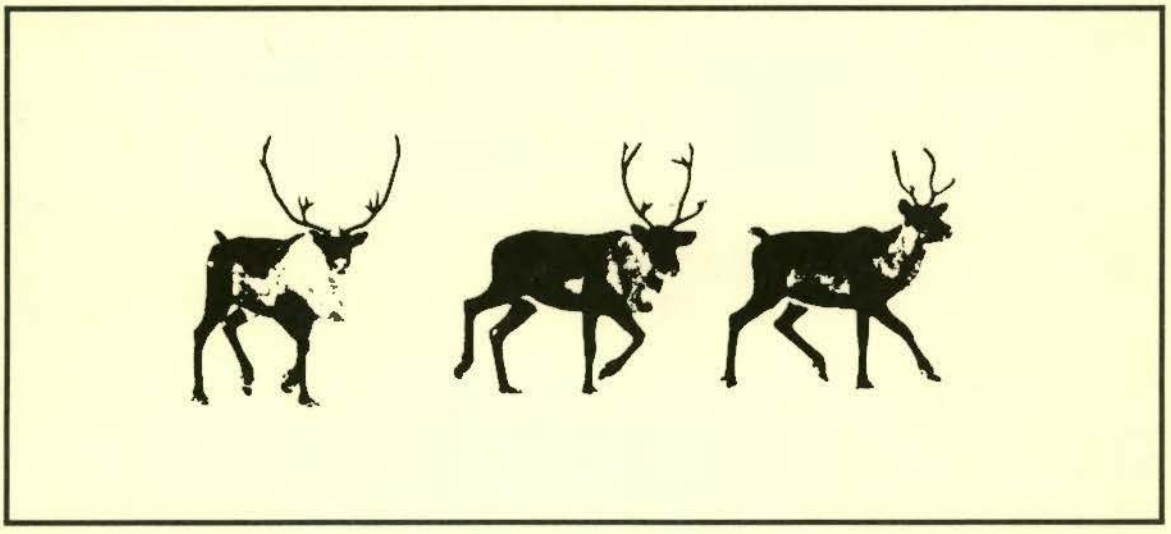
Alaska Department of Fish and Game
Division of Game
Federal Aid in Wildlife Restoration
Research Progress Report

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



by
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Project W-22-6
Job 3.33
July 1988

STATE OF ALASKA
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PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperator: Steve Fleischman, University of Alaska, Cooperative Wildlife Research Unit

Project No.: W-22-6 Project Title: Big Game Investigations

Job No.: 3.33 Job Title: Demography of the Delta Caribou Herd Under Varying Rates of Natural Mortality and Harvest by Humans

Period Covered: 1 July 1986-30 June 1987
(Includes data through April 1987)

SUMMARY

Some of the progress during this reporting period was summarized in 3 papers that were presented at the 3rd North American Caribou Workshop (Chena Hot Springs, Alaska) in November 1987. An abstract, a draft manuscript, and an expanded abstract for these papers are included in Appendices B through D, respectively (Davis et al. 1988, Valkenburg et al. 1988, Adams et al. 1988).

This study is an expansion of, and is complementary to, Projects W-21-2 and W-22-1 through W-22-4 (Job 3.27R); a final report for these projects has been published (Davis and Valkenburg 1985). A progress report for this study was published in 1987; both reports contain relevant background material.

Distribution of the Delta Caribou (Rangifer tarandus granti) Herd (DCH) and Yanert Caribou Herd (YCH) overlapped during the census of postcalving aggregations in 1987. The 1987 census resulted in a combined estimate of 8,380 caribou (including calves) in these herds. Natality data were obtained primarily from monitoring radio-collared females from the DCH and YCH. Natality remained relatively high at 89% in 1987. On 6 April 1988 we classified 1,280 caribou according to sex and age so that an estimate of overwinter calf survival could be made; the unadjusted calf:cow ratio of this group was 29:100.

Key Words: caribou, census, Delta Herd, demography, grizzly bear, Ursus arctos, mortality, population dynamics, Rangifer, recruitment, wolf, Yanert Herd.

CONTENTS

BACKGROUND

The Alaska Department of Fish and Game's (ADF&G) goals for caribou (Rangifer tarandus granti) herds are to stabilize some of them at specific levels and to ensure that others do not decline below set minimum sizes; however, few caribou herds in Alaska have remained stable for more than a few years, and it has been particularly rare for a heavily harvested herd to remain stable. If these goals are to be accomplished and if any caribou management program is to be successful, understanding the mechanics of caribou population dynamics is essential. The factors that determine population dynamics for all wildlife species are the same: births, deaths, emigration,

and immigration. However, the specific variables affecting these 4 factors can differ greatly.

A quantitative assessment of the demography of an Alaskan caribou herd has never been conducted over a period when greatly varying rates of natural mortality and human harvest have occurred. In a recent workshop (Klein and White 1978) attended by leading caribou researchers in North America, the need for an intensive demographic study of one or more caribou herds in Alaska was identified.

Proximity of the Delta Caribou Herd (DCH) to Fairbanks, our considerable background information on the herd, and options for its intensive management (i.e., manipulation) make it ideal for a long-term demographic study. Regarding many aspects of general caribou ecology, hypotheses may be more feasibly tested on the DCH than on larger herds (i.e., Western Arctic or Porcupine Herds). A recent study of the DCH (Davis and Preston 1980) revealed that herd demography was misunderstood from 1975 through 1979. The DCH will continue to be intensively managed, so a thorough understanding of its demography is essential.

Davis and Neiland (1975) compiled all available data for the DCH in 1974. Additional background information has been presented by Davis and Preston (1980), Davis and Valkenburg (1981, 1983, 1985), and Davis et al. (1982, 1983). During the past 16 years, the population of the DCH has varied dramatically: declining from 5,000 in 1969 to about 2,000 in 1975 and increasing from about 2,000 in 1975 to 17,000 in 1982. Since 1982 herd growth has been slowed by hunting. During the past 16 years, high and low levels of both natural mortality and harvest have occurred, and much has been learned about caribou population dynamics (Davis et al. 1983). More importantly, much has been learned about the interrelationships between large predators, prey, and humans in Subunit 20A (Gasaway et al. 1983).

By continuing to study the DCH's demography and by simultaneously intensifying study of the herd's behavior, nutrition, energetics, and interaction with the biotic (including predators) and abiotic environment, we should ultimately understand caribou ecology to the degree presently demanded by the growing pressures on caribou and their habitat. Since study of the DCH was intensified in 1979, considerable data on herd movements and distribution have been collected. Skoog (1968:202, 655) and Bergerud (1974a) discussed movements and distribution mechanisms of caribou as they affect herd demography. As populations increase, caribou travel more widely and may increase their use of marginal ranges. Use of marginal ranges could result in lower natality and increased

mortality due to greater energy expenditures, poorer quality forage, and greater vulnerability to predation.

Our rudimentary understanding of the movements and distribution of caribou herds, as they relate to population demography, are sufficient to warrant collation and analysis of existing movement and distribution data. If the DCH continues to increase, any change in movements and distribution will be better interpreted if earlier patterns are well documented.

Opposing views are emerging among caribou biologists regarding basic social organization of caribou, including questions of herd identity, herd definition, and fidelity to calving areas and seasonal ranges (Bergerud et al. 1984, Carruthers 1985, Martell and Russell 1985). The known histories of radio-collared caribou in the DCH and the Yanert Caribou Herd (YCH) could prove invaluable in contributing empirical evidence about the social organization of caribou (Davis et al. 1986).

The use of aerial photography for estimating population size of caribou herds is becoming more popular. The assumption that all caribou that are photographed (including calves) can be counted from photos has not been validated. Many other caribou management and/or research techniques that are presently employed require validation. For example, the reliability of conducting herd composition counts in April as an indication of "yearling recruitment" has not been critically examined. Also, using a small cohort of radio-collared cows to estimate herd natality and calf survival has not been critically evaluated.

Availability of radio-collared caribou with known histories is requisite for several objectives of the current study. Fortunately, caribou that were collared for Job 3.27R (Davis and Valkenburg 1985) still have functioning radio collars and are available for study (Table 1).

GOAL

To estimate population parameters (birth, death, and dispersal) of the DCH and YCH and to evaluate field procedures for estimating those parameters.

OBJECTIVES AND PROCEDURES

1. Objectives a through g will be accomplished over a 5-year period (1986-90) by the ADF&G survey and inventory program and/or by this research project. Procedures for

these objectives have been described or cited in a prior Federal Aid report (Davis and Valkenburg 1985).

a. To census the DCH and the YCH in 1986, 1987, 1988, 1989, and 1990. We will use modified aerial photo-direct count-extrapolation (APDCE), radio-search, or total-count techniques (using 2 helicopters) to annually census the 2 herds.

b. To determine the annual natality rates and calving chronologies of the 2 herds. Monitoring about 50 radio-collared cows and sampling the herd at large will enable us to determine the natality rate. Other supporting information will be acquired by using a helicopter to aid in obtaining composition counts and udder counts. Documenting annual calving distribution is a priority.

c. To determine yearling recruitment in the DCH and the YCH. We will monitor the radio-collared cows to determine their natality rate and subsequent calf survival. Composition counts will be conducted during April on the herd at large. We will attempt to obtain random, even-sized subsamples to facilitate evaluation of bias and to calculate a confidence interval for the data. To ensure classification of entire groups, our sample design requires classifying approximately 100 caribou closest to each radio-collared caribou. This rationale for sampling assumes that the basic social structure of caribou consists of "temporary tenuous association(s) of individuals" (Lent 1965) or "open social units" (Bergerud 1974b) that have been validated for some Alaskan caribou herds through radiotelemetry studies (Valkenburg et al. 1983).

d. To measure harvest by hunters. Survey and inventory program staff will collect harvest data through various reporting procedures.

e. To determine when major mortality occurs to both calves and adults and to characterize caribou dying from natural causes. Data from radio-collared caribou and composition counts will determine the chronology of calf mortality. Survival rates of adult caribou will be calculated from the radio-collared caribou. Carcasses of caribou dying from natural causes will be collected and examined.

f. To determine caribou:predator ratios in the range of the DCH and YCH. These ratios will be determined

using data from (1) annual caribou censuses, (2) caribou distribution surveys of radio-collared caribou, (3) results of wolf (Canis lupus) surveys conducted in GMU 20A by the management staff (augmented by our surveys when required), and (4) results of a concurrent ADF&G study of grizzly bears (Ursus arctos) (Reynolds et al. 1987).

g. To determine the seasonal movements, distribution, and fidelity to respective calving grounds of radio-collared caribou. We will locate all radio-collared caribou monthly and monitor all female radio-collared caribou 2 or more times during the calving period.

2. Objectives a through k will be addressed by collecting data during 1 or more years of this 5-year study.

a. To determine if bearing a calf when a cow is 24-36 months old or for several successive years influences the probability of calving in subsequent years. We will keep active radio collars on about 50 cows to determine their reproductive history.

b. To determine if there are any differing cohort-specific pregnancy probabilities for cows 24 or 36 months old. Same procedure as 2a.

c. To determine if the natality rate of 24- and 36-month-old cows is determined by their weight at the time of the rut. We will collar ten 12-month-old females in each cohort to determine natality rate at 24 months. We will weigh 16-month-old females and correlate their weight with subsequent natalities.

d. To determine if caribou killed by predators are taken in proportion to their representation in the population in terms of sex and age. We will compare the sex and age data of radio-collared caribou killed by predators with data from the total radio-collared sample. We will do likewise for caribou in the population at large.

e. To determine the correlation between wolf abundance and the number of caribou killed by wolves. Estimates of the population size and distribution of caribou and wolves as well as caribou mortality rates from wolf predation will allow this correlation to be tested.

f. To determine if DCH and YCH caribou are faithful to their respective calving grounds. We will determine this by monitoring radio-collared cows and by conducting aerial surveys of the respective calving areas.

g. To determine if dispersal is important to the population dynamics of the DCH and YCH. We, including those individuals involved in concurrent studies, will monitor radio-collared caribou in the Delta, Yanert, Denali, Nelchina, Macomb, and Fortymile Herds. Also, annual censuses should identify major increases or declines that suggest immigration or emigration has occurred.

h. To compare food habits of the Delta, Yanert, Denali, and Fortymile Herds. Monthly fecal pellet collections will be made for herds where data are currently unavailable.

i. To determine if all caribou photographed during censuses appear as discrete images and are enumerated during photo interpretation. Ground counts will be made to determine the exact number of calves and older caribou in groups that will subsequently be photographed at the scale (i.e., altitude) used during censuses. Different scales, photo angles, and film will be evaluated.

j. To determine if yearling recruitment is precisely and accurately estimated by conducting herd composition surveys in April. Precision will be tested by conducting aerial counts of the same sample area (e.g., on successive days, weeks, or months). Evaluating accuracy will involve modeling for the cross-checking recruitment data.

k. To identify the limits of validity in using a small sample of radio-collared cows to estimate herd natality and recruitment. Modeling results will be compared with empirical data from the herd at large and from the radio-collared cohort. The validity of judging calf recruitment by monitoring radio-collared females will be evaluated by determining when the cow-calf bond breaks and the sex and age of caribou that unbonded calves associate with.

STUDY AREA

Skoog (1968) originally described the range of the DCH. Based on subsequent study, Hemming (1971) modified Skoog's description and described the physical environment. Little has changed since Hemming's revision. The DCH currently ranges over about 9,600 km² on the northern slopes of the Alaska Range between the Nenana River on the west and the Delta River on the east (Fig. 1); the area lies approximately 110 km south of Fairbanks. The Alaska Range rises abruptly from its foothills and consists of rugged, glaciated ridges 1,830-2,740 m in elevation interspersed with glacier-capped mountains exceeding 3,660 m. The northern foothills of the Alaska Range are flat-topped ridges 610-1,370 m in elevation separated by rolling tussock tundra and muskegs and lowlands covered in spruce (Picea spp.). North of the foothills lies the predominantly spruce-covered Tanana Flats. The entire area is drained by the Tanana River.

The transition is abrupt from the foothills to the Tanana Flats. The Flats have little relief, and elevations range from 130 to 300 m. The Flats are underlain by permafrost; consequently, the drainage is poor, resulting in numerous shallow ponds and extensive bogs.

Fire has greatly influenced the lowland vegetation, resulting in the creation of a mosaic of shrub and young forest-dominated seres, climax bogs, and mature black spruce (P. mariana) forests (LeResche et al. 1974). Fires have also occurred on the calving area and adjacent tundra and uplands (Davis et al. 1985). Vegetation in the hills, foothills, and mountains grades from taiga of white spruce (P. glauca), black spruce, paper birch (Betula papyrifera), and quaking aspen (Populus tremuloides) into shrub communities of willow (Salix spp.), and dwarf birch (B. glandulosa and B. nana) at low elevations and alpine tundra at high elevations (LeResche et al. 1974).

The study area is largely snow-free from May until October. Temperatures annually range from approximately 29 C to -51 C. Annual precipitation averages about 30 cm; snow accumulation averages 0-50 cm and rarely exceeds 80 cm. Ground vegetation in the foothills and mountains is frequently exposed during winter because of strong winds. Although the DCH is widely distributed from the mountains to the flats during winter, foothills appear most used.

As calving time approaches, cows and many short yearlings move into the upper portion of the Little Delta River and Delta Creek to the traditional core calving areas (Fig. 1), which have been used since before the 1950's. Most calves are born

in tussock tundra, but many others are born in the low-shrub and sparse spruce-dominated areas. Most bulls and some short yearlings remain widely scattered throughout the herd's entire range during calving.

In this report, all references to the DCH prior to 1980 include the Delta and Yanert Herds.

RESULTS AND DISCUSSION

Census of the DCH and YCH

On 2 July 1987 J. Davis and E. Crain used a Bellanca Scout to census the combined DCH and YCH. All groups containing more than 50 caribou were photographed with 35-mm SLR cameras using color print film (Kodak VRG, 100 ASA). The aircraft combined radio tracking and visual searches of the area adjacent to the locations of radio-collared caribou in the Yanert River watershed and the adjoining portion of the Wood River drainage. The Bellanca Scout was used on 3 July to search areas peripheral to where caribou were located on 2 July and to locate 2 radio-collared caribou not found on 2 July.

The 1987 census located 8,380 (i.e., $\bar{x}$ of high and low number counted on photos) caribou in association with (or in the proximity of) the radio-collared DCH and YCH caribou. Hence, 8,380 is the mean of our high and low estimate for the combined size of the DCH and YCH (Appendix A).

During the 1987 census, distribution of the radio-collared DCH caribou overlapped that of the YCH caribou; this factor made it difficult to estimate the number of caribou in either the DCH or YCH alone. We attempted to estimate the YCH population size during the rut, but we aborted the attempt because approximately one-third of the radio-collared DCH caribou were within the YCH distribution at the time.

Natality Rate

During this reporting period, natality data were obtained primarily from radio-collared DCH caribou (Table 2).

Yearling Recruitment in the DCH and YCH

The April 1987 composition survey of the DCH obtained 14 subsamples (n = 1,280) totaling 838 cows, 199 bulls, and 243 short yearlings (i.e., 11 months old) (Table 3).

Harvest by Hunters

Historical harvest data for the DCH and YCH are summarized in Table 4. Historical hunting seasons and bag limits are

summarized in Tables 5 and 6 for the YCH and DCH, respectively. During regulatory year 1987-88, M. McNay and others manned a hunter check station near the main access route for hunters seeking YCH caribou, and they contacted several hundred DCH hunters while they were in the field. McNay's field checks will ultimately be used to determine the rate of reporting by successful and unsuccessful hunters via the hunter report card or harvest ticket systems presently in use. The hunter reporting data will appear in the 1987-88 S&I report for the DCH and YCH.

Mortality

Serial herd composition surveys at the end of calving and during fall and late winter in 1987 (Tables 7 and 8) were our principal means of determining the timing of calf mortality. The composition surveys, however, gave little insight into principal sources of mortality on calves.

Mortality in the DCH was the subject of a paper (Davis et al. 1988) we presented at the 3rd North American Caribou Workshop (Chena Hot Springs, Alaska) in November 1987. The manuscript will appear in the workshop proceedings, and the abstract is included as Appendix B.

Wolf:Caribou and Grizzly Bear:Caribou Ratios

Our last progress report (Davis et al. 1987) presented the data base and rationale for calculating and discussing wolf:caribou and grizzly bear:caribou ratios in both the DCH and YCH. Although we have attained additional caribou census data and an updated estimate of wolf abundance, the general discussion in our last report does not warrant updating. Wolf numbers, pack distribution, harvest rate, necropsy data, and burdens of radio-cesium will be reported in the next progress report.

Seasonal Movements, Distribution, and Fidelity to Calving Grounds

Throughout the study period, we monitored radio-collared caribou to document seasonal movements and distribution. A University of Alaska, Cooperative Wildlife Research Unit Master of Science project by Steve Fleischman is contributing toward collation, analysis, and interpretation of movements and distribution data. The thesis should be available in fall 1988.

In addition, we presented a paper on this subject at the 3rd North American Caribou Workshop. The manuscript (Valkenburg

et al. 1988) appears as Appendix C and will be published in the workshop proceedings.

Data to be Collected During 1 or More Years to Test Hypotheses

Some field data pertaining to several of the objectives (i.e., 2a-k, pp. 5-6) were collected. However, no in-depth analysis was conducted, so reporting will occur in subsequent reports.

Other Progress During This Reporting Period

In cooperation with the ADF&G survey and inventory wolf project, project personnel assisted in radio-collaring 11 wolf packs in GMU 20A. Because many objectives of this study require radio-collared caribou, we radio-collared a number of additional caribou during the study period and recollared others. Histories of radio-collared individuals are summarized in Table 1. General procedures are described in the methods of manuscripts in Appendices B and C. Further discussion of the use of carfentanil and naloxone as a capture drug and an antagonist, respectively, is included in an expanded abstract (Appendix D) of a talk presented at the 3rd North American Caribou Workshop (Adams et al. 1988), and it will also appear in the workshop proceedings.

ACKNOWLEDGMENTS

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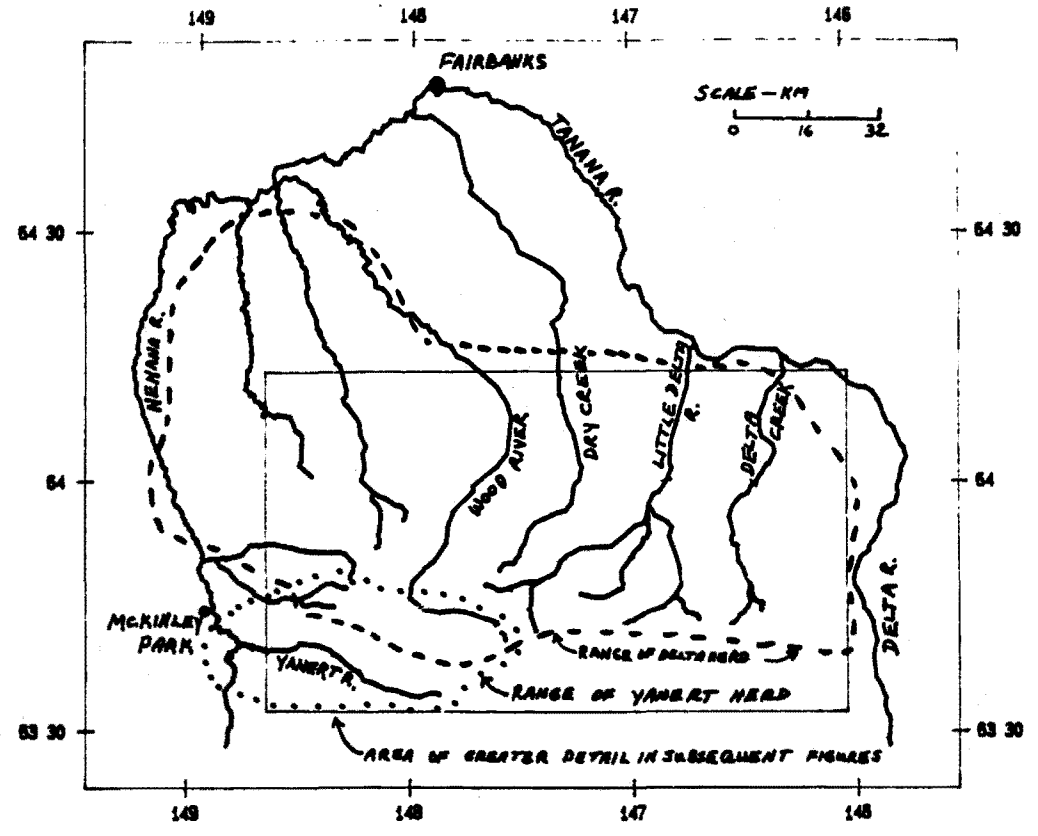

Fig. 1. Study area.

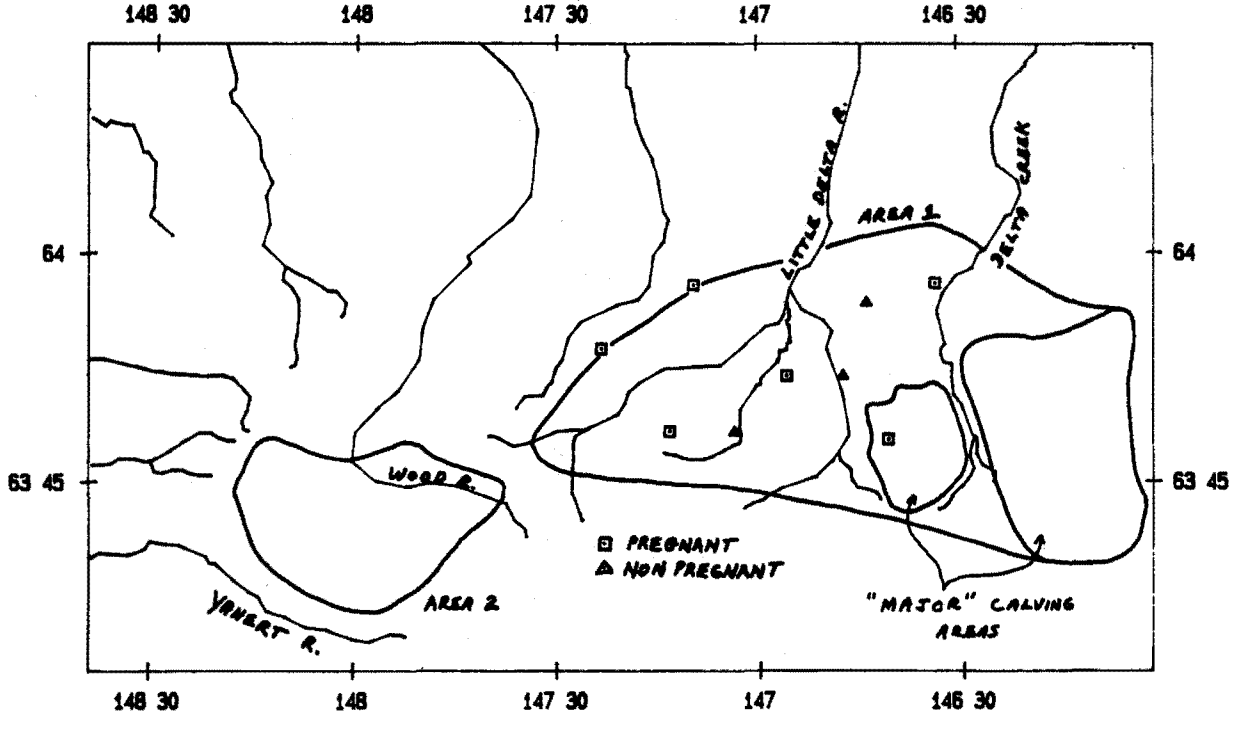

Fig. 2. Approximate calving locations of radio-collared parturient and nonparturient female Delta caribou older than yearlings in 1980.

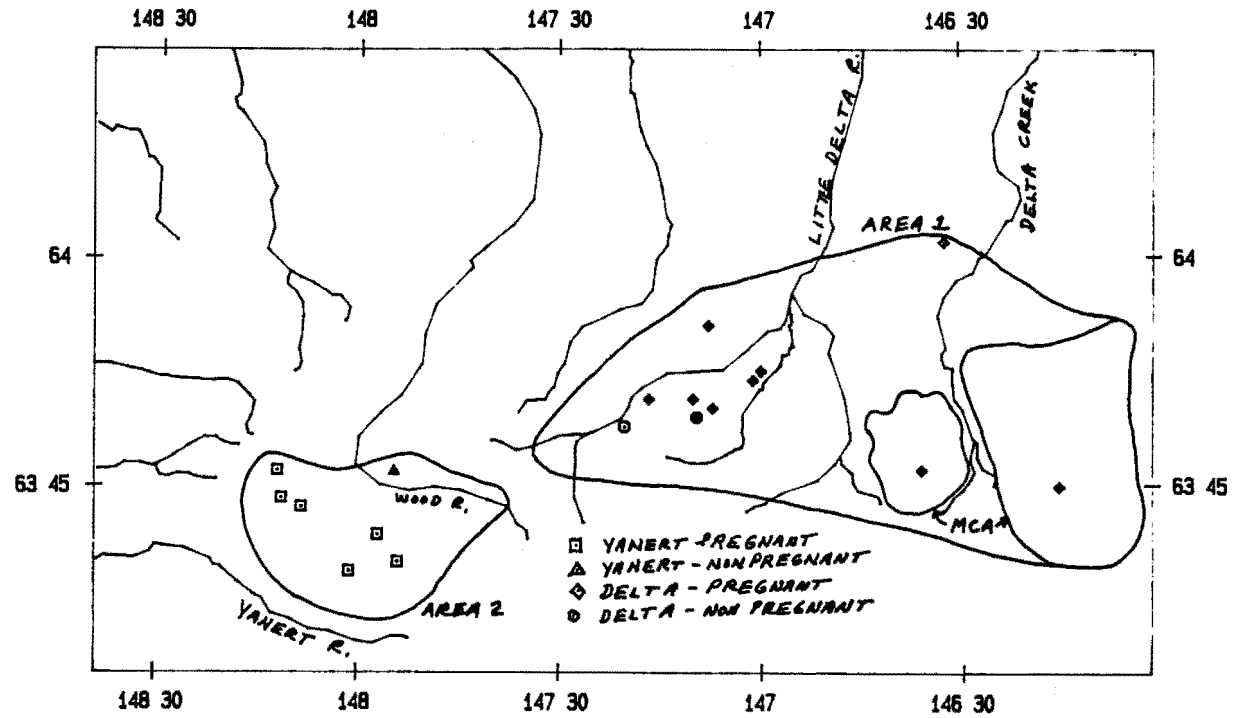

Fig. 3. Approximate calving locations of radio-collared parturient and nonparturient female Delta caribou older than yearlings in 1981.

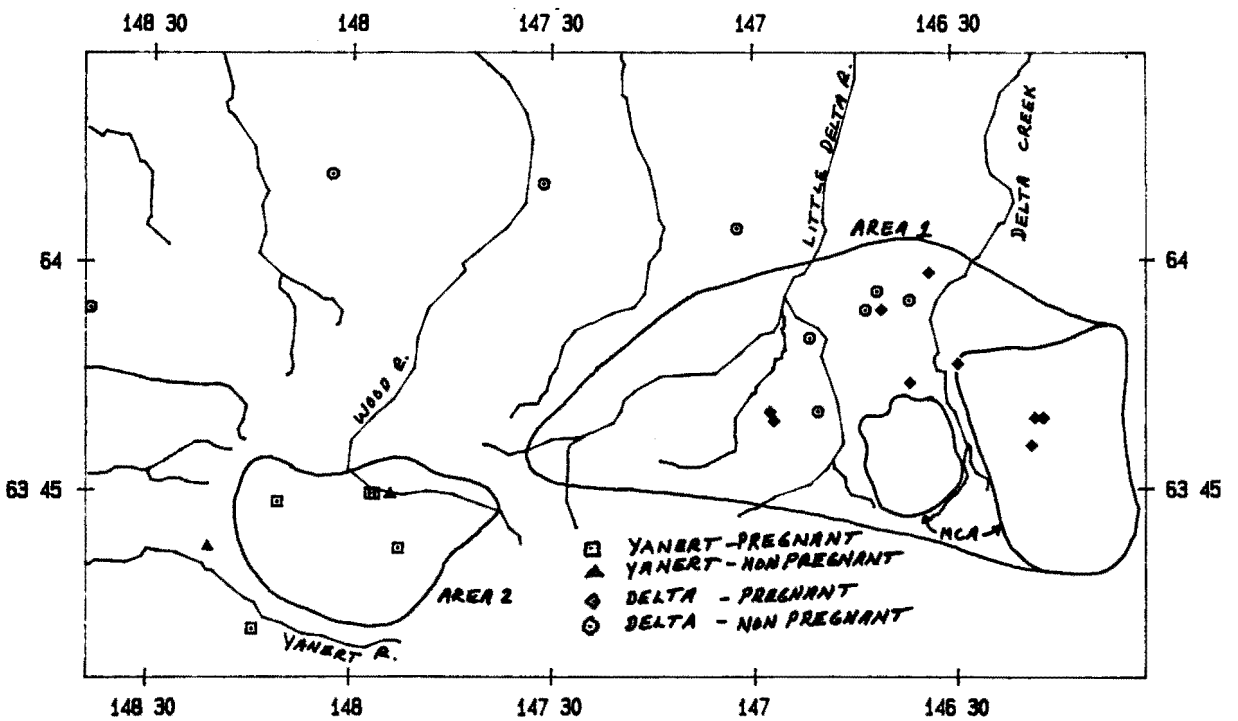

Fig. 4. Approximate calving locations of radio-collared parturient and nonparturient female Delta caribou oder than yearlings in 1982.

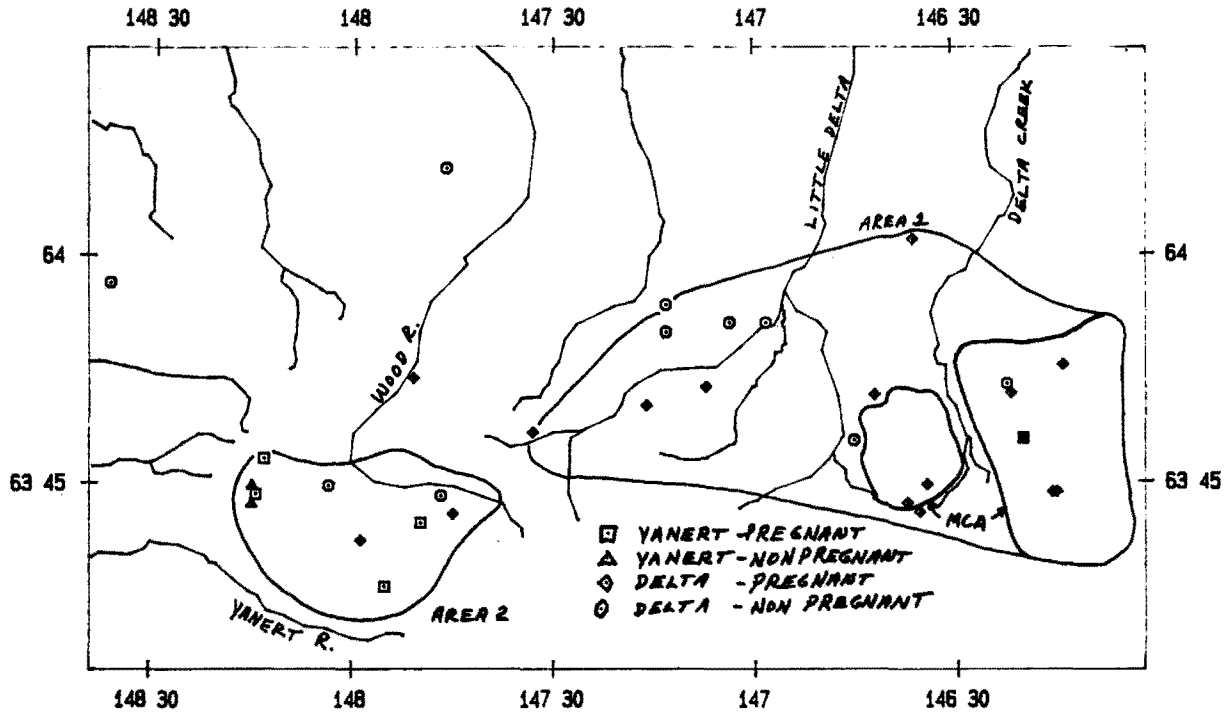

Fig. 5. Approximate calving locations of radio-collared parturient and nonparturient female Delta caribou older than yearlings in 1983.

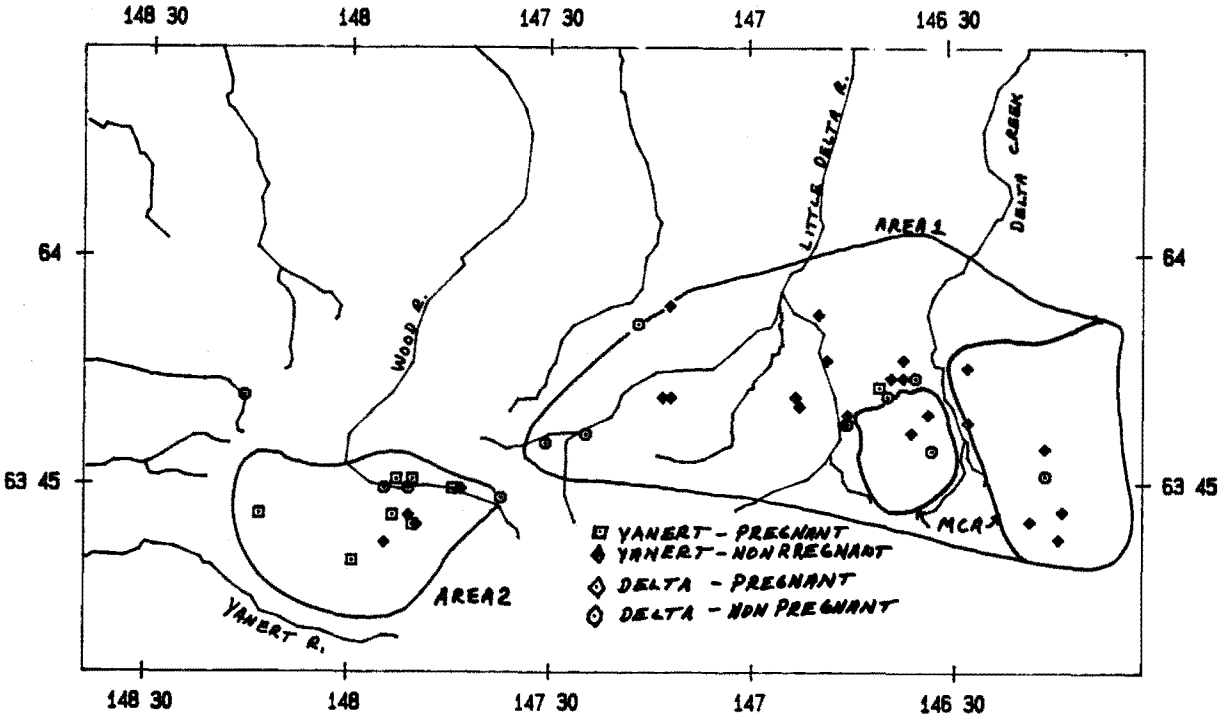

Fig. 6. Approximate calving locations of radio-collared parturient and nonparturient female Delta caribou older than yearlings in 1984.

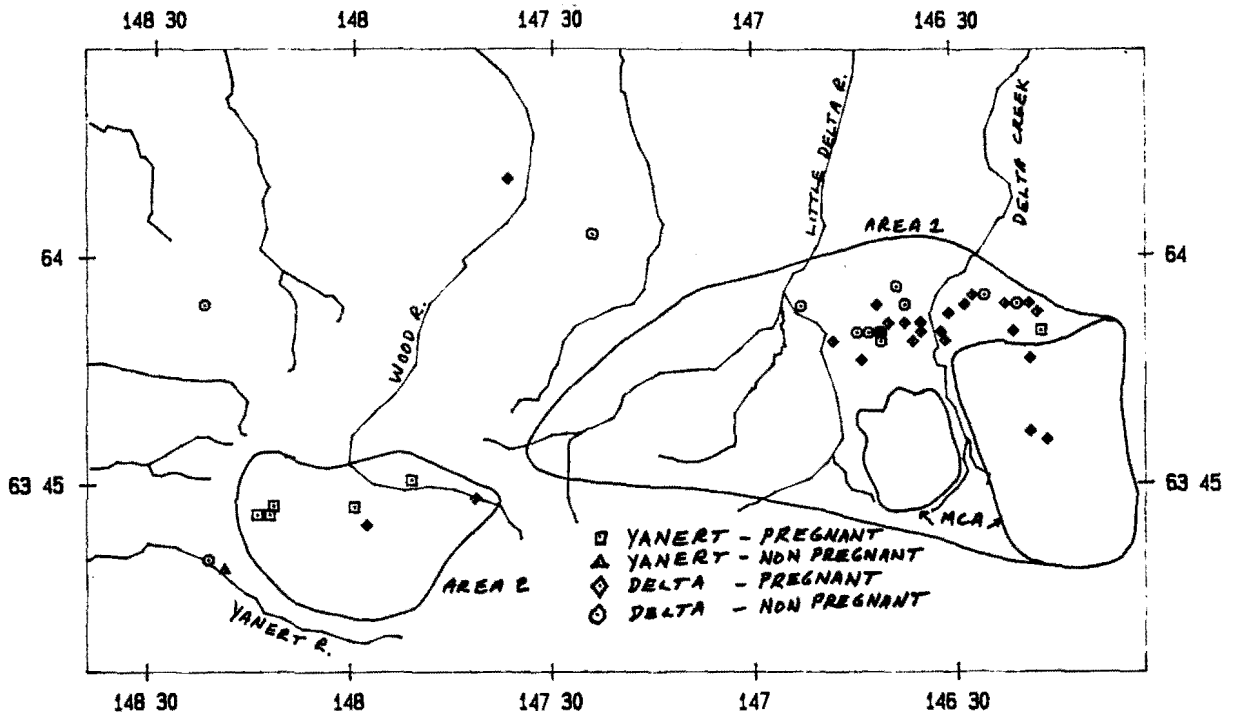

Fig. 7. Approximate calving locations of radio-collared parturient and nonparturient female Delta caribou older than yearlings in 1985.

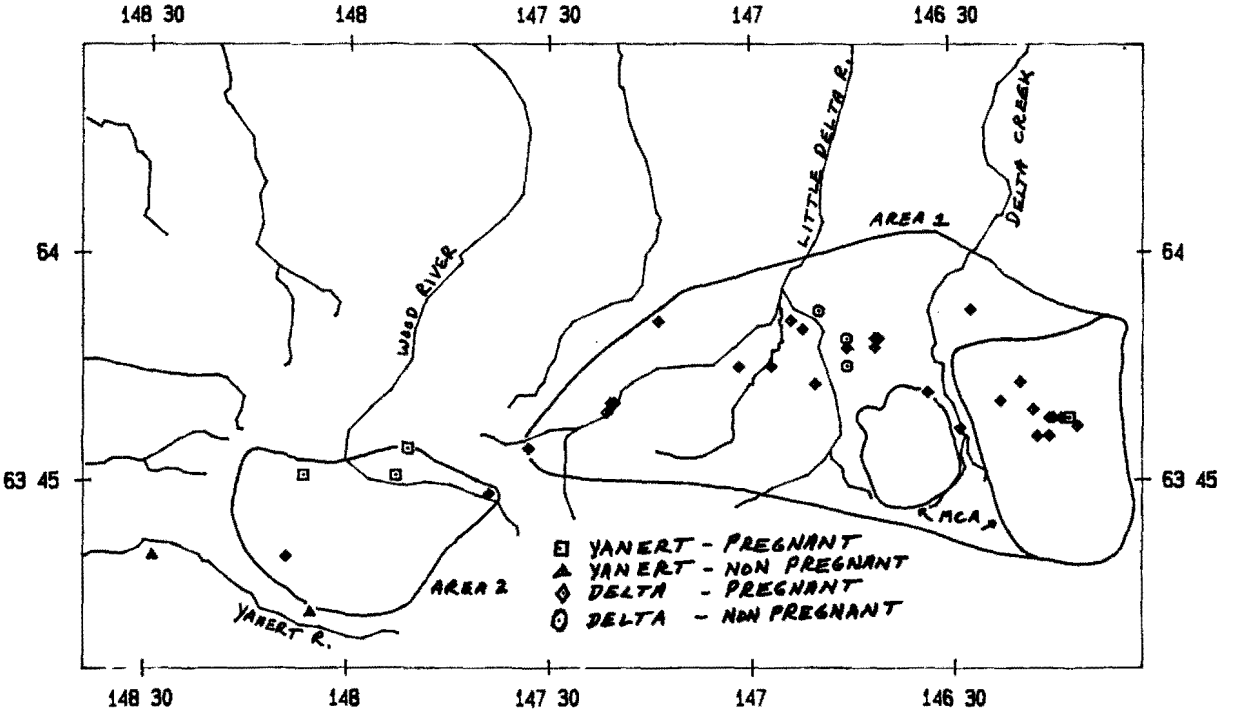

Fig. 8. Approximate calving locations of radio-collared parturient and nonparturient female Delta caribou older than yearlings in 1986.

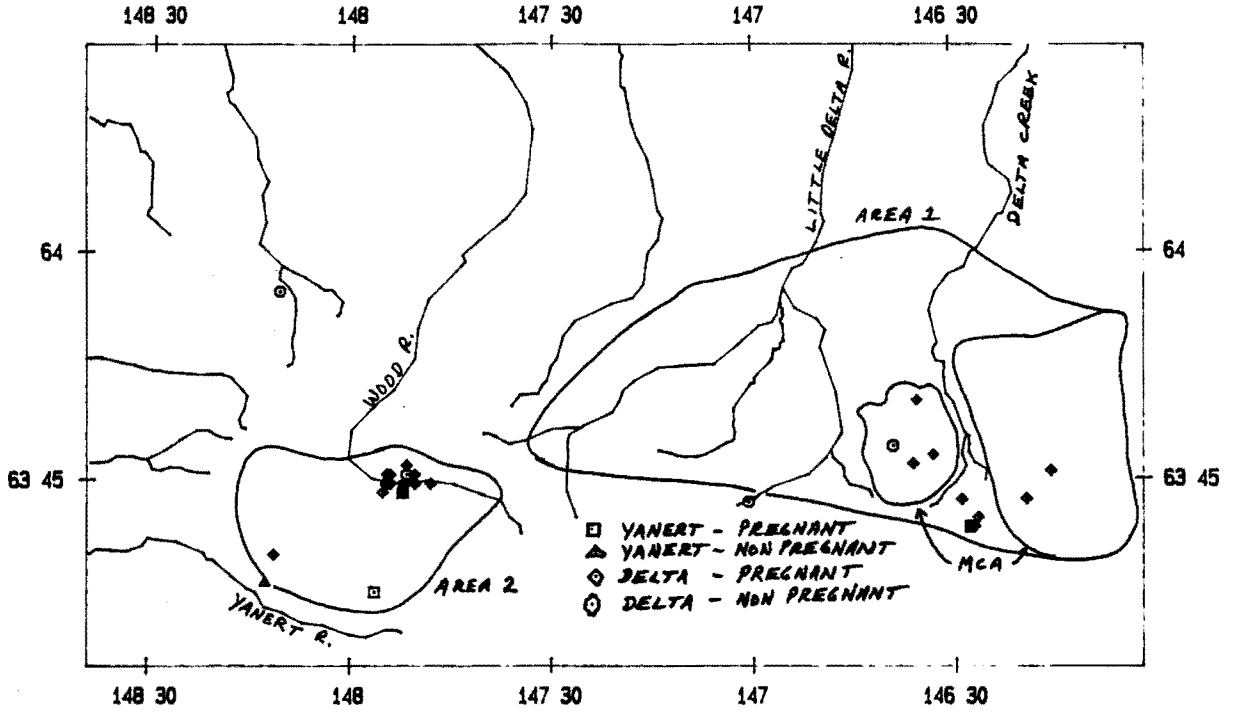

Fig. 9. Approximate calving locations of radio-collared parturient and nonparturient female Delta caribou older than yearlings in 1987.

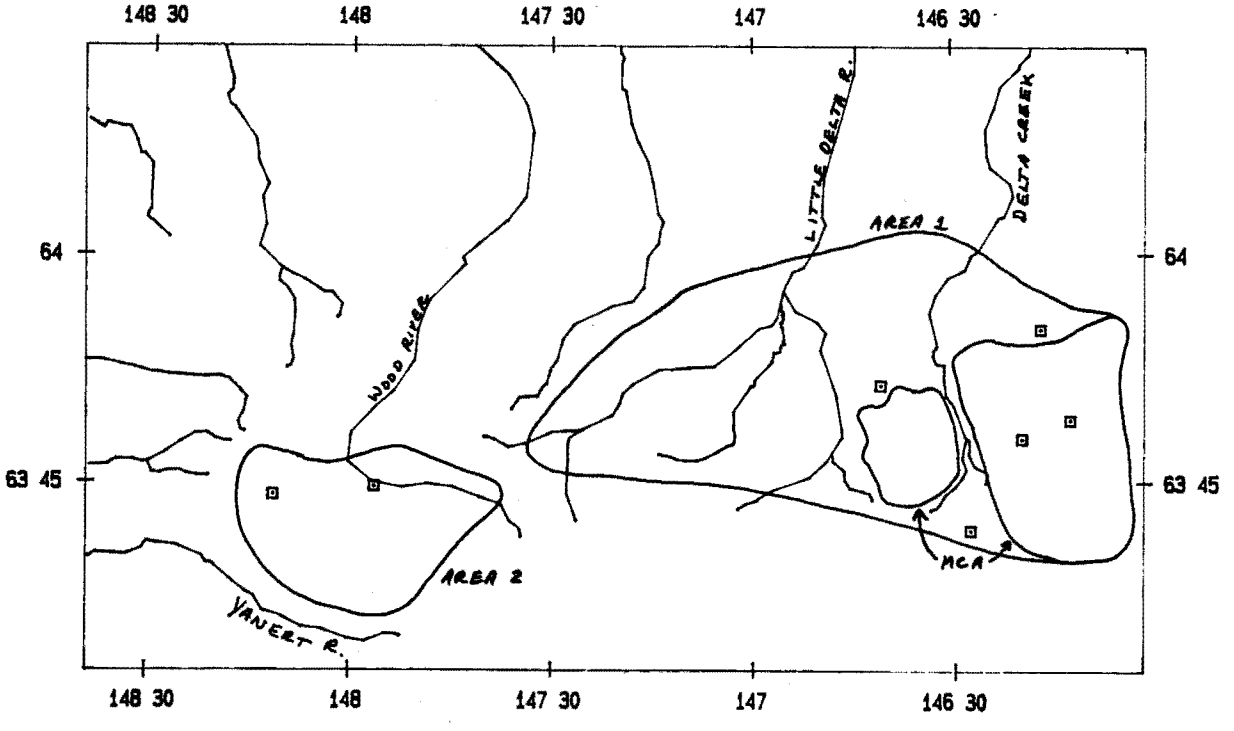

Fig. 10. Approximate calving locations of female no. 102368, 1981-87.

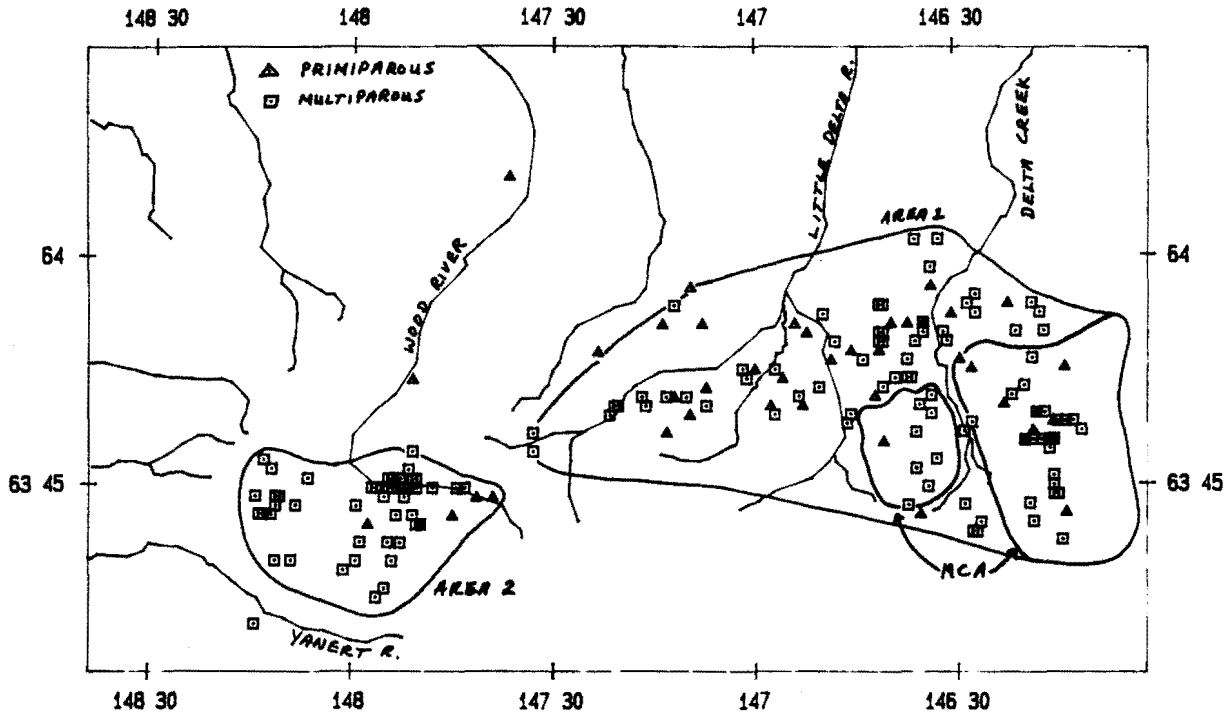

Fig. 11. Approximate calving locations of primiparous and multiparous radio-collared female Delta and Yanert caribou, 1980-87.

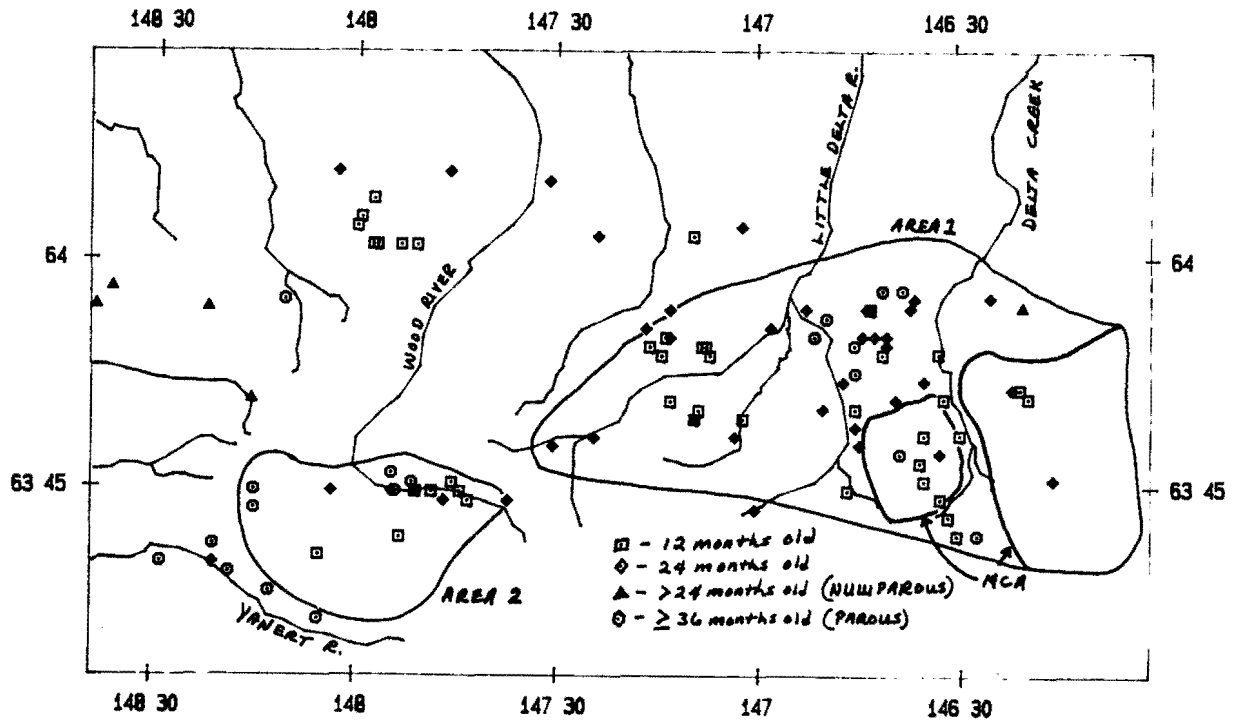

Fig. 12. Approximate locations of radio-collared nonparturient female Delta and Yanert caribou during the peak of calving, 1979-87.

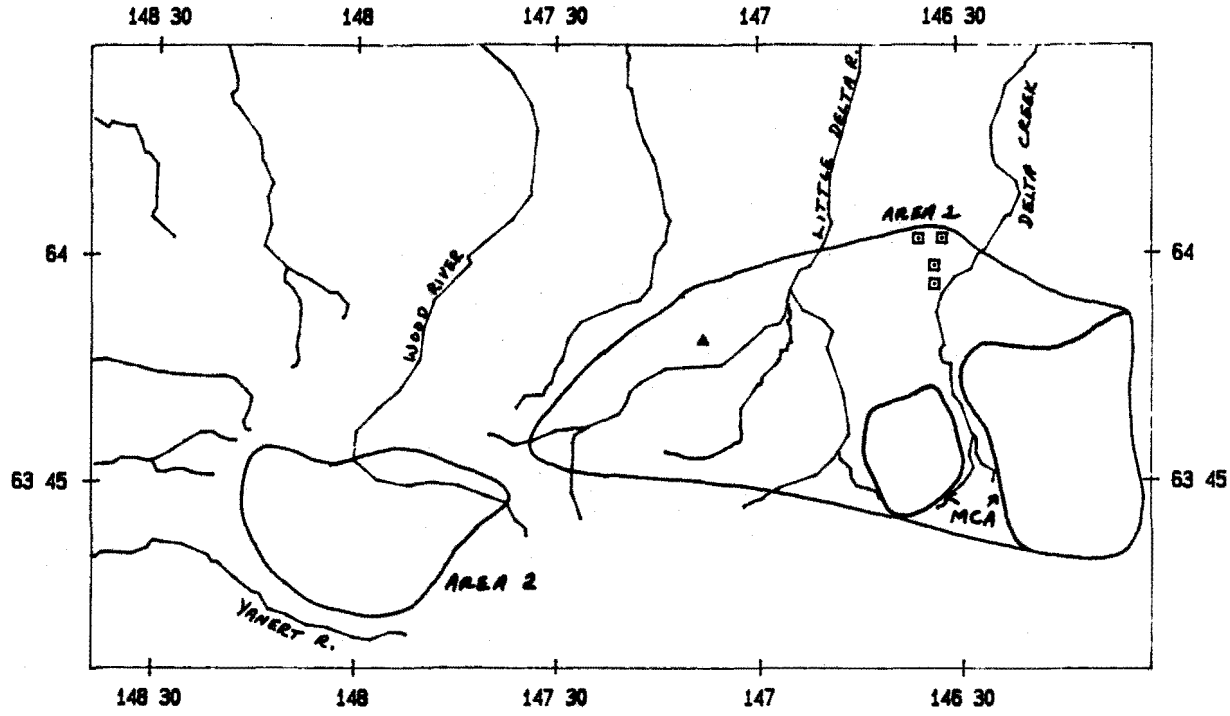

Fig. 13. Approximate locations of female no. 101972 during the peak of calving, 1980-84.

Table 1. Permanent accession numbers and other pertinent information for radio-collared Delta and Yanert Herd caribou, 1979-88.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
101972	Y36	78	F	02/11/82	D	Dead unknown cause 1/84
101972	R57	78	F	01/04/79	D	Recollared 2/11/82
101973	R53	78	F	01/04/79	D	Recollared 2/11/82
101973	Y28	78	F	02/11/82	D	Possible bear kill 9/11/85
101974	R88	78	F	01/08/79	D	Recollared 2/11/82
101974	B 3	78	F	11/21/85	D	
101974	Y37	78	F	02/11/82	D	Recollared 11/21/85
101975	B62	78	M	01/09/79	D	Probable wolf kill 2/16-19/79
101976	R17	78	M	01/09/79	D	Missing after 4/79
101977	Y49	78	F	02/26/82	D	Probable capture mortality 3/82
101977	R78	78	F	01/09/79	D	Recollared 2/26/82
101978	Y57	78	M	01/09/79	D	Died unknown cause 3/79
101979	R18	78	M	01/04/79	D	Shot 11/80
101980	Y58	78	M	01/10/79	D	Missing 2/79
101981	Y20	78	F	05/30/81	D	Capture mortality
101981	R59	78	F	01/10/79	D	Recollared 5/30/81
101982	Y78	78	F	02/11/82	D	Collar failed 5/27/85
101982	R52	78	F	01/10/79	D	Recollared 2/11/82
101983	Y59	78	M	01/10/79	D	Bear kill 8/80
101984	O57	78	F	11/21/85	D	
101984	Y47	78	F	02/26/82	D	Recollared 11/21/85
101984	R54	78	F	01/11/79	D	Recollared 2/26/82
101985	Y79	78	M	02/11/82	D	Shot 10/3/83
101985	Y56	78	M	01/11/79	D	Recollared 2/11/82
101985	R58	78	M	03/30/79	D	
101986	Y69	78	M	01/11/79	D	Missing 2/79

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
101987	R19	78	M	01/08/79	D	Shed collar 1/79
101988	R56	78	F	01/04/79	D	Recollared 2/26/82
101988	B 9	78	F	11/22/85	D	
101988	Y25	78	F	02/26/82	D	Recollared 11/22/85
101989	Y47	78	M	01/11/79	D	Dropped collar 6/79
101990	Y58	78	F	01/08/79	D	Capture mortality 1/8/79
101991	Y79	78	M	01/10/79	D	Radio failed 9/80
101992	B63	78	M	01/11/79	D	Radio failed 3/79
101993	Y26	78	F	02/26/82	D	Probably shot 8/84
101993	R/ 6	78	F	03/30/79	D	Recollared 2/26/82
101994	R79	78	F	03/30/79	D	Radio failed fall 80
101995	Y67	78	M	03/30/79	D	Missing 7/17/79
101996	B62	78	M	03/30/79	D	Radio failed 3/79
101997	O69	78	F	11/20/85	D	
101997	Y20	78	F	02/26/82	D	Recollared 11/20/85
101997	R/ 7	78	F	03/30/79	D	Recollared 2/26/82
102341	Y53	80	F	11/03/84	D	
102341	Y15	80	F	02/08/81	D	Recollared 11/3/84
102341	B 4	80	F	04/14/87	D	
102342	Y86	79	M	02/08/81	D	Probable wolf kill 2/81
102343	Y54	80	F	11/03/84	D	Wolf kill 4/15/86
102343	Y13	80	F	02/08/81	D	Recollared 11/3/84
102348	O46	80	F	04/15/87	D	
102348	Y68	80	F	10/30/84	D	Recollared 4/15/87
102348	Y14	80	F	02/27/81	D	Recollared 10/30/84
102349	Y12	79	F	02/27/81	D	Battery died 11/84

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
102350	047	78	F	04/22/86	D	Missing 5/86
102350	Y22	78	F	02/27/81	D	Recollared 4/22/86
102360	062	80	F	10/12/85	D	Wolf kill-tagging? 10/15/85
102360	Y16	80	F	03/22/81	D	Recollared 10/12/85
102361	046	80	M	11/02/84	D	Dropped or died 7/85 or 8/85
102361	Y21	80	M	03/22/81	D	Recollared 11/2/84
102362	074	0	F	11/03/84	D	Killed by wolves 7/22/86
102362	Y18	0	F	03/22/81	D	Recollared 11/3/84
102363	049	0	F	11/02/84	Y	Killed by predator 6/86
102363	Y29	0	F	04/17/81	Y	Recollared 11/2/84
102364	051	0	F	10/31/84	Y	
102364	Y30	0	F	04/18/81	Y	Recollared 10/31/84
102365	064	0	F	10/31/84	Y	
102365	Y31	0	F	04/18/81	Y	Recollared 10/31/84
102366	061	0	F	11/02/84	Y	
102366	Y32	0	F	04/18/81	Y	Recollared 11/2/84
102367	060	0	F	10/31/84	Y	
102367	Y33	0	F	04/18/81	Y	Recollared 10/30/84
102368	Y11	0	F	11/02/84	Y	Probable wolf kill 10/5/87-12/4/88
102368	Y34	0	F	04/18/81	Y	Recollared 11/2/84
102369	B 7	0	F	11/22/85	Y	Wolf kill 11/25/85
102369	Y35	0	F	04/18/81	Y	Recollared 11/22/85
102370	065	0	F	11/02/84	Y	
102370	Y70	0	F	04/18/81	Y	Recollared 11/2/84
102411	066	80	F	11/03/84	D	Died unknown cause 8/86
102411	Y19	80	F	05/30/81	D	Recollared 11/3/84

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
102412	063	80	F	10/30/84	D	Died unknown cause ca. 10/7/86
102412	Y23	80	F	05/30/81	D	Recollared 10/30/84
102413	Y51	80	F	10/30/84	D	
102413	Y27	80	F	05/30/81	D	Recollared 10/30/84
102413	030	80	F	04/14/87	D	
102546	Y 9	81	F	05/03/82	D	Died unknown cause 8/83
102547	Y10	81	F	05/03/82	D	Possible bear kill 5/5/82
102548	Y52	81	F	11/21/85	D	
102548	Y 7	81	F	05/03/82	D	Recollared 11/21/85
102549	047	81	F	10/20/85	D	Snared 1/26/86
102549	Y 6	81	F	05/03/82	D	Recollared 10/20/85
102560	052	81	F	10/20/85	D	
102560	Y 1	81	F	05/03/82	D	Recollared 10/20/85
102561	B 6	81	F	12/13/85	D	
102561	Y 4	81	F	05/03/82	D	Recollared 12/13/85
102562	B 5	81	F	11/21/85	D	Shot 9/86
102562	Y 2	81	F	05/03/82	D	Recollared 11/21/85
102563	044	81	F	11/21/85	D	Capture mortality ca. 11/25/85
102563	Y 5	81	F	05/03/82	D	Recollared 11/21/85
102564	Y 3	81	F	05/03/82	D	Died unknown cause ca. 10/82
102565	B 4	81	F	11/21/85	D	Probable wolf kill 3/86
102565	Y 0	81	F	05/03/82	D	Recollared 11/21/85
102566	053	81	F	11/20/85	D	
102566	Y 8	81	F	05/03/82	D	Recollared 11/20/85
102803	Y40	82	F	04/01/83	D	Recollared 4/7/86
102803	043	82	F	04/07/86	D	
102804	Y43	82	F	04/01/83	D	Recollared 4/7/86
102804	B10	82	F	04/07/86	D	

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
102805	Y41	82	F	04/01/83	D	Recollared 4/22/86
102805	B 0	82	F	04/22/86	D	
102806	Y42	82	F	04/01/83	D	Recollared 4/21/86
102806	021	82	F	04/21/86	D	
102807	Y39	82	F	04/01/83	D	Died unknown cause ca. 8/83
102808	Y48	82	F	04/01/83	D	Recollared 4/21/86
102808	023	82	F	04/21/86	D	
102809	Y10	82	F	04/01/83	D	Recollared 4/22/86
102809	B11	82	F	04/22/86	D	Predator kill 10/5-11/27/87
102810	Y45	82	F	04/01/83	D	Recollared 4/21/86
102810	B 8	82	F	04/21/86	D	Died unknown cause 5/87
102811	Y44	82	F	04/01/83	D	Died unknown cause 5/85
102812	Y17	82	F	04/01/83	D	Recollared 4/7/86
102812	025	82	F	04/07/86	D	Shot 9/9/86
102813	NONE	82	F	04/01/83	D	
102814	Y46	82	F	04/01/83	D	Recollared 4/7/86
102814	024	82	F	04/07/86	D	
102815	Y 3	82	F	04/01/83	D	Recollared 4/21/86
102815	B 1	82	F	04/21/86	D	
102816	None	82	F	04/01/83	D	Capture mortality
102982	076	83	F	03/30/84	D	
102982	050	83	F	04/14/87	D	
102983	074	83	F	03/30/84	D	Capture mortality
102984	075	83	F	03/30/84	D	
102984	020	83	F	04/14/87	D	
102985	079	83	F	03/30/84	D	
102985	052	83	F	04/14/87	D	

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
102986	Y49	83	F	03/30/84	D	Dropped collar ca. 4/1/84
102987	071	83	F	03/30/84	D	Wolf kill 2/86
102988	078	83	F	03/30/84	D	
102988	051	83	F	04/14/87	D	
102989	072	83	F	03/30/84	D	
102989	033	83	F	04/14/87	D	
102990	070	83	F	03/30/84	D	
102990	Y47	83	F	04/15/87	D	
102991	067	83	F	03/30/84	D	Recollared 4/15/87
102991	032	83	F	04/15/87	D	
102992	077	83	F	03/30/84	D	
102992	062	83	F	04/14/87	D	
102993	Y50	83	F	03/30/84	D	
102993	044	83	F	04/14/87	D	
102994	Y49	83	M	04/13/84	D	Hunter kill 9/84
103042	Y62	0	M	10/30/84	D	Dropped 11/84
103043	Y63	0	M	10/30/84	D	Dropped early 3/85
103044	Y66	0	M	10/30/84	D	Shot 9/2/85
103045	Y64	0	M	10/30/84	D	Dropped collar 11/1/84
103046	Y61	0	M	10/30/84	D	Dropped collar 4/85 ??
103047	Y67	0	M	10/30/84	D	Dropped collar ca. 1/85
103048	Y60	0	M	10/31/84	Y	
103049	Y65	0	M	10/31/84	Y	Dropped collar 3/85
103050	Y52	0	M	10/31/84	D	Dropped collar 12/84

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
103051	Y59	0	M	10/31/84	D	Wolf/wolverine kill 12/4/87-1/13/88
103052	Y55	0	M	10/31/84	D	Shot 9/10/86
103054	059	0	M	11/02/84	Y	Hunter kill 9/3/85
103055	050	0	M	11/02/84	Y	Shot 9/9/86
103074	Y66	0	M	11/21/85	D	
103094	097	0	M	10/23/86	D	Wolf kill ca. 11/15/86
103095	096	0	M	10/23/86	D	Dropped collar 10/28/86
103096	095	0	M	10/23/86	D	Died within a week ca. 10/28/86
103097	045	0	M	10/23/86	D	Shot Iowa River/Portage 9/6/87
103111	094	0	M	02/27/87	D	
103112	092	0	M	02/27/87	D	
103113	091	0	M	02/27/87	D	Wolf kill 12/4/87-1/13/88
103114	090	0	M	02/27/87	D	
103115	096	0	M	02/27/87	D	
103130	031	86	F	04/15/87	D	
103131	042	86	F	04/15/87	D	
103132	035	86	F	04/15/87	D	
103133	036	86	F	04/15/87	D	
103134	039	86	F	04/15/87	D	
103135	038	86	F	04/15/87	D	Predator kill 10/5/87-1/30/88
103136	034	86	F	04/15/87	D	

Table 1. Continued.

Accession No.	Collar color and No.	Birth year	Sex	Date collared	Herd name	Comments
103137	041	85	F	04/15/87	D	
103138	037	84	F	04/15/87	D	
103139	040	86	F	04/15/87	D	Shot 11/87
103140	None	86	F	04/15/87	D	
103141	None	86	F	04/15/87	D	
103142	None	0	F	04/15/87	D	
103143	None	85	F	04/14/87	D	
103144	None	85	F	04/15/87	D	
103284	049	87	F	04/20/88	D	
103285	011	87	F	04/20/88	D	
103286	0 4	87	F	04/20/88	D	
103287	010	87	F	04/20/88	D	
103288	013	87	F	04/20/88	D	
103289	0 3	87	F	04/20/88	D	
103290	059	87	F	04/20/88	D	
103291	093	87	F	04/20/88	D	
103292	043	87	F	04/20/88	D	
103293	012	87	F	04/20/88	D	
103294	095	87	F	04/20/88	D	
103295	0 8	87	F	04/20/88	D	
103296	None	87	F	04/20/88	D	

Table 2. Comparison of natality rate of Delta, Western Arctic, and Fortymile Caribou Herds based on counts of calves and proportions of pregnant radio-collared females ≥2 years old, 1981-87.

Herd and year	Calf counts (late May or early June)			Radio-collared caribou ≥36 mos.		
	No. calves counted	No. cows counted	Calves: 100 cows	No. pregnant	Total	Natality rate (%)
Delta 1981	--	--	--	10	13	77
Delta 1982	108	151	72	7	10	70
Delta 1983	1,629	2,052	80	17	22	77
Delta 1984	395	482[a]	82	28	31	90
Delta 1985	--	--	--	38	41	93
Delta 1986	--	--	82	33[b]	40	83
Delta 1987	649	1,080	60	25	28	89
Western Arctic 1981	885	1,079	82	31	37	84
Western Arctic 1982	1,380	1,764	78	24	29	83
Fortymile 1984	1,072	1,478	72	20	23	87
Fortymile 1985	--	--	--	19	19	100
Fortymile 1986	--	--	--	20[c]	21	95
Fortymile 1987	--	--	--	18	19	95

[a] Includes some yearlings.

[b] Twenty-six had distended udders, 7 had hard antlers (indicating pregnancy but udder was not seen), 5 had no distended udder, and 2 were antlerless (udder was not seen, but neither one was a naturally polled animal).

[c] Sixteen had distended udders, 3 had hard antlers during calving, and 1 was seen in August and September with a calf following her.

Table 3. Sex and age composition of 14 caribou sample units, and identity of radio-collared caribou present in each sample, surveyed to estimate the ratio of 11-month-old calves:100 cows in the Delta Caribou Herd, 6 April 1988.

Sample unit	Cows	Calves			Bulls	Total	Radio-collared caribou present
		Male	Female	Total			
1	81	9	15	24	4	109	033
2	90	3	16	19	15	124	050
3	73	13	12	25	18	116	034
4	91	14	13	27	19	137	B 9
5	115	8	12	20	18	153	B 0,052
6	88	8	16	24	20	132	032
7	19	4	1	5	12	36	057,062
8	65	18	24	42	24	131	Y47
9	11	1	1	2	9	22	024
10	29	1	5	6	5	40	B 4
11	31	0	5	5	0	36	B10
12	10	2	3	5	1	16	Y52
13	85	15	14	29	38	152	039
14	50	5	5	10	16	76	036
Total	838	101	142	243	199	1,280	

29 calves:100 cows
24 bulls:100 cows

Table 4. Harvest from the Delta Caribou Herd and Yanert Caribou Herd, 1968-87.[a]

Year	Males N (%)	Females N (%)	Sex unk N (%)	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	
1982-83 (fall)	92	11	1	104	
1982-83 (winter)	101	65	3	169	
1982-83 (total)	193	77	4	274	
Delta 1983-84	576	98	20	694	
Yanert 1983-84	40	12	2	54	
Delta 1984-85	258	153	2	413	
Yanert 1984-85	77	22	0	99	130
Delta 1985-86	250	67	15	332	
Yanert 1985-86	52	12	0	64	
Delta 1986-87	260	77	4	341[d]	
Yanert 1986-87	54	16	2	72	

Table 4. Continued.

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

[b] From 1969 Alaska Department of Fish and Game Survey and Inventory Progress Report.

[c] From J. Sexton memo 3 December 1970.

[d] Independent assessment of harvest by M. McNay indicates that only about 54% of successful hunters report their kill (M. McNay files, ADF&G, Fairbanks) in the general season (i.e., correction factor may not apply to permit hunt).

Table 5. Hunting seasons and bag limits for Alaska's Yanert Caribou Herd, 1984-87.[a]

Year	Season	Bag limit
1984-85[b]	10 Aug-31 Mar Unit 20(A), that portion within the Yanert River drainage	1 caribou
1985-86[c]	1 Sep-28 Feb Unit 20(A) within the Yanert Controlled Use Area	1 caribou
1986-87[d]	1 Sep-28 Feb Unit 20(A) within the Yanert Controlled Use Area	1 caribou
1987-88	1 Sep-15 Sep 1 Jan-28 Feb Unit 20(A) within the Yanert Controlled Use Area	1 bull

[a] The 1st year that the Yanert Herd caribou season was not included as part of the Delta Herd season was 1984-85.

[b] Amended by emergency announcement to close the Yanert River drainage on 8 February 1985.

[c] Amended by emergency announcement to close the Yanert River drainage on 19 February.

[d] Amended by emergency announcement to close the Yanert River drainage on 14 January.

Table 6. Hunting seasons and bag limits for Alaska's Delta Caribou Herd, 1968-87.[a]

Year	Season	Bag limit
1968-69	10 Aug-31 Mar	3 caribou
1969-70	10 Aug-31 Mar	3 caribou
1970-71	10 Aug-31 Mar	3 caribou
1971-72	10 Aug-31 Mar	3 caribou
1972-73	10 Aug-31 Mar	3 caribou
1973-74[b]	10 Aug-31 Dec	1 caribou
1974-75[c]	10 Aug-20 Sep	1 caribou
1975-76 through 1979-80	No open season	
1980-81	1 Sep-30 Sep	1 male by drawing permit. 200 permits issued.
1981-82	10 Aug-30 Sep 15 Nov-31 Dec	1 caribou by drawing permit from 10 Aug-30 Sep; 150 permits issued, up to 25 will be issued to nonresidents. Antlered caribou may be taken from 15 Nov-31 Dec by registration permit. A total of 400 caribou may be taken.
1982-83	10 Aug-30 Sep 1 Dec-31 Mar	1 caribou by drawing permit from 10 Aug-30 Sep; 175 permits issued, up to 30 will be issued to nonresidents. Antlered caribou may be taken from 1 Dec-31 Mar by registration permit. A total of 500 caribou may be taken.
1983-84[d]	10 Aug-31 Mar	1 caribou

Table 6. Continued.

Year	Season	Bag limit
1984-85[e,f]	20 Aug-20 Sep	1 caribou by registration permit only. 600 caribou may be taken. The 20 Aug-20 Sep season will be closed when 300 caribou have been taken; the 1 Feb-31 Mar season will be closed when the total harvest reaches 600 caribou.
	10 Aug-31 Mar	1 caribou.
1985-86[g] Alaskan Residents	10 Aug-31 Dec Unit 20(A) north of the Yanert Controlled Use Area, west of Wood River Controlled Use Area, and south of the Rex Trail	1 caribou by Tier II hunting permit only. 200 permits will be issued.
	1 Sep-15 Sep Remainder of Unit 20(A)	1 caribou
1985-86 Nonresidents	No Open Season Unit 20(A) north of the Yanert Controlled Use Area, west of Wood River Controlled Use Area, and south of the Rex Trail	
	1 Sep-15 Sep Remainder of Unit 20(A)	1 caribou
1986-87	6 Sep-31 Dec Unit 20(A) north of the Yanert Controlled Use Area, west of Wood River Controlled Use Area, and south of the Rex Trail	1 caribou by drawing permit only. 200 permits will be issued.
	1 Sep-15 Sep Remainder of Unit 20(A)	1 caribou

Table 6. Continued.

Year	Season	Bag limit
1987-88	10-25 Aug 21 Sep-31 Dec Unit 20(A) north of the Yanert Controlled Use Area, west of Wood River Controlled Use Area, and south of the Rex Trail	1 caribou by drawing permit only. 200 permits will be issued.
	1-15 Sep Remainder of Unit 20(A)	1 bull

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

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

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

[d] Amended by emergency announcement to close 28 October, except the Yanert River drainage which remained open through 31 March.

[e] Amended by emergency announcement to close 5 September, except the Yanert River drainage.

[f] Amended by emergency announcement to close the Yanert River drainage on 8 February 1985.

[g] The 1985-86 seasons and bag limits which for the 1st time (at least since 1968) differentiated between residents of Alaska and nonresidents was the result of a judicial ruling which said the State Subsistence Bill had not been properly implemented.

Table 7. Sex and age composition of Alaska's Yanert Caribou Herd, 1982-88.

Date	Bulls: 100 cows	Yrlgs: 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
11/26/82	59	0	36	0	0	18	56	51	156	30	92	304
4/13/84	22	0	44	0	0	26	44	60	101	13	22	167
10/12/85	65	0	40	0	0	19	152	49	383	32	252	787
5/2/86	21	0	49	0	0	29	53	59	107	12	22	182
10/22/86	70	0	38	0	0	18	105	48	274	34	191	570
10/5/87[a]	41	0	38	0	0	21	192	56	505	23	209	906

[a] Sample contains many Delta Herd caribou. Distribution of radio-collared caribou from the Delta and Yanert Herd confirmed overlap of the 2 herds at the time these data were obtained.

Table 8. Sex and age composition of Alaska's Delta Caribou Herd, 1969-88.

Date	Bulls: 100 cows	Yrlgs: 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	85	15	116	53	410	21	166	777
10/21-23/70	77	23	34	9	88	14	129	42	383	33	296	896
10/29-31/71	29	11	16	7	78	9	109	64	738	18	214	1,139
10/27-31/72	32	6	10	4	46	7	85	67	795	21	259	1,185
10/23-24/73	28	4	10	3	29	7	76	70	735	20	210	1,050
10/23-25/74	27	2	2	1	16	1	17	76	868	21	240	1,141
6/11-12/75	3	1	12	1	3	11	108	86	839	2	26	976
6/3/76	1	0	41	0	0	28	395	70	955	1	15	1,365
6/6-22/76	1	0	55	0	0	35	390	63	699	1	10	1,099
10/29-31/76	38	1	45	1	5	24	258	54	572	20	220	1,055
6/16-19/77	9	12	34	8	95	22	269	64	784	6	76	1,224
10/26-31/77	32	6	42	3	44	23	319	55	756	18	246	1,365
6/13-14/78	12	8	23	6	52	16	157	69	661	8	81	951
10/26/78	75	10	39	5	33	17	126	44	324	33	242	725
6/23/79	12	18	45	10	76	26	189	57	424	7	49	738
12/7/79	39	0	65	0	0	32	115	49	177	19	69	361
6/14/80	18	0	43	0	0	27	324	62	748	11	137	1,209
10/80	85	0	49	0	0	21	288	43	585	36	496	1,369
6/17/81	13	16	34	9	87	21	182	62	543	8	68	880
10/2/81	59	0	41	0	0	21	319	50	776	29	458	1,553
5/23/82	0	0	72	0	0	42	108	58	151	0	0	259
10/8/82	54	0	29	0	0	16	215	55	736	30	398	1,349
11/26/82	60	0	38	0	0	19	65	51	173	30	104	342
4/20/83	23	0	29	0	0	19	205	66	708	15	166	1,079
5/21/83	0	7	80	7	275	41	1,629	52	2,052	0	26	3,982
6/15/83	4	0	51	0	0	33	522	64	1,021	3	44	1,587
10/4/83	54	0	41	0	0	23	307	50	665	27	361	1,333
4/10/84	10	0	49	0	0	31	194	63	396	6	38	628

Table 8. Continued.

Date	Bulls: 100 cows	Yrlgs: 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
5/20/84	0	0	82	0	0	0	0	0	482	0	0	877
6/22/84	17	0	56	0	0	32	837	58	1,508	10	259	2,604
10/17/84	42	0	36	0	0	20	222	56	613	24	258	1,093
5/3/85	0	0	0	0	0	34	256	66	503	0	0	759
10/9-12/85	49	0	36	0	0	20	228	54	630	26	306	1,164
4/20/86	21	0	29	0	0	19	302	67	694	14	145	1,041
10/22/86	41	0	29	0	0	17	330	59	1,136	24	468	1,934
5/30/87	1	30	60	16	325	31	649	52	1,080	1	12	2,066
10/5/87	32	0	31	0	0	19	323	61	1,030	20	329	1,682
4/6/88	22	0	29	0	0	19	285	66	976	14	212	1,473

Appendix A. Distribution and size of caribou groups and distribution of radio-collared caribou from the Delta and Yanert Caribou Herds during the 2-3 July 1987 census (see Fig. A-1).

Group No.	No. of caribou[a] in group Low	High	x	No. of radiocollars in groups
1	1,273	1,297	1,285	10
2	1,578	1,578	1,583	7
3	450	459	455	1
4	478	498	488	3
5	66	66	66	1
6	231	235	233	2
7	659	659	659	2
8	8	8	8	1
9	1,275	1,364 1,326[b]	1,322	8
10	89	90	90	0
11	1,011	1,034	1,023	4
12	210	213	212	2
13	242	246	244	0
14	118	120	119	0
15	581	592	587	4
Subtotal	8,269 + 6	8,468 + 6	8,374	45[c]
Total	8,275	8,474	8,380	

[a] All photos were counted 2 or more times.

[b] This group was counted 3 times.

[c] Four additional radio-collared caribou were located away from the groups included in Appendix A.

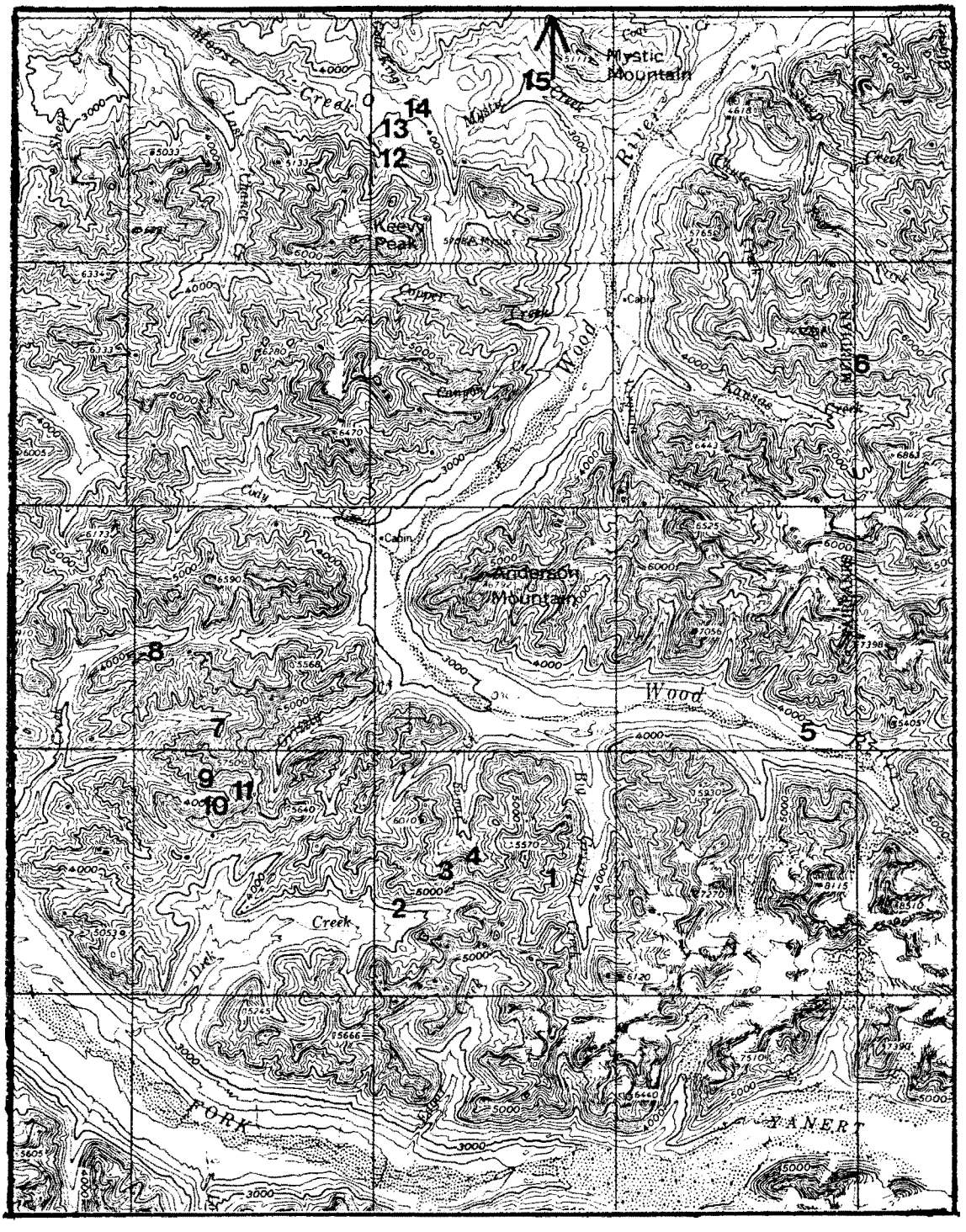

Fig. A-1. Locations of Delta and Yanert Herd caribou during the census, 2-3 July 1987.

Appendix B. Abstract of a paper presented at the 3rd North American Caribou Workshop, Chena Hot Springs, Alaska, November 1987. The manuscript will appear in the Workshop Proceedings, 1988.

SURVIVORSHIP FROM BIRTH TO TWO YEARS IN THE DELTA CARIBOU HERD

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Abstract: From 1979 through 1987 we investigated survivorship of Delta Herd caribou (Rangifer tarandus granti) from birth to 24 months of age. The mean mortality rate from birth to 5 months was 50% (±14 SD), with a range of 21-65%. The literature on natural mortality of barren-ground caribou suggests that the calf cohort commonly experiences ≥50% mortality. The literature is limited regarding natural mortality rates of "adult" (>24 months) caribou, but suggests that rates are highly variable and generally are less than half that of the calf cohort. Lacking empirical estimates of mortality rates for the 5- to 12- and 12- to 24-month-old cohorts, modelers have commonly assumed rates that were intermediate between those for caribou <5 months and adults. However, in our study, natural mortality rates from 5 to 24 months of age differed little from those for caribou >24 months old. Natural mortality was higher for males than females for all age cohorts. To realistically model caribou population dynamics, and hence understand and intelligently manage caribou populations, it is essential to ascertain age-specific mortality rates.

Key Words: calf cohort, caribou, Delta Herd, mortality rate, survivorship, yearling cohort.

Appendix C. Draft manuscript of a paper presented at the 3rd North American Caribou Workshop, Chena Hot Springs, Alaska, November 1987. The manuscript will appear in the Workshop Proceedings, 1988.

DISTRIBUTION OF RADIO-COLLARED CARIBOU FROM THE DELTA AND YANERT HERDS DURING CALVING

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Abstract: Each year from 1980 through 1987, we located 9-55 radio-collared female caribou (Rangifer tarandus granti) and 1-10 radio-collared male caribou from the Delta and Yanert Herds during the calving period. All but 3 of the Delta Herd females were collared at 8-12 months of age. Of 186 calves born to the radio-collared Delta and Yanert Herd females, 183 were apparently born in 2 disjunct areas totaling about 2,500 km^2. Most (>50%) radio-collared Delta females calved within a previously defined "major calving area" in only 1 of 8 years, and only 1 female exhibited affinity to a specific calving site. In 1984 and 1987, major unexplained shifts in calving distribution occurred in the Delta Herd. Distribution of caribou during calving is discussed in relation to sex, reproductive status, previous experience, snow conditions, and predator numbers.

Key Words: calving, caribou, Delta Herd, radio-collar, Rangifer

Calving grounds are perhaps the most predictably used portion of a caribou herd's (Rangifer tarandus) annual range (Skoog 1968:121, Thomas et al. 1968, Bergerud 1974, Pare and Huot 1985, Brown and Theberge 1986, Davis et al. 1986, Gunn and Miller 1986, Hatler 1986). However, major exceptions to calving ground fidelity have been reported (Davis et al. 1986, Valkenburg and Davis 1986). In addition, fidelity varies among individuals (Edmonds and Bloomfield 1984, Pare and Huot 1985, Hatler 1986). Davis et al. (1986) discussed patterns of range use (including apparent anomalies) of the Delta and Yanert Caribou Herds (DCH and YCH) between 1950 and 1985 and compared those patterns to existing theoretical models of caribou socioecology. In this paper, we present 2 years of additional data and summarize the calving distribution of radio-collared Delta and Yanert caribou for the entire period. We also discuss the implications of our results to caribou management and ecological theory.

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calving-related data, and assisted with changing radio collars. J. Venable assisted with data management and analysis. W. Regelin and K. Whitten critiqued the manuscript.

METHODS

Caribou Capture and Collaring

From January 1979 through April 1987, we captured and radio-collared (collars from Telonics, Inc., Mesa, Ariz.) 61 female caribou in the DCH and 8 in the YCH. DCH females were collared at 8-12 months of age, except for 3 which were collared as adults; all YCH females were collared as adults. Collars were replaced every 3-4 years. Most caribou were immobilized by darting with M99 (Valkenburg et al. 1983) or Wildnil (3 mg/ml carfentanil citrate, Wildlife Laboratories, Fort Collins, Colo.) from a helicopter. The remaining caribou were captured with a shoulder-held net gun (Valkenburg et al. 1983) and handled without chemical immobilization or sedation. Unless otherwise stated, the terms DCH caribou and YCH caribou refer to caribou that were radio-collared within the respective ranges of the 2 herds (Fig. 1).

Relocating Radio-collared Caribou and Determining Reproductive Status

Davis et al. (1986) described the methods used to relocate caribou during the calving period, 1979-85; methods used in 1986 and 1987 were similar. We relocated caribou with a Piper Super Cub or a Bellanca Scout aircraft on 14, 15, 17, and 28 May 1986 and on 14, 15, 20, 27, and 31 May 1987. Each female $\geq$24 months old was located and observed 1-3 times per year. For 75-80% of the relocations, reproductive status of the female was judged from the presence or absence of a distended udder (Bergerud 1964); otherwise, the presence of hard antlers or a calf was accepted as evidence of pregnancy. In 4 of 294 cases (all in 24-month-olds), we were unable to judge reproductive status. Radio-collared males and yearling females were relocated at least once during the last 2 weeks of May each year. On 30 May 1987, and 2 June we used helicopters (Allouette A-star and Bell Jet Ranger) to obtain sex and age composition and pregnancy data (as above).

Calving Location of Radio-collared Females

Calving location is defined as the site where a female was first found with a newborn calf. In years when a pregnant female was never seen with a newborn (i.e., some newborns died before being observed), calving location was defined as the site where relocated on the date closest to the peak of calving. Peak calving date was estimated as the day(s) when approximately half of the pregnant females in the herd had calved. Calving distribution is defined as the area within a convex polygon which connects the outermost calving locations for all radio-collared females in a given year.

Data Analysis

During radio-tracking flights, locations of caribou were recorded on topographic maps (USGS, scale 1:250,000). Subsequently, locations were electronically digitized by latitude and longitude and then transferred to a computer file (DBase III, Ashton-Tate, Torrance, Calif.). Other information was later entered into each record. We replotted location data using a Hewlett-Packard 7475A plotter and a computer graphics program developed by J. Venable (Alaska Department of Fish and Game,

Fairbanks). Statistical testing for non-independent ratio estimates was by Student's t-test (Cochran 1977). Significance level is presented in the narrative.

RESULTS

Size of Delta and Yanert Calving Areas and Range Size of the Herds

From 1980 through 1987, 183 of 186 calves born to the DCH and YCH females were found in 2 disjunct areas (Figs. 2-9): the Little Delta River and Delta Creek area (Area 1, 2,020 km^2) and the Yanert/Wood River area (Area 2, 450 km^2). Two of the 3 calves found outside Areas 1 and 2 were produced by primiparous DCH cows (age 36 mo) in an area used by the herd during the preceding winter. The 3rd calf was with a YCH female on a plateau south of the Yanert River.

The total range of the DCH increased from 8,000 km^2 in 1980 to 10,800 km^2 in 1987. Range of the YCH was about 1,500 km^2 and overlapped that of the DCH between 1980 and 1987.

Fidelity to Calving Areas

The discussion that follows requires familiarity with the DCH's historical main calving area (MCA), which consists of 2 adjacent areas separated by a timbered river valley about 2 km wide (Fig. 2). The MCA was identified as the DCH's traditional calving area by extensive aerial surveys conducted from the late 1950's through the mid-1970's (Skoog 1968; Hemming 1971; ADF&G 1976; M. Buchholtz and L. Jennings, retired ADF&G employees, pers. commun.).

Intensive monitoring of calving distribution in the late 1970's and early 1980's confirmed the fidelity of the DCH to the MCA for calving (Davis and Preston 1980; Davis and Valkenburg 1981, 1983, 1984; Davis et al. 1982; ADF&G 1986); for example, investigators estimated that 75-90+% of all calving occurred within the boundaries of the MCA in 1979, 1980, and 1983 while date of snowmelt was correlated with $\leq$50% of the calving occurring within the MCA in 1981 and 1982. In summary, from the late 1950's through 1980, there is evidence of calving occurring annually within the MCA, but no evidence of significant calving outside the MCA.

From 1980 to 1987 over 98% of all parturient radio-collared DCH females calved within Areas 1 and 2 (Figs. 2-9). However, a majority (>50%) of the radio-collared females have not calved within the MCA in any year after 1983. In 1982 and 1983 deep snow (>10 cm) covered the MCA throughout May, and most caribou calved on the northern periphery of the area where snow was patchy or absent (Figs. 4 and 5). In 1986, 12 of 29 parturient DCH females calved within the MCA, and at least 5 more moved onto the MCA within several days after they had calved. In 1987 about 50% of the collared parturient DCH females calved on the upper Wood River within the area normally used by YCH females (Area 2).

We first detected calving in Area 2 by DCH caribou in 1983 when 2 parturient and 2 nonparturient females ($\geq$24 months old) were observed there during the period of calving. In 1984, 4 of 24 parturient and 3 of 12 non-parturient females ($\geq$24 months old) used Area 2 (note: numbers differ slightly from Davis et al. 1986 due to slight changes in definition of calving date and calving areas). From 1982 through 1987,

Area 2 was frequented during the calving period by both radio-collared DCH caribou 12-24 months old and uncollared caribou 12-24 months old.

The 8 YCH females generally calved in Area 2, but there were notable exceptions. In 1 year a YCH female calved on a high plateau south of the Yanert River. A 2nd YCH female (No. 102368) calved in Area 2 in 1981 and 1982 and then calved in Area 1 from 1983 through 1987 (Fig. 10). A 3rd YCH female (No. 102366) calved in Area 2 and remained year-round in the Yanert River drainage from 1981 through summer 1985. She did not produce a calf in 1986 and from November 1985 through 2 May 1987 she remained south of the Alaska Range in the upper Nenana and Susitna River drainages with about 200 caribou assumed to be members of a discrete resident herd (Pitcher 1987). Between 2 and 15 May 1987, she traveled >70 km across the crest of the Alaska Range and returned to Area 2 where she calved.

Selection of Calving Areas by Primiparous vs. Multiparous Females

Within Area 1, primiparous DCH females were no more likely to calve outside the MCA than multiparous females ($P > 0.1$; $t = 0.33$, d.f. = 44) (Fig. 11). Excluding replicates, 13 of 37 (35%) of the primiparous females calved outside the MCA and 14 of 37 (38%) of the multiparous females calved outside the MCH.

Location of Nonparturient Females During Calving

During the peak of calving from 1979 through 1987, 82% of the 99 locations of nonparturient radio-collared DCH females ≥12 months old were within Areas 1 and 2 (Figs. 2-9). Yearling DCH females were no more likely to be outside (36 inside vs. 43 outside) Areas 1 and 2 than nonparturient DCH females older than yearlings (45 inside vs. 56 outside) ($P > 0.1$, $t = 0.43$, d.f. = 57) (Fig. 12). In contrast, 4 of 6 locations of nonparturient YCH females were outside Area 2 in the Yanert River valley in lowland spruce (Picea spp.) forest.

Calving Site Affinity of Females

We verified affinity to a specific calving site by 1 DCH female, but we may have underestimated birthing site affinity because our surveys were too infrequent to ascertain most birth sites. However, most workers experienced with barren-ground caribou behavior believe that birth site affinity is low and there is little evidence of it in the literature.

Distribution of Males During Calving

Eight of 30 locations of radio-collared DCH males during May were within Area 1, and none were within Area 2. Until June most males remained on winter ranges at lower elevations (often in spruce woodland or muskeg habitat) to the north and northwest of Area 1; YCH males also remained on their winter range, occupying similar habitats in the lower Yanert valley. Furthermore, the sex ratio from composition samples on the calving areas never exceeded 5 males:100 females in late May, whereas samples during the rut indicated 40-50 males:100 females in the DCH and 70:100 in the YCH.

DISCUSSION

Fidelity to Calving Areas

Clearly the 640 km^2 MCA has remained an important area for calving. Furthermore, during the 8-year study period, the vast majority of parturient DCH females have calved in the 2,020 km^2 of Area 1, which encompasses the MCA. That most DCH females did not calve within the MCA between 1980 and 1987 may reflect a change in calving distribution, an increase in herd size, improved knowledge resulting from the use of radiocollars, or a combination of those factors. Between the late 1950's and 1979 the DCH was considerably smaller (2,500-5,000) than it was in 1985-87 (7,000-8,000). Prior to 1980, major shifts in calving distribution, as in 1984 and 1987, could have occurred but not been detected because surveys were relatively infrequent.

The major shifts in calving distribution of the DCH contrast with conventional concepts of calving tradition and herd identity (c.f. Skoog 1968, Gunn and Miller 1986, Davis et al. 1986). In reporting the 1984 shift in calving distribution, Davis et al. (1986) noted that most females returned to Area 1 in 1985 and 1986. Most of these females again used Area 2 in 1987 when snowmelt was particularly early; although virtually all DCH females were present on, or in close proximity to, Area 1 during early May. The caribou that eventually calved in Area 2 moved there along the route used since the early 1980's for postcalving movements. In addition, many females that had never previously used Area 2 for calving went there in 1987. The "Yanert" female (No. 102368) that "moved" to the DCH in 1982 was not one of those.

A possible explanation for the 1987 shift in distribution during calving may be that caribou concentrated near the retreating snowline, perhaps minimizing predator contact while allowing access to emerging Eriophorum spp. buds. Snowmelt was indeed early in 1987, which could partially explain why these caribou that calved in Area 1 concentrated farther south than ever observed before (i.e., closer to large mountains). The conditions presumably present in southern Area 1 and being sought by the calving caribou were presumably also present in Area 2 (albeit Area 2 has more low elevation forest and a greater abundance of alternate prey for wolves and bears than the southern portion of Area 1). Wolf and grizzly bear (Ursus arctos) population densities appear to be comparable in both areas.

Influence of Sex, Reproductive Status, and Individual Experience on Calving Distribution

The pronounced difference in the distribution of radio-collared bulls and cows during the calving period suggests that the sex of individuals has the greatest influence on their distribution. More than 98% of the parturient females and 82% of the nonparturient females (regardless of age and calving tradition) went to Areas 1 and 2 during calving; this contrasts with less than 30% for the males. Reproductive status is apparently the next most important influence on calving distribution, because again, over 98% of the parturient radio-collared females were found in Areas 1 and 2. Previous pregnancy may influence calving distribution of individuals because 2 of 3 radio-collared pregnant caribou that did not calve in Areas 1 and 2 were primiparous 3-year-olds.

The observed distribution of pregnant and nonpregnant YCH females supports the idea that, as parturition approaches, pregnant females forego feeding in areas of high phytomass of nutritious plants in favor of higher elevation, more open habitat to avoid predation. Five of 10 locations of nonparturient YCH females during calving time were in the Yanert River valley, which was not used by pregnant, radio-collared females during calving. In the Yanert valley (elevation about 900 m), dwarf birch (Betula spp.) and willow (Salix spp.) leaves emerge by about 25 May in most years, in contrast to a 10 day later emergence at calving locations (1,500-2,500 m) chosen by YCH cows.

Perhaps most nonparturient Delta females were in the same areas as parturient females because of the greater availability of lowland tundra in Area 1 than in Area 2. However, some nonparturient females used the highest parts of Area 1, and none were found in the lowest parts (300-400 m), which were frequented by radio-collared adult males and male yearlings. Presumably, quantity, quality, and diversity of new plant growth were greatest at the lowest elevation.

Apparently, DCH females select open habitats regardless of their reproductive status. This preference could have a phylogenic basis or be a conditioned response to predators. Bergerud (1974) hypothesized that predator harassment acts as an environmental trigger, which causes barren-ground caribou to seek open habitats and form large groups during calving. Observations from the Fortymile Caribou Herd (FCH) may or may not be consistent with this hypothesis. Calving distribution of the FCH has varied annually during the past 10 years and calving has not consistently occurred in the most open habitat (Valkenburg and Davis 1986). There may be no area within or adjacent to the range of the FCH where predator numbers are low, which suggests no advantage to a specific calving area (however, open habitat should still enhance predator detection). Present data are insufficient to critically test the hypothesis for either the DCH or FCH.

Calving Site Affinity

Radio-collared DCH and YCH females apparently did not exhibit as much affinity to birthing sites as has been reported for woodland caribou (R. t. caribou) (Edmonds and Bloomfield 1984, Hatler 1986, Pare and Huot 1986). Only 1 DCH female clearly exhibited site affinity. Others may have exhibited it but were not detected because many parturient cows were not located the day they calved. Apparently, individuals with different behavioral tendencies may exist within a herd (c.f., Davis et al. 1986). Whether these tendencies are inherent in individuals or are facultative responses to the environment is an interesting question. Changing calving strategy by individuals (i.e., from site affinity to non-affinity or vice-versa) could be construed as evidence of facultative responses.

CONCLUSIONS

Because of progressive development in the North, it has become increasingly important that we learn how and why caribou select calving areas. It has proven difficult to learn what motivates caribou because both environmental and phylogenic factors are likely involved, as well as variation in individual behavior. As more data on the movements of

radio-collared caribou accrue, it becomes increasingly apparent that short-term, and perhaps long-term, shifts in calving distribution are to be expected. Calving grounds are less easily delineated than previously believed, and infidelity of individual females to a designated calving area may be more frequent than implied in the literature. The above observations have important management implications. For example, census techniques may have major limitations if based on the assumption that all females in a herd use a traditional calving area or that all calving occurs in a continuous distribution. Furthermore, recognition that calving distribution may shift appreciably between years should influence strategies to mitigate the impacts of development on caribou. For example, inviolate protection of a relatively small areas may be insufficient mitigation, given long-term variability of caribou distribution. Moderate protection of calving habitat over a larger and/or discontinuous area may prove more beneficial to caribou.

It is important to maintain access to larger areas for calving than what may be identified at a narrow time interval. Empirical evidence is mounting to show that changes in snow condition and population size are just 2 of many possible variables that are apt to affect calving distribution.

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Appendix D. Expanded abstract of a paper presented at the 3rd North American Caribou Workshop, Chena Hot Springs, Alaska, November 1987. Expanded abstract only will appear in the Workshop Proceedings, 1988.

EFFICACY OF CARFENTANIL CITRATE AND NALOXONE FOR FIELD IMMOBILIZATION OF ALASKAN CARIBOU

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Abstract: Previously, M-99 (used with adjunct tranquilizers and reversed with M50-50) was the "drug of choice" for field immobilization of caribou (Rangifer tarandus granti) in Alaska that required darting from a helicopter. However, M-99 in a concentrated form has never been widely available in the United States, and large-bodied adult caribou could not be efficiently immobilized using the drug in 1 mg/ml concentration.

To overcome this problem, we began using Carfentanil Citrate (with adjunct tranquilizers and reversed with Naloxone), which is more potent than M-99 and available in 3 mg/ml concentration. This has allowed effective immobilization of adult caribou using 3-ml dart syringes.

In Denali National Park and Preserve, Alaska, 41 adult (>1 year old) and 11 10-month-old female caribou were immobilized with 3.9-4.5 mg Carfentanil and 5.0 mg Acepromazine. When ambient temperatures were <0°C, 1 ml propylene glycol was added as antifreeze.

Of the 41 adult caribou, 35 were immobilized with 1 dart of Carfentanil (0.029-0.045 mg/kg body weight); induction time averaged 6.8 minutes. All caribou survived initial immobilization, and 100-150 mg Naloxone/mg Carfentanil was administered. Two animals died within 24 hours following capture, apparently from recycling narcosis. The remaining 6 females required 2 darts for immobilization (total Carfentanil doses, 0.057-0.082 mg/kg body weight). All 6 survived immobilization, and the effects were reversed with 77-100 mg Naloxone/mg Carfentanil. Two animals died within 24 hours from recycling narcosis. A 2nd dart was required for 3 of 36 females immobilized in late fall/early winter compared with 3 of 5 captured in late winter.

The 10-month-old females were immobilized with 1 dart of Carfentanil (0.057-0.075 mg/kg body weight); induction time averaged 4.2 minutes. Drug reversal for all was successful with 100 mg Naloxone/mg Carfentanil, and all 11 survived.

Elsewhere in Alaska, adult caribou have been immobilized using similar doses of Carfentanil in combination with Acepromazine and M-99, or with Xylazine. M-99 is marketed in propylene glycol solution which functions as an antifreeze and eliminates the need to dilute the other drugs. Twenty-eight adult females were immobilized with 3.0 mg Carfentanil (estimated mean dose, 0.026 mg/kg body weight), 5.0 mg Acepromazine, and 1.5 mg M-99; induction time averaged 7.0 minutes, and all other caribou recovered following injection of 133-150 mg Naloxone/mg Carfentanil. Thirteen other females were immobilized with 4.0 mg Carfentanil (mean dose, 0.036 mg/kg body weight) and 100 mg Xylazine; induction time averaged 8.2 minutes, and all animals were revived with 125 mg Naloxone/mg Carfentanil.

Carfentanil, in these various combinations and doses, has proven effective in immobilizing caribou in Arctic and sub-Arctic Alaska. Known mortalities related to capture and handling have apparently resulted from recycling narcosis, suggesting that the antagonist, Naloxone, is too short-lived to counteract Carfentanil during its active life in the animal. Naloxone has a relatively wide margin of safety, however, and can be used in higher doses until a better antagonist becomes available. Intramuscular, rather than intravenous injection of the antagonist is recommended.

Key Words: Carfentanil, caribou, immobilization, Rangifer.

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