MUSKOXEN AND CARIBOU

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

ROBERT G. WHITE, PRINCIPAL INVESTIGATOR

1994 ANNUAL REPORT (Including 1994 Field Report)

TO:	Center for Field Research
DATE:	April 1995
PROJECT:	Muskoxen and Caribou
PROJECT TITLE:	Caparison of Lactation, Nursing Behavior and Breeding Success of Muskoxen and Caribou
PRINCIPAL INVESTIGATOR:	Robert G. White
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LARGE ANIMAL RESEARCH STATION

Institute of Arctic Biology, University of Alaska Fairbanks

April 1, 1995

Dear 1994 Earthwatch Volunteer,

We hope that this copy of our Annual Report will help to present a complete picture of the 1994 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

TABLE OF CONTENTS

INTRODUCTION

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 volunteers for 1994, their hometowns and duties while at LARS is shown in Appendix C.

The 1994 EarthCorps continued with the long-term collection of data on daily activity budgets of female muskoxen and their calves through the summer and fall into the start of winter. They also assisted in many aspects of daily animal care, and with the collection of biological samples for assessing milk production and body composition.

In brief, the objective of this 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 reproductive strategies. 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 captive, pregnant and lactating female muskoxen is controlled by altering both food availability and quality (mainly protein content) to simulate a *wide* (arctic) and *narrow* (high arctic) plant growth period. Females subjected to the *wide* plant growth period are on a high plane (HP) of nutrition while those given the *narrow* period are on a low nutritional plane (LP). Summer grazing quality was initially restricted in the LP treatment group, but since 1993 LP and HP cows are given access to the same quality spring and summer pasture. The HP treatment group are supplemented year-round with a high-protein pelleted ration. Both groups are offered free-choice access to medium-high quality brome hay year-round. These treatments have been maintained since 1987 and, beginning in 1990, offspring follow the nutritional treatment of their mother.

Nutritional effects on calf play, nursing and foraging behaviors are determined using 25-hour activity budgets and are related to maternal activity and behavior. Calf growth rate, milk intake, weaning dates and maternal body weight and condition are measured regularly throughout

the lactation cycle. Courtship behavior and mating are recorded, and combined with information on blood progesterone levels, collected throughout the fall on a subsample of females. The study will determine the body weight and body condition necessary for successful breeding among adults and the pubertal body weight in juveniles.

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

Again in 1994 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 study focuses 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 Earthwatch teams is difficult. But, the 39 team members in 1994 (Appendix C) contributed more than 1800 hours on *observations alone* – equivalent to over $19,000 in wages at the current rate for hiring student technicians.

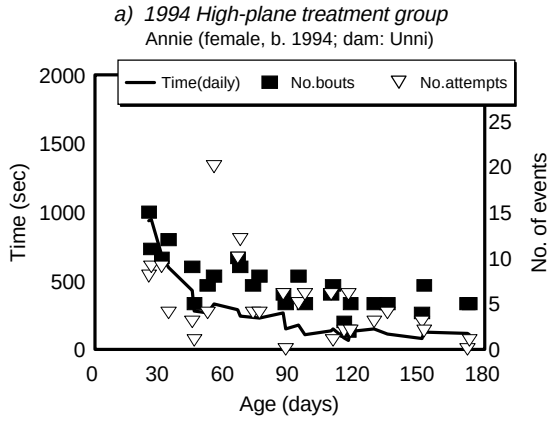
RESEARCH RESULTS

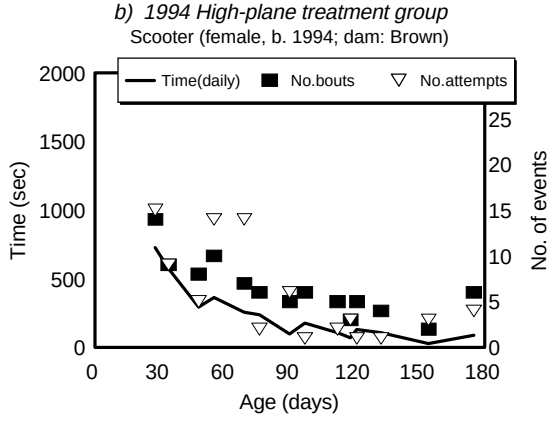
Nursing behavior

During the field season of 1994, seven calves (2 LP and 5 HP) were involved in behavior observations. One of the LP calves died at 125 days of age. Nursing behavior, here expressed as the total daily time spent nursing, generally followed the trend of a steep decline over the first 60 days post-partum (Fig. 1a-c, Fig. 2a-d). For three calves an initial increase in total nursing preceeded the decline, peaking at about day 30 (Fig. 1c, Fig. 2a and d). After day 70 total daily time spent nursing declined exponentially from 250 s/day to less than 60 s/day in both HP and LP calves.

Nursing declined from approximately 10-15 bouts/day at 20-30 days to less than 5 at day 170. Insufficient data were collected in the first 3 weeks to detail the initial response. In general, the number of nursing attempts equalled and mirrored successful bouts. More successful bouts and unsuccessful attempts were noted for LP than for HP calves.

All cows except Unni (HP), who is not pregnant, and Taimyr (LP) appear to have weaned their calves by the end of February 1995.





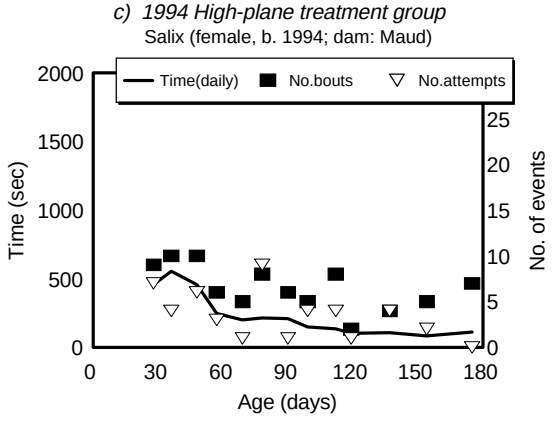
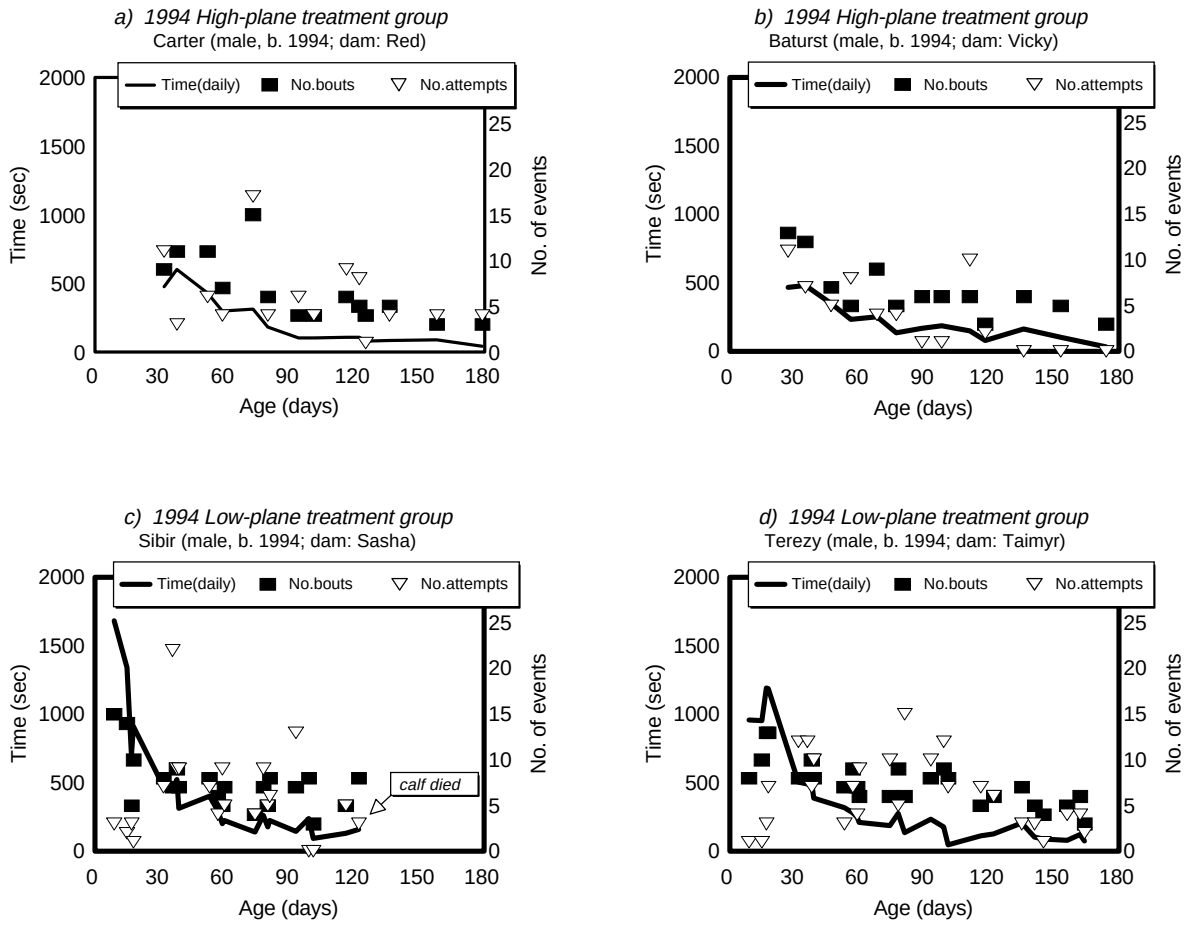


Figure 1a-c. Nursing behavior of female muskox calves born in 1994. Total daily time spent nursing and number of successful bouts and unsuccessful attempts are shown relative to calf age.

Figure 2a-d. Nursing behavior of male muskox calves born in 1994.



Feeding and lying activity budgets

The field season was subdivided into three "seasons" based on the presence or absence of a bull: pre-rut, rut, and post-rut. During these periods, food quality varied. Grazing was available for all animals pre-rut while hay (LP) or hay and pelleted supplement (HP) was available during the rut and post-rut periods. Cows are classified within seasons by maternity state and according to nutritional treatment group. The effect of season, plane of nutrition, and maternity status on time spent feeding and lying is shown in Figures 3 and 4.

Results from this year differ only slightly from last year in that both season and plane of nutrition appear to have significant effects on the amount of time that females spend engaged in feeding behaviors, but not in lying. In all three seasons LP females spent more time feeding than those on HP (Fig. 3a-c). We associate this difference to access to the pelleted ration by HP

females, which reduces the time necessary to maximize food intake through grazing in the pre-rut season or by eating hay in the rut and post-rut seasons.

Maternity status in the LP group did not appear to have a significant effect on either time spent feeding or lying (Fig. 5a and b). If observations on feeding time give an estimate of food intake, then these data suggest that there are no differences in food intake between lactating and non-lactating LP cows.

Figure 3a-c. The proportion of the day spent *feeding* during the pre-rut, rut and post-rut seasons for adult female muskoxen on high and low planes of nutrition (HP and LP).

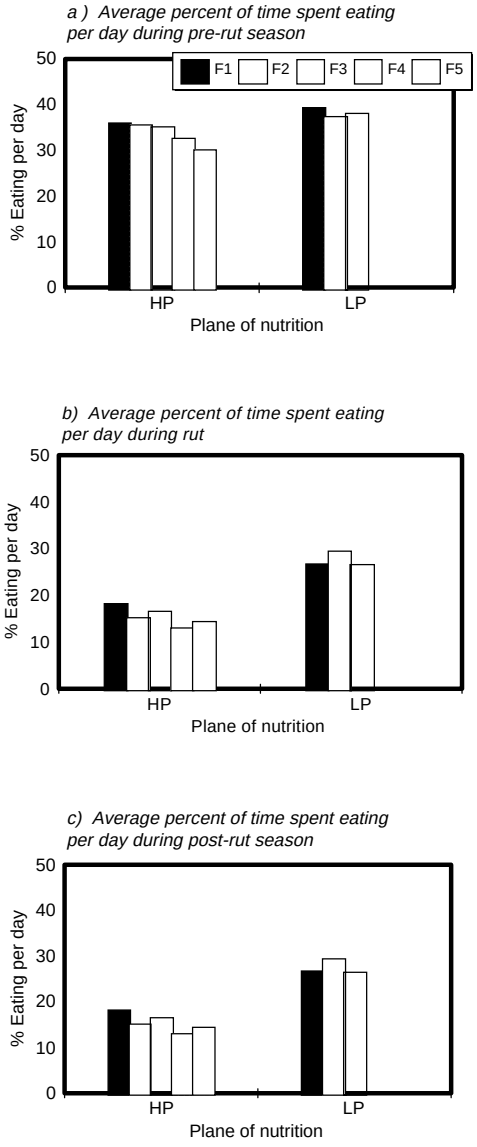


Figure 4a-c. The proportion of the day spent *lying* during the pre-rut, rut and post-rut seasons for adult female muskoxen on high and low planes of nutrition (HP and LP).

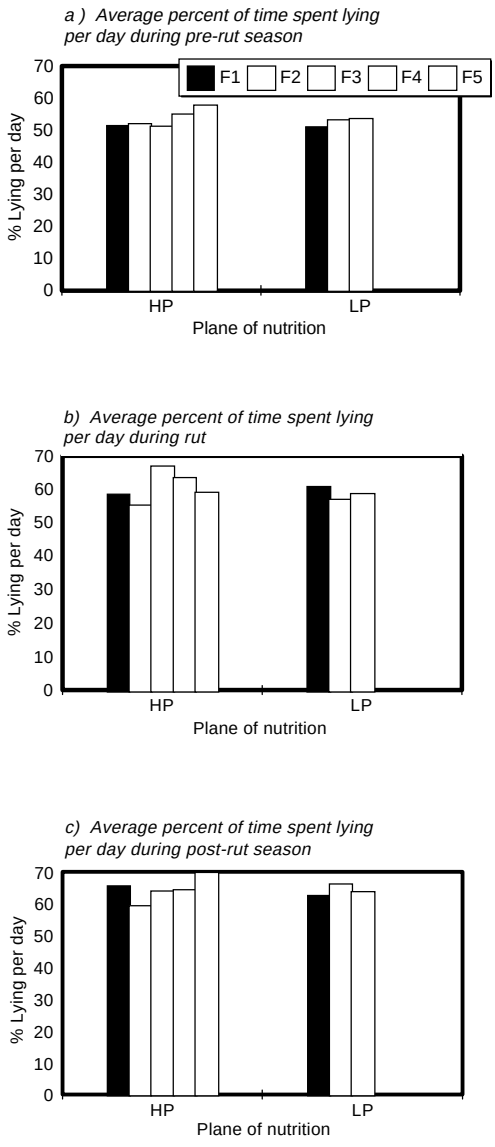
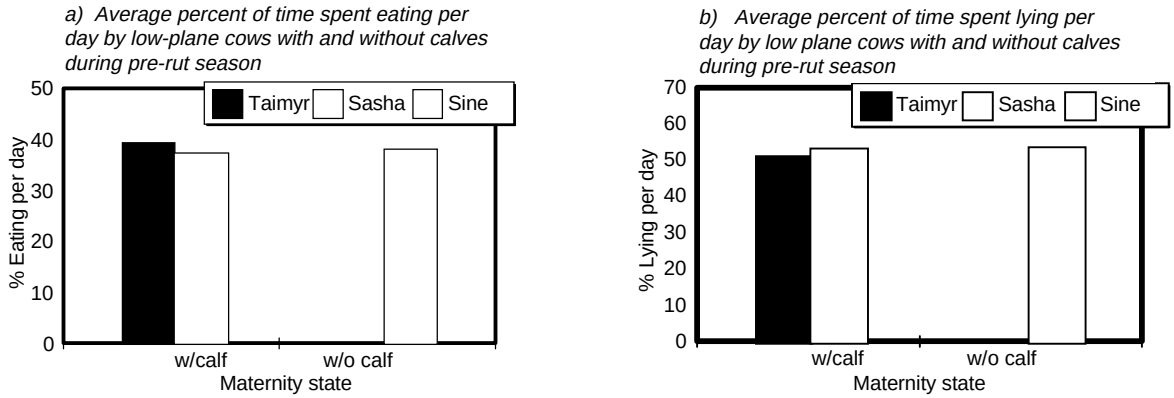


Figure 5a and b. Daily eating and lying patterns of lactating and a non-lactating LP muskox cows during the pre-rut season.



Body weight trends

Figure 6a-d depicts body weight changes in three HP cows and one L P cow with calves. Three of the cows (Maud, Victoria, and Taimyr) are all daughters of the fourth (Brown). All four cows lost weight at, and immediately following, calving. All four cows began increasing weight in approximately mid-July, and continued gaining until the beginning of rut, when their weight gain stabilized. The other cows with calves (Fig. 7a-c) followed the same general trends of body weight loss, gain, and stabilization. Three HP cows (Maud, Vicky, and Unni; Fig. 6b and c, Fig. 7c) appeared to go through an additional weight gain shortly after the beginning of rut.

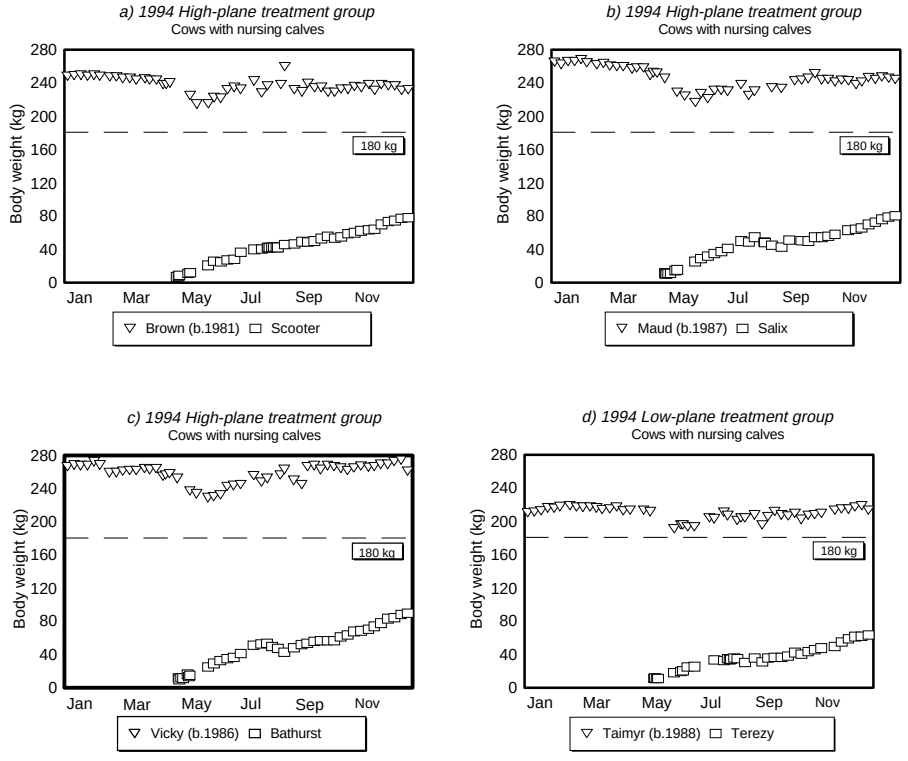


Figure 6a-d. Yearly body weight curves of maternally-related adult muskoxen and their nursing calves.

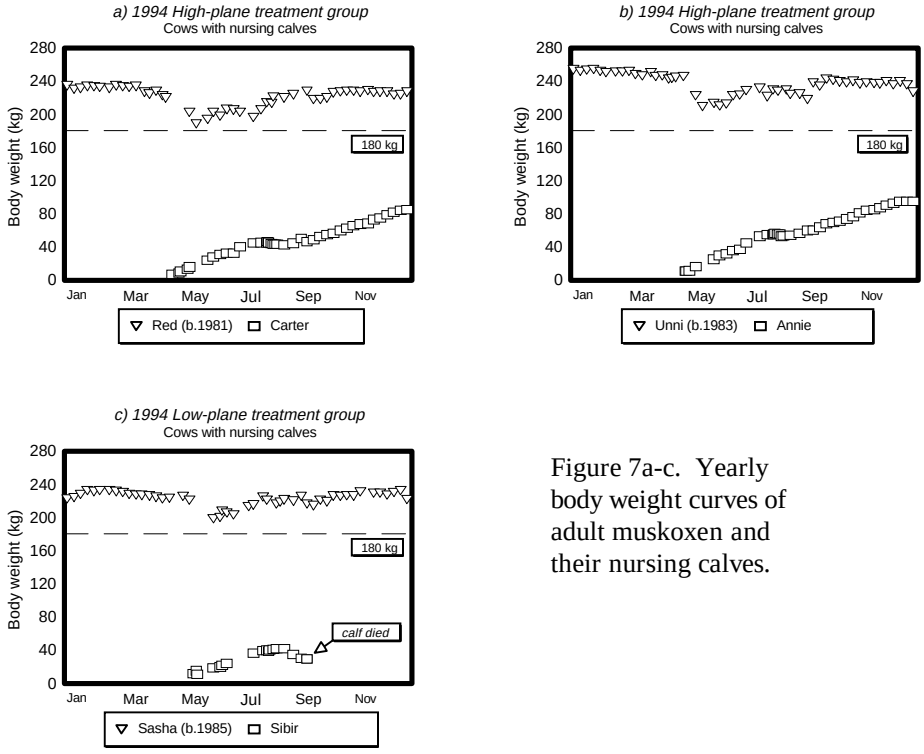


Figure 7a-c. Yearly body weight curves of adult muskoxen and their nursing calves.

Cows with neonatal losses (Fig. 8a-c), as well as cows without calves (Fig. 9a and b) demonstrated relatively steady summer weight gains from approximately late-May/early-June through August. The cows who lost their calves shortly after calving also showed the typical weight loss associated with producing a calf.

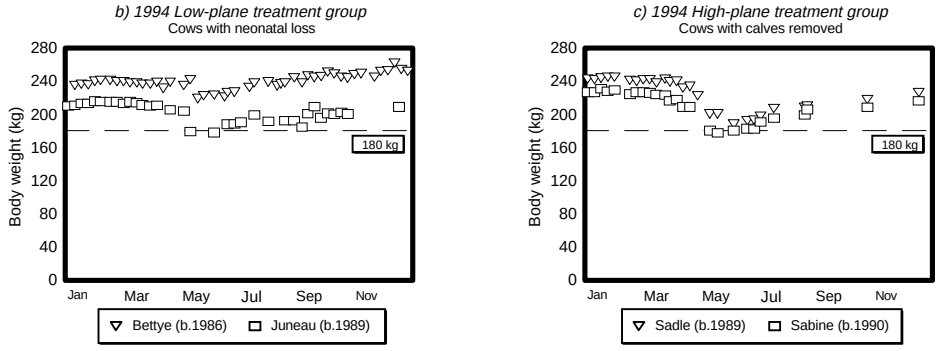


Figure 8a-c. Yearly body weight curves of adult female muskoxen with neonatal losses.

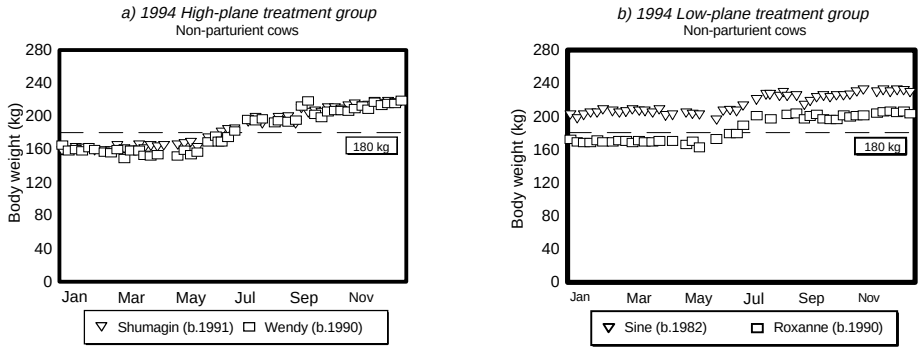


Figure 9a and b. Yearly body weight curves of adult female muskoxen with neonatal losses.

Body weight, body condition score and pregnancy

Body condition score (BCS) is a subjective measurement of subcutaneous fat reserves. The ribs, hip pins and saddle region are palpated, and the amount of fat covering these bony structures is evaluated on a scale of 1 – 5, where 5 is maximum fat covering and 1 is no fat covering. The scores for each region are totaled, giving an overall index of body condition (BCS) – ranging from a low of 3 (no fat reserves) to 15 (extremely well conditioned).

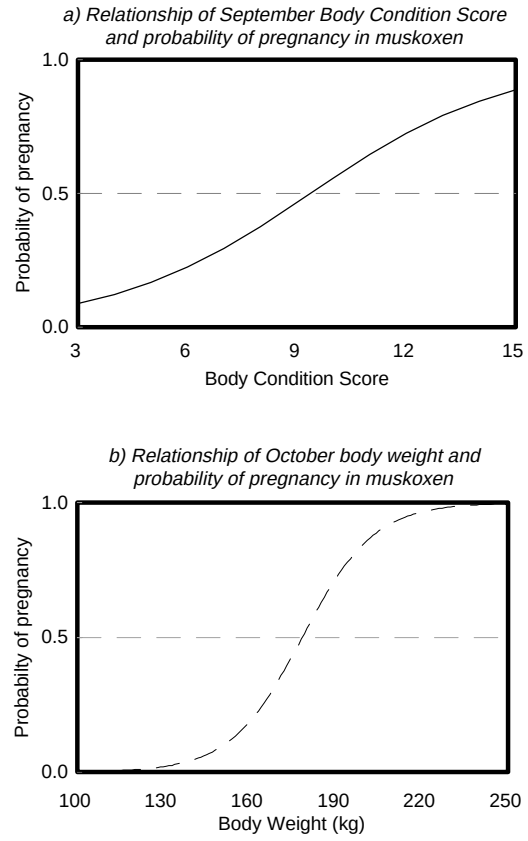


Figure 10a and b. Logistic curves produced by the regression of body weight and Body Condition Score against calving success in muskoxen.

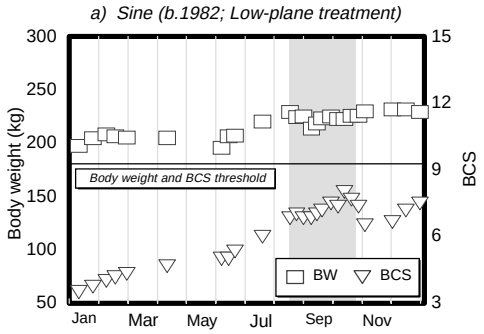
Body weight and BCS during the fall breeding period of September and October have been found to be good predictors of pregnancy in muskoxen (White *et al*., in prep.). Those females with a BCS above 9 in September and/or a body weight above 180 kg in October have a greater than 50% chance of calving in spring (Fig. 10a and b). Body condition score is statistically a more accurate predictor of successful calving than body weight.

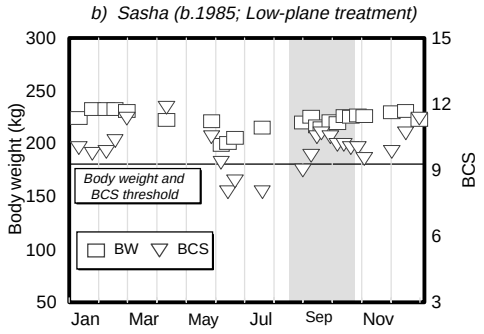
Figures 11a-e and 12a-g shows seasonal body weight and BCS of mature female muskoxen. High-plane cows typically maintain conditioning above the body weight and BCS threshold throughout the year, showing a decline

in both parameters at calving, with a gradual regain in conditioning throughout summer and fall. All HP cows were well above the body weight and BCS threshold during the breeding season (August - October), and all except Wendy nursed calves.

Low-plane females tended to have a more pronounced cyclicity in seasonal BCS, with abrupt declines in body condition at calving and again toward the end of rut. This decline in BCS at the end of October indicates a retrospective study of the data is necessary to see if this phenomenon is characteristic of the LP treatment group.

Taimyr was the only female in the LP group to successfully raise a calf; Sasha lost her calf in September, while Bettye and Juneau experienced neonatal losses. Sine did not calve in 1994 and never achieved a BCS above nine even though her body weight was above 180 kg throughout the year. She was pregnant at the end of rut, but aborted in December.





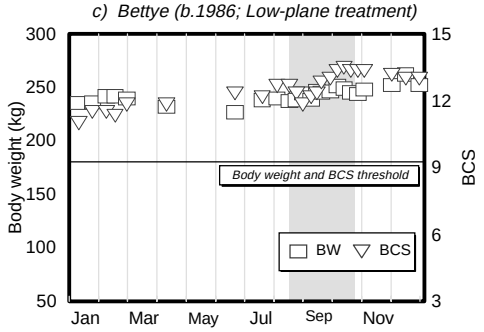
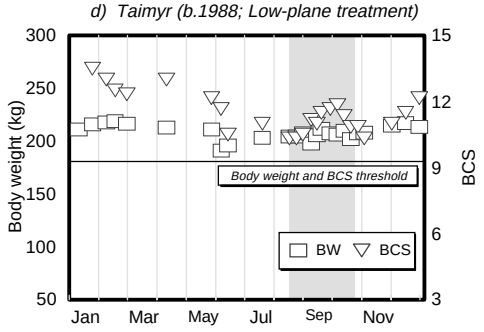
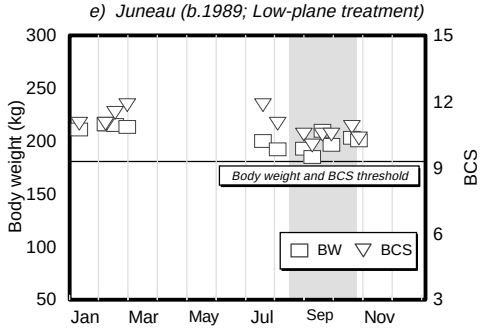


Figure 11a-e. Seasonal body weight and Body Condition Score (BCS) of female muskoxen on a *low plane of nutrition*.





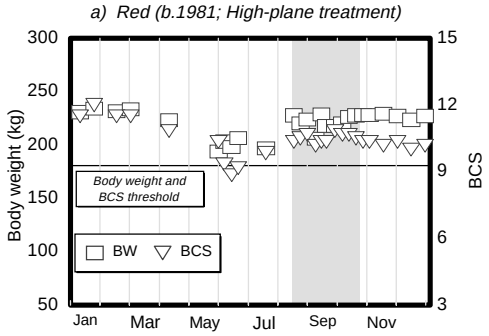
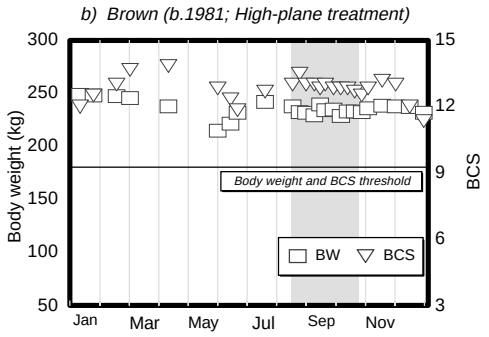
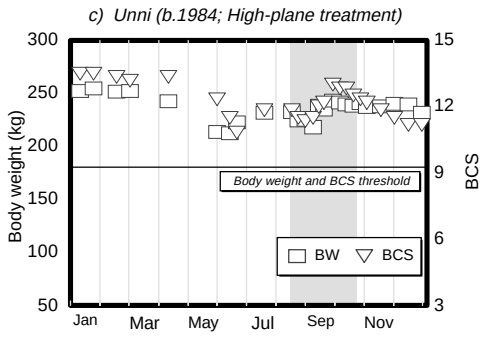
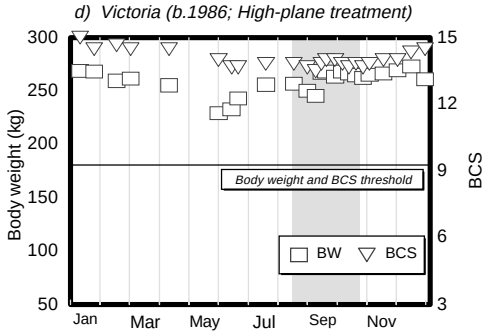
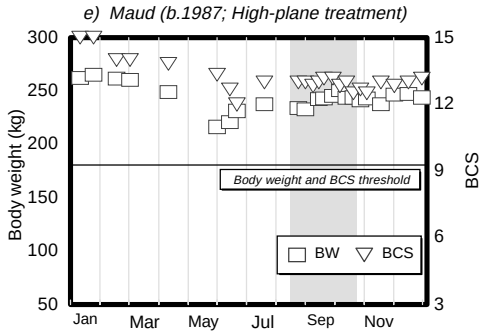


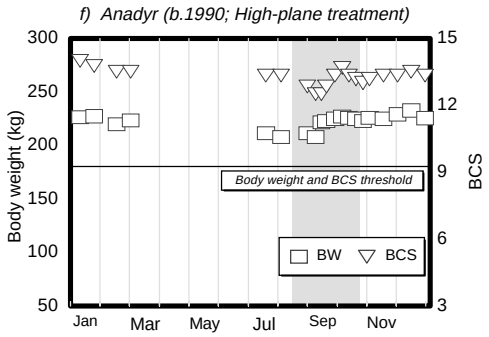
Figure 12a-g. Seasonal body weight and Body Condition Score (BCS) of female muskoxen on a *high plane of nutrition*.

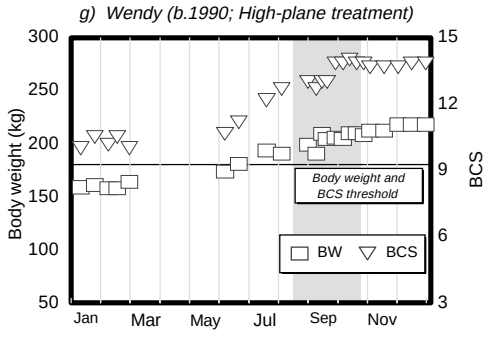






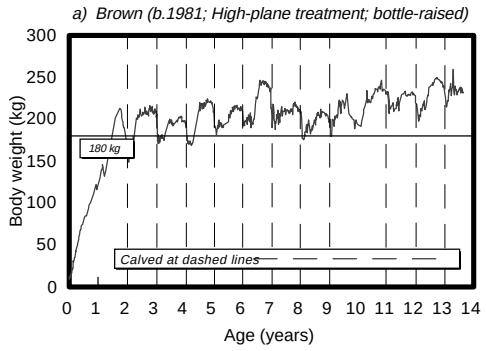


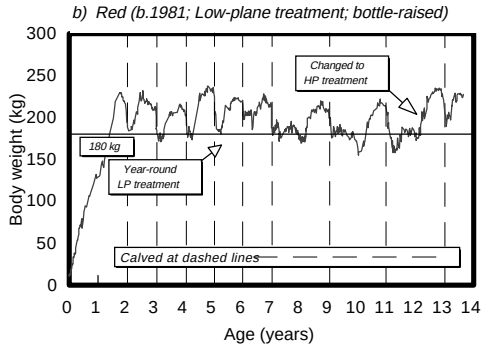




Lifetime reproductive histories

Figure 13a-o demonstrates the relationship of seasonal body weight and lifetime calf production in female muskoxen on HP and LP treatments. The most apparent and consistent treatment effect is a 1 -2 year delay in puberty among LP females relative to sub-adult HP females. This is most likely dependent on achieving and maintaining a 180 kg pubertal body weight. Delayed puberty in LP females has been followed by yearly calf production, suggesting that this conservative reproductive strategy is successful in more marginal habitats. The effort to regain sufficient body weight following calving is pronounced in all mature LP females, and may not be possible in every year with older females.





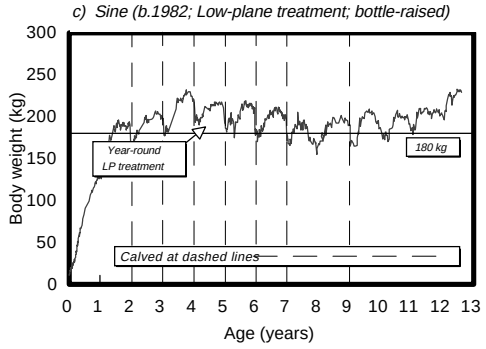
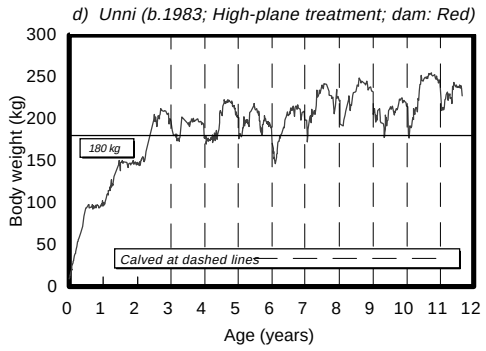
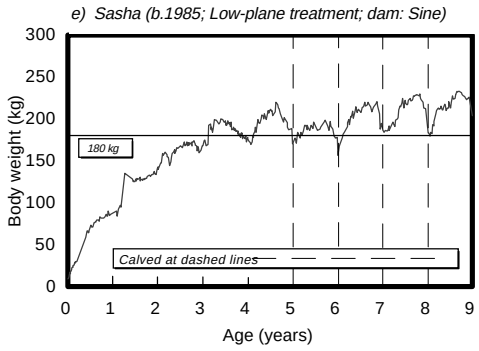


Figure 13a-o. Lifetime body weight and reproductive history of female muskoxen on high and low planes of nutrition.





Red (Fig. 13b) characterizes a female responding to changing habitat as she moves from HP (arctic) to LP (high arctic) and back to HP treatment. Changing from a HP to LP diet required 2 years to induce a breeding pause and alternate-year calving. But the reverse, moving from a LP to HP diet produces an immediate response in body weight gain, with a resumption of yearly calving (she is predicted to calve in 1995).

Figure 13a-o *(continued)*

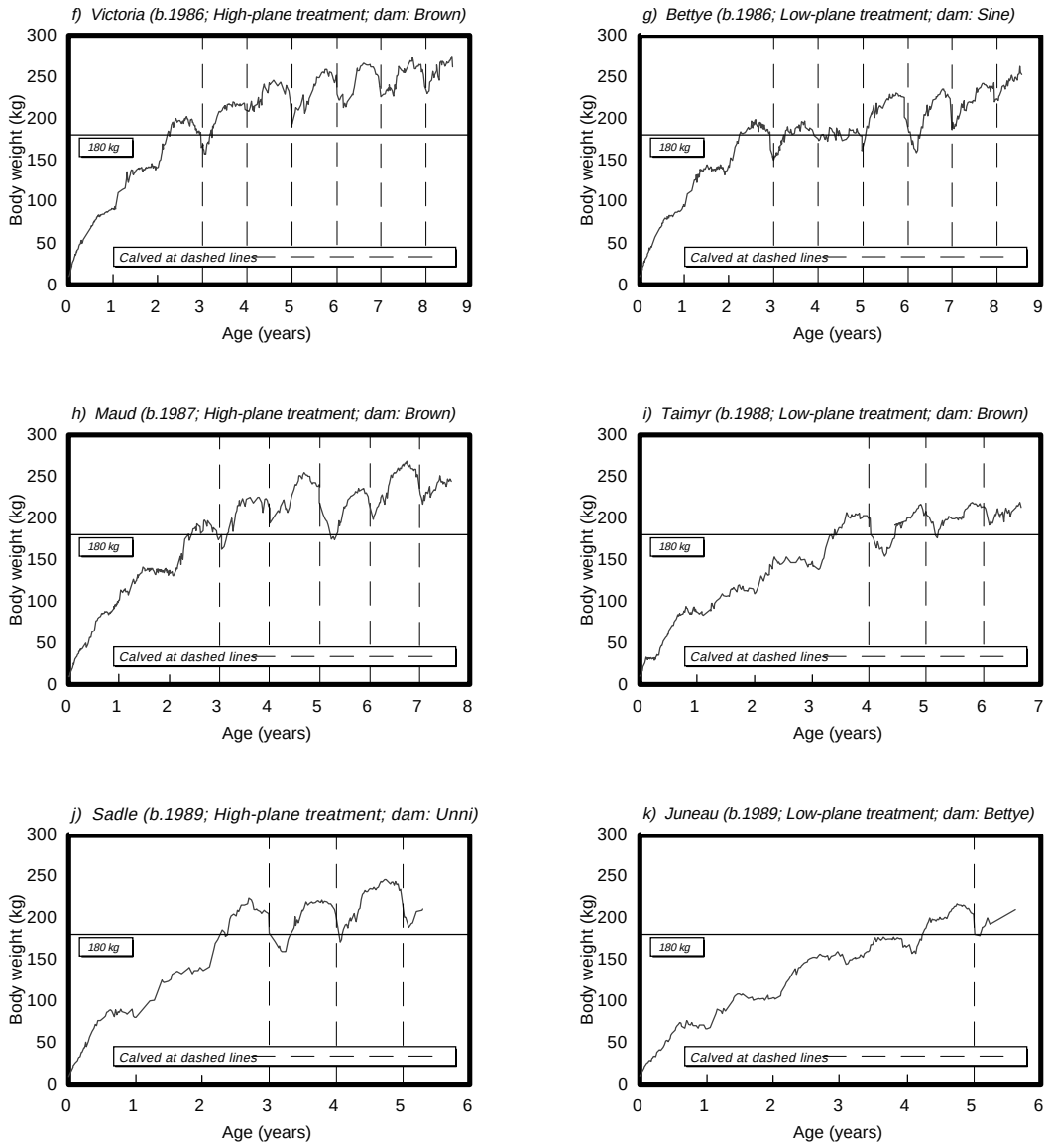
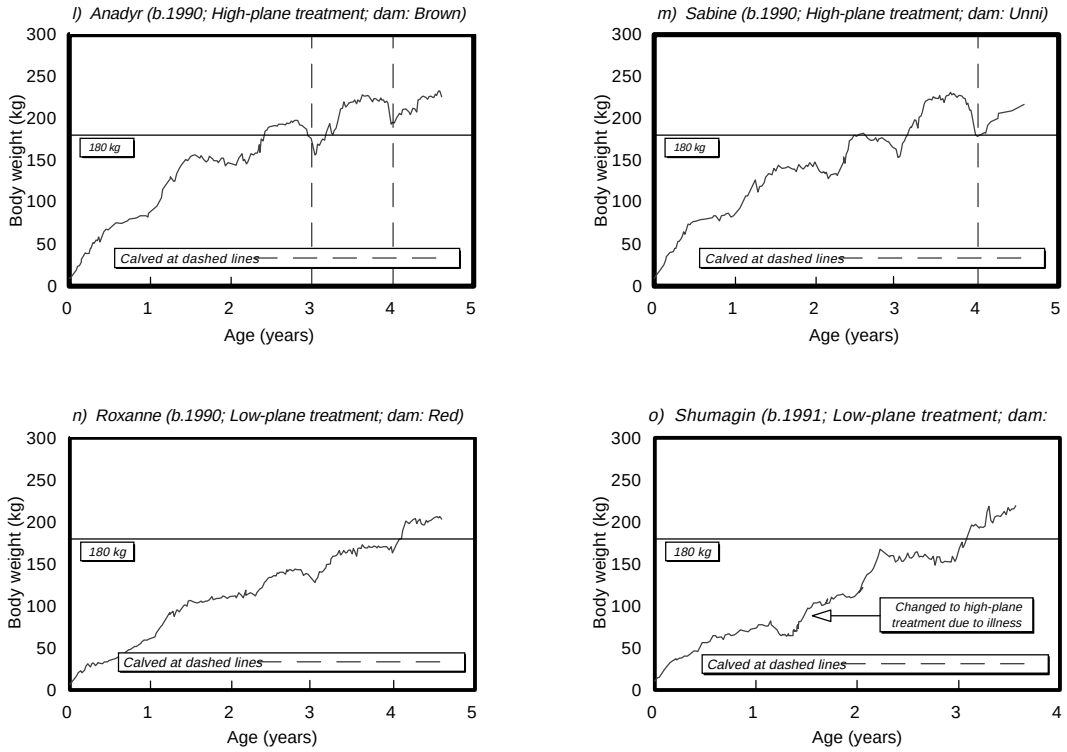


Figure 13a-o *(continued)*



Courtship and pregnancy

Harems were formed on August 22, 1994. Some courtship and breeding activity was noted almost immediately and was most intense in the HP pen. Very little activity was observed in the LP pen this year and over the entire breeding season only three matings were recorded in this group.

Blood samples were collected on a weekly basis throughout the breeding season. These will provide hormonal information that will corroborate behavioral observations and hopefully provide insight into endocrine differences between the HP and LP breeding activity. Because blood sampling is continuing on a bi-monthly basis throughout pregnancy, analyses for hormones of the estrous cycle and pregnancy will not begin until spring 1995.

In November, Dr. Greg Adams, a specialist in large animal ultrasonography, did a teaching workshop at LARS and we were able to examine nine muskox cows for pregnancy. In the HP group, ultrasound was done on Unni, Brown, Red, Wendy and Schumigan. All were pregnant, with the exception of Unni. Unni was apparently healthy and of adequate body weight during the

rut to become pregnant. Further understanding of her non-pregnant condition will have to await hormonal analyses.

In the LP group Sine, Sasha, Bettye and Taimyr were all confirmed pregnant by ultrasound. In December, Sine aborted. Before confirming this as a treatment effect, all obvious clinical causes must be ruled out.

Fetal measurements were obtained from seven of the eight pregnant cows at the time of ultrasound and from these, breeding and calving dates have been estimated (Table 1). While these estimates incur some error, they do reinforce the trend seen in past years of earlier breeding among HP cows.

Table 1. Estimates of the number of days pregnant, date of conception and calving dates derived from real-time ultrasound of fetal crown-rump and fetal transcranial measurements in muskoxen. Estimates are based on formulas taken from Pharr *et al*., 1994, Can. J. Vet. Res. 58:167-172.

	Measurements		*Estimates*		
Name	Crown-Rump (mm)	Transcranial (cm)	No. days pregnant*	Date of conception**	Date of calving
High-plane treatment					
Red	na	2.7	85	Aug 18[a]	Apr 15
Shumagin	na	2.5	81	Aug 22[a]	Apr 19
Brown	na	1.7	64	Sep 8	May 6
Low-plane treatment					
Bettye	na	2.8	87	Aug 16[a]	Apr 13
Sine	na	1.3	57	Sep 15	May 13
Sasha	na	1.1	54	Sep 18	May 16
Taimyr	47	na	50	Sep 22	May 20

***** There is a known error of $\pm$4 days in this estimate

****** This estimate is based on a 235 day gestation which also carries an error of $\pm$4 days.

[a] These conception dates occur on or before harem formation and most likely arise from an error in estimating days pregnant. Shumigan was observed mated on Aug 25 and Red on Aug 26 and 27, both dates falling within the normal range of error. There are no mating observations for Bettye but she were almost certainly bred shortly after harem formation.

RESEARCH SUMMARY

- Neo-natal calf losses were again a factor in the 1994 research season. These occurred predominantly in the LP group this year 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.

- Nursing behavior and feeding / lying activity patterns both reinforce trends observed in previous years.

- Body Condition Score varies more dramatically on a seasonal basis than body weight, and is a better predictor of calving success.

- Ultrasound revealed a high pregnancy rate among all seven females examined and is consistent with the BCS / body weight model proposed in White *et al.*

- 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.

Appendix A PROJECT STAFF AND GRADUATE STUDENTS

NAME	AFFILIATION/POSITION	PROJECT INVOLVEMENT
Robert G. White	Institute of Arctic Biology	Principal Investigator
J. Rowell	Assistant Director, LARS	Science design and management
A. Schulman	M.S. student	Muskox cow/calf behavior analysis Daily EW scheduling and instruction
W. E. Hauer	LARS Supervisor	
J. Carpenter	EW cook/counselor	Cooking and supplies; LARS / EW team liaison
T. DeRuyter	LARS animal technician	Animal care and handling Daily activities management
K. Higgs	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
J. Lawler	M.S. student	Muskox CH_4 production

Appendix B 1994 FIELD REPORT

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

PRINCIPAL INVESTIGATOR: Robert G. White, Institute of Arctic Biology, University of Alaska, Fairbanks, AK 99775-0180

This report summarizes the activities of the Earthwatch (EW) volunteers while participating in this project during the May - October 1994 field season, and how this will contribute to the project objectives. A total of eight teams participated this season, involving 39; including seven volunteers from other countries and two returning volunteers from 1988. A list of the volunteers, their hometowns, and their research involvement and general activities is included in Figure 1.

In 1994, 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 1994 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.

Two muskox calves were weaned early in summer for imprinting and training. The EW volunteers were involved in this project, including preparation of milk supplement and measuring milk intake, mo nitoring body weight, and in taming protocols.

Caribou observations were not conducted in 1994, again because resources were not sufficient to allow concurrent muskox and caribou observations.

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 1994 Annual Report. We hope that each 1994 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 1994.

Appendix C 1994 EARTHWATCH VOLUNTEERS

Team I *May 23- June 6*

	Activities:
Diane Longenecker, Saint Louis, MO	*-behavioral observations*
Ellen Rosenbaum, Carlsbad, CA	*-lactation trial*
Akie Sakaue, Osaka, Japan	*-qiviut combing*
Masami Tezuka, Osaka, Japan	*-lichen and willow collection*
	-pen and pasture maintenance
	-public tours
	-Denali Park

Team II *June 13 - June 27*

	Activities:
Amy Culpepper, Fort Valley, GA	*-behavioral observations*
Bryant Culpepper Fort Valley, GA	*-lactation trial*
Richard Dale, Tucson, AZ	*-lichen and willow collection*
Rivkah Feldman, Sloansville, NY	*-bottle-feed MOX calves*
Lu Shafer, Denver, CO	*-pen and pasture maintenance*
George Van Buren, Houston, TX	*-public tours*
	-Denali Park

Team III *July 4- July 18*

	Activities:
Richard Godfrey, Columbia, MD	*-behavioral observations*
Rebecca Greenberg, Cambridge, MA	*-lactation trial*
Elizabeth Guertler, Columbia, MD	*-lichen and willow collection*
Robert Mayko, Wimauma, FL	*-bottle-feed MOX calves*
Ken Pearson, Lancashire, UK	*-reindeer forage collection*
Lila Steyert, Colorado Springs, CO	*-pen and pasture maintenance*
	-public tours
	-Denali Park

Team IV *July 25 - August 8*

	Activities:
Angie Anderson, Des Moines, IA	*-behavioral observations*
Scott Brase, Lincoln, NE	*-lactation trial*
Richard Cirelli, Bergenfield, NJ	*-lichen and willow collection*
Ruth Link, Fairlawn, NJ	*-bottle-feed/train MOX calves*
Richard McGrath, Worcester, MA	*-stain and trim EW cabin*
Suzy Pence, Boston, MA	*-pen and pasture maintenance*
	-breeding pen set-up
	-public tours
	-Denali Park

Team V *August 15 - August 29*

	Activities:
Margaret Baisley, Richmond Hill, NY	*-behavioral observations*
Susan Field, Portsmouth, RI	*-breeding activity observations*
Wendy Goidell, New York, NY	*-lichen and willow collection*
Shai Morris, Los Angeles, CA	*-bottle-feed/train MOX calves*
DeAnne Shank, Anaheim, CA	*-pen and pasture maintenance*
Susan deNeufville, New York, NY	*-public tours*
	-Denali Park

Team VI *September 5- September 18*

	Activities:
Barbara Allen, Austin, TX	*-behavioral observations*
	-breeding activity observations
	-lichen and willow collection
	-feed/train MOX calves
	-pen and pasture maintenance
	-public tours
	-Denali Highway

Team VII *September 26 - October 10*

	Activities:
Fenella Boxall, Hong Kong, China	*-behavioral observations*
John Boxall, Hong Kong, China	*-breeding activity observations*
Sherri Bush, Riverdale, NY	*-feed/train MOX calves*
Jennifer Forsyth, Durango, CO	*-pen and pasture maintenance*
Gail Lovinger, Evanston, IL	*-public tours*
Ericka Mann, Springfield, MO	*-Chena Hot Springs*

Team VIII *October 17 - October 31*

	Activities:
Sandra Dunn, Kent, WA	*-behavioral observations*
Bill Dunn, Kent, WA	*-feed/train MOX calves*
Kerry Wilson, Midlothian, Scotland	*-qiviut processing*
Amanda Holmes, London, England	*-lactation trial*
	-Chena Hot Springs