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SEROLOGIC AND HEMATOLOGIC VALUES OF WILD COYOTES IN WISCONSIN

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Abstract: Blood samples were obtained from 30 coyotes *(Canis latrans)* captured in northern Wisconsin in conjunction with radio-telemetry studies. Samples were assayed for seven hematologic values, seven serum chemistries, serum albumin, globulin and total protein. Results are given with respect to sex and age and are compared with available data for captive wild and pen-raised coyotes. Leukocyte counts were greater for males than females and packed cell volumes were greater for adults than young, possibly due to differential response to capture and handling stress. Hemoglobin concentrations and calcium levels suggest differences in nutrition between pen-raised and wild coyotes. Sex and age differences in serum calcium for wild coyotes probably reflect nutritional differences between groups examined. Juvenile coyote serum alkaline phosphatase levels declined curvilinearly with age for coyotes less than one year old, suggesting a possible technique for separating juveniles and yearlings captured in autumn that are released for research purposes. Elevated glucose levels and leukocyte counts in wild coyotes may reflect greater handling stress than for pen-raised and captive coyotes. No significant sex or age effects were found for levels of serum urea nitrogen, total protein, cholesterol, and total bilirubin.

INTRODUCTION

This paper describes serologic and hematologic values of wild, free-ranging coyotes *(Canis latrans)* in northern Wisconsin. These values are examined for normal physiologic variation in terms of age and sex, and are compared with data for wild captive and pen-raised coyotes under controlled conditions.

The coyote has been subject to an increasing amount of research, largely stimulated by the need for predator control. Coyotes are important not only in terms of livestock depredations but also as fur-bearers, game animals and for esthetics.[5] An increase in coyote field research has created a demand for baseline physiological data.[7] Seal *et al.*[10] described the potential for integrating field and laboratory studies to provide a more complete understanding of animal populations.

Hematology and serum chemistry analyses have been described for captive wild coyotes[2,4] and for pen-raised coyotes.[7] These studies have provided comparative data for evaluating blood values of wild, free-ranging coyotes. Blood values for animals in captivity reflect constant and adequate levels of nutrition.

Blood values may be influenced by nutrition, sex, age, habitat, season, reproductive status, trauma and other factors due to environmental stress.[1,7,10] Several studies have evaluated blood parameters of wild ungulates with respect to age, sex, habitat, nutrition, season, immobilization, and capture stress.[6,9,11,12] There are few data available on the effects of these factors on wild canid blood values. Comparative baseline studies are essential for determining the effects of these factors on blood analysis for wild populations.[12] Blood studies of wild, free-ranging mammals may not only serve as indicators to habitat condition, but may provide useful techniques for assessment of environmental impacts on animal and habitat quality.

METHODS

Blood samples were obtained from undrugged coyotes, captured using No. 3 leg-hold traps, during all seasons of the year. Blood was removed from the lateral saphenous vein on a hind leg. Blood for hematological studies was placed in a 2 cc vacutainer tube containing a premeasured amount of ethylenediaminetetraacetic acid disodium salt (EDTA). Air-dried blood smears were prepared in the field, and whole blood was refrigerated until mailed to the laboratory. Blood for serological studies was placed in a 10 cc vacutainer tube, centrifuged, the serum removed and immediately frozen until sent to the laboratory.

Whole blood and serum analysis were done by the Central Animal Health Laboratories, Madison, Wisconsin. Hemoglobin (Hb) concentrations were determined by spectrophotometric methods. Packed cell volumes (PCV) were determined by the microhematocrit method, and white blood cell (WBC) counts were made with a hemocytometer. Differential WBC counts were made from Wright-stained blood smears using standard counting procedures. Mean corpuscular hemoglobin concentration (MCHC) was determined by calculation.[8] Serum chemistries were analyzed using a Technicon auto-analyzer (SMA 12/60).

Coyotes were aged on the basis of tooth eruption or tooth wear as described by Gier.[3] Animals greater than one year old are treated here as adults. Juveniles were assigned a standardized age (in weeks) using a 1 May parturition date. This approximate whelping date for our study area, was estimated by monitoring denning activities of radio-tagged adult females.

Sex and age effects on blood parameters were statistically analyzed using analysis of variance.[14] Comparisons of pooled adult male and female blood values with similar samples from other studies were made using the Student's "t" test for unpaired variates.[14]

RESULTS

Blood samples were obtained from 30 coyotes captured in northern Wisconsin from February 1978 to November 1979. Of the 30 coyotes sampled, 16 were captured in autumn, eight in winter, five in summer, and one in spring. One sample obtained during the summer period was analyzed for serum chemistries but not for hematological parameters.

The results of hematological assays with respect to age and sex are compared with data for 18-month-old pen-raised coyotes[7] (Table 1). Serum chemistry (Table 2) and protein analysis (Table 3) are also compared with data for pen-raised coyotes.[7] Serum alkaline phosphatase levels for juvenile coyotes decreased curvilinearly with age until about January (Fig. 1).

A summary of significant differences between sex and age groups for hematologic values, serum chemistries, and serum protein values is given in Table 4. All comparisons within our wild, free-ranging coyote sample were made using analysis of variance.

DISCUSSION

Blood samples were obtained from manually restrained, undrugged coyotes. Interpretations of these blood data must take these methods into account. Several studies have related capture and handling effects to elevated blood values.[2,11,12] Baseline data for captive coyotes reported by Gates and Goering,[2] Goering *et al.*,[4] and Rich and Gates[7] were also collected from restrained, undrugged coyotes. Coyotes we sampled were subject to capture and handling related bias, while captive coyote blood values likely reflect only handling bias.

TABLE 1. Hematologic values of coyotes captured in northern Wisconsin, 1978-79. Captive coyote data from Rich and Gates (1979). Mean values ± 1 standard deviation.

		Hematologic value[1]				Leukocyte differential[2]			
Cohort	Sample Size	Hb g/dl	PCV %	MCHC g/dl	Total WBC $\times 10^3$/ul	N %	L %	M %	E %
Adult ♂	6	14.2 ± 2.5	47.7 ± 8.7	29.8	20.3 ± 8.5	80	12	4	4
Adult ♀	4	15.0 ± 0.8	49.0 ± 0.8	30.6	15.5 ± 5.8	89	5	5	—
Juvenile♂	12	12.8 ± 1.5	41.2 ± 4.0	31.1	24.0 ± 8.0	84	4	4	7
Juvenile ♀	7	13.2 ± 3.2	41.7 ± 9.2	31.6	17.5 ± 6.2	84	12	3	3
Captive ♂ + ♀[3]	48	17.1 ± 1.2	50.5 ± 3.4	33.9	9.0 ± 1.9	62	26	5	6

[1]Hb, hemoglobin; PCV, packed cell volume; WBC, white blood cells; MCHC, mean corpuscular hemoglobin concentration.
[2]N, neutrophils; L, lymphocytes; M, monocytes; E, eosinophils. Mean values only.
[3]Data from Rich and Gates (1979) represents blood obtained from 18-month-old pen-raised coyotes. Coyotes were undrugged and restrained by hand.

TABLE 2. Serum chemistries of coyotes in northern Wisconsin, 1978-79. Captive coyote data from Rich and Gates (1979). Mean value ± 1 standard deviation.

Cohort	Sample Size	Calcium mg/dl	Inorganic phosphorus mg/dl	Cholesterol mg/dl	Glucose mg/dl	BUN mg/dl	Bilirubin mg/dl
Adult♂	6	8.6 ± 0.6	3.4 ± 0.5	153 ± 35	161 ± 44	28.2 ± 13.2	0.1 ± 0.1
Adult♀	5	8.8 ± 0.7	3.5 ± 0.7	157 ± 40	181 ± 47	21.2 ± 8.3	0.2 ± 0.1
Juvenile ♂	12	9.6 ± 0.5	6.3 ± 0.1	196 ± 54	159 ± 34	17.2 ± 9.1	0.1 ± 0.1
Juvenile ♀	7	8.9 ± 0.4	5.1 ± 1.0	178 ± 53	158 ± 44	19.4 ± 9.2	0.1 ± 0.1
Captive ♂ + ♀[1]	48	9.8 ± 1.4	3.8 ± 1.0	—	125 ± 28	26.6 ± 7.1	0.2 ± 0.1

[1]Data from Rich and Gates (1979) represents blood obtained from 18-month-old pen-raised coyotes. Coyotes were undrugged and restrained by hand.

TABLE 3. Serum protein levels of coyotes in northern Wisconsin, 1978-1979. Captive coyote data from Rich and Gates (1979). Mean values ± 1 standard deviation.

Cohort	Sample Size	Total Protein gm/dl	Albumin[2] gm/dl	Globulin gm/dl	Albumin/ Globulin ratio
Adult ♂	6	6.4 ± 0.5	2.9 ± 0.2	3.5 ± 0.4	0.9 ± 0.1
Adult ♀	5	6.4 ± 0.6	3.1 ± 0.4	3.3 ± 0.5	1.0 ± 0.2
Juvenile ♂	12	6.4 ± 0.4	3.1 ± 0.2	3.3 ± 0.4	0.9 ± 0.1
Juvenile ♀	7	6.0 ± 0.3	2.7 ± 0.4	3.2 ± 0.4	0.9 ± 0.2
Captive ♂ + ♀[1]	48	6.5 ± 0.3	2.7 ± 0.3	3.7 ± 0.3	0.7 ± 0.1

[1]Data from Rich and Gates (1979) represents blood obtained from 18-month-old pen-raised coyotes. Coyotes were undrugged and restrained by hand.
[2]Technicon SMA 12/60 using BCG dye-binding method.

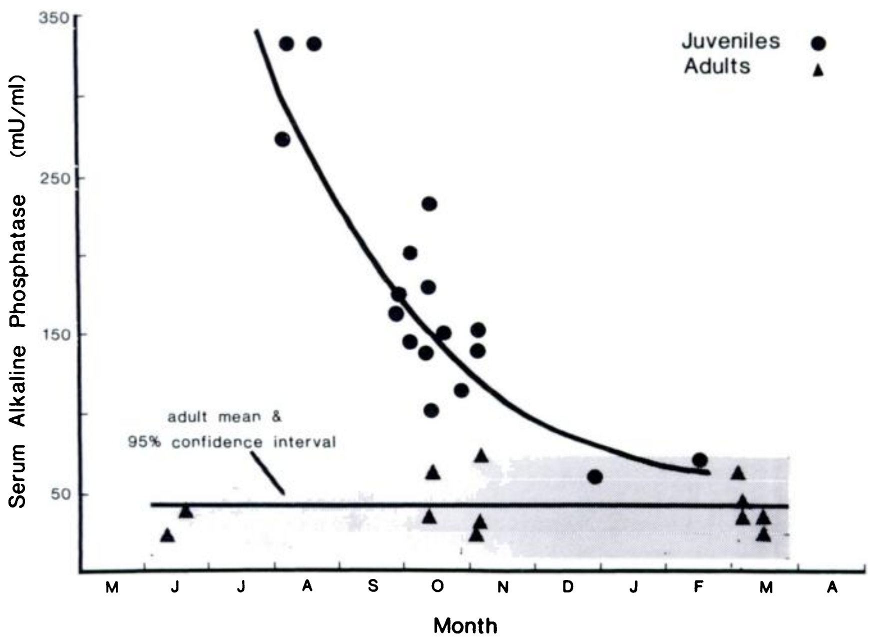

FIGURE 1. The relationship between serum alkaline phosphatase levels and juvenile coyote age. Coyote ages (in weeks) are standardized to a 1 May parturition date. The mean adult alkaline phosphatase value and 95% confidence interval is given in the shaded region.

Total WBC counts were higher in males than females in our sample ($P < 0.05$). Pen-raised coyotes[7] and captive wild coyotes[2] had significantly lower total WBC counts compared with our adult sample ($P < 0.001$). Male coyotes we sampled generally were more active and aggressive in the trap and during handling than females, resulting in higher stress and increased muscle activity

TABLE 4. Summary of significant age and sex difference in blood values of coyotes in northern Wisconsin, 1978-79.

Assay	Factor	Relative magnitude of blood values in group	Significance probability
Packed cell volume	Age	Adults > Juveniles	$P<0.05$
White blood cells	Sex	Males > Females	$P<0.05$
Albumin	Sex × Age	interaction	$P<0.05$
Calcium	Sex × Age	interaction	$P<0.05$
Calcium	Age	Juveniles > Adults	$P<0.05$
Inorganic phosphorus	Age	Juveniles > Adults	$P<0.001$
Alkaline phosphatase	Age	Juveniles > Adults	$P<0.001$

reflected in higher WBC counts. These elevated WBC counts probably represent 'stressed' neutrophilia due to capture stress and resulting splenic contraction.[8] Wild coyotes we sampled were likely to be more active and stressed than conditioned captive coyotes, again resulting in the observed elevated WBC counts in our sample.

Higher packed cell volumes in adults compared with juveniles ($P < 0.05$) may reflect nutritional differences between these age cohorts. However, capture stress may also have contributed to this difference. Seal *et al.*[9] suggested that elevated hematological values may result from handling stress in white-tailed deer *(Odocoileus virginianus)*.

No significant sex or age effects were found in hemoglobin concentrations in coyotes we sampled. Mean hemoglobin values for pen-raised coyotes were significantly higher than for wild coyotes ($P < 0.001$). Lower hemoglobin concentrations in wild coyotes likely reflect a lower nutritional plane for these animals. Seal and Hoskinson[11] reported that hematology values may reflect long term nutritional status in ungulates. Gates and Goering reported hemoglobin values for wild captive coyotes that were conditioned a minimum of 3 months prior to sampling. Hemoglobin values and packed cell volumes reported for these captive wild coyotes did not differ significantly from values we observed. Again, long term nutrition influencing these values may explain this lack of difference.

Juvenile coyotes had higher serum calcium levels than adults ($P < 0.05$). However, a significant sex × age interaction for calcium levels was determined by analysis of variance ($P < 0.05$). Calcium values were higher for pen-raised coyotes than for adult wild coyotes we sampled ($P < 0.05$). Seal *et al.*[10] reported lower calcium values for wild wolf *(Canis lupus)* pups than dogs *(Canis familiaris)*, and attributed this difference to nutrition. The major factor for lower calcium levels in wild coyotes compared with pen-raised animals may also be nutritional.

Juvenile coyotes had significantly higher inorganic phosphorus levels than adults ($P < 0.001$). Phosphorus absorption correlates positively with calcium concentrations and is important in bone metabolism.[13]

No significant sex or age differences were found in serum glucose levels among coyotes we sampled from northern Wisconsin. However, adult coyotes we sampled did have significantly higher serum glucose levels than pen-raised coyotes[7] ($P < 0.001$). Elevated glucose levels likely reflected transitory hyperglycemia caused by increased adrenal activity in response to capture stress.[1] Seal *et al.*[10] noted that high serum glucose levels in wolves, captured and sampled by methods similar to ours, may be attributable to capture stress. Capture effects have also been related to high glucose levels in pronghorn antelope *(Antilocapra americana)*.[11]

No significant age or sex effects were found for serum cholesterol, serum urea nitrogen (BUN), and total bilirubin.

There were no significant differences between age or sex cohorts examined for total serum protein or globulin values. Georing *et al.*[4] reported that captive wild coyotes had lower total protein and albumin values than dogs, and males had higher total protein levels than females. Globulin levels were higher in pen-raised coyotes[7] than in wild coyotes we sampled ($P < 0.01$). A significant sex × age interaction was determined for albumin values by analysis of variance ($P < 0.05$). The pattern of albumin values for each age class differed in males and females. Elevated albumin levels may occur with shock or dehydration, while low protein intake may result in depressed albumin values.[1] Adult wild coyotes we sampled had higher serum albumin levels than pen-raised coyotes[7] ($P < 0.01$). Pen-raised coyotes were maintained on commercial dog food[7] and, therefore, lower albumin values likely reflect a lower protein intake compared with wild coyotes.

Juvenile coyotes had significantly higher serum alkaline phosphatase levels than adults ($P < 0.001$). These levels decreased curvilinearly with time up to about 8 months of age (Figure 1). The equation for the curve fitted to juvenile alkaline phosphatase levels, given in Figure 1, is $Y = 634 - 28.8x + .37x^2$, where x is juvenile coyote age (weeks), and Y is serum alkaline phosphatase (mU/ml). Fitting this curve to decreasing juvenile alkaline phosphatase levels reduced the residual variance about the line from $s^2=2486$ using a linear model to $s^2=1143$.

The mean adult alkaline phosphatase level for coyotes we sampled was 40.8 mU/ml with a standard deviation of 18.0 mU/ml. The juvenile alkaline phosphatase curve does not intersect the adult 95% confidence interval until about January, assuming a 1 May parturition date. Therefore, serum alkaline phosphatase levels for coyotes captured in autumn are useful for separating juveniles and yearlings when animals are to be released for research. Some juvenile coyotes are adult weight by October and tooth wear may not always be used as a practical aging tool. Alkaline phosphatase levels are not affected by capture stress,[11] and are directly related to the rate of bone formation and osteoblast differentiation.[13] Coyotes attain adult size and weight within their first year,[3] by which time major bone formation should be complete.

Although some blood parameters such as leukocyte counts and glucose levels may reflect capture stress and may differ between sex and age cohorts, other blood values such as hemoglobin may provide a useful measure of long term nutrition. The relationship between serum alkaline phosphatase levels and juvenile coyote age may be integrated with measurements of coyote weight, tooth wear, and body size to reduce ambiguity in field techniques for separating juvenile and yearling coyotes, prior to January.

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