ARCTIC
VOL. 34, NO. 2 (JUNE 1981), P. 180-185

Behavioral Response of Barren Ground Caribou to a Moving Vehicle

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ABSTRACT. Behavioral responses of individual Barren Ground caribou (*Rangifer tarandus granti*) to a ¾-ton pickup truck were quantified on 36 occasions. During 34 of those observations the vehicle initially approached at a speed of over 56 km/h. Forty-eight percent of the individual caribou reacted to the vehicle by running away while 38% trotted away. The mean flight duration of females was 73 ± 11 sec, that of males 38 ± 6 sec. ($p=0.09$). Caribou encountering a moving vehicle exhibited signs of excitement and fright, including the excitation jump and tail-up response. Reversal of direction and/or splitting of the group involved 29% of the individual caribou. The type of habitat (forested *vs*. open) did not have an effect on observation duration ($p > 0.50$) or on the mean distance at which caribou were first encountered ($p > 0.50$). The distance from the vehicle at which animals began to flee did not differ between sexes ($p > 0.50$) or habitats ($p > 0.50$) but was as great for both sexes as that reported for females with young calves. In forested habitat male caribou allowed a much closer approach than females ($p = 0.08$) but closeness of approach did not differ between the sexes in open habitat ($p > 0.50$).

RÉSUMÉ Les comportements individuels de caribous des barren-grounds (*Rangifer tarandus granti*) en réaction à la présence d'un camion de ¾ de tonne ont été quantifiés dans 36 cas. Pour 34 de ces observations, le véhicule s'est approché au début à une vitesse de plus de 54 km/h. Quarante-huit pourcent des individus ont réagi au véhicule par la fuite tandis que 38% sont partis au trot. La durée moyenne de la fuite des femelles fut de 73 ± 11 secondes, celle des mâles, de 38 ± 6 secondes ($p=0.09$). En rencontrant un véhicule qui se déplace, les caribous ont montré des signes d'agitation et de frayeur, comme de sursauter et de dresser la queue. Un changement de direction et/ou le détachement du groupe ont impliqué 29% des individus. Le type d'habitat (boisé vs ouvert) n'a influencé ni le temps d'observation ($p > 0.50$) ni la distance moyenne à laquelle les caribous ont été rencontrés en premier ($p > 0.50$). La distance du véhicule à laquelle les animaux ont commencé la fuite n'a pas varié selon le sexe ($p > 0.50$) ou l'habitat ($p > 0.50$) mais était aussi grande pour les deux sexes que celle rapportée pour les femelles avec des jeunes veaux. Dans l'habitat boisé, les mâles ont permis une approche beaucoup plus grande que les femelles (p 0.80) mais cette proximité n'a pas varié entre les sexes pour l'habitat ouvert ($p > 0.50$).

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INTRODUCTION

Recent energy-related developments in arctic North America have focused attention (Berger, 1977; Lysyk *et al.*, 1977) on the reaction of caribou to human activities (Curatolo, 1975; Tracy, 1977), structures (Miller *et al.*, 1972; Child, 1974), and machines (Calef *et al.*, 1976; Miller and Gunn, 1979).

Abrupt changes in the physical environment, although not barriers in the mechanical or structural sense, may act as behavioral or ecological barriers (Cameron *et al.*, 1979) or diversions (Urquhart, 1973; Jakimchuk *et al.*, 1974; Surrendi and DeBock, 1976). Roads may be used as pathways (Tracy, 1977; Roby, 1978) although they are frequently crossed (Bergerud, 1974; Johnson and Todd, 1977).

The reactions of caribou to vehicles have previously been expressed in general terms only (Surrendi and DeBock, 1976; Tracy, 1977). In this paper I have quantified the responses of caribou to a moving vehicle.

METHODS

The study area was along the Dempster Highway, Yukon Territory, between km 103 and 263 (65° 00′ N, 138° 20′ W). The highway extends from a point 40 km south of Dawson City, Yukon Territory, to Fort MacPherson and Inuvik, Northwest Territories.

Thirty-four observations were begun while the vehicle was moving and two while it was stationary. They were distributed as follows: 10 on 13-14 December 1976; 22 during 21-29 January 1977; and two on 13-14 March 1977. During that period the two-lane gravel road was snow-covered. The vehicle used in each instance was an orange and black ¾-ton pickup truck with an open box.

Timed observations ($n = 29$) are those for which the duration of observation and duration of flight (time the animal spent running or trotting) were recorded. Those observations are supplemented by seven untimed observations. Two stop watches were used to obtain times. They were taped back-to-back and held in one hand, one being used to time the length of the observation and the second the duration of flight.

In 34 of the 36 observations caribou were initially encountered when the vehicle was travelling at speeds of 56-81 km/h. Exact speed was not recorded. After a caribou was sighted the vehicle was driven along the road to the point at which it was as close to the animal as possible. This was done in minimum time but without accelerating. When necessary to maintain visual contact after reaching the point of closest approach the vehicle was moved, as often as twice, at a speed of less than 8 km/h. This was not done until visual contact was lost. Neither driver nor passenger left the vehicle. During two observations the vehicle was stationary when the caribou appeared. Those observations are not considered in the analysis of flight response.

Upon initial sighting of caribou, one animal was selected for observation. The following information was recorded: 1) an estimate of the size and composition of the group; 2) the duration of observation from time of initial sighting until the caribou could not be resighted or was judged not to be responding to the vehicle; 3) the response of the animal under observation to the vehicle and the

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road, including whether it smelled the road surface, looked at the vehicle, urinated, ran or trotted, exhibited an excitation jump or had its tail erect; 4) whether the group split or reversed direction; 5) an estimate of the distance from the vehicle at initial sighting; 6) flight distance, this being the distance from the vehicle at which the caribou began to run, if it did so at all; 7) the distance from the vehicle to the caribou at point of closest approach; 8) flight duration, meaning the time the caribou spent running or trotting in response to the vehicle; and 9) habitat type (forested or open).

If the caribou remained in view, observations were terminated after 600 seconds when it appeared that the caribou involved would show no additional response to the vehicle. This stage was reached when a caribou slowed to a walk or began to feed and did not look at the vehicle.

The excitation jump was recognized as defined by Pruitt (1960). A caribou which lowered its muzzle to within a few cm of the road surface was judged as smelling it. Running was defined as that gait during which the forelegs move in unison. Trotting was recognized as that gait during which a front leg and the opposite rear leg move in unison. Distance of animals from the vehicle or road surface was estimated. A number of distance estimation/pacing trials were conducted at the beginning of each field trip.

Forested habitat was defined as that in which it was not possible to maintain extended visual contact with a caribou because of trees. Areas where vegetation caused only momentary loss of visual contact were classed as open habitat.

Multiple regression analysis was used to determine the relationships between the following variables: 1) group size; 2) observation duration; 3) flight distance; 4) flight duration; 5) closest approach; 6) distance at first encounter; 7) sex of animal; 8) type of habitat; and 9) date. A step-wise regression analysis was used in which one variable is added to the equation at each step (Mitchell, 1970). The variable added is that which makes the greatest reduction in the error sum of squares and produces the highest overall (combined) F value. The variables habitat, sex of animal and date were dichotomous: for habitat, forested = 1, open = 2; for sex of animal, male = 0, female = 1; for date, December observation = 1, and January - March observations = 2.

Where mean values are given in the text the standard error is included. The equality of variances was tested with a variance ratio test. Mean values were then compared using Student's *t*-test for equal or unequal variance.

RESULTS AND DISCUSSION

Group Size

Groups were classified as male or female on the basis of the majority of members being males or females with calves, respectively. In the case of male groups, nine consisted of males only while three contained a single female each. Fifteen of the 16 female groups contained calves and eight of the 16 contained subadult males. The number of calves present in female groups was not determined.

In open areas, female groups (17 ± 4.5 animals, n = 9) were larger than male groups (6 ± 1.4 animals, n = 4) ($p<0.05$). In forested areas, male groups (n = 8) averaged 4.4 ± 0.6 animals while female groups (n = 7) averaged 5.3 ± 0.5 animals ($p>.25$). Group size in open areas was larger than that in treed areas for females ($p<0.02$) but not for males ($p>0.5$).

Multiple regression analysis revealed that 27% of the variation in group size could be attributed to habitat type and sex of animal being observed ($p<0.05$). This effect was brought about solely by a difference in group size between females in open and forested habitats.

Observation Duration

Mean duration of all observations in open habitat exceeded that in forested areas (Table 1); however, the two means were not significantly different ($p>0.10$). There was no difference between males and females in observation duration ($p>0.50$) and there were no within-sex differences according to habitat type ($p>0.50$). One observation was terminated at 600 seconds for each sex in each habitat type. Their exclusion from Table 1 would not have produced any difference ($p>0.20$) in mean observation duration.

TABLE 1. Mean duration of observations (in seconds) by sex of animal and habitat type, ± standard error

		Habitat Type	
	All observations	Forested	Open
All observations	267 ± 40 (27)	218 ± 56 (13)	312 ± 57 (14)
Females	284 ± 48 (17)	210 ± 72 (6)	324 ± 61 (11)
Males	238 ± 75 (10)	224 ± 89 (7)	270 ± 168 (3)

[a] Sample size
Differences within columns and rows are not significant ($p>.10$)

Flight distance, flight duration, and distance at closest point of approach accounted for 36% of the variation in observation duration amongst those caribou that showed a flight response ($p<0.05$). The inclusion of habitat type did not have a significant bearing on R^2 ($p>0.20$).

There was a positive correlation between flight distance and observation duration ($r = .48$, $n = 26$, $p<0.05$) meaning the greater the distance from the vehicle at which the caribou began to run, the longer it was observed. The extended period of visual contact between caribou and the vehicle-borne observer in forested habitat suggests that, to a degree, caribou used the open habitat of the highway right-of-way when escaping from the vehicle.

This may be related to maintaining an aggregation, based on visual contact with conspecifics, the argument being made that there is a benefit to the members with respect to minimizing predation (Bergerud, 1974). A preference for open areas could also be related to snow depth, although I discount it in this instance because snow depth was unusually shallow.

Distance at First Encounter

The mean distance from the vehicle at which males (n = 10) and females (n = 18) were first encountered was equal, being 267 ± 57 m and 251 ± 56 m, respectively (p>0.5). There were no sex-related differences within or between habitat type. The two animals, both females, which did not flee from the vehicle were encountered at 175 and 700 m, indicating a degree of individuality in response.

The distance at which male and female caribou were first encountered was as great in forested areas (232 ± 60 m; n = 14) as it was in open areas (265 ± 55 m; n = 15) (p>0.5). This is attributable to a combination of factors including microtopographic variation, the width of the highway right-of-way and the driver's need to watch the highway, resulting in selection, for observation, of caribou within the highway right-of-way.

Excitation Jump, Tail-Up and Urination

Of 26 caribou which fled from the truck, four females and one male (19%) each exhibited a maximum of two excitation jumps. There was a minimum of one excitation jump per 164 caribou minutes of observation involving 249 animals. The excitation jump is considered a social releaser (Lent, 1966) which serves to alert other caribou. It appears that interdigital scent is deposited on the ground from the interdigital gland which can "elicit a flight response in caribou crossing the spot sometime later" (Lent, 1966:727).

The presence or absence of tail erection was noted in 17 animals showing a flight response to the vehicle: 15 (88%) of the caribou displayed a tail-up posture. "Tail erection accompanies the alarm posture and flight" (Lent, 1966).

Only two of 28 animals (7%) were observed to urinate and one of these showed no flight response although it assumed the alarm posture. Urination often occurs when an animal is frightened; however, it seems likely that this response is restricted to those instances when an animal has a few moments prior to fleeing. Such is not often the case with respect to a rapidly approaching vehicle, an event during which most unhabituated caribou show a very rapid response.

Visual Contact with Vehicle and Smelling of Road Surface

Thirty-five of 36 caribou (97%) looked directly at the vehicle at least once and in some cases as many as eight different times during the observation period. This activity was often accompanied by body orientation toward the vehicle. Animals on the road surface usually (16/19 = 84%) looked at the vehicle while still on the road. In almost all intances I saw the caribou before they indicated they saw the vehicle. The vehicle was relatively quiet and sound did not appear to be a factor in alerting the animals.

Five of 17 animals (29%) on the road stopped to smell the surface. None was observed to lick the surface and none showed any olfactory response to caribou which may have preceded them. Caribou appear to perceive the road surface as a novel object in the same sense that they would an ice flow or frozen stream. Their reaction to these surfaces appears to be dictated by whether they are feeding/resting in an area or travelling. When unhurried they show greater interest.

Group Splitting and Direction Reversal

In four of 35 observations (11%) involving more than one animal the groups split, probably as a result of excitement generated by the vehicle and the relative novelty of the road. In two other cases (6%) groups reversed direction, returning in the direction from which they had come. These events involved 29% of all caribou observed. Whether the individuals in a split group were able to reunite or whether groups that reversed their direction returned to their original line of travel was not determined.

The two instances of reversal occurred at 20 and 225 m from the vehicle and initially resulted in the caribou increasing the distance between themselves and the vehicle. In two of the four instances of group splitting, there were indications that relatively strong social bonds exist between some animals when caribou in one part of the group actually moved closer to the vehicle in order to rejoin the other part of the group. Surrendi and DeBock (1976), who also worked on the Dempster Highway, reported that 31% of 36 groups approaching the road surface either reversed direction, were interrupted or temporarily split.

The groups of caribou observed in this study were not exposed to frequent vehicle traffic (estimate 12 vehicles/24 hours) even though some were relatively localized in their winter movements.

Flight Distance

Analysis of variance (Table 2) revealed that the distance at which a caribou was first encountered and the distance at closest approach were significantly related to flight distance. The addition of other variables was not important in predicting flight distance. Closest approach was positively correlated with flight distance meaning that flight distance was not determined by the closeness of the vehicle, at least within the observed range of 25 to 450 m. Distance at first encounter ranged from 25 to 700 m and was positively correlated with flight distance in that in most instances caribou began to flee as soon as they saw the vehicle. I interpret this as meaning that it is not movement *per se* nor the absolute size of the threatening object nor its distance from the caribou but rather the rate at

TABLE 2. Regression analysis of some factors (X_i) which may have influenced the flight distance (Y) of caribou encountering a moving vehicle, based on timed observation during which a flight response was shown

Independent variable (X_i)	n[a]	r	R^2	F
Closest approach	24	+ 0.57**	0.38	10.73**
Encounter distance	24	+ 0.56**	0.54	12.49**
Sex-of-animal[b]	24	+ 0.13	0.60	10.02**
Habitat	24	+ 0.25	0.63	8.16**
Flight duration	24	+ 0.06	0.64	6.38**
Group size	24	+ 0.01	0.64	5.03**

[a] n = sample size; r = simple correlation coefficient; R^2 = cumulative coefficient of multiple determination; F = cumulative F-value of multiple regression

[b] Sex-of-animal and habitat are dichotomous variables

** $p<.01$

which the object approaches (a function of speed and direction) which causes the animal to flee. This is the phenomenon known as looming. It is defined as accelerated magnification of the form of an approaching object and is perceived as an imminent collision, causing the subject to move out of the way (Gibson, 1970:101). Through this mechanism the individual can deal with any object, known or unknown, which is approaching rapidly enough to pose a threat. Tracy (1977) provides further evidence for this, observing that only 6% of caribou within 200 m of a road reacted strongly to a shuttle bus passing at a speed of less than 24 km/h whereas 18% reacted strongly when bus speed was over 24 km/h. This fear of collision can be mediated, partially, only by learning. I would thus expect a caribou to react to a rapidly approaching conspecific, vehicle or predator.

Caribou are continually exposed to movement whether it be that of other caribou or wolves. Thus casual movement seems likely to be of limited importance in alert, and particularly flight, responses. Rapid movement, however, is comparatively uncommon. In the same vein, the majority of movement to which caribou are exposed is parallel to the direction of travel shown by a given animal. A rapid approach directly towards, or at a slight tangent to, an animal is relatively uncommon, particularly outside of the rut. Thus, a rapid and direct approach should elicit alertness and/or flight in a caribou.

Sex of animal and type of habitat did not have an influence on flight distance. The latter may be a function of season and/or type of threat. Bergerud (1974) found that females were more wary than males, but his conclusions are based on spring and summer observations of caribou responding to the presence of a man on foot. He reports mean spring flight distances of 81 ± 11 m and 165 ± 11 m for females without calves and females with calves, respectively. I observed mean flight distances of 144 ± 29 m for females in groups containing calves (n = 15) and 167 ± 27 m for males in male groups (n = 10) ($p>0.50$). Although females with young have been identified as being very sensitive to disturbance (Bergerud, 1974; Rowe-Rowe, 1974; Cameron *et al.*, 1979), both sexes of caribou along the Dempster Highway in mid-winter exhibited a flight distance equal to that reported by Bergerud (1974), which suggests that a vehicle moving at speeds of 56-81 km/h is indeed disturbing to caribou. The absence of a sex-related difference in flight distance is attributed to the speed at which the truck approached.

Distance at Point of Closest Approach

Since the vehicle often closed the gap between itself and the already fleeing caribou, distance at point of closest approach was, on average, less than flight distance.

Flight distance and sex of animal accounted for 44% of the variation in the distance at point of closest approach ($p<0.05$). The greater the distance from the vehicle at which the animal began to run the further away from the vehicle it was able to stay. However, as emphasized in the preceding section, flight distance is greatly influenced by encounter distance.

Sex of animal became a factor because of the significant difference between males and females in treed habitat, where closest point of approach averaged 113 ± 27 m for females (n = 10) and 61 ± 6 for males (n = 7) ($p = 0.08$). The mean distances at closest approach in open habitat, 73 ± 25 m for females (n = 5) and 78 ± 25 m for males (n = 3), were not different ($p>0.10$).

Flight Duration

Thirty out of 34 animals (88%) reacted to the moving vehicle by running or trotting. Fifteen of the 30 (50%) ran at some time during their flight; the remainder did not exceed a trot. One out of the two caribou that approached the stationary vehicle ran away. Although caribou frequently trotted up or down short, steep slopes such as the side of a raised portion of the highway, they reacted to the presence of the vehicle with an exaggerated trot of greater duration. In the four instances of no-flight response to a moving vehicle, two involved caribou not on the road. Of the 11 animals which were not on the road surface proper, nine reacted to the vehicle by fleeing.

When a caribou fled from the moving vehicle (n = 24) it did so for an average of 58 ± 11 seconds (Table 3). Flight time for females was almost twice that of males ($p = 0.09$), in both open and forested habitats. There

TABLE 3. Flight duration of caribou (in seconds), in response to a moving vehicle, by sex and habitat type, ± standard error

		Habitat Type	
	All observations	Forested	Open
All observations	58 ± 11 (24)[a]	53 ± 15 (12)	64 ± 18 (12)
Females	73 ± 19 (14)*	72 ± 33 (5)	73 ± 24 (9)
Males	38 ± 6 (10)	38 ± 8 (7)	37 ± 6 (3)

[a] Sample size in brackets

* Females *vs.* males, all observations, $p = 0.09$

were no differences in mean flight duration, within the sexes, between open and forested habitats, suggesting that observation error due to obstruction of vision by trees was small.

There was no single variable amongst the seven considered which had a significant bearing on the duration of flight (Table 4). Sex of animal, observation duration, distance at closest point of approach, and flight distance combined accounted for 32% of the variation in flight duration (p = 0.10). This further suggests that the rate at which an object approaches is a highly significant factor in the flight response of caribou.

TABLE 4. Analysis of some variables (X_1) thought to influence the duration of flight (Y) in caribou during their encounters with a moving vehicle[1]

Independent variable (X_1)	n[a]	r	R^2	F
Sex of animal[b]	24	+ 0.31	0.10	2.35
Observation duration	24	+ 0.30	0.19	2.39
Closest approach	24	+ 0.23	0.21	1.80
Flight distance	24	− 0.06	0.32	2.27*
Group size	24	+ 0.27	0.34	1.88
Habitat	24	+ 0.10	0.36	1.60
Encounter distance	24	− 0.06	0.37	1.33

[1] Includes only animals which showed a flight response

[a] n = sample size; r = simple correlation coefficient; R^2 = cumulative coefficient of multiple determination; F = cumulative F-value of multiple regression

[b] Sex of animal and habitat are dichotomous variables

* p<.10

With noted exceptions (Surrendi and DeBock, 1976), caribou which do flee withdraw to a limited distance from the disturbing object provided that object does not pursue them. It would be maladaptive to continue fleeing when the threat has been reduced to near zero. Despite what might be termed a limited flight response, the time spent running or trotting in response to a vehicle exceeds (as a percent of total activity) that seen among undisturbed caribou in winter (Horejsi, unpublished data).

The flight of caribou in response to a pursuing object, such as a snowmachine or slow-moving aircraft, can be expected to be more prolonged since the threatening object can keep itself within a certain distance of the animal. Caribou will commonly run along the road when persistently but not too closely pursued by a vehicle and in those instances their flight may resemble their response to a snowmachine or an aircraft making several passes. During this study an adult male ran along the road for 650 m when pursued by a vehicle but distances of 1.5 km (Tracy, 1977) and 16 km (Hoefs, pers. comm.) have been observed. Deep snow and high snow banks keep the fleeing caribou on the road; this was the case in the latter instance.

CONCLUSIONS

In general, caribou exhibit signs of anxiety and fear when encountering a fast-moving vehicle, and they exert themselves strenuously for a short period when withdrawing from a vehicle. It appears that caribou react to a vehicle based on the rate of approach, involving the principle of looming, rather than on the movement itself; in most instances, caribou flee for a relatively short period of time, that period very likely ending when the animal feels it has reduced the threat to near zero.

One of the tenets of behaviour in response to harassment is that animals avoid the area(s) in which they experience disturbance (Geist, 1971). Reindeer did exactly this in Finland when herders began using snowmachines (Pelto, 1973). Cameron *et al.* (1979) also present data to support an avoidance response by female caribou and their calves in relation to the Trans-Alaska Pipeline. I suggest that caribou might begin to avoid the Dempster Highway Corridor if traffic increases in frequency and remains unregulated.

ACKNOWLEDGEMENTS

Financial support during the preparation of this manuscript was provided by a National Research Council of Canada Grant to Dr. V. Geist, University of Calgary. The Faculty of Environmental Design, University of Calgary, provided facilities. I thank Dr. Geist and the anonymous reviewers for their constructive review of this work and Dr. J. Vrbik, University of Calgary, for statistical advice. The author was in the employ of the Yukon Game Branch when the data were collected.

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