A C T A T H E R I O L O G I C A

VOL. XVI, 28: 439—447. BIAŁOWIEŻA December, 1971

BISONIANA XLIII

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Morphological Blood Indices in Hybrids of European Bison and Domestic Cattle

[With 6 Tables and 1 Fig.]

The morphological blood picture in European bison and domestic cattle hybrids (5 individuals of the F_1 generation and 19 od the B_1 generation) is described and also compared with data for the parental forms. The average volume of red cells and *MCH* are significantly greater statistically in F_1 than in B_1 hybrids. The values of red cell system indices are higher in hybrids of both generations than in European bison and domestic cattle. The leukocytic blood picture in hybrids is lymphocytic in character, and consequently the ratio of $L:N$ is almost twice higher in hybrids than in cattle and five times higher than in European bison.

I. INTRODUCTION

The level of morphological blood indices reflects the metabolic intensity of animal organisms. The phenomenon of heterosis, characteristic of inter-genera hybrids, is manifested chiefly in changes in growth and development metabolism and in the productivity and hardiness of the animals. These processes are regulated by a complicated system of physiologically active substances differing in different species and breeds. Crossbreeding or mutation causes imbalance of the evolutionally established equilibrium of genes regulating physiological systems. The formation of a new equilibrium of active substances produces in effect increased or decreased vigour (K o ł ą t a j, 1967).

It is to be expected that the vigour observed in hybrids of the European bison and domestic cattle, particularly in the first generation, will be reflected in the blood picture. On this account studies were made of the morphological indices of the erythro- and leukocyte systems in F_1 and B_1 hybrids, and the results obtained compared with data for the parental forms.

II. MATERIAL AND METHODS

Studies were made of hybrids of European bison crossbred with cattle [black and white lowland (*bw*) and Polish red (*pr*)] obtained during the period from 1960—1969 in the Mammals Research Institute of the Polish Academy of Sciences

Table 1

Morphological indices of the leukocyte count in hybrids of generations F_1 and B_1.

Name & age, years	Leukocytes per c. mm	Lymphocytes, %	Eosinophils, %	Basophils, %	Neutrophils, %	Monocytes, %	Limph / Neutr.	Remarks
			F_1 generation					
Fakir, 5	4,500	62.5	8.5		29.0		2.2	1)F.++
Farad, 6 1/2	11,500	95.5	1.5		2.5	0.5	38.2	1)
Filutka, 7	3,800	54.0	2.0		44.0		1.2	1)
Filip, 8	7,725	57.0	5.5		37.5		1.5	1)
Fama, 9	6,487	58.0	10.3	0.7	30.3	0.7	1.9	1)
			B_1 generation					
Felpa, 1	12,950	65.0	6.0		29.0		2.2	3)
Felly, 1 1/4	5,925	87.5	6.0		5.5	1	15.9	1)
Ferma, 1 1/2	14,950	66.0	4.0	1.3	27.0	1.7	2.4	1)
Feld, 1 1/2	8,600	56.0	9.0		35.0		1.6	2)
Fewa, 2	10,375	48.0	7.5		44.5		1.1	3)
Fenny, 2	15,425	21.5	14.5	1.5	61.5	1.0	0.3	3)
Fellach, 2	8,312	66.9	9.8		23.0	0.3	2.9	2)
Festyn, 2 1/2	8,750	51.5	9.0		39.5		1.3	1)F.+4)
Fema, 2 1/2	4,400							1)
Feb, 3 1/2	9,550	58.0	6.0		36.0		1.6	2)
Fen, 3 1/2	10,525	51.0	8.0		41.0		1.2	2)
Feg, 3 1/2	17,400	55.7	7.2		36.7	0.2	1.5	1)
Femina, 4	7,375	66.0	6.5		27.5		2.4	3)
Fey, 4	11,425	83.4	2.0		14.3	0.3	5.8	1)F.+
Fez, 4 1/2	6,800	43.0	4.0		52.0	1.0	0.8	2)
Fetysz, 4 1/2	6,000	44.0	12.0		44.0		1.0	2)
Fenix, 5 1/2	2,150	74.0	1.0		25.0		3.0	2)F.+
Felon, 1/2	6,737	82.0	1.7		15.7	1.0	5.2	1)C.+
Fest, 1/2	11,325	88.5	1.7		9.5	0.2	9.6	1)E.

1) Blood was taken: from shot animals; 2) From animals shot after transport; 3) From live animals; 4) *Cysticercus bovis* (?); F. — *Fasciola hepatica:* + small intensity, ++ great intensity; C. — Cestods in intestines; E. — *Endocarditis fibrinosa.*

at Białowieża. Blood was taken from 5 hybrids of the F_1 generation, aged from 5—9 years and from 19 individuals of the second backcross generation (B_1) (3/4 cattle) aged from 0.5—5.5 years. All the studies were carried out in autumn, except in the case of the hybrid »Filip« (June) and 4 individuals of generation B_1 (May). Blood was taken from the jugular vein, either from live animals (4 individuals) or animals

which had been shot. Some of the latter were shot in the nature reserve, and the remainder in the local slaughterhouse 7 km away, to which they had been taken in cages (Table 1). Hemoglobin content was defined with a Zeiss hemometer, erythrocytes were counted in a Thom chamber, leukocytes in a Bürker chamber, and the percentages of the various forms of leukocytes in the total amount were defined in blood smears stained by the Pappenheim method. Using a Zeiss micrometric ocular and the same smears calculation was made of the diameter of erythrocytes, taking 50 measurements of red cells of one individual. This amount was sufficient for calculating averages. The volume of cellular elements of blood (hematocrit) was defined by the microhematocrit method. Anisocytosis curves were drawn for individuals of both generations.

Calculation was made of the mean corpuscular hemoglobin (*MCH*), average volume and thickness of red cells, mean corpuscular hemoglobin concentration (*MCHC*) and ratio of lymphocytes to neutrophils (*L* : *N*).

The two generations of hybrids were described by means of average values of the various indices. The significance of differences between the average values for the two generations of hybrids was checked by Student *t* test for difference in averages for two independent groups. The correlation coefficient was calculated between the mean hemoglobin and body weight of the animals. The data given in tables 1 and 2 for two hybrid calves of the B_1 generation aged 6 months were not used in calculations, as at that age the morphological composition of the blood is not yet stabilized. The remaining B_1 generation animals were treated as forming one age group. According to Holman (1956) the blood picture is established in cattle at the age of about 1.5 years.

Blood morphology for European bison elaborated on the basis of blood analysis of four European bison in the Internal Diseases Clinic of the Veterinary Faculty of Warsaw Agricultural University (Tomicki, pers. com.) was supplemented by material obtained in our own studies from one female European bison. Comparative material in relation to cattle was obtained from data on the black and white lowland breed (Stankiewicz *et al.*, 1962).

III. RESULTS AND DISCUSSION

Individual results for various animals are given in tables 1 and 2 on account of the unique character of the material.

No significant differences were found in values of indices for males and females, or age differences. The number of hybrids studied in spring was too small to enable seasonal differences to be considered, and the results were therefore analyzed in two groups: the first generation of hybrids (F_1) and first backcross generation (B_1).

Comparison of morphological blood indices for hybrids of the two generations (Table 3 and 4) shows that the mean corpuscular hemoglobin (*MCH*) is significantly greater in the F_1 generation ($.05 > P > .02$), and average volume of red cells is on the borderline of significance ($P = .05$).

Heterosis characteristic of the F_1 generation is also manifested in the greater diameter and thickness of red cells in this generation, although the differences are not statistically significant. The other indices do not

differ significantly. It would, however, appear that hybrids of the back-cross generation (B_1) have more favourable conditions for gas metabolism, as a larger number of erythrocytes of smaller dimensions occur in them, and thus their overall area is greater.

Table 2

Morphological indices of the red cell system in hybrids of generations F_1 and B_1.

Name & Body wt., kg	Hb Conc., g/100 ml	RBC, mln	MCH, $\gamma\gamma$	Hemato-cirt, %	RBC diameter, μ	RBC thickness, μ	RBC vol., μ^3	MCHC, %
			F_1 generation					
Fakir++ 841	15.0	6.1	24.4	46.0	5.6	3.1	74.8	32.6
Farad+++ 1015	15.1	6.6	22.9	45.5	5.9	2.5	68.9	33.2
Filutka+ 490	16.8	10.4	16.1	35.0	5.6	1.4	33.6	48.0
Filip+ 830	13.6	4.2	32.3	41.5	5.5	4.1	98.6	32.8
Fama++ 532	12.2	7.4	16.4	38.5	6.3	1.7	51.7	31.7
			B_1 generation					
Felpa+ 310	15.0	16.5	9.1		5.6			
Felly 279	16.5	11.9	13.8	53.0	5.3	2.0	44.4	31.1
Ferma 284	14.0	9.4	15.0	45.7	5.0	2.4	48.8	30.6
Feld 330	13.8	10.2	13.5	41.0	5.1	2.0	40.1	33.7
Fewa 340	12.3	10.4	11.8	43.0	5.5	1.7	41.2	28.6
Fenny++ 400	13.0	11.2	11.6	46.7	5.9	1.5	41.7	27.8
Fellach+ 520	15.1	12.1	12.4	50.0	5.4	1.9	41.3	30.5
Festyn++ 540	15.0	11.0	13.7	53.5	5.1	2.4	48.9	29.0
Fema 330	14.0	6.3	22.1	34.5			54.4	40.6
Feb 540	13.9	9.4	14.7	48.5			51.5	28.7
Fen 580	13.9	8.5	16.3	42.0	5.6	2.0	49.1	33.1
Feg+ 552	14.3	11.1	12.9	50.0	5.2	2.1	45.2	28.4
Femina 390	13.2	12.0	11.0	40.2	5.8	1.3	33.5	32.8
Fey+ 672	13.6	9.4	14.5	38.3	5.3	1.9	40.8	35.5
Fez 613	14.1	9.4	15.1	39.0	6.0	1.5	41.6	36.1
Fetysz 567	14.2	6.7	21.3	31.3	6.1	1.6	47.0	45.4
Fenix 520	10.9	6.0	18.1	34.0	5.4	1.9	56.6	32.1
Felon++ 286	12.5	8.6	14.6	45.8	4.8	3.0	53.6	27.3
Fest++ 263	15.5	13.1	11.8	55.6	4.8	2.3	42.3	27.9

The degrees of intensity of heterosis up to 6 months od life are shown: + weak, ++ strong, +++ stronger.

The distribution of measurements of erythrocyte diameters is similar to the normal one (Table 5). Anisocytosis of red cells in hybrids of B_1 generation is greater than in F_1 generation, which agrees with the general tendency for greater divergence of characters in more distant generations of hybrids (Fig. 1).

As heterosis of hybrids is expressed, *inter alia*, in a rise in hemoglobin

Table 3

Average values and confidence intervals of morphological indices of the erythrocytic system in hybrids of European bison and domestic cattle.

Generation	N	Hb Conc., g/100 ml	*RBC*, mln.	*MCH*, $\gamma\gamma$	Hematocrit, %	*RBC* diameter, μ	*RBC* thickness, μ	*RBC* vol, μ^3	*MCHC*, %
F_1	5	14.5 ± 2.3	6.9 ± 2.5	22.4 ± 7.5	41.3 ± 5.2	5.8 ± 1.5	2.6 ± 0.4	65.5 ± 27.4	35.7 ± 7.4
B_1	17	13.9 ± 0.8	10.1 ± 1.2	14.5 ± 1.8	43.2 ± 3.4	5.5 ± 0.2	1.9 ± 1.7	45.4 ± 3.1	32.7 ± 3.5

Table 4

Average values and confidence intervals of morphological indices of the leukocytic blood picture in hybrids of European bison and domestic cattle.

Generation	N	Leukocytes per c.mm.	Lymphocytes, %	Eosinophils, %	Basophils, %	Neutrophils, %	Monocytes, %	Lymph. / Neutr.
F_1	5	6802 ± 3393	65.4 ± 19.1	5.6 ± 3.1	0.1 ± 0.3	28.7 ± 5.6	0.2 ± 0.4	1.7 ± 2.4[1])
B_1	16	9948 ± 1215	58.6 ± 8.2	7.0 ± 1.7	0.2 ± 0.1	33.8 ± 1.8	0.3 ± 0.3	1.9 ± 1.0[2])

Average ratio $L : N$ in generation F_1 and B_1 (3/4 cattle) was calculated, omitting the hybrids »Farad« and »Felly«, the results of which raised the average value twice or three times. [1]) Without »Farad«, [2]) Without »Felly«.

Table 5

Distribution of values of erythrocyte diameter measurements (in %).

Generation	3.00—3.49	3.50—3.99	4.00—4.49	4.50—4.99	5.00—5.49	5.50—5.99	6.00—6.49	6.50—6.99	7.00—7.49	7.50—7.99
F_1	—	—	0.83	10.00	30.83	40.00	17.08	1.25	—	—
B_1	0.25	0.50	5.69	19.60	32.24	26.04	13.15	1.90	0.50	0.13

level (P a t r u s h e v, 1938a), the body weight of animals was correlated with the amount of hemoglobin found in them. No correlation of this kind was found ($r = .13$). This lack of correlation may possibly have been due to the fact that hemoglobin content was compared in adult animals, whereas heterosis is most strongly manifested during the first six months of life (K r a s i ń s k a, 1969) (cf. Table 2).

Fasciola hepatica was found to be present in four individuals and tapeworm (*Taenia* sp.) in one. Parasitization of the animals did not appear to have had any distinct effect on the leukocyte count (cf. Table 1).

It is interesting to compare blood indices for hybrids with the corresponding values characterizing European bison and domestic cattle (Table 6).

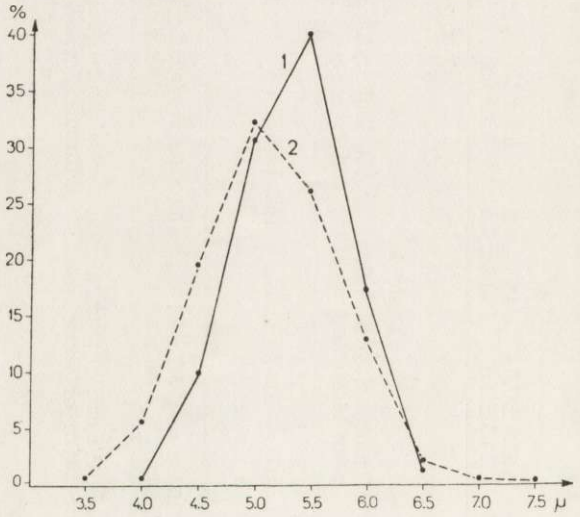

Fig. 1. Anisocytosis curves of hybrids. 1 — F_1, 2 — B_1 generation.

The blood indices of the hybrids of both generations are highest in the red cell system. Changes of this type in the blood picture, pointing to better oxygenation of the blood and consequent more intensive metabolism, were found in a large number of hybrids, *e.g.* in the nars (hybrid obtained by crossbreeding Arabian and Bactrian camels), mules, hybrids of the yak and cattle (K u s h n e r, 1938; P a t r u s h e v, 1938b).

The total number of leukocytes is similar in all the groups of animals examined, but the differential leukocyte count distinctly differs. While it is of a lymphocytic character in hybrids of the two generations, in European bison there is distinct predomination of neutrophils, and in cattle almost balanced occurrence of the two basic forms of leukocytes. Hence the ratio of lymphocytes to neutrophils, almost balanced in cattle and far lower

in European bison, attains a value almost twice higher in hybrids than in domestic cattle.

F o l e j e w s k i (1962) connects the ratio of granulocytes to agranulocytes with the constitutional and utility type of the animals. In this

Table 6

Comparison of average values of some morphological blood indices for domestic cattle, European bison and hybrids of the European bison and cattle of generation F_1 and B_1. Average, maximum and minimum values are given.

Indices	Domestic cattle *bw*	Europen bison	Hybrids	
			F_1	B_1
Hb Conc., g/100 ml	9.1	12.3 11.0—13.0	14.5 12.2—16.8	13.9 10.9—16.5
RBC, mln	5.4	6.4 5.6—7.6	7.0 4.2—10.4	10.1 6.0—16.5
Hematocrit, %		40.3 30.5—52.3	41.3 35.0—46.0	43.2 31.3—53.5
MCH, $\gamma\gamma$	16.7	19.1	22.4 16.1—32.3	14.5 9.1—22.1
RBC diameter, μ	5.3—6.4		5.8 5.5—6.3	5.5 5.0—6.1
RBC thickness, μ			2.6 1.4—4.1	1.9 1.3—2.4
RBC vol., μ^3			65.5 33.6—98.6	45.4 33.5—56.6
MCHC, %			35.7 31.7—48.0	32.7 27.8—45.4
Leukocytes per c. mm.	9440	7425	6802 4500—11500	9948 2150—17400
Lymphocytes, %	42.6	25.7 18.0—33.0	57.9[1]) 54.0—62.5	58.6 21.5—87.5
Eosinophils, %	11.3	1.7	5.6 2.0—10.3	7.0 1.0—14.5
Basophils, %			0.1	0.2
Neutrophils, %	46.7	68.3 61.0—74.0	28.7 2.5—44.0	33.8 5.5—61.5
Monocytes, %		4.3 2.0—8.0	0.2	0.3 0.2—1.0
L : *N*	0.96	0.37	1.7[1])	1.9[2])
Author and data	Stankiewicz *et al.*, 1962	our own data and Tomicki pers. comm.	our own data	our own data

1) Without »Farad«, 2) Without »Felly«.

author's opinion, the higher percentage of agranulocytes, in particular of lymphocytes, in the peripheral blood occurs in animals with less intensive metabolic processes. He connects physiological lymphocytosis with the greater resistance of the organism to certain diseases, as lymphocytes

participate in formation of globulin. The hardiness and greater resistance to extreme habitat conditions observed in hybrids of European bison and cattle (Krasińska & Pucek, 1967) is reflected in the predominance of lymphocytes in the leukocytic picture of the blood.

In summing up it is necessary to emphasize the intensivity of the metabolic processes in hybrids, which is reflected in the increased red cell indices in relation to the initial forms. This is manifested particularly clearly in the higher mean corpuscular hemoglobin and greater number of erythrocytes. A second important character of the blood in hybrids is the lymphocytic character of the leukocytic picture, which is connected with the greater resistance and hardiness of the animals.

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Accepted, August 5, 1971.

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MORFOLOGICZNE WSKAŹNIKI KRWI HYBRYDÓW ŻUBRA Z BYDŁEM DOMOWYM

Streszczenie

Przedstawiono wyniki badań nad morfologią krwi mieszańców żubra z bydłem domowym, uzyskanych w Zakładzie Badania Ssaków PAN w Białowieży. Do badań użyto 5 sztuk hybrydów F_1 w wieku 5—9 lat i 19 sztuk pokolenia wstecznego (B_1) w wieku 0,5—5,5 lat (Tabele 1 i 2). Uzyskane wyniki porównano z danymi dla żubrów i bydła rasy ncb.

Porównanie wskaźników morfologicznych krwi mieszańców obu pokoleń (Tabela 3 i 4) wykazało, że ilość Hb w krwince (*MCH*) jest w pokoleniu F_1 statystycznie istotnie wyższa niż w B_1 ($.05>p>.02$), a objętość krwinek różni się na granicy istotności ($p = .05$). Heterozja występująca w I pokoleniu mieszańców zaznaczyła się również w większej średnicy i grubości krwinek, jakkolwiek różnice między pokoleniami nie są istotne statystycznie.

Anizocytoza erytrocytów pokolenia B_1 jest większa niż w pokoleniu F_1 (Fig. 1, Tabela 5).

Nie stwierdzono korelacji między ciężarem ciała mieszańców a ilością Hb ($r = .13$).

W układzie czerwonokrwinkowym wskaźniki krwi mieszańców obu pokoleń przewyższają dane charakterystyczne dla żubrów i bydła rasy ncb (Tabela 6). Fakt ten można wiązać z lepszym utlenieniem krwi mieszańców. Umożliwia to w efekcie intensywniejszy metabolizm, co jest wyrazem heterozji obserwowanej szczególnie w pierwszym pokoleniu mieszańców. Ogólna liczba leukocytów jest podobna we wszystkich grupach zwierząt. Natomiast różni się obraz białokrwinkowy. U mieszańców ma on charakter limfocytowy. W związku z tym stosunek L : N jest u nich prawie dwukrotnie wyższy niż u bydła i pięciokrotnie wyższy niż u żubrów. Przewaga limfocytów w białokrwinkowym obrazie krwi może być związana ze wzrostem odporności mieszańców i wytrzymałości na skrajne warunki klimatyczne.