CAUSES OF NEONATAL MOOSE CALF MORTALITY IN SOUTH CENTRAL ALASKA

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Abstract: During spring 1977 and 1978, 136 moose (*Alces alces gigas*) calves were radio-collared in the Nelchina and Susitna river basins of south central Alaska in an effort to determine causes of mortality. Thirteen calves (9.5%) died as a result of collaring activities. Of 123 remaining calves exhibiting normal cow-calf bonds, contact with 3 calves was lost and 66 (55%) died of natural causes. Predation by brown bears (*Ursus arctos*) was the most important cause of mortality, accounting for 79% of the deaths. Timing of the deaths of radio-collared calves was similar to that of uncollared calves of radio-collared adults, which indicated that collaring did not predispose the calves to predation. Ninety-four percent of the natural mortality occurred before 19 July each year. Little scavenging of either abandoned or predator-killed calves was observed. Radio-collared brown bears were observed on 78 kills during 1978, averaging 1 ungulate kill/6.1 observation days. Moose of all age-classes comprised 87% of the kills and calves were the most common prey (57%). Identification of brown bear as a significant predator of moose complicates attempts to understand and manage ungulate-carnivore relationships.

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The Nelchina and upper Susitna river basins of south central Alaska have been important areas for moose hunting in recent years, accounting for 18% of the annual statewide harvest. The moose population peaked in 1960, and began declining after the severe winter of 1961–62. Severe winters also occurred in 1965–66 and 1971–72. Severe winters were thought to have precipitated the decline, but factors such as predation, range deterioration, hunting, and low bull:cow ratios were also thought to have contributed (Bishop and Rausch 1974).

During this decline the moose population began exhibiting low calf recruitment, reflected by moose sex and age composition counts (Alaska Department of Fish and Game [ADF&G], unpubl. data). Even after relatively mild winters, calf:cow ratios remained low and declined to 15 calves/100 cows in 1975. Predation by gray wolves (*Canis lupus*) was thought to prevent the moose population from increasing.

Similar declines occurred in at least 2 other Alaskan moose populations, but the timing and the ecological situations were considerably different. On the Kenai Peninsula the moose populations remained high or increased prior to 1970, then declined due to severe winters (Bishop and Rausch 1974) and a decline in browse quality and quantity (Oldemeyer et al. 1977). The resulting moose die-off coincided with a wolf population increase that resulted in a wolf density of 1 wolf/65 km^2 (Franzmann et al. 1980). On the Tanana Flats, however, the moose population increased, crashed, and then recovered between 1950 and 1972; severe winters were thought to be the controlling factor (Bishop and Rausch 1974). In the mid-1970's, the population again declined and wolf predation was suspected of preventing the population from recovering (Gasaway et al. 1977).

Several studies were initiated in an effort to identify the reasons for the moose population declines. Several approaches were used, as described by Franzmann and Bailey (unpubl. rep., Alaska Dep. Fish and Game, Fed. Aid Proj. W-17-9, 1977), Oldemeyer et al. (1977), Gasaway et al. (1977), Stephenson (unpubl. rep., Alaska Dep. Fish and Game Fed Aid Proj. W-17-8, 1978), and Ballard and Spraker (unpubl. rep., Alaska Dep. Fish and Game Fed. Aid Proj. W-17-9 and 10, 1979). The Tanana Flats and Nelchina Basin studies evaluated the effects of wolf predation on moose calf survival in part by reducing wolf densities. All study approaches attempted to enumerate predator and prey densities by using radiotelemetry and aerial surveys.

In the Nelchina study, food habit studies of the gray wolf indicated that moose comprised the bulk of the year-round diet, but rates of predation on calves were not sufficient to cause the low moose calf:cow ratios in the basin (Ballard and Spraker, unpubl. rep., Alaska Dep. Fish and Game Fed. Aid Proj. W-17-9 and 10, 1979). A preliminary analysis of moose population data indicated either small or no increases in numbers of calves/100 cows following reduction in wolf densities. Evaluation of several blood parameters, used by Franzmann and LeResche (1978) to assess the physical condition of Alaskan moose populations, revealed that Nelchina Basin moose rated high in comparison to other populations, and indicated that deteriorating range conditions probably were not the cause. Moose pregnancy rates determined by rectal palpation were normal (88%), and thus low initial calf production due to low bull:cow ratios was ruled out (Ballard and Taylor, unpubl. rep., Alaska Dep. Fish and Game Fed. Aid Proj. W-17-9 and 10, 1978). As a result of these studies, it became apparent that a more direct method of determining causes of moose calf mortality was needed.

In Idaho, newborn elk (*Cervis elaphus*) calves were fitted with radio-collars and monitored to determine the causes of mortality (Schlegel 1976). Schlegel's technique was adapted to newborn moose calves concurrently for both this study and a study on the Kenai Peninsula (Franzmann et al. 1980). The objectives were to identify specific causes of moose calf mortality between parturition and November, when fall sex and age counts are conducted. This paper reports results of the Nelchina calf mortality study and brown bear predation studies, and discusses their management implications. These studies and the Kenai Peninsula moose calf mortality study (Franzmann et al. 1980) were conducted concurrently during 1977 and 1978.

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STUDY AREAS

The study was conducted in portions of the Nelchina and upper Sustina river basins in south central Alaska (Fig. 1). The area, referred to as Game Management Unit 13, consists of approximately 61,595 km^2, of which 18,798 km^2 are above 1,200 m in elevation.

Moose calf mortality was studied in 3 areas (Fig. 1). Area 1, the Susitna River Study Area, was selected because of its low density of wolves (averaging 1 wolf/567 km^2), which resulted from wolf removal by ADF&G personnel in 1976 and 1977 (Ballard and Spraker, unpubl. reps., Alaska Dep. Fish and Game Fed. Aid

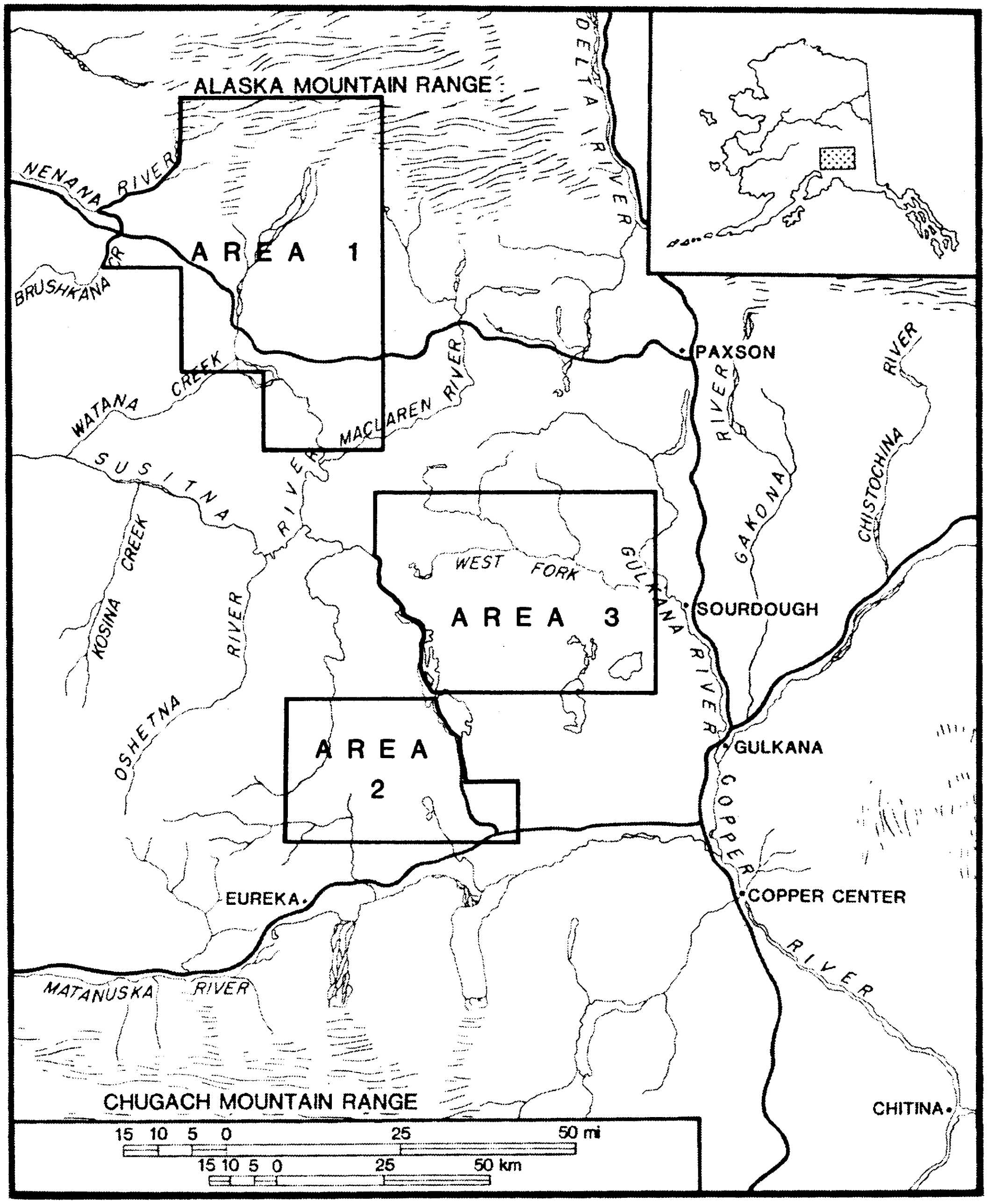

Fig. 1. The Nelchina and upper Susitna river basins and locations of study areas where causes of moose calf mortality were studied during 1977–78.

Proj. W-17-9 and 10, 1979). Areas 2 and 3, the Mendeltna and Hogan Hill study areas, respectively, were studied for comparative purposes. Gray wolf densities in these 2 areas averaged approximately 1 wolf/277 km^2.

All 3 study areas were inhabited by alternate prey species, including caribou (*Rangifer tarandus*), snowshoe hare (*Lepus americanus*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*). They also supported populations of brown bear and black bear (*Ursus americanus*), the latter in low densities. Topography, vegetation, and climate of these areas have been described elsewhere (Skoog 1968, Rausch 1969, Bishop and Rausch 1974, Ballard 1981).

METHODS

Design and materials used during our study were described by Ballard et al. (1979), and were also used by Franzmann et al. (1980). However, a number of differences did exist between the methods used in the 2 studies. Schlegel's (1976) collar design was used during both years of our study (orange collars in 1977, green in 1978). Newborn moose calves were first located from fixed-wing aircraft. Their locations were relayed via radio to a nearby helicopter, and calves were captured according to methods described by Ballard et al. (1979). However, no attempt was made to capture accompanying cows, as Franzmann et al. (1980) did.

Radio-collared moose calves were monitored from fixed-wing aircraft by methods similar to those of Mech (1974). Calves were observed twice daily during the first 2 weeks of the study, then one daily for 4 weeks, and less frequently until their collars fell off or radio contact was lost. Monitoring from fixed-wing aircraft was not supplemented with a ground station, as was done in the Kenai Study (Ballard et al. 1979).

For comparison of mortality rates, we monitored survival of uncollared calves of radio-collared cows within the study areas. These cows and calves were visually observed from fixed-wing aircraft at 3- to 5-day intervals beginning on 24 May each year. Repeated low passes were made until the observer was satisifed that a calf was present or absent. After 1 July, cows were monitored every 2 weeks until November, then at least once/month until spring. Causes of death were not determined for these calves.

When a radio-collared calf was observed dead, or death was indicated by its radio signal, the area within approximately 0.8 km of the mortality site was searched from fixed-wing aircraft in an attempt to sight predators. The presence or absence of radio-collared wolves and brown bears in the vicinity was checked. Twenty-three brown bears and all wolf packs in the study areas were radio-collared. Wolf summer food habits were described in Ballard and Spraker (unpubl. rep., Alaska Dep. Fish and Game Fed. Aid Proj. W-17-9 and 10, 1979) and Ballard (1981).

Following our calf mortality studies in 1977, 23 adult brown bears (3 years old or older) were captured and radio-collared in the 3 study areas during 1978 using helicopter capture techniques (Spraker and Ballard, unpubl. rep., Alaska Dep. Fish and Game Fed. Aid Proj. W-17-10 and 11, 1979). Ages of captured bears were classified using methods described by Mundy and Fuller (1964). Bears were classified as sexually mature if at least 6 years old (Hensel et al. 1969). Radio-collared brown bears and wolves were observed during the same flights made to monitor moose calves. Sex and age (adult or calf) of moose killed by brown bears were identified from fixed-wing aircraft on the basis of size, coloration, and antler growth (Ballard 1981).

Dead radio-collared calves were examined on the ground, usually within 2 hours after detection. Identities of the predators were established from observations of predators at the kill site or by the presence of sign (Ballard et al. 1979, Franzmann et al. 1980). When the cause of death was not predation or abandonment, calves were necropsied within 24–

Table 1. Numbers of moose calves collared (includes uncollared siblings) and subsequent causes of mortality in the Nelchina and upper Susitna river basins of south central Alaska, 1977–78.

Calves	Area 1[a]		Area 2		Area 3	All areas		Totals	
	1977	1978	1977	1978	1978	1977	1978	N	%
Radio-collared	25	31	30	26	24	5	81	136	
Abandoned[b]	2	4	4	2	1	6	7	13	
Lost radio contact	1			2		1	2	3	
Remaining	22	27	26	22	23	48	72	120	100.0
Death from									
Brown bear predation	8	11	16	10	7	24	28	52	78.8
Gray wolf predation			1		1	1	1	2	3.0
Unknown predation			1	1	1	1	2	3	4.5
Misc. factors[c]	1	1	2	1	1	3	3	6	9.1
Unknown		1	1		1	1	2	3	4.5
All causes	9	13	21	12	11	30	36	66	55.0
Surviving to 1 Nov.	9	13	5	10	12	18	36	54	45.0

[a] See Fig. 1.
[b] Abandoned by its mother due to tagging activities.
[c] Includes drownings, pneumonia, and injuries inflicted by cows.

36 hours following death. Calves that died due to study-induced abandonment by their mothers were not visited on the ground for at least 1 day and, in most cases, up to 2–3 days. For both abandoned and predator-killed moose calves the area was revisited regularly by means of fixed-wing aircraft to observe subsequent scavenging activity.

RESULTS AND DISCUSSION

During 25 May–10 June, 136 moose calves (55 in 1977 and 81 in 1978) were radio-collared in the 3 study areas, and we subsequently determined the fate of 96% of them (Table 1). Abandonment induced by collaring activities resulted in the deaths of 13 calves (9.5%): 6 in 1977 and 7 in 1978. The fate of 3 calves was unknown because radio contact was lost before November. Contact was lost after 94% of the observed mortality had occurred, so these calves probably survived; however, they were not included in survival calculations.

Of the 120 remaining calves, 66 (55%) died of natural causes during their first 6 months of life (Table 1). Predation was the greatest cause of mortality, accounting for at least 86% (57 of 66) of the natural deaths. Brown bears were the most important predators in all 3 study areas, accounting for 78.8% of the natural mortality during the months studied. Approximately 9% of the mortality resulted from miscellaneous factors such as injury inflicted by the cow, drowning, or pneumonia. Causes of mortality for 3 (4.5%) calves were not determined because the site could not be reached, or was reached too long after the calf's death to determine the cause.

Ratios of identified causes of natural mortality for radio-collared calves were pooled for both years of study, and were compared (chi-square test) among study areas. No differences in causes of mortality ($P > 0.05$) were detected among the 3 study areas. Thus, the differences in wolf density among the study areas did not appear to be an important factor affecting calf mortality.

Calves ($N = 13$) died within 4 days after abandonment, and the carcasses remained unmolested for 30 hours to several days. Only 1 instance of scavenging

Table 2. Prey of radio-collared brown bears in the Nelchina and upper Susitna river basins of south central Alaska, 26 May–1 November 1978.

Family-age status of bear	*N*	Observation days (*N*)	Prey: Moose calf	Adult moose	Unident. moose	Adult caribou	Misc.[a]
Single adult sow	6	141	17	9		2	1
Single adult boar	6	65	4	5	1		
Sow with young	5	110	9	3	1		3
Single subadult	6	121	7	11	2	1	2
Totals	23	437	37	28	4	3	6

[a] Includes beaver, small mammals, and unidentified species.

by birds was observed within a 30-hour period following death. Predator-killed calves that were examined also received little use by scavengers. In all cases following examination, at least 2 days passed before any use by scavengers was observed. Where <50% of the carcass had been consumed, the carcass laid unmolested for several days before being consumed by scavengers. Neither brown bears nor wolves were observed returning to a kill site after the disturbance caused by our examination. Nonuse of dead calves by scavengers was also observed on the Kenai Peninsula (Franzmann et al. 1980).

Examination of natural mortalities was made within 24 hours for 68% of the deaths and within 48 hours for 87%. Cause of death was accurately determined for 91% of the mortalities due to lack of scavenging and the short interval between death and examination.

During summer and fall 1978, radio-collared brown bears were observed on 78 kills (Table 2), of which 87% were moose. Moose calves comprised 57% of the moose kills and 47% of the total kill. Based upon observation days, radio-collared brown bears made 1 ungulate kill/6.1 days. Kill rates varied by individual bear from zero to 1/2.2 days. We pooled both numbers of observation days and numbers of kills by family class (single boars and sows, sows with 1.5- to 2.5-year-olds, and sows with 0.5-year-olds) to determine if any particular sex or age group was disproportionately represented. Single adult sows had the largest ungulate kill rate (1/5.0 days), whereas sows with young had the lowest rate (1/8.5 days); however, no statistical differences in ratios ($P > 0.05$) were detected, indicating that all adult bears were preying upon ungulates in the same proportions regardless of family status. Also, we could detect no differences ($P > 0.05$) for mean number of kills/bear between sexually mature (≥6 years old) and immature bears. Brown bears were observed on calf carcasses for as long as 2 days, but averaged 1.1 days. On adult moose, however, they stayed with a carcass from 1 to 6 days, averaging 1.8 days. Some adult moose carcasses were revisited, but no revisiting was observed on calf carcasses.

Ninety-four percent of the natural mortality of radio-collared calves occurred before 19 July of each year (Fig. 2). The loss pattern of uncollared calves of radio-collared adult cows was similar to that of radio-collared calves. This suggests that mortality of collared calves was essentially the same as that of uncollared calves, and that the collars did not predispose calves to predation. These findings support those obtained by observing radio-collared brown bears. Of the 37

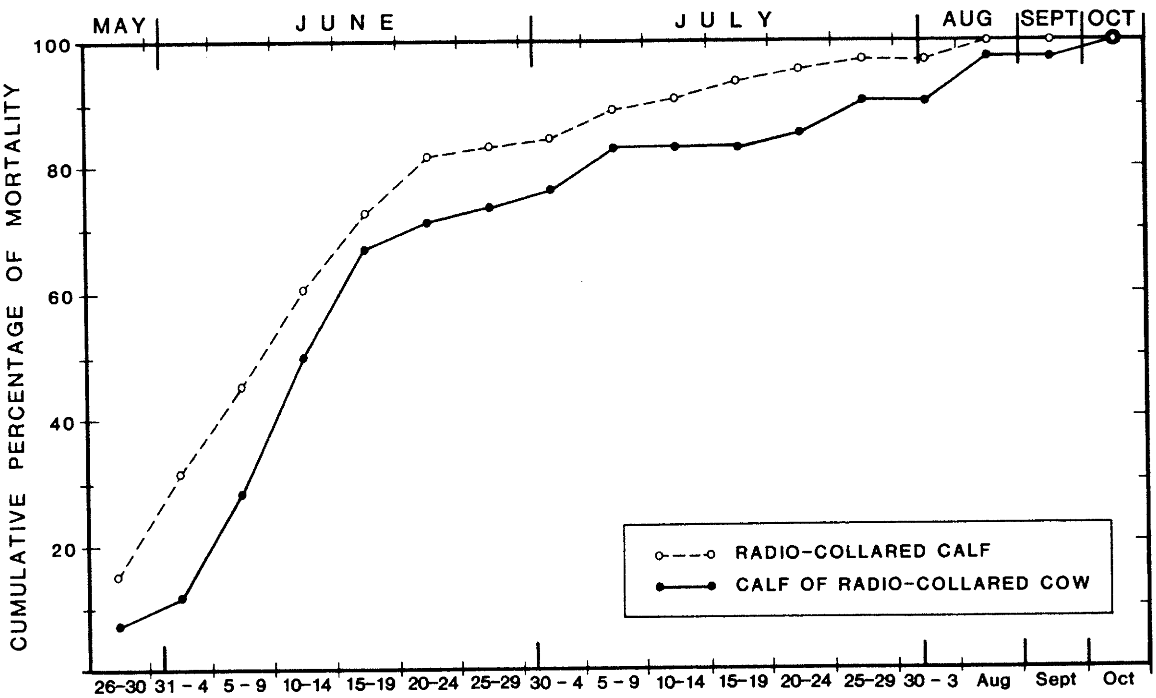

Fig. 2. Dates of deaths of 107 collared and uncollared moose calves in the Nelchina and upper Susitna river basins, Alaska, 1977–78.

kills of moose calves, all were observed before 19 July. Thereafter, adult moose and adult caribou comprised the observed prey.

Only 6% of the total natural mortality of radio-collared calves occurred after 19 July. Most calves that survived to 19 July also survived to 1 November. Thereafter, we began losing contact with radio-collared calves due to collars falling off, radio failure, and migration. We do not know the ultimate fate of the calves in most instances. We did, however, maintain contact with calves of radio-collared adults until at least April of the following year, when cows and calves began separating. No additional mortality was observed during this period in 1977–78, whereas in 1978–79, a relatively severe winter, 7 of 17 surviving calves were lost in late winter, probably due to either starvation or predation. The timing of mortality indicates that most losses occur during the first 7–8 weeks of a moose calf's life.

Several investigators have reported instances of brown bear predation on moose, and some concluded that it may be an important cause of moose mortality. Chatelain (1950) noted that black and brown bears took both adult and calf moose, according to analysis of scats from the Kenai Peninsula. LeResche (1968) observed 2 instances of brown bear predation during his study of 59 marked calves near Palmer, Alaska. Brown bears also killed 4 radio-collared moose calves on the Kenai Peninsula (Franzmann et al. 1980). Results of our study and the Kenai Peninsula study (Franzmann et al. 1980) are the first to document predation by both brown and black bear as more than just incidental causes of moose calf mortality.

Brown bears were responsible for 79% of the mortality of radio-collared moose calves in our study. No substantial increases in calf survival were observed following reductions in wolf densities (Ballard and Spraker, unpubl. reps., Alaska Dep. Fish and Game Fed. Aid Proj. W-17-9 and 10, 1979). The hypothesis that wolf predation was the main cause of moose calf mortality in the Nelchina Basin (Bishop and Rausch 1974) is not supported. However, wolf predation has been identified as the major cause of calf mortality on the Tanana Flats (Gasaway et al. 1977), whereas black bears have been identified as a major cause of calf mortality on the Kenai Peninsula (Franzmann et al. 1980). Identification of 3 predator species being responsible for relatively large calf losses in 3 different Alaska moose populations presents problems for game managers. Attempts to manipulate 1 predator species to benefit moose, while not manipulating, or at least monitoring the status of others, may produce negligible effects on calf survival. These studies emphasize the need for evaluating predator-prey relationships in individual moose populations.

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