International Scholars Journals

International Journal of Microbiology Research and Reviews ISSN 2329-9800 Vol. 8 (4), pp. 001-006, April, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Hematology and serum biochemistry values in adult racoon dogs and foxes in Changli farms of Hebei Province, China

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Accepted 17 October, 2018

This study examined 41 hematology and serum biochemistry status of adult raccoon dogs (*Nyctereutes procyonoides*, n = 20) and silver foxes (*Vulpes fulva*, n = 20), living in the farms of Hebei Province. These values were compared between sexes of each kind animal and between raccoon dogs and foxes. The results showed that genders and species influenced the hematology and serum biochemistry values. Specifically, female foxes had higher (P < 0.05) eosinopil counts and chloride content, and lower (P < 0.05) glucose content than males. Female raccoon dogs had lower (P < 0.05) glutamyltransferase activity and higher (P < 0.05) contents of creatinine and triglyceride (TG) than males. For leukocyte counts, mean cell volume (MCV) and mean cell haemoglobin (MCH) values were significantly higher (P < 0.01) in raccoon dogs when compared with the foxes. However, erythrocyte count of foxes was significantly higher (P < 0.01) than that of raccoon dogs. The activities of amylase, creatine kinase, aspartate aminotransferase (AST), glutamyltransferase (GGT), and the contents of total protein, globulin, uric acid, triglyceride, potassium, and sodium were significantly higher in raccoon dogs than those in foxes (P < 0.01, P < 0.05). While, the activities of alanine aminotransferase (ALT), alkaline phosphatase and the contents of glucose, blood urea nitrogen, creatinine, magnesium and total cholesterol were significantly higher in foxes than that in raccoon dogs.

Key words: Blood serum biochemistry, silver fox (*Vulpes fulva*), hematology, raccoon dog (*Nyctereutes procyonoides*).

INTRODUCTION

Raccoon dogs and foxes, being the special economic animals, are known as excellent species that played vital role in fur industry in the world. Fur animals were originally cultivated and breed in European countries, while fur animal breeding has developed rapidly in China, which stimulated the regional economic development in recent years. With the expanded farming and lack of corresponding systematic basic researches on wild animals, the difficulties in diseases diagnosis of raccoon dogs and foxes came under concern.

Previous studies by Kennedy (1935) and Spitzer et al. (1941) on hematological parameters in raccoon dogs and foxes were reported about 60 to 70 years ago. Hematological values differ with variation among different animal species, sex, age, nutritional status and seasons (Crooks et al. 2000). Additionally, the hematological indicators are widely used to assess animal health, physical condition, indirectly reflecting the nutritional status, disease, injury, life environmental quality, external stimulus and so on (Delgiudice et al., 1991; Gates et al., 1976; McCue et al., 1987). The hematology and serum biochemistry of captive swift foxes (*Vulpes Velox*) were reported (Mainka SA, 1988). However, there were no

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further study related to the hematological indicators in the captive raccoon dogs and foxes in China.

Hematology and serum chemistry values are essential diagnostic tools to assess the health of captive and free-ranging animal populations. Therefore, it is necessary to provide updated reference values for raccoon dogs and foxes. The experiment was conducted to measure the normal values of hematology physiological and biochemical indicators for raccoon dogs and foxes and hopefully to provide reference data for future captive breeding and clinical veterinary diagnosis in the corresponding animal species.

MATERIALS AND METHODS

Sample animals

Twenty raccoon dogs (7 months old) and 20 silver foxes (7 months old), male and female ratio 1:1, were taken from the fur animal breeding farms (Jinsheng Animal Husbandry Co., Ltd., Changli 066600, China) in Changli county of Hebei province, Eastern China, which is located at longitude 118°45 ′ to 119°20 ′ and latitude 39°22 ′ to 39°48 ′. However, it has a warm temperate and semi-humid continental climate. The sampled animals were domesticated for many years and were species representative. All animal were in good condition and seemed overtly healthy.

Blood samples collection and analysis

After the experimental animals were fasted for 12 h, 5 ml blood samples from each individual were collected from the saphenae of raccoon dogs and foxes. For each animal, 1 ml blood sample was collected into an Ethylenediaminetetraacetic acid (EDTA) evacuated tube (Hebei Xinle Science and Techonlgy Co. Ltd., Xinhua District, Shijiazhuang, Hebei, 050000, China) for hematology analysis, and 4 ml blood samples were collected into a tube voided of an anticoagulant (Hebei Xinle Science and techonlgy Co. Ltd., Xinhua District, Shijiazhuang, Hebei 050000, China) to obtain serum for biochemistry analysis. All blood samples were stored in cool boxes (4 to 8°C) for the 20 to 30 min transport to Changli People's Hospital (No.117, the Second Street, Changli, Hebei 066600, China). Aliquots with no EDTA were centrifuged at 3,000 rpm for 10 min (TGL-16G, Centrifuge, Shanghai Anting Science Instrument Factory, Shanghai, 5353 Cao'an Road, 201805, China) and then serum was recovered.

Hematology measurements were performed on whole blood using a hematology analyzer (KX21, Sysmex Corporation, 1-5-1 Wakinohama-Kaigandori, Chuo-ku, Kobe 651-0073, Japan). Analyses included red blood cell (RBC) count, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and hemoglobin content; total white blood cell (WBC) count, including eosinophils, basophiles, neutrophils, lymphocytes, monocytes counts .

Serum chemistry measurements were carried out on serum samples using an automatic biochemical analyzer (Liasys, AMS Corporation, Via Forianini s.n.c - (Via Tibutina Km.18, 300), Guidonia, Rome, 00012, Italy). Analyses included amylase, creatine kinase (CK), lactate dehydrogenase (LDH), total protein, albumin and creatinine (Assay Kits, Biosino Bio-technology and Science Inc., Changping District, Beijing 102200, China); hydroxybutyric dehydrogenase (HDH), total bilirubin, direct bilirubin, indirect bilirubin, alanine aminotransferase (ALT), aspartate aminotransferase AST, glutamyltransferase (GGT), alkaline phosphatase, glucose, uric acid, blood urea nitrogen, inorganic phosphorus, magnesium, total cholesterol and triglyceride (TG) (Assay Kits, Beijing Shouyi Clinical Medicine Scientific Center, Fengtai District, Beijing 100069, China); Potassium, sodium, chloride and calcium in serum were determined by electrolyte analyzer (XD-685, Shanghai Xunda Medical Device Co., Ltd., Shanghai, Pudong, 201600, China).

Statistical analysis

Data are presented as means and standard errors. Statistical analyses were performed using SPSS 14.0. Comparison of mean hematology and blood biochemistry values on the basis of gender and comparison of them between raccoon dogs and foxes were performed using one-way analysis of variance. Differences were considered significant at $P < 0.05$ or $P < 0.01$.

RESULTS

Comparison of hematologic mean values across sexes for raccoon dogs or foxes

Our data analysis results showed that there was no significant difference between genders for hematological values in raccoon dogs. Compared with male foxes, the percent of eosinophils was significantly increased ($P < 0.05$) in female foxes. The other values were not significantly different between male and female foxes ($P > 0.05$) (Table 1).

Comparison of hematologic mean values between raccoon dogs and foxes

Our results showed that the leukocyte count, mean corpuscular volume (MCV) and the content of mean corpuscular hemoglobin (MCH) of raccoon dogs were significantly higher than those of the foxes ($P < 0.01$). However, the count of erythrocytes of foxes was significantly higher than that of raccoon dogs, and the counts of basophile and platelet of foxes were higher than that of raccoon dogs ($P < 0.05$) (Table 2). The other hematologic mean values were not significantly different between raccoon dogs and foxes ($P > 0.05$).

Comparison of serum biochemistry means values across sexes for raccoon dogs or foxes

Our results indicated that the contents of creatinine and triglyceride of female raccoon dogs were significantly higher than those of male raccoon dogs ($P < 0.05$); however, the glutamyltransferase activity of female raccoon dogs was significantly lower than that of males. Glucose content was significantly higher in male foxes than in females ($P < 0.01$). However, chloride in serum was significantly lower in male foxes than in females ($P <$

Table 1. Comparison of the hematologic mean values with one-way ANOVA across sexes for raccoon dogs and foxes.

Hematology trait	Raccoon dogs		Foxes	
	Female (n = 10)	Male (n = 10)	Female (n = 10)	Male (n = 10)
Leukocytes (10^9/L)	17.53 ± 3.50	16.25 ± 4.78	8.62± 2.83	13.50 ± 4.92
Erythrocytes (10^{12}/L)	7.51 ± 1.00	7.71 ± 0.97	8.94± 0.82	8.60 ± 0.68
Hemoglobin (g/L)	140.2 ± 19.7	142.8 ± 21.15	139.73 ± 14.52	140.3 ± 10.96
Hematocrit (L/L)	0.46 ± 0.07	0.47 ± 0.06	0.48± 0.05	0.47 ± 0.04
Mean corpuscular volume (fL)	61.59 ± 1.79	61.57 ± 2.37	53.18 ± 1.60	54.43 ± 1.13
Mean corpuscular hemoglobin (Pg/cell)	18.67 ± 0.63	18.49 ± 1.31	15.62 ± 0.46	16.31 ± 0.34
Mean corpuscular hemoglobin concentration (g/L)	303.2 ± 6.68	300.5 ± 17.23	293.45 ± 3.93	299.7 ± 4.11
Platelets (10^9/L)	325.33 ± 109.41	353.87 ± 118.77	348.12± 164.18	490.00 ± 238.99
Basophils (%)	0.00 ± 0.00	0.00 ± 0.00	0.17± 0.41	0.67 ± 0.82
Eosinophils (%)	2.33 ± 2.52	1.33 ± 0.58	2.50 ± 1.05^a	2.33 ± 2.42^b
Neutrophils (%)	36.33 ± 5.51	38.00 ± 11.53	37.67 ± 4.27	39.5 ± 9.09
Lymphocytes (%)	58.00 ± 8.89	59.33 ± 11.02	57.00 ± 3.95	54.17 ± 8.86
Monocytes (%)	2.33 ± 0.58	1.67 ± 0.58	2.331.63	3.33 ± 1.63

^{a,b} Means in the same line with different superscripts are significantly different (P < 0.05).

Table 2. Hematologic values in raccoon dogs and foxes.

Hematology trait	Raccoon dogs (n = 20)	Foxes (n = 20)
Leukocytes (10^9/L)	16.89 ± 4.13^A	10.94 ± 4.60^B
Erythrocytes (10^{12}/L)	7.61 ± 0.97^B	8.78 ± 0.76^A
Hemoglobin (g/L)	141.50 ± 19.9^a	140.00 ± 12.63^a
Hematocrit (L/L)	0.47 ± 0.06^a	0.47 ± 0.05^a
Mean corpuscular volume (fL)	61.58 ± 2.04^A	53.78 ± 1.50^B
Mean corpuscular hemoglobin (Pg/cell)	18.58 ± 1.00^A	15.95 ± 0.53^B
Mean corpuscular hemoglobin concentration (g/L)	301.85 ± 12.80^a	296.43 ± 5.06^a
Platelets (10^9/L)	338.76 ± 111.24^b	408.93 ± 204.43^a
Basophils (%)	0.00 ± 0.00^b	0.42 ± 0.67^a
Eosinophils (%)	1.83 ± 1.72^a	2.42 ± 1.78^a
Neutrophils (%)	37.17 ± 8.13^a	38.58 ± 6.84^a
Lymphocytes (%)	58.67 ± 8.98^a	55.58 ± 6.71^a
Monocytes (%)	2.00 ± 0.63^a	2.83 ± 1.64^a

^{A,B} Means in the same line with different superscripts (capital letters) are significantly different (P ≤ 0.01); ^{a,b}, Means in the same line with different superscripts (small letters) are significantly different (P< 0.05).

Table 3. Serum biochemistry values in raccoon dogs and foxes among genders.

Serum biochemistry trait	Raccoon dogs		Foxes	
	Female (n = 10)	Male (n = 10)	Female (n = 10)	Male (n = 10)
Amylase (U/L)	2397.38 ± 321.66	2166.64 ± 330.23	643.78± 178.79	894.80± 204.23
Creatine kinase (U/L)	490.31± 161.46	459.51± 270.28	119.90 ± 77.75	258.96± 117.81
Lactate dehydrogenase (U/L)	127.84± 102.99	120.17 ± 89.69	68.08± 48.38	84.42 ± 80.81
Hydroxybutyric dehydrogenase (U/L)	93.43± 70.82	89.96± 61.82	53.01± 31.88	64.66 ± 36.61
Totalbilirubin (μmol/L)	2.22± 0.87	3.10± 1.10	2.63 ± 1.12	3.00 ± 1.54
Direct bilirubin (μmol/L)	1.55± 0.55	1.78± 0.92	1.55 ± 0.85	2.00 ± 1.02
Indirect bilirubin (μmol/L)	0.69± 0.50	1.32± 0.55	1.10 ± 0.51	1.01 ± 0.72
Alanine aminotransferase (U/L)	76.31± 60.22	71.68± 51.77	136.35 ± 59.42	168.73 ± 95.04
Aspartate aminotransferase (U/L)	121.02 ± 86.00	92.99± 45.78	55.97± 15.11	62.72 ± 14.54
ALT/AST	0.63± 0.30	0.74± 0.24	2.54 ± 1.18	2.77 ± 1.38
Glutamyltransferase (U/L)	10.58 ± 3.15^{b}	12.93 ± 6.56^{a}	4.70 ± 1.19	5.15 ± 1.63
Alkaline phosphatase (U/L)	33.99±12.19	27.97 ± 6.04	63.58± 31.23	131.37 ± 58.05
Total protein (g/L)	90.38 ± 5.44	94.35± 11.01	75.23 ± 6.30	71.58 ± 6.97
Albumin (g/L)	32.16 ± 2.89	34.74 ± 3.82	34.01 ± 2.58	34.35 ± 2.69
Globulin (g/L))	58.21 ± 6.49	59.62± 14.11	41.22 ± 4.85	37.21 ± 7.93
A/G	0.56± 0.10	0.63± 0.21	0.84 ± 0.12	0.96 ± 0.20
Glucose (mmol/L)	3.58± 0.53	3.09± 0.35	6.84 ± 1.41^{B}	8.32 ± 0.53^{A}
Uric acid (mmol/L)	60.41± 39.37	58.10± 44.51	24.28± 17.13	40.35 ± 20.27
Blood urea nitrogen (mmol/L)	3.15± 1.24	3.85± 0.88	5.61 ± 2.38	6.67 ± 2.27
Creatinine (μmol/L)	65.55 ± 12.04^{a}	61.30 ± 6.04^{b}	66.53± 41.89	94.70 ± 28.96
Inorganic phosphorus (mmol/L)	1.35± 0.13	1.46± 0.19	1.33 ± 0.60	2.30 ± 0.50
Magnesium (mmol/L)	1.07± 0.13	1.10± 0.12	1.15 ± 0.15	1.31 ± 0.14
Total cholesterol (mmol/L)	3.49± 0.68	3.65± 0.60	4.03 ± 0.89	4.29 ± 0.79
Triglyceride (mmol/L)	1.21 ± 0.32^{a}	1.15 ± 0.10^{b}	0.89 ± 0.19	0.92 ± 0.25
Potassium (mmol/L)	5.43± 0.36	5.38± 0.33	4.95 ± 0.33	4.78 ± 0.63
Sodium (mmol/L)	152.53 ± 4.02	155.84 ± 4.09	151.99 ± 2.54	147.07 ± 4.72
Chloride (mmol/L)	105.52 ± 3.78	106.71 ± 3.35	109.51 ± 1.8^{a}	106.68 ± 6.16^{b}
Calcium (mmol/L)	1.29± 0.03	1.29± 0.03	1.26 ± 0.04	1.26 ± 0.06

^{A,B} Means in the same line with different superscripts (capital letters) are significantly different (P≤0.01); ^{a,b} Means in the same line with different superscripts (small letters) are significantly different (P < 0.05).

0.05); whereas, in the other mean values, there were no significant differences between genders of raccoon dogs or foxes (Table 3).

Comparison of serum biochemistry means values between raccoon dogs and foxes

The results indicated that the activities of amylase, creatine kinase, AST, GGT, and the contents of total protein, globulin, uric acid, triglyceride, potassium, and sodium were significantly higher in raccoon dogs than those in foxes (P < 0.01, P < 0.05). While, the activities of ALT, alkaline phosphatase, and the contents of glucose, blood urea nitrogen, creatinine, magnesium and total cholesterol were significantly higher in foxes than that in raccoon dog (P < 0.01, P < 0.05) (Table 4).

DISCUSSION

There is no information on the normal blood parameters of domestic raccoon dogs and foxes living in Hebei province. The hematological reference values are the mainly indicators not only for health prevalence, but also for diagnosis and detection of disease.

It was reported that the blood biochemical parameters varied with the seasons. Nine serum biochemical indicators including alkaline phosphatase, blood urea nitrogen, creatinine, cholesterol, glucose of island foxes

Table 4. Serum biochemistry values in raccoon dogs and foxes.

Serum biochemistry trait	Raccoon dog (n = 20)	Foxes (n = 20)
Amylase (U/L)	2287.50 ± 338.75^{A}	763.31± 226.40^{B}
Creatine kinase (U/L)	474.91 ± 217.26^{A}	186.12± 119.72^{B}
Lactate dehydrogenase (U/L)	124.39 ± 94.79^{a}	75.86± 64.65^{a}
Hydroxybutyric dehydrogenase (U/L)	91.87 ± 65.21^{a}	58.56± 33.86^{a}
Total bilirubin (μmol/L)	2.64 ± 1.06^{a}	2.82± 1.32^{a}
Direct bilirubin (μmol/L)	1.66 ± 0.73^{a}	1.76± 0.94^{a}
Indirect bilirubin (μmol/L)	0.99 ± 0.61^{a}	1.06± 0.61^{a}
Alanine aminotransferase (U/L)	74.10± 55.00^{B}	151.77 ± 78.13^{A}
Aspartate aminotransferase (U/L)	107.67 ± 69.62^{A}	59.19± 14.87^{B}
Glutamyltransferase (U/L)	11.70 ± 5.08^{A}	4.91± 1.40^{B}
Alkaline phosphatase (U/L)	31.12 ± 10.01^{B}	95.86± 56.64^{A}
Total protein (g/L)	92.27 ± 8.57^{A}	73.49±6.73^{B}
Albumin (g/L)	33.39 ± 3.53^{a}	34.17 ± 2.58^{a}
Globulin (g/L)	58.88 ± 10.54^{A}	39.31 ± 6.65^{B}
Glucose (mmol/L)	3.35 ± 0.51^{B}	7.55± 1.30^{A}
Uric acid (μmol/L)	59.37 ± 40.64^{a}	31.93± 19.98^{a}
Blood urea nitrogen (mmol/L)	3.49 ± 1.12^{B}	6.11± 2.33^{A}
Creatinine (μmol/L)	63.52 ± 9.68^{b}	79.94± 38.24^{a}
Inorganic phosphorus (mmol/L)	1.40 ± 0.17^{a}	1.79± 0.73^{a}
Magnesium (mmol/L)	1.09 ± 0.12^{B}	1.23± 0.16^{A}
Total cholesterol (mmol/L)	3.57 ± 0.63^{b}	4.15± 0.84^{a}
Triglyceride (mmol/L)	1.18 ± 0.24^{A}	0.91± 0.22^{B}
Potassium (mmol/L)	5.41 ± 0.34^{A}	4.87± 0.49^{B}
Sodium (mmol/L)	154.03 ± 4.30^{A}	149.65 ± 4.43^{B}
Chloride (mmol/L)	106.06 ± 3.56^{a}	108.16 ± 4.58^{a}
Calcium (mmol/L)	1.29 ± 0.03^{a}	1.26± 0.05^{a}

^{A,B} Means in the same line with different superscripts (capital letters) are significantly different ($P \leq 0.01$); ^{a,b} Means in the same line with different superscripts (small letters) are significantly different ($P < 0.05$).

were significantly higher in the wet season than those in the dry season, which were consistent with California, San Joaquin kit foxes (Crooks et al., 2000; McCue et al., 1992). Some blood parameters of animals showed considerable variations at different physiological stages. Generally, alkaline phosphatsase (ALP), serum calcium and serum phosphorus are higher in young animals than in adult animals, which are possibly due to the fast bone formation speed and different osteoblasts of young animals (Seal et al., 1975; Smith et al., 1980).

In this experiment, all raccoon dogs and foxes were 7 months old and the blood samples were collected in winter. Our determination results showed that there was no significant difference in RBC count and hemoglobin content between genders of raccoon dog or fox ($P > 0.05$). Those are similar that McCue and O'Farrell (1987) reported that found no difference between male and female San Joaquin kit foxes. However, the date collected during this study show several differences between raccoon dogs and foxes. The lower MCV and MCH indicated a smaller RBC for foxes compared to the raccoon dogs, although the concentration of hemoglobin in the cells was similar. In addition, the proportions of basophils, eosinophils and lymphocytes were different between genders in raccoon dogs or foxes. The eosinophils count was significantly higher in female foxes than in males ($P < 0.05$), which was similar to island foxes (Crooks et al., 2000). The platelets counts in foxes were lower which indicated that their blood coagulation ability was higher than raccoon dogs.

Twenty eight serum biochemistry values were determined. In raccoon dogs, except for glutamyltransferase, creatinine and TG, the other biochemical parameters showed no significant difference between sexes. In foxes, except for the contents of glucose and chloride, the others also showed no significant

difference between males and females. However, there were notably different between raccoon dogs and foxes. Although raccoon dogs and foxes all belong to canine family, the physiological and biochemical indexes are different. The variations in the biological characteristics and the physiological and biochemical indexes of different animal kinds may explain part of these differences found in this study. Under different breeding and management conditions, the blood parameters are also different. The contents of glucose, creatinine, cholesterol and TG of rancoon dogs were lower than those reported by Juha et al. (2004). This could be caused by the remarkable difference in ecology environment or diet.

The significant difference was found through the statistical analysis of blood biochemical values of the raccoon dogs and foxes. Our results showed that some parameters were related to diagnosis disease. For example, the serum amylase activity was significantly higher in raccoon dogs than that in foxes. Amylase is secreted by the pancreas with the pancreatic juice into the duodenum. The serum amylase level was increased when the acute or chronic pancreatitis was attacking. This may explain why raccoon dogs tends to be more heavily pancreatitis in clinical cases.

Herein, we report for the first time the hematological and serum biochemistry data for domestic populations of raccoon dogs and foxes. Knowledge of these “normal” values should prove to be of significance in the evaluation of future disease problems that may arise in this species.

ACKNOWLEDGEMENTS

Authors wish to thank Dr. Fang Hai for the use of the facilities of the Key Laboratory of Preventive Veterinary Medicine of Hebei Province. They sincerely thank Dr. Sun Sufen, Changli People’s Hospital, for her kind and technical cooperation. The authors are grateful to Dr. Liu Zhengzhu for computer analysis. Also, they would like to thank Mrs. Li Zongfeng (Changli Fur Farms), without whose cooperation this study would not have been conducted. However, this study was financially supported by a grant from Hebei Provincial Bureau of Animal Husbandry and Veterinary (No. 2011-1-19).

REFERENCES

Crooks KR, Scott CA, Bowen L, Van Vuren D (2000). Hematology and Serum Chemistry of the Island Fox on Santa Cruz Island. J. Wildl. Dis., 36(2): 397-404.

Delgiudice GD, Mech LD, Seal US (1991). Gray wolf density and its association with weights and hematology of pups from 1970 to 1988. J. Wildl. Dis., 27(4): 630-636.

Gates NL, Goering EK (1976). Hematologic values of conditioned, captive wild coyotes. J. Wildl. Dis., 12(3): 402-404.

Kennedy AH (1935). A graphical study of the blood of normal foxes. Can. J. Res., 12(6): 796-802.

Mainka SA (1988). Hematology and serum biochemistry of captive swift foxes (*Vulpes velox*). J. Wildl. Dis., 24(1): 71-74.

McCue PM, O’Farrell TP (1987). Hematologic values of the endangered San Joaquin kit fox (*Vulpes macrotis* mutica). J. Wildl. Dis., 23(1): 144-151.

McCue PM, O’Farrell TP (1992). Serum chemistry of the endangered San Joaquin kit fox (*Vulpes macrotis* mutica). J. Wildl. Dis. , 28(3): 414-418.

Seal US, Mech LD, Van Ballenberghe V(1975). Blood analyses of wolf pups and their ecological and metabolic interpretation. J. Mammal., 56(1): 64-75.

Smith GJ, Rongstad OJ (1980). Serologic and hematologic values of wild coyotes in Wisconsin. J. Wildl. Dis., 16(4): 491- 497.

Spitzer EH, Coombes AI, Wisnicky W (1941). Preliminary studies on the blood chemistry of the fox. Am. J. Vet. Res., 2:193-195.