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Dynamics of muskox groups in northeastern Alaska

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Abstract: Group size and stability was studied in a population of re-established muskoxen (*Ovibos moschatus*) in northeastern Alaska by re-locating radio-collared animals. Mixed-sex groups (cows, calves, sub-adults and often adult bulls) ranged in size from 2-118 with a mean of 19.2. Almost 60 % of all mixed-sex groups contained 5-19 individuals. Solitary cows were seen infrequently. Adult bulls were observed in mixed-sex groups, in bull groups or alone. Bull groups averaged 3.9 and ranged in size from 2 to 12. Thirty percent of all adult bulls seen outside mixed-sex groups were solitary animals. Mixed-sex groups were significantly smaller in summer/rut (July-September) than in midwinter (January-March), spring/calving (April-June) and early winter (October-November). Mean group size was 12.2 in August compared with 23.6 in February. In August, during the rut, numbers of small groups (2-14) increased, while numbers of medium-sized (15-29) and large groups (>29) decreased. Bull groups were significantly larger in spring/calving than during other seasons. The ratio of single bulls to bull groups was less than 0.30 in winter, increased in June, and reached a maximum during the rut in August when more than 2 single bulls were seen for every bull group. Group size and individuals within a group changed frequently. This fluid social system provides a balance between protection from predators, efficient food acquisition and the formation of harems during the rut.

Key words: muskoxen, group size

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Introduction

Muskoxen (*Ovibos moschatus*) usually occur in mixed-sex groups, but bulls may live in bull groups or alone (Tener, 1965; Jingfors, 1980; Gunn, 1982; Gray, 1987; Oakes, 1989; Smith, 1989). Seasonal changes in group size and stability of muskox groups has implications for management of populations and contributes to an understanding of ecological influences on social behavior.

The objective of this study was to describe seasonal changes in muskox groups observed in a re-established population in northeastern Alaska.

Methods

The study area was located in northeastern Alaska on the coastal plain of the Arctic National Wildlife Refuge (ANWR) between the Arctic Ocean (Beaufort Sea) and the Brooks Range mountains. Vegetation in the study area is arctic tundra. Willows, forbs and grasses grow along the partially vegetated gravel bars of north-flowing rivers, tussock-shrub, low shrub and shrub-heath communities are found on the slopes of adjacent rolling hills and sedge-moss communities dominate flaat poorly-drained areas (Bliss, 1981).

Muskoxen were re-established in the study

Table 1. Characteristics of muskox social units in northeastern Alaska, 1982–1991.

Social unit	N	Group size				
		%	Mean	STD	Min.	Max.
Single cow	13	0.008	1.0	1.0	1	1
Mixed-sex group	1211	0.758	19.2	13.6	2	118
Single bull	113	0.071	1.0	1.0	1	1
Bull group	261	0.163	3.9	2.1	2	12

area in 1969–70 and by 1990, the population was estimated to be about 500 animals (Reynolds, 1991). Between 1982–1991, 78 individual muskoxen were captured and radio-collared. Animals were estimated to be 2 years, 3 years, young adult (4 - 6 years) or old adult (>6 years) based on horn characteristics (Olesen, 1989) and tooth eruption and wear.

I identified 4 muskox social units: mixed-sex groups, comprised of adult cows, calves, juveniles, and often adult bulls, bull groups containing 2 or more adult bulls, solitary cows, and solitary bulls. Four seasons were defined: midwinter (January–March) included the darkest, coldest months of the year when food availability was limited and muskoxen moved very little; spring/calving (April–June) spanned the calving period which began in late April and peaked in mid May; summer/rut (July - September) encompassed the breeding season in August; and early winter (October - November) included that period after the ground was snow-covered and muskoxen were present in wintering areas.

Group size, type of social unit, and the presence of marked animals within a group were recorded during radio-relocation surveys flown at monthly to bi-monthly intervals. Five to eleven surveys were flown each year from 1982–1991, during all months except December. Surveys in late March, late June, and late October included flights along drainages not commonly used by muskoxen to search for unmarked animals. Mean group sizes, calculated from all observations of bull groups or mixed-sex groups seen during a radio-tracking survey, were compared by month and by season (GLM procedure and Tukey's Studentized Range Test, SAS Institute, Inc. Cary, NC, USA). Frequencies of observations of different bull and mixed-sex group sizes and ratios of solitary bulls to bull groups were compared by month and by season (FREQ procedure, Cochran - Mantel - Haenszel test, SAS Institute, Inc. Cary, NC, USA). Movement of individuals between groups was determined from observations of 25 marked cows and 4 marked bulls which were followed for at least two years between 1987 and 1990.

Results

In northeastern Alaska, muskox cows were seldom seen alone. Less than 1 % (13 of 1598) of observations of muskoxen during ratio-relocation surveys were of solitary cows (Table 1). Most solitary cows observed were old animals which were alone during calving or summer and later rejoined mixed-sex groups or died. Mean size of mixed-sex groups was 19.2 (n=1221) and ranged from 2–118 animals (Table 1). Almost 60 % of all mixed-sex groups contained between 5 and 19 muskoxen (Fig. 1). Very small and very large groups were infre-

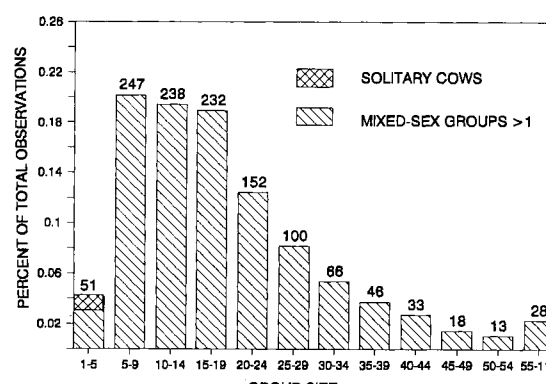


Fig. 1. Size distribution of mixed-sex groups of muskoxen, northeastern Alaska, 1982–1991.

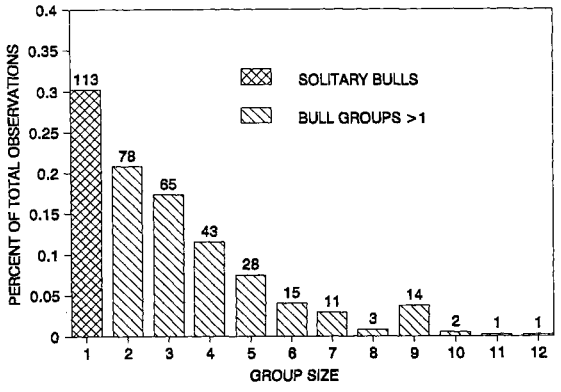


Fig. 2. Size distribution of bull groups of muskoxen, northeastern Alaska, 1982–1991.

quently seen. Only 4 % of mixed-sex groups had fewer than 5 members or were larger than 44 animals (Fig. 1).

Adult bull muskoxen (>3 years) occurred in mixed-sex groups, bull groups, or as solitary animals. Bull groups, ranged in size from 2 to 12 animals, with a mean of 3.9 (Table 1). Solitary bulls comprised 30 % (113 of 374) of observations of bulls and bull groups. Over 70 % of all bull groups contained 2–4 individuals (Fig. 2).

Both bull groups and mixed-sex groups showed seasonal differences in group size. Mixed-sex groups were smaller in summer/rut than during other seasons (Tukey's Studentized Range Test, df = 1207, $P<0.05$). This was due to a significant decrease ($P<0.05$) in group size in August, during the rut, when mixed-sex groups averaged 12.2 compared to 23.6 in February (Table 2). The largest groups were seen in mid winter and spring/calving. Groups over 100 were seen in February, March and April, but in August, maximum group size was 33 (Table 2).

Relative numbers of small (2–14), medium-sized (15–29) and large (>29) mixed-sex groups also changed seasonally (Cochran - Mantel - Haenszel statistic, df = 2, $P<0.001$). During the rut in August, numbers of small groups reached a yearly maximum, while numbers of medium-sized groups and large groups were at minimum levels (Fig. 3).

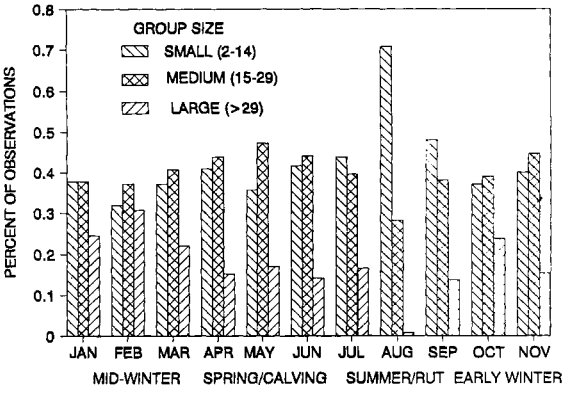


Fig. 3. Seasonal changes in relative numbers of small (2–14), medium (15–29), and large (>29) mixed-sex groups of muskoxen, northeastern Alaska, 1982–1991.

Table 2. Seasonal change in the average size of mixed-sex groups of muskoxen in northeastern Alaska, 1982–1991.

Month	N	Mean	STD	Minimum	Maximum
Jan	53	22.6	15.6	5	85
Feb	78	23.6	16.1	5	105
Mar	172	21.4	16.3	2	109
Apr	66	21.1	19.9	2	118
May	112	20.7	12.5	2	70
Jun	163	18.0	10.6	2	68
Jul	139	18.0	10.6	3	61
Aug	127	12.2**	6.5	3	33
Sep	131	17.3	11.8	3	80
Oct	105	21.5	13.0	2	63
Nov	65	20.6	14.6	3	80

** Significantly smaller than all other months, except Sept, Tukey's Studentized Range Test, df = 1200, $P<0.05$.

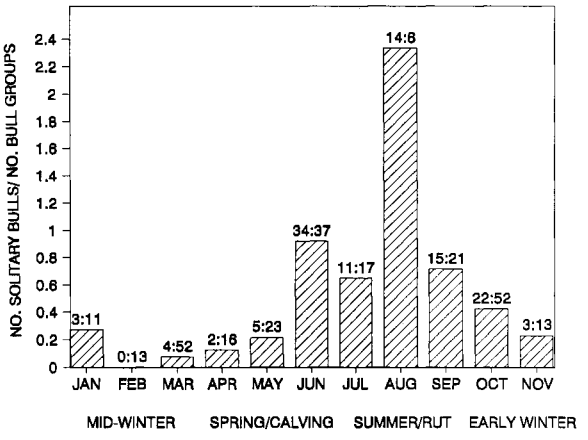


Fig. 4. Seasonal changes in numbers of solitary muskox bulls relative to bull groups, northeastern Alaska, 1982–1991.

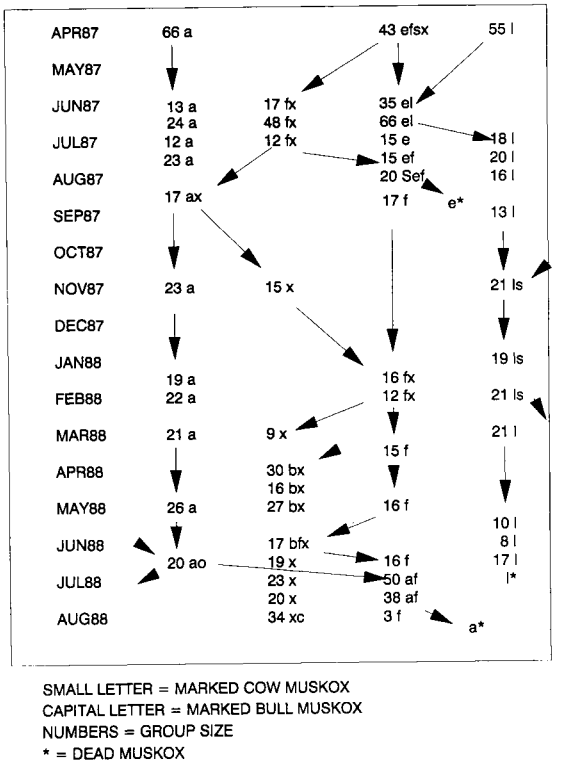


Fig. 5. An example of changes in size and group identity of groups containing marked cow muskoxen, northeastern Alaska, 1987–1990.

Bull groups were significantly larger in spring/calving than during other seasons (Tukey's Studentized Range Test, df = 257, $P<0.05$). Significant differences occurred in February and March (Table 3). During the rut, the maximum size of bull groups was 3 in August, compared with 6 in February and 12 in November. Few solitary bulls were seen between November and May, but numbers increased in June and again in August during the rut, when single bulls outnumbered bull groups by 2.3 to 1 (Fig. 4).

Muskox groups were not stable units. Group size and individual animals within mixed-sex groups changed frequently (Fig. 5). Changes in both group identity (based on the presence of marked muskoxen) and group size occurred in 41 and 88 %, respectively, of all consecutive ob-

Table 3. Seasonal change in the average size of muskox bull groups in northeastern Alaska, 1982–1991.

Month	N	Mean	STD	Minimum	Maximum
Jan	11	4.2	2.0	2	9
Feb	13	6.1*	2.9	2	11
Mar	52	5.1**	2.4	2	10
Apr	16	5.0	1.9	2	9
May	23	3.2	1.1	2	5
Jun	37	2.7	0.8	2	4
Jul	17	2.9	1.1	2	7
Aug	6	2.5	0.5	2	3
Sep	21	3.4	1.7	2	9
Oct	52	3.7	2.0	2	12
Nov	13	4.0	1.2	2	6

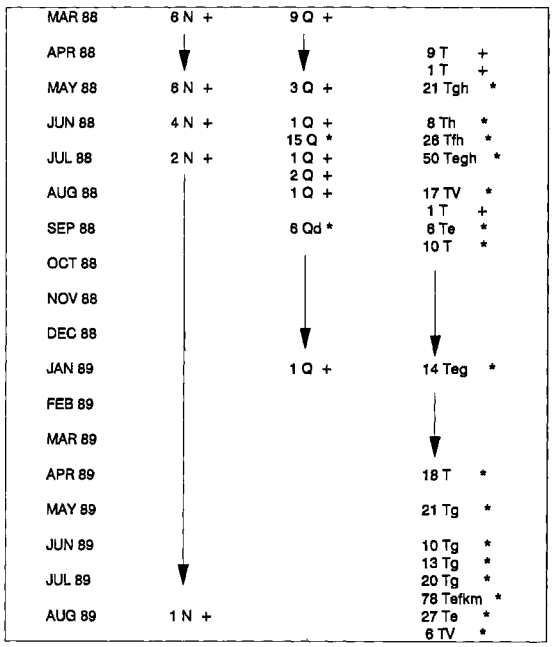
* Significantly larger than May-Oct.
** Significantly larger than May-July, Sept-Oct. Tukey's Studentizied Range Test, df = 250, $P<0.05$.

Table 4. Changes in size of muskox groups associated with collared cows and bulls in the Arctic National Wildlife Refuge, Alaska, 1987–1990, based on consecutive observations.

	Changes in group identity (marked animals in a group)		Changes in group size		
	N	%	N	%	Mean change
Cows	255	41	534	88	10.6
Bulls	24	34	58	82	9.2

servations of 25 radio-collared cows (Table 4). Most changes in group size were small: 36 % were changes of 1–5 animals, and 25 % were changes of 6–15 animals. Eleven percent of all consecutive observations of mixed-sex groups showed no change in group size.

Groups with which marked bulls were associated changed in size and group identity. Some old bulls (see N, Fig. 6) were never seen with mixed-sex groups, but associated only with other bulls or were alone. Other bulls (see Q, Fig. 6) were seen with bull groups in winter and occasionally with mixed-sex groups during summer/rut. At least one young mature male (see T, Fig. 6) wintered in a bull group and was associated with a number of different mixed-sex groups during the following summer and winter. Changes in group size occurred in 82 % of all consecutive observations of marked bulls (Table 4).



CAPITAL LETTER = MARKED BULL MUSKOX
SMALL LETTER = MARKED COW MUSKOX
NUMBERS = GROUP SIZE
+ = SOLITARY BULL OR BULL GROUP
* = MIXED-SEX GROUP

Fig. 6. An example of changes in size and group identity of groups containing marked bull muskoxen, northeastern Alaska, 1987–1990.

Discussion

Muskox group defense behavior is an effective deterrent to predators (Tener 1965, Gray 1987); this and other social behavior in muskoxen is likely to have evolved in response to predation. Larger groups may provide more protection from predation, resulting in higher fitness for group-living individuals. Heard (1992) found a strong relationship between wolf densities (*Canis lupus*) and muskox group size. Most (>90 %) of mixed-sex groups in this study contained between 5 and 44 individuals. Group sizes reported from other areas (Miller, 1977 *in* Gunn, 1982; Gray, 1987, Oakes, 1989, Yakushkin 1989, Heard 1992) fall within these bounds (winter = 12–30, summer = 5–12) suggesting that a range of optimum group size exists in this species.

Very large groups (45–118) which were seen occasionally during this study, and reported in other areas (Gray 1987, Heard 1992), may be aggregations of large mixed-sex groups which soon fracture into smaller units. Observations of groups joining and splitting (this study, Gray, 1987) as well as frequent changes in numbers of animals associated with groups containing marked individuals emphasizes the open nature of muskox mixed-sex groups. The infrequent occurrence of mixed-sex groups containing fewer than 5 animals suggests that very small mixed-sex groups provide little protection from predators.

Group size reflects a balance between costs and benefits of acquiring food and avoiding predation (Wilson 1975, Clark and Mangel 1986, Turner and Piteher 1986). Seasonal shifts in group size may be related to changes in predation pressure, food availability, or breeding behavior. Heard (1992) argued that a lower risk of wolf predation may account for smaller group sizes in summer. But in northeastern Alaska, predation risks are higher in summer than winter. In the study area, brown bears (*Ursus arctos*) kill more muskoxen than wolves (Reynolds *et al.* in prep) and are present only between late April and October. Wolves usually winter outside the study area and occur on the coastal plain after the arrival of caribou in June.

In summer, muskoxen maximize food intake and weight gain to replace winter losses (White *et al.* 1989). Smaller group size in August may allow more efficient use of forage during a time when habitat productivity is declining and patchiness of resources is increasing (White *et al.* 1981). However, under these conditions, small groups would be expected to persist into September. This study showed that the average size of mixed-sex and bull groups were larger and that relative numbers of small mixed-sex groups were fewer in September than August.

In this study, the most significant changes in group size occurred in August during the rut. The decrease in the mean size of mixed-sex groups and the increase in numbers of solitary bulls and small-sized mixed-sex groups in August indicates these changes are related to the formation of harems during the rut (Smith 1976). Young (3–4 years) and subordinate males may leave mixed-sex groups during this time, possibly in response to the presence of a dominant male. Also groups may fracture into smaller units as dominant males attempt to acquire females. Gray (1987) observed muskox fighting on Bathurst Island from May until September with most fights occurring in August.

Heard (1992) argued against courtship behavior as a possible cause of seasonal changes in muskox groups size, citing changes which occurred in the absence of breeding behavior (Gray 1987), and the early summer timing of group-size changes. But the magnitude of seasonal change in typical group size (7.6 in winter, 5.9 in summer, Heard 1982) during the reproductive failure reported by Gray (1987) appears to be less than that calculated for the same area in other years (winter = 18.3, summer = 10.0) (Heard 1992, Table 1). In ANWR, the largest changes in the size of both mixed-sex and bull groups occurred during the rut in August, rather than in June.

Food availability may also influence group size in winter and spring/calving. During these times, habitat patchiness is increased because of snow cover. Distribution of muskoxen groups may be restricted by habitat, and large groups may be forced to aggregate in limited areas. Also, large groups may forage more efficiently where vegetation is covered by snow, because of cooperative cratering (Heard 1992).

Muskox cows remain in social groups yearround as the benefits of group protection from predators and group feeding in winter outweighs the costs of competition for resources. These mixed-sex groups are flexible units which can aggregate or split into smaller units depending on local conditions. Muskox bulls have two different social strategies. Associating with mixed-sex or bull groups provides protection from predators during most of the year. But prior to and during the rut, bulls maximize their breeding opportunities by being aggressive toward other males and travelling between mixed-sex groups as solitary animals. For males, the opportunity for successful acquisition of females during the breeding season offsets the risks of increased predation.

The nature of muskox group dynamics reflects a fluid social system in which benefits of small or large group size may shift seasonally. Small groups can use resources efficiently, and can be defended by dominant males during the breeding season, and larger groups are more effective against predator attacks and efficiently utilize vegetation covered by snow.

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