MOOSE CALF MORTALITY ASSESSMENT

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Abstract: The moose (*Alces alces*) calf mortality part of the Kenai Peninsula Predator-Prey study was initiated in spring 1977 to assess mortality transmitters, capture and immobilization techniques, an automated monitoring system, physiologic characteristics of both cows and calves, and ultimately, the cause of calf mortality. Fifteen radio-collared, postcapture bonded calves were monitored and mortality experienced by these calves was attributed to; black bear predation (6 calves, 40 percent), wolf predation (1 calf, 6.7 percent), brown bear predation (1 calf, 6.7 percent), unknown predation (1 calf, 6.7 percent) and unknown (1 calf, 6.7 percent). Total predation accounted for 60 percent of moose calf mortality. Total calf mortality was 66.7 percent.

A continual recurring gap of knowledge in moose (*Alces alces*) population dynamics relates to neonatal and summer calf mortality. LeResche (1968) reported a drop in calves per 100 cows from 84.3 to 36.2 from May to October near Palmer, Alaska. LeRoux (personnal communication) recognizes a significant drop in spring to fall cow/ calf ratios annually on the Kenai Peninsula. Chatelain (1950:231) suggested a high incidence of black bears (*Ursus americanus*) eating young moose calves on the Kenai Peninsula, Alaska. LeResche (1968) did not consider black bears an important predator of moose calves, but observed a brown bear (*Ursus arctos*) killing a cow and two calves. He also reported several accidental calf deaths and desertion of calves by cows in two instances.

In an Idaho study 16 of 27 radio-collared elk *(cervus elaphus)* calves were killed during the 1974 calving season by predators, 8 by black bear, 4 by mountain lion *(Felis concolor)* and 4 by unknown predators. During the 1975 calving season 15 of 27 elk calves were killed by predators, 13 by black bear, one by mountain lion, and one by unknown predator (Schlegel 1976).

Other studies have reported significant predation by wolves (*Canis lupus*) on young ungulates (Rausch and Bratlie 1965, Mech 1966, Mech and Frenzel 1971, Kuyt 1972, and VanBallenberghe et al. 1975).

Wolves reappeared on the Kenai Peninsula, Alaska, during the 1960's and are presently at a density of approximately 1 wolf/78 km^2. With three major predators on the Kenai Peninsula (wolves, black bear, and brown bear) and four major ungulates (moose, caribou [*Rangifer tarandus*], Dall sheep [*Ovis dalli*], and mountain goat [*Oreamnos americanus*], it was necessary that we obtain a better understanding of predator-prey relationships. In 1976 a cooperative agreement between the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service was signed which outlined a predator-prey study consisting of three main parts; a wolf study, a moose calf mortality study, and a bear study. This paper presents our initial work on the moose calf mortality study. The objectives of this study were to assess the use of mortality transmitters, immobilization and capture techniques (immobilizing cows and capturing calves versus capturing calves alone), an automated monitoring system, physiologic characteristics of cows and calves, and the causes of mortality.

METHODS

The study area was in the northcentral Kenai Peninsula lowlands in the vicinity of the 1947 Kenai burn (Oldemeyer et al. 1977). The area is bounded on the north by Moose Lake, on the east by the Chickaloon River, on the south by Bear Lake and the Moose River Flats, and on the west by the Moose Research Center (MRC).

On May 29, 1977, eleven moose calves were processed and radio-collared following capture by means of a Bell Jet Ranger II helicopter (Kenai Air Service). The 10 associated cows (1 cow had twins) were also immobilized, visual-collared, and processed. On May 31, 1977, eight more moose calves were radio-collared. Three of the calves' dams (2 cows with twins) were immobilized, visual-collared, and processed; the remainder of the calves (4) were radio-collared and processed without immobilizing the associated cows. On June 7, 1977, another six calves were radio-collared and processed without immobilizing the associated cows.

Processing the cows and calves included blood-sampling the cows from the jugular vein (Franzmann et al. 1976); blood-sampling the calves from the radial vein using a 21 gauge needle on a 10 cc syringe; plucking and collecting at least 1 gram of hair from the hump (Franzmann et al. 1975); measuring total length, chest girth, and hind foot length (Franzmann et al. 1978); weighing the calves; extracting the first incisor from the cow for aging (Sergeant and Pimlott 1959); and assessing condition class of the cow (Franzmann et al. 1976). Roto-tags (Nasco Inc., Modesto, CA) were placed in each calf's ear and cows were visual-collared, ear-tagged and flagged (Franzmann et al. 1974). A small burlap bag was placed over each calf's head and all four legs were tied together to assist handling.

The cows were immobilized using a combination of 7 mg etorphine (M-99, D-M Pharmaceuticals Inc., Rockville, MD), 300 mg xylazine hydrochloride (Rompun, Chemagro, Kansas City, MO), and 250 units hyaluronidase (Wydase, Wyeth Laboratories, Inc., Philadelphia, PA). Upon completion of processing both cow and calf or calves, the antagonist diprenorphine (M 50-50, D-M Pharmaceuticals, Inc., Rockville, MD) was injected into the cow's jugular vein. The cow was generally up in 2 to 4 minutes following injection.

The cow and calf or calves were together when the cow was given the antagonist, except for twin calves 39-171 and 39-173, which were 200 m from their cow when processed. We left the calves on a bog island when the cow left them during immobilization. We classified the remaining capture events as follows: (A) the calf was caught or caught and processed and placed in the helicopter; the cow was immobilized; and the calf was kept with the cow during processing (5 calves); (B) the cow was immobilized; the calf was caught and carried to the downed cow; and the cow and calf were processed together (4 calves); and (C) the cow was immobilized; the calf or calves stayed with the cow; and the cow and calf or calves were processed together (5 calves, including 2 sets of twins). Location of calves captured was recorded.

The radio transmitters (AVM Instrument Co., Champaign, IL) placed on the calves ranged in frequency from 164.025 to 164.919 and while in motion pulsed at approximately 60 beats/minute. When movement ceased for approximately four hours the pulse tripled (188 to 217 beats/min). The radio-collar was designed to expand with calf growth to 66 cm circumference and then fall off. The beginning circumference was 33 cm (13 in.). The collar was fashioned after the design for expanding goose neck bands and was constructed of vinyl plastic (4 cm wide x 2 mm thick). The transmitter was encased in acrylic and fastened to the collar by vinyl plastic rings through which the collar could freely expand. A 25 cm insulated wire antenna protruded from the encased transmitter and extended along the side of the collar.

From May 30 to June 15, 1977, the calves were monitored and located by daily flights (at 0700 hrs) in a Super Cub equipped with two yagi antennas clamped to each wing strut. Locations and movements were plotted using Kenai National Moose Range (KNMR) aerial color photographs. During this period daily flights in a Super Cub (1900 hrs) were made by circling up over Kenai airport to an altitude necessary to obtain a signal from each calf.

By June 15, 1977, a 30 m tower equipped with two yagi antennas had been erected at the MRC. A Falcon Five receiver (Wildlife Materials Inc., Carbondale, IL) and a memory unit (W. W. Cochran design) were used to monitor the calves. The original intent was to utilize the system which would activate a signal to the Kenai National Moose Range (KNMR) repeater station when the fast mode was detected and broadcast it through the KNMR communications system. The signal consisted of a siren burst, followed by the pulse beat and then by binary coded tones which indicated which transmitter had been activated. The system was operational for fast mode signals at close range; however, it could not always detect the fast mode signal from the study area (up to 9.7 km from tower) when the collar was on the ground. Standing calves were easily monitored on slow mode. These circumstances provided another option to monitor the calves, that of regularly (every hour or two) monitoring the calves with the receiver at the MRC. If a calf's signal was not heard for several hours, we would be alerted to monitor more intensively, and if no signal was heard for 4 to 6 hours we would check the calf by Super Cub. When a fast signal was monitored we would similarly respond. If a calf's fate could not be determined from the Super Cub, a helicopter or Super Cub on floats was employed to go to the area and proceed to the calf on ground. A thorough investigation of the calf and area was made at that time. If predation was suspected, a form designed by Mike Schlegel, Idaho Fish and Game Department, was used to record area, carcass, and predator data. A necropsy was performed on calves which were sufficiently intact. Appropriate samples were collected. A photograph was taken of each calf prior to handling or movement.

RESULTS AND DISCUSSION

Capture Method

The mean induction time for adult female moose was 7.3 minutes (range 3-15 min.). Gasaway et al. (1978) reported mean induction times of 16 minutes (range 5-50 min.) for adult moose immobilized in August and April. The addition of 250 units of hyaluronidase may have been responsible for the decrease in induction time; however, moose immobilized in this study were in very poor condition (most were class 5 or 6 - see Franzmann et al. 1976). The poorer condition, in addition to stress of recent calving and lactation, may have been primarily responsible for decreased induction time. The post-immobilization tranquilizing effects of xylazine hydrochloride may have partially influenced cow-calf separation. No data suggests this, but separation occurred in some instances and anything which may have been a contributing factor should be investigated. The partially tranquil cow may not respond to stimuli that maintain or reinstate the cow-calf bond. Conversely, the partially tranquil cow may not be affected by post-capture activity (helicopter in area) and may rebond more readily. To assess cow response, future immobilization attempts should be made with reduced dosages of xylazine hydrochloride.

We immobilized the cow of each calf or calves for the first 14 cows (17 calves). Subsequent monitoring of these individuals indicated potential cow-calf separation. Additionally, one cow died from unknown causes at capture prior to receiving the antagonist and female #47 bogged down after capture. In spite of slinging her to high ground with the helicopter, she continued to weaken and was sacrificed. She was in extremely poor condition at capture (she fell down on initial pursuit). She was 14 years old, yet she had twin calves. Her packed cell volume (PCV) was 31 percent and hemoglobin was 10.5 gm/100ml. These were the lowest we ever recorded for an adult female moose (Franzmann et al. 1976).

The remainder of the calves radio-collared were processed without immobilizing the cow.

Cow/Calf Separation

Three of five cows immobilized by method A (the calf was caught or caught and processed, placed in helicopter; the cow was immobilized, and cow and calf were kept together during processing) experienced permanent separation. By method B (the cow was immobilized, the calf caught and carried to cow, and the calf and cow were processed together) no permanent separation was experienced (n=4). Using method C (the cow was immobilized, the calf or calves stayed with the cow, and the cow and calf or calves were processed together) one of three experienced permanent separation; however, that calf was apparently adopted by another unmarked cow and they bonded permanently. When one cow (#39) was processed separately from her calves, absolute separation occurred. When calves alone were captured 2 of 8 cow-calf groups were permanently separated, and one outcome unknown. Of the 22 total cow-calf groups, 15 bonded post-capture, 6 separated post-capture, and one outcome was unknown.

It is apparent that permanent cow-calf separation may occur during this type of study. Methods which lessen this possibility should be adopted whenever feasible. If the objectives include obtaining data from the cow, it seems beneficial to immobilize the cow prior to handling the calf. It may be necessary to refrain from immobilizing the cow if upon initial pursuit the cow/calf bond appears weak, with separation occurring at the first sign of the cow's disinterest in her calf. If study objectives do not include obtaining data from the cow, immobilizing the calf alone would be proper. Separation occurred with this method also; however, each case involved processing the calf for physiologic and morphometric data. If such data are not part of the objectives and simply radio-collaring the calf will suffice, separation would likely be lessened by capturing the calf, installing the radio-collar, and leaving as soon as possible. It should be noted that calves alone were captured later during this study and thus were older, a factor which may have increased their ability to maintain a post-capture bond.

The lack of physiologic and morphometric data from the cows and calves or from calves collared alone may be a substantial loss in terms of interpreting events taking place at this critical period in the life history of moose.

We found that considerable time was saved during observational monitoring of cows and calves when the cow wore a visual collar. The visual collar was a definite aid in obtaining data about cow-calf separation and recording post-predation movement of the cow. The adoption of calf #40-148 by an unmarked cow would not have been detected had this calf's mother also been unmarked. In addition, radio-collaring at least some of the cows for purposes of monitoring predator-prey activities during calving is warranted by the presence of three major predator species in the area.

The helicopter costs of radio-collaring and processing a calf alone were $197.00; capturing and processing a cow cost $201.00. Drug cost per cow processed was $54.50. Costs for doing calves alone were somewhat biased in that these calves were larger and harder to find. Unfortunately, we do not have same-day cost comparisons, but the costs/ unit do not appear to be a limiting factor.

Physiologic and Morphometric Measurements

Preliminary blood data from adult female moose reflected poor condition (Franzmann et al. 1976). No packed cell volumes (PCV) exceeded 45 percent ($\bar{x}$ = 39%) and hemoglobin (Hb) values did not exceed 16.5 gm/100ml ($\bar{x}$ = 14.0 gm/100ml). Calf PCV values did not exceed 39 percent ($\bar{x}$ = 29.9%) and Hb vlaues did not exceed 13.5 gm/100ml). Other blood chemistries have not yet been assessed but should provide more information regarding physiologic status of cows and calves (Franzmann et al. 1976). The 13 cow ages (cementum annuli) ranged from 4 to 14 years ($\bar{x}$ = 9.3 years). Comparative physiologic data from cows with calves experiencing predation and/or separation may provide clues as to the possibility of a physiologic basis for vulnerability to predation or bond breakdown. These possibilities will be investigated when analyses are complete and additional data is obtained.

Calf weights at time of capture were used in estimating age. A male calf born at the MRC weighed 14.5 kg (32 pounds) at birth and at age one week weighed 23.6 kg (52 pounds), a gain of 1.3 kg (2.9 pounds) per day (Franzmann and Arneson 1973). The range in moose calf weights for this study was 14.4 kg (30 pounds) to 36.3 kg (80 pounds) for calves age 1-16 days.

Morphometric measurements also reflected calf age. For calves age 1-16 days, total length measurements ranged from 88 to 115 cm; heart girth ranged from 55 to 75.5 cm; hind foot ranged from 31 to 41 cm (length to dewclaw was approximately 10 cm less on all age classes); and neck circumference ranged from 27 to 36 cm. Reported total length/weight correlation was 0.94; chest girth/weight correlation was 0.90; and hind foot/weight correlation was 0.87 (Franzmann et al. 1978). Measurement/ weight relationships from calves age 1-16 days corresponded to these correlations. Neck circumference measurements were not available from older moose.

Bonded Calf Mortality

Only calves that had retained the cow/calf bond after capture were monitored to establish natural mortality. Fifteen calves remained bonded with their cows for 48 hours or more after capture (Table 1). An additional unradioed twin calf (#159, brother of calf #157) was available for observation until June 15, 1977, when two brown bears killed #157. The fate of calf #159 was unknown. Total predation of bonded calves was 60 percent (9 calves). Black bear predation was 40 percent (6 calves); wolf predation was 6.7 percent (one calf); brown bear predation was 6.7 percent (one calf); unknown predation was 6.7 percent (one calf), and unknown mortality was 6.7 percent (one calf). Total mortality was 66.7 percent (10 calves) (Table 1). Calves were monitored until August 1, 1977. By then the remaining transmitters had fallen off or gone dead.

Table 1. Mortality of moose calves with good post-capture cow/calf bond.

Calf Number	Predator and Predation Date: Black Bear	Brown Bear	Wolf	Unknown	Other Mortality and Date	
38-161						
38-163					7/5/77	
40-148	7/13/77					
41-145				6/2/77		
42-143	6/3/77					
43-141			6/2/77			
44-189	6/21/77					
46-185						
48-178	6/12/77					
50-126	6/12/77					
146						
155						
157		6/15/77				
167						
191	6/29/77					
						Total
Percent	40.0%	6.7%	6.7%	6.7%	6.7%	66.7%

Calf #41-145 was monitored on fast mode at 1600 hrs on June 2, 1977, and we arrived at the site at 1900 hrs. No predators were seen in the area. The cow was sighted 100 m from carcass (#41 collar). The birch (*Betula papyrifera*)-spruce (*Picea mariana*) canopy cover was approximately 10 percent. The uncovered carcass was 90 percent consumed, with only parts of skull, mandible and teeth, broken femurs, other bone pieces and the partially inverted hide remaining. No predator sign was located (scats, hair, or prints). The hide was ripped in several areas. The cause of mortality was recorded as unknown predator but was likely a black or brown bear.

Calf #43-141 was located by Super Cub on June 2, 1977, with a black wolf near the slow mode signal site at 0800. At 1930 we went to the area by helicopter. The black wolf was again sighted in the area, and the signal was still on slow mode. The calf's carcass was found buried in the duff layer at the base of a hill in a mature birch stand with 50 percent canopy cover. The calf was approximately 40 percent consumed (hind legs, entrails), with the hind legs lying 47 m from the remainder of the buried carcass (hide still intact). The radio-collar was on the carcass. The cow was not seen in the area. The cause of mortality was determined as wolf predation.

On June 3, 1977, a black bear was sighted at 0745 near the slow mode signal origin of calf #42-143, but neither cow nor calf was observed. On subsequent morning flights (June 4 and 5) neither cow nor calf was sighted, though the signal origin location remained the same. At 1900 on June 5 a fast mode signal was detected at 1900 m over Kenai Airport. On June 7 we went to the site via helicopter and found the calf carcass 84 percent consumed (by weight). All that remained were bone fragments and the partially inverted hide, which had 30-40 cm tears. The radio was 20 m from the feeding site. Four bear scats were located within a 30 m radius of the feeding site. The cause of mortality was determined as black bear predation.

On June 11, 1977, cow #48 and calf #48-148 had moved 17.6 km up Thurman Creek into the mountains. The signal location was identified but the calf was not seen in the heavy spruce. Two black bears were sighted in the area. On June 12 at 0830 the slow mode signal was located farther up Thurman Creek but neither cow nor calf was sighted. A black bear was sighted 1 km from the signal. On the morning of June 13 the signal was on fast mode. We went to the area via helicopter and located the uncovered calf carcass on a hillside near Thurman Creek in a 20 percent spruce canopy cover. The partially inverted hide and partially eaten head (ears, tongue, and nose) were at a site 12 m from the broken radio-collar, parts of broken femur, and scapula. No predator sign was found in the area. The cause of mortality was determined as black bear predation.

On June 12, 1977, at 0930 the carcass of calf #50-126 was sighted by Super Cub in a clump of spruce. A large black bear was feeding on a winter-kill calf 60 m from the calf carcass. Cow #50 was not in the area. The radio signal was on slow mode. On June 13 we went to the site via helicopter. The signal was still on slow mode and the cow was still not in sight. The uncovered carcass was 80 percent consumed (all flesh except one thigh) and was located in a spruce bog area with 30 percent canopy cover. The leg bones were not cracked and the head was eaten.

The hide was partially inverted and torn. The cause of mortality was determined as black bear predation.

From 0300 on June 14, 1977, to 1400 on June 15, we were not able to monitor any signal from calf #157 using the tower and receiver at the MRC. A Super Cub was flown to the area and two large brown bears were seen feeding on the carcass of calf #157. This calf was a twin to unradioed calf #159 and its fate was unknown. No flights were made to land at the site because the predator had been positively identified. The remains at the site were negligible. The cause of mortality was determined as brown bear predation.

The signal from #44-189 was sporadic or not heard at MRC on June 21 and 22, 1977. The fast mode signal was received via Super Cub on June 23 at 0930 and the carcass was sighted. At 1500 we arrived at the site via Super Cub on floats. The calf carcass was 300 m south of Buteo Lake in spruce-birch regrowth with 10 percent canopy cover. The carcass was 95 percent utilized with only mandibles and teeth, hooves, hide and bone fragments remaining. The broken radio-collar was at the feeding area. Black bear sign was evident (4 scats, and tracks). The carcass was not covered, but there were two dug areas (1 m^2) within 10 m of the carcass. The cow was not in the area. The cause of mortality was determined as black bear predation.

The signal from calf 191 was picked up at MRC on fast mode at 0645 on July 1. The calf was sighted on June 27 at Bear Lake. The signal went off on June 29 (0715 hrs) and was not picked up again until June 30 (2130 hrs) when it was on slow mode. The next morning (July 1, 0645 hrs) it was on fast mode. We inspected the site on afternoon of July 1 and determined it to be black bear predation. There were 10 black bear scat piles in the area. The carcass was 90 percent utilized under 20 percent canopy cover. The calf had moved nearly 20 km from June 27 to June 29. The kill site was 20 km from tower, and we received a good signal, perhaps, because the transmitter was lying under a very tall spruce tree.

On July 5, calf #38-163 was monitored by aircraft on fast mode. Nothing could be sighted in the area which was 25 km east of the tower near the Chickaloon River. The helicopter was used to go to the area and we found only the intact collar. An intensive search of the area provided no clues; however, the collar had small teeth marks imbedded in it and we assumed the collar was carried to the area by a small mammal. No cause of mortality could be determined for this calf.

On July 15, calf #40-148 was monitored by aircraft on fast mode. An on ground inspection at the site indicated black bear predation. Black bear scats, tracks and hair were found at the site. The calf was sighted in the area on July 12, and we assumed that no significant movement was associated with predation in this case.

As of July 15, only three calves remained with transmitting radioes, and by August 5, two of these had fallen off and one radio went dead.

The question arises as to whether or not the calves classified as predation mortalities may have died of other causes prior to predation. Separation and starvation of four calves (one set of twins) and capture-related deaths of two cows (one cow at capture, one scraficed after unsuccessful attempts to sling her from a bog) occurred during this study. Their carcasses remained on the study area. We were not able to check back on all the capture-related deaths, but those which we checked were virtually unutilized for days. Cow #47 was sacrificed on May 31, 1977, and no sign of disturbance was noted until June 12, 1977. Calf #39-171 died on June 6, 1977, and had not been disturbed as of June 14, 1977. Calf #169 was dead 36 hours prior to radio recovery, and it was undisturbed at that time. Calf #151 died June 8, 1977, was necropsied that same day, and, when visited on June 18, had not been utilized. Warren Ballard witnessed similar predator-scavenger non-use of dead moose calves in his study conducted in the Nelchina Basin, Alaska (pers. comm.). Using calf carcasses for baiting wolf traps during early June, we observed similar predator-scavenger non-use of dead calves. We concluded that in those instances when we did not see the predator at or near the kill site the predator signs at the area warranted a conclusion that predation was the cause of death.

During the flights over the study area, 13 adult or subadult black bears were seen in addition to a sow and three cubs, which were observed several times. Two subadult brown bears were seen on two occasions and two adult brown bears were seen on three occasions. A single gray and a single black wolf were also seen. With three major potential predators (black bear, brown bear and wolf) in the area, it was difficult to identify the specific predator without witnessing it at the kill site when signs (scats, tracks, etc.) at the site were absent.

Movements (Bonded Calves)

From capture dates (May 29 and 31 and June 7, 1977) movement of the cow and calf or calves was plotted by daily Super-Cub flights until June 15, 1977, when monitoring from the MRC was begun. Thereafter, moose calves were located on a schedule compatible with radioed wolf tracking and flights to assess calf mortality.

No specific movement activities were evident from this small sample; however, certain movement observations may be associated with predation or predation attempts. In general, all bonded calves tended to remain within 1.6 km (1 mile) of the capture site (usually within 100 m). Movements of 1.6 km or more (up to 14.4 km) were recorded for what seemed, at the time, no apparent reason. When movements were compared with predation a pattern seemed to develop. The moose calves killed by black bears had traveled 3.2, 4.8, 14.4, and 20 km one or two days prior to predation. Calves killed by the wolf and by brown bears and the unknown kill were within 1.6 km of capture site. Calves not killed by June 15 had on occasion made sporadic moves, but only one exceeded 3.2 km. Calf #44-189 moved 4.8 km 7 days after capture. It was later killed by a black bear on June 21, but no pre-kill movement data were available. Calf #40-148 moved nearly 12 km 11 days after capture, but did not move significantly prior to being killed by black bear as far as we could tell.

During the study a black bear was observed stalking a cow and calf. The bear made no direct moves toward the pair but continually moved in their general direction, forcing the nervous cow to move in bursts. She would stop, observe the bear, and then proceed at a rapid gait, gradually slowing and then stopping. She would then repeat the process. The calf stayed with her. The bear continued to stalk the pair until it sighted the observer (A. Franzmann) and bolted in the opposite direction. The cow and calf came right by the observer without concern.

Moose calf movements associated with black bear kills may be interpreted from this observation to be the result of tactics used by black bears in stalking and killing moose calves. The cow and calf may be forced into unfamiliar surroundings, thus increasing the predator's chances for success. The lack of movement of calves killed by the wolf and brown bears may be the result of a different predator strategy. Other major movements not actually followed by black bear predation may have occurred because of attempted predation.

Obviously, more observations and data are required, but these preliminary findings indicate that there are opportunities to obtain such data and that there is need for a more intensive approach to the study.

CONCLUSIONS

The use of mortality transmitters on moose calves provided important post natal life history information, particularly regarding predation. The four hour setting for activation of the fast mode was too long. In the future one hour setting will be employed. The plastic material used in the expandable collar design was susceptible to breaking and several collars were lost prior to providing information desired.

Immobilization of the cow and capture of the calf versus capture of the calf alone both resulted in cow/calf separation. If information from the cow is important in the study design she should be immobilized; however, it appears that cow/calf separation may occur at a higher rate when the cow is immobilized. Decreased amounts of xylazine hydrochloride in the immobilization dose may improve rate of cow/calf separation. Hyaluronidase was apparently a useful additive to the immobilizing dose.

The automated monitoring system was helpful and decreased the requirements for flights; however, we could not depend upon it alone since much valuable information was derived from daily flights over the area to locate radio collared calves. Improvement in tuning of radio transmitters should be pursued to obtain the strongest signal possible. The addition of an activity receiver system would be an important adjunct to the study.

Physiologic characteristics of the cows sampled indicated a relative poor physiologic state. Additional data would be desireable from both calves and cows to establish base-line data at this critical period of the life history of moose.

The high rate of predation experienced with the radio collared calves was alarming. Black bears appeared to be the major predators of these calves, although wolves and brown bear were present on the calving grounds. It would be desirable to radio collar some of the predators, particularly bears, in the calving area to obtain information regarding predation behavior. We need to determine if this calf predation is general for the black bears in the area or if just certain black bears with learned predation behavior are responsible. It would be helpful to have some cows radio collared as well as their calves for ascertaining the cow-calf bond characteristics in an area with such a high calf predation rate.

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