The Second International Arctic Ungulate Conference,
Fairbanks, Alaska, 13–17 August, 1995.

Brief communication

Seasonal Patterns in Growth Hormone, Insulin and Insulin-like Growth Factor-1 in Female Muskoxen

Jan Z. Adamczewski[1]*, Susan C. Tedesco[1], Bernard Laarveld[2] & Peter F. Flood[1]

[1] Department of Veterinary Anatomy, 52 Campus Drive, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5B4, Canada. (*Present address: c/o Sahtu Renewable Resources Board, P.O. box 490, Norman Wells, Northwest Territories X0E 0V0, Canada).

[2] Department of Animal & Poultry Science, 72 Campus Drive, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5B5, Canada.

Abstract: Over a year, mean serum growrh hormone concentrations ranged from 0.5 to 3 ng/ml in tame muskoxen with the lowest values and fewest pulses between October and January. Serum insulin ranged from 0.25 to 0.92 ng/ml, with minima in summer. There were marked seasonal changes in serum insulin-like growth factor-1 in both tame and wild muskoxen but the late summer peak was higher and more disrinct in the tame animals with levels reaching 160-250 ng/ml in September.

Key words: *Ovibos moschatus, nutrition*, weight.

Rangifer, 17 (3): 131–134

Large annual changes in weight and body composition of female muskoxen (*Ovibos moschatus*) are partly due to lactation and decreased nutrient availability in winter (Thing *et al.,* 1987; White *et al.,* 1989). However, tame well-fed non-breeding muskoxen also lose weight in late winter and gain weight in autumn and early winter (Groves, 1992; Adamczewski *et al.,* 1994), suggesting an effect of photoperiod, independent of nutrition. Growth processes in ruminants are regulated by hormones such as growth hormone (GH), insulin-like growth factor-1 (IGF-1) and insulin (Pearson & Dutson, 1991). To investigate the seasonal regulation of weight change in muskoxen, we measured seasonal patterns in GH, IGF-1, and insulin in muskox cows offered a diet of constant medium quality, and IGF-1 in hunter-killed wild muskoxen. A summary of preliminary IGF-1 data was presented previously (Adamczewski *et al.,* 1992).

The tame muskoxen were part of a research herd kept near Saskatoon, Saskatchewan, Canada (52°N), and were offered brome-alfalfa hay [9–12% crude protein (CP)] and a pelleted supplement (13–14% CP; 20% of diet; Adamczewski *et al.,* 1994) during each blood-sampling period and for at least 12 days previously, in 1990 and 1991. We studied 3 cows which bred annually and 2 non-breeding hysterectomized cows with intact ovaries, all ≥ 4 years old. Jugular catheters were installed 36-48 hours prior to sampling, using local anaesthetic and mild sedation (Tedesco, 1996). During sampling, the muskoxen were kept loosely tied in shaded outdoor stalls with access to hay and water or snow. Blood samples of 5-10 cc were taken every 15 min for 24 h

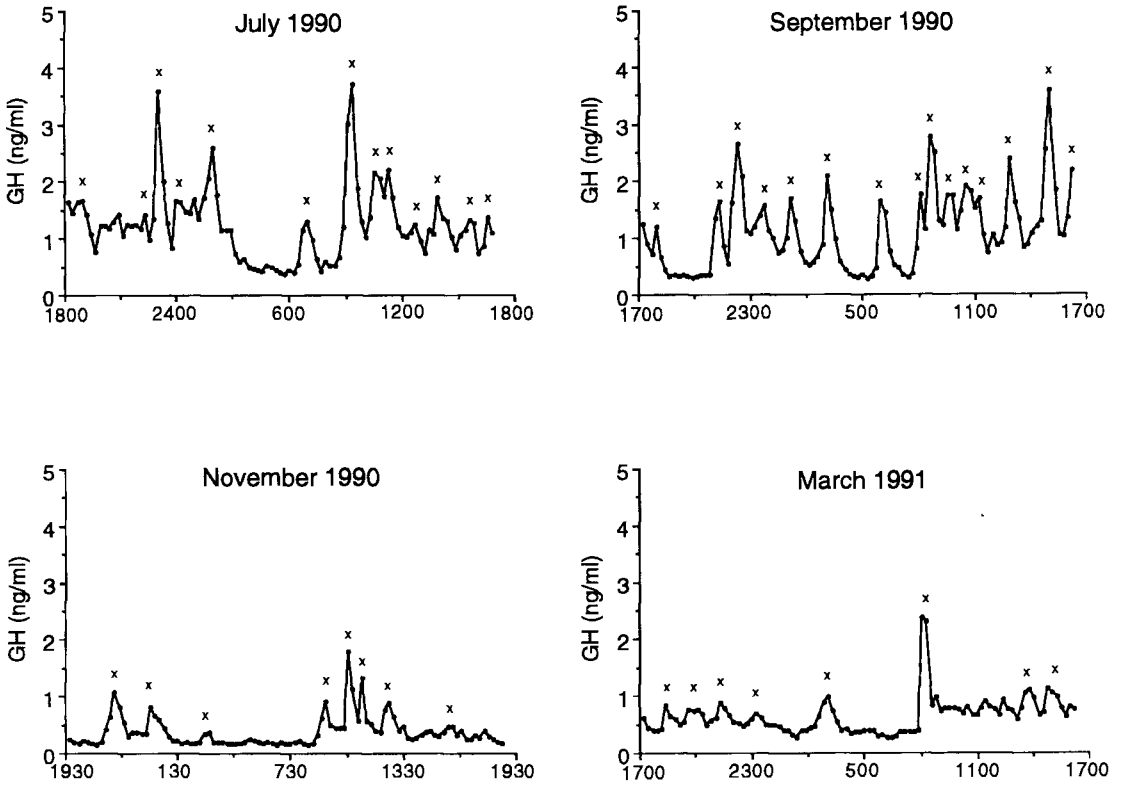

Fig. 1. Selected 24-h growth hormone profiles for Athabasca, a non-breeding muskox cow in Saskatoon. Pulses identified by PULSAR are denoted by x's.

Table 1. Seasonal changes in serum concentrations (ng/ml) of growth hormone and insulin in tame muskox cows offered a constant-quality diet in Saskatoon, Saskatchewan, 1990-1991. Samples were taken from the same animals throughout. Means with standard errors in parentheses.

	Growth hormone		Insulin	
Month	Intact Cows (n = 3)	Hysterectomized Cows (n = 2)	Intact Cows (n = 3)	Hysterectomized Cows (n = 2)
May	-	1.10 (0.45)	-	0.55 (0.01)
July	2.01 (0.85)	2.02 (0.79)	0.24 (0.04)	0.27 (0.48)
Sept.	1.12 (0.20)	2.62 (1.50)	0.46 (0.09)	0.92 (0.06)
Nov.	0.53 (0.05)	1.33 (0.95)	0.43 (0.08)	0.40 (0.05)
Jan.	0.99 (0.31)	1.46 (0.97)	0.69 (0.02)	0.69 (0.02)
Mar.	1.38 (0.30)	2.48 (1.83)	0.31 (0.03)	0.41 (0.08)
May	2.37 (1.30)	-	0.52 (0.05)	-

under ambient light augmented by dim red lights at night. Cortisol analysis of samples taken periodically showed that the muskoxen were unstressed at these times (Tedesco, 1996). Wild muskox cows ≥ 3 years old were shot by Inuit hunters near Cambridge Bay during 15 hunts in April, May, July, August, September and November from 1989 to 1993 (Adamczewski, 1995). Blood was collected just after death from a jugular vein.

Serum GH, IGF-1 and insulin were assayed by radioimmunoassays described by Van Kessel (1992). The GH assay was developed for ovine serum and

validated for muskox serum by showing parallelism to the standard curve in a serial dilution of a concentrated sample. GH was assayed in representative 24-h sequences from 5 muskox cows, and GH pulsatility was analysed using the pulse-detection algorithm PC-PULSAR (J. Gitzen and V. Ramirez, Univ. Illinois), following Merriam & Wachter (1982). The IGF-1 assay was developed and tested for sera from various species and validated for muskox serum as above. The insulin assay was developed for bovine and ovine serum, and similarly validated. IGF-1 and insulin were assayed in samples pooled from 24-h profiles from tame muskoxen, and IGF-1 was assayed in individual samples from wild muskoxen. Monthly values from tame muskoxen were compared for all three hormones by split-plot analysis-of-variance (ANOVA) and values from wild muskoxen by one-way ANOVA, using season as the main effect.

Serum GH was pulsatile in the tame muskoxen (Fig. 1), with highly individual profiles. Mean GH ranged from 0.5 to 3 ng/ml and GH pulse frequency ranged from 6 to 18 pulses/24 h. Both the frequency of pulses and mean GH were lowest between October and January, with significant (P=0.04) or near-significant (P=0.06) monthly variation, respectively (Table 1). Serum insulin means ranged from 0.25 to 0.92 ng/ml, with significant monthly variation (P<0.001) and the lowest concentrations in June and July. Individual variation in insulin was high and a clear seasonal progression was not apparent. There was a strong seasonal progression (P<0.001) in serum IGF-1 in the tame muskox cows, with mean concentrations increasing during summer, a clear peak in September (160–250 ng/ml) and lowest concentrations in November (60–120 ng/ml) (Table 2). There was a strong (P<0.001) but different seasonal pattern in serum IGF-1 in wild muskoxen, with a plateau of high values (80–120 ng/ml) in July, August and September, and the lowest values (30–50 ng/ml) in November. Serum IGF-1 was lower throughout the year in wild muskox cows than in tame ones.

These endocrine patterns are consistent with the tendency of muskox cows to gain weight in autumn and early winter, and with a large seasonal variation in intake and diet quality in free-ranging muskoxen. Although the insulin values varied widely in tame muskoxen, they were lowest in early summer, a period when fat deposition is limited (White *et al*, 1989; Adamczewski, 1995). The autumn peak in IGF-1 in tame muskox cows, despite a diet of constant quality, is also consistent with lean tissue growth at this time of year (Adamczewski, 1995) and may account for the high IGF-1 in August and September in wild muskox cows at a time of decreasing forage quality. The proximate cause of this peak is unknown but may include seasonal changes in melatonin secretion (Tedesco, 1996) or increased estrogen due to reproductive cycling (cf. Sauerwein *et al.*, 1992). These results are consistent with the strong seasonality in growth and intake of temperate and arctic cervids (Suttie *et al.*, 1993) but suggest that the effects of season on growth are subtly different in muskoxen and caribou, as has been shown for the effects of season on reproduction in muskoxen (Tedesco, 1996). The late IGF-1 peak, in particular, appears to contrast with the earlier peak of IGF-1 in red deer (Suttie *et al.*, 1992) and reindeer (Suttie *et al.*, 1993), where the IGF-1 rise appears to anticipate lean growth. Female muskoxen appear predisposed to an apparently simultaneous surge in growth of lean and adipose tissue toward the end of summer, well past the period of peak forage quality (White *et al*, 1989; Adamczewski 1995). This timing underscores the association of weight gain in female muskoxen with reproductive events, as suggested in reindeer by Tyler (1987). The elevated IGF-1 and insulin in the autumn also suggest that serum concentrations of these hormones, intimately involved in ovarian physiology (Spicer & Echternkamp, 1995), influence the highly variable productivity of female muskoxen.

Table 2. Seasonal changes in serum concentrations (ng/ml) of insulin-like growth factor-1 (IGF-1) in tame muskox cows offered a constant-quality diet in Saskatoon, Saskatchewan, 1990-1991 (repeated samples from the same animals) and from wild muskox cows on Victoria Island, NT (single samples from individual animals). Means with standard errors in parenrheses.

Month	Tame Muskoxen (n = 5)	Wild Muskoxen	n
March	82.1 (8.9)	-	-
April	-	45.1 (3.2)	47
May	79.7 (6.0)	54.7 (5.1)	38
July	122.8 (13.8)	106.5 (8.6)	8
August	-	116.5 (14.4)	18
Sept.	191.9 (28.7)	93.7 (10.3)	12
Oct.	94.5 (25.9)	-	-
Nov.	85.3 (20.1)	50.9 (3.5)	40
Jan.	72.3 (5.1)	-	-

Acknowledgements

We are very grateful to Charlotte Hampton, Blair Goldade and Anita Lemke for their patient help with assays, and to Ewald Lammerding for his care of the muskoxen and help with sample collection. We extend special thanks to Anne Gunn for making possible the field study on Victoria Island. We thank Amos Wamikon, David Kaomaoyok and other guides and officers from Cambridge Bay for skilled field assistance, and Charlotte Mayes, Rob Wagner, Gord Clark, Jay Thrush, Mike Bass, Barb Hanbidge, Glenna Miller, and Michelle Follensbee for help in blood sampling and lab analyses. Primary funding for field studies was from the Department of Renewable Resources of the Northwest Territories, with additional support from the Boone and Crockett Club, the Arctic Institute of North America, and the Wildlife Health Fund at the University of Saskatchewan. The muskox herd in Saskatoon has been primarily supported by grants from the Natural Science and Engineering Research Council of Canada. J.Z.A. was supported primarily by a scholarship from the University of Saskatchewan and his travel by the Northern Scientific Training Program funded by the Department of Indian and Northern Affairs.

References

Adamczewski, J. Z. 1995. *Digestion and body composition in muskoxen.* PhD thesis, Univ. Saskatchewan, Saskatoon, Sask., Canada.

Adamczewski, J. Z., Gunn, A., Laarveld, B. & Flood, P. F. 1992. Seasonal changes in weight, condition and nutrition of free-ranging and captive muskox females. – *Rangifer* 12: 179–183.

Adamczewski, J. Z., Chaplin, R. K., Schaefer, J. A. & Flood, P. F. 1994. Seasonal variation in intake and digestion of a high-roughage diet by muskoxen. – *Can. J. Anim. Sci.* 74: 305–313.

Groves, P. 1992. *Muskox husbandry: a guide for the care, feeding and breeding of captive muskoxen.* Biol. Pap. Univ. Alaska Spec. Rep. No. 5.

Merriam, G. & Wachter, K. 1982. Algorithms for the study of episodic hormone secretion. – *Am. J. Physiol.* 243: E310–E318.

Pearson, A. M. & Dutson, T. R. (eds.). 1991. *Growth regulation in farm animals. Advances in meat research Vol.* 7. Elsevier Science Publishing, Barking, Essex, England.

Sauerwein, H., Meyer, H. D. & Schams, D. 1992. Divergent effects of estrogens on the somatotropic axis in male and female calves. – *J. Reprod. Develop.* 38: 271–278.

Spicer, L. J. & Echternkamp, S. E. 1995. The ovarian insulin and insulin-like growth factor system with emphasis on domestic animals. – *Domest. Anim. Endocrinol.* 12: 223–245.

Suttie, J. M., White, R. G., Manley, T. R., Breier, B. H., Gluckman, P. D., Fennessy, P. F. & Woodford, K. 1993. Insulin-like growth factor 1 and growth seasonality in reindeer (*Rangifer tarandus*) – comparisons with temperate and tropical cervids. – *Rangifer* 13: 91–98.

Tedesco, S. C. 1996. *Melatonin and seasonal cycles in muskoxen.* PhD thesis, Univ. Saskarchewan, Saskatoon, Sask., Canada.

Thing, H., Klein, D. R., Jingfors, K. & Holt, S. 1987. Ecology of muskoxen in Jameson Land, northeast Greenland. – *Holarct. Ecol.* 10: 95–103.

Tyler, N J. C. 1987. Body composition and energy balance of pregnant and non-pregnant Svalbard reindeer during winter. – *Symp. zool. Soc. Lond.* 57: 203–229.

Van Kessel, A. G. 1992. *Somatostatin immunoneutralization: physiological response and potential for growth enhancement in lambs.* PhD thesis, Univ. Saskatchewan, Saskatoon, Sask., Canada.

White, R. G., Holleman, D. F. & Tiplady, B. A. 1989. Seasonal body weight, body condition, and lactational trends in muskoxen. – *Can. J. Zool.* 67: 1125–1133.

Manuscript accepted 25 February, 1997