

## **CHARACTERISTICS OF PHENOGRUUPS OF THE A BLOOD GROUP SYSTEM IN CATTLE OF BEEF BREEDS\***

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### **Abstract**

Phenotypes of four beef breeds (Charolais, Hereford, Limousin and Piemontese) were determined based on the transmission of antigens from parents to offspring in the A blood group system of cattle. The effective number of alleles per locus (E) and the degree of heterozygosity (H) were calculated for different breeds based on the frequency of these phenogroups. Most A-phenogroups (18) were found in Limousin cattle and least in Charolais and Hereford cattle (12). A-phenogroups with the Z' antigen, especially the AIZ' phenogroup were characteristic of the breeds studied. The greatest variation in this blood group system was found in the Limousin breed (E and H values of 9.7 and 0.8977, respectively) and the smallest variation in the Hereford breed (7.0 and 0.8578, respectively). The identification of A-phenogroups and confirmation of the fact that the D antigen is only found in one phenogroup with the PLB-8 antigen could be used for parentage verification of cattle of beef breeds.

**Key words:** cattle, blood groups, A system, phenogroups

The A blood group system in cattle is a complex (multiantigenic) system in which blood cell antigens are transmitted from parents to offspring in the form of complexes known as phenogroups. Compared to a similar B blood group system, in which about 50 erythrocyte antigens and over 100 phenogroups have been identified (Morita and Kanemaki, 1987; Georges et al., 1990; Duniec M.J. et al., 2002), the number of antigens in the A system is relatively small. It includes only 5 antigens, designated as A1, A2, H, D, Z' in keeping with the nomenclature adopted by the International Society for Animal Genetics (ISAG) and two antigens designated as PLB-4 and PLB-8 (Duniec M.J. et al., 1998; Duniec et al., 2000). Research carried out to date on the identification and inheritance of erythrocyte antigens in this blood group system of cattle raised in Poland covered four breeds: Polish Red (Rychlik et al., 1999; Duniec et al.,

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2000; 2001), Black-and-White (Duniec et al., 2000; 2001), Simmental (Duniec et al., 2000; 2001; 2002) and Red-and-White (Rychlik et al., 2008). These breeds were also analysed for the inheritance of PLB-4 and PLB-8 antigens detected at the Department of Animal Immuno- and Cytogenetics of the National Research Institute of Animal Production (Duniec et al., 2001). The objective of the present study was to determine phenogroups of the A blood group system in four breeds of beef cattle raised in Poland (Charolais, Hereford, Limousin and Piemontese) and to confirm genetic relationships between D, PLB-4 and PLB-8 antigens.

### Material and methods

Results of haemolytic tests performed with the blood of heifers, bulls and their parents, sampled during 1999–2008 all over Poland, were used for parentage verification.

Antigenic characters of the A blood group system were determined using the haemolytic test. Blood samples were tested using sera that identified the following antigens of the A blood group system: A1, A2, D, H, PLB-4, PLB-8 and Z'. The animals studied were also tested for the presence of 60 antigens representing the other 11 blood group systems in cattle. The test sera, produced at the Department of Animal Immuno- and Cytogenetics of the National Research Institute of Animal Production, were standardized in international comparison tests organized by the International Society for Animal Genetics.

The results of tests performed on the progeny and their parents were used to analyse 816 cattle, including 191 Charolais (CH), 138 Hereford (HH), 247 Limousin (LM) and 240 Piemontese (PI). By analysing offspring phenotypes and parent phenotypes and genotypes, and in some cases also those of grandparents, the genotypes of individual animals in the A blood group system were determined.

The frequency of A-phenogroups was calculated based on the genotypes determined. The frequency of antigens was expressed as percentage of animals whose blood cells reacted with particular test sera. In the analysed system, the degree of heterozygosity (H) (Nei and Roychoudhury, 1974) and the effective number of alleles per locus (E) (Kimura and Crow, 1964) were also calculated for different cattle breeds.

### Results

The present study provided data on the polymorphism of erythrocyte antigens from the A blood group system in 4 breeds of cattle: CH, HH, LM and PI. In the analysed group system, a total of 7 erythrocyte antigens were identified: A1, A2, D, H, PLB-4, PLB-8 and Z' (Table 1). In total, 18 A-phenogroups were determined by analysing the entire material for the transmission of these antigens from parents to offspring. The number of phenogroups identified was as follows: 12 in CH, 12 in HH, 18 in LM,

15 in PI. Phenogroups of the A system, their frequency, degree of heterozygosity (H) and the effective number of alleles per locus (E), determined in the breeds studied, are presented in Table 2.

Table 1. Antigen frequencies in the A blood group system in cattle of the breeds studied

Antigenic character	CH Charolais n = 191	HH Hereford n = 138	LM Limousin n = 247	PI Piemontese n = 240
A1	0.8462	0.5652	0.6802	0.4667
A2	0.0157	0.0869	0.0486	0.1042
D	0.5969	0.5217	0.5506	0.4750
H	0.1885	0.1739	0.4858	0.3042
PLB-4	0.5340	0.6522	0.5668	0.3667
PLB-8	0.1571	0.3043	0.1457	0.4583
Z'	0.3141	0.0435	0.2186	0.1250

Table 2. Phenogroup frequencies in the A blood group system in cattle of the breeds studied

Phenogroups	CH Charolais n = 191	HH Hereford n = 138	LM Limousin n = 247	PI Piemontese n = 240
A1	0.1099	0.0870	0.0972	0.0750
A1DPLB-4	0.0785	0.2174	0.0607	0.0666
A1H	0.0628	0.0435	0.1458	0.1625
A1HDPLB-4	0.0209	0.0652	0.1580	0.0250
A1HZ'	0.0524		0.0283	0.0167
A1HDPLB-4Z'			0.0121	
A1Z'	0.2199	0.0290	0.1093	0.0500
A2		0.0217	0.0081	0.0125
A2DPLB-4	0.0079	0.0145	0.0121	
A2HDPLB-4			0.0081	0.0167
A2H			0.0081	0.0562
DPLB-4	0.1885	0.1522	0.1336	0.1667
DPLB-4Z'			0.0081	
DPLB-8	0.1257	0.1957	0.0729	0.2375
H	0.0052	0.0217	0.0162	0.0375
HDPLB-4	0.0340		0.0364	0.0146
Z'		0.0217	0.0121	0.0125
-	0.0943	0.1304	0.0729	0.0500
Number of phenogroups	12	12	18	15
Effective number of phenogroups	7.4	7.0	9.7	7.5
Degree of heterozygosity	0.8648	0.8578	0.8977	0.8681

The effective number of phenogroups and the degree of heterozygosity were the highest in the LM breed (9.7 and 0.8977, respectively). For the other beef breeds, the respective values were 7.4 and 0.8648 (CH), 7.0 and 0.8578 (HH) and 7.5 and 0.8681 (PI).

## Discussion

Over 100 erythrocyte antigens have been identified in cattle and based on inheritance they belong to the following 12 blood group systems: A, B, C, F, J, L, M, S, Z, N', R' and T' (results of the International Comparison Test 2003/2004).

The characteristics of one system are inherited independent of the characteristics of the other systems. The most polymorphic systems include B, C and S with several dozen known blood cell antigens, transmitted from parents to offspring in complexes called phenogroups (Duniec M.J. et al., 2002; Rychlik and Duniec, 2005; 2006). In terms of the number of known antigenic characters, the A system is less polymorphic and ranks fourth after B, C and S systems. For this reason, research on inheritance and genetic relationships between the antigens of this system in different breeds of cattle is of prime importance. The present study concerned 4 breeds of beef cattle raised in Poland, with unidentified phenogroups of the A group system. In the analysed system of these breeds, 7 antigenic characters were found (A1, A2, D, H, PLB-4, PLB-8 and Z'). The highest frequencies for the A1 antigen were shown in the CH (0.8462) and LM breeds (0.6802), for PLB-4 in the HH breed (0.6522) and for the D antigen (0.4750) in the PI breed (Table 1). The Z' antigen, found in all the breeds, was not detected in the other recently investigated cattle breeds in Poland: Polish Red (Rychlik et al., 1999), Black-and-White (Duniec et al., 2000), Simmental (Duniec M.J. et al., 2002) and Red-and-White (Rychlik et al., 2008). This antigen had previously been found in the 1970s (Ormian, 1978), where it occurred with low frequency (0.0060) in SM cattle and with high frequency (0.3670) in the CH breed (Trela et al., 1979). Analysis of the results of several recent international comparison tests and haemolytic tests that have been performed for many years at the Department of Animal Immuno- and Cytogenetics of the National Research Institute of Animal Production to determine the antigenic composition of blood in parentage-tested cattle, demonstrates that the Z' antigen is very rare, and in some breeds (e.g. those of Dutch or Scandinavian origin) it does not occur at all. It is found in cattle originating from central and southern Europe as well as in Jersey cattle.

In the present study, we used the findings of an earlier study on the inheritance of and relationships between D, PLB-4 and PLB-8 antigens (Duniec et al., 2001), which showed that PLB-4 and PLB-8 antigens always occur with the D antigen in the phenogroup. There was no case where PLB-4 and PLB-8 antigens occurred together in one phenogroup. The identified correlation represents a non-linear relationship between erythrocyte antigens. The same study also revealed that the PLB-8 antigen occurs only together with the D antigen to form the DPLB-8 phenogroup, which enables the second allele in this animal (and thus complete genotype in this system) to be determined. These relationships also proved correct for the beef breeds studied. They were found to contain 18 A-phenogroups, in which the PLB-8 antigen occurred only in the DPLB-8 phenogroup and there was no phenogroup in which PLB-4 and PLB-8 antigens occurred together or without the D antigen.

The greatest number of phenogroups (18) was found in the LM breed, followed by 15 in the PI breed and 12 each in the HH and CH breeds (Table 2). In individual breeds, the most frequent phenogroups were A1Z' (0.2199) in the CH breed, A1D-

PLB4 (0.2174) in HH, A1HDPLB-4 (0.1580) in LM and DPLB-8 (0.2375) in PI. The characteristic phenogroups for the breeds studied are phenogroups with the Z' antigen, especially the AIZ' phenogroup, which occurred in all of the breeds. The greatest differences in the blood group system analysed were found for the LM breed, in which the effective number of phenogroups was 9.7 and the degree of heterozygosity was 0.8977. For the other breeds, the respective values were 7.5 and 0.8681 (PI), 7.4 and 0.8648 (CH), 7.0 and 0.8578 (HH).

In conclusion, the present study provided further evidence on the polymorphism of the A blood group system in beef breeds of cattle and gave better insight into the genetic and serological relationships between the antigens of this system. It has been proven that the PLB-8 antigen occurs only in one phenogroup with the D antigen. In an animal with the PLB-8 antigen, it is possible to determine one of the A system alleles, which increases the possibility of using this system for parentage control. This holds much significance, because although microsatellite DNA polymorphism is increasingly used to verify parentage in cattle (Radko et al., 2002; Cervini et al., 2006; Rehout et al., 2006), a considerable proportion of the pedigrees (especially in beef cattle) is validated based on blood group tests. The identified relationships and the determination of A-phenogroup in the blood group system studied will enable animals with incorrect parentage to be detected with greater probability.

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### **Charakterystyka fenogrup układu grupowego krwi A u bydła ras mięsnych**

#### STRESZCZENIE

Na podstawie przekazywania cech antygenowych przez rodziców potomstwu w układzie grupowym krwi A u bydła, ustalono fenogrupy u czterech ras mięsnych – Charolaise, Hereford, Limousin, Piemontese. W oparciu o częstość występowania tych fenogrup obliczono dla poszczególnych ras efektywną liczbę alleli w locus (E) oraz stopień heterozygotyczności (H). Najwięcej A-fenogrup (18) stwierdzono u bydła Limousin, a najmniej u Charolaise i Hereford (12). Charakterystycznymi dla badanych ras były A-fenogrupy z cechą antygenową Z', a zwłaszcza fenogrupa A1Z'. Największą zmienność w tym układzie zaobserwowano u rasy Limousin, gdzie wartość E i H wynosiła odpowiednio 9,7 i 0,8977, a najmniejszą u rasy Hereford (7,0 i 0,8578). Ustalenie A-fenogrup oraz potwierdzenie zależności, że antygen D występuje wyłącznie w jednej fenogrupie z antygenem PLB-8 będzie można wykorzystać w kontroli rodowodów bydła ras mięsnych.