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The Reactions of Muskoxen to Snowmobile Harassment

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ABSTRACT. Twenty-one harassment trials on 14 muskox herds were conducted in April and May 1982 on eastern Melville Island, N.W.T. Each trial consisted of a slow approach directly toward the herd on a snowmobile. The snowmobile returned along its approach path as soon as 50% of the herd was alerted. Distance at which the first animal reacted (IRD) averaged 345.0 m (range 162–650 m) and the distance from the herd at closest approach (CAD) averaged 267.2 m (range 87–645 m). IRD was positively correlated with wind speed. No correlation between CAD and any of the measured variables was found. Maximum reaction level of the herd was positively correlated with herd size ($r_S = 0.488$, $P<0.05$). No significant differences in IRD or CAD were found between or among classes of discrete variables such as topography and wind direction, but sample sizes were small. Adult female muskoxen reacted first more frequently than expected ($P<0.02$).

Two herds were approached repeatedly (one six times and one three times) to assess habituation. Results were inconclusive. IRD for the herd that was approached three times decreased progressively. IRD for a herd approached six times was variable but shortest on the sixth approach and the reaction level of the herd also was low on the sixth approach.

Key words: muskoxen, harassment, snowmobile, Melville Island, N.W.T.

RÉSUMÉ. Vingt-et-un essais de harcèlement de 14 troupeaux de boeufs musqués furent effectués en avril et mai 1982 dans l'est de l'île Melville, dans les T. N.-O. Chaque essai consistait d'une motoneige se déplaçant lentement en direction du troupeau. La motoneige revenait suivant le même tracé aussitôt que 50% du troupeau avait été alerté. La distance à laquelle le premier animal réagissait (IRD) était en moyenne de 345.0 m (variant entre 162 et 650 m) et la distance minimale entre le troupeau et la motoneige (CAD) était en moyenne de 267.2 m (variant entre 87 et 645 m). L'IRD fut reliée de façon positive avec la vitesse du vent. Aucune corélation entre la CAD et les variables mesurées ne put être distinguée. Le niveau de réaction maximal du troupeau fut relié de façon positive avec la taille du troupeau ($r_S = 0.488$, $P<0.05$). Aucune différence importante dans l'IRD ou la CAD ne fut relevée parmi ou entre les groupes de variables discrètes telles que la topographie et la direction du vent, mais la taille des échantillons était limitée. Les femelles adultes réagissaient les premières plus souvent que prévu ($P<0.02$).

Deux troupeaux furent approchés plusieurs fois (l'un, six fois, et l'autre, trois fois) afin d'évaluer l'accoutumance. Les résultats ne menèrent à aucune conclusion. L'IRD pour le troupeau approché trois fois diminua de façon progressive, tandis que celle pour le troupeau approché six foix fut variable mais plus courte au sixième essai. Le niveau de réaction de ce troupeau fut aussi peu élevé à la sixième approche.

Mots clés: boeuf musqué, harcèlement, motoneige, île Melville, T.N.-O.

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INTRODUCTION

Muskoxen in many parts of the Canadian Arctic have been increasingly exposed to man and his activities in recent years. On the arctic islands, activities associated with hydrocarbon exploration have been extensive, but much of the disturbance of muskoxen by hydrocarbon exploration has been unintentional. Nevertheless, the unique appearance of muskoxen often attracts amateur photographers and many herds have been deliberately approached for the purpose of obtaining pictures (Russell, 1975; pers. obs.). Frequently, an approach to a muskox herd either by people on foot or by snowmobile or other vehicle results in the herd breaking and stampeding (Gray, 1973; Russell, 1975). In this paper, we use the term harassment to denote the deliberate disturbance of muskoxen by human activity such that the animals react detectably. Muskoxen may also react detectably to human activity that is not directed toward them (e.g., aircraft overflights), but we do not consider such activity to be harassment.

A number of factors make muskoxen particularly vulnerable to harassment. Because muskoxen inhabit open tundra they can be seen from long distances. In winter, at least, the hard, windblown snow and lack of obstructing vegetation makes approaches to muskox herds relatively easy. The tendency of muskoxen to stand their ground in a defence formation (Gray, 1974) when threatened is an energy-conserving adaptation. However, even the act of becoming alert may increase metabolic costs (MacArthur *et al.*, 1982; Moen *et al.*, 1982). More importantly, the defence formation frequently tempts people to approach ever closer until the herd finally stampedes. In at least the High Arctic (north of 70°N) many muskoxen may starve or be in extremely poor condition by late winter of some years (Parker, 1978; McLaren and Green, 1982). Increased energy expenditure as a result of repeated harassment could result in death of some animals, particularly younger animals. Winter mortality on Melville Island in 1981–82 was greatest among yearlings and two-year-olds (McLaren and Green, 1982).

As part of a study of the potential effects on muskoxen of a proposed natural gas liquefaction plant at Bridport Inlet, southeastern Melville Island, N.W.T., we assessed the reaction of muskoxen to approaches by snowmobile during April and May 1982. Our objectives were to determine the variability in the distance at which herds reacted to a standardized harassment and to assess the effects of weather and other environmental conditions on this reaction. Muskoxen in the Bridport Inlet area have been subject to low-flying aircraft, and many of the muskoxen probably have some experience with enclosed tracked vehicles, snowmobiles, and people on foot. These activities have occurred sporadically since 1977 and muskoxen in this area have possibly not learned either to avoid or to ignore vehicles.

METHODS

We conducted our harassment trials during the calving

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season and, therefore, decided, *a priori*, that the maximum reaction we would attempt to elicit would be to alert 50% of the herd. An alert animal was defined as one that either stood up if bedded or ceased feeding if standing, and stood with its head up looking in the direction of the snowmobile. Each harassment trial consisted of a slow (8–10 $km \cdot h^{-1}$) approach directly toward a herd by one person on a snowmobile. The snowmobile turned back along its approach path as soon as 50% of the muskoxen being approached were visibly alerted.

Muskox herds were located by ground search of areas where herds had been seen either from the air or during previous ground searches. Once a herd had been located, the snowmobile (a black Bombardier Skidoo 500) was stationed 1–1.5 km from the herd and two observers walked to a station about 1 km from the herd where they could see both the herd and the snowmobile. The herd was visible to the driver from the starting position during 13 of 21 trials. In 18 of 21 trials, the herd was visible for a least several seconds before a response was seen. The remaining three trials were all on one herd and are discussed below.

Prior to each trial, we recorded the herd size, sex and age structure, activity (number bedded, number feeding, number engaged in other activities), herd dispersion, the visibility of the snowmobile at the start, and seven topographic and weather-related variables (Tables 1 and 2). During "downwind" approaches the wind was at the driver's back. Wind speed was measured with a hand-held wind meter (Edmund Scientific Co.) accurate to 2 $km \cdot h^{-1}$.

Muskoxen were occasionally alerted during positioning of the observers. No harassment trial was conducted until all animals had been engaged in maintenance activities for at least 5–10 min after being alerted. The driver was instructed when to begin a trial by means of a hand-held radio. The observers instructed him, by radio, to drop markers when the first animal was alerted and when either 50% of the herd was alerted or the herd made any movement toward a defence formation. The driver turned back along the approach path after dropping the "50% alert" marker and maintained the same speed as he had during the approach.

Observers recorded sex and age of the first and usually the second and third animals to react, the maximum reaction level (MRL), the number of animals reacting at the time of MRL, and whether MRL occurred at the point of closest approach or after the snowmobile had begun to retreat. MRL was recorded on a six-point ordinal scale (Table 1). Time from first reaction until the first animal began foraging after the retreat of the snowmobile was measured on only a few occasions because of malfunctioning equipment. Distance from the closest approach marker to the herd was measured with a range finder accurate to ± 10 m at 1 km or, if the herd had departed, with a thread-type measuring device (Topofil®). Distance between the markers also was measured with the Topofil. The data were not normally distributed and were analysed using non-parametric tests for correlation and equality of means (Siegel, 1956).

TABLE 1. Discrete variables recorded during muskox harassment trials

Variable	Categories	No. of categories recorded
Topography (general)	River valley, coastal plain, upland	3
Topography (relative to approach)	Upslope, flat, downslope	3
Wind direction (general)	Eight compass ordinals	4
Wind direction (relative to approach)	Up, down, side	3
Wind type	Continuous, gusty, variable, barely perceptible	4
Cloud cover	Tenths	8
Sun relative to approach	In front, behind, to the side	3
Herd dispersion	Average interanimal distance: >10 m, 5–10 m, <10 m	3
Snowmobile visible at start	Yes, no	2
Maximum reaction level[1]	(1) 50% of herd alert (2) >50% but <100% of herd alert (3) 100% of herd alert (4) Any walking movement toward a defence formation (5) Some portion of the herd runs (6) All animals run	6

[1]We assume that the intensity of the response increases with classification 1 to 6.

TABLE 2. Spearman rank correlation coefficients for selected variables potentially influencing the reaction of muskoxen to snowmobile harassment

	Initial reaction distance	Closest approach distance	Maximum reaction level[1]
Herd size	−0.116	−0.138	0.488*
Proportion of adult males	0.316	0.039	0.119
Proportion of adult females	0.072	0.388	−0.046
Proportion of 2-year-olds	−0.172	−0.305	−0.291
Proportion of yearlings	−0.126	−0.022	0.208
Proportion bedded at start	−0.011	−0.316	−0.165
Cloud cover	−0.194	−0.266	0.186
Temperature	−0.067	−0.184	0.086
Wind speed	−0.655**	−0.408	0.363
Start time	−0.449*	−0.156	−0.108
Date	−0.508*	−0.137	0.318

[1]Coded on a six-point ordinal scale. See Table 1.
* $0.01 < P < 0.05$.
** $P < 0.01$.

RESULTS

We conducted 21 harassment trials between 25 April and 12 May 1982 within approximately 10 km of Bridport Inlet, southern Melville Island, N.W.T. During this period, there were 99 to 133 muskoxen in the study area, with considerable movement of herds into and out of the area. Herd sizes varied from 1 to 19 individuals (McLaren and Green, 1982).

The topography around Bridport Inlet varies from gently rolling in the east to moderately hilly to the north along the Mecham River valley. To the west the land rises abruptly to

about 60 m ASL beyond the 0.5–2.5 km wide coastal lowland. Well-vegetated meadows constitute only a small portion of the available habitat near Bridport Inlet, and most herds were found in areas with 25–60% vegetation cover (based on A.P.P., 1977). Herds were dispersed throughout the study area and in only two cases is it possible, but unlikely, that the sound of the snowmobile was audible during one harassment trial to a herd subsequently harassed on the same day. Nevertheless, some herds undoubtedly heard the snowmobile as we travelled through the study area.

During our study, the size and age/sex composition of most muskox herds were not stable. Since the animals were not marked, interchange of animals between herds within the study area could have occurred and some individuals may have been present during more than one trial. The observed movement of herds into and out of the study area reduces the probability that particular individuals were harassed more than once. Two herds that were stable during at least the two-week period when we harassed them were each approached several times to assess short-term habituation. We defined short-term habituation as the reduction of either reaction distance or MRL over the course of our harassment trials. These trials were opportunistic since we did not know that the herds would remain stable and we could not be certain of finding the same herds repeatedly even if they did remain stable.

During the period when the trials were conducted, temperature ranged from −17°C to −9°C and wind speeds ranged from 2 to 37 $km \cdot h^{-1}$. Snow cover was close to 100% on 25 April but had been reduced by sublimation to about 50% in coastal areas and on slopes by 12 May.

Muskox herds first reacted to the standardized snowmobile approach (initial reaction distance, IRD) at a mean distance of 345.0 m ±SD 98.1 m (range: 162–650 m). The distance at closest approach (closest approach distance, CAD) averaged 267.2 m ±SD 119.2 m (range: 87–645 m) and distance between IRD and CAD averaged 77.7 ±SD 91.1 m (range 0–266 m). These values include the results of multiple approaches to the two stable herds since there was little evidence of habituation (see below).

Maximum reaction level (MRL) (Table 3) was positively correlated with herd size. However, the scale of measurement was coarse and in cases where MRL occurred after the snowmobile had begun to retreat may have been influenced by social facilitation. When we considered only the cases where MRL occurred at the point of closest approach (N = 13), there was no correlation between herd size and MRL. IRD was strongly negatively correlated with wind speed and less strongly negatively correlated with time of day and date. The correlation with time of day is probably an artifact of the correlation with date, since trials tended to be later in the day in the latter half of the study period. The correlation with wind speed remained even when the results of downwind approaches were excluded ($r_S = 0.64$, N = 18, $P < 0.02$). CAD was not correlated with any of the measured variables (Table 2).

No significant differences in IRD or CAD were found between or among classes of discrete variables such as topography or wind direction, but the sample size was small, especially in the case of variables with more than two categories. For example, the IRD for downwind approaches ($\bar{x}$ = 462.3 m; N = 3) was considerably larger than for crosswind ($\bar{x}$ = 320.3 m; N = 10) or upwind ($\bar{x}$ = 331.6 m; N = 8) approaches, but differences were not statistically significant. MRL was similar whether it occurred at or after the snowmobile reached CAD (Fisher Exact Probability test, $P \gg 0.05$).

The first animal to react visibly to an approach was more frequently an adult (≥3 yr) female than would be expected

TABLE 3. Sex-age structure and maximum reaction level of muskox herds to harassment trials conducted near Bridport Inlet, Melville, Island, N.W.T., 25 April–12 May 1982

Herd no.	No. of harassment trials	Herd size	Males				Females		Yearling	Maximum reaction level[2]
			≥5	4	3	2	≥3	2		
1	6	5	0	0	0	1	3	1	0	—[3]
2	3	9	2	0	0	1	6	0	0	—[3]
3	1	12[1]	1	0	2	2	4	1	1	5
4	1	5	2	0	0	0	3	0	0	3
5	1	11	2	0	0	2	6	1	0	6
6	1	12	3	0	0	2	4	2	1	2
7	1	20	3	3	0	3	9	1	1	4
8	1	12	0	0	0	2	6	1	1	4
9	1	8	1	0	0	2	5	0	0	3
10	1-2[4]	27	1	3	1	5	13	3	1	5
11	1	10	3	0	0	1	4	1	1	6
12	1	4	4	0	0	0	0	0	0	3
13	1	14	1	1	1	2	7	2	0	6
14	1-2(?)[5]	15	1	1	1	1	8	1	2	6

[1]One animal was not classified in Herd 3 and two animals were not classified in Herd 8.
[2]See Table 1.
[3]See Table 4.
[4]Includes the animals in Herd 9.
[5]Probably includes some of the animals from Herd 7.

from the proportion of adult females in the herds tested (x^2 = 4.33, df = 1, $P<0.02$). Adult females constituted only 47.6% of the herds tested but reacted first in 15 (71.4%) of 21 approaches. Adult males and two-year-old females reacted first on two occasions each, and on one occasion a two-year-old male reacted first. In the remaining approach, all 12 muskoxen in the herd reacted simultaneously. The second and third animals to react were most often adult females (10 of 17 possible records and 6 of 10 possible records respectively).

Duration of reaction varied from 2.1 to 6 min on the five occasions when it was measured. During the remaining trials, duration of reaction was estimated to be more than 10 min on only two occasions.

Two identifiable herds were approached repeatedly. One herd of five (Herd 1) containing three adult females, one two-year-old female and one two-year-old male was approached once a day on six days from 27 April to 12 May. A second herd (Herd 2) containing two adult males, six adult females and one two-year-old male was approached once a day on three days from 28 April to 12 May. IRD decreased consistently over the three approaches to Herd 2 but was quite variable for Herd 1 for the first four approaches (Table 4). MRL increased during the first five approaches. During the final approach, however, the MRL was quite low despite a very short IRD and CAD (Table 4).

DISCUSSION

Muskoxen on southeastern Melville Island were in poor physical condition in spring 1982. Only one calf was seen among 160 individuals and six carcasses showed low fat levels in the marrow of long bones (McLaren and Green, 1982).

We do not know whether IRD, MRL or duration of reaction was affected by the physical condition of the animals. Certainly, MRL and duration of reaction can affect metabolic cost, the former directly and the latter indirectly by reducing time spent foraging or ruminating. With respect to MRL it is energetically less costly for the animals to become alert than for them to gallop away. As noted above, we deliberately avoided evoking the latter reaction.

Hearing is apparently highly important in the detection of threatening stimuli by muskoxen. Downwind approaches, although few in number, tended to result in greater reaction distances. Although olfaction could have influenced these reactions, the highly significant negative correlation between wind speed and initial reaction distance even when downwind approaches were excluded suggests that high winds masked the noise of the snowmobile. In support of this hypothesis, we also observed that on calm days muskoxen were alerted by the snowmobile at distances over 1 km even when it was not moving toward them.

Changes in sound level also alerted muskoxen. On two occasions muskoxen 950–1000 m away reacted to the starting of the snowmobile engine. On one of these occasions we had walked up a hill, upwind of the herd, to a distance about 400 m from them, spent 0.5 h sexing and aging the animals, and walked back to the snowmobile with no indication from the animals that they had detected our presence, until the engine was started. Sound level changes also occurred during harassment trials when it was necessary for the driver to accelerate over bare patches or up hills. In at least four cases, the initial reaction occurred at the point of acceleration. Miller and Gunn (1979) studied reactions of muskoxen to various helicopter-based activities and they, too, observed muskoxen to react when sound level abruptly increased.

Although hearing is clearly important, sight and smell probably are also involved. The greater reaction distances found in downwind approaches could have resulted from early detection by scent as well as sound. Muskoxen became alert when the wind was blowing toward them and we were on foot 750 m from them on several occasions. In one trial at a different location (Rea Point), standard except that it was conducted in a large, bright yellow tracked vehicle (Bombardier Skidozer), IRD was 1300 m (pers. obs.), a much greater distance than any IRD observed with the snowmobile. This vehicle was almost certainly seen before it was heard or scented. The wind was from the side during this approach and the Skidozer was not audible to the observers who were 500 m closer to it than the muskoxen were.

In many ungulate species, females, especially those with calves, react to disturbances at the greatest distances, are more

TABLE 4. Reaction distance and maximum reaction level of two muskox herds to a first and to subsequent snowmobile approaches

	Herd 1[1]			Herd 2[2]		
Approach no.	1st reaction distance (m)	Closest approach distance (m)	Maximum reaction level[3]	1st reaction distance (m)	Closest approach distance (m)	Maximum reaction level[3]
1	260	225	3	650	645	4
2	412	190	2	325	305	5
3	336	310[4]	4	292	280	6
4	400	341	3	—	—	—
5	235	225[4]	6	—	—	—
6	162	135[4]	2	—	—	—

[1]Five animals.
[2]Nine animals.
[3]Higher numbers indicate stronger responses.
[4]Snowmobile approach partially hidden by stream bank.

likely than other sex-age classes to avoid unusual stimuli, and react more strongly to disturbance than do other sex-age classes (Bergerud, 1974; Rowe-Rowe, 1974; Roby, 1978; Miller and Gunn, 1979; Horejsi, 1981). Although no calves were present in the herds we approached, adult females were nevertheless more wary than males or young muskoxen. Adult females reacted first significantly more often than expected, and often the second and third animals to react were adult females. Miller and Gunn (1979) did not report reaction distances but did state that muskox cows and calves reacted most strongly to helicopter overflights. They did not separate reactions of cows with calves from reactions of cows without calves.

A number of unquantified factors also affect maximum response and reaction distance. On a number of occasions we observed herds that had been disturbed either by our activities on foot or by the snowmobile to the extent that they ran or moved to a defence formation but had returned to maintenance activities within several minutes. These herds tended to react to our activities, usually by becoming alert, at distances much greater than their IRD distance during harassment trials. MacArthur *et al.* (1982) also observed that previous arousal, whether resulting from disturbance by a predator or actions of a conspecific, resulted in sensitivity to subsequent disturbance in bighorn sheep (*Ovis canadensis*). After disturbances, the sheep reacted with increases in heart rate to stimuli that normally had no effect.

Social interactions among muskoxen within a herd also affected the distance at which muskoxen reacted to us. Two herds in which agonistic interactions between animals were observed subsequently reacted to us unexpectedly. Some members of one herd, in which a bull had several times directed supplanting attacks toward other members of the herd, immediately ran when the snowmobile was started at a distance of 1 km from them. Another herd, in which two bulls had head butted while we were watching, broke into a brief stampede (100 m) about 15 min later when they detected us, upwind and on foot, about 600 m from them. Most herds gave no indication that they had detected us at this distance. Miller and Gunn (1980) reported that reaction level to helicopter disturbance tended to be higher during the rut when social interactions between bulls frequently caused other muskoxen to run briefly.

It is difficult to assess whether habituation occurred during the repeated approaches. Although the reaction distance decreased with each subsequent approach to Herd 2, only three trials were conducted and the MRL of the herd increased with each approach. Assessment of the approaches to Herd 1 is confounded by the fact that during the third, fifth and sixth approaches, the herd was in a position where the only possible approach path was along a stream bed and over a raised bank. The snowmobile was not visible to the animals while in the stream bed, and the first response occurred immediately before or just after the snowmobile topped the bank. Nevertheless, MRL of this herd on the sixth approach was weak (four of five animals alert) despite a short IRD and CAD. When we passed this herd about 1 km away 15 min later they were alerted, but on a return pass at the same distance about 1.5 h later they remained bedded.

Disturbance to muskox herds, whether the result of intentional harassment or not, raises energy costs to some presently unmeasurable degree. The consequences of such increased energetic costs are known at neither the individual nor population level. However, energetic costs will be reduced if intensity of reaction is reduced as the animals learn that some forms of disturbance are not threatening. The likelihood that muskoxen will learn to accept approaches as close as those attempted by many amateur photographers and other curious people seems remote, especially in hunted populations (*cf.* Geist, 1978). We agree with Miller and Gunn's (1979) recommendations that muskox herds should not be approached more closely than 1 km by either vehicles or people on foot. Further, we suggest that as the human population of the North increases education programs for transient workers and residents will be necessary to prevent undue harassment of muskoxen.

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