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QUALITATIVE AND QUANTITATIVE ASPECTS OF NATURAL MORTALITY OF THE WESTERN ARCTIC CARIBOU HERD

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SUMMARY

Estimated natural mortality rates of radio-collared Western Arctic Herd (WAH) caribou (Rangifer tarandus granti) remained relatively stable between 1979-81 and 1981-82. The number of collared individuals shot by hunters increased substantially. Apparently, hunters are selecting for collared caribou.

Preliminary results of the 1982 aerial photo census indicated that the WAH numbers about 175,000. The adult mortality rate may be growing in response to increased hunting, especially of females, and possibly increased natural mortality. However, precision of population censuses and harvest estimates was not sufficient to confirm the apparent trend.

Key words: Caribou, mortality, Rangifer tarandus, Western Arctic Herd.

CONTENTS

BACKGROUND

The Western Arctic Herd (WAH) was 1 of several Alaskan caribou (Rangifer tarandus granti) herds that declined during the early 1970's. Because the WAH was the largest herd in North America and its decline was dramatic, its population dynamics and management have been a focus of public and scientific attention since the decline was detected in 1975 (Davis and Valkenburg 1978).

Recent population modeling of the WAH (Doerr 1979, 1980; Davis et al. 1980) and intensified management have demonstrated the need for better biological data. Several studies initiated in recent years are providing some of the required data. However, rates and causes of natural mortality have not been adequately determined. Caribou biologists familiar with population demography acknowledge that such data are essential to understanding the population dynamics of any caribou herd. Davis et al. (1980) concluded that natural mortality, particularly predation, contributed greatly to the recent decline of the WAH.

Because empirical data were not available for ongoing modeling and management decisions, natural mortality rates have been estimated based on the literature. The few published rates of natural mortality are of limited value because they consist primarily of generalities from studies conducted a decade or more ago under different conditions than now exist in the WAH. Skoog (1968) and Kelsall (1968) suggested annual natural mortality rates of 5-6% for caribou older than yearlings when relatively few wolves (Canis lupus) or grizzly bears (Ursus arctos) were present. Bergerud (1971) found that males had a higher natural mortality rate (9%) than females (4%) in Newfoundland. In a recent review of population dynamics of North American caribou, Bergerud (1978) stated, "The natural mortality rate of adults

when there are normal densities of predators has not been determined yet, but it probably will average 7-1[illegible]%, depending upon predator densities."

Determining actual mortality rates and the extent to which mortality is compensatory is important for management and is requisite to understanding herd population dynamics.

OBJECTIVES

To determine the age, sex, condition, and cause of death of adult caribou dying from natural causes (all factors other than human-induced mortality), and to monitor 50 radio-collared caribou to help quantify mortality factors.

PROCEDURES

Quantifying Natural Mortality

Adult mortality rates were estimated primarily using radio-collared caribou and a formula empirically derived by W. Gasaway (Davis and Valkenburg 1982). We also estimated adult natural mortality using a simple mathematical population model based on estimates of changes in herd size, recruitment, and harvest by humans (Bergerud 1978, Martel and Russell 1983). Calf mortality was estimated from composition counts conducted during 2 or more of the following times: calving, postcalving migration, autumn, and April. The relative abundance of caribou carcasses, evidence of predators, and predation were also noted. Aerial surveys were often multi-purpose, including radio-tracking caribou, searching for wolves and caribou carcasses, and conducting composition counts.

Between September 1981 and October 1982, we flew 268 hours to monitor radio-collared caribou, investigate causes of mortality, and assess calving success and overwinter calf survival (Table 1). Proportionately more hours were flown on the Arctic coastal plain than in previous years in response to reports from area residents that freezing rains during the winter had caused unfavorable foraging conditions and might increase mortality to wintering caribou.

Using standard techniques (Valkenburg et al. 1983a), we radio-collared 4 female WAH caribou in April 1982, which supplemented the 37 WAH females and 11 males with functioning radios. In addition, 12 females and 6 males collared from the Teshekpuk Caribou Herd in 1981 (Reynolds 1982) had functioning radio collars.

Censusing

Population size of the WAH was estimated using a modified aerial photo-direct count-extrapolation technique (Davis et al. 1979). Transects were flown over the Arctic coastal plain to estimate the number of caribou there and not in the postcalving aggregations. The remainder of the WAH's range was not sampled because only a relatively small number of caribou were found there in 1978 and 1980 (Davis et al. 1979, Davis and Valkenburg 1982). Details of the 1982 census will appear in the 1982 WAH Annual Progress Report of Survey and Inventory Activities.

Comparing Visual-Search and Radio-Search Censuses

Department biologists have become increasingly interested in censusing caribou herds by radio-locating collared caribou and counting associated caribou rather than conducting extensive searches for scattered groups. Recent studies have demonstrated that radio-collared WAH caribou distribute themselves throughout the herd generally independent of collaring location (Valkenburg et al. 1983b). In addition, locating radio-collared WAH caribou during the 1980 WAH census possibly helped locate some small groups of caribou that may otherwise have gone uncounted (Davis and Valkenburg 1982).

The 1982 WAH census was used to compare the conventional approach of intensive visual searching for postcalving groups (Davis et al. 1979), to searching only for aggregations containing radio collars and other caribou found incidentally to locating radio collars.

RESULTS

Estimating Natural Mortality Rates Using Radio Telemetry

Three radio-collared females and 1 male died of natural causes between September 1981 and October 1982 (Tables 2, 3). One female was killed by a grizzly bear, 1 by a wolf, and 1 which appeared lethargic in early April 1982 was subsequently killed by a wolf in mid-April and its primary cause of death was listed as malnutrition/disease. The 1 male died of malnutrition/disease. Natural mortality rates may have increased slightly during this reporting period especially for females (Tables 2, 3), but the difference was not significant (X^2, $P > 0.05$). Even if 2 females and 2 males that died of unknown causes during the 1981-82 period were included as natural mortalities, there would still be no significant difference in natural mortality rates between periods.

Calculations of total (natural and human-induced) herd mortality based on radio-collared caribou may be biased because hunters appear to be selecting for radio-collared individuals, especially

males. Three male and 2 female radio-collared caribou were shot between September 1981 and October 1982. A collared male from the Teshekpuk Herd was also shot (Table 4).

Productivity of radio-collared caribou was unchanged from previous years (Table 5). Survival of calves to 3 months was not monitored, but analysis of previous data indicated that the presence or absence of a calf with a radio-collared female may not accurately indicate calf survival or mortality. Calves may not be seen or considered associated with a female on a particular relocation, but subsequent observations reveal a calf to be associated with her. This could be due to poor sightability or possible adoption of calves.

Estimating Natural Mortality Using Modeling

Estimating natural mortality rates by simple arithmetic modeling (Bergerud 1978) can be instructive if limitations are recognized. Required information includes population size at times 1 and 2 and recruitment and harvest data from times 1 to 2. Accuracy of calculated mortality rates depends on the accuracy of estimates of population size, recruitment, and hunter harvest.

Conventional censuses of caribou normally yield estimates with broad confidence intervals and/or employ several untested assumptions; estimates of hunter harvest can be poor, particularly from large herds hunted for subsistence such as the WAH; and it is difficult to obtain unbiased recruitment data (Davis et al. 1979). We recognized these limitations and calculated natural mortality rates for the WAH (Tables 6, 7) to compare with rates determined from monitoring radio-collared caribou (Tables 2, 3). The calculated mean adult natural mortality rate for the WAH for 1980 through 1982 (Table 7) was $\bar{x}$ = 12.9% (SD = 6.3). A comparable figure from the radio-collared caribou (Tables 2, 3) can be derived. The approximate composition of the WAH in fall from 1980 through 1982 was 50% females, 30% males, and 20% calves. The mean natural mortality of females and males for the period was 5.9% (SD = 2.6) and 9.2% (SD = 0.6), respectively. Using these mortality rates and mean fall composition, the weighted adult mortality in the herd based on radio-collared caribou was 7.1%.

Disparity between the annual natural mortality rates calculated from modeling (i.e., 12.9%) and from the radio-collared caribou (i.e., 7.1%) is considerable. Martel and Russell (1983) discussed the potential inaccuracies of calculating mortality rates using arithmetic models (Bergerud 1978) and proposed that monitoring radio-collared caribou would produce more accurate estimates of natural mortality.

There is no basis to conclude that our mortality estimate from monitoring radio-collared caribou is any better than that calculated from Table 7. We do know that the accuracy and precision of population size and harvest estimates is such that it could

account for the difference between the calculated mortality rate in Table 7 and the mortality rate derived from the radio-collared caribou. Small sample sizes and missing radio-collared caribou are 2 of the most apparent problems with the radio-collaring approach.

Assessing Qualitative Aspects of Natural Mortality

Although total mortality of WAH caribou probably increased during the 1981-82 report year, natural mortality remained at a moderate level. We found no evidence of increased wolf predation and reports from pilots in the Kotzebue area and local residents on the Arctic coastal plain did not indicate increased predation. We spent very little time flying caribou range south of the Kobuk River, however, and could not compare our incidental observations to previous years.

The number of wolf pelts sealed in the range of the WAH did not increase (Table 8), and the 1 successful wolf survey in the range of the WAH revealed a moderately low density (1 wolf/230-384 km^2 for the central Brooks Range) (Alaska Department of Fish and Game files).

We flew approximately 50% more hours on the Arctic coastal plain this year radio-tracking and searching for carcasses. Caribou wintering there apparently had relatively little trouble feeding. Even though some areas were largely ice-covered due to the rain in January, there were still extensive areas of softer snow, especially along the coastal fringe. Two of the radio-collared individuals that died there were food-stressed, judging from appearance of their bone marrow after death; however, we found only 1 other dead caribou and observed normal cratering in areas where caribou were present.

Comparing Visual-Search and Radio-Search Censuses

Preliminary results of the 1982 aerial photo census revealed about 170,000 caribou distributed in 17 postcalving aggregations. Extrapolation from transect sampling on the Arctic coastal plain yielded about 4,000 more. About 154,000 (88%) of the caribou were associated with radio-collared individuals in close enough proximity that they should have been located by searching for radio-collared individuals only. It appears unwise to abandon the intensive visual search procedure, but it is clear that radio-collared caribou facilitate censusing.

RECOMMENDATIONS

Thorough documentation of harvest should be a major priority for management. Management biologists have made good progress since 1976 in obtaining voluntary harvest reports and harvest ticket returns, especially in Unit 23. However, we have been unable to

estimate total WAH harvest with any degree of confidence for several years. An intensive effort to measure the harvest, even if range-wide for only 1 season and then in selected areas subsequently, would help greatly. Seasons and bag limits are unlikely to change significantly for several years. Distribution of caribou will probably be the greatest influence on a particular village's harvest. If individual village harvest estimates were accurately made during a year of abundance and a year of scarcity, we would be in a position to interpolate harvest in other years for those villages where voluntary reporting is particularly poor but caribou distribution was known. Management activities for 1982-83 should also include a range-wide survey to estimate wolf numbers.

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Table 1. Summary of flights conducted for radio-tracking, locating carcasses, and collaring caribou in northwestern Alaska, October 1981-October 1982.

Month	Hours flown				Total hours flown
	Bellanca Scout	Cessna 185	Super Cub	Bell 206 helicopter	
October		45			45
November		5			5
December					0
January					0
February					0
March	35	25			60
April	22	11		14	47
May					0
June	25	32	12		69
July	14	10			24
August					0
September					0
October		16		2	18
Totals	96	144	12	16	268

Table 2. Comparison of mortality rates of radio-collared female WAH caribou older than 1 year, 1979-1982.

Cause of mortality	Time period: April 1979-August 1981 Number dying (% annual mortality)[a]	September 1981-October 1982 Number dying (% annual mortality)	April 1979-October 1982 Number dying (% annual mortality)
Grizzly bear[b]		1 (2.6)	1 (1.3)
Wolf[b]		1 (2.6)	1 (1.3)
Birth complication	1 (2.0)		1 (1.3)
Malnutrition/disease	1 (2.0)	1 (2.6)[d]	2 (2.6)
Total natural[c]	2 (4.1)	3 (7.7)	5 (6.4)
Legal hunting		2 (5.2)	2 (2.6)
Illegal hunting			
Total hunting[b]		2 (5.2)	2 (2.6)
Unknown		2 (5.2)	2 (2.6)
Total annual mortality	2 (4.1)	7 (17.9)	9 (11.5)
Number of radio collars operating during the period	42	41	45
Collar-years of monitoring	39	36	75

[a] Calculated from Gasaway's empirically derived formula (see Procedures).
[b] These are suspected causes of death; actual cause can only be determined when deaths are witnessed.
[c] These are minimum figures. Deaths from unknown cause should be added to obtain maximum figure.
[d] Proximate cause of death was suspected wolf predation; lethargic and emaciated when sighted prior to death.

Table 3. Comparison of mortality rates of radio-collared male WAH caribou older than 1 year, 1979-82.

Cause of mortality	Time period: April 1979-August 1981 Number dying (% annual mortality)	Time period: September 1981-October 1982 Number dying (% annual mortality)	Time period: 1979-October 1982 Number dying (% annual mortality)
Grizzly bear	1 (4.8)		1 (3.7)
Wolf	1 (4.8)		1 (3.7)
Malnutrition/disease		1 (8.7)	1 (3.7)
Total natural	2 (9.6)	1 (8.7)	3 (11.2)
Legal hunting	1 (4.8)	3 (26.1)	4 (14.9)
Illegal hunting	1 (4.8)		1 (3.7)
Total hunting	2 (9.6)	3 (26.1)	5 (18.7)
Unknown[a]	1 (4.8)	2 (17.4)	3 (11.2)
Total annual mortality	5 (23.9)	6 (52.2)	11 (41.1)
Number of radio collars operating during the period	24	11	26
Collar-years of monitoring	19	7	26

[a] Two of these deaths were probably of natural causes, and 1 was probably due to humans.

Table 4. Mortality rates of male and female Teshekpuk caribou, July 1981-July 1982.

Cause of mortality	Males Number dying (% annual mortality)	Females Number dying (% annual mortality)	Both sexes Number dying (% annual mortality)
Natural	1 (11.4)		1 (4.2)[a]
Legal hunting	1 (11.4)		1 (4.2)
Unknown			
Total annual mortality	2 (22.8)	0	2 (8.4)
Number of radio collars operating during the period	8	12	20
Collar-years of monitoring	7	15	22

[a] Found near death by Barrow residents who speculated that the collar had impaired feeding, but this was not verified.

Table 5. Productivity and survival of calves to 1 week of age of radio-collared caribou in the Western Arctic Herd, 1979-1982.

Date	No. of females with radio collars	No. seen in June	No. of adults[a]	No. with distended udders (%)	No. with calves (%)	Calves/100 females from aerial classification[b] (general population)
1979	4	4	4	4 (100)	4 (100)	65 (N = 2,600)
1980	22	18	15	14 (93)	14 (93)	82 (N = 2,166)
1981	41	38	38	32 (84)	25 (66)[c]	82 (N = 2,222)
1982	40	35	34	30 (83)	16 (53)[d]	78 (N = 3,308)
Totals	107	95	91	80 (88)	59 (65)	

[a] Three years old or older.
[b] Counts done when numbers of calves were thought to be maximum.
[c] When relocated on 6 June, 2 females had apparently not yet calved as indicated by retention of hard antlers.
[d] When relocated 7 June, 13 females had not yet calved, as indicated by retention of hard antlers.

Table 6. Calf survival and mortality in the Western Arctic Caribou Herd, 1976-1982.

Cohort year	Calves/100 females at birth[a]	Survival to 1 month calves/100 females (% mortality to 1 month)	Survival to 4 months calves/100 females (% mortality 1-4 months)	Survival to 10 months calves/100 females[b] (% mortality 5-10 months)	Total annual calf mortality (%)
1976	73	54 (26)	48 (5)	55 (0)[c]	31
1977	69	52 (25)	42 (14)	29 (19)[c]	58
1978	68	63 (7)	48 (22)	50 (0)[d]	29
1979	65	NA	NA	53 (NA)	18
1980	82[e]	66 (20)	53 (20)	53 (0)	40
1981	82[e]	NA	NA	65 (NA)	21
1982	78	NA	61		

[a] These figures are based on observed calf:cow ratios after the peak of calving and not from distended udder frequency, so they underestimate natality.

[b] This figure is adjusted to compensate for the addition of female yearlings to the adult female segment of the population.

[c] These figures indicate that mortality was not measurable over winter by standard survey methods.

[d] This figure was calculated using numbers of calves/100 caribou older than calves and by assuming a ratio of 50 bulls/100 females in the population.

[e] Counts occurred in the core calving area where calf:female ratios are highest; therefore, mortality subsequent to birth was actually lower than indicated for this year.

Table 7. Adult natural mortality rates calculated from estimates of population size, recruitment, and human harvest in the Western Arctic Caribou Herd, 1976-1982.

Year	July population	July population (older than calves)	Recruitment (% short-yearlings in April)	Projected population before mortality	Total mortality[a] (%)	Human harvest (%)[b]	Annual adult natural mortality[c] from previous July to July (%)
1976	75,000	51,750					
1977	90,000	63,450	27.5	71,415	7,965 (11.1)	3,100 (4.3)[d]	4,865 (6.8)
1978	102,000[e]	72,114[f]	16.7	76,140	4,026 (5.3)	3,000 (3.9)[d]	1,026 (1.4)
1979	113,000[e]	77,744[f]	25.6	96,633	18,889 (19.6)	4,000 (4.2)[d]	14,889 (15.4)
1980	140,000[g]	94,000[g, f]	26.8	106,509	12,509 (11.7)	5,000 (4.7)[d]	7,509 (7.0)
1981	157,500[g]	108,360[g, f]	26.8	128,780	20,420 (15.9)	5,000 (3.9)[d]	15,420 (12.0)
1982	175,000[h]	119,318[f]	31.0	157,122	37,804 (24.1)	7,000 (4.5)[i]	30,804 (19.6)

[a] $$\text{Total mortality \%} = 1 - \frac{\text{July population older than calf}}{\text{(Previous July population older than calf) X (1+ short yearling:adult ratio in April)}}{\text{Previous July population older than calf}}$$

[b] Calculated from harvest figures and estimates of illegal kill. Harvest begins in the previous year (i.e., 1977 harvest is that which occurred in 1976-77).

[c] Natural mortality = total mortality less human harvest.

[d] Harvest subjectively estimated to be 80% male and 20% female.

[e] Probably low because this was a calving ground census; all other censuses were aerial photo-direct count-extrapolation censuses.

[f] In 1979 and 1982, the percentage of calves in the herd in July was not determined, so the mean value (31.2%) for other years was used.

[g] Interpolated from 1980 and 1982 censuses.

[h] Preliminary results of 1982 aerial photo census.

[i] Harvest subjectively estimated to be 50% male and 50% female.

Table 8. Reported harvest of wolves in the range of the Western Arctic Caribou Herd, 1975-82.

Year	GMU 23[a]	GMU 24[b]	GMU 26[c]	Total
1974-75	47	65	6	118
1975-76	144	45	34	223
1976-77	150	55	35	240
1977-78	64	55	38	157
1978-79	48	102	31	181
1979-80	16	49	15	80
1980-81	41	69[d]	42[e]	152
1981-82	19	33	39	91

[a] Kobuk River, Noatak River, Selawik River areas.

[b] Upper Koyukuk drainage, central Brooks Range. Up to 20% of these animals are from areas outside the WAH caribou range.

[c] Arctic slope. Although this Unit includes the entire Arctic slope east to the Canadian border, more than 90% of the wolves taken came from the area between Anaktuvuk and Etivluk Rivers.

[d] Up to 25 of these were not in the range of the WAH.

[e] Of these, 24 were in the range of the WAH.