new lamb, selected at random.

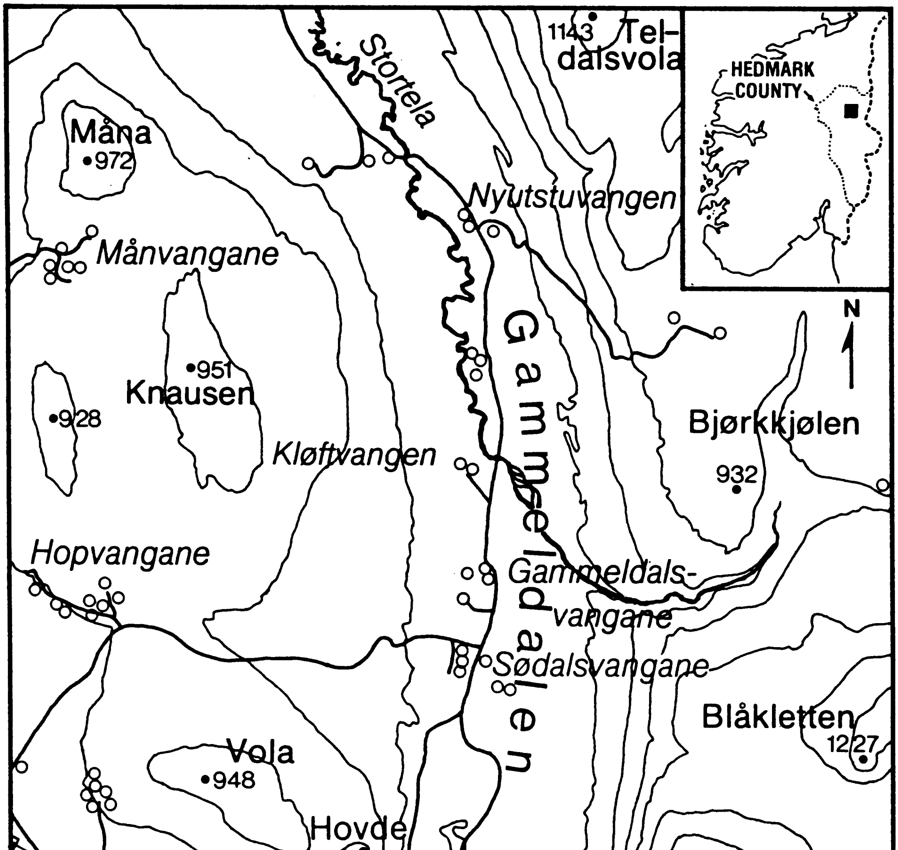

Figure 1. The Gammeldalen study area near Tynset in Hedmark, southern Norway.

All carcasses, both radio-instrumented and others were examined. Standard veterinary procedure was employed in those cases involving diseased animals. Animals killed by predators were examined according to necropsy methods developed in past carnivore field research (*Mysterud* 1984).

Results

A total of 314 lambs were instrumented or re-instrumented with transmitters in 1988 (Table 1). Of these, only 2 animals lost their transmitters (0.6 %). They fell off on June 18 and July 4, respectively 1 and 21 days after attachment. One lamb was found with the transmitter's antenna caught in vegetation. Veterinary examination showed that this lamb had died of enteritis. The expansion mechanism in the collars did not function properly, as the elastic bands did not weather as expected.

Total losses in the herds during the grazing season were 27 lambs and 7 ewes. Of these, 19 lambs and 3 ewes were found dead and examined. The first carcass was found on June 14, shortly after the sheep were released; the last on August 30 (Table 2). Carcasses were found throughout the entire study area, but were mostly concentrated about the chalet areas in the valley (Fig. 3).

A total of 10 animals succumbed to disease (45.5 %), and 12 were killed by predators (54.5 % (Table 2). The 3 ewes all died of mastitis. Among the diseased lambs, various common diseases were diagnosed. Eleven lambs were taken by lynx, while a 12th (No. 9/88) was driven to exhaustion and subsequent death, presumably by a predator. The veterinary diagnosis was acute cardiovascular collapse (Table 2).

Diseased animals were found on or near the chalet complex in the valley bottom, and on the west slope. The distribution of lambs taken by predators was much wider, from

Table 1. Loss of animals in herds A-D in the Gammeldalen study area, Tynset, southern Norway.

Herd	Number of animals fitted with radios		Number of radio-fitted animals lost		Number of animals without radios		Number of animals without radios lost		Total number		Total loss		Loss percent		Total
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	
A	3	97	0	7	88	88	4	3	91	185	4	10	4.4	5.4	5.1
B	3	68	0	7	101	131	2	3	104	199	2	10	1.9	5.0	4.0
C	3	74	0	2	88	82	1	2	94	156	1	4	1.1	2.6	2.0
D	3	75	0	2	61	38	0	1	64	113	0	3	0.0	2.7	1.7
Total	12	314	0	18	338	339	7	9	350	653	7	27	2.0	4.1	3.4

Table 2. Carcasses recovered in the Gammeldalen study area, Tynset, southern Norway.

Carcass No.	Date	Age	Cause of death
1/88	17.06	lamb	Sepsis
2/88	14.06[1)]	lamb	Enteritis
3/88	20.06	lamb	Pleuropneumonia
4/88	25.06	2 yrs	Mastitis
5/88	29.06	lamb	Lynx
6/88	29.06	lamb	Probable lynx[2)]
7/88	29.06	lamb	Probable lynx[2)]
8/88	30.06	lamb	Lynx
9/88	01.07	lamb	Chased by unknown agent, presumably predator, development of acute cardiovascular collapse
10/88	03.07	4 yrs	Mastitis
11/88	06.07	lamb	Lynx
12/88	13.07	3 yrs	Mastitis
13/88	14.07	lamb	Lynx
14/88	15.07	lamb	Uremia; nephritis
15/88	21.07	lamb	Pericarditis
16/88	21.07	lamb	Pneumonia; enteritis
17/88	22.07	lamb	Lynx
18/88	23.07	lamb	Enteritis
19/88	23.07	lamb	Lynx
20/88	31.07	lamb	Lynx
21/88	26.08	lamb	Lynx
22/88	30.08	lamb	Lynx

1) Recovered by owner 14.06, registered 17.06.

2) Carcass bitten in throat area; original wounds not visible. Lynx scat found, typical bone handling and eating pattern noted.

Måna in the very north of the study area, to Kvitkuven in the south (Fig. 3). Several carcasses were found within 1 km of each other and were apparently killed within the same time period, perhaps by the same individual. Lynx began killing lambs in the area at the end of June. The 1st find was made north of Vola (Fig. 3). Here, 2 lambs were mistakenly left lying too long, and were completely consumed. Cause of death could therefore not be established with certainty. Lynx excrement found close to 1 carcass, and the manner in which the remains of both were handled, however, implied that these were eaten and therefore presumably killed by lynx (Table 2). All other lambs were recovered fresh.

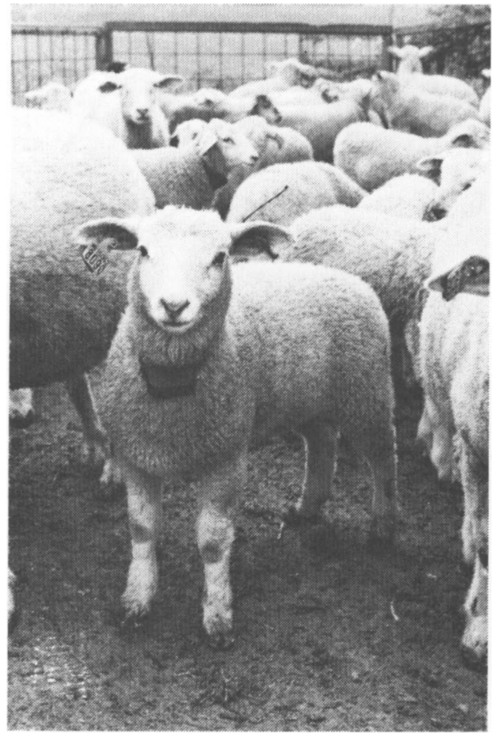

Figure 2. Mortality transmitter fitted just prior to release.

Other carcasses were eaten to a varying degree immediately after they were taken. Bites and skin punctures were found on the head, throat, forlegs, thighs and at or near the anus. One animal was killed, but not eaten. Lamb 21/88 appeared completely untouched, no bite marks were visible and no trace of external bleeding was found. Examination revealed however widespread hemorrhage in the throat area, and the trachea was punctured.

A distinct pattern of throat biting and pre-

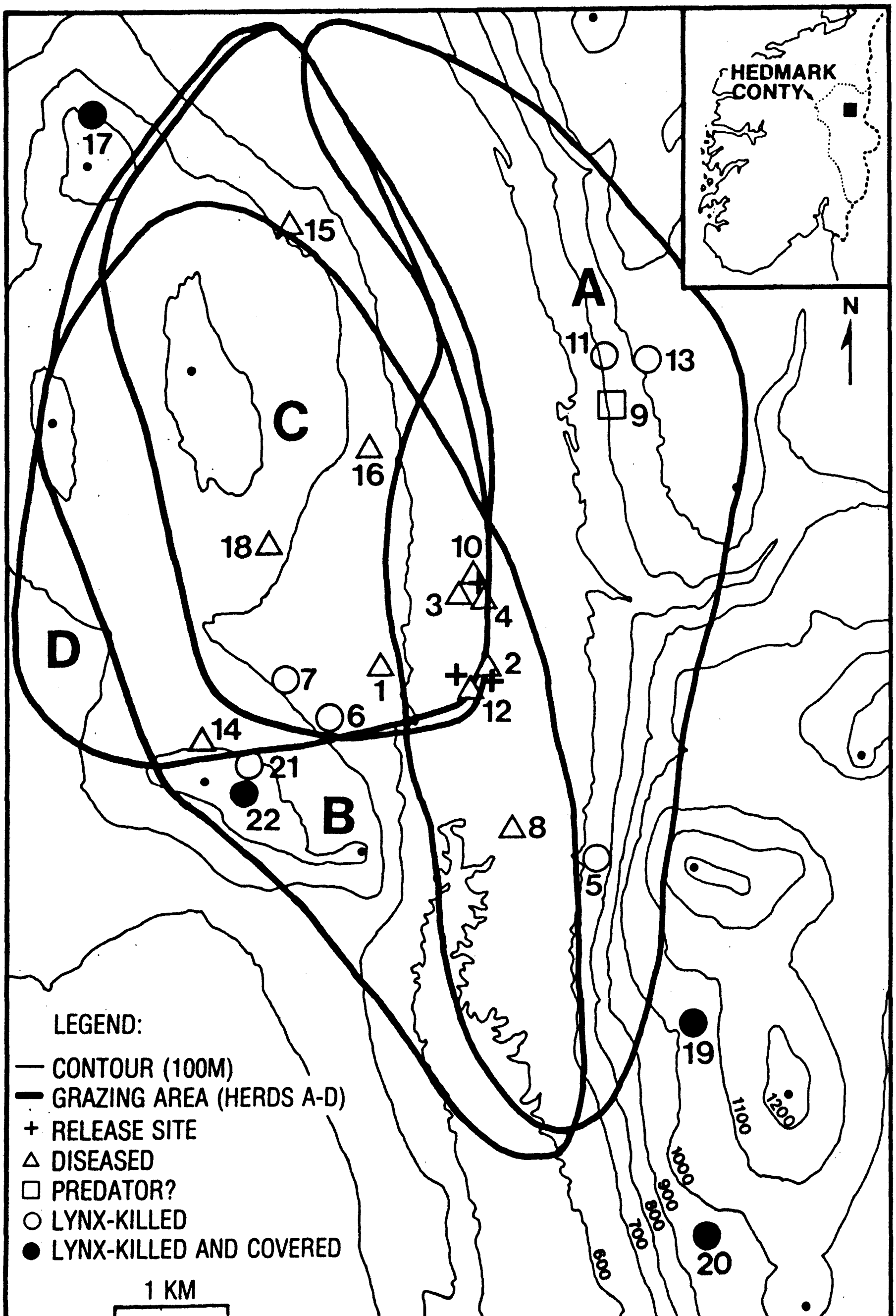

Figure 3. Location of diseased (triangle) and predator-killed animals (circle) in the Gammeldalen study area, Tynset 1988. Normal grazing areas for herds A-D (solid lines).

Table 3. Lambs killed by predators, Gammeldalen study area, Tynset, southern Norway

Carcass No.	Date	Sex	Weight (kg) in spring	Weight kg[1]) at death	Bites	Sign Excrement	Sign Covering
5/88	29.06	M	7.5	5.7	+	–	–
6/88	29.06	F	10.0	(1.2)	+	–	–
7/88	29.06	F	10.0	(0.2)	+	+	–
8/88	30.06	F	9.0	(9.0)	+	–	–
9/88	01.07	M	7.5	(7.5)	–	–	–
11/88	06.07	M	5.0	(7.5)	+	–	–
13/88	14.07	M	6.0	(9.2)	+	–	–
17/88	22.07	F	11.0	(25.0)	+	–	+
19/88	23.07	F	12.0	(21.0)	+	–	+
20/88	31.07	M	11.0	(15.5)	+	–	+
21/88	26.08	M	9.0	27.0	–	–	–
22/88	30.08	M	12.0	(32.0)	+	–	+

[1]) Lambs were consumed to varying extents, incomplete carcass weights given in brackets.

ferential feeding was noted repeatedly on the lynx-killed lambs. Four of the lambs killed were partly covered with moss and litter scraped from the ground around the carcasses (Table 3). In 2 cases in which the animals had been killed and torn apart, even the discarded organs and bones were covered.

Discussion

The mortality transmitters made possible a continuous study of lamb mortality in the 4 flocks in the study area, and proved to be an excellent technique in identifying losses on summer ranges. By marking the poorest lambs, 66.7 % (18 of 27) of the lambs that were lost during the season were recovered for necropsy. Average lamb mortality in the 4 herds cannot be considered abnormally high (3.9 %), however. Mortality among ewes in the studied herds was normal for Norwegian sheep ranges (2.0 %).

Most diseased lambs succumbed in the early summer, 3 of them in the first days after release. This was expected since it is in the first, stressful part of the grazing season that the animals' resistance is lowest.

The first losses to lynx occurred a week after the sheep were released. Further losses occurred at irregular intervals, mostly in the first half of the grazing season. Lamb mortality declined in August and September. This finding is similar to that of other studies which has shown that predation is greatest in the spring and early summer, when predators have young (*Nass et al.* 1984). It is not possible to assess fully the lynxs' utilization of sheep flocks in the region based only on losses sustained in these 4 herds. There are also herds in the surrounding areas. Several herds grazing east of the study area have reported considerable lamb loss in 1988 (*Erling Semmingsen*, pers. comm.). The reasons for this are unknown.

The lambs killed by lynx in the study area were located in or near steep, inaccessible terrain. They were killed 1 or 2 at a time, often 1–3 days apart, followed by a period without mortality. The animals were usually killed at night. No signs of a chase were noted, nor was nervousness or restlessness noted among other sheep. Lynx were neither heard nor seen by the owners or project personnel and no tracks were found. Only through studies of carcasses and their immediate surroundings could cause of death and predator species be identified.

Covering of carcasses with litter and moss is known for several predator species, including lynx (*Bjärvall & Franzen* 1981). Covering might influence competition from ravens (*Corvus corax*) and golden eagles (*Aquila chrysaetos*) which sight carcasses from the air. It also reduces odor from the carcass which can attract scavengers. It may also physically prevent insects from laying eggs in the carcass (*Mysterud* 1973). Covering also makes the carcass difficult to find for sheep owners patrolling the range.

The owners and a paid shepherd, who kept regular watch over the sheep in the area, located only 1 of the 3 ewes, and a diseased lamb. Lynx therefore inflicted the 4 herds a subtle "hidden loss" of lambs which proved impossible to reveal without mortality transmitters. Several investigations have previously demonstrated that predation on young animals is indeed difficult to uncover (*Nass et al.* 1984).

The total loss in the study area herds was less than expected based on the recent years' losses. It has been speculated as to whether the chronically high losses could be the result of poaching (*Henning Sandmæl,* pers. comm.). Examples of poaching have previously been documented (*Per Oldertrøen,* pers. comm.). The project and subsequent media coverage can have had a preventive effect. In studies in Spekedalen, Hedmark (*Lutnes & Paus* 1981) and Grane in Nordland, lamb mortality also declined in wake of mortality studies (*Fylkesmannen i Nordland* 1985, *Sørvig* 1985). However, there are other factors that may have influenced the extent of losses in the study area. During the winters 1986–87 and 1987–88, 4 lynx were shot in the region, 2 just south of the study area (*Henning Sandmæl,* pers. comm.). Isolated forested valleys and mountainous terrain in the Tynset-Alvdal region seem to provide excellent habitat for lynx. Local shooting of these animals can influence losses of the type documented in the study area. Studies in Alaska suggest that lynx numbers adjust relative to number of lynx present and not to prey density (*Kesterson* 1988). This means that if local lynx were shot so that their density decreased, the remaining lynx may increase their home range size. In the study area, this could result in lamb loss being dispersed over a greater area. The 4 lynx shot, however, were all juvenile or subadults (*Henning Sandmæl,* pers. comm.), so that the chance of such effects in the study area is presumably slight. Overall losses in the region were also generally lower than in recent years (*Ola Jordet,* pers. comm.). It must be stressed though, that great annual variations in predation rates are common (*Nass et al.* 1984).

Disease among lambs can vary greatly from year to year with climate. Cold, damp weather during, and just after the onset of the grazing season can make it difficult for lambs to adapt to the range. The owners reported good lamb performance in 1988, which may suggest that the seasonal production was high. Because of this, loss due to disease might have been minimized.

Due to delay in equipment delivery, the sheep were kept on local pastures for up to a week longer than normal. This may have improved the starting point for the weakest lambs and led to a reduction in lamb loss in the first part of the season. Early fall herding, necessary to reduce carcass cesium from Chernobyl fallout, may also have contributed to reduce lamb loss at the end of the grazing season.

It is not possible to apply the results presented here to sheep ranges in other part of Hedmark. Greater knowledge of geographic and annual variation on lamb mortality is necessary. Mortality transmitters, however, proved to be a valuable tool, well suited for loss studies on Norwegian summer ranges.

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Sammendrag

Dødelighetssendere – nytt verktøy for tapsundersøkelser på norske utmarksbeiter.

I 1988 ble 315 lam fra 4 besetninger av sau (*Ovis aries*) på til sammen 1003 dyr merket med "tause dødelighetssendere" i Tynset, Hedmark fylke, Norge. Målsettingen var å belyse dødsårsaker og kartlegge "mørketap" av lam på utmarksbeiter.

I alt 22 dyr, 19 lam og 3 søyer ble funnet døde. Av disse var 18 radiomerket. Dødsårsak ble fastslått i hvert tilfelle. Totalt døde 10 dyr av sykdom (45.5 %), 12 ble drept av rovdyr (54.5 %). Av de 18 radiomerkede lam døde 6 av sykdom (33.3 %) og 12 ble drept av rovdyr (66.7 %). Flere vanlige lammesykdommer ble påvist (f. eks lunge-, brysthinne- og tarm-infeksjoner). Elleve lam ble drept av gaupe (*Lynx lynx*), et tolvte ble funnet sprengt.

Bruk av "taus dødelighetssender" er en velegnet teknikk for tapsundersøkelser av sau på utmarksbeiter.

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