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MOOSE CALF MORTALITY IN SUMMER ON THE KENAI PENINSULA, ALASKA

Although neonatal and summer mortality of moose (*Alces alces*) calves is recognized as an important factor in moose population dynamics, few data are available defining causes of mortality. In the Tanana Valley of central Alaska, Gasaway et al. (1977) recorded a decrease in moose (*A. a. gigas*) calf numbers from 44 to 14 per 100 cows from June to November 1975, and concluded that predation by wolves was the most probable cause of these losses. Predation by wolves on young ungulates has been reported also by Mech (1966), Mech and Frenzel (1971), Kuyt (1972), Miller and Broughton (1974), and Van Ballenberghe et al. (1975).

LeResche (1968) observed that moose calf numbers decreased from 83 to 36 per 100 cows from May to October, near Palmer, Alaska. He did not consider black bears (*Ursus americanus*) or wolves (*Canis lupus*) to be important predators of moose calves, but observed a brown bear (*Ursus arctos*) killing a cow and 2 calves. LeResche (1968) also reported several accidental deaths of calves and desertion of calves by cows in 2 instances. Chatelain (1950) reported a high incidence of black bears eating carcasses of young moose calves on the Kenai Peninsula.

After an absence of about 50 years, wolves reappeared on the Kenai Peninsula during the 1960's. Recently, densities peak during early winter to approximately 1 wolf/65 km^2 on primary wolf range (R. Peterson, unpubl. data). Because there are 3 major predators of ungulates on the Kenai Peninsula (wolves, black and brown bears), and 4 major ungulates (moose, caribou [*Rangifer tarandus*], Dall sheep [*Ovis dalli*], and mountain goats [*Oreamnus americanus*]), we needed to obtain a better understanding of predator-prey relationships and specifically how predators influence mortality of moose calves in summer. Techniques developed by Schlegel (1976) in Idaho to determine the influences of predators on elk (*Cervus canadensis*) calves were adapted for our study.

Table 1. Capture status of moose cows and calves captured (*N*) for calf mortality study, Kenai Peninsula, Alaska.

Year	Cows immobilized	Calves processed with cow			Calves processed without cow[a]		
		Bonded	Unk.[b]	Separated	Bonded	Unk.	Separated
1977	13[c]	10	2	4	5	2	2
1978	10[d]	5	2	5	27	2	2
Total	23	15	4	9	32	4	4

[a] Calves processed without cow in 1978 were radio-collared only.
[b] Unknown category includes calves dead at capture and those whose radio transmitter failed immediately.
[c] Three cows had twin calves.
[d] One cow had twin calves.

METHODS

The study was conducted from the Kenai Moose Research Center (MRC), which is on the Kenai National Moose Range in the northwestern Kenai Peninsula lowlands. A detailed description of the study area was presented by Oldemeyer et al. (1977).

Calves were located by visual search from a helicopter (Bell Jet Ranger) during the peak calving period (late May, early June), and were captured when they were 1–3 days old. Calves were captured by immobilizing the cow (Gasaway et al. 1978) or by using the helicopter to force the cow away from the calf and landing nearby to capture the calf. When the cow was immobilized, physiological and morphological data were obtained from the cow and the calf (Franzmann and LeResche 1978, Franzmann et al. 1978) and a radio-collar was attached to the calf. When the 2nd capture method was used, only radio-collaring was done.

The design of the radio-collars and monitoring systems was outlined by Ballard et al. (1979). The transmitters pulsed at approximately 60 beats/minute (slow mode) while the calf moved, and when movement ceased for 4 hours the pulse tripled (fast, or mortality, mode). During 1978, the time setting for the fast mode was decreased to 1 hour. Moose calf mortality assessment and the characteristics of predator-killed moose calves were discussed by Ballard et al. (1979).

During our study the 1-hour setting for activation of the fast radio pulse (to detect death of the calf) was better than the 4-hour setting. We had 6 false alarms with the 1-hour setting, but in general we benefited by getting to the dead animal sooner. When the fast mode was detected we located the calf from a fixed-wing aircraft and, if the calf was dead, noted if predators were on or near the calf. We subsequently went to the calf and made a thorough investigation of the remains and the area. The carcass was examined for puncture wounds, claw marks, parts consumed and chewed, subcutaneous hemorrhage, and position. Signs around the carcass such as tracks, scats, hair, and beds were noted. Calves that were sufficiently intact were necropsied. We sampled hair, scat, and bones, and photographed the carcass.

RESULTS AND DISCUSSION

Sixty-eight moose calves were radio-collared and 23 cows were immobilized during the 2-year study. Cow-calf bonds were retained by 15 radio-collared calves that we had captured by immobilizing the cow. Another 32 calves captured without immobilizing the cow remained bonded, and so we had 47 radio-collared bonded calves to monitor (Table 1). We

Table 2. Causes of death of moose calves based on monitoring 15 calves until 15 August in 1977 and 32 calves until 30 July in 1978, Kenai Peninsula, Alaska.

Cause of death	1977	1978		1977–78	
	N	*N*	%[a]	*N*	%[b]
Black bear	6	10	31	16	34
Brown bear	1	2	6	3	6
Wolf	1	2	6	3	6
Unknown predator	1			1	2
Total predator mortality	9	14	44	23	49
Accidental		2	6	2	4
Unknown	1	1	3	2	4
Total mortality	10	17	53	27	57

[a] Percentage of 32 calves monitored.
[b] Percentage of 47 calves monitored.

define a bonded cow and calf, or calves, as a unit that remained together at least 48 hours after capture.

We altered the capture technique for calves in 1978 by not collecting physiological and morphological data from the calf, because in 1977, 2 of 7 calves whose mothers we immobilized separated from their mothers after we took the additional time to collect the data. Consequently, cow-calf separation took place in 1978 for only 2 of 29 calves (7%) (Table 1).

Of 15 bonded calves studied in 1977, predators killed 9 before 13 July and 1 died of an unknown cause. Black bears killed 6 calves, wolves 1, brown bears 1, and unknown predation accounted for 1 (Table 2). Among 32 bonded calves monitored in 1978, predators killed 14 (44%) by 30 July. Black bears killed 10 calves (32%), brown bears 2, wolves 2, and unknown causes 1 (Table 2). The pattern and proportion of mortality were similar for both years. Total predation accounted for about half of the calf mortality through late July and black bears accounted for a third of the predation. Total moose calf mortality from all causes for both years was 58%.

Black bear predation appears to occur when moose calves are small, and may nearly cease by the time the calves are 1–2 months old. In 1977, when we monitored calves until 15 August, 5 of 6 kills by black bears occurred in June and the last one occurred on 13 July. In 1978, we observed no kills by black bears after the end of June (6 of the radio-collared calves were still alive in February 1979).

The question arises as to whether or not the calves classified as predation mortalities may have died of other causes. We made 784 aerial sightings of radio-collared moose calves and 4,313 radio contacts with unseen calves. With this intensive monitoring we were able to examine 55% of the carcasses within 12 hours after death and 85% within 24 hours. We observed 26% before the fast-pulse signal was activated, and in 13 cases the predator was seen eating the carcass or was nearby. Separation from their dams and starvation of 4 calves (including 1 set of twins) and capture-related deaths of 2 cows occurred. We were not able to check back on all capture-related deaths, but carcasses of calves that we checked were unused by bears or wolves during 1 or more days after death. A cow necropsied on 31 May 1977 showed no sign of disturbance from then until 12 June 1977. A calf that died on 6 June 1977 was not disturbed as of 14 June 1977. Another calf had been dead 36 hours before radio recovery and was undisturbed at that time. A calf that died on 8 June 1977 was necropsied the same day, and when visited again on 18 June, had not been disturbed. Lack of use of dead calves also was reported in another study of moose calf mortality in Alaska (Ballard and Taylor, Alaska Dep. Fish and Game, Pittman-Robertson Proj. W-17-9, 10, unpubl. rep., 1978).

The Kenai Peninsula moose population has declined since the early 1970's, but stabilized at a low point around 1975. Random stratified counts from the Kenai National Moose Range reflect this; the estimates were 7,904 ± 1,461 (SE) in 1971, 5,692 ± 1,348 in 1973, 4,850 ± 1,045 in 1974, 3,375 ± 986 in 1975, 3,782 ± 605 in 1976, and 3,394 ± 878 in 1979. No counts were made in 1977 or 1978 due to lack of snow. The population decline was attributed primarily to the decrease in browse quality and quantity (Oldemeyer et al. 1977) and the severity of winter mortality during the early 1970's. Heavy calf mortality in winter and poor recruitment in the early 1970's influenced the age structure of the moose population in such a manner that moose, in what would have been part of their peak productive years, were absent from the population. The mean age of 23 cows in this study was 8.7 years and only 4 were in the 4- to 7-year age-classes.

Reestablishment of wolves on the Kenai Peninsula coincided with the moose population deline, and heavy mortality of moose in winter in the early 1970's contributed to the rapid buildup to a recent density of 1 wolf/65 km^2 (R. Peterson, unpubl. data) on the northern Kenai lowlands. Road kills on the Kenai vary from 100 to 250 moose per year depending on snow conditions (Alaska Dep. Public Safety files, Soldotna). The annual harvest (bull only) since 1974 has ranged from 285 to 368. Poaching, accidental, and miscellaneous causes also contributed to the total mortality.

Nevertheless, in recent years, mild winters and certain habitat changes have been benefiting the Kenai Peninsula moose population. A mechanical rehabilitation program using tree crushers (LeTourneau Co., Longview, Tex.) was started on the Kenai National Moose Range in 1975. Approximately 2,805 ha of moose habitat had been rehabilitated by 1978. The treated areas have attracted large numbers of moose at various times of the year. In 1969, a 33,000-ha burn occurred on the Kenai Peninsula lowland, and use of this area by moose has increased in recent years. The past 3 winters have been relatively mild, and that has increased the overwinter survival of moose. The twinning rate for moose in spring 1978 was 22% (8 of 36) on our study area. With this relatively high twinning rate we submit that this moose population is demonstrating high reproductive potential.

The problem facing the Kenai Peninsula moose population appears to be—can this lower-density, older-age population maintain or expand itself in spite of the high rate of black bear predation on calves during the summer and the year-round wolf and brown bear predation, in addition to other forms of mortality?

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CORRIGENDUM

Burnham, K. P., and D. R. Anderson. 1979. The composite dynamic method as evidence for age-specific waterfowl mortality. J. Wildl. Manage. 43:356–366. At the bottom of page 359, the formula for the degrees of freedom of the goodness of fit test for the composite dynamic model should be

$$\frac{k(k+1)}{2} + k(l-k) - l.$$

This correct formula was used in analyzing the data underlying Tables 1 and 2. In particular, the significance levels reported in Table 2 for this test are correct.