

## The Hematology of the Free-ranging European Bison

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This paper presents the values of hematological parameters and indices for 46 European bison, *Bison bonasus* (Linnaeus, 1758), 37 of which were free-ranging bison and 9 bison kept in enclosures. The samples were taken from bison shot during the winter period. Significant differences were found in some blood values connected with the age of the animals examined. In sexually mature bison over 4 years old from the free-ranging herd hemoglobin value, thickness of erythrocytes, mean corpuscular hemoglobin and mean corpuscular volume indices are significantly higher than in younger animals. The eosinophil percentage increases with the animals' age and is significantly lower in calves than in older animals. The number of lymphocytes is significantly lower in the group of oldest animals than in calves. The lymphocyte: neutrophil index decreases regularly with increase in the animals' age. Comparison was made of the blood values for the European bison, American bison, *Bison bison* (Linnaeus, 1758) and domestic cattle. Attention has been drawn to the frequency of occurrence of invasive diseases among the European bison examined (from 12 to 82% in different age groups) and also to the commonness of other diseases, which might have contributed to the wide range of variations in hematological data.

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### 1. INTRODUCTION

The first studies on the physiological properties of the European bison *Bison bonasus* (Linnaeus, 1758), preceded by anatomical studies, began during the sixties (see Gill, 1967), and were concerned chiefly with digestion physiology and the animals' reaction to anaesthesia. Many of the studies dealt with the polymorphism of red-cell antigenic factors, the serologic specificity of bison normal sera and serum globulins, and the polymorphism of hemoglobins and transferrins (see Gasparski, 1967). There is, however, a lack of the hematological data in literature relating to this species which could form a basis for the further studies being carried out on the physiology, and also on the ecology and behaviour of the European bison. The mean value of hematological parameters of the European bison given by Buchalczyk *et al.*, (1971) was based on a small number of samples only.

Standard hematological data on bison from the free-ranging herd in the Białowieża Primeval Forest, and thus from the place in which this threatened species was re-established in 1952, may be of importance not only to supplementing information on its physiology, but also as a point of reference for European bison breeders. For purposes of comparison hematological parameters and indices for free-ranging bison have been compared with data obtained from several individuals living in enclosures at Białowieża. In addition the blood values of adult bison have been compared with the corresponding data for the American bison *Bison bison* (Linnaeus, 1758) and the lowland black-and-white domestic cattle in Poland.

## 2. MATERIAL AND METHODS

The data presented here were obtained from 38 European bison from the free-ranging herd and from 9 bisons kept in enclosures. All the individuals examined were selected for the breeding aims and shot from the free-ranging herd in the Białowieża Primeval Forest during the period from 1972 to 1982. Selection was made during the winter from November 29th to March 17th, which made it possible to avoid seasonal variations. Blood samples were taken from the jugular vein cut immediately after the animal was shot, with the exception of one sample taken from the ear of a live bison anaesthetized with immobilon. Heparine was used as an anti-coagulant. The blood was examined within a few hours after sampling, or in extreme cases (in 3 individuals) on the following day, and in one case after 48 hours of keeping it at a low temperature.

Hemoglobin values (Hb) were obtained by using the standard procedure for cyanmethemoglobin determination on a Lars Ljungberg hemometer. Hematocrit determinations (Htc) were performed by the microhematocrit method. The red blood cells (RBC) were counted in a Thoma chamber. The diameter of erythrocytes (RBC diam.) was measured with a Zeiss micrometric eye-piece on smears stained by Pappenheim's method. On the basis of data obtained by the method given above calculation was made of mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV) and mean thickness of cell (RBC thick.). White blood cells (WBC) were counted in a Bürker chamber and differential counts were made from Pappenheim stained blood smears examined under oil immersion, using standard counting techniques.

The bisons examined were dissected by the veterinary service of the Białowieża National Park, and the data as to the animals' state of health were obtained from this source.

## 3. RESULTS

Hematological parameters and indices have been given for European bison of three age groups: calves from 5 months to 1 year old, animals from 1 year to 4 years old and sexually mature animals over 4 years

old (about 100% of females of this age take part in reproduction, Kraśniński & Raczyński, 1967).

In this last group of bison from the free-ranging herd no statistically significant differences were observed in blood values connected with sex. Females were observed to have slightly lower values of Hb, RBC, Htc, WBC and slightly higher MCH, MCV values and greater diameter and thickness of red blood cells (Tables 1, 2). Significant differences were found in hematological parameters between the three age groups

Table 1  
Red blood cell values of free-ranging European bison in Białowieża Primeval Forest. Mean values and SD are given.

Age groups, in years	< 1	1-4	> 4 <sup>1</sup>		> 15	
N; sex	15; 6M, 9F	6; 4M, 2F	16; 11M, 5F	11M	5F	1M, 2F
Hb, g/100 ml	11.04 ± 3.24	10.35 ± 2.79	12.18 ± 1.31	12.26	11.99	12.42
RBC, 10 <sup>6</sup> /mm <sup>3</sup>	6.87 ± 2.00	6.39 ± 1.60	6.09 ± 0.93	6.18	5.88	5.58
Htc, %	31.85 ± 9.16	30.33 ± 7.45	35.16 ± 5.29	35.41	34.60	37.67
RBC diam., μ	5.39 ± 0.15	5.40 ± 0.18	5.49 ± 0.16	5.47	5.51	5.46
MCV, μ <sup>3</sup>	46.81 ± 5.99	47.69 ± 4.50	57.21 ± 9.21	56.30	59.20	67.37
MCH, pg	16.19 ± 1.93	16.18 ± 1.53	20.22 ± 2.15	20.09	20.49	22.22
MCHC, %	34.62 ± 0.97	33.94 ± 1.17	34.90 ± 2.11	34.96	34.78	32.98
RBC thick., μ	2.05 ± 0.30	2.09 ± 0.25	2.43 ± 0.42	2.39	2.55	2.89

<sup>1</sup> Including 3 bisons over 15 years old.

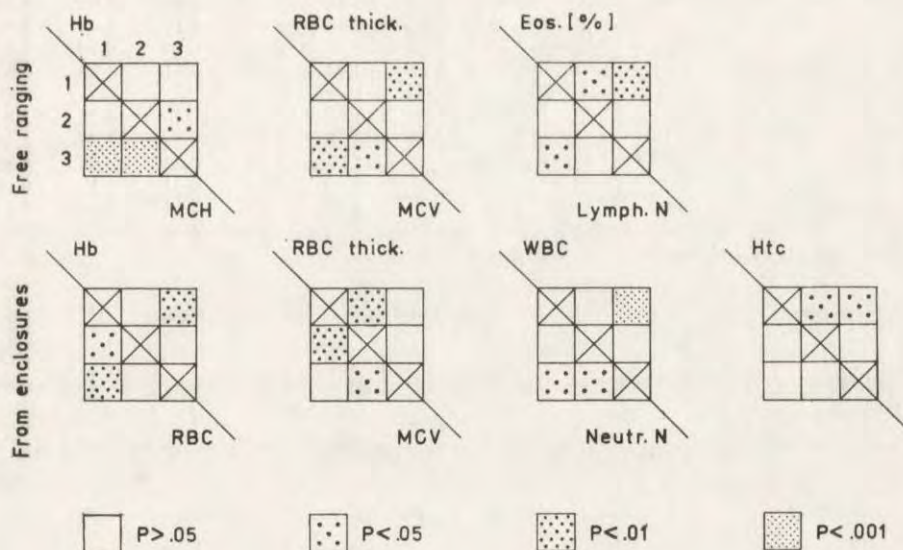


Fig. 1. Significant differences between some hematological parameters and indices of the European bison. Data with no differences were omitted. The Student *t* test was used to determine statistical differences. 1 — animals younger than one year, 2 — animals 1-4 year old, 3 — animals older than 4 years.

(Table 1, Fig. 1). Hemoglobin level is transitorily lowered in the group of young 1—4 year old animals in relation to calves, as are similarly the number of erythrocytes and hematocrit, although these differences are not statistically significant. In adult animals Hb value significantly increases in relation to that for 1—4 year olds, and *RBC* thickness in relation to calves. As a result of the decrease in number of *RBC* as the bison grows older, and also increase in Hb value, and diameter and thickness of red blood cells, *MCH* and *MCV* also increase significantly. *MCHC*, on the other hand, does not vary with the animals' age.

In the *WBC* picture changes connected with age are far smaller (Table 2, Fig. 1). The number of *WBC* does not significantly change, nor does that of neutrophils, eosinophils and monocytes. The number of lymphocytes is significantly smaller in the group of adult animals

Table 2  
White blood cell values of free-ranging European bison  
in Białowieża Primeval Forest.  
Mean values and *SD* are given.

Age groups, in years	< 1		1—4		> 4 <sup>1</sup>		> 15
	N; sex		N; sex		N; sex		N; sex
WBC, 10 <sup>9</sup> /mm <sup>3</sup>	12; 6M, 6F	6.16 ± 3.09	6; 4M, 2F	4.73 ± 1.45	16; 11M, 5F	4.82 ± 2.23	5.26 3.86 4.49
Neutrophils, %	12; 6M, 6F	31.79 ± 21.52	6; 4M, 2F	34.50 ± 14.74	16; 11M, 5F	43.83 ± 22.42	42.82 46.04 54.33
10 <sup>9</sup> /mm <sup>3</sup>	12; 6M, 6F	1.72 ± 0.92	6; 4M, 2F	1.79 ± 1.02	16; 11M, 5F	2.05 ± 1.80	2.17 1.81 2.47
Eosinophils, %	12; 6M, 6F	3.33 ± 3.42	6; 4M, 2F	7.00 ± 1.73	16; 11M, 5F	8.41 ± 6.75	9.18 6.70 8.67
10 <sup>9</sup> /mm <sup>3</sup>	12; 6M, 6F	0.19 ± 0.18	6; 4M, 2F	0.32 ± 0.12	16; 11M, 5F	0.44 ± 0.43	0.51 0.29 0.43
Basophils	only an occasional cell noted						
Lymphocytes, %	12; 6M, 6F	63.65 ± 22.03	6; 4M, 2F	58.33 ± 13.61	16; 11M, 5F	46.46 ± 22.92	47.45 44.26 32.33
10 <sup>9</sup> /mm <sup>3</sup>	12; 6M, 6F	4.19 ± 2.99	6; 4M, 2F	2.61 ± 0.63	16; 11M, 5F	2.28 ± 1.41	2.57 1.64 1.40
Monocytes, %	12; 6M, 6F	1.06 ± 1.67	6; 4M, 2F	rare	16; 11M, 5F	1.25 ± 2.70	0.45 3.00 4.33
10 <sup>9</sup> /mm <sup>3</sup>	12; 6M, 6F	0.06 ± 0.09	6; 4M, 2F	"	16; 11M, 5F	0.05 ± 0.11	0.01 0.13 0.19
Lymph./Neutr.	12; 6M, 6F	2.00	6; 4M, 2F	1.69	16; 11M, 5F	1.06	1.11 0.96 0.60

<sup>1</sup> Including 3 bisons over 15 years old.

as compared with calves. Despite the lack of significant differences in the number of neutrophils and the only faint decrease in the number of lymphocytes with increasing age, tendencies to increase in both percentage contents and number of neutrophils, and tendencies to decrease in percentage contents and number of lymphocytes lead to regular reduction of the lymphocyte : neutrophil index (Table 2). The hematological relations of 3 very old bison, over 15 years old, merit separate discussion. It is an interesting fact that all tendencies to changes observed in European bison from the age of under one year to over 4 years are even more pronounced in old animals (Tables 1, 2).

Differences in hematological values in analogical age groups of bisons kept in enclosures from those previously discussed present a different

picture. It is, however, necessary to bear in mind the small numbers in these groups. Hb value decreases with the animals' age and the difference between calves and adult animals is statistically significant (Table 3, Fig. 1). RBC value similarly decreases with age as in the case of bison from the free-ranging herd. As a result of these tendencies MCH index is not subject to changes connected with age. Hematocrit

Table 3  
Red blood cell values of European bison in enclosed centres in Białowieża.  
Mean values and SD are given.

Age groups, in years N; sex	<1	1—4	>4
	2; 2F	5; 1M, 4F	2; 1M, 1F (pregnant)
Hb, g/100 ml	15.20±0.40	10.92±2.03	10.55±0.15
RBC, 10 <sup>6</sup> /mm <sup>3</sup>	8.18±0.15	6.28±0.75	5.48±0.15
Htc, %	44.00±1.00	28.60±4.71	30.00±1.00
RBC diam., μ	5.60±0.06	5.34±0.15	5.77±0.02
MCV, μ <sup>3</sup>	53.79±0.24	45.31±2.25	54.84±3.33
MCH, pg	18.60±0.83	17.28±1.72	19.28±0.81
MCHC, %	34.59±1.70	38.20±4.18	35.19±0.67
RBC thick., μ	2.19±0.04	2.02±0.03	2.10±0.12

value is significantly higher in calves as compared with older animals. RBC diameter and thickness decrease transitorily in animals 1—4 years old, in comparison with calves, and consequently their volume decreases. MCHC index, similarly to that in bison from the free-ranging herd, varies only slightly. The number of leukocytes is strikingly low in calves, but afterwards increases with age, so that the difference between WBC count in the youngest and oldest groups is highly significant

Table 4  
White blood cell values of European bison in enclosed centres in Białowieża.  
Mean values and SD are given.

Age groups in years N; sex	<1	1—4	>4
	2; 2F	5; 1M, 4F	2; 1M, 1F (pregnant)
WBC, 10 <sup>3</sup> /mm <sup>3</sup>	2.78±0.03	6.73± 1.44	7.10± 0.05
Neutrophils, %	27.50±6.50	21.25±13.85	49.00± 5.00
10 <sup>3</sup> /mm <sup>3</sup>	0.76±0.17	1.51± 0.65	3.48± 3.30
Eosinophils, %	10.50±5.50	2.75± 3.27	9.50± 5.50
10 <sup>3</sup> /mm <sup>3</sup>	0.29±0.16	0.20± 0.26	0.54± 0.36
Basophils	—	—	—
Lymphocytes, %	62.00±1.00	73.75±11.43	41.50±10.50
10 <sup>3</sup> /mm <sup>3</sup>	1.72±0.04	5.01± 1.56	2.95± 0.77
Monocytes	only an occasional cell noted		
Lymph./Neutr.	2.25	3.47	0.85

(Table 4, Fig 1). Among different forms of leukocytes only the number of neutrophils varies with the animals' age. In calves this number is significantly lower than in older animals (Fig. 1). The lymphocyte : neutrophil ratio is lower in adult bison than in young animals, as it is in the group of free-ranging bison.

## 4. DISCUSSION

Trends in the changes in blood values connected with growth and sexual maturation in European bison are revealed when comparing calves, young sexually immature individuals and adult animals. The transitory decrease in the level of Hb and hematocrit in the group of young 1—4 year old bison from the free-ranging herd is striking. Both these parameters next increase in adult animals, increase in Hct with further decrease in the number of RBC being caused by increasing diameter and thickness of the erythrocytes. This is probably connected with the transition of calves from the suckling period to independent feeding, and also with the low social position occupied by those young bison in the herd, involving stress situations and probably also insufficiency of food. Adult bison are characterized by higher Hb level, greater RBC volume and higher MCH index, while MCHC remains almost unchanged.

In the case of bison from enclosures average data relating to the group of adult bison are under-estimated, since one of the three animals examined was a gestating cow with a lower Hb level and lower RBC and Hct values. Anaemia connected with the gestating period is a fairly general phenomenon in mammals.

The percentage of eosinophils increases significantly with the animals' age in the leukogram for free-ranging bison, and the number of eosinophils in mm<sup>3</sup> of blood also increases. This increase in the proportion of eosinophils in peripheral blood may be connected with the allergizing action of parasites such as liver fluke or lung nematodes. Decrease in the lymphocyte : neutrophil index with the bison's age is distinct in the free-ranging bison, whereas tendencies to variations in this ration, and also changes in the number and percentage content of eosinophils in the blood of bison from enclosures are not so distinct. They are subject to disturbance particularly in the group of young 1—4 year old. This may be due to the care given by man during this critical period when the young become independent.

The following parasites were found to occur in the majority of the animals examined: *Fasciola hepatica* (Trematoda) and *Dictyocaulus viviparus* (Nematoda), and in two 2-year old bison *Moniezia* sp. (Cestoda), as well as pathological changes after invasion by the first two of these parasites. The degree of intensity of such changes differed. Generally speaking, *Fasciola hepatica* or post-invasion changes were found on dissection in 76% of calves, 82% of 1—4 year olds and 71% of older animals.<sup>1</sup> Drózdź (1961) considered *Fasciola hepatica* as the most dan-

<sup>1</sup> As pathological changes, particularly those connected with invasion by *Fasciola*

gerous parasite of European bison in Poland, occurring in 53.8% of the animals he examined, hence invasion by this parasite of the bison examined is over 20% greater. Pulmonary helminthiasis caused by the nematodes *Dictyocaulus viviparus*, and also pneumonia caused by invasion by this parasite, was found in 53% of calves, 54% in 1—4 year old bison and 12% of the oldest group of bison. According to Drózdź (1961) during the fifties this parasite occurred in 30.7% of the bison examined. Various purulent processes, particularly purulent inflammation of the prepuce in males, were found in only 2% of calves, but in older age groups the corresponding figures were 27% and 23% of the bison. Changes in the bone and joint system did not occur at all in calves, but were found in 9% of the 1—4 year old and 12% of older animals. In both older age groups other diseases also occurred such as, for instance, scour. Only 2 bison from the youngest age groups (12%) and 2 from the oldest group (12%) were considered as healthy after dissection, and the reason for such elimination in the case of adult animals was their aggressiveness constituting a danger to humans.

This cursory analysis of the health of the bison examined may point to the large number of individuals with various diseases. It must not, however, be forgotten that animals which differed in some way from the normal, e.g., lame or emaciated etc. individuals, were the first to be eliminated from the herd.

A separate problem is formed by the scanty knowledge we have of the normal physiological state of bison. There can be no doubt that a certain part of the population is invaded by parasites to a degree not necessarily disturbing physiological balance. Also in a certain percentage of animals with diseases of traumatic origin no deterioration in condition was observed. It may, however, be considered that the pathological factors discussed above form the causes of the wide range of variation in hematological data, and therefore of the great standard deviation. This applies particularly to WBC indices, the reaction of which to infection is most distinct. The wide range of variation in hematological parameters is the more astonishing since the Białowieża herd of European bison is to a great extent inbred. It may be that this is the cause of their lowered resistance.

In comparison with corresponding parameters for lowland black-and-white domestic cattle in Poland (Stankiewicz *et al.*, 1962) the red cell hemogram of the bison is characterized by higher values. This is certainly connected with the greater vigour of the European bison as a wild-

*hepatica* and *Dictyocaulus viviparus*, occurred in both free-ranging bison and those from enclosures, the percentage of diseased animals was calculated from the whole sample, excluding the 9-year old bull anaesthetized with immobilon, which was not dissected.

living species. The bison leukogram, on the other hand, although distinguished by a lower number of leukocytes, but lymphocyte percentage and neutrophil percentage are almost identical in both species (Table 5).

It is an interesting fact that the hematological values of American bison (Marler, 1975) are far higher than in European bison. This applies to Hb value, Htc value and WBC count. It may be that this difference is due to the time at which samples were taken. In American bison blood was sampled in October, that is, at a time more favourable from the food aspect than the winter months in which the European bison were examined. Although the latter are abundantly supplied with hay in winter, this food most certainly is not as varied and fully nourishing as that they consume during the growing period of plants. It may be

Table 5  
Comparison of hematology mean values for domestic cattle,  
American bison and European bison.

	Domestic cattle <sup>1</sup>	American bison <sup>2</sup>		European bison	
	3—9 yrs (adults)	>2 yrs	>2 yrs (adults)	1—4 yrs	>4 yrs (adults)
Hb, g/100 ml	9.10	16.60	17.20	10.35	12.18
RBC, 10 <sup>6</sup> /mm <sup>3</sup>	5.40	—	—	6.39	6.09
Htc, %	—	49.80	50.00	30.33	35.16
RBC diam., $\mu$	5.3—6.4	—	—	5.40	5.49
MCH, pg	16.70	—	—	16.18	20.22
MCHC, %	—	33.33	34.40	33.94	34.90
WBC, 10 <sup>3</sup> /mm <sup>3</sup>	9.44	8.00	6.99	4.73	4.82
Lymph., %	42.6	56.0	42.0	34.5	46.5
Neutroph., %	46.7	34.0	46.0	58.3	43.8
Eosinoph., %	11.3	7.0	10.0	7.0	8.4
Monoc., %	0	2.0	1.0	0	1.3
Basoph., %	0	0	0	0	0
Lymph./Neutr.	0.96	1.65	0.91	1.69	1.06

<sup>1</sup>Stankiewicz *et al.*, 1962; <sup>2</sup>Marler, 1975

connected also with the probably stricter natural selection in herds of American bison. Lymphocyte percentage in young is higher than in European bison, which may contribute to the former's greater resistance. The very similar percentage content of eosinophils in both species of the genus *Bison* and in domestic cattle, and also the almost negligible number of monocytes and basophils, is very striking.

Hematological values in the herd of European bison from the Białowieża Primeval Forest are important to an assessment of the state of health of the present and future population and for breeding purposes in closed centres. Further data on seasonal variation in blood indices are required, and also on the range of their variation in individuals, populations and age groups of *Bison bonasus*.



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## HEMATOLOGIA ŻUBRÓW Z WOLNO ŻYJĄCEGO STADA

## Streszczenie

Przedstawiono wartości parametrów i wskaźników hematologicznych 46 żubrów, *Bison bonasus* (Linnaeus, 1758) z Puszczy Białowieskiej, w tym 37 żubrów z wolnego stada oraz 9 żubrów z hodowli zamkniętej. Dane pochodzą od żubrów odstrzelonych zimą w ramach selekcji przeprowadzanej w latach 1972—1982.

Stwierdzono istotne różnice w wartościach niektórych parametrów i wskaźników krwi, związane z wiekiem badanych żubrów (Tabele 1 i 2, Ryc. 1). U dojrzałych płciowo żubrów w wieku ponad 4 lata poziom hemoglobiny (Hb), grubość erytrocytów (RBC thick.) oraz wskaźniki średniej zawartości hemoglobiny w krwince (MCH) i średniej objętości krwinki (MCV) są wyższe, niż u zwierząt młodych (Tabela 1, Ryc. 1). Procent eozynofiliów zwiększa się z wiekiem zwierząt i jest wyższy u żubrów dwu starszych grup wiekowych, niż cieląt. Liczba limfocytów jest niższa w grupie żubrów w wieku ponad 4 lata w porównaniu z cielętami. Wskaźnik Limfocyty: Neutrofile regularnie obniża się z wiekiem żubrów (Tabela 2, Ryc. 1). U zwierząt z hodowli zamkniętej stwierdzono nieco inny typ związanych z wiekiem żubrów zmian w wartościach hematologicznych (Tabele 3 i 4, Ryc. 1).

Porównano parametry krwi żubra, bizona amerykańskiego, *Bison bison* (Linnaeus,

1758) i bydła domowego nizinnego rasy czarno-białej (Tabela 5). Parametry czerwonekrwinkowe żubra (poziom hemoglobiny, liczba czerwonych ciałek, wartość hematokrytu) są wyższe niż u bydła domowego, natomiast są znacznie niższe niż u bizona.

Zwrócono uwagę na częstość występowania chorób inwazyjnych wśród badanych żubrów (od 12—82% w poszczególnych grupach wiekowych), a także na powszechność innych schorzeń, co może rzutować na duży zakres zmienności danych hematologicznych.