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DEMOGRAPHY OF THE DELTA CARIBOU HERD UNDER VARYING RATES OF NATURAL MORTALITY AND HARVEST BY HUMANS

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(including data through October 1982)

SUMMARY

During this reporting period, we radio-collared and obtained morphometric and physiological data from 21 Delta Herd caribou (Rangifer tarandus granti). Ten had been previously collared in 1979; 11 were short yearlings. Unsatisfactorily long drug induction times and incomplete immobilization of some caribou with the drugs and doses we were using stimulated us to review the problem and submit a manuscript (Effects of darting and netting on caribou in Alaska) to the Journal of Wildlife Management. The manuscript appears as Appendix A.

The Delta Herd bull:cow ratio (54:100) remained high in the 1982 fall composition sample, but the calf:cow ratio (29:100) was lower than any year since 1976. Natality of radio-collared caribou was lower in 1982 than in 1980 and 1981. In particular, this was illustrated by 6 of 9 2-year-old cows producing calves in 1980 compared to 1 of 8 in 1982. The peak of calving occurred from 23-26 May 1982, several days later than in preceding years. The traditional calving area remained totally snow-covered during the calving period, and most calving occurred in a snow-free area immediately to the north and northwest of the traditional calving area. The area used for calving in 1982 had been burned by wildfire in 1979.

Censuses of both the Delta and Yanert Caribou Herds in 1982 revealed population sizes of 6,500-7,500 and 700-900, respectively. We also compared the results of 2 independent censuses (1 relying only on relocating radio collars) of the Yanert Herd. The Delta and Yanert Herds continued to be discrete subpopulations with ecological differences.

Natural mortality in the Delta Herd has been low since 1976, and the herd has apparently grown annually by 19-22%. Mortality from hunting was relatively unimportant to herd dynamics from 1974

through 1981 but will likely be a major factor influencing the herd's future dynamics. The history of wolf (Canis lupus)/Delta caribou relationships was reviewed. A paper on this subject (Demography and limiting factors of Alaska's Delta Caribou Herd, 1954-1981) was presented at the 3rd International Reindeer/ Caribou Symposium in Finland (August 1982) and appears as Appendix B.

Key words: caribou, censusing, Delta Herd, demography, population dynamics, Rangifer, Yanert Herd.

CONTENTS

BACKGROUND

Davis and Neiland (1975) reviewed and compiled all available data for the Delta Caribou (Rangifer tarandus granti) Herd in 1974. Additional background information was presented by Davis and Preston (1980), Davis and Valkenburg (1981a), and Davis et al. (1982).

OBJECTIVE

To determine demography of the Delta Caribou Herd under varying rates of natural mortality and harvest by humans.

PROCEDURES

Study Area

The study area included the range of the Delta Herd, as defined by Davis and Neiland (1975), and the range of the Yanert Herd (Fig. 1).

Radio-collaring/Morphometry/Physiology

From 1 July 1981 through 30 June 1982, we captured, radio-collared, and obtained morphometric and physiological data from 21 Delta caribou (Table 1). Of the 21 caribou, 10 were originally radio-collared in 1979 as 7- to 9-month-old calves. Their collars were replaced in 1982 because of expected battery failure after approximately 36 months. The 11 caribou captured for the 1st time were all 11-month-old females (i.e., short yearlings).

Caribou to be captured were first visually located (by radio telemetry for those already radio-collared) from a fixed-wing aircraft (Bellanca Scout or Piper Super Cub). A helicopter (Bell Jet Ranger) and immobilizing equipment (Cap-Chur, Palmer Co., Douglasville, Ga.) were used to capture the caribou. The immobilizing drug consisted of 5.0 mg (1 mg/ml) of etorphine (M99, D-M Pharmaceuticals, Inc., Rockville, Md.) for the 10 adult caribou. The dose for the 11 short yearlings was 4.8 mg of etorphine and 20 mg (100 mg/ml) of xylazine (Rompun, Haver-Lockhart, Shawnee, Kans.). The antagonist, diprenorphine (M50-50, D-M Pharmaceuticals, Inc., Rockville, Md.), was administered intravenously and/or intramuscularly in the same volume (2 mg/ml) as the etorphine.

Caribou not completely immobilized by the drug(s) were pursued on foot and either tackled or captured with a shoulder-held net gun (Mountain Helicopters, Greymouth, New Zealand).

Radio collars were constructed of triple-layered, rubberized machine belting to which a hermetically sealed metal box containing the transmitter and batteries was attached. 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 transmitted in the 150-152 MHz frequency range (Table 1) and contained movement-sensitive mortality switches (Telonics, Inc., Mesa, Ariz.). Normal pulse frequency was approximately 60 beats/min. When movement ceased for approximately 4 hours, the pulse doubled or tripled.

Relocating Radio-collared Caribou

Radio-collared caribou were relocated from fixed-wing aircraft (Cessna 185, Bellanca Scout, Piper Super Cub) equipped with 2

Yagi antennas. An antenna was attached to the wing struts on each side of the plane. The antenna leads were attached to a right/left switch coupled to a radio receiver/scanner (Telonics Co., Mesa, Ariz.). Some or all radio-collared caribou were monitored during 21 aerial surveys at uneven intervals during the year (Table 2). We recorded the general location of each signal heard for caribou not seen. Several collared caribou were sighted from the ground by members of the public and by Department personnel conducting sheep (Ovis dalli) studies and caribou composition counts. For each observation of a radio-collared caribou, we recorded information on group size and composition, habitat, weather conditions, antlers, and location.

When a mortality mode signal was heard, we tried to locate the carcass and determine the cause of death. When unsuccessful, a helicopter was flown to the vicinity at a later date; the carcass was relocated with a hand-held antenna attached to a receiver. We investigated the caribou remains and adjacent area to determine the cause of death. Tracks, scats, hair, and other evidence around the carcass were noted and photographed.

Calving/Productivity/Recruitment

Calving distribution, success, and chronology of the Delta and Yanert Herds were monitored by 5 fixed-wing surveys of radio-collared and associated caribou in late May. No surveys from the ground were conducted.

Herd productivity and recruitment were investigated by measuring natality, estimating mortality rates by monitoring radio-collared caribou, by modeling of the Delta Herd's population dynamics.

Composition surveys of the herd were conducted in May and October. L. Jennings and D. Yount conducted a standard fall composition survey on 8 October 1982 (Table 3) using a helicopter to classify caribou from the air, supplemented by classification from the ground using a 20X-60X spotting scope. In May, we flew several fixed-wing surveys over the calving area to document calving progression and record the ratio of calves to animals older than calves. No distended udder surveys and herd composition counts were conducted in conjunction with the 1982 photo census because of inadequate funding for a helicopter.

Herd Identities

Discreteness of the Delta and Yanert Herds and their relationships to neighboring Macomb, McKinley, and Nelchina Herds were determined by monitoring movements and calving distribution of caribou that were previously radio-collared and tentatively identified as members of the Delta or Yanert Herds. This effort was complemented by continuing studies of the other herds, particularly the Nelchina caribou (Pitcher 1982).

Delta Census

The modified aerial photo-direct count-extrapolation (APDCE) census procedure (Davis et al. 1979) was used during the 1982 Delta Herd census. The principal modification of the APDCE technique developed by Hemming and Glenn (1968) involved adjustments that preclude relying on summer and fall herd composition data to extrapolate the population estimate. A more recent modification is the use of radio-collared caribou to locate aggregations to be photographed or visually counted in APDCE or modified APDCE censuses.

Increasing use of radio-collared caribou to locate aggregations during censuses prompted us to assess validity of this approach by comparing 1982 population estimates derived by 2 independent methods for the Yanert Herd. One estimate was derived by counting only caribou aggregations containing radio-collared individuals and closely associated groups (i.e., groups encountered in the process of locating the radio-collared caribou). A 2nd estimate included caribou located during aerial search of the entire range of the Yanert Herd.

J. Davis and W. Lentsch (pilot, PD&G Aircraft) flew a radio-tracking reconnaissance in a Cessna 185 on 21 May 1982 and found that Delta Herd caribou were sufficiently aggregated for censusing. On 22 May 1982, P. Valkenburg and J. Davis flew a Bellanca Scout to radio-locate aggregations and to visually search the census area. They directed L. Jennings (photographer) and W. Lentsch, who were flying in a Super Cub, to each aggregation. Each aggregation was photographed with a hand-held auto-wind 35mm SLR Nikon camera. After photographing the known groups, the Super Cub assisted in visually searching the census area.

The 35mm color slides were enlarged to 130 mm x 88 mm 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 ensure that discrete segments of a caribou group were counted on each print.

Several factors made counting caribou on the photos difficult. Varying scale and perspective due to the low altitude of the photo aircraft sometimes confounded photo analysis. Because of suboptimal photo quality and because many caribou were lying down and/or were in shrub cover, distinguishing calves from adults was impossible. Many calves were probably not detected on some photos. Errors resulting from incorrect delineation of overlap were insignificant. L. Jennings and E. Crain each independently interpreted the photos.

Yanert Census

The Yanert Herd was censused systematically for the 1st time in 1982. On 23 June 1982, J. Davis (observer) and W. Lentsch

(pilot) used a Super Cub to locate the 7 radio-collared Yanert caribou (Table 1). All caribou associated with the radio-collared caribou were visually counted and classified as calves or older than calves. Immediately following those activities, Davis and Lentsch visually searched 100% of the caribou habitat in the Yanert River watershed. All caribou were again visually counted and classified as calves or older than calves. The visual census was completed on 24 June in a Cessna 185 with L. Jennings and J. Davis as observers and W. Lentsch as pilot. The personnel involved believed that no caribou were missed or counted twice during the 2-day census because of caribou movements in and out of the 2 areas. However, this does not imply a 100% sightability of caribou during the survey.

Population Dynamics

The Delta Herd's population parameters were estimated by modeling using data from censuses and from indices and surveys of recruitment and mortality. The natural mortality rate of caribou older than calves was estimated by modeling and by determining the natural mortality rate of radio-collared caribou (Davis and Valkenburg 1981a, Davis et al. 1982). Natural mortality of calves was estimated through serial herd composition surveys.

The mortality rate of radio-collared caribou was calculated from a procedure empirically derived by W. Gasaway (see Gasaway et al., In press) as follows:

$$\text{percent dying annually} = \frac{a}{b}$$

where

a = number of mortalities tallied among radio-collared animals

b = estimated number of collared animal-years (If the time interval differs from 12 months, units will not be in years.) A collared animal-year is equivalent to 12 collared animal-months; a collared animal-month is equivalent to 1 radio collar functioning on 1 animal for 1 month.

b is estimated as follows:

$$b = \frac{c \cdot d}{e}$$

where

c = mean number of months that collars were transmitting, excluding animals that died

d = total number of radio-collared animals, including animals that died

e = time interval--12 months for annual mortality (The number of months differs from 12 when calculating seasonal rates of mortality.)

This formula underestimates mortality rates when there are both a seasonal peak in mortality and radio transmitter failure during the observation period. However, we know of no better estimator of mortality rates.

RESULTS
Part I - Delta Herd

Radio-collaring

Twenty-one caribou were radio-collared (including 10 whose collars were replaced) during the year. At the end of this reporting period, we had 7 Yanert caribou (all adult females) and 30 Delta caribou (2 adult males, 18 adult females, and 10 yearling females) with functioning radio collars.

Immobilizing Caribou

The 10 caribou from the 1978 cohort which were recollared in February 1982 included 9 females and 1 male. Each caribou was initially drugged with 5 mg of M99 (Table 4). Immobilization time ranged from 13 to 40 min ($\bar{x}$ = 24.4 ± 8.8).

Three of the caribou were never totally immobilized but were caught and physically restrained. Live weights (Table 5) ranged from 107 to 125 kg ($\bar{x}$ = 115 ± 3.6), and a mean dose of 0.044 mg of M99/kg was used for their capture.

Immobilization time ranged from 11 to 40 min ($\bar{x}$ = 21 ± 11.7) for the 11-month-old caribou captured in May 1982. For these 11 caribou, immobilization time was considered as the elapsed time from being darted to becoming recumbent, or being partially immobilized and then physically caught or netted (only 4 were totally immobilized by the drug). Drug dose was 4.8 mg of M99 plus 20 mg Rompun. Live weights ranged from 52 to 70 kg ($\bar{x}$ = 62.5 ± 5.7), and a mean dose of 0.077 mg of M99/kg and 0.32 mg of Rompun was used for their capture.

Larger doses of M99 or a better immobilizing drug are required because induction was too long. Increasing the dose necessitates using a dart with greater volume than 5 cc or acquiring M99 in a greater concentration (>1 mg/ml). Using more concentrated M99 is preferred because the velocity required to stabilize a longer, heavier dart increases the chance of the dart penetrating the skin (Turner 1982). Unfortunately, more concentrated M99 is unavailable in the U.S.A.

Possibilities exist for discovering a more satisfactory drug or drug combination. Fong (1982) immobilized Newfoundland caribou with Immobilon (2.45 mg M99/ml and 10 mg acepromazine maleate/ml) with good results and lowered immobilization time. However, Immobilon is unavailable in the U.S.A. K. Taylor and T. Spraker, ADF&G biologists (pers. commun.) used 4 mg of M99 plus 7.5 mg of

acepromazine (10 mg/ml) to immobilize 8 Mulchatna Herd caribou. They reported shorter immobilization times compared to use of 5.2 mg of M99 without acepromazine.

The desire to improve efficiency in capturing caribou stimulated us to review our caribou capture data from 1979-82 and the relevant literature. Results were presented in a manuscript submitted to the Journal of Wildlife Management (Appendix A): Valkenburg, P., R. D. Boertje, and J. L. Davis. Effects of darting and netting on caribou in Alaska. J. Wildl. Manage. (In press).

Morphometry/Physiology

Body measurements of the 11-month-old (1981 cohort) female short yearlings collared during the year (Table 5) are essentially identical to measurements of the 1978 cohort measured at 7-9 months of age (Davis and Preston 1980:10-11).

Recapturing the 10 caribou in 1982 that were previously captured at 7-9 months of age in 1979 allowed us to measure weight gain and body (i.e., skeletal) growth to 44 months (Table 6). The mean percentage of growth to 44 months achieved by 7-10 months was 89 ± 3.5% for the females (N = 9) and 84 ± 6.7% for the 1 male. In contrast, the mean percentage of total live weight attained at 7-10 months was 54 ± 4.6% for the females and 49% for the male.

No females lost their collars or had them become too tight between collaring at 7 months and recapture at 40-44 months. The mean increase in neck circumference during this period was 4 cm.

Relocating Radio-collared Caribou

Movement and distribution data will be summarized in the job final report.

Calving Chronology and Distribution

No fixed-wing aircraft surveys were flown specifically to monitor calving chronology, but 6 flights flown for other purposes from 16 to 26 May provided some indication of this phenomenon. It appears that peak calf numbers occurred from 23 to 26 May 1982. The natality survey flown 23 May 1982 located 151 adults that were practically all adult females (i.e., 3 years or older). These 151 caribou were accompanied by 108 calves (72 calves/100 adults), and only 8 retained hard antlers. The relatively high calf:adult ratio and the low percentage of adults with hard antlers suggested that calving had peaked.

Peak calf:older than calf, and calf:cow ratios, have occurred on the following dates: 25 May 1979, 19 May 1980, approximately 17 May 1981, and 23-26 May 1982. Bergerud (1975) and Espmark (1980) have demonstrated that gestation period in R. tarandus can

vary by a few days depending upon the nutritional plane of the cow during pregnancy (i.e., poor nutrition = prolonged gestation). The later calving peak in 1982 as opposed to 1980 and 1981 when environmental factors (i.e., weather) were more favorable may indicate nutritional stress during 1982.

Distribution during calving in 1982 showed a displacement from the traditional main calving area(s) (Fig. 2). In contrast to other years when 75-90+% of the adult cows in the herd calved in the main calving area (Davis and Valkenburg 1981a), probably fewer than 5-10% calved in the main area in 1982.

The traditional main calving area was observed from the air on 16, 17, 19, 20, 22, 23, and 26 May 1982. From 16 to 23 May, 100% snow cover persisted on the traditional main calving area. From aerial observation, it appeared that the snow was 15-45 cm deep throughout the area. Main area B (Fig. 2) appeared to have a uniformly deep snow cover that was heavily wind-packed and/or crusted. On 26 May, even after considerable snow melt in other areas, main area B remained snow covered. In contrast, by 26 May, a number of caribou had moved into main area A (Fig. 2) from the north and northwest where they had been from 16 May. By 26 May, snow was rapidly melting in main area A; snow cover ranged from 5-30 cm by visual estimate with a few bare areas present. Snow cover in the traditional calving area during 1982 persisted longer than any other year since annual observations began in the late 1960's.

The Delta caribou were able to utilize snow-free tussock tundra habitat (similar in many respects to that of the traditional main area[s]) for calving by remaining in an area about 16 km northwest of the traditional main area (Fig. 2). Most of the area used for calving in 1982 was burned by wildfire in June 1979. We are unaware of other instances where major calving by barren-ground caribou has occurred in an area recently burned by wildfire.

Composition/Production

No dramatic departure from expected herd composition values occurred in 1982 (Table 3). However, the fall calf:cow ratio was lower than any year since 1976 (when wolf control was initiated).

Past experience has shown that a single fall sex and age composition survey can often produce a biased estimate because of differential segregation within segments of the herd (Davis et al. 1979, Doerr 1979). However, data from several indices suggested that calving success was lower in 1982 than from 1976 through 1981. These indices include the following: (1) a reduced calf:100 older-than-calf ratio obtained from fixed-wing aircraft surveys during calving, (2) natality of the radio-collared 1978 cohort females was lower in 1982 than 1981, and (3) natality of radio-collared 2-year-old caribou was much lower in 1982 than in 1980 (no 1981 data available).

We classified 381 caribou from a Bellanca Scout on 23 May 1982 including 151 adults (predominately adult females, but possibly some males), 108 calves, 122 subadults (predominantly 24-month-old caribou), and 1 adult male. Calculated ratios were 72 calves:100 adults and 40 calves:100 older-than-calves. The 72 calves:100 adults figure approximates a calf:adult cow ratio because few males were present. If we assume peak calf:cow ratios occurred on 23 May, it appears that initial calf production and survival were comparable to preceding years (Fig. 3). However, when one compares the ratio of 40 calves:100 older-than-calves in 1982 to ratios from the 3 preceding years (61-63:100), the data suggest substantially reduced calf production in 1982.

It could be argued that the calf:100 older-than-calves ratio might have increased after 23 May. This is improbable, however, because monitoring of radio-collared cows indicated a calving peak prior to 26 May, and on 23 May only 8 of 273 caribou older than calves retained hard antlers.

Available data clearly indicate that natality of 2-year-old cows was greatly reduced between 1980 and 1982 (no 1981 data available). In 1980, 6 of 9 radio-collared 2-year-old cows calved compared to 1 of 8 in 1982.

Reproductive history of the radio-collared 1978 cohort has been monitored since 1979 (Table 7), but we did not reach a straight foward conclusion by comparing the 1981 and 1982 natality rates of these radio-collared caribou, partly because of the small sample size.

In 1981 when these radio-collared caribou were 3 years old, 8 of 11 cows calved compared to 5 of 8 in 1982 which is not significantly different when tested with an X^2 test ($P = 0.05$, df = 1). However, concluding there was no significant difference in natality between the 2 years is confounded because the literature suggests that female caribou do not attain maximum reproductive age until 48 months (Bergerud 1978, 1980). Capture for recollaring in February 1982 may have reduced natality and/or calf survival, but Valkenburg et al. (In press) concluded that capture as close as 1 month preparturition did not affect natality or calf survival.

There has been some conjecture and limited evidence from reindeer (*R. tarandus*) in Norway that early breeding (i.e., producing a calf at 24 months) might cause alternate-year production (R. White, pers. commun.). However, reproductive histories of the 1978 cohort (Table 8) suggest that early breeding enhances subsequent annual natality. Of the 6 1978 cohort cows that calved at 24 months, 5 produced a calf at 36 months, and 3 of 4 produced a calf again at 48 months.

In conclusion, it appears that the fall calf:cow ratio was (lower in 1982 than could be accounted for by the changing herd composition) primarily because of a significantly reduced natality rate among subadult females (2 years old and possibly 3 years old) in a population containing large cohorts of those age classes. It is also possible that calf survival to fall was lowered.

Factors contributing to the reduced natality and calf survival were not conclusively identified. Possible causes included severe winter conditions, lack of high-quality vegetation in the fall, displacement from traditional calving areas, overstocking of range, or increased predation.

Winter conditions in 1982 were subjectively judged to be more harsh than any winter since 1974 because of generally deeper snow accumulation and scattered severe ice crusting. However, there is no evidence that any caribou died of malnutrition, nor did we subjectively determine that caribou were in poorer physical condition than in recent past years. Further, short yearlings in spring 1982 were comparable in body size and weight to those measured in 1980. The few calf birth weights available showed no discernible difference between years (Table 8).

Hard frosts in August 1982 killed willow (Salix spp.) leaves and other vegetative and floral parts of several forage species perhaps a month earlier than average and probably reduced forage quality.

A major displacement from the traditional main calving area occurred during calving. A 100% snow cover of 15-45 cm depth appeared to be the reason that the traditional calving area was not used. However, it does not appear that displaced calving was the cause of lowered calf production in 1982.

Monitoring of the radio-collared 2-year-old females suggested that 7 of the 8 never developed distended udders (Table 9), so they presumably did not carry a calf to term (Bergerud 1964). Therefore, it appears that reduced natality contributed to the herd's poorer reproductive success in 1982. Therefore, displacement from the traditional "core" calving areas could not entirely account for the reduced reproduction.

Another possible explanation is that the decreased reproduction in 1982 is a density-dependent response. Size of the Delta Herd has nearly tripled since 1976 (from <2,400 to 6,500-7,500). Density has increased from <0.25 caribou/km^2 in 1976 to 0.67-0.78 caribou/km^2 in 1982. However, many other herds have attained higher densities before reproduction was lowered (Klein 1968; Bergerud 1978, 1980).

Although increased predation between calving and fall could have contributed to the reduced calf:cow ratio in 1982, we have no evidence to support this possibility.

Delta Census

From the 1982 photo census, L. Jennings counted 5,290 caribou on the 35mm photos of the postcalving aggregations, and E. Crain counted 5,352. The mean of the 2 counts, 5,321, was considered the best estimate of the number of caribou identifiable from the photos. In addition, 790 caribou were visually counted during the census, including both small groups closely associated to the large aggregations and other groups scattered throughout the portion of the herd's range that was intensively searched.

The 6,111 caribou counted during the census constitute the known minimum population. We believe that the population was considerably larger. L. Jennings and E. Crain agreed that calves were often difficult to observe on the photos, and they suspect that many were not counted. In addition, judging from past experience, we believe some caribou were present in areas not searched during the census. Although we did not rigorously classify the caribou located during the census by sex and age, our subjective impressions were that a considerable number of adult males were not present. From the above, we believe that 6,500-7,500 is the best estimate of the Delta Herd's population size in June 1982 (this excludes the 700-900 caribou in the Yanert Herd).

Natural Mortality

Throughout the year, we monitored 19 females and 2 males older than calves in the Delta Herd and 7 adult females in the Yanert Herd. In addition, on 3 May 1982, we radio-collared 11 short yearling females (i.e., 11.5 months old) in the Delta Herd.

During this reporting period, no radio-collared caribou died from natural causes. The 2 deaths of radio-collared caribou (Accession Nos. 101,977 and 102,547) during the reporting period were capture-related. Caribou 101,977 was recollared 26 February 1982 and was later found dead and scavenged near the collaring site. Caribou 102,547 received a large dose of Rompun during immobilization and was still recumbent 4 hours after handling. She appeared likely to recover, but when relocated 2 days later, she had been killed by a grizzly bear (Ursus arctos) 400 m from where last seen. We judged that she was predisposed to predation from aftereffects of handling.

Natural mortality rates from past years are summarized briefly as follows (from Davis et al. 1982):

> "Although the number of radio-collared caribou we have monitored in the Delta Herd has been relatively small (25 in 1979, 15 in 1980, 32 in 1981), a consistent

mortality pattern has emerged. In 1979, 2 of 14 males and none of 11 females died from natural causes; both mortalities were apparently from wolf (Canis lupus) predation. In 1980, 1 of 4 males and none of 11 females died from natural causes; a grizzly bear (Ursus arctos) apparently killed the male. In 1981, 1 of 5 males and none of 30 females died from natural causes (radio failures caused only 32 of the 35 to be monitored); the male was probably killed by wolves about 1 month after it was collared in February 1981, but we inspected the carcass too late to be certain."

From 1979 through 1982, we monitored radio-collared females in the Delta and Yanert Herds for approximately 85 collared-animal-years without any deaths from natural causes. During the same 4 years, 4 males died from natural causes during less than 25 collared-animal-years of monitoring. Though our sample size has been relatively small, we believe 2 major findings are valid: (1) overall natural mortality in the herd has been quite low, and (2) natural mortality of males has been considerably greater than for females. Davis and Valkenburg (1981b) reported similar findings in Alaska's Western Arctic Caribou Herd. Through 1981, they had calculated a natural mortality rate of 13% for male radio-collared caribou during 265 collared-animal-months, compared to a rate of 4% for females during 580 collared-animal-months. Bergerud (1971) reported similar results from Newfoundland.

Predation:

Detailed study of caribou/predator relationships is currently beyond the scope of this study. However, complementary studies on grizzly bears (Reynolds 1982) and wolves (annual Alaska Department Fish and Game survey and inventory activities) do supply some information on the caribou/predator relationship.

Available data on wolf/Delta caribou relationships were reviewed and synthesized during this study period and presented at the 3rd International Reindeer/Caribou Symposium, Saariselka, Finland 23-26 August 1982. The manuscript appears as Appendix B; the citation is as follows: Davis, J. L., P. Valkenburg, and R. Boertje. Demography and limiting factors of Alaska's Delta Caribou Herd, 1954-1981. Acta. Zool. Fennica. In Press.

This synthesis of information on wolves and Delta caribou was integrated into a major analysis of the large mammal, predator-prey system in Game Management Subunit 20A (Gasaway et al., In press).

Harvest

Since 1973, harvest of the Delta Herd has not significantly influenced the herd's population dynamics (Tables 10, 11).

Population Dynamics

The Delta Herd's size has continuously grown from 1973 through 1982 (Table 12).

However, no censuses were conducted from 1974 through 1978, and Davis and Preston (1980) speculated that the population probably declined from 1973 through 1975 and began increasing in 1976 (based on available composition and productivity data).

Calculating exponential growth rates (r) can be instructive in understanding population trends and the factors affecting population dynamics (Bergerud 1978), although there are limitations (Martel and Russell, In press). Bergerud (1978) has calculated that the maximum r value for North American caribou is $r = 0.30$ (=35% annual increase). Thus, with no mortality (other than animals dying of old age) and maximal reproductive success, a caribou herd could grow at $r = 0.30$.

If the Delta Herd contained 2,200-2,400 caribou in 1973 and 6,500-7,500 in 1982, then the minimum (i.e., 2,400-6,500) and maximum (i.e., 2,200-7,500) exponential growth rates would have been $r = 0.11$ (12% annually) and $r = 0.14$ (15% annually), respectively. If, however, the herd did not begin to increase until 1976 as speculated by Davis and Preston (1980), the comparable minimum and maximum exponential growth rates to 1982 would have been $r = 0.17$ (19% annually) and $r = 0.20$ (22% annually), respectively.

The calculated r values are plausible when considered in the context of estimates of recruitment and mortality experienced by the herd since 1976. Mean calf percentage of the herd in fall is our best available index to recruitment and was $\bar{x} = 21.9 \pm 5.34$ for 1976 through 1982. To calculate the % increase (from the preceding year) that 21.9% calves in fall represents, a ratio conversion can be used as follows:

$$\frac{21.9}{(100-21.9)} = \frac{x}{100}, \text{ therefore, } x = 28(\%).$$

Thus, a mean of 21.9% calves present in fall represents a mean calf increment from the preceding year of 28%. Davis and Preston (1980) estimated calf survival from October 1978 to May 1979 to be 80-92%, and there is no indication it has changed (Davis and Valkenburg 1981a, Davis et al. 1982). The potential 28% increase from calves present in fall can be adjusted to 22.4-25.8% to allow for mortality to yearling age. This then suggests that mortality of caribou yearlings and older should have ranged from a low of 0 to 2.8% up to 4.4 to 7.8% from 1976 through 1982. These results are consistent with the results discussed in the Natural Mortality and Harvest sections of this report. Although the data set presented above is just 1 of several credible sets that could be calculated, it is heartening that the above

scenario seems to represent on-the-ground happenings. We acknowledge that less heartening, but credible, scenarios could be developed by combining other values lying within broad confidence intervals.

RESULTS
Part II - Yanert Herd

Herd Identity/Productivity

Davis et al. (1982) confirmed the existence of the Yanert Caribou Herd. The herd numbered at least 500-600 in 1981 and exhibited all characteristics required for herd designation. Continued study has not contradicted these conclusions, and additional evidence suggests that the Yanert Herd is sufficiently different from the Delta Herd to warrant separate management.

Several members of the public reported that the acute lack of calf recruitment from 1971 through 1976 experienced by the Delta Herd did not occur in the Yanert Herd. No data were collected during that period for the Yanert caribou, but differences between calving behavior and calving success during 1981 and 1982 suggest that the earlier reported differences were possible. In both 1981 and 1982, unlike the Delta Herd, the Yanert caribou were widely dispersed during calving. All radio-collared Yanert cows calved at locations above 5,000 ft (1,500 m) and were usually on very high rocky ridges above nearby Dall sheep. This behavior is dissimilar to that reported for most barren-ground caribou herds. The Yanert Herd's calving behavior may well be an adaptive strategy to escape predators, primarily wolves and grizzly bear. In contrast, the Delta caribou typically are gregarious (i.e., clumped) during calving (albeit during parturition they are normally solitary) and apparently exhibit clumping behavior as an apparent strategy to escape predation (Cumming 1975).

Yanert Census

The census based on relocating radio-collared caribou and counting associated groups resulted in locating only 244 caribou, including 57-58 (24%) calves (Fig. 4). This included 6 groups which contained the 7 radio collars. Group size ranged from 4 to 103 ($\bar{x}$ = 41 ± 41). Search time and counting of groups required approximately 2 hours in a Super Cub (excluding ferry time).

In contrast, the visual search required 4.5 hours in a Super Cub and 2 hours in a Cessna 185 (excluding ferry time). However, the visual search located 680 caribou including 185 (27%) calves (Fig. 5). Although 2.8 times more caribou were located in the visual census, the calf percentage was similar. The visual search located 38 groups ($\bar{x}$ = 18 ± 28) compared to the 6 groups containing radio-collared caribou. Relative to the smallest group (4 in group) containing a radio-collared caribou, 14 groups in the visual census were smaller and 21 were larger.

The above comparison suggests that a census based on locating only 7 radio collars is inadequate. However, our comparison required that we not visually search the area adjacent to aggregations containing a transmitter. We recorded only aggregations sighted while going to or from a transmitter. This differs from conventional use of transmitters for censusing when some undefined area adjacent to radio-located aggregations is visually searched.

Groups 22-38 (Fig. 5) which contained 63 caribou (9%) were widely separated from groups containing radio collars and would be missed in most "radio-relocation censuses." It is impossible to ascertain which remaining groups (i.e., groups 1-21) without a transmitter would be sighted during a conventional visual search adjacent to the groups containing radios. A straightforward comparison of the 2 census procedures is further complicated because sightability of caribou during the visual census was unknown.

During the visual census, we attempted to look at all observed groups closely enough to observe any collared caribou present. We visually located all radio-collared caribou except BKY-29, which had been located several hours earlier, during the telemetry census, with 3 other caribou. It is possible that BKY-29 was in a tightly coalesced group and its collar not seen. Aggregations are very dynamic at this time of year with groups often coalescing and dispersing several times daily.

In summary, 64% of the caribou located in an intensive visual census were not located during a census based on locating 7 radio-collared adult females. This is a worst-case scenario. A best-case scenario would have missed only 9%. In this experiment, there was approximately 1 radio-collared caribou/100 total caribou or 1 collar/5.4 groups.

For small, relatively sedentary caribou herds inhabiting mountainous terrain, summer may not be the optimum time for censusing. Typically, these herds aggregate less during postcalving than the larger migratory herds, and they are often most aggregated during rutting time. Rutting aggregations can be efficiently located after fresh snow, and radio-collared animals further help in finding groups.

During a 2-hour survey on 11 November 1981, R. Boertje and P. Valkenburg counted 525 caribou while locating the 7 radio-collared Yanert caribou. The herd may have increased from 1981 to 1982 and the effort in November 1981 was minimal, so censusing during the rut may be most efficient. One possible complicating factor is that during the rut the degree of mixing between the Yanert and Delta Herds is unknown.

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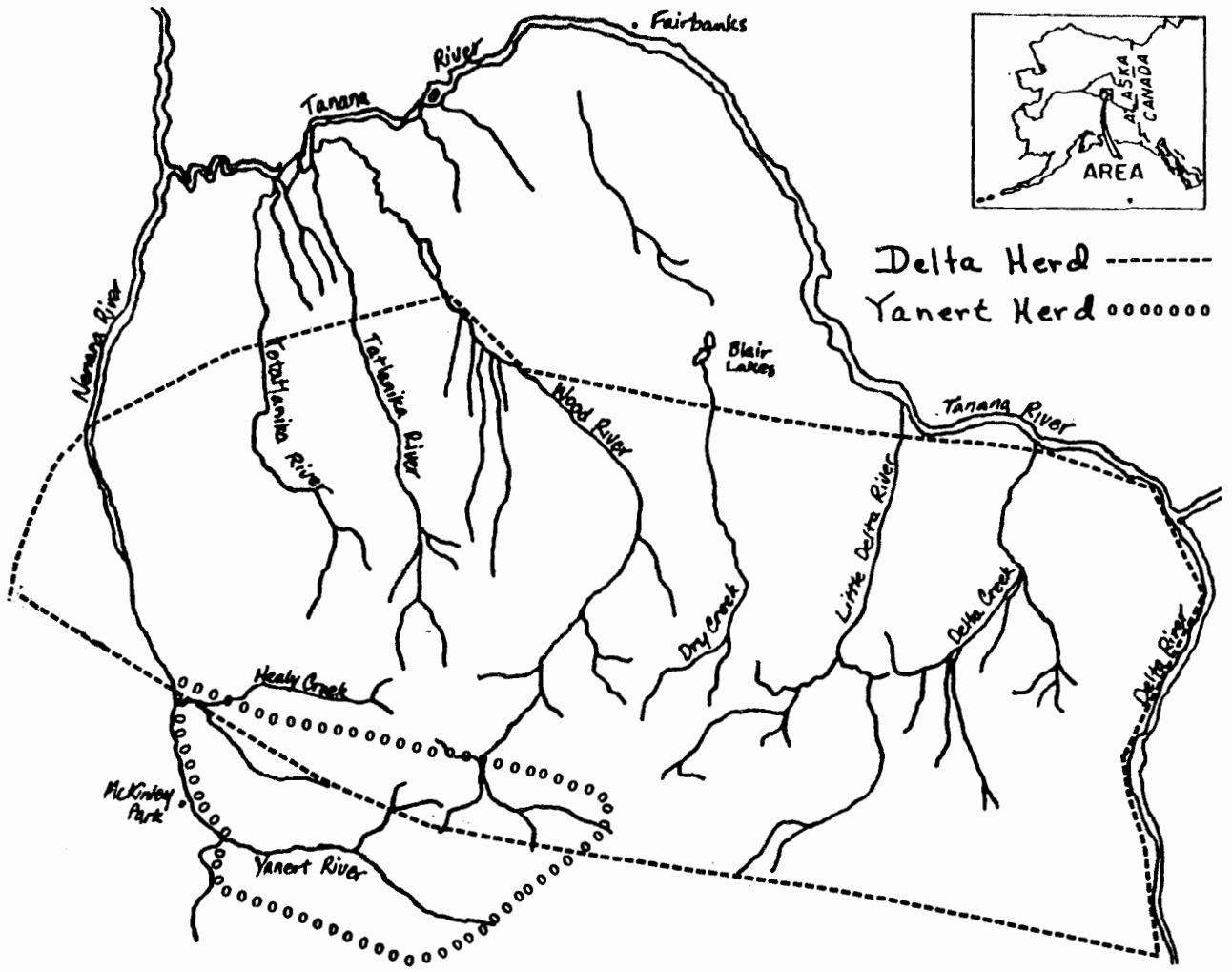


Fig. 1. Ranges of the Delta and Yanert Caribou Herds, 1981-82.

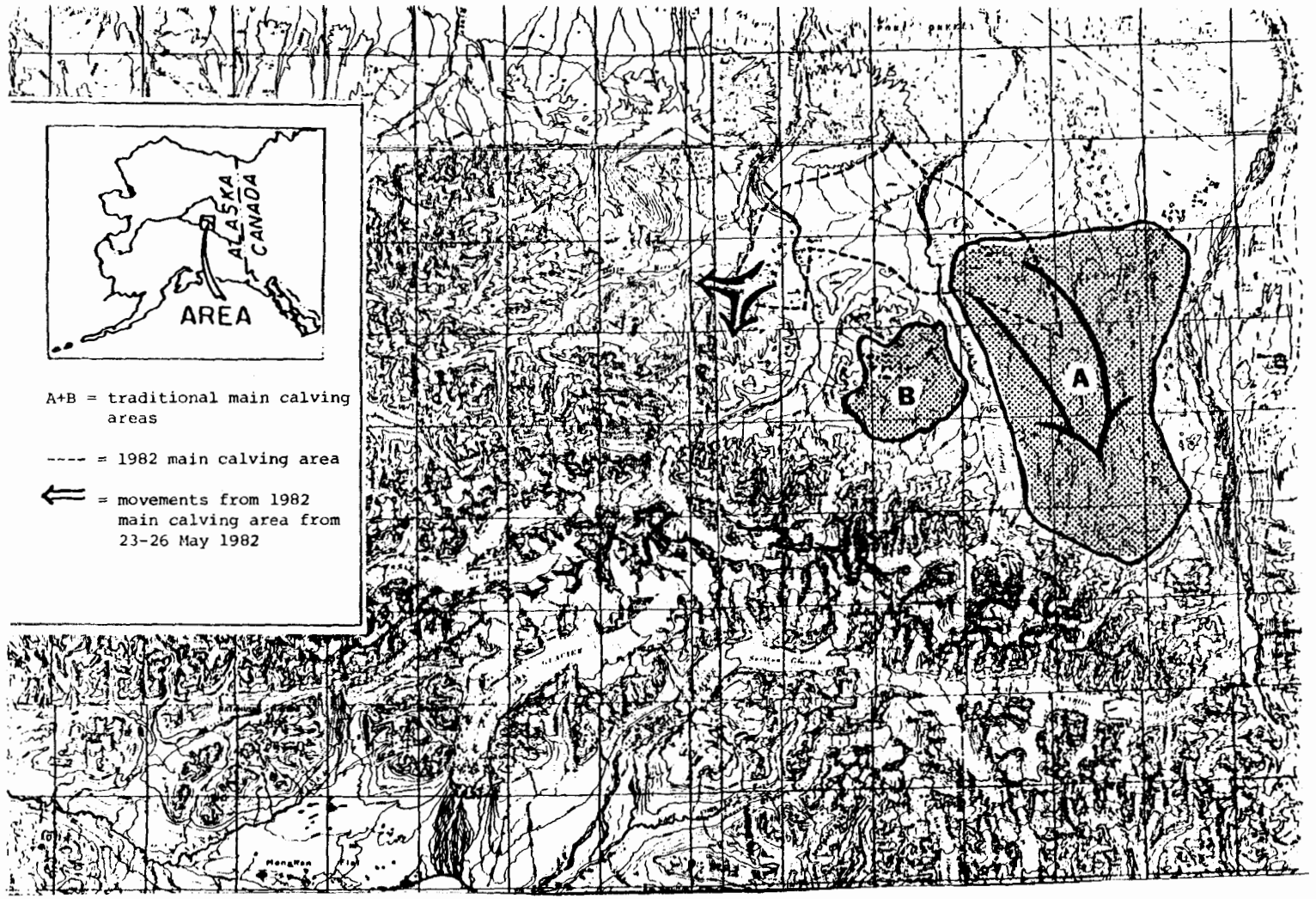


Fig. 2. Location of and movement from the 1982 Delta Caribou Herd calving area in relation to traditional calving areas.

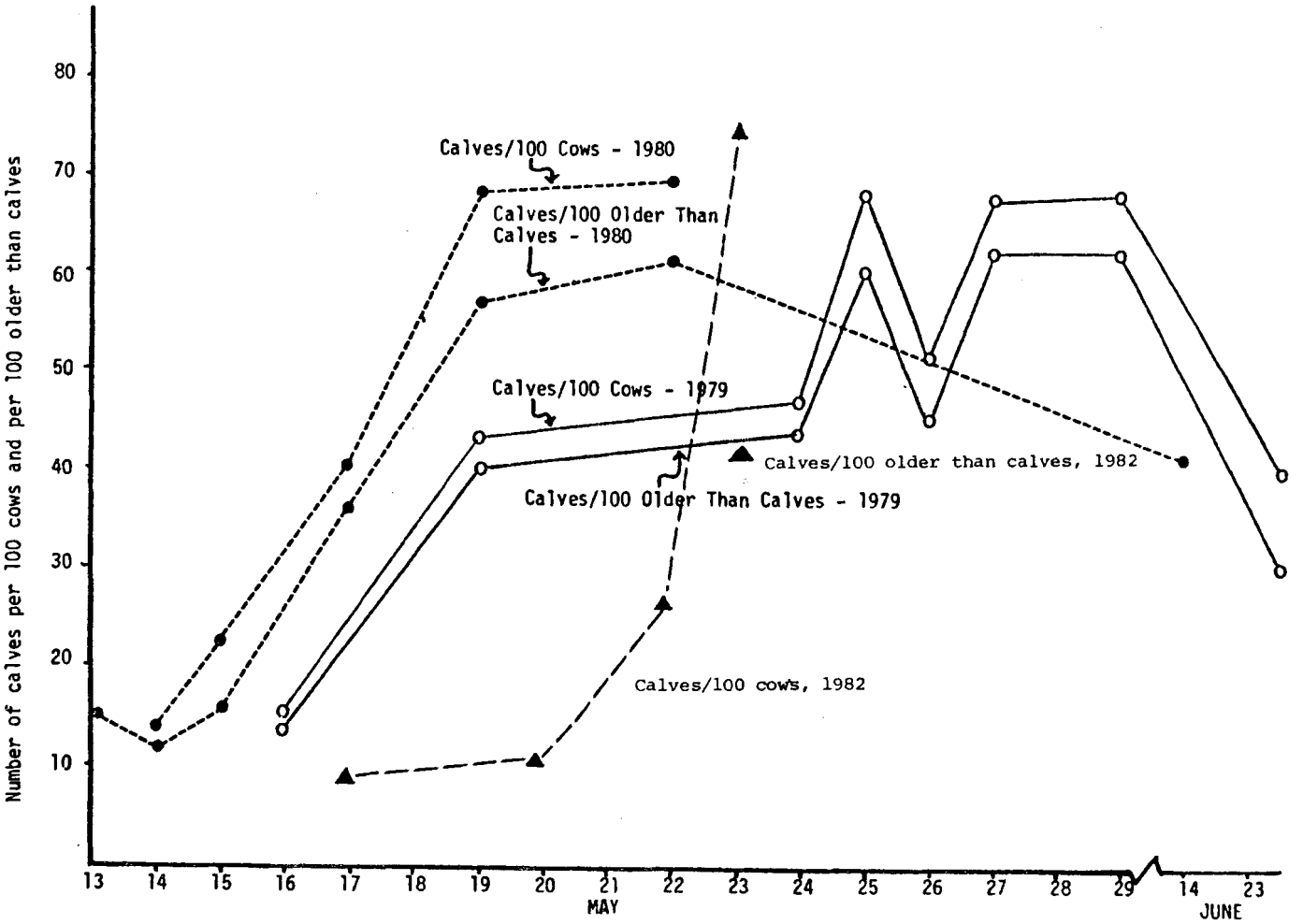
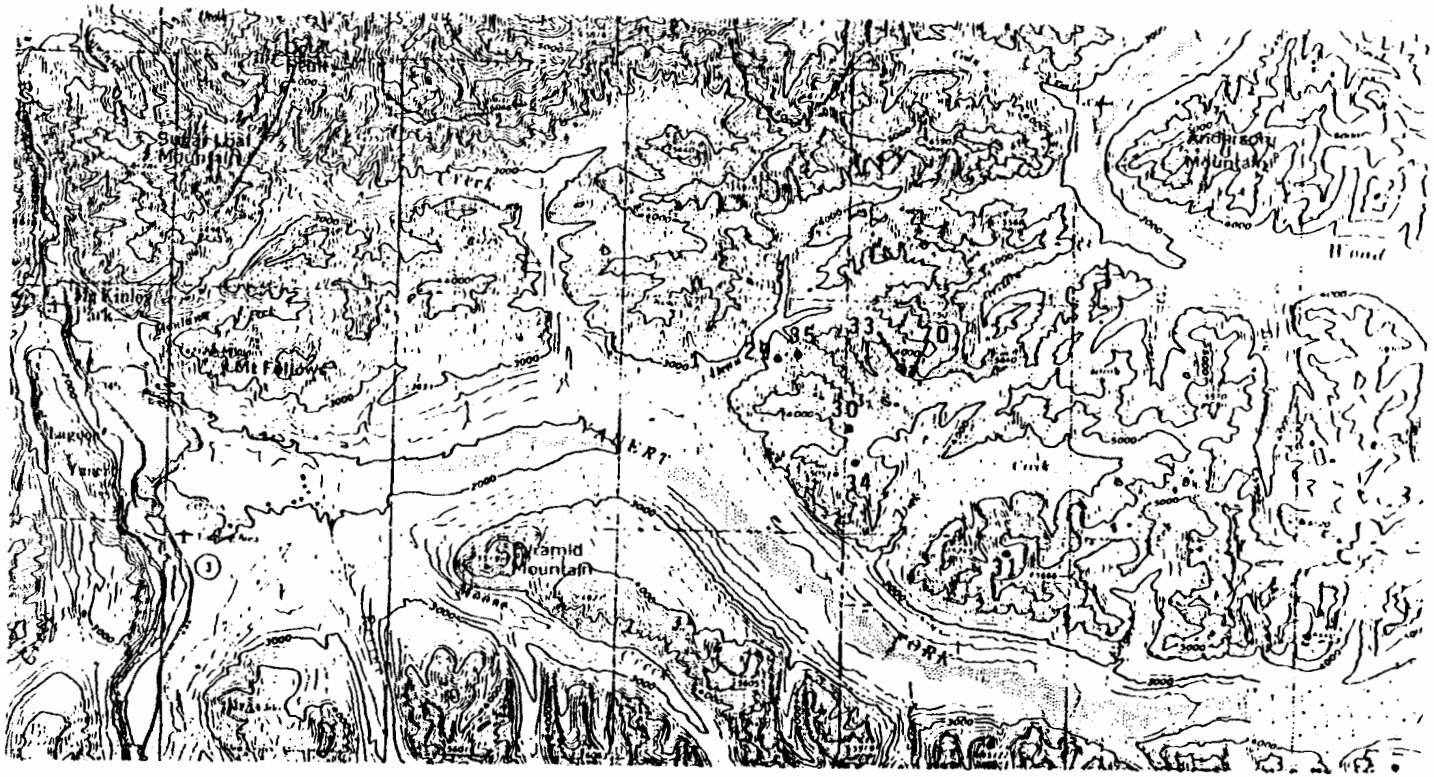


Fig. 3. Calving, chronology, and comparison of calves/100 calves and calves/100 caribou-older-than-calves ratios in the Delta Caribou herd, 1979, 1980, and 1982.



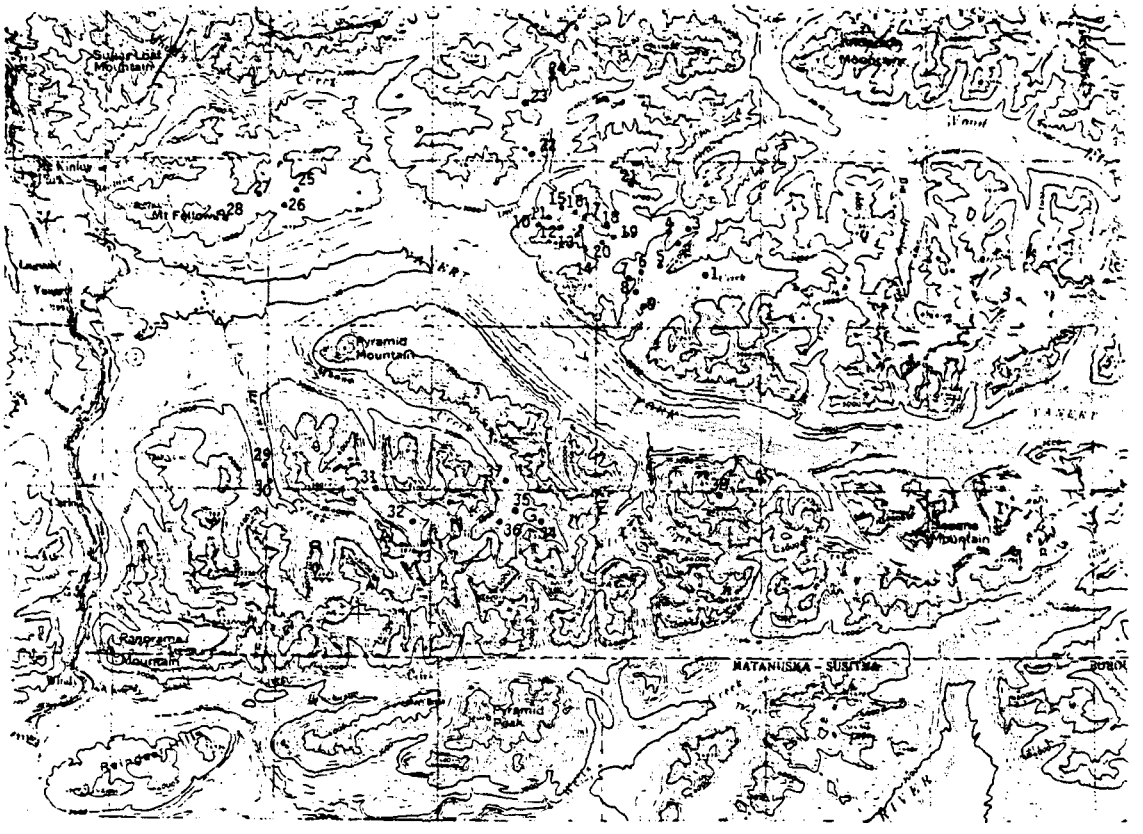
Radio Collar #	Group Size and Composition
29	4
30	64 (including 20 calves)
31	5 (including 2 yearlings)
33,70	60 (including 17 calves)
34	103 (including 18-19 calves)
35	8 (including 2 calves)

Total 244 (including 57-58 calves)

Group Size $\bar{x}$ = 40.7

Std. dev. = 41.2

Fig. 4. Distribution of the 7 Yanert Herd radio-collared caribou from 09:00-11:00, 23 June 1982, and the numbers and composition of caribou associated with the radio-collared caribou.



Group #	Total Number & Composition	Group #	Total Number & Composition
1	11 (5 calves)	20	4 (1 calf)
2	25 (10 calves)	21	40 (11 calves)
3	98 (32 calves)	22	3 (0 calves)
4	91 (28 calves)*	23	5 (1 calf)
5	50 (15 calves)	24	8 (1 calf)
6	31 (9 calves)	25	4 (3 bulls)
7	29 (8 calves)	26	8 (3 bulls, 5 sub-adults)
8	88 (21 calves)**	27	4 (2 bulls, 2 sub-adults)
9	3 (0 calves)	28	7 (3 bulls, 4 sub-adults)
10	4 "	29	3 (0 calves)
11	2 "	30	4 "
12	2 "	31	1 (1 bull)
13	2 "	32	1 "
14	4 (1 calf)***	33	3 (0 calves)
15	16 (4 calves)	34	1 (1 bull)
16	2 (0 calves)	35	2 (0 calves)
17	81 (28 calves)	36	4 "
18	33 (10 calves)	37	1 (1 bull)
19	1 (0 calves)	38	4 (2 bulls)

*...Radio collar #'s 70 & 33

**...Radio collar # 34

***...collared cow with calf

Total 680 (185 calves)
$\bar{x}$ group size = 17.9
Std. dev. = 27.7

Fig. 5. Distribution, size, and composition of post-calving aggregations during the census of the Yanert Caribou Herd, 11:00-15:00, 23 June 1982 and 24 June 1982.

Table 1. Permanent accession numbers and other pertinent information for radio-collared Delta and Yanert Herd caribou, 1979-82.

Accession No.[a]	Collar No.[b]	Frequency (MHz)	Year of birth	Sex	Date collared (recollared)	Herd	Comments
101,972	YR-57 BKY-36	151.960 150.020	1978	F	1/4/79 (2/11/82)	Delta	
101,973	YR-53 BKY-28	151.955 150.030	1978	F	1/4/79 (2/11/82)	Delta	
101,974	YR-88 BKY-37	151.940 150.180	1978	F	1/8/79 (2/11/82)	Delta	
101,976	YR-17	151.905	1978	M	1/9/79	Delta	Missing 4/79
101,977	YR-78 BKY-49	151.935 150.330	1978	F	1/9/79 (2/26/82	Delta	
101,979	YR-18	151.980	1978	M	1/4/79	Delta	Shot 11/80
101,980	BKY-58	151.880	1978	M	1/10/79	Delta	Missing 2/79
101,981	YR-59 BKY-20	151.890 150.050	1978	F	1/10/79 (5/30/81)	Delta	Died from recapture
101,982	YR-52 BKY-78	151.915 150.170	1978	F	1/10/79 (2/11/82)	Delta	
101,983	BKY-59	151.895	1978	M	1/10/79	Delta	Killed by grizzly 8/80
101,984	YR-54 BKY-47	151.990 150.300	1978	F	1/11/79 (2/26/82)	Delta	
101,985	YR-58 BKY-79	151.985 150.110	1978	M	3/30/79 (2/11/82	Delta	
101,986	BKY-69	151.995	1978	M	1/11/79	Delta	Missing 2/79
101,987	YR-19	151.975	1978	M	1/8/79	Delta	Shed collar
101,988	YR-56 BKY-25	151.885 150.000	1978	F	1/4/79 (2/26/82)	Delta	
101,991	BKY-79	151.930	1978	M	1/10/79	Delta	Radio failed 9/80
101,992	BY-63	151.910	1978	M	1/11/79	Delta	Radio failed

Table 1. Continued.

Accession No.[a]	Collar No.[b]	Frequency (MHz)	Year of birth	Sex	Date collared (recollared)	Herd	Comments
101,993	YR-76 BKY-26	151.875 150.020	1978	F	3/30/79 (2/26/82)	Delta	
101,994	YR-79	151.945	1978	F	3/30/79	Delta	Radio failed
101,995	BKY-67	151.965	1978	M	3/30/79	Delta	Missing 7/17/79
101,997	YR-77 BKY-20	151.970 150.050	1978	F	3/30/79 (2/26/82)	Delta	Alive, but collar on mortality pulse
102,341	BKY-15	150.120	1980	F	2/8/81	Delta	
102,342	BKY-86	150.110	1979(?)	M	2/8/81	Delta	Killed 2/81 (wolves?)
102,343	BKY-13	150.150	1980	F	2/8/81	Delta	
102,348	BKY-14	150.100	1980	F	2/27/81	Delta	
102,349	BKY-12	151.950	1979(?)	F	2/27/81	Delta	
102,350	BKY-22	150.130	1978(?)	F	2/27/81	Delta	
102,360	BKY-16	150.090	1980	F	3/22/81	Delta	
102,361	BKY-21	150.010	1980	M	3/22/81	Delta	
102,362	BKY-18	150.060	pre-1978	F	3/22/81	Delta	
102,363	BKY-29	150.070	pre-1979	F	4/18/81	Yanert	
102,364	BKY-30	150.080	pre-1980	F	4/18/81	Yanert	
102,365	BKY-31	150.140	pre-1979	F	4/18/81	Yanert	
102,366	BKY-32	150.150	pre-1979	F	4/18/81	Yanert	Missing since 4/18/81
102,367	BKY-33	150.190	pre-1980	F	4/18/81	Yanert	
102,368	BKY-34	150.200	pre-1979	F	4/18/81	Yanert	
102,369	BKY-35	150.230	pre-1979	F	4/18/81	Yanert	
102,370	BKY-70	150.240	pre-1979	F	4/18/81	Yanert	

Table 1. Continued.

Accession No.[a]	Collar No.[b]	Frequency (MHz)	Year of birth	Sex	Date collared (recollared)	Herd	Comments
102,430	BKY-19	150.210	1980	F	5/30/81	Delta	
102,431	BKY-23	150.160	1980	F	5/30/81	Delta	
102,432	BKY-27	150.040	1980	F	5/30/81	Delta	
102,546	BKY-9	151.860	1981	F	5/3/82	Delta	
102,547	BKY-10	151.930	1981	F	5/3/82	Delta	Killed by grizzly ?
102,548	BKY-7	151.920	1981	F	5/3/82	Delta	
102,549	BKY-6	151.970	1981	F	5/3/82	Delta	
102,560	BKY-1	151.900	1981	F	5/3/82	Delta	
102,561	BKY-4	151.880	1981	F	5/3/82	Delta	
102,562	BKY-2	151.940	1981	F	5/3/82	Delta	
102,563	BKY-5	151.890	1981	F	5/3/82	Delta	
102,564	BKY-3	151.910	1981	F	5/3/82	Delta	
102,565	BKY-0	151.950	1981	F	5/3/82	Delta	
102,566	BKY-8	151.870	1981	F	5/3/82	Delta	

Note: Underlined collar numbers are those that were functioning during the period covered by this report.

[a] Each caribou was assigned an accession number which remained unchanged even when recollared.

[b] YR = yellow numbers on red collar; BKY = black numbers on yellow collar; BY = blue numbers on yellow collar.

Table 2. Dates of flights from which radio-collared Delta Herd caribou were observed, 1 July 1981-10 October 1982.

Date	Aircraft	Remarks
8-10 Aug 1981	Scout	
30 Sep 1981	Scout	
2 Oct 1981	Bell 206B Helicopter	Fall composition survey
29 Oct 1981	C-185	
26 Jan 1982	Scout	
4 Feb 1982	Scout	
11 Feb 1982	Scout & Bell 206B helicopter	Tagging
26 Feb 1982	Scout & Bell 206B helicopter	Tagging
3 May 1982	Super Cub & Bell 206B helicopter	Tagging
8 May 1982	Scout	
17 May 1982	Scout	
19 May 1982	Scout	
20 May 1982	Scout	
22 May 1982	Scout	
26 May 1982	Super Cub	
18 Jun 1982	Scout	
21 Jun 1982	C-185	
22 Jun 1982	Scout, Super Cub	Census
23 Jun 1982	Super Cub	
24 Jun 1982	C-185	
8 Oct 1982	Bell 206B helicopter	Fall composition survey

Table 3. Sex and age composition of Alaska's Delta Caribou Herd, 1969-82.

Date	Bulls/ 100 cows	Yrlg/ 100 cows	Calves/ 100 cows	Yrlg % in herd	No. yrlg	Calf % in herd	No. calves	Cow % in herd	No. cows	Bull % in herd	No. bulls	Sample size
10/13-15/69	40	21	28	11.0	85	15	116	53	410	21	166	777
10/21-23/70	77	23	34	9.3	88	14	129	42	383	33	296	896
10/29-11/1/71	29	11	16	6.8	78	9	109	64	738	18	214	1,139
10/27-31/72	32	6	10	3.9	46	7	85	67	795	21	259	1,185
10/23-24/73	28	4	10	2.8	29	7	76	70	735	20	210	1,050
10/23-25/74	27	2	2	1.4	16	1	17	76	868	21	240	1,141
6/11-12/75	3	<1	12	0.3	3	11	108	86	839	2	26	976
Fall 1975	No counts conducted											
6/3/76	1	--	41	--	--	28	395	70	955	1	15	1,365
6/6-22/76	1	--	55	--	--	35	390	63	699	0	10	1,099
10/29-11/1/76	38	1	45	0.5	5	24	258	54	572	20	220	1,055
6/16-19/77	9	12	34	7.8	95	22	269	64	784	6	76	1,224
10/26-11/2/77	32	6	42	3.2	44	23	319	55	756	18	246	1,365
6/13-14/78	12	8	23	5.5	52	16	157	69	661	8	81	951
10/26/78	75	10	39	4.5	33	17	126	44	324	33	242	725
6/23/79	11	18	44	10.3	76	25	189	57	424	6	49	738
12/7/79	39	--	65	--	--	32	115	49	177	19	69	361
6/14/80	18	--	43	--	--	26	324	61	748	11	137	1,209
10/15-11/3/80	85	--	49	--	--	21	288	42	585	36	496	1,369
6/17/81	12	16	33	9.0	87	21	182	62	543	8	68	880
10/2/81	59	--	41	--	--	20	319	50	776	29	458	1,553
10/8/82	54	--	29	--	--	16	215	55	736	30	398	1,349

Table 4. Drug dosages and induction times for Delta caribou immobilized during 1982.

Accession No.	Collar No.[a]	Sex	Date immobilized	Drug: mg M99 (mg Rompun)	Induction time (min)	Live weight: kg	Live weight: lb	Comments
101,972	BKY-36	F	2/11/82	5	13	107.5	237	
101,973	BKY-28	F	2/11/82	5	40	116.6	257	Died after handling
101,974	BKY-37	F	2/11/82	5	33	113.4	250	
101,977	BKY-49	F	2/11/82	5	30	119.3	263	
101,982	BKY-78	F	2/11/82	5	19	114.3	252	Physically captured
101,984	BKY-47	F	2/26/82	5	<28	113.4	250	
101,985	BKY-79	M	2/11/82	5	<22	125.6	277	
101,988	BKY-25	F	2/26/82	5	17	117.9	260	
101,993	BKY-26	F	2/26/82	5	18	114.8	253	Physically captured
101,997	BKY-20	F	2/26/82	5 + 5	>60	unk.	unk.	Darted twice, physically captured
102,546	BKY-9	F	5/3/82	4.8 + (20)	4	56.7	125	
102,547	BKY-10	F	5/3/82	4.8 + (20)[b] 1.1 + (40)[b]	>35	68.0	150	Netted, 2nd injection by hand (eaten by grizzly bear by 5/6/82)
102,548	BKY-7	F	5/3/82	4.8 + (20)[b] 0.6 + (20)[b]	>35	62.6	138	Netted
102,549	BKY-6	F	5/3/82	4.8 + (20)	11	52.2	115	
102,560	BKY-1	F	5/3/82	4.8 + (20)	11	70.3	155	
102,561	BKY-4	F	5/3/82	4.8 + (20)	>20	66.2	146	Physically captured
102,562	BKY-2	F	5/3/82	4.8 + (20)	13	68.0	150	
102,563	BKY-5	F	5/3/82	4.8 + (20)	>30	63.5	140	Physically captured
102,564	BKY-3	F	5/3/82	4.8 + (20)	>120	56.7	125	Possibly darted twice
102,565	BKY-0	F	5/3/82	4.8 + (20)	>30	63.5	140	
102,566	BKY-8	F	5/3/82	4.8 + (20)	unk.	59.9	132	

[a] All collars are yellow with black numbers.

[b] These caribou were darted twice.

Table 5. Body measurements of Delta caribou collared in 1982.[a]

Accession No.	Date	Age (months)	Sex	Total length	Heart girth	Metatarsal length	Total hindfoot length	Face length	Neck circumference	Body weight lb	Body weight kg
102,546	5/3/82	11	F	--	96	38	52	31	42	125	56.7
102,547	5/3/82	11	F	175	100	39	53	39	42	150	68.0
102,548	5/3/82	11	F	164	94	37	52	33	37	138	62.6
102,549	5/3/82	11	F	152	88	36	49	30	35	115	52.2
102,560	5/3/82	11	F	--	101	38	54	33	42.5	155	70.3
102,561	5/3/82	11	F	--	96	39	56	30	39	146	66.2
102,562	5/3/82	11	F	--	--	40	54	34	43	150	68.0
102,563	5/3/82	11	F	165	--	38	53	32	37	140	63.5
102,564	5/3/82	11	F	164	100	--	--	32	40	125	56.7
102,565	5/3/82	11	F	165	102	38	51	34	40	140	63.5
102,566	5/3/82	11	F	170	95	38	53	32	39	132	59.9
			$\bar{x}$ =	165.0	96.9	38.1	52.7	32.7	39.7	137.8	62.5
			SD =	7.0	4.4	1.1	1.9	2.5	2.7	12.5	5.6

[a] All linear measurements in cm.

Table 6. Comparative body measurements of Delta caribou born in 1978 and measured in 1979 and 1982.[a]

Accession No.	Date measured	Age (months)	Sex	Shoulder height	Total length	Heart girth	Meta-tarsal length	Total hindfoot length	Face length	Neck circum-ference	Body weight lb	Body weight kg
101,972	1/4/79	7	F	106	177	108	40	58	--	--	145	65.8
	2/11/82	44		117	193	106	43	61	40	44	237	107.5
Difference				11	16	-2	3	3	--	--	92	41.7
101,973	1/4/79	7	F	106	174	104	40	57	32	42	135	61.2
	2/11/82	44		108	197	117	44	62	39	47	257	116.6
Difference				2	23	13	4	5	7	5	122	55.3
101,974	1/8/79	7	F	107	170	105	39	54	34	45	145	65.8
	2/11/82	44		101	194	122	38	57	38	50	250	113.4
Difference				6	24	17	-1	3	4	5	105	47.6
101,977	1/9/79	7	F	101	162	102	37	51	31	44	130	59.0
	2/26/82	44		115	--	117	40	55	--	--	263	119.3
Difference				14	--	15	3	4	--	--	133	60.3
101,982	1/10/79	7	F	102	169	99	37	52	30	40	138	62.6
	2/11/82	44		112	200	134	42	61	39	47	252	114.3
Difference				10	31	35	5	9	9	7	114	51.7
101,984	1/11/79	7	F	91	160	105	36	52	30	42	132	59.9
	2/26/82	44		107	185	117	39	53	39	44	250	113.4
Difference				16	25	12	3	1	9	2	118	53.5
101,988	1/4/79	7	F	105	181	109	39	54	34	44	145	65.8
	2/26/82	44		121	206	122	41	56	39	45	260	117.9
Difference				16	25	13	2	2	5	1	115	52.2

Table 6. Continued.

Accession No.	Date measured	Age (months)	Sex	Shoulder height	Total length	Heart girth	Meta-tarsal length	Total hindfoot length	Face length	Neck circum-ference	Body weight lb	Body weight kg
101,993	3/30/79	10	F	94	162	104	38	52	--	39	118	53.5
	2/26/82	44		112	188	122	45	62	41	44	253	114.8
Difference				18	26	18	7	10	--	5	135	61.2
101,997	3/30/79	10	F	--	168	109	37	53	37	44	--	--
	2/26/82	44		--	--	--	--	--	--	--	--	--
Difference				--	--	--	--	--	--	--	--	--
7-10 month old females			$\bar{x}$ =	101.5	169.2	105.0	38.1	53.7	32.6	43.0	136.0	61.7
			SD =	6.0	7.2	3.3	1.5	2.4	2.6	2.1	9.4	4.3
44-month-old females			$\bar{x}$ =	111.6	194.7	19.6	41.5	58.4	39.0	45.9	252.8	114.7
			SD =	6.3	7.1	7.8	2.5	3.5	1.2	2.3	7.9	3.6
Difference from 7-10 to 44 months for females			$\bar{x}$ =	11.6	24.3	15.1	3.3	4.6	6.8	4.2	116.8	52.9
			SD =	5.5	4.5	10.1	2.3	3.3	2.3	2.2	14.1	6.4
101,985	1/11/79	7	M	106	160	114	39	55	32	46	135	61.2
	3/30/79	10		107	172	105	39	55	29	37	127	57.5
Difference				1	12	-9	0	0	-3	-9	-8	3.7
101,985	2/11/82	44	M	117	191	126	45	64	45	56	277	125.5
				11	31	12	6	9	13	10	142	64.3

[a] All linear measurements in cm.

Table 7. Reproductive history of radio-collared female caribou from the Delta and Yanert Herds, 1979-82.

Accession No.	Collar No.[a]	Year collared	Year of birth	Produced a calf 1979	1980	1981	1982	Comments
101,972	BKY-36	1979	1978	no	yes	yes	yes	
101,973	BKY-28	1979	1978	no	no	yes	no	
101,974	BKY-37	1979	1978	no	yes	yes	yes	
101,977	BKY-49	1979	1978	no	no	yes	--	Died
101,981	BKY-20	1979	1978	no	yes	no	--	Died
101,982	BKY-78	1979	1978	no	unk.	no	no	
101,984	BKY-47	1979	1978	no	yes	yes	no	
101,988	BKY-25	1979	1978	no	no	no	yes	
101,993	BKY-26	1979	1978	no	unk.	yes	yes	
101,994	YR-79	1979	1978	no	yes	yes	--	Radio failed
101,997	BKY-20	1979	1978	no	yes	yes	yes	
102,341	BKY-15	1981	1980	--	--	no	no	
102,343	BKY-13	1981	1980	--	--	unk	no	
102,348	BKY-14	1981	1980	--	--	no	no	
102,349	BKY-12	1981	1979?	--	--	yes	--	
102,350	BKY-22	1981	1978?	--	--	yes	yes	
102,360	BKY-16	1981	1980	--	--	no	no	
102,362	BKY-18	1981	pre-1978	--	--	yes	yes	
102,363	BKY-29	1981	pre-1979	--	--	yes	no	
102,364	BKY-30	1981	pre-1980	--	--	no	yes	
102,365	BKY-31	1981	pre-1979	--	--	yes	yes	
102,366	BKY-32	1981	pre-1979	--	--	--	--	Not seen since collaring
102,367	BKY-33	1981	pre-1980	--	--	yes	yes	
102,368	BKY-34	1981	pre-1979	--	--	yes	yes	
102,369	BKY-35	1981	pre-1979	--	--	yes	yes	
102,370	BKY-70	1981	pre-1979	--	--	yes	yes	
102,430	BKY-19	1981	1980	--	--	no	no	
102,431	BKY-23	1981	1980	--	--	no	no	
102,432	BKY-27	1981	1980	--	--	no	no	

[a] BKY = black numbers on yellow collar; YR = yellow numbers on red collar.

Table 8. Calf weights from the Delta Caribou Herd, 18 May 1981 and 20 May 1982.

Date	Sex	Weight kg	Weight lb	Remarks
18 May 1981[a]	M	7.7	17	Walked/ran 50' & lay down, easily caught
18 May 1981	M	8.2	18	Walked/ran 50' & lay down, easily caught
18 May 1981	F	5.7	12.5	1 of these was difficult to catch, the
18 May 1981	F	5.4	12	other 2 females did not run and could
18 May 1981	F	7.3	16	barely walk
		$\bar{x}$ = 6.9, SD = 1.2	$\bar{x}$ = 15.1, SD = 2.7	
20 May 1982[b]	M	5.4	12	Little effort made to estimate age of
20 May 1982	M	9.8	21.5	calves captured 20 May 1982, except
20 May 1982	F	6.8	15	the personnel thought that ages were
20 May 1982	F	9.1	20	variable by a few days based upon
20 May 1982	F	7.7	17	differential flight from the helicopter
		$\bar{x}$ = 7.8, SD = 1.8	$\bar{x}$ = 17.1, SD = 3.8	

[a] We estimated that all calves caught this date were less than 1 day old, except 1 of the females that weighed 12 or 12.5 lbs, which was thought to be 1 to 2 days old.

[b] Ages of calves captured this date were not estimated, but it was possible for a man to leap from the helicopter and run them down.

Table 9. Antler retention and development, udder distention, and calving chronology of radio-collared female caribou >2 years old and older, Delta Herd, 1982.

Accession No.	Collar No.[a]	17 May A[b]	U	C	19 May A	U	C	20 May A	U	C	22 May A	U	C	26 May A	U	C	Calf produced in 1982
101,972	BKY-36	Y[c]	-	N							-	Y	N	N[d]	Y	N	yes
101,973	BKY-28	N	N	N				N	N	N				N	N	N	no
101,974	BKY-37	Y	-	Y				Y	-	Y				N	-	Y	yes
101,977	BKY-49	(not located during calving)															unk.
101,981	BKY-20	Y	-	N				Y	-	N				Y	-	Y	yes
101,982	BKY-78				N	N	N										no
101,984	BKY-47	N	N	N				-	-	N							no
101,988	BKY-25	N	Y	N				N	N	N	-	-	Y	-	-	Y	yes
101,993	BKY-26	Y	Y	N				Y	-	N	-	Y	Y	Y	-	Y	yes
101,994	YR-79	(not located during calving)															unk.
101,997	BKY-20							Y	-	N	-	Y	N				yes
102,341	BKY-15	N	N	N													no
102,343	BKY-13	N	N	N										N[c]	N	N	no
102,348	BKY-14	N	N	N				N	N	N				N[c]	N	N	no
102,349	BKY-12																unk.
102,350	BKY-22	Y	-	N				Y	-	N	-	Y	N	Y	-	Y	yes
102,360	BKY-16	Y	-	N							Y	Y	N	Y	-	Y	yes
102,362	BKY-18	Y	-	N				Y	-	N	-	Y	N	Y	-	N	yes
102,430	BKY-19	N	N	N							N	N	N				no
102,431	BKY-23																no
102,432	BKY-27	N	-	N													no

[a] BKY = Black numbers on yellow collar; YR = yellow numbers on red collar.

[b] A = hard antlers present, U = distended udder present, C = calf present.

[c] Y = yes, N = No, - = no data.

[d] 2-3" long velvet antlers present.

Table 10. Harvest of Delta caribou, 1968-82.[a]

Year	Males no. (%)	Females no. (%)	Sex unk. no. (%)	Reported total	Extrapolated total
1968-69	119(81)	25(17)	3(2)	147[b]	160
	--	--	--	205[c]	NA
1969-70	169(75)	54(24)	2(1)	225	324
1970-71	198(72)	68(25)	9(3)	275	428
1971-72	387(62)	226(36)	12(2)	624	740
1972-73	372(72)	132(25)	13(3)	517	NA
1973-74	158(70)	67(30)	8	233	301
1974-75 through 1979-80, no open season					
1980-81	104(100)			104	
1981-82 (fall)	78	9		87	
1981-82 (winter)	113	64	4	181	
1981-82 (total)	191	73	4	268	

[a] Harvest from Subunit 20A and part of 20C.

[b] From 1969 Alaska Department of Fish and Game survey and inventory report.

[c] From J. Sexton memo 12/3/70.

Table 11. Hunting seasons and bag limits for Delta caribou 1968-82.[a]

Year	Season	Bag limit
1968-69	Aug 10-Mar 31	3 caribou
1969-70	Aug 10-Mar 31	3 caribou
1970-71	Aug 10-Mar 31	3 caribou
1971-72	Aug 10-Mar 31	3 caribou
1972-73	Aug 10-Mar 31	3 caribou
1973-74[b]	Aug 10-Dec 31	1 caribou
1974-75[c]	Aug 10-Sep 20	1 caribou
1975-76 through 1979-80	No Open Season	
1980-81	Sep 1-Sep 30	1 male by drawing permit. 200 permits issued.
1981-82	Aug 10-Sep 30 Nov 15-Dec 31	1 caribou by drawing permit from Aug 10-Sep 30; 150 permits issued, up to 25 will be issued to nonresidents. Antlered caribou may be taken from Nov 15-Dec 31 by registration permit. A total of 400 caribou may be taken.
1982-83	Aug 10-Sep 30 Dec 1-Mar 31	1 caribou by drawing permit from Aug 10-Sep 30; 175 permits issued, up to 30 will be issued to nonresidents. Antlered caribou may be taken from Dec 1-Mar 31 by registration permit. A total of 500 caribou may be taken.

[a] Subunit 20A and part of 20C areas.

[b] Amended by emergency announcement to close Sep 20.

[c] Amended by emergency announcement to No Open Season.

Table 12. Estimates of population size of Alaska's Delta Caribou Herd, 1973 and 1979-1982.[a]

Year	Caribou counted in postcalving aggregations	% females older than calves in postcalving composition counts	Extrapolated number of females excluding calves	Extrapolated[b] total from census results (APDCE census estimate)
1973	2,088-2,288	75	1,585-1,737	2,198-2,409
1979	3,166[c]	62	1,817	3,691
1980	3,020[d]	61	1,924	4,448
1981	3,758-4,414[c]	61	2,090-2,441	4,180-4,882
1982	5,679[e]	No data	No data	6,500-7,500[f]

[a] Census methodology varied annually and must be considered for between-year comparisons.

[b] This is the population estimate extrapolated from the caribou counted from photos and peripheral groups visually counted, and from composition data obtained at the time of each photo census and from the following fall. No adjustments are made to account for probably biased composition data.

[c] Some aggregations were comprised mainly of males and were not included in calculations to obtain the extrapolated number of females (column 4).

[d] An additional 58 females not in postcalving aggregations were counted directly from aircraft.

[e] The number of caribou counted on photos was 5,321; an additional 358 were closely associated with the major aggregations and visually counted; 432 caribou were visually counted in the remainder of the herd's range that was reconnoitered.

[f] This total is not extrapolated; it is simply a subjective estimate derived from the known minimum population of 6,111.

APPENDIX A.

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EFFECTS OF DARTING AND NETTING ON CARIBOU IN ALASKA

Key words: capture, caribou, darting, etorphine, netting, Rangifer.

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There are several reports on the short-term effects of capturing caribou (Rangifer tarandus) from helicopters using darting equipment or net guns (Haigh 1978, Fuller and Keith 1981, Barrett et al. 1982, Fong 1982) but no reports on the long-term effects. Monitoring captured caribou by radio telemetry provides a unique opportunity to study both short- and long-term effects of capture on individuals. This paper discusses these effects and recommends collaring procedures to minimize injury to caribou. Data were collected incidentally to capturing caribou from several herds in Alaska. Consequently, detailed information such as body weights or length of chase of caribou captured was frequently not recorded.

METHODS

From 1979 through 1981, 62 caribou were captured by darting using M99 (etorphine hydrochloride 1.0 mg/ml; D-M Pharmaceuticals Inc., Rockville, Md.), and 101 were captured using a combination of M99 and Rompun (xylazine hydrochloride, 100.0 mg/ml, Haver Lockhart, Shawnee, Kans.) Doses ranged from 1.5 mg of M99 plus 20 mg of Rompun to 15 mg of

M99 plus 30 mg of Rompun. Antagonist M50-50 (diprenorphine, 2.0 mg/ml; D-M Pharmaceuticals Inc., Rockville, Md.) was administered intravenously or intramuscularly in doses (mg) double those of M99. All 163 caribou were darted with 3 or 5 cc darts and Palmer Cap-Chur guns (Palmer Chemical and Equipment Co., Inc., Douglasville, GA) fired from a helicopter.

One hundred and forty caribou were captured during January through early May, 19 during late May through July, and 4 in October; 38 were males and 125 were females. The caribou ranged in age from 7 months to old-age adults. Most caribou were darted in the hindquarters, but some were inadvertently hit in the back, flank, or ribs. Of the 163 darted, 145 were darted once, 15 twice, and 3 more than twice.

Based on previous experience with small-bodied (average adult female weight 75 kg; Skoog 1968:25) caribou on the arctic coastal plain and semi-domestic reindeer of similar body size, we used a dose of 1.5 mg of M99 plus 10.0 mg of Rompun at the beginning of our collaring program in 1979. After trying this dose on a few yearling caribou in the Alaska Range, we increased the dose to 3.0 mg of M99 and 20.0 mg of Rompun and used this on all caribou regardless of sex or age until 1981. Due to continued inconsistent results and induction times in excess of 20 minutes, we subsequently adopted 5 cc darts filled with M99 (5.2 mg) or with 30.0 mg of Rompun and the remainder M99 (4.9 mg).

From February 1981 through May 1982, a shoulder-held net gun (.308 caliber, Mountain Helicopters, Greymouth, N.Z.) was used to capture 53 female and 2 male caribou, including 36 undarted caribou, and 19 darted caribou that were not immobilized. The gun discharged a net 5 m on each side with a mesh size of 11 cm. After several accidental deaths of caribou, we increased mesh size to 22 cm to increase the elasticity of

the net and to prevent injury to caribou from sudden, total entanglement. Cylindrical 270 g steel weights attached to each corner of the net were propelled from the gun's 3 barrels simultaneously by a powder charge of 1.6-2.0 g (25-32 grains) of Hercules Blue Dot Powder (Hercules Inc., Wilmington, Del.). These charges produced minimally acceptable net propulsion, but higher charges caused mechanical damage to the gun.

Caribou were netted on open, generally snow-covered tundra, but we captured about 20% of the animals on snow-free tundra. About 60% of the caribou were captured in shallow snow where their movements were only slightly impeded. The remaining caribou were captured in snow deep enough (at least 50 cm) to restrict their movements.

When darting or netting, caribou were pursued with the helicopter for 0.2-2.0 km per pass during which they frequently ran at what appeared to be full speed. The net or dart was fired when the helicopter was approximately 2 m above and 4-8 m behind the caribou. About 75% of the time, more than 1 pass at a group was necessary, depending on the skill of the pilot and gunner, wind conditions, and the caribou's evasive movements. We often tried to capture either 2 or 3 caribou from a group. Although we did not record the number of passes per group, the average group was probably subjected to 3 or 4 passes. We avoided making more than 3 or 4 passes where possible, so that groups were not unduly harassed especially if the group included a darted caribou. Chases to dart caribou usually lasted less than 20 seconds, and once a caribou was hit, every effort was made to allow the animal to relax. Generally, darted caribou were continually observed from a Super Cub or other fixed-wing aircraft from high overhead. Darted caribou generally rejoined a group until they became immobilized. After netting

and sometimes after darting, caribou were pursued on foot and subdued. Following restraint, blood samples, an incisiform tooth, and body measurements were collected; and an individually distinguishable radio collar was attached.

RESULTS AND DISCUSSION

Capture-related Mortality

Of the 163 darted caribou, 9 died (5.5%); 7 from dart-inflicted mechanical injuries, 1 fell while partially immobilized and broke its scapula, and 1 from unknown causes. Excessive velocity of the darts coupled with poor shot placement contributed to 5 of the 7 dart-related deaths. One caribou died from a punctured ureter and 1 from a massive hemorrhage of a major blood vessel. Long needles (3.2 cm rather than 1.9 cm) may have been contributing causes in these deaths. Four of the caribou died within 3 days of handling, and the rest died or were dispatched immediately. Caribou darted more than once were more likely to die ($P<0.001$) than those darted only once. Hyperthermia may have been involved in some deaths (although we did not record rectal temperature) because 3 of the 9 caribou that died were chased long distances (between 2 and 5 km). Necropsy and blood analysis of the caribou that died of unknown causes indicated bacterial hepatitis and bacterial pneumonia. Use of Rompun did not obviously reduce mortality although animals appeared calm when immobilized.

Twenty three of the darted caribou were not immobilized, but were captured by netting or manually by dropping onto them from the helicopter. Approximately 10 or more additional caribou were darted and not captured (we did not record each case). Most of these dartings occurred on 2 occasions when we were trying to capture caribou in the Alaska Range after having worked on caribou in deep snow on the arctic

coastal plain. Drug doses were too low (initially 1.5 mg/100 kg M99), and topographical features and patchy snow made caribou particularly difficult to follow. Areas where caribou were darted but not handled were searched for up to an hour by helicopter and Super Cub the same day and again the following day. Two apparently healthy caribou still carrying darts were found in this area the following day. From these observations and our searches of the area, we surmised that most darted caribou survived.

Seven of 55 (12.7%) caribou died after capture by netting. Four caribou suffered broken legs and 3 suffered broken necks. The thigh muscle of an additional caribou was penetrated by a net weight. This animal may also have died, but we did not follow or collar it. Six of the 7 caribou killed during netting in the range of the Western Arctic Herd died in 1 day. We were not sure why mortality was so high in that instance, but we were relatively inexperienced, snow was shallow, the caribou were running fast, and we had not yet increased mesh size. After this experience we avoided using the net gun on undarted caribou except where snow was deep enough to substantially impede their movements, or when the ground was soft enought to cushion their falls.

Chasing caribou with a helicopter rarely resulted in mortality or severe injuries independent of actual darting or netting. During chases to capture caribou, 1 caribou was accidentally struck and killed with the skid of the helicopter and 1 stumbled and broke a leg.

Effects of Capture and Handling on Productivity

Capture and handling of females apparently did not affect production or survival of their calves. Of 43 adult female caribou captured and radio-collared during spring in the Western Arctic Herd, 84% produced calves the same spring they were collared. Calving in this

herd takes place from 25 May to 10 June. There was no difference in productivity between netted and drugged caribou. The mean proportion of adult females observed with calves in early June in the total population was 78%±6 SD from 1979 through 1981 (N = 7,835 females). In addition, 22 of 36 (61%) radio-collared Western Arctic caribou located between August and October following collaring were accompanied by calves. Comparable autumn calf:female ratios sampled from the population at large (N = 1,354 females) indicated that the survival rate of calves to autumn 1980 was 64%. Autumn composition data were unavailable for other years and no standard deviation could be calculated from the data.

CONCLUSIONS AND RECOMMENDATIONS

The most significant effects of capture and handling on caribou were physical injuries or death from darts or entanglement in nets. Natality and calf survival were not detrimentally affected by capture.

Although there was no good correlation between dose (mg/kg) and induction time (r^2 = -0.16), the two groups of caribou receiving the largest doses (7 and 8 mg/100 kg) had the lowest induction times (10.8±5.5 SD and 15.2±9.0 SD minutes respectively). Also, caribou receiving light doses (3-4 mg/100 kg) were more likely to escape completely ($P<0.001$) after being darted, and induction time was more variable than those receiving higher doses. Long induction times promote prolonged movement which can lead to exhaustion and possible hyperthermia or capture myopathy. When darting from a helicopter, we recommend using 5 to 7 mg of M99/100 kg body weight.

In practice, we used a standard dose of 5.2 mg M99 or 30 mg Rompun and 4.9 mg M99 (a full 5 cc Cap-Chur dart) on all caribou 7 months or older. This dose was actually light for most adult male and female caribou in central and southern Alaska where the average adult female

weighs about 115-125 kg and an average adult male weighs about 180 kg (Skoog 1968:25). Use of Rompun, especially in warmer weather, is recommended by A. Franzman (pers. commun.) to reduce the likelihood of hyperthermia and capture myopathy. Another tranquilizer acepromazine maleate has also been used with success (Fuller and Keith 1981, Fong 1982).

In our experience, the only acceptable combination of Cap-Chur equipment suitable for capturing caribou from a helicopter with M99 (1.0 mg/ml) in spring is a 5 cc dart barrel, "brown" (extra low power) charge, and 1.9 cm barbed needle. Higher power charges, larger darts and longer needles increase the risk of trauma. Experimenting with lighter darts of a different design and variable power guns may be worthwhile, but the major remaining problem is that a more concentrated form of M-99 such as Immobilon (Reckitt and Coleman Pharmaceutical Division, Hull, England) is unavailable in the United States.

Inconsistent Cap-Chur charges remain a problem. "Brown" charges acquired as recently as July 1981 were highly variable. Some barely propelled the dart from the gun barrel, while others caused the entire dart barrel to penetrate the caribou's skin.

We originally acquired the net gun to avoid injuries to caribou that seemed inevitable with darting. We also thought the net gun would be more efficient because there is no induction time. To date, the net gun has been of limited use on Alaskan caribou because we seldom find caribou in areas where snow is deep enough or the ground soft enough to allow us to use without injuring caribou. We still rely primarily on darting to capture caribou but use the net gun to capture partially immobilized caribou. We avoid multiple darting because it increases the amount of trauma and the chance of a lethal wound. Using the net on

partially drugged caribou is economical and time-efficient. If caribou are in deep snow (>70 cm), or if the ground is unfrozen and soft the net gun method alone can be efficient.

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APPENDIX B.

Demography and limiting factors of Alaska's Delta Caribou Herd, 1954-1981

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The Delta Caribou Herd grew rapidly following wolf control in 1954 and 1976. We attempted to determine if this relationship was cause-and-effect or coincidental. Data were inadequate from the 1954-1960 period to unequivocably ascribe herd growth to lowered wolf predation. During the early 1970s, predation by wolves was clearly the primary limiting factor until wolf control was initiated in 1976. We assessed alternative hypotheses explaining demographic changes, including weather, emigration/immigration, nutrition, disturbance, hunting, other predators, disease, and catastrophe. High parturition rates, rapid calf growth, accelerated sexual maturity, and other indices suggest that the herd's range/energetic status was high.

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1. Introduction

Understanding caribou (Rangifer tarandus) population dynamics through identification of limiting factors ranks high in the concern for North American caribou and their management. Of the many possible limiting factors, those discussed most are food quality and quantity, predation, and harvest.

Factors limiting the Delta Caribou Herd (DCH) were identified through demographic studies and predator control programs in the herd's range from 1954-1960 and from 1976-1981. Two adjacent herds were used as experimental controls.

The DCH ranges the northern slopes of the Alaska Mountain Range and adjacent lowlands. The area lies approximately 110 km south of Fairbanks. The Macomb Caribou Herd is distributed immediately to the east and the McKinley (or Denali) Caribou Herd is immediately to the west. All occupy similar habitat.

2. Methods

Pre-1975 data were largely obtained from the literature, unpublished reports and files of the Alaska Department of Fish and Game (ADF&G),and interviews of individuals who worked and/or spent time in the study area continuously since the early 1950s.

Since 1972, estimates of herd size were obtained from aerial photo-direct count-extrapolation (APDCE) censuses. Methods for estimating caribou natality, productivity, recruitment, harvest, and sex and age composition were similar to those described or referenced in Davis et al. (1980).

Abundance and distribution of wolves in the DCH's range were determined by aerial surveys (Stephenson 1978) from 1973-1982. From 1954-1960, poisoning and aerial shooting were used for wolf control, but harvest documentation was poor on wolves and other predators (including grizzly bears (Ursus arctos) and wolverines (Gulo gulo)). Removal of wolves since 1976 was by trapping and aerial shooting by ADF&G personnel and the public. Mandatory harvest reports for wolves provided good harvest data.

3. Results

3.1. Caribou Demography, 1954-1981

From the mid-1930s until 1954, caribou were scarce in the DCH's range; all 4 estimates from this period indicated several hundred resident caribou. There were 1,500 caribou by 1957 and 5,000 by 1963 (excluding calves). Estimates from 1963-1970 were consistently about 5,000, including 1,000 caribou in the present range of the Macomb Herd.

The first APDCE census of the DCH (in 1973) estimated 2,198-2,409 caribou. Subsequent APDCE census estimates were 3,700-3,961 in 1979; 4,194-4,448 in 1980; and 4,180-5,320 in 1981. (Ranges do not indicate confidence intervals--they are extrapolations by 2 methods.) No censuses were conducted between 1973 and 1979, but calf survival data suggest that the herd declined through 1975 and began increasing in 1976.

The mean fall calf:100 cows ratio for 1971-1974 was 9.7 (s.d. = 5.8); following wolf control in 1976-1981, the comparable ratio increased dramatically to 47 (s.d. = 9.5). The actual difference in these ratios is even greater if based on cows $\geq$ 3 years old. In a rapidly growing herd, the calf:100 cows ratio declines because of the increased proportion of sexually immature cows.

3.2 Wolf Demography 1954-1981

Wolves were quite numerous in 1954 when a predator control program was initiated (C. Gray and P. Shepherd, pers. commun.). P. Shepherd, (a predator control officer between 1955 and 1957) observed that wolf abundance in 1957 was comparable to spring 1976. Wolf control ceased in 1960, and wolf abundance increased through the 1960s. Data on wolf abundance are equivocable prior to 1975 when 324 hours of aerial survey were flown to estimate wolf abundance; however, wolf abundance was likely similar from the late 1960s to 1975.

Regarding the wolf/caribou relationship, we divided the DCH's range in two parts: east of the Wood River (the area inhabited by most of the DCH when calves were <4 weeks old) and west of the Wood River (additional habitat used annually).

Prior to calving in 1976, 41-50 wolves were killed out of 53-63 wolves inhabiting caribou habitat east of Wood River, and 26 out of 50-67 wolves were killed west of Wood River. Continued control through 1981 has maintained those relative levels of reduction. Implications, in terms of reduced wolf predation on calves and older age classes, can be extrapolated from the literature.

3.3 Indices to Nutrition

No habitat studies per se have been conducted for the DCH. However, nutrition indices such as rapid growth, early sexual maturity, high pregnancy rates, high natality and calf survival rates, and early parturition (i.e., shortened gestation period) have been monitored and indicate a high nutritional status. Calves were large at 7.5 months in 1979; live weight was 71.1 kg (s.d. = 5.4) for 8 males, and 62.5 kg (s.d. = 2.8) for 9 females. Of 9 radio-collared female calves, at least 6 produced viable calves on their second birthday. Five of these 6 again produced viable calves on their third birthday. From 24-28 May 1979 we classified 479 cows and 98% had produced a calf. Data on calf survival to fall were presented in 3.1 above. Peak of calving in recent years has been as early as 16-17 May, almost a week earlier than adjacent herds.

3.4 Harvest of Caribou

No harvest data are available prior to inception of a mandatory harvest report program initiated in 1968-69, but it is believed that trophy hunting of adult males constituted the primary hunting pressure prior to 1968. Harvest peaked from 1970-1973 when 7-19% of the herd was harvested annually. The season was closed in 1973 and remained closed until fall 1980.

3.5 Other Limiting Factors

The roles of weather, emigration/immigration, disturbance, disease, catastrophe, and other potential limiting factors were considered but inadequately accounted for the observed population dynamics of the DCH. Discussion of our evaluation of these factors is beyond the scope of this paper.

4. Discussion

The DCH grew rapidly following 2 effective wolf control programs. Increased calf survival was clearly documented during the second growth period. We believe the DCH increased from 1954-1963 through increased survival resulting from reduced wolf predation. However, a portion of the Nelchina Caribou Herd moved into the DCH's range during winter 1956-57 and fall 1963. Some net exchange possibly occurred but was never documented, .

Inferring cause-and-effect from lowering wolf numbers and the subsequent increase in caribou is supported by the relatively constant calf survival in adjacent herds not receiving wolf control. We assume, a priori, that environmental variables between the three areas were comparable. Following wolf control in 1976, the DCH fall calf:100 cows ratio increased from 2:100 in 1974 to 45:100 in 1976 (no fall 1975 data available, but there were only 13 calves:100 cows in June 1975). Comparable figures from the Macomb Herd were 15:100 in 1974 (no 1975 data) and 20:100 in 1976; and in the McKinley Herd 18:100 in 1974 (no 1975 data) and 16:100 in 1976. While the Delta Herd doubled from 1976- 1981, the Macomb and McKinley Herds remained at approximately 800 and 1,500, respectively.

Based on indices of nutrition and the rapid increase of the DCH from 1976 to present, it is improbable that food quality and/or quantity could have decreased sufficiently during the early 1970s to cause the drastic population decline and poor calf survival and yet recover sharply in 1976. Further,

range/energetic relationships of the DCH appear comparable to or better than those in the McKinley Herd where Boertje (1981) concluded that nutritional status was high, and predation on calves <4 weeks old was presumably the key factor limiting the herd since 1972.

Excessive harvest was a major factor in the precipitous decline of the DCH from 1970-1973. However, overharvest was more a proximate than ultimate limiting factor because calf survival during this period was so low that a decline would have occurred without hunting, and the decline continued from 1973-1975 after hunting was eliminated.

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