

Serum Biochemistry and Hematology in Blue Fox (*Vulpes lagopus*)

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Abstract

The blue fox (*Vulpes lagopus*) is a colour mutation of wild arctic fox. It is commonly farmed for its fur. The aim of the present study was to analyse a baseline biochemical profile of serum from adult farmed blue foxes during pelting season. Serum biochemical profile can be used later on as a reference in chemical analysis of blood serum. Biochemical profile here consists of liver enzymes alanine aminotransferase (ALAT), aspartate aminotransferase (ASAT), alkaline phosphatase (ALP), and total bilirubin (T-BIL); kidney function substances creatinine, urea and inorganic phosphate (Pi); muscle enzyme creatinine kinase (CK); glucose (GLUK) from pancreas; serum total proteins (PROT) and albumin (ALB); electrolytes potassium (K), sodium (Na), chloride (CL), calcium (S-Ca); and lipids such as total cholesterol (T-Cho). For some of the measured parameters reference values were also available from previous studies. Certain values were close to those previously published but some differed markedly. These differences can be explained by differences e.g. in techniques, conditions, unit reports, and breed and age of the animals. The present study additionally reviewed previously published haematological data concerning small blood count, *i.e.* hemoglobin, hematocrit, white blood cells and red blood cells. Summarized material revealed that these variables are very similar despite of study and animal material. Thus, small blood count can be reliably used to screen general welfare status of farmed blue foxes. The reference values presented in this paper will be valuable as a guide for clinical diagnosis and research.

Keywords

Farm-Raised Fox, Blood Analysis, Haematology, Animal Welfare, Small Blood Picture

1. Introduction

Serum is the liquid portion of blood. It is extracted from blood sample by spinning down or centrifuging the sample to separate cellular components and coagulation factors of blood from the liquid part. Serum biochemis-

try refers to the chemical analysis of blood serum. The analysis can include many different tests, each of which provides targeted information about one or more organs [1]. Assessment of the test results may indicate which organ system is affected, and may provide valuable information about the nature and severity of the problem or disease [2]. Biochemical profile of serum is typically species-specific [3]. However, for example in foxes, the concentrations of serum biochemical indicators seem to be fairly similar to the reference values previously reported for the dog [4] [5].

The most common fox species raised for its fur are the blue fox, a colour mutation of wild arctic fox (*Vulpes lagopus*), and the silver fox, a colour mutation of red fox (*Vulpes vulpes*). Farming history of both fox species is about 100 years old. Earliest evaluations on haematology and blood biochemistry in farmed foxes were published over 70 - 80 years ago [6]-[8]. These data are from red and silver foxes. As concerns blue foxes, earliest haematology screenings derive from 1980's [2] [3] [9] [10]. Some haematology and serum biochemistry evaluations have also been made for wild arctic foxes [11] [12]. The latest haematological measurements regarding farm-raised foxes were published by [13] and [14]. A total serum biochemical profile, however, is lacking from farmed blue foxes. The small blood count is best illustrated by [15] and [16].

The purpose of the current study was to screen baseline serum biochemical profile for adult farm-raised blue foxes during pelting season. A selected group of tests for serum biochemistry applied for dog-like canids were employed. Previously published haematological data in farmed blue foxes mainly includes small blood count [15] [16]. The second aim was to summarize the existing data for background screening of general health status.

2. Material and Methods

2.1. Animals and Health Evaluation

The present study was carried out at the Fur Farming Research Station of MTT, in Kannus, western Finland (63.54°N, 23.54°E). The use of experimental animals was evaluated and approved by the Animal Care Committee of MTT Agrifood Research Finland. Health of animals was visually checked daily. Health evaluation was based on general appearance of animals, including consistence of faeces.

The animals were born at the Fur Farming Research Station in Kannus. Blood samples were taken from fifteen 21 months old female blue foxes in November. Because of artificial insemination, adult females are more common than adult males on farms. Therefore, only females were used here. Body weights of animals were measured with a Mettler SM 15 balance, accuracy ± 1 g. Before sampling, experimental animals were kept in wire-mesh cages measuring 105 cm long \times 115 cm wide \times 70 cm high. Each cage had a wire-mesh platform (105 cm long \times 25 cm wide) and a wooden block for chewing (diameter 7 cm, length 35 cm). Daily routine treatments were conducted according to standard farming procedures [16]-[18]. Feed composition was based on the recommendations of the Finnish Fur Breeders' Association [13] [18]. Watering was automatic *ad libitum*.

2.2. Blood Collection and Analysis

Animals were clinically healthy at the time of blood collection. They were fasted overnight prior to blood sampling. Each fox was manually restrained and blood was collected from the jugular vein through a 20-gauge needle into a syringe. Serum and plasma were separated by double centrifugation. For the serum biochemical evaluation, 3 mL blood samples were centrifuged at 3000 rpm for 10 min within 1 h of collection. Sera were stored at -80°C in a freezer prior to analysis.

Serum biochemical assays (Table 1) were carried out by using an automatic analyzer (Shimadzu CL-7200, Kyoto, Japan), and automatic electrolyte analyzer (Ciba-Corning 644, USA) [5] [12] [19]. Haematological analyses here include the small blood count, *i.e.* hemoglobin, hematocrit, white blood cell count and red blood cell count. This data is based on previous publications listed in Table 2.

3. Results

Body weights of the foxes averaged 8.0 ± 0.9 kg (mean \pm SD). The main biochemical results are presented in Table 1. Serum biochemical assays here consisted of liver enzymes alanine aminotransferase (ALAT), aspartate aminotransferase (ASAT), alkaline phosphatase (ALP), and total bilirubin (T-BIL); substances describing kidney function creatinine, urea and inorganic phosphate (Pi); muscle enzyme creatinine kinase (CK); glucose

Table 1. Serum biochemistry analyses in blue foxes (N = 15). Results are presented as means with standard deviation (SD). Reference values (mean or range) from previous publications (a - e) are presented on the right. See References in more details. For variables in details see Material and methods.

Parameter	Mean	SD	Reference values
ALAT (U/l)	171.5	56	132 ^a , 121 ^b , 260 ^c , 49 - 65 ^d , 12 - 14 ^e
ASAT (U/l)	49.2	25	48 ^a , 53.8 ^b , 99 - 168 ^c , 87 - 104 ^d , 23 - 28 ^e
CK (U/l)	84.0	27	227 ^a , 184 - 363 ^c
ALP (U/l)	101.2	32	34.6 ^b
UREA (mmol/l)	6.4	3.3	6.4 ^b
KREA (μmol/l)	52.6	3.9	62 ^b
ALB (G/l)	35.9	2.0	
S-Ca (mmol/l)	2.9	0.1	
GLUK (mmol/l)	7.6	1.2	
T-Cho (mmol/l)	5.1	0.6	
T-BIL (μmol/l)	1.7	0.4	
Pi (mmol/l)	1.5	0.4	
K (mmol/l)	4.6	0.3	
Na (mmol/l)	145.7	1.9	
CL (mmol/l)	108.2	2.7	

^a[15], ^b[14], ^c[13], ^d[9], ^e[2].

Table 2. Small blood count for farmed blue foxes. Hb = hemoglobin, HC = hematocrit, WBC = white blood cells, RBW = red blood cells. Results are with or without mean and standard deviation (SD), except in [20] as standard error (SE). N = number of animals.

Hb	HC	WBC	RBC	N	Reference
(g/l)	(%)	(10 ⁹ cells ⁻¹)	(10 ⁹ cells ⁻¹)		
155 ± 10	49.3 ± 50	8.4 ± 7.2	8.4 ± 8.7	20	[16]
160 ± 2	51.7 ± 51	8.8 ± 8.7	8.9 ± 8.0	20	[19]
159 ± 0.2	50.2 ± 0.8	7.7 ± 0.8	9.0 ± 0.2	12	[20]
171	57.0	8.9	9.5	20	[15]
164	52.0	7.4	8.8	60	[17]
178	57.1	7.8	9.2	50	[18]
168	58.4	7.9	9.7	16	[21]

(GLUK) from pancreas; serum total proteins (PROT) and albumin (ALB); electrolytes potassium (K), sodium (Na), chloride (CL), calcium (S-Ca), and lipid substance total cholesterol (T-Cho). **Table 1** also provides some reference values from previous publications in farm-raised blue foxes.

Table 2 summarizes previously published haematological data concerning small blood count, *i.e.* hemoglobin, hematocrit, white blood cells and red blood cells. These variables are very similar despite of study and animal material.

4. Discussion

It is known that individual animal variability can affect study results. To minimize animal variability, research-

ers should be provided with normal, healthy, well-adapted animals having a narrow range of physical, behavioural, and clinical parameters. The establishment of standard basic data is therefore important. The present biochemical study was carried out at pelting season in November. At that time of the year there is the highest number of animals on farms. By then, juvenile animals have already reached maturity, too. Comparison of serum biochemistry profile can be expected to be then most needed and justified. Animals in this study were clinically healthy at the time of blood collection and maintained under similar husbandry practices.

Values of certain blood parameters determined in the present study were close to previously documented reference values, but there were also variables that differed markedly from each other. These differences quite likely can be explained by differences in techniques, conditions, unit reports, and breed and age of the animals [12].

Serum biochemical profile contains a series of blood tests that provide an overview of many of the body's functions. The term "liver function tests" is often used to describe a panel of laboratory measures of a variety of hepatic enzymes, including serum aspartate aminotransferase or AST and alanine aminotransferase or ALT and alkaline phosphatase (ALP). With a disturbance of the structure and function of hepatocytes the cytoplasmic enzyme ALAT is liberated and supplied to the blood earlier than the mitochondrial enzyme ASAT [2]. ASAT is most abundant in the heart, the liver and the skeletal muscle, while the liver and kidneys are good sources of ALAT. Cirrhosis of the liver, where hepatic cells are irreversibly damaged and part of the tissue becomes fibrous, increases serum ASAT too, as a result of a deep organ disturbance of hepatic cells [2]. Normal ASAT values in blood serum for blue foxes at pelting time have been described to be between 23 - 28 U/l, and ALAT values between 12 - 14 U/l [2]. It has, however, found higher values, 87 - 104 U/l for ASAT and 49 - 65 U/l for ALAT in Finnish blue foxes [9]. In dogs, ALAT and ASAT value in the serum range between 21 - 102 U/l and 23 - 66 U/l [22]. High ALAT and ASAT values can be related to the seriousness of liver lipodosis [13]. In the present study, ALAT values found were higher than previously measured. ASAT values, on the other hand, were very similar than those documented by [14] and [15]. In dogs, ASAT value has been described to be 35 U/l [5]. ALP values found were higher than those found in blue fox study [14]. In silver foxes, ALP value of 57 - 122 U/l has been measured [4]. These are rather close to values found in the present study. In human beings, normal ALK range typically is from 44 to 147 U/l.

The two substances most commonly measured to assess kidney function are urea and creatinine. Urea is a by-product of protein breakdown. It is produced in the liver and secreted from the body in urine. Creatinine is a by-product of muscle metabolism. Increased levels of creatinine indicate decreased kidney function. Both urea and creatinine values measured here were comparable to those values previously found [14].

The enzyme most frequently evaluated to assess muscle health is creatinine kinase (CK). Elevations in muscle enzymes are often found with muscular activity, trauma, and muscle inflammation. CK values in the present study were lower compared to previously values by [2] and [14]. In silver foxes, on the other hand, it was found similar values (84.9 U/l) than in the present study for blue foxes [4].

For the rest of measured parameters there are no actual reference values available in the literature. Because of lack of specific reference it is difficult to estimate their true relevance. Typically values outside of normal range are suggestive of a lack of good health. Further studies will be needed to evaluate normal range of certain serum biochemistry variables in farmed foxes.

Summarized haematological data on small blood count revealed that these four blood parameters are fairly similar despite of experiment or animal material. All haematological analyses were done by the same laboratory which probably declined variability of results. It looks that small blood count can be reliably used to screen general welfare status of farmed blue foxes [22]. More data on serum biochemistry is needed. However, it can be expected that small blood count together with serum biochemistry profile is a potential test combination for analysis of animal welfare and health.

5. Conclusion

The present study evaluated a wide scale serum biochemical assays for adult farm-raised blue foxes. For some of the measured blood parameters, also reference values were available from previous studies. Some of the measured variables were close to values previously published, but some differed markedly. These differences can be most likely explained by the differences in techniques, conditions, unit reports, and breed and age of the animals. It is essential to reduce errors by determining the normal ranges as accurately as possible. Small blood

count can be reliably used to estimate general welfare status of blue foxes. The reference values presented in this paper will be valuable as a guide for clinical diagnosis and research.

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