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Expanded abstract:

Hematology and serum biochemistry values in muskoxen.

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This study was undertaken to define normal ranges of clinical hematologic and serum biochemistry values in mature muskoxen *(Ovibos moschatus)*, and to describe changes associated with various physiological and pathological conditions. Two groups of animals were sampled: (1) captive adult muskoxen at the University of Saskatchewan's Goodale Farm and (2) free-ranging adult muskoxen on Victoria Island, Northwest Territories, Canada.

Captive muskoxen were maintained on pasture with a daily pelleted supplement and locally grown grass hay (10–12% protein) was available throughout the winter. Blood samples were obtained by jugular venipuncture at several times of year while animals were held in a headgate without chemical restraint. Analyses were performed the same day. Wild muskoxen were chased 5–20 minutes before being shot, after which blood was collected by lacerating a jugular vein. Serum was then drawn off and chilled or frozen within 24 hours. Samples were analysed up to two weeks later.

Analyses were performed at the clinical pathology laboratory, Western College of Veterinary Medicine, on the Coulter DACOS and the Coulter S+IV (Coulter Electronics; Hialeah, Florida, USA). Normal ranges for each analyte were calculated using univariate statistical procedures (SAS, Version 6) and expressed as mean ± 2 standard deviations. Reference values will be evaluated and updated annually.

Hematologic and serum biochemistry values represent normal profiles in healthy, minimally stressed, adult muskoxen. Most values were similar to those of domestic ruminants (Table 1) and did not vary with season. Serum urea and creatinine levels, however, were higher than in domestic ruminants and varied seasonally. Mean urea values were 13 mmol/l ± L in winter and 16 mmol/L ± 1 in summer; mean creatinine levels were 300 μmol/L ± 22 in winter and 247 μmol/L ± 16 in summer.

Most serum biochemistry values in wild muskoxen differed from those in captive animals and showed larger seasonal changes (Table 2). Stable gamma glutamyl transferase activities indicate little change in biliary epithelium, while fluctuations in alkaline phosphatase activity correspond to annual changes in liver size and may reflect associated changes in metabolic activity. Decreased protein intake during arctic winters may elicit the low urea levels at this time, and may also lead to the elevated creatinine levels due to increased muscle catabolism. Similar phenomena have been documented in white-tailed deer *(Odocoileus virginianus)* (Kirkpatrick *et al.*, 1975).

Responses in blood parameters of muskoxen to various conditions were much like those of domestic

Table 1. Hematology and serum biochemistry values.

	Muskoxen[1]	Cattle[2]
Red Blood Cells (x 10^{12}/L)	5.1 - 8.9	5 - 10
Hemoglobin (g/L)	88 - 160	80 - 150
Packed Cell Volume (L/L)	.24 - .44	.24 - .46
Mean Corpuscular Volume (L/L)	45 - 53	40 - 60
Mean Corpuscular Hemoglobin (Pg)	16.1 - 18.9	11 - 17
Mean Corpuscular Hemoglobin Concentration (g/L)	344 - 378	300 - 360
Platelets (x 10^9 /L)	123 - 355	100 - 800
Protein (g/L)	61 - 77	57 - 81
Fibrinogen (g/L)	1 - 5	< 6
White Blood Cells (x 10^9 /L)	5.5 - 12.2	4 - 12
Neutrophils (x 10^9 /L)	2.460 - 7.450	.6 - 4
Eosinophils (x 10^9 /L)	0 - 1.228	0 - 2.4
Lymphocytes (x 10^9 /L)	1.205 - 5.008	2.5 - 7.5
Basophils (x 10^9 /L)	0 - .357	0 - .2
Monocytes (x 10^9 /L)	0 - .502	.025 - .84
Sodium (mmol/L)	137 - 147	135 - 151
Potassium (mmol/L)	4.3 - 6.1	3.9 - 5.9
Chloride (mmol/L)	95 - 113	96 - 110
Carbon Dioxide (mmol/L)	14 - 32	20 - 32
Anion Gap (mmol/L)	12 - 32	14 - 26
Calcium (mmol/L)	2.24 - 2.82	2.11 - 2.75
Phosphorus (mmol/L)	1.22 - 3.26	1.08 - 2.76
Magnesium (mmol/L)	.87 - 1.43	.8-1.32
Urea (mmol/L)	7.5 - 22.7	< 7.5
Creatinine (μmol/L)	137 - 429	67 - 175
Glucose (mmol/L)	2.9 - 5.5	1.8 - 3.8
Alkaline Phosphatase (U/L)	< 1517	< 121
Creatine Kinase (U/L)	< 600	< 350
Aspartate Aminotransferase (U/L)	40 - 108	46 - 118
γ - Glutamyl Transferase (U/L)	43 - 135	< 31
Total Protein (g/L)	60 - 80	66 - 78
Albumin (g/L)	27 - 41	23 - 43
Albumin: Globulin Ratio (g/L)	.62 - 1.32	.66 - 1.3
Total Bilirubin (μmol/L)	< 1	< 30

1. 15 mature muskoxen sampled repeatedly over 12 months.
2. Reference values from clinical pathology labioratory, Western College of Veterinary Medicine.

ruminants. Muskoxen would occasionally struggle during blood collection making repeated venipuncture necessary. This type of stress increased packed cell volume and white blood cell counts (WBC) with a neutrophilia, slight eosinophilia and relative lymphopenia. Similar responses have been seen in immobilized muskoxen (Dieterich, 1970) and stressed cattle, although cattle may also show a decrease in eosinophil numbers (Jain, 1986).

Subcutaneous abscesses in several captive muskoxen produced an inflammatory leukogram with WBC counts up to 17,000 x 10^9, a left shift (bands as high as 16%), increased fibrinogen and occasionally toxic white blood cells.

Three cases of cronic glomerulonephritis were associated with urea levels as high as 54 mmol/L, creatinine up to 1200 μmol/L, and phosphorus levels up to 6.5 mmol/L - values that are higher than would be expected in similarly diseased cattle (Campbell *et al.*, 1970). This observation may indicate an unusual ability to retain and tolerate elevated levels of nitrogen. Caribou have been shown to recycle urea more

Table 2. Seasonal serum biochemistry values in wild muskoxen.

	n	Urea mmol/L	Creatinine µmol/L	ALP[1] U/L	GGT[2] U/L
April	35	3.3 - 4.1	277 - 311	853 - 1115	69 - 91
May	27	3.2 - 3.8	253 - 293	888 - 1028	101 - 117
July	9	9.2 - 14.4	78 - 124	1967 - 3091	69 - 109
August	8	6.1 - 10.1	104 - 176	1603 - 2671	65 - 109
Sept	12	4.3 - 6.1	171 - 215	1513 - 2117	78 - 109
Nov	25	2.5 - 2.9	251 - 295	584 - 686	94 - 110

1. Alkaline Phosphatase
2. Gamma Glutamyl Transferase

efficiently than domestic ruminants (Wales and Milligan, 1975), and this ability may also apply to muskoxen.

Creatine kinase (CK) values in serum samples from free-ranging muskoxen ranged from 600–40,000 U/L and aspartate aminotransferase (AST) from 90–4273 U/L. Dramatic increases in CK are associated with acute muscle exertion or damage, while AST levels tend to increase more slowly, with elevations reflecting earlier tissue injury (Cardinet, 1989).

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