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A preliminary study of some observable responses by Peary caribou to helicopter induced harassment, Prince of Wales Island, Northwest Territories, July–August 1976

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Abstract

On Prince of Wales Island, Northwest Territories, during July and August 1976 we observed the overt behavioural responses of Peary caribou (*Rangifer tarandus pearyi*) to a Bell-206 turbo-helicopter. We designed our helicopter harassment to simulate 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 work parties (landings and ground activity).

We obtained 2674 caribou samples excluding 113 samples analyzed separately (in this note) in simulated work parties. Of the 2674 samples 29.0% were bulls, 43.8% cows, 10.6% juveniles, 1.7% yearlings and 14.8% calves. We obtained 597 group samples with an overall mean size of 4.4. Mean group size tended to increase during the post-calving period.

In total 2337 (87.4% of total sampled) caribou responded in detectable manner to helicopter induced harassing stimuli: 40.4% trotted, 13.2% galloped, 12.7% walked, 21.0% were alerted but remained in place. The remaining 12.6% did not respond in a detectable manner and appeared to remain unalerted and engaged in pre-harassment activities: 8.5% foraging and 4.1% bedded. Our data suggest that bulls were less responsive than cows and all immature caribou. In addition, bedded caribou tended to be less responsive than foraging caribou to harassment. Caribou in large groups responded more than caribou in small groups. As expected, lower flights elicited greater responses but the roles of factors such as sun position, terrain, and wind direction relative to the helicopter and animals in influencing response levels require further analyses.

Introduction

The construction and maintenance of a gas pipeline which is proposed for the eastern Arctic, will be accompanied by considerable use of helicopters and fixed wing aircraft and human and vehicular activities on the ground. It is not known how those activities will affect the Peary caribou, which number 6000–7000 animals (estimated 1974), distributed along the proposed routes (Renewable Resources 1976, Miller *et al.* 1977).

The objective of this study is to determine the responses, if any, of Peary caribou to helicopter induced harassment in an area of potential pipeline construction. We noted only observable responses or the apparent lack of responses. We did not measure the cost of harassment to ungulates on psychological or physiological terms. Any harassing stimulus causes a change in an animal's environment and the animal will respond in an attempt to adapt to the change. Therefore, the apparent lack of response during some harassments is, in fact, a reflection of our inability to detect the response.

The study area (Fig. 1) and methods are described in Miller and Gunn (1977). We emphasize that statements in this paper are both tentative and conditional on further analyses. We believe, however, that statements made herein will hold under more detailed analyses, but it is prudent that we state that some conditions may be modified or even reversed under further scrutiny of the data. The variables tested in the preliminary regression analysis that contribute at least 1% of the original sum of squares will be subjected to further testing in our completion report in 1977. The distributions of those variables will be related to all other biological and physical variables recorded during our study.

Results and discussion

Sample characteristics

Biological variables

In total we obtained 2674 caribou samples (excluding 113 samples reported in the section on Landings): 779 (29.1%) bulls, 1170 (43.8%) cows, 284 (10.6%) juveniles, 46 (1.7%) yearlings and 395 (14.8%) calves. We define a sample as the responses of one animal during one harassment flight. We could not always differentiate cows from juveniles and, when in doubt, classified the animal as a cow. Thus the cow samples are possibly slightly inflated. We also may infrequently have mistaken yearlings for juveniles.

We believe that our classification by sex and age is a good approximation of the sex and age classes of the caribou that we sampled. The sex and age segregation of the groups during first time flights is the best estimate of the true sex and age composition of the caribou that we sampled: 382 (20.8%) bulls, 943 (51.5%) cows, 164 (8.9%) juveniles, 40 (2.2%) yearlings and 304 (16.6%) calves.

We harassed, with a helicopter, 597 group samples. Mean group size tended to increase during the post-calving period. We obtained the expected pattern of increasing average group size with increases in numbers of calves.

We encountered 20 group types (Table 1). The seasonal distribution of group sex and age classes possibly reflects more the sampling effort than the actual relative occurrences of group types in the study areas. Most caribou groups were sampled between 8 and 23 July. The relatively high number of bull groups during 8 to 15 August is a reflection of repeated harassment of one group of four bulls. Of the 417 group samples obtained during first time flights 201 were composed of animals of a single sex and age class: 104 bulls, 84 cows, 11 juveniles, one yearling and one calf group. The

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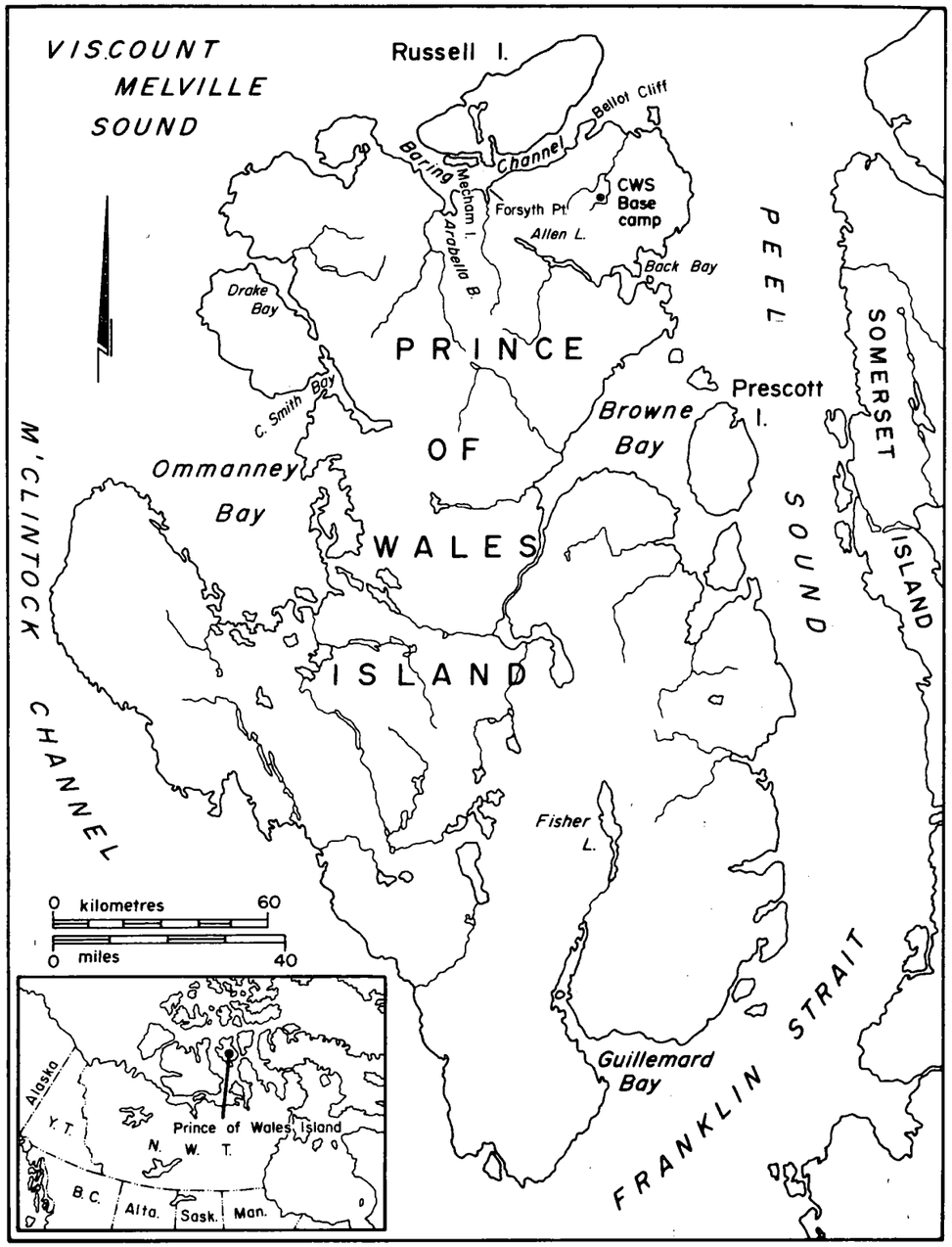
Figure 1
Prince of Wales Island, NWT



remaining 216 of those 417 groups were composed of individuals of different sex and/or age classes: 56 groups with bulls present, 167 with cows, 78 with juveniles, 35 with yearlings and 143 with calves.

Of the 180 groups sampled during subsequent overflights 103 were composed of animals of a single sex and age class: 97 bull groups and 6 cow groups. The remaining 77 groups were composed of individuals of different sex and/or age classes: 35 groups with bulls, 48 with cows, 44 with juveniles, 4 with yearlings and 33 with calves.

Bulls occurred in 295 (49.4%) of the 597 groups sampled. In total 203 of those groups were solitary bulls or bulls only in the company of other bulls. In the remaining 92 groups bulls were present with other sex and age classes. Cows occurred in 299 (50.1%) of the 597 groups sampled. In total 90 of those groups were composed of solitary cows or cows only in the company of other cows. In the remaining 209 groups cows were present with other sex and age classes. Juveniles occurred in 134 (22.4%) of the 597 groups sampled. In total 11 of those groups were composed of solitary juveniles or juvenile only groups. Juveniles were present with other sex and age classes in the remaining 123 groups. Yearlings occurred in 40 (6.7%) of the 597 groups sampled. Only one yearling occurred as a solitary animal and no yearlings were seen only in the company of other yearlings. Calves occurred in 178 (29.8%) of the 597 groups sampled. We did not see solitary calves but we did see two groups of calves only. Calves were present with other sex and age classes in the remaining 176 groups.

Association of sex and/or age classes and distributions by group sizes varied considerably. Bulls tended to be mainly associated with groups of less than the overall mean group size of 4.4 (<5), while cows, juveniles and calves were associated more with the larger groups (≥5).

Physical variables

We recorded six sets of physical variables during helicopter overflights (Table 2). As flights over 200 m agl are lacking, data from flights between 200–300 m agl are probably insufficient for quantitative analyses.

Responses to harassing stimuli

Passes and circles

We observed responses to helicopter induced harassment by 2337 (87.4%) of the 2674 caribou samples: 1081 (40.4%) responded strongly (trotted), 353 (13.2%) extremely (galloped), 338 (12.7%) moderately (walked) and 565 (21.1%) mildly (alerted but remained in place). We saw no response in 337 (12.6%) caribou samples which continued pre-harassment activities. The response pattern consisted of four parts (A, B, C, D): A = minimum response during initial stage of approach; B = maximum response during approach before point of closest contact with the animals; C = maximum response during departure after point of closest contact; D = minimum response during departure.

We observed the following minimum responses and activities during the initial stage (A) of the helicopter approach: 1615 (60.4%) foraging; 423 (15.8%) bedded; 307 (11.5%) alerted, but remaining in place; 243 (9.1%) trotting; 70 (2.6%) walking; and 16 (0.6%) galloping. We believe that most, if not all, caribou not foraging or bedded on approach (n = 636) were responding to the approaching helicopter before we had detected their presence. The likely exceptions would have been caribou that were walking when we first observed them.

We did not observe any response by 2038 (76.2%) of the caribou samples during stage A of the approach. All those animals were either foraging or bedded. Subsequently all but 337 of them responded to the helicopter (Table 3). A smaller percentage of bedded caribou (73.3%) responded than of foraging caribou (86.1%) even though there were more (65.2%) bulls among the foraging caribou than among the bedded caribou (54.5%). Other data (see Table 7) suggest that bulls were less responsive than cows and all immature caribou. Also, only 18.0% of all bedded caribou subsequently responded strongly or extremely compared to 53.4% of all foraging caribou (Table 3). Most caribou that were apparently unalerted during stage A of the helicopter approach responded at the strong level 38.3% (780) followed by responses at the mild level 24.2% (494) and moderate level 13.2% (269). Only 7.8% (158) of those caribou samples responded at the extreme level. However, 30.7% (195) of the caribou samples that were apparently responding to harassing stimuli during stage A did so at the extreme level.

The four segments (A, B, C and D) of the record of response patterns exhibited by caribou during helicopter harassments were used in an attempt to evaluate variation in the intensities of responses to harassing stimuli. A total of 2055 caribou samples were included in the analysis. Samples of caribou that showed no apparent response to harassments (n = 337) or were already responding to harassing stimuli during the initial part (A) of the harassments at what were their maximum responses (n = 282) were not included in the intensities of different maximum responses. Caribou samples responding on contact (A) equalled 636 (23.7%) and 354 subsequently responded at higher levels during the harassment. In total 1704 (63.7%) of the caribou samples did not respond during the initial stage of the approach (A) but subsequently responded to harassing stimuli at some time during the harassment (B, C or D or any combination thereof).

The following five levels indicate the intensities of maximum responses during the harassments. The highest level of intensity is considered at the "first level" and supposedly is reduced throughout to the "fifth level".

(1) 1st level. The maximum response was reached during the approach (B) and was maintained throughout the remainder of the harassment (C and D), where B = C = D in Table 4.

(2) 2nd level. The maximum response was reached during the approach (B) and was maintained after point of closest contact between helicopter and animals and during part of the departure (C) but was reduced to a lower level response during part of the departure (D), where B = C > D in Table 4.

(3) 3rd level. When the maximum response was reached during the approach (B) and was reduced to a lower level response after point of closest contact and throughout the departure (C and D), where B > C ≥ D in Table 4.

(4) 4th level. When the maximum response was not reached until after point of closest contact, but was reached and maintained through the departure (C and D), where B < C = D in Table 4.

(5) 5th level. When the maximum response was not reached until the departure (C) and was reduced to a lower level response during part of the departure (D), where B < C > D in Table 4.

Of the 597 caribou groups sampled 105 were of solitary animals, 244 were of two or more caribou that showed uniform responses and 248 were of two or more caribou that exhibited mixed group responses. The degree of association between sex and age classes varied and groups of mixed sex and age composition accounted for 48.6% (290) of all groups observed. In total 53.8% (156) of the mixed sex and age class groups showed uniform responses.

We saw solitary bulls, cows, juveniles, and yearlings. Fourteen of the 20 group types that we observed exhibited uniform group responses and 16 exhibited mixed group responses. Cows occurred in 35.0% (209) of the groups and bulls occurred in only 15.4% (92) of the groups.

Calves showed the highest percentages of maximum responses in groups exhibiting mixed responses (Tables 5 and 6). Yearlings, however, were involved the least in minimum responses by groups exhibiting mixed responses, but were closely followed by calves (Tables 5 and 6). The percentages of bulls and cows involved in both maximum and minimum responses in groups exhibiting mixed responses are noticeably different from those percentages of immature caribou (Table 6).

We determined which animal was first to respond during each harassment on 159 (6.0%) occasions. We observed 59 calves (37.1%), 35 cows (22.0%), 28 juveniles (17.6%), 25 bulls (15.7%) and 12 (7.6%) yearlings responding first to harassing stimuli.

Levels of responses by sex and age classes varied considerably (Table 7). Calves responded the most (85.6%) disrupting their ongoing pre-harassment activities and moving from their pre-harassment locations. On the basis of age 81.4% of all immature animals responded with disruption of pre-harassment activities and movement from pre-harassment locations compared to 60.6% of all adults. However, almost as great a percentage of adult cows (70.1%) as juveniles (76.1%) and yearlings (78.2%) responded by displacement (Table 7).

Bulls (46.5%) were the only sex and age class that showed a noticeably lower percentage of responses at the moderate through extreme levels (Table 7). The pattern for sex and age classes not responding to harassing stimuli is the reverse of the responsive pattern: calves the least unresponsive; cows, juveniles and yearlings more unresponsive and comparable; and bulls the most unresponsive.

Caribou appeared most responsive between 24 July and 7 August and least responsive during the first and last weeks of the study (Table 8). The seasonal changes in numbers of immature animals sampled, especially increases in numbers of calves; larger group sizes on the average and possibly a higher state of excitability due to recent movements onto new areas of summer ranges may have all contributed to the increased responsiveness of caribou later in the summer.

The comparison of data for two sets of group sizes (Table 10), <5 vs ≥5 and <10 vs ≥10, shows that on a percentage basis, fewer caribou in smaller groups responded to harassing stimuli (Table 10), except at mild and moderate levels. Caribou in relatively large groups responded noticeably more at the strong and, to a lesser degree, at the extreme levels than caribou in relatively small groups (Tables 9 and 10).

The reduction in differences in the percentages of caribou responding at the strong level in groups of <10 vs ≥10 as compared to groups of <5 vs ≥5 (Table 10) can be explained by the relative increase in percentages of caribou responding at the strong level in groups of sizes five to nine (Table 9). The similar average percentages of caribou responding at the extreme levels for groups <5 (11.4%) and groups ≥5 <10 (11.7%) accounts for much of the marked differences in the percentages of responses at the extreme level in groups <5 ≥ and <10 ≥. The data (Table 10) suggest that caribou in groups less than the mean group size (4.4) are less responsive than caribou in groups larger than the mean. Contagious behaviour probably caused much, if not all, of the apparent greater responsiveness of caribou in larger groups, as would have the presence of calves (which were more numerous in larger groups) and other immature animals.

As expected lower flights elicited greater responses (Table 11). Unfortunately our data lacked samples in 200 m agl classes, but our data suggest that 200 m agl is a transitional height for caribou responses to helicopter overflights.

Our data suggest that caribou were more responsive to slower flights (Table 12). Caribou responded by moving (walk, trot or gallop) to 91.7, 71.3 and 63.7% of all flights at <80 km/h, <129 km/h and >129 km/h, respectively. Longer exposures at speeds <80 km/h likely caused higher level responses than shorter exposures at faster speeds. Our data suggest that fastest speeds (>129 km/h, cruising speeds) were of short enough duration to reduce markedly the impact of the helicopter harassment (Table 12). Some of the apparent effects of lower speeds may actually be a reflection of flight patterns and other variables.

We determined the maximum distances at which caribou responded by displacement to the approaching helicopter subsequent to being alerted. Those observations were difficult to make and the validity of the measurement was restricted.

The overall distributions of responses by distances from the helicopter to the caribou (Table 13) suggest that "excitable" caribou respond at the greatest distances. In our preliminary regression analysis the variable "response distance" was positive and significant ($p > 0.001$).

We could not detect a readily apparent pattern of influences of the three classes of sun position relative to the helicopter and caribou on responses if the "not applicable" class was excluded. We recorded sun position as "not applicable" during all but the first half of the first circle of multiple circle flights. The helicopter back lighted by being between sun and caribou (sun class one) was identified as a positive and significant variable ($p > 0.0001$) in our preliminary regression analysis. The presence of the "not applicable" class in the regression analysis distorted the other sun variables. This will be investigated further in our completion report.

We observed no apparent distinction in responses to the different wind classes. Presence of the "not applicable" wind class in the regression resulted in wind classes one to three each being negative and significant in the preliminary regression analysis. That condition resulted because the "not applicable" class recorded during multi-circle harassments was associated with higher level responses. We will examine the problem in more detail in the completion report.

We classified the topography where caribou were encountered into five general categories. It is likely that the categories were too generalized to be of value in determining their influences on responses to the helicopter. We suggest from the pattern of distributions of responses that caribou were most responsive on areas restricted on one or more sides by water, followed by caribou on ridge areas and plateaus. The lesser responses of caribou on lowland flats and intermediate slopes was perhaps a reflection of the larger sample sizes for those two categories. The data on topographical distributions of caribou probably serve to approximate the distributions of caribou on the study area during the field season.

Simulated cargo slinging flights

We flew five simulations of cargo slinging over the same group of four bulls. (1) Nine descending passes; (2) later on the same day eight descending passes; (3) nine passes at a fixed altitude the following day; (4) 11 and 10 descending passes on later days.

During three of the simulations the helicopter turned at about 8 km on either side of the group, and at about 15 km on either side of the group, during two simulations.

Pre-harassment: the responses of the helicopter landings to position observers are described under "Simulated work parties". The pre-harassment periods were all ≤30 min (9–30 min). In Nos. 808 and 529 the two observers were in sight of the caribou. Immediately before the first passes the bulls were all foraging except the lead bull in Nos. 529 and 554 (Figs. 2–6).

Harassment: the 47 passes resulted in 188 samples. As we could distinguish the bulls by their relative sizes, pelages and antler development, we were able to record an individual's responses (Figs. 2–6).

Of the 188 samples, 44.2% did not detectably respond but continued to forage (43.1%) or remained bedded (1.1%). However, 29.3% of the 188 samples responded mildly, 11.7% strongly, 8.5% moderately and 6.4% extremely. There was a weak trend of increasing response level with lower altitude flights. The bulls only galloped (extreme level) during passes ≤60 m agl. No bull galloped more than 50 m; on most occasions the bull only galloped a few strides.

Two bulls walked during only one pass of the nine passes at 244 m agl (Fig. 4). During four other passes the animals only looked up at the helicopter (mild response) and did not respond to four other passes. Eight passes at similar altitudes (>200 m agl) during the other observations also elicited either no detected response (20 samples), alerted (9) and walking (3). Responses to passes at <200 m agl were variable.

During 44.7% of the 47 passes the four bulls responded uniformly; the only three occasions when the bulls responded by galloping they did so as a group, although the galloping was always initiated by one animal.

Between helicopter passes the bulls either foraged (139 of 168 samples) or were bedded (29 of 168 samples). On two occasions the lead bull was bedded before the first pass and remained bedded for one and five passes. On one occasion the four bulls bedded during the series of passes but rose together when the helicopter suddenly descended from 213 m agl to 61 m agl because fog had blown in.

Our sample size prevents us from examining the sequence of responses to the pass series but we suggest that there was an increase in response level during the fourth and fifth pass series (Figs. 2–6). Those two series were also the only two with heavy cloud conditions and north to northwest winds in excess of 10 km/h (helicopter flight pattern north-south).

Post-harassment: within 2 min of the final passes the caribou bulls were foraging, and on two occasions continued to drift away from the observers. When the helicopter landed to pick up the observers, the animals did not respond on two occasions, twice one and three animals were momentarily alerted, and once one bull trotted several yards and two bulls were alerted. When last observed all bulls were foraging.

We observed the same group of four bulls on a sixth occasion, about 7 h after flying 10 passes over them. We flew two passes at 69 m agl as the bulls were crossing a river. Two bulls were foraging, one bull was alerted while standing in the river and the fourth bull trotted a few paces toward the river. On the second pass three bulls continued to wade across the river and the fourth bull stood on the bank.

The group of four bulls was the only caribou group that we knowingly repeatedly harassed. On the six occasions they remained within 5 km of the original sighting.

Simulated work parties

We obtained 91 caribou samples during helicopter landings: 36.2% bulls, 38.5% cows, 4.4% juveniles and 20.9% calves (Table 14). We recorded responses during 14 landings.

Prior to those helicopter landings 91.2% of the caribou samples were foraging and 8.8% were bedded (Table 14). Immediate responses to the landings were 45.0% mild, animals alerted but remained in place; 25.3% none detectable, animals remained foraging; 26.4% strong, animals trotted away; 2.2% none detectable, animals remained bedded; and 1.1% moderate, animals walked away (Table 14). Activities and/or responses 2 min after first responses to landings were 75.8% (no detectable response) foraging, 14.3% mild, 5.5% strong, 2.2% moderate and 2.2% (no detectable response) bedded (Table 14).

During all landings a total of 28.6% samples (26) trotted and 6.6% (6) walked. No animals galloped (extreme level) during helicopter landings. Animals that the helicopter landed closest to moved away the shortest distances. During landings animals moved from 150 to 400 m.

In total 83 caribou samples were harassed by ground observers (28.9% bulls, 39.8% cows, 8.4% juveniles and 22.9% calves, Table 15) during 14 occasions. Prior to those harassments by ground observers 66.3% of the caribou samples were foraging, 18.1% were alerted (mild response), 14.4% were walking away (moderate response) and 1.2% were bedded (Table 15). Immediate responses to ground observers were 41.0% mild, animals alerted but remained in place; 30.1% strong, animals trotting away; 14.5% moderate, animals walking away; and 14.4% extreme, animals galloping away (Table 15). Activities and/or responses 2 min after first responses to ground observers were 36.2% strong, 24.1% extreme, 24.1% (no detectable response) foraging, 9.6% moderate, 4.8% mild and 1.2% (no detectable response) bedded (Table 15).

In total 67 (80.7%) samples responded by displacement: 30.1% trotted, 25.3% galloped and 25.3% walked. The caribou sampled appeared to respond more to humans on the ground, especially humans approaching them, than to the helicopter.

Summary

We noted only overt behavioural responses of Peary caribou to helicopter harassment for three reasons.

(1) We could not detect subtle behaviour patterns, if any (head and/or ear movements, widening of eyes, tightness of back muscles and other indications of tension), from the helicopter or over relatively large distances on the ground.

(2) Other effects of harassment (Geist 1975:4–9) would only become apparent months or even years after harassment and so could not be detected during a 2-month field season. Within the duration of our study period the only physiological and/or pathological conditions that we would have recognized would have been traumatic injuries caused by panic behaviour. We never observed any such conditions nor circumstances likely to produce them.

(3) Although some aspects of caribou physiology have been studied, it is currently infeasible to describe harassment in terms of physiological parameters.

We designed our study to meet as many as feasible of the points raised by Geist (1975) in his critique of aircraft harassment studies. We considered the type of helicopter flights likely to be associated with pipeline construction and maintenance and recognized three categories which we simulated. We chose response categories based on behavioural positions or movements that involved almost no subjective decisions. Such categories are repeatable, and are also verifiable from the films. Equally our standardized single and multiple flights are repeatable.

The difficulties of recognizing and maintaining contact with individual groups prevented us from estimating straight-line distances travelled by caribou between harassments. In any case the paucity of knowledge of daily movements of Peary caribou would have limited the interpretation of any estimated distances. Wilkinson and Shank (1974) and Gauthier (1975) describe some distances travelled during daily movements of Peary caribou.

Our data showed that 66.3% of all caribou samples responded by displacement (walk, trot or gallop). Excluding 713 caribou samples that were still moving when the helicopter departed, we estimated that caribou seldom moved >400 m and always <1000 m during a helicopter flight, and usually <400 m. Bergerud (1963) and Calef and Lortie (1973) also observed that caribou generally move less than 500 m when overflown by an aircraft.

Differences between our study and those studies of Calef and Lortie (1973), Klein (1973), McCourt and Horstman (1974), McCourt *et al.* (1974) and Surrendi and DeBock (1976) restrict a detailed comparison of their results with our results. The use of different response categories and helicopter versus fixed wing in particular reduce comparability but also the studies were of *R. t. granti*, and we do not know whether there are sub-specific differences in behaviour. In general the studies emphasized altitude as an important determinant of response level but group size, sex and age class, season, terrain, previous activity and aircraft type also all contributed to response levels.

Our preliminary study does not allow us to make any comment on accommodation by Peary caribou to helicopter harassment. McCourt and Horstman (1974:32) suggested the decline in reactivity of caribou during their study period may have been the result of habituation (we question how such adjustment could have been made on the basis of their study). Thomson (1972) suggested habituation in reindeer to aircraft and Espmark *et al.* (1974) suggested accommodation of sheep and cattle to sonic booms.

Further work is necessary to establish what altitudes and diagonal distances will not cause apparent harassment of Peary caribou. Subsequent work will be necessary to examine phenomena such as active inhibition and accommodation.

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Table 1
Group statistics by established group types based on sex and age classes, excluding solitary animals, Prince of Wales Island, NWT, 1976

Group types	No. groups	No. caribou	Group statistics		
			$\bar{x} \pm$ SE	SD	Range
Bull-cow-juv-calf	3	20	6.7 ± 1.7	2.9	5–10
Bull-cow-juv	6	47	7.8 ± 0.8	1.8	5–9
Bull-cow-calf	3	28	9.3 ± 2.7	4.6	4–12
Bull-juv-yr	1	5	5.0 ± –	–	5–5
Bull-juv-calf	1	5	5.0 ± –	–	5–5
Bull-juv	72	388	5.4 ± 0.5	4.6	2–24
Bull-yr	6	17	2.8 ± 0.2	0.4	2–3
Bull	134	450	3.4 ± 0.1	1.1	2–9
Cow-juv-yr-calf	1	9	9.0 ± –	–	9–9
Cow-juv-yr	1	3	3.0 ± –	–	3–3
Cow-juv-calf	18	124	6.9 ± 1.2	5.2	3–26
Cow-yr-calf	21	165	7.9 ± 0.8	3.6	4–15
Cow-juv	19	58	3.1 ± 0.5	2.3	2–12
Cow-yr	8	27	3.4 ± 0.4	1.1	2–5
Cow-calf	129	957	7.4 ± 0.5	5.3	2–27
Cow	60	226	3.8 ± 0.3	1.9	2–9
Juv-yr	1	3	3.0 ± –	–	3–3
Juv	6	33	5.5 ± 1.3	3.3	2–9
Yr	0	–	– ± –	–	–
Calf	2	4	2.0 ± 0.0	0.0	2–2

Table 2
Distributions of caribou and caribou groups sampled during helicopter harassment flights by six sets of physical variables, Prince of Wales Island, NWT, 1976

Physical variables	No. flights	No.* caribou sampled
Altitudes (m agl)		
<50	92	422
50–100	226	1084
101–200	250	1031
201–300	27	129
>300	2	8
Response distances (m)†		
<50	25	110
50–100	112	574
101–200	253	1017
201–300	114	483
301–500	74	397
501–700	13	67
701–1000	6	26
Air speeds (km/h)		
<80	15	72
<129	118	660
>129	464	1942
Position of sun relative to helicopter and animals		
SHA‡	204	852
SAH§	205	906
Sun obscured	127	549
Not applicable	61	367
Direction of wind relative to helicopter flight		
Flying with wind	198	863
Flying into wind	123	578
Flying >60° to wind	215	866
Not applicable	61	367
Topography		
Lowland flats	236	1043
Intermediate slopes	206	1028
Ridge areas	125	452
Plateaus	15	67
Areas restricted by water	15	84

*Number of flights equals number of groups sampled.
†First observed response subsequent to standing alerted, given as diagonal distance from helicopter to animals.
‡Helicopter between sun and animals, sun–helicopter–animals (SHA).
§Animals between sun and helicopter, sun–animals–helicopter (SAH).

Table 3
Matrix of activities and/or responses of caribou samples as percentages of all samples and as percentages of initial activity or response, obtained during helicopter overflights, Prince of Wales Island, NWT, 1976

Subsequent activity or response (B, C, D)	Initial activity or response (A)					
	Bedded	Foraging	Alerted	Walking	Trotting	Galloping
As % of all the samples (n = 2674)						
Bedded	4.1					
Foraging	0.1	8.4				
Alerted	6.1	12.4	2.7			
Walking	2.6	7.4	1.9	0.6		
Trotting	2.4	26.8	3.9	0.7	6.7	
Galloping	0.4	5.5	3.0	1.3	2.4	0.6
As % of the number of caribou recorded in each activity or response*						
Bedded	26.0					
Foraging	0.7	13.9				
Alerted	38.8	20.4	23.1			
Walking	16.5	12.3	17.0	24.3		
Trotting	15.4	44.3	34.2	25.7	73.2	
Galloping	2.6	9.1	25.7	50.0	26.8	100.0

*Activity or response during stage (A) of helicopter approach: bedded = 423, foraging = 1615, alerted = 307, walking = 70, trotting = 243 and galloping = 16.

Table 4
An estimation of intensities of maximum responses based on the recorded sequence (A, B, C, & D) during helicopter harassment flights, Prince of Wales Island, NWT, 1976 (n = 2055)*

Intensities of subsequent maximum responses (B, C, & D)	Initial approach activity or response (A)				
	Bedded	Foraging	Alerted	Walking	Trotting
1st level (B = C = D)					
Alert	52	111			
Walk		21	1		
Trot	11	166	19	8	
Gallop		1		1	
2nd level (B = C > D)					
Alert	36	115			
Walk	5	30	4		
Trot		181	37	5	
Gallop	5	21	24		31
3rd level (B > C ≥ D)					
Alert	6	18			
Walk	11	62	24		
Trot	12	130	25	2	
Gallop		31	10	23	34
4th level (B < C = D)					
Alert	33	38			
Walk	3	19			
Trot	7	66	12	1	
Gallop		2			
5th level (B < C > D)					
Alert	37	48			
Walk	51	67	23		
Trot	30	172	12	2	
Gallop	11	92	45	11	

*Division of any column value by summation of its column will give the percentage of those caribou initially encountered in the activity of the column heading that responded at the level of intensity of the row heading.

Table 5
Distribution by group types of sex and age classes of caribou that were responsible for maximum and minimum responses within groups in which individuals exhibited mixed responses (248 groups), Prince of Wales Island, NWT, 1976

Group type	No. mixed group responses									
	Maximum					Minimum				
	Bull	Cow	Juv	Yr	Calf	Bull	Cow	Juv	Yr	Calf
Bull-cow-juv-calf		2	2		2	3	1			1
Bull-cow-juv		1	2			2	1			1
Bull-cow-calf		2			3	3	1			
Bull-juv-yr										
Bull-juv-calf			1		1	1				
Bull-juv	14		25			30		10		
Bull-yr	1			3		3				
Bull	78					78				
Cow-juv-yr-calf					1		1	1	1	
Cow-juv-yr				1			1			
Cow-juv-calf		1	2		4		5	3		1
Cow-yr-calf		6		5	6		11		6	9
Cow-juv		3	7				7	2		
Cow-yr				5			5		1	
Cow-calf		23			46		55			18
Cow		33					33			
Juv-yr										
Juv			3					3		
Yr										
Calf										

Table 6
Distributions of maximum and minimum responses by sex and age class in groups in which individuals exhibited mixed responses to harassing stimuli from helicopter overflights, Prince of Wales Island, NWT, 1976

Sex and age class	Occurrences in groups involving mixed responses	Involved in maximum responses		Involved in minimum responses	
		Along with other sex and age classes	As only sex and age class	Along with other sex and age classes	As only sex and age class
As % of occurrence of the sex and age class in groups exhibiting mixed group responses (bulls, n = 295; cows, n = 299; juv, n = 134; yr, n = 40; and calves, n = 178)					
Bulls	15.0	33.3	17.8	91.1	66.7
Cows	32.4	39.2	16.5	90.7	54.6
Juveniles	18.3	70.9	38.2	32.7	9.1
Yearlings	7.3	63.6	45.5	31.8	0.0
Calves	27.0	77.8	48.1	34.6	2.5
As % of the total number of groups exhibiting mixed group responses (n = 300)					
Bulls	15.0	5.0	2.7	13.7	10.0
Cows	32.4	12.7	5.3	29.3	17.7
Juveniles	18.3	13.0	7.0	6.0	1.7
Yearlings	7.3	4.7	3.3	2.3	0.0
Calves	27.0	21.0	13.0	9.3	0.7

Table 7
Distributions of the samples as percentages of each sex and age class by levels of responses to helicopter induced harassing stimuli during overflights, Prince of Wales Island, NWT, 1976

Sex and age class	Activities		Responses to harassing stimuli			
	Bedded No response	Foraging No response	Alerted Mild	Walking Moderate	Trotting Strong	Galloping Extreme
Adult cows (n = 1170)	2.5	6.0	21.4	14.7	40.5	14.9
Adult bulls (n = 779)	7.7	19.0	26.8	10.7	27.5	8.3
Sex unknown						
Juveniles (n = 284)	4.9	2.1	16.9	10.2	55.7	10.2
Yearlings (n = 46)	4.4	4.4	13.0	4.4	43.4	30.4
Calves (n = 395)	1.3	0.2	12.9	13.2	54.4	18.0

Table 8
Distributions of the samples as percentages of responses within each time interval and by levels of responses to helicopter induced harassing stimuli during overflights, Prince of Wales Island, NWT, 1976

	Activities		Responses to harassing stimuli			
Date	Bedded No response	Foraging No response	Alerted Mild	Walking Moderate	Trotting Strong	Galloping Extreme
July 4–7 (n = 130)	19.2	6.1	26.2	12.3	28.5	7.7
July 8–15 (n = 803)	5.5	8.2	25.3	14.1	36.5	10.4
July 16–23 (n = 384)	6.0	6.0	22.1	21.6	27.1	17.2
July 24–31 (n = 689)	0.7	6.1	16.4	9.7	46.9	20.2
August 1–7 (n = 308)	1.9	4.9	11.4	3.6	69.1	9.1
August 8–15 (n = 360)	2.0	20.3	26.4	13.3	30.8	7.2

Table 9
Distributions of the samples as percentages of caribou that occurred in one or more groups of each group size sampled and by levels of responses to helicopter induced harassing stimuli during overflights, Prince of Wales Island, NWT, 1976

	Activities		Responses to harassing stimuli			
Group size	Bedded No response	Foraging No response	Alerted Mild	Walking Moderate	Trotting Strong	Galloping Extreme
1	1.9	9.5	34.3	13.4	29.5	11.4
2	6.0	9.7	25.5	15.3	28.2	15.3
3	13.3	15.3	23.8	13.2	24.5	9.9
4	4.5	23.5	22.7	10.6	28.3	10.4
5	3.1	8.9	21.3	8.9	50.7	7.1
6	4.6	8.3	16.7	13.0	45.4	12.0
7	0.6	5.6	10.0	3.7	62.7	17.4
8	4.4	6.2	20.6	15.0	46.9	6.9
9	1.5		26.7	14.1	47.4	10.3
10			12.9	4.3	67.1	15.7
11	0.7	6.2	23.1	22.4	24.5	23.1
12		0.8	46.7	16.7	25.8	10.0
13			17.9	33.3	38.5	10.3
15	28.9		33.3	4.5	33.3	
16			10.9		89.1	
18				100.0		
20					100.0	
22					86.4	13.6
24					100.0	
25					50.0	50.0
26				76.9	23.1	
27						100.0

Table 10
Responsiveness of caribou within two sets of group size classes exposed to helicopter induced harassing stimuli, Prince of Wales Island, NWT, 1976

	Level of responses				
Group size class	None	Mild	Moderate	Strong	Extreme
<5	23.8	24.9	12.6	27.3	11.4
versus					
≥5	5.8	18.9	12.6	48.4	14.3
to					
<10	15.7	23.1	11.9	38.4	10.9
versus					
≥10	3.2	17.2	14.6	45.8	19.2

Table 11
Distributions of the samples as percentages of each of the five altitude classes and by levels of responses to helicopter induced harassing stimuli during overflights, Prince of Wales Island, NWT, 1976

	Activities		Responses to harassing stimuli			
Altitude class (m agl)	Bedded No response	Foraging No response	Alerted Mild	Walking Moderate	Trotting Strong	Galloping Extreme
<50 (n = 422)	1.9	5.5	10.2	6.6	62.8	13.0
50–100 (n = 1084)	4.4	5.6	22.3	10.7	38.3	18.7
101–200 (n = 1031)	4.9	10.4	20.5	17.6	37.5	9.1
201–300 (n = 129)	2.3	24.0	51.9	10.1	10.9	0.8
>300 (n = 8)		75.0	25.0			

Table 12
Distributions of the samples as percentages of each of the three air speed classes and by levels of responses to helicopter induced harassing stimuli during overflights, Prince of Wales Island, NWT, 1976

	Activities		Responses to harassing stimuli			
Air speed (km/h)	Bedded No response	Foraging No response	Alerted Mild	Walking Moderate	Trotting Strong	Galloping Extreme
<80 (n = 72)		8.3	1.4	16.7	48.6	25.0
<129 (n = 660)	0.5	8.0	20.2	12.1	34.4	24.8
>129 (n = 1942)	5.5	8.6	22.2	12.7	42.2	8.8

Table 13
Distributions of the samples as percentages of each of the seven "response" distances and by levels of responses to helicopter induced harassing stimuli during overflights, Prince of Wales Island, NWT, 1976

Response distance (m)*	Activities		Responses to harassing stimuli				
	Bedded No response	Foraging No response	Alerted Mild	Walking Moderate	Trotting Strong	Galloping Extreme
<50 (n = 110)	1.8	7.3	12.7	19.1	41.8	17.3
50–100 (n = 574)	3.0	4.4	14.4	9.4	48.1	20.7
101–200 (n = 1017)	4.8	10.6	26.2	13.3	37.5	7.6
201–300 (n = 483)	6.0	7.9	18.4	11.8	42.9	13.0
301–500 (n = 397)	2.5	11.6	23.2	16.9	29.7	16.1
501–700 (n = 67)	4.4	3.0	25.4	6.0	52.2	9.0
701–1000 (n = 26)			15.4		65.4	19.2

*First observed response subsequent to standing alerted, given in metres as diagonal distance from helicopter to animals.

Table 14
A summary of observed activities and responses by caribou to helicopter landings,* Prince of Wales Island, NWT, 1976 (observers remained inside helicopter for 2 min during these observations)

Observ. no.	Group size and composition					Distance of animals from helicopter (m)	No. of caribou										
							Initial activity		Immediate response to helicopter landing					Response 2 min after helicopter landing				
	Bull	Cow	Juv	Calf	Total		Bed	Forage	Rise	Alert	Walk	Trot	None	Bed	Forage	Alert	Walk	Trot
331		7		4	11	800		11		6			5		11			
332		3		3	6	400		6		6					6			
499	4				4	200		4		2			2		4			
500			2		2	200		2				2			2			
529	4				4	500	1	3					4	1	3			
533	6				6	400	1	5	1				5		6			
535	4				4	400		4			1		3		4			
538	4				4	400	2	2	1	1			2	1	1		2	
808	4				4	200		4					4		4			
546		9		4	13	500		13				13				13		
554	4				4	800	1	3				4			4			
560		4		2	6	200	3	3	3	3					6			
562	3		2		5	20		5		4		1						5
563		12		6	18	70		18		14		4			18			

*Landings were made out of sight of the caribou involved in observation Nos. 334, 484, 487 and 571 and no data were obtained.

Table 15
A summary of observed activities and responses by caribou to observers moving on the ground by the helicopter after each landing,* Prince of Wales Island, NWT, 1976

Observ. no.	Group size and composition					Distance of animals from observers (m)	No. of caribou													
							Initial activity				Immediate response to observers				Response to observers after 2 min					
	Bull	Cow	Juv	Calf	Total		Bed	Forage	Alert	Walk	Alert	Walk	Trot	Gallop	Bed	Forage	Alert	Walk	Trot	Gallop
331†		7		4	11	300		11						11						11
332†		3		3	6	400		6			6									6
334†		6	2	4	12	400		12			12								12	
484		1		1	2	250				2	2								2	
487	3				3	250		3			3									3
499	4				4	200		2	2				4						4	
500			2§		2	50		2					1	1†			2			
529	4				4	300	1	3			3	1			1	3				
533	6				6	250		6			4		2			4		2‡		
808	4				4	100		4			4					3	1			
546		9		4	13	500			13				13				1		12	
560		4		2	6	200		6				6						6		
562	3		2		5	150				5			5			5				
571		3	1	1	5	300				5		5				5				

*Observers stayed aboard the helicopter during observation Nos. 535, 538 and 563 for the entire harassment periods.
†Observers upwind to animals.
‡Juveniles approached observers, one gave two alarm bounds before galloping away.
§Juveniles approached helicopter, circling to be downwind of observers.

Figure 2
Maximum level of responses during, and minimum level of activities between, helicopter passes by individual bulls of a Peary caribou group during simulated cargo slinging, No. 808, Prince of Wales Island, NWT, 1976

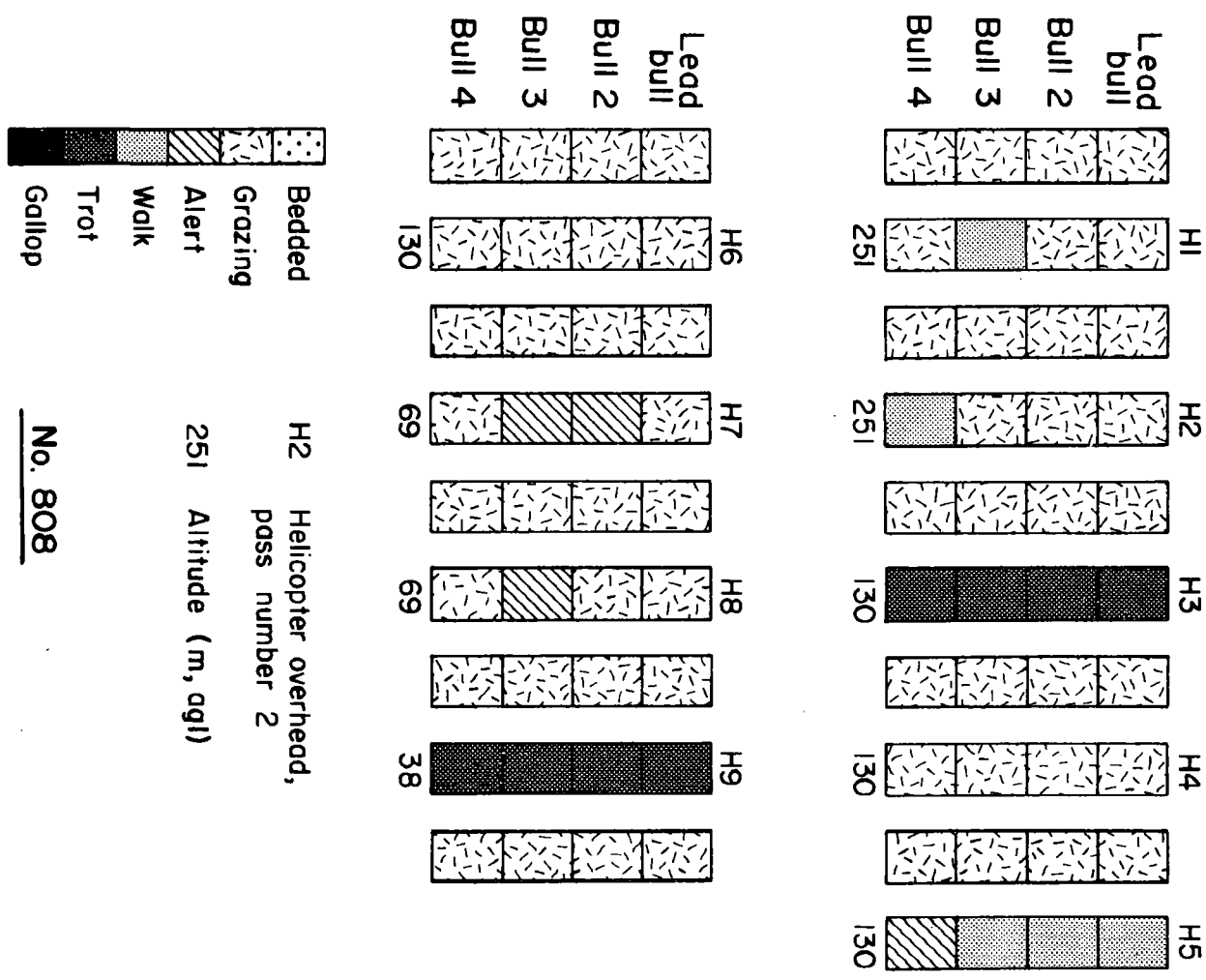

Figure 3
Maximum level of responses during, and minimum level of activities between, helicopter passes by individual bulls of a Peary caribou group during simulated cargo slinging, No. 529, Prince of Wales Island, NWT, 1976

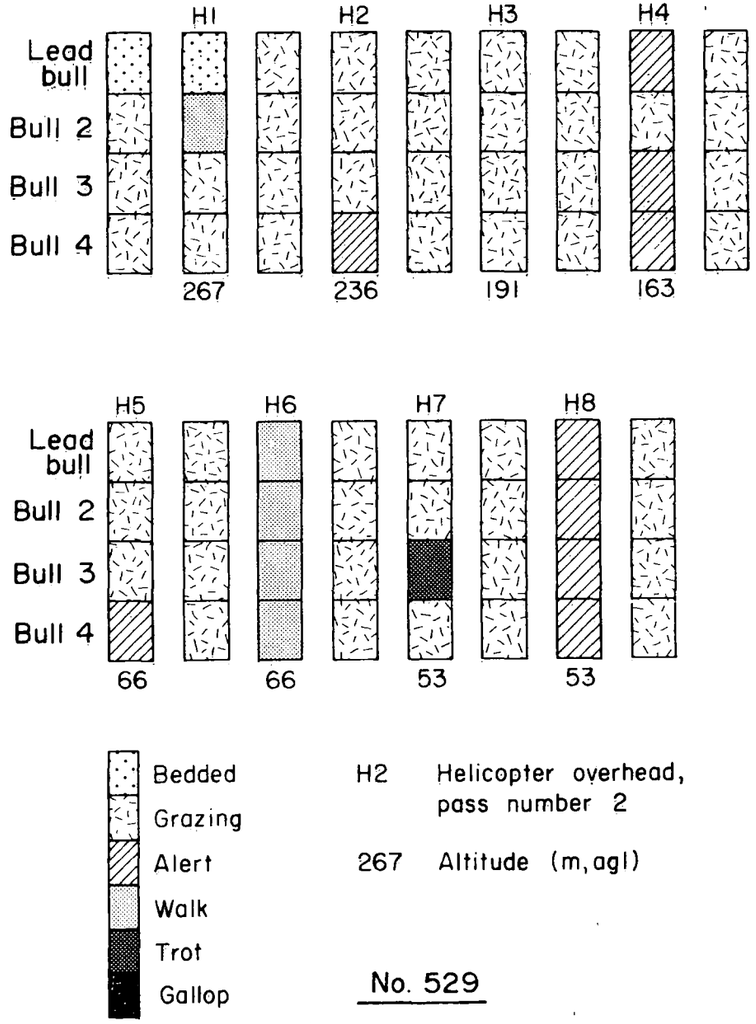

Figure 4
Maximum level of responses during, and minimum level of activities between, helicopter passes by individual bulls of a Peary caribou group during simulated cargo slinging, No. 535, Prince of Wales Island, NWT, 1976

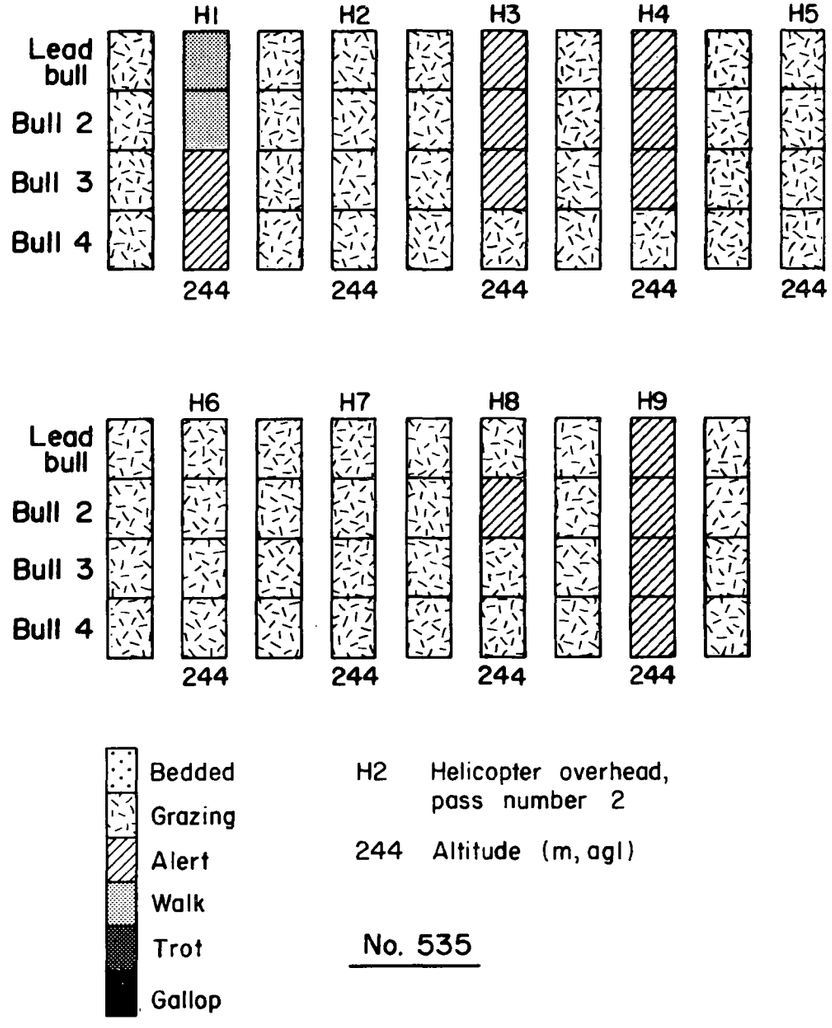

Figure 5
Maximum level of responses during, and minimum level of activities between, helicopter passes by individual bulls of a Peary caribou group during simulated cargo slinging, No. 538, Prince of Wales Island, NWT, 1976

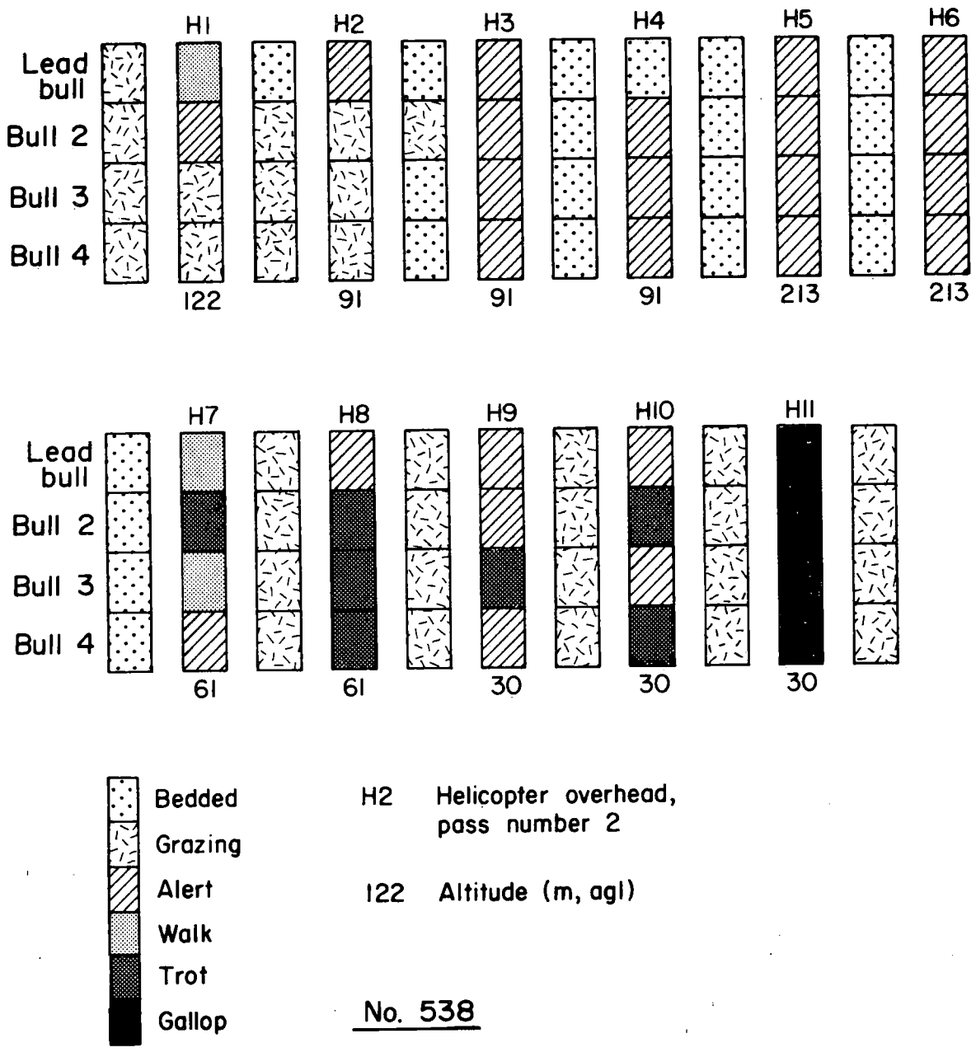

Figure 6
Maximum level of responses during, and minimum level of activities between, helicopter passes by individual bulls of a Peary caribou group during simulated cargo slinging, No. 554, Prince of Wales Island, NWT, 1976