Reindeer (*Rangifer tarandus*) response to feces and urine from sheep (*Ovis aries*) and reindeer

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Abstract: In many Norwegian alpine and tundra areas sheep and reindeer graze sympatrically. Areas covered with dung or urine may have consequences for reindeer pasture utilization. Experiments were conducted on 5 stall fed male reindeer calves where animals were individually presenred with two troughs (experimental and control) containing 200 g of concentrate. Fresh and dry sheep and reindeer pellets (50 g wet weight) were mixed with the concentrate in the experimental trough and the aversive response was tested against the control. Both fresh sheep ($P < 0.0001$) and reindeer ($P < 0.0001$) pellets were associated with aversive response by reindeer. A similar response was found for dry sheep ($P = 0.006$) and dry reindeer ($P = 0.0009$) pellets. Similar trials were conducted using sheep and reindeer urine (20 g sprayed evenly on the food) and the aversive response by reindeer was tested against the control (sprayed with 20 g of water). Both sheep and reindeer urine stimulated an aversive response by reindeer ($P = 0.03$ for both tests). The differences in the aversive response of reindeer ro fresh sheep and reindeer pellets, dry sheep and reindeer pellets and sheep and reindeer urine were also tested. No differences by reindeer were found between sheep and reindeer pellets, either for fresh ($P = 0.28$) or dry ($P = 0.07$), or between food treated with sheep and reindeer urine ($P = 0.28$). Possible habituation to sheep and reindeer pellets was tested using 8 consecutive trials with dry pellets, followed by 2 additional trials when dry pellets were soaked in water. This was done to simulate natural dry periods followed by rain showers. Habituation effects were found in trials with dry sheep and reindeer pellets. Subsequent trials with fecal pellets soaked in water significantly reduced food intake when compared with the last habituation trial with dry pellets ($P < 0.05$).

Key words: aversion, fecal contamination, food-choice, large herbivores, parasite avoidance.

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Introduction

Pastures affected by deposition of fecal matter and urine from previous animal grazing are often grazed differently in comparison to unaffected areas (Day & Detling, 1990). Two effects of fecal matter deposition altering animal foraging behavior may be separated; a primary effect resulting from the odor (or taste) of the fecal matter before it decomposes (Arnold *et al.,* 1980), and a secondary effect caused by possible nutritional changes in the vegetation due to the fertilizing effect of feces and urine (Day & Detling, 1990).

As a result of increased quantity and quality of the vegetation, urine patches are in some cases pref-

erentially grazed by American bison (*Bison bison*), American elk (*Cervus elaphus*) and cattle (*Bos taurus*) (Day & Detling, 1990; Jaramillo & Detling, 1992 a,b). Since cattle tend to avoid areas contaminated with dung, the effects of pasture dung fouling have received considerable attention within domestic stock grassland management (e.g. Marsh & Campling, 1970; Spörndly, 1996).

While pasture dung fouling has been focused on for domestic stock, most of the works on wild ungulates have concentrated on repellent effects of commercial substances (Harris *et al.,* 1983) or on predator odors (Sullivan *et al.,* 1985; Melchiors & Leslie, 1985; Swihart *et al.,* 1991). Focus has been on the development of chemical signals to modify herbivore feeding behavior in order to protect tree or crop plantings (e.g. Conover, 1987; Melchiors & Leslie, 1985; Arnould & Signoret, 1993). These studies have shown that predator odors not only are effective repellents for certain deer species (Sullivan, 1985; Swihart *et al.,* 1991), but also for domestic sheep and catrle (Pfister *et al.,* 1990). Hutchings *et al.* (1999) have documented that sheep are able to make decisions between fecal avoidance and nutrient inntake.

Information on the response of wild herbivores towards domestic stock fecal matter is lacking. However, studies on the reaction of white-tailed deer (*Odocoileus virginianus*) towards odors from cottontail rabbit (*Sylvilagus floridanus*) and human (*Homo sapiens*) urine showed no aversive response from these sources (Swihart *et al.,* 1991).

In parts of Scandinavia, semi-domesticated and wild reindeer (*Rangifer tarandus*) populations commonly graze sympatrically with sheep (*Ovis aries*) on summer alpine ranges. In Norway, attention has been given to possible adverse affects for domestic and wild reindeer populations resulting from sheep utilizing the same pastures (Skogland, 1984; Ballari, 1986; Warren & Mysterud, 1995). One of the issues raised has been whether reindeer avoid grazing in areas were sheep have defecated (Warren & Mysterud, 1995).

The objectives of this study were to test aversive response of reindeer to sheep and reindeer pellets and urine when mixed in their food. We also tested possible habituation to dry sheep and reindeer pellets.

Materials and methods

Five stall fed 1 year old domesticated reindeer males were used. The deer were fed twice a day with a 12-hour interval and given a daily food ration of 800 g pelleted concentrate and about 500 g of lichens. The same feeding routine (e.g. type and amount of food, time of feeding) was followed throughout the experimental period and for a 5 month period prior ro the experiment.

Our experimental design and food-choice tests were similar to the one used by Levy *et al.* (1983) and Arnould & Signoret (1993). Each reindeer feeding box was divided in two troughs separated by 20 cm. The animals were given 200 g concentrate in each trough. Sheep or reindeer pellets (50 g wet weight) were mixed in the experimental trough when testing for aversive effects. The amount of feces used corresponded to an average single sheep pellet group (Welch, 1982). We also tested sheep versus control, reindeer versus control, and reindeer versus sheep, using both fresh and dry pellets and urine in the experimental trough.

During the first series of experiments (day 1 to day 9), we tested the reindeer's aversive response towards sheep and reindeer pellets and sheep and reindeer urine. Both fresh pellets (< 12 hours old) and dry pellets (oven dried at 40 °C for 36 hours) were used in the test. In experiments with urine, we used 20 g of sheep or reindeer urine sprayed evenly on the food in the treatment trough. Similarly, 20 g water were sprayed evenly on the food in the control trough. To avoid dissolving the concentrate food, a relatively small amount of urine and water was used. Reindeer urine and pellets were taken from the experimental animals, while sheep pellets and urine were taken from concentrate fed animals in the same barn.

For all trials, the food eaten was recorded after 30 minutes. Each test (treatment) was repeated twice on each animal reversing the position of experimental and control troughs (Arnould & Signoret, 1983).

In a second series of experiments (day 10 to day 12), we tested whether the 5 reindeer showed aversion towards food mixed with a neutral substance. In the treatment trough, we added 50 g of a burned clay particle (leca) with an approximate size, shape and total volume as reindeer and sheep fecal matter.

In a third series of experiments (day 13 to day 22), we tested possible reindeer habituation to dry sheep and reindeer pellets (pellets were oven dried in the same manner as described above). A combination of concentrate (200 g) and pellets (50 g wet weight) were given in both troughs. Again, the total amount of food eaten was recorded after 30 minutes. The habituation trials were repeated 8

consecutive times (lasting 4 days, corresponding to the normal feeding routine) with dry pellets. Immediately following the 8 habituation trials with dry pellets, 2 additional trials were conducted with fecal pellets soaked in water for 12 hours. This treatment in the end of the habituation series was used to simulate a natural field situation where fecal pellets have first dried (the first 8 trials) and then become wet again (the last 2 trials) due to precipitation. Because of an antler injury, only 4 animals were used in the habituation experiment with reindeer pellets. All animals were weighed before the experiments began and once again when all the tests had been completed.

Reindeer aversion was analyzed using a paired *t*-test that enabled us to control for different amounts of food consumption by individual deer. For the habituation experiments, we used Friedman's repeated measures analysis of variance on ranks, where the total amount of food consumed in each trial was ranked. Friedman's ANOVA was followed by Dunnet's multiple comparison test (Glantz, 1992). All statistical analyses were conducted using the program SigmaStat (Jandel Scientific, 1994).

Results

Reindeer aversion towards sheep and reindeer fecal matter

Most animals consumed all the food in the control troughs. Treatments with both fresh sheep ($P < 0.0001$) and fresh reindeer ($P < 0.0001$) pellets were associated with aversive response by reindeer (Fig. 1). A similar response was found for dry sheep ($P = 0.006$) and dry reindeer ($P = 0.0009$) pellets (Fig 2). No difference was found when testing the aversive effect between wet sheep versus wet reindeer pellets ($P = 0.28$; Fig. 1) or between dry reindeer versus dry sheep pellets ($P = 0.07$; Fig. 2). In these experiments, the reindeer ate only a limited amount from the 2 troughs.

Treatments with both sheep urine ($P = 0.03$) and reindeer urine ($P = 0.03$) were associated with a significant aversive effect (Fig. 3). No difference was found when testing between food treated with sheep versus reindeer urine ($P = 0.30$; Fig. 3).

No significant differences were found when testing control (pure concentrate) versus control ($P = 0.21$), burned clay particles (leca) versus burned clay particles ($P = 0.52$) or burned clay particles versus control ($P = 0.13$) (Fig. 4).

All animals increased in weight (by 1 to 6 kg) during the experimental period, indicating that they were in a positive energy balance throughout the study.

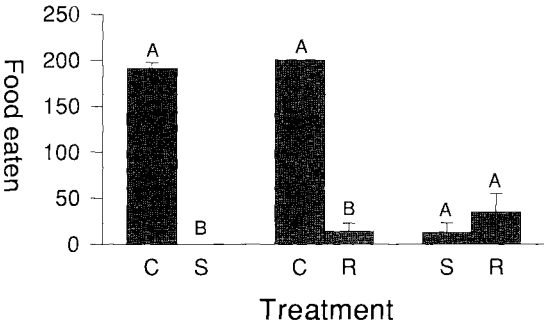

Fig. 1. Reindeer ($n = 5$) feeding response to fresh sheep (S) and reindeer (R) fecal material mixed in food when tested against controls (C) and against each other. A feeding ration of 200 g concentrate was used in both troughs, while 50 g of pellets (fresh weight) were added to the experimental trough. Paired bars with different letters are significantly different (Paired *t*-test, $P < 0.05$).

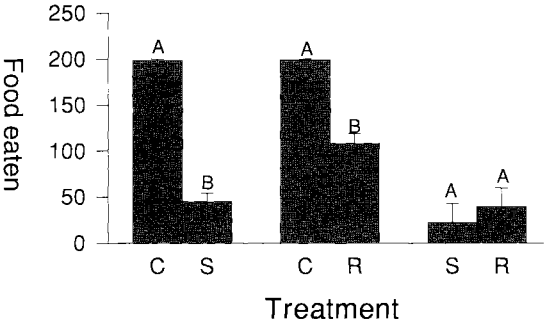

Fig. 2. Reindeer ($n = 5$) feeding response to dry sheep (S) and reindeer (R) fecal material mixed in food when tested against controls (C) and against each other. A feeding ration of 200 g concentrate was used in both troughs, while 50 g of pellets (fresh weight) were added to the experimental trough. Paired bars with different letters are significanrly different (Paired *t*-test, $P < 0.05$).

Habituation to dry pellets

Eight consecutive trials when given concentrate mixed with dry sheep pellets in both troughs resulted in a marked habituation (Fig. 5). Comparing the first with other trials showed that the feed intake was higher from the third trial onwards. Soaking the dried pellets in water reduced food intake significantly compared with the last trial with dry pellets 12-hours earlier ($P < 0.05$). Never the less, food intake with wet pellets in the ninth and tenth trial was significantly higher than at the start of the experiment using dry pellets ($P < 0.05$; Fig. 5).

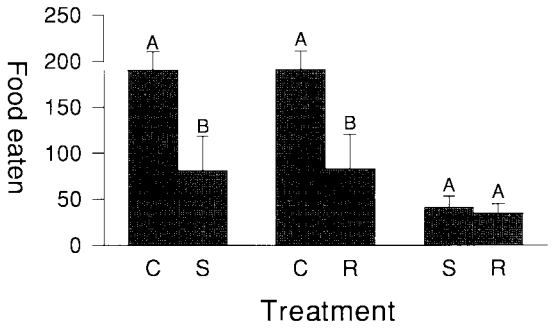

Fig. 3. Reindeer (n = 5) feeding response to sheep (S) and reindeer (R) urine sprayed on the food when tested against controls (C) and against each other. A feeding ration of 200 g concentrate was used in both troughs, while 20 g of urine and water were added to the experimental and control trough, respectively. Paired bars with different letters are significantly differenr (Paired t-test, $P < 0.05$).

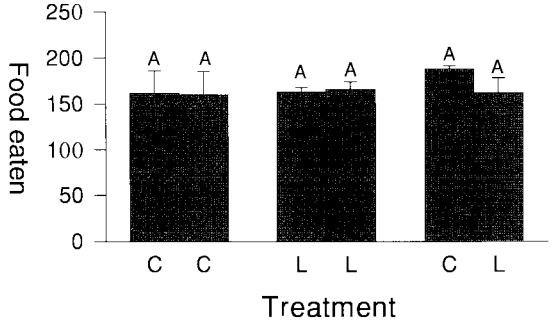

Fig. 4. Reindeer (n = 5) feeding response to pure concentrate (C) and to neutral burned clay parricles "Leca" (L) mixed in food. A feeding ration of 200 g of concentrate was used in both troughs, while 50 g of burned clay particles (approximately the same volume as 50 g fresh sheep and reindeer pellets) were added in rhe experimental troughs. Paired bars with the same letters are not significantly different (Paired t-test, $P > 0.05$).

A habituation effect was also found using reindeer pellets, although less pronounced than in the experiment with sheep pellets (Fig. 6). This was because the reindeer consumed considerable amounts of the food already in the first trial. However, consumption increased significantly during the seventh and the eighth trials ($P < 0.05$). Compared with the eighth trial (last trial with dry pellets), food intake dropped significantly 12-hours later when using wet pellets in trial nine and ten ($P < 0.05$). No statistical difference was found between wet reindeer pellets at the end and dry reindeer pellets at the onset of the habituation experiment ($P > 0.05$).

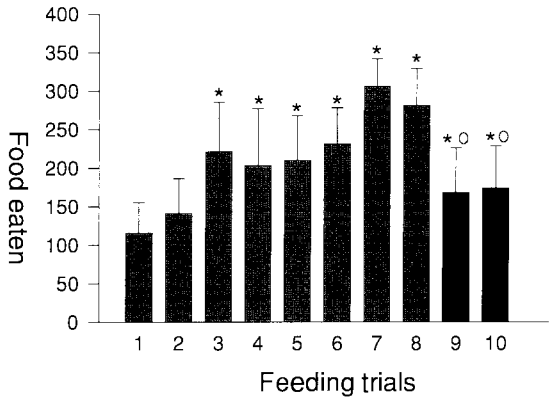

Fig. 5. Reindeer (n = 5) habituation to dry sheep pellets. A total feeding ration of 400 g concentrate was divided equally in 2 troughs while 50 g (fresh weight) of sheep pellets were mixed in both troughs. After 8 consecutive trials with dry dung (gray bars), the sheep pellets in the last 2 trials were soaked in water for 12 hours (black bars). All trials were tested for significant differences (*) using trail 1 as a control group, while the last 2 trials were also tested for significanr differences (0) using trail 8 as a control group (Friedman's repeated measures analysis of variance on ranks followed by Dunnet's multiple comparison tests, $P < 0.05$).

Discussion

In a pen fed experiment, reindeer avoided food mixed with pellets and urine from sheep and reindeer. The aversion was strong when fresh pellets of either sheep or reindeer were mixed in the food. The difference between fresh and dry pellets was not specifically tested.

Although the reindeer preferred the unaltered concentrate ration, they consumed considerable amounts of food from troughs that were treated with dry pellets or urine. Neutral clay particles were mixed with the food to test whether any unnatural substance (Fig. 4) could have caused the aversion response. When clay particles were mixed in both troughs, the reindeer consumed the same amount as when they were fed with pure concentrate. Also, no obvious preference was found between pure concentrate and food mixed with clay particles.

Although the reindeer calves rejected contaminated food during the first trials, a marked habituation effect was found. After seven habituation trials both with dry sheep and dry reindeer pellets, the reindeer consumed a similar total amount of feed as when they were given pure concentrate in both

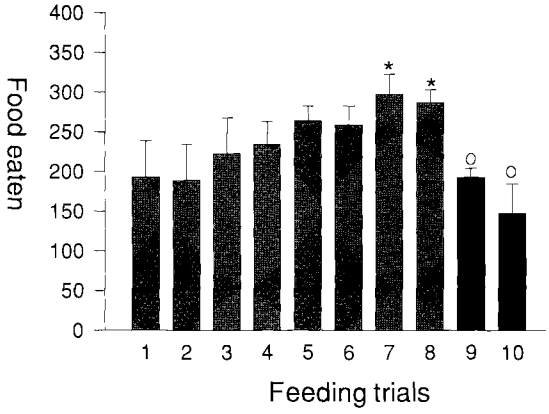

Fig. 6. Reindeer (n = 4) habituation to dry reindeer pellets. A total feeding ration of 400 g of concentrare was divided equally in 2 troughs while 50 g (fresh weight) of sheep pellets were mixed in both troughs. After 8 consecutive trials with dry dung (gray bars), the reindeer pellets in the last 2 trials were soaked in water for 12 hours (black bats). All trials were tested for significant differences (*) using trail 1 as a control group, while the last 2 trials were also tested for significant differences (0) using trail 8 as a control group (Friedman's repeared measures analysis of variance on ranks followed by Dunnet's multiple comparison tests, $P < 0.05$).

troughs. When Arnould & Signoret (1993) tested the habituation of sheep to ftesh dog feces, they found a strong aversion even after 9 trials. Possibly, ungulate aversion to potential predators odors are stronger than to odors from other ungulates or the animals could easier habituate to dry feces. We did not test habituation to fresh pellets. However, after 8 habituation trials with dty pellets, consecutive trials with wet pellets significantly decreased food intake. Reindeer under free-ranging conditions may, during periods of dry weather, be accustomed to dry sheep and reindeer dung. Results of this study indicate that rain showers, or humidity in general (e.g. morning dew), could potentially reinforce the aversion to dry pellets.

Testing animals in a pen situation is obviously not directly comparable to free-ranging conditions. The experimental animals used in this study had been stall fed since they were 8 months old. Prior to that, they had been free-ranging as part of a semidomestic herd located in a mountain area in southern Norway.

All reindeer increased in weight during the study, showing that they wete in a positive energy balance. Thus, it is possible that animals on maintenance diets or lower may show different behavioral patterns, for example, consuming more of the contaminated food. Recent studies have shown that parasitized sheep become more selective when avoiding contaminated swards (Hutchings *et al.*, 1998). Other factors like sex and age of animals could also potentially influence animal aversive behavior (Holand *et al.*, 1998).

In former studies of ungulate repellents, mainly predator substances have been effective (Melchiors & Leslie, 1985; Swihart *et al.*, 1991). This has led to the suggestion that deer do not respond aversively to odors of nonpredatory animals (Swihart *et al.*, 1991). This study demonstrated an aversive response by reindeer to fecal matter from both sheep and reindeer. One should expect that the strong aversive response from fecal matter has evolved in reindeer to reduce the risk of parasite infection (Taylor, 1954; Edwards & Hollis 1982). It is well known that abomasal nematodes, common in both reindeer and sheep (Bye, 1987), may reduce growth in ruminants through reduced food utilization (Sykes, 1978), and hence have implications for the fitness of the infected individuals. Reindeer and sheep have shared summer ranges in Norway for several hundred years, long enough for aversive mechanisms to have evolved if selection pressures are present. Reduced risk of parasite infection has also been suggested as one factor leading to post-calving migrations in reindeer (Folstad *et al.*, 1990). This study did not show any difference in aversion to sheep versus reindeer fecal matter, which may be associated with a large degree of parasitic overlap between the two species. Earlier studies have indeed shown that reindeer and sheep share many abomasal nematode parasites transmitted through feces (Bye, 1987). However, on shared summer ranges, such nematode parasitic load has not been found to increase in reindeer with increasing densities of sheep, although this parasite problem is increasing when reindeer densities increase (Bye, 1987). Thus, the strong aversive response by reindeer to sheep fecal material could be one of the explanations for the limited parasite transfer between sheep and reindeer.

In conclusion, in a pen fed situation reindeer avoid food mixed with pellets and urine from sheep and reindeer. It should be emphasized that in order to draw more conclusive evidence, additional experiments under more natural grazing situations are needed.

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