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Biometric Analysis of Some Internal Organs of Hybrids between the European Bison and Domestic Cattle

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The liver, heart and kidneys of 32 hybrids of different generations between the European bison and domestic cattle were subjected to a biometric analysis and the results obtained were compared with data for the initial forms. Despite a great difference in body weight (80%) F_1 males have a relatively lighter liver, heart and kidneys than females. In B_1 males the weight of the heart in relation to that of body is larger and the weights of the liver and kidneys smaller than in females. The liver and heart of both sexes of F_1 hybrids and the kidneys of males are heavier in relation to body weight than they are in the two initial forms. In the B_1 generation the liver and heart also have a higher relative weight than they have in the European bison and cattle, but the differences are smaller than in the case of F_1 hybrids except the relative weight of the liver in B_1 females. As regards the build of these internal organs, the European bison characters are dominant in the liver (thickness, backwardness of the left lobe as compared with the size of the right and quadrate lobes) and in the number of the renal lobes. The dominance of the cattle characters was found in the size of the caudate process of the liver in the F_1 hybrids, the higher weight of the left kidney compared with the right one in hybrids of both sexes, and the greater relative weights of the heart and liver in females than in males. The morphological characters typical of the hybrids, such as the icicle-shaped heart, are also observed. As the share of cattle blood increases in backcross hybrids, their internal organs show more similarity to those of the cattle.

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I. INTRODUCTION

The occurrence of hetorosis during the postnatal development of F_1 hybrids between the European bison and domestic cattle prompted us to carry out a close investigation of some internal organs. The commonest signs of heterosis in these hybrids is the acceleration of growth and differentiation of tissues, the attainment of a large body weight and changes in metabolism (Kirpichnikov, 1960; Hutt, 1972; Kołataj, Krzanowska & Wolański, 1973). The intense development

of the Białowieża F_1 hybrids caused that they reached a larger body weight and size than the initial forms in the period of great juvenile growth and at their adult age (Krasińska, 1969).

The purpose of the present work was to find whether heterosis observed in the F_1 generation of hybrids has an effect on the size of the internal organs. At the same time an attempt was made to grasp possible regularities in the inheritance of the morphological characters of internal organs in hybrids in generations with different shares of blood of the initial forms.

Such organs as the liver, heart and kidneys, were subjected to a biometric analysis in this work. The spleen of hybrids is the subject of a separate paper (Pytel, Krasińska & Węgrzyn, 1976). Data concerning both parental forms, the European bison and cattle, were used for comparison.

II. MATERIAL AND METHODS

The material for study consisted of the organs of 32 hybrids of different generations obtained at a slaughter analysis carried out in 1969—1973 (Table 1). The F_1 generation was represented only by material derived from adult animals, whereas the B_1 hybrids were divided into three groups within either sex.

The method of slaughter of all hybrids was similar and is described in a paper by Szulc, Tropiło & Krasińska (1971). The hybrids, irrespective of what generation they belonged to, were fed according to the same principles, allowing for the physiological state, age and body weight, which secured a uniform state of animals in respect of their physical condition.

After their removal from the body cavities, the organs designed for study were weighed and fixed in 4% formalin. After fixation, which took at least 6 months, the organs were weighed again and their measurements were taken. Since the absolute weights of all organs decreased during fixation, the linear measurements must also have undergone changes, but seeing that this decrease concerned a three-dimensional solid body, the differences in dimensions in relation to the unfixed organs are not great. The organs were weighed to an accuracy of 1 g and measurements were taken to an accuracy of 1 mm by means of a pair of compasses, slide caliper and tape measure.

The weights of unfixed organs are given in absolute values and in relation to the body weight of hybrids. The significance of differences in weight between two kidneys was calculating according to Student's t test for comparison of two independent groups.

Measurement of the liver was carried out by the method adopted for cattle (Eichel, 1925), where the right lobe includes the quadrat lobe, which is important to the determination of the length of lobes. Measurements of the heart were taken by Schubert's (1909) method, applied also for the European bison by Węgrzyn (1968). The kidneys were measured according to the data given by Wehn (1924) and used for the European bison by Pilarski (1967).

No complete data concerning the morphological characters of the internal organs of the European bison and cattle were available for comparison. They chiefly concerned adult animals and in the case of the European bison were limited to one sex or based on scanty material. Papers by Schneider (1904), Schubert (1909)

and Eichel (1925) provide the most numerous and complete data about the morphological characters of the cattle organs. As regards the European bison, we based ourself on the investigations carried out by Pilarski (1967), Węgrzyn (1968) and Pytel & Węgrzyn (1976).

III. RESULTS

1. Liver

1.1. Absolute and Relative Weight of Unfixed Liver

The liver of F_1 males outweighs that of females by 61.3%, whereas in the B_1 generation on the contrary the absolute weight of the liver of females is slightly higher (2.5%) than that in males. In both generations of adult hybrids the relative weight of the liver in females is greater than

Table 1

Material examined.

No.	Name	Generation	Age, years	Body weight	Body length (oblique)
			MALES		
1.	Fakir	F_1	5	841	210
2.	Farad	F_1	6.5	1015	205
3.	Filip	F_1	8	885	188
4.	Facet	F_1	12.5	1080	—
5.	Filon	F_1	13.5	805	194
6.	Fest	B_1	0.5	263	133
7.	Felon	B_1	0.5	286	135
8.	Feld	B_1	1.5	380	156
9.	Fellach	B_1	2.0	500	167
10.	Festyn	B_1	2.5	540	172
11.	Fen	B_1	3.5	580	157
12.	Feb	B_1	3.5	540	167
13.	Feg	B_1	3.5	552	172
14.	Fey	B_1	4.0	675	182
15.	Fez	B_1	4.5	613	165
16.	Fetysz	B_1	4.5	567	168
17.	Fenix	B_1	5.5	520	154
			FEMALES		
1.	Fatima	F_1	4.5	520	168
2.	Filutka	F_1	7.0	490	153
3.	Fama	F_1	9.0	532	161
4.	Feeria	B_1	0.5	236	132
5.	Felly	B_1	1.0	279	136
6.	Ferma	B_1	1.5	284	138
7.	Fema	B_1	2.5	330	145
8.	Felpa	B_1	4.5	552	163
9.	Feska	B_1	4.5	596	180
10.	Fewa	B_1	5.5	547	172
11.	Fera	B_1	6.5	504	168
12.	Femina	B_1	7.5	449	160
13.	Fela	B_2	2.5	429	162
14.	Ferajna	B_2	4.5	565	183
15.	Fega	B_2	4.5	498	178

F_1 — hybrids first generation; B_1 — backcross hybrids; 1/4 bison 3/4 cattle
B_2 — backcross hybrids 1/8 bison 7/8 cattle

in males (Fig. 1). It should be emphasized that the males of both generations have a greater body weight by as much as 80% in the F_1 generation and by 9% in the B_1 generation. The size of liver in males of both generations was proportional to their body weight (Fig. 1). In the group of adult females of both generations there is a great similarity in the

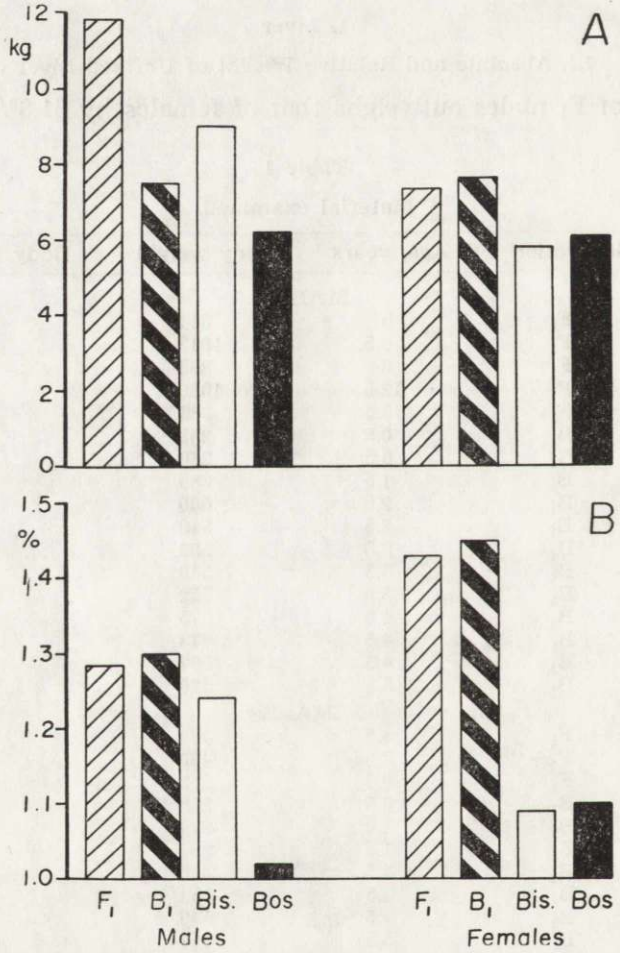

Fig. 1. Absolute (A) and relative (B) liver weight.
Bis. — *Bison bonasus* (after Pytel & Węgrzyn, 1976), *Bos* — *Bos taurus* (after Eichel, 1925).

absolute and relative weight of the liver (Table 2), which is plain, if one takes into consideration the similarity of the body weight of these animals.

In the B_1 generation of hybrids of both sexes the highest values of the relative weight of liver is noted in young animals 1.5—2.5 years old and

Table 2

Comparison of average liver measurements (± SD) of F_1, B_1 and B_2 hybrids (weights in g, linear measurements in mm).

Age in years	Males				Females				
	F_1 5—12.5	B_1 3.5—5.5	B_1 1.5—2.5	B_1 0.5	F_1 4—9	B_1 4.5—7.5	B_1 1—2.5	B_1 0.5	B_2 2.5—4.5
n	2	6	2	2	3	5	2	1	3
Absolute weight	11,860 ± 2,068[1]	7,470 ± 482[2]	6,733 ± 1,700[3]	3,695	7,353 ± 385	7,660 ± 1,020	4,720 ± 527[3]	3,000	6,127 ± 1,618
Weight after conservation	9,407 ± 1,296[3]	5.767 ± 1,473		2,800	5,200 ± 300	6,024 ± 1,135	3,150	2,900	5,077 ± 1,962
Relative weight	1.28	1.30	1.41	1.34	1.43	1.45	1.58	1.27	1.22
Length									
total	54	50 ± 3	43	37	47 ± 2	47 ± 3	36	31	46 ± 0
right and intermediate lobes	37	34 ± 2	28	22	31 ± 1	29 ± 2	19	21	30 ± 1
left lobe	15	15 ± 2	15	14	16 ± 2	17 ± 3	12	10	16 ± 1
caudate process	16	18 ± 2	16	13	15 ± 2	14 ± 4	13	13	18 ± 4
Breadth									
right lobe max.	34[4]	27 ± 2	25	22	29 ± 3	30 ± 2	24	20	28 ± 1
right lobe min.	28[4]	22 ± 1	21	18	24 ± 2	26 ± 2	22	16	24 ± 1
left lobe	23	22 ± 3	19	12	22 ± 3	23 ± 3	21	14	22 ± 1
caudate process	10	11 ± 2	12	8	10 ± 2	7 ± 3	7	6	11 ± 3
Thickness									
right lobe	12	10 ± 1	9	9	9 ± 1	10 ± 1	7	10	8 ± 3
left lobe	4	6 ± 1	4	5	4 ± 0	5 ± 2	5	6	5 ± 2
caudate lobe	10[4]	9 ± 1	9	5	7 ± 1	11 ± 1	6	6	7 ± 3
caudate process	5	7 ± 2	6	4	5[5]	5 ± 2	4	5	4 ± 3

[1] n=5; [2] n=7; [3] n=3; [4] n=1; [5] n=2

the lowest in a half-year old female. The females of the B_2 generation have the lowest relative weight of liver of all the animals under study (Table 2).

1.2. Linear Measurements of Fixed Liver

In adult hybrids of both generations the right and quadrate lobes are better developed than the left and caudate ones (Table 2). The left lobe is somewhat longer than half the length of the right and quadrate lobes and the thinnest of all. These differences are however smaller in the B_1 generation, which causes that in it the liver is more elongate in shape than in the F_1 generation. All the measurements of the right and quadrate lobes in the F_1 males exceed those in the B_1, the measurements of the left lobe being similar (Table 2). In females of both generations the shape and dimensions of the liver are similar (Table 2).

The caudate lobe of the liver of hybrids is considerably thicker, sometimes twice as thick as the left lobe but only exceptionally exceeds the thickness of the right lobe.

It may be stated that during the postnatal development of B_1 hybrids of both sexes (assuming the half-a-year-old animal as the starting point) the highest increase occurs in the thickness of the caudate process in males (1.9-fold increase) and in the thickness of the caudate lobe in the hybrids of both sexes (1.8) and the lowest in the thickness of the caudate process of females (1.04) and in the length of the left lobe in males (1.1).

1.3. Comparison of Adult Hybrids and Initial Forms in Respect of the Morphological Characters of Liver

A paper by Pytel & Węgrzyn (1976) shows that the livers of the European bison and cattle have many similar characters, differing only in morphological details. The shape of the liver of the former species is most frequently triangular, while in the latter it is elongate. With the similar overall length of the liver in the two species, in European bisons the measurements of the right and quadrate lobes are larger and those of the left lobe smaller than in cattle. The relative weight of the liver of bison females is lower and that of males higher than it is in cattle (Pytel & Węgrzyn, 1976).

F_1 hybrids of both sexes exceed the initial forms in respect of both the absolute and the relative weight of the liver (Fig. 1). The differences in weight in relation to cattle are distinct in males, while in females they come out only in comparison with the data given by Eichel (1925). The relative weight of liver given for domestic cows in other papers is higher (Schneider, 1904; Kwiatkowski, 1973). The

absolute weight of liver in B_1 males is intermediate between those of F_1 and cattle, whereas in B_1 females it is the highest (Fig. 1). In the hybrid females of both generations the relative weight of liver is higher than in males, just as it is in cattle (Schneider, 1904; Eichel, 1925) and inversely to the situation in the European bison (Pytel & Węgrzyn, 1976) (Fig. 1).

In the liver of F_1 males the right and quadrate lobes show a stronger development as compared with the measurements of the left lobe, which is also the case with the liver of the European bison (Table 3). The livers of the females of both generations have the overall length

Table 3

Comparison of average liver measurements of adult hybrids, European bison and cattle (in mm).

Measurements	Males				Females			
	Hybrids		European bison[1]	Cattle[2]	Hybrids		European bison[1]	Cattle[2]
	F_1	B_1			F_1	B_1		
Length								
whole liver	537	489	531	533	467	467	561	557
right and intermediate lobes	370	342	383	300	307	292	396	307
left lobe	152	155	152	233	160	175	168	250
caudate process	162	178	202	162	153	145	217	156
Breadth								
right lobe max.	340	266	390	310	290	298	378	329
left lobe	232	223	216	268	220	230	206	270
caudate process	105	107	94	100	103	73	92	102
Thickness								
right lobe	121	105	104	90	88	97	88	84
left lobe	42	58	44	37	42	46	38	37

After: [1] Pytel & Węgrzyn (1976); [2] Eichel (1925).

smaller than it is in both initial forms. The thickness of the hepatic lobes in the hybrids of both generations is greater than in cattle, verging upon or even higher than that of the European bison. The measurements of the caudate process in the hybrids of both generations are smaller than in the European bison and approximate those in cattle (Table 3).

2. Heart

2.1. Absolute and Relative Weight of Unfixed Heart

In F_1 males the heart is heavier than in females on the average by 69.4%, the situation being reversed as regards the relative weight. In adult B_1 hybrids the heart of males is on the average 25% heavier than the heart in females, but in contradistinction to what is observed in the F_1 its relative weight is also higher in males than in females (Fig. 2). The size of heart in the hybrid males of both generations is proportional to

the body weight (Table 4), whereas the F_1 females have a heavier heart, in relation to their body weight, than the B_1 females (Fig. 2).

During the postnatal development the relative weight of heart decreases with age in B_1 hybrids of both sexes (one female, half a year old, was an exception). In B_2 females the relative weight of heart was the lowest compared with that of the other hybrids (Table 4).

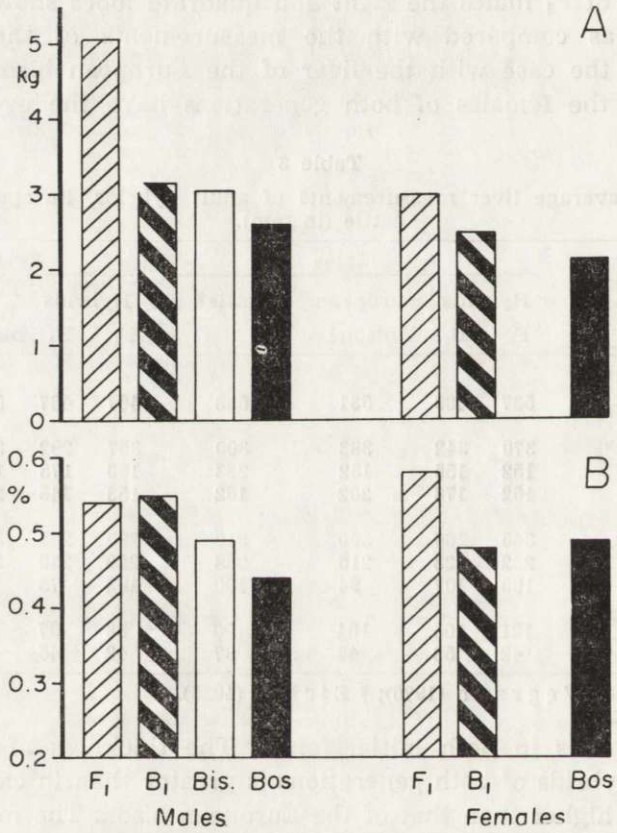

Fig. 2. Absolute (A) and relative (B) heart weight.
Bis.— *Bison bonasus* (after Węgrzyn, 1968), *Bos* — *Bos taurus* (after Schneider, 1904).

2.2. Measurements of Fixed Hearts

In F_1 hybrids the heart has greater measurements in males than in females and in B_1 hybrids of both sexes all the measurements of the heart are similar (Table 4). During the postnatal development the heart of B_1 hybrids of both sexes shows a similar rate of increase. The height of the right ventricle increased most with age in comparison with the half-a-year-old animals (1.4-fold).

The heart of F_1 males is higher and more flattened and in B_1 males more spherical. The heart of F_1 females is slendered than in the B_1.

2.3. Comparison of Adult Hybrids and Initial Forms in Respect of some Morphological Characters of Heart

Węgrzyn's (1968) paper shows that there are some morphological differences between the hearts of the European bison and cattle. The heart of male European bisons has a higher absolute weight and relative weight and greater measurements than the heart of the bulls of cattle. It is higher and more flattened and in consequence it attains the shape of a cone, strongly dilated at the base and laterally flattened. The heart of female European bisons is lower but, like that of males, is also broader and more flattened than in domestic cows.

Table 4

Comparison of average heart measurements (±SD) of F_1, B_1, B_2 hybrids (weights in g, linear measurement — in mm).

Group; Age, years	n	Weight			Height			Width		
		Absolute	After conservation	Relative	Left surface	Right surface	Right ventricle	Min.	Max.	Circumference
Males F_1 5—12.5	3	5,060 ±1113	4,133 ±742	0.54	233 ±14	202 ±14	162 ±27	158 ±10	207 ±20	586 ±1
Males B_1 3.5—5.5	7	3,157 ±167	2,630 ±242	0.55	205 ±15	179 ±21	152 ±18	136 ±9	190 ±12	481 ±20
Males B_1 1.5—2.5	3	2,727 ±835	2,148 ±851	0.57	181 ±28	169 ±15	150 ±7	128 ±6	171 ±33	451 ±50
Males B_1 0.5	2	1,760	1,561	0.65	168	138	109	105	159	423
Females F_1 4—9	3	2,987 ±61	2,700 ±80	0.58	214 ±4	203 ±4	170 ±10	134 ±10	187 ±6	477 ±14
Females B_1 4.5—7.5	5	2,526 ±353	2,426 ±267	0.48	205 ±23	172 ±8	147 ±11	134 ±15	189 ±16	523 ±20
Females B_1 1—2.5	2	1,867 ±354 [1]	1,586	0.62	163	154	127	103	159	432
Females B_1 0.5	1	1,200	1,250	0.51	165	135	105	105	151	422
Females B_2 2.5—4.5	3	2,163 ±271	2,138 ±317	0.43	196 ±24	162 ±5	129 ±10	128 n=2	160 n=2	445 n=2

[1] n=3

The heart of F_1 males is characterized by its higher absolute and relative weight as compared with both initial forms (Fig. 2) and so is the heart of F_1 females in relation to domestic cows (lack of data does not permit a comparison with this organ in female European bisons). In F_1 hybrids, as in cattle, the relative weight of heart is higher in females than in males (Fig. 2).

The absolute weight of heart in male B_1 hybrids resembles that in the European bison and slightly exceeds this weight in cattle, while the relative weight is distinctly higher. In relative weight the heart of B_1 females approximate that of the domestic cow (Fig. 2).

The heart of F_1 males is more elongate than in both initial forms. All its measurements age greater than those characteristic of the heart of the bull of domestic cattle; the greatest differences occur in the circumference and height of the heart (Table 5). In width the heart of B_1 bulls comes close to that of the males of domestic cattle, its height being greater. The heart of F_1 females is slenderer than in both initial forms (Table 5), while in B_1 cows it has similar measurements to those of the heart of domestic cows, but is more spherical in shape.

Table 5

Comparison of heart measurements (averages ± SD) of adult European bison and domestic cattle and their hybrids (in mm).

Measurements	Males					Formales			
	Hybrids F_1	Hybrids B_1	European bison[1] < 6 yrs.	European bison[1] > 6 yrs.	Cattle[2]	Hybrids F_1	Hybrids B_1	European bison[1]	Cattle[2]
Height (the left surface)	233 ± 14	205 ± 15	207	196	150—180	214 ± 4	205 ± 23	181	170—220
Maximal width	207 ± 21	190 ± 12	211	204	174—199	187 ± 6	189 ± 16	200	180—195
Minimal width	158 ± 10	136 ± 9	141	155	130—140	134 ± 10	134 ± 15	149	125—150
Circumference (below the coronary groove)	586 ± 1	481 ± 20	610	587	480—529	477 ± 15	523 ± 20	595	475—517

After: [1] Węgrzyn (1968); [2] Schubert (1909)

3. Kidneys

3.1. Absolute and Relative Weight of Kidneys in Hybrids

The absolute weights of both kidneys are higher in F_1 males than in corresponding females. On the contrary, in the B_1 generation the kidneys of adult females have a higher absolute weight than have those of males (Table 6). It is interesting that in F_1 hybrids of both sexes the left kidney is heavier than the right one, but the difference is not statistically significant. The relative weight of the kidneys of F_1 hybrids is higher than in the B_1 generation (Fig. 3).

During the postnatal development the relative weight of the kidneys of B_1 hybrids of both sexes decreases with age (Table 6).

3.2. Linear Measurements of Fixed Kidneys

In the F_1 generation all the measurements of both kidneys are greater in males than in females (Table 6). In adult B_1 hybrids both kidneys

are longer in females and broader and higher in projection in males. All the measurements of the kidneys of B_1 males are smaller than in the F_1, whereas in B_1 females the kidneys are slightly longer but lower in projection and narrower than in the F_1 (Table 6). It is difficult to observe any regularity in the changes of measurements of the left and right kidneys according to sex and age during the postnatal development (Table 6).

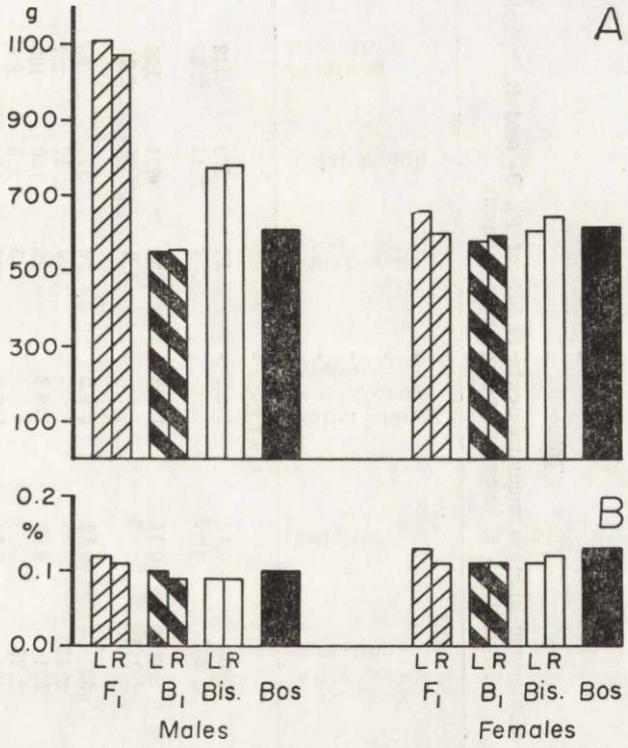

Fig. 3. Absolute (A) and relative (B) kidneys weight.
Bis. — *Bison bonasus* (after Pilarski, 1967), *Bos* — *Bos taurus* (atfer Schummer & Nickel, 1975). L — left, R — right.

3.3. Relationship between Length of Kidneys and Oblique Length of Trunk

In adult hybrids of both generations the kidneys of females are longer in relation to the length of trunk than age those of males. The shortest kidneys in relation to the trunk length occur in B_2 females (Table 6). In the course of development this ratio grows in B_1 females, whereas in adult males it falls slightly in comparison with the half-a-year-olds (Table 6).

Table 6

Comparison of average kidneys measurements (± SD) of F_1, B_1 and B_2 hybrids (weights in g, linear measurements in mm).

Group; Age, years		n	Weight: Absolute	Weight: After conservation	Weight: Relative	Ratio: kidney length/body length	Number of lobes	Total length	Maximal breadth	Breadth in hilus	Hight in projection
						MALES					
Hybrids F_1 5—12.5	L	3	1,118 ± 418 n=5	980 ± 237	0.12 n=5	1:8.9	27 ± 7	228 ± 13	112 ± 27	86 ± 3	72 ± 24
	R	3	1,074 ± 431 n=5	942 ± 215	0.11 n=5	1:9.3	32 ± 8	221 ± 26	126 ± 21	97 ± 28	68 n=2
Hybrids B_1 3.5—5.5	L	7	556 ± 109	527 ± 123	0.10	1:9.5	25 ± 4	177 ± 17	93 ± 7	69 ± 14	68 ± 10
	R	7	553 ± 84	531 ± 79	0.09	1:9.3	26 ± 5	180 ± 8	103 ± 6	86 ± 5	62 ± 7
Hybrids B_1 1.5—2.5	L	3	547 ± 122	499 ± 82	0.12	1:8.6	25 ± 7	192 ± 7	93 ± 6	68 ± 6	61 ± 8
	R	3	507 ± 109	491 ± 145	0.10	1:8.8	26 ± 2	184 n=2	81 ± 3	64 ± 2	62 ± 3
Hybrids B_2 0.5	L	2	360	244	0.13	1:9.1	26	147	71	54	46
	R	2	330	264	0.11	1:8.5	26	156	85	50	45

FEMALES

	L	3	657	547	0.13	1:8.3	27	191	94	73	63
Hybrids F_1			± 66	± 23			± 3	± 17	± 12	± 5	± 6
4—9	R	3	599	530	0.11	1:8.5	28	188	100	78	54
			± 127	n=2			± 2	± 18	± 2	± 5	± 2
	L	5	578	509	0.11	1:8.5	23	197	91	70	52
Hybrids B_1			± 64	± 65			± 5	± 9	± 17	± 9	± 5
4.5—7	R	5	594	570	0.11	1:8.7	24	192	99	71	48
			± 69	± 88			± 3	± 22	± 6	± 8	± 5
	L	3	325	285	0.12	1:8.4	31	166	82	60	56
Hybrids B_1			n=2	n=2			± 1	± 16	± 13	± 8	± 22
1—2.5	R	3	315	281	0.11	1:7.9	31	176	77	63	45
			n=2	n=2			± 1	± 11	± 8	± 7	± 2
Hybrid B_1	L	1	370	300	0.16	1:9	31	146	91	62	58
0.5	R	1	340	300	0.14	1:9.2	28	143	71	56	57
	L	3	487	466	0.10	1:9.9	25	176	87	69	55
Hybrids B_2			± 93	± 104			± 2	± 19	± 8	± 10	± 7
2.5—4.5	R	3	487	450	0.09	1:10	23	177	98	72	52
			± 93	± 133			± 2	± 33	± 9	± 7	± 9

L — left; R — right

3.4. Number of Kidney Lobes

In all the groups of hybrids the number of kidney lobes varies in both kidneys. In the B_1 generation the number of lobes decreases during the postnatal development (Table 6).

There are more kidney lobes in males of both generation than in females. The kidneys of F_1 hybrids of both sexes have more lobes than those of B_1 (Table 6).

3.5. Comparison of Kidneys of Adult Hybrids and Initial Forms in Respect of their Morphological Characters

As in both initial species, the kidneys of hybrids are of the grooved multipapillary type. The kidneys of males have higher absolute and relative weights than the kidneys of both initial forms. As regards F_1

Table 7

Comparison of kidneys measurements of adult European bison, domestic cattle and their hybrids (in mm).

Group		Number of lobes		Ratio: length kidney /body length		Length		Maximal breadth		Hight in projection	
		M	F	M	F	M	F	M	F	M	F
Hybrids F_1	L	27—31	27—28	1:8.9	1:8.3	228	191	112	94	72	63
	R			1:9.3	1:8.5	221	188	126	100	68	54
Hybrids B_1	L	24—25	23—24	1:9.5	1:8.5	177	187	93	91	68	52
	R			1:9.3	1:8.7	180	192	103	99	62	48
European bison[1]	L	27—28		1:9.6	1:8.4	192	191	105	82	92	62
	R			1:9.3	1:9.8	192	164	121	104	73	70
Hybrids B_2 Cattle[2]		23—26 12—25									

After: [1] Pilarski (1967); [2] Schummer & Nickel (1975). L — left; R — right.

females, the left kidney is heavier and the right one lighter than the kidneys of females of the European bison. On the other hand, their absolute weight is higher and the relative weight slightly lower than in domestic cows (Fig. 3). In adult B_1 males the relative weight of kidneys is similar to that in both initial forms and in females it is lower than in cattle (Fig. 3).

In F_1 hybrids the left kidneys are heavier than the right ones, but the differences are not statisticaly significant, which resembles the situation observed in the kidneys of cattle (Auernheimer, 1909,

1925; Sisson, 1959) and is opposite to the state found in European bisons (Pilarski, 1967).

Since no data concerning the kidneys of cattle have been found in available literature, a comparison was carried out only with the European bison (Table 7). Both kidneys of F_1 males are longer and wider but thinner than those of European bisons and in B_1 male they have considerably smaller dimensions than in this last species. However, the left kidney of males is always thicker than the right one (Table 7). The kidneys of F_1 and B_1 females show no major differences in measurements in comparison with the kidneys of females of the European bison, but the right kidney of hybrids is longer and as a result it has not the spherical shape characteristic of the right kidney of these last (Pilarski, 1967). Only the left kidney of F_1 males is longer in relation to the trunk length than it is in males of the European bison and B_1 hybrids; in the case of the right kidney this relation is similar in all males. In the female hybrids of both generations this relation is similar to female European bisons as regards the left kidney, whereas the right kidney of female bisons is conspicuously shorter in relation to the trunk length than it is in hybrids (Table 7).

The number of renal lobes in F_1 hybrids is slightly greater than in European bisons and considerably greater than in cattle (Table 7), whereas in B_1 and B_2 hybrids it lies within the limits of the mean values for cattle.

IV. DISCUSSION

An analysis of the structural sexual dimorphism of mammals carried out by Glucksmann (1974) shows that in most species males are larger and have higher absolute weights of organs than females. The differences in the absolute weights of organs than females. The differences in the absolute weight of organs need not however be proportional to the body weight. At the same time Glucksmann (1974) emphasizes that the differences in the weight of organs may result from fat deposition, especially in females, and from the development of sustentacular tissue in the organs of males. In the considerations of the structural sexual dimorphism in hybrids of the European bison and cattle the body weight ratio between females and males was assumed, as in Glucksmann (1974), as the basis for comparison and the weight ratio of the internal organs under study was compared with it. If the value obtained exceeded the body weight ratio, the given organ was relatively larger in the male.

In F_1 hybrids the body weight and the absolute weights of organs are higher in males than in females. However, in spite of the great

difference in body weight (80%) males have a relatively lighter liver, heart and kidneys than females (Table 8). In the B_1 generation they have a relatively greater weight of the heart and smaller weights of the liver and kidneys than females (Table 8).

Table 8

Ratios of body weight and organ weights for adult hybrids, European bison and domestic cattle, compared in different combinations.

Group	n	Ratios				
		Body weight	Liver	Heart	Kidney left	Kidney right
Males F_1	5	1.80	1.61	1.69	1.70	1.79
Females F_1	3					
Males B_1	7	1.09	0.97	1.25	0.96	0.93
Females B_1	5					
Males F_1	5	1.60	1.58	1.60	2.0	1.94
Males B_1	7					
Females F_1	3	0.97	0.96	1.18	1.14	1.01
Females B_1	5					
Males F_1	5	1.27	1.31	1.65	1.44	1.37
Males *Bis.*	6					
Males B_1	7	0.79	0.82	1.03	0.71	0.70
Males *Bis.*	6					
Males F_1	5	1.72	1.91	1.95	1.78	
Males *Bos*	?					
Males B_1	7	0.99	1.20	1.21	0.90	
Males *Bos*	?					
Females F_1	3	0.97	1.27	—	1.08	0.93
Females *Bis.*	3					
Females B_1	5	1.00	1.32	—	0.95	0.91
Females *Bis.*	3					
Females F_1	3	1.13	1.21	1.35	1.02	
Females *Bos*	?					
Females B_1	5	1.16	1.26	1.14	0.95	
Females *Bos*	?					

Bis. — European bison; *Bos* — cattle
The data conferning hybrids used to calculate the ratios were derived from the present study and those for the European bison and cattle from the following sources: European bison — weight of body an liver — Pytel & Węgrzyn (1976), heart weight — Węgrzyn (1968), kidney weight — Pilarski (1967); Cattle: weight of body and heart — Schneider (1904), liver weight — Eichel (1925), kidney weight — Schummer & Nickel (1975).

Admittedly, the phenomenon of heterosis occurs as a rule only in hybrids of the first generation and gradually subsides in the next generations (Kirpichnikov, 1960; Hutt, 1972). One of the signs of heterosis is the attainment of greater body weights by hybrids as

compared with the initial forms (Hutt, 1972; Kołątaj *et al.*, 1973). It is instructive to determine the body constituents responsible for this high weight. In her investigation of inter-racial hybrids of pigs Glebina (1966) demonstrated that they were characterized, among other details, by the intense growth of the liver and muscle fibres and the greater weight of the thyroid gland than in the initial forms. It has been found in our earlier studies that the F_1 hybrids between the European bison and cattle have a greater mass of muscular tissue and skin and a greater capacity of the stomach and intestines than have the initial forms (Pytel & Krasińska, 1971; Pietrzykowski & Krasińska, 1971; Szulc *et al.*, 1971).

An analysis of the degree of influence of heterosis upon the size of organs permits the statement that in F_1 hybrids of both sexes the heart and liver and in males the kidneys were heavier in relation to the body weight than in both initial forms. On the other hand, the right kidney of F_1 females was relatively lighter than in females of the European bison. The heart shows the greatest influence of heterosis (Table 8).

In the B_1 generation the liver and heart were also found to have a greater weight in relation to their body weight as compared with the European bison and cattle, but the differences were smaller than in F_1 hybrids except for the relative weight of the liver of B_1 females (Table 8).

It may then be stated that heterosis had an effect on the size of internal organs in F_1 hybrids just as it had on the development of muscular tissue. Thus, in addition to the other constituents, the increased mass of internal organs contributed to the increase of the total body weight as compared with that in the initial forms.

Investigation of the degree of inheritability of morphological characters from the parental forms was difficult, because we had not at our disposal complete data for the initial forms, and the comparative material concerning particular organs examined was not derived from the same specimens. In addition, the differences in morphological characters between the European bison and cattle are not very distinct and often occur only in some anatomical details.

As regards proportions, the liver of F_1 hybrids was found to bear more similarity to the liver of the European bison and its left lobe to be backward as compared with the right and quadrate lobes, but the difference is smaller than in the European bison. As in this last species, the thickness of the right lobe of the liver is greater than in cattle, the difference being here still more conspicuous. The number of renal lobes in F_1 hybrids approximates that in the European bison and so it is considerably higher than in cattle. The left kidneys of F_1 hybrids are heavier than the right ones, which is characteristic of cattle, inversely

to the situation in the European bison. The relative weight of the liver and heart in the F_1 generation is higher in females than in males, as it is in cattle. Some specific morphological characters, different from those in the initial forms, are also observed in these hybrids, *e.g.* the shape of the heart, which is longer and slenderer than in the parental forms.

As the share of cattle blood increases in hybrids of the backross generations, the internal organs become more and more similar to those in cattle.

REFERENCES

1. Auernheimer O., 1909: Grössen- und Formvëränderungen der Baucheingeweide der Wiederkäuer nach der Geburt bis zum erwachsenen. Zustande: 44—49. Zürich.
2. Auernheimer O., 1925: Anatomie der Rindernieren. Berliner Trztl. Wschr. *44*: 719—720. Berlin.
3. Eichel J., 1925: Masse, Formen und Gewichte der Lebern von Rinden und Schafen. Inaug. Diss.: 1—48.
4. Glebina E. I., 1955: O nekotoryh biologičeskih osobennostjah pomesnyh životnyh. Žurn. obšč. Biol., *16*, 3: 80—85.
5. Glucksmann A., 1974: Sexual dimorphism in mammals. Biol. Rev., *49*: 423—475.
6. Hutt F. B., 1972: Genetyka zwierząt. Państw. Wyd. Roln. i Leśn.: 1—541. Warszawa.
7. Kirpichnikov V. S., 1960: Genetičeskie osnovy geterozisa. [In: »Voprosy evolucii, biogeografii, genetiki i selekcii«]: 94—98. Moskva, Leningrad.
8. Kołątaj A., Krzanowska H. & Wolański N., 1973: Biologiczne podstawy heterozji. Państw. Wyd. Nauk.: 1—413. Warszawa.
9. Krasińska M., 1969: The postnatal development of F_1 hybrids of European bison and domestic cattle. Acta theriol., *14*, 7: 69—117.
10. Kwiatkowski J., 1973: Próba oceny i porównania wartości rzeźnej krów rasy polskiej czerwonej, jersey i mieszańców F_1 tych ras. Prace i Materiały Zootechn., *3*: 7—23.
11. Pietrzykowski W. & Krasińska M., 1971: Characteristic of skin of European bison and domestic cattle hybrids. Acta theriol., *16*, 33: 505—512.
12. Pilarski W., 1967: Układ moczowy żubra *Bison bonasus* (Linnaeus, 1758). Msc.
13. Pytel S. & Krasińska M., 1971: Morphology of the stomach and intestines in hybrids of European bison and domestic cattle. Acta theriol., *16*, 31: 471—481.
14. Pytel S. Krasińska M. & Węgrzyn M., 1976: Morphology of the spleen in European bison and its hybrids with domestic cattle. Acta theriol., *22*, 7: 141—149.
15. Schneider J., 1904: Gewicht von Organen des Rindes. Z. f. Fleisch- und Milchhygiene, *14*: 393—398.
16. Schubert F., 1909: Beitrage zur Anatomie des Herzen der Haussäugetiere. Diss., 1—90. Dresden.

17. Schummer A. & Nickel R., 1975: Lehrbuch der Anatomie der Haustiere. P. Parey, *2*: 1—430. Berlin, Hamburg.
18. Sisson S., 1959: The anatomy of the domestic animals. W. B. Saunder Company: 1—972. Philadelphia, London.
19. Szulc M., Tropiło J. & Krasińska M., 1974: Dressing percentage and utility value of the meat of European bison and domestic cattle hybrids. Acta theriol., *16*, 32: 483—504.
20. Wehn R., 1924: Anatomische und histologische Untersuchungen über der Bau der Nieren eines Flusspferdes. Diss. 1—15.
21. Węgrzyn M., 1968: Blood vascular system of European bison. I. Morphology of the heart. Acta theriol., *13*, 12: 177—218.

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ANALIZA MORFOLOGICZNA NIEKTÓRYCH NARZĄDÓW WEWNĘTRZNYCH HYBRYDÓW ŻUBRA Z BYDŁEM DOMOWYM

Streszczenie

Poddano analizie biometrycznej wątrobę, serce i nerki 32 hybrydów żubra z bydłem, różnych pokoleń (Tabela 1). Uzyskane wyniki porównano z danymi dla form wyjściowych. Mimo wysokiej różnicy w ciężarze ciała (80%) samce F_1 mają proporcjonalnie do ciężaru ciała lżejsze wątrobę, serce i nerki niż samice (Tabela 8). W pokoleniu B_1 samce mają proporcjonalnie większy ciężar serca a mniejszy wątroby i nerek niż samice.

Hybrydy F_1 obu płci przewyższają proporcjonalnie do ciężaru ciała obie formy wyjściowe ciężarem wątroby i serca oraz nerek u samców (Ryc. 1, 2, 3; Tab. 8). W pokoleniu B_1 również wątroba i serce jest proporcjonalnie cięższe niż u żubra i bydła ale różnica jest mniejsza niż u hybrydów F_1 z wyjątkiem ciężaru względnego wątroby samic B_1. Można więc stwierdzić, że heterozja miała również wpływ podobnie jak na rozwój tkanki mięśniowej, na wielkość narządów wewnętrznych hybrydów pierwszego pokolenia, najwyraźniej w przypadku serca. W pokoleniu B_1 wpływ heterozji na wielkość narządów maleje.

W ukształtowaniu narządów wewnętrznych hybrydów F_1 dominację cech żubra obserwujemy w wykształceniu grubości wątroby, uwstecznieniu płata lewego w stosunku do rozmiarów płata prawego i czworobocznego wątroby, ilości płatów nerek (Tabela 3, 7). Natomiast dominację cech bydła obserwujemy w rozmiarach wyrostka ogoniastego wątroby, większym ciężarze nerek lewych niż prawych u hybrydów F_1 obu płci (Tab. 3, 6) oraz w większych ciężarach względnych wątroby i serca u samic F_1 niż u samców (Ryc. 1, 2). Obserwujemy też cechy morfologiczne odmienne od form wyjściowych, swoiste dla hybrydów jak na przykład soplowaty kształt serca hybrydów.

W miarę wzrostu udziału krwi bydła u mieszańców pokoleń wstecznych wzrasta podobieństwo ukształtowania narządów do bydła.