BIOCHEMICAL AND HAEMATOLOGICAL VALUES IN VENOUS BLOOD OF CAPTIVE RED DEER (*Cervus elaphus*) AT HIGH ALTITUDE

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Abstract

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Biochemical values were determined in venous blood of 30 and haematological values in 60 red deer of average body mass 53.9 kg, aged 5 months, kept on pasture in Central Mexico at the altitude of 2 450 m. In blood samples from jugular vein of clinically healthy animals without sedation, the average serum concentrations were as follows: urea 6.32 mmol/L, glucose 5.09 mmol/L, Na^+ 142.3 mmol/L, K^+ 7.03 mmol/L, Cl^- 100.5 mmol/L, Ca^{2+} 2.12 mmol/L, inorganic P 2.41 mmol/L, Mg^{2+} 0.91 mmol/L, Cu 9.86 µmol/L, Zn 16.97 µmol/L and activity of AST 54.3 IU/L and creatine kinase 221 IU/L. Blood pH was 7.41, pCO_2 37.7 mm Hg, actual bicarbonate 24.3 mmol/L, base excess 0.73 mmol/L, total CO_2 25.3 mmol/L, haemoglobin 156 g/L, PCV 0.47 L/L, leukocytes 4.8 x 10^9/L and plasma protein 66.0 g/L. Biochemical and haematological values determined in red deer at the altitude above 2000 m are the first reference and can be used for health control and diagnosis of diseases.

Red deer, venous blood, biochemical values, haematology, high altitude

In recent years red deer has been farmed in Mexico. Some biochemical and haematological analytes have been described in this species, however, their values depend mainly on nutrition, management and environmental conditions. Biochemical and haematological values are important for monitoring of health status and diagnosis of diseases. Great differences were described in values of plasma analytes, especially in concentrations of Na^+ and K^+ in red deer (Wilson and Pauli 1983; Knox et al. 1988; Hargreaves and Matthews 1995).

The objective of this study was to determine biochemical and haematological values in venous blood of farm red deer in central Mexico at the altitude of 2 450 m.

Materials and Methods

Blood biochemical values were determined in 30 red deer *(Cervus elaphus)* (15 males, 15 females) and haematological values in 60 animals (30 males and 30 females) aged 5 months, average body mass 53.9 kg without clinical signs of disease. The animals were kept on pasture in the Valley of central Mexico at the altitude of 2 450 m. The climate was moderate, rainy during summer, with average temperature between 5 and 14 °C. The pasture was composed of rye grass, orchard, kikuyo, white clover and alfalfa. Daily calculated dry matter consume was 2.06 kg per animal. During sampling the animals without sedation were gently restrained in standing position, in a small pen, with covered eyes and plugged ears.

Samples of blood were taken from jugular vein into plain tubes for biochemical analyses, into tubes containing $EDTA_{k3}$ for haematological analyses and in syringes previously coated with 2 per cent $heparin_{Na}$ for determination of acid-base values. The air bubbles were expelled from the syringe immediately after blood collection and then the needle was inserted into a rubber stopper to prevent exposure of sample to air. The sealed syringes after collection were immersed in a mixture of ice and water.

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Blood samples were centrifuged within 60 min after collection at 1000 *g*, serum was immediately drawn off and refrigerated for analyses of enzyme activities or frozen for later analyses of other analytes. Serum urea, glucose, inorganic phosphorus concentrations and enzyme activities of aspartate aminotransferase (AST) and creatine kinase (CK) were measured by Microchem analyser 565 (Ciba-Corning). The enzyme assays were performed at 30 °C. Serum concentrations of Ca^{2+}, Mg^{2+}, Cu and Zn were determined by atomic absorption spectrometry (Perkin-Elmer 3110). Serum levels of Na^{+}, K^{+} and Cl^{-} were determined by the electrolyte analyser 644 (Ciba-Corning). The acid-base values: pH, partial pressure of CO_2 (pCO_2), base excess (BE), actual bicarbonate (HCO_3^- a), and total CO_2 (TCO_2) were determined by pH/blood gas analyser 238 (Ciba-Corning) within 3 h after blood sampling.

Haemoglobin (Hb) was measured spectrophotometrically using the cyanomethaemoglobin method, packed cell volume (PCV) by microhaematocrit centrifuge and plasma protein by refractometer. Total leukocytes were counted using haemocytometer and differential counts were carried out on Wright's stained blood smears (Jain 1993).

Results were analysed by descriptive statistics and were expressed as mean, standard deviation (SD), minimum and maximum.

Results

Animals did not show any clinical signs of disease and their body condition was good. The mean values, standard deviations and ranges for blood biochemical, acid-base and haematological analytes are shown in Tables 1-2.

Table 1
Biochemical values in blood of red deer (n = 30)

Analyte	Mean	SD	min	max
Urea (mmol/L)^s	6.32	1.45	4.85	8.11
Glucose (mmol/L)^s	5.09	1.36	2.80	8.42
AST (IU/L)^s	54.3	15.9	36.0	123.0
CK (IU/L)^s	221	103	79.0	409
Na^+ (mmol/L)^s	142.3	2.5	137.0	147.0
K^+ (mmol/L)^s	7.03	1.03	5.46	9.53
Cl^- (mmol/L)^s	100.5	2.3	96.0	106.0
Ca^{2+} (mmol/L)^s	2.12	0.26	1.90	2.55
P (mmol/L)^s	2.41	0.32	2.03	2.90
Mg^{2+}(mmol/L)^s	0.91	0.20	0.62	1.32
Cu (µmol/L)^s	9.86	1.64	6.46	14.48
Zn (µmol/L)^s	16.97	9.05	8.41	33.55
pH^b	7.41	0.04	7.30	7.51
pCO_2 (mm Hg)^b	37.7	4.4	31	52
HCO_3^-a (mmol/L)^b	24.3	3.1	19.1	31.0
BE (mmol/L)^b	0.73	3.22	-5.7	8.10
TCO_2 (mmol/L)^b	25.3	3.2	20.8	31.7

SD = standard deviation, AST = aspartate aminotransferase, CK = creatine kinase, pCO_2 = partial pressure of carbon dioxide, HCO^-_3 a = actual bicarbonate, BE = base excess, TCO_2 = total carbon dioxide, s = serum, b = blood

Discussion

Blood serum urea concentration (6.32 mmol/L) was lower in this study than that determined by Wilson and Pauli (1983) and Knox et al. (1988). This analyte reflects the intake of effective rumen-degradable protein and its balance with fermentable metabolizable energy. Increased levels of blood serum urea may be associated with an excess of dietary protein, with deficiency of energy in the ration, with augmented catabolism of the animal or with prerenal, renal and postrenal azotemia (Kelly et al. 1988; Seglar 1997, Meyer and Harvey 1998).

The mean serum glucose concentration determined by us was lower and less variable than that determined by Wilson and Pauli (1983) but it was three times higher than the value

Table 2
Haematological values in red deer (n = 60)

Analyte	Mean	SD	min	max
Haemoglobin (g/L)	156	29.5	72	182
PCV (L/L)	0.47	0.047	0.32	0.56
Plasma protein (g/L)	66.0	6.6	50.0	80.0
Total WBC ($x10^9$/L)	4.8	1.38	2.20	9.55
Neutrophils (%)	40.07	8.01	26	63
Bands (%)	0.44	1.15	0	5
Lymphocytes (%)	48.13	7.83	22	63
Monocytes (%)	5.31	2.70	0	15
Eosinophils (%)	2.94	2.57	0	11
Basophils (%)	3.12	2.28	0	9

SD = Standard deviation, PCV = packed cell volume, WBC = white blood cell

described by Knox et al. (1988). The reference range values for plasma glucose (0.18 - 3.32 mmol/L) determined by Knox et al. (1988) are extremely low and markedly different from other domestic ruminants (Jagoš and Bouda 1981; Kaneko et al. 1997) and we have not determined such low concentration as 0.18 mmol/L. The glucose level is related to a nutritional status, although some factors such as stress can contribute to its higher value (Wolfe et al. 1982).

The activities of AST in serum of red deer in our study were mildly higher than those determined by Wilson and Pauli (1983), but corresponded to the values described by Knox et al. (1988). Serum AST activities are elevated during muscle or liver damage in bovine and equine species, and their peak activities occur 24 - 48 h after injury (Meyer and Harvey 1998).

Serum CK activities determined by us were lower than those described by Wilson and Pauli (1983) and they were similar to activities stated by Knox et al. (1988), Reid and Towers (1985). Increased CK activities are usually associated with muscular dystrophy or exercise (Anderson 1976; Anderson et al. 1976).

Blood serum concentrations of Na^+ and K^+ (142.3 and 7.03 mmol/L, respectively) were higher than those (138.4 and 4.67 mmol/L, respectively) determined by Wilson and Pauli (1983), but they were lower than those described by Knox et al. (1988) (150 and 12.8 mmol/L, respectively). The average serum K^+ concentration in red deer determined by us and specially the reference value for K^+ described by Knox et al. (1988) is markedly higher in comparison with that in other domestic animals (Jagoš and Bouda 1981; Meyer and Harvey 1998; Kaneko et al. 1997). However, the average serum concentrations of Na^+, Cl^- and blood acid-base values were consistent with those in cattle and sheep (Jagoš and Bouda 1981). The variations in reference blood plasma concentrations, the ranges for Na^+ (70-220 mmol/L) and K^+ (2.1-21.4 mmol/L) described by Knox et al. (1988) are markedly different from values determined by us and those in other domestic animals (Jagoš and Bouda 1981; Meyer and Harvey 1998; Kaneko et al. 1997). We have never found these extreme serum values for Na^+ and K^+ in domestic species. Average serum Cl^- concentration was lower than that described by Hargreaves and Matthews (1995). Serum electrolyte concentrations are important for the estimation of hydration in deer and according to Hargreaves and Matthews (1995) they are more useful than haemoconcentration as an hydration index in red deer.

The plasma concentrations of Na^+, K^+, Cl^- and TCO_2 are also important for the exact determination of acid-base disorders, especially mixed acid-base disorders (Russell et al. 1996). The average serum concentrations of Ca^{2+}, inorganic P and Mg^{2+} (2.12, 2.41 and 0.90

mmol/L, respectively) were higher than those (1.79, 2.11 and 0,75 mmol/L, respectively) described by Wilson and Pauli (1983), but they were lower than those determined by Knox et al. (1988) (2.78, 2.83 and 1.04 mmol/L, respectively). These differences can be explained by the composition of pasture, management and age of animals.

The average serum Cu concentrations were less variable in our study than those measured by Knox et al. (1988). Copper is an important serum trace element and its deficiency has been associated frequently with poor growth and hair colour changes (Fyffe 1996). The optimum plasma concentration of Cu is important for normal reproduction and performance (Suttle 1986; Gooneratne et al. 1989).

The average serum Zn concentration found by us was consistent with reference values described by Jagoš and Bouda (1981) in other ruminants, but the lower range value was below reference range values. Optimum serum Zn concentrations are needed for adequate immunity (Mills 1987).

Blood acid-base values determined in this study are the first reference in red deer and are consistent with the values described by Presidente et al. (1973) in White-tailed deer during immobilization with etorphine and xylazine and with values in bovine (Jagoš and Bouda 1981).

The values of PCV, haemoglobin and plasma protein in this study corresponded to values in unsedated farmed red deer (Cross et al. 1988; Hargreaves and Matthews 1995). The values of PCV and Hb in farmed red deer with xylazine sedation were lower than those in physically restrained animals (Cross et al. 1988). Wilson and Pauli (1982) concluded that samples collected from fully conscious deer are likely to produce higher concentrations of haemoglobin and values of PCV. According to Turner and Hodgetts (1959) the spleen of the red deer has a bilayered capsule with substantial amounts of smooth muscle, indicating that this has red cell storage as a major function. It seems probable that a major contribution to the observed changes is caused by the spleen contraction due to adrenaline, released during manual restraint of the animal.

The average WBC value in our study was consistent with that in red deer described by Upcott and Herbert (1965), but a higher value was determined by Wilson and Pauli (1982). Differential WBC counts varied markedly according to these authors. In our study the percentage of neutrophils was lower than that recorded by Wolfe et al. (1982), Wilson and Pauli (1982), whereas percentage of lymphocytes was higher. The values of other granulocytes and monocytes determined by us were similar to those described elsewhere on many deer species (Peterson and Pedersen 1975).

Biochemical and haematological values determined in red deer at the altitude above 2 000 m are the first reference and can be used as indicators for control of health status and diagnosis of disease in farmed red deer.

Biochemické a hematologické hodnoty ve venózní krvi jelenů *Cervus elaphus* ve vysoké nadmořské výšce

Biochemické hodnoty byly stanoveny ve venózní krvi 30 a hematologické hodnoty u 60 jelenů, průměrné hmotnosti 53,9 kg, věku 5 měsíců, chovaných na pastvě v centrálním Mexiku, v nadmořské výšce 2450 m. V krevním séru klinicky zdravých zvířat bez použití sedace byly průměrné hodnoty koncentrace močoviny 6,32 mmol/L, glukózy 5,09 mmol/L, Na^+ 142 mmol/L, K^+ 7,03 mmol/L, Cl^- 100,5 mmol/L, Ca^{2+} 2,12 mmol/L, anorganického P 2,41 mmol/L, Mg^{2+} 0,91 mmol/L, Cu 9,86 µmol/L, Zn 16,97 µmol/L, aktivit AST 54,3 IU/L a kreatinkinasy 221 IU/L. V krvi byly hodnoty pH 7,41, pCO_2 37,7 mm Hg, aktuálního bikarbonátu 24,3 mmol/L, přebytku bází 0,73 mmol/L, celkového CO_2 25,3 mmol/L, hemoglobinu 156 g/L, hematokritu 0,47 L/L, leukocytů 4,8 x 10^9/L a celkových bílkovin v krevní plasmě 66,0 g/L. Biochemické a hematologické hodnoty stanovené v krvi jelenů

v nadmořské výšce nad 2000 m jsou první referencí a zároveň mohou být využity v diagnostice a prevenci onemocnění těchto zvířat.

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