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Author: MEHRER, CLIFFORD F.

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SOME HEMATOLOGIC VALUES OF BISON FROM FIVE AREAS OF THE UNITED STATES¹

CLIFFORD F. MEHRER, Department of Biology, University of North Dakota,
Grand Forks, North Dakota 58201, USA.

Abstract: Seventeen hematologic values of the American Bison (*Bison bison*) from five areas of the United States were determined using standard techniques. The means of the principal blood measurements for all bison were 10.08 ± 1.43 million erythrocytes/mm³, 8.03 ± 1.41 thousand leukocytes/mm³, 16.92 ± 1.43 gm % hemoglobin and $47.11 \pm 4.06\%$ hematocrit. There was a significant variation ($P < 0.05$) among age groups of males for erythrocytes, neutrophils, lymphocytes and monocytes. However, no significant variation between female age groups or sexes was found for any of the blood cell values determined.

INTRODUCTION

The collection of bison (*Bison bison*) whole blood samples in 1971-1972 from several areas of the United States for sero-diagnosis of leptospirosis and brucellosis presented an excellent opportunity to collect additional information on the hematology of this species. Little has been published concerning the blood values in bison, and physiologic information concerning bison has been taken from a single or small group of animals.

As herds of bison are becoming increasingly popular for esthetic and economic reasons, and animals are more frequently transported from geographical area to geographical area, the need for standards upon which to evaluate hematological samples from these animals has become important. Blood composition with regards to hematologic values is of extreme importance in diagnosing and monitoring disease conditions in American bison. As these herds are becoming larger, means to detect epizootic disease are needed. Therefore, it is desirable to determine these values in a large sample taken from several areas of the United States. These data are presented to help determine the range of normal variation in bison blood values.

MATERIALS AND METHODS

The blood of the American bison was analyzed for: The number of erythrocytes and leukocytes, hemoglobin content, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and the percentage occurrence and absolute numbers of neutrophils, lymphocytes, monocytes, eosinophils, and basophils. The number and place of sample collections were: 91, National Bison Range, Montana; 320, Custer State Park, South Dakota; 14, Medora, North Dakota; 120, Wichita Mountains Wildlife Refuge, Oklahoma; and 26, Fort Niobrara National Wildlife Refuge, Nebraska. Samples were taken from the jugular vein of live bison or from the heart of freshly killed animals. If possible, the sex and age of each bison was recorded when samples were collected.

Blood was placed in vials containing an anticoagulant (disodium ethylenediaminetetracetate in a concentration of 1 mg/ml of blood), and shipped, by air or special delivery, in a cooler to Grand Forks, North Dakota. With the exception of those from Oklahoma, which required three days, samples were in transit no more than two days. Upon arrival, a

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blood sample from each vial was centrifuged for five minutes at 12,500 rpm; only samples which were not hemolyzed were used for hematologic study.

Total leukocyte and erythrocyte counts were made using a model B Coulter Counter,^[2] 100 μ m aperture. The lower and upper threshold limits were 5 and 100 respectively. Two consecutive counts were taken and the second then corrected for coincidence and background. Saponin^[3] was used to lyse erythrocytes when counting leukocytes. Hemocytometer counts were made periodically to check the performance of the Coulter Counter. Hematocrit values were determined by centrifuging tubes containing blood samples in an Adams-Microhematocrit Centrifuge^[4] for 10 min at 12,500 rpm.

Hemoglobin concentration was determined by the cyanmethemoglobin method⁵ using a Bausch and Lomb Spectrophotometer.^[5] Blood smears were prepared from preserved blood after arrival in the laboratory. Although some cellular distortion resulted from the use of preserved blood and the delay in preparing smears, leukocytes were easily identified. The percentage occurrence

of neutrophils, lymphocytes, monocytes, eosinophils and basophils was determined by staining blood smears with Wright's stain and counting 100 cells using oil immersion (950X). Absolute numbers of leukocyte types, mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration were calculated using standard formulas.

RESULTS

The average of seventeen blood cell values from all bison is shown in Tables 1 and 2. The means of the principal blood measurements were: 10.08 ± 1.43 million erythrocytes/ mm^3 , 8.03 ± 1.41 thousand leukocytes/ mm^3 , 16.92 ± 1.43 gm % hemoglobin, and $47.11 \pm 4.06\%$ hematocrit.

The National Bison Range herd had the greatest mean number of erythrocytes (10.71 million/ mm^3) and percentage neutrophils (66.2/100); the lowest mean total leukocytes (7.90 thousand/ mm^3) and lymphocyte numbers (23.07/100 and 1,820/ mm^3). Mean total number of leukocytes (9.10 thousand/ mm^3),

TABLE 1. Erythrocytic values of 163 bison from five wildlife refuges.

	Range	Mean	S.D.
Erythrocytes/ mm^3 ($\times 10^6$)	6.53 - 13.90	10.08	1.43
Hemoglobin gm%	12.24 - 19.19	16.99	1.43
Hematocrit %	37.00 - 57.00	47.11	4.06
MCV ^[6] μm^3	41.01 - 87.29	59.74	8.76
MCH ^[7] pg	11.42 - 29.38	19.79	4.40
MCH ^[8] %	21.47 - 51.86	35.92	6.21

[2] Coulter Diagnostics, Hialeah, Florida 33014.

[3] Coleman and Bell, Norwood, Ohio 44709.

[4] Clay-Adams, Inc., New York, N.Y. 10519.

[5] Bausch and Lomb, Inc., Rochester, N.Y.

[6] Mean corpuscular volume

[7] Mean corpuscular hemoglobin

[8] Mean corpuscular hemoglobin concentration

TABLE 2. Leukocytic values of 163 bison from five wildlife refuges.

	Range	Mean	S.D.
Leukocytes/mm ³ (X10 ³)	4.67 - 10.74	8.03	1.41
Leukocytes/100			
Neutrophils	40.00 - 83.00	63.77	7.95
Lymphocytes	12.00 - 44.00	24.86	6.40
Monocytes	0.00 - 36.00	6.34	4.17
Eosinophils	0.00 - 20.00	3.98	3.31
Basophils	0.00 - 10.00	0.77	1.01
Total Leukocytes/mm ³ (X10 ³)			
Neutrophils	3.19 - 8.79	5.12	1.13
Lymphocytes	0.67 - 4.12	2.00	0.92
Monocytes	0.00 - 2.61	0.51	0.28
Eosinophils	0.00 - 1.51	0.32	0.21
Basophils	0.00 - 0.40	0.08	0.04

MCV (58.24 μ^3), MCH (22.14 pg), MCHC (38.01%), total neutrophils (5,930/mm³), and hemoglobin content (19.11 gm %) were greatest in the Fort Niobrara herd. But this herd had the lowest mean number of erythrocytes (8.18 million/mm³) and percentage monocytes (3.55/100).

The Wichita Mountains herd had the greatest mean percentage lymphocytes (28.17/100), eosinophils (6.50/100), and basophils (1.06/100); lowest mean number of neutrophils (58.56/100 and 4,650/mm³) and smallest mean hemoglobin content (16.17 gm%). Mean hematocrit reading (48.70%), percentage monocytes (9.43/100) and total lymphocytes (2,670/mm³) were greatest, but mean percentage of eosinophils (0.25/100) and basophils (0.13/100) lowest in the Custer State Park herd. The average for the seventeen hematologic values for each herd is presented in Table 3.

Sample means and standard deviations for male and female bison blood values without regard to age are given in Table 4. There was no significant ($P < 0.05$) added variance between sexes for any of the 17 blood values measured.

Means and standard deviations of the 17 blood values for 1-2, 3-4, and 5+ year age class males are presented in Table 5 and for females in Table 6. There was no significant added variation between female age classes for any of the values. Five year and older male bison had significantly more erythrocytes/mm³ ($P < 0.01$), and neutrophils/100 ($P < 0.05$), but lower mean corpuscular volume ($P < 0.05$) than the other two year classes. However, 3-4 year class males had significantly more total and percentage lymphocytes and percentage monocytes ($P < 0.05$) than the other two age classes.

DISCUSSION

With the exception of total leukocytes and percentage lymphocytes, the hematologic values presented for bison compared favorably to American elk (*Cervus canadensis*), white-tailed deer (*Odocoileus virginianus*), and mule deer (*O. hemionus*).^{2,5,6,8} Total leukocytes for bison averaged approximately three thousand/mm³ more than reported for elk,

TABLE 3. Hematologic values of American bison from National Bison Range, Fort Niobrara, Wichita Mountains, Custer State Park, and Medora.

	Natl. Bison Range		Fort Niobrara		Wichita Mtns.		Custer State Park		Medora	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Erythrocytes/mm ³ (X10 ⁶)	10.71	1.24	8.18	1.15	9.00	0.99	9.53	1.43	9.65	1.16
Hemoglobin gm%	16.88	1.34	18.11	1.25	16.17	1.76	16.92	1.15	17.21	1.75
Hematocrit %	47.07	4.06	47.64	2.61	45.94	4.65	48.70	3.51	45.07	4.43
MCV μ m ³	43.9	9.47	58.24	10.13	50.55	11.41	51.11	9.43	46.71	10.04
MCH pg	15.76	5.23	22.14	3.96	17.96	4.38	17.75	4.71	17.83	4.01
MCHC %	35.86	6.43	38.01	5.51	36.37	7.01	34.74	4.97	38.18	5.11
Leukocytes/mm ³ (X10 ³)	7.90	1.44	9.10	0.78	7.94	1.67	8.10	1.43	7.99	0.90
Leukocytes/100										
Neutrophils	66.20	7.18	65.18	4.51	58.56	9.97	59.70	7.50	62.21	6.47
Lymphocytes	23.07	4.94	24.91	3.53	28.17	7.84	28.07	6.94	25.16	9.26
Monocytes	5.91	4.24	3.55	1.51	5.00	2.38	9.43	4.11	6.43	3.78
Eosinophils	3.90	2.85	5.64	3.26	6.50	5.54	2.70	1.93	2.71	2.76
Basophils	0.91	1.07	0.81	0.60	1.06	1.21	0.13	0.35	0.86	1.17
Total Leukocytes/mm ³ (X10 ³)										
Neutrophils	5.23	0.83	5.93	0.69	4.65	0.92	4.84	1.16	4.97	0.91
Lymphocytes	1.82	0.71	2.27	0.80	2.24	0.50	2.67	0.78	2.01	0.88
Monocytes	0.47	0.23	0.32	0.19	0.40	0.17	0.76	0.31	0.51	0.23
Eosinophils	0.31	0.16	0.51	0.20	0.52	0.24	0.22	0.13	0.23	0.13
Basophils	0.07	0.04	0.07	0.04	0.08	0.03	0.02	0.00	0.07	0.06
N =	90		11		18		30		14	

TABLE 4. Hematologic values of male and female bison.

	Female		Male	
	Mean	S.D.	Mean	S.D.
Erythrocytes/mm ³ (X10 ⁶)	10.33	1.45	9.97	1.32
Hemoglobin gm%	16.93	1.47	16.72	1.34
Hematocrit %	47.20	4.46	46.90	3.73
MCV/μm ³	45.69	9.41	47.00	9.73
MCH pg	16.39	4.53	16.77	4.38
MCHC %	35.87	5.34	35.65	4.71
Leukocytes/mm ³ (X10 ³)	7.83	1.60	8.11	1.14
Leukocytes/100				
Neutrophils	64.03	8.21	63.18	8.10
Lymphocytes	24.47	6.08	25.35	7.18
Monocytes	6.67	4.39	6.64	4.05
Eosinophils	4.21	3.81	3.41	2.42
Basophils	0.77	1.09	0.77	0.97
Total Leukocytes/mm ³ (X10 ³)				
Neutrophils	4.69	1.13	5.12	0.97
Lymphocytes	1.92	0.87	2.06	0.83
Monocytes	0.52	0.15	0.54	0.21
Eosinophils	0.33	0.16	0.28	0.19
Basophils	0.06	0.04	0.06	0.04
N =	86		66	

TABLE 5. Hematologic values of 1-2 year, 3-4 year, and 5 year and older male bison.

	1-2 year		3-4 year		5 year	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Erythrocytes/mm ³ (X10 ⁶)	9.64	1.28	9.93	1.28	11.24	0.92
Hemoglobin gm%	16.51	1.58	16.93	1.24	17.00	0.85
Hematocrit %	46.17	4.27	47.63	3.49	47.70	2.83
MCV/μm ³	47.89	8.43	47.97	7.56	42.44	8.47
MCH pg	17.17	3.59	18.15	4.13	15.13	4.53
MCHC %	35.76	4.87	35.54	3.96	35.63	5.11
Leukocytes/mm ³ (X10 ³)	8.09	1.28	8.13	1.22	8.10	1.18
Leukocytes/100						
Neutrophils	64.23	6.64	59.96	8.96	68.40	6.00
Lymphocytes	24.14	6.80	27.81	7.71	22.00	4.08
Monocytes	5.33	3.04	8.93	4.70	5.10	2.60
Eosinophils	3.73	2.33	2.93	2.74	3.70	1.34
Basophils	0.93	0.91	0.41	0.75	1.20	1.40
Total Leukocytes/mm ³ (X10 ³)						
Neutrophils	5.20	1.10	4.87	0.97	5.54	0.86
Lymphocytes	1.95	0.84	2.26	0.67	1.78	0.91
Monocytes	0.43	0.22	0.73	0.15	0.41	0.17
Eosinophils	0.30	0.11	0.24	0.06	0.30	0.11
Basophils	0.08	0.06	0.02	0.02	0.10	0.01
N =	30		27		10	

TABLE 6. Hematologic values of 1-2 year, 3-4 year, and 5 year and older female bison.

	1-2 year		3-4 year		5 year	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Erythrocytes/mm ³ (X10 ⁶)	10.14	1.41	10.01	1.67	10.97	1.12
Hemoglobin gm%	17.06	1.60	16.97	1.04	16.52	1.49
Hematocrit %	46.95	4.99	48.52	3.29	46.14	4.03
MCV/ μ m ³	46.30	7.56	48.47	8.63	42.06	8.97
MCH pg	16.82	2.96	16.95	3.63	15.06	3.97
MCHC %	36.34	3.29	34.97	4.56	35.80	4.99
Leukocytes/mm ³ (X10 ³)	7.75	1.69	8.03	1.39	7.80	1.69
Leukocytes/100						
Neutrophils	62.67	9.83	64.14	6.01	66.90	5.80
Lymphocytes	25.16	6.97	24.71	5.99	22.95	3.96
Monocytes	6.28	5.51	7.29	2.59	5.71	2.65
Eosinophils	4.98	4.79	3.52	1.94	3.38	2.67
Basophils	0.86	1.12	0.31	0.80	1.00	1.22
Total Leukocytes/mm ³ (X10 ³)						
Neutrophils	4.86	1.31	5.15	1.20	5.22	1.11
Lymphocytes	1.95	1.01	1.98	0.92	1.79	0.97
Monocytes	0.49	0.31	0.59	0.40	0.45	0.39
Eosinophils	0.39	0.15	0.28	0.18	0.26	0.22
Basophils	0.07	0.06	0.06	0.07	0.08	0.05
N =	43		21		21	

and five thousand/mm³ more than reported in white-tailed and mule deer. The percentage lymphocytes averaged approximately 25 per 100 less in bison than in elk and mule deer.

The erythrocytic values presented here also compared favorably to, but were somewhat greater, than those of domestic cattle (*Bos taurus*).¹⁰ Bison averaged approximately 1.5 million/mm³ erythrocytes, 6 gm% hemoglobin, 7% hematocrit, 13 μ m³ mean corpuscular volume, 6 pg mean corpuscular hemoglobin, and 7% mean corpuscular hemoglobin concentration greater than 3-4 year old purebred Jersey cattle.

With the exception of the neutrophil/lymphocyte ratio the leukocytic values of domestic cattle and bison were also quite similar. The neutrophil/lymphocyte ratio in these bison is opposite of those of domestic cattle. This is especially interesting since these animals are of the *Bovidae* family and hence are more

closely related to each other than they are to the other animals previously mentioned. Stress in these bison may be causative of opposite ratios.

These data also compared closely with data for American Bison from Kansas.⁷ A significant difference in total leukocytes, neutrophil percentage and lymphocyte percentage was found between adult bison and those under 2 years of age in Kansas bison. Of these values, only lymphocyte percentage was significantly different between 3-4 year bison and 1-2 year bison in this study. These differences in values could be due to geographical area or they may reflect differences in sample sizes. The sample size of 1-2 year animals is approximately two and one-half times larger in this study.

Most of the variation among age groups was a result of the age differences among males. This may reflect true physiological changes due to aging or may have been due to small sample sizes,

especially in the 5 year and older age class males which contained samples from only 10 individuals. Members of this age group were collected in October from the National Bison Range; samples from the other age classes were taken in August, September, November, and December. Thus, the time of collection may have influenced variation in hematologic values among male age groups. Seasonal variation in hematologic values has been reported in other wild species.¹

Male and female blood values were not significantly different, but this has

been reported in other large mammal species. For example, none of 19 mule deer blood cell components studied were significantly different between males and females.¹ Also, of 25 blood cell components analyzed in white-tailed deer, only hematocrit was significantly different in males and females.¹¹

The effects of handling animals prior to collecting the samples are not considered in this study. Stress, or fright, can cause significant changes in many hematological parameters.^{4,9} Therefore, resting values may be different than those presented here.

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