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MOOSE CALF MORTALITY STUDY, Game Management Unit 13

by
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Volume I
Project Progress Report
Federal Aid in Wildlife Restoration

Projects W-17-9 (2nd half) and W-17-10 (1st half), Job 1.23 R

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

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Job No.: 1.23R Job Title: Nelchina Moose Calf Mortality Study

Period Covered: April 1, 1977 through December 31, 1977

SUMMARY

Between 26 May and 9 June 1977 a total of 54 newborn moose calves were captured with the aid of a helicopter and fitted with an expandable radio transmitter. Twenty-nine calves were collared in the Mendeltna study area within one wolf pack's territory, and 25 were collared in the Susitna River study area where wolf densities had been greatly reduced. Transmitters were designed to indicate mortality by a doubling of the pulse rate once the calf remained motionless for a 4-hour period. Radio-collared calves were monitored and observed from fixed-wing aircraft twice daily during the first month of the study and less frequently thereafter.

Most calves were measured, weighed, and their sex determined. Hair samples, blood samples and rectal swabs were secured when time allowed. Most calves appeared to be in good physical condition at the time of handling.

Thirty-five of 54 collared calves died during the study. Causes of mortality by study area were as follows: a) Area 1--Mendeltna, 16 - brown bear predation, 4 - project induced abandonments, 1 - wolf predation, 1 - broken back, 1 - drowning, and 1 - unknown predation; b) Area 2--Susitna River, 8 - brown bear predation, 2 - project induced abandonments, and 1 - pneumonia. One collar fell off in late August. Predation accounted for 90 percent of the natural mortality. Eighty-three percent of the natural mortality occurred prior to 24 June or within one month after parturition.

Three of seven adult members of the Mendeltna wolf pack which had been equipped with radios prior to this study were monitored intensively along with radio-collared calves. The pack was observed on 11 kill sites between 27 May and 15 July 1977; seven adult moose, three calf moose and one yearling brown bear. Brown bears were also observed along with the wolves on six of the kills.

We tallied 76 brown bear observations during the study, 53 in the Mendeltna area and 23 in the Susitna River area. At least 28 individual bears were identified based on differences in color and age.

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BACKGROUND

In recent years moose (*Alces alces*) populations within several of Alaska's Game Management Units have exhibited downward trends in total numbers (McKnight 1976). Reasons for these declines are not known, but low annual recruitment due to poor calf survival prior to November moose sex and age composition counts has been suggested as the predominant factor. Some biologists have suggested more specifically that wolf (*Canis lupus*) predation has been the most significant factor contributing to the low calf survival rates (Gasaway 1976 and McIlroy 1976). One such area where total population numbers have declined is Alaska's Game Management Unit (GMU) 13 in Southcentral Alaska.

Moose population indices for GMU 13 for the period 1960 through 1974 exhibited downward trends in nearly all sex and age classifications examined (McIlroy 1976). Wolf predation was thought to be the most important factor contributing to low neonatal moose calf survival, although other factors such as decreasing range quality, brown bear (*Ursus arctos*) predation, low bull:cow ratios, and periodic severe winters were not ruled out (McIlroy 1974). As a consequence of declining population trends and the findings of Stephenson and Johnson (1972) and McIlroy (1976), a wolf-moose study was initiated.

This study, initiated in March 1975, was designed to field test the hypothesis that wolf predation was responsible for low neonatal calf survival in GMU 13. It basically involved two interrelated projects: 1) a wolf project consisting of removing wolves from one area, monitoring wolf population status in another area, and comparing moose population indices in the two areas in following years and 2) a moose project focused on assessing moose physical condition, pregnancy rates, population identity and movements, primarily within the wolf removal area. Results of both projects (Jobs 14.10R and 1.20R, respectively) will be reported in greater detail elsewhere under Federal Aid to Wildlife Restoration Project Numbers W-17-9 and W-17-10.

Prior to and during the early phases of the studies mentioned above, advances in radio telemetry and collar design for elk (*Cervus canadensis*) calves (Schlegel, pers. comm.) made it feasible to study moose calf mortality directly by radio-collaring and monitoring newborn moose calves. This provided us the opportunity to measure and determine the causes of moose calf mortality in two areas; one area theoretically devoid of wolves and another area with a moderate wolf density. This report presents the initial findings of the calf mortality study.

STUDY AREAS

The areas selected for the calf moose mortality study are referred to as the Mendeltna Creek Study Area (Area 1) and the Susitna River Study Area (Area 2) (Fig. 1). Area 1 is located in the upper Nelchina River Basin of GMU 13 and roughly consists of 1,030 km^2 lying north of the headwaters of the Little Nelchina River. Boundaries of this area roughly correspond to the territory boundaries of the Mendeltna wolf pack which had been studied for the past year. Area 1 is outlined by: Old Man Lake on the east; then north in a straight line to the southern end of Lake Louise; hence in a straight line northwest to Moore Lake; then southwest in a straight line to the head of Daisy Creek; from Daisy Creek directly south to the Little Nelchina River on the south; then directly east back to Old Man Lake.

Area 1 contains flat, wet muskegs with numerous scattered ponds and lakes on its eastern one-third. Slightly rolling, drier hills cover the middle of the area, with hills becoming progressively steeper to the west as the area encompases the foothills and portions of the Talkeetna Mountains. Elevation of Area 1 ranges from 700 m at Old Man Lake to approximately 1,300 m on the western edge. Vegetation of the area is varied and consists of several plant associations. Much of its lowlands are vegetated with sparse to dense stands of both white spruce (*Picea glauca*) and black spruce (*P. mariana*) interspersed with wet muskeg areas edged with several species of grasses, sedges (*Carex* sp.), willows (*Salix* sp.) and birches (*Betula* sp.). Slightly drier, better drained sites contain a mixture of relatively taller white spruce, willow and shrub birch (*Betula glandulosa*). Toward the western half of Area 1, densities of spruce begin to diminish and the area is a transition zone between spruce-muskeg and subalpine tundra. Here the area contains sparse stands of short spruce interspersed with mixed stands of shrub birch and willow. Subalpine portions are dominated by willow and scrub birch, with spruce occurring primarily on southerly exposures. Well-drained, sandy sites on the lowlands often contain relatively homogenous stands of aspen. Understory vegetation, typical of that found elsewhere in the Nelchina Basin, is comprised of varying densities of low bush cranberry (*Vaccinium vitis-idaea*), high bushcranberry (*Viburnum edule*) and two species of blueberry (*Vaccinium ovalifolium, V. uliginosum*). Lichens are found in varying quantities throughout the area. Most of the area has been described previously (Skoog 1968), conforming to Skoog's description of Area 15 - Lake Louise Flats.

Area 2, in the upper Susitna River Basin of GMU 13, is located halfway between the communities of Cantwell and Paxson with the Denali Highway bissecting the area from east to west (Fig. 1). Its boundaries consist of the following: the Alaska Range on the north; the Maclaren River on the east; the Maclaren and Susitna Rivers on the south; the confluence of Deadman Creek with the Susitna River northward to headwaters of Brushkana Creek, downstream to Brushkana Creek's confluence with the Nenana River and then northwest upstream to the Alaska Range on the west. The area comprises approximately 7,800 km^2. Its topography,

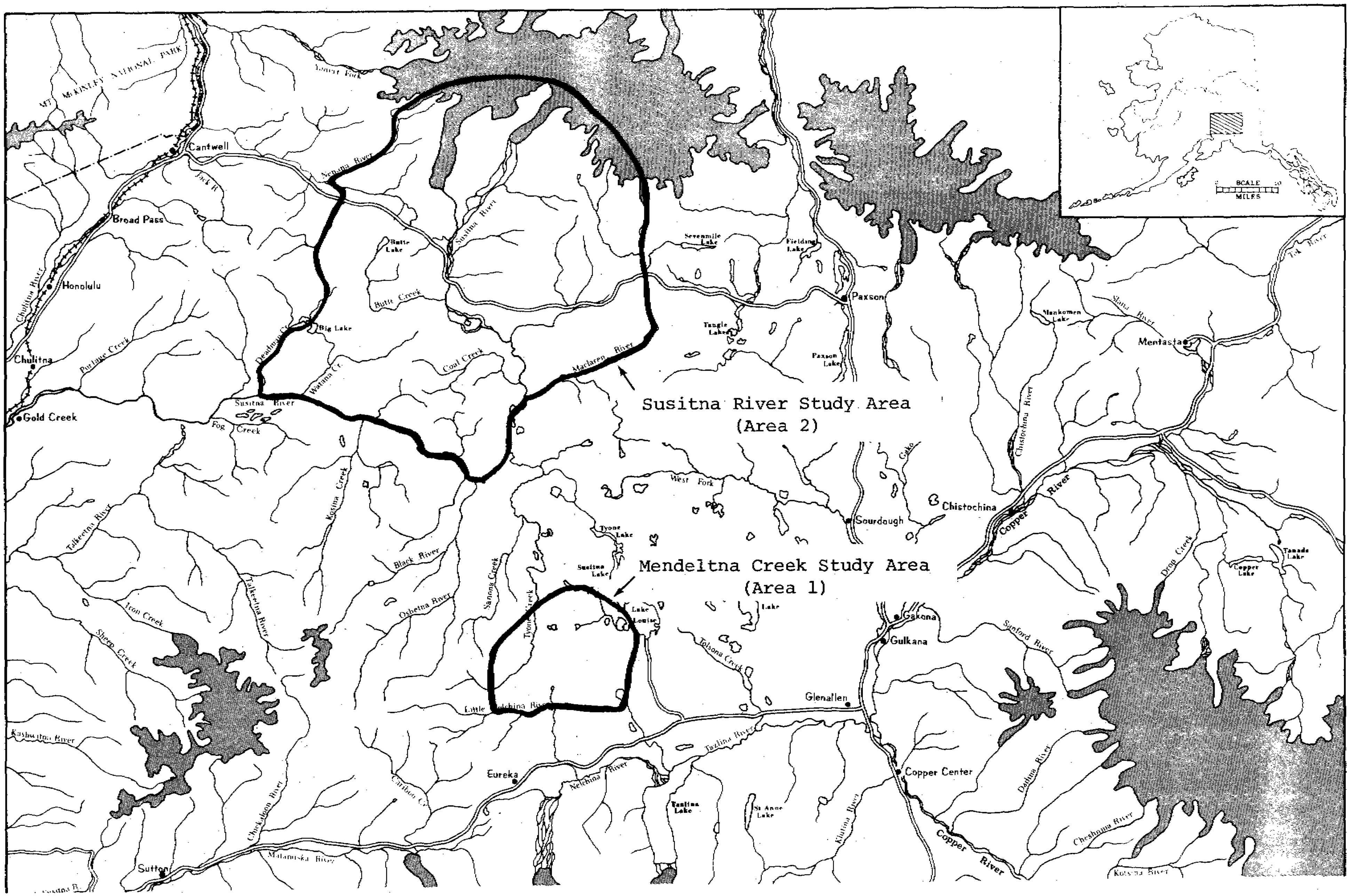

Figure 1. Locations and boundaries of two study areas in GMU-13 where newborn moose calves were radio-collared during 1977.

climate and vegetation were also described by Skoog (1968). Wolf control, conducted in the area since January 1976, has reduced its wolf density to a low level.

As previously mentioned, Area 1 encompasses both the winter and summer territory of the Mendeltna wolf pack. This pack was chosen for comparative purposes because it represented a moderate wolf density of approximately one wolf/100 km^2. Three of its seven members had been radio-collared, allowing determination of the location of most of the pack members at any time.

Both study areas are inhabited by alternate wolf prey species including caribou (*Rangifer tarandus*), snowshoe hares (*Lepus americanus*), beaver (*Castor canadensis*), and muskrats (*Ondatra zibethica*). Both areas also support populations of brown bears and black bears (*Ursus americanus*); the latter in very low densities.

OBJECTIVES

To determine the extent and causes of moose calf mortality in the Nelchina Basin.

PROCEDURES

Expandable calf collars constructed of international orange polyvinyl plastic were 10 cm wide with an inner circumference ranging from 25 to 69 cm. These collars consisted of two strips sewn together with single stitches of cotton thread. The center of the double strip folded to form a casing for the radio which was then riveted to the collar through two metal flaps on each side. Nylon elastic 36 cm long and 1.3 cm wide was sewn to the base of the collar between the polyvinyl strips. One side was sewn so the elastic would remain permanently attached and the other side was loosely stitched so the elastic would break away as the collar expanded. Each side of the collar was overlapped at the top and loosely stitched together to permit the collar to break away as the calf grew. On the finished collar, 10 cm up from the rivet, a 5-mm wide piece of nylon elastic 9 cm long was sewn to the inner portion of the collar to facilitate a better fit on newborn calves. This elastic was designed to break away in approximately one month, allowing the calf to grow into the remainder of the collar. Collars were designed and constructed by Mr. Mike Schlegel, biologist, Idaho Department of Fish and Game. His successful design for elk calves was modified to conform to moose calf measurements. The entire collar with transmitter weighed 296 grams.

Radios were supplied by Telonics Company, 1048 East Norwood, Mesa, Arizona, 85203. Each transmitter (without collar) weighed 170 grams. Transmitters emitted a pulsed signal on frequencies ranging from 148.487 through 148.975 MHz. Each transmitter was equipped with a "mortality sensor" which doubled the pulse rate of the signal when the transmitter remained motionless for a 4-hour period. Power was provided by a lithium battery measuring 24.1 mm by 50.8 mm giving a theoretical operating life span of 12 to 15 months. Ribbon antennas (2 cm wide by 42 cm long) were between the two polyvinyl strips of the collar, and each transmitter was hermetically sealed in a waterproof metal housing containing internal magnetic switching for storage after use.

We used a portable radiotelemetry receiver manufactured by A.V.M. Instrument Company, Champaign, Illinois. This receiver contained four bands with 12 channels per band and covered frequencies ranging from 148.500 to 149.675 MHz.

We flew over both study areas every two days beginning on 20 May 1977 to determine the onset of moose parturition. Parturition was first recorded on 24 May and the calf collaring operation was initiated on 26 May. Newborn moose calves were first located from fixed-wing aircraft; then their exact location was relayed by radio to a nearby Jet Ranger B helicopter. The helicopter was equipped with a steel rimmed box on each side measuring approximately 0.6 x 1.2 m which served as a platform from which to jump.

Initially, the tagging crew consisted of pilot and three biologists. Two biologists processed captured calves while the third stood by with a 12 guage shotgun for protection purposes.

Calves were captured by lowering the helicopter toward a cow and calf until the cow moved away from the calf. The calf then would usually lie down or run a short distance before lying down, and the tagging crew would jump to the ground and capture it. The helicopter remained airborne and, if the cow started to charge, it would be used to keep her away from the ground crew.

Each calf was collared and its sex was determined immediately. Usually a hair sample was plucked from its back between the shoulder blades to aid in assessing the animal's condition using techniques presented by Franzmann et al. (1975). All hair samples were later sent to Dr. Arthur Flynn, Case Western Reserve University, Cleveland, Ohio.

When practical, several body measurements were recorded. Calves were weighed by placing them in a nylon net with 5 cm stretch mesh and affixing a scale (Overland Handy scale #241) to the net. Measurements included total length, heart girth, neck circumference and length of hind foot (Fig. 2). Dentition of most calves was photographed.

Samples of blood were taken from the radial vein of each calf using sterile evacuated containers. Upon returning from the field, the blood was centrifuged and serum separated and placed into 5-ml plastic vials and immediately frozen. One-ml samples were later sent to Alaska Medical Laboratories, Anchorage, Alaska for blood chemistry analysis (Technical Autoanalyzer SMA-12) and protein electrophoresis (Franzmann and Arneson 1973). Generally one or two 10-ml vials were filled 1/3 to 1/2 full. One of the vials contained heparin which provided whole blood for determination of the percent hemoglobin (Hb) with an HB-meter (American Optical Corporation, Buffalo, New York) and packed cell volume (PCV) with a micro-hematocrit centrifuge (Readocrit-Clay-Adams Company, Parsippany, N.J.). Remaining sera are being stored for possible future analysis.

Rectal swabs were taken when practical to culture for pathogenic bacteria. Swabs were placed in sterile, screw-capped tubes and refrigerated until transferred to Richard Barret, Alaska State-Federal Lab., Palmer,

Moose Calf Collaring Form

Calf Number:______ Date:__________ Time: Caught ________________ Released ___________

Collar: Color______Number_____ Radio Frequency________ B/M_____ Channel______________
Tone Number__________

Ear Tag: Color_______ Number________ Ear: Rt.________ L.___________

Location: Drainage______________________ Code Number____________ Elevation_____________

Slope______________Vegetation Type________________ Aspect_________________

Measurements: Weight_______ Total Length________ Rt. hind Leg_________ Neck Cir._______

Heart Girth________ Head length___________ Blood: Yes____ No_____ Sex____
Hair: Yes____ No_____

Moisture of Hair: Wet____ Dry____ Matted____ Dampness inside ears__________________

Dentition: Front Incisors: Covered by membrane or protruding less than 1/8" ________

Protruding 1/8" to 1/4" ___________

Protruding 1/4" to 3/8" ___________

Protruding 3/8" to 5/8" ___________

Upper canines: Not through____ Barely through_____ 1/8" or more__________

Check teeth: Not through or barely so_______ 1/16" or less

1/16" or more _________

Estimated Age: _______________

Navel: Bloody________ Scab diameter_______ Moist________ Dry_________

Hooves: Entirely soft______ Less than 1/2 hardened_________ All hardened__________
Ragged: Yes______ No______ Grass stained: Yes_____ No_____ Dew Claws: Soft______
Hard______

Stature and stability: Insecure and wobbly: Yes______ No____ Legs spread: Yes____No______
Humped posture when standing: Yes_____ No_____

General comments(How captured, how cows reacted, how calf reacted):

Figure 2. Form utilized to record data on moose calves captured and radio-collared in two study areas in southcentral Alaska during 1977 (adapted from Schlegel 1976).

Alaska. All samples were cultured on the following laboratory media: Blood agar, EMB, SS, BG and Mac. Enterobacteria were identified by the Enterotube method (R. Barret, Pers. Comm.).

Ground crews left the calf after processing and met the helicopter a considerable distance away from the site. Notes were taken on the cow's reaction to the collared calf from the helicopter, usually 0.4 km away.

Radio-collared calves were monitored from fixed-wing aircraft generally twice per day for the first 2 weeks; flights were usually made between 0800 hr and 1000 hr, and 1700 and 1900 hr. Thereafter calves were observed once daily and the radio signal was monitored twice daily for two weeks. After the first month calves were monitored less frequently, averaging once per week up to 1 August and then every 6-8 weeks until radio contact was lost or the collar fell off.

Calves were located using twin 3-element antennas mounted on each of the airplane struts using methods similar to those described by Mech (1974). Three radio-collared wolves from the Mendeltna wolf pack were also monitored during the same flights made to track calves. Wolves were visually located twice daily from 27 May through 30 June and once daily from 30 June through 15 July.

Total flight time for each monitoring period rarely exceeded 2 hours. When calves were either observed dead or the mortality unit was activated, an aerial search within approximately 0.8 km of the kill site was made in an attempt to sight predators. Locations of all three of the radio-collared wolves were also checked. We used a helicopter to return to the site of observed or suspected calf mortality within 2 hours during the first three weeks of the study. Afterwards, suspected kills were examined via floatplane, which significantly lengthened the time between locating a suspected kill site and returning to examine it.

A two-element, hand held antenna (Telonics Co., Mesa, Arizona) attached to a receiver was utilized to locate suspected kills. The antenna was held outside the helicopter window allowing us to pinpoint and often observe the carcass. When kills were not observable, the same antenna was used to locate the carcass on the ground.

The area surrounding a dead calf was searched for tracks and predator scats. Once this was accomplished, other pertinent observations were recorded on the mortality form (Fig. 3). For predator related deaths, the vegetation within a 15 m radius of the kill or kill site was thoroughly searched for the presence of hair for use in species identification. Hair samples were later independently verified by Mr. Jack Jordan, Investigative Unit of Fish and Wildlife Protection, Division of the Alaska Department of Public Safety, Palmer, Alaska, according to a modification of the methods described by Adorjan and Kolenosky (1969).

All of the dead calves not killed by predators and, initially, a few of those killed by predators were retrieved and transferred to Palmer for necropsy by Richard Barret, Alaska State-Federal Lab., Palmer, Alaska.

Moose Calf Mortality Form

Calf Number____________ Date & time________________ Date Captured__________

Kill Location________________________ How long dead________________

Approx. age of calf______________ Last Monitored: Date________ Time________

Photos____________ Carcass weight__________ Incisor length____________

Hind leg length______________ Heart girth________ Total length____________

Description of Kill Site: Slope__________ Aspect________ Vegetation__________

Canopy Cover________%

Comments:

Description of Carcass: Amount consumed______% Distance from kill site__________

Tongue removed: Yes_____ No_____ Ears Removed: Yes_____ No_____

Collar removed: Yes_____ No_____ Hide inverted: Yes_____ No_____

Eyes removed: Yes_____ No_____ Subsutaneous hemorrhage: Yes_____ No_____

Claw marks on hide: Yes_____ No_____ Location______________________________

Puncture wounds: Yes_____ No_____ Diameter:_______________________________

Location:____

Comments:

Predator sign: Scats near carcass: Yes_____ No_____ How many:______ Species__________

Scat collected: Yes_____ No_____ Carcass Covered: Yes_____ No_____ Material__________

Tracks near carcass: Yes_____ No_____ Species______________

Track measurements:____

Comments:

Figure 3. Form utilized to describe moose calf mortality within two study areas in southcentral Alaska during 1977.

RESULTS

Between 26 May and 9 June 1977 a total of 54 moose calves were radio-collared in the two study areas; 29 in Area 1 and 25 in Area 2. In Area 1, four calves had twin siblings which were also collared and another had a twin which was not collared and in Area 2 three sets of twins were collared.

All calves which we attempted to capture were successfully collared except for three within Area 1. These unsuccessful attempts resulted from an aggressive defense by the cow and tall vegetation which prohibited using the helicopter to force the cow to leave.

Time spent processing each calf ranged from 30 seconds to 25 minutes; averaging approximately 10 minutes when calves were sexed, measured, collared, weighed, and hair and blood extracted. When calves were only collared and sexed, processing time was reduced to an average of 3 minutes.

Initial efforts on 26 May resulted in collaring 20 calves, 19 of which were fully processed. Subsequent monitoring on 27 May revealed that four of these calves had been abandoned, apparently as a result of handling. Observations of cow behavior following field crew withdrawal suggested that both human scent and extreme harassment were responsible. Initially, the helicopter was used extensively to insure that the field crew would not be charged. On at least two occasions the cow apparently became disoriented as a result of this harassment and, even when the field crew and helicopter pulled away, did not return to the calf. In the other two cases the cow was observed to run back to the calf and, when approximately 10 m away, the cow lowered her head and slowed her approach to the calf. The cow then appeared to sniff her young, bolt backwards and run from the calf. After 27 May, capture methods were modified the following ways: (1) the helicopter stayed away from the cow until it became evident that the field crew would be charged, (2) the collars were sterilized with detergent and ethyl alcohol, and (3) sterilized latex gloves were worn and the calf was held away from our torsos. Following these modifications, calves were sometimes collared with full processing or collared after securing only sex and hair samples. A total of 15 calves were collared using these procedures, resulting in only one abandonment. Observations showed that the cow went directly to the calf even when fully processed.

A total of 25 hours of helicopter and 27 hours of Super Cub flying time were used to collar the 54 calves. Cost of collaring each calf was $155.00. Costs of full processing of calves were not compared to those for collaring alone, but full processing was obviously more expensive. Calf monitoring and subsequent examination of dead calves required 250 hours of fixed-wing and 26 hours of helicopter flying time, costing $22,150.00.

Table 1 lists dates and locations of capture, sex, estimated age, and physical measurements of collared newborn moose calves. Initially, ages of all calves tagged during this study were subjectively estimated on the basis of size and appearance of the umbilical cord; estimated ages ranged from a few hours to 7 days old. Notes on calf tooth eruption were recorded inconsistently and those that were recorded showed no apparent age correlation.

We noted some differences in length and texture of scabs on the umbilical cord. Calves estimated to be less than one day old often had fleshy, bloody umbical scabs ranging from 50 to 60 mm in length. Older and larger calves, however, had dried, shriveled umbilical cords. Notes on hardness of hooves and wetness of hide proved meaningless as only one calf was recorded as having soft hooves. Nearly all calves were recorded as being dry and those that were judged wet were in that condition because of rain or moisture from surrounding vegetation.

Ages listed in Table 1 are based on the weight and the rate of growth of one newborn captive moose raised at the Kenai Moose Research Center (Franzmann and Arneson 1973). These estimated ages corresponded well with our estimates for 1-day-old calves but did not for the others, as we judged most of the calves to be less than 7 days old.

Sex ratios of examined calves were skewed towards males in both study areas, 62 percent in Area 1 and 78 percent in Area 2. Calf weights ranged from 10.9 to 26.3 kg. Total length measurements ranged from 81 to 118 cm. Other measurements and their respective ranges were: hind leg - 39 to 49 cm, neck circumference - 22 to 36 cm, and heart girth - 49 to 71 cm. Gross examination of these data indicates that correlations probably exist between the measurements and estimated age. However, these data will not be analyzed further until sample size is increased.

Table 2 lists the values, means and standard deviations by calf sex of the various blood parameters tested from samples acquired in both study areas. Hemoglobin (Hb) values ranged from 6.5 to 14.9 mg/100 ml, packed cell volume percentages ranged from 28 to 44, and total protein ranged from 4.2 to 7.1 gm/100 ml. Other selected parameters had the following ranges (expressed as mg/100 ml): calcium, 11.0 to 13.4; phorphorus, 4.3 to 9.3; glucose, 44 to 183; B.U.N., 5 to 46; and cholesterol, 62 to 149. Further analyses will be performed and results compared between study areas and to similar studies being conducted on the Kenai Peninsula (Franzmann, pers. comm.) when sample sizes are increased and the data are permanently transferred to computer tapes. Results of hair analyses for trace element composition were not available for this reporting segment and thus will be recorded in future reports.

No bacteria were isolated from 7 of 33 (21.2%) rectal swabs and the most prevalent bacterium isolated from the others was *Escherichia coli* (Table 3). Other bacteria isolated were *Enterobacter* sp., *Klebsiella* sp., *Shigella* sp., *Corynebacterium* sp., *Streptococcus* sp. and *Citrobacter diversus*. Calves 120031, 120034 and 120080 had the largest diversity of bacteria species identified.

All calves but two were judged to be in good physical condition at the time of collaring. This subjective evaluation was based on weight, appearance while being collared, and behavior before and after collaring.

Table 1. Locations and physical measurements of 54 moose calves radio-collared in both the Mendeltna Creek and Susitna River Study areas between May 26 and June 9, 1977.

Mendeltna Study Area (Area 1)

Moose calf accession #[a]	Date collared	Collaring location	Sex	Weight (kg)	Estimated Age (days)[1/]	Measurements (cm) Total Length	Hind Leg	Neck circum.	Heart Girth
120029	5/26/77	6.4 km W Nickolson Lake	M	18.2	4	99.7	45.1	-	59.1
120030[a]1	5/26/77	4.8 km SE Kelly Lake	F	11.8	1	86.4	40.3	22.2	49.5
120031[a]1	5/26/77	4.8 km SE Kelly Lake	M	13.2	1	96.5	38.7	24.8	51.4
120032	5/26/77	8.9 km W Nickolson Lake	M	17.3	3	95.8	44.1	27.9	54.0
120033[a]2	5/26/77	2.4 km WSW Kelly Lake	F	-	-	87.0	41.9	26.0	50.5
120034[a]2	5/26/77	2.4 km WSW Kelly Lake	F	14.5	1	95.3	42.6	25.4	55.3
120035[a]3	5/26/77	3.2 km W Old Man Lake	F	-	-	82.6	41.6	25.8	53.7
120036[a]3	5/26/77	3.2 km W Old Man Lake	F	12.7	1	89.5	43.5	27.9	54.6
120037	5/26/77	3.2 km SW Cat Lake	F	18.6	4	93.0	25.1	26.4	60.3
120038	5/26/77	2.4 km W Marie Lake	F	25.4	9	109.2	46.2	31.4	71.1
120039	5/26/77	1.6 km NE Marie Lake	M	18.2	4	94.3	45.7	31.1	60.0
120040	5/26/77	2.4 km SSW Cat Lake	M	19.1	4	97.8	45.1	27.3	62.2
120041	5/26/77	3.2 km W Nickolson Lake	M	12.7	1	85.1	44.5	24.5	48.9
120042	5/26/77	0.8 km W Blue Lake	M	17.7	4	-	47.0	29.2	54.6
120043	5/26/77	7.3 km WSW S-Lake	-	18.2	4	90.2	46.0	27.3	60.3
120044	5/26/77	4.8 km WNW Tawawe Lake	-	26.3	10	-	47.0	-	-
120045	5/26/77	5.6 km NW Tawawe Lake	F	19.1	5	105.1	45.7	27.0	-
120046	5/26/77	3.2 km S Kelly Lake	M	19.1	5	117.5	45.1	28.6	60.3
120047	5/26/77	2.4 km SW Kelly Lake	M	19.1	5	97.8	42.9	27.6	62.2
120048	5/26/77	0.8 km NW John Lake	M	-	-	-	-	-	-
120049	5/27/77	3.2 km SW Cat Lake	F	19.1	5	-	-	-	-

120050	5/29/77	3.4 km SW Cat Lake	M	–	–	–	–	–	–
120051	5/29/77	4.0 km E John Lake	M	–	–	–	–	–	–
120052[a]7	5/29/77	4.0 km SW S-Lake	–	–	–	–	–	–	–
120053[a]4	5/29/77	4.0 km SW S-Lake	M	–	–	–	–	–	–
120054[a]5	5/31/77	4.0 km W Kelly Lake	F	–	–	–	–	–	–
120054[a]5	Uncollared	4.0 km W Kelly Lake	–	–	–	–	–	–	–
120055	5/31/77	4.8 km W S-Lake	M	–	–	–	–	–	–
120056	5/31/77	0.8 km N Kelly Lake	M	–	–	–	–	–	–
120057	5/31/77	4.0 km E Head Nicolie Ck.	M	–	–	–	–	–	–

Susitna River Study Area (Area 2)

120058	5/28/77	3.2 km N Old Denali	–	–	–	–	–	–	–
120059	5/28/77	8 km upstream Butte Cr.	M	26.3	10	118.1	48.9	36.2	71.1
120060	5/28/77	2.9 km N Old Denali	F	13.6	1	94.0	43.2	25.4	55.9
120061	5/28/77	3.5 km E mouth of Clearwater Creek	M	17.3	3	101.6	47.6	28.6	59.7
120063	6/1/77	0.6 km below Susitna Glacier	M	–	–	–	–	–	–
120064	5/28/77	0.3 km NW Snodgrass Lk.	F	14.5	1	95.9	43.8	27.6	55.3
120065	6/8/77	1.0 km NW mouth Boulder Creek	M	–	–	–	–	–	–
120066	5/28/77	3.2 km NNW Old Denali	F	10.9	1	81.3	40.6	28.6	53.3
120067	5/28/77	6.1 km upstream from mouth McClaren R.	–	22.7	7	–	–	–	–
120068	5/28/77	0.6 km W of confluence of east & middle banks of Susitna River	M	20.4	6	94.0	43.2	33.0	66.0
120069	5/30/77	0.6 km below Susitna Glacier	F	–	–	–	–	–	–
120070	5/28/77	1.9 km NW Old Denali	M	19.1	5	97.8	45.7	34.3	63.5
120071[a]6	5/28/77	5.8 km NNE mouth of Valdez Creek	F	–	–	–	–	–	–

120072[a]6	5/28/77	5.8 km NNE mouth of Valdez Creek	M	-	-	-	-	-	-
120073[a]7	5/28/77	3.5 km N Denali Hwy. Bridge on Susitna R.	M	-	-	-	-	-	-
120074[a]8	5/28/77	1.3 km N Denali Hwy. Bridge on Susitna R.	M	-	-	-	-	-	-
120075[a]8	5/28/77	1.3 km N Denali Hwy. Bridge on Susitna R.	M	-	-	-	-	-	-
120076[a]7	5/28/77	3.8 km N Denali Hwy. Bridge on Susitna R.	M	-	-	-	-	-	-
120077	5/30/77	0.3 km SW Swampbuggy Lake	M	22.7	7	104.1	48.3	33.0	71.1
120078	5/27/77	0.6 km S Susitna Lodge	M	21.8	7	99.1	45.7	33.0	63.5
120079	5/27/77	1.6 km SW Swampbuggy Lake	M	17.3	3	-	-	-	-
120080	5/27/77	0.6 km S Swampbuggy Lake	M	15.0	1	94.0	44.5	30.5	57.2
120081	5/31/77	5.1 km NE confluence of McClaren & Susitna R.	M	-	-	-	-	-	-
120082	6/9/77	1.3 km W Hatchet Lake	M	-	-	-	-	-	-
120086	5/28/77	1.8 km SSE mouth of Butte Creek	M	14.5	1	94.0	45.1	26.0	54.0

a/ Letter subscript indicates sets of twins.

1/ Ages estimated from weight based on one known calf's weight from the Kenai Peninsula (Franzmann and Arneson 1973).

Table 2. Blood values[1] of newborn moose calves radio-collared from 26 May to 9 June 1977 from two study areas in GMU 13.

Accession #	Hemoglobin	Packed Cell Vol. %	Calcium	Pho-phorus	Glucose	B.U.N.	Uric Acid	Cholesterol	Bilirubin	SGOT	Total Protein	Albumin %	Globin %	Alpha 1 %	Alpha 2 %	Beta %	Gamma %	A/C Ratio
Female																		
120030			11.8	9.1	183	13	0.5	113	0.4	59	5.7	48.9	51.1	7.6	5.6	20.4	17.6	0.96
120033	11.3	32	12.9	7.7	152	17	0.6	93	0.6	63	5.4	43.3	56.7	7.9	11.0	15.8	21.9	0.76
120035			13.4	5.9	130	19	0.2	116	1		5.3	42.5	57.6	8.3	7.1	24.7	17.6	0.74
120036	10.6	41	13.2	5.7	139	18	0.5	103	0.9	256	4.2	44.7	55.3	8.4	9.0	22.8	15.1	0.81
120037	10.5	37	12.2	9.1	154	11	0	108	0.7	67	5.0	48.9	41.1	10.4	10.9	16.3	13.6	0.96
120038	11.0	35																
120060	14.9	36	11	5.1	113	15	.3	81	1.2	89	4.4	53.4	46.6	9.7	13.1	9.9	13.8	1.15
120064			10.8	4.3	131	5	1.3	62	0.7	66	5.0	46.8	53.2	9.7	9.0	11.2	23.4	0.88
$\bar{x}$	11.7	36.2	12.2	6.7	143.1	14.0	.49	96.6	0.79	100	5.0	46.9	53.1	8.9	9.4	17.3	17.6	0.89
S.D.	1.84	3.3	1.04	1.9	22.5	4.9	.41	19.6	0.27	77.1	0.54	3.8	3.8	1.1	2.5	5.6	3.9	0.14
Male																		
120029	6.5	36																
120039	10.7	38	12.0	9.3	171	9	0.6	112	0.6	54	5.9	42.3	57.7	6.3	9.6	20.3	21.5	0.73
120040	11.4	38	12.0	7.9	165	17	0.5	104	0.4	41	5.8	41.9	58.1	10.3	5.1	15.9	26.9	0.72
120041	10.9	37	11.9	5.5	44	46	1.0	90	0.5	96	6.0	40.1	59.9	8.7	8.6	14.4	28.2	0.67
120042			12.7	6.1	149	23	0.7	98	2.6	91	6.0	42.8	57.2	10.3	4.8	15.3	26.9	0.75
120043	13.4	42	11.3	4.9	136	16	0.2	84	1.1	70	6.1	39.9	60.1	7.7	7.1	13.3	32.0	0.66
120045	9.5	30	12.6	7.4	144	25	0.2	125	14.		4.8	38.1	61.9	8.1	7.5	28.2	18.1	0.61
120047	11.6	36	11.6	7.8	134	16	1.0	149	1.3		5.8	36.9	64.1	8.9	4.0	36.4	14.7	0.56
120059	10.9	28	11.7		205	15	0.0	121	0.5	50	5.7	49.4	50.6	5.3	3.9	22.4	19.0	0.98
120061	14.4	39																
120065	11.4	27	11.0	5.4	63	21	1.2	90	1.3	88	6.6	34.5	65.5	7.5	7.0	15.9	35.2	0.53
120066	13.6	34									4.5	36.7	63.3	12.1	5.1	10.6	27.5	0.58
120068	12.8	31	13.1	5.9	174	26	0.7	92	0.4	57	5.4	45.5	54.5	10.8	7.1	16.5	20.1	0.84
120070	11.7	34	12.6	6.3	145	23	0.8	79	0.5	61	6.4	38.5	61.5	8.9	4.0	14.0	34.7	0.63
120077	10.2	36	11.6		176	15	0.2	129	0.4	55	5.1	55.5	44.5	7.5	8.2	20.1	8.7	1.25
120078	11.7	33	12.8	5.4	181	20	1.0	96	0.9	50	5.1	49.4	50.5	8.8	8.3	16.2	17.3	0.97
120079	14.2	44									7.1	22.0	78.0	4.2	1.3	54.5	18.0	0.28
120080	12.7	30	12.0	8.5	159	13	0.7	99	0.5	71	5.0	44.3	55.7	8.2	9.8	19.6	18.0	0.8
$\bar{x}$	11.6	34.9	12.1	6.7	146.1	20.4	0.63	104.9	0.86	65.3	5.7	41.05	58.9	8.4	6.3	21.4	23	0.72
S.D.	1.9	4.7	0.61	1.43	43.9	8.8	0.37	19.9	0.6	18	0.69	7.5	7.5	2.02	2.4	10.7	7.5	0.22
Sex Unk.																		
120067	11.8	29									6.3	39.0	61.0	9.1	5.4	29.0	17.5	0.64
$\bar{x}$																		
S.D.																		
Total																		
$\bar{x}$	11.6	35.2	12.1	6.7	145.1	18.5	0.58	102.1	0.84	76.9	5.53	42.7	57.3	8.5	7.1	20.5	21.1	.77
S.D.	1.9	4.4	0.72	1.58	37.5	8.20	0.38	19.63	0.54	47.4	0.72	6.98	7.0	1.7	2.7	9.4	6.9	0.21

1 Values expressed as mg/100 ml., except as designated otherwise and total protein as gm/100 ml.

Table 3. Bacteria cultured from rectal swabs taken from selected newborn moose calves located in two study areas in Southcentral Alaska during late spring and early summer 1977[1/].

Calf #	Bacteria identified	Identification probability - %	Calf #	Bacteria identified	Identification probability - %
120030	Negative		120046	*Escherichia coli*	
120031	*Escherichia coli*		120047	*Escherichia coli*	
	Enterobacter sp.	49.8	120049	*Escherichia coli*	
	Klebsiella sp.	27.2	120059	*Escherichia coli*	
	Shigella sp.	10.7	120060	Negative	
120032	*Escherichia coli*		120061	*Escherichia coli*	
120033	Negative			*Streptococcus* sp.	
120034	*Escherichia coli*	28.0	120064	Negative	
	Enterobacter	64.0	120066	Negative	
	agglomorensa		120067	*Escherichia coli*	
	Shigella sp.	8.0		*Citrobacter diversus*	
120035	*Escherichia coli*		120068	*Escherichia coli*	
120036	*Escherichia coli*		120069	*Citrobacter diversus*	
120037	*Escherichia coli*		120070	*Escherichia coli*	
120038	*Escherichia coli*		120077	*Escherichia coli*	
120040	*Escherichia coli*		120078	*Escherichia coli*	
120041	Negative		120079	*Escherichia coli*	
120042	*Corynebacterium* sp.		120080	*Enterobacter* sp.	49.8
120043	*Escherichia coli*			*Klebsiella* sp.	27.2
120044	*Escherichia coli*			*Shigella* sp.	10.5
120045	Gram negative		120086	Negative	
	rod - no I.D.				

1/ All samples were cultured on the following media: Blood agar, Emb, SS, BG and Mac. Enterobacteria were identified by Entero-tube method (R. Barret, pers. comm.).

Calves judged to be in good condition: 1) were observed standing close to cow prior to tagging, 2) made reasonable effort (usually by running with the cow a short distance) to escape from the helicopter, 3) had no physical abnormalities, 4) had normal appearing coat sheen, and 5) made an attempt to escape when released.

Most calves collared during this study did not exhibit stress or fright while handled and most made no attempt to escape until released. Several instances were recorded where the calf apparently imprinted on the field crew and attempted to follow them back to the helicopter. Squalling and attempting to escape occurred occasionally and was the most extreme behavior observed. Calves which exhibited this type of behavior were processed quickly.

Calf Movements

From 27 May through 31 December 1977, a total of 1,002 visual observations of collared calves were made. Calf radio transmissions were checked on 773 additional occasions to determine if the mortality unit had been activated. Most calves remained within approximately 0.8 km of where they were tagged either until death or approximately 13 June when first significant movements were noted (Appendix 1, Table 1). Thirty-nine percent (n=14) of the collared calf mortality occurred within 0.8 km of the collaring site. Some calf movements appeared to be directly related to predation, indicating that calves may in some cases be pursued by a predator for considerable distances (1.6 to 21 km). The longest straight line movement recorded during this study was by calf 120057 which moved approximately 26 km between 1 October and 7 November. This movement was peculiar because the animal had moved from the tagging site between 15 July and 17 August to an area close to Eureka and then 2 months later moved back to the tagging site. A similar movement in the opposite direction was made by calf 120055 (Appendix 1 Table 1, Fig. 1). However, calf 120057 was still alive as of 7 November, whereas calf 120055 was killed by a predator between 17 August and 21 August. Calf movements will be analyzed more completely in subsequent reports.

Calf Mortality

Of the 54 radio-collared calves, only 18 were still alive as of 1 November 1977 when moose sex and age composition counts were conducted (Table 4). Project induced abandonment resulting in starvation was responsible for six mortalities, four in Area 1 and two in Area 2. The most significant cause of natural mortality was brown bear predation (83 percent of the calves dying naturally). This figure includes calf 120033 which died from starvation or exposure after its twin (120034) and mother were killed by a brown bear on 7 June. Calf 33 lived for 4 days and moved 1.6 km before succumbing.

The radio signal from calf 120038 was not received after collaring until 19 June at which time it was activated and the calf was found to be dead. Aerial observation revealed that the carcass was buried. The carcass was examined on the ground on 2 August, revealing that the carcass was totally consumed and that bear scats and bear hair were

Table 4. Summary of mortality factors influencing neonatal survival of radio-collared moose calves within two study areas in Game Management Unit 13 for the period 26 May through 1 November 1977.

	Area 1 Mendeltna Creek Study Area	Area 2 Susitna River Study Area
Total number of calves collared	29	25
Total number of project induced mortality	4	2
Total natural mortality	20	9
Causes of natural mortality -		
brown bear predation	16	8
wolf predation	1	-
pneumonia	-	1
drowning	1	-
physical disability	1	-
unknown predation	1	-
Loss of contact with calves		
collar fell off		1
Number of calves surviving to 1 November 1977	5	13

present. The length of time between the possible date of death and actual ground examination does not permit an evaluation of the cause of death. However, our observation did indicate predation and the kill was subsequently classified as unknown predator.

Calf 120046 was observed with a cow on 9 June adjacent to the Little Nelchina River surrounded by standing water. A storm the previous night had swollen the river to flood stage. The radio was activated on the morning of 11 June, 2 days after the previous observation. Ground inspection the same day traced the radio signal to a log jam on a sandbar where the radio and assumed calf were pinned underwater. Flood waters did not recede until mid-August at which time the collar was retrieved. The collar was stained and smelled of rotting flesh. A brown bear consumed the exposed carcass. The cause of mortality was diagnosed as drowning.

Calf 120047 was noted to have a shakey standing posture when first approached by the helicopter, and it did not attempt to run. Physical examination revealed that the anus was swollen and the fecal material collected on the rectal swab was an abnormal color. When monitored the next day (27 May) during the morning and afternoon the calf was observed with the cow. On the morning and evening of the 28th it was not observed with the cow, although the cow was close by in the evening. On the morning of the 29th the calf was observed alone with a cow approximately 180 m away. The calf looked weak. Its radio was activated by 6:00 p.m. that day and by 8:00 p.m. we arrived for ground examination. The unmolested carcass was lying on its sternum with all legs curled backwards. Necropsy revealed the following: lungs, gastro-intestinal tract and lymph nodes were normal, liver and kidneys were congested, bladder was enlarged and distended with urine, and the 4th, 5th and 6th lumbar vertebrae were surrounded by a fibrous blood clot. Upon dissection of the clot a complete separation between the 4th and 5th vertebrae was noted (R. Barret, pers. comm.). Collaring weight was 19.1 kg, and its weight at necropsy was 16.1 kg. Death was attributed to a broken back occurring at or shortly after birth.

Calf 120055 was the last mortality known to occur during the study. It had been observed alive with its cow on 17 August, and its remains were observed on 22 August. Ground examination on 23 August revealed that the carcass had been totally consumed. Wolf scats, tracks and hair were present, indicating that it was killed by wolves.

When initially collared, calf 120067 was alone on a sandbar in the Maclaren River. The cow was observed on the river bank 90 m to the north. During collaring a brown bear was observed feeding on freshly killed twin calves (I.D. numbers 120027 and 120028) less than 0.4 km away. After collaring, the calf was not observed with the cow for 36 hours, then it was observed with the cow for a 2-week period until its radio was activated the morning of 16 June. On 17 June the carcass was examined. It was unmolested and had no physical lacerations except that birds had picked some flesh from the anal area. Necropsy revealed the following: peritonitis, capsullar hemmorhage of kidneys, congested kidneys, mesenteric veins enlarged, adrenals enlarged and pneumonia present on right lung. Rumen, liver and gastro-intestinal tract appeared normal. Collaring weight was 22.7 kg and necropsy weight was 28.2 kg. Death of this animal can be attributed to any or all of the following conditions: peritonitis, kidney involvement, and pneumonia (R. Barret, pers. comm.).

Table 5 summarizes data collected from aerial observations and ground examinations partially utilized to interpret the cause of death of 45 moose. Included is information on nine calves (Accession Numbers 1200-54A, 27, 28, 87, 88, 89, 90, 91, 92) which were not radio-collared but, which were either examined on the ground, were uncollared siblings of a twin which was collared, or were seen with the predator. Excluding project induced abandonments, we recorded 37 calf mortalities, 33 of which were attributed to predation. The 33 predator kills were classified as follows: brown bear - 29, unknown predator - 3, and wolf - 1. Nine of the 29 kills attributed to bear predation, were classified on the basis of observation of bears alone at the kill site. The remainder of our bear kill classifications were based on combinations of the presence of tracks, hair, scats, and in some cases the way the calf had been devoured.

We observed considerable variation in the degree of utilization (expressed as a percentage) of bear-killed calves. Many calves had been totally consumed by the time we arrived; however, 13 of the kills ranged from almost 0 to 50 percent utilization. In most of these cases the tongue, eyes, and ears were the first parts of the carcass removed, and it was obvious that the brains and/or viscera were readily sought. Observations of bear-killed calves suggested that the calf usually was taken to the ground and killed by bites or a blow to the neck. We also observed variation on the occurence of inverted hides (8 kills) and buried carcasses (9 kills). In cases where the carcass was almost totally devoured it was impossible to determine if the animal had been skinned, although in some cases it appeared that the animal may have been skinned while the flesh was being consumed. Where we did not observe the predator, we attempted to collect hair from surrounding brush to aid in our determination of cause of mortality. We did this on 20 occasions and 19 were identified in the field as being from brown bear and one from wolf. At the time of writing, half of our identifications have been verified by hair scale impressions (J. Jordan, pers. comm.).

In 18 of 25 predator kills the collar had been ripped from the neck. Six of these transmitters were damaged but continued to transmit. Distance of the carcass from the kill site varied from 0 to 100 m. Although carcasses were often a considerable distance from either the collar and/or the kill site, we had little difficulty locating them. Carcasses which were moved were dragged in such a fashion that a trail was evident. Often the trail contained tracks and hair of the predator along with hair and pieces of flesh from the calf.

We collected data on the topography and vegetational characteristics at each kill site. We could detect no preference for a particular site characteristic.

Table 5. Characteristics and causes of mortality for individual moose calf kills examined in both the Mendeltna Creek and Susitna River study areas for the period 27 May through 1 November 1977.[1]

Mendeltna Creek Study Area (Area 1)

	Description of Carcass										Predator Sign				
Calf #[2]	Date of Examination	Maximum Time Dead	% Amount Consumed	Distance Carcass to Kill Site (m)	Collar Removed	Tongue Removed	Ears Removed	Eyes Removed	Hide Inverted	Wounds Present	Predator Observed	Predator Tracks Present	Predator Scats Present	Carcass Covered	Predator Hair Present	Cause of Death
120029	06/10/77	12 hr.	40	0	Yes	Yes	Yes	Yes	No	Yes-3.18 cm	No	Yes-B.B.	Yes-B.B.	No	Yes-B.B.	B.B. Predation
120030[a]1	05/31/77	18 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Abandonment
120031[a]1	05/29/77	28 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Abandonment
120032	05/29/77	30 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Abandonment
120033[a]2	06/11/77	13 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Bear Related Aban.
120034[a]2	06/07/77	17 hr.	30	0	No	Yes	Yes	Yes	No	Yes-.79 cm	No	Yes-B.B.	Yes-B.B.	No	Yes-B.B.	B.B. Predation
120035[a]3	06/22/77	19 hr.	99	0	Yes	Yes	Yes	Yes	?	Yes-?	No	Yes-B.B.	Yes-B.B.	No	Yes-B.B.	B.B. Predation
120037	05/27/77	21 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Abandonment
120038	08/02/77	36 days	99	?	Yes	?	?	?	?	?	?	Yes-B.B.	Yes-B.B.	Yes	Yes-B.B.	Unk. Predation
120040	06/13/77	24 hr.	20	1.52	Yes	No	Yes	No	No	Yes-.64 cm	No	Yes-B.B.	No	No	Yes-B.B.	B.B. Predation
120041	05/31/77	18 hr.	98	0	Yes	Yes	Yes	Yes	No	Yes-.79 cm	No	Yes-B.B.	No	No	Yes-B.B.	B.B. Predation
120042	06/05/77	17 hr.	50	0	No	Yes	Yes	Yes	No	Yes-.95 cm	No	Yes-B.B.	No	No	Yes-B.B.	B.B. Predatio
120044	06/17/77	21 hr.	90	0	Yes	Yes	Yes	Yes	Yes	Yes-.79 cm	No	?	Yes-B.B.	No	Yes-B.B.	B.B. Predation
120046	06/11/77	19 hr.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Drowned
120047	05/29/77	10 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Broken back
120048	06/07/77	11 hr.	99	3.05	Yes	Yes	Yes	Yes	?	Yes-?	No	Yes-B.B.	Yes-B.B.	Yes	Yes-B.B.	B.B. Predation
120049	05/29/77	28 hr.	99	0	Yes	Yes	Yes	Yes	Yes	?	Yes-B.B.	Yes-B.B.	No	No	NA	B.B. Predation
120050	06/15/77	16 hr.	99	36.59	Yes	Yes	Yes	Yes	?	?	No	Yes-B.B.	Yes-B.B.	No	Yes-B.B.	B.B. Predation
120051	06/25/77	96 hr.	90	15.24	No	No	Yes	No	No	Yes-.64 cm	No	Yes-B.B.	Yes-B.B.	Yes	Yes-B.B.	B.B. Predation
120052[a]4	05/31/77	27 hr.	70	?	Yes	Yes	Yes	Yes	Yes	Yes-.48 cm	Yes-B.B.	Yes-B.B.	No	No	Yes-B.B.	B.B. Predation
120053[a]4	05/31/77	27 hr.	70	?	Yes	Yes	Yes	Yes	No	Yes-.95 cm	Yes-B.B.	Yes-B.B.	No	No	Yes-B.B.	B.B. Predation
120054[a]5	06/16/77	19 hr.	99	9.15	Yes	Yes	Yes	Yes	No	Yes-1.11cm	No	Yes-B.B.	No	No	Yes-B.B.	B.B. Predation
120054A[a]5	Uncollared - missing by 06/08/77															
120055	08/23/77	42 hr.	99	6.10	Yes	Yes	Yes	Yes	?	?	No	Yes-Wolf	Yes-Wolf	No	Yes-Wolf	Wolf Predation
120056	06/03/77	11 hr.	50	99.09	Yes	Yes	Yes	Yes	No	Yes-.95 cm	Yes-B.B.	Yes-B.B.	No	No	NA	B.B. Predation
120087 (Uncollared)	06/11/77	2 hr.	1	?	NA	Yes	Yes	Yes	No	Yes-?	Yes-B.B. W	?	No	No	Yes-B.B.	B.B. Predation
120088 (Uncollared)	06/21/77	5 min.	1	0	NA	?	?	?	No	?	Yes-B.B.	?	?	No	?	B.B. Predation
120089 (Uncollared)	06/15/77	30 min.	80	0	NA	?	?	?	?	?	Yes-B.B. W	?	?	No	?	B.B. Predation
120090 (Uncollared)	06/27/77	1 hr.	50	?	NA	?	?	?	No	?	Yes-B.B.	?	?	No	?	Unk. Predation
120091 (Uncollared)	08/25/77	?	?	?	NA	?	?	?	-	?	Yes-B.B. W	?	?	No	?	Unk. Predation
120092 (Uncollared)	06/03/77	?	0	0	NA	No	No	No	No	No	Yes-W	?	?	No	?	Accident

Continued

Table 5. Continued. Characteristics and causes of mortality for individual moose calf kills examined in both the Mendeltna Creek and Susitna River study areas for the period 27 May through 1 November 1977.[1/]

Susitna River Study Area (Area 2)

				Description of Carcass							Predator Sign					
Calf #[2/]	Date of Examination	Maximum Time Dead	% Amount Consumed	Distance Carcass to Kill Site (m)	Collar Removed	Tongue Removed	Ears Removed	Eyes Removed	Hide Inverted	Wounds Present	Predator Observed	Predator Tracks Present	Predator Scats Present	Carcass Covered	Predator Hair Present	Cause of Death
120027[a]9	05/28/77	2 hr.	50	0	NA	Yes	Yes	Yes	Yes	Yes-.64 cm	Yes-B.B.	No	No	Yes	NA	B.B. Predation
Uncollared																
120028[a]9	05/28/77	2 hr.	50	22.87	NA	Yes	Yes	Yes	Yes	Yes-.64 cm	Yes-B.B.	No	No	Yes	NA	B.B. Predation
Uncollared																
120058	05/31/77	10 hr.	10	1.83	No	No	No	No	No	Yes-?	No	Yes-B.B.	No	No	NA	B.B. Predation
120059	06/01/77	27 hr.	40	0	No	No	No	No	?	?	Yes-B.B.	No	No	Yes	NA	B.B. Predation
120060	05/30/77	12 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Abandonment
120061	06/21/77	44 hr.	0	0	No	No	No	No	No	Yes-.95 cm	Yes-B.B.	No	No	No	NA	B.B. Predation
120065	07/08/77	231 hr.	95	0	No	Yes	Yes	Yes	Yes	Yes-?	No	Yes-B.B.	Yes-B.B.	No	Yes-B.B.	B.B. Predation
120067	06/17/77	24 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Pneumonia
120068	05/29/77	24 hr.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Abandonment
120073	08/18/77	NA	Collar fell off													
120076	07/17/77	209 hr.	99	?	Yes	Yes	Yes	Yes	?	?	No	No	Yes-B.B.	Yes	Yes-B.B.	B.B. Predation
120078	07/17/77	204 hr.	90	?	Yes	Yes	Yes	Yes	Yes	Yes-?	No	No	Yes-B.B.	Yes	Yes-B.B.	B.B. Predation
120081	06/09/77	12 hr.	99	12.20	Yes	Yes	Yes	Yes	No	Yes-?	No	Yes-B.B.	Yes-B.B.	Yes	NA	B.B. Predation
120086	07/09/77	255 hr.	95	?	Yes	Yes	Yes	Yes	Yes	Yes-?	No	Yes-B.B.	Yes-B.B.	Yes	Yes-B.B.	B.B. Predation

1/ Abbreviations used to describe characteristics are as follows: NA = not applicable, B.B. = brown bear and W = wolf.
2/ Letter subscripts indicates twins.

Figure 4 presents the timing of natural mortality for 48 individual radio-collared calves. Area 1 had a considerably higher mortality rate of collared calves than did Area 2; 20 of 25 versus 9 of 23, respectively. In both areas, 83 percent of the mortality occurred by 24 June or within approximately 1 month of parturition (Fig. 5). Nearly all mortality (97%) had occurred by 19 July--8 weeks after parturition.

Bear Observations

From 26 May through 1 November 1977 we made 76 brown bear observations while aerially tracking moose calves or wolves (Appendix II). Fifty-three of our observations were in Area 1. Bears were classified as adults, yearlings or cubs of the year. The age classifications of bear sightings for both areas combined were: adults - 57 percent, yearlings - 30 percent, and cubs - 13 percent. On the basis of color and sow-yearling-cub associations, we were certain that at least 18 of 53 bear sightings in Area 1 were of different bears. For our observations in Area 2, we were certain that at least 10 were individual bears (Appendix III).

Forty-one percent of the brown bear observations were associated with either calf or adult moose kills. Bears were observed on the following kills: adult moose - 4, calf moose - 13, and unknown - 1. Of that total, eight were also associated with one or more radio-collared wolves at the kill site. All the carcasses (8) at which bears and wolves were observed together were those of uncollared calves (4) and cows (4).

Wolf Observations

During the study we located the three radio-collared members of the Mendeltna wolf pack 225 times. These locations represented approximately 500 individual sightings of the seven adult members of the pack.

We observed one or more members of this wolf pack at 18 kills between 27 May and 19 October. Kills consisted of the following: 8 adult cow moose, 4 calf moose, 3 adult caribou, 1 calf caribou, 1 yearling brown bear and 1 unknown. Brown bears were also present on eight of these kills. The radio-collared wolves and their associates were observed daily from 27 May through 15 July. During this period we observed the wolves on 11 kills, six of which also had brown bears present. On two kills (both calves) the evidence strongly suggested that bears had made the kill, and on the remaining four we were unable to determine which predator may have made the kill. When bears were not observed with wolves, we assumed that the kill had been made by wolves.

Our observations at kills which were occupied by both wolves and bears revealed that in most, and perhaps all, cases both predators fed on the carcasses for varying periods of time. Bears stayed near kills until they were totally consumed; usually less than one day on calf kills and from one to two days on adult kills. Wolves, on the other hand, initially stayed with carcasses for less than one day but revisited them up to 5 days later.

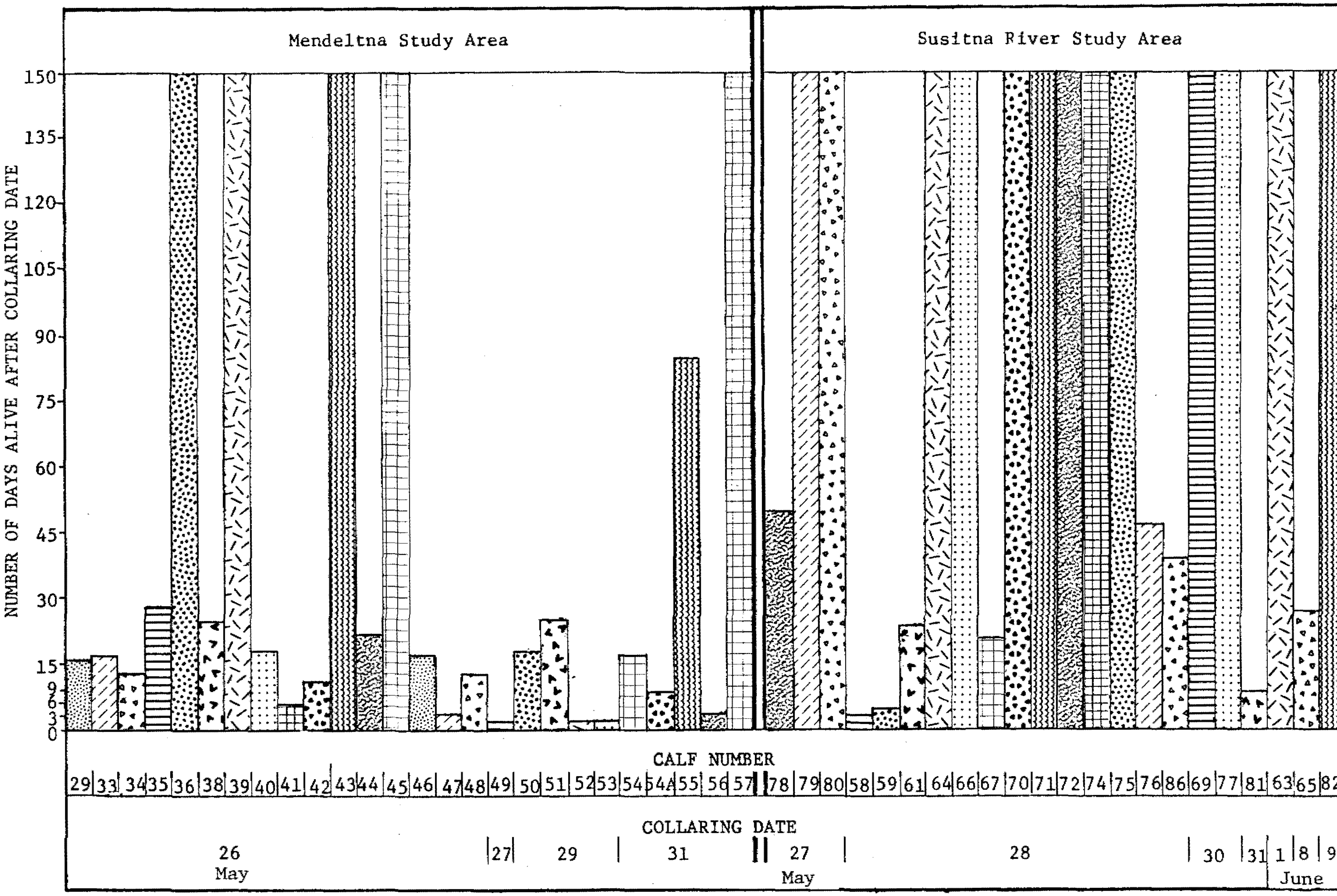

Figure 4. Number of days each radio-collared newborn moose calf survived within two study areas in GMU-13, 1977.

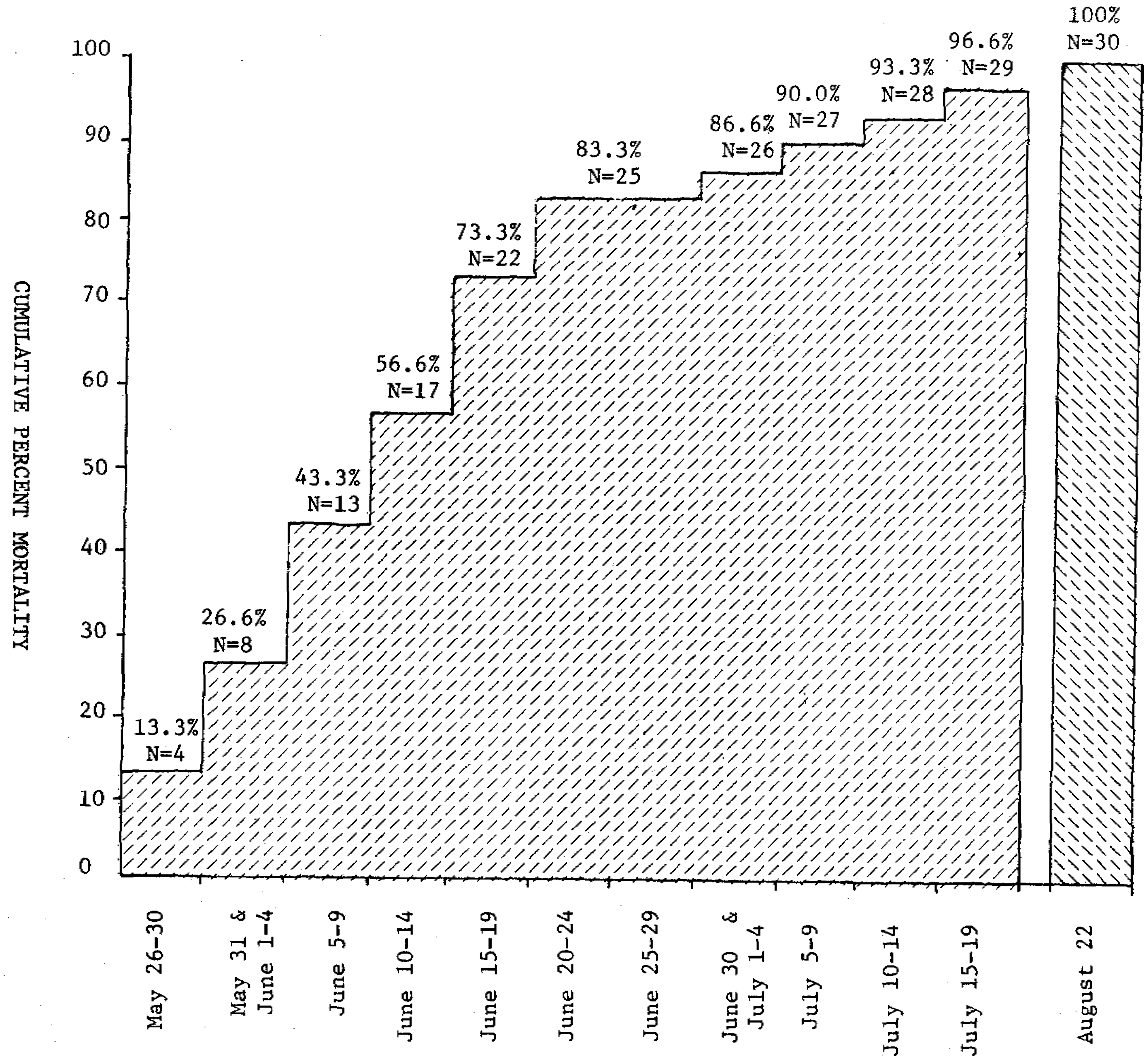

Figure 5 . Cumulative percentages by 5 day increments of radio-collared moose calf mortality for two study areas in Game Management Unit 13, Spring-Summer 1977.

There appeared to be considerable antagonism between predator species at kill sites and in areas relatively close to wolf dens. On several occasions wolves were almost caught by bears and on two occasions we observed wolves attempting to take yearling bear cubs. On 22 June, two adult wolves were observed from the air consuming what we believed to be a calf moose. Subsequent examination on the ground revealed that it was actually a yearling brown bear. We were unable to determine definitely whether the wolves had in fact killed the bear, but tracks, bent vegetation, and large areas of torn up soil indicated that some type of confrontation had occurred. This observation, when considered with our numerous observations of bear-wolf encounters, strongly indicated that the bear was killed by wolves.

On three occasions we observed unsuccessful attempts by wolves to take moose. One of these observations involved one wolf attempting to kill a calf moose (#120092) which was stuck in a bog. The calf was successfully defended by the cow, and remained alive and stuck in the mud for at least three days with the cow present. Observations revealed that the animal subsequently perished and decomposed in the mud; up to 30 days after the initial wolf encounter it had not been fed upon by any scavenger.

In an attempt to record the fate of some carcasses we returned to them in fixed-wing aircraft. Seven abandoned calves wandered alone for as long as 4 days, died, and lay in the field for as long as 30 hours with only one instance of scavenging being observed (by birds). We observed similar non-use by scavengers of bear-killed collared calves. In all cases following ground examination, at least 2 days passed before any scavenger use was recorded. In some cases where originally less than 50 percent of the carcass had been consumed, the carcass lay in the field for several days before being consumed by unknown scavengers. We never observed that either bears or wolves returned to calf carcasses after the initial feeding period. Usually bears or wolves stayed on a carcass and consumed it in less than 1 day. All kills where bears were the last known visitors had been buried. For kills utilized by wolves, the skeletal remains were either left intact and in place, or scattered in the vicinity of the kill.

DISCUSSION

Within recent years radio telemetry has been used in attempts to determine the causes of neonatal mortality in several species of ungulates. The most noteworthy studies were those of Beale and Smith (1973) on antelope (*Antilocapra americana*), Cook et al. (1971) and Carrol and Brown (1977) on white-tailed deer (*Odocoileus virginianus*), and Schlegel (1976) on elk. Prior to this study and one being conducted concurrently on the Kenai Peninsula by Dr. Albert Franzmann, no similar studies have been conducted on moose calf survival.

The lack of moose studies was primarily attributable to two factors: (1) it was believed that it would be difficult, if not impossible, to develop a collar which would accomodate a moose from birth to yearling age size and (2) it was believed that unless investigators either actually observe the predator make the kill, see it feeding on the kill and/or could get to the scene before scavengers, it would be impossible to determine the cause of death. However, use of the collar designed by Schlegel (1976) for elk and modified to conform to measurements for moose made this study possible. We know of only one instance when a collar was removed from a calf prematurely, and then the calf was seen to have pulled the collar off by pulling against some brush. Fortunately we observed this occurrence from a helicopter and immediately put the collar back on the calf.

As of 31 December 1977 we had observed no mortalities or atrophied limbs resultings from use of the collar. We noted two instances, however, where the elastic band caused lacerations on the neck. One of the lacerations was very minor but the other was fairly deep on the upper portion of the neck of a 5-month-old calf. We believe these minor problems resulted from too much stitching on one side of the elastic and can be easily alleviated by reducing the number of stitches.

During the annual moose sex and age composition counts conducted in November we observed that most of the calf collars had split apart and appeared to be in the process of falling away from the calves. As of 31 December 1977, we lost radio contact with 11 of 18 surviving calves. We do not know the final fate of the missing calves, but studies using the same radios and collar design elsewhere indicated premature radio failure (Schlegel, pers. comm.) as the reason for loss of contact.

We were able to examine most (83 percent) of the collared calf mortalities on the ground within 48 hours of the maximum length of time they could have been dead. Fifty-seven percent were examined within 24 hours, and likely many were examined within several hours of death. The time between death and our examination was brief enough to allow us to accurately assess the cause of death. When calves had been dead more than 48 hours there was a greater potential for misidentifying the cause of death. We believe that the cause of death was properly identified in all cases except for calf 120038, which we listed as unknown predator. The other calves appeared healthy, were in close contact with the cow when last observed, and no evidence of any other predator was discovered at the kill site. In addition, the observed lack of scavenging on dead calves suggests that the evidence of the cause of death will remain relatively unmolested for a considerable length of time. Similar non-use of dead calves by scavengers was reported by Franzmann and Bailey (1977) on the Kenai Peninsula.

An unhealthy calf would likely be more susceptible to predation than a healthy one. During this study we saw little evidence to indicate that calves were in poor condition either at the time of collaring or just prior to death. We believe that observed variations in weight were related to the age of the calf and that our initial subjective evaluation of age was incorrect.

Blood values obtained during this study can not be thoroughly evaluated at this time because we have no other data for comparison. Nevertheless, we believe the values probably represent values from calves in good condition for the following reasons: 1) blood parameters of adult cows in early spring 1977 in Area 2 were as high as those previously sampled in Unit 13 (Ballard and Taylor 1978); 2) adult moose blood parameters for Unit 13 rate higher than any of the other populations sampled (Franzmann et al. 1976); and 3) calf Hb and PCV values appeared higher than those at Moose River Flats on the Kenai Peninsula during 1977 (Franzmann and Bailey 1977).

Bacteria which were identified in the 25 calves are known to be present in the newborn of many species of domestic ungulates and may constitute normal flora for moose calves (R. Barrett, pers. comm.). Our observations of calves at the collaring site gave us no indication of health problems associated with bacteria except for two possible exceptions. Calf 120047 had diarrhea when collared and the culture showed the presence of *E. coli*. We initially suspected problems and it is probable that the observed diarrhea was the result of complications from a broken back which occurred prior to collaring. The other exception which may or may not be related to bacterial infection is that of calf 120067. This calf, when tagged, was alone for 36 hours. At collaring the calf weighed 22.7 kg but after death only 28.2, a gain of only 5.5 kg. Based on the growth rate of one captive calf (Franzmann and Bailey 1977) this calf should have weighed about 46 kg. Kramer et al. (1971) reported that orphaned animals often succumb to gastrointestinal and/or respiratory infections. It is known that *E. coli* can cause diarrhea and death in domestic animals if they are subjected to either stress or unfavorable nutritional factors (Sojka 1965). Because the calf had little weight gain, we speculate that the animal was not receiving adequate nutrition. If this is correct, perhaps the calf's resistance to infection was lowered resulting in death.

We can not totally exclude the possibility that stress on the calves during collaring may have had some impact on their survival. Stress can upset physiological processes and lower an animal's resistance to infection (R. Barret, pers. comm.), possibly resulting in increased susceptibility to predation. Observations during collaring, however, indicated that few calves exhibited stressful behavior and those which did were released quickly.

Our results on the timing of mortality of collared calves correspond closely with the findings based on observations of the calves of radio-collared adult cow moose (VanBallenberghe, pers. comm.). It appears that most neonatal mortality takes place within several weeks after parturition. After that period calf mortality due to predation is minimal and survival is high at least until separation from the cow the following spring. Our results also are comparable to those from neonatal mortality studies on white-tailed deer (Cook et al. 1971), elk (Schlegel 1976) and moose (Franzmann and Bailey 1977), all of which implicate predation as the main mortality factor.

Two of these studies (Schlegel 1976 and Franzmann and Bailey 1977) implicated black bear predation as being by far the leading cause of calf mortality; 64 percent and 27 percent, respectively. Although our study areas contain black bears, they are at very low population densities and were not a factor in this study.

To our knowledge this study is the first to document brown bear predation on moose calves at the magnitude indicated. Previously, several investigators had observed incidences of brown bear predation on moose calves and some concluded that the phenomenon may be of significance. Chatelain (1950) noted that both black and brown bears took moose calves and adults on the Kenai Peninsula. LeResche (1968), during his study of 59 visually marked calves near Palmer, Alaska, observed two instances of brown bear predation. Brown bear predation of newborn calves and "winter weakened" adults is reportedly common on the Copper River Delta (Reynolds 1977). Franzmann and Bailey (1977) reported that one of seven predator-killed calves was taken by a brown bear. Stephenson (1978) observed brown bears on 12 moose kills and brown bears with wolves on nine additional moose kills during wolf telemetry studies in GMU 13. He concluded that brown bears were a significant source of mortality in that they were killing moose more than incidentally.

In the nine instances where we actually saw bears alone on the kills, four were single adult bears; the remainder were sows with young. Overall, young bears (yearlings and cubs of the year) comprised 43 percent of all of our bear sightings. Further investigation is needed to determine if certain sex and age classes of brown bears are more likely to prey upon calf moose.

During the study period we observed considerable variation in the distances traveled and frequency of movement by collared calves. Many of the calves moved short distances (less than 0.8 km) during the first two weeks of life, and we were able to observe the calf in the same location for 3 to 4 days without using the transmitter. After that period, calf movements became more frequent and distances moved increased. We suspected that some of this activity was directly related to predation. Franzmann and Bailey (1977) suspected that similar calf movements were related to predation and documented one chase by a black bear. Because most of our mortality occurred prior to 24 June, we suspect that the decrease in the mortality rate after that date is perhaps attributable to the calves' improved ability to evade brown bears.

The differential in survival of collared calves between the two areas may be accounted for by one or a combination of the following factors: differing bear density, small sample size, unrepresentative sample, or errors in moose sex and age composition counts.

During the course of our studies we recorded 76 sightings of brown bears; 53 in Area 1 and 23 in Area 2. These observations were made during 142 hours of fixed-wing flying time in Area 1 in comparison to 134 hours in Area 2 resulting in 0.37 and 0.17 bear sightings per hour, respectively, in the two areas. If these figures are representative, they suggest that bear densities were higher in Area 1 than in Area 2.

Moose sex and age composition counts were conducted in both study areas during Fall 1977. Count results were 20 and 31 calves:100 cows for areas 1 and 2, respectively. The calf:cow ratios for our surviving study animals were 20 calves:100 cows in Area 1, versus 61 calves:100 cows in Area 2. Both sets of data have inherent biases: the composition count data are lower because yearlings are included while the ratios from our study results would be high in comparison because they do not include yearlings or cows which never bore calves. Nevertheless, composition count data indicate that actual survival in Area 2 was not as high as the collared calf data suggested. Because the composition count data are based on significantly larger sample sizes, we believe they better represent actual survival rates.

Most of our collaring effort in Area 2 was done adjacent to the Susitna River and either close to or north of the Denali Highway. In recent years there has been considerable mineral exploration in this area. One large mine is currently active and several commercial lodges are present along the Denali Highway. It is possible that human activity in the area may have had some impact on its bear density and thus our calf survival data may not be representative of the other portions of the study area.

When we were monitoring the Mendeltna wolf pack's activities either once or twice daily, we observed all or some of their members on 11 kills. Six of these 11 kills which had wolves at the scene also had one or more brown bears present. In most cases both predators fed on the carcasses for varying periods of time. We began observing both predator species at kills on 11 June and our mortality data indicate that approximately 50 percent of the collared calf mortality had already occurred prior to that date. We hypothesize that the increased frequency of bear-wolf encounters at kills after 11 June reflects competition for adult kills as a result of the decline in the available calf resource.

RECOMMENDATIONS

1. This mortality study should be conducted for two more years to increase sample size and to sample other areas within Game Management Unit 13.

2. In an effort to reduce costs, calves should to be monitored twice daily but should only be observed once a week. Mortality sensors in the radios should be modified to indicate mortality after 1 hour rather than 4 hours.

3. When calves are collared in areas occupied by wolves, a large percentage of the pack members should be collared to facilitate determination of location and activity of each adult pack member.

4. A long-term brown bear study should be initiated in GMU 13 with emphasis placed on the areas where calves are collared. The study is designed to delineate sex and age composition, abundance, movements, and late spring-early summer feeding habits.

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LITERATURE CITED

Adorjan, A. S. and G. B. Kolenosky. 1969. A manual for the identification of hairs of selected Ontario mammals. Ont. Dep. Lands For. Res. Rep. (Wildl.) No. 90. 64 pp.

Ballard, W.B. and K.P. Taylor. 1978. Upper Susitna River Moose Population Study. Alaska Dept. Fish and Game. P-R Proj. Rep., W-17-10, Job 1.20R.

Beale, D. M. and A. D. Smith. 1973. Mortality of pronghorn antelope fawns in western Utah. J. Wildl. Mgmt. 37(3):343-352.

Carroll, B. K. and D. L. Brown. 1977. Factors affecting neonatal fawn survival in southcentral Texas. J. Wildl. Mgmt. 41(1):63-69.

Chatelain, E. F. 1950. Bear-moose relationship on the Kenai Peninsula. Proc. 15th N. Am. Wildl. Conf. pp. 224-234.

Cook, R. S., M. White, D. O. Trainer, and W. C. Glazener. 1971. Mortality of young white-tailed deer fawns in south Texas. J. Wildl. Mgmt. 34(L):27-56.

Franzmann, A. W. and P. D. Arneson. 1973. Moose Research Center studies. Alaska Dept. Fish and Game. P-R Proj. Rep., W-17-5. 60 pp. (multilith).

__________, A. W., A. Flynn, and P. D. Arneson. 1975. Levels of some mineral elements in Alaskan moose hair. J. Wildl. Mgmt. 39(2):374-378.

__________, A. W., R. E. LeResche, P. D. Arneson and J. L. Davis. 1976. Moose productivity and physiology. Alaska Dept. Fish and Game Fed. Aid in Wildl. Rest. P-R Proj. Final Rep., W-17-2, W-17-3, W-17-4, W-17-5, W-17-6, and W-17-7. 87 pp. (multilith).

__________, A. W. and T. N. Bailey. 1977. Moose Research Center Report. Alaska Dept. Fish and Game Fed. Aid in Wildl. Rest. P-R Proj. W-17-9. 76 pp. (multilith).

Gasaway, W. C. 1976. Moose survey-inventory progress report - 1974, Game Management Subunits 20A and 20B. pp 145-161. In McKnight, D. E. (Ed.) Ann. Rep. Survey-Inventory Activities, Part II Moose. Ak. Fed. Aid in Wildl. Rest. Rep., Proj. W-17-7. 187 pp. (multilith).

Kramer, T. T., J. G. Nagy, and T. A. Barber. 1971. Diarrhea in captive mule deer fawns attributed to *Escherichia coli*. J. Wildl. Mgmt. 35(2):205-209.

LeResche, R. E. 1968. Spring-fall calf mortality in an Alaska moose population. J. Wildl. Mgmt. 32(4):953-956.

McIlroy, C. 1974. Moose survey-inventory progress report - 1972, Game Management Unit 13. pp. 66-74. In McKnight, D. E. (Ed.) 1974. Annual Report of Survey-Inventory Activities, Part II. Moose, Caribou, Marine Mammals and Goat. Ak. Fed. Aid in Wildl. Rest. Rep., Proj. W-17-5. 269 pp. (multilith).

__________. 1976. Moose survey-inventory progress report - 1974, Game Management Units 11 and 13. pp. 49-55 and 61-79. In McKnight, D. E. (Ed.). Ann. Rep. Survey-Inventory Activities, Part II. Moose Ak. Fed. Aid in Wildl. Rest. Rep., Proj. W-17-7. 187 pp. (multilith).

McKnight, D. E. (Ed.). 1976. Annual Report of Survey-Inventory Activities, Part II. Moose. Ak. Fed. Aid in Wildl. Rest. Rep., Proj. W-17-7. 187 pp. (multilith).

Mech, L. D. 1974. Current techniques in the study of elusive wilderness carnivores. Proc. of XI. Internat. Congress of Game Bio., pp 315-322.

Reynolds, J. 1977. Copper River Delta moose population identity study. In Didrickson, J. C., D. Cornelius and J. Reynolds. Southcentral moose population studies. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. P-R Proj. W-17-6, W-17-7, and W-17-8. 14 pp. (multilith).

Schlegel, M. 1976. Factors affecting calf elk survival in northcentral Idaho. A progress report. Proc. 56th Ann. Conf. W. Assoc. State Game Fish Comm. pp. 342-355.

Skoog, R. O. 1968. Ecology of caribou (*Rangifer tarandus granti*) in Alaska. PhD. Thesis, Univ. of California, Berkeley, California. 699 pp.

Sojka, W. J. 1965. *Escherichia coli* in domestic animals and poultry. Commonwealth Bur. Animal Health, Rev. Ser. 7. Commonwealth Agricultural Bureau, Bucks, England. 231 pp.

Stephenson, R. O. 1978. Unit 13 Wolf Study. Ak. Dept. Fish and Game Fed. Aid in Wildl. Rest. P-R Proj., W-17-8. 75 pp. (multilith).

__________ and L. Johnson. 1973. Wolf report. Alaska Fed. Aid in Wildl. Rest. Rept., Proj. W-17-3. Juneau 51 pp.

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Appendix 1. Table 1. Dates and approximate distances of known movements in relation to mortality dates of newborn moose calves radio-collared in two study areas in GMU 13 for May 26 through November 1, 1977.

Mendeltna Creek Study Area

Calf #[1/]	Dates calf known to remain within 0.8 km of previous observations	Dates between which calf known to have moved from previous observation	Approximate distance of movement (km)
120029	5/26-6/9	6/9-6/10 (dead)	3.2
120030[a]	5/26-5/28 (dead)		
120031[a]1	5/26-5/28 (dead)		
120032	5/28-5/28 (dead)		
120033[a]2	5/26-6/6	6/7-6/11 (dead)	1.6
120034[a]2	5/26-6/6	6/6-6/7 (dead)	1.6
120035[a]3	5/26-6/7	6/7-6/8	4.8
	6/8-6/14	6/14-6/22 (dead)	3.2
120036[a]3	5/26-6/7	6/7-6/8	4.8
	6/8-6/14	6/14-6/22	3.2
		6/22	3.2
	6/22-7/15	7/15-7/25	4.8
	?	7/25-8/17	13.7
	?	8/17-10/1	1.6
	?	10/1-10/14	4.0
	?	10/14-11/7 (alive)	9.7
120037	5/26-5/27 (dead)		
120038	5/26-6/14	6/14-6/19 (dead)	9.7
120039	5/26-6/24	6/24-6/27	1.6
	5/26-6/27	6/27-7/12	11.3
	7/12-7/15	7/15-7/25	18.5
	?	7/25-8/17	6.4
	?	8/17-10/1	4.0
	?	10/1-11/7 (alive)	4.8
120040	5/26-6/2	6/2-6/3	3.2
	6/3-6/6	6/6-6/7	2.4
	6/7-6/9	6/9-6/12 (dead)	12.1

Appendix 1. Table 1. (continued). Mendeltna Creek Study Area

120041	5/26-5/31 (dead)		
120042	5/26-6.4	6/4-6/5 (dead)	2.4
120043	5/26-6/6	6/6-6/7	2.4
	6/7-6/24	6/24-6/27	4.0
	6/27-7/15	7/15-7/25	3.2
	?	7/25-8/17	3.2
	?	8/17-10/1	3.2
	?	10/1-11/7	1.6
	?	11/7-12/20 (alive)	4.0
120044	5/26-6/14	6/14-6/17 (dead)	3.2
120045	5/26-6/4	6/4-6/5	3.2
	6/5-7/15	7/15-7/25	13.7
	?	7/25-8/17	6.4
	?	8/17-10/1	3.2
	?	10/1-11/17	17.7
	?	11/7-12/20 (alive)	17.7
120046	5/26-6/9	6/9-6/11 (dead)	1.6
120047	5/26-5/29 (dead)		
120048	5/26-6/6	6/6-6/7 (dead)	1.6
120049	5/27-5/28 (dead)		
120050	5/29-6/15 (dead)		
120051	5/29-6/6	6/6-6/7	1.6
	6/7-6/8	6/8-6/9	1.6
	6/9	6/9-6/13	2.4
	?	6/13-6/27	12.1
	?	6/27-7/25 (dead)	14.5
120052[a]4	5/26-5/30 (dead)		
120053[a]4	5/26-5/30 (dead)		
120054[a]5 Uncollared twin	5/31-6/8	Missing	
120054[a]5	5/31-6/9	6/9-6/12	6.4
	6/12	6/12-6/14	16.9
	?	6/14-6/17 (dead)	2.4

Appendix 1. Table 1. (continued). Mendeltna Creek Study Area

120055	5/31-6/28	6/28-7/13	24.1
	7/13-7/15	7/15-8/17	13.7
	8/17-8/21 (dead)		
120056	5/31-6/3 (dead)		
120057	5/31-6/25	6/25-6/27	1.6
	6/27-7/15	7/15-8/17	21.7
	8/17-10/1	10/1-11/7 (alive)	24.9

Susitna River Study Area

120058	5/28-5/31 (dead)		
120059	5/28-5/31	5/31-6/1 (dead)	1.6
120060	5/28-5/29 (dead)		
120061	5/28-6/18	6/18-6/19 (dead)	3.2
120063	6/1-6/2	6/2-6/3	2.4
	6/3-6/4	6/4-6/5	2.4
	6/5-6/18	6/18-6/19	4.8
	?	6/19-6/23	3.2
	?	6/23-6/25	6.4
	?	6/25-7/15	11.3
	?	7/15-8/17 (alive)	3.2
120064	5/28-6/8	6/8-6/9	1.6
	6/9-7/15	7/15-7/23	1.6
	?	7/23-8/13	1.6
	?	8/13-9/17 (alive)	6.4
120065	6/8	6/8-6/9	12.1
	6/9-6/19	6/19-6/23	2.4
	6/23-6/28	6/28-6/30 (dead)	11.3
120066	5/28-5/31	5/31-6/1	1.6
	6/1-6/2	6/2-6/3	3.2
	6/3-6/13	6/13-6/17	4.0
	6/17-6/19	6/19-6/22	3.2
	6/22-6/24	6/24-6/25	3.2
	6/25-6/28	6/28-7/15	5.6
	7/15-8/17	8/17-9/17 (alive)	2.4
120067	5/28-6/13	6/13-6/16 (dead)	1.6

Appendix 1. Table 1. (continued). Susitna River Study Area

120068	5/28-5/29 (dead)		
120069	5/30-6/5	6/5-6/6	1.6
	6/6-6/10	6/10-6/11	4.8
	6/11-6/13	6/13-6/17	6.4
	6/17-6/24	6/24-6/25	2.4
	6/25-8/17	8/17-9/17 (alive)	1.6
120070	5/28-6/11	6/11-6/17	3.2
	?	6/17-6/22	3.2
	6/22-7/15	7/15-8/17 (alive)	19.3
120071[a]6	5/28-6/22	6/22-6/23	5.6
	6/23-6/28	6/28-7/15	4.8
	?	7/15-8/17	9.7
	?	8/17-9/17 (alive)	3.2
120072[a]6	5/28-6/22	6/22-6/23	5.6
	6/23-6/28	6/28-7/15	2.4
	?	7/15-8/17	16.1
	?	8/17-9/17 (alive)	3.2
120073[a]7	5/28-6/19	6/19-6/22	4.0
	6/22-6/24	6/24-6/25	4.0
	?	6/25-7/7	11.3
	?	7/7-7/15	5.6
	?	7/15-8/17 collar fell off	11.3
120074[a]8	5/28-6/25	6/25-6/29	12.1
	?	6/29-7/15	17.7
	?	7/15-8/17 (alive)	1.6
120075[a]8	5/28-6/25	6/25-6/29	12.1
	?	6/29-7/15	17.7
	?	7/15-8/17 (alive)	1.6
120076[a]7	5/28-6/19	6/19-6/22	4.0
	6/22-6/24	6/24-6/25	4.0
	?	6/25-7/7	11.3
120076[d]	?	7/7-7/15 (dead)	18.5
120077	5/30-7/15	7/15-8/17 (alive)	4.8
120078	5/27-6/18	6/18-6/19	4.0
	6/19-6/28	6/28-7/7	13.7
	?	7/7-7/15 (dead)	20.9

Appendix 1. Table 1. (continued). Susitna River Study Area

120079	5/27-6/12	6/12-6/18	3.2
	6/18-6/24	6/24-7/15	1.6
	?	7/15-7/23	8.0
	?	7/23-8/17	8.9
	?	8/17-10/5 (alive)	3.2
120080	5/27-6/24	6/24-7/15	1.6
	?	7/15-8/17 (alive)	20.1
120081	5/31-6/7	6/7-6/8 (dead)	3.2
120082	6/9-6/28	6/28-7/15	4.0
	7/15-8/17	8/17-9/17 (alive)	19.3
120086	5/28-6/7	6/7-6/8	1.6
	6/8-6/13	6/13-6/16	1.6
	6/16-6/19	6/19-6/22	6.4
	6/22-6/28	6/28-6/29	3.2
	?	6/29-6/30 (dead)	14.4

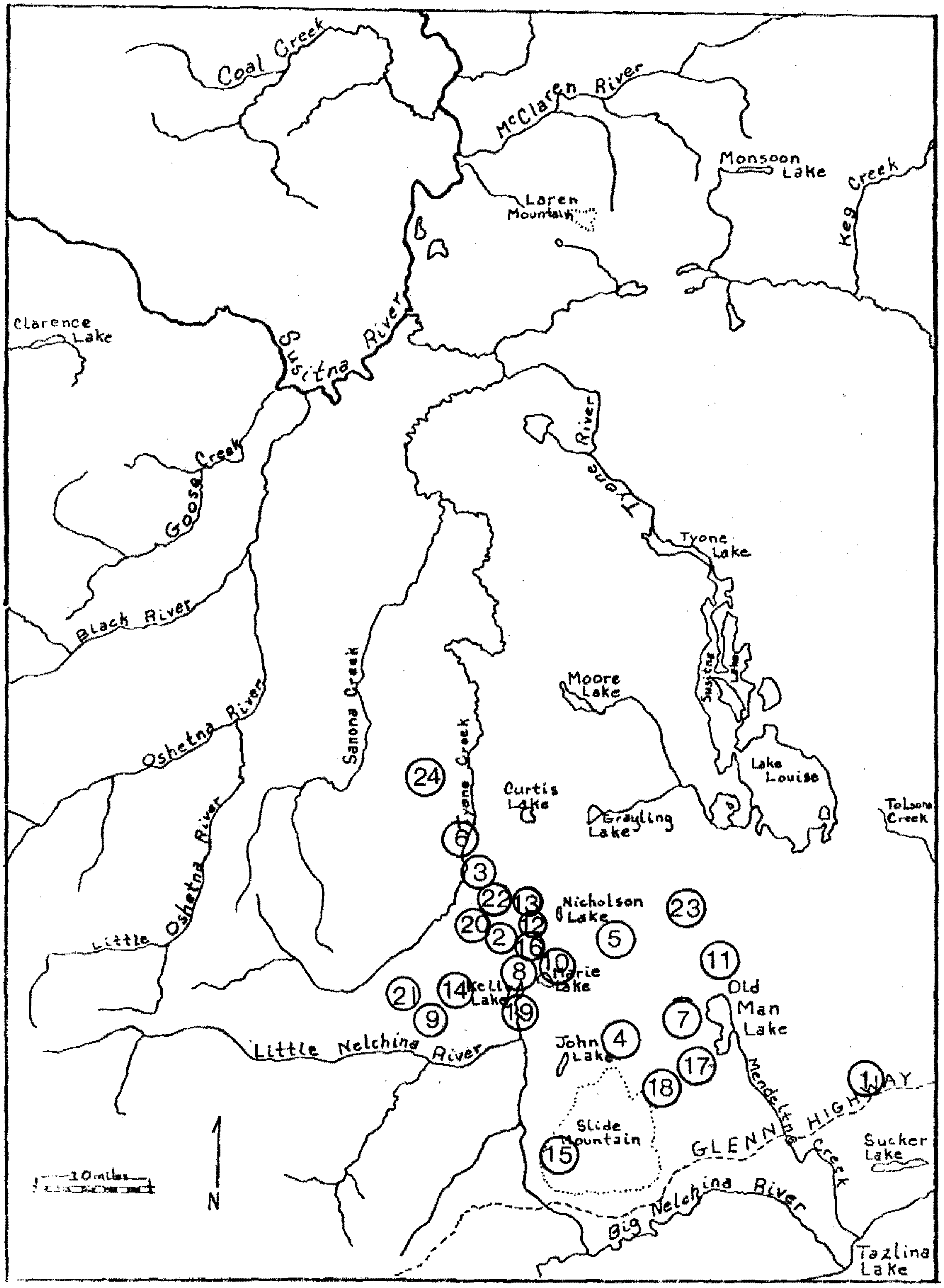
1/ Letter subscript denotes twin calves.

Appendix II. Table 1. Brown bear observations made in the Mendeltna Creek study area while aerial-tracking radio-collared moose calves and wolves from 26 May through 1 November 1977 (see Appendix II fig. 1 for approx. locations of sightings).

Location number	Date	Time	Age-Sex Composition	Description of observation
1	5/26-5/28	0800	1 sow 4 cubs	-
2	5/28	1900	1 sow 2 cubs	Observed at kill site of moose calf 120049.
3	5/30	1825	1 sow 2 yearlings	Observed at kill site of moose calf #120052 and 120053
4	5/31	0840	1 sow 2 yearling	-
5	6/1	0845	1 sow 2 yearlings	Observed sow with fresh killed moose calf (#120088) in mouth. Sow had calf by neck. Cow moose still present and continually charged sow while being chased by one yearling bear.
6	6/2	1930	1 adult	Bear laying on small sized kill which was buried.
7	6/3	0830	1 sow 1 yearling	
8	6/3	1900	1 adult	Observed running from kill site of moose calf #120056
9	6/4	1800	1 adult	-
10	6/6	1815	1 sow 1 yearling	-
11	6/8	2200	1 adult	-
12	6/11	2100	1 sow 2 yearlings	Observed yearling cubs huddled over freshly killed uncollared moose calf #120087. Cow moose still present and very aggressive. Two radiocollared wolves present.
13	6/12	1000	1 sow 3 yearlings	-
14	6/14	1720	1 adult	Bear was on an adult moose kill which was 80% consumed. One radiocollared wolf observed resting short distance away.
15	6/15	0850	1 sow 1 yearling	Bears initially on uncollared moose calf kill (#120089). Three wolves present. Plane and perhaps wolves spooked bears from kill allowing wolves to feed. Kill approximately 80% consumed.

16	6/15	1710	1 sow 3 yearlings	-
17	6/16	1030	1 sow 1 yearling	-
18	6/16	1945	1 adult	Observed adult bear feeding on adult moose kill which was approximately 50% consumed. Four wolves were present and they were observed harassing the bear.
18	6/17	1040	2 adults	Bears observed feeding on same adult moose kill reported for location #18. Estimated kill to be 80% consumed.
18	6/19	0945		Kill consumed and no predators observed.
19	6/24	1000	1 adult	-
20	6/24	1640	1 adult	Observed bear feeding on adult moose kill. One radioed wolf lying 20 yds. off. Rear quarters, head, guts and half of front quarters still present indicating kill was fairly fresh.
20	6/25	1300	1 adult	Same bear on kill as reported for location #21.
20	6/25	1730	1 adult	Same bear on kill as reported for location #21.
21	6/27	1020	1 adult	Bear observed eating moose calf (#120090). Three wolves resting 50 yards from bear. Kill approx. 50% consumed with head and read quarters gone. Cow moose in area exhibiting agressive behavior.
21	6/28	1000	1 adult	Same bear on calf, kill almost totally consumed.
22	6/28	1020	1 adult	-
23	8/8	0700	1 adult	Bear observed feeding on adult moose kill. Four wolves present. Wolves momentarily ran bear from kill allowing one wolf to take chunk of flesh and run off with it as bear charged.
24	8/25	1845	1 adult	Observed bear feeding on moose calf kill (#120091) Two wolves present and stalking bear.

Appendix II. Figure 1. Approximate locations of brown bear sightings made in the Mendeltna Creek study area from 26 May through 1 November 1977 (see Appendix II, Table 1 for dates and sex-age data for each observation).

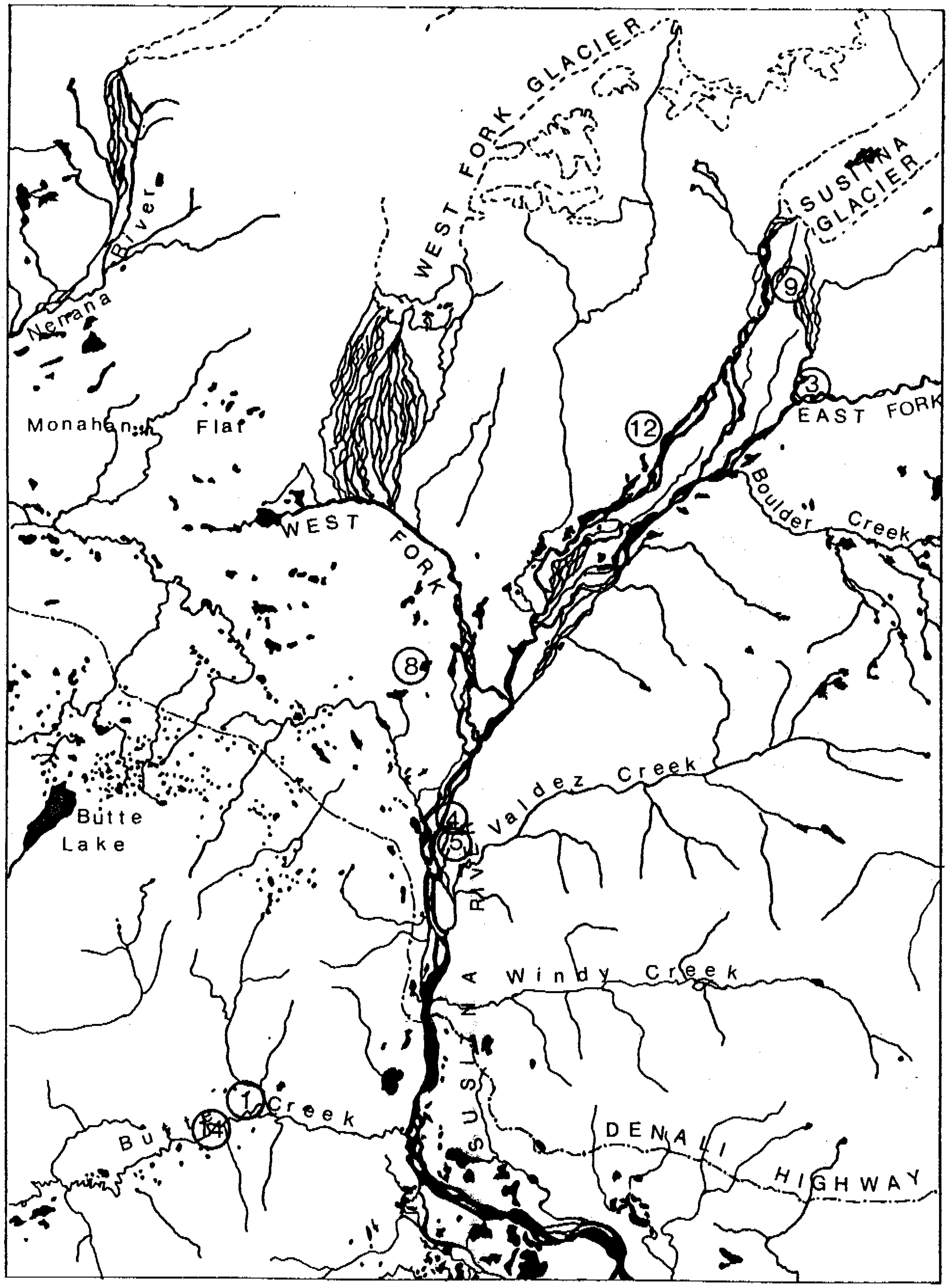


Appendix III, Table 1. Brown bear observations made in the Susitna River study area while aerial tracking radio-collared moose calves from 28 May through 1 November 1977 (see fig. 1 for locations of sightings).

Location number	Date	Time	Age-Sex Composition	Description of observation
1	5/28	1200	1 adult	Bear observed near kill site of collared moose calf #120059
2	5/28	2130	1 sow- 2 yearlings	Bears observed feeding on uncollared moose calf kills 120027 and 120028
3	5/28	?	1 adult	
4	5/29	2230	1 adult	
5	5/30	1030	1 adult	
6	6/3	1555	1 adult	
7	6/4	?	1 adult	
8	6/10	2200	1 adult	
9	6/13	0800	2 adults	
10	6/19	?	1 adult	Observed running from collared moose calf kill #120061
11	6/19	?	1 sow- 1 cub	
12	6/19	?	1 adult	
13	7/3	?	1 sow- 2 yearlings	
14	7/9	?	1 sow- 3 cubs	

5/28-Nov.1

Appendix III. Figure 1. Approximate locations of brown bear sightings made in the Susitna River study area from 27 May through 1 November 1977 (see Appendix III, Table 1 for dates and sex-age data for each observation).



Appendix III. Figure 1. continued.