# 1995 Annual Project Report

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Comparison of Lactation, Nursing Behavior and Breeding Success of Muskoxen

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## Project introduction and objectives

From 1987 to 1995, Earthwatch research volunteers assisted in data collection at the Large Animal Research Station (LARS), Institute of Arctic Biology, University of Alaska Fairbanks. Their effort was part of a continuing study, begun in 1983, investigating the effect of plane-of-nutrition on reproduction in muskoxen (*Ovibos moschatus*) and barren ground caribou (*Rangifer tarandus granti*). Earthwatch volunteers conducted extensive behavioral observations of muskoxen, and assisted in the collection of samples for measuring milk production and body condition.

The primary objective of the study is to assess the influence of plane-of-nutrition on yearly reproductive success of muskoxen and caribou by observing daily activity patterns, which may reflect reproductive strategy as a cow attempts to optimize reproductive effort while faced with the constraints of lactation and habitat. It is hypothesized that the nursing behavior of the calf may act as a feedback mechanism affecting maternal breeding strategy in those species sensitive to habitat deterioration. Muskoxen, with restrictive home ranges and potentially high population densities, should show this effect, while caribou, because of a migratory life history, should show less of this effect.

Secondary objectives of the study are to determine 1) a seasonal threshold of body weight for successful breeding, and 2) maternal investment in lactation and weaning.

Nutrient intake for captive female muskoxen at LARS 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 treated to the *wide* plant growth period are on a high plane (HP) of nutrition while those on the *narrow* period treatment are on a low nutritional plane (LP). Summer grazing quality was initially restricted in the LP treatment group, but since 1993 both treatments 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 (18-21% crude protein, dry matter; Alaska Mill and Feed, Anchorage) in twice-weekly feedings at an overall rate of 14 g • kg $BW^{-0.75}$ /day (50% of maintenance energy requirements – White, Holleman, Wheat, Tallas, Jourdan & Henrichsen, 1984). Both groups are offered free-choice access to medium to high-quality brome-grass hay throughout the year. These treatments have been maintained since 1987, and beginning in 1990, healthy offspring follow the nutritional treatment of the mother. HP calves are allowed free-choice access to the pelleted supplement from creep feeders, while LP calves do not receive the pellets.

Nutritional effects on cow-calf behaviors are determined using 25-hour activity budgets. 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 in the fall.

Andrea Schulman, finishing her M.Sci., has developed a model to determine the role of nutrition in the termination of parental investment in offspring. Her analyses incorporate 25-hour behavior observations, estimates of milk transfer through nursing and reproductive histories collected on the captive muskoxen since 1987.

After 10 years of behavioral observations, rigorous analysis of the data is now necessary to evaluate the effect of current treatments. The recording of activity budgets will be suspended in 1996 until analysis and interpretation are complete.

### *1995 Field season*

In 1995, HP and LP observation groups were established after calving. The HP group consisted of two females nursing calves born in 1995 (*Brown* and *Red*) and one dam (*Unni*) nursing a yearling calf (born 1994). The LP group consisted of three females with calves of the year (*Sasha*, *Bettye* and *Taimyr*) and one adult female (*Sine*) who did not calve in 1994 or 1995.

Thus, five calves (two HP; three LP) and one yearling (HP) were initially observed for nursing and play behavior. One HP and one LP calf died at the end of summer and the remaining HP calf had to be removed from her dam at the same time because of sickness. Unfortunately this reduced the sample size of observed nursing calves to two (LP) by mid-breeding season, along with the nursing yearling (HP). A mid-summer illness affected all but one of the 15 calves born in 1995, and seemed to affect the high plane cohort the most severely, resulting in low summer growth rates for most HP calves.

For activity budget analysis, the field season was subdivided into three "seasons" – *pre-rut*, *rut* and *post-rut* – based on food availability and quality, and the presence or absence of a bull in the groups. As in previous years, both HP and LP animals had access to similar high-quality grazing during the summer, pre-rut season. During the rut and post-rut seasons, HP females were offered *ad lib*. brome hay and were supplemented with the high-protein pelleted ration, while LP females were offered *ad lib*. brome hay only. Limited breeding pen size and ground snow cover minimized grazing opportunity for both groups during the rut and post-rut seasons.

### *Earthwatch as a source of funding*

The participation of Earthwatch in the project has provided the personnel necessary to extend the field season from early summer through breeding and early winter – from calving to weaning. Earthwatch teams are essential for the continuous collection of 25-hour behavioral observations. They also supplement the project graduate students and support staff through their assistance in sample collection and animal care.

Currently, the study focuses on muskoxen and could not be completed without Earthwatch support. While we are gaining tremendously in our understanding of muskoxen response to nutritional variations, lack of matching support for our caribou studies means that we are presently unable to pursue the muskox-caribou comparison. We are pursuing funding for this aspect of the study.

Placing a monetary value on the overall contribution of the Earthwatch teams is difficult. But, the 25 team members in 1995 (Appendix C) contributed more than 1050 hours on *observations alone* – equivalent to over $11,550 in wages at the current rate for hiring student technicians. Beyond this monetary calculation though is the tremendous investment in enthusiasm and dedication the volunteers bring to the project, a non-tangible benefit which is extremely difficult to realize and maintain in salaried personnel. This volunteer commitment compensates for lack of experience by insuring a continued high standard of concentration and effort during their stay.

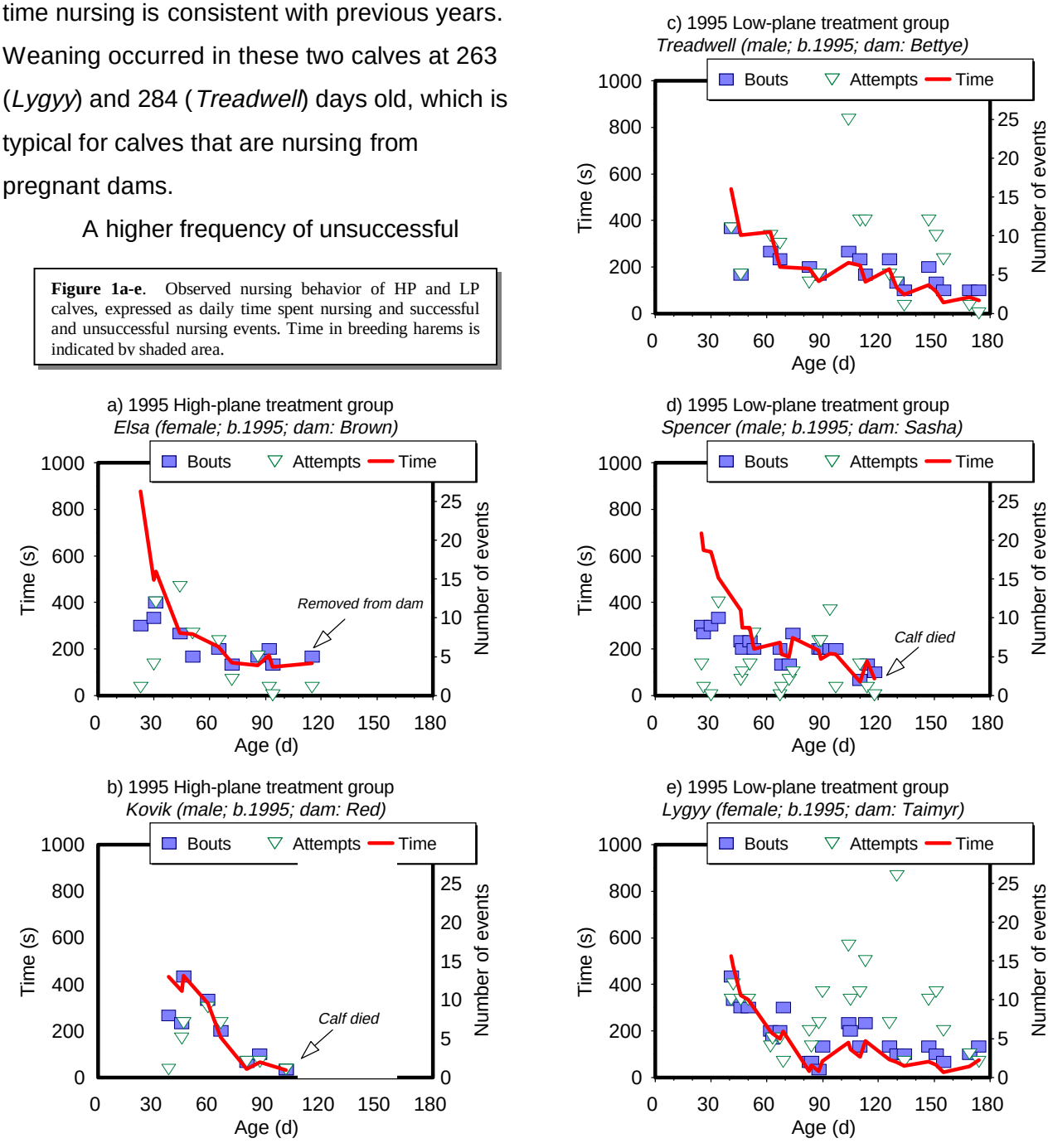
## 1995 Research Results

### *Calf nursing behavior*

With the unfortunate cancellation of Team 1 in 1995, early summer nursing behavior data was not collected. Regardless, a characteristic steep decline in daily time nursing was observed in all calves to approximately 200 seconds/day (s/d) at 60-70 days old, after which daily time nursing declined more gradually (Fig. 1a-e). In the two surviving LP calves (Fig. 1c, e), time nursing had decreased to approximately 50 s/d at 180 days old. This trend in daily time nursing is consistent with previous years. Weaning occurred in these two calves at 263 (*Lygyy*) and 284 (*Treadwell*) days old, which is typical for calves that are nursing from pregnant dams.

A higher frequency of unsuccessful

**Figure 1a-e**. Observed nursing behavior of HP and LP calves, expressed as daily time spent nursing and successful and unsuccessful nursing events. Time in breeding harems is indicated by shaded area.



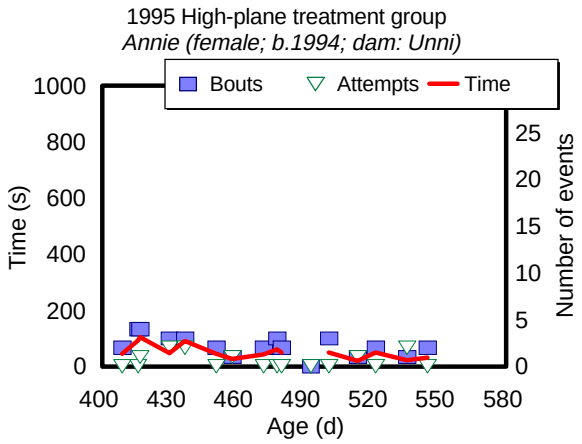



**Figure 2**. Nursing behavior of a HP yearling.

attempts to nurse was observed in the LP calves, particularly in late summer and early fall (Fig. 1c-e). The number of nursing bouts declined from approx. 10 bouts/d in both HP and LP calves at 30 days old, to fewer than five bouts/d in the LP calves at 180 days old.

The HP yearling experienced a very gradual linear decline in time nursing, from approx. 75 s/d in early summer to 25 s/d in early winter (Fig. 2). The number of unsuccessful attempts was generally very low in this animal, and number of bouts stayed below five bouts/d through the entire season. Weaning for this yearling occurred at 653 days old. The average age of weaning for prolonged nursing events observed previously at LARS is 536 days old (n=5).

Mean nursing bout duration for 1995 calves also declined steeply to approx. 60-70 days old, where it then stabilized at 20-30 s/bout (Fig. 1a-e). Variability in nursing bout duration decreased with calf age, presumably a function of experience and a resulting greater nursing

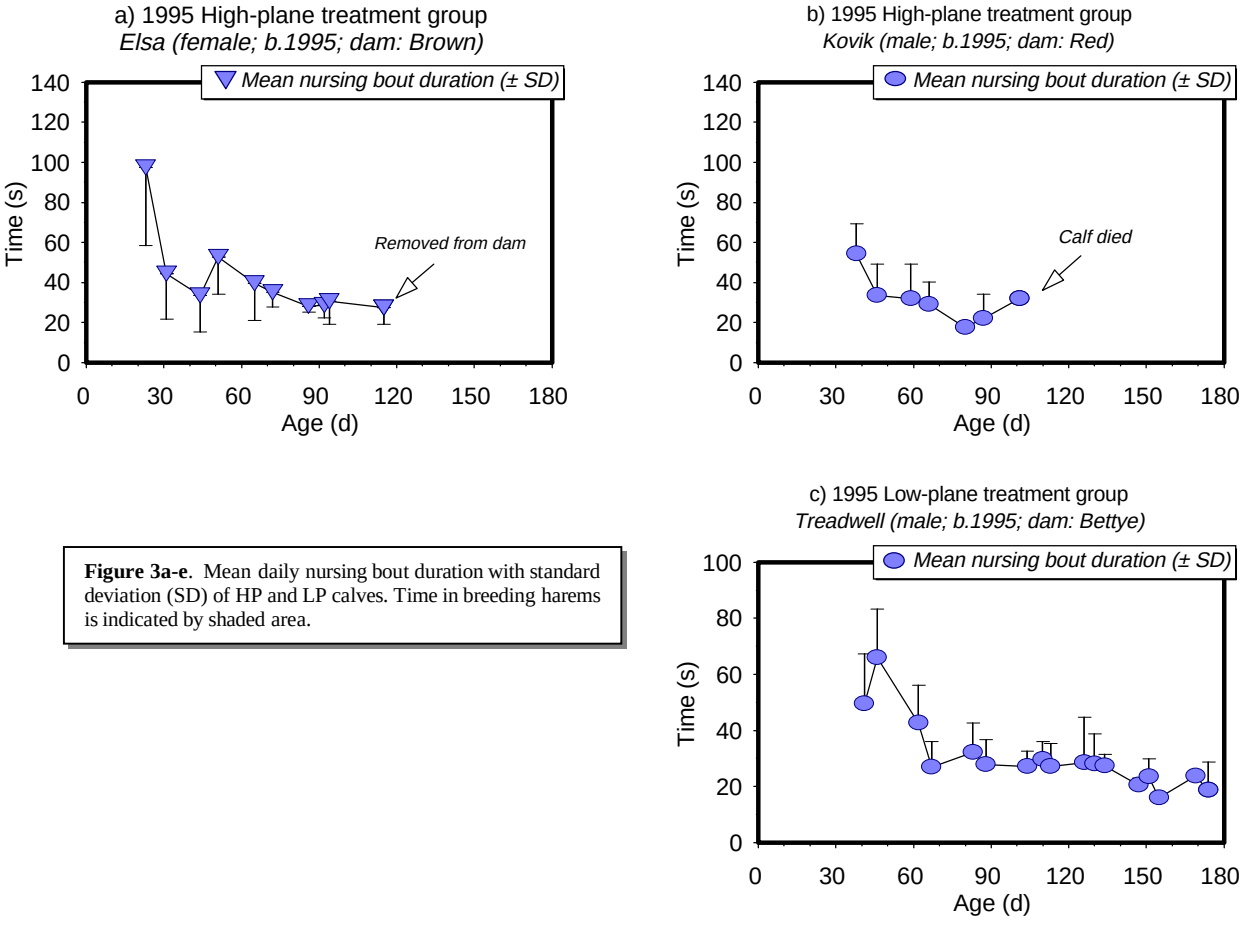
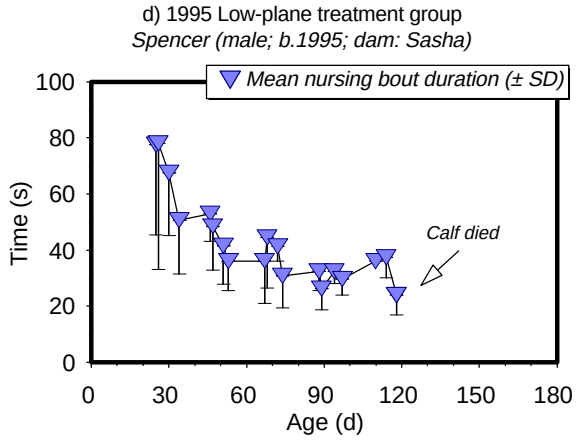
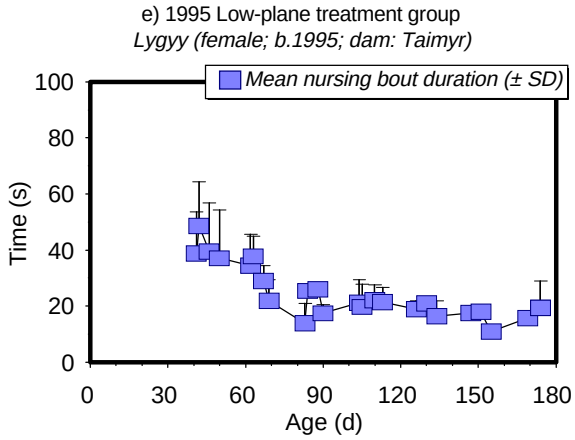



**Figure 3a-e**. Mean daily nursing bout duration with standard deviation (SD) of HP and LP calves. Time in breeding harems is indicated by shaded area.




efficiency, since the yearling maintained a constant mean bout duration (30 s/bout) and low variability throughout its second summer of nursing (Fig. 4).

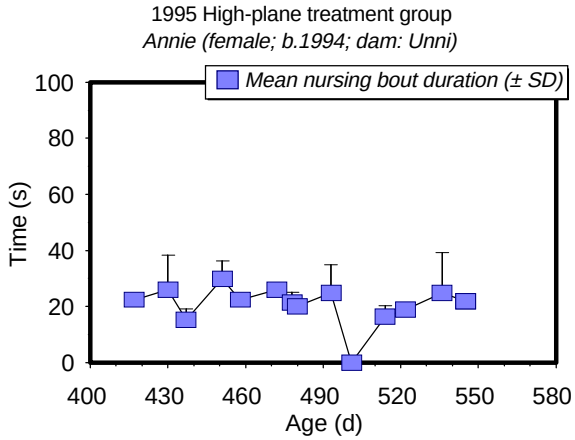
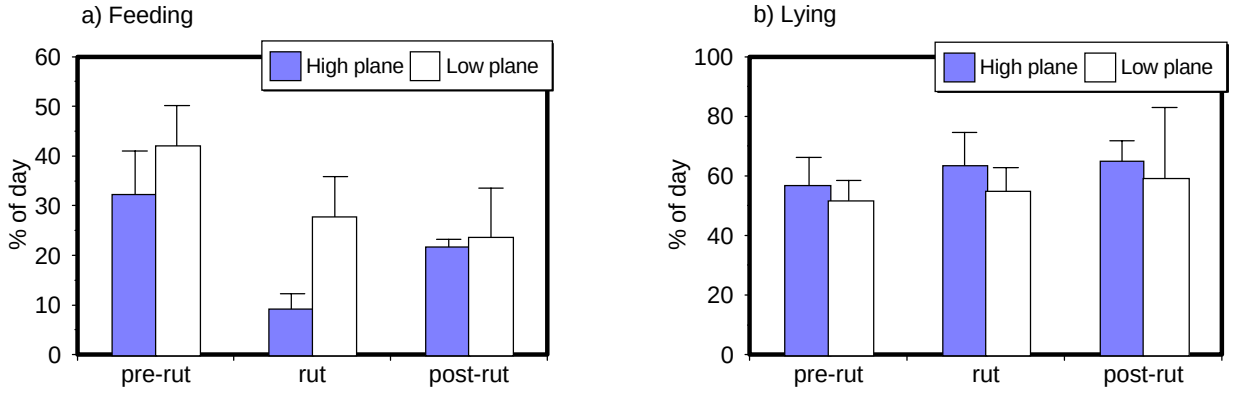



**Figure 4**. Mean daily nursing bout duration for a HP yearling.

## *Feeding and lying activity budgets*

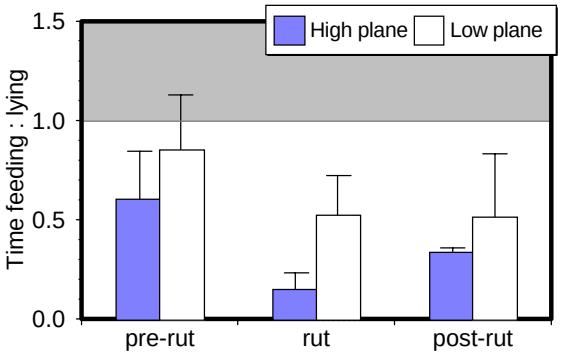
Low plane females spent considerably more time feeding and less time lying during the pre-rut (summer) and rut (fall) seasons than HP females (Fig. 5 a, b). During the pre-rut season, both treatment groups have access to the same high-quality grazing, but during the rut and post-rut seasons, LP females have access to brome hay only, while HP females are supplemented with a pelleted ration in addition to having access to brome hay. During the rut and post-rut seasons, grazing opportunity is severely limited by animal density and snow

**Figure 5 a and b**. Mean proportion of the day (± SD) spent Feeding and Lying in mature HP and LP female muskoxen.



cover in the breeding pens, and the contribution of the pelleted ration in the diet of the HP females becomes significant in extending the "grazing" season of this treatment group.

**Figure 6**. Mean daily Feeding-to-Lying ratio (± SD) of mature HP and LP female muskoxen.




The LP females appear to compensate for this abrupt decline in food quality by maximizing feeding effort – expressed as the ratio of daily time spent feeding to lying (Fig. 6) – during the summer, where this ratio approaches equal time feeding and lying in a day (a ratio of 1.0). By the post-rut season, differences in time spent feeding in the two groups are small, but the LP group still shows noticeably more feeding effort than HP as well as maintaining higher individual variation.

## *Seasonal body weights*

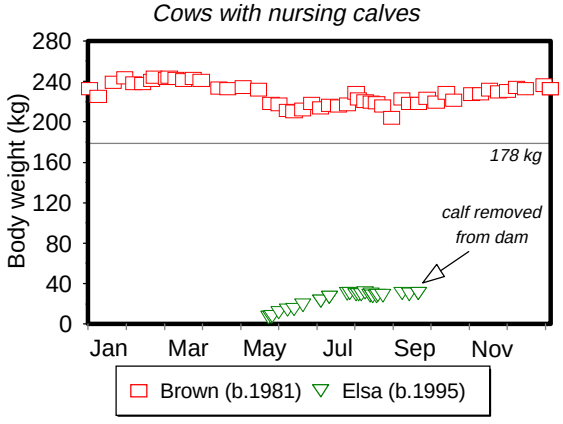
### Lactating females and calves

Pregnant females of both nutritional treatments experienced post-partum body weight loss of approximately 20-25 kg in May, consistent with data from years past (Fig. 7a-k). Mean calf birth weight was 10.6 kg (± 1.3 kg). High-plane female *Brown* experienced a noticeably lower post-partum weight loss (12 kg), but produced a calf with a birth weight of only 6.8 kg.

Post-partum weight regain in the HP treatment group was observed by early June and continued through the rut. In LP females, any summer weight regain ended by mid-August, and body weights remained stable through the breeding season. *Taimyr* had no post-partum weight gain, maintaining a summer and breeding season body weight only slightly above 178 kg. All calves again experienced a mid-July

**Figure 7a-k**. Seasonal body weight curves of HP and LP muskox dams and calves. Shaded area indicates time in breeding harems.

a) 1995 High-plane treatment group
*Cows with nursing calves*




b) 1995 High-plane treatment group
*Cows with nursing calves*

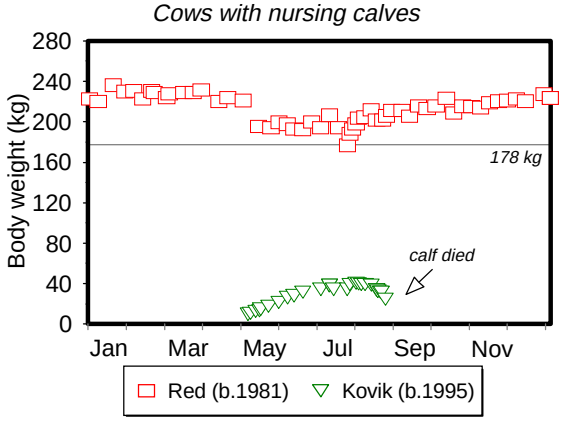
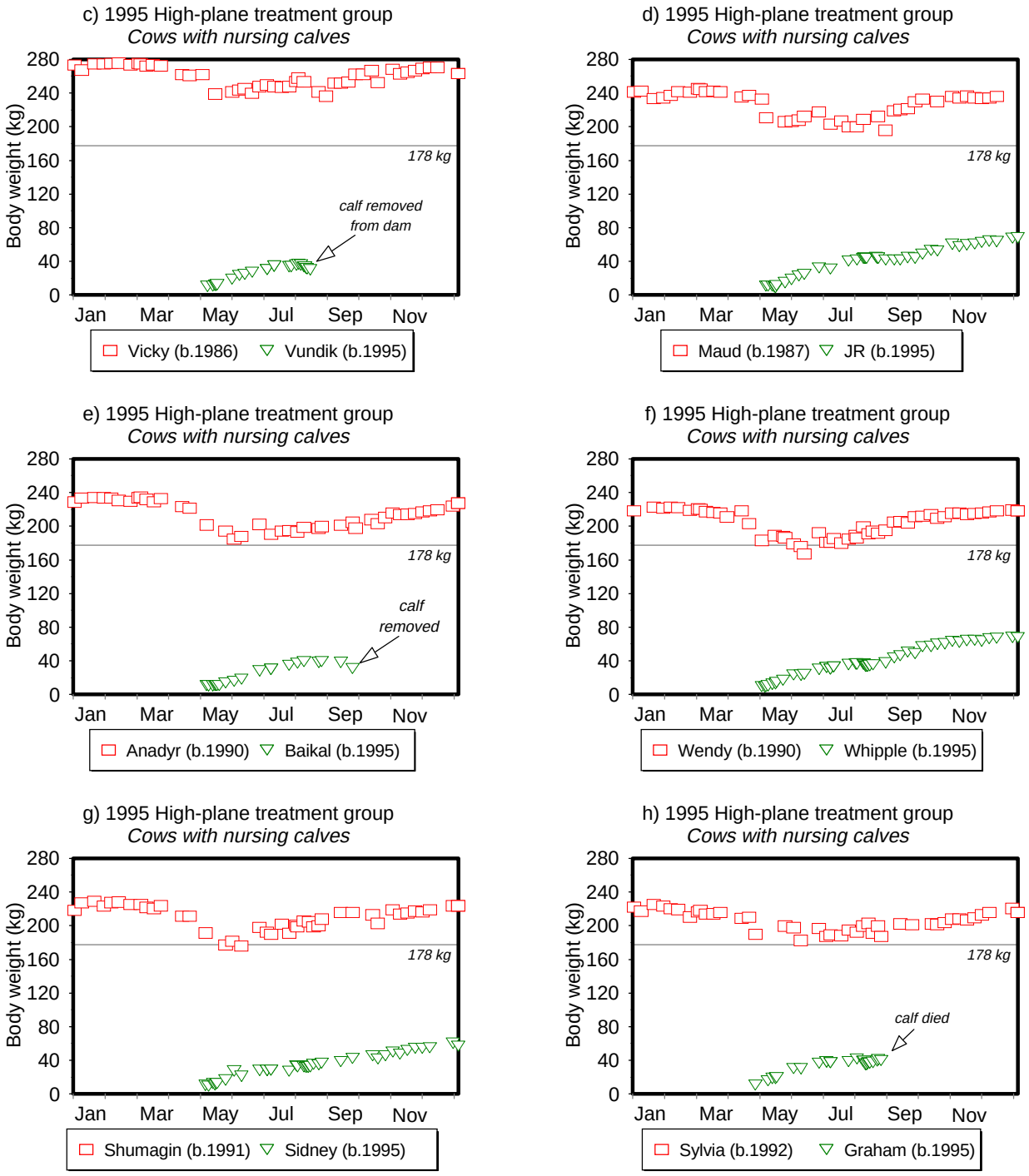
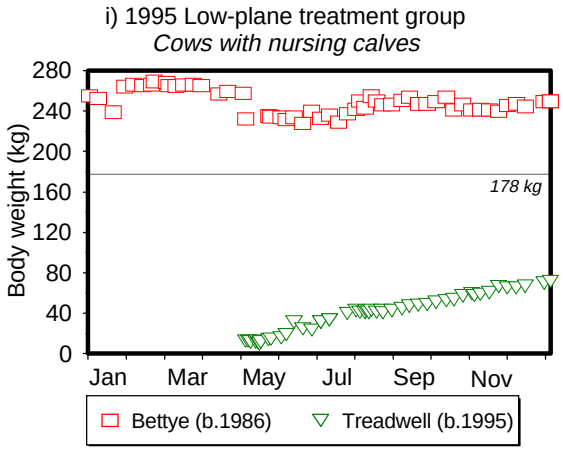
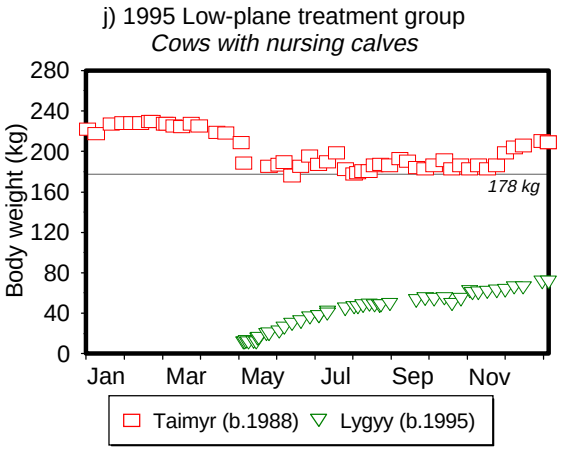


Figure 7 cont'd




body weight stasis or loss associated with a still undetermined organism or mineral imbalance which causes an intestinal malabsorption and diarrhea, with concurrent muscle wasting. Two calves died as a result (Fig. 7b, k) and three calves were removed from their dams in late August or September for more aggressive treatment (Fig. 7a, c, e). For those calves that survived, body weight gain resumed by late September and continued through the end of the



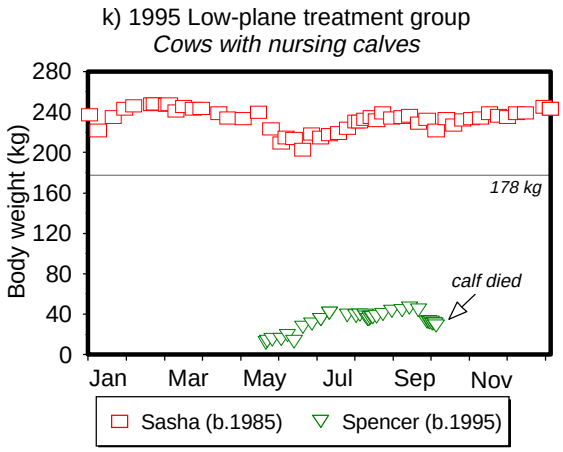




Figure 7 cont'd

year. All calves were allowed free-choice access to pelleted feed by mid August to stabilize body weight and encourage pre-winter weight gain.

One calf (Fig. 7h) died in August of trauma from intraspecies conflict.

Early summer body weight gain in the calves showed a slightly higher daily rate of gain in the LP group (Fig. 8), though the difference between treatments groups is small. This is contrary to data from previous years, where HP calves typically have significantly greater summer daily body weight gain than LP, because of the access HP calves have to supplemental pelleted feed. This year's HP calves though were less likely to use the creep feeders than in years past, for reasons that are not clear (e.g., HP calf *Kovik* was directly observed at the creep feeder a total of only 128 sec, n=8).

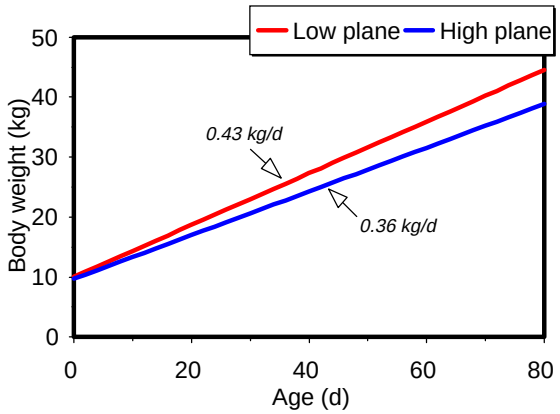



**Figure 8**. Daily rate of summer body weight gain in HP and LP muskox calves.

The non-pregnant HP female (*Unni*) nursing the yearling (*Annie*) experienced a weight loss in early spring that was reflected to a lesser extent in the yearling (Fig. 9). At this time it was suspected that weaning was occurring because of a slight change noticed in milk

**Figure 9**. Seasonal body weights of a HP female muskox nursing a female yearling.

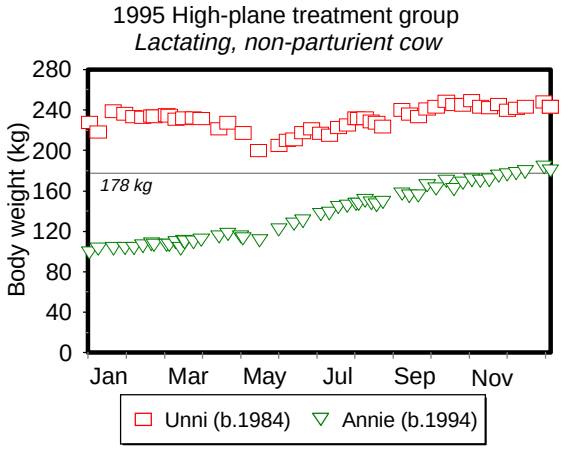
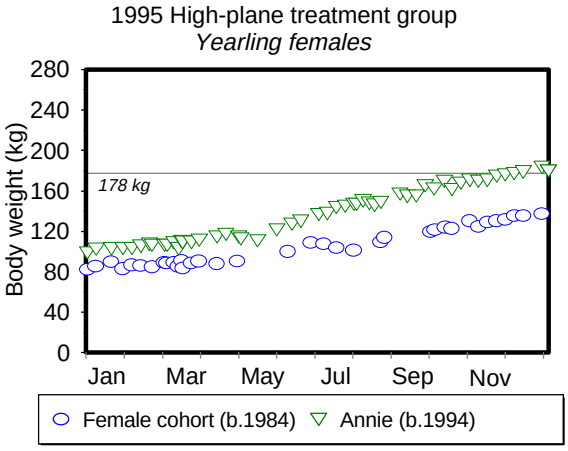



**Figure 10**. Seasonal bodyweights of a nursing female yearling muskox and females in the same cohort.




appearance. Nursing was continued throughout the rest of the year though, and body weight gain in the yearling was at a rate significantly greater than that in females of the same age (n=2) which had been weaned in early February (Fig. 10). *Annie* reached a pubertal body weight of 178 kg by the end of the breeding season.

**Non-parturient cows and cows with neo-natal loss**

Figure 11 shows the body weights of three LP females who didn't calve in 1995. *Sine* is an older female (13 years) who has not calved since 1992 and who aborted in December 1994. Her body weight remained stable throughout the year. *Andreé* and *Saydy* are young females who show a steady increase in body weight throughout summer, exceeding 178 kg by the fall breeding season.

Figure 12 shows the post-partum weight loss of a young HP female whose calf was stillborn, and her subsequent mid to late-summer weight regain. Her weight gain also proceeded through the breeding season.

**Figure 11**. Seasonal body weights of LP female muskoxen which did not calve in 1995.

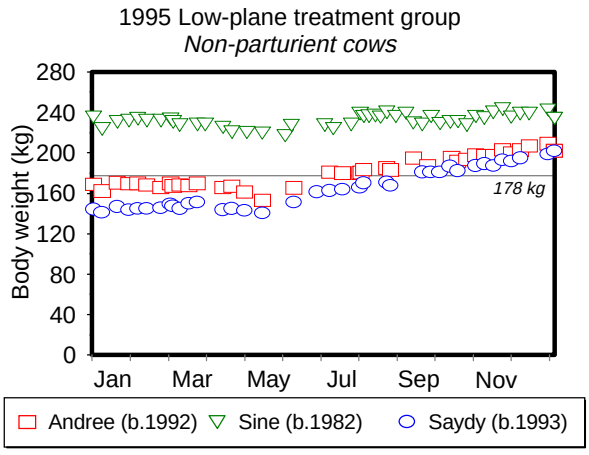
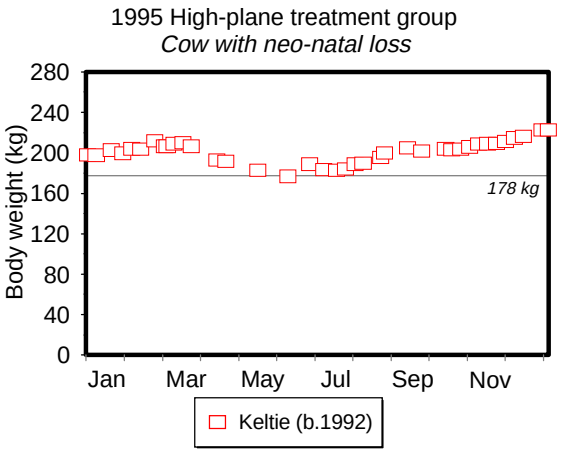


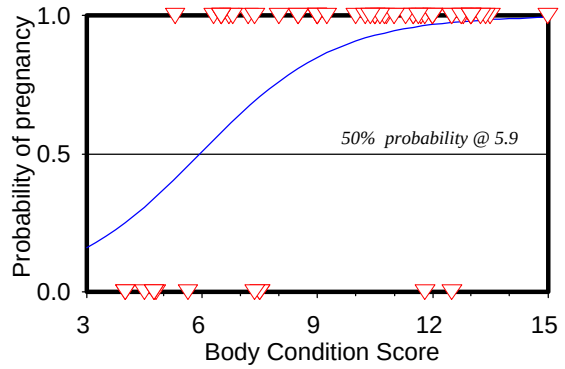

**Figure 12**. Seasonal body weights of a HP female muskox experiencing a neo-natal loss.



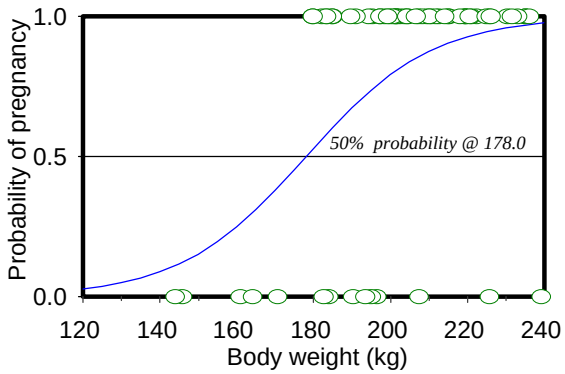
## *Body condition score, body weight and pregnancy success*

**Figure 13a and b**. Logistic regression curves showing the probability of muskoxen becoming pregnant based on BCS and body weight.

*a) Pregnancy success vs. mean September BCS*




*b) Pregnancy success vs. mean October body wt.*



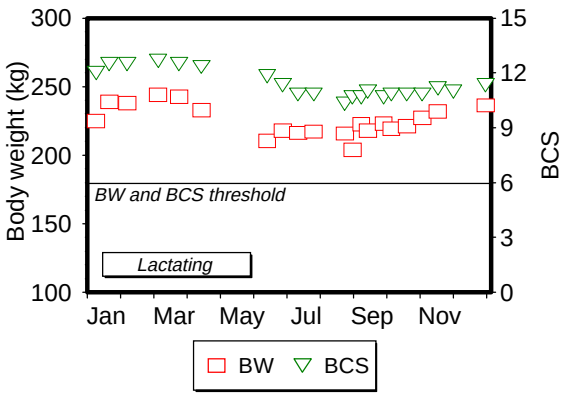

White *et al.* (1996) have shown that late fall body fat reserve (body condition) is a significant indicator of breeding success in female muskoxen – without sufficient pre-winter fat reserves, females may undergo a breeding pause. Measurement of body conditioning is derived by palpation of three areas of the body: the ribs, hip pins and saddle region, and the amount of fat covering each of these regions is rated on a scale of 1-5, where 1 is no fat covering and 5 extreme fat covering. The scores for the three regions are summed to arrive at an overall body condition score (BCS). The BCS for females is measured throughout the year, and bi-weekly through the breeding season. Body weight (BW) of females is measured weekly.

In a logistic regression, a BCS above 5.9 in September and a BW above 178 kg in October are good individual predictors of pregnancy in muskoxen (Fig. 13a, b). All the study animals in 1995 had BW and BCS at or above these thresholds by the end of the breeding season (Fig. 14a-p), and all calved in 1996.

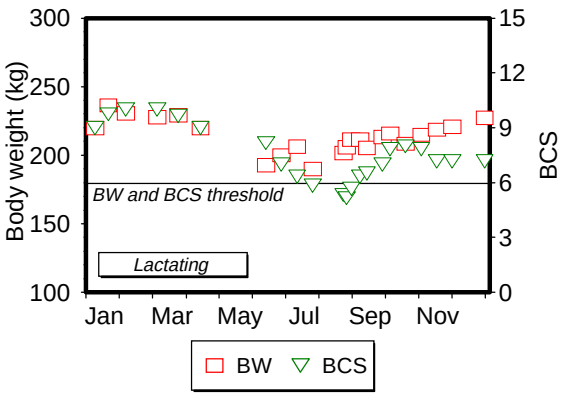
Three of the six LP females were lactating prior to the breeding season, and all three lost body

**Figure 14a-p**. Seasonal body weight and body condition score (BCS) of HP and LP, lactating and non-lactating female muskoxen.

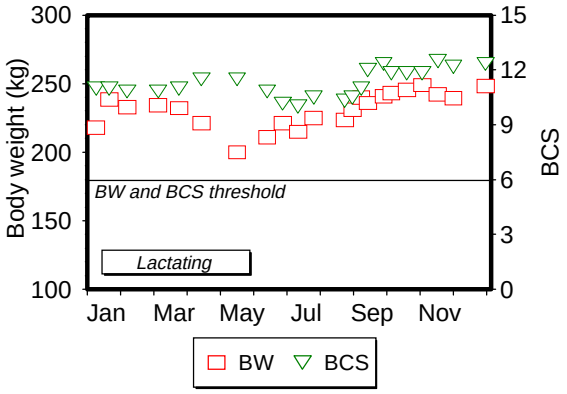
a) High-plane treatment group
*Brown (b.1981)*



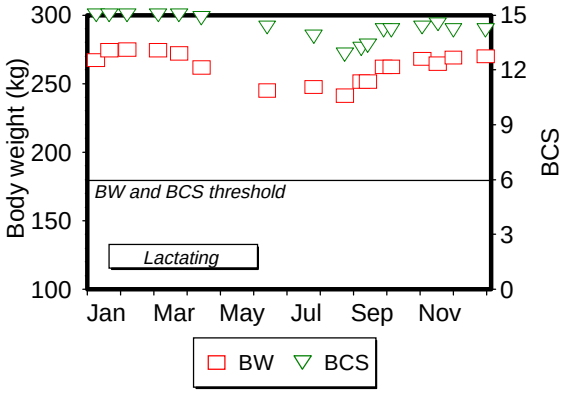

b) High-plane treatment group
*Red (b.1981)*



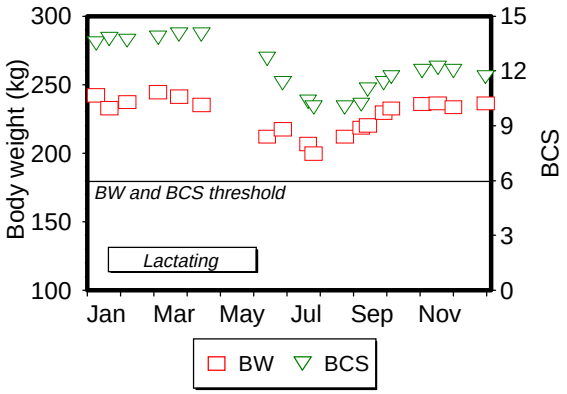
c) High-plane treatment group
*Unni (b.1983)*



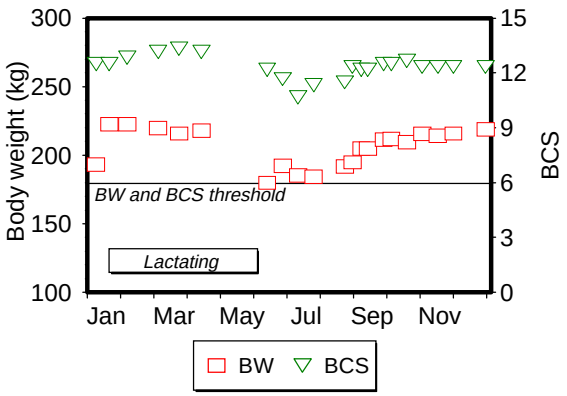

d) High-plane treatment group
*Vicky (b.1986)*



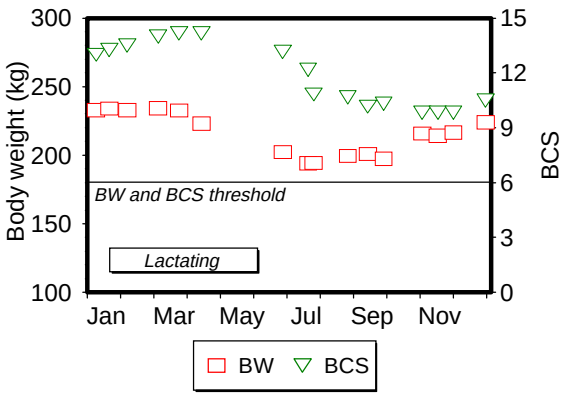

e) High-plane treatment group
*Maud (b.1987)*




f) High-plane treatment group
*Wendy (b.1990)*




g) High-plane treatment group
*Anadyr (b.1990)*

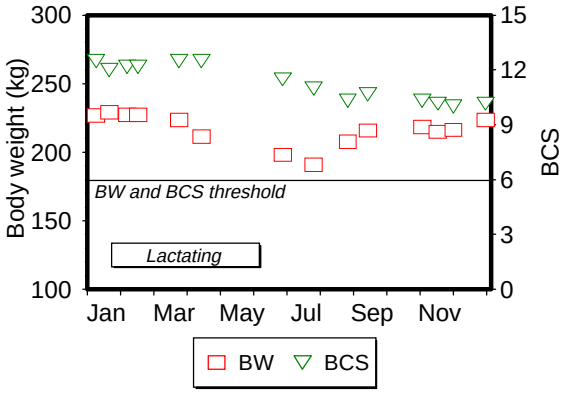



conditioning during this period (Fig. 14k-m). LP female *Sine* had BCS well below 5.9 in 1994, though she maintained BW above 178 kg (Fig. 14n). She aborted in December 1994 and subsequently improved in body conditioning throughout 1995. Her BCS and BW during the 1995 breeding season were above the thresholds for pregnancy, and she was carrying a fetus at the time of her death in March 1996.

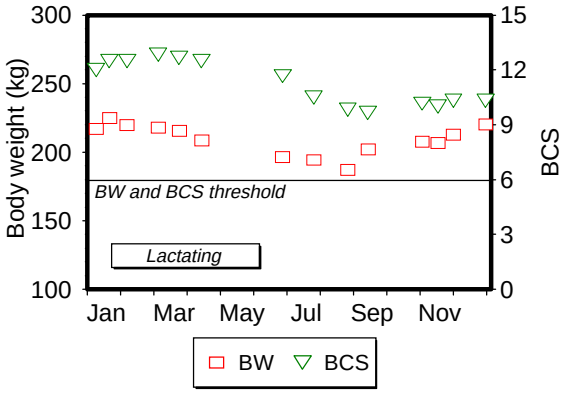
The BCS and BW of a young LP female (*Saydy* – Fig. 14p) exceeded the pubertal threshold during the rut, and she had her first calf in 1996 at three years old.

All nine lactating HP females lost body condition during summer. Seven began increasing BCS by mid-August (Fig. 14a-i). The increase in BCS stabilized in early October and this BCS was maintained through the end of the year. Two of three lactating LP females also experienced increasing BCS in late August, but this was not sustained – BCS declined in these females in late September through the end of the year, though BCS remained above 5.9.

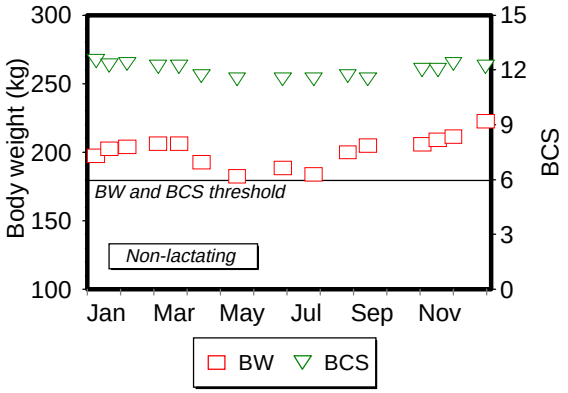
h) High-plane treatment group
*Shumagin (b.1991)*



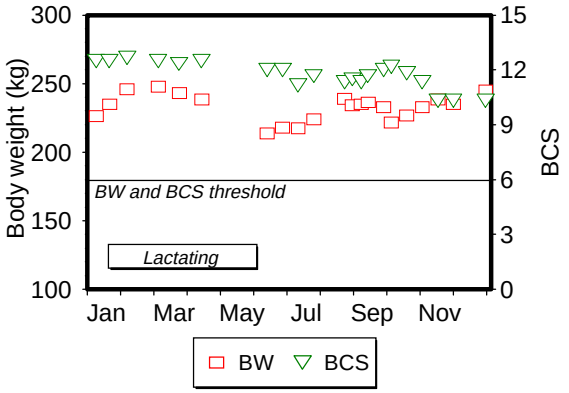

i) High-plane treatment group
*Sylvia (b.1992)*



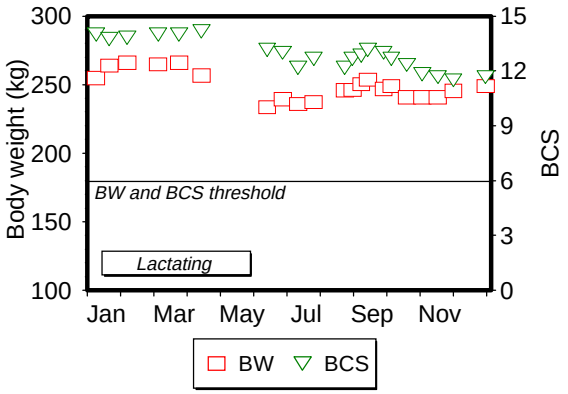

j) High-plane treatment group
*Keltie (b.1992)*



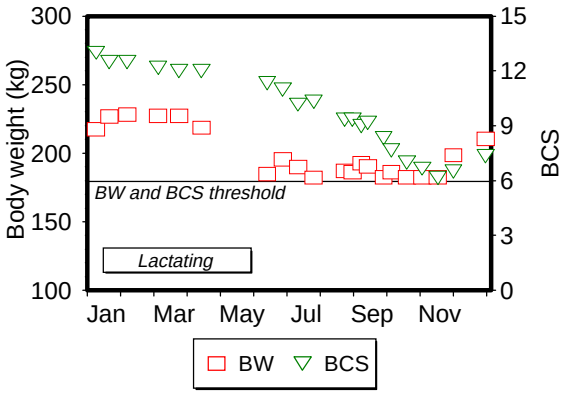

k) Low-plane treatment group
*Sasha (b.1985)*



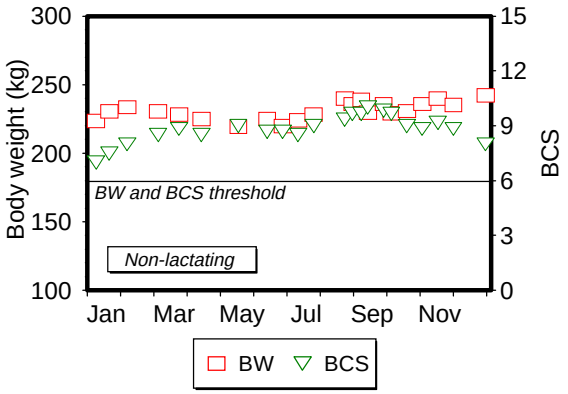

l) Low-plane treatment group
*Bettye (b.1986)*



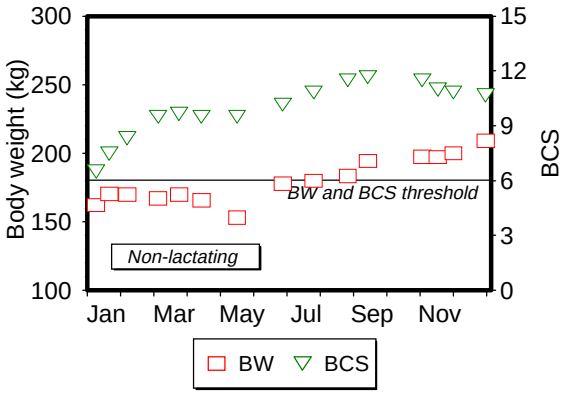

m) Low-plane treatment group
*Taimyr (b.1988)*




n) Low-plane treatment group
*Sine (b.1982)*




o) Low-plane treatment group
*Andree (b.1992)*



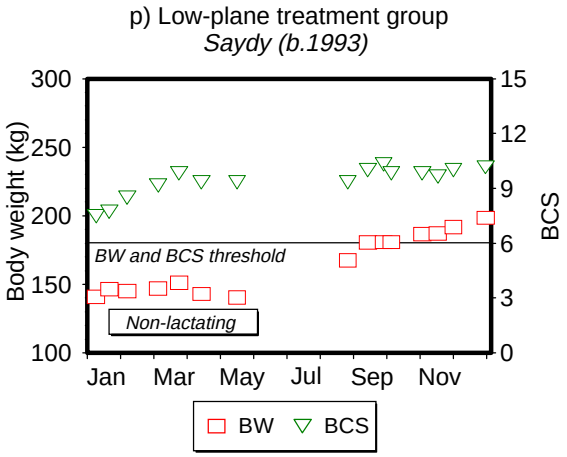


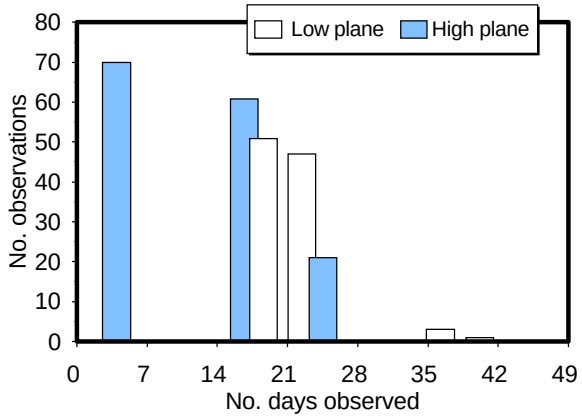

Figure 14a-p cont'd

## *Courtship behavior*

Courtship behavior of the bull may be an indicator of estrus in females. The types of behavior observed range from harem maintenance to active courting to successful copulation.

Courtship behavior in the HP and LP breeding harems was done concurrent with the collection of behavioral observations. The usefulness of these observations as a tool for predicting breeding success or gestation length in muskoxen is necessarily limited. In 1995, seven 24-hour behavioral observations were made for each treatment group over the six weeks of harem formation, potentially leaving a substantial portion of courtship behavior unobserved.

**Figure 15**. Number of attempted and successful mounts observed in HP and LP female muskoxen while in breeding harems (mid-August – mid-October).




Nevertheless, most females in the two harems were observed during periods of attempted or successful copulation. Figure 15 shows that the majority of HP females came into heat and were bred two or three weeks earlier than LP females. This is consistent with observations in past years.

## Summary of Results

- Nursing behavior followed a characteristic trend of steep initial decline in daily time spent nursing to a more stable daily time nursing starting at about 60 days old. This trend in daily time nursing was observed in both nutritional treatments.
- More variability (a higher frequency) in the daily number of unsuccessful nursing attempts was observed in LP calves.
- LP females spent more of the day feeding (active) relative to time spent lying (inactive) than HP females, particularly during the pre-winter breeding period.
- Lactating LP females showed only slight post-partum, summer body weight gain, and no weight gain during the pre-winter breeding season. Young, non-lactating LP females showed steady weight gain during summer and fall. Lactating HP females began seasonal body weight gain by June and continued until the end of the breeding season.
- Lactating females on both nutritional treatments lost body condition during summer while maintaining steady or increasing body weight. Most lactating HP females gained considerable body condition during the rut, while LP females remained steady or gained and then lost body condition during this period.
- Observations of breeding activity showed that mature HP females came into heat and were bred two to three weeks earlier than LP females.

### *Papers cited*

Rowell, J.E., White, R.G. and Hauer, W.E. 1997. The role of nutrition, body condition and lactation on calving success in muskoxen. J. Zool. *In Press*.

White, R.G., Holleman, D.F, Wheat, P., Tallas, P.G., Jourdan, M., & Henrichsen, P. 1984. Seasonal changes in voluntary intake and digestibility of diets by captive muskoxen. In Proceedings of the First International Muskox Symposium, Fairbanks, AK, May 22-25, 1983. Edited by D.R. Klein, R.G. White, & S. Keller. Biol. Papers Univ. Alaska Sp. Rep. No. 4. pp. 193-194.

# Appendixes

## *Appendix A. 1995 Field Report*

**1995 FIELD REPORT TO THE CENTER FOR FIELD RESEARCH**

***Comparison of lactation, nursing, and breeding success of muskoxen and caribou***

Dr. Robert G. White
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University of Alaska
Fairbanks, AK 99775-7000
FFRGW@aurora.alaska.edu

The 1995 Earthwatch field season conducted at the Large Animal Research Station (LARS) involved the participation of 25 volunteers in seven teams; including two volunteers from Japan, two from the UK and three returning from previous years. Low recruitment this year resulted in the cancellation of Team I and the utilization of local student volunteers for Teams VII and VIII. Earthwatch volunteers in 1995 and their hometowns are listed in Table 1.

Nevertheless, we were able to collect 1050 hours of direct behavioral observations on the daily activity cycles of female muskoxen and their calves maintained on two significantly different planes of nutrition, as well as the courtship behavior displayed in breeding harems during the fall. The activity budgets generated give an indication of how energy is partitioned among the variety of behaviors monitored, and whether differences in energy partitioning arise because of the different nutritional treatments.

This year's work supplements the data collected over eight years of Earthwatch participation in this research project, and three years of behavior observations conducted 1984-1986. During the period 1987-1995, 323 Earthwatch volunteers have amassed 11200 hours of observations.

Preliminary analyses of these data indicate:

- In muskoxen, the ability to reproduce in a year is regulated by female body conditioning attained during the August-October breeding period, and this conditioning is a function of habitat carrying capacity (e.g. White *et al.* 1989; White *et al.* 1994).
- The ability for autumn body weight gain and conditioning in a female nursing a calf results from a shift in lactational strategy in late summer, and this shift is evident in both quantitative measurement of milk production and in the nursing behavior of the calf (White *in prep*.).
- This potential shift in lactational and reproductive strategy is controlled by the nursing offspring; i.e., the nursing behavior of the calf, as an expression of calf fitness, may override the importance of body conditioning in the dam and result in a period of extended lactation and a breeding pause (Schulman and White 1996).
- Females who undergo a breeding pause do so because of a cessation of the estrous cycle -- progesterone levels remain low and courtship activity is minimal while in harem (Rowell *et al*. 1996).
- Active:inactive cycles are an indicator of nutritional state and can be used to assess the nutritional status of populations in the field (White *in prep*.).

In addition to muskox behavioral data collection, Earthwatch volunteers assisted in the collection of biological samples for milk intake and reproductive hormone studies, in the collection and processing of browse for a metabolic study of muskoxen, and with the measurements of body weight and body condition. This year, Earthwatch volunteers also provided four 24-hour observations of reindeer feeding activity, to establish baseline feeding cycles for a study of appetite control.

Four muskox calves were artificially weaned and bottle-raised for taming purposes, and a caribou calf who became ill was also bottle-raised. Earthwatch volunteers assisted in the preparation and feeding of replacement milk to the calves, monitoring body weights and health, and with training. The data gathered from this activity will be used to establish proper husbandry protocols and in comparing the growth and development of bottle-raised and maternally-reared calves.

Earthwatch volunteers assisted with the care of the research animals, which involved daily feeding, collection of browse and lichen during summer, cleaning paddocks and stalls, harvesting hay and unloading feed shipments. Individual talents were utilized to organize and update records, as well as to maintain and improve the facility. Volunteers participated in LARS summer tours, by explaining the Earthwatch program and describing their impressions and experiences to interested visitors.

Each team participated in an overnight field trip mid-way through their stay -- to Denali Park during summer, or on a trip over the Denali Highway or to a local hot springs after the park had closed. This provided the opportunity for each volunteer to relate the work being conducted at LARS to natural ecosystems.

In 1995, two Ph.D. students associated with the Earthwatch project graduated:

- Dr. Pam Groves, who was co-PI on the project during the 1992 field season, used mDNA and other data collected at LARS to show that even though muskoxen and takin have morphological, behavioral, social and ecological similarities, they are not closely related – muskoxen are more closely related to the Asian goral, and takin to sheep. This is contrary to current taxonomic classification.
- Dr. Karen Gerhart utilized LARS caribou to generate body condition indices for field studies, and to calibrate activity monitor collars through direct 24-hour observations.

Other graduate students associated with the Earthwatch project in 1995:

- M.Sc. student Andrea Schulman, who supervised behavioral data collection in 1993 and 1994, continues to investigate the phenomenon of extended lactation in muskoxen, particularly the factors causing a female to forego breeding in a year and continue nursing her calf through the winter.
- Ph.D. student Jim Lawler is investigating the influence of different browse on the seasonal energy metabolism of muskoxen, and will pioneer use of a recently cannulated muskox to study *in vivo* digestion.
- Ph.D. student Raphaela Stimmelmayr is using behavioral data of reindeer feeding cycles to investigate the neurological factors responsible for appetite control.

The University of Alaska hosted two international scientific meetings in Fairbanks in 1995:

- the 2$^{nd}$ International Arctic Ungulate Conference
- the 46$^{th}$ Arctic Division Science Conference of the AAAS

Fifteen lecture or poster presentations related to areas of LARS research directly or indirectly supported by Earthwatch were made at these two meetings. Abstracts of these are attached.

## *Appendix B. 1995 Earthwatch volunteers*

| | | |
|---|---|---|
| ***Team II*** | Melody Adler | Louisville, KY |
| ***June 12 - 26*** | Dean Darbe | Little Rock, AR |
| | Elizabeth Darbe | Little Rock, AR |
| ***Team III*** | Lauren Baum | Upper Saddle River, NJ |
| ***July 3 - 17*** | Lindsay Baum | Upper Saddle River, NJ |
| | Karen Davidson | Mayville, NY |
| | Kim Homer | Middletown, RI |
| | Susanne Phipps | Mannheim, Germany |
| | Liz Walker | Middletown, RI |
| ***Team IV*** | Carole Altman | Las Vegas, NV |
| ***July 24 - August 7*** | Sherri Bush | Riverdale, NY |
| | Chiyo Ikegame | Aichi, Japan |
| | Diane Johns | Columbia, MD |
| | Suzanne Mason | Philadelphia, PA |
| | Patricia Presby | Attica, MI |
| ***Team V*** | Matthew Diem | Croton, NY |
| ***August 14 - 28*** | Michael Doherty | Croton, NY |
| | Lynda Karanbensh | Los Angeles, CA |
| | Hilde Noe | Denver, CO |
| | Kathleen Saunders | Boulder, CO |
| ***Team VI*** | Lydia Gillham | Newcastle-upon-Tyne, England |
| ***September 4 - 17*** | James Raiher | London, England |
| ***Team VII*** | Mikiko Hagiwara | Kobe, Japan |
| ***September 25 - October 9*** | Bob Mayko | Wimauma, FL |
| ***Team VIII*** | Carolyn Chard | Phoenix, AZ |
| ***October 16 - 30*** | | |

## *Appendix C. 1995 Project staff, LARS Interns and graduate students*

| *Name* | *Position Title* | *Project Involvement* |
|---|---|---|
| **Robert G. White** | Director, Institute of Arctic Biology | Principal Investigator |
| **Janice Rowell** | Assistant Director, LARS | Science management |
| **Andrea Schulman** | MS graduate student, IAB | Muskox cow/calf behavior analysis |
| **William Hauer** | Supervisor, LARS | Project management |
| **Judy Carpenter** | Cook/counselor | Project cooking and accommodations |
| **Thomas DeRuyter** | Field Crew Leader, LARS | Daily operations, animal management |
| **Kimberly DeRuyter** | Technician, LARS | Technical support |
| **Karen Hills** | Student Assistant, LARS | Animal care and management |
| **Suzanne Pence** | Intern | Animal care and management |
| **Meera Heller** | Intern | Animal care and management |
| **Craig Gibson** | Intern | Animal care and management |

## *Appendix D. 1995 Earthwatch team journal*