

# BLOOD GROUPS IN THE CARPATHIAN BREED GOATS

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## Abstract

The paper makes an immunogenetic description at the determinant loci of blood groups in goats of Carpathian breed. The immunoserological typification of animals was performed with a battery of 12 specific monovalent reagents: 10 isoimmune reagents (anti-Aa, anti-Bb, anti-Bc, anti-Bd, anti-Be, anti-Bf, anti-Bg, anti-Ca, anti-Cb and anti-Ma) and two heteroimmune reagents: anti-R and anti-O. By the haemolytic test method 12 erythrocyte factors were detected belonging to five blood group systems: Aa (system A), Bb, Bc, Bd, Bf, Bg, Bi (system B), Ca, Cb (system C), Ma (system M), R and O (system R-O). The richness and heterogeneity of antigenic structures determine a very emphasized polymorphism of blood groups in the Carpathian breed. The incidences of blood factors present a very large variability ranging between 8.85% (Cb) and 95.20% (Ma). The most polymorphic immunogenetic system is the system B, comprising six blood group factors; the factor Bf is commonest and the other factors have a middle representation. The systems C and R-O have a more limited polymorphism, each possessing two factors. The factor Ca has a better representation than the factor Cb, and the factor O records a relatively higher frequency than the factor R. Each of the systems A and M possesses only one factor. On the whole, the genetic analysis at the determinant loci of blood group factors in the Carpathians breed shows: the manifest phenotypes (42.89%) are less spread than the "silent" ones (57.11); the recessive genes are more widespread (75.57%) than their dominant alleles (24.43%); genotypically, there comes out very low frequencies of dominant homozygotes (5.97%), considerable distributions of heterozygotes (36.92%) and high incidences of recessive homozygotes (57.11%).

**Key words:** blood groups, immunogenetics, goat

## INTRODUCTION

The caprine haematology benefited by a considerable attention in the last 30 years. During this time a series of data on haematological profile of this species have been reported, sometimes these being contradictory concerning the normality or pathological significance of values of these physiological indices. These discrepancies could due to some internal factors of animals evaluated (variations of age, sex, breed, health status) or they would be caused by some external factors (differences of environment, climate, experimental methodology, sample size). Despite these inconsistencies, there are insufficient data for a reasonable standardization of the normal haematological values and of their variability in goats (4, 5). In contrast, the information about the organization of goat

immunogenetic system and the peculiarities of immune response are more limited (13).

Currently, most references to blood groups in goats are compared to those of sheep, such as nomenclature of blood group systems (6, 8, 9), peculiarities of system R-O, relationship between system M and genetic types of potassium (2), emphasized polymorphism of antigenic structures (11, 12), structural complexity of the system B, existence of multiple phenogroups in this system (8, 14), immunoserological testing methodology (haemolysis) (1, 7), genetics of blood groups (9, 14), correlation or association of immunogenetic structures with animal productivity, affiliation, phylogeny, speciation etc. (6, 8, 9, 11, 12). But not always the specific immunogenetic similarities and differences between the small ruminant species were very clear (10, 13).

In 1992, the American Dairy Goat Association has instituted a voluntary program of blood typing to improve the

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breeding technologies of goats, especially for identification and verification of animal parentage (13).

Based on these considerations, the present study has proposed the immunogenetic characterization of the Carpathian goats to use the blood group factors as genetic markers in the selection works for production, reproduction and health improving of this breed.

## MATERIAL AND METHOD

A randomized population of goats belonging to the Carpathian breed from the *Research and Development Station for Sheep and Goat Breeding Popauti-Botosani* was used for the determination of blood groups.

The typological identification of erythrocyte antigens in goats was achieved using the haemolytic test based on antigen-antibody serological techniques being similar to those from sheep (3). The antigens were represented by red blood cells of goats analyzed from which the standard solutions of erythrocyte suspensions were obtained. 12 specific monovalent reagents were used as antibodies: 10 reagents are isoimmune: *anti-Aa*, *anti-Bb*, *anti-Bc*, *anti-Bd*, *anti-Be*, *anti-Bf*, *anti-Bg*, *anti-Ca*, *anti-Cb* and *anti-Ma*, and two reagents are heteroimmune obtained by immunization on cattle: *anti-R* and *anti-O*. In the reaction medium the complement was added, represented by rabbit serum absorbed on erythrocyte goat. Haemolysis occurred in microtitrater Takátsy, in thermostatic conditions at 26°C for four hours, taking into account the reactions that had the haemolysis degrees 2, 3 and 4.

In the Carpathian breed the serological typing at the determinants loci of erythrocyte factors was possible only by haemolytic method. It has been used for the systems A, B, C, M and R-O. The typification was tried also for the system D, where there used the erythrocyte agglutination method with the serum isoimmune *anti-Da*, but none of the erythrocyte sets of any animal did not react with this antiserum.

The distributions of all erythrocyte factors and the frequencies of gene and genotypic structures at the loci of these factors were calculated.

## RESULTS AND DISCUSSIONS

*Phenotypic structure of the blood group factors* (fig. 1a)

Using the battery of 12 monospecific sera with erythrocytes sets of Carpathian goats, 12 antigenic types were identified in this breed, belonging to five blood group systems: *Aa* (system A), *Bb*, *Bc*, *Bd*, *Bf*, *Bg*, *Bi* (system B), *Ca*, *Cb* (system C), *Ma* (system M), *R* and *O* (system R-O).

As in sheep, by the haemolytic test method applied to goats, the phenotypes of blood group factors were detected: these antigenic entities are designated as manifest or dominant phenotypes (in which the erythrocytes were haemolysed by specific antibodies - positive reaction) and hidden or "silent" phenotypes (in which the erythrocytes did not react with specific antibodies - negative reaction) (3).

The results of haemolytic test in Carpathian goats have revealed a considerable polymorphic immunogenetic profile materialized by detection of the 12 types of heterogeneous antigenic structures included in the five blood group systems. In terms of immunogenetic endowment, the erythrocyte mosaic is richer in some individuals, while in others the endowment with antigenic determinants is weaker.

Thus, to almost half of blood factor loci (*Aa*, *Bf*, *Bi*, *Ca* and *Ma*), the red cells possess antigenic specificities in significant proportion, the number of erythrocytes that react with specific antisera is higher than that of those which give negative reaction in haemolytic test. At the level of the other factors (*Bb*, *Bc*, *Bd*, *Bg*, *Cb*, *R* and *O*), the goat erythrocytes that have different antigenic specificities react in a lower proportion with specific antisera than those which do not possess these immunoserological properties. The most endowed with antigen determinants are goats of type *Ma*, in which most erythrocytes (95.20%) react positively with reagent *anti-Ma*. Also, at the level of loci *Aa*, *Bi* and *Ca*, the goats are well enough equipped with erythrocyte antigens (61%-62%). Although the goats of type *Bf* have a considerable immunogenetic endowment, a more balanced ratio is observed between the phenotype manifest and the "silent" one (54.24% / 45.76%). On the contrary, at the level of factor *Cb*, the

reactivity of reagent *anti-Cb* with erythrocytes of type *Cb* is very weak, only 8.85% of the red cells of these individuals developing positive reactions. Very close to this intensity of haematic lysis there are also the individuals of type *Bc* (9.23%) and even those possessing antigen *Bg* (12.17%). Also, one fourth of individuals possess red blood cells with antigenic specificity *Bd* (25.83%). At the level of factors *R* and *O*, although the number of positive reactions is lower than of the negative ones, the reactivity of the erythrocytes with specific antisera is considerable (43.17% and 46.13%). Concerning these phenotypic distributions, it comes out a very wide variability range of blood factor manifestation (from 8.85% for the factor *Cb* to 95.20% for the factor *Ma*).

On average, the manifest phenotypes (42.89%) are with 13% less frequent than the "silent" phenotypes (57.11%).

#### ***Gene structure at the loci of blood group factors*** (fig. 1b)

The intergenic ratio shows a preponderance of recessive alleles in most blood factors. The only factor to which level the dominant gene (78.09%) is much more frequent than its recessive allele (21.91%) is the factor *Ma*. At the level of the other factors, the dominant alleles record lower frequencies than the recessive alleles. A better representation of the dominant alleles (approximately 40%) is met at the level of loci *Aa*, *Bi* and *Ca*. The dominant allele is found in one third of individuals, the recessive allele being present in the other two thirds of them. In the individuals of type *A* and *O*, a quarter of the genes are in dominant status and three-fourths are in recessive status. In the individuals of type *Bc*, *Cb* and *Bg*, the recessive alleles have a very high proportion, the dominant alleles registering the lowest incidences (between 4% and 6%).

The average of all erythrocyte factors on the five blood group systems shows a 1/3 interallelic ratio between the dominant genes (24.43%) and the recessive ones (75.57%).

#### ***Genotypic structure at the loci of blood group factors*** (fig. 1c)

The genotypic configuration at the level of blood group factors is determined by their phenotypic distributions and by ratios between the two genes that control their expression.

Firstly, we notice very little incidence of dominant homozygotes. In most cases, the dominant homozygotes record lower frequencies both to heterozygotes and especially to recessive homozygotes. The only situation in which the dominant homozygotes are more frequent (60.98%) than heterozygotes and especially than recessive homozygotes is in individuals of type *Ma*. Relatively low frequencies achieve the dominant homozygotes at the level of factors *Bf*, *Ab*, *Ca* and *Bi* (between 10% and 15%). The dominant homozygosity at the loci *R* and *A* is poorly represented in the immunogenetic panel (6%-7%). The dominant homozygotes of type *Bd* and *Bc* have a very low frequency (1%-3%), and those of type *Bc*, *Bg* and *Cb* are sporadically found in the population.

With a few exceptions, the heterozygosity is well represented for all blood factors. Thus, almost half of individuals (47%-48%) of type *Aa*, *Bi* and *Ca* are heterozygous. Also at the level of locus *Bf*, the heterozygosity has a considerable value (43.77%). Appreciable frequencies (between 35% and 40%) were recorded for the factors *Ma*, *R* and *O*. The heterozygotes *Bb* (30.73%) and *Bd* (23.91%) have a more moderate occurrence. The heterozygotes *Bg* have a relatively low spreading (11.78%). The individuals of type *Bb* and *Cb* record the lowest heterozygosity (about 9%). The heterozygosity is better represented compared to the dominant homozygosity in most of factors (except the factor *Ma*), but also to the recessive homozygosity at the level of factors *Aa*, *Bi* and *Ca*. The heterozygotes *Bf* (43.77%) are slightly less common than the recessive homozygotes *Bf* (45.76%). At the level of the other factors, the heterozygosity is lower than the recessive homozygosity.

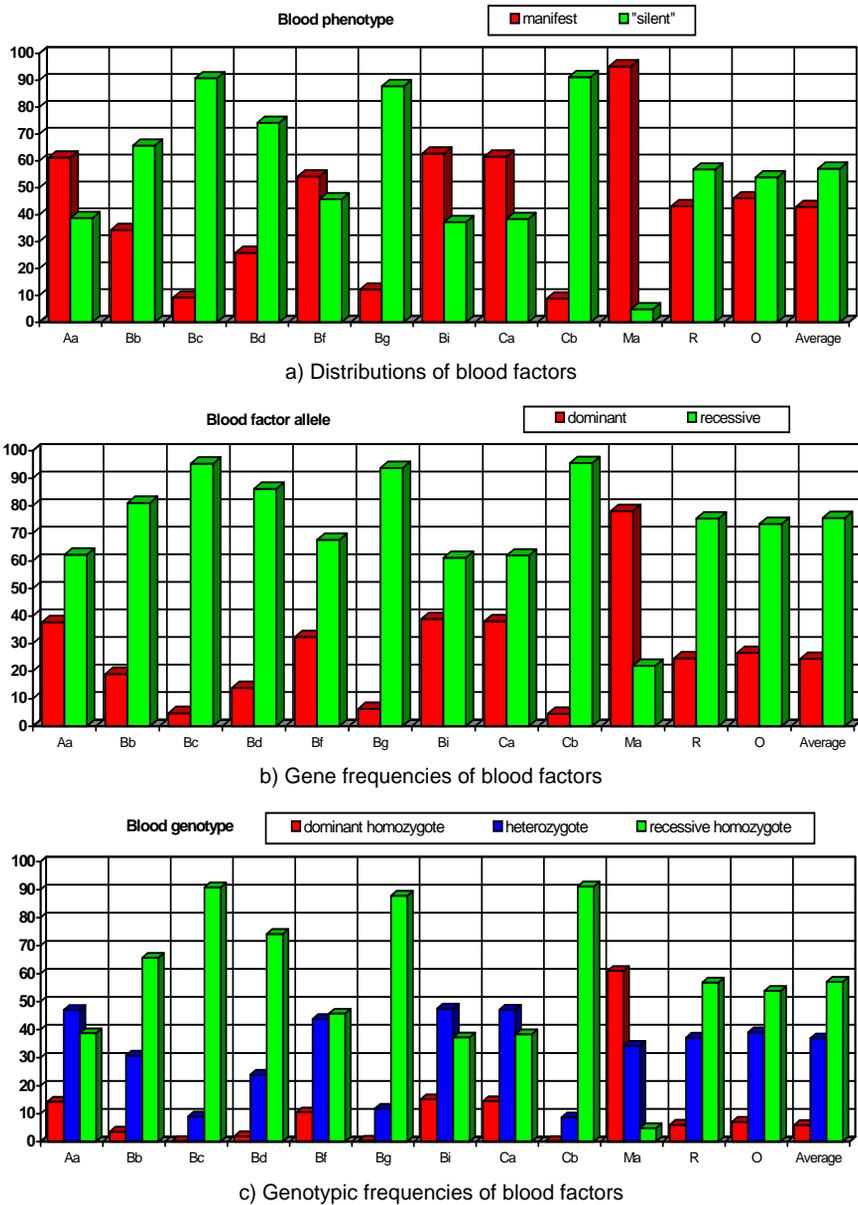


Fig. 1 Genetic structure at the determinant loci of blood group factors in the Carpathian breed

The recessive homozygosity is well represented for most blood factors. The highest incidence of the recessive homozygosity happens at the level of locus *Cb* (91.15%), closely followed by the one from the level of locus *Bc* (90.77%). Very high frequencies are achieved also by the recessive homozygotes *Bg* (87.83%), *Bd* (74.17%) and

*Bb* (65.68%). At the level of factors *R* and *A* the recessive homozygotes are slightly more than half of all individuals (56.83%, respectively 53.87%), and at the level of factor *Bf* the recessive homozygotes are a little less than half of the population (45.76%). Also, about 38% of individuals *Aa*, *Bi* and *Ca* are recessive homozygotes. The lowest recessive

homozygosity is met only at the level of factor *Ma* (4.80%). The recessive homozygosity is more developed at the level of factors *Bb*, *Bc*, *Bd*, *Bf*, *Bg*, *Cb*, *R* and *O* both compared to heterozygosity but especially compared to the dominant homozygosity. At the level of factors *Aa*, *Bi* and *Ca* the recessive homozygosity is more common than the dominant homozygosity, but it is somewhat lower than heterozygosity. At the level of factor *Ma*, the recessive homozygotes are the least spread both to heterozygotes and especially to dominant homozygotes.

On average, on all systems, the immunogenetic table is dominated by recessive homozygotes (57.11%), the heterozygosity is well represented (36.92%) and the dominant homozygosity has a very low spreading (5.97%).

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Due to the very heterogeneous immunogenetic systems found in the Carpathian breed, the polymorphous structures of blood groups can be successfully used as genetic markers in the early selection works to improve the goat herds in the direction dictated by economic imperatives.

## CONCLUSIONS

1. In the Carpathian goat breed the blood groups were determined by hemolytic test method using 12 specific monovalent reagents: 10 isoimmune (*anti-Aa*, *anti-Bb*, *anti-Bc*, *anti-Bd*, *anti-Be*, *anti-Bf*, *anti-Bg*, *anti-Ca*, *anti-Cb* and *anti-Ma*) and two heteroimmune: *anti-R* and *anti-O*.

2. The immunogenetic typification revealed a very emphasized polymorphism of blood groups in the Carpathian breed materialized in detection of 12 erythrocyte factors distributed in five blood group systems: *Aa* (system A), *Bb*, *Bc*, *Bd*, *Bf*, *Bg*, *Bi* (system B), *Ca*, *Cb* (system C), *Ma* (system M), *R* and *O* (system R-O).

3. The variability range of representation of blood factors is very wide from 8.85% (for the factor *Cb*) to 95.20% (for the factor *Ma*).

4. The most polymorphic blood group system is the system B (with six antigenic factors), the systems C and R-O have a binary immunogenetic structure and the systems A and M are monofactorial.

5. On average, on whole population, the manifest phenotypes (42.89%) are less frequent than the "silent" phenotypes (57.11)

because of the 1/3 ratio between the dominant genes (24.43%) and the recessive ones (75.57%) which determine a high recessive homozygosity (57.11%), a well represented heterozygosity (36.92%) and a very low spreading of dominant homozygosity (5.97%).

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