



ALASKAN MUSKOX AND CARIBOU

*COMPARISON OF LACTATION, NURSING BEHAVIOR AND BREEDING SUCCESS OF
MUSKOXEN AND CARIBOU*

ROBERT G. WHITE, PRINCIPLE INVESTIGATOR

1993 ANNUAL REPORT (Including 1993 Field Report)

TO: Center for Field Research

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PROJECT: Alaskan Muskox and Caribou

PROJECT TITLE: Comparison of Lactation, Nursing Behavior and Breeding
Success of Muskoxen and Caribou

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March 24, 1994

Dear 1993 Earthwatch Volunteer,

We hope that this copy of our Annual Report will help to present a complete picture of the 1993 field season that you were such an integral part of. Your two-week contribution was invaluable, because the data you collected is now part of a data base comprising over seven years of nutritional treatment and the effect of this treatment on the life cycles of muskoxen, particularly on reproduction. This information has never before been collected in such detail, accuracy, or breadth. This will provide a powerful tool for evaluating muskoxen in their native habitats and will, with hope, be useful in maintaining their future survival.

Thank you again for your tremendous investment in this project!

Sincerely yours,

Robert G. White, Professor of Zoophysiology and Nutrition
Director, Institute of Arctic Biology

William E. Hauer, LARS Supervisor

Enclosure

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INTRODUCTION AND EARTHWATCH TEAMS

Since 1987, Earthwatch Research Teams have contributed to the collection of research data at the Large Animal Research Station (LARS), Institute of Arctic Biology, University of Alaska Fairbanks. A listing of team names and duties for 1993 is shown in Table 1.

The 1993 Earthwatch Corps continued the collection of data on daily activity budgets of female muskoxen and their calves throughout the summer and fall rutting season. They also assisted in many aspects of animal care, and in the collection of biological samples.

In brief, the objective of the study, begun in 1983, is to determine the influence of plane of nutrition on maternal-offspring behavior of muskoxen (*Ovibos moschatus*) and caribou (*Rangifer tarandus granti*) and to assess the role of calf behavior as feedback for prolongation of lactation. It is hypothesized that feedback from offspring nursing behavior affects maternal breeding behavior in species sensitive to habitat deterioration. Muskoxen, with restrictive home ranges and potentially high population densities, should show these effects, while caribou, because of a migratory life history, should show less of these effects.

Nutrient intake for pregnant and lactating female muskoxen was controlled by altering both food availability and quality (mainly protein content) to give a "wide" and "narrow" plant growth period resembling that of arctic and high arctic ranges respectively. Females subjected to the "wide" plant growth period were on a high plane (HP) of nutrition while those given the "narrow" period were on a low nutritional plane (LP). Low-plane cows were originally given restricted grazing during the summer, supplemented with a medium quality hay. Beginning in 1993, LP cows were given access to the same quality spring and summer pasture as the HP cows. From mid-August through winter, the LP cows have access to hay only while the HP animals have hay plus a year round supplement of high-protein pellets. These treatments have been run since 1987. Beginning in 1990, offspring also follow the nutritional treatment of their mother.

Nutritional effects on calf play behavior, nursing and foraging were determined using 25-hour activity budgets and were related to maternal activity and behavior. Calf growth rate, milk intake and maternal body weight and condition were measured regularly throughout the lactation cycle. Dates of breeding behavior and copulation were recorded, as well as were weaning dates and age of first breeding in young

females. The study will determine critical conceptual body weight of adults and breeding weight in juveniles.

Andrea Schulman, an M.S. student, will develop a model to determine the role of nutrition in the termination of parental investment in muskoxen. The analyses will incorporate 25-hour behavior observations, estimates of milk transfer and reproductive histories collected on the captive muskoxen since 1987.

In 1993 the main study focused principally on muskoxen. However, Earthwatch teams also assisted Julie Kitchens, a PhD student, in collecting caribou activity data. As part of a larger study, captive caribou will be used to test specific hypotheses, and activity cycles will be compared between captive and wild animals. The specific objectives in the captive study were to compare caribou behavior at night, in dark versus lighted pens and in large versus small pens

Earthwatch research teams made 25-hour behavioral and activity budget observations, collected milk and urine samples, weighed animals and provided general animal care. Activity/behavioral changes were monitored from viewing towers and entered on a field computer.

Earthwatch as a source of funding

Earthwatch teams are essential for the continuous collection of 25-hour behavioral observations. In addition, they relieve the base project support staff through their assistance in animal care. Currently, the overall project centers on muskoxen and could not be completed without this support. While we are gaining tremendously in our understanding of muskox responses to nutritional variations, lack of matching support for our caribou studies means that we are presently unable to pursue the muskox-caribou comparison. We hope to resume the comparative aspect of the study, but this will depend on funding.

Placing a monetary value on the overall contribution of the 1993 teams is difficult. But, the 36 team members (Table 1) contributed a total of 1400 hours on *observations alone* -- equivalent to at least \$15,000 at the current rate for hiring student technicians.

RESEARCH RESULTS

Nursing behavior

During the summer of 1993, four calves (three LP and one HP) were under continuous observation. One of the LP calves had to be weaned at 80 days of age for health related reasons. Nursing behavior, expressed as the daily time spent nursing, followed the now established trend of a steep decline over the first 60 days post-partum (Fig. 1a-d). Following this initial decline, total daily time spent suckling remained under 200 seconds per day in both HP and LP animals. Beyond 60 days, individual variation between the two LP calves (Saydy and Ozero) was apparent in time spent nursing and in the number of successful and attempted bouts. Ozero demonstrated a greater number of successful and attempted bouts than Saydy, and a slightly greater total daily time nursing. Ozero had a slower growth rate (Fig. 2a), and Taimyr (his mother) had a lower body weight (Fig. 6c), suggesting that Ozero needed to invest more nursing effort to maintain growth rate. In Saydy (LP) and the one HP calf, Cambridge, overall nursing behavior is comparable, and growth rates for the first 60 days of age are essentially equal. But beyond 60 days old, the daily rate of body weight gain in the LP calf drops to less than one-third that of the HP calf (Fig. 2b and d).

This year there were no cows from either nutritional group nursing a yearling calf.

Feeding and lying activity budgets

Andrea Schulman is currently analyzing the muskox behavioral data. The field season has been subdivided into three "seasons" based on food availability and the presence or absence of a bull - pre-rut, rut, and post-rut. Cows are classified as being with or without a calf (maternity state) and according to nutritional plane (HP or LP). The effect of season, plane of nutrition, and maternity state on time spent feeding and lying is being statistically analyzed. Preliminary work indicates that both season and plane of nutrition have significant effects on the amount of time females spend engaged in eating or lying (Fig. 3a-c and 4a-c). However, the females' maternity state did not appear to have a significant effect on either behavior category (Fig. 5a-b).

Adult body weight trends

Figure 6a-c depicts body weight changes in LP cows with calves. All three LP cows lost weight at, and immediately following, calving. However, they all began increasing weight in approximately mid-July and continued gaining through to the beginning of the rut when weight gain stabilized in two of the three cows. In the third case (Bettye) removal of her calf early in the rut may have been responsible for a more erratic pattern of weight change. The weight gain in early to mid-summer is in contrast to the one HP cow with a calf (Fig. 6d), and to previous years, where the major weight gain occurred during the rutting period.

LP cows without calves (including juveniles) demonstrated relatively steady summer weight gain, approximately mid-May through August (Fig. 7a-b), similar to HP cows without calves (Fig. 8a-d).

Body weight, body condition score and pregnancy

This study has now accumulated sufficient data to begin to analyze long-term trends and identify predictive events. Lifetime calving histories for the HP and LP cows have been compiled. Four of five HP cows consistently calved every year while four of five LP cows have undergone either calving pauses or delayed onset of puberty.

In the LP muskoxen, failure to breed appeared related to body weight attained in the fall (Fig. 9a-b). To test the hypothesis that the critical body weight for conception is about 180 - 185 kg, we analyzed the relationship between successful pregnancies, fall body weight (BW), fall body condition score (BCS -- an index of subcutaneous fat), lactation, age, year, calving date, calf weight and nutritional plane (HP or LP). There was a highly significant relationship between pregnancy and nutritional plane for both BW and BCS; only BCS differed significantly with lactation status. Using a mathematical model (logistic regression), relationships between BW, BCS, age, lactation status, year and pregnancy were examined. In this model BCS in September was the most powerful predictor of pregnancy. An animal with a BCS of 9.3 (on a possible scale of 3 - 15) had a 50% chance of becoming pregnant. The probability of pregnancy rose as BCS increased. While body condition score is the variable that most accurately predicted pregnancy, body weight can be used. This model identified a body weight of 180 kg as the critical weight at which 50% of the cows became pregnant.

Courtship and pregnancy

Harems were formed in mid-August. Courtship and breeding activity was noted almost immediately in the HP pen with virtually all observed matings in this group completed by August 28. Blood progesterone levels confirmed pregnancy in Brown, Unni, and Red (Fig. 10a-c). Breedings were observed for both Unni and Red and correspond precisely with hormonal profiles. No mating was observed for Brown, but her hormonal profile suggests that she was bred during the period between Earthwatch teams. Victoria, Maud, and Sadle were all observed mated during the last week of August (blood progesterone values are not available for these animals). Although interest was expressed in Anadyr and Sabine, there are no confirmed matings. On the basis of body weight and interest from the bull, we predict they are both pregnant.

All breeding in the LP pen occurred between September 9 - 17. Sasha, Bettye, Sine, and Taimyr have pregnancies confirmed by progesterone analyses (Fig. 11a-d) and all were observed mated. Interest was shown in Juneau and Roxanne but, again, there were no confirmed matings. Based on body weight, Juneau should have successfully conceived, but Roxanne was below threshold weight and has less than 50% chance of being pregnant.

Both the LP and the HP groups were tightly synchronized within harems and there is no indication of repeat cycling in either group. The HP cows came into heat a full two weeks earlier than the LP group (Fig. 10 and 11).

Caribou behavior

The caribou behavior is currently being analyzed using statistics for circular and/or cyclical data. It will form part of Julie Kitchens' PhD thesis. Two posters, from her first two thesis chapters -- "Effects of low-altitude jet aircraft over flights on caribou activity and movements" -- will be presented at The 59th North American Wildlife and Natural Resources Conference and the Sixth North American Caribou Workshop later this spring. Julie anticipates defending her thesis in the spring of 1995.

GENERAL CONCLUSIONS

Neo-natal calf losses were a factor in the 1993 research season. These occurred predominantly in the HP group and no single factor could be identified. Calf losses such as these are common among captive muskoxen, making information collected on every cow/calf pair extremely valuable.

Using behavioral parameters to infer individual, herd or population status, has the advantage of being non-invasive and can be done at low cost by both researcher and manager. Such diagnostic methodologies are essential to the study of muskox ecology and for the successful management of the species.

Serum progesterone provides precise information on estrus cycles and pregnancy in those cows that can be easily sampled. The endocrinology acted as quality control for behavioral data and verified the accuracy of the Earthwatch observations. Similar to the last nine years of these studies, HP cows reached critical body weight for conception, displayed a high level of sexual behavior and were successfully mounted by the bull. This year, while sexual activity was observed in both HP and LP animals, the HP animals came into heat three weeks before the LP cows.

The results of the logistic regression model support the hypothesis of a threshold body weight for conception. The model also identifies a predictive relationship between fall body condition score and the probability of an animal being pregnant. Because body condition scores can be easily collected from immobilized muskoxen, this relationship could have direct applicability to the management of wild populations.

FIGURES

Figure 1a - d. Daily totals of nursing behavior -- total time spent nursing, number of successful nursing bouts and number of attempts -- in high and low-plane muskox calves.

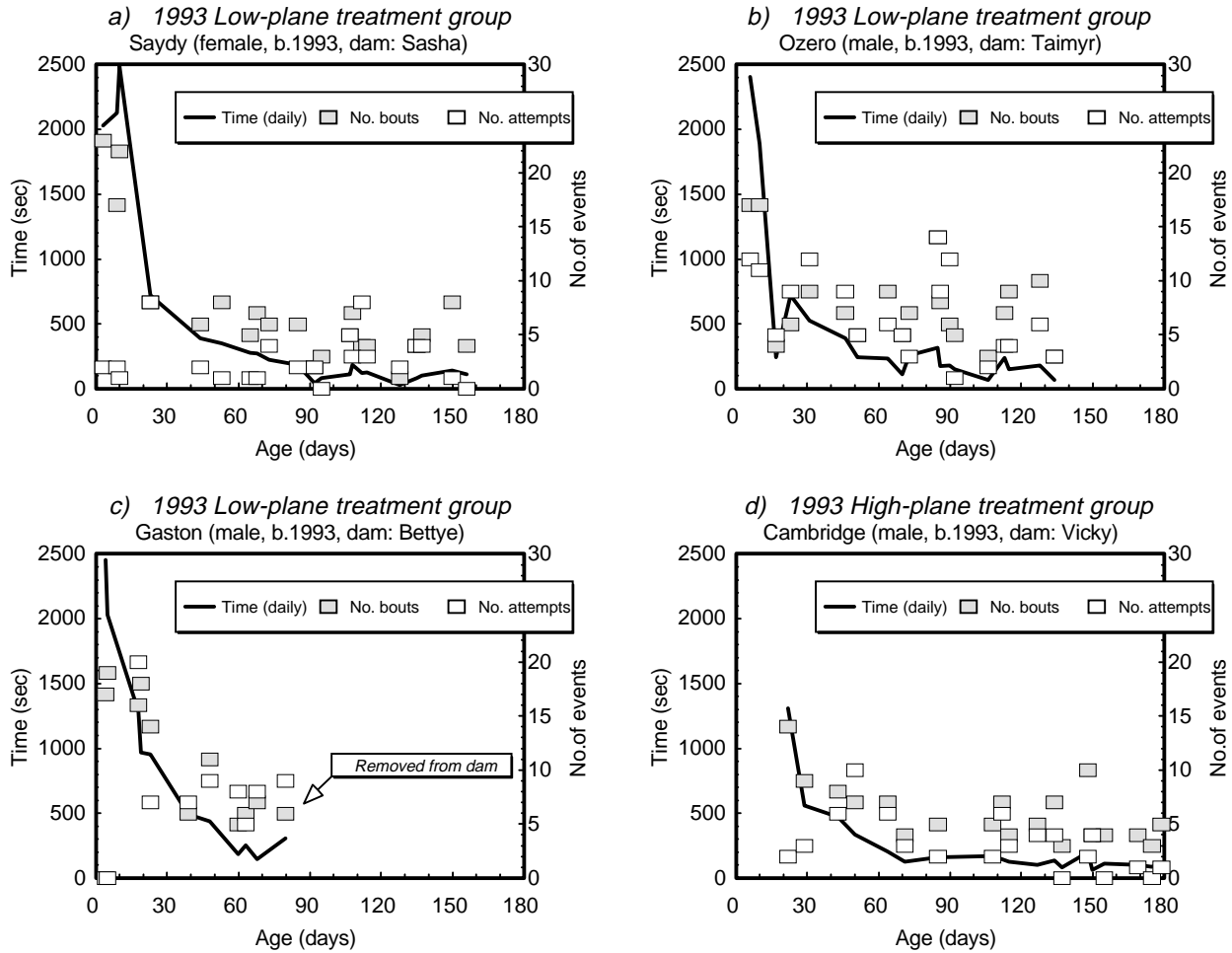


Figure 2a - d. Post-natal growth rates of high and low-plane muskox calves.

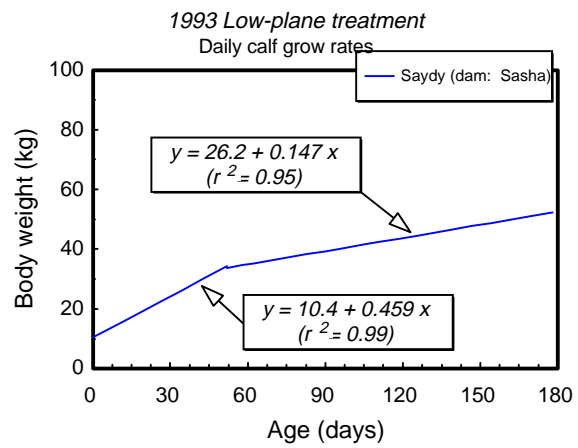
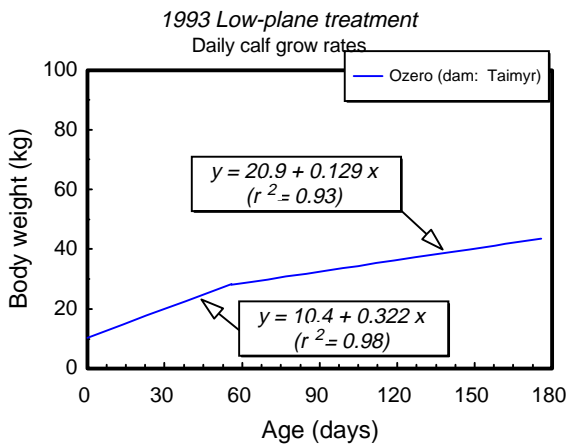
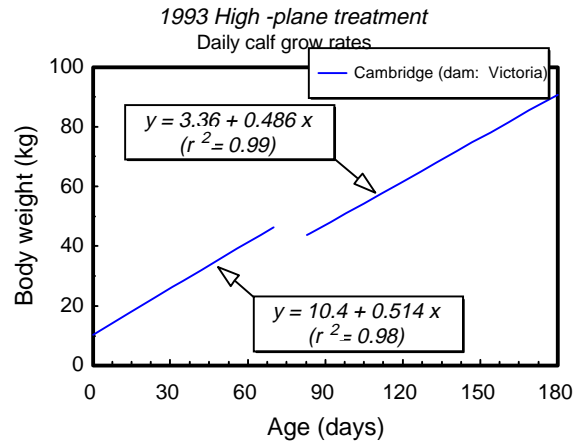
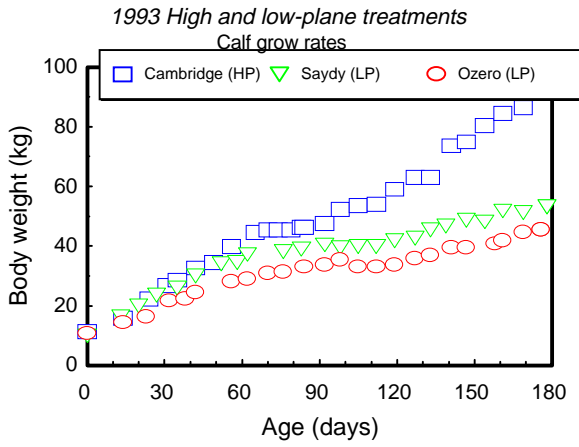


Figure 3a - c. Percentage of total day spent lying by female muskox on different planes of nutrition during pre-rut, rut, and post-rut periods. F1, F2, and F3 indicate individual muskox.

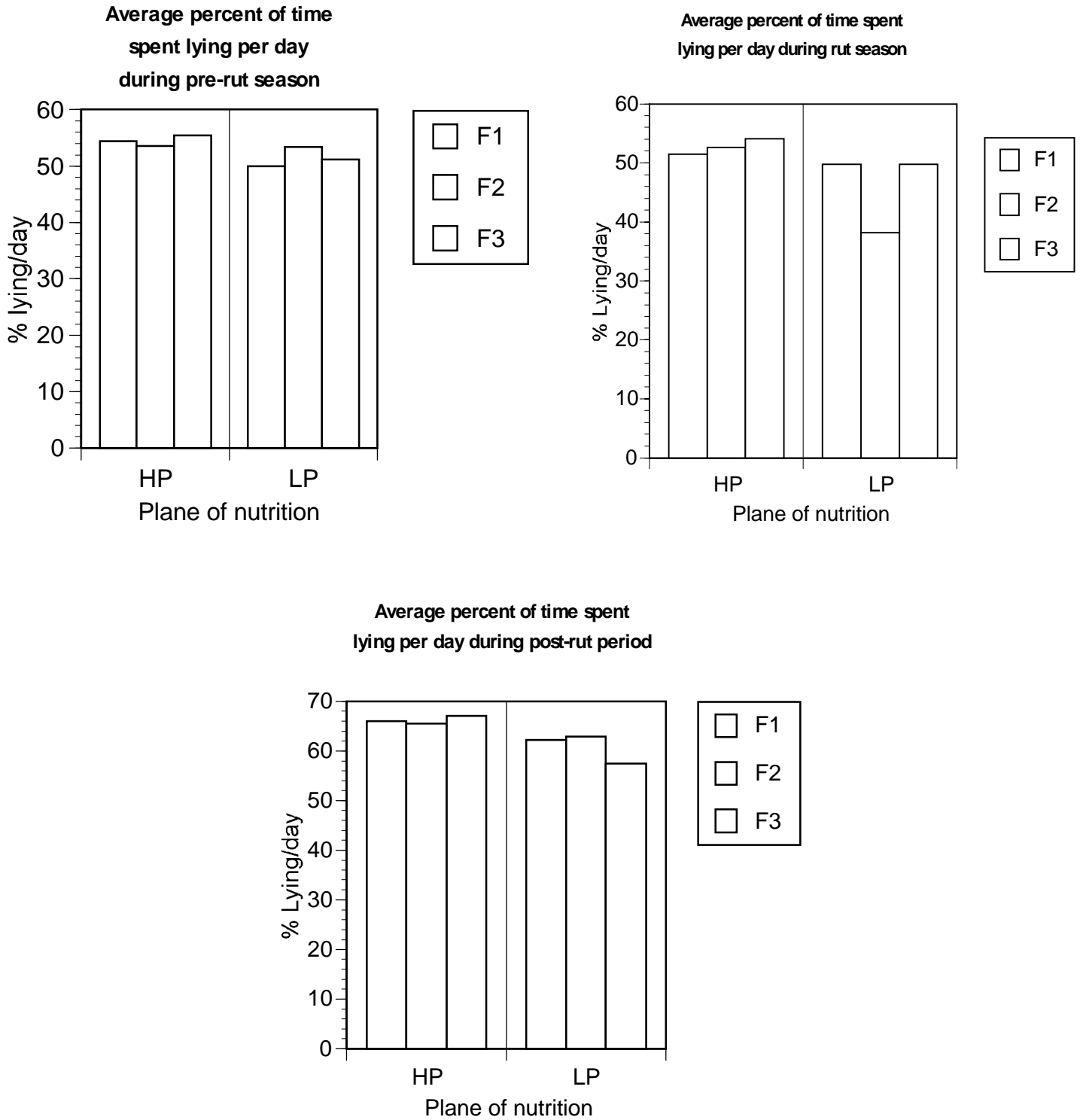


Figure 4a - c. Percentage of total day spent eating by female muskox on different planes of nutrition during pre-rut, rut, and post-rut periods. F1, F2, and F3 indicate individual muskox.

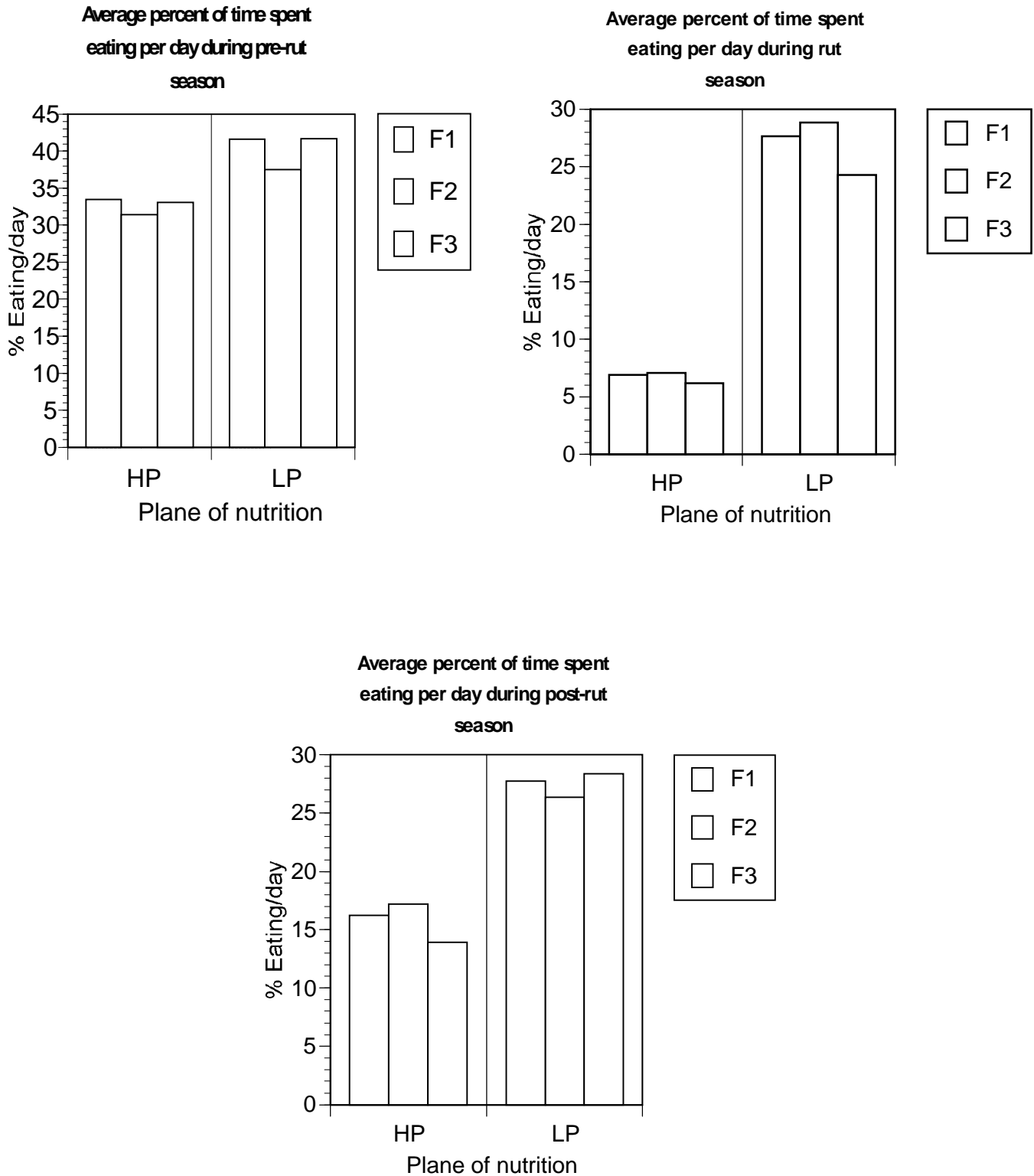


Figure 5a and b. Percentage of total day spent lying and eating by lactating and non-lactating muskox on different planes of nutrition during the pre-rut period.

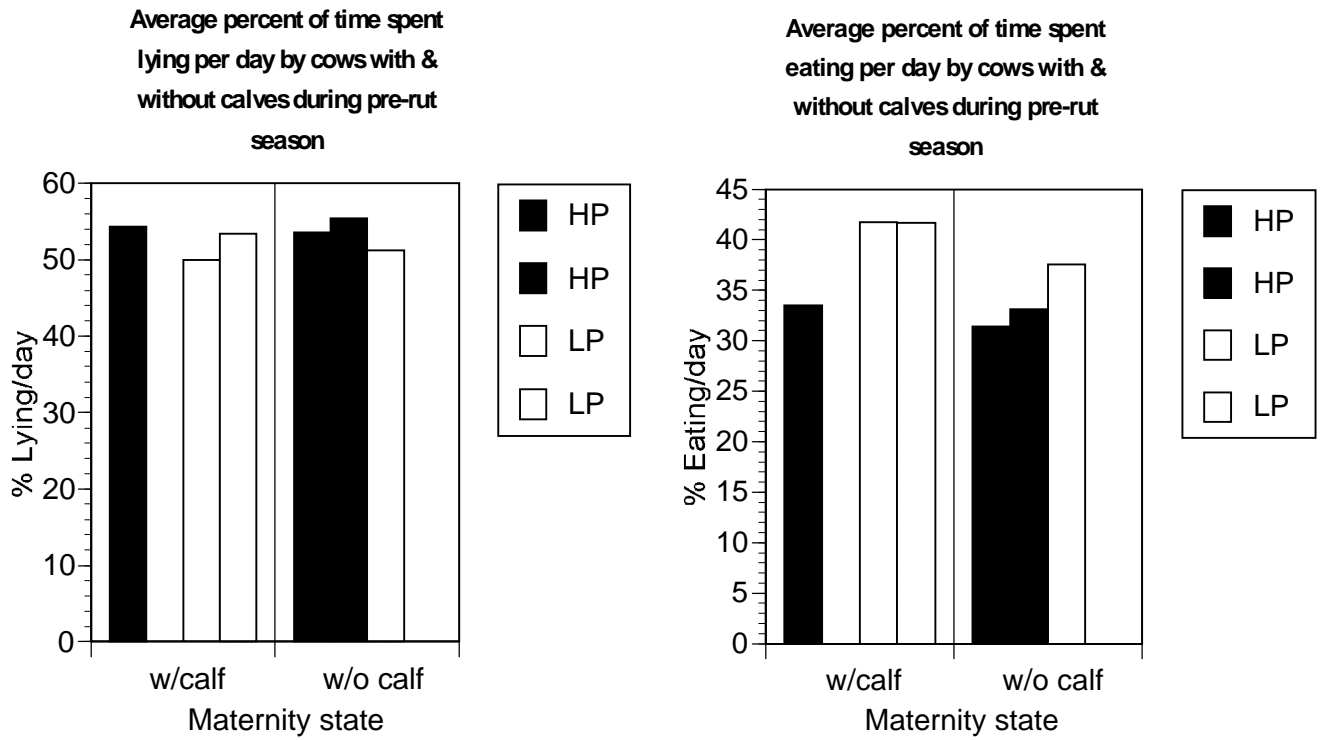


Figure 6a - d. Body weights of high and low-plane muskox cows with calves.

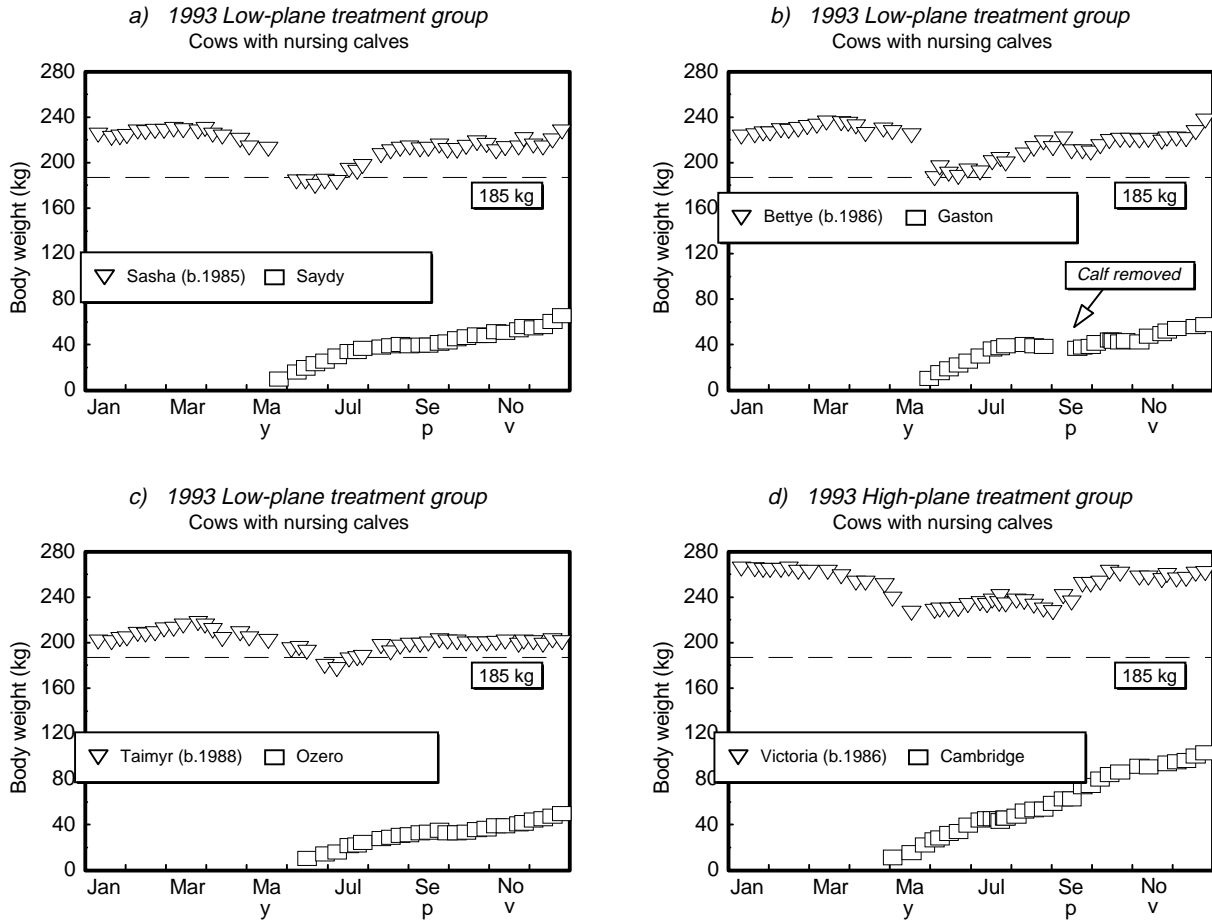


Figure 7a - b. Body weights of non-lactating low-plane muskox cows.

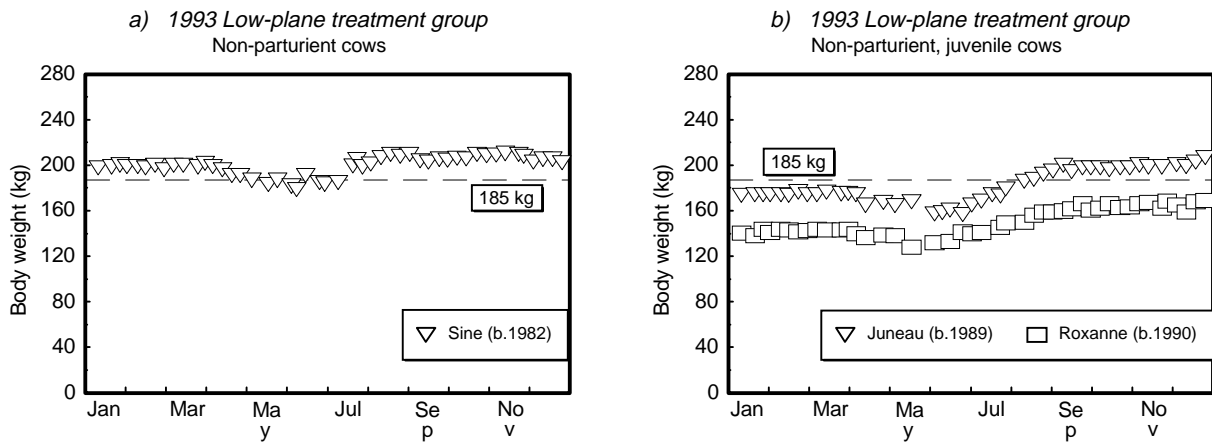


Figure 8a - d. Body weights of non-lactating high-plane muskox cows.

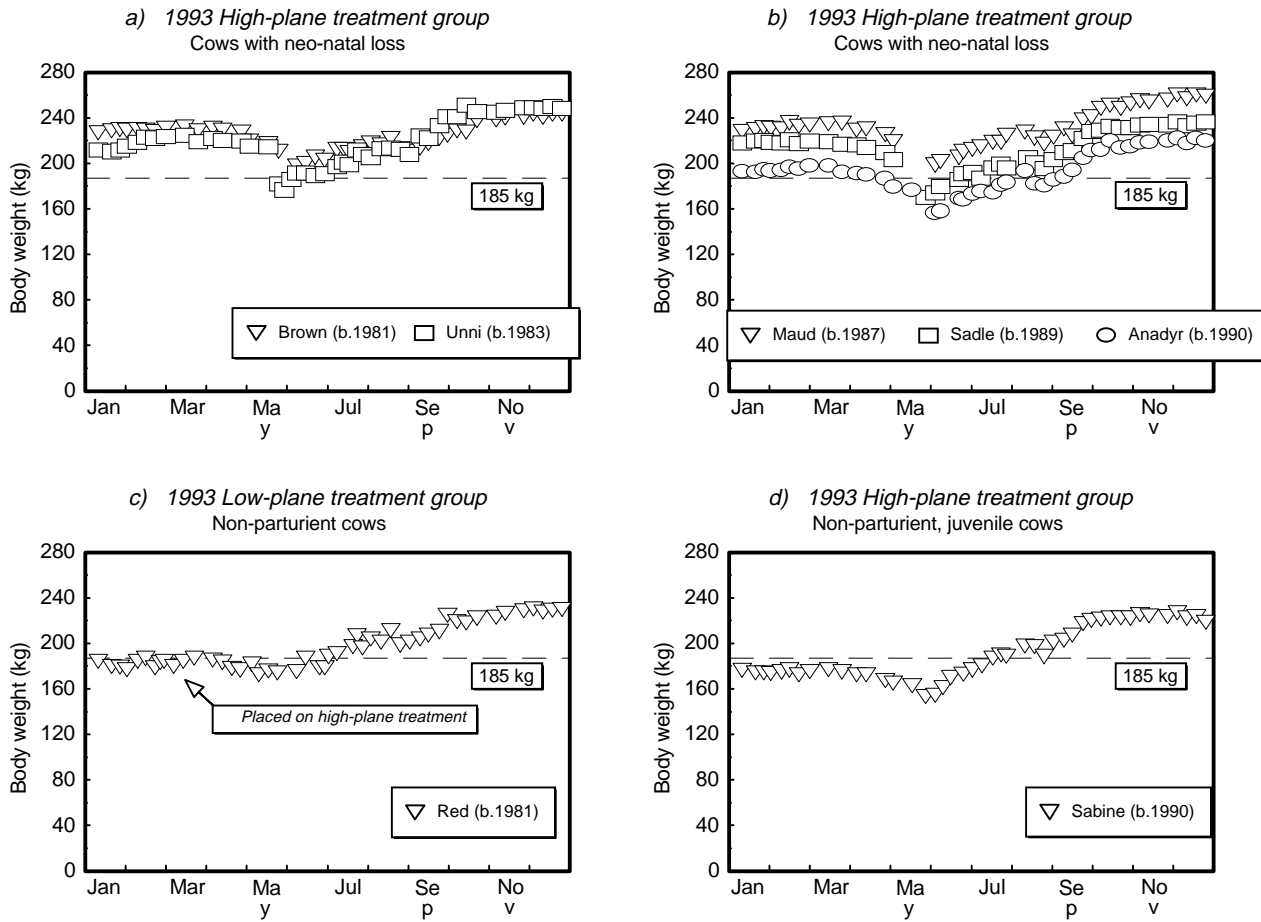


Figure 9a - b. Examples of the lifetime reproductive history and seasonal body weights of a high-plane

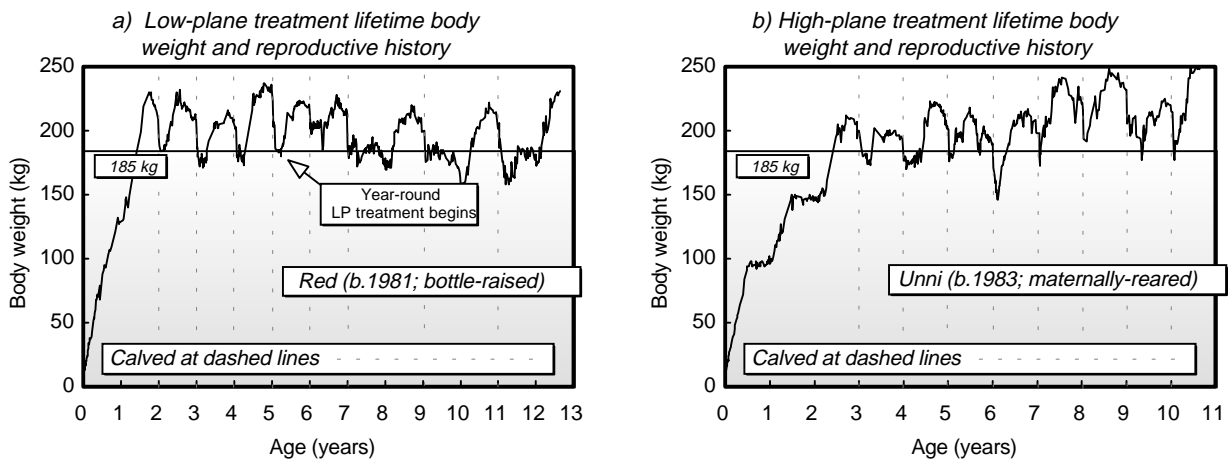
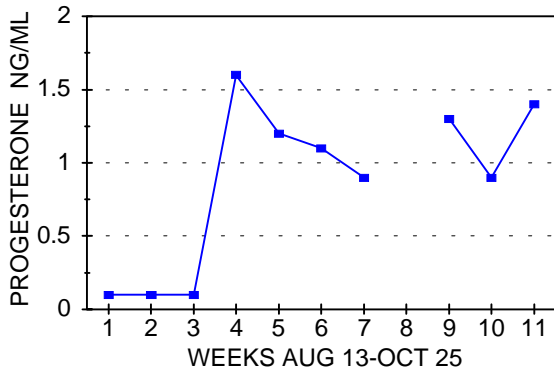
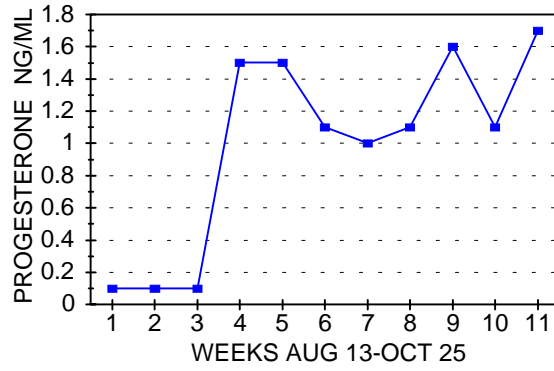


Figure 10a - c. Progesterone levels in HP muskoxen.

UNNI



BROWN



RED

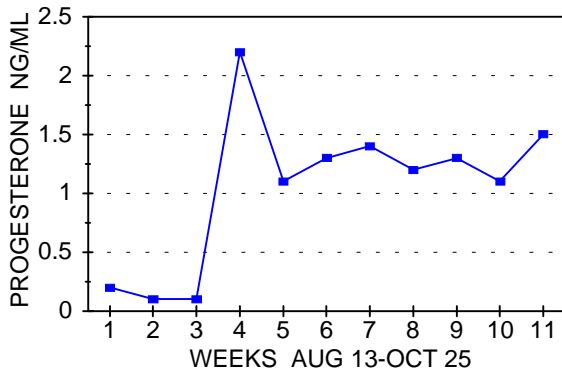
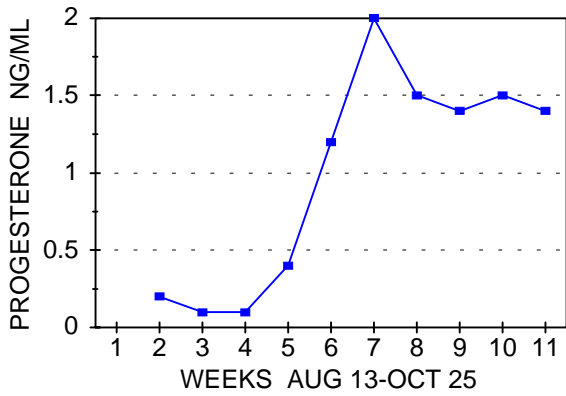
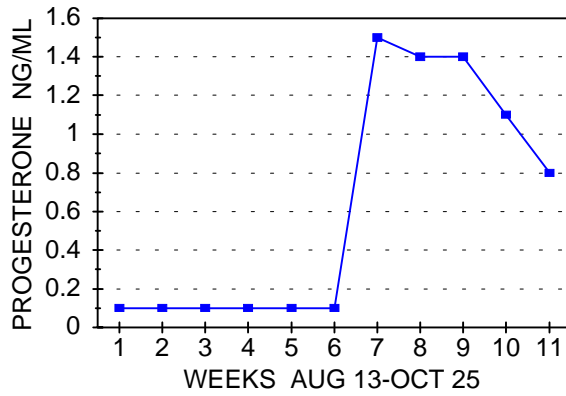


Figure 11a - d. Progesterone levels in LP muskoxen.

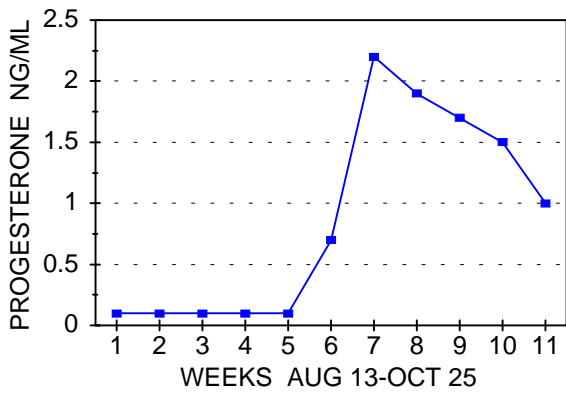
TAIMYR



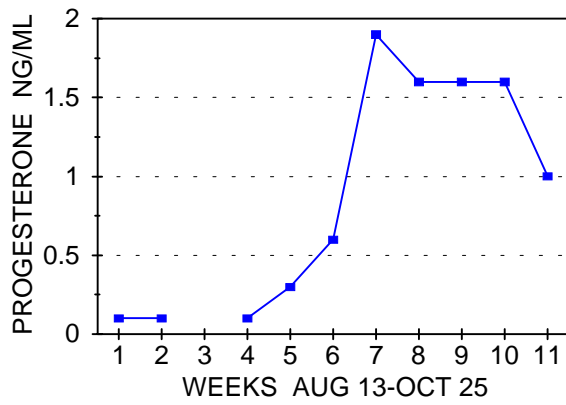
SINE



SASHA



BETTYE



PROJECT STAFF AND GRADUATE STUDENTS

NAME	AFFILIATION/POSITION	PROJECT INVOLVEMENT
Robert G. White	Institute of Arctic Biology	Principle Investigator
J. Rowell	Assistant Director, LARS	Science design and management
W. E. Hauer	LARS Supervisor	Daily scheduling and instruction
J. Carpenter	EW cook/counselor	Cooking and supplies; LARS / EW team liaison
K. Higgs	LARS animal technician	Animal care and handling
T. DeRuyter	LARS animal technician	Animal care and handling
K. DeRuyter	LARS, IAB technician	Technical support for processing samples; tours and sales
V. Baxter	LARS Animal Caretaker	Animal care and handling
A. Schulman	M.S. student	Muskox cow/calf behavior
J. Kitchens	PhD. student	Caribou behavior
J. Lawler	M.S. student	Muskox CH ₄ production

1993 FIELD REPORT

TITLE: Comparison of lactation, nursing, and breeding success of muskoxen and caribou

PI: Robert G. White, Institute of Arctic Biology, University of Alaska, Fairbanks, AK 99775-7530

This report summarizes the activities of the Earthwatch (EW) volunteers while participating in this project during the May - October 1993 field season, and how this will contribute to the project objectives. A total of eight teams participated this season, involving 36 volunteers (one last-minute cancellation); including five volunteers from other countries and a returning volunteer from 1988. A list of the volunteers, their hometowns, and their research involvement and general activities is included in Table 1.

In 1993, the EW volunteers were instrumental in collecting behavioral data of muskox cow - calf pairs maintained on different planes-of-nutrition. This work involved collecting the data from observation towers and recording it on field computers running a program specifically written for this work. The activity budgets generated give an indication of how energy is partitioned among the variety of behaviors monitored, and if differences in partitioning arise because of the different nutritional treatments. In particular, the nursing behavior of the calf is monitored to see if this may act as an indicator of calf fitness, and if this in turn determines the reproductive strategy of the cow for the year.

EW volunteers also observed and recorded the rutting behavior displayed by muskoxen during the mid-August - October breeding period. This information provides insight into how plane-of-nutrition (physical condition of the cow) may influence levels of sexual activity and how this may be used to predict the reproductive success of a cow in a year. Differences in the level of sexual activity between nutritional treatments may also indicate different states of endocrine activity. Direct measurements of progesterone taken from females during the 1993 breeding season will provide a means of testing the validity of these observations.

Milk intake, milk composition, and body condition (body weight and body composition) were measured throughout the season and EW volunteers participated in the collection of samples for these analyses.

One muskox calf which failed to nurse after four days post-partum, was bottle-raised. The EW volunteers were involved in this project, including preparation of milk supplement and measuring milk intake, monitoring body weight, and in taming protocols. Another calf was weaned during the fall because of disease, and EW volunteers were involved in the care and monitoring of this animal.

Caribou observations were conducted by EW volunteers once during each two-week period in 1993, in an effort to establish seasonality of activity patterns of caribou on a high plane -of-nutrition. These data will be used in a preliminary comparison with patterns observed in high-plane muskoxen.

Detailed results from this season, including body weight curves, breeding behavior, activity budgets, nursing behavior, and endocrine profiles, and the implications these data have on the objectives of this study, will be included in the 1993 Annual Report. We hope that each 1993 volunteer will receive a copy of this report from Earthwatch, so that they will be able to understand how their two-week involvement contributed to these overall objectives.

Also enclosed is the final budget accounting for 1993.

1993 Earthwatch volunteers and their related activities while at the Large Animal Research Station.

Team I May 24 - June 7

Thomas Grow / Messena, NY
Paul Husted / Fort Collins, CO
Jean Lewis / Stuart, FL
Joyce Maggard / Yucaipa, CA

*-behavioral observations
-lactation trial
-qiviut combing
-lichen and willow collection
-bottle-feed MOX calf
-pen and pasture maintenance
-public tours
-Denali Park*

Team II June 14 - June 28

Shirin Barakzai / Sutton, Surrey, UK
Helen Callbeck / San Rafael, CA
Mike Chamberlin / Thompsonville, MI
Dana Petri / Houston, TX
Gilbert Petri / Houston, TX

*-behavioral observations
-lactation trial
-lichen and willow collection
-bottle-feed MOX calf
-pen and pasture maintenance
-public tours
-Denali Park*

Team III July 5 - July 19

Jackie Cooperman / Larchmont, NY
Ann Goldstein / Upper Saddle River, NY
Saul Goldstein / Upper Saddle River, NY
Chad Leonard / Meriden, NY
Neal Robbins / Niskayuna, NY
Dan Silbert / Pt. Washington, NY
Morris Tyler / Providence, RI

*-behavioral observations
-lactation trial
-lichen and willow collection
-bottle-feed MOX calf
-pen and pasture maintenance
-public tours
-Denali Park*

Team IV July 26 - August 9

Dorothy Fine / Hollywood, FL
Heather Searles / Royston, Herts UK
Cliff Ward / Battle Creek, MI
Kathy Ward / Battle Creek, MI
Peggy Wilgis / Houston, TX
Jane Zahurak / Lebanon, PA

*-behavioral observations
-lactation trial
-lichen and willow collection
-bottle-feed MOX calf
-feed/train 2nd MOX calf
-sampling for reindeer project
-pen and pasture maintenance
-observation tower construction
-public tours
-Denali Park*

1993 Earthwatch volunteers (cont'd)

Team V August 16 - August 30

Irwin Aloff / Chicago, IL	-behavioral observations
Beth Bieck / Churchville, NY	-rutting activity observations
Cary Guido / Orinda, CA	-lichen and willow collection
Ray Heinicke / Indianola, IA	-bottle-feed MOX calf
Norma Kendall / Greenwich, CT	-feed/train 2nd MOX calf
Catherine Willeford / Seattle, WA	-pen and pasture maintenance
	-sampling for reindeer project
	-public tours
	-Denali Park

Team VI September 6 - September 19

Chris Ball / UK	-behavioral observations
Carla Pietrson / London, ON, Canada	-rutting activity observations
Sharon Hollensbe / Atlanta, GA	-lichen and willow collection
	-bottle-feed MOX calf
	feed/train 2nd MOX calf
	-pen and pasture maintenance
	-public tours
	-Denali Park - day hike
	Chena Hot Springs

Team VII September 27 - October 11

Tom Grow / Maseea, NY	-behavioral observations
Edwin Keener / Eighty Four, PA	-rutting activity observations
Lois Keener / Eighty Four, PA	-bottle-feed MOX calf
Pam Lucas / Cleveland, UK	-feed/train 2nd MOX calf
	-pen and pasture maintenance
	-public tours
	-Chena Hot Springs

Team VIII October 18 - November 1

Pat Collier / Vashon Is., WA	-behavioral observations
	-feed/train 2nd MOX calf
	-barn maintenance
	-lactation trial
	-Chena Hot Springs