Summer Habitat Use by Muskoxen *(Ovibos moschatus)* and Peary Caribou *(Rangifer tarandus pearyi)* in the Canadian High Arctic

By G. R. Parker and R. K. Ross *

Summary: Summer daily activity and movement patterns and habitat selectivity by Peary caribou *(Rangifer tarandus pearyi)* and muskoxen *(Ovibos moschatus)* were studied at two sites in Canada's High Arctic. Caribou showed a greater mobility and broader selection of habitat than muskoxen. Muskoxen fed more than they rested in contrast to the greater amount of time spent resting than feeding by caribou. The sedge-producing hydric-meadow vegetation type was highly selected for by muskoxen at both study areas; caribou selected against the hydric-meadow type and preferred the polar desert and mesic-meadow types. Caribou displayed a greater variety in plant species selection than muskoxen, favouring willow *(Salix arctica)*, grasses, forbs, and the flowers of vascular plants. Muskoxen fed extensively on sedges in the hydric-meadow. It is suggested the abundance and distribution of sedge-producing meadows may control the regional abundance and distribution of muskoxen. Winter climate is probably the ultimate factor controlling densities of muskoxen and caribou in the High Arctic.

Zusammenfassung: Sommerliche Tagesaktivität, Wanderungsrhythmus und Habitat-Präferenzen des Peary-Karibus *(Rangifer tarandus pearyi)* und Moschusochsen *(Ovibos moschatus)* wurden an zwei Stellen in der kanadischen Hocharktis untersucht. Die Karibus zeigten dabei eine größere Mobilität und breiter gefächerte Habitat-Wahl als die Moschusochsen. Im Gegensatz zu den Karibus verbrachten die Moschusochsen mehr Zeit mit der Nahrungssuche als mit Ausruhen. Die an Seggen reichen Sumpfwiesen wurden von den Moschusochsen in beiden Untersuchungsgebieten bevorzugt, während die Karibus diesen Vegetationstyp mieden und stärker die Polarwüsten und die Trockenwiesen beweideten. Die Karibus zeigten eine größere Vielseitigkeit in der Pflanzenwahl als die Moschusochsen und bevorzugten Weiden *(Salix arctica)*, Gräser, Kräuter und die Blüten der Gefäßpflanzen; die Moschusochsen nahmen vornehmlich die Seggen der Sumpfwiesen auf. Es wird vermutet, daß Größe und Verbreitung der seggenreichen Sumpfwiesen über die Zahl und die Verteilung der Moschusochsen bestimmen. Das Winterklima ist vermutlich der entscheidendste Faktor bei der Festsetzung der Populationsdichten von Moschusochsen und Karibus in der Hocharktis.

INTRODUCTION

The muskox *(Ovibos moschatus)* and Peary caribou *(Rangifer tarandus pearyi)* are important herbivores in most of the Arctic Archipelago. However, there have been few studies of their feeding habits, hatitat use or interspecific competition.

The Canadian Wildlife Service began a study in 1973 to obtain information on the above subjects in the Canadian High Arctic. The investigation was twofold in design: (1) to document summer habitat utilization, and, (2) to quantify the seasonal and regional diet of both species. This paper presents the results of the first objective. The diets of both species will be determined through rumen and faecal analysis, the results of which are yet to be published.

Recent concern over the potential unfavourable effects on the Arctic environment by the construction of gas pipelines has stimulated the need for baseline data on Arctic wildlife populations. Knowing the habitat requirements of an animal population is necessary to predict potential effects of environmental disturbances on that population. Our approach was to locate two regions supporting high densities of both species and observe their activities over a prolonged period. We felt the data would be of greatest value when interpreted on a comparative basis.

Other than aerial surveys to document their numbers and seasonal and geographical distribution (Tener 1963; Miller and Russell 1974; Miller and Russell 1975; Miller, Russell and Urquhart 1973), the ecology of Peary caribou has been completely ignored.

Although the ecology of muskoxen has not been so sorely neglected, earlier studies have not thoroughly analysed the interrelationship between it and its range. Tener

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(1965) provided detailed descriptions of muskox range and summer food preferences; however, he made no attempt to quantitatively correlate movements with food availability. Boss (1967) described muskox range on Nunivak Island, Alaska, while Gray (1973) described in detail the behaviour of muskoxen on Bathurst Island with brief mention of their feeding preferences and summer distribution in the Bracebridge — Goodsir Inlet area. Hubert (1974) studied muskox productivity on Devon Island and analysed their contribution to the energy flow of the ecosystem. Wilkinson *et al.* (1976) studied the caribou — muskox interrelationship on Banks Island, concurrent with our studies on the Queen Elizabeth Islands. All work on muskoxen prior to the early 1960 's is summarized by Tener (1965). Jonkel and Smith (1972) provide a synopsis of subsequent studies in Canada.

STUDY AREAS

Physiography. The two areas chosen for study were at Mokka Fiord, Axel Heiberg Island (79° 43' N — 87° 30' W) and Bailey Point, Melville Island (74° 50' N — 115° 00' W) (Figure 1).

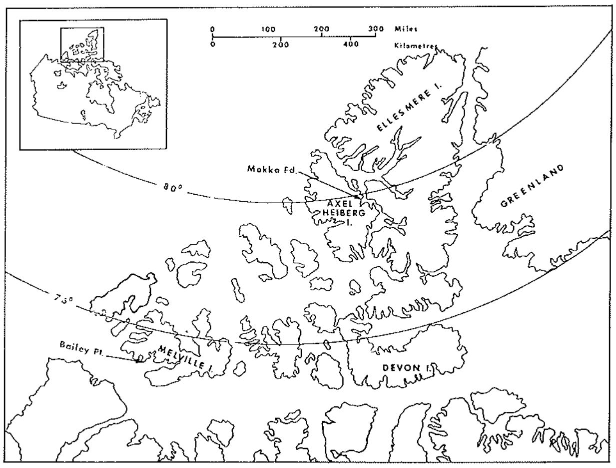

Fig. 1: The location of the two study areas at Mokka Fiord and Bailey Point.

Abb. 1: Lage der beiden Untersuchungsgebiete im Mokka Fjord und bei Bailey Point.

The Axel Heiberg study area was located in a broad valley, 6 to 12 km wide, just north of Mokka Fiord. The valley is delimited by the Princess Margaret Range on the west and a long ridge of gypsum piercement domes to the east. The floor of the valley has an elevation of approximately 200 m asl although it drops off rapidly just before the fiord. The terrain separates into two distinct physiographic forms. The first is an area of elevated gravel barrens, highly dissected by streams. This stretches approximately 4 km north from Mokka Fiord, before giving way to an extensive area of more level and highly vegetated wetlands. That area features meandering streams, tundra ponds and high and low centred ice-wedge polygons, all of which are associated with large meadows. Low hills, often covered by hummocky tundra, are spotted throughout that section.

Bailey Point is at the extreme southerly tip of a 250 km^2 projection of land on the southwestern portion of Melville Island. Southwestern Melville Island consists of ridges and plateaux developed on terrain that has undergone Tertiary faulting. The region in general is a high plateau, reaching 740 m asl with high cliffs forming much of the coast (Tozer and Thorsteinsson 1964). The coastal region at Bailey Point is unique, consisting of a low, undulating plain, gradually rising to meet the plateau several kilometers inland.

The two dominant vegetation types on the plateau are the polar desert and the moss-clay plateau. The former is sparsely vegetated with grasses, forbs and lichens; the latter supports mosses, grasses, and forbs. Hydric meadows, supporting abundant sedges, are common at the base of the plateau. The coastal lowlands consist of two dominant vegetation types: the clay barrens and the clay-moss slope. The clay barrens are common on elevated ridges and support a mosaic of willow *(Salix arctica), Dryas integrifolia,* and bare ground. The clay-moss slope supports a vegetation of similar composition but greater percentage plant cover.

Climate. Annual precipitation at Mould Bay, approximately 160 km northwest of Bailey Point, is 8.3 cm while mean maximum daily temperatures for July and August are 6.5° C and 3.9° C respectively (Thompson 1967). The effect of the polar sea tends to keep mid-summer temperatures below those of most other Arctic stations.

Eureka, which is only 30 km northeast of Mokka Fiord, has a total annual precipitation of 6.7 cm and a mean annual temperature of — 17.8° C. Mean maximum daily temperatures for July and August are 8.7° C and 6.2° C respectively (Thompson 1967).

METHODS

The two areas chosen for study were selected for their known high densities of musk-oxen. Miller and Russell (1974) surveyed the western Queen Elizabeth Islands and found the highest densities at Bailey Point. Although quantitative aerial surveys had not been flown on Axel Heiberg Island prior to 1973, the Mokka Fiord region was known to support a high muskox population.

The mobility and nomadic nature of caribou made the selection of an area for prolonged observation of that species hazardous. Although caribou were believed to be rare at both sites, we felt they would probably be present for some of the time throughout the summer season.

To evaluate vegetation type use by both species we chose to sample their activity and distribution in relation to vegetation type over a prolonged period. The application of similar techniques in two areas would allow for a valid comparison of the data.

Studies were carried out within a 35.5 km^2 area at Mokka Fiord from June 22 to August 12, 1973 and within a 38.5 km^2 area at Bailey Point from June 24 to August 18, 1974. A two-man basecamp was established at both sites affording a view of much of each study area, while lookout sites facilitated total coverage. Each study area was early defined as that area within which all animals could be observed and vegetation types identified from the two lookout sites. The area was delineated on 1:25.000 aerial photographs and observers familiarized themselves with terrain features and prominent landmarks to facilitate precise location of animals under observation.

Each study area was normally under watch from early morning to late afternoon. On those days weather decided against prolonged observation, only the distribution of herds was plotted. Individual herd observation cards assisted in organized compilation of data and later statistical analyses. The size, composition and identifying code were first assigned each herd. Herd activity and its location in relation to vegetation type was then recorded. Where different vegetation types were in use by a herd, the number of animals in each, and their activity, were entered. Observations of each herd were made at 30 minute intervals at Mokka Fiord and at 20 minute intervals at Bailey Point.

The location of the herd at each observation was plotted on a copy of the aerial photograph. Observation was aided by 10 x 40 Trinovid binoculars and 15—60x Bausch and Lomb spotting scopes. The exact times for individual and herd resting and feeding periods were recorded whenever possible. The activity recorded for both muskoxen and caribou was either resting or feeding.

After brief reconnaissances, each study area was divided into broad habitat classifications. Those vegetation types were then sampled for plant species composition and annual above-ground productivity of vascular plants. The sampling occurred in early to mid-August when the growing season was near completion. Annual production included all the above-ground current year's growth of monocots and flowering forbs and the leaves, flowers and new stem growth of arctic willow. The increase in diameter of previous year's twigs of willow is not considered in those estimates of current year's annual production.

One representative stand of each type was selected for sampling; the point frame method (Levy and Madden 1933) was the technique used throughout. The point frame method has been recommended for estimating cover in short grass communities (Brown 1954), and although slower than such methods as the line intercept and ocular estimation, it provides objective values for importance of plant species in the community. The specifications for the vertical frame are provided by Brown (1954).

The point frame was used to sample 20 quadrats, 0.1 m^2 (20 cm x 50 cm) at 5 m intervals along three parallel transects in each stand selected. The transects were 10 m apart, the first two 30 m in length, the third 25 m. The frame was placed five times equidistant within each quadrat, allowing 50 drops of the pin. All vegetation hit by the pin was recorded. "Percentage of total hits" was obtained for each species rather than true cover values, the latter referring only to a vertical projection of plant cover upon the ground.

The above-ground living material of all vascular plants, except for *Dryas integrifolia* and *Cassiope tetragona* was clipped from ten plots 20 cm x 50 cm located systematically in each of the seven vegetation types. Neither of these species are known to be an important forage plant for caribou or muskoxen. As they are evergreen species, determining current year's growth would also be difficult. Clipped vegetation was separated in the field into the following classes: willow, sedges, grasses, and forbs. Dried vegetation was weighed in grams to four decimals in the laboratory.

With the aid of 1:25,000 aerial photographs, the study area was cover mapped according to vegetation types. As most areas large enough to be accurately delineated on the aerial photograph contained two or more types, such areas were complexed on the map and the proportion of each type within the delineated area estimated to the nearest 10 per cent.

RESULTS

Populations and Herd Structure

Although daily records were kept on numbers of muskoxen and caribou in the study areas, we made no specific attempt to estimate maximum numbers of animals over the study periods. We were aware of considerable local movement of muskoxen in both years, while caribou were particulary transitory, especially in 1974.

Aerial surveys by the Canadian Wildlife Service (Miller and Russell 1974) showed approximately 400 muskoxen on the Bailey Point peninsula although not all of those would have frequented our study area. An aerial survey of eastern Axel Heiberg Island on

July 25, 1973 (Ross 1975) produced a total count of 866 muskoxen and 32 Peary caribou. Two hundred and seventy-five muskoxen were between Gibbs Fiord and Buchanan Lake and may have appeared in our study area during the summer.

At Mokka Fiord, muskoxen were recorded daily on the study area from June 27 to July 25 (except for three days when conditions were too inclement for counting). From July 26 to August 10, muskoxen were present on only 9 of the 15 days that counts were taken. The highest daily count was 60 on July 1, while the largest herd (26) was seen on August 10.

In the Bailey Point study area, muskoxen were observed daily from July 3 to August 2. No muskoxen were seen on 5 of the 16 days from August 3 to 18. The highest daily count of muskoxen in the study area was 100 on July 16; the largest herd (41) was also seen that day.

Table 1 presents pertinent muskox population parameters for the two study areas. Each study duration was divided into approximately 10 day periods numbered from 1 to 6. They are as follows: 1 — June 22 to July 1, 1973; 2 — July 2 to 11, 1973 and July 3 to 11, 1974; 3 — July 12 to 21, 1973 and 1974; 4 — July 22 to 31, 1973 and 1974; 5 — August 1 to 10, 1973 and 1974; 6 — August 11 to 18, 1974.

Mean densities were of the same order in the two areas for comparable periods although numbers dropped off much more quickly at Mokka Fiord. Calf ratios were slightly greater at Mokka Fiord but showed greater maxima and lower minima than at Bailey Point. Yearling fraction was only recorded at Bailey Point and was very low (3. 1 per cent). Four yearling carcasses were found in the Bailey Point study area, all attributed to over-winter mortality.

Mean herd sizes in the two study areas were roughly similar although the Mokka Fiord herds appeared more variable in size. The pronounced increase in herd size in the final observation period at Bailey Point was not verified at Mokka Fiord because of lack of time. However, it is perhaps significant that the largest herd of the season was seen there on August 10.

Caribou were less abundant and more transitory than muskoxen. At Mokka Fiord, 22 bands of 93 animals were seen. The mean band size was 4.2; the largest group was 10, seen on July 15 and 18. Caribou were only seen on 16 days from June 28 to July 21. A single female and calf were observed on July 21.

At Bailey Point 26 bands of 127 caribou were recorded. The mean band size was 4.8; a maximum band size of 15 was observed on July 22 and 24. No calves were seen although many of the adults were female.

Observation period	Number of herds *	Mean herd size	Number of muskoxen	Average per day	Muskoxen per km²	Per cent calves	Per cent yearlings
1	82 — n. d.	7.4 — n. d.	432 — n. d.	48.0 — n. d.	1.35 — n. d.	12.3 — n. d.	n. d. — n. d.
2	61 — 52	8.4 — 6.3	356 — 331	35.6 — 36.7	1.00 — 0.95	20.8 — 12.0	n. d. — 3.3
3	59 — 52	7.2 — 7.4	308 — 367	30.8 — 42.2	0.87 — 1.09	22.4 — 16.3	n. d. — 2.9
4	46 — 45	8.1 — 7.4	66 — 334	8.3 — 31.2	0.23 — 0.80	10.8 — 12.2	n. d. — 2.9
5	21 — 35	5.6 — 7.0	36 — 264	4.0 — 26.5	0.11 — 0.68	8.5 — 15.9	n. d. — 0.7
6	n. d. — 11	n. d. — 13.0	n. d. — 144	n. d. — 28.8	n. d. — 0.74	n. d. — 18.0	n. d. — 8.3
Totals	269 — 195		1198 — 1440				n. d. — 3.1

* Includes herds adjacent to study area.

Tab. 1: The composition of muskox herds observed at the two study areas (Mokka Fiord — Bailey Point).
Tab. 1: Zusammensetzung der in den beiden Untersuchungsgebieten beobachteten Moschusochsen-Herden.

Daily Activity Cycle

Adult muskoxcen spent more time feeding than resting (Table 2); our summer records showed a resting: feeding ratio of 0.76:1.00 at Bailey Point and 0.67:1.00 at Mokka Fiord. The feeding and resting times were similar in the two study areas from June 21 to July 11 after which resting times declined significantly in both cases (Mokka Fiord $p < 0.01$, Bailey Point $p < 0.001$, U-test). Feeding times remained stable at Mokka Fiord but declined at Bailey Point ($p < 0.001$, U-test); feeding periods were significantly different for the two areas from July 12 to 31 ($p < 0.001$, U-test). Examining the ratios of resting to feeding times, it appears that the proportion of the day spent resting declined slightly at Mokka Fiord while increasing at Bailey Point.

The number of observations of caribou activity patterns at Mokka Fiord were too few to be reported. However, although the number of caribou observations at Bailey Point did not allow a comparison of resting and feeding times through the summer period, the overall mean resting and feeding times were found to be 66 ($s=18$; $n=33$) and 56 ($s=14$; $n=34$) minutes respectively for a resting: feeding ratio of 117:100. Resting comprised a greater proportion of the daily activity of caribou than muskoxen.

	Time in minutes		
Date	Resting *	Feeding *	Ratio
June 21 — July 11	96(35) — 89(66)	134(22) — 128(29)	0.72:1.00 — 0.69:1.00
July 12—31	77(14) — 71(89)	138(13) — 88(45)	0.55:1.00 — 0.81:1.00
August 1—18	n. d. — 60(43)	n. d. — 73(18)	n. d. — 0.82:1.00
Overall	91 — 75	136 — 98	0.67:1.00 — 0.76:1.00

* Sample size in parentheses.

Tab. 2: The mean summer resting and feeding times of muskoxen observed at the two study areas (Mokka Fiord — Bailey Point).

Tab. 2: Mittlere sommerliche Ruhe- und Nahrungsaufnahme-Zeiten der in den beiden Untersuchungsgebieten (Mokka Fjord — Bailey Poyint) beobachteten Moschusochsen.

Summer Mobility

Mean distances travelled by muskoxen at Mokka Fiord and at Bailey Point per hour of activity are shown in Table 3.

Muskoxen at Mokka Fiord were more mobile than those at Bailey Point in all comparable time periods, a possible result of the distinctly different environments. Mobility at Mokka Fiord varied with time although no trend was evident. It should be mentioned that the high mobility in Period 2 was partly due to the inclusion of data on two non-feeding herds trekking quickly through the study area; this behaviour is discussed later. Exclusion of those observations reduces the mean mobility to 393 m/hour. At Bailey Point, muskox mobility increased consistently throughout the study, concomitant with a decrease in both feeding and resting durations.

The caribou at Bailey Point were far more mobile than muskoxen; the difference in the overall mean (per 20 minute activity) for caribou (393.0 m) and the maximum in August for muskoxen (133.5 m) was highly significant ($p < 0.001$, U-test). The maximum distance moved by caribou per hour was 5.70 km and for muskoxen 3.04 km.

Vegetation Types

Plant cover was characterized into five broad vegetation types at Mokka Fiord. Each is described below; its percentage of the total study area is shown in parentheses.

Study period	Distance travelled by herd			
	Mokka Fiord		Bailey Point	
	Metres	N	Metres	N
Muskoxen				
1	427	40	n. d.	—
2	603	32	216	71
3	358	40	313	101
4	547	3	382	56
5 & 6	n. d.	—	401	53
Caribou				
2—5	n. d.	—	1179	44

Tab. 3: The mean distances travelled by muskoxen and caribou herds per one hour of activity (non-resting) at Mokka Fiord (muskox only) and Bailey Point.

Tab. 3: Mittlere Größe der von Moschusochsen- und Karibuherden während einer Stunde zurückgelegten Strecken, Mokka Fjord (nur Moschusochsen) und Bailey Point.

(a) *Dryas-Salix* raised tundra (13.6 %)

That type was characterized by *Dryas integrifolia* and *Salix arctica* although lichens were also present. It was located in more elevated, exposed and well-drained areas, often at the edges of the clay-gravel barrens, and appeared either as a flat, somewhat scattered turf or as slight hummocks.

(b) *Dryas-Salix* moss hummocky tundra (12.4 %)

That was a much more densely vegetated type than the previous, showing a much greater cover of *Salix arctica, Dryas integrifolia,* and particularly moss. It was located on more moist, protected areas, often on creek banks and poorly drained slopes, and was composed of pronounced, ice-formed hummocks. A subtype of that group was the occasional *Cassiope tetragona* patch.

(c) Mesic-meadow (2.2 %)

That was a continuous, flat turf of vegetation, dominated by moss, *Carex* spp. and *Salix arctica.* Annual production was the highest of all range types. Meadows were found in low-lying and poorly drained areas, often by streams or lakes.

(d) Willow-moss mat (4.4 %)

That association was found on exposed and poorly drained slopes and was composed predominantly of a flat mat of moss from which grew very low-lying, creeping willow.

(e) Polar desert (67.4 %, including 30.0 % Saxifrage barrens)

That area was largely devoid of vegetation. It was composed of patches of almost total barrens, dissected by shallow ice-formed gulleys in which extensive vegetation, particularly willow, was found. Although production of willow in those locations was by far the highest of the various range types, the area of the gulleys was limited, representing probably less than 5 % of the total polar desert type. A subtype of the barrens was found on the upper slopes at the west end of the study plot. That has been termed a Saxifrage barren as patches of *Saxifrage oppositofolia* and *S. tricuspidata* were visible at a distance. However, no analysis of cover or production was made as that area was little utilized.

The Bailey Point study area contained seven vegetation types; two, the polar desert and the mesic-meadow, being essentially similar to those at Mokka Fiord. The percentage of each vegetation type within the study area is shown in parantheses.

I Polar desert (15.5 %)

Polar desert was generally restricted to the plateau adjacent to the lowland. Total cover of vascular plants was less than 12 % but the number of species was equalled only by the moss plateau type. Soil consisted of unconsolidated gravel and small stones, and drainage was good.

II Clay barrens (19.7 %)

Soils of the clay barrens, like those of the polar desert, consisted of unconsolidated gravel and stones, but also included quantities of clay. Drainage was poor, and the type was subject to considerable frost action. The type was mainly restricted to exposed ridges of the coastal lowland. The vascular plant cover was sparse. Willow was the dominant species, and it was restricted to scattered mats in depressed or otherwise protected sites. Where intensive frost action created considerable microtopographic relief, willow reached 40 to 50 % ground cover.

III Dry tundra (11.2 %)

Dry tundra supported a variable plant cover but was usually distinguished by an abundance of the grasses *Alopecurus alpinus* and *Arctagrostis latifolia;* the dead material from previous years' growth gave most sites a gray appearance. Soils were fairly stable and apparently highly fertile, supporting a rich flora of vascular plants. Vascular plant cover was approximately 20 %. Dry tundra often occurred between hydric- or mesic-meadow types and the moss-willow slope type, and is probably a seral stage advanced beyond the mesic-meadow type.

IV Mesic-meadow (11.6 %)

The mesic-meadow type is probably a seral stage between the true hydric-meadow and the dry tundra type. The mesic-meadow consisted of dry *Eriophorum-Carex* interstices within an extensive moss mat and water could be found within some depressions throughout the summer. The lichens and forbs were restricted to the dry tussocks.

V Moss plateau (13.0 %)

The moss plateau type was restricted to the plateau and supported a rich flora over an extensive moss mat. It was broken only by occasional rock outcrops, polar desert and streams. Soils were highly saturated in the spring and subject to moderate congeliturbation but became firm as the summer progressed. Among the most common vascular plants were *Arctagrostis latifolia, Salix arctica* and *Oxyria digyna.*

VI Clay-moss slope (23.5 %)

The clay-moss slope was the most common vegetation type on the coastal lowlands, often found on gradual to moderate slopes away from the barren ridges. The slope affords greater shelter for vascular plants creating a gradual cline in vegetation from the exposed ridge to the protected lower slope. Soils were unstable, becoming highly saturated in the spring and subject to erosion and slumping. In plant species composition the moss-willow slope is similar to the moss plateau type.

VII Hydric-meadow (4.9 %)

The hydric meadow type was not extensive at Bailey Point, but was scattered throughout the study area, especially along the narrow belt below the plateau that was kept moist throughout the summer by runoff from the highlands. The hydric meadow type was also common near pond and stream edges and below areas of late snow cover.

Eriophorum Scheuchzeri and *Carex stans* were most important monocots, while forbs were poorly represented and lichens absent. A moss mat comprised over one-half the ground cover. Hydric-meadow was most often found interspersed with the mesic-meadow and dry tundra types.

Annual Productivity

The annual production of plant groups for vegetation types at Mokka Fiord and Bailey Point is shown in Table 4. There were only two similar types in both study areas: the polar desert and the mesic-meadow. The hydric-meadow was very limited in distribution at Mokka Fiord and was not sampled. The intermediate types showed great variation between study areas.

Those data show that although Mokka Fiord supports an overall lower annual production of vascular plants, the production of willow is higher than at Bailey Point. Willow comprises only 15.3 per cent of the annual production at Bailey Point but 59.7 per cent of the annual production at Mokka Fiord.

	Annual production (g/m²)				
Vegetation type	Sedge	Grass	Willow	Forb	Total
Mokka Fiord					
Polar desert		0.01	0.76		0.78
Dryas-Salix raised tundra	0.89	0.54	4.72	1.48	7.64
Dryas-Salix-moss hummocky tundra	0.25	3.32	7.47	1.31	12.36
Mesic-meadow	7.81	1.19	6.43	1.23	16.68
Salix-moss slope			8.57	0.79	9.36
Bailey Point					
Polar desert	3.10	1.60	1.59	6.00	12.30
Clay barrens	0.02		9.51	0.60	10.14
Dry tundra	5.30	8.23	2.30	3.29	19.12
Moss-clay plateau	1.82	4.70	2.32	2.93	11.77
Clay-moss slope		0.04	2.16	4.10	6.32
Mesic-meadow	20.82	2.22	4.44	1.05	28.59
Hydric-meadow	50.32	5.79		1.36	57.54

Tab. 4: The measured above-ground annual production of vascular plants in the recognized vegetation types at Mokka Fiord, Axel Heiberg Island and Bailey Point, Melville Island, sampled in 1973 (August 1—9) and 1974 (August 6—16) respectively.

Tab. 4: Die gemessene oberirdische jährliche Produktion an Gefäßpflanzen in den Vegetationstypen im Mokka Fjord, Axel Heiberg Island, und Bailey Point, Melville Islang, gesammelt 1973 (1.—9. August) bzw. 1974 (6.—16. August).

Habitat Utilization

Table 5 gives the per cent occurrences of feeding muskoxen in the recognized vegetation types in the Mokka Fiord study area. Chi-square homogeneity tests were performed for each study period. Those tests showed muskoxen did not assort themselves randomly over the study area but were found disproportionately in the various vegetation types. The nature of that pattern changed with time. The mesic-meadow and raised tundra became more heavily utilized with time while the importance of the polar desert declined. Those trends were investigated by sub-dividing the time periods and applying the Spearman rank correlation test; all were found significant at the 0.02 level at least. Utilization of the moss-hummocky tundra and willow-moss mat types was low, particularly the former which appeared to have been actively avoided; no test for change in importance was attempted because of the small numbers.

At Bailey Point muskoxen and caribou distribution patterns were tested for vegetation type selectivity.

As at Mokka Fiord in 1973, muskoxen at Bailey Point were not found at random among the seven recognized vegetation types (Table 6, Figure 2). Muskoxen selected for the polar desert type in early July but avoided it in late July and August. The dry tundra

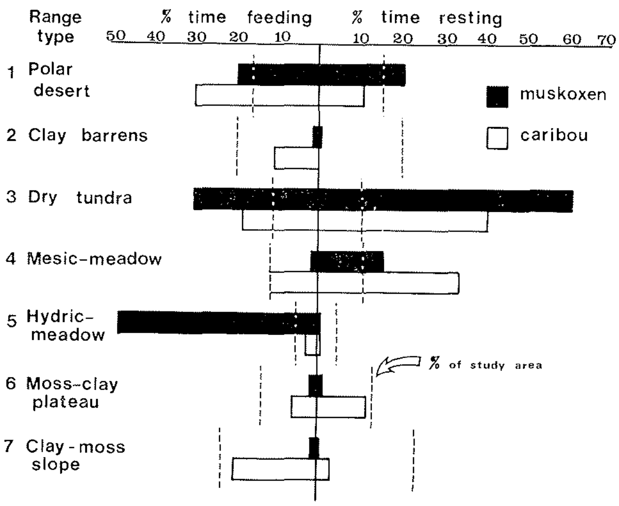

Fig. 2: The summer use of vegetation types by muskoxen and caribou at Bailey Point, Melville Island.

Abb. 2: Sommerliche Nutzung der Vegetationstypen durch Moschusochsen und Karibus bei Bailey Point, Melville Island.

type was selected for throughout July and the mesic-meadow, clay barrens and moss-clay plateau were selected against throughout the study period. Muskoxen avoided the clay-moss slope type in July but selected for that type in August. The trend in vegetation type use with time was again tested by the Spearman rank correlation test. The trends of avoiding the polar desert, and selecting for the clay-moss slope through the study period were both significant ($p < 0.05$).

Although caribou showed a preference in range type use throughout July ($x^2 = 25.2$; $p < 0.001$), this selectivity was not as pronounced as with muskoxen.

Study period	Number of observations	Percentage observations in vegetation type *					x^2
		1	2	3	4	5	
1	430	77.1	13.3	1.6	4.7	3.3	39.2 **
2	1285	60.7	31.8	1.0	3.6	2.9	224.6 **
3	946	42.2	30.3	2.2	5.8	19.5	313.5 **
4	138	15.9	46.4	0.0	0.0	37.7	234.7 ***
5	70	0.0	42.9	0.0	0.0	57.1	—
Type representation in study area		67.4	13.6	12.4	4.4	2.2	

* 1 = polar desert; 2 = raised tundra; 3 = moss-hummocky tundra; 4 = willow-moss mat; 5 = mesic-meadow.
** $p < 0.001$
*** Results of study periods 4 and 5 combined for homogeneity test

Tab. 5: The percentage of muskox feeding observations per vegetation type at Mokka Fiord.

Tab. 5: Verteilung der Beobachtungen von Moschusochsen bei der Nahrungsaufnahme an den verschiedenen Vegetationstypen im Mokka Fjord (in %).

Study period	Number of observations	Percentage observations in vegetation type *							x^2
		1	2	3	4	5	6	7	
Muskoxen									
2	1490	21.2	1.4	16.3	0.0	60.8	0.0	0.0	707.2 **
3	2579	21.7	0.5	39.3	2.4	34.3	1.3	0.2	308.9 **
4	1561	12.6	0.1	27.2	1.0	55.3	3.0	0.4	601.3 **
5	1321	2.7	2.8	30.1	4.1	49.1	0.6	10.3	479.4 **
6	431	0.0	3.0	4.1	0.0	7.6	0.0	85.1	221.5 **
Caribou									
2—4	673	29.8	10.8	17.6	12.0	3.2	6.3	19.9	25.2 **
Type representation in study area		15.5	19.7	11.2	11.6	4.9	13.0	23.5	

* 1 = polar desert; 2 = clay barrens; 3 = dry tundra; 4 = mesic-meadow; 5 = hydric-meadow; 6 = moss-clay plateau; 7 = clay-moss slope.
** $p < 0.001$

Tab. 6: The percentage of muskox and caribou feeding observations in vegetation types at Bailey Point, Melville Island, summer, 1974.

Tab. 6: Verteilung der Beobachtungen von Moschusochsen und Karibus bei der Nahrungsaufnahme an den verschiedenen Vegetationstypen bei Bailey Point, Melville Island, im Sommer 1974 (in %).

DISCUSSION

The population structure, daily activity cycles, movement patterns, and habitat selectivity for muskoxen at Mokka Fiord and Bailey Point were remarkably consistent. Densities of muskoxen in the two areas are among the highest in the Canadian Arctic; the sex and age composition and behaviour of populations of lower densities may well display considerable variation.

We must conclude that such high densities are a result of more favourable environmental conditions than found over most of the High Arctic. The mean annual snowfall at Eureka is only 37.5 cm, much less than the 68.0 cm for Resolute Bay. The weather at Resolute Bay is representative of regions in the Central High Arctic affected by storms tracking along the Lancaster Sound and influenced by the open waters in the summer which stimulate local cloud formation and precipitation. Bailey Point, at the western extremity of the open waters in the summer and slightly north of the normal path of most storms, also receives less annual snowfall than the more easterly stations (Mould Bay — 50 cm).

A serious decline in muskox and caribou populations on parts of the Canadian High Arctic in the winter of 1973—74 (Miller and Russell 1975; Parker *et al.* 1975) suggests that weather may be the dominant factor controlling densities of ungulates in the far north. Record snowfall was recorded that winter at Resolute Bay. Two areas which were not affected by the overwinter decline were Bailey Point and Mokka Fiord. Both areas received much less total snowfall than Resolute Bay.

Calf production in both study areas was normal. Although monthly calf counts varied, we believe the average percentage of calves over the summer in both areas was 12 to 15 per cent. Yearlings were not common in either area, suggesting a high overwinter loss of calves. Miller *et al.* (1973) found 13 per cent of muskoxen seen during aerial surveys of Melville Island in March to April, 1972, were short-yearlings while in August new calves accounted for 11 per cent of total animals counted. The winter of 1971—72 must have been exceptionally favourable for the survival of calves. In summer, 1973, the proportion of calves on parts of Banks Island was 24.3 per cent (Wilkinson *et al.* 1976).

The production and survival of muskox calves in the High Arctic is apparently highly dependent upon favourable climatic conditions. A harsh winter may not only deplete the short-yearling cohort but reduce the production and survival of new calves and influence the success of the next breeding season.

Mean herd size for both areas was seven to eight, slightly higher than the four to seven for summer herd size on Bathurst Island (Gray 1973). It is reasonable to assume that herd size is proportionate to density; the population on the Bathurst Island study area was lower than at Mokka Fiord or Bailey Point.

Muskoxen at both study areas spent more time feeding than resting. Whereas muskoxen on Bathurst Island rested and fed at intervals of approximately 150 minutes each, at Mokka Fiord resting and feeding times averaged 91 and 136 minutes, and at Bailey Point 75 and 98 minutes. Although resting and feeding times were shorter at Bailey Point than at Mokka Fiord, the ratios of the two for both areas were quite similar.

Summer studies on Banks Island found muskoxen to rest longer than they fed (102 minutes vs. 86 minutes) (Wilkinson *et al.* 1976). The daily rhythm of muskoxen alternately resting and feeding during the summer period is consistent for all parts of its range.

The variation in resting and feeding times between Mokka Fiord and Bailey Point may be explained by differences in vegetation types and plant productivity. Muskoxen at both study areas utilized the raised vegetation types in early summer prior to the emergence of sedges in the low-lying meadows. The elevated sites were the first to produce new green growth of willow, grasses, and forbs. By early July muskoxen were seeking out the meadows which were then supporting new growth of sedges. Sedge-producing meadows, however, were more common and far more productive at Bailey Point than at Mokka Fiord.

Muskoxen at Mokka Fiord used more time and travelled greater distances to secure their required forage than animals at Bailey Point. Both observations relate to the paucity of highly productive sedge-producing hydric-meadows at Mokka Fiord relative to Bailey Point.

The ability of muskoxen to regain expended fat reserves and maintain normal reproductive levels following a harsh winter is probably a function of the availability of sedge-producing meadows during the summer period. The scarcity or absence of muskoxen on many of the islands in the High Arctic may well be related to the abundance and distribution of sedge-producing meadows.

Caribou at Bailey Point were much more mobile than muskoxen. That is consistent with summer studies on Banks Island (Wilkinson *et al.* 1976). Although moving over greater distances than muskoxen, caribou rested more than they travelled or fed. Times of resting and feeding, however, were shorter than for muskoxen. Based upon distance travelled per hour of activity, caribou were three times more mobile than muskoxen. Most movement by caribou was linear in contrast to the local movement by muskoxen within areas of feeding; caribou were seldom in the study area for more than one day. Muskoxen occasionally displayed a trekking behaviour. In contrast to the characteristic local movement displayed by most herds, the occasional group would suddenly move off at a rapid pace and leave the study area. Although such behaviour often occurred following disturbance, it could not be predicted and often occurred for no obvious reason. The group usually travelled in single file and was most often led by an adult male. Young calves occasionally experienced difficulty in keeping up to the main group.

Muskoxen and caribou displayed selectivity for feeding and resting areas. Selectivity was not as pronounced for caribou as for muskoxen. The most striking contrast in summer habitat use by both species was the preference by muskoxen for the meadow type and the virtual avoidance of that type by caribou. That contrast in summer habitat use by muskoxen and caribou virtually eliminated potential interspecific competition for food. Our observations show caribou to use all vegetation types in much the same proportion to their occurrence in the study area.

Caribou showed a preference for the flowers of certain vascular plants, especially *Saxifraga oppositifolia*, *Pedicularis* spp., and *Papaver radicatum*. Caribou were often seen feeding exclusively on the flowers of *Saxifraga oppositifolia* for periods of 30 to 40 minutes. Flowers provide a readily available source of high caloric food in the early summer. Field observations proved willow to be the plant most sought after by caribou throughout the summer in both study areas.

Caribou and muskoxen were occasionally found together on the same vegetation type. Prolonged observation showed, however, that direct competition for food did not occur. Caribou most often moved through an area occupied by muskoxen and feeding consisted of occasional bites of willow or flowers. Muskoxen were invariably feeding on the sedges and grasses.

CONCLUSIONS

Muskoxen and caribou living in the far north are adapted to surviving in an environment where resistance to their survival approaches maximum tolerable levels. On the islands of the Arctic Archipelago climatic conditions often dictate calf production, survival and population levels. Early winter ice storms, heavy snowfalls, and late thaws occur sufficiently frequent to maintain most populations at low densities.

Productivity of most habitat types in the High Arctic is extremely low, relative to more southerly regions. Most of the land mass falls within one of three broad physiographic types: (1) upland polar desert; (2) lowland meadows; and, (3) intermediate mesic tundra.

We believe the ability of an area to support muskoxen is dependent upon the abundance of lowland meadows. That type provides the sedges and grasses required for winter and summer forage. Caribou show no preference for the meadow type but rather use the lichens, grasses, sedges, and forbs of the polar desert and mesic tundra types. The low productivity of those types is offset by the high mobility of caribou. Muskoxen have evolved to obtain their forage requirements through deep snows and heavy crusts. Once a meadow with optimum snow conditions is found, muskoxen may remain within a few acres for several weeks or longer. Caribou favour upland sites in winter due to a lighter covering of snow and easier access to forage.

Competition between muskoxen and caribou for food and space is minimal. Not only are the food and habitat preferences different for both species, but there are also behavioural differences which decrease interspecific conflict.

We believe the highly productive meadows at Bailey Point and Mokka Fiord are responsible for permitting muskoxen to reach the high densities they have in those areas. Observations at Mokka Fiord in late winter suggest meadows are also important to muskoxen at that season. Human disturbance in such areas which may prevent muskoxen from using the meadows or which change the habitat itself may well cause severe declines in those populations. Caribou are more mobile and less dependent on specific habitat types. We believe those characteristics contribute to a greater level of tolerance to human disturbance by caribou.

We strongly recommend that prior to human disturbance in any area of the High

Arctic inventories be conducted of the fauna and flora and areas considered critical to the welfare of any species be identified and protected.

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