ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

STATE OF ALASKA
Jay S. Hammond, Governor

DEPARTMENT OF FISH AND GAME
Ronald O. Skoog, Commissioner

DIVISION OF GAME
Ronald J. Somerville, Director
Donald McKnight, Research Chief

CALF MORTALITY IN THE DELTA CARIBOU HERD

BY
James Davis
and
Diane Preston

Volume I

Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-11, Job 3.26R

(Printed March 1980)

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: James L. Davis, Diane Preston, and Patrick Valkenburg

Project No.: W-17-11 Project Title: Big Game Investigations

Job No.: 3.26R Job Title: Calf Mortality in the Delta Caribou Herd

Period Covered: July 1, 1978 through June 30, 1979 (including studies through October 1979)

SUMMARY

This study was initially designed to determine chronology and quantify sources of mortality occurring to calves between October 1978 (5 months of age) and mid-May 1979 (12 months of age) in the Delta Caribou Herd. Belated receipt of radio collars prevented us from collaring calves until January 1979. From 4 through 11 January 1979 and on 30 March 1979 we captured, radio-collared, and obtained morphometric and physiological data (i.e. blood profiles) from 25 calves (11 females and 14 males).

The expandable collars for males worked poorly. Many were prematurely "shed" which confounded calculation of survival rates. All 11 females survived to 17 months of age (the time of this writing). Two deaths of male calves were confirmed (wolves were implicated in both deaths), 9 males survived to 1 year of age, and the fate of 3 males was unknown. Estimated calf survival from October 1978 to May 1979 was 80 to 92 percent.

An aerial photo-direct count-extrapolation census of the Delta Caribou Herd in 1979 resulted in enumeration of 3,160 caribou and an extrapolated estimate of approximately 4,000 animals. This was about twice the number believed to be in the population (based on estimates of recruitment rates made since the herd was last censused in 1973). Analysis of herd demography suggests that the herd was stable, or slightly declining, from 1973 through 1975 and grew rapidly from 1976 through 1979. We believe that inception of a wolf control program in early winter 1976 resulted in increased calf survival and yearling recruitment into the population after 1975. Existing Survey and Inventory techniques and/or their application inadequately detected changes in the population dynamics of the herd.

CONTENTS

Summary i
Background 1
Herd Identity 1
Productivity 2
Objective 4
Procedures 4
Study Area 4
Radio-Collaring 4
Productivity and Recruitment 6
Population Census 6
1979 Census 6
Analysis of 1973 APDCE Census Data 7
Results 8
Radio-Collaring 8
Physiological Data 8
Relocation of Collared Calves 8
Status Summary of Radio-Collared Calves 14
Movement of Collared Calves 15
1979 APDCE Census 15
1973 APDCE Census 18
1979 Calving Data 19
Recruitment Estimation 22
Recommendations 25
Acknowledgments 25
Literature Cited 26

BACKGROUND

Herd Identity

Although caribou (*Rangifer tarandus*) have resided on the north slopes of the Alaska Range between the Canadian border and the Nenana River since at least 1918 (Murie 1935), their subpopulation (i.e. herd) identity has been poorly understood. Skoog (1968) and Hemming (1971) considered these caribou to be members of the Mentasta, Chisana or Delta Herds. They agreed on the distribution and identity of the Chisana Herd but defined the ranges of the other two herds differently.

Skoog (1968) described the range of the Delta Herd as, "...the north slopes of the Alaska Range from the upper Wood River on the west to the Robertson River on the east." Hemming (1971) described the Delta Herd as ranging the north slopes of the Alaska Range between the Alaska Railroad on the west and the Richardson Highway on the east. Skoog included the caribou inhabiting the area between the Delta and Robertson Rivers as part of the Delta Herd. Hemming, however, included these as part of the Mentasta Herd.

On the basis of more recent information, Davis and Neiland (1975) and Davis (1978, in press) redefined herd identity of caribou occupying the area between the Nenana River and the Glenn Highway to include the Delta and Macomb Herds. From 1969, or earlier, to the present, caribou inhabiting the northern slopes of the Alaska Range west of Alaska Highway #1 (Tok Cutoff) and east of the Alaska Railroad have existed as two discrete groups. One group, the Delta Herd, has consistently ranged west of the Delta River and east of the Alaska Railroad and calved near Trident and McGinnis Glaciers. This is consistent with Hemming's description of the Delta Herd. The second group, the Macomb Herd, has occupied the area east of the Delta River and west of Alaska Highway #1. They have calved annually on the Macomb Plateau since at least the mid-1950's according to the late Marvin Warbelow, a long-time pilot from Tanacross (L. Jennings, Alaska Department of Fish and Game, pers. comm.). L. Jennings or Delta Area Biologist R. Larson have observed calving on the Macomb Plateau annually since 1969.

Skoog (1968) included the Macomb subpopulation as part of the Delta Herd. Hemming (1971) considered the subpopulation as part of the Mentasta Herd although he reported that, "...local bush pilots have observed some calving activity on the Macomb Plateau east of the Johnson River."

Davis and Neiland (1975) considered Macomb Plateau caribou to be a herd distinct from either the Delta Herd or Mentasta Herd. This designation is consistent with Skoog's (1968) herd definition, "...thus a herd becomes an entity (subpopulation) when it establishes a calving area distinct from that of any other herd and uses this area repeatedly over a period of years." The Delta Herd has used a traditional calving area since at least the mid-1950's. The Mentasta Herd has continued to use its traditional calving area in the Wrangell Mountains and recently has not occupied the range of the Macomb Herd even during winter and summer (Bos 1974). Sex and age structure and recruitment in the Macomb Herd differ from those of the Delta and Mentasta Herds. For management purposes, the Macomb Herd has been considered distinct from the Mentasta and Delta Herds. Between October 1966 and March 1968, 205 Delta Herd caribou were marked with metal ear tags and plastic ear streamers by the University of Oklahoma (Department of the Army Project 1577) and none of these marked animals have been seen east of the Delta River.

Productivity

Fall composition counts of the Delta Herd (as defined by Hemming 1971) have been conducted annually since 1969, and mid-June calf production/ survival data are available for most years since 1973 (Table 1). A steady decline in calf production and/or survival and yearling recruitment indices is evident for the years 1969-1975. In 1975 Davis and Neiland (1975) proposed a study to identify and assess the causes of recruitment failure between 1973 and 1975, but unfortunately it was not

Table 1. Summary of sex and age composition counts of the Delta Caribou Herd since 1969.

Date	Bulls per 100 Cows	Yrlgs per 100 Cows	Calves per 100 Cows	Yrlg % in Herd	(Total Yrlg)	Calf % in Herd	(Total Calves)	Cow % in Herd	(Total Cows)	Bull % in Herd	(Total Bulls)	Sample Size
10/13-15/69	40.0	20.0	28.0	10.3	(85)	14.0	(116)	49.5	(410)	20.0	(166)	828[a]
10/21-23/70	77.0	23.0	34.0	9.8	(88)	14.4	(129)	42.7	(383)	33.0	(296)	896
10/29-11/1/71	29.0	11.0	16.0	6.8	(78)	9.6	(109)	64.8	(738)	18.8	(214)	1139
10/27-31/72	32.4	5.8	10.7	3.9	(46)	7.2	(85)	67.1	(795)	21.8	(259)	1184
6/19/73	4.4	8.1	24.4	6.0	(67)	17.9	(201)	72.9	(820)	3.2	(36)	1124
10/23-24/73	28.6	4.0	10.3	2.8	(29)	7.2	(76)	70.0	(735)	20.0	(210)	1050
6/13-14/74	-	-	-	3.1	(33)	3.1	(33)	89.0	(942)	4.7	(50)	1058
10/23-25/74	27.6	1.8	2.0	1.4	(16)	1.5	(17)	76.1	(868)	21.0	(240)	1141
6/11-12/75	3.1	0.4	12.9	0.3	(3)	11.1	(108)	86.0	(839)	2.7	(26)	976
Fall 1975 no counts conducted												
6/76	1.6	-	41.4[b]	-	-	28.9	(395)	70.0	(955)	1.1	(15)	1365
6/16-22/76	1.4	-	55.8	-	-	35.5	(390)	63.6	(699)	0.9	(10)	1099
10/29-11/1/76	38.5	0.9	45.1	0.5	(5)	24.4	(258)	54.2	(572)	20.9	(220)	1055
6/16,19/77	9.7	12.1	34.3	7.8	(95)	22.0	(269)	64.1	(784)	6.2	(76)	1224
10/26-11/2/77	32.5	5.8	42.2	3.2	(44)	23.4	(319)	55.4	(756)	18.0	(246)	1365
6/13-14/78	12.2	7.9	23.8	5.5	(52)	16.5	(157)	69.5	(661)	8.5	(81)	951
10/26/78	75.0	10.0	39.0	4.5	(33)	17.3	(126)	44.7	(324)	33.5	(242)	725
6/23/79	11.5	17.9	44.6	10.3	(76)	25.6	(189)	57.4	(424)	6.6	(49)	738
12/7/79	39.0	-	65.0[b]	-	-	32.0	(115)	49.0	(177)	19.0	(69)	361

a Includes some animals of unknown age or sex.
b Yearlings not differentiated from cows.

funded. The following year, after initiation of a wolf (*Canis lupus*) control program, there was a dramatic increase in calf production and/or survival. Surveys conducted in 1976 showed that there were 56 calves: 100 cows in late June, 3 weeks after calving, and 45 calves:100 cows during October. Nevertheless, recruitment to yearling age appeared to remain poor because only 12 yearlings:100 cows were counted the following June. This trend continued in 1977, suggesting that overwinter mortality was the predominant factor limiting recruitment of yearlings into the herd.

OBJECTIVE

To ascertain the chronology and quantify sources of overwinter caribou calf mortality in the Delta Herd and to relate the findings to the population dynamics of the herd.

PROCEDURES

Study Area

The study area included the range of the Delta Herd as defined by Hemming (1971), Davis and Neiland (1975), and Davis (1978) in the BACKGROUND section of this report.

Radio-Collaring

From 4 through 11 January 1979, and on 30 March 1979 we captured, radio-collared, and obtained morphometric and physiological data from 25 different Delta Herd calves (8-10 months of age). Calf caribou were visually located from a fixed-wing aircraft (C-185 or PA-18-150 Super Cub). A helicopter (Bell 206B) and immobilizing equipment were used (Cap-Chur, Palmer Co., Douglasville, Georgia) for capturing the calves. The immobilizing drug consisted of 1.5 to 4.5 cc of etorphine (M-99, D-M Pharmaceuticals, Inc., Rockville, Maryland) and 20 mg of xylazine (Rompun, Haver-Lockhart, Shawnee, Kansas). The antagonist diprenorphine (M-50-50, D-M Pharmaceuticals, Inc., Rockville, Maryland) was administered in equal volume to the etorphine.

"Collaring" the calves included taking the following body measurements: shoulder height, total length, heart girth, metatarsal length, hindfoot length, face length, neck circumference, and ear notch length. Length of the main beam of each antler was measured if antlers were present. The calves were weighed and tagged on each ear.

Blood samples were taken by jugular venipuncture using 18-gauge 1-1/2 inch needles and vacutainers. Plain vacutainers were used to collect blood for serum and EDTA vacutainers were used to collect whole blood. Hair samples were taken from the dorsal midline in the scapular region, and tooth eruption was checked to confirm age. Whole blood was processed by Mt. McKinley Animal Hospital, Fairbanks, Alaska. Sera were processed by Reference Laboratory, Newbury, California.

Radio collars were constructed of triple layered, rubberized machine belting to which was attached an hermetically sealed metal box containing the transmitter and batteries. Radios were activated by removing a magnet from the transmitter box. A highly visible vinyl-covered canvas collar, 15.2 cm wide and 71 or 86 cm long with 10 cm high numerals of a contrasting color, was pop-riveted to each radio collar. The entire unit weighed less than 850 g. All radios were in the 151 MHz frequency range (Appendix I) and contained movement-sensitive mortality switches (Telonics, Inc., Mesa, Arizona). Normal pulse frequency was approximately 60 beats per minute. When movement ceased for approximately 4 hours the pulse would double or triple.

The radio collar machine belting was slightly shorter than the visual collars and was permanently fastened by bolts on female calves. These were tight enough to not slip over the head when antlers were shed yet would allow growth of the neck to adult size. The males presented a problem because if collars were permanently fastened tight enough to not fall off when antlers were shed strangulation as adults was possible. When this study was initiated, available data suggested that overwinter calf mortality averaged 80 percent. Therefore, it was believed that most males would have died before permanently fastened collars caused strangulation. We planned to immobilize and remove collars from any survivors at the end of the study. However, when we received our radios in late December 1978 (which we originally had planned to use in October 1978), reconnaissance of the caribou herd revealed that few if any calves had died since late October when sex and age composition counts were conducted. Also, during the October composition counts we saw many more young bulls (apparently 1-, 2-, and 3-year-olds) than expected from previous survey data. Therefore, we hypothesized that existing methods grossly underestimated overwinter calf survival and that we should expect good survival of the calves we planned to collar. Consequently, we hastily devised an expandable collar for the male calves. The machine belting of the radio collars was "temporarily" fastened snugly around the necks of the male calves by using two pieces of surgical tubing. The visual collars, pop-riveted over the radio collars, were permanently fastened at a length suitable for adult size. We hoped that the surgical tubing would hold the collars on into the following summer or fall. We reasoned that neck size would increase enough during summer to retain the collar after the surgical tubing separated.

Calves were relocated from 7 January 1979 to 15 October 1979 from fixed-wing aircraft (C-185, Bellanca Scout, PA-18-150 Super Cub) equipped with two Yagi antennas, one attached to wing struts on each side of the plane. The antenna leads were attached to a right/left switch box which coupled to a radio receiver/scanner (Telonics Co., Mesa, Arizona). A minimum of two flights per month were made for each month except July when only one flight was made and September when no flights were made due primarily to poor weather conditions. All collars were monitored audibly during each flight and an attempt was made to determine the general location of each signal heard. A few calves were selected to be

visually located during each flight. A number of collared calves were sighted from the ground during June and July 1979 by Department personnel conducting sheep (*Ovis dalli*) studies and caribou composition counts. Information on group size and composition, habitat, weather conditions, antlers, and behavior were noted for each calf which was visually located, and the exact location was recorded on a 1:250,000 topographic map.

When a mortality signal mode was heard, visual location of the collar was made and evidence of mortality was noted. In the two confirmed instances of mortality, a helicopter was flown to the vicinity at a later date and the kill was relocated from the ground with the aid of a hand-held antenna attached to a receiver. An investigation of the caribou remains and the adjacent area was made to determine the cause of death. Tracks, scats, and hair around the carcass were noted and photographs were taken.

Productivity and Recruitment

In addition to using the radio-collared calves to estimate survival rates, serial herd composition surveys were conducted. Surveys were conducted in May, June, and October. In other months reconnaissance surveys were conducted concurrent with radio-tracking to subjectively determine if survival of the radio-collared cohort was similar to that of the overall herd. During October, composition counts were conducted from a helicopter and animals were classified from the air or from the ground with the aid of a 20X-60X spotting scope. In May, several fixed-wing surveys were conducted over the calving area to document progression of calving and record the ratio of calves to animals older than calves. A five-member field crew conducted ground counts on the calving ground from 24 to 29 May. They classified all animals seen, searched for dead calves, and conducted distended udder counts (Bergerud 1964). The crew consisted of ADF&G biologists J. Davis and J. Wright, and U.S. Army Lts. H. Griese and J. Kerns, and Mr. W. Gossweiler. A U.S. Army helicopter was used for transportation to and from the calving area.

Additional distended udder counts and herd composition counts were conducted by ADF&G personnel M. Buchholtz and D. Simpson on 23 June in conjunction with a photo census.

Population Census

1979 Census

An aerial photo-direct count-extrapolation (APDCE) census of the Delta Herd was conducted in 1979. The field procedure was similar to that used in a multitude of studies (see review in Davis et al. 1979) since its initial development by Hemming and Glenn (1969). On 15 June L. Jennings and E. Crain conducted a reconnaissance survey in a C-185 and concluded that caribou were aggregated sufficiently to make photo coverage feasible. On 16 June a C-185 was used to relocate the aggregations seen on 15 June and a PA-18-150 Super Cub was directed to the aggregations

to photograph them. Each of these aggregations was photographed with a hand-held 35-mm SLR camera while the crew in the C-185 looked for additional groups. The Super Cub was used after photographing the known groups to locate as many radio-collared caribou as possible to determine if significant portions of the cow-calf segment of the herd were missed in the photo coverage.

Inclement weather until June 23 precluded using a heliocopter to conduct composition counts of the groups photographed. Fall composition data from 1977, 1978 and 1979 were used to extrapolate several total herd size estimates based on the calculated 1979 photo census cow base. J. Wright analyzed the 1979 photos.

To facilitate counting caribou, the original 35-mm color slides were enlarged to 8 x 10 color prints. When necessary, "endlap" (i.e. overlapping coverage along a single flight line) and "sidelap" (i.e. overlapping coverage on adjacent flight lines) were delineated to insure that discrete segments of a caribou group were counted on each print. Each image of a caribou located on a print was marked with a pin; then the print was turned over and the number of pinholes was tallied.

Several factors made counting difficult, including: "grainy" prints resulting from Ektachrome slides and rough-textured printing paper, varying scale and perspective due to the low altitude of the photo aircraft and "hand-holding" of the camera, and reversed images on some prints caused by placing slides incorrectly in the enlarger during printing. Because of these technical difficulties the discrimination of calves from adults was frequently impossible. It is likely that many calves were not detected at all because of poor image quality. Errors resulting from incorrect delineation of overlap were not considered significant.

Analysis of 1973 APDCE Census Data

Because findings of this study suggested that recruitment into the herd for several preceding years was better than past surveys suggested, we decided that a review of apparent herd demography was appropriate. Prior to 1979 the only concerted effort to census the herd was a 1973 APDCE census. Though cursory analysis of the census was reported (Buchholtz pers. comm.), no thorough data analysis was completed. J. Wright conferred with M. Buchholtz and reviewed the 1973 census data.

Caribou on 9 x 9 black and white contact prints (photographs taken 16 June 1973, scale=1:3000) were counted following procedures outlined by Bente and Roseneau (1978) and Davis et al. (1979).

RESULTS

Radio-Collaring

From 4 January through 11 January 1979, 21 calves (12 males and 9 females) were immobilized, processed, and radio- and visual-collared. One of these died following administration of the antidote (discussed below). On 30 March 1979, five additional calves were immobilized, processed, and radio- and visual-collared. One radio from the January collaring was not functional and that calf was also immobilized and its radio collar replaced. A summary of accession numbers, collar numbers, and radio frequencies appears in Appendix I.

The initial dosage of 1.5 to 3.0 cc of etorphine and 20 mg of xylazine was sufficient to immobilize or adequately tranquilize 23 of the calves. In four cases additional etorphine was administered by another dart or syringe injection following physical capture. The one capture-related mortality was a calf which received 5 cc of etorphine in four doses. It ran a long time after being darted with 1.5 cc of etorphine and 20 mg of xylazine and was subsequently darted with 1 cc etorphine but continued to run. After considerable chasing on foot, it was captured, physically restrained, and injected intramuscularly with 1 cc etorphine. It continued to thrash wildly and was difficult to physically restrain. It was subsequently given 1.5 cc intravenously. That dosage immobilized and tranquilized the calf to a condition similar to others that received 1.5 to 2.5 cc etorphine and 20 mg xylazine. After handling, it was given 2.5 cc M-50-50. It stood up after receiving the antidote, began hyperventilating, collapsed, and died. Post-mortem necropsy suggested abnormal physical condition (Appendix II) as did the blood parameters in Table 2.

Physiological Data

Blood profiles for the calves are listed in Table 2, and body measurements for all radio-collared calves are presented in Table 3. In five instances body weights were not measured because the calves were too active. Measurement, blood, and drugging data will be further analyzed and reported in the final job report.

Relocation of Collared Calves

Relocation information and current status of the collared calves are summarized in Tables 4 and 5. Collared calves were relocated 144 times visually and 241 times audibly during 24 relocation flights. "Visual relocations" included hearing a signal from a group of caribou, even if the collared individual was not specifically identified. This occurred occasionally when flying conditions precluded low or repeated passes.

Table 2. Blood profile for collared caribou calves from the Delta Herd, 1979.

Accession No.	PCV	Glucose Mg/DL	Uric Acid Mg/DL	Chol. Mg/DL	Ca Mg/DL	Inorg. Phosph. Mg/DL	Protein Gm/DL	Albumin Gm/DL	Bili-rubin Mg/DL	BUN Mg/DL	Creati-nine Mg/DL	LDH U/L	SGOT U/L	Alkaline Phosphatase U/L
101,972	56	135	0.3	74	10.7	7.1	6.7	4.0	0.2	6	2.6	510	85	89
101,973	58	113	0.4	69	10.1	5.4	5.9	3.2	0.2	5	2.0	561	85	89
101,974	45	117	0.3	53	10.4	5.9	6.8	3.7	0.2	5	2.3	477	106	160
101,975	55	128	0.3	59	11.0	4.8	6.4	3.6	0.2	11	2.7	380	69	121
101,976	--	131	0.2	46	10.4	5.2	7.0	3.5	0.2	4	2.2	364	81	69
101,977	54	115	0.3	68	10.2	6.3	7.1	3.8	0.2	7	1.8	478	84	117
101,978	No blood drawn													
101,979	46	158	0.2	43	10.5	7.2	6.6	3.7	0.2	6	2.4	413	74	93
101,980	46	193	0.1	64	10.0	6.2	6.4	3.4	0.0	3	2.3	258	66	153
101,981	54	130	0.2	62	10.1	6.0	6.8	4.0	0.3	4	2.5	428	98	113
101,982	53	Quantity of serum not sufficient												
101,983	--	Quantity of serum not sufficient												
101,984	--	109	0.2	71	9.9	6.4	8.0	3.7	0.3	7	2.4	398	85	143
101,985	45	173	0.8	68	10.7	5.2	5.9	3.2	0.2	13	3.3	486	101	85
101,985*	--	114	0.2	67	10.4	6.5	6.5	3.9	0.1	9	2.7	456	78	157
101,986	45	78	0.3	56	11.1	6.9	7.5	4.0	0.2	4	2.6	400	87	109
101,987	45	209	0.4	66	10.0	6.9	7.1	3.9	0.4	11	2.4	408	101	160
101,988	--	96	0.3	53	10.6	6.8	6.2	3.7	0.2	4	2.2	361	139	85
101,989	--	79	0.4	59	10.7	6.4	6.4	4.0	0.2	10	2.6	314	64	133
101,990**	--	(46)	(1.8)	(99)	(10.1)	(5.1)	(7.4)	(4.5)	(0.5)	(8)	(3.4)	(1095)	(165)	(150)
101,991	--	164	0.3	54	10.3	6.7	6.7	3.4	0.2	10	2.6	397	58	140
101,992	54	64	0.2	51	10.5	5.5	6.7	3.9	0.2	2	2.7	473	91	104
101,993	46***	127	0.4	60	9.1	5.6	6.0	2.8	0.3	6	2.5	296	63	76
101,994	51***	185	0.5	72	9.3	5.5	6.4	3.5	0.1	7	2.1	403	78	92
101,995	--	136	0.3	50	10.5	6.1	6.1	3.7	0.1	10	2.5	372	56	61
101,996	56***	107	0.4	51	10.1	4.0	6.0	3.3	0.2	6	2.9	367	108	99
101,997	53***	165	0.5	66	10.1	5.7	7.0	3.2	0.2	7	2.4	376	82	121
MEAN	50.5	131.6	0.33	60.1	10.3	6.0	6.6	3.6	0.2	6.8	2.5	407.7	84.3	111.7
S.D.	5.1	37.5	0.15	8.8	0.5	0.8	0.5	0.3	0.08	2.9	0.3	70.6	19.0	30.1

* 101,985 recollared March 1979.

** Died during capture, results omitted from mean (Appendix II).

*** Results questionable due to age of blood samples--omitted from mean.

Table 3. Body measurements (cm) and weights (lb, kg) of Delta Herd collared calves, 1979.

Accession No.	Sex	Shoulder Height	Total Length	Heart Girth	Metatarsal Length	Total Hind Foot Length	Ear Notch Length	Face Length	Neck Circumference	Body Weight (lb)	Body Weight (kg)
January											
101,972	F	106.0	177	108	39.5	58.0	--	--	--	145	65.9
101,973	F	106.0	174	104	40.0	57.0	15.5	32	42.0	135	61.4
101,974	F	107.0	170	105	39.0	54.0	15.0	34	45.0	145	65.9
101,975	M	111.0	163	110	41.0	57.0	13.5	32	48.0	155	70.5
101,976	M	111.0	173	112	41.0	56.0	14.0	34	48.0	158	71.8
101,977	F	101.0	162	102	37.0	51.0	13.5	31	44.0	130	59.9
101,978	M	107.0	172	110	39.0	56.0	13.0	34	47.0	--	--
101,979	M	115.0	171	120	41.0	58.5	13.5	36	49.0	160	72.7
101,980	M	105.0	178	107	38.0	54.0	12.0	34	49.0	178	80.9
101,981	F	104.0	163	101	36.0	52.0	14.0	31	41.0	130	59.1
101,982	F	102.0	169	99	37.0	52.0	12.0	30	40.0	138	62.7
101,983	M	105.0	157	110	40.0	56.0	--	35	41.0	--	--
101,984	F	90.5	160	105	36.0	52.0	12.5	30	42.0	132	60.0
101,985	M	106.0	160	114	39.0	54.5	12.0	32	46.0	135	61.4
101,986	M	104.0	162	104	40.0	58.0	12.5	32	46.5	153	69.6
101,987	M	115.0	182	105	41.0	59.0	14.0	35	46.0	--	--
101,988	F	105.0	181	109	38.5	54.0	12.5	34	44.0	145	65.9
101,989	M	104.0	171	110	39.0	56.5	14.0	33	46.0	152	69.1
*101,990	F	104.0	170	96	38.0	50.0	11.0	35	41.0	135	61.4
101,991	M	106.0	164	104	38.0	55.0	13.0	32	45.0	160	72.7
101,992	M	99.0	174	100	39.0	52.0	--	--	--	--	--
AVERAGE	M	107.3	168.9	108.8	39.7	56.0	13.2	33.5	46.5	156.4	71.9
for January	F	102.8	169.6	103.2	37.9	53.3	13.3	32.1	42.4	137.2	62.5

Table 3. Continued.

Accession No.	Sex	Shoulder Height	Total Length	Heart Girth	Metatarsal Length	Total Hind Foot Length	Ear Notch Length	Face Length	Neck Circumference	Body Weight (lb)	Body Weight (kg)
MARCH											
101,985**	M	107.0	172	105	39.0	54.5	13.0	29	51.0	127	57.7
101,993	F	94.0	162	104	38.0	52.0	--	--	38.5	118	53.6
101,994	F	107.0	166	97.5	37.0	54.0	12.5	33	43.0	135	61.4
101,995	M	100.0	161	97	39.0	54.0	12.0	32	49.0	130	59.1
101,996	M	100.0	174	108	39.0	55.0	12.0	29	51.0	145	65.9
101,997	F	--	168	109	37.0	53.0	14.0	37	44.0	--	--
AVERAGE	M	102.3	169.0	103.3	39.0	54.7	12.3	30	50.3	134.0	60.9
for March	F	100.5	165.3	103.5	37.3	53.0	13.3	35	41.8	126.5	57.5

* Died during capture.
** Originally collared in January. Recollared in March due to nonfunctional radio.

Table 4. Relocation information and status as of 15 October 1979 of Delta Herd caribou collared in 1979.

Collar Number	Sex	Date Collared	No. Times Audibly Located	No. Times Visually Located	Status* May	Status* Oct.	Comments
17Y-R	M	9 Jan	6	5	U	U	Radio draped over head, not heard since 10 April
18Y-R	M	4 Jan	18	7	A	A	One sighting by hunters
19Y-R	M	8 Jan	9	5	A	U	Last seen 5 July, no collar
47BK-Y	M	11 Jan	10	4	A	U	Collar off 1 June
52Y-R	F	10 Jan	10	7	A	A	
53Y-R	F	4 Jan	13	9	A	A	
54Y-R	F	11 Jan	18	7	A	A	
56Y-R	F	4 Jan	13	10	A	A	
57Y-R	F	4 Jan	10	11	A	A	False mortality 1 Oct
57BK-Y	M	9 Jan	4	2	D	D	As of 18 March
58Y-R	M	11 Jan	13	7	A	A	Recollared after radio failure
58BK-Y	M	10 Jan	2	3	U	U	Not heard since 16 Feb
59BK-Y	M	10 Jan	11	6	A	A	
59Y-R	F	10 Jan	16	9	A	A	
62Y-B1**	M	9 Jan	4	0	D	D	As of 19 February
62Y-B1	M	30 March	1	3	A	U	Collar off 18 May
63Y-B1	M	11 Jan	6	5	A	U	Not heard since 18 March, incidental sightings since
67BK-Y	M	30 March	5	5	A	U	Not heard since 17 July, collar on by visual only as of 5 June
69BK-Y	M	11 Jan	4	2	U	U	Not heard since 18 March
76Y-R	F	30 March	10	4	A	A	
77Y-R	F	30 March	6	5	A	A	
78Y-R	F	9 Jan	12	10	A	A	
79Y-R	F	30 March	10	5	A	A	
79BK-Y	M	10 Jan	15	7	A	A	Put foot through collar, redarted 11 April
88Y-R	F	8 Jan	15	6	A	A	
TOTAL			241	144			

* U = Unknown, A = Alive, D = Dead.

** On 9 January 62Y-B1 was originally installed on a calf which was killed by wolves in February. The collar was recovered and placed on another calf on 30 March.

Table 5. Summary of the status of radio-collared calves from the Delta Herd as of 15 October 1979.

	Total	Male	Female
Number collared	25	14	11
Alive as of 15 October	15 (60%)	4	11
Dead as of 15 October	2 (8%)	2	0
Unknown status	8 (32%)	8	0
Collar off	3	3	0
Radio not heard*	5	5	0

* Includes one of two known radio failures.

On five occasions a fast mode or mortality signal was heard during a relocation flight. In two cases a carcass was found, in two cases a collar had fallen off, and there was one instance of a false mortality signal (i.e. the animal had apparently been at rest for 4 hours).

Collar 62Y-B1 was heard on normal mode on 16 February, but on 19 February a mortality signal was heard from the collar and it was seen on a carcass in the spruce trees approximately 9 miles north of the collaring site. On 20 February the site was reached by helicopter, the carcass was examined for cause of death, photos were taken, and the collar was retrieved. Wolf sign, including substantial hemorrhaging at death and evidence of a struggle, led us to conclude that wolves killed the calf. Half of the carcass was eaten, apparently by wolves. Examination of the kill site on 23 February indicated that the carcass had not been utilized further since 20 February.

On 18 March a mortality signal was heard from collar 57BK-Y. It was last heard on slow mode on 7 March. On 19 March the carcass was located in sparse spruce 9 miles south of Japan Hills and 22 miles northwest of the collaring site. When the carcass was first seen, the ribs, backbone, and portions of the head were all that remained. Five ravens (*Corvus corax*) were feeding and wolf tracks were seen around the carcass. On 30 March a helicopter was used to retrieve the collar. At this time some hair remained but no bones. Fox (*Vulpes fulva*) tracks were seen in the area. The cause of mortality was unknown but circumstantial evidence implicated wolves.

A fast mode signal was heard on 18 May from collar 62Y-B1 which was audibly located on slow mode on 2 May. The collar was found on the tundra approximately 1 mile east of Portage Airstrip and 27 miles east-southeast of the tagging site. There were no signs of mortality and we

concluded that the collar had dropped off. The collar was later retrieved and we determined that the surgical tubing had broken.

On 1 June a fast mode signal was heard from collar 47BK-Y. On 30 March the male calf had been visually located and the collar appeared to be dislocated to one side of the neck at that time. A subsequent visual location was made on 6 April and the radio collar at that time had separated and was attached to the calf only by the visual collar. The calf was audibly located again on 10 April, 17 April, and 2 May, but no signal was heard on 18 May. On 1 June the collar was found 12 miles south of Gold King Airstrip and approximately 1 mile north of the tagging site. There was no sign of mortality and we concluded that it was dropped. This collar was not retrieved.

On 1 October a fast mode signal was heard from collar 57Y-R. The signal was weak, and due to receiver problems a visual location was not made. On 15 October the signal was on slow mode and when visually located the female calf was feeding and appeared healthy. This was the only instance of a false mortality signal.

Difficulty with three other collars was confirmed. Collar 63Y-B1 was last heard on 19 March. It was incidentally seen on a live caribou on 16 May, 24 May, and 16 June which confirmed failure of the radio. Collar 56BK-Y was relocated seven times between 11 January and 7 March. However, it was not located on 18 March and 29 March. Fortuitously, while we were collaring calves on 30 March, caribou 56BK-Y was seen, radio failure was confirmed, and it was refitted with another radio (58Y-R) which functioned properly. On 5 July caribou 19Y-R was seen and identified by ear tags, but no collar was seen. The collar was last heard on 2 May.

Two radios which are no longer audible probably have been dropped. A male calf was collared on 9 January with collar 17Y-R. When visually located on 16 February the collar was draped over the antlers. This collar was last heard on 10 April and it is presumed that the collar was lost when the antlers were shed. Another male calf was collared on 30 March with collar 67BK-Y. When the calf was visually located on 5 June the collar was attached by the visual collar only. This collar was last heard on 17 July.

Status Summary of Radio-Collared Calves

Table 4 shows that all 11 collared female calves survived to 1 year of age. Further, by 15 October 1979 when they were 17 months old, all were still alive and all radios were functioning.

Interpretation of corresponding survival rates of the males is not as straightforward. Of the 14 collared male calves, 2 deaths were confirmed prior to 1 year of age, 3 caribou were of unknown status by May, and 9 were confirmed to survive until May. By the end of October no additional deaths were confirmed, but only four radio-collared males

were still audible. Two of these four collars were inadvertently permanently fastened in the same manner as were all female collars (see METHODS). Of the remaining 8 collared male calves, 1 radio failure was confirmed, 3 collars were confirmed to have been dropped, and 2 of the remaining 4 were last seen with partially detached collars. The remaining two collars appeared normal when last seen.

Movement of Collared Calves

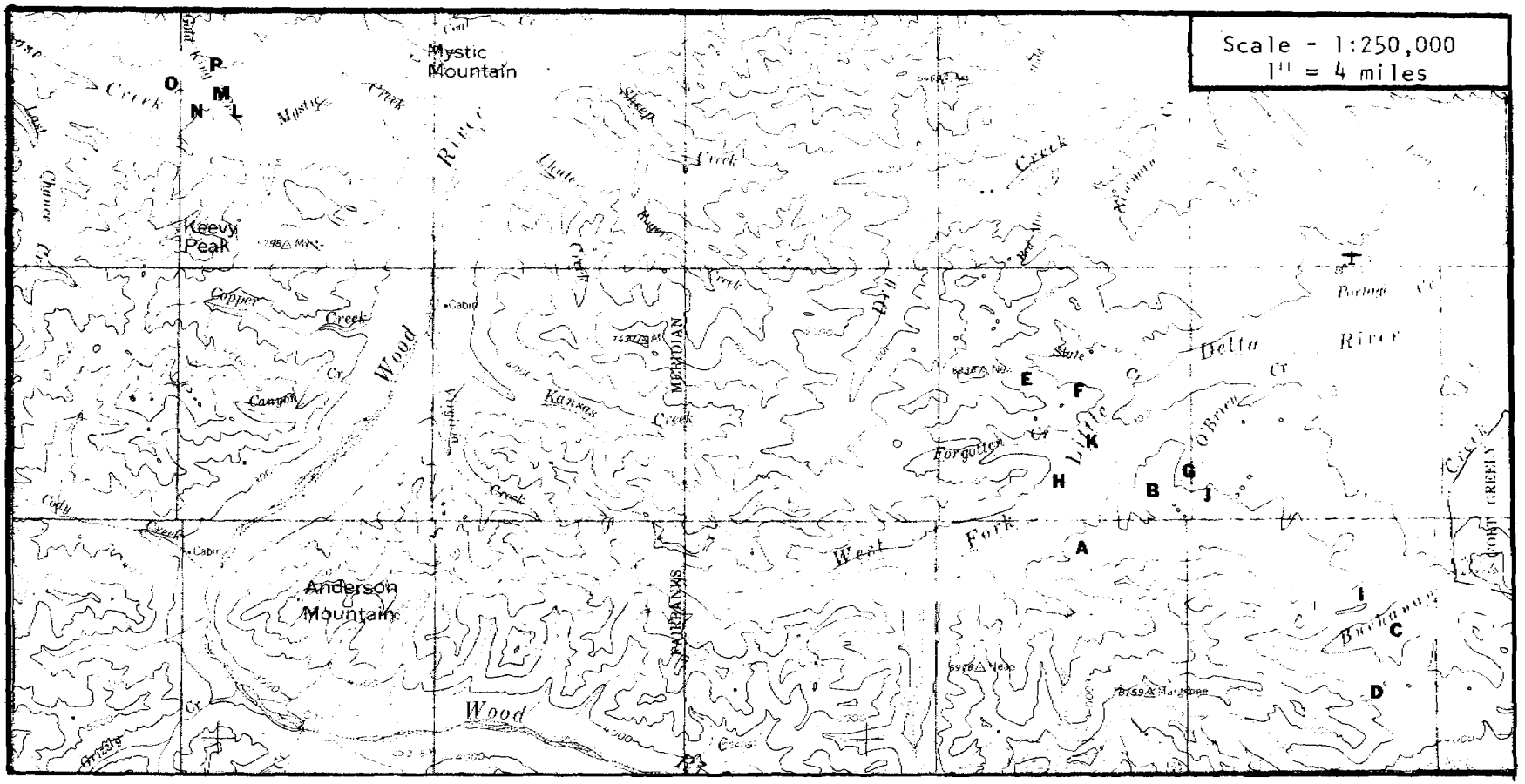
With only four exceptions, the collared calves were always visually located on the north slopes of the Alaska Range between Delta Creek on the east, Tatlanika Creek on the west, and south of the 1,500-ft contour of the Tanana Flats. Male calf 59BK-Y moved from the Gold King area west-southwest to Lignite Creek. It was last audibly located again in the Gold King area. Female calf 56Y-R moved from its collaring site north of Molybdenum Ridge about 12.9 km north onto the Tanana Flats, and east to a point 9.7 km east of Delta Creek before moving back to the West Fork area. Male calf 63Y-B moved east from the Gold King area to a point 6.4 km east of Delta Creek and then moved to the West Fork area. Male calf 58Y-R moved west from the Gold King area to the Totatlanika River and then moved east to Dry Creek.

1979 APDCE Census

During the 16 June APDCE census, 3,160 caribou were counted (Fig. 1). Two thousand eight hundred and ninety-two of these were counted from photographs taken of the six major post-calving aggregations (Fig. 1). By searching the area adjacent to the post-calving aggregations and locating radio-collared animals, 274 others were visually counted from a Super Cub (Fig. 1). Inclement weather precluded obtaining composition data of animals photographed on 16 June until 23 June when a sample of 738 from an aggregation of about 1,400 (Table 1) were classified from a helicopter and the ground.

The estimated number of cows in the herd was calculated by assuming the sample of 738 was representative of the 2,892 caribou counted on photos. Therefore, 2,892 x .574 = 1,660 cows on the photos. Assuming the same composition for animals visually located around the post-calving aggregations, we calculated that there were 97 cows out of 125 animals older than calves. In the area west of Wood River, 140 caribou were located including a minimum of six more cows. Therefore, the calculated cow base was 1,763.

Conventional application of the APDCE census technique involves obtaining sex and age composition data during the rut to extrapolate a total population estimate from the cow base calculated from the photo coverage. This is based on the assumption that herd composition samples obtained during rut are representative of true herd composition. Davis et al. (1979) and Doerr (1979) demonstrated that this assumption is not valid. Davis et al. (1979) proposed a modification of the APDCE technique



A[1]	993	(mixed)
B	162	(mixed)
C	1003	(mixed)
D	459	(mixed)
E	275	(mixed)
	2892	

F[2]	34	(mixed)
G	3	(1 male, 2 yearlings)
H	20	(mixed)
I	26	(mixed)
J	20	(mixed)
K	25	(mixed)
	128	

L[3]	52	(males and yearlings)
M	22	(12 males, 6 females, 4 calves)
N	50	(males and yearlings)
O	14	(males)
P	2	(1 male, 1 yearling)
	140	

1 - Groups A through E were post-calving aggregations photographed in 35mm color.
2 - Groups F through K were considered part of the post-calving aggregation for extrapolation purposes in the APDCE calculations but were not photographed.
3 - Groups L through P were not considered part of the post-calving aggregation for extrapolation purposes.

Figure 1. Location, size, and sex and age composition of groups of caribou found during the 1979 Delta Herd APDCE census.

to circumvent the problem. The modified procedure was not utilized in this census, so use of some fall composition data is essential to extrapolate an estimate. We used fall composition data from 1978, 1977, and 1979, respectively, to calculate estimates for reasons that follow. Use of 1978 fall composition data for extrapolation follows:

cow base from 1979 post-calving extrapolation	=	1,763 cows
1,763 x .75 bulls	=	1,322 bulls
1,763 x .10 yearlings	=	176 yearlings
1,763 x .39 calves	=	688 calves
		3,949 total

In contrast, if 1977 fall composition data are used for extrapolation the following is calculated:

cow base from 1979 post-calving extrapolation	=	1,763 cows
1,763 x .325 bulls	=	573 bulls
1,763 x .058 yearlings	=	102 yearlings
1,763 x .422 calves	=	744 calves
		3,182 total

If one assumes that the change in these ratios in 1 year is improbable, then the difference in the two calculations illustrates some of the shortcomings of conventional application of the APDCE technique (Davis et al. 1979).

Use of 1979 fall data for extrapolation (which is appropriate for conventional APDCE application) is significantly confounded by having classified the 23 June sample as cows, bulls, yearlings, and calves, but classifying only cows, bulls, and calves in the fall.

Several people (Bos 1974, Irvine 1976) have circumvented this problem by classifying animals photographed in post-calving aggregations and also during fall as to cows, bulls, and calves without attempting to differentiate yearlings. Although this allows straightforward calculation of an APDCE population estimate, it assumes no differential segregation of yearlings between the two counts. As stated above, it is generally assumed that composition counts during the rut reflect true population composition, but recent evidence refutes this (Davis et al. 1979, Doerr 1979). Many workers have recognized the great variation in the proportion of bulls and yearlings present in post-calving aggregations between years and between herds. In many years, substantial proportions of yearlings (of both sexes) do not join post-calving aggregations. So calculating total females (adult cows and female yearlings) from animals photographed in post-calving aggregations would produce a substantial underestimate of females.

If we assume that 50 percent of the yearlings classified in June 1979 were male and 50 percent were female, we can estimate the 1979 female population and the total population using only 1979 data as follows. Assuming that of 2,892 caribou counted on photos, 57.4 percent

were cows and 10.3 percent were yearlings, half of which were females, then 57.4 + 5.15 = 62.55 percent is the proportion of the total number photographed that were females. So, there were 2,892 x .6255 = 1,809 females older than calves in photos. There is no way to readily adjust the total females figure to account for yearling females in the peripheral groups that were collectively counted as bulls and yearlings in 1979. Therefore, we will assume that the above figure is a conservative total female estimate. Then to extrapolate the total population estimate using 1979 fall data, we calculate as follows:

post-calving estimate = 2,892 x .6255% cows	=	1,809 females
1,809 x .390 (December bull/cow ratio)	=	706 bulls
1,809 x .650 (December calf/cow ratio)	=	1,176 calves
Total December estimate	=	3,691

Many calves were likely not detected on the photos of the post-calving aggregations and the extrapolated number of cows (or cows and yearling females) is likely conservative because of a conservative post-calving aggregation total from which the female base is calculated. This suggests that total population estimates are likely conservative if composition data are assumed to be accurate.

1973 APDCE Census

Problems encountered during this census characterize difficulties which may arise when aerial photography of an APDCE census is contracted to private industry or another agency (Davis et al. 1979). The date for photography was predetermined and fell on a day with intermittent rain and sunshine. This affected photo quality (i.e. exposure and contrast) as well as caribou distribution and activity. The crew of the photo aircraft demanded wide clearance from reconnaissance planes which compromised the close communication necessary for precise direction of the photo aircraft to caribou groups. As a result, one group of about 50 was completely missed and others were only partially covered by the aerial photos. ADF&G biologist M. Buchholtz (pers. comm.) estimated that no more than 200 caribou were missed in the photo coverage, but verification was impossible.

Two thousand and eighty-eight (2,088) caribou in 10 groups were counted on the aerial photos taken 16 June 1973 (Appendix III). No additional caribou were counted directly from fixed-wing aircraft.

Using composition data from June 1973 for extrapolation, the calculated number of cows photographed in the post-calving aggregations was 2,088 x .73 = 1,524. By adding 200 for those caribou estimated missed, we calculate the number of cows to be 2,288 x .73 = 1,670. Using fall ratios of herd composition, the October population size was derived as follows:

Cow base from post-calving extrapolation	=	1,524 or 1,670 cows
1,524 or 1,670 x .286 bulls	=	436 or 478 bulls
1,524 or 1,670 x .103 calves	=	157 or 172 calves
1,524 or 1,670 x .040 yearlings	=	61 or 67 yearlings
		2,178 or 2,387 total

If an alternative extrapolation is used where all yearlings are classified as bulls or cows in June and October, the calculations are as follows:

2,088 or 2,288 x .759 females (older than calves)	=	1,585 or 1,737 females
1,585 or 1,737 x .286 bulls (older than calves)	=	453 or 497 bulls
1,585 or 1,737 x .101 calves	=	160 or 175 calves
		2,198 or 2,409 total

1979 Calving Data

Prior to conducting composition counts from the ground on 24-29 May, fixed-wing reconnaissance surveys were flown on 16, 19, and 23 May. Caribou distribution in the calving area was determined, peripheral area calving was monitored, and all caribou seen were classified to document calving progression.

On 16 May reconnaissance was flown in the area east of Wood River and west of the East Fork of Little Delta River. We saw 31 caribou in this area, including 1 adult female with hard antlers, 2 adult bulls, 26 yearlings, and 2 unclassified. East of this area in the traditional calving area we saw 39 newborn calves and 297 caribou older than calves, a ratio of 13.1 calves:100 caribou older than calves. This suggested, as did observations related to us by Lt. H. Griese, that calving was several days ahead of previously generalized calving dates (Davis et al. 1978). Bergerud (1975) discussed factors that may attribute to "early" or "late" calving.

Results of the aerial count are summarized in Fig. 2 and the ground count data appear in Fig. 2 and Table 6. The opportunity to obtain good distended udder counts (Bergerud 1964) on the calving ground provided insight to a question which had been asked since 1973: was the reproductive problem characterizing the herd attributable to low natality, high early calf mortality, or both? In past years distended udder counts (ADF&G files) were obtained during post-calving aggregation composition counts in mid- to late June when large sample sizes were most easily obtained. An index to yearling recruitment was estimated after yearlings joined the aggregations. Results since 1973 are summarized in Table 6. We calculated an "adjustment factor" for computing adjusted distended udder frequencies from past years as follows. From 24-28 May 1979 we classified 479 cows and observed 97.7 percent with distended udders. On 23 June (Table 6), 45 percent of 424 cows had distended udders. Thus 97.7 ÷ 45 = 2.17 times more distended udders were seen immediately after the calving peak than in mid-June. Although many

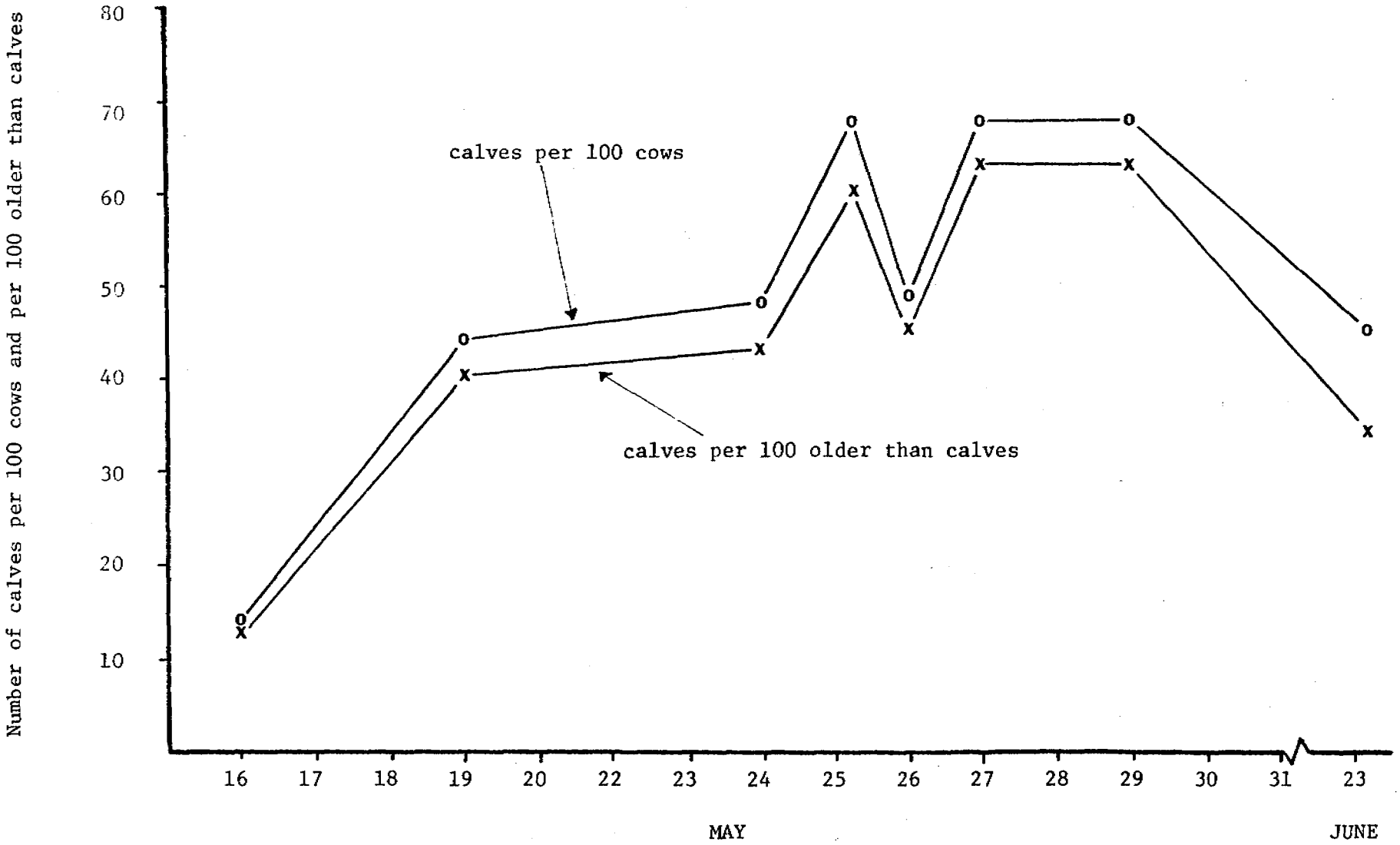


Figure 2. Progression of calving and calf survival during May and June 1979 in the Delta Herd.

considerations are necessary to extrapolate this adjustment factor to other years with confidence, we believe, nevertheless, it is an instructional exercise. We also acknowledge that distended udder frequency counts from the calving area are likely slightly inflated for a herd average, because more nonparturient females are on the periphery of the calving area than in the core area. The adjusted distended udder frequencies (Table 6) suggest that low natality was less likely than high initial mortality as an explanation of low numbers of calves observed in the past in mid-June. This is consistent with Bergerud's (1978) argument that natality rates are consistently high in mainland North American caribou, and that when recruitment failures are observed high mortality rather than low natality is the most probable cause.

Table 6. Summary of observed calf:100 cow ratios and percent of cows with distended udders during mid-June counts in Alaska's Delta Caribou Herd, 1973-1979.

Date	Calf:100 Cow Ratio	(Calves/Cows)	(Distended Udders/ Total Cows)	Percent Cows with Distended Udders	
				Observed	Adjusted[a]
6/19/73	24.5	(201/820)			
6/13-14/74	3.5	(33/942)	(227/942)	24	52
6/11-12/75	12.9	(108/839)	(315/839)	38	82
6/16,18,22/76	56.0	(390/699)	(432/699)	62	100[b]
6/16,19/77	34.0	(269/784)	(236/784)	30	65
6/13-14/78	24.0	(157/661)	(187/661)	28	61
6/23/79[c]	44.6	(189/424)	(191/424)	45	98

a Adjusted values are the observed values multiplied by the 1979 correction factor of 2.17.
b Adjusted value exceeds 100 percent.
c From 24-28 May 1979 we classified 479 cows with a 97.7 percent distended udder frequency. This converts to 97.7/45 = 2.17 times greater distended udder frequency than during late June count.

It is noteworthy that on 28 May 1978 J. Davis observed from a fixed-wing aircraft 243 calves with 343 caribou older than calves. If all caribou older than calves were adult females, a minimum of 71 percent should have had distended udders. Undoubtedly some were not adult cows and some would have recently lost calves so 71 percent would be a minimum value. Yet on 13 and 14 June 1978, ground counts showed 157 of 661 cows (29%) with distended udders. An "adjustment factor" for the year then would be 2.45 which lends credence to our qualified extrapolation of the 1979 adjustment factor to other years.

However, the above two instances both occurred after 1976 when a general trend toward improving calf survival (and/or natality) following initiation of a wolf control program was noted. For 1973 through 1975, the 3 years preceding wolf control for which mid-June data are available, the average calf/cow ratio was $\bar{X}$ = 13.6 (s.d. = 10.5) compared to the 1976 through 1979, 4-year average after control began of $\bar{X}$ = 39.7 (s.d. = 13.87). A similar comparison of available distended udder frequency data (Table 6) shows respective pre-wolf control and post-wolf control values of $\bar{X}$ = 31, s.d. = 9.9 and $\bar{X}$ = 41.3, s.d. = 15.8.

We have not yet reviewed all available weather data, but it does not appear that weather on the calving ground during the calving period was more favorable after 1976 than before that time. In fact, ADF&G biologists J. Coady and W. Gasaway flew moose calf surveys prior to 28 May 1978, saw total snow cover of several inches in the caribou calving area, and recommended a caribou calf survival survey be flown. J. Davis obtained the 28 May data mentioned above after essentially all snow had melted and the weather became warm and sunny. Calf mortality from windchill (Kelsall 1968) should have occurred prior to the survey.

Recruitment Estimation

Estimating reproductive recruitment (as opposed to recruitment through immigration) since the herd first began to decline in 1971 has been difficult and has apparently not been very accurate. Since 1973 yearling recruitment has been estimated from mid-June and fall composition counts when the percentage in the herd of 13- and 16- to 18-month-old yearlings, respectively, was estimated. In retrospect it appears that, even though these counts were always acknowledged to be only indices of relative abundance of yearlings, they predictably and consistently grossly underestimated recruitment. Davis et al. (in press) documented in the Western Arctic Caribou Herd (WAH) that fall counts apparently underestimated true yearling abundance in the herd by 40 percent or more. Bergerud (1971) suggested increasing the number of yearlings classified in fall by a 0.4 adjustment factor. The apparent reason for the underestimation in fall is that growth may make some yearlings indistinguishable from adults. Cases of classing yearlings as calves are also known. The exceptionally large size of Delta Herd calves (Table 3) suggests that identification as yearlings (16-18 months old) during fall could be very difficult.

It is common knowledge that substantial numbers of yearlings may be absent from post-calving aggregations in June but that this is variable between years. Therefore, underestimates can also be expected at that time. The best means to estimate overwinter calf survival (index to yearling recruitment) is to conduct April composition counts before sex and age segregation becomes pronounced. However, herd composition during this time may also be subject to between year variance (Bergerud 1968).

The apparently low yearling recruitment observed from 1973 through 1978 suggested that few young bulls would be in the 1978 fall population. However, on 26 October only 31 percent of 242 bulls observed were judged to be older than 4 years by criteria suggested by Skoog (1968). Males that appeared to be 2 and 3 years old were abundant. This observation and subsequent good survival of calves collared in this study led us to speculate that recruitment of yearlings had probably been substantial since survival of calves to fall improved following wolf control in 1976. The collaring project suggested that 80-92 percent of calves collared survived to yearling age.

Development of herd growth scenarios to examine the observed population change (including probable decline from 1973 to 1976) from approximately 2,400 in 1973 to approximately 3,900 in 1979 is instructive in attempting to understand the population dynamics of the herd. Simple iterative arithmetic models using different exponential growth rates can be particularly useful. Bergerud (1978) calculated the theoretical maximum exponential growth rate for caribou to be r = 0.30. This needs to be qualified to the extent that short-term exponential growth rates can be larger if the population initially has disproportionately more females than males (Bergerud assumed a 1 male:2 female ratio).

If we assume that the herd remained stable from 1973 through 1975 and then began to grow at the theoretical maximum, r = 0.30, we can calculate the 1979 population using the formula for exponential growth rate (r) = $\frac{\ln N_{t}+i - \ln N_{t}}{t}$ as follows:

ln = natural logarithm

$\ln N_{t+i} = \ln N_{t} + rt$ where

$\ln N_{t+i}$ = natural log of 1979 population

$\ln N_{t}$ = natural log of 1975 population

r = the exponential growth rate (assumed at 0.30)

t = number of years from 1975 to 1979

Therefore, assuming the 1975 population was 2,400, the theoretical maximum 1979 population would be 7,943. Because the 1979 population is approximately 4,000, the apparent herd growth between 1973 and 1979 is clearly possible through reproduction. We do not need to infer that immigration (for which there is no evidence) or underestimation of the 1973 population was responsible for the change. We calculate the exponential growth rate from 1973 to 1979 as r = 0.12 which is only 40 percent of the potential growth rate. If the herd actually declined from 2,400 in 1973 to 1,500 in 1975, the growth to 3,900 between 1975 and 1979 required that r = 0.24. This is possible considering that the hunting season was closed, a wolf control program was in effect, and the initial adult sex ratio in the herd heavily favored females. Davis et al. (in press) reported that the Western Arctic Caribou Herd (WAH) increased after 1975 at r = 0.14 with some human use and wolf predation.

Reconnaissance surveys in conjunction with calf tagging in the Delta Herd in early January 1979 suggested that little if any calf mortality occurred following the fall counts on 26 October 1978 when 39 calves:100 cows were observed. Results of radio-tracking documented 100 percent survival of the 11 radio-collared female calves through October 1979 when the calves were 17 months old. As discussed earlier, poor collar retention by the males confounded accurate determination of male survival rates. However, only two mortalities were confirmed. The maximum survival rate for all calves was 92 percent (23 of 25). The minimum survival rate to at least 1 year of age for the 25 collared calves was 80 percent (20 of 25). Given the poor collar retention, confirmed failure of two radios and only two confirmed mortalities, it is likely that survival to yearling age exceeded the 80 percent minimum estimate. These data suggest that of the 39 calves:100 cows in fall, 31.2 to 35.9 yearlings per 100 cows were likely recruited into the population in 1979 (assuming proportional adult female mortality). Using the extrapolated population estimate for 1979, we calculate that 550 to 633 yearlings were present in the pre-calving population of about 3,300. This suggests that yearlings comprised 17 to 19 percent of the pre-calving population or a maximum exponential growth rate of 17 to 19 percent for the 1978-79 year (this assumes no mortality of other cohorts).

DISCUSSION

Results of this study demonstrate that the ongoing ADF&G Survey and Inventory (S&I) program for the herd did not obtain necessary data to accurately predict herd status. While the S&I program was useful, it did not evolve as rapidly as did "State of the Art" knowledge of caribou population demography. Deficiencies included the low priority given to the herd for study, infrequent critical data analysis and evaluation of ongoing programs, insufficient communication from all sectors within the field of wildlife management to make knowledge and application of innovations available to managers in a timely manner, a tendency to maintain the same schedule and type of surveys from year to year and to use outdated techniques to obtain comparable between-year comparisons even though options existed that should yield more accurate data, and often inadequate budgets, manpower, and personnel training.

However, the ongoing S&I program did obtain pertinent data in a timely manner that was sufficient to detect the need for harvest restriction when herd reduction and recruitment decline began in the early 1970's. Subsequent work also provided sufficient data to illustrate a direct correlation between increased herd productivity and decreased wolf abundance. The data supporting the observed correlation between lowered wolf abundance beginning in 1976 and increased survival of calves are more convincing of a cause and effect relationship than those collected when wolf control was previously initiated in the area in the mid-1950's (Davis et al. 1978).

RECOMMENDATIONS

A reliable expandable radio collar should be developed for collaring male caribou calves. Standard collars can apparently be permanently fastened on most female calves after they are 7 months old and be retained for life without undue constriction of the neck during growth to maturity. Males, however, realize much greater neck growth between 7 months of age and maturity. Seasonal neck expansion during rut confounds this problem and all males less than 5 or 6 years old must be collared carefully to allow expansion for neck enlargement while ensuring collar retention.

Mid-June and fall composition counts predictably (but erratically) underestimate yearling recruitment and should not be used for that purpose. Unless, and until, suitable criteria become available to accurately classify yearlings in fall, late winter calf survival counts should be conducted to estimate yearling recruitment. Mid-June counts (when peak of calving is in mid- to late May) of the frequency of distended udders in cows do not accurately indicate natality rates, particularly when early calf mortality rates are high.

Although the "range" of the Delta Herd has apparently supported 5,000 or more caribou in the past, some earlier descriptions of the range limits included the area occupied by the Macomb Herd. Therefore, the estimate of 5,000 should be adjusted downward to 4,000 for the Delta Herd as now defined. We suggest a conservative stocking rate until additional studies are conducted.

The status of the herd should be evaluated annually, hypotheses to explain the status and trend of the population should be stated in writing, and a program to test the stated hypotheses should be initiated, when practical, using existing resources. If available resources are insufficient, then needs should be stated and help from outside the Division should be solicited.

A concerted effort should be directed toward obtaining a representative sample of the population age structure to test our hypothesis that the Delta Herd has increased substantially since 1976 through good yearling recruitment.

ACKNOWLEDGMENTS

A substantial portion of the Fairbanks Game Division Staff, as well as others, collected data contained in this report. M. Buchholtz, L. Jennings, and D. Simpson collected much of the data on herd composition and population size. J. Coady and P. Valkenburg flew most of the radio-collared caribou relocation surveys. R. O'Connor, K. Whitten, E. Crain, D. Haggstrom, and J. Coady assisted in caribou tagging. R. O'Connor organized data and efforts and aided in all other facets of the early part of the radio-collaring project. J. Wright aided in field work and counted the census photos for 1973 and 1979. He and P. Valkenburg aided in data collection and summarization.

Charter pilots W. Lentsch and J. Kannebec safely flew operations demanding considerable skill and experience during portions of the study.

The U.S. Army made possible the 1979 calving ground work that made a major contribution in our analysis of the demography of the Delta Caribou Herd. Army personnel Lt. H. Griese, Lt. J. Kerns, and Mr. W. Gossweiler participated in the field. The Army provided helicopter transportation and Cols. L. Bonito and D. Pinney and Mr. W. Quirk authorized and coordinated the logistic support for the project.

LITERATURE CITED

Bente, P. J. and D. G. Roseneau. 1978. An aerial photo estimate of the 1977 Porcupine herd population. Renewable Resources Consulting Services, Ltd. Fairbanks, Alaska. 84pp.

Bergerud, A. T. 1964. A field method to determine annual parturition rates for Newfoundland caribou. J. Wildl. Manage. 28(3):477-480.

_____. 1971. The population dynamics of Newfoundland caribou. Wildl. Monogr. 25. 55pp.

_____. 1975. The reproductive season of Newfoundland caribou. Can. J. Zool. 53:1213-1221.

_____. 1978. Caribou. Pages 83-101 in J. L. Schmidt and D. L. Gilbert, eds. Big Game of North America (Ecology and Management). Stackpole Books, Harrisburg, Pa.

_____. In press. A review of the population dynamics of caribou in North America. Proc. 2nd Int. Reindeer/Caribou Symp., Røros, Norway, 1979.

Bos, G. N. 1974. Nelchina and Mentasta Caribou Reports. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Final Rep. Proj. W-17-6, Job 3.2. Juneau. 16pp.

Davis, J. L. 1978. History and current status of Alaska caribou herds. Pages 1-8 in D. R. Klein and R. G. White, eds. Parameters of caribou populations in Alaska. Proc. Symposium and Workshop. Biol. Pap. Univ. Alaska, Fairbanks, Spec. Rep. No. 3.

_____. In press. Distribution and status of *Rangifer tarandus* in the USA. Proc. 2nd Int. Reindeer/Caribou Symp., Røros, Norway, 1979.

_____ and K. A. Neiland. 1975. A study proposal: Evaluation of condition of animals in the Delta herd and its bearing upon reproduction. Alaska Dept. Fish and Game, Fairbanks. 40pp. (Unpubl. mimeo rep.)

_____, R. T. Shideler and R. E. LeResche. 1978. Fortymile Caribou Herd studies. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. Final Rep. W-17-6 and 7, Jobs 3.13R, 3.15R and 3.16R. Juneau. 151pp.

_____, P. Valkenburg and S. J. Harbo, Jr. 1979. Refinement of the aerial photo-direct count-extrapolation caribou census technique. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-17-11. Juneau. 23pp.

_____, _____ and H. V. Reynolds. In press. Population dynamics of Alaska's Western Arctic Caribou Herd. Proc. 2nd Int. Reindeer/Caribou Symp., Røros, Norway, 1979.

Doerr, J. 1979. Population analysis and modeling of the Western Arctic Caribou Herd with comparisons to other Alaska *Rangifer* populations. M.S. Thesis, Univ. Alaska, Fairbanks.

Hemming, J. E. 1971. The distribution and movement patterns of caribou in Alaska. Alaska Dept. Fish and Game, Tech. Bull. No. 1. 60pp.

_____ and L. P. Glenn. 1969. Caribou Report. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-15-R-5 and W-17-1. Juneau. 37pp.

Irvine, C. 1976. Population size of the Alaska Peninsula caribou herd. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-17-7 and 8. Juneau. 10pp.

Kelsall, J. P. 1968. The migratory barren-ground caribou of Canada. Queen's Printer, Ottawa. 340pp.

Murie, O. J. 1935. Alaska-Yukon caribou. U.S. Bur. Biol. Surv., N. Am. Fauna 54:1-93.

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

PREPARED BY:

James L. Davis and Diane J. Preston
Game Biologists

APPROVED BY:

Donald J. Spencer
Director, ~~Division~~ of Game

SUBMITTED BY:

John W. Coady
Regional Research Coordinator

Donald E. McKnight
Research Chief, Division of Game

Appendix I. Accession numbers, collar numbers, and radio frequencies for caribou calves collared in the Delta Herd in 1979.

Accession No.	Collar No.	Frequency (151.)	Sex	Ear Tags Left	Ear Tags Right	Comments
January						
101,972	57Y-R	.960	F	253Y	279R	
101,973	53Y-R	.955	F	269Y	280R	
101,974	88Y-R	.940	F	292R	267Y	
101,975	62Y-B1	.925	M	17851	17852	
101,976	17Y-R	.905	M	17854	17853	
101,977	78Y-R	.935	F	17873	17872	
101,978	57BK-Y	.950	M	17856	17855	
101,979	18Y-R	.980	M	263Y	281R	
101,980	58BK-Y	.880	M	17861	17862	
101,981	59Y-R	.890	F	17857	17858	
101,982	52Y-R	.915	F	17860	17859	
101,983	59BK-Y	.895	M	17871	17870	
101,984	54Y-R	.990	F	17868	17869	
101,985	56BK-Y	.920	M	293R	278R	Radio failed
101,986	69BK-Y	.995	M	17876	17877	
101,987	19Y-R	.975	M	287R	255Y	Collar missing
101,988	56Y-R	.885	F	261Y	283R	
101,989	47BK-Y	.900	M	17867	17866	Collar off
101,990		--	F	17874	17875	Died after immobilization
101,991	79BK-Y	.930	M	259Y	291R	
101,992	63Y-B	.910	M		256Y	Radio failed
March						
101,985	58Y-R	.985	M	293R	278R	
101,993	76Y-R	.875	F	12528	12526	
101,994	79Y-R	.945	F	17865	17864	
101,995	67BK-Y	.965	M	17863	17878	
101,996	62Y-B1	.925	M	17879	17880	Collar off
101,997	77Y-R	.970	F	17881	17882	

APPENDIX II. Necropsy report of Delta Herd caribou calf #101,990.

University of Alaska, Fairbanks

Division of Life Sciences
Department of Veterinary Science
Fairbanks, Alaska 99701

March 16, 1979

Dr. Randy Zarnke
Alaska Department of Fish and Game
1300 College Rd.
Fairbanks, Alaska 99701

Dear Randy:

We have completed out examination of the tissues and serum you submitted from the caribou that died during capture in the Delta area (your number 101990, our number 2822). The fixed tissues consisted of liver and lung. The liver had areas of serosal fibrosis with extension of the lesions into the parenchyma. The lung lesions extended from the surface deep into the parenchyma. On microscopic examination, both tissues had discrete areas of mononuclear infiltration with giant cell formation. Calcification was apparent in some areas.

The card and plates tests for brucellosis were negative. Tissue cultures of lung and liver were negative for Brucella but had a mixture of other organisms including E. cloacae, Pseudomonas stutzeri, Flavobacterium sp. and Non-hemolytic Strep. Our diagnosis is bacterial hepatitis and bacterial pneumonia.

It is interesting to note that the microscopic appearance of these lesions is very similar to those of brucellosis. One always wonders if the causative organism was overgrown and killed by saprophytes within the tissues.

Sincerely,

ROBERT A. DIETERICH
Professor of Veterinary Science

RAD:mlk

Appendix III. Summary of counts of caribou from photographs of post-calving aggregations of the Delta Herd, 16 June 1973.

Block No.	Group	Picture Numbers	Number of Caribou Counted
1	A	1-11	298[1]
	B	2-15	48
	C	2-5, 2-6	227
		3-6	96
2	A	11-3, 11-4, 11-5	30[1]
6 (same as 3)	A	18-6	246
		18-7	147
		18-8	120
4	A	20-4	136
	B	20-10	48
		20-11	140
	C	20-17	330[1]
		20-18	164[1]
5			0
7	A	26-9	5
		27-10	18
8	A	24-A	6
		Total	2088

[1] These groups were incompletely covered by the aerial photos (i.e. an unknown portion of the group was missed).