Insect avoidance may override human disturbances in reindeer habitat selection

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Abstract: Habitat selection of semi-domesticated reindeer (*Rangifer tarandus tarandus*) was investigated through faecal pellet-group counts and by direct observations of reindeer from helicopter in the Långfjället area in Idre reindeer herding district (62°10'N) and in Mittådalen reindeer herding district (62°50'N, aerial observations only). Reindeer pellets were found to be most abundant in habitats at high altitudes, and in some vegetation types. Pellet-group densities tended to be higher near the tourist trails, which often follow higher altitudes in the terrain. The aerial surveys showed that the reindeer moved towards higher altitudes when the wind speed was low and the temperature was high both in June and July. In June they moved towards lower regions when temperature was low and the wind speed was strong. The conclusion is that the reindeer use Långfjället to escape insect harassment and warm weather, even though disturbance by tourism sometimes is high.

Key words: aerial observations, human attendance, insect relief, pellet-group count, *Rangifer tarandus,* thermoregulation.

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Introduction

It is well documented that reindeer prefer higher grounds during insect harassment, and it is also known that reindeer can be disturbed by human activities. During warm weather, harassment by warble flies, nose bot flies (the oestrids *Hypoderma tarandi* L and *Cephenemyia trompe* L. respectively), species of Tabanidae, mosquitoes (*Aedes* spp., Culicidae), and species of Simuliidae (all hereafter referred to as harassing insects), influences habitat choice of *Rangifer tarandus*. The insect harassments are usually most severe during the oestrid flight season from late June until the early and mid August (Anderson & Nilssen, 1996; Nilssen, 1997; Anderson *et al.*, 2001). In periods of insect harassment, *R. tarandus* are often considered to walk against the wind while foraging and to move towards higher grounds and summits (White *et al.*, 1975; Anderson & Nilssen, 1998; Hagemoen & Reimers, 2002).

Reindeer habitat selection can also be affected by activities of humans, such as road traffic, residence areas and tourism (Helle & Särkelä, 1993; Nelleman & Cameron, 1996; Nellemann & Cameron, 1998; Dyer *et al.*, 2001; Vistnes *et al.*, 2001; Vistnes & Nellemann, 2001). Even though the animals are disturbed by human activities they can increase their tolerance for human activities if insect harassments are severe (Noel *et al.*, 1998). Since, *R. tarandus* tend to avoid human disturbances, the animals

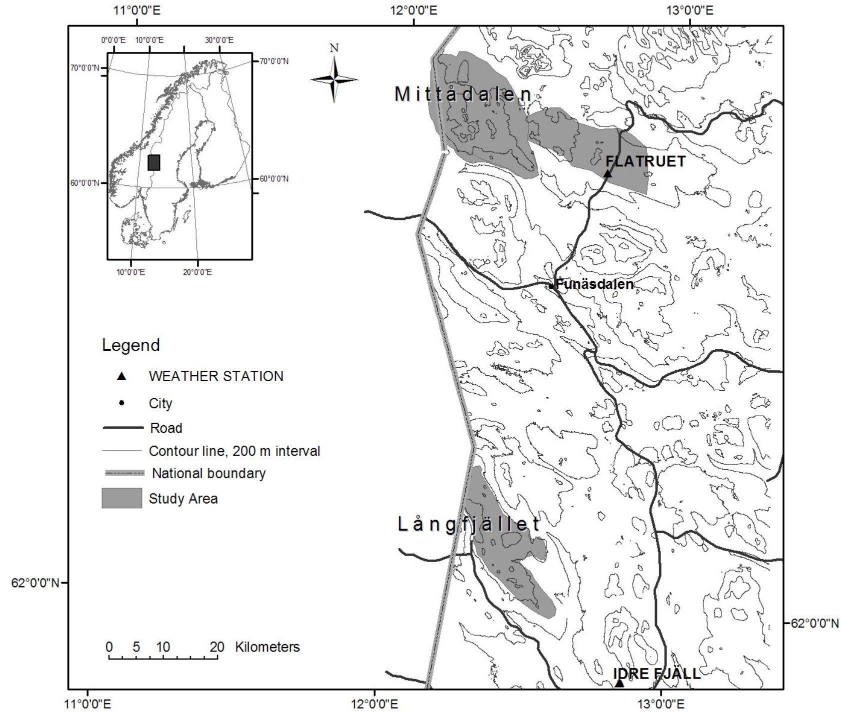

Fig. 1. The map shows the locations of the two study areas (grey) Långfjället in Idre, and the open area in Mittådalen reindeer herding districts. The elevation lines shown have an equidistance of 200 m starting at 600 m of elevation. The map also shows the positions of the two weather stations Flatruet and Idre Fjäll (▲).

may choose areas with a higher predation risk (Frid & Dill, 2002). Thus there seems to be a trade-off between different types of disturbances.

The scale perspective has often been applied in recent *R. tarandus* habitat selection studies (Rettie & Messier, 2000; Johnson *et al.*, 2001; Johnson *et al.*, 2002; Mårell *et al.*, 2002). At the landscape scale, other factors than insects activity and human activities affect the reindeer habitat selection. Topography, substrate, water location and microclimate, affect the forage resources and may therefore be of great importance for the forager (Senft *et al.*, 1987; Bailey *et al.*, 1996). The summer forage for reindeer can consist of several hundred plant species, to compare with winter diets when they mainly forage on lichens, and a limited number of green plants (Warenberg, 1977; Skogland, 1980). In summer, fresh and nutritive forage is preferred, and *R. tarandus* follow the snow-line to explore the early stages of plant growth. Preferred vegetation types with nutritive plants are grass heaths and meadows among others containing *Deschampsia flexuosa*, one of the most important food plants for reindeer after lichens (Warenberg, 1977; Skogland, 1984).

In this study we wanted to see if there is an interaction between insect harassment and human disturbances in reindeer habitat selection. We studied reindeer habitat selection through a faecal pellet-group count and aerial observations in a relatively sensitive area with tourist resorts and walking trails (Allard *et al.*, 1998). We expected the reindeer to move towards higher areas during warm weather, to use vegetation types differentially, and to avoid tourist trails, if possible. In Idre reindeer herding district the reindeer have little choice in using alternative areas during insect harassment periods, as there are no other higher grounds in the herding district. Tourists are generally abundant in the study area during the same period as the reindeer, apart from the months of May, October and November (Fredman & Emmelin, 1999). Studies on soils and vegetation changes in this area show that increased trampling from tourism (Bryan, 1977) and reindeer (Ihse & Allard, 1995; Nordberg & Allard, 2002) could damage the vegetation. There has also been a steady increase in mountain tourism in Sweden and especially in the southern parts of the Swedish mountains since the beginning of the 20th century (Fredman*,* *et al.*, 2001).

Material and methods

Study area

The study was conducted in the southern part of the Scandinavian mountain chain at Långfjället in Idre reindeer herding district (62°10'N, 12°20'E) and in the summer grazing area of Mittådalen reindeer herding district (62°50'N, 12°20'E) in Sweden (Fig. 1). The studied areas were 210 km^2 and 560 km^2, respectively, and were above the continuous birch forest, i.e. above an elevation of 800-900 m.

Långfjället constitutes about ¼ of the ranges

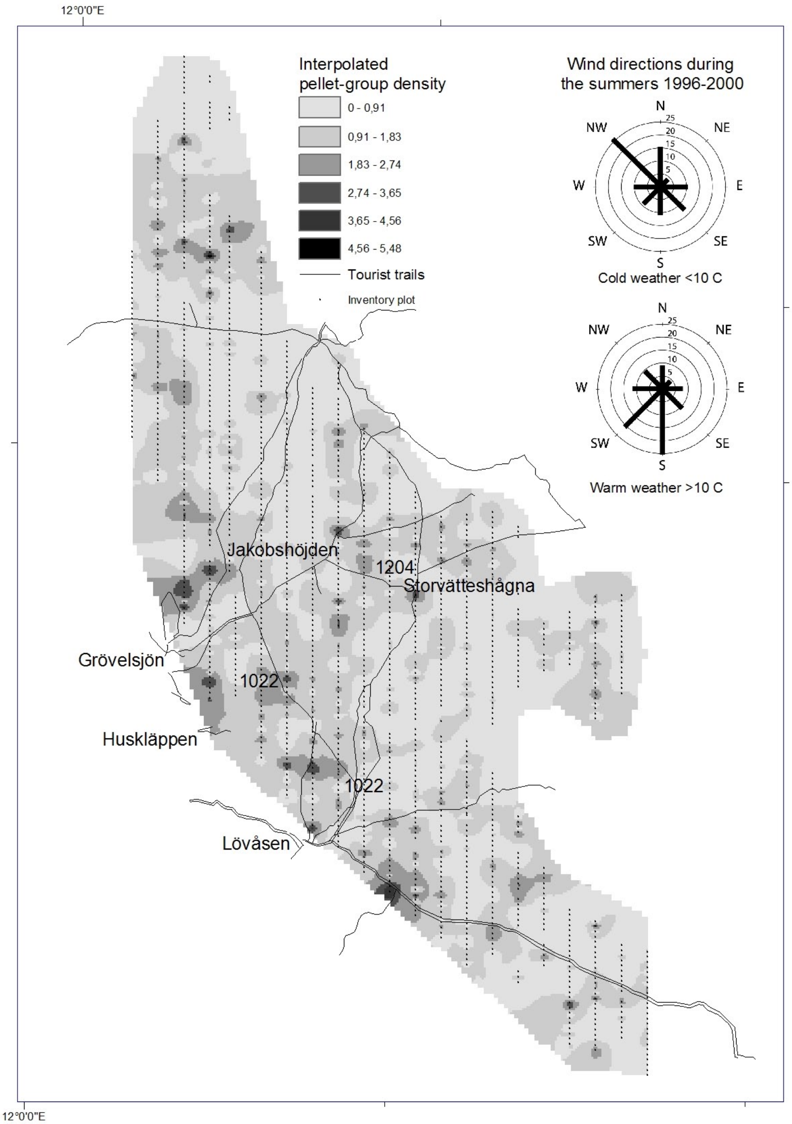

Fig. 2. The pellet-group densities over Långfjället are visualized through an interpolation from inventory plots. The darker areas have a higher pellet-group density. The inventory plots are shown by the small plots. The wind directions for the period of 1996-2000 from June to September are shown for warm (>10 ºC) and cold (<10 ºC) weather, respectively. © Lantmäteriverket 1998. Ur GSD - Vägkartan, dnr 507-98-4720.

used by reindeer during the snow-free period (May-November) in Idre reindeer herding district. The ranges outside Långfjället consist of mires, birch and coniferous forest. Långfjället is a low alpine landscape with its highest peak at 1204 m elevation. The southwest part of the area has sharp slopes towards a valley with a road, tourist resorts and residential areas. Low-growing vegetation, including lichens (*Cladina* spp.), often interspersed with dwarf birch (*Betula nana*) and heather (*Calluna vulgaris*), dominates in the area. At higher levels the dry heath is replaced by grass heath dominated by *Carex bigelowii*. Meadow vegetation occurs along the streams, and some smaller meadows are also found at higher altitudes where there are late-melting snow patches. At summits and along ridges, where the snow cover is shallow during winter, the lichen cover is often scarce. The mean annual precipitation in Långfjället is within the range of 800-1000 mm (National Land Survey of Sweden, 2002). Southern winds dominate during warm weather (weather observations from June-July, 1996-2000 at the Idre Fjäll weather station, located 30 km south-east from the centre of Långfjället, Fig 2). Weather records used along with the observations from Långfjället were taken from Idre Fjäll weather station. The area between Långfjället and Idre Fjäll is very flat and weather patterns were assumed to be similar in the two areas. The correlation between the weather parameters from Flatruet (in the other study area, see below) and Idre weather stations supports this assumption since they are also strongly correlated (r_{temp} = 0.922; P<0.0001, $r_{wind\ speed}$ = 0.765; P<0.0001).

The southwest part of the Långfjället area is easily reachable for tourists by car or bus, since the road runs along the valley south of Långfjället up to Lake Grövelsjön. Close to the road there are a number of areas with cabins and tourist resorts, where one of the largest hotels has approximately 11 000 visitor nights

Table 1. Distributions of inventory plots, mean altitudes (with standard deviation *s*) of each vegetation type, and mean number of pellet-groups per vegetation type.

Vegetation types		Distribution of plots (%)	Mean altitude of vegetation type (*s*)	Mean number of pellet-groups per plot
1	Blocky areas	4.3	977 (89)	0.37
11	Grass heath	3.1	984 (76)	1.37
12	Extremely dry heath	28.7	967 (68)	0.92
13	Dry heath	33.9	891 (80)	1.06
131	Dry heath with lichens	8.4	920 (63)	0.98
14	Fresh heath	11.5	886 (58)	0.95
15	Wet heath	7.4	888 (53)	0.77
21	Meadow	0.7	930 (70)	0.73
53, 56, 57	Fen	2.0	875 (51)	0.79
Total		100	921 (80)	0.95

every summer during June-September (unpubl. data from the Grövelsjön Tourist Station).

The study area in Mittådalen reindeer herding district is more alpine and has in parts a higher mean annual precipitation than Långfjället (800-1200 mm per year; National Land Survey of Sweden, 2002). There are two peaks higher than 1500 m in the western part of the area, where long lasting snow beds occur. On the east side of the peaks there is a calcareous plateau, which supports growth of alpine calcicolous plants. The areas around the peaks, especially in the south and southwest, are high alpine region with blocky areas and bedrock outcrops, and middle alpine region covered with grass heaths, rich meadows and fens. Extremely dry heaths and fens characterize the flat area further to the east. Weather data for the Mittådalen study area were obtained from the Flatruet weather station situated in the flat eastern part (Fig. 1). The weather records from Flatruet were considered to be representative for the whole area of Mittådalen.

Pellet-group counts

During the second half of August 2000, faecal pellet-groups were counted on plots along 21 transects running in a north-south direction over Långfjället (Fig. 2). The distance between the lines was 750 m, with one exception where a 13.5 km long line was mistakenly located 170 m to the west. The lines had a total length of 270 km. In total 1567 circular plots of 15 m^2 (*radius*=2.18 m) were located 150 m apart along the lines. All pellet-groups were counted within each plot. To be counted, the centre of the pellet-group had to be inside the plot. As the animals often move when they defecate, the pellets could be spread over a larger area or separated in smaller groups. In these cases the separate pellets were counted; 20-119 pellets were counted as one pellet-group, and ≥20 pellets as two pellet-groups (based on a separate survey of complete pellet-groups). Both fresh and old pellets were counted, *i.e.* counted pellets reflected at least two summers of reindeer habitat use. The vegetation at each plot was classified according to the categories used in the Swedish vegetation map (Rafstedt, 1982; Table 1). When a plot contained a mixture of vegetation types the predominating type was noted.

Aerial observations

In order to verify that reindeer in the area change the preferences for higher altitudes with weather, the two study areas were systematically over-flown with helicopter once a day during 8 and 12 days, respectively, to search for reindeer. At each search the distance flown over Långfjället was 90 km and over Mittådalen 120 km. The search started over Långfjället at the earliest at 10.00 am and finishing at the latest at 5.30 pm over Mittådalen, during June 12-19 in both areas, and only in Mittådalen during July 6-9, 2001. Flights in July over Långfjället were omitted because of the calf marking which included handling and moving of the reindeer during several days. Observed reindeer groups were positioned with a Global Positioning System (GPS) equipment, (Garmin 12XL®), and each observation was marked on a map. One observer and the pilot counted the reindeer. When less than 40 reindeer were observed, each individual was counted, when between 40 and approximately 200 reindeer the numbers were estimated to the nearest tens. When between approximately 200 and 1000 reindeer they were estimated to the nearest fifties, and when more than 1000 reindeer they were estimated to the nearest thousands. To be considered to belong to the same group, the estimated distances between animals were less than 100 m. The flight altitude was below 500 meters. The reindeer were disturbed by the helicopter and often started to run when the helicopter approached, but the counting was over in one minute or less after which we flew away. The survey was also done after consultations with the reindeer owners, who judged the reindeer would not be strongly disturbed as they often use helicopter when gathering the reindeer.

In total, 285 observed group locations were recorded in the two areas together. In the first period, 110 groups were located in Mittådalen and 128 in Långfjället. In July, 47 groups were located in Mittådalen.

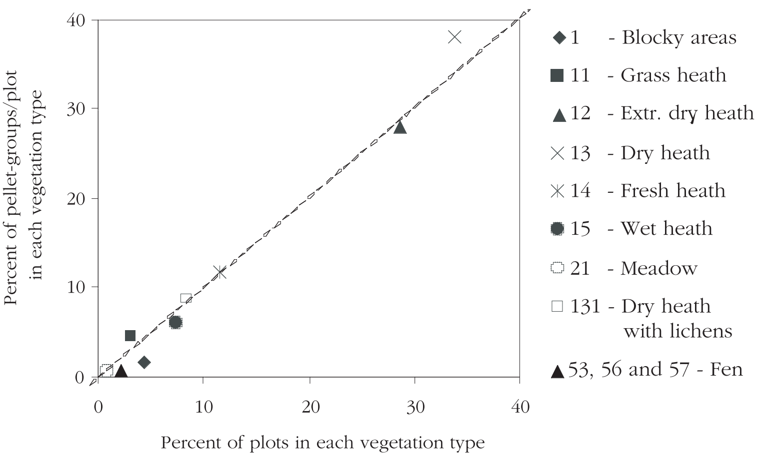

Fig. 3. The relative number of pellet-groups in different vegetation types plotted against the relative number of plots found in each vegetation type. The diagonal line is a 1/1 line.

Weather records from the weather stations Idre Fjäll and Flatruet for each survey day were obtained from The Swedish Meteorological and Hydrological Institute. The temperature, wind velocity and wind direction at the time of each observation were calculated by linear interpolation from weather observations every third hour. The average difference between subsequent temperature observations was 1.9±1.3 °C and between subsequent observations of wind speed it was 1.4 ±0.9 ms^{-1}.

Data analyses

The spatial data was handled using ArcView™ (ESRI) GIS Software. Digitalized geographical map information was obtained from Metria (www.lantmateriet.se). Altitudinal position for pellet group plots and aerial observations were derived from digital elevation models. The distance from the nearest tourist trail was calculated for each pellet group plot.

A linear model including individual regressions was used to analyse the dependence of the number of pellet-groups per plot on altitude and distance from the nearest trail in each vegetation type. A resource selection analyses (RSF; Manly *et al.*, 2002) was also done, were presence or absence of pellet-groups was treated as a binary observation for each sample plot in a logistic regression model with vegetation type, aspect class, altitude, distance to nearest tourist trail as explanatory factors. All fen vegetation types (53, 56 and 57; Table 1) were pooled because of too few observations in each type, giving either presence or absence observations in the type.

In the statistical analyses of the aerial survey, a linear model was fitted to the data with the altitudinal locations of reindeer as response variable and weather class as fixed effect. Initially, logistic regression models on the data gave poor model fits due to overdispersion in the data. The weather observations were classified according to wind speed and temperature thresholds for the harassing insect's activity (Table 2). The thresholds were set at 6 ms^{-1} and at 10 °C, respectively (White *et al.*, 1975; Russell *et al.*, 1993; Anderson *et al.*, 1994; Mörschel, 1999; Anderson *et al.*, 2001; Hagemoen & Reimers, 2002); fairly well the thresholds chosen when all of the harassing insects are active. Mosquitoes and species of Simuliidae have been found active between 7 to 10 °C and

Table 2. Number of observed reindeer groups during systematic aerial observations in the two study areas, distributed over the occurring weather classes. The numbers in parenthesis are the average group sizes with standard deviations (*s*) based on approximate estimates of animal numbers.

Weather class	Temperature °C	Wind speed m/s	No. of reindeer observations (average group size (*s*))		
			Långfjället June	Mittådalen June	Mittådalen July
1	> 10	< 6	82 (54, *s*=80)	44 (27, *s*=28)	18 (508, *s*=689)
2	> 10	> 6	-	-	29 (222, *s*=205)
3	< 10	< 6	28 (32, *s*=29)	51 (27, *s*=27)	-
4	< 10	> 6	18 (39, *s*=55)	15 (30, *s*=62)	-
Total no. of observations			128 (47, *s*=69)	110 (28, *s*=34)	47 (332, *s*=470)

at wind speeds below 6 ms^{-1} (Anderson *et al.*, 2001), but this is only a small part of our aerial observations (25 observations).

Results

Pellet-group spatial distribution

Of the 1567 prelocated plots, 1473 were accessible during the survey. In total, 11 vegetation types were identified in the examined plots (Table 1). In almost half of the plots no pellet-groups were found and the maximum number found was six pellet-groups. A chi-square test indicated that the pellet-groups could be treated as randomly distributed over the vegetation types (χ^2 (10) =0,841, Fig. 3). The RSF model, in contrast, showed differentiated use of vegetation types (P<0.0001); blocky areas was avoided (P<0.0001), grass heath (P<0.045), dry heath (P=0.003) and fresh heath (P=0.030) was preferred in relation to the use of dry heath with lichens (the type defined as intercept in the model), while the other vegetation types were not significantly different from dry heath with lichens. A tendency of preferences for certain aspects was found in the RSF model (P=0.077), and a pattern of higher densities was noticed along the southwest side of Långfjället that has a sharp slope (Fig. 2).

Spearman rank correlations (r=0.099), the linear regression and the RSF model showed that pellet-group density increased significantly with altitude (with P_r<0.0001, $P_{\text{linear regr}}$=0.01, P_{RSF}<0.0001 respectively). In the linear regression model the individual regressions within vegetation types on altitudes showed significantly more pellet-groups at higher altitudes in the most common vegetation type dry heath (slope 0.0022±0.0006 pellet-groups per 15 m^2, P<0.0001), but in the other vegetation types the slopes were non-significant. The model explained only a small part of the variation in density (R^2=0.06), which is not surprising because of the fairly limited extension of the area in relation to the distances reindeer may cover in short time, and thereby cause a stochastic spread of pellet-groups over different vegetation types.

The results were diverging concerning distance to the nearest tourist trail. Spearman rank correlations and the RSF model showed significant increase in pellet-group density with proximity to trails (r=-0.079, P=0.003; P_{RSF}=0.037), while the linear regression was non-significant.

Altitude and distance to the nearest trail were negatively correlated in the data (r=-0.142, P<0.0001), indicating that trails tend to follow the elevations in the landscape.

Aerial observations

The average size of the observed groups in the two areas and the two observation periods was 101 animals. The mean group size was 47 animals during the first period in Långfjället and 28 in Mittådalen, and 332 during the second period in Mittådalen. The number of aerial observations in different weather classes is shown in Table 2. As the observations were done over a limited period we were not able to observe reindeer in every possible weather class.

The altitudinal locations of the reindeer versus temperature and wind speed showed selection for higher areas when the wind speed was low and the temperature was high (weather class 1) both in June and July in both study areas (Långfjället: P=0.001; Mittådalen: P=0.001 in June, and P=0.016 in July). In June the reindeer responded in the same way in both areas, i.e. selected lower areas when temperature was low and the wind speed was strong (weather class 4; P<0.0001). In July they moved to lower areas when the temperature was high and the wind speed was high (weather class 2; P=0.016). The reindeer altitudinal locations in the different weather classes are shown in Table 3. All model fits had low R^2-values (R^2=0.12 and R^2=0.14) indicating that the reindeer were only partly influenced by weather when choosing habitat.

Table 3. The altitudinal positions of the reindeer groups [in meter (with standard deviation s)] observed during the aerial survey. Weather classes are defined in Table 2.

Weather class	Altitudinal position of reindeer groups		
	Långfjället June	Mittådalen June	Mittådalen July
1	902 (39)	1002 (46)	1088 (108)
2	-	-	1014 (92)
3	892 (57)	992 (47)	-
4	855 (44)	945 (48)	-

Discussion

A common result is that the reindeer had a preference for higher altitudes when they were in Långfjället. As indicated by the pellet-group count, the reindeer did show a preference for some of the vegetation types at Långfjället, and they avoided blocky areas. Grass heath occurred at higher altitudes (Table 1), and therefore the use of grass heath could be partly confounded by the preference for higher terrain. The preference for dry heath may be explained by the fact that it was more used at higher altitudes. The low preferences for the other vegetation types, although they usually are attractive for reindeer, may be described by the characteristics of Långfjället. It has relatively homogenous vegetation and a small areal extent of what is usually regarded as highly preferred forage. It may well be that the proximity to richer forage resources in the areas surrounding Långfjället makes the scarce forage at Långfjället less important. This suggestion is supported by our own observations that the reindeer seemed to leave Långfjället as soon as the weather was not promoting insect activity (Anderson *et al.*, 2001). Skogland (1984) reports that four different herds of wild reindeer in alpine habitats and caribou in arctic ranges choose snow-bed meadows rather than other habitats, snow-bed meadows correspond here to meadow vegetation types, which are scarce (0.7%) in the area. Thus, even if the reindeer would have preferred to forage in meadows, we would not have found a significant number of pellet-group observations showing that they preferred this vegetation type.

The observed preferences for higher altitudes during warm and calm weather confirm the expected behaviour of reindeer trying to avoid insect harassment and/or trying to thermo-regulate (White *et al.*, 1975; Anderson & Nilssen, 1998). In Idre reindeer herding district, Långfjället is the only easily accessible place that can provide higher peaks and ridges where the wind velocity is higher than in the lower surrounding areas during days of warm and calm weather. As indicated by the RSF model and the pellet-group density map (Fig. 2), the reindeer seemed to have had higher preference for the relatively steep-sloping high areas on the southwest to west side. Since this side is facing the prevailing wind directions (S to SW) when the temperature is high, this indicates that the reindeer probably use these slopes more during warm weather. At a higher altitude in Alaska, Quayle & Kershaw (1996) found a clear relationship between pellet-groups and altitude in a more alpine and differentiated area than Långfjället. They recorded the highest mean numbers of pellet-groups on the summit of a mountain. They also concluded that the caribou regularly defecated when they stood up after having rested and ruminated at the summits.

An interesting observation is that in the beginning of the June period the reindeer were likely to seek higher grounds only to thermo-regulate, which was also observed by Anderson & Nilssen (1998). Oestrid flies usually do not eclose before the end of June (Nilssen, 1997). The insect activity was generally low at the beginning of the aerial observation period in June and increased during the last four observation days when mosquitoes and simuliids were observed in the field. The reindeer also formed smaller groups in June than in July, which may be a consequence of the lower insect activity in June. The group sizes of caribou and reindeer are known to increase with insect activity (Helle & Aspi, 1983; Downes *et al.*, 1986; Noel *et al.*, 1998). This behaviour is commonly used by reindeer herders when gathering the reindeer.

A possible explanation for the non-antagonistic relationship between pellet-group density and distance to tourist trails, shown in the Spearman rank correlation and the RSF model, is that the trails follow the ridges and summits, which were also preferred by the reindeer. This indicates that the reindeer and the human may interfere with each other in these parts of the area. Långfjället is easily reached by tourists because it is close to roads and resorts (Fredman & Emmelin, 1999). The high densities of pellet-groups on the southwest side of Långfjället (Fig. 2), where the tourist resorts are situated, increase the probability that the tourists and the reindeer meet frequently. We were not able to observe to which extent tourists had a negative impact on the reindeer habitat use of Långfjället, but reindeer are expected to avoid humans on foot (Noel *et al.*, 1998; Vistnes *et al.*, 2001). This in turn may cause both energy costs for the reindeer and vegetation wear. The animals may however also habituate to human activities and increase the tolerance for humans (Colman *et al.*, 2001). Caribou, for instance, did not avoid insect-free areas (only moved more within the area) during severe insect harassment even though human activities was higher there than elsewhere (Noel *et al.*, 1998).

In Idre reindeer herding district the likelihood of finding an alternative insect-free area without human activities are quite low. Therefore it would not be surprising to find the reindeer at Långfjället during warm weather even though there are tourists in the area. The results in this study support the reindeer herders own observations that the reindeer can be found in the area during warm weather at the same time as tourists are walking in the area. Therefore the conclusion may be, with support from local knowledge, that the reindeer use Långfjället to escape insect harassment and warm weather, even though they may be disturbed by hikers, since Långfjället is the only place within their summer range where they can easily reach higher grounds. The level of insect harassment (especially by the oestrids) can also affect the reindeer sensitivity to human disturbance, if the harassment is more severe they can not afford to distinguish human disturbances. The results exemplify a situation where the reindeer select for insect-free areas instead of selecting against human disturbance and abundant vegetation. Their need for insect-free areas overrides the need for high quality forage and disturbance-free areas. If the tourism would increase in the area, along with a warmer climate, this would probably mean that the disturbance on the reindeer would increase, and with that their movements in the area (Noel *et al.*, 1998). The sensitive vegetation at Långfjället would then be exposed to more trampling both from tourism and from the reindeer probably affecting the vegetation negatively (Nordberg & Allard, 2002). The combined trampling of humans and reindeer is an alternative explanation to the suggested wear of Långfjället by reindeer itself, as suggested in previous investigations (Ihse & Allard, 1995).

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References

Allard, A., Ihse, M. & Nordberg, M.-L. 1998. *Vegetationsförändringar i fjällen - Metodstudier i norra fjällen med hjälp av IRF-flygbilder och satellitbilder.* Rep. No. 109. Department of Physical Geography, Stockholm University, Stockholm.

Anderson, J. R. & Nilssen, A. C. 1996. Trapping oestrid parasites of reindeer: the response of *Cephenemyia trompe* and *Hypoderma tarandi* to baited traps. – *Medical and Veterinary Entomology* 10: 337-346.

Anderson, J. R. & Nilssen, A. C. 1998. Do reindeer aggregate on snow patches to reduce harassment by parasitic flies or to thermoregulate? – *Rangifer* 18: 3-17.

Anderson, J. R., Nilssen, A. C. & Folstad, I. 1994. Mating behavior and thermoregulation of the reindeer warble fly, *Hypoderma tarandi* L. (Diptera: Oestridae). – *Journal of Insect Behavior* 7: 679-706.

Anderson, J. R., Nilssen, A. C. & Hemmingsen, W. 2001. Use of host-mimicking trap catches to determine which parasitic flies attack reindeer under different climatic conditions. – *Canadian-Field Naturalist* 115: 274-286.

Bailey, D. W., Gross, J. E., Laca, E. A., Rittenhouse, L. R., Coughenour, M. B., Swift, D. M. & Sims, P. L. 1996. Mechanisms that result in large herbivore grazing distribution patterns. – *Journal of Range Management* 49: 386-400.

Bryan, R. B. 1977. The influence of soil properties on degradation of mountain hiking trails at Grövelsjön. – *Geografiska Annaler* 59: 49-65.

Colman, J. E., Jacobsen, B. W. & Reimers, E. 2001. Summer response distances of Svalbard reindeer *Rangifer tarandus platyrhynchus* to provocation by humans on foot. – *Wildlife Biology* 7: 275-283.

Downes, C. M., Theberge, J. B. & Smith, S. M. 1986. The influence of insects on the distribution, microhabitat choice, and behaviour of the Burwash caribou herd. – *Canadian Journal of Zoology* 64: 622-629.

Dyer, S. J., O'Neill, J. P., Wasel, S. M. & Boutin, S. 2001. Avoidance of industrial development by woodland caribou. – *Journal of Wildlife Management* 65: 531-542.

Fredman, P. & Emmelin, L. 1999. *Values of Mountain Tourism - Economic benefits across visitor segments in Femundmarka, Rogen and Långfjället.* Rep. No. 1999:26. European Tourism Research Institute, Östersund.

Fredman, P., Emmelin, L., Heberlien, T. A. & Vuorio, T. 2001. Tourism in the Swedish Mountain Region. – *In*: B. Sahlberg (ed.). *Going North*, Report series R2001:6, pp. 123-146. ETOUR, European Tourism Research Institute, Östersund.

Frid, A. & Dill, L. 2002. Human-caused disturbance stimuli as a form of predation risk. – *Conservation Ecology* 6.

Hagemoen, R. I. M. & Reimers, E. 2002. Reindeer summer activity pattern in relation to weather and insect harassment. – *Journal of Animal Ecology* 71: 883-892.

Helle, T. & Aspi, J. 1983. Does herd formation reduce insect harassment among reindeer? A field experiment with animal traps. – *Acta Zoologica Fennica* 175: 129-131.

Helle, T. & Särkelä, M. 1993. The effect of outdoor recreation on range use by semi-domesticated reindeer. – *Scandinavian Journal of Forest Research* 8: 123-133.

Ihse, M. & Allard, A. 1995. *Vegetationsförändringar i Renbetesfjäll. Metodstudier i södra fjällen med hjälp av flygbilder i IR-färg.* Rep. No. 2:95. WWF, Stockholm.

Johnson, C. J., Parker, K. L. & Heard, D. C. 2001. Foraging across a variable landscape: Behavioral decisions made by woodland caribou at multiple spatial scales. – *Oecologia (*Berlin*)* 127: 590-602.

Johnson, C. J., Parker, K. L., Heard, D. C. & Gillingham, M. P. 2002. Movement parameters of ungulates and scale-specific responses to the environment. – *Journal of Animal Ecology* 71: 225-235.

Manly, B. F. J., McDonald, L. L., McDonald, T. L. & Erickson, W. P. 2002. *Resource selection by animals*. Kluwer Academic Publishers, Dordrecht.

Mårell, A., Ball, J. P. & Hofgaard, A. 2002. Foraging and movement paths of female reindeer: insights from fractal analysis, correlated random walks, and Levy flights. – *Canadian Journal of Zoology* 80: 854-865.

Mörschel, F. M. 1999. Use of climatic data to model the presence of oestrid flies in caribou herds. – *Journal of Wildlife Management* 63: 588-593.

National Land Survey of Sweden 2002. *National atlas of Sweden*, Vol. 2004. Metria.

Nelleman, C. & Cameron, R. D. 1996. Effects of petroleum development on terrain preferences of calving caribou. – *Arctic* 49: 23-28.

Nellemann, C. & Cameron, R. D. 1998. Cumulative impacts of an evolving oil-field complex on the distribution of calving caribou. – *Canadian Journal of Zoology* 76: 1425-1430.

Nilssen, A. C. 1997. Effect of Temperature on Pupal Development and Eclosion Dates in the Reindeer Oestrids *Hypoderma tarandi* and *Cephenemyia trompe* (Diptera: Oestridae). – *Environmental Entomology* 26: 296-306.

Noel, L. E., Pollard, R. H., Ballard, W. B. & Cronin, M. A. 1998. Activity and use of active gravel pads and tundra by Caribou, *Rangifer tarandus granti*, within the Prudhoe Bay oil field, Alaska. – *Canadian Field-Naturalist* 112: 400-409.

Nordberg, M.-L. & Allard, A. 2002. Remote sensing methodology for monitoring lichen cover. *Canadian Journal of Remote Sensing*, 28: 262-274.

Quayle, J. F. & Kershaw, G. P. 1996. Use of summer habitat by caribou on the north slope of a mountain near the Macmillan Pass, N.W.T. – *Rangifer* Special Issue No. 9: 311-317.

Rafstedt, T. 1982. Vegetationskarta över de svenska fjällen: Kartblad nr 21 Idre (16C, 16D). Department of Physical Geography, Stockholm University and LiberKartor, Stockholm.

Rettie, W. J. & Messier, F. 2000. Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. – *Ecography* 23: 466-478.

Russell, D. E., Martell, A. M. & Nixon, W. A. C. 1993. Range Ecology of the Porcupine Caribou Herd in Canada. – *Rangifer* Special Issue No. 8: 1-167.

Senft, R. L., Coughenour, M. B., Bailey, D. W., Rittenhouse, L. R., Sala, O. E. & Swift, D. M. 1987. Large herbivore foraging and ecological hierarchies. – *BioScience* 37: 789-799.

Skogland, T. 1980. Comparative summer feeding strategies of Arctic and Alpine *Rangifer*. – *Journal of Animal Ecology* 49: 81-98.

Skogland, T. 1984. Wild reindeer foraging-nisch organisation. – *Holarctic Ecology* 7: 345-379.

Warenberg, K. 1977. *Vegetation och renbete inom Ottfjällets renfarm* (A study of the vegetation and of reindeer grazing habits on the Ottfjäll reindeer range), Östersund.

White, R. G., Thomson, B. R., Skogland, T., Person, S. J., Russel, D. E., Holleman, D. F. & Luick, J. R. 1975. Ecology of Caribou at Prudhoe Bay, Alaska. – In: J. Brown (ed.). *Ecological Investigations of the Tundra Biome in the Prudhoe Bay Region, Alaska*, Biological papers of the University of Alaska. Special Report Number 2 Oct., 1975, pp. 151-187. University of Alaska, Fairbanks.

Vistnes, I. & Nellemann, C. 2001. Avoidance of cabins, roads, and power lines by reindeer during calving. – *Journal of Wildlife Management* 65: 915-925.

Vistnes, I., Nellemann, C., Jordhøy, P. & Strand, O. 2001. Wild reindeer: Impacts of progressive infrastructure development on distribution and range use. – *Polar Biology* 24: 531-537.

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Abstract in Swedish / Sammanfattning:

Habitatval hos tamren (*Rangifer tarandus tarandus*) undersöktes genom att göra en spillningsinventering och genom att göra flygobservationer från helikopter. Studien gjordes på Långfjället (62°10'N) i Idre nya sameby och i Mittådalens samebys sommarbetesområde (62°50'N, endast flygobservationer). På Långfjället finns det vandringsleder som är frekventerade av vandrare från juni månad fram till september. Spillningen visade att renarna föredrog höjderna i området samt en del av vegetationstyperna. Det var också mer spillning närmare vandringslederna. Detta kan förklaras av att vandringslederna följer höjderna i terrängen. Flyginventeringarna under både juni och juli visade att renarna rörde sig mot högre terräng när det var varmt och lugnt väder. I juni rörde dom sig också i lägre terräng när det var stark vind och kallt väder. Slutsatsen är att renarna väljer att vistas i högre terräng för att undvika störningar från insekter och för att finna svalka trots att det är mänsklig aktivitet i området.