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BEHAVIOR RESPONSES OF WILD REINDEER TO DIRECT PROVOCATION BY A SNOWMOBILE OR SKIER

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Abstract: To better understand the effect of winter tourism and public recreation on wild mountain reindeer (*Rangifer tarandus tarandus*), we compared reindeer response distances after direct provocations by skiers and snowmobiles during 3 winters in Setesdal-Ryfylke, southern Norway. Reindeer being provoked by a snowmobile discovered the observer at longer distances than reindeer being provoked by a skier (370 [skier] vs. 534 [snowmobile] m; $P = 0.002$), while total flight (756 vs. 570 m; $P = 0.037$) and total distance moved (970 vs. 660 m; $P = 0.008$) by reindeer were shorter for snowmobile than skier provocation. The fright (328 [skier] vs. 328 [snowmobile] m), flight (281 vs. 264 m), and escape (543 vs. 486 m) distances due to skier or snowmobile provocation were not different ($P > 0.05$). For pooled data, fright distances of reindeer were affected by 2 other independent variables. Fright distance was longer when the animals were provoked from below rather than from above ($P = 0.046$), while their escape distances were longer when the animals were lying rather than when grazing prior to being provoked ($P < 0.05$). Based on maximum and minimum distance moved for all provocations pooled, daily estimated energy expenditure of reindeer increased between 31 and 590 kJ, representing 0.2 and 2.9% of their estimated total daily energy expenditure. Overall, provocations by skiers or snowmobiles revealed similar behavioral responses. An estimated maximum rate of 3 daily encounters between reindeer and skiers or snowmobiles during winter vacation and Easter would result in moderate energy costs that should be easily compensated for and thus have no demographic consequences. Increasing snowmobile use will, however, significantly expand the area where humans are in contact with reindeer during winter and spring, a period of negative energy balance for reindeer.

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Key words: anthropogenic disturbance, harassment, Norway, *Rangifer tarandus*, snowmobile, tourism, winter.

On a global scale, tourism, public recreation, and industrial activities in remote areas are steadily increasing (United Nation Envoroment Programme 2001), with an associated rise in close encounters between humans and wildlife. In the high alpine mountains of southern Norway, anthropogenic activities have increased steadily over the last 175 years and are forecast to continue (Direktoratet for naturforvaltning 1994). Europe's remaining wild reindeer also inhabit these mountain ranges, and their expansive home ranges and regional movement patterns make them vulnerable to increases in human development and activity.

The unique experience of viewing wild reindeer often attracts people to approach herds in otherwise remote, high alpine habitat. Deliberately or inadvertently approaching reindeer may interrupt their feeding and result in their flight (Dervo and Muniz 1994, Kind 1996, Eftestøl 1998).

To promote survival through harsh winters, reindeer have evolved the capacity to store large fat reserves, reduce activity rates in response to season, and survive on limited and nutrient-poor winter forage (e.g., lichens; Reimers 1980). Human disturbance during winter may negatively influence this pattern, and thus winter survival, unless reindeer become habituated to humans. Any factor that reduces grazing time may become a constraint on productivity. Minimal changes in grazing patterns and nutrient acquisition can induce multiplier effects (White 1983), resulting in marked influences on animal performance, body weight, and, for females, conception rate and age of first reproduction (Reimers 1997). Furthermore, studies on reactions of wild reindeer to humans on foot or skis (Dervo and Muniz 1994, Kind 1996, Eftestøl 1998) have revealed longer reaction distances during winter than in other seasons, indicating that reindeer are especially vulnerable to disturbance during winter, a period of negative energy balance.

Cross-country skiing has occurred in Norway for centuries. In the mountains of southern Norway, this activity has increased rapidly during the

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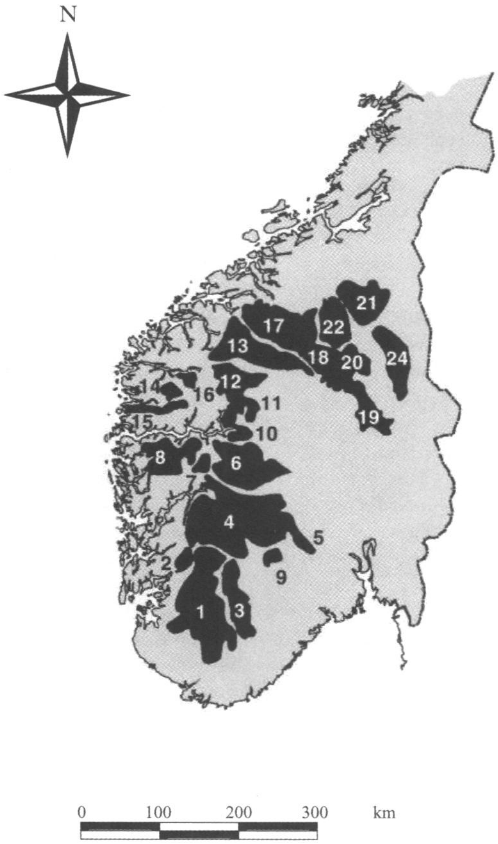

Fig. 1. The distribution of wild reindeer in southern Norway. Our study area, Setesdal-Ryfylke, is section 1 on the map.

last 50 years in association with an increasing number of mountain cabins and improved access to alpine ranges with the development of an extensive road and trail system (Direktoratet for naturforvaltning 1994). Snowmobile use also has increased since the mid-1960s, as reflected in the 2002 numbers of 49,260 snowmobiles in mainland Norway and 1,208 on Svalbard (Vegdirektoratet, personal communication).

Off-road vehicles (ORVs), including snowmobiles, are strictly regulated in Norway. In general, their use is permitted only when industrial or utility requirements dictate. Hence, the number of snowmobiles operating in wild reindeer habitat has been limited. With an increasing number of snowmobiles, however, the pressure for more liberal use regulations has also increased, as has illegal recreational driving into remote, unpermitted areas. Lobbyists for deregulation of snowmobile use claim that motorized transportation elicits weaker fright reactions from ungulates than humans on foot or skis (as reported by Richens and Lavigne 1978, Eckstein et al. 1979, Freddy et al. 1986, Andersen et al. 1996). Furthermore, habituation of ungulates toward snowmobile traffic, as indicated by Tyler (1991) and suggested by Mahoney et al. (2001), as well as Dorrance et al. (1975) for elk (*Cervus canadensis*), add to the lobbyist's arguments for allowing less regulated snowmobile use.

In a literature survey, Reimers (1991) concluded that noise and the sight of snowmobiles appear to have little effect on ungulates in areas where drivers follow predetermined trails. In areas with unhindered driving and no trails, and where animals are provoked and chased by snowmobiles, changes in reindeer behavior, activity, and energy budget may occur.

To understand how increasing recreation and tourism in remote alpine areas affect wild reindeer behavior and energy budgets, we compared the fright and flight response of reindeer due to a person on skis versus on a snowmobile in Setesdal-Ryfylke, southern Norway. Based on earlier findings, we predicted that longer fright and flight distances would result from direct provocation by skiers than by snowmobiles. We also measured environmental variables and reindeer herd characteristics that could influence behavioral responses to human disturbances.

STUDY AREA

In southern Norway, 30,000–40,000 wild reindeer occupy 26 defined management areas. We conducted our study in Setesdal-Ryfylke (5,700 km^2), focusing on the second largest and southernmost wild reindeer herd in Europe (Fig. 1). The winter population since the 1990s has been stable at about 3,000 animals (0.5 reindeer/km^2), with an annual recruitment of 800 calves (Jordhøy et al. 1996). Our study area is devoid of large predators, thereby removing a major ecological factor possibly associated with reindeer behavior. We conducted our fieldwork within a 250-km^2 area around Rosskrepfjord (59°4′N, 7°9′E) in Valleheiene. We were granted permission to drive snowmobiles in this area.

Our study area is alpine (900–1,400 m) and mostly bedrock, with productive forage areas generally limited to valley bottoms. A coastal climate dominates the area, and in winter, frequent rains followed by freezing temperatures result in hard-packed and crusted snow or icing on reindeer ranges.

Snowmobile traffic in the area generally was restricted to environmental control and transportation of supplies along specific trails to the numerous cabins in the forested areas surrounding the alpine areas, and to the few private and tourist cabins within reindeer alpine habitat. During our study, snowmobile transportation of supplies to the alpine cabins occured only 2–3 times during winter. Although skiing is mostly concentrated during the Easter holiday, skiing may occur sporadically in the alpine areas throughout winter.

METHODS

Data Collection

Our methods were similar to Tyler (1991), Colman et al. (2001), and Mahoney et al. (2001), except for the use of Leica Geovid 7 × 42 BDA laser-binoculars (accuracy 1 m at 1,000 m). During each provocation, the observer approached a reindeer herd directly at a constant speed (skier: 4 km/hr; snowmobile: 20 km/hr) until reaching the original location of the herd.

We recorded 9 independent variables at the start of each provocation: (1) provocation method (skier or snowmobile); (2) visibility/weather (sunny/partly sunny, cloudy, raining/snowing, or foggy); (3) wind speed (Beaufort scale: calm, light/gentle breeze, moderate/fresh breeze, or strong/moderate gale); (4) topography of the surrounding area (level or hilly); (5) activity of the reindeer prior to being provoked (lying, foraging, moving [walking or trotting without foraging], or mixed in cases when reindeer in a herd were engaged in different activities); (6) herd size (<20 animals, 20–75 animals, or >75 animals); (7) herd composition (adult males only, adult females and calves, or adult animals of both sexes with or without calves [mixed]); (8) wind direction from the observer at start of provocation (the reindeer upwind, downwind, sidewind, or no wind), and (9) topographic position of the observer relative to the reindeer (downhill, level, or uphill).

We measured 7 response distances (the first 5 distances are similar to Colman et al. [1991], Mahoney et al. [2001], and Tyler [2001]) between the observer and the estimated center of the herd:

(1) Start distance: distance between observer and the estimated center point of the herd at the beginning of the provocation.

(2) Sight distance: distance between the observer and the herd center point when ≥1 reindeer looked up in the observer direction.

(3) Fright distance: distance between the observer and the herd center point when the herd exhibited a fright response by grouping together.

(4) Flight distance: distance between the observer and the herd at the moment of flight.

(5) Escape distance: air distance from where reindeer took flight to where they resumed more relaxed behavior (i.e., grazing or lying).

(6) Total flight distance: air distance covered if the herd moved farther away from the observer after resuming more relaxed behavior the first time, and we determined that the movement was caused by the provocation.

(7) Total distance moved: total flight distance measured by total ground distance covered. The air and ground distance are equal if the reindeer escape in the same direction upon provocation. Any directional change during escape makes the ground distance longer.

The observer recorded the herd's escape route after a provocation, determining whether the herd ran uphill, downhill, or level, and if they ran against the wind, with the wind, or crosswind. We coded field data for statistical analyses with Microsoft Excel version 7.0 and S-Plus 2000 Professional. To test for differences between provocation methods and to relate independent variables to reindeer responses, we used a mixed, stepwise analysis of variance (ANOVA) for preliminary identification of important variables (Colman et al. 2001). As a control, we looked at the influence of each independent variable alone and together with the provocation factor. We set the P-value to enter at 0.15 and the P-value for rejection at 0.10, and used the closeness of Mallow's Cp to p (number of parameters) +1 when selecting models (Kleinbaum et al. 1988). We compared the results of this procedure to the results of backward, stepwise regression to confirm our selection of variables. We tested residuals for each model for normality and homoscedacity (Fry 1993). To determine the effects of the independent variables on the responses, we pooled data from the 2 provocation methods and used 1-way ANOVA tests.

To estimate energy loss, we calculated the mean response distances and estimated their energy costs on the basis of total horizontal distance moved on medium-soft snow with a sinking depth of 12–32 cm and an estimated average speed of flight at 4 km/hr. The net cost of locomotion is calculated as 2.64 kJ/kg/km (Boertje 1985, Fancy and White 1987), with an additional cost of standing of 5.02 kJ/kg/hour (Fancy and White 1985:155). For example, the energy cost of 1 km

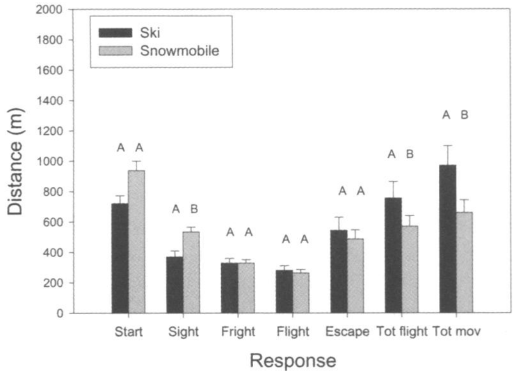

Fig. 2. Response distances (+SE) of wild mountain reindeer to provocation by an observer on a snowmobile versus an observer on skis in Setesdal-Ryfylke, Norway, in April 1998, 1999, and 2000. We recorded distance from observer to herd at the start of the provocation and at the first sight, fright, and flight response by the herd. We also measured straight-line distance traveled by the herd during their initial flight (Escape) and any subsequent flights related to the provocation (Tot flight), as well as the total ground distance covered by the herd (Tot mov). Different letters signify significant differences ($P \leq 0.05$).

total distance moved for a 60 kg reindeer is locomotion + standing = 233.7 kJ (locomotion = 2.64 × 60 × 1 = 158.4 kJ; standing = 5.02 × [60/4] = 75.3 kJ). The total daily energy expenditure (DEE) of a 60 kg (estimated average live weight for reindeer in this area; Colman 2000) undisturbed reindeer in April is estimated at 20,300 kJ or 2.5 times its standard metabolic rate (377 × [body weight]$^{0.75}$; Fancy and White 1985).

RESULTS

Because few herds were present in our study area, and because we had difficulties finding the few that were present, we recorded too few provocations in 1998 and 2000 to use year as a factor in our analysis. Because of a large herd (approx 600 animals) we engaged in 2000, average herd size was significantly larger that year. However, in our ANOVA models, herd size was not a significant factor for any response distance in any year or when years were combined. The 3 winters during our study had similar precipitation and temperature conditions (The Norwegian Meteorological Institute, personal communication). Since the weather variables did not interfere with the response variables, we anticipate that year had little, if any, effect on the response variables. Reindeer sinking depth, an important variable, rarely exceeded 20 cm and was usually measured at between 10 and 15 cm during our study. These snow conditions are common in the alpine habitats during March and April (and generally most of the winter) due to frequent strong winds that pack the snow. Therefore, we assumed that effects on response distances caused by these independent variables were similar for the 3 years. We pooled our data, providing 55 provocations by snowmobiles and 29 by skiers.

We began with complete models, including all independent variables, but present and discuss only those factors that entered the models with a significant effect. Nothing entered the ANOVA model for start distance ($P > 0.05$), indicating that no measurable bias existed in regard to any of the independent variables influencing the response distances.

Compared to provocations by skiers, reindeer provoked by snowmobiles discovered the observer (sight distance) at longer distances ($F = 10.817$; df = 1, 64; $P = 0.002$). Total flight ($F = 4.540$; df = 1, 62; $P = 0.037$) and total distance moved ($F = 7.630$; df = 1, 62; $P = 0.008$) were shorter for provocations by snowmobiles than by skiers (Fig. 2, Table 1). Hence, reindeer were more easily disturbed by snowmobiles, but reacted stronger when provoked by skiers. However, fright, flight, and escape distances were not different ($P > 0.05$) when provocations by snowmobiles and skiers were compared (Fig. 2, Table 1). Besides provocation method, 2 other independent variables entered the ANOVA models: fright distance was longer when animals were provoked from below than from above ($F = 3.256$; df = 2, 55; $P = 0.046$), and escape distance was longer when reindeer were lying compared to grazing prior to provocation ($F = 5.435$; df = 1, 54; $P = 0.024$; Fig. 3).

Total distance moved after a provocation varied between 134 and 2,526 m, with a mean distance of 660 m for snowmobiles and 970 m for skiers (Table 1). Thus, a flight response after provocation represented an energy increment between 0.2 and 2.9% of total DEE, with mean values of 0.8 and 1.1% for snowmobile and skier provocation, respectively (Table 1).

DISCUSSION

Reindeer sighted snowmobiles on average 164 m farther away than skiers. Noise from the motor and/or flashing from the headlights cause snowmobiles to be more obvious than skiers, and could account for this difference. However, despite being aware of snowmobiles at longer distances, reindeer's fright, flight, and escape distances were not significantly different from those due to

Table 1. Observed response distances and estimated energy costs of wild mountain reindeer in Setesdalen-Ryfylke, Norway, when provoked by an observer on a snowmobile or on skis in April 1998, 1999, and 2000 (data pooled across years).

	Provocation by a snowmobile				Provocation by a skier			
	Mean	Median	Range	*n*	Mean	Median	Range	*n*
Herd size	56	42	3 to 600	55	60	47	9 to 204	29
Start[a] (m)	937	874	226 to 2,100	41	721	657	280 to 1,500	26
Sight[a] (m)	534	533	170 to 1,250	40	370	327	122 to 760	26
Fright[a] (m)	328	280	90 to 715	44	328	263	122 to 731	24
Flight[a] (m)	264	216	63 to 710	46	281	220	109 to 595	24
Escape[b] (m)	486	300	106 to 1,650	44	543	373	150 to 1,500	21
Total flight[b] (m)	570	374	134 to 2,300	45	756	550	201 to 1,500	19
Total moved[c] (m)	660	471	134 to 2,526	45	970	850	365 to 2,500	19
Total cost[d] (kJ)	155	110	31 to 590		227	199	85 to 584	
% of DEE[e]	0.8	0.5	0.2 to 2.9		1.1	1.0	0.4 to 2.9	

[a] Distance from observer to reindeer herd at time of response.
[b] Straight-line distance moved by reindeer herd.
[c] Ground distance moved by reindeer herd.
[d] Energy costs are estimated on the basis of total horizontal distance moved on medium soft snow with a sinking depth of 12–32 cm and an estimated average speed of flight at 4 km/hr. The net cost of locomotion is calculated as 2.64 kJ/kg/km (Boertje 1985, Fancy and White 1987) and the additional cost of standing as 5.02 kJ/kg/hr (Fancy and White 1985:155).
[e] Daily energy expenditure (DEE) of a 60 kg, undisturbed reindeer in April is estimated at 20,300 kJ, or 2.5 times its standard metabolic rate (377 × [body weight]$^{0.75}$; Fancy and White 1985).

provocation by skiers. Because total flight and total distance moved were longer (186 and 310 m, respectively) for skier than snowmobile provocations, reindeer probably travel longer before resuming undisturbed behavior and incur greater energy loss when provoked by a skier.

Our observations partly support previous conclusions that people on foot elicit stronger reactions by ungulates than do vehicles (Richens and Lavigne 1978, Eckstein et al. 1979, Freddy et al. 1986). Hunting is not allowed from motorized vehicles in Norway, and chasing and harassing wildlife is strictly forbidden. However, reindeer are hunted by humans on foot and probably do not discriminate between a hunter and a tourist. Therefore, skiers possibly continue to invoke fright and flight reactions despite non-negative interactions with reindeer.

The mean flight distances in our study, 281 m from a skier and 264 m from a snowmobile, are longer than recorded for other ungulates. Persons on foot during winter elicited locomotor behavior by mule deer (*Odocoileus hemionus*) at a distance of 191 m (Freddy et al. 1986), by elk at 86 m (Schultz and Bailey 1978), and by mountain sheep (*Ovis canadensis*) at 50 m (MacArthur et al. 1982). White-tailed deer (*Odocoileus virginianus*) fled from snowmobiles at a distance of 61 m (Eckstein et al. 1979), whereas elk (Schultz and Bailey 1978) and caribou (*R. t. terranovae*; Horejsi 1981) fled from highway vehicles at 77 and 144 m, respectively. The explanation for the shorter reaction distances may be that these provocations mostly occurred in forested areas and were positioned obliquely to the animals.

Tyler (1991) found that Svalbard reindeer (*R. t. platyrhynchus*) discovered snowmobiles at similar median distances (640 vs. 533 m [Tyler 1991 vs. our data]), showed fright reaction at longer distances (410 vs. 280 m), and flight at shorter distances (80 vs. 216 m) compared to our findings. The longer fright distance found by Tyler (1991) may relate to smaller group sizes in Svalbard reindeer (median = 3.31, range = 1–11 reindeer)

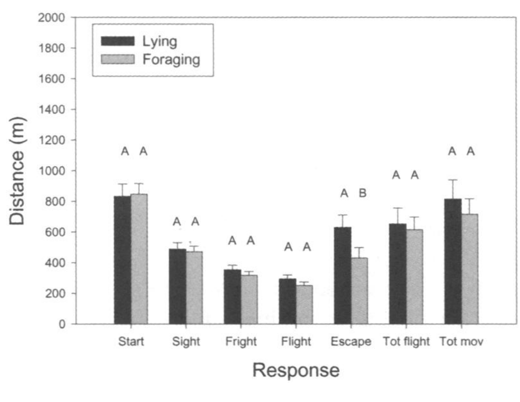

Fig. 3. The effect (+ SE) of pre-disturbance behavior on reindeer response to provocation by snowmobiles and skiers in Setesdal-Ryfylke, Norway, in April 1998, 1999, and 2000. We recorded distance from observer to herd at the start of the provocation and at the first sight, fright, and flight response by the herd. We also measured straight-line distance traveled by the herd during their initial flight (Escape) and any subsequent flights related to the provocation (Tot flight), as well as the total ground distance covered by the herd (Tot mov). Different letters signify significant differences ($P \leq 0.05$).

compared to the mountain reindeer in our study (median = 42, range = 3–600 reindeer). No large reindeer predators exist on Svalbard, and the reindeer population in Adventdalen (1 of Tyler's [1999] study areas) is fully protected from hunting. Moreover, snowmobiles are the dominant form of transportation as well as being popular recreational vehicles in Adventdalen. The short flight distance among Svalbard reindeer may thus reflect a combination of habituation toward the frequent presence of snowmobiles and the absence of predators. Reindeer fright and flight distances in response to humans on foot also were considerably shorter in more heavily populated areas of Svalbard than in more remote areas, suggesting habituation (Colman et al. 2001).

In a similar snowmobile provocation study in Gros Morne National Park, Newfoundland, Mahoney et al. (2001) recorded fright and flight distances for caribou that were even shorter than Tyler (1991) reported for the sedentary Svalbard reindeer. Median response distances were considerably longer among reindeer in our study than among caribou in Gros Morne National Park: sight distance 533 versus 205 m (our study vs. Mahoney et al. 2001), fright distance 280 versus 172 m, flight distance 216 versus 100 m, and net flight distance 374–471 versus 65 m. The lower response distances of Gros Morne caribou probably reflect habituation toward the extensive use of snowmobiles in the area and the more forested habitats in which provocations occurred.

The study design obviously influences the interpretation by researchers of reindeer reactions to provocation. Reindeer in Setesdal-Ryfylke, like Svalbard reindeer (Tyler 1991) and caribou (Horejsi 1981), apparently respond according to the direction of provocation. Direct provocations most likely represent a worst-case scenario (Tyler 1991). The fright and flight distances recorded in our study, therefore, should be regarded as potential maximus for reindeer, at least for single snowmobiles traveling at moderate speed in this area under similar sinking-depth conditions.

We did not observe any skiers near reindeer, nor activity from reindeer that would indicate that they had discovered or been alarmed by skiers other than us. However, we observed 7 occasions on approximately 45 field days when snowmobiles gained the attention of reindeer. During all 7 occasions, the reindeer were located above the snowmobile's course along snowmobile trails. When reindeer heard or observed the snowmobiles, they would stand if lying or pause and lift their heads while grazing, but did not flee. We observed a similar response when we drove past grazing or lying herds of reindeer at distances of 350–1,000 m (E. Reimers, unpublished data).

Estimated energy cost of a single provocation for a 60 kg reindeer ranged from a maximum of 590 kJ (2.9% of DEE) to a minimum of 31 kJ (0.2% of DEE; Table 1). Bradshaw et al. (1998) estimated a 5 times higher energy cost for a similar maximum flight distance (2.11 km) from an oil exploration disturbance event. The difference was due to trotting/galloping costs and excitement costs (10–25% more than required for maintenance) added to the energy cost of distance traveled (Bradshaw et al. 1998). Heart rate reflects metabolic rate (Nilssen et al. 1984); and work by Moen et al. (1982), Langvatn and Andersen (1991), and Weisenberger et al. (1996) indicates that the heart rate of various ungulates exposed to aircraft, snowmobiles, and weapon firing was either unaffected or increased but returned to the pre-trial rate after 1–3 min. Based on these results and our general observations of reindeer behavior following a provocation that indicate negligible excitement costs, we estimate the maximum energy cost of a single winter provocation to be 3% of DEE, rather than the 15% estimated by Bradshaw et al. (1998).

Wild reindeer in the Norwegian mountains likely have no more than 3 encounters per day with humans during holidays such as winter and spring vacations. Contrary to the rest of the winter season, cross-country use of alpine areas is widespread during these holidays, but traffic mostly is concentrated on prepared or marked trails. Accumulated energy costs from 3 encounters with skiers would average 681 kJ/day (3.4% of DEE) compared to 465 kJ (2.3% of DEE) with snowmobiles. Such moderate energy costs from human encounters during 2–3 weeks in winter should be easily compensated for and will most likely not have any demographic consequences. However, avoidance behavior and loss of access to optimal habitats or overgrazing of remaining undisturbed habitats (Nellemann et al. 2000, Vistnes and Nellemann 2001) may be more important for animal condition and demography than the direct effects of provocations. This aspect was not within the scope of our study.

MANAGEMENT IMPLICATIONS

We were concerned only with overt effects of disturbance stimuli used to provoke reindeer. Disturbance by snowmobiles or skiers may cause trauma or avoidance of otherwise favored habitats, but these effects were beyond the scope of our study. We did not observe injuries, even though reindeer groups frequently galloped at full speed tightly bunched over rough terrain for short distances. Our observations are similar with those of reindeer hunters who very rarely report injuries from violent flights upon firing. As suggested by their long response distances, reindeer in Setesdal-Ryfylke most likely have not habituated to snowmobiles (Tyler 1991, Mahoney et al. 2001).

An energetic cost arises if avoiding a disturbance is incompatible with grazing and thereby reduces time for food intake. Repetitive disturbances over time could result in significant energy loss that the animals are unable to compensate for during winter. We found that encounters between skiers or snowmobiles and reindeer did not result in energy costs that could not be easily compensated for under the recorded snow conditions. An increase of sinking snow depth to 40–50 cm may increase the cost of locomotion up to 400% (Fancy and White 1987). Though occurring occasionally, such snow conditions in alpine Norway rarely last more than a few days due to wind action. In addition, deep, soft snow makes both skiing and snowmobiling difficult. Possibly more serious consequences from frequent encounters are the energetic costs associated with avoidance and displacement behaviors that result in loss of access to optimal habitats or overgrazing of remaining undisturbed areas. This disturbance aspect is gaining popularity but lacks critical scrutiny of alternative explanations for altered reindeer area use. We suggest that this disturbance aspect be closely monitored.

Although reindeer most likely will habituate to snowmobiles upon increased use and continued non-negative interactions, the net disturbance effect will increase as snowmobiles allow human presence in previously undisturbed alpine habitat. We therefore recommend continued restricted recreational use of snowmobiles. One way to ease the coexistence between reindeer and humans is to channel traffic into trail systems that are established with regard to minimizing interaction with the reindeer herds. Because reindeer more easily escape provocations from below than from above, we recommend placing trails for both skiers and snowmobiles in relatively low-lying terrain, such as frozen river beds and valleys.

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