BEHAVIOR AND CALF SURVIVAL IN ALASKAN MOOSE

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BEHAVIOR AND CALF SURVIVAL IN ALASKAN MOOSE

A

THESIS

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By

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NATURAL PROPOSITIONS
or
To hairy cows, the hairy bull
Is handsomer than horrible.

Bull moose are beastly and contrary.
Ornery, horned, humped-up, and hairy.
It seems hard to imagine how
A bull moose could attract a cow.
But every spring the mooselets come
To prove he must attract her some.
Perhaps because, though hornless, she
Is just as downright ornery
At times, and as humped-up as he.
She's just as hairy, certainly.

Whatever it is that makes him seem
The answer to a girl-moose dream,
He's all the answer Mrs. Moose gets.
And every spring -- here come the mooselets.

It seems just as mysterious
To ask what makes him serious
About her. But we must allow
Ladies their secrets. Anyhow,
There are the mooselets every spring.
Proving -- if they prove anything --
It must be true what Noah knew
About the animals two by two.

However beastly and contrary,
Ornery, horned, humped-up and hairy
Moose (bull or cow) may seem to be
To such non-moose as you and me,
Clearly, whatever first made moose meant
To provide them some inducement
To shun mere sentimental looseness
And yearn for one another's mooseness.

Else mooselets would be far and few.
And so should I. And so would you.

---John Ciardi
Saturday Review

ABSTRACT

Behavior and calf survival were studied in a population of moose (Alces alces gigas Miller) near Palmer, Alaska, from May through November, 1965. The study utilized ground and aerial observations and counts, and was aided by the tagging of 59 calves to allow their recognition as individuals. Calf mortality during the first two weeks after parturition was between 22% and 26%. Mortality during the first five months was at least 55% of the initial calf crop. Mortality of twin calves was significantly higher than that of single calves. Drowning, entrapment by vegetation, abandonment, injury inflicted by the dam, and predation by brown bears were observed and suspected causes of mortality of calves.

A majority of moose in all age-sex classes were seen most often in bog-meadow, black spruce habitat. Group size increased from the May-August period to October 31, with the greatest tendency toward aggregation occurring in bulls and in cows unaccompanied by calves. Females with calves remained predominantly unassociated with other moose throughout the period of the study. Moose migrated from valley lowlands to higher ground beginning in mid-July, with greatest numbers observed in alpine habitat in October and November. Extent of movements of cows with calves was significantly less than that of all cows. Summer post partum home range was probably little more than 1 km^2 for most cows leading calves. All moose feeding on aquatic vegetation, when considered as a group, exhibited one activity peak per day. This peak occurred shortly after dawn. Cows with calves displayed three

major peaks of activity daily. Bulls fed uninterruptedly for the longest periods. Length of feeding periods decreased progressively in cows with calves, cows without calves, calves, and yearlings. Females leading calves behaved most shyly when confronted with human beings. Some calves participated in alert toward disturbance. Moose reacted strongly to brown bears, but seldom reacted to black bears when they were in close proximity. Aggressive interactions between females leading calves and other moose and among calves were observed. Effective concealment of calves by calf behavior and by maternal "ignoring" of the calf was observed. Nursing was initiated mutually by dam and calf. Two cases of maternal confusion of possession of calves were observed.

ACKNOWLEDGMENTS

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STUDY AREA

The study was conducted near the Jim-Swan Lakes on an area of approximately 60 km^2 located on the outwash plain of the Knik Glacier, 14.5 km south of Palmer, Alaska (Figure 1). The area is bounded on the east by Friday Creek, on the south by the Knik River, on the north by mountains rising precipitously to 1,830 m, and on the west by a 2.4 km wide strip of deciduous timber, partially cleared, that separates it from the old Anchorage-Palmer highway.

Topography and Flora:

The area is relatively flat, except for a ridge approximately 30 m high adjacent to the Knik River and hills and cliffs at the foot of the mountains in the northern part of the area. The major portion of the area, comprising about 36 km^2, is wet habitat (Figure 2). This portion contains many small streams, shallow lakes of seasonally varying surface areas, and open marshy meadows. Dwarf birch (*Betula nana*), sedges and scouring rush (*Equisetum* spp.) are the dominant plants in the meadows. The streams are bordered by bands of dense alder (*Alnus crispa*) and occasional black spruce (*Picea mariana*) extending 15-30 m from their banks. The entire habitat type is dotted with "fingers" or islands of black spruce, characteristically better drained than the surrounding meadows. The lakes produce large quantities of pondweed (*Potamageton* spp.).

The east end of the valley is flat and dry, forming a small flood plain for Friday Creek. The two vegetation types on this plain are

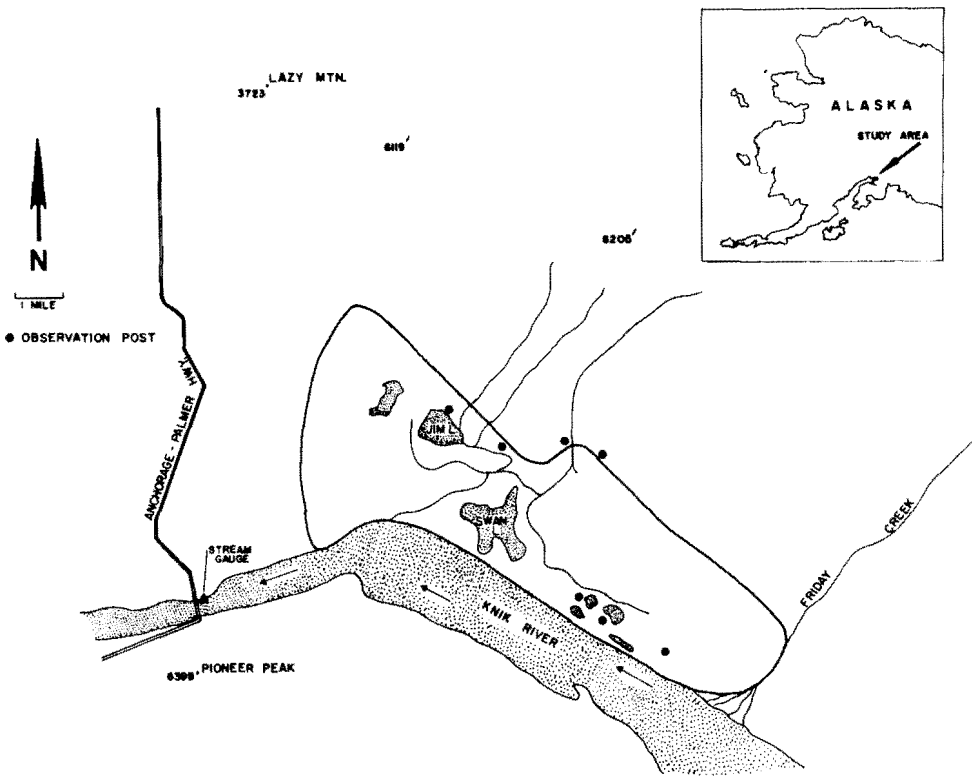

Figure 1. Map of the Jim-Swan Lakes study area, showing observation points.

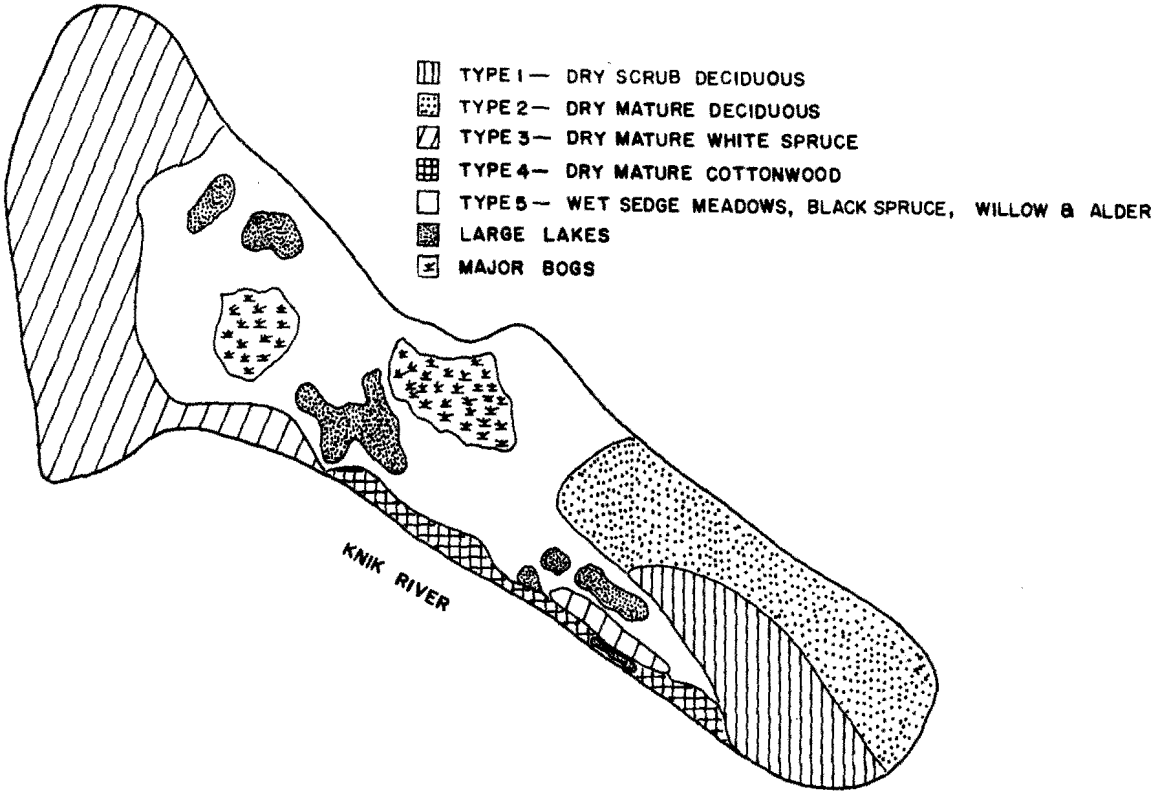

Figure 2. Map showing habitat types within the Jim-Swan Lakes area.

immature and scrub deciduous (birch and alder) stands, and mature deciduous stands of birch (Betula papyrifera) and aspen (Populus tremuloides). The ridge which lies .4 km from the Knik River is a dry, mature white spruce (Picea glauca) and birch habitat, with open sandy areas characteristically covered by rose (Rosa acicularis).

The habitat at the west end of the area is characterized by white spruce and cottonwood (Populus tricocarpa) with an understory composed primarily of devil's club (Oplopanax horridus).

A final, small area bordering the Knik River is predominantly cottonwood disturbed by logging, with an open understory of rose and fireweed (Epilobium spp.).

Annual Flooding:

During July or August of most years, the Knik River rises rapidly and remains high for a short time due to the natural emptying of glacier-dammed Lake George, approximately 13 km upstream from Friday Creek. Maximum height of the river, as recorded by gauges at the Glenn Highway bridge, discharges, and dates of occurrence of flooding during the past six years are shown in Table 1. A gauge height of 40.2 feet above sea level or a discharge of greater than 30,000 cfs was taken as the minimum condition affecting the valley. These figures were derived by comparing observations made during July, 1965, with the hydrographic data available for the same period.

The extent of maximum flooding, as it occurred on July 12, 1965, the day after maximum discharge, is illustrated in Figure 3. By July 20, water had receded from the area almost completely, leaving only extensive

Table 1. Summer flooding by the Knik River.

Year	Approximate % of Area Under 0.3 m Or More of Water	Date of Maximum Discharge*	Maximum Gauge Height (Mean Sea Level)*	Maximum Discharge (cfs)*	Dates (Inclusive) of Gauge Height Over 40 Ft or Discharge Over 30,000 cfs*
1965	.60	11 July	51.55	236,000	10 July - 15 July
1964	.55	1 July	50.25	216,000	29 June - 3 July
1963	.20	26 August	41.45	41.500	15 July - 17 July, 19 August, 23 August - 27 August
1962	.50	29 June	48.70	165,000	28 June - 1 July
1961	.65-.70	26 July	54.50	355,000	24 July - 5 August
1960	.65-.70	17 July	54.55	328,000	15 July - 31 July

*Data from: United States Department of the Interior, Geological Survey, Water Resources Division, Anchorage, Alaska

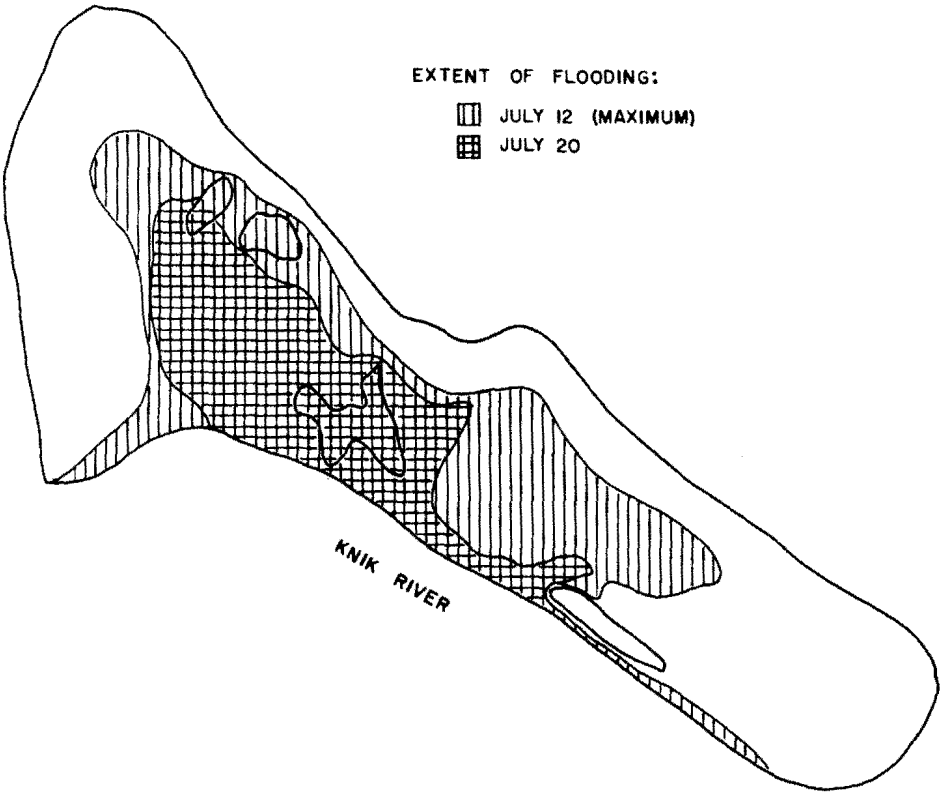

Figure 3. Map showing extent of flooding of the Jim-Swan Lakes area during July.

marshes, as shown in Figure 3. By the first of August, water levels were as they had been the first of June.

Mammalian Fauna:

The moose (Alces alces gigas Miller) is the dominant mammalian species in the valley. The second most abundant large mammal is probably the black bear (Ursus americanus). At least one individual of this species was observed on approximately 75% of the days spent in the field. Brown bears (Ursus arctos) were observed on four occasions (at least two individuals), and tracks indicated the presence of at least one cub. One wolf (Canis lupis) was seen from the air in May, and the carcass of a pup of this species was discovered near the northern boundary of the area in June. Scats indicated that coyotes were present. Lynx (Lynx canadensis) tracks were observed once. Dall sheep (Ovis dalli) and mountain goats (Oreamnos americanus) were observed in the mountains north of the area.

Moose Population:

The moose population is discrete within the study area. In four years of hunter returns of tagged moose, none of the 174 animals tagged in the area since 1962 have been recovered outside it. The fact that hunting is heavy in surrounding areas and that the Glenn Highway is heavily travelled makes this fact significant. Moose were occasionally observed crossing the Knik River to small areas of range to the south which are tightly enclosed by Pioneer Peak, and there was a constant but limited exchange with the area of approximately 8 km^2 east of Friday

Creek and west of the Knik Glacier. This exchange was assumed on occasionally observing tagged animals in this area. In autumn, the moose population moved almost completely into alpine areas to the north and as far west as Lazy Mountain, but remained in a discrete group. These emigrations and immigrations are assumed, for the purposes of this study, to be temporary and self-balancing, and the population is studied as an entity.

As estimated from aerial counts during the parturition period in May, 1965 and an aerial count on October 31 (Table 3), the moose population on the study area was just over 300 animals during the summer and fall of 1965. The area thus supported approximately 5 moose per km^2 during the period of the study; however, it is doubtful that the entire population was concentrated on the valley floor at any one time. Rather, certain segments of the population, notably adult males, occupied the hillsides to the north, except while feeding. Conversely, cows and calves were sometimes present on portions of the valley floor in densities far exceeding 5 per km^2.

METHODS OF OBSERVATION

Aerial Counts:

Aerial counts were flown in two-place PA-18 Supercubs piloted by Alaska Department of Fish and Game pilots or professional guides. With one exception (noted in Table 2), the pilots were experienced observers and added greatly to the efficiency of the counting operation. The technique was one of complete coverage of the area on each count. North-south transects of approximately 200 m separation were flown at an altitude of 70-100 m and an airspeed of approximately 45 knots. Both pilot and observer watched for moose, and the observer recorded number, age class, sex (when possible), flag presence and color, and the square mile area in which seen, as well as notes on behavior. When there was any doubt of the sex of a moose, whether or not a cow was accompanied by a calf, or the presence or color of flags, the animal was circled at a very low altitude until the necessary information was obtained.

Counts were flown immediately after dawn in most cases, and usually required approximately 1.5 hours of counting time. When possible, complete counts were flown on two successive days.

In addition to the above observations, the observer noted activity (bedded, feeding, standing, running) and microhabitat (spruce finger, open meadow, scrub, etc.) of the moose. Yearlings, recognizable by general size and body conformation until October, were recorded as such. Their supposed sex was recorded, but with unknown accuracy. Bulls were

recorded as such, being distinguished from yearling males and other moose on the basis of antler presence and size. Adult females were checked most carefully, and were circled at low altitudes until the presence of a calf was confirmed or could be reasonably ruled out. Parturient females had a characteristic "slab-sided" appearance, most noticeable early in the season, especially when viewed from directly above, and would almost invariably stand still, casting frequent glances in the direction of the calf. When disturbed a good deal by the aircraft, the parturient cow most often ran hesitantly to her calf. Cows without calves behaved much like yearlings and bulls, and reacted to the aircraft with no particular pattern, sometimes running in circles, sometimes ignoring the plane completely, but never giving the described glance toward the brush.

A third category of females displayed all the "calf-signs" described but never revealed a calf to the observer. These females gave the glance, often had a slab-sided appearance, and oriented their nervous movements in one direction. Moose that the observer was convinced were accompanied by calves were placed in this "female/?" category, and were considered equivalent to a "female/1 calf", even though the calf was never actually observed.

Ground Observations:

Ground observations were made from the seven observation points indicated in Figure 1 and while hiking throughout the area. Most time was spent at the fixed posts, and animals observed during hiking

were seen only incidentally to other purposes.

All observation points were on elevated ground, 50-350 m above the valley floor. From some positions, moose could be observed undisturbed at distances of less than 25 m. Other vantage points afforded views of open areas as large as 11 km^2, and allowed observation of general patterns of motion of many moose. The total area visible from the seven observation posts was approximately 34 km^2, and included all the open habitat on the valley floor.

Observations were made with the aid of a tripod-mounted Bausch and Lomb 15-60x variable spotting scope and 6x30 binoculars.

CALF SURVIVAL

Methods:

The extent and nature of calf mortality was studied through aerial counts and visual and physical recovery of tagged calves. On May 28 and May 31, 1965, 59 calves were tagged to allow recognition as individuals from either the air or the ground. In addition, six adult females were marked by paint, identifying them as dams of single calves, and three additional females were similarly marked with a different color for identification as mothers of twins. Tagging and marking methods are described in Appendix 1. Animals tagged are tabulated in Table 2.

Extent of Mortality:

Aerial Counts. Table 3 shows moose observed during aerial counts, and Table 4 shows the decrease in number of calves and in calves:100 cows between May 27 and October 31, 1965. These results are presented in part in Figures 4 and 5. Since the category "females/?" is composed of females that in all probability are accompanied by calves but whose calves are not observed during the count, this category is considered equivalent to females accompanied by one calf in Figures 4 and 5. Yearlings present on May 27, 1965 are plotted following the final fall count of calves in 1965, and are assumed to represent the calf population as it will be present in May, 1966.

The peak of parturition apparently occurred about June 1. This

Table 2. Tagging data

	May 28	May 31	Total
Total Moose Tagged	29	30	59
Males Tagged	16	17*	33*
Females Tagged	13	12*	25*
Sets of Twins Tagged	2	4	6
One of Set Tagged	1	1	2
Females Painted (Singles)	1	5	6
Females Painted (Twins)	1	2	3

*one calf sex unrecorded

Table 3. Results of aerial counts.

Date	Time	Total Time	Moose /hr	Calves (Tagged/Untagged) Cow /0	Cow /1	Cow /2	Cow /?	Yearlings W/O Cows	Cow /1	Cow /2	Male	Total Cows	Total Cows-Cows/?	Total Calves	Total Moose
[a]27 May	0340-0507	1:27	66.2	9	26	2	1	10	4	1	7	43	42	30	96
[a]31 May	0100-0700	3:15	44.3	13	12/22	3/5	9	4/16	0	2	12	66	55	50	144
[b] 1 June	0310-0440	1:30	29.3	2	6/2	0	8	6	1/4	0	2	23	15	8	44
12 June	0325-0510	1:45	42.9	8	7/7	1/1	5	1/5	6	*	10	37	32	18	75
24 June	0325-0450	1:25	5:44	11	4/11	2	2	12	2/3	0	6	35	33	19	77
25 June	0335-0500	1:25	46.6	7	2/10	1	7	2/14	0	1**	4	30	23	14	66
12 July	0812-0850	0:32	36.8	0	4	0	0	2/1	0	0	2	4	4	4	14
20 July	0402-0541	1:39	20.0	6	2/6	0	0	2	2	0	5	16	16	8	33
5 Aug.	0419-0600	1:41	17.9	0	5	0	5	2	1	0	11	11	6	5	30
11 Aug.	1409-1523	1:14	19.5	0	1/6	0	4	3	0	0	3	11	7	7	24
21 Aug.	0536-0636	1:00	20.0	2	6	1	0	3	0	0	0	9	9	8	20
[c]30 Oct.	(Below timberline) 0837-1026	1:49	1.3	2	0	0	0	0	0	0	0	2	2	0	2
31 Oct.	(Above timberline) 0921-1151	2:30	97.2	102	3/31	1/3	0	1/0	0	0 (20 young 40 adult)	60	140	(115)*** 140 (115)***	42	243

[a]Rausch observer
[b]Pilot did not participate in observations
[c]Yearlings no longer distinguishable with accuracy

*1 yearling/2 cows
**2 cows/3 yearlings

***revised estimates, discounting yearling females

Table 4. Estimates of calves:100 cows and total number of calves present, derived from aerial counts, showing estimated yearlings through June with a revised estimate of calves on October 31.

Date	Cows/? = Cows/1	+ 2 Std.Dev.	Ignoring Cows/?	+ 2 Std.Dev.	Cows/1 = Cows/?	+ 2 Std.Dev.	Ignoring Cows/?	+ 2 Std.Dev.
27 May	67.4	53.1- 81.7	71.4	57.4- 85.4	101	79.7-122.5	107	86.2-128.0
31 May 1 June	84.3	76.7- 91.9	80.6	71.2- 90.0	127	114.9-138.1	121	106.9-134.9
12 June	62.2	46.2- 78.2	56.3	38.7- 73.9	93	69.4-117.2	85	58.1-110.9
24 June 25 June	65.6	54.5- 76.7	60.0	46.8- 73.2	98	80.6-116.2	90	70.2-109.8
12 July	100	50 -150	100	50 -150	150	0-300	15	0-300
20 July	50	25 - 75	50	25 - 75	75	37.4-112.6	75	37.4-112.6
5 Aug. 11 Aug.	95.5	86.7-104.3	92.3	77.6-107.0	143	130.1-156.5	138	115.8-160.2
21 Aug.	88.9	67.9-109.1	88.9	67.9-109.1	133	101.8-165.0	133	101.8-165.0
31 Oct.	30.0	22.3- 37.0	30	22.2- 37.8	45	33.4- 56.6	45	33.4- 56.6
Revised estimate for 31 Oct.	38.2	28.8- 47.6	38.2	28.8- 47.6	57.3	43.3- 71.3	57.3	43.3- 71.3
27 May- 25 June yearlings:100 cows	42.7	36.3- 49.1	50.0	43.0- 57.0	64	59.2- 69.0	75	64.4- 85.6

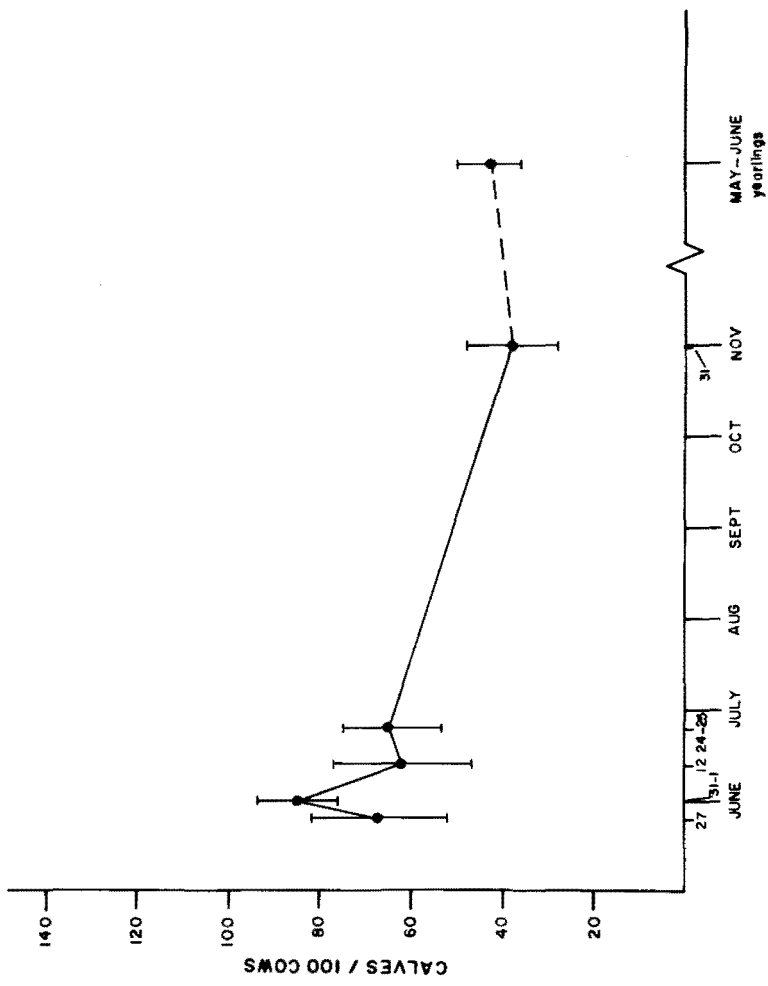

Figure 4. Calves per 100 cows present on the Jim-Swan Lakes area on various dates, estimated from aerial counts. Vertical bars show the range of two standard deviations for each estimate.

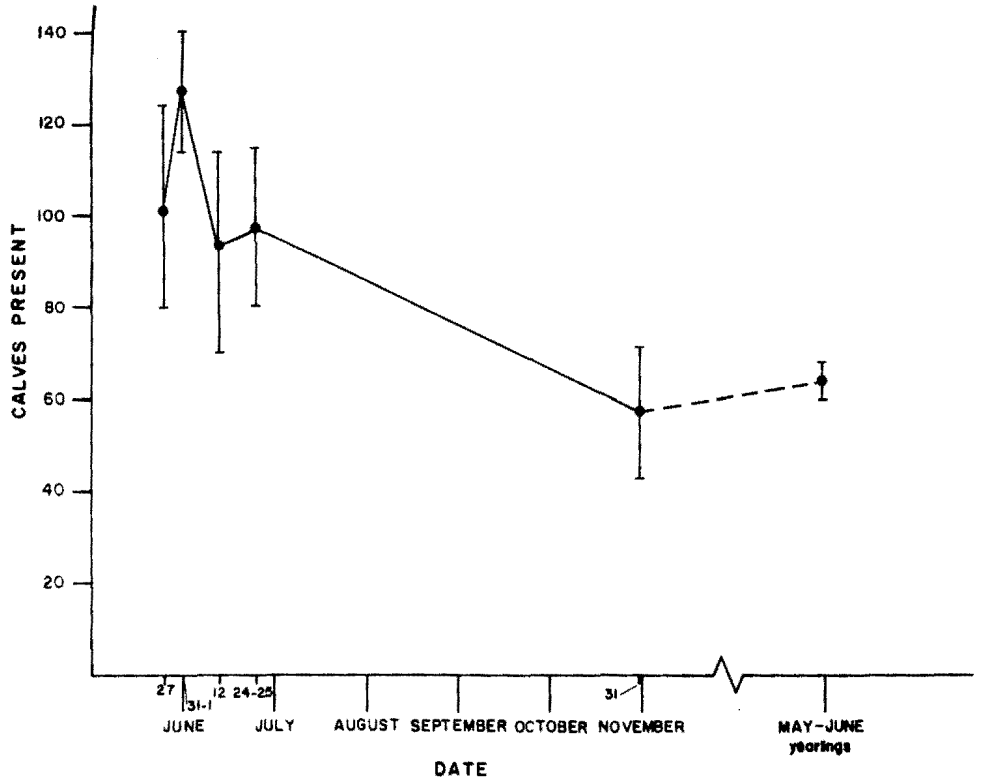

Figure 5. Total number of calves present on the Jim-Swan Lakes area on various dates, estimated from aerial counts on a basis of a population of 150 cows. Vertical bars show the range of two standard deviations for each estimate.

is consistent with similar data collected in other years throughout the Matanuska Valley (Atwell, 1963 and Didrickson, 1961). Results of counts made on May 31 and June 1, combined, indicate that 84.3 calves: 100 cows were present on these dates. On the basis of this data and the .375 ratio of tagged calves:untagged calves observed in May and June, supplemented by the sample of 140 cows and yearling females counted in October, an estimate of 150 mature females present on the area throughout the summer was made. Using this estimate, the numbers of calves present on the day of each count were calculated from calf: cow ratios and plotted in Figure 5.

Parturition was concluded by June 12. A count on that date showed only 62.2 calves:100 mature females, or 93 calves present on the area compared to 127 at the peak of parturition. This drop of 26.8% in calves present during the 12 days immediately succeeding parturition is significant at the 94% confidence level, as is the decline of 22.1 calves:100 cows. Counts conducted on June 24 and 25 showed no significant difference in calf:100 cow ratio or number of calves present from the count of June 12.

The flooding of the study area on July 11 altered the apparent composition of the population. The effect lasted through the month of August. Apparently, the flood induced cows without calves to leave the valley -- probably to ascend into the hills -- to a much greater degree than it affected cows with calves. As a result, the calf:100 cows ratios observed between June 25 and October 31 were inflated. Counts made during this period are omitted in Figures 4 and 5 because of this

and because the samples of females available during this period were small (Table 2).

Counts flown on October 30 and 31 showed that moose were concentrated at treeline and near the Knik Glacier. This condition, in addition to the light covering of snow on the ground at the time, made possible a count approaching a complete census. This count revealed 42 calves and 140 females -- a ratio of 30.0 calves:100 cows and an estimated calf population (assuming the estimated population of 150 mature females) of 45. These figures underestimate the number of calves present because yearling females were indistinguishable from mature females by this time and were included among the 140 females observed. A rough estimate of a more reasonable calf:100 cows ratio may be made by estimating the number of yearling females present, subtracting these from the total number of females seen, and recalculating the ratio.

Aerial counts made during May and June indicated a ratio of 100 yearlings:234 mature females, or 42.7 yearlings:100 cows (Table 4). Assuming a 1:1 sex ratio among yearlings, the yearling female: adult female ratio was approximately 22:100 during these months. If, as is probably the case, the yearling female:adult female ratio remained constant through the summer, there would be expected to be 140/1.22, or 115 adult females present among the 140 females counted, the remaining 25 moose being yearling females. Using this revised estimate of the number of cows seen, the revised estimate of calves: 100 cows present on October 31 is 36.5. Similarly, the revised

estimate of calves present, assuming a population of 150 cows, is 55. Both of these estimates are significantly lower (99% confidence level) than the corresponding estimates for June 24-25.

An absolute maximum estimate of calves:100 cows and calves present may be made by estimating that 30 yearlings, rather than 25, were present among the 140 females counted on October 31, leaving only 110 mature females observed with the 42 calves. This estimate should override any sampling error made in May and June and any bias toward yearling females which may have occurred during the October 31 count. The revised estimate of calves:100 cows, using this figure, is 38.2, and the similarly derived estimate of calves present per 150 adult females is 57. Both these estimates are still significantly lower than the June 24-25 estimates at the 99% level of confidence.

As shown in Table 4, the counts conducted in May and June indicated a yearling population of 42.7:100 females or 64 yearlings in the population. This estimate, which approximates those from other sources (Atwell, 1963), is not significantly lower than either the original, or revised estimates for calves present at the end of October. This evidence indicates that in 1965 in the Jim-Swan Lakes area the greatest mortality of calf moose occurred during the first 5 months after birth, when more than 55% of the calf crop was lost. Within the first 5 months, the greatest mortality occurred within 2 weeks after parturition, when approximately 26% of the newborn calves were lost.

Observations and Recovery of Tagged Calves. Forty-three visual and physical recaptures of 28 tagged calves were made between June 1

and October 31. The few calves visually recovered comprised too small a sample to allow estimation of population level by calendar graph or some similar means; however, mortality of nine calves was confirmed between May 31 and June 25. No mortalities were confirmed after June 25. A summary of observed mortalities is given in Table 5, and a survivorship curve drawn on the basis of a cohort of 59 calves is presented in Figure 6.

The nine confirmed mortalities occurring before June 25 represent 15.3% of the 59 calves tagged in May. They comprise only little more than half of the 22-26% mortality indicated by the aerial counts of June 12 and June 24-25. Even though the area was examined carefully during this period, other carcasses probably escaped detection. The estimate of mortality from recoveries is a minimum estimate of mortality, therefore, and the estimates derived from aerial counts are probably more accurate.

Discussion. The 55% calf mortality observed in the Jim-Swan Lakes area between May and November is probably higher than the usual mortality in the Matanuska Valley. Rausch (1965) estimated as many as 55 calves:100 cows and yearling females in some areas of the valley (47:100 for the entire valley exclusive of Jim-Swan Lakes) in November. These estimates suggest a mortality of only about 44% during the first five months. However, counts made in 1956 (Rausch, 1959) in much the same area estimate May-October mortality at 56%. It is probable that calf mortalities during the first summer vary each year and with each population.

Table 5. Confirmed calf mortalities.

Calf No.	Date	Method of Confirmation	Probable Cause of Death
10	31 May	Recovered live	Deserted by female
27	31 May	Fresh carcass recovered	Kicked in head by dam (?)
2*	1 June	Observed predation - carcass recovered	Killed by brown bear
3*	1 June	Observed predation - lower joint of leg and hoof, piece of scapula, and end of femur recovered	(Cow also killed)
34	Before 16 June	Carcass recovered	Desertion by female
41*	Between 6 June & 24 June	Cow and other twin observed (6/24 and 6/25) unaccompanied by this twin	Unknown
Unknown	Before 19 June	Cow with red paint unaccompanied by calf observed 18, 20, 24, and 25 June	Unknown
Twin of 1*	Before 25 June	Cow and other twin observed (6/25) unaccompanied by twin	Unknown (drowning ?)
Twin of 53*	Before 25 June	Cow and other twin observed (6/25) unaccompanied by twin	Unknown

*one of set of twins

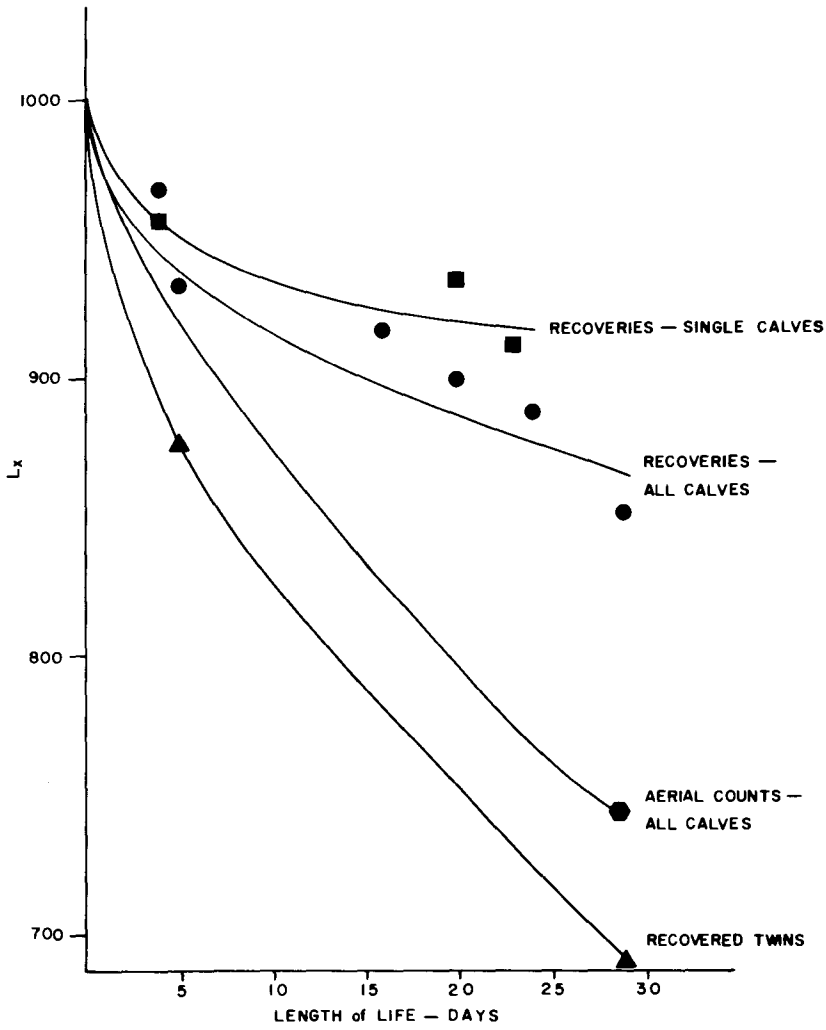

Figure 6. Survivorship curve for the first 30 days of life of single calves, twin calves, and all calves, incorporating data obtained by aerial counts and by physical and visual recovery of tagged calves.

No obvious deficiency was present in the environment of the Jim-Swan Lakes study area. Browse was not noticably over-used, and all moose appeared externally healthy. Due to light hunting pressure, the age structure in the population is probably more strongly weighted toward older animals than it is in other Matanuska Valley populations. The presence of only 20 young males in 60 total males observed (33%) on October 31 supports this assumption. Comparable figures for the rest of the valley (Rausch, 1965) average over 68% young bulls (87: 127 total males). High calf survival is obviously not as important to the Jim-Swan Lakes population as it is to surrounding populations.

Nature of Mortality:

Causes. Causes of confirmed calf mortality were accidents, predation, and desertion. Of nine confirmed mortalities, two were attributed to accidents. Accidents observed or suspected included drowning, entrapment by vegetation, and being kicked or stepped upon by other moose. Two confirmed deaths were the result of predation. Predation by brown bear was observed, and predation by black bears and wolves was suggested by evidence gathered. Scavenging by small animals was noted on the area. Two mortalities were attributed to desertion of calf by cow. Three confirmed mortalities were from unknown causes.

Accidents. Drowning was the probable cause of mortality in two instances, although no drowned calf was actually recovered. During the tagging operation on May 28, a cow with twin calves was driven across Friday Creek by the helicopter. She crossed at a point where the swift

stream was less than 7 m wide. Both calves, which were probably no more than 2 days old, were swept downstream in trying to follow. One calf was pulled out and tagged, but the second calf disappeared behind streamside willows and was not found.

On June 25, the first calf (no. 1) was visually recovered approximately 7 km from the site of tagging. The second calf did not accompany no. 1 and its dam, and was presumed dead. Probably this calf drowned in Friday Creek due to the swift current, boulder strewn bottom, and abundant snags of driftwood. It seems likely that calves as old as 3 or 4 weeks could succumb trying to cross at this particular spot. Surprise by predators or cows acting beyond the calves' capacities could substitute for the disruptive effect of tagging.

The fact that the calf which disappeared was one of a set of twins further supports the contention of its dying due to this incident. Cows with twin calves invariably seemed to forget their second calf if they were still accompanied by one twin. In this instance, even if the twin had managed to pull itself from the stream, it probably would have died due to abandonment.

On July 1, a similar incident was observed on the Matanuska River near Mile 76 of the Richardson Highway north of Palmer. A large calf, probably weighing over 80 lb., was observed on a small gravel bar in the middle of the river, which was swollen by recent rains. The river was approximately 1.3 m deep on one side of the bar, and deeper on the other. The current was strong enough to make wading difficult for a

man. The calf was approached on the island and coaxed close enough for capture by a twig of willow leaves, indicating its great hunger.

Unaided, this calf probably would have died of one of three causes: starvation on the bar, were its fear of the river to persist long enough: drowning, were it unable to negotiate the water; or subsequent starvation or predation, were it to escape the island and attempt to survive without parental care.

During the tagging operation in 1965, Rausch (verbal communication) observed two calves held by scrub trees. In travelling, whether or not fleeing a helicopter, young calves encounter alders, birches, and willows with numerous trunk branchings at heights which may entangle their long legs. The resiliency and denseness of these shrubs makes them effective traps.

In both cases observed by Rausch, the leg was bent at the knee and was held in the bent position. One calf was held by its front leg and the other by a hind leg. One calf had become entangled upon being disturbed by the helicopter, but the other showed signs of hunger and weakness and had apparently been held for more than a day. Both calves were still accompanied by cows.

It is highly possible that a calf under two or three weeks of age might be held like this long enough to starve, to injure itself seriously by struggling, or to become the defenseless victim of predation.

The fresh carcass of calf no. 27, tagged on May 28, was recovered on May 31 near the site of tagging. Uncoagulated blood in the nostrils

and the fact that the body was warm indicated that the calf had died very recently. The calf was still closely protected by a cow, which circled nervously and was driven from the carcass by the helicopter only with difficulty. No external wounds were present. An autopsy conducted on the frozen carcass in November by Kenneth Neiland, parasitologist of the Alaska Department of Fish and Game, revealed a fractured skull and indicated that this was the cause of death.

Probably the fractured skull was incurred as a result of the calf's being kicked by its dam. Cows often were observed stumbling over calves, especially when agitated. This was extremely prevalent during the first two weeks of the calves' lives, when they were less agile than later, and occurred most often in open hummocky areas, where cows could move with little obstruction, but calves encountered great difficulty. Calf no. 27 was recovered in this type of area. In all the other cases observed, the flexibility of the calf's body and the usually soft ground obviated any apparent injury; however, a direct blow to the head could easily crush a calf's skull.

Accidents -- Discussion. Accidents seem a major cause of mortality in very young moose calves. Drownings are probably of import only during the first month of life. Calves observed in the latter half of July were accomplished swimmers and were observed negotiating bodies of water as large as Jim Lake in the face of .6 m waves and high winds. It is doubtful that the flooding of the Knik River in July caused any mortalities of calves. The water did not rise rapidly enough to inundate moose, nor did it reach great depths over sufficient

areas to cause drownings. In fact, aerial counts in July and August suggest that cows with calves preferred the inundated area even more than did other moose.

Broken limbs, entrapment by brush and injuries sustained through the clumsiness of cows also were probably important only during the first few weeks after parturition. By the first of July, calves appeared large enough and robust enough to avoid such injuries. Calves observed in July showed agility and balance comparable to that of adults. With its inexperience being compensated for by the presence of a cow, a calf over a month old is probably no more susceptible to accidents of this type than is an adult moose.

Predation -- Brown Bears. One instance of brown bear predation resulting in the death of two calves and a cow was observed. Rausch (verbal communication) observed one instance of successful predation by a brown bear and one instance in which attempted predation was unsuccessful.

On June 1 the carcass of a cow was observed from the air at the boundary of a thicket of mature birch and aspen and an open field of habitat type 5. A large brown bear was standing over the carcass. Orange and white ear flags were seen moving through dense shrubs 3 or 4 m from the bear, which appeared to give chase. After repeated buzzing from the plane, the bear disappeared into the thicket and the ear flags were no longer visible.

On return to the site by helicopter the following day, the carcass of a mature cow moose was found approximately 8 m from

where it was killed. Tracks indicated that the bear had dragged the carcass into the thicket. Scattered moose hair and trampled vegetation within a radius of 15 m surrounded the position of the kill. The bear had chewed the cow's left shoulder and eaten the upper portion of the head and about half the right haunch. The cow's back was broken in the thoracic region.

The eviscerated carcass of tagged calf no. 2 was found 7-8 m from the cow, further into the thicket. Its vertebral column was broken just behind the shoulder and its entrails had been eaten. No other bones were broken, and the remainder of the carcass had not been fed upon. Both ear tags and both flags were intact and in place.

The site was visited for the final time on June 16. The carcass of the cow had been dragged 3 m further into the thicket and most of the loin and hindquarters had been eaten. Traces of yellow paint were found on moose hair scattered about the area. On the far side of the thicket, 50 m away, a foreleg with hoof, radius and ulna attached, a piece of scapula, and the end of a femur of a calf moose were found. All the flesh had been cleaned from the bones, which showed evidence of having been gnawed upon by a large animal. Because of the yellow paint found on remains of the cow, the presence of calf no. 2, and the aerial sighting of orange and white flags, these remains are assumed to be those of calf no. 3 (no. 2's twin, marked with an orange and a white ear flag on May 28).

A brown bear could have hidden easily within the edge of the thicket where the predation occurred. The same area is of the type

heavily used by cows and young calves for concealment. An attack by the bear might have taken one calf (no. 2) and provoked a counter-attack by the cow, which subsequently succumbed. The second calf (no. 3), probably no more than 1 week old, could then have been easily captured by the bear.

On June 2, Rausch (verbal communication) observed a brown bear feeding on a tagged calf in the Willow-Kashwitna area, northeast of the Jim-Swan Lakes. A cow moose circled the bear nervously 200 m away. On June 7, Rausch observed a calf (probably 2 to 3 weeks old) and a cow outrun a brown bear sow with two cubs in a wet hummocky area. On August 28, I observed an adult cow moose, surprised on land near the shore of Jim Lake, easily outswim a mature brown bear, reaching the far side of the lake, 1.2 km away, a full 5 minutes before the bear. Despite the apparent ease with which she outswam the bear, the moose was very agitated by the attack and seemed terrified of the bear.

These few instances indicate a) that brown bear predation is a factor in very early mortality of moose calves, and b) that this predation occurs for only a short time and that moose are capable of escaping from brown bears in most situations, perhaps even when as young as 3 weeks of age.

Predation -- Black Bears. Evidence of predation by black bears was all indirect. Black bears were numerous in the study area, and were observed on the majority of days I was in the field. Thirty-five bear scats were examined in the field, and only two (5.7%),

probably from the same bear, contained a small bit of moose calf hair. These two scats, examined on June 13, were the earliest found and the hair they contained could well have been the result of scavenging. Two moose calf carcasses, both dead since about June 12, were found by Laurence Ellison (correspondence), a biologist working on the Kenai National Moose Range, near Sterling, Alaska. Both carcasses had been fed upon by large animals, probably black bears.

That no direct evidence of black bear predation was discovered in the Jim-Swan Lakes area, where many bears were observed, suggests that black bear predation on moose calves was slight in this area. The low level of fear response shown by moose confronted with black bears substantiates this idea. In any case, no evidence was found of black bear predation occurring after the third week following peak parturition.

Predation -- Other Predators and Scavengers. An adult wolf was observed on the area on May 28, 1965, and the old carcass of a pup was discovered in June, indicating that wolves breed on the area. Canid scats containing adult moose hair and bone chips, and a piece of calf hoof and calf hair, were found also. Both scats probably dated from the previous year. The hoof fragment was of the same size and configuration as the comparable part of a hoof recovered from a calf known to be approximately two weeks old. In 1963, Jack Didrickson, Game Biologist, (verbal communication) watched a wolf take a very young calf from near its mother on the area. No more recent evidence of wolf predation on moose was available, however, and it is believed that this factor, in

the spring and summer, is of short duration and small magnitude.

Scavenging was common in the area, and may have obscured further evidence of predation. Canid scats containing calf moose hair were found near the scene of the brown bear kill of calves no. 2 and no. 3. The bones thought to be the remains of calf no. 3 had been cleaned by small animals. Canid tracks (probably of coyote, Canis latrans) were found near the carcass of calf no. 34, and the carcass had been fed upon in a way characteristic of scavengers.

Predation -- Discussion. Predation, like accidents, is probably an important mortality factor only in very young calves. Calves more than a month old seem capable of escaping bears under ordinary circumstances, and probably fall prey only in unusual situations of surprise or harsh environmental conditions. The myriad of small bits of evidence of predation collected suggests that predation and accidents affect the survival of young calves about equally.

Evidence indicated that, despite a large black bear population on the area, brown bears were responsible for more deaths than were other predators. The demonstrated ability of a brown bear to take a young calf even though it is closely protected, as well as the much greater fear shown by moose at the presence of a brown bear, suggests that the larger bear is the more important predator. Moose were seen in association with black bears on five occasions and with brown bears three times, in addition to the instance of confirmed mortality. Only once did moose respond to the presence within less than 100 m of a black bear, and this response was only a nervous, not precipitous,

retreat. On all three occasions when brown bears were encountered at such close range, moose fled precipitously with great agitation. Such fear suggests that dangerous contacts with brown bears are more common than are those involving black bears.

Abandonment. Two apparently deserted calves were recovered on the study area, and one was captured elsewhere in the Matanuska Valley. A fourth calf was observed without a cow present, but desertion was not substantiated. Calf no. 10 was recovered alive from the same sector in which it was tagged. The calf, tagged on May 28 and observed with the cow immediately thereafter, was recovered on May 31. A thorough aerial search did not locate a cow near the calf, which was hungry but in good health and approximately one week old.

On June 16, the carcass of calf no. 34, tagged May 31, was found beside a heavily-used moose trail at the crest of an open ridge. The calf had been dead for about one week, and had been fed upon by small animals in the pelvic and anal regions. The body lay on one side, in the normal position a calf assumes while bedded down. Only a small part of the calf's flesh had been removed, all bones were intact, and no wounds were present other than in the pelvic region. An examination of the viscera revealed no abnormalities. The rumen was full, and the animal had browsed on willow, spruce, and a small amount of Ledum. The plant material in the digestive tract was undigested.

A deserted calf removed from the Matanuska River was described earlier in the discussion of drowning. No cow was observed accompanying one calf (no. 52) during its tagging on May 31. The calf was not

subsequently observed, but no further evidence of abandonment was present.

Abandonment -- Discussion. No one explanation can account for all instances of desertion. The tagging process, maternal confusion, physical obstacles, and predation attempts are possible precipitating factors.

Although both deserted calves recovered on the area had been tagged, neither desertion could be positively attributed to tagging. Calf no. 10 was reaccepted by its dam immediately after tagging. Any rejection caused by this disturbance did not occur immediately. It is doubtful that calf no. 34 survived for over a week without maternal care, as must have been the case if it was deserted upon tagging. It is uncertain how long this calf had actually been dead when discovered, however, so no conclusion is possible regarding its survival after tagging.

Immediate reacceptance of tagged calves by females was observed in almost every instance, so it is unlikely that the normal tagging operation caused desertion in a great number of cases. Thirty-four cows were chased more vigorously than others in attempts to mark them with paint. Eighteen of the calves of these cows (53%) were observed with a cow one or more days after tagging. Of all 59 calves tagged, only 28, or 47%, were later observed with cows. Thus, no correlation between degree of harassment of cows and calf mortality was detected, although such a correlation might well have existed.

Maternal confusion of calves was observed twice, and is a

possible cause of desertion. During tagging, a cow whose calf had just been released challenged a second cow for possession of another calf. In this case, the tagged calf returned to its dam and was reaccepted; however, had the tagged calf become lost, the confused cow could conceivably have persisted in the challenge long enough to preclude recovery of her calf. On July 26, a cow was observed in Jim Lake, trying to gain possession of a calf feeding with another cow. The first cow had a calf hidden less than 100 m away, but apparently mistook the second calf for her own. After failing to gain possession of the second calf, the first cow returned to the brush and almost immediately discovered her calf. This incident is described in detail below. Again, it is conceivable that such confusion, prolonged, might lead to the loss of a young calf incapable of following its dam.

It is possible that a calf trapped by a natural barrier, such as a swollen river or a tree limb, might subsequently escape and be unable to rediscover its cow. Predation would not seem to be a factor in maternal desertion of young calves for, were a cow-calf group attacked by a predator and the calf abandoned, it would in all liklihood fall prey. Older calves (more than a month of age) might conceivably escape predation on their own once separated from their dam. In such a case, the inexperienced animal, if less than 5-6 months old, probably would have only a slight chance of survival and its death could be attributed to predator-induced desertion.

Twin Differential. Of the nine confirmed mortalities, five involved twin calves. Within 30 days, the original population of 16

recoverable twins decreased by five (31%). In the same period, 45 tagged single calves were depleted by four (9%). These mortality rates are significantly different at the 90% confidence level. They are presented graphically in Figure 6.

As shown in Table 5, the visual confirmation of three mortalities depended upon the presence of a second tagged twin. The six sets of twins tagged afforded 12 chances of such inferred visual recovery, and the two single twins tagged added two additional chances for inferred recovery. Further, the three painted cows leading twins provided three chances to confirm double mortalities by inference. Among single calves, the only chances for inferred recovery lay in the sighting of six painted cows. Thus, the possibilities of inferring mortality among twins were more numerous than among single calves, so the compared mortality rates may be misleading. However, the unknown probability of the death of the second calf in a set of twins and the difference in probability of recovering a carcass and sighting a painted cow make precise quantitative description of this factor impossible.

Behavioral characteristics observed during tagging substantiate the reality of the mortality differential between single calves and twins. Cows with twin calves seemed content if accompanied by only one calf, and did not actively defend the second calf. When both calves were captured simultaneously, the cow fled with the first one released. When only one twin calf was captured, the dam displayed much less intense agitation and antagonism toward the captors than did cows with single calves.

Tagging-Induced Mortality. It is unknown how much, if any, mortality was induced by the tagging operation. As mentioned previously, immediate reacceptance of tagged calves by cows was almost invariably the case. Subsequent desertion for reasons associated with tagging seems unlikely. It has been shown that the degree of harassment of the cow showed no negative correlation with later observations of the calf with a cow. No obvious injuries to calves occurred during tagging, and most calves fled vigorously when released. One calf was tagged within moments after birth, and was observed in apparent robust health four times, last on October 31.

All five calves physically recovered had been tagged. The two mortalities due to predation were probably unrelated to tagging, unless it is possible that ear flags made the calves more obvious to the brown bear. The two mortalities attributed to desertion may have been encouraged by the tagging operation, but the effect was probably not immediate. Finally, the mortality attributed to injury inflicted by the cow could have been the result of tag-induced hostility in the cow. If this response occurred, however, it did not do so until three days after tagging. A delayed tag response in cows cannot be positively ruled out as a mortality factor in calves, but seems unlikely.

The proportion of tagged calves observed during aerial counts decreased significantly from May 31-June 1 through October 31 (Table 2). The large part of this decrease, however, did not occur until after June 24-25, so any differential in early mortality between tagged and untagged calves is not evident from this data.

BEHAVIOR

The following accounts of moose behavior result from both aerial counts and observations made from the ground. The former were most valuable in locating the animals and in establishing general patterns of behavior; whereas, the latter were necessary in gathering detailed observations of individual behavior necessary for the accounts of such things as social, maternal, agonistic, and feeding behavior.

Habitat Preference:

The study area was divided into five different habitat types, characterized by topography and dominant vegetation (Figure 2). Table 6 shows numbers and percent of total observed moose by age-sex class observed during aerial counts in specific habitat types. Figure 7 illustrates habitat preference for each age-sex group.

Ease of observation of moose from the air was nearly equal in habitat types 1, 2, and 5, the most important habitats in both surface area and food content for moose. Habitat types 3 and 4 were so limited in extent and available palatable food that the difficulty of aerial observations in these areas was inconsequential. Ground observations were not used in deriving habitat preferences because nearly all of the ground observations of moose were made from points overlooking only habitat type 5.

No distinction is made according to date in Figure 7 and Table 6 because no significant difference in habitat preference was detected between counts in May and those conducted through August 21. However,

Table 6. Habitat preferences of age-sex classes of moose during spring and summer, as indicated by aerial observations, showing number and (%) of moose of each class observed in each type of habitat.

	Habitat Type (See Figure 2)					
	1	2	3	4	5	Total
Cows With Calves	16(.07)	38(.15)	8(.03)	0(.00)	185(.75)	247(1.00)
Cows Without Calves	14(.13)	16(.15)	2(.02)	0(.00)	74(.70)	106(1.00)
Mature Males	0(.00)	5(.18)	2(.07)	0(.00)	21(.75)	28(1.00)
Yearlings	0(.00)	8(.13)	3(.05)	0(.00)	48(.80)	60(1.00)

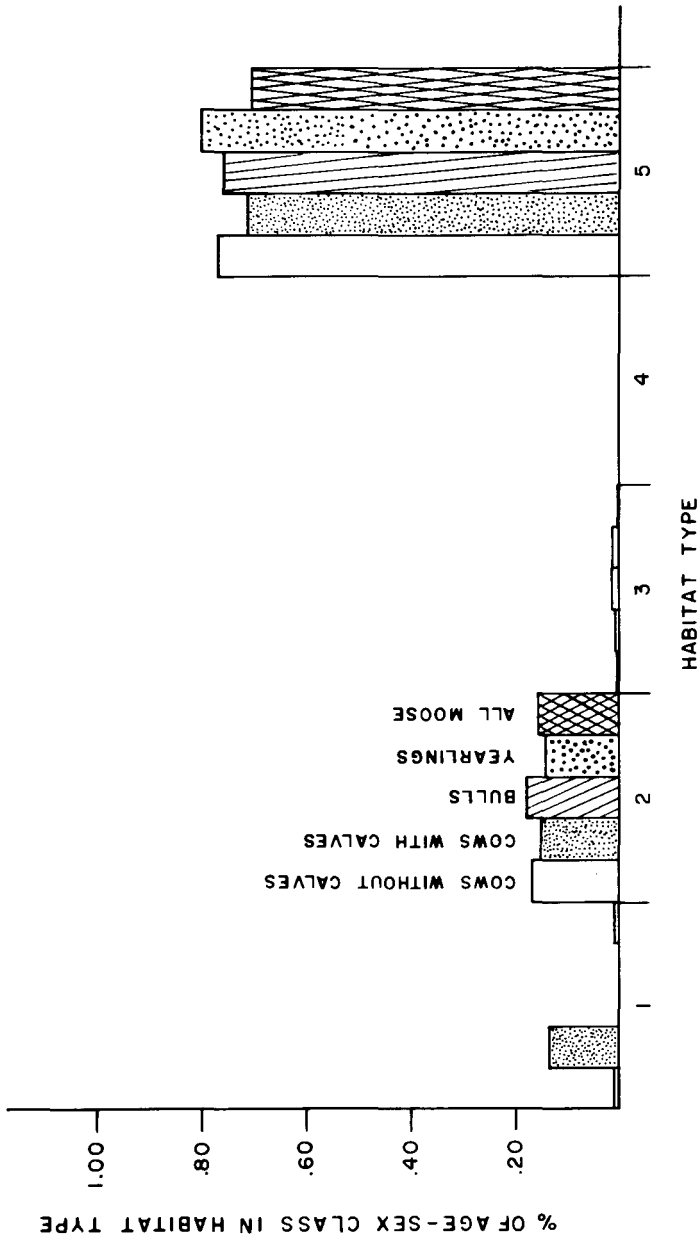

Figure 7. Habitat preference of all moose and of single age-sex classes, showing % of each class observed in each habitat type during aerial counts. (Habitat types are described in Figure 2.)

the count conducted on October 31 found 100% of the animals observed in a sixth habitat type -- alpine -- in the mountains to the north of the study area. This habitat, characterized by patches of birch and alder 3-4 m high and, on that date, by approximately 50 cm of snow, occurred at 0.9-1.1 km elevation above sea level, approximately at timberline. The moose had apparently migrated to these areas following the rut period.

Figure 7 shows that, in general during the study, moose preferred habitat type 5 -- the wet sedge-dwarf birch bog-meadow habitat with islands of black spruce that covered most of the study area. Parturition was witnessed exclusively in this habitat, with most births and early hiding taking place on the drier spruce islands. During the months of June, July, and August, moose fed on the vegetation produced by this habitat, utilizing both the shallow lakes and the open meadows, and bedded down in bordering spruce and willow.

The habitat second in preference was type 2 -- the sparse forest of mature birch and aspen covering the dry northeast portion of the area. This habitat, preferred by approximately 15% of each age-sex class, provided food (the open understory allowed much birch and aspen regeneration) and better cover for adult animals than did the bordering meadows to the west and scrub forest to the south.

The one anomaly discovered in the otherwise consistent pattern of habitat preferences concerns the 13% of females with calves preferring habitat type 1 -- the scrub birch, aspen habitat in the dry southeast sector of the area. The vegetation in this area was very dense, and

provided secluded places for the bedding of calves. Food was abundant, but presumably less palatable than that in the bog meadows. The unique behavior of parturient cows in occupying this habitat type is probably due to their selection for the added seclusion it affords.

A second anomaly can be inferred from the study, but was not directly observed. I suspect that adult males remain hidden a good portion of the day in mature deciduous stands as far as 0.6 km up the slopes on the north side of the valley. Well-worn paths lead up into the hills, and bulls were often observed on these paths. Further, aerial counts of the valley floor revealed an average of 22 bulls: 100 cows, whereas a "total count" in open alpine areas revealed 43 bulls:100 cows, suggesting that many bulls escaped aerial detection during the summer. It is logical to assume they did so by frequenting the higher areas of denser cover.

Within habitat type five, moose made use of specific features of the habitat. Most conspicuously, the edges of open bog-meadows and lakeshores were used for concealment by both resting and travelling moose. Calves and older animals almost invariably bedded within 1 m of the edge of willow or spruce islands. In this position, nestled among the hummocks and further obscured by scrubby willows, calves and adults were all but invisible. Examination of beds indicated that the animals sought out drier areas between hummocks, and tended to re-use established beds in these dry areas.

Cows with calves moved almost exclusively along the edge of spruce and willow islands and fingers, either moving along the scrub

at the edges or just within the periphery of the taller timber. Other moose followed the same pattern, but to a lesser extent. Such a mode of travel was doubly concealing, for the animals, in addition to being partially hidden by willows, were then viewed against the more disruptive dark background of the taller vegetation.

Moose travelling to open areas made maximum use of timber fingers as concealing factors. When about to enter a lake or bog-meadow, an animal would skirt the open area until it reached a projection of timber, and would then enter the area via this projection. Conspicuous examples of this behavior occurred at the long, thin peninsula that extends north from the south shore of Swan Lake, reaching perhaps 50 m into the lake. All cows with calves observed entering Swan Lake from the south entered from the tip of this peninsula, as did a large majority of other moose seen entering the lake. Likewise, animals leaving the lake also utilized the peninsula.

Open areas -- lakes and bog-meadows -- in habitat type 5 had use primarily as feeding areas and, as such, often contained groups of animals.

Sociability:

Although moose are considered asocial cervids, and no formal herding occurs under normal conditions, definite patterns of grouping were observed. Group sizes and composition varied with the season and the age-sex class of the moose involved.

Group Size. Groupings of moose were recorded during aerial counts.

It was very evident from both air and ground observations whether or not two or more moose were associated in a group or merely happened to be in close proximity to one another. Moose composing a group were almost invariably within 10-20 m of one other, and seemed oblivious of each other's presence. When disturbed, all moose in a group moved off at the same rate in the same direction. Moose in association only briefly were alert to one another, and most often faced each other with ears erect and heads up.

Group size increased significantly (92% confidence level) from the period of parturition and summer feeding, when 258 of 311 groups observed (83%) consisted of only one moose or a cow and her one or two calves, to the beginning of the post-rut period on October 31, when only 55 of 87 groups observed (63%) were single animals or cows with calves. During the pre-rut summer period, only three groups containing more than four moose each were seen, and no group larger than nine moose was observed. On October 31, ten groups exceeding four moose were seen, and three of these groups were composed of 12, 12, and 20 moose. Change in size of groups from the summer to October 31 is shown in Figure 8.

As shown in Figure 9 and Table 7, cows without calves and bulls were the two classes contributing most to the seasonal change in group size. During the May-August summer period, 32% of 99 females unaccompanied by calves and 56% of 46 mature bulls seen were solitary. During this period, 36 additional females without calves were in groups of only two animals. On October 31, 65% of 100 cows without

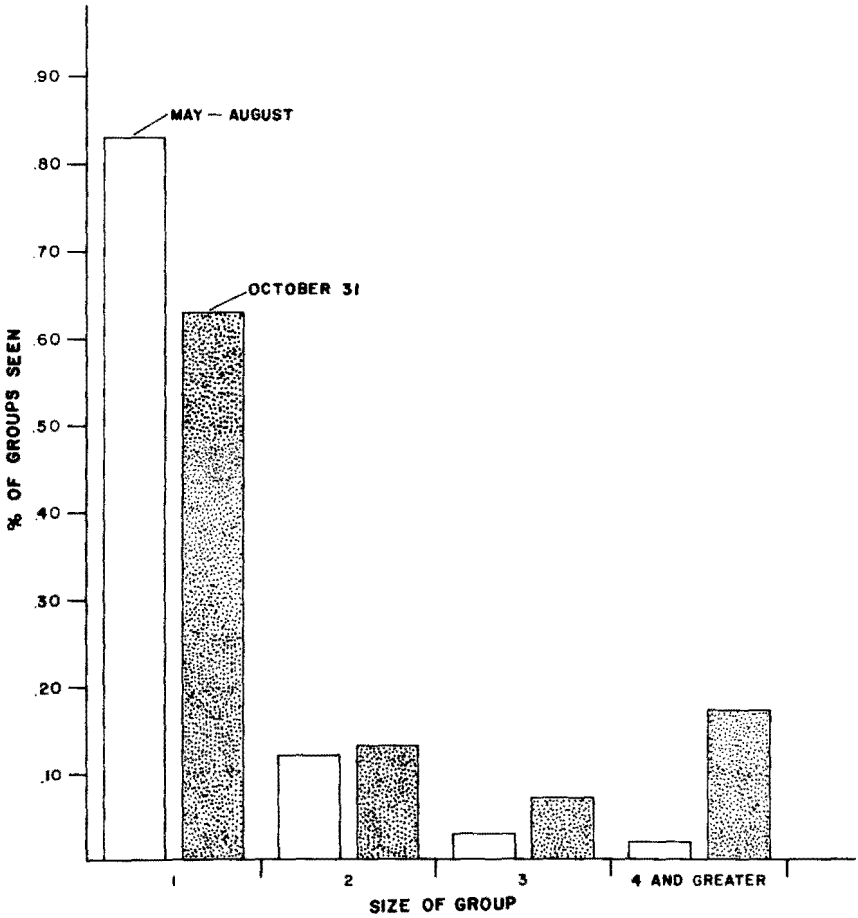

Figure 8. Sizes of groups of moose observed in aerial counts during the period from May 27–August 21 and on October 31, showing % of groups observed composed of an indicated number of moose. A group size of "1" indicates a solitary moose.

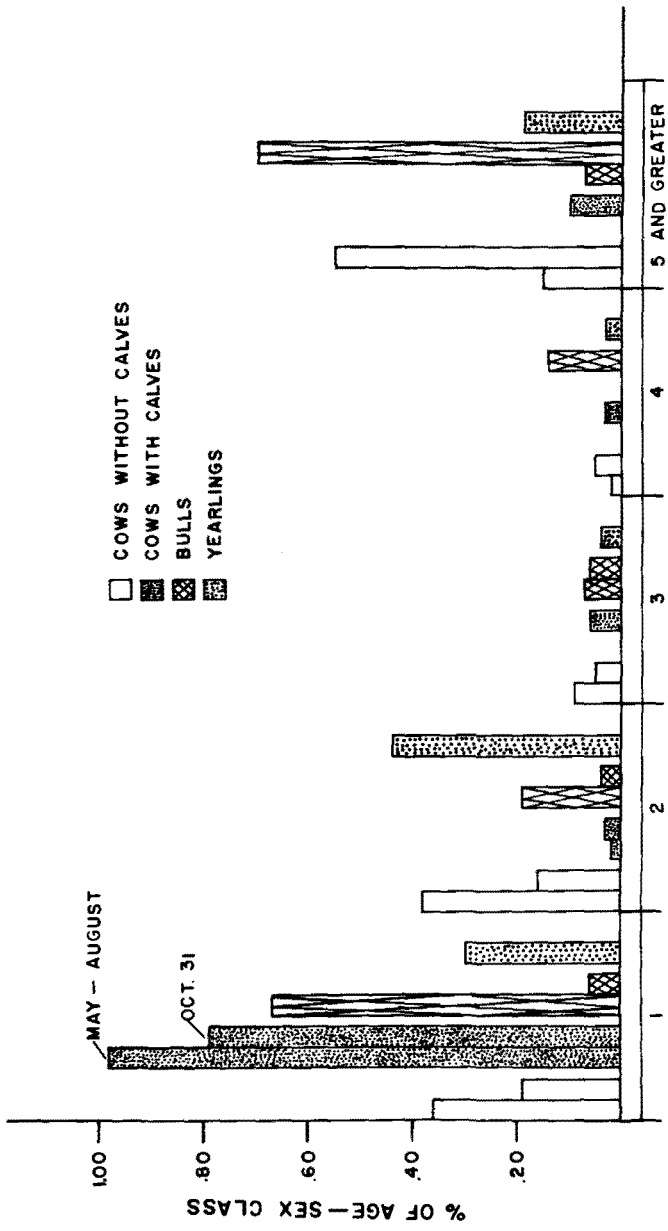

Figure 9. Sizes of groups with which age-sex classes of moose were associated during the May-August period and on October 31, showing the % of moose of each age-sex class observed within groups of various sizes.

Table 7. Group size associations of specific age-sex classes of moose during various periods of summer and autumn.

	Number of Moose in Group						
	Total	1	2	3	4	5+	Dates
Cows Without Calves	44	12(.27)	15(.34)	7(.16)	2(.05)	8(.18)	1 June - 12 June
	55	20(.36)	21(.38)	5(.09)	1(.02)	8(.15)	24 June - 21 Aug.
	99	32(.32)	36(.36)	12(.12)	3(.03)	16(.16)	1 June - 21 Aug.
	100	19(.19)	16(.16)	5(.05)	5(.05)	55(.55)	31 October
Yearlings	58	25(.43)	20(.34)	4(.07)	3(.05)	6(.10)	1 June - 12 June
	68	20(.29)	30(.44)	3(.04)	2(.03)	13(.19)	24 June - 21 Aug.
	126	45(.36)	50(.40)	7(.06)	5(.04)	19(.15)	1 June - 21 Aug.
	4		3(.75)			1(.25)	31 October
Mature Males	19	8(.42)	1(.05)		3(.16)	7(.37)	1 June - 12 June
	27	18(.56)	5(.19)	2(.07)		2(.07)	24 June - 21 Aug.
	46	26(.56)	6(.13)	2(.04)	3(.07)	9(.20)	1 June - 21 Aug.
	49	3(.06)	2(.04)	3(.06)	7(.14)	34(.70)	31 October
Cows With Calves	46	44(.96)	1(.02)	1(.02)			1 June - 12 June
	62	61(.98)	1(.02)				24 June - 21 Aug.
	108	105(.97)	2(.02)	1(.01)			1 June - 21 Aug.
	38	30(.79)	1(.03)	2(.06)	1(.03)	4(.10)	31 October

calves and 90% of 49 mature bulls seen were in groups of three or more moose. Both these changes are significant at the 99% confidence level.

During summer and autumn, females with calves were usually not associated with other moose. No significant change was noted in group size on October 31, but eight females with calves were observed to be associated with other moose on that date. Yearlings, which were indistinguishable from other moose on October 31, were most often solitary or in association with one other moose during the post parturition and summer season. Counts were not begun early enough to show when dissociation of yearlings from parturient cows occurred.

The observed changes in group sizes correlated well with rutting activity and the concurrent change in habitat by the population. All moose observed on October 31 were seen in alpine environment, very close to tree line and approximately 0.9 km above the valley floor. This open environment, with little cover but much browse, seemed conducive to grouping. Most moose observed in groups were bedded, ruminating, and no physical interactions were observed at this time. Further, rut had just finished, and almost all of the groups observed were heterosexual in composition.

Specific Associations. Figure 10 and Table 8 show associations between the classes of moose distinguished during aerial counts. Associations observed during the May-August period and on October 31 are recorded.

As suggested in the above data concerning group size, females

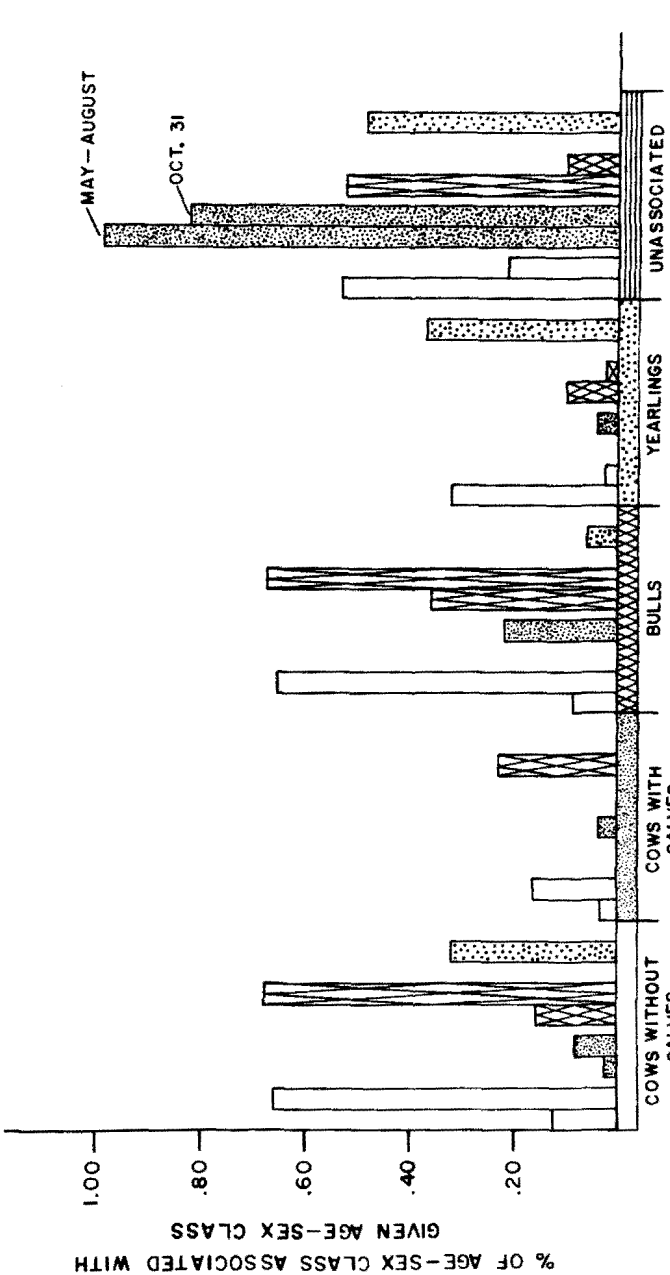

Figure 10. Associations between age-sex classes of moose during the May-August period and on October 31.

Table 8. Associations between age-sex classes of moose during various periods of spring, summer, and autumn, observed during aerial observations and showing number and (%) of each class associated with at least one individual of another class.

	Age-Sex Class Associated With						
	Cows With Calves	Cows Without Calves	Mature Males	Year-lings	Unasso-ciated	Totals	Dates
Cows With Calves	0(.00)	1(.02)	0(.00)	1(.02)	46(.96)	48(1.00)	1 June - 12 June
	0(.00)	1(.02)	0(.00)	0(.00)	61(.98)	62(1.00)	24 June - 21 Aug.
	1(.02)	3(.07)	8(.18)	1(.02)	31(.71)	44(1.00)	31 October
Cows Without Calves	1(.02)	14(.24)	5(.09)	26(.45)	12(.20)	58(1.00)	1 June - 12 June
	1(.02)	5(.12)	3(.07)	12(.29)	20(.50)	41(1.00)	24 June - 21 Aug.
	7(.06)	48(.40)	41(.34)	2(.02)	21(.18)	119(1.00)	31 October
Mature Males	0(.00)	10(.33)	3(.10)	9(.30)	8(.27)	30(1.00)	1 June - 12 June
	0(.00)	5(.13)	12(.32)	3(.08)	18(.47)	38(1.00)	24 June - 21 Aug.
	13(.13)	42(.41)	40(.39)	1(.01)	6(.06)	102(1.00)	31 October
Yearlings	1(.01)	26(.37)	6(.09)	13(.19)	24(.34)	70(1.00)	1 June - 12 June
	0(.00)	18(.25)	3(.04)	22(.30)	30(.41)	73(1.00)	24 June - 21 Aug.

without calves and mature bulls were associated at a significantly (99% confidence level) higher rate on October 31 than during the earlier period. Although the size of groups in which cows with calves were found did not change significantly with the season, the proportion of these females associated with bulls increased significantly (95% confidence level) from the summer period to October 31, at which time it was still significantly lower than the proportion of cows without calves associated with bulls.

Table 8 shows that yearlings changed their association patterns significantly (95% confidence level) from the period May 27-June 12 to the period June 24-August 21. In the earlier period, immediately following parturition, 37% of 70 yearlings seen were associated with females without calves, 19% were associated with other yearlings, and 34% were solitary. From June 24 through August 21, of 73 yearling associations observed, only 25% were with adult females without calves; whereas, 30% were then associated with other yearlings and 41% were solitary. In only one case (on June 1) was a yearling observed loosely associated with a cow accompanied by a calf. The yearling was at some distance from the cow and calf, but followed them in their movements.

Social Interactions. Social interactions between moose were observed during aerial counts and, most often, from ground observation posts. Interactions between all combinations of classes of moose, with the exception of cows leading calves, were observed on at least one occasion during the summer.

During June, when most moose remained on the valley floor, feeding in extensive bog-meadows, many non-directed interactions occurred. Groups of three, four, and up to six moose associated loosely in the feeding areas and did not interact specifically with one another. The group as a whole, however, had an amorphous consistency of movement. While moving in a seemingly aimless manner on a meadow 0.85 km^2 in extent, a single group of three-six animals invariably remained within less than 30 m of one another. No leader or dominant animal was recognizable during such movements. Most often, when one moose left an open meadow to enter brush, the entire group followed, one at a time, by the same route within 5-10 minutes. Occasionally, a single member of the loose group continued grazing for as long as 30 minutes, but eventually departed in approximately the same direction taken by the others.

Yearlings were the most mobile and easily observed moose during early summer. About half were solitary, and the others were either associated in "clubs" as described by Altmann (1960) or were in the company of adult females. Groups of two and three and, less commonly, four yearlings were seen feeding in meadows and travelling throughout the area. Sexes of the animals composing these groups followed no pattern, and no one yearling seemed to dominate any of these clubs or lead its movements. Association was characteristically very loose, with the animals 15-25 m from one another in most cases. Physical contact was observed in only one case, when two yearlings touched noses briefly. Sizes of clubs changed often with the loss or gain of one or

more yearlings. On some occasions, a club temporarily associated with one or more mature bulls or cows, but most often members of a club moved off as a complete unit, unaccompanied by an older animal.

During June, movements of yearlings seemed to be of much greater magnitude than later and, most certainly, were greater than movements of any other age class. On June 18 and 19, two yearling males, one marked with a plastic ear flag, travelled 3.2 km in less than 23 hours, showing no directional pattern of movement, but wandering seemingly aimlessly.

Many associations of yearlings with adult female moose were of a tenuous nature, and showed no discernable interactions. In three cases, however, yearlings were seen with cows in interactions of an offspring-maternal nature. Table 9 traces one instance in which a yearling was adopted by an adult female. The female was marked with red paint, indicating that she had dropped a single calf but had lost it sometime before June 19, when she was observed alone. The yearling probably had not followed the female continuously since calving, for it was seen associated with other yearlings, more than 3 km from the female's probable position. Probably the female accepted a yearling unrelated to her. The acceptance lasted for at least two days, during which time the yearling was observed following the female and grazing in close proximity to her.

The two other cases observed, on June 22 and 24, involved females that may or may not have produced calves. Each cow was associated with a single yearling that actively followed her cues in feeding, bedding

Table 9. Social interactions of a male yearling moose in June.

18 June:	1500	Yearling A moving in consort with another male yearling (B).
19 June:	1400	Yearling A and B still together, two miles from where first observed. Joined by third male yearling.
20 June:	0920	Yearling A associated with adult female, marked with red paint. Both feeding in open meadow.
	1150	A follows red-painted female into brush.
	1155	A re-emerges and grazes alone.
	1545	A and two other yearlings in consort with red-painted cow.
	1555	Painted female moves off; A follows 100 m behind.
	1708	Painted female and A grazing with same two yearlings.
21 June:	0255	Red-painted female and A grazing alone, in close association.
	0325	Red-painted female and A grazing alone, in close association.

down, hiding, and travelling. When they entered the brush or initiated any major movement, both cows showed the characteristic pause of females leading calves, and thereby seemed to stimulate the yearlings to follow. In addition to these two cases, yearling-adult female pairs within large feeding groups often acted more in unison than other moose within the group, indicating that some ties persisted through the month of June.

Bulls remained predominantly solitary during the summer period, when all associations observed were temporary. Geist (1963) made similar observations in British Columbia. Bulls were seen followed by yearlings on four occasions, but no "satellite" relationships, described by Altmann (1960), were observed. In one case, a bull struck twice with its front hooves at a yearling grazing very close to him in a shallow lake. The yearling retreated to 5 m distance, and the bull ignored it thereafter. Bulls often were observed tenuously associated with loose groups of feeding cows, yearlings and other bulls, but acting independently within the group. Sexual behavior was noted only once during the summer, on June 19, when a mature bull was seen nosing the vagina of a cow that had just urinated. Following perfunctory testing, the two animals moved away from each other.

With the exception of those associated with yearlings after June, females unaccompanied by calves remained solitary or only loosely associated during the summer. Cows in feeding groups acted much as did bulls, with no obvious recognition of other moose in the group. While in the meadows, however, cows tended to follow the shifting movements

of the group more than did bulls, and left the group less often than did males. Adult females were observed travelling in consort with other adult moose on only two occasions. On June 27, one female followed a bull within 5 m for 400 m, probably taking cues from his movements. In July, two cows cavorted together for 0.6 km across a meadow.

Movements and Home Range:

Seasonal Migration. Aerial counts and ground observations revealed a migration of moose from valley lowlands beginning in mid-June or early July. Figure 11, showing moose observed per hour of aerial counting, illustrates this emigration from the valley floor. Flooding of the valley by the Knik River on July 11 may have hastened the emigration, but normal activities preceding rut were probably its primary cause. As early as August 21, apparent movements of the heaviest concentrations of moose to the northeast were noted, and moose were first observed on bluffs north of the area on this date. Rutting moose were observed at altitudes of 500 m on October 1 and 2. On the latter date, a rutting group of two young males and one young female was observed on the valley floor, but close to the rising slopes in the north.

Only two moose were observed in 109 minutes flying time over the valley floor on October 30. On October 31, 243 moose were observed in 152 minutes flying time in the alpine areas to the north of the valley. No moose were seen on the valley floor during a short reconnaissance flight on November 30.

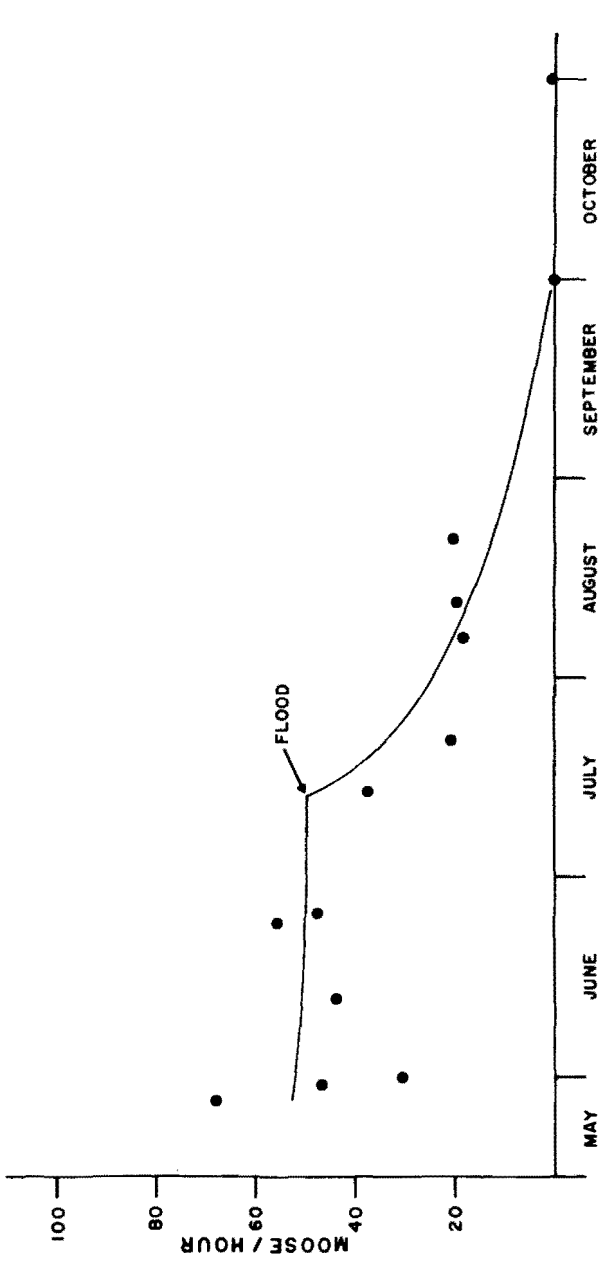

Figure 11. Migration of moose from the Jim-Swan Lakes area as indicated by the decrease in number of moose observed on the valley floor per hour of aerial counting from May 27 through October 31. The line showing migration is sketched by sight only.

The rutting migration took the Jim-Swan Lakes moose population to altitudes of approximately 1 km, almost precisely at tree line. The October 31 aerial count revealed moose at tree line along the northern boundary of the area and as far as 10 km from the area on the slopes of Lazy Mountain. Tagged calves observed confirmed that these moose were of the Jim-Swan Lakes population. A heavy concentration (48 in 2.5 km^2) of moose was also seen in the alpine-like vegetation close to the Knik Glacier.

Seasonal migration seemed to have lateral as well as altitudinal limits. Whereas, on all other areas, moose were seen at tree line, on the broad, gently sloping bed of Friday Creek none were present more than 6.5 km from the valley floor, where the altitude was only 750 m and the vegetation was still more dense than at tree line.

Home Range. Visual recoveries of tagged calves and returns of tagged animals by hunters afforded some basis for estimating the extent of movements of moose. Although these data may indicate maximum distances travelled, home range, or some intermediate estimate of movement, they are the best figures available for estimating home range. Home range was estimated from these data and from observations of movements of specific moose over a period of time.

Figure 12 compares movements of calves less than six months old and older moose, as revealed by visual and physical recoveries of tagged animals. Distances were recorded to the nearest mile, and are presented in this manner to avoid implication of greater accuracy than was employed. The figure suggests that cows leading one or more

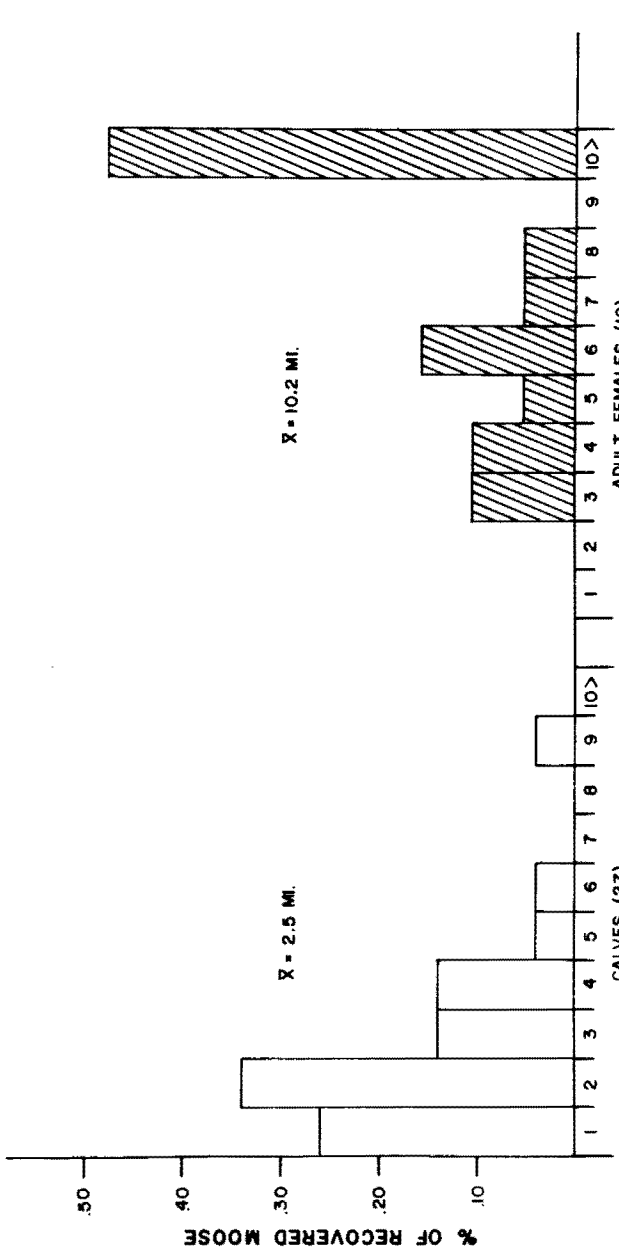

Figure 12. Movement of calf moose and adult females, as indicated by distance between the point of tagging and the point of recovery.

calves maintained a smaller home range than other moose. One of the 19 adult females recovered was tagged and recovered in the study area; whereas, the rest were tagged and recovered in other parts of the Matanuska Valley during 1963, 1964, and 1965. Average distance from the tag site of these females was 10.3 miles (16.6 km) (Rausch, 1965 -- unpublished data). The same average distance for 26 tagged calves on the Jim-Swan Lakes area was 2.5 miles (4.0 km). It is unknown how many of the 19 recovered cows were leading calves.

It is probable that the average distance a cow with calf travels from the parturition site during the calf's first five months is even less than indicated by Figure 12, because visual recoveries made after the summer-fall migration to higher altitudes are included in calculation of the average distance travelled. The same average, calculated for 25 calves seen before October 31, is 1.8 miles (2.9 km). Further, cows with calves were observed for as long as six consecutive days within areas of less than 1.6 km^2. Two cows with calves first seen at Jim Lake were observed in the same spot 40 days later. Such instances suggest that cows leading calves move only very short distances from the parturition site during summer.

Feeding:

Methods of Feeding. Almost all moose observed during the summer were feeding, because most bedding down was in secluded spots where observation was not possible. Only occasionally did moose bed in an open meadow where they also fed. Most often they moved at least a short distance into the brush. Bedded moose observed were almost

always observed ruminating and occasionally taking a few bites of sedge or low shrub while lying down. Most feeding observed was on sedges and pondweed in bogs and lakes and low willow and birch along bog edges. Moose reached above their shoulders for browse only occasionally, and this behavior never persisted for as long as a minute, before the animal moved off.

Certain feeding patterns were observed in all classes of moose. Every moose observed standing in plain view was feeding to some extent. Even moose travelling in a rapid walk across meadows snatched bites of food regularly. Animals entering or leaving lakes fed en route. Moose fed on aquatic vegetation while standing in water up to shoulder height. The depth of water selected varied, and investigation of lake bottoms showed that the animals selected for abundance of vegetation rather than for any given water depth. Adult moose submerged the entire head during most feeding, and kept it underwater for periods as long as 45 seconds. Moose chewed and swallowed the entire time the head was out of the water, and resubmerged after about 15-20 seconds in the air. When vegetation was close enough to the surface to allow cropping without entirely submerging the head, ears were kept in a half-cocked position, suggesting alertness. When the head was entirely submerged, ears were drooped on emergence and, unless the moose was disturbed, remained in this position until the next submergence. On three occasions, moose were observed eating floating vegetation while swimming.

Moose cropped sedges along pond edges both while standing on

shore and while in the water. Less time was spent along lake shores than in the water or browsing shrubs along the edges of timber. Browsing of willow and birch shrubs was less concerted than feeding in lakes and bogs, and was most often done in association with travelling or entering and leaving meadows. Adult moose plucked or stripped leaves from these shrubs, rather than breaking off twigs as is reportedly common in wintertime (Geist, 1963).

Yearlings, bulls, calves and cows each had characteristic feeding styles. In June and July, no pattern was recognized in yearlings' feeding, which was most often fitful snatching rather than steady feeding. Most yearlings were observed drifting from one spot on a meadow to another, seldom stopping for more than 5 minutes in any one spot. Feeding yearlings seldom showed signs of alertness, and were often very noisy in their movements. In August, most yearlings observed fed more concertedly, with shorter periods of inattention than in early summer. Even at this time, however, feeding was nervous. Choking and coughing were observed on two occasions, and appeared to be the result of eating too fast.

Bulls were most purposeful in feeding. Like other moose, they fed selectively while moving; but, most often bulls entered a lake or bog rapidly, fed in one spot for a long period of time with little behavior extraneous to feeding, and re-entered the brush. Bulls feeding by submerging their heads emerged only long enough to breathe, usually re-submerging in less than 10 seconds.

Whereas feeding bulls and yearlings were alert only rarely and

for very brief intervals, cows feeding in water assumed an alert or semi-alert position with almost every emergence of the head. A cow in this position stood motionless except for continued chewing and swallowing, with head erect and ears either fully erect or half-cocked. Orientation of the gaze did not seem to be toward the calf, but was determined by the position of the body, which seemed to be random in relation to the calf. Of eight females feeding in water requiring submergence of the entire head, and timed for 15 minutes or more, the mean ratio of time spent with head submerged:time spent alert was 1.7:1. Actual length of alert and feeding periods varied with the individual. No consistent difference in duration of alert periods or feeding:alert ratio was detected between cows with calves and those without.

Feeding cows with calves bedded down in brush close to the shore of the lake in which they were feeding restricted their feeding movements to a semi-circle about the calf. The radii of these circles varied greatly, from under 10 m to almost 300 m, although in most instances the cow did not move more than 30-40 m from the calf.

Calves fed on vegetation much as did yearlings, but concentrated even less on feeding. Calves commonly directed more attention toward their dam than toward feeding, actively observing the cow 60-80% of the time they were in the open. Calves grazed sedges on relatively dry ground and browsed shrubs more than they fed on submerged vegetation. No calf was observed with its entire head submerged. Browsing calves either picked individual leaves or stripped small bunches from the ends of branches.

Feeding Periods. In general, bulls spent the longest periods in uninterrupted feeding. One bull fed for 116 minutes without stopping, and most bulls observed fed for at least 60 minutes. In contrast, yearlings fed intermittently for long periods, but the longest observed period of uninterrupted feeding by a yearling observed was 39 minutes. Cows without calves fed generally for a little less than 60 minutes (average for seven periods of seven different cows, 54 minutes), and no cow without a calf was observed feeding for longer than 78 minutes without cessation.

Twenty-four complete feeding periods of cows leading calves averaged 66 minutes each (maximum 143 minutes), and 26 complete feeding periods of calves averaged 37 minutes (maximum 138 minutes). Geist (1960) found that in winter most calves and cows began feeding simultaneously and bedded down at the same time. During summer, calves on the Jim-Swan Lakes area most often left hiding after their dams had fed for 3-4 minutes, and bedded down while the females remained feeding. In about half the cases observed, the calf reappeared momentarily one or more times to approach the cow or feed while the cow continued feeding and then returned to hiding on its own. In the other cases, the calf re-emerged only to greet the cow as she entered the brush, or was not seen again after bedding down.

Figure 13 shows daily feeding periods of all moose and of cows with calves, as represented by the number of feeding animals observed in each hourly period per day of observation during that hour. Observations were made during 36 days during June, July, and August. One

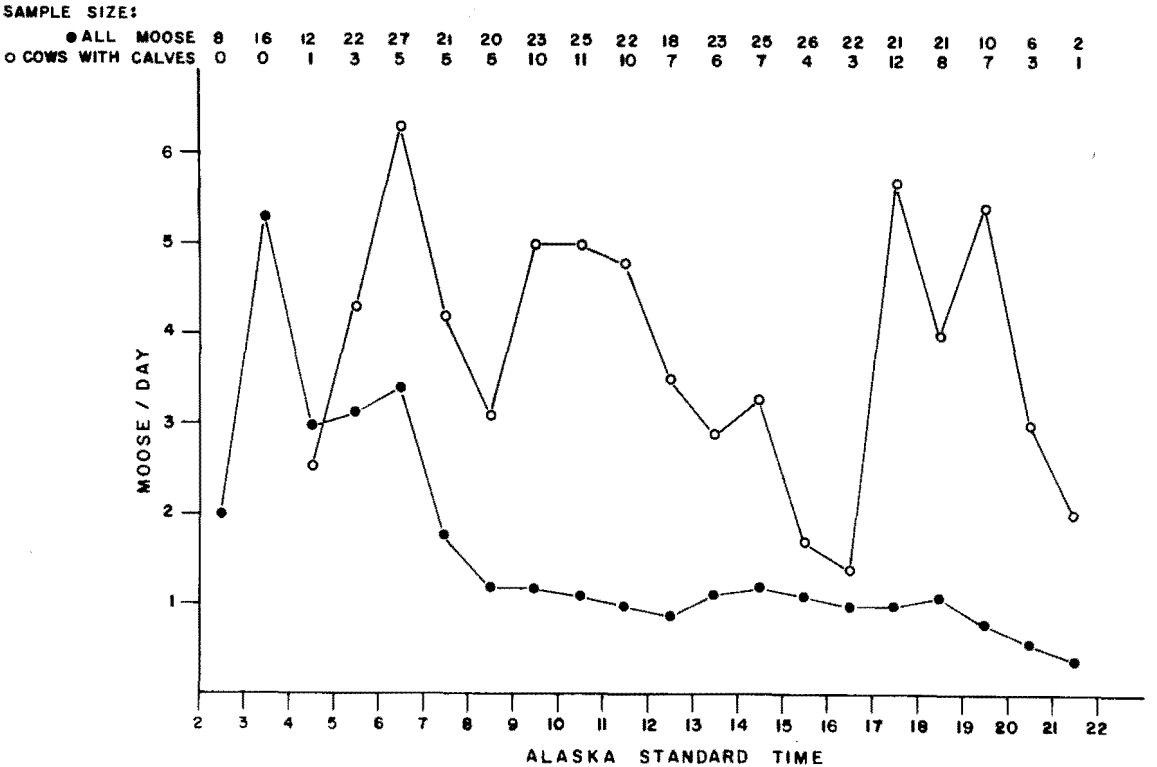

Figure 13. Feeding periods of all moose and of cows with calves, showing the number of feeding moose observed per day of observation during each one-hour period. Values for cows with calves have been increased by a factor of 10 for clearer graphic representation.

peak in feeding activity, from 0300 to approximately 0700, was detected for all moose. This peak roughly corresponds with the hour after dawn, and the wide spread may be a result of the change in the hour of sunrise from May through August. A suggestion of a second peak in feeding activity is present from about 1300 to 1500, but is not large enough to qualify as a true peak.

Cows with calves exhibited three major peaks of feeding activity during the summer. Their earliest peak occurred between 0600 and 0700, and is probably roughly analagous to the post-sunrise peak for all moose, since most observations of cows with calves were made in late July and August. A second peak was evident between 0900 and 1100, and a third occurred shortly before sunset, between 1700 and 1900.

Reaction to Disturbance:

Reaction to Human Disturbance. The reactions of moose to human disturbances varied from precipitous flight, to slow drifting away, to seeming disinterest. These reactions did not seem characteristic of any age-sex class of moose or to any specific type of disturbance factor, but seemed to depend upon the situation. Aggression toward humans by cows leading calves was observed in some cases during the tagging operation.

On many occasions, yearlings, cows without calves, and bulls showed reactions to close approaches by the author. Moose stood, ruminating, with ears up, staring toward the disturbance until I had approached usually within less than 100 m, and then either fled noisily or drifted ahead of my path of travel. The flight distance

varied greatly in individuals of these three groups of moose, from less than 10 m to almost 100 m, and did not seem correlated with the stealth of my approach. No cow leading a calf was ever approached closer than 75 m, even when I exercised utmost caution, although cows and calves often approached to within 30 m of me when I remained well hidden.

In fleeing, most moose behaved as described by Geist (1963), drifting off with many pauses to check the back trail. Behavior suggesting displacement feeding was observed briefly in a majority of such cases. On two occasions, yearlings allowed approach to within 50 m across an open meadow before they arose from a bedded position. Upon arising, they walked slowly away, keeping the separation between the author and themselves approximately 50 m and frequently pausing to stand broadside, turn their head and stare at me for a few seconds. Cracking twigs led to observed tensing and quivering of muscles in the hind legs of one moose in this position. A few moose, especially those startled in thick timber, fled precipitously and noisily. In every case, however, the moose paused at least once to stand broadside and observe the source of disturbance.

Cows leading calves were the most wary of all moose observed. Most often, stalking from a distance of 300 m or less resulted in the silent disappearance of cow and calf into the brush. On three occasions, attempting to stalk moose in a meadow where both a cow with calf and other moose were feeding, I came upon the others -- bulls, yearlings, and cows without calves -- grazing apparently

undisturbed, but found that the cow with calf had disappeared into the brush.

Occasionally, cows continued feeding after sighting a human observer 100 m or more away. In every case, the cow was between her calf and the observer, and much closer to the calf than to the observer.

Truly precipitous flight was never observed in a cow with a calf. The common means of retreat was slow, with frequent pauses for broadside alert in the direction of disturbance. On about half the occasions observed, the calf ran ahead, pausing every 30-40 m to wait for its dam. In these cases, the calf seemed to determine the path of retreat. In the other instances, the calf either maintained position alongside the retreating cow, or the cow paused about every 40 m in the broadside alert posture to await the calf.

Geist (1963) did not observe calves participating in alerts to disturbance. On two occasions in August on the Jim-Swan Lakes area, calves were observed in precisely the same head high, ears cocked, broadside posture seen in cows alerted to human disturbance. In one of these cases, the calf actually assumed the position, in response to whistles by the observer, 10-15 seconds before the cow did.

On two occasions, females with calves were approached closely on the ground. In both cases, the alerted animals used sound communication to become reunited. In one instance, a calf was flushed from high grass 10 m from the hiking observer. The cow was feeding 40 m away in a shallow lake. The calf fled silently, parallel to the lake

shore, and paused 20 m away in thick brush. The cow stared briefly, with ears up, at the calf, but continued feeding for almost 8 minutes, when she saw the observer at the spot where the calf was first discovered. The cow then commenced a fast walk toward the calf on shore, snatching occasional bites of floating pondweed and, on reaching shore, called to the calf with a quizzical, low-pitched "hmmmmmmm?" The calf bleated in return and trotted to join the cow as she approached. Both walked diagonally away from me, the cow frequently stopping to look back in the usual way.

On the second such occasion, I shouted, startling a cow feeding in a lake 65 m away. The cow ran ashore toward her hidden calf, paused on shore and grunted at the calf 60 m away, and then crashed into the brush, moving diagonally from the calf, which ran to join her within 100 m. In this case, the cow and calf were not seen again in the four following days I spent at the spot; whereas, in the former case, the disturbed cow and calf returned to feed in the same spot 12 hours later.

Cows with calves approached by helicopter reacted in a variety of ways. A majority of the cows approached circled near the calf nervously, with hair on the back erect, and head and ears down in the "head-low threat" described and illustrated by Geist (1963). Almost all cows urinated profusely on the initial approach. Often a cow ran a few meters from the calf, paused for the calf's approach, and then ran back to the calf. When approached very closely by the helicopter, most cows fled to a distance of 50 m or more, leaving the calf to

follow as best it could. About 15% of the cows approached did not leave their calves, even when the helicopter hovered less than 1 m over them. These cows stood in the head-low threat posture, shielding the calves crouching below their flanks. On two occasions, cows reared on hind legs and struck at the helicopter with front hooves.

When a calf was in the hands of the tagging crew and the helicopter hovered overhead, the cow most often circled the calf at a trot, with head and ears up, in a circle of ever-decreasing radius. Depending upon the degree of harassment by the helicopter, the cow approached within 20-30 m of the tagging crew, and stood briefly and repeatedly displaying the "head-high threat" described by Geist (1963). On four occasions, the cow exhibited the head-low threat and initiated a charge, usually from 15-25 m distance. The charge was rapid, with legs lifted high, head low, mane up, and ears back. In three cases the charge was halted by the tagging crew's shouting and waving of arms. In the fourth instance, the moose completed her charge at one member of the crew, but cut aside just before contact without pausing or raising her hooves. I suspect that the moose was dissuaded by the noise and propwash of the helicopter suddenly arriving overhead.

In all cases in which twin calves were handled, cows with one twin showed almost no aggressive tendencies, even though the second twin was in the hands of the tagging crew. Cows with twins fleeing the initial approach of the helicopter did not pause to wait for the second twin if one twin was close to them.

"Heeling" (Altmann, 1958) was observed in three calves, which

followed the tagging crew to the helicopter.

Reaction to Other Animals. OTHER MOOSE. Reaction to other moose varied as much as did reaction to human disturbance. As with human disturbance, the most consistently "shy" reactions were observed in cows leading calves. In a great majority of cases not involving cows with calves, the only reaction to the approach of another moose was initial ear-up alert, lasting from 15 seconds to 3 minutes, followed by return to normal posture. When approached closely by other moose, yearlings, bulls, and cows without calves seldom reacted to a greater extent than moving almost imperceptibly away from the new arrival. One exception, in which a bull chased a yearling, was described above.

Cows leading calves also reacted variously to other moose. No clear evidence of Altmann's (1958) described "sliding territory" surrounding the moose calf was observed. Rather, cows seemed to defend their calves as entities, often allowing close non-threatening approaches by other moose. In five cases, cows allowed other moose to move between themselves and their calves, and to approach the calves within 20-25 m, without responding with more than a brief alert in the direction of the calf. In one case, a cow did not react even when another cow approached her calf and thrice led it 5 m away from her.

Three cases of active defense of a calf from other moose were observed. In each case, the cow with calf, employing the head-down threat, easily dominated the other moose. Once, the cow chased off the intruder, a yearling that had moved between the feeding cow and bedded calf, with two arrested dashes in the yearling's direction, each

followed by a stamping of both stiff forelegs in the water. When the yearling approached her again, the cow displayed the head-down threat, at which the yearling stopped, and trotted into the brush to her calf. Cow and calf then retreated into the timber.

The other two incidents were initiated by aggressive behavior on the part of the intruding moose, but involved seemingly retaliatory aggression, beyond that required for defense of the calf, by the dam. In one case, a two-three year old male, moving between a calf feeding on shore and its dam feeding 75 m away in a pond, ran at the calf for two or three steps. The calf trotted rapidly into the brush, away from its mother. Alerted, the cow urinated and trotted after the calf, passing the bull within 3 m and slowing as she did so. A full 6 minutes later, the cow re-emerged from the timber, trotting full-speed and followed 10 m behind by the calf. With head down and ears back, the cow rushed the bull, which retreated into the pond. When he stopped, she rushed a second time, and he retreated still further, not stopping until he returned to shore 50 m from the cow and calf.

In the second case, as a cow which had been feeding in a pond walked toward her calf on shore, a second adult female walked beside her toward the calf. Soon both females were running toward the calf. Upon close approach to the calf, the second female gave the head-down threat, at which the dam did the same, stamping twice with front legs stiff. The second female retreated momentarily, but followed the cow and calf at less than 10 m distance. The calf and both cows stopped to feed, and the cow with calf drifted away from the other female.

Thirty-five minutes later, the calf, investigating the second female, caused its dam to charge this female again. Within the next 5 minutes, the dam charged 13 times, driving the other cow a total of almost 1 km along the shore and in the pond. At no time did the attacked cow noticeably threaten the calf.

BLACK BEARS. Black bears were observed in close association with moose five times. Only once did a moose react presumably to the presence of a black bear. On June 30, a 3-4 year old male moose, feeding in a shallow stream, suddenly held its head high, raised its ears, and trotted 300 m across a meadow into timber, pausing in the broadside, head-high alert position every 75-100 m. Thirty-three minutes later, a black bear was observed feeding following a course that would have taken it, in the brush, within 5 m of the bull's position when frightened. A yearling and an adult female, grazing no more than 30 m from the bull, showed no signs of alert.

Black bears were observed feeding in bogs within 50 m of undisturbed moose twice during aerial counts. A large black bear was observed crossing a meadow 300 m from an adult cow and a yearling and clearly visible to them. Neither moose showed any signs of alert. A young black bear was constantly present in and around my camp at Jim Lake for almost 4 weeks in July and August. Its presence did not deter the regular appearance of three cows with calves within 100 m of camp, nor did it prevent them from using a trail that passed within 30 m of camp.

BROWN BEARS. Four instances of interactions between moose and

brown bears were observed. All cases led to extreme agitation in the moose. On June 1, a large brown bear killed a moose and her twin calves. Evidence indicated that the bear had taken one calf, followed by the dam, and then the second calf. On August 28, a brown bear apparently surprised an adult cow bedded down near the shore of a large lake. The moose dashed headlong into the water and outswam the bear so that she reached the far shore, 1.2 km distant, five minutes before the bear. On reaching the far shore, the cow trotted at nearly full speed, head and ears up, along the shore of the lake, perpendicular to the swimming bear's path, and then into shoreline brush.

In the other two instances observed, brown bears did not actively pursue moose, but caused them to flee nevertheless. In both cases, the bear approached the moose from upwind. On June 22, a bull moose suddenly left a meadow in which it was grazing. Three minutes later, a brown bear appeared in the far end of the meadow, travelling toward the bull's original position. One hundred fifty meters behind the bear, a cow and calf were observed momentarily as they crossed a narrow open strip of meadow. The cow stood tensely at timber's edge, with nose and ears up, staring at the bear, as the calf entered the brush. The cow quickly followed the calf. Eighty minutes later, a mature cow was seen 800 m away, in the bear's presumed path, trotting rapidly across a meadow, with nose raised and ears and mane erect. The bear was not seen at this time.

On July 25, observing from a bluff overlooking a lake, I recorded: "1921: Cow and calf enter water to feed. 1936: Female

leaves water and walks, then trots, toward woods. Calf follows. 1940: A second cow, head down, and calf pass immediately behind camp at a good trot. 1943: Third female and calf enter water noisily at approximately same place first pair did. Female alerts 3-4 seconds to brush, then trots and swims into deep part of lake. Calf tries to keep up. 1946: Medium size brown bear travels up hill from where first and third females seen, and passes directly behind camp."

Maternal and Calf Behavior:

Protection of Calves -- Concealment. Aggressive defense of calves and retreat from disturbance have been described. Concealment of the calf is at least as important as these two factors in maternal protection.

Calves are the best-concealed age-sex class of moose, and are best hidden in the month following parturition. Figure 14 shows "exposure factors" of calves, yearlings and bulls. Exposure factor, the ratio of the number of a given class of moose:100 cows seen during observations made from the ground to the number of the same class:100 cows seen during aerial counts, is a rough estimate of the hiding ability and activity of various classes of moose. Figure 14 shows that, during the month of June, calves had an exposure factor of approximately 0.6, as compared to 2.1 for yearlings and 2.6 for bulls. During July and August, the exposure factor for calves increased to approximately 0.8, indicating that calves were more active and less well hidden in their second and third months than during the first month after birth. This contention is supported by observations of

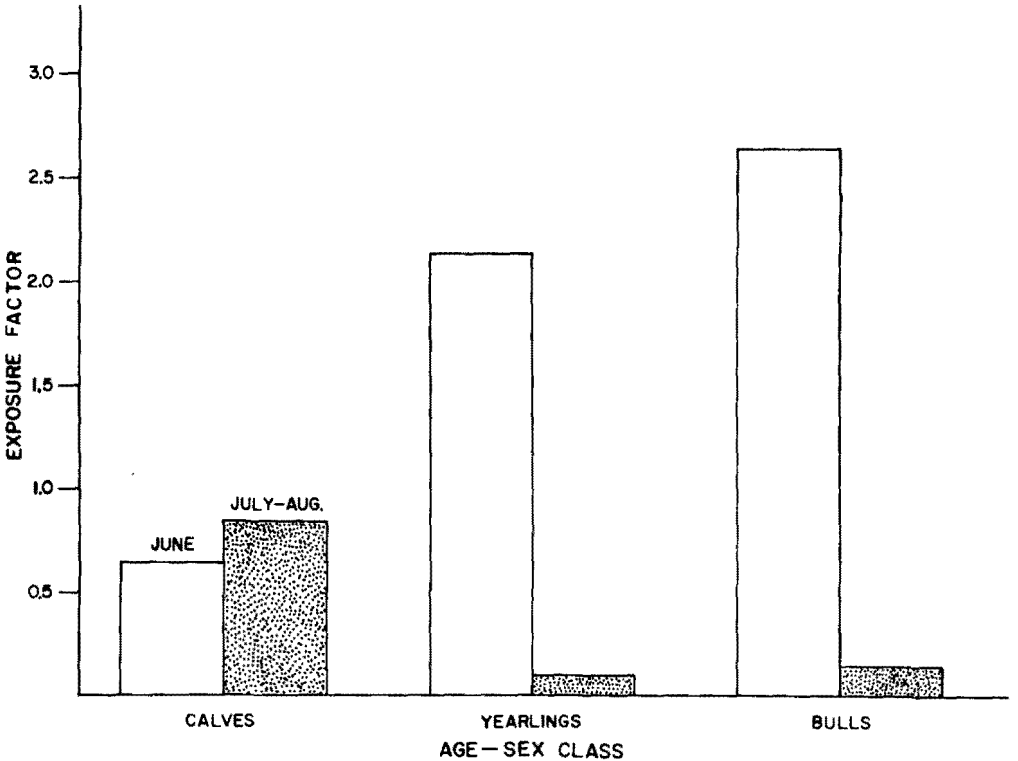

Figure 14. Hiding tendencies of calf, yearling, and bull moose in June and July-August. "Exposure factor" is the ratio of calves, yearlings, or bulls per 100 cows seen during ground observations to the same parameter observed during aerial counts.

calf activity. The exposure factors for yearlings and bulls have little meaning in the second time period, for ground observations during July and August were concentrated in an area containing predominantly adult females and calves.

Calves were hidden from observation by their own behavior and by the behavior of their dams. Characteristically, cows and calves either entered an open meadow together, or the cow entered and began feeding 3-4 minutes before the calf appeared in the open. After feeding or cavorting, calves returned to brush or high grass and bedded down, becoming all but invisible. A strong factor in the effectiveness of concealment of the calf was the female's "indifferent" manner. Cows fed and bedded down, within 10-20 m of bedded calves, for periods as long as 90 minutes, without giving any indication of the presence of the calf. Except when disturbed, cows feeding in the vicinity of calves did not look in the direction of the calf any more often than they looked in other directions. Perhaps the most striking instance of maternal "indifference" occurred on June 27, when a cow grazed almost 300 m from her bedded twin calves for 90 minutes.

Concealment -- Reunion of Calves with Cows. Re-uniting of cow and calf after completion of the cow's feeding period was accomplished either directly, indirectly, or through a delayed action. Direct reunification of the bedded calf with the dam was most prevalent during the month of June. When the cow ceased feeding, she approached the bedded calf, nuzzled, licked, or sniffed it, thereby apparently stimulating it to rise, and led it into the brush. Indirect and

delayed reunification were observed most often in late July or August. In the indirect approach, the feeding cow entered the brush moving diagonally away from the bedded calf. Usually just before the female entered the brush, the calf rose and quickly took a course convergent with that of the cow some distance in cover. Cow and calf disappeared in the timber, as much as 50 m from each other, almost simultaneously.

Delayed reunion was observed in a majority of calves in July and August, and was observed once as early as June 19. While the calf remained bedded and out of sight, the female would enter the brush with little or no discernible recognition or sign in the calf's direction. Thirty seconds to 2 minutes later, the calf would rise quickly and trot into the brush where the female had disappeared. On July 24, I recorded: "1225: Cow feeds at moderate rate toward calf, feeds right by it with no response from either, save an almost imperceptible pause by the female 2 m from the calf. Female feeds into timber. Just as cow enters brush, calf jumps up, jerks head and trots toward her. Female proceeds 15 m into brush, stands alert but not looking directly at calf. Calf pauses momentarily at edge of timber, then trots in, catching up with cow, which started to move away as soon as calf entered cover."

When bedded down, calves most often lay on one side, with legs stretched out or folded under the body. Calves seldom slept while the dam was feeding. Most often, calves held their heads up, with ears cocked and constantly twitching. Occasionally, a calf rested its chin on the ground in front of it. Calves in these positions were extremely

well hidden, even when they carried colored flags on both ears.

In August, calves observed spent more time on their feet than did calves seen in June and July. This fact is reflected in the increased exposure factor during these months. Three month old calves browsed and fed along the shorelines of lakes in which their dams were feeding on aquatic plants, usually staying opposite their dam's position, but in some cases, moving down the shoreline as far as 100 m from the cow. Every 15-25 minutes, these calves walked, ran, or swam to the feeding cow, nuzzled her and circled her for 2-3 minutes, and then returned to shore to continue feeding. An active calf was never without contact with its dam for longer than 30 minutes at a time.

Nursing. Altmann (1963) suggests that nursing occurs on the calf's initiative. Of seven instances of nursing behavior I observed, only two were initiated by the calf. Both occurred in middle June, and neither resulted in nursing by the calf. In both cases, the cow, feeding in water, was approached from the rear and nuzzled by the calf. She licked the calf, and stepped away when the calf reached for her udder.

Five nursings were observed in June and July. In all cases, cow and calf met "half way," the cow walking toward shore and the calf wading toward the cow. In all cases the calf moved directly for the udder, was licked by the cow, and nursed for 35-50 seconds with its posterior toward the cow's shoulder. In all cases, nursing was terminated when the cow took one step away. Never did a calf attempt to nurse after the cow had thus given what appeared to be a signal to

halt. Twin calves were observed nursing simultaneously on two occasions.

Communication. Communication between cow and calf was by movements and vocal signals. The former means was most common, and was used primarily to signal initiation of travel and changes in activity. Calf moose often acted mimetically, displaying the "heeling" response described by Altmann (1958), rather than in response to evident special maternal signals. When cow moose ceased feeding and entered timber, calves followed. When cows fled disturbance, calves did the same. Exceptions occurred when activities involved separate actions in calf and cow. In such cases, vocal communication was common, as was apparently independent initiation of the activity by the calf with no signal from the cow.

Vocal communication was noted twice preceding nursing behavior. In both cases, the female, feeding 10-20 m offshore in a lake, stood with ears up, facing the calf bedded on the shore, and uttered a quizzical, low-pitched "hmmmmmm?" sound. The calf responded with the high-pitched bleat characteristic of calves, and the animals moved toward each other, the calf continuing to bleat until it began to nurse. On one occasion the "hmmmmmm?" sound, made by cows before nursing and when threatened (page 69), was uttered by a feeding cow, whose calf responded by emerging from the brush in which it was hidden and commencing to graze sedges along the lakeshore. In another instance a cow made the same sound just as she ceased feeding and began to wade ashore. Her calf followed her diagonally into the

brush.

Calves used a somewhat higher pitched bleat as a distress signal. This sound was uttered by every one of the 59 calves captured for tagging and by two calves surprised by the observed on the ground. The cow's verbal response to a calf's distress call was a short deep-throated grunt. This sound preceeded either flight or aggressive behavior.

Maternal Confusion of Calves. Maternal confusion of calves was observed twice, once during the tagging operation in May and once on July 26. In the first instance, a cow whose calf was being tagged was chased 200 m away by the helicopter. Here she met another cow and a calf, and ran toward the calf. The calf's dam gave the head-down threat and the first female retreated very nervously. Ten minutes later, this female was seen reunited with her calf.

In July, a cow, which I shall call cow A, whose calf was bedded in shoreside brush, was feeding in a pond when another cow ("B"), accompanied by a calf, entered the pond 50 m away. Cow A immediately raised her ears and stood briefly in the alert position, and then ran toward cow B and her calf. Cow B alerted for 15 seconds, but then resumed feeding. Cow A stopped 10 m from cow B and the calf, and flopped her ears, shaking her head. The calf took a few steps toward cow A, but ran behind cow B when A came toward it. The calf approached A twice more within 5 minutes, fleeing behind its dam each time A approached it. B showed no strong reaction to A, but continued feeding. Finally, A ran into the timber, ears up and chin high. Two minutes

later she was reunited with her calf, and the two moved off.

Agonistic Behavior in Calves. Agonistic behavior was directed toward other calves by a captive calf on June 2. On introduction into a pen with seven other calves, all smaller than she, a two-three week old female calf stood rigidly, muzzle, mane and ears up and nose sniffing, in the center of the pen. Suddenly she lowered her ears and head, assuming the head-down threat described in adult moose, and attacked a small calf standing shakily whimpering in the center of the pen. She struck the second calf with both front hooves, knocking it down, and proceeded over it, striking with hind hooves also. She repeated this attack twice in less than a minute, striking each time the younger calf stood up. Then she struck in the same manner at the other six calves huddled together in the corner of the pen, knocking two of them off their feet. The calf was removed by the keeper, whom she also struck with her front hooves.

Appendix 1

TAGGING AND MARKING METHODS

Calves were tagged with 75x150 mm plastic impregnated canvas flags, folded over the anterior margin of the ear and held in place by numbered metal ear-piercing tags. Seven solid colors were used, and tags were placed on one or both ears in order to make use of all possible color permutations. Due to the similarity of some colors to others, it was necessary to stripe some of the flags to make individual identification of the 59 calves possible. Strips of the same material of contrasting color, 30 mm in width, were sewn in place 30 mm from one end of the flag, using a regular garment sewing machine and heavy waxed cotton thread. The flags were attached to the calf so that the stripe was clearly visible on the upper surface of the ear. These stripes seemed permanent enough to allow identification throughout the first summer (they were noted on October 31), and were easily identifiable from the air and from within 800 m on the ground with the aid of the spotting telescope.

Parturient cows were spotted by an observer in a Supercub, who radioed directions to the pilot of a Hiller 12-E helicopter. The helicopter carried a two-man tagging crew and a pilot. On sighting a cow with a calf, the helicopter pilot descended and attempted to land or hover low between the calf and cow. When this occurred, the tagging crew left the helicopter and pursued the calf, tagged it, and returned to be picked up. During the time the crew was on the ground, the helicopter hovered near the cow and herded her away from the taggers.

One man of the tagging crew carried tags, flags, and pliers; the other man carried a rifle and forms on which he recorded sex of the calf, tag numbers, and area where tagged. During the operation in the Matanuska Valley in 1965, 260 calves were tagged at the rate of approximately 8.7 per hour.

Cows were marked with day-glow paint diluted two parts paint to one part paint thinner. The paint was poured into glass Christmas ornaments, about the size of baseballs, which were plugged with masking tape. The method was of little success. Except on rare occasions, it was necessary to harass the cow more than desirable in order to get her into a position where she could be hit with a paint bomb. Secondly, when a cow was hit, the ball often did not break. This was due to the drying of the paint on the interior surface of the ornament, and the resulting strengthening of the glass, and to the soft cushion of hair on the backs of the still unshed cows. The marking was probably temporary on those cows which were marked, due to shedding subsequent to marking. No painted cow was seen after June 25. Of 34 cows chased in an attempt to mark them, only nine were marked. Of these, four were marked only slightly, and the remaining five were well marked.

LITERATURE CITED

Altmann, Margaret. 1958. Social integration of the moose calf. Animal Behaviour, VI(3&4):155-159.

_____. 1959. Group dynamics in Wyoming moose during the rutting season. J. Mammal., 49(3):420-424.

_____. 1960. The role of juvenile elk and moose in the social dynamics of their species. Zoologica, 45(1):35-39.

_____. 1963. Naturalistic studies of maternal care in moose and elk, p. 233-253. In Harriet L. Rheingold, ed. Maternal behavior in mammals, John Wiley & Sons, New York.

Atwell, G. 1963. Moose Report. Alaska Department of Fish and Game, Vol. IV, Annual Project Segment Report, Federal Aid in Wildlife Restoration, Project W-6-R-4.

Didrickson, J. C. 1961. Annual Report of Progress, Investigations Project, Completion of the 1960-1961 Segment, Alaska Department of Fish and Game, Annual Report of Progress, 1960-1961, Federal Aid in Wildlife Restoration Project W-6-R-2:51-64.

Geist, V. 1960. Diurnal activity of moose. Memoranda Societatis pro Fauna et Flora Fennica 35. 1958-1959:95-100.

_____. 1963. On the behavior of the North American moose (Alces Alces Andersoni Peterson 1950) in British Columbia. Behavior, XX (3,4):377-416.

Rausch, R. A. 1959. Some aspects of population dynamics of the railbelt moose populations Alaska. Unpublished M. S. thesis. University of Alaska.

_____. 1965. Unpublished data.