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SEROLOGIC AND HEMATOLOGIC VALUES OF BISON IN COLORADO[1]

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Abstract: Recent economic and aesthetic interest in North American bison *(Bison bison)* has lead to increased interstate transport of these animals. Serologic and hematologic standards for bison are needed to detect disease in transported animals as well as within herds. This paper describes variation in blood physiological parameters in bison caused by variations in diet and season. Blood was taken from six bison and analyzed for serologic and hematologic parameters. Significant variation was found in blood urea nitrogen, chloride, cholesterol, creatinine, eosinophil, glucose, hemoglobin, lactic dehydrogenase, leukocyte, packed cell volume, potassium, serum globulin, serum glutamic oxalacetic transaminase, SGPT, and sodium levels between animals receiving a high energy-high nitrogen diet and animals receiving a low energy-low nitrogen diet.

INTRODUCTION

Bison are becoming increasingly popular for aesthetic and economic reasons creating a need for baseline information. Transport of bison also has become more frequent. Therefore, the need for standards to evaluate hematologic and serologic samples from these animals has arisen. Data presented here contribute to determining the range of normal variation in bison blood values.

MATERIALS AND METHODS

Values presented were taken from six bison maintained at the Pawnee Site, field research facility of the Natural Resource Ecology Laboratory, Colorado State University, located on the United States Department of Agriculture, Science and Education Administration - Federal Research, Central Plains Experimental Range in northeastern Colorado. The location, vegetation, physiography, and climate have been described by Jameson.[7] The animals had been used for diet selection and digestibility studies from 1969 to 1972.[12] During blood sampling, the animals were being used to investigate nitrogen metabolism, especially urea recycling.[8]

Samples were taken on 1 December 1975, 1 March 1976, 9 June 1976, and 21 October 1976. From 11 November 1975 to 1 May 1976, the animals were divided into two groups, one of which received a high energy-high nitrogen diet consisting of crested wheatgrass hay (6% crude protein, 4030 cal/g gross energy) and a supplement (Pawnee mix: 15% crude protein, 4160 cal/g gross energy). The other group received a low energy-low nitrogen diet consisting solely of the crested wheatgrass hay. Both groups were fed *ad libitum*. After 1 May 1976 all animals received approximately 11 kg of supplement per day, and grazed freely on a 16.2-ha native pasture (11% crude pro-

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tein). On 1 October 1976 the bison began receiving a different crested wheatgrass hay in addition to the pasture forage and Pawnee mix which was probably similar to the hay fed previously.

At the start of feeding trials, six animals obtained from the Wichita Mountains Wildlife Refuge, Oklahoma were available for blood sampling. Four of these had rumen fistulas and two had esophageal fistulas (Table 1). However, in September, 1976 an animal (#10) died of unknown causes. Samples were taken from the remaining five animals on 21 October. Necropsy of Animal 10 did not reveal any single major cause of death, although encapsulated kidneys were implicated.

Blood was taken from the left external jugular vein and placed in two Vacutainers,[2] one containing a premeasured amount of EDTA anticoagulant. The blood was kept chilled during transport to the Clinical Pathology Laboratory, Veterinary Hospital, Colorado State University, for analysis. Time from collection of blood until delivery to the lab varied from 2 to 6 h, depending on the order of animal sampled. A Hycel Mark 17[3] was used to determine serological values, and a Coulter Counter Model FN[4] was used for total leukocyte and erythrocyte counts. Packed cell volume was determined by micro-hematocrit and differential counts were made from Wright-stained blood smears examined under oil immersion using standard counting techniques. Student's-T tests[4] were used to detect significant differences between the groups for selected parameters. Significant differences are discernible in Table 2. Values followed by the same letter indicate significant differences in the same row, or between diet groups for the first two sample dates.

RESULTS

Results of analyses are presented in Table 2. Because the two groups of bison were receiving different diets during the first two sampling dates, averages (±1 SD) for each diet group (3 animals per group) are presented for the 1 December and 1 March sample dates. Data collected after completion of the diet trials, when all animals were receiving the same ration, are presented as mean values for all animals for the 9 June (6

TABLE 1. Diet groups of bison.

Group	Sex*	Fistula Type†	Fistula Date
Group A — High Diet			
Bison 15	F	E	1971
Bison 10	M	R	16 Sept. 1975
Bison 12	F	R	12 Dec. 1975
Group B — Low Diet			
Bison 1	M	E	1971
Bison 8	F	R	1971
Bison 13	F	R	12 Dec. 1975

*F = female; M = male.
†E = esophageal; R = ruminal.

[2] Becton, Dickinson and Company, Rutherford, New Jersey.

[3] Hycel, Incorporated, Houston, Texas.

[4] Coulter Diagnostics, 740 W. 83rd Ave., Hialeah, Florida 33014, USA.

TABLE 2. Serologic and hematologic values for bison in Colorado (mean ± SD). Values in the same row followed by the same lower case letter are significantly different: a,b,c,d = $P < 0.05$; w,x,y,z = $P < 0.01$.

Parameter (Units)	Diet Group*	1 Dec. 1975	1 March 1976	9 June 1976‡	21 Oct. 1976§
Packed cell volume/(%)	High	43.0 ± 4.0	41.7 ± 2.5z	26.8 ± 3.1	51.4 ± 4.2
	Low	48.0 ± 0.0†	50.7 ± 1.5z		
Hemoglobin (g/dl)	High	15.8 ± 1.1a	15.2 ± 0.6z	16.7 ± 1.4	18.6 ± 1.3a
	Low	17.8 ± 0.0†	18.5 ± 0.5z		
Fibrinogen (mg/dl)	High	533.3 ± 152.7	233.3 ± 152.8	366.7 ± 103.3	340.0 ± 54.8
	Low	350.0 ± 70.7	266.6 ± 115.5		
Leukocytes (no.)	High	8566.7 ± 251.7azy	8466.7 ± 1850.2	6433.3 ± 898.1yce	6200.0 ± 640.3ebdz
	Low	7600.0 ± 141.4ab†	8666.7 ± 1457.2cd		
Neutrophils (no.)	High	44.0 ± 8.9	43.0 ± 9.0	50.2 ± 12.8	48.2 ± 4.6a
	Low	39.0 ± 1.4a†	40.7 ± 6.0		
Lymphocytes (no.)	High	50.0 ± 7.8	53.3 ± 8.1	37.8 ± 11.3	40.8 ± 4.9
	Low	45.5 ± 3.5†	50.3 ± 5.1		
Monocytes (no.)	High	2.7 ± 0.6	2.0 ± 1.7	4.5 ± 2.6	2.6 ± 0.9
	Low	3.5 ± 0.7†	1.7 ± 0.6		
Eosinophils (no.)	High	3.7 ± 2.1a	2.0 ± 1.7bc	8.6 ± 3.0c	8.0 ± 4.2
	Low	11.5 ± 2.1a†	6.7 ± 2.1b		
Basophils (no.)	High	0.0	0.0	0.3 ± 0.5	0.2 ± 0.4
	Low	0.5 ± 0.7†	0.7 ± 0.6		
Glucose (mg/dl)	High	112.7 ± 25.7ab	83.7 ± 1.5	77.5 ± 9.7a	80.6 ± 8.3b
	Low	82.0 ± 1.4†	91.0 ± 9.9		
Blood urea nitrogen (mg/dl)	High	13.5 ± 1.0	18.3 ± 5.1	16.3 ± 4.1	15.7 ± 2.2a
	Low	11.9 ± 1.2†	10.8 ± 1.4a		
Globulin (g/dl)	High	5.9 ± 0.6ab	6.1 ± 1.3	4.9 ± 0.2bz	4.7 ± 0.6
	Low	4.2 ± 0.1az†	5.6 ± 0.8		

TABLE 2. continued

Parameter (Units)	Diet Group*	1 Dec. 1975	1 March 1976	9 June 1976‡	21 Oct. 1976§
Total protein (g/dl)	High	8.1 ± 0.6	9.2 ± 1.9	8.0 ± 0.6	8.1 ± 0.5
	Low	7.3 ± 0.2	8.4 ± 0.9		
Chloride (meq/l)	High	101.7 ± 4.7ay	100.0 ± 2.6z	113.3 ± 5.9zab	116.0 ± 4.3wxcy
	Low	98.3 ± 8.1bx	106.3 ± 4.0cw		
Cholesterol (mg/dl)	High	122.7 ± 19.0ayw	83.3 ± 14.4b	76.0 ± 8.2zy	82.6 ± 7.3wx
	Low	74.7 ± 15.5a	50.0 ± 0.0bzx		
Potassium (meq/l)	High	5.6 ± 1.1	4.7 ± 0.7	4.2 ± 0.6	4.3 ± 0.5
	Low	4.6 ± 0.8	4.4 ± 0.9		
Sodium (meq/l)	High	140.2 ± 1.5y	139.6 ± 0.8za	145.0 ± 1.8zyx	142.0 ± 1.1a
	Low	140.9 ± 1.0x	142.5 ± 3.0		
Bilirubin (mg/dl)	High	1.8 ± 0.9	0.7 ± 0.4	0.7 ± 0.2	0.8 ± 0.1
	Low	3.2 ± 4.7	0.6 ± 0.1		
Alkaline phosphate (U/l)	High	9.9 ± 2.8	13.3 ± 1.2	21.0 ± 8.6	13.4 ± 1.6
	Low	11.9 ± 3.0	13.4 ± 1.5		
SGOT (U/l)	High	93.0 ± 17.1	110.3 ± 22.0a	57.0 ± 24.8abz	102.5 ± 11.3z
	Low	120.7 ± 63.4	109.0 ± 20.5b		
SGPT (U/l)	High	45.7 ± 25.0	62.3 ± 27.3	57.8 ± 20.0	41.4 ± 2.2
	Low	34.0 ± 2.0z	51.7 ± 10.1		
CPK (U/l)	High	15.2 ± 4.9	26.4 ± 11.8	62.7 ± 52.8	42.4 ± 31.9
	Low	26.7 ± 22.2	19.7 ± 14.2		
Phosphorus (mg/dl)	High	6.3 ± 1.3	6.3 ± 2.4	5.8 ± 1.0	6.0 ± 1.9
	Low	4.8 ± 1.2	4.2 ± 1.3		
LDH (U/l)	High	291.7 ± 28.4z	300.0 ± 75.7	545.8 ± 149.5	522.6 ± 216.5
	Low	405.0 ± 18.0z	300.0 ± 0.0		

TABLE 2. (continued)

Calcium (mg/dl)	High	10.7 ±	0.8	10.4 ±	0.8	10.4 ±	1.0	10.1 ±	0.8
	Low	9.3 ±	0.3	12.0 ±	1.6				
Creatinine (mg/dl)	High	3.2 ±	1.2	2.5 ±	0.4a	2.3 ±	0.6b	2.7 ±	0.1zc
	Low	3.2 ±	0.4c	3.6 ±	0.3abz				

*Diet group: High - receiving a diet high in nitrogen (3 animals)
Low - receiving a diet low in nitrogen (3 animals)
†Data from 2 animals in this group.
‡Data from 6 bison.
§Data from 5 bison.

bison) and 21 October (5 bison) sample dates.

If the December and March data are pooled to give a total of six samples per group for an assessment of "winter" condition, the high diet group had significantly higher average BUN levels ($P < 0.05$) and average cholesterol levels ($P < 0.01$) but had significantly lower packed cell volumes (hematocrit) ($P < 0.01$) than the low diet group.

In Table 3 the data for the 9 June and 21 October samples are compared to data presented by Mehrer,[10] who examined 163 bison from five wildlife refuges across the United States, and to those of Marler,[9] who examined 47 adult bison for hematological values and 25 for blood chemistry values, all in Kansas.

DISCUSSION

Payne *et al.*[11] suggest three major sources of variation in blood physiological parameters. They are: 1) season, 2) genetics, and 3) production level for lactation. Other factors, he concedes, may have an effect; these include age, sex, and stage in lactation. However, Payne was dealing with uniformly fed, well-housed dairy cattle. Other authors[2,6,13,14] have stressed that many environmental factors can cause variation in blood chemistry values. Drevemo *et al.*[3] list other factors affecting blood physiological parameters. Among them are stress, disease, excitement, and circadian and diurnal rhythms. Using data from a variety of sources, Bailey[1] compared various blood chemistry values for mule deer *(Odocoileus hemionus)* and white-tailed deer *(O. virginianus)* on varying planes of nutrition. Differences in blood chemistry values apparently caused by nutrition were evident. Torrel *et al.*[16] discussed using blood urea nitrogen as an index to the nutritional status of sheep. BUN was correlated to nitrogen intake ($r = 0.99$) and weight gain ($r = 0.95$).

Marler[9] compared blood values for young (less than 2 years old) vs. old

TABLE 3. Comparison of Pawnee bison data to those of Marler[10] and Mehrer.[11]

Parameter (Units)	9 June	21 October	Marler	Mehrer
Packed cell volume (%)	46.8 ± 3.06	51.4 ± 4.2	50.0 ± 4.5	47.1 ± 4.1
Hemoglobin (g/dl)	16.7 ± 1.4	18.6 ± 1.3	17.3 ± 1.5	16.9 ± 1.4
Leukocytes (no.)	6433.3 ± 898.0	6400.0 ± 600.0	6985.0 ± 2082.0	8030.0 ± 1410.0
Neutrophils (no.)	50.2 ± 12.8	48.2 ± 4.6	46.0 ± 13.0	63.8 ± 8.0
Lymphocytes (no.)	37.8 ± 11.3	40.8 ± 4.9	42.0 ± 12.0	24.9 ± 6.4
Monocytes (no.)	4.5 ± 2.6	2.6 ± 0.9	10.0 ± 5.0	6.3 ± 4.2
Eosinophils (no.)	8.6 ± 3.1	8.0 ± 4.2	1.0 ± 1.0	4.0 ± 3.3
Total protein (g/dl)	8.0 ± 0.6	8.1 ± 0.5	8.6 ± 0.6	
Cholesterol (mg/dl)	76.0 ± 8.2	82.6 ± 7.3	97.0 ± 11.0	
Bilirubin (mg/dl)	0.7 ± 0.2	0.8 ± 0.1	0.3 ± 0.1	
Alkaline phosphatase (U/l)	21.0 ± 8.6	13.4 ± 1.6	48.0 ± 10.0	
SGOT (U/l)	57.0 ± 24.8	102.5 ± 11.3	99.0 ± 18.0	
Phosphorus (mg/dl)	5.8 ± 1.0	6.0 ± 1.9	2.8 ± 0.8	
Calcium (mg/dl)	10.4 ± 1.0	10.1 ± 0.8	10.6 ± 0.6	
Creatinine (mg/dl)	2.3 ± 0.7	2.8 ± 0.2	3.0 ± 0.2	

bison, and found significant differences in leukocyte numbers, neutrophil percentage, lymphocyte percentage, and cholesterol, alkaline phosphatase, and SGOT levels. Mehrer[10] also found significant differences between age groups of male bison, but not of female bison. Because our animals were all about the same age, differences due to age were not distinguishable.

Our major interest was in variation of blood values caused by diet. Animals receiving a low protein diet in December had low serum globulin levels, while animals receiving an adequate diet had high globulin values. Animals receiving a high protein-high energy diet had high glucose, potassium, and cholesterol levels. BUN for both groups in December was slightly lower than later values, as were sodium, LDH, and SGPT. In March the groups were not as different as they were in December, the low diet group having more normal total protein and serum globulin levels, but lower cholesterol levels and the high diet group having a lower blood glucose average and a lower cholesterol level. The low BUN of the low diet group in winter may be caused by that group's low protein intake.[15]

The low-diet group had significantly higher SGOT levels in March than in June, indicating that these animals were under some stress during this period. SGOT values for the high diet group in March, and for all animals in December and October were comparable to those obtained by Marler.[9] Significantly high values could indicate cell necrosis and myopathy.[5] Low LDH levels indicate that the animals were under little stress at the time of sampling,[14] while higher levels have little meaning without isoenzyme determinations to identify the source.

A sidelight not evident from the data presented is that bison with esophageal fistulas had higher leukocytic counts than did other animals in the March samples. This perhaps is a reflection of stress caused by the fistula; however, counts were not different in any other sample period. SGOT levels in esophageally fistulated animals were not different in the March sample, indicating little cell necrosis in these animals. Except for this single aberration no significant differences were discernible between animals with different fistulas, although we were unable to sample nonfistulated animals to examine the effects of fistulation itself.

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