Progress Notes

Fisheries and Environment Canada / Pêches et Environnement Canada

Aussi disponible en français

No. 78, October 1977

A preliminary study of some observable responses by muskoxen (Ovibos moschatus) to turbo-helicopter induced harassment, Prince of Wales Island, Northwest Territories, July–August 1976

by Frank L. Miller[1] and Anne Gunn[1]

Abstract
On Prince of Wales Island, Northwest Territories, during July and August 1976 we observed the overt behavioural responses of muskoxen to a Bell-206 turbo helicopter. Our helicopter harassment simulated three likely categories of activity associated with the construction and maintenance of a pipeline: reconnaissance and inspection flights (single and multiple passes and/or circles); cargo-slinging (multiple passes) and flights for positioning of ground parties (landings and ground activity).

We obtained 1363 muskox response samples from 92 observations of 498 muskoxen harassed by 212 helicopter flights. We assumed from group size, sex and age composition that we actually harassed 265 individuals in 65 discrete groups. We observed no injuries, desertion of calves or splintering of groups after our harassments, and only on group was observed to gallop more than 1000 m during any harassment. Groups that we observed subsequent to harassment resumed either foraging or bedded activities within 4–17 min of the final harassment flight. However, we rated 48.1% of the responses during the 212 harassments as extreme (galloping and/or tight group defence formation) and 33.0% as strong (cantering and/or loose group defence formation). Thus, muskoxen most often responded to harassment by gathering into classical group defence formations. Only 5.2% muskoxen responded moderately (walking in response to harassment), 9.4% mildly (standing alerted), while 4.3% showed no apparent response.

Solitary bulls characteristically backed up against a topographical feature, such as gully bank or hummock, or stood in a stream when harassed. The bull groups we observed showed components of both characteristic defence behaviour of solitary bulls and of muskoxen in mixed sex groups. We believe the distances of solitary bulls from a topographic feature and the distances between members of groups were the principal determinants of the intensities of locomotive responses leading to defence positioning or formations.

At least some muskoxen responded overtly to all the different patterns of helicopter flights we used. The altitude of the helicopter and its closeness (diagonal distance) to the muskoxen were the most important factors in determining the level of responses. If helicopter flights that cause galloping and/or defence positioning or formations are detrimental, then at least 75% of our flights caused stress. Those flights were as high as 325 m above ground level (agl), and at diagonal distances of as much as 3 km from the animals. Therefore, any flight within those distances has the potential to stress muskoxen.

[1]CWS, Edmonton, Alberta, T5J 1S6.

Introduction
The construction and maintenance of a pipeline will probably lead to great increases in the activities of helicopters and fixed-wing aircraft along the route of the pipeline. At present we lack sufficient knowledge of the behaviour of muskoxen (*Ovibos moschatus*) to predict the effects of the potential increase in such aircraft activity on the species.

At present, knowledge of possible effects of harassment on muskoxen has to be drawn largely from parallels with other ungulates and predicted from descriptions of muskox behaviour.

The objective of this study is to determine overt responses, if any, of muskoxen to helicopter-induced harassment in an area of potential pipeline construction. Harassment is here defined as the phenomenon resulting from the introduction of unidentified stimuli into an animal's environment. Geist (1971) gives a good analysis of the meaning of harassment. We measured harassment only through overt responses by the harassed animals. Therefore, harassment would have been undetected in cases where animals did not respond in an observable manner.

Until now there have been no specific studies on harassment of muskoxen by aircraft. One study described the effects of seismic activity on muskoxen (Beak Consultants 1975). There are some descriptive accounts of isolated harassments by aircraft (Gray 1973, 1974), seismic activity (Urquhart 1973, Riewe 1973, Slaney 1975), and human activity (Hone 1934, Tener 1965, Smith 1976).

Most of the concern about potential wildlife problems that increased exploration has brought to the Arctic has been for caribou, still an integral part of native culture. Hunting of muskoxen (except by a few settlements) was banned in 1917 to allow their numbers to recover. Overhunting had led to extermination of muskoxen in some areas (Hone 1934, Tener 1965) and to severely decreased numbers elsewhere.

Tener (1965) outlined the biology of the species and noted some of its adaptations to the Arctic. Gray (1973) wrote a descriptive account of muskox behaviour and later (1974) described the characteristic defence formation of muskoxen.

Geist (1971, 1975) outlined some of the effects of harassment, using mainly ungulates as examples. He noted (1971:419) that "Another serious consequence of persistent disturbance is voluntary withdrawal from available habitat." Beak Consultants (1975) suggested that seismic activity subtly modified muskox distribution on Banks Island, but Urquhart (1973) and Riewe (1973) could ascribe no major changes of distributions to seismic activities. Lent (1974) predicted from his observations of muskox calving that calves would be especially vulnerable to the effects of aircraft disturbance.

Study area

Prince of Wales Island is about 32 000 km^2 in area, lying between 71° and 74° north and 96° and 103° west. Our aerial reconnaissance included all of Prince of Wales Island except the extreme south and a southern coastal strip (3 x 42 km) on Russell Island between 98°00′W and 99°20′W. We restricted ground work to northeastern Prince of Wales.

Dunbar and Greenaway (1956), Bird (1967) and Blackadar (1967) describe the physiography of Prince of Wales Island. Woo and Zoltai (1975) classified regions and districts of the island using physiographic, soil and plant distribution characteristics. Russell and Edmonds (1977) give further botanical information and caribou and muskox ranges for the island.

Inuit have never been known to settle on Prince of Wales, but they have travelled there from Resolute Bay and Spence Bay to hunt Peary caribou. Dunbar and Greenaway (1956) noted "No trading post or other settlement has ever been established on the island". Although in recent years there have been seismic activities, there has been no intensive exploration on the island.

We selected Prince of Wales Island for our study area as it lies along a potential route for the proposed eastern Arctic pipeline, at the juncture of the high and mid-arctic regions (Polunin 1948, Woo and Zoltai 1975). It also has characteristics in common with other high and mid-arctic islands along the proposed pipeline routes. In addition, present distributions and numbers of both muskoxen and caribou are more favourable for study on Prince of Wales than on adjacent islands (Renewable Resources 1976, Miller and Russell 1976, Russell and Edmonds 1977).

Methods

Three observers used a Bell-206 helicopter as a harassment agent with 49.9 and 33.7 hours flown in July and August 1976, respectively. Our helicopter harassment simulated three likely categories of activity associated with construction and maintenance of an oil or gas pipeline in the Arctic.

We flew reconnaissance flights to obtain relative numbers and distributions of muskoxen and their overt reactions to the helicopter. Random encounters with solitary animals or groups were either single or repeated passes or circles. The altitude of the helicopter was partly determined by weather but we flew all at 30 m intervals below 325 m above sea level (asl). Some flights were at 30–70 m above ground level (agl) to simulate aerial inspection of pipelines.

We looked for groups within 2–4 km of the helicopter. On spotting a group or an individual, the helicopter flew past them, turning, if necessary, to have the animals on the left side of the helicopter. For each observation we recorded helicopter speed (km/h) and altitude (m agl), the actual (diagonal) distance (m) to the first animal to react and to the animals when opposite, using a clinometer. We also recorded verbal observations of sex, age and overt responses of individual animals and photographed them (Kodachrome 40 or Ectachrome 40 Super 8 film) when conditions allowed. We noted the location, terrain, and direction of wind and position of sun relative to the helicopter for each overflight.

We categorized the following overt behavioural responses: (1) bedded, (2) foraging, (3) standing alerted, (4) walking, (5) cantering, and (6) galloping. We noted the position of individuals in relation to each other and if the individuals moved toward taking up a group defence formation. We recorded the type of group defence formation and the subsequent response of the group to the harassment. We divided each observation into approach, closest contact with animals (opposite) and departure of the helicopter. We also recorded activities such as calves moving to cows, animals bolting, milling, aggressive and grooming behaviour.

To simulate the slinging of cargo by helicopter we flew a series of five or more passes over the same group at relatively low speeds (<100 km/h). We were able to make these simulations when animals were found in areas that allowed observation from nearby high ground. Two observers, 0.4–1.6 km away from the muskoxen, watched from the ground while the third observer remained in the helicopter and recorded the time, altitude (asl), speed and direction of each pass. All three observers recorded overt behavioural responses which fell in the six categories described above; those on the ground also recorded other specific types of adaptive behaviour.

The observers on the ground divided their observations into three periods: pre-harassment (undisturbed), harassment, and post-harassment (recovery). We tape recorded behaviour at 5 min intervals and/or whenever changes occurred during pre- and post-harassment periods, and continuously during periods of harassment.

We simulated harassment from survey and inspection crews landed by helicopter. The helicopter landed and shut down within 100 to 800 m of animals. The observers left the helicopter but remained in its immediate vicinity and made no attempt to conceal themselves. The observers recorded on tape and filmed overt behavioural responses using the categories for ground observation already described. We also recorded terrain, distance to the animals, and wind direction in relation to us and to the animals.

Results

We recorded 498 muskox response samples composed of 265 individuals: 42.3% bulls, 29.0% cows, 9.4% juveniles, 3.8% yearlings and 15.5% calves (Table 1). We observed 13 bull-only groups and 19 mixed-sex groups with mean group sizes of 2.6 and 10.0 respectively. We observed 33 solitary bulls, and in August seven bulls that we designated "intruder" bulls. These were bulls associated with a mixed-sex group during the rut and which were attempting to join the group to breed.

We classified the responses by harassed muskoxen into four categories on the basis of the type of group formation

and movement during the helicopter overflight. When we could not observe any responses we classified the animal as not apparently responding.

Rating	Movement	Group type
Extreme	Gallop	Tight
Strong	Canter	Loose
Moderate	Walk	–
Mild	Alert in place	–

The defence circle (also called defence formation or defence ring) is the classical grouping of muskoxen in a circle, crescent, or line formation practised as a mutual defence manœuvre. We refer to mutual group defence by groups of bulls only as "defence formations", and by mixed-sex groups as "defence circles". We make the distinction as it is difficult to conceive of two or three muskoxen as forming a circle. A "loose" group was one with animals up to one body length apart, where group members could be readily counted. In a "tight" group the animals were compacted together, calves and juveniles were difficult to identify, and it was not easy to count group members.

The initial responses to first-time helicopter flights during the 92 observations of muskoxen were: 34% galloped, 27% walked, and 39% stayed in place. Of the animals that stayed in place 83% subsequently responded during first overflights. Only six mixed groups did not apparently respond during the first flights.

The helicopter harassment flights were made at <50 m (25%), 50–100 m (24%), 101–200 m (30%) and 201–325 m (21%) agl. The muskoxen responded to flights at <50, 50–100, 101–200 and 201–325 m agl, by galloping 48, 42, 23 and 14% of the times respectively (Table 2). Intensity of responses by muskoxen apparently increased with decreasing heights of the helicopter above ground level. Closest contact between the helicopter and animals was proportional to the altitudes, as we generally maintained angles of 40–50° between the helicopter's vertical axis and the animals, i.e. the shortest distances between animals and the helicopter were almost 1½ times the altitudes.

Solitary bull muskoxen

We flew over 36 solitary bull muskoxen at least once, then made a second pass over one bull, flew second overflights (circles) around five, third overflights (circles) around two and landed near two. We obtained a total of 46 muskoxen response samples; 54% of the responses were extreme, 30.4% strong and 15.2% mild. Of the 10 samples obtained on second and third overflights, we rated 30% extreme, 60% strong and 10% mild (Table 3).

All animals appeared to be already alerted to the approach of the helicopter when we first sighted them. We never saw a solitary bull either bedded or grazing. They were sometimes alerted to the approaching helicopter at 2–3 km. The distance over which we first observed a response by an animal subsequent to its being alerted varied considerably (34–1600+ m). Three solitary bulls responded initially at >1000 m, 11 bulls at >400 m and six bulls at <400 m but before closest contact with the helicopter. The remaining 16 solitary bulls did not respond after being alerted until the helicopter was closest to them.

Sixteen bulls galloped from several metres to about 200 m to take up defence positions: 13 during helicopter approaches and three during departures. These latter three, however, were walking away from the helicopter throughout the approaches. Three bulls walked, one cantered, and 15 initially stood their ground at defence positions without moving to new sites; four subsequently galloped to other defence positions and 11 remained in place. Of the 20 bulls that moved to defence positions, only five subsequently broke and galloped to second defence positions; the others remained at the first positions. Twenty-two bulls took up defence positions in contact with gully banks or hummocks. Nine bulls stood on top of banks or hummocks and four stood belly deep in streams.

We did not detect a consistent relationship between the bulls' responses and the helicopter approach variables such as speed, altitude, terrain, and position relative to sun and wind. We believe that the proximity of a suitable topographic feature for a defence position largely determined a bull's response to the approaching helicopter. All the bulls, except one that galloped on approach, reached a topographic feature and initially stood in place regardless of the altitude or speed of the helicopter. The exception was a bull that was caught on a large flat area that lacked gullies, streams or hummocks. He did not attempt to stand his ground but continued galloping away from the oncoming helicopter.

The solitary bull's response to a given kind of harassment may be more intense than the response of a group of muskoxen under similar conditions. The muskox group finds security in mutual group defence and the lone bull, lacking companions, must take advantage of natural features for added protection against predator attack.

Bull-only groups

We obtained 120 muskox response samples during 54 helicopter harassment flights over 48 bulls in 19 single-sex groups (Table 4). All muskoxen in these groups responded to harassing stimuli during all helicopter flights; 70.4% of the group responses were extreme, 22.2% strong, 3.7% moderate, and 3.7% mild.

When the responses of individuals within a group varied and the resultant group response rating was higher than some individual ratings, the group response was called mixed. When individual behaviour, regardless of how different, was all rated at the same response level the group response was called uniform. Ratings for groups with mixed responses tended to mask the actual behaviour of most individuals within those groups.

When we harassed groups of two bulls, both bulls involved responded uniformly on 11 of the 12 occasions. On the one remaining occasion, one of the two bulls stood while the other bull walked to him. Only two of the five groups of three bulls responded uniformly. In one group of three one bull galloped to the other two bulls, which stayed in place in a tight defence formation. In another group of three, one bull walked to the other two bulls which stayed in place and were alerted, but separated by several metres. In the last group of three, one bull stood alerted by himself while the other two bulls came together in a loose defence formation. All muskoxen in the group of four bulls and the group of five bulls responded uniformly.

We noted aggressive behaviour in 11 (29.7%) of the 37 observations of single-sex groups. In total, 17 bulls made 63 aggressive acts during 35 helicopter harassments: lateral head-swinging on 31 occasions; gland-rubbing on 26 occasions; head-butting on 3 occasions; and horning and pawing the ground on 3 occasions. In general, aggression appeared to increase with higher intensities and greater durations of harassing stimuli. We did not, however, determine any quantitative differences between bulls that exhibited aggression and those that did not.

Our sampling is not conclusive, but the distribution of responses between the first and subsequent helicopter flights suggests that bulls in single-sex groups were more responsive to a series of overflights than to single flights. This assumption is also supported by the increase in the number of aggressive acts by these bulls during successive helicopter harassment flights.

The movement by bulls in single-sex groups during helicopter harassments was apparently tied to both the suitability of the locale for defence positioning and the spatial relationship of group members during helicopter approaches. Flight behaviour of bull muskoxen in single-sex groups appeared to be an expression of both the flight behaviour patterns of solitary bulls and of muskoxen in mixed sex groups. The availability of suitable defence positions apparently caused some bulls to function independently of other group members during harassments.

Mixed-sex groups

We obtained 1154 muskox response samples during 102 helicopter flights over, and 10 landings near, mixed-sex groups (Table 5). On 37 occasions we observed 401 muskoxen, 191 of which were different individuals, in mixed-sex groups that were in 19 discrete groups.

In total, 79.0% of the 1154 response samples from mixed-sex groups were extreme or strong. Of the 401 muskoxen observed, 52.9 and 93.2% of the 191 individuals responded at more than one level. Larger groups (>10) did not apparently respond more strongly than smaller groups. Groups with more calves, and especially groups in which calves represented a higher percentage (>20%) of the groups, tended to respond more often at higher levels, but the pattern was not consistent

A total of 24 (61.5%) of 39 extreme ratings were indicated by animals galloping: 8 (33.3%) before, 10 (41.7%) after, and 2 (8.3%) before and after formation of group defence circles. The remaining four (16.7%) ratings involved animals that galloped but did not subsequently form group defence circles. Fourteen (58.3%) of the 24 responses indicating animals galloping would in any case have been rated as extreme because of the formation of tight group defence circles. The remaining 15 (38.5%) of the 39 extreme ratings were indicated solely by formation of tight group defence circles.

We probably did not see many aggressive acts that occurred during the harassments of mixed sex groups, because of the numbers of animals involved and the partial obscuring of animals when in group defence circles. We saw only 8 (4.2%) of the 191 individuals in mixed sex groups act aggressively during 20 (17.9%) of the 112 harassments. Six different bulls during 15 harassment flights performed 23 aggressive acts: 8 displacement chases, 6 lateral head-swinging, 5 gland-rubbing, 3 hornings of the ground and 1 butting of heads.

Simulated ground parties

On two occasions when we landed near solitary bulls (400 m and 100 m away), the animals stood in place. One bull broke from his position in a gully and galloped as observers walked to within 100 m of him. The other bull remained backed up against a hummock as observers moved within 75 m.

We also landed near two single-sex groups on separate occasions. We landed 100 m away from a group of three bulls. Their response was extreme; they broke and galloped 50 m before slowing to a walk. When we landed 400 m from another group of three bulls, they stood in place until observers approached within 40 m, then broke and galloped about 800 m.

The helicopter landed by six mixed-sex groups on 10 occasions. We repeated three landings near each of two of the groups. Except on one occasion the landings were preceded by a pass and/or circle. The distance of landing point from the group varied, although we always landed where we were visible to the group. While the helicopter shut down (4–8 min) two or three observers left it and walked around within 30 m of the helicopter for varying periods of time (10–70 min).

The group response to six of the landings was extreme, and strong to four of them. Six groups responded to the landings at higher levels than to the preceding passes or circles, and three responses remained the same. Of the former, three closed ranks and one member of the group subsequently broke and galloped about 10 m; one group galloped in tight formation, and two in loose formation. There was no apparent relationship between the rated response and the distance to the helicopter.

Of the four groups that galloped one was already galloping as the helicopter descended to land—the group galloped about 800 m until out of sight over a ridge. One tight group stood in place for about 30 s, but when an observer left the helicopter, the group broke and galloped about 100 m before stopping again. Two groups galloped (10 and 200 m respectively) as the helicopter descended. The six groups that did not gallop all stood in place, three grouped tightly and three loosely.

Because we made the landings in August, at the beginning of the rut, "intruder" and/or displaced bulls were associated with five of the groups. This may have influenced the behaviour of the muskoxen. The 30 aggressive acts which we observed both during and after landings were almost all associated with the presence of "intruders."

On eight occasions an "intruder" joined the herd and was chased out by the herd bull; only one of these was as the helicopter was landing. We suggest that an "intruder" bull joining a herd was not necessarily doing so as a mutual defence move, but as rutting behaviour, which perhaps was strengthened by the higher level of excitability caused by the harassment.

Six groups reverted to apparently undisturbed behaviour after the helicopter landed. Within 3–9 min the herds started to disperse, and within 12 min of the helicopter's landing the six groups were foraging. Aggressive acts by herd bulls and intruders caused individual members of groups to gallop but the group did not respond together. Only one group bedded down—the first animal bedded 9 min after the landing, and within 44 min all the group had stopped foraging and were bedded down.

Our impression is that the responses of the muskoxen to overhead flights increased during a landing especially if the landing was visible to the animals. Landing without a preceding overhead flight and out of sight of the animals elicited the least response. The only landing not preceded by an overflight and within sight of the animals caused an extreme response. The visibility of the helicopter landing as well as distance from the animals is important in determining the responses to a landing.

Cargo-slinging simulation

We flew two simulations of cargo slinging over a group of two bull muskoxen, first a series of 14 passes (observation no. 239) and then a series of 12 passes (no. 266). The first pass of both series was at 305 m agl, and the subsequent passes were at decreasing altitudes with the last two passes of each series at 15 m agl. The helicopter turned at 3 km on either side of the group and the passes were at approximately 2-min intervals. Ground observers were stationed on a ridge 800 m away from the muskoxen in the first series and 150 m away in the second.

The two bulls responded to all helicopter passes by group defence formation. The responses during 11 of the passes (in no. 239) were extreme and, during three of the passes, strong. Five and seven of the passes (in no. 266) elicited extreme and strong responses, respectively. The two bulls stood either touching tail to tail (extreme) or separated by about one body length (strong). The bulls stood parallel to the direction of the helicopter's flight, one bull faced the helicopter as it approached and the other faced the helicopter as it departed.

In the second series (no. 266), fewer flights (5) elicited an extreme response compared to the first (no. 239). The difference was probably caused by modification of the response by the topography. The bulls, especially bull no. 2, took up a typical solitary bull defence position against a stream bank as well as typical group defence formation. This preference for the stream bank modified their group defence formation such that they were separated from each other by one to two body lengths (strong rating). Bull no. 2 also showed the most gland-rubbing and lateral head-swinging, and apparently initiated the head-pushing during the pre-harassment period of observation no. 239.

We noted further differences between the two bulls in their behaviour between helicopter passes. The most frequent activity between passes was standing in place. During no. 239 the bulls stood in place between two passes; bull no. 1 foraged despite bull no. 2 standing alerted and gland-rubbing. Between passes in no. 266 we observed no apparently undisturbed behaviour (either foraging or bedded).

The bulls were standing tail to tail during the last pass and for 3 min after the helicopter flew overhead in no. 239. Bull no. 1 bedded down 7 min after the helicopter could no longer be heard. Bull no. 2 horned a hummock and gland-rubbed before bedding down 1.5 min after bull no. 1. The bulls were bedded when the observations ended 7 min later. Five minutes after the final pass in no. 266 both bulls were foraging.

We also simulated cargo slinging by a helicopter during 42 passes over eight mixed-sex groups of muskoxen (Fig. 1a–c). We repeated a series of passes over one group on three occasions (nos. 570, 272 and 274) and over one group twice (nos. 273 and 282). However, a wolf attack and subsequent inadvertent human harassment prevented undisturbed observation of the muskoxen in no. 282 and we have not included it in our description of helicopter multi-passes. We flew the multi-passes over 65 muskoxen and obtained 385 muskox response samples: 89 bulls, 124 cows, 70 juveniles, 32 yearlings and 70 calves.

Prior to each simulated cargo slinging flight, observers took up ground positions 400 to 800 m away from the group at suitable vantage points. We observed the animals from 60 to 390 min. The pre-harassment period varied from 8 to 342 min.

Groups responded extremely to 13 passes, moderately to 15 passes, and mildly to 12 passes (Fig. 1a–c). We observed no apparent response in only two of the 42 passes.

The group response is, however, the maximum response of one or more individuals, and in some groups with an extreme group response we found considerable spread in individual reactions. Only one extreme group (18 muskoxen) response involved both galloping and formation of tight group defence circles. In the other instances of extreme group response, only one or two individuals galloped a few steps. The animals that galloped did not form a tight group defence circle but rather galloped toward the group and slowed to a walk after a few paces.

Of the 385 muskox samples: 30.9% galloped; 22.1% walked; 19.5% stood alerted; 18.9% foraged, and 8.6% remained bedded. The uniform extreme responses (n = 108) of the 18 muskoxen in no. 547 masks the variation within the other six groups that we simulated cargo slinging over. If no. 547 is excluded, only 4.0% of the remaining muskox samples galloped but 30.7% walked, 27.1% stood alerted, 26.3% foraged, and 11.9% remained bedded.

A comparison of the sex and age composition of the muskoxen with responses (Table 6) indicates that calves were the most responsive to the helicopter passes. In total, 85.7% of all calves responded compared to 81.3% yearlings, 59.2% juveniles, 78.2% cows and 60.7 % bulls. A calf responded first in 11 (41%) of the 27 passes in which we could identify the first animal to respond, and in five of these 11 passes the calf's response apparently directly caused another animal to respond (either the maternal cow or another animal).

We watched the muskox groups after the final pass until they were either bedded, foraging or had moved out of sight (6–31 min). During the final pass of the helicopter 27.6% of the muskoxen were bedded or foraging; within 17 min of the helicopter's final pass this figure had increased to 83.1% of 65 samples: 38.5% bedded; 44.6% foraging; and 1.5% standing alerted and 15.4% galloping until out of sight.

The commonest minimum level of activity between passes was foraging (40.6% of 320 muskoxen foraged between passes; 29.7% stood alerted; 23.1% were bedded and 6.6% walked). Our comparison of activity between passes by sex and age composition reinforces the indication of the greater reactivity of calves (Table 6). Of the 64 adults bedded between passes, 29 remained bedded for the subsequent pass Of the 20 calves that bedded between passes only one remained bedded during the subsequent pass.

We observed no absolute differences in post-harassment behaviour between the two groups that had the highest ranked responses during the final pass and the other groups. The only apparent difference was that it took a few minutes longer for animals that had responded at a higher level either to bed or forage. We had one group, however, that was severely harassed (no. 282) and we noted some differences in their post-harassment behaviour; it took almost 3 h before they exhibited apparently undisturbed behaviour.

Repeated harassments

We repeatedly harassed two solitary bulls and could not discern any pattern to their response. We also repeatedly harassed a group of two bulls and a group of three bulls on more than one occasion.

We first flew a series of five descending circles over the group of two bulls on 13 July. The response to the first circle was moderate; the responses to subsequent circles were all extreme. Again, 51 min later the same day we flew three low circles (15 m agl) over the bulls, and observed extreme responses to each circle. On 15 and 16 July we flew multi-passes over the animals which responded extremely and strongly (already described in section on cargo-slinging). Finally, on 24 July, we flew two passes over them. The first pass (76 m agl) elicited a mild response, but the response increased to strong when the helicopter descended to 46 m agl for the second pass.

When we first harassed a group of three bulls on 30 July, we flew a single pass at 49 m agl. The harassment elicited a moderate response, and one bull gland-rubbed. A day (17 h) later the helicopter approached at a similar height (46 m agl) and we rated the response as extreme.

We harassed the same three bulls on 12 August. We passed over them at 78 m agl and landed, eliciting extreme responses. We do not have enough data to comment on the significance of the apparent lessening of the response during the last harassment of the two bulls. In the 10-day period preceding the final harassment, the bulls responded extremely or strongly to 34 flights at varying altitudes.

The differences in group size and number of harassment flights between the two series of repeats prevent us from making comparisons. It appeared from within-group results that responses were consistent and increased with continued exposure and stronger harassment stimuli.

We identified seven mixed-sex groups by their characteristic group compositions and by their locations. Recognizing these groups, we were able to repeat varying patterns of harassment flights over them (Fig. 1a–c). We flew a total of 57 passes, six circles over and made six landings near the seven groups. Six of the harassment events were simulations of cargo slinging.

During the 69 harassment flights 39.2% of them elicited extreme and 37.9% strong, responses. During all other harassment flights which elicited responses, formation of group defence circles did not occur; 10.2% of the flights elicited moderate and 5.1% mild, responses. In 7.6% of the flights we did not observe any apparent response. Sixty eight per cent of the muskoxen formed a defence circle during the first pass. Of the 32% that did not do so, 16% subsequently formed a defence circle during the following flights. Four of the flights during which no defence circle was formed were, however, single flights.

The difficulties of relocating and identifying groups limited our sample of repeated harassments and consequently we cannot draw detailed conclusions. But in general, the repeated harassments of several groups indicate variation among group responses to similar harassment flights, and the responses were often consistent within groups.

Two of the groups over which we made repeated harassments had "intruder" bulls associated with them. When the harassing stimuli increased, the "intruder" bulls were more likely to attempt to join the group and were repulsed by the herd bull. During the harassment flights the "intruder" bulls remained loosely grouped, and when observed between flights they also usually appeared to remain within several body lengths of each other. The presence of the "intruder" bulls may have stimulated the herd bull into galloping or walking around his group.

Discussion

We describe only overt behavioural responses of muskoxen to helicopter harassment for the following three reasons. First, the stocky appearance and long hairy coat of muskoxen make it difficult to detect subtle behaviour patterns (movements of head, ears, tightness of back muscles and other indications of tension) and to recognize a state of tension (active inhibition). Thus we cannot say positively whether the muskoxen which apparently did not respond were actually stressed or not.

Second, other effects of harassment (Geist 1975:4–9) would only become apparent months or even years after the event and so could not be detected during one 2-month field season. In the period of our study the only physiological and/or pathological conditions that we could have recognized would have been traumatic injuries caused by panic behaviour. We never observed any such conditions or circumstances likely to produce them. Although we observed an increase in aggressive activity, apparently triggered by the helicopter harassment, we did not see any injuries resulting from the aggression, although aggression between bulls is known to lead to severe injury, even death (Tener 1965, Wilkinson and Shank 1974).

Third, as so little is known about muskox physiology, we cannot describe the harassment effects in any meaningful quantitative terms. We have described the durations and types of overt responses, but it would be premature to speculate on the relationships of those responses to physiological parameters.

The dispersion of solitary bulls in relation to local topography and the dispersion of individuals in a group relative

to other individuals apparently influenced locomotory responses and the distances covered during a harassment. As defence group formation is an integral part of the flight behaviour of muskoxen, the distance moved by individuals during harassment was, in part, directly related to the distance required to attain the defence group formation. The gait an individual used was a function of the distance to be covered, the intensity of the harassing stimuli, and the age and sex of the individual.

Movements after the group took up a defence formation or position were related to the intensity of the harassing stimuli, but varied among the groups. Most groups galloped less than 200 m and only one group consistently moved more than 200 m during harassment flights. We cannot tell whether the apparent variation among groups was the result of previous experiences with helicopters of some or all muskoxen in the group.

The straight-line distances that we recorded between the different locations of the same group on several harassment occasions are difficult to interpret as we know little about the daily rates of travel by unharassed muskoxen. The group that consistently responded most extremely to the helicopter harassment (galloping 3 km in an arc during one flight) only moved 4.8 km from the site of the first harassment after five subsequent harassments in a 17-day period. A group that did not respond extremely to seven harassments during 25 days moved 16.8 km from the site of the first harassment. Both those series of observations were during the snow-free period.

Muskoxen are relatively sedentary (Hone 1934, Tener 1965, Gray 1973, Wilkinson and Shank 1974). Gauthier (1975) described movements of apparently undisturbed muskox groups on central Bathurst Island and Wilkinson and Shank (1974:122–136) described detailed movements of some muskox herds on Banks Island. Their results show that although muskoxen remained feeding in relatively small areas for days at a time, they would also move several kilometres to new foraging areas. All the movements that we observed are within the ranges of daily movements described by Wilkinson and Shank (1974) and Gauthier (1975). We do not know the influence on movements of terrain, snow cover, phenology of vegetation, weather, and phase in the reproductive cycle.

Neither Urquhart (1973) nor Beak (1975) noted major changes in muskox distribution after seismic activities in the area, although Beak (1975:13) suggested that seismic activity subtly modified the distribution. As we have no knowledge of the muskox distribution prior to our harassments we do not know if and how we influenced it. We did not see, as apparently did Gray (1974:27), muskoxen stampeding from an area after the departure of the helicopter. On one occasion we observed a muskox group harassed by helicopter, man, and wolf. The herd subsequently moved into a relatively barren area, as Gray (1974:27) has suggested may happen. The group left the barren ridge and walked to a sedge-meadow within 4 h of the harassment.

Although we did not observe herd splitting and calf abandonment, the reported incidents of harassment leading to calf abandonment were in April (Urquhart 1973) and May (Riewe 1973), when the calves are younger and probably less able to keep up with the herd. Also, we never deliberately pursued muskoxen as this may be more likely to induce panic leading to group splintering.

Our helicopter flights interrupted on-going activity of 93.6% of the 498 muskoxen that we observed. The characteristic response was the formation of the defence circle, and 75% of the responses during 212 flights involved some form of the defence formation. Gray (1974:28) noted that formation of a defence circle in winter, spring or early summer is potentially harmful to the weaker members of the group. We concur with Gray (1974:28), who suggests that group defence formation is a useful indication of the effect of human activities on muskoxen. We have observed group defence formations in response to flights as high as 325 m agl and at diagonal distances as much as 3 km from the muskoxen. Therefore, further work needs to be carried out to establish what altitudes and diagonal distances will not cause apparent harassment of muskoxen.

Acknowledgements

We thank D.B.M. Lamperd for his help in the field. We thank M.C.S. Kingsley for statistical help, and B. Chubb for draughting the figures. We particularly appreciate the support of Polar Continental Shelf Project, Department of Energy, Mines and Resources, especially the logistical and technical assistance of A. Alt and W. Presley. The work was jointly funded by CWS and the Arctic Island Pipeline Program of the Environmental Management Service of Fisheries and Environment Canada.

References

Beak Consultants. 1975. Seismic activities and muskoxen and caribou on Banks Island, N.W.T. Panarctic Oils Ltd., Calgary, Alberta. 15 p.

Bird, J.B. 1967. The physiography of Arctic Canada, with special reference to the area south of Parry Channel. Johns Hopkins Press, Baltimore. 336 p.

Blackadar, R.G. 1967. Precambrian geology of Boothia Peninsula, Somerset Is. and Prince of Wales Is., District of Franklin. Geol. Surv. Can. Bull. 151. 62 p.

Dunbar, M. and K.R. Greenaway. 1956. Arctic Canada from the air. Can. Def. Res. Bd. 541 p.

Gauthier, M.C. 1975. An investigation of the food preferences of muskoxen, Peary caribou and arctic hare on Bathurst Island, N.W.T. 1974. Unpubl. rep., Can. Wildl. Serv. Ottawa. 35 p.

Geist, V. 1971. A behavioural approach to the management of wild ungulates. Pages 413–424 in the Scientific Management of Animal and Plant Communities for Conservation. Edited by E. Duffey and A.S. Watt, Blackwell Scientific Publ., Oxford. 652 p.

Geist, V. 1975. Harassment of large mammals and birds. Unpubl. report to the Berger Commission, Univ. Calgary, Calgary, Alberta. 62 p.

Gray, D.R. 1973. Social organization and behaviour of muskoxen (*Ovibos moschatus*) on Bathurst Island, N.W.T. Ph.D. thesis, Univ. Alberta, Edmonton, Alberta. 212 p.

Gray, D.R. 1974. The defence formation of the musk-ox. The Muskox 14:25–29.

Hone, E. 1934. The present status of the muskox. Spec. Publ. Amer. Comm. Intern. Wildl. Protection No. 5. 87 p.

Lent, P.C. 1974. Mother–infant relationships in ungulates. Pages 14–55 *in* The behaviour of ungulates and its relationship to management. Vol. 2. Edited by V. Geist and F. Walther. Int. Union. Conserv. Natur. & Natur. Res., Morges, Switz. Publ. new ser. no. 24. 940 p.

Miller, F.L., R.H. Russell and A. Gunn. 1977. Distributions, movements and numbers of Peary caribou and muskoxen on western Queen Elizabeth Islands, Northwest Territories, 1972–74. Can. Wildl. Serv. Rep. Ser. No. 40. 55 p.

Polunin, N. 1948. Botany of the Canadian eastern arctic. Part III. Vegetation and ecology. Nat. Mus. Can. Bull. No. 104, Biol. Ser. 32. 304 p.

Renewable Resources Consulting Services Ltd. 1976. Ecological studies of caribou and muskoxen in the Arctic Archipelago and northern Keewatin. Unpubl. rep. to Polargas Environmental Program, Edmonton, Alberta. 194 p.

Riewe, R.R. 1973. Final report on a survey of ungulate populations on the Bjorne Peninsula, Ellesmere Island. Determination of numbers and distribution and assessment of the effects of seismic activities on the behaviour of these populations. Department of Zoology, University of Manitoba, Winnipeg, on contract to the Dept. of Indian and Northern Affairs. 59 p.

Russell, R.H. and E.J. Edmonds. 1977. Report on caribou (*Rangifer tarandus*) and muskoxen (*Ovibos moschatus*) habitat studies on Prince of Wales and Somerset islands and Boothia Peninsula, 1975 and 1976; a completion report. Unpubl. report prepared for Arctic Islands Pipeline Program by CWS, Edmonton, Alberta. 69 p.

Selye, H. 1950. Stress—the physiology and pathology of exposure to stress. Acta Inc. Medical Publishers, Montreal. 445 p.

Slaney, F.F. 1975. Peary caribou and muskoxen and Panarctic's seismic operations on Bathurst Island, N.W.T. 1974. Panarctic Oils Ltd., Calgary, Alberta. 85 p.

Smith, T.E. 1976. Reproductive behavior and related social organization of the muskox on Nunivak Island. MS thesis, Univ. Alaska, Fairbanks, Alaska. 138 p.

Tener, J.S. 1965. Muskoxen in Canada: a biological and taxonomic review. Can. Wildl. Serv. Monogr. 2. 166 p.

Urquhart, D.R. 1973. Oil exploration and Banks Islands wildlife. Game Management Division, Govern. N.W.T. 105 p.

Wilkinson, P.F. and C.C. Shank. 1974. The range-relationship of muskoxen and caribou in northern Banks Islands in summer of 1973: a study in interspecific competition. Unpubl. rep., LGL Ltd. Environmental Research Associates, Edmonton, Alberta. 3 vols. 749 p.

Woo, V. and S.C. Zoltai. 1975. Ecological districts of Somerset, Prince of Wales, and adjacent islands, Northwest Territories. Unpubl. prel. rep., Environmental Management Serv., Edmonton, Alberta. EMS-6-76. 30 p.

Table 1
Sex and age composition of muskoxen by group size, Prince of Wales Island, NWT, 1976

Group size	Number of individuals					
	Bulls	Cows	Juveniles	Yearlings	Calves	Totals
1	38[1]					38
2	18[2]					18
3	9					9
4	4					4
5	6[3]	2		1	1	10
6	2	2	1		1	6
7	4	8	4	1	4	21
8	3	8	3		2	16
9	8	10	3	1	5	27
10	12	19	4	3	12	50
15	2	6	2		5	15
16	2	8	2	1	3	16
17	2	7	3	1	4	17
18	2	7	3	2	4	18

[1]Includes 5 "intruder" bulls.
[2]Includes 2 "intruder" bulls.
[3]Includes 1 bull from a mixed sex group of 5 animals.

Table 2
Percentage distributions of initial movements of muskoxen by social units and altitude (above ground level) of helicopter during harassment flights, Prince of Wales Island, NWT, 1976

Altitude (m agl) Initial responses	Solitary bulls %	Single sex groups %	Mixed sex groups %
<50			
Stand	15	40	40
Walk	15		60
Gallop	70	60	
50–100			
Stand	50	60	40
Walk	7		20
Gallop	43	40	40
101–200			
Stand	38	25	60
Walk	25	38	40
Gallop	37	37	
201–325			
Stand			41
Walk		100	47
Gallop	100		12
<50–325			
Stand	33	37	46
Walk	14	21	43
Gallop	53	42	11

Table 3
Distributions of 46 helicopter harassment flights over solitary bull muskoxen by rated levels of responses and physical variables during first and subsequent passes or circles, Prince of Wales Island, NWT, 1976

	Levels of responses					
	To passes			To circles		
Physical variables	Extreme	Strong	Mild	Extreme	Strong	Mild
Altitudes (m agl)						
<50	9(1)[1]	3(1)	1		(3)	(1)
50–100	7	2(1)	3	1(1)	1(1)	1
101–200	3	1	1	1(1)	1	
201–325				1		
Response distances[2] (m)						
<400	10(1)	3(2)	2	2(2)	1(4)	1(1)
400–750	5	2	3	1	1	
751–1200	2	1				
1201–1600+	2					
Position of sun relative to helicopter and animals						
SHA[3]	5	1(1)		1		1
SAH[4]	5(1)	1	3	1		
Sun obscured	9	4(1)	2	1	2	
Not applicable[5]				(2)	(4)	(1)
Direction of wind relative to helicopter flight						
Flying with wind	8(1)	2(1)	2	2	1	1
Flying into wind	1	2(1)	2		1	
Flying >60° to wind	10	2	1	1		
Not applicable				(2)	(4)	(1)
Topography						
Lowland flats	16(1)	6(2)	4	3(2)	2(4)	1(1)
Intermediate slopes	3		1			

[1] First value equals number of samples at that level of responses during the first harassment flight of each observation; value in parentheses equals number of samples at that level of responses for all harassment flights subsequent to the first flight during each observation.
[2] First observed response subsequent to standing alerted, given as diagonal distance from helicopter to animals.
[3] Helicopter between sun and animals, sun-helicopter-animals (SHA).
[4] Animals between sun and helicopter, sun-animals-helicopter (SAH).
[5] Sun and wind were not considered applicable during subsequent circles and were not recorded.

Table 4
Distributions of 54 harassment flights over 48 bull muskoxen in 19 single-sex groups by rated levels of group responses and physical variables during first and subsequent passes or circles, Prince of Wales Island, NWT, 1976

	Levels of group responses						
	To passes				To circles		
Physical variables	Extreme	Strong	Moderate	Mild	Extreme	Strong	Moderate
Altitudes (m agl)							
<50	4(8)[1]	(1)	1		1(4)		
50–100	2(2)	1(2)		2	(4)		
101–200	2(1)	(5)			3		1
201–325	1(6)	1(2)					
Response distances[2] (m)							
<400	6(15)	2(10)		1	3(8)		1
400–750	3(2)		1	1	1		
Position of sun relative to helicopter and animals							
SHA[3]		(1)			1		
SAH[4]	3		1	1	1		
Sun obscured	6(17)	2(9)		1	2		1
Not applicable[5]					(8)		
Direction of wind relative to helicopter flight							
Flying into wind	2	(1)					1
Flying with wind	4		1	2	4		
Flying >60° to wind	3(17)	2(9)					
Not applicable[5]					(8)		
Topography							
Lowland flats	7(12)	1(3)	1		3(2)		
Intermediate slopes	2	(1)		1	1(6)		1
Ridges		1(6)					
Plateaus	(5)			1			

[1]First value equals number of samples at that level of responses during the first harassment flight of each observation and value in parentheses equals number of samples at that level of response for all harassment flights subsequent to the first flight during each observation.
[2]First observed response subsequent to standing alerted, given as diagonal distance from helicopter to animals.
[3]Helicopter between sun and animals, sun-helicopter-animals (SHA).
[4]Animals between sun and helicopter, sun-animals-helicopter (SAH).
[5]Sun and wind were not considered applicable during subsequent circles and were not recorded.

Table 5
Distribution of 102 helicopter harassment flights over and 10 harassment landings near muskoxen in 37 mixed-sex groups by rated levels of group responses and physical variables obtained during first and subsequent passes, circles, or landings, Prince of Wales Island, NWT, 1976

	Levels of group responses										
	To passes					To circles				To landings	
Physical variables	Extreme	Strong	Moderate	Mild	None	Extreme	Strong	Mild	None	Extreme	Strong
Altitudes (m agl)											
<50	1(9)[1]	(6)		1(1)		(1)	3(1)			(6)	1(3)
50–100	4(1)	(4)				1(1)		(2)			
101–200	(3)	7(4)			2(2)	(2)	1(2)	1(2)			
201–325	3(13)	5(6)	2(9)		2(1)		1(4)		2		
Response distances[2] (m)											
<400	2(4)	3(20)	(9)	1(2)		1(3)	2(5)	1(4)		(6)	1(2)
400–750	2	5	2	1		(1)	2(1)				
751–1200	1(1)	3					1(1)				
1201–1600	3(21)	1									(1)
Position of sun relative to helicopter and animals											
SHA[3]	2(9)	3(8)	(4)	1(1)	2(1)		2		2	(2)	(1)
SAH[4]	4(7)	2(9)	1(4)	1	2(1)		1	1		(2)	1(1)
Sun obscured	2(10)	7(3)	1(1)	(1)	(1)	1	1	1		(2)	(1)
Not applicable[5]						(4)	(7)	(4)			
Direction of wind relative to helicopter flight											
Into wind	4(10)	6(10)	1(3)	(1)	3(1)	1	3		1	(1)	1(1)
With wind	1(14)	2(9)	1(3)	2(1)	1(2)		2		1	(4)	(1)
>60° to wind	3(2)	4(1)	(3)					1		(1)	(1)
Not applicable[5]						(4)	(7)	(4)			
Topography											
Flats	4(19)	10(17)	2(9)	3(1)	4(3)	1(3)	2(5)	1(3)	1	(4)	(3)
Slopes	1(7)	2(1)		(1)		(1)	4(2)	(1)	1	(2)	1
Ridges	1										
Plateaus	2	(2)									
Group sizes											
5–7	3(9)	3(13)	2(6)	1(2)	2(3)		1(1)	(1)			1(2)
8–10	1(8)	6(5)	(3)	1		1(1)	2(4)	1(3)	2	(3)	
11–15	1										
16–18	3(9)	3(2)			2	(3)	2(2)			(3)	(1)
Number of calves in each group											
0	(1)					(1)	1			(1)	
1	4(3)	2(12)	1(9)	2(2)	2(3)		1(1)	(1)			1(2)
2	(9)	4(5)	1						2	(2)	
3	1(5)	3(1)			1	1(1)	1(5)	1(3)		(1)	
4	2(8)	3(2)			1	(2)	2(1)			(2)	(1)
5	1										

[1]First value equals number of samples at that level of responses during the first harassment flight of each observation and value in parentheses equals number of samples at that level of responses for all harassment flights subsequent to the first flight during each observation.
[2]First observed response subsequent to standing alerted, given as diagonal distance from helicopter to animals.
[3]Helicopter between sun and animals, sun-helicopter-animals (SHA).
[4]Animals between sun and helicopter, sun-animals-helicopter (SAH).
[5]Sun and wind were not considered applicable during subsequent circles and were not recorded.

Table 6
Percentage distributions of responses by sex and age of muskoxen during simulated cargo slinging, Prince of Wales Island, NWT, 1976

	Maximum response during helicopter passes						Minimum response between passes				
Sex and age	No. ind.	Gallop (%)	Walk (%)	Stand (%)	Forage (%)	Bed (%)	No. ind.	Walk (%)	Stand (%)	Forage (%)	Bed (%)
Bulls	89	15.7	21.4	23.6	29.2	10.1	74	9.5	20.3	48.6	21.6
Cows	124	36.3	23.4	18.6	16.1	5.6	103	4.9	32.0	45.6	17.5
Juveniles	70	28.6	10.0	21.4	21.4	18.6	59	5.1	32.2	35.6	27.1
Yearlings	32	37.5	31.3	12.5	18.7	0.0	26	7.7	26.9	50.0	15.4
Calves	70	40.0	28.6	17.1	8.6	5.7	58	6.9	36.2	22.4	34.5

Figure 1a
Group responses by flight patterns and altitudes of multiple harassment flights over four mixed sex groups of muskoxen, Prince of Wales Island, Northwest Territories, 1976

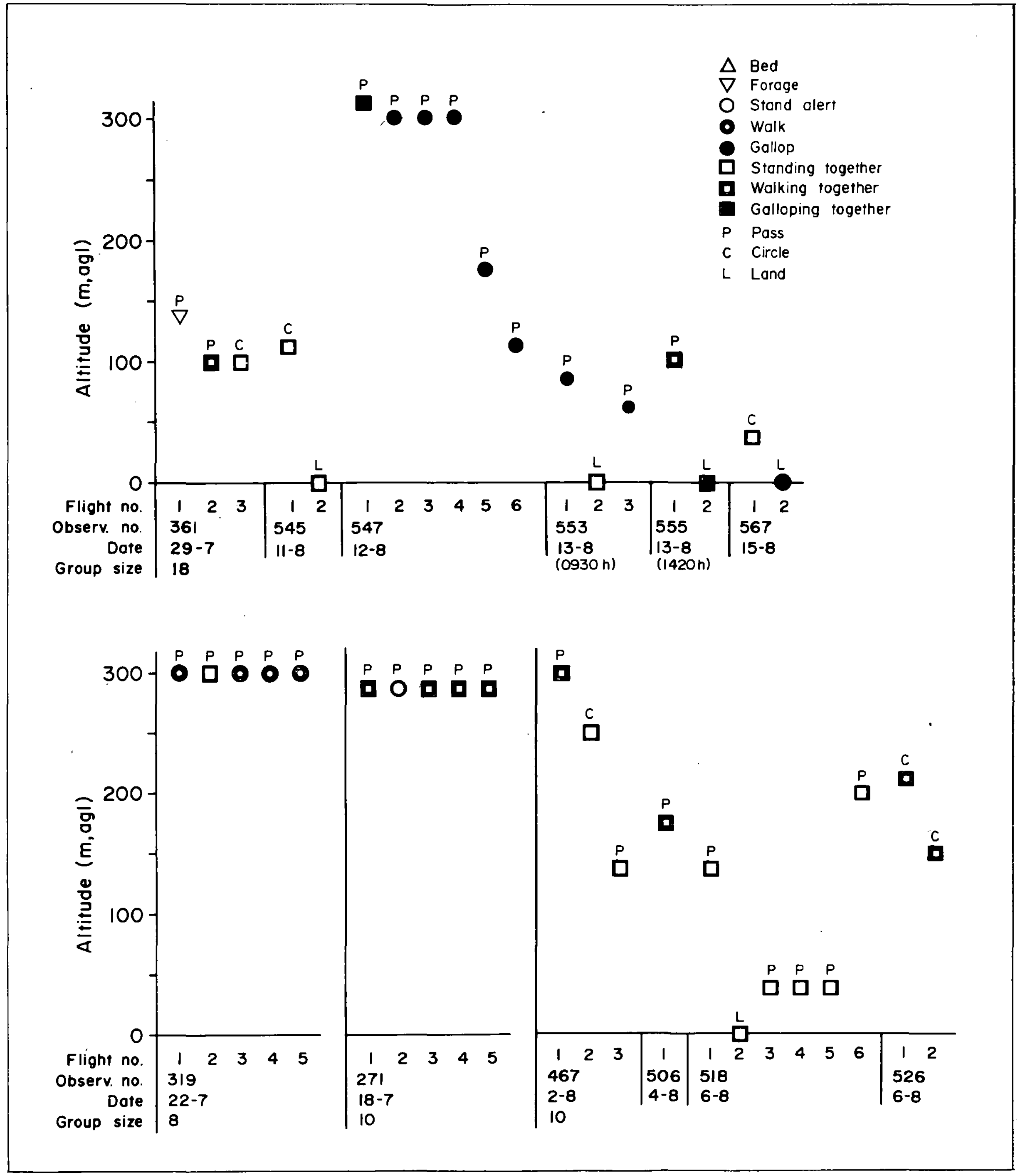

Figure 1b
Group responses by flight patterns and altitudes of multiple harassment flights over eight mixed sex groups of muskoxen, Prince of Wales Island, Northwest Territories, 1976

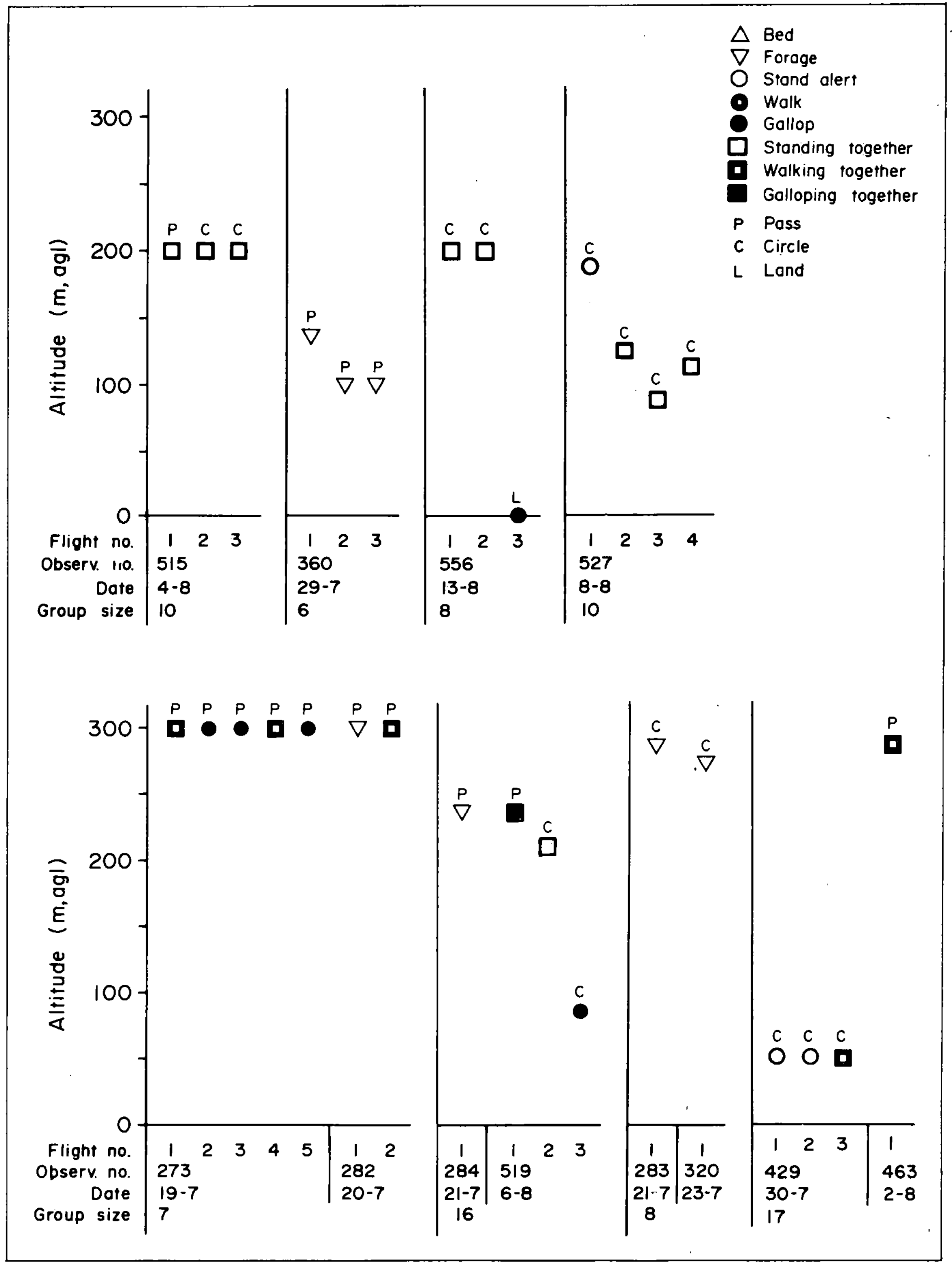

Figure 1c
Group responses by flight patterns and altitudes of multiple harassment flights over one mixed sex group of muskoxen, Prince of Wales Island, Northwest Territories, 1976