Movements of tagged and radio-instrumented wild reindeer in relation to habitat alteration in the Snøhetta region, Norway

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Abstract: In winter, 1981, 103 reindeer, out of a population of 3600, were herded into a fence by snowmobiles and marked. During the next 4½ years reindeer were followed from the ground, or by radiolocations from an airplane. On the average one animal was tagged per 42 animals in any group. A total sample of 175 locations in all seasons indicated that snow conditions, traffic on a road lying parallel to a railroad, and the damming of a lake significantly affected annual distribution as compared with expected modern as well as prehistoric distribution.

Keywords; reindeer, movements, habitat alterations, demographic effects.

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Introduction

Previous to and during the nineteenth century a single herd, called the Dovrefjell herd wintered in the Rondane and Knutshø region, and moved westward to the Snøhetta region for calving and summer pastures (Skogland and Mölmen, 1980). During the early years of the nineteenth century overshooting had reduced all wild reindeer herds in Norway to a very low level, resulting in 5 years of hunting prohibition. Subsequent to this period, herds increased again and hunting was resumed. By 1920 the Dovrefjell herd had again been severely depleted, perhaps to a few hundred animals in Snøhetta in the fall of 1920 (see Skogland, 1977). In the period 1920-1926 a railroad was built across the migration route (see map in Skogland and Mölmen, 1980) to the fall-winter range in Rondane. At the time of hunting (late August, early September) reindeer were usually found in the central and western parts of Snøhetta and were not shot in any large numbers near the railroad. One might argue that lead animals coming to traditional crossings are the first to be shot so that the crossing tradition is shot out. Since hunting licences are tied to land ownership and many land owners in five municipalities are involved, hunting is distributed relatively even over the entire area. This tends to minimize the shooting out argument. During the construction period no animals were reported crossing eastwards. After the completion of the railroad, during the 1920s, the herd slowly recovered from its low numbers of 1920, probably due to the controlled hunting program that had been established.

During the second World War hunting was prohibited, and the herd increased west of the transportation corridor, reaching more than 8000 individuals in 1950 (Holaker, 1955). By this time, a year-round road, parallel to the railroad track, had also been completed. By the winter of 1956 the herd on the *west* side of the corridor numbered about 15000 head (Holaker, 1955). Starvation was found that winter, the harshest on record (with 250% of normal snow accumulation; meterorological records of Norway), and

several hundred animals starved to death (Holaker, 1957). The lichen mats were completely denued (Nordhagen, 1963; Gaare, 1968), and about 2000 animals finally crossed the railroad and road (P. Holaker, pers. comm.). A reduction-shooting program was undertaken to prevent mass starvation on the west side of the corridor, and by 1965 the herd had been reduced to a few thousand (Krafft, 1965).

Since 1971 the herd had been slowly increasing from 1200, to a maximum of 3500 head in the winter of 1981. During the 16-year period, a few to several hundred animals crossed the railroad and highway occasionally or even every winter. In the winter of 1972 - 73 a few hundred adult females failed to return across the transportation corridor, presumably because the Driva river opened up a month earlier than usual. They stayed and calved in the Knutshø region (P. Holaker, pers. comm.), and formed what is now called the Knutshø herd, which today numbers 1000 wintering head. They live on superfluous winter pastures and similar summer pastures as compared to Snøhetta, and attain record size (see Skogland, 1983), whereas the Snøhetta deer are still suffering from the effects of winter range overgrazing.

In the period of population reduction in the 1960s the recruitment rate of reindeer in the Snøhetta area was down to about 20 calves/100 does, and body size was smaller than it is today. The lichen mats in Knutshø today have a mean of 600 g DM (dry matter)/m^2. In Snøhetta in the early 1960s it was about 25 g DM/m^2. It has slowly been restored to about 100 g DM/m^2 by the present time (Skogland, 1983, 1985).

The recruitment rate and body size of Snøhetta reindeer vs. the Knutshø reindeer have been followed for over a period of about 10 years (Skogland, 1985). The mean calf/doe ratio in Snøhetta was about 38 calves/100 does $\geq$1 yr, whereas the ratio in Knutshø has been about 62/100 (Skogland, 1985). Body size (dressed weight) for adult does $\geq$3 yr in Knutshø was about 46 kg, compared to about 32 kg in Snøhetta (Skogland, 1983), and represents a rather spectacular demographic effect. The size of Snøhetta reindeer was similar to present-day Knutshø reindeer in the 1950s before the overgrazing took place (Hjelmeland, 1981). The

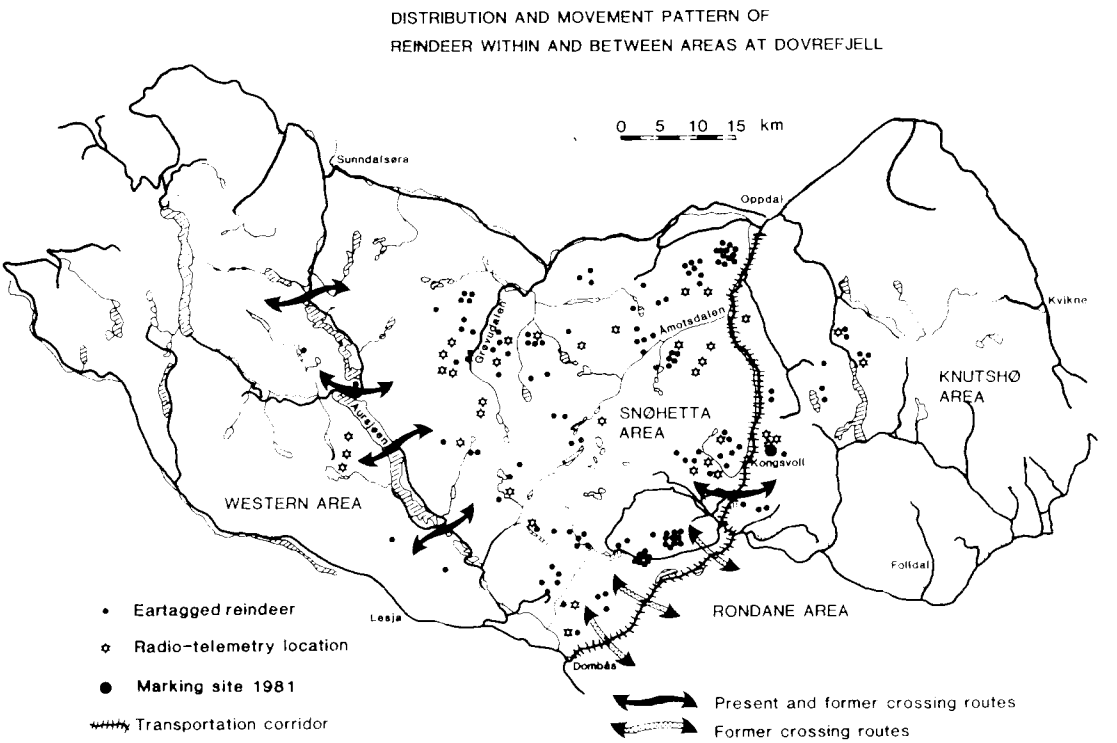

Fig. 1. The distribution of ear-tagged and radio-collared reindeer in Snøhetta - Knutshø 1981 - 85. Roads are shown by a dark line.

lower calf productivity in Snøhetta after this period is due to worse feeding conditions in Snøhetta compared to Knutshø during gestation with subsequent higher calf mortality (Skogland, 1984, 1985).

In the period between 1955 and 1965 a hydroelectric dam was constructed in the western part of Snøhetta. The shores of two lakes, Aursjøen and Torbu, were raised by 28 m (Fig. 1). An access road, two hydroelectric power lines, and an increasing number of cabins for recreational purposes were established along the access road. The two flooded lake valley floors interfered with the lowest altitude portion of the previous calving area, and flooded the seasonal routes of reindeer movement to the western early spring and summer pastures. After dam construction had been completed, a marked drop in use of areas to the west of the lakes was noted, and calving shifted to the east (Skogland and Mölmen, 1980; Skogland *et al.*, 1981).

In order to be able to quantify the effects of habitat alteration on the access to calving — summer range in the western area (Snøhetta), as well as to the winter range in the east (Knutshø), a program of tagging reindeer was initiated. The hypothesis tested was that habitat alteration, in the form of flooded valley floors, and an all-weather road and railway acted as barriers to free passage of reindeer along long established, prehistoric access routes between seasonal habitats.

Methods

The winter of 1981 was as hard as the winter of 1956 and there was evidence of some starvation on the Snøhetta side of the transportation corridor, and 44% of the Snøhetta herd, about 1600 animals, crossed into Knutshø.

About 150 of a group of 600 of these reindeer was herded by snow mobiles into a 2 m high fenced corral where 103 were eartagged and 3 of them also fitted with radio collars. An equal number of both sexes were tagged. About 2.9% of the total population of 3600 wintering reindeer in 1981 was tagged.

After tagging, the animals were followed on the ground and by telemetry locations from a small airplane fitted with receiving antennas on the wings.

Results

During the regular hunting season following tagging, 23 tagged reindeer have been shot by hunters. Included in this number are two of the three radio-collared does (one shot in 1983 and one shot in 1984), while the last one was still transmitting by mid May 1985. A total of 175 relocations representing about 80% of tagged reindeer were recorded, 37 of which were of the three radio-collared females (Fig. 1).

Social dispersal

During the first year following tagging, an attempt was made to record the dispersal pattern of individuals from the winter aggregation in Knutshø. After release the animals stayed in Knutshø until the spring return to Snøhetta during the end of April 1981. During the following year I recorded in Snøhetta an average of one marked individual for evey 42 animals ±9.42 SE, n=58 groups). The mean group size in Snøhetta was 77 animals (Skogland, 1977).

Movments to the western area during spring and summer

During the period following tagging, the mean population size in Snøhetta was 2800 wintering reindeer and 3500 animals after calving (Skogland, unpublished data). During the period after marking, only 8 tagged animals including 4 radio-locations were recorded in the area west of Aursjøen.

A total of 175 observations of tagged or radio-collared animals were recorded in the period following tagging. Out of these five were from animals wintering in Knutshø, and eight from the summer range in the western area. Thus, in the western area about 4.6% of all observations (or 140 animals of the total herd of 3500) were recorded. Annual ground counts from the western area carried out since 1975, have yielded from 130 — 170 animals annually in this area, indicating that the proportion of recorded tagged individuals in this area corresponds to the proportion of the total herd distributed east and west of the dammed Aursjøen area.

Out of the recorded animals in the western area, only 20% were does with calves. A maximum of 10 calves has been counted in any summer since 1975. Thus, the previous calving and summering in the western area has, to a large extent, been relocated further to the east.

Previous distribution patterns have not returned after a period of 21 years following the completion of the dam.

Movements to the winter range in Knutshø

During the period 1976 — 85 I have recorded the annual crossing of the transportation corridor, as far as possible. The historic or traditional crossing places were used. In 1977 recording was made impossible by incessant poor weather conditions. In Fig. 2 I have plotted the proportion of the Snøhetta herd which crossed in relation to the percentage snow accumulation in the first part of winter at which time they normally crossed. The data suggest that there is a positive correlation between snow condition, as influencing foraging conditions, and the chance of crossing the corridor to obtain better food ($r=0.64$, $P<0.05$).

During the years following tagging, 44% in 1981, 5% in 1982, and no animals in 1983, 1984 and 1985 crossed the corridor. In 1982 one radio-collared and five tagged animals crossed. In the 3 following years no tagged animals crossed. The distribution of tagged reindeer thus complements the distributional pattern of the herd in general, both during winter and summer. On approaching the transportation corridor, groups were usually frightened back from distances of 100 — 300 m. This usually led to flight up to ½ — 1 km away. Flight releasers were usually moving cars or trains. Most crossings occurred at night when traffic was minimal.

Table 1 shows the distribution of observed tagged reindeer in relation to the three parts of the former reindeer range. Most of the observations were concentrated in the central Snøhetta, where a seasonal pattern of use has been established following the earlier habitat modifications. Compared to the expected observations, the null hypotesis that annual distribution is homogenous in relation to seasonal habitats must be rejected ($x^2=159.15$, $P<0.001$).

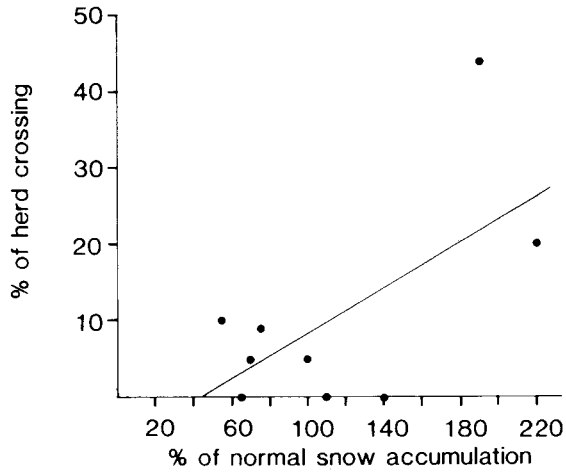

Fig. 2. The percentage of the Snøhetta herd which crossed the transportation corridor (European highway No. 6, and railroad track) across Dovrefjell in relation to percentage normal snow accumulation (data from Norwegian Meteorological Records).

Discussion

On the average, the likelihood of recording at least one tagged reindeer in every group in Snøhetta was high. This result indicates a very open social system which would tend to minimize the bias of using tagged individuals which may be expected from a more clumped distribution.

These results support Valkenburg *et al.*'s (1983) hypothesis that the basic social unit of caribou (or in this case reindeer) is a temporary, tenuous association of individuals in an open

Table 1. Observation frequency of tagged reindeer in relation to expected, based on size of different areas and the assumption of a homogenous distribution.

	Size (km²)	Observations	Expected
Central Snøhetta	2375	162	79
Knutshø (wintering area)	1600	5	54
Western area (summer range)	1225	8	42
Totals	5200	175	175

social system. From the aggregated winter band in which they were caught and tagged a marked social dispersion occurs during the following spring, summer and autumn.

Examination of the distribution of prehistoric trap sites in Snøhetta (Skogland and Mölmen, 1980) reveals a concentration of pit trap sites in the western area which is very high compared to central Snøhetta. A very high concentration of pit trap sites (1200 is also found along the transportation corridor between Snøhetta and Knutshø and Rondane, through which animals previously would move during their annual spring and autumn migrations.

The present distribution of reindeer in Snøhetta in the western area is therefore clearly lower than that found prior to habitat alteration by modern man as suggested by prehistoric evidence.

Fiftynine years after the completion of the railroad, and about 35 years after the opening of an all-weather highway across Dovrefjell, movements across this transportation corridor to wintering areas to the east are far below the prehistoric level (Fig. 2).

Evidence accumulated after nearly 5 years of following tagged individuals strongly suggests that severity of winter weather in the form of snow accumulation, which limits access to the already denuded lichen heaths in the central Snøhetta, is the major driving force initiating crossing of the transportation corridor. Snow levels above 160% of normal accumulation appear to act as a threshold to crossing. In winters of normal or below average snow conditions, reindeer in central Snøhetta prefer to stay within this area instead of crossing the transportation corridor to better winter ranges in Knutshø. All evidence suggests that traffic along the corridor is the inhibiting factor for crossing. Recent work on caribou in Alaska along the trans-Alaska oil pipeline suggests that vehicles act in a synergistic fashion with a pipeline to produce a negative stimulus that resulted in decreased crossing success (Curatalo and Murphy, unpublished data). See also Horjesi (1981).

The consequence of lowered use of the western part of Snøhetta is most likely an additional trampling of the already previously denuded lichen heaths, caused by a year-round existence in the central Snøhetta area. This will slow the recovery rate of the overgrazed lichen heaths.

The study suggests that in the western area that was previously used as a calving-summering area, males have resumed use to a larger extent than females with young. The ratio of males to females in the area was 80:20 while the population sex ratio was on average 40:60 (Skogland, unpublished data). Cameron (1983) and Whitten and Cameron (1983) found that caribou males were found closer to the trans-Alaska oil pipeline and haul road than females. Both in Knutshø and Snøhetta there were access roads with restricted traffic (see Fig. 1). These roads do not appear to hinder movement of reindeer when there was no traffic. In the western area it appears that the combined effects of a dammed lake, roads with some traffic, recreational activity as well as two high-power electrical lines parallel to the lakes and roads could act in a synergistic fashion to prevent the more shy females with young from crossing.

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