Caribou Feeding Sites in Relation to Snow Characteristics in Northeastern Alaska

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ABSTRACT. Caribou select areas of relatively shallow snow for winter feeding, and do so on at least two levels: broad area and microsite. They do not normally select sites with snow-packs having mean integrated Ram hardness values in excess of 85. However, in areas of relatively shallow hard-packed snow, which is easily fractured into slab-like pieces, they can obtain access to vegetation with less expenditure of energy than Ram hardness values alone would suggest. Alpine feeding areas in the Porcupine Lake basin of northeastern Alaska had this type of snowpack in the winter of 1972-73. In typical taiga winter range, caribou use areas where the snow depth is less than 50 centimetres.

RÉSUMÉ. *Lieux où s'alimente le caribou, en relation avec les particularités de la neige dans l'Alaska du nord-est.* Pour s'alimenter en hiver le caribou choisit des tapis de neige relativement peu profonds, et ceci sur au moins deux sortes de terrains: vastes étendues et espaces très restreints. Normalement il ne choisit pas les emplacements dont les tapis de neige tassée dépasse en dureté des valeurs moyennes intégrées de Ram de 85. Cependant, sur des étendues de neige dure tassée relativement peu profonde et qui peut être facilement brisée en plaques, le caribou a accès à la végétation en dépensant moins d'énergie que ne le donneraient à supposer, à elles seules, les valeurs de dureté de Ram. Les régions de pâturages alpins du lac du Hérisson dans l'Alaska du nord-est ont eu ce type de tapis neigeux au cours de l'hiver 1972-73. Pendant un hiver typique de taiga, le caribou utilise, pour s'alimenter, des étendues couvertes par une épaisseur de neige inférieure à 50 centimètres.

РЕЗЮМЕ. *Участки кормлення карибу и характер снежного покрова на северо-востоке Аляски.* В зимний период карибу кормятся на участках с относительно неглубоким снегом, причем это справедливо как для широкой территории, так и для микроучастков. Животные обычно выбирают места, где средняя интегральная плотность спежного покрова по Раму не превышает 85. Однако там, где плотный, но относительно неглубокий снег легко ломается на куски, карибу может иметь доступ к растительности, затрачивая на это меньше энергии, чем это следует из одной лишь величины плотности по Раму. Участки альпийских пастбищ в бассейне о. Поркьюпайн на северо-востоке Аляски характеризовались именно таким типом снега зимой 1972-73 гг. В типичной тайге карибу кормятся зимой на участках, где толщина снежного покрова не превышает 50 см.

INTRODUCTION

The characteristics of snow cover have often been acknowledged as a critical factor influencing the survival and wellbeing of ungulates in the Arctic and Subarctic (Pruitt 1959; Formozov 1964; Vibe 1967; Henshaw 1968; Kelsall and Telfer 1971). This paper reports results of snow measurements on caribou winter ranges in northeastern Alaska.

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METHODS

Data were obtained during April 1972 and March 1973. In both years, aerial reconnaissance flights began in late February or early March to determine the location and approximate numbers of wintering animals. On these flights, winter feeding areas were noted as well as conspicuously trackless areas.

During both years, the snow cover in the Chandalar and Junjik Valleys was extensively cratered as a result of the feeding activities of wintering bands of caribou. In April 1972, a field camp was established on the northwestern shore of Anvil Lake (68°23′N; 145°40′W) in the Junjik Valley (Fig. 1). Five feeding areas which had been used by caribou during the preceding twenty-four hours were selected for data collection. Feeding areas, as defined here, are extensively cratered sites surrounded by relatively undisturbed areas. In general, the snow is shallower in such feeding areas than in surrounding areas in the valley bottom, as has been previously reported (Pruitt 1959; Formozov 1964; Henshaw 1968). Within these feeding areas, the depths of craters and of adjacent undisturbed snow were measured. A Rammsonde penetrometer shaft was placed at the deepest part of the crater and a ski pole positioned horizontally across the adjacent undisturbed snow surfaces (Fig. 2). Crater depths were then read to the nearest centimetre on the penetrometer scale.

Caribou were observed to paw snow out of one side only of most craters, normally the side of their approach. The opposite sides of the craters had a clean edge of undisturbed snow. Approximately 50 cm from this clean edge the penetrometer was pushed down through the snow-pack to the ground surface, and snow depth measured to the nearest centimetre of its scale.

Except in the case of one area, all observations were paired, i.e., each crater depth was associated with a depth measurement of adjacent undisturbed snow. The purpose of pairing observations was to allow for the additional variability occurring between pairs. The statistical analysis involved comparisons of sample means for paired observations (Steel and Torrie 1960 pp. 78-79). In this case, the null hypothesis is that the difference between sample means is zero and, using a t-test, the null hypothesis is either accepted or rejected. For example, significance at the 0.001 level indicates there is only one chance in a thousand that the null hypothesis could be correct.

In the case of unpaired observations (Area 3), simple comparison of sample means was made (Steel and Torrie 1960 pp. 73-75).

In March 1973, snow data were obtained for seven areas in northeastern Alaska (Fig. 1). For five of them, all located in general areas frequented by wintering bands of caribou, the same paired measurements as described above were obtained. The two other areas were nearby upland plateaus which were obviously unused by caribou.

Additional data concerning depth and hardness of the snow-pack were obtained for all seven areas. Transects within both the feeding areas and uncratered adjacent areas were sampled. These transects were each approximately 400 m in length with ten Rammsonde profiles spaced about 50 m apart. At each sample point, data were obtained which permitted calculation of the integrated Ram

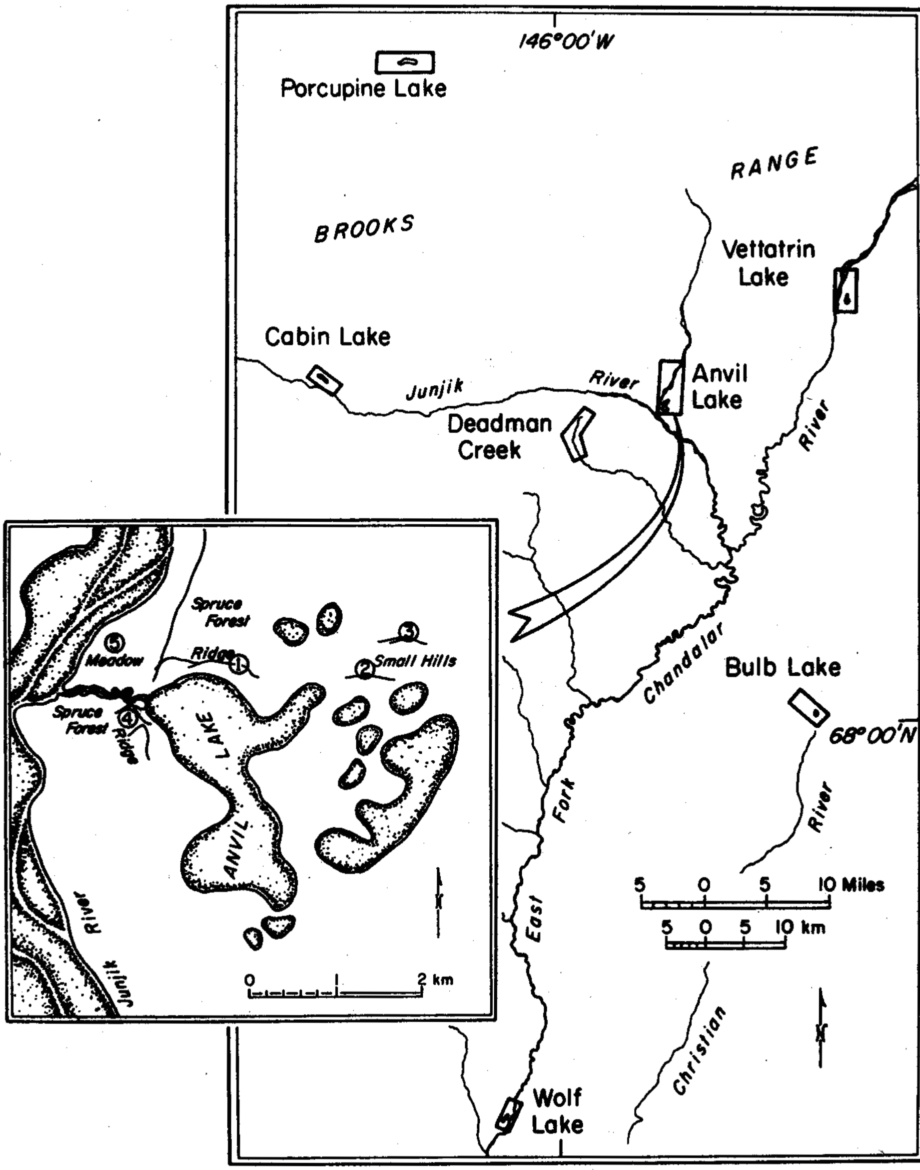

FIG. 1. The study areas.

hardness of the snow-pack (Benson 1962; Testlab 1970). This value is correlated to the density/water equivalent of the snow-pack (see Keeler 1969) and, presumably, to the amount of energy required to dig through that snow-pack. Because of deteriorating weather conditions, no transect data for adjacent undisturbed areas were obtained at Porcupine Lake or Wolf Lake. Data were obtained at two areas obviously unused by wintering caribou.

Because integrated Ram hardness may be either relatively uniform or highly variable in different geographical areas, the variance of data observation for

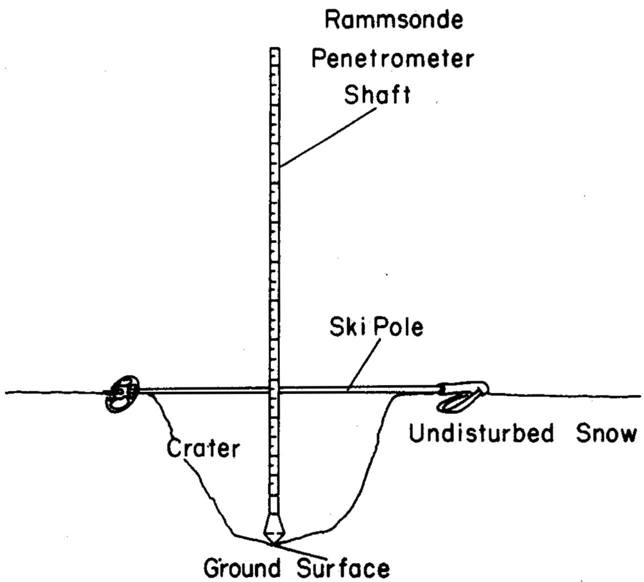

FIG. 2. Assembly for measurement of depths.

each area was calculated. Statistical variance is the square of standard deviation, and both are measures of spread or dispersion. Low variance indicates that observations are closely grouped about the mean; whereas, high variance indicates that they are more widely dispersed throughout their range.

RESULTS

The mean depths of adjacent undisturbed snow were greater than mean crater depths at all five feeding areas visited in 1972 (Table 1). The differences were highly significant for the four areas where observations were paired, but the differences for the unpaired observations from Area 3 were significant only at the 0.1 level, because the additional variance removed by the pairing procedure was still present in these data, since the data for this area were obtained before

TABLE 1. Statistical analysis of mean snow depth within the caribou feeding areas shown in Fig. 1.

	No. of observations		Mean depth (cm)			Level of significance
	Paired	Unpaired	Crated site	Adjacent	Difference	
March 1973						
Anvil Lake	44	0	41.0	46.3	5.3	0.001
Vettatrin Lake	44	0	38.7	48.2	9.5	0.001
Cabin Lake	37	0	25.5	29.6	4.1	0.001
Wolf Lake	44	0	45.9	51.7	5.8	0.001
Porcupine Lake	44	0	35.7	37.8	2.1	not sig.
April 1972						
Area 1	44	0	39.5	46.9	7.4	0.001
Area 2	44	0	32.0	44.9	12.9	0.001
Area 3	0	46	33.2	51.5	8.3	0.100
Area 4	44	0	38.1	48.8	10.7	0.001
Area 5	44	0	31.6	39.5	7.9	0.001

the decision to pair observations was made. Similar results were observed in the 1973 data (Table 1). The only site where the differences were not highly significant was Porcupine Lake.

Mean snow depths measured along Rammsonde transects were less within feeding areas than in adjacent uncratered areas (Table 2). Integrated Ram hardness values were lower in feeding areas than in adjacent uncratered areas (Table 2). However, mean snow depths at the conspicuously-unutilized upland plateau areas were less than at the Wolf Lake feeding area (Table 2), and mean integrated Ram hardness values at these upland plateau areas were lower than at the Porcupine Lake feeding area (Table 2).

TABLE 2. Mean snow depths and integrated Ram hardness values for transects within caribou feeding areas (F) and obviously unused sites (U) in March 1973.

Location		Mean snow depth (cm)*	Integrated Ram hardness value			
			Minimum	Maximum	Mean	Variance
Anvil Lake	F	43.6	44.26	118.09	74.31	531
Anvil Lake	U	51.3	48.90	131.61	89.78	746
Vettatrin Lake	F	43.5	50.10	105.91	77.71	387
Vettatrin Lake	U	45.1	62.55	131.75	89.06	527
Wolf Lake	F	48.8	35.21	118.73	82.56	488
Cabin Lake	F	27.6	38.41	245.49	94.47	3,836
Cabin Lake	U	39.1	48.59	464.48	223.49	24,113
Porcupine Lake	F	36.8	54.71	352.34	167.26	10,352
Bulb Lake	U	50.3	55.55	298.09	117.80	5,226
Deadman Creek	U	47.6	75.43	155.13	103.64	1,002

*Mean for all locations: F 40.1, U 46.7

DISCUSSION

Pruitt (1959) and Henshaw (1968) both suggest that snow depths of 50-60 cm form a critical limit to caribou activity. Similarly, Lent and Knutson (1971) report that reindeer on Nunivak Island, Alaska, rarely dig through more than 50 cm, and often abandon craters in deeper snow before reaching vegetation. These findings agree closely with those of Soviet investigators (Avranchik 1939; Nasimovich 1955; Formozov 1964) who have reported that caribou and reindeer selectively feed and travel in areas of shallow snow. Henshaw (1968) reports a mean snow depth of 34 cm in locations occupied by caribou, whereas the mean snow depth at his random observation points was 70 cm. Both he and Pruitt (1959) suggest that caribou have a strong tendency to avoid areas covered by relatively deep snow, but their work deals principally with differences in snow depth and density resulting from meso-relief characteristics such as wind shadows of forest or hills.

Although Soviet scientists have reported similar findings for reindeer, Nasimovich (1955) suggests that reindeer make use of both meso- and micro-relief features to facilitate digging food from under the snow. He cites Avranchik (1939) whose observations indicate that reindeer feeding in a hillocky bog will dig for lichens only on the hillocks where the snow is shallower, rather than in depressions between hillocks.

Tushinskii (1949) contends that the mechanism of cratersite selection in reindeer is olfactory. He reports convective air currents in the snow-pack which, he maintains, permit reindeer to smell forage beneath the snow. He suggests its odour is strongest where snow is shallowest, and is the basis for cratersite selection. Bergerud and Nolan (1970) have concluded, from experimental work, that caribou are unable to detect the presence of lichens through snow cover over 25 cm thick, unless holes are present in it such as can be made by protruding plant stems.

Pruitt (1959) has postulated a "snow fence" hypothesis — that caribou move about within the confines of "fences" of adverse snow conditions.

The results of the present writers generally support both hypotheses. In any general area, caribou seem to select sites of shallowest and softest snow for feeding activity. However, neither depth nor hardness considered individually seem to determine selection of general wintering areas. There are upper limits both for depth and for hardness of crust. Maximum snow depth is approximately 50-60 cm (see above); and "reindeer cannot survive on winter ranges where ice crusts thicker than 1½-2 inches [4-5 cm] habitually form" (unpublished report by Robert E. Pegau to the Alaskan Department of Fish and Game in 1964). It seems reasonable to conclude that, within these upper limits of tolerance, selection of feeding areas is influenced by both factors.

The Porcupine Lake area seems to be an atypical winter range for caribou, snow data obtained there being significantly different from those obtained at all other winter-range areas visited by the present authors. Mean integrated Ram hardness there is almost twice as great as at any other feeding area (Table 2) and, furthermore, it was the only feeding area where there was no significant difference between crater depth and depth of adjacent undisturbed snow (Table 1). As regards the latter, there are two possible explanations: either the snow-pack was too dense for the animals to accurately sense differences in snow depth; or the terrain has almost no micro-relief — a condition which was in fact revealed during summer visits to the ridge-top feeding area. As to hardness, caribou were observed walking and running on the snow without fracturing the upper surface. It was also revealed during summer field work at Porcupine Lake in 1973 that the lichen crop there was substantially more abundant than over all other winter-range areas visited. Additionally, none of the caribou pellet groups found there showed evidence of decomposition. In contrast, at all other winter ranges visited, the pellets were observed to be in various states of decomposition, suggesting a long history of caribou use.

The snow data seem to indicate that the Porcupine Lake area should not have been selected for winter use by caribou, but it was in fact extensively used by caribou in the winter of 1972-73. For this two contradictory hypotheses may be advanced, which both seem plausible. On the one hand, it may be suggested that the advantages of easy travel and high-quality abundant forage counterbalance the disadvantage of digging through hard-packed snow. Furthermore, hard-packed snow that is easily fractured into slab-like pieces may provide access to vegetation at lower energy cost than would be predicted from Ram hardness values (Lent and Knutson 1971). Thus, in terms of energy, it is possible that the area was excellent winter range in that particular year.

The alternative hypothesis is that the area is marginal winter range which the animals were forced to use because of pressure of numbers. Most of the Porcupine herd, according to their normal migratory habits as described by Hemming (1971) and others, occupy winter ranges in the southern Yukon Territory. In the fall of 1972, migration to these ranges was proceeding as usual until early October when, upon reaching the Porcupine River in the vicinity of Old Crow, a substantial portion of the herd turned southwest and returned to Alaska instead of crossing the Porcupine River and continuing south to their usual wintering areas.

Various estimates of the numbers of animals involved were offered by American and Canadian biologists who followed the progress of the migration. Some reported that 20,000 caribou returned to Alaska, while others suggested as many as 50,000 did so. Certainly, there were many more caribou in Alaska than usual in the winter of 1972-73. Perhaps the population pressures on winter ranges forced some animals to utilize marginal ranges which would not otherwise have been grazed. This may explain use of the Porcupine Lake basin where snow conditions were markedly different from those at all other winter-range areas visited.

CONCLUSIONS

Caribou have the ability to select areas of relatively shallow snow for winter feeding, and they do so on several levels. First, they select general areas, such as particular valleys, which they occupy for at least part of the winter. Second, within these general areas, the animals select feeding areas where they proceed to concentrate their cratering activities. Finally, within these feeding areas, the animals select specific sites for those activities. At all levels, selection seems to operate toward progressively shallower snow depths; that is, the mean snow depth within large general areas which are not used by the wintering animals is usually greater than the mean snow depth in general areas which are used by them. Within such general areas, the mean snow depth in feeding areas is usually less than mean snow depth outside them. Finally, depth of crater is significantly less than depth of adjacent undisturbed snow wherever the terrain has micro-relief such as hummocks or tussocks.

Lent (1974) has reported the occurrence of similar micro-relief selection by reindeer on Nunivak Island. There, snow depth at craters averaged 21 cm; whereas at randomly-selected adjacent sites it had a mean depth of 56 cm. The differences for both depth and hardness were significant ($P < 0.05$).

The hardness of snow does seem to influence the winter feeding behaviour of caribou, but the relationship appears to be more complex than one of simple inverse proportionality. Certain advantages, such as ease of travel and escape from predators, may accrue to animals wintering on hard-packed snow, particularly if they are able to fracture the snow-pack easily for forage. On most of the utilized winter-range areas the mean integrated Ram hardness of the snow-pack was under 85, whereas on the unused areas it always exceeded that figure. The two utilized areas with Ram hardness values exceeding 85 were also the ones with lowest mean snow depths among all the areas visited.

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