HAEMOGLOBIN TYPES IN THE CARPATHIAN BREED AND THEIR RELEVANCE FOR GOAT ADAPTATION

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Abstract

This study describes the genetic structure from the Hb locus in goats of the Carpathian breed. The haemotypification of the individuals at the Hb locus was achieved by horizontal electrophoresis in starch gel. The Carpathian goat presents a haemoglobin polymorphism of middle level with a structure of binary type. The haemoglobin polymorphism in the Carpathian breed was stood out by identification in the electrophoretical field of three migration zones: the fast haemoglobin named HbA type, the haemoglobin with intermediate migration labelled HbAB type and the slow haemoglobin designed HbB type. These phenotypes are determined by two co-dominant alleles, Hb^A and Hb^B. According to the codominance phenomenon, the haemoglobin phenotypes are similar to the haemoglobin genotypes. Thus, the two alleles control three haemoglobin genotypes: two homozygotes, Hb^AHb^A and Hb^BHb^B, and one heterozygote, Hb^AHb^B. The allele Hb^B registers a higher frequency (69.13%) than the allele Hb^A (30.87 %). Therefore, the Hb^BHb^B homozygotes register a high incidence in population (52.36%) in comparison with the other two genotypes; the heterozygotes Hb^AHb^B have a middling frequency (12.31%) and the homozygotes Hb^AHb^A are less spread (12.31%). From the viewpoint of general zygosity, the haemoglobin homozygotness (64.67%) is a little higher than the haemoglobin heterozygotness (35.33%). The environment conditions, selection systems or breeding technologies cannot disturb the Hardy-Weinberg genetic equilibrium at the Hb locus level in the goat population of the Carpathian breed.

Key words: haemoglobin polymorphism, goat

INTRODUCTION

Although the goat breeding is a very ancient tradition, no breeding and improvement program was ever organised for this species in Romania. Also, nowadays, the research in the caprine field is less developed than the one performed in cattle, sheep, pigs and poultry. All the more so, the researches of biochemical genetics in goat are scarce in the world and non-existent in our country.

The goat breeds have been variously evaluated for genetic variation based on morphological, physiological, pathological physiology, productive, reproductive and behaviour features [5, 7]. However, these characters underestimate the true levels of genetic variations. Therefore, the polymorphic variants of different proteins, enzymes, mineral elements or blood group factors represent accuracy procedures for a better measurement of genetic variation in the caprine species [1, 4].

One of the important blood proteins is haemoglobin that has attracted attention because of its biochemical, biophysical and physiological properties, having relevance to the selection phenomenon of animals [6].

This paper proposed to describe the genetic structure from the level of determinant locus of haemoglobin in goats belonging to the Carpathian breed. This is the first step to use the biochemical and molecular polymorphism, incorporated in systematic breeding technologies of goats, as an important and objective tool for improving both this breed and other goat breeds which are bred in Romania.

MATERIAL AND METHODS

The biological material used for investigation of the haemoglobin polymorphism was composed of goats belonging to the Carpathian breed from the *Station of Research and Development for Sheep and Goat Breeding, Popauti-Botosan*i.

The blood from the goats was sampled in heparinized test-tubes, by jugular venipuncture. The blood samples were

centrifuged at 3000 rotations/minute for five minutes, the plasma supernatant was eliminated and then the erythrocyte stores were washed three times with physiological serum solution; after each centrifugation, the washing solution was removed. After the third washing, each erythrocyte store was mixed with three distilled water volumes to produce erythrocyte lysis.

The haemoglobin solutions resulted from the haemolysed red cells are ready for electrophoresis to separate the globin fractions of the β-chains of haemoglobin. The electrophoretical substratum was represented by starch gel (12.5%) and the electrolyte contained Tris(hidroxymethyl)aminomethane, EDTA.Na_2 and boric acid (!0/1/0,75). The *p*H of the electrolytic solution was stabilized at 8.9. The gel solution had the same composition with the one of the electrolyte but it was 3.5 times more diluted. The electrophoretical migration time was four hours till the electrophoretical bands migrated at 4 cm from the start line. The power parameters were 40 mA (intensity) and 300 V (tension). The starch gels were coloured in an alcoholic-acid solution of 10B amidoschwartz (1%) and their discolouring were made in a bath (solution) composed of methanol, icy acetic acid and distilled water (3/1/3).

The frequencies of genes and genotypes from the Hb locus of goats were calculated. The χ^2 test was used to estimate the conformation mode of the goat population to the Hardy-Weinberg genetic equilibrium low.

RESULTS AND DISCUSSIONS

By the electrophoresis method, the haemoglobin fractions were separated. The identification of the haemoglobin types in goats is achieved in accordance with the migration speed of the light spots on the electrophoretical substratum, detected from the start line towards the cathodal zone.

The haemoglobin polymorphism in goats belonging to the Carpathian breed was pointed out by detection of three migration zones which had the same electrophoretical characteristics as in sheep too (fig. 1):

- the fast haemoglobin named HbA type, identified by a dark band in the anodal zone;
- the haemoglobin with intermediate migration labelled HbAB type, identified by two bands of different chromatic intensities, the anodal band being lighter than the cathodal one;
- the slow haemoglobin designed HbB type, identified by a dark band in the chatodal zone.

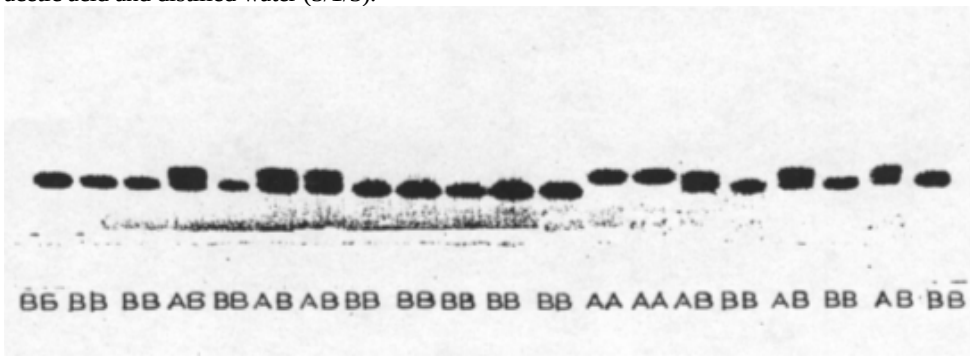


Figure 1. Haemoglobin electrophoregram in goats of Carpathian breed

These three haemoglobin phenotypes are produced by two codominant alleles Hb^A and Hb^B. The two haemoglobin alleles have a differentiated spreading within the breed, the allele Hb^B (69.13%) being over two times more frequent than its codominant Hb^A (30.87%) (fig. 2).

The haemoglobin alleles control the phenotyping of three genotypes: two homozygous (Hb^AHb^A şi Hb^BHb^B) and one heterozygous (Hb^AHb^B). The spreading of the haemoglobin genotypes in the goat population is relatively unbalanced. Thus, the most wide-spread individuals are

homozygous for the allele Hb^B (52.36%), a little over half of the goat population being homozygous for this allele. Instead, the homozygotes for the allele Hb^A have the lowest frequency (12.31%) within the population. However, the heterozygotness from the Hb locus level of the goats is present enough (35.33%) (fig. 3).

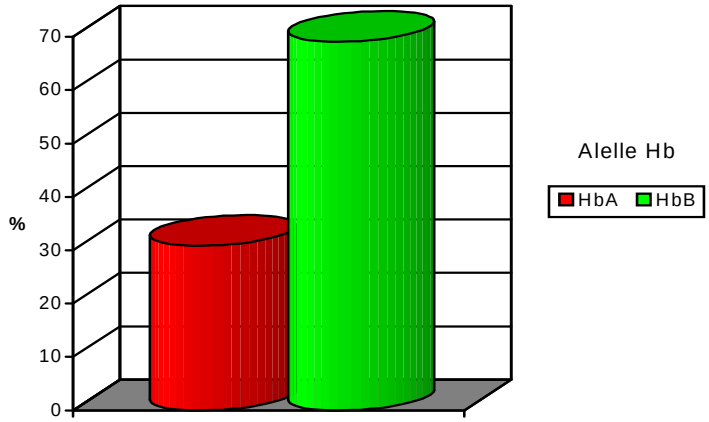
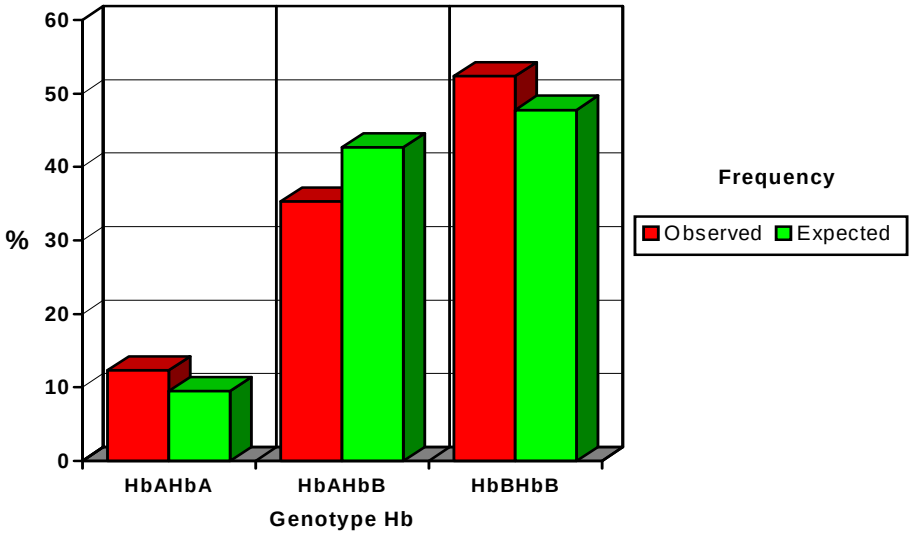


Figure 2. Allelic structure at the locus-ul Hb in the Carpathian breed

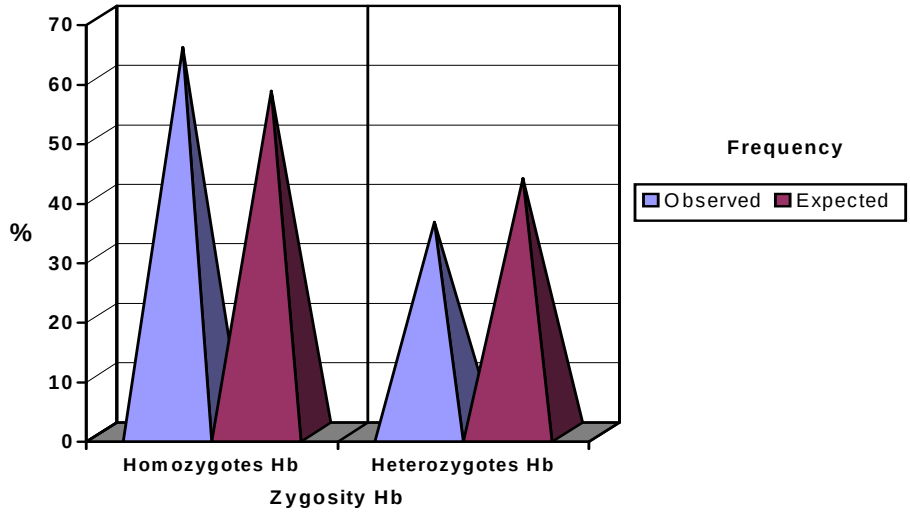


χ^2= 2,5137; L.D.=2; p>0,05

Figure 3. Genotypic structure at the locus Hb in the Carpathian breed

In the whole aspect of zygosity, the haemoglobin homozygotness (64.67%) is much more frequent than the haemoglobin heterozygotness (35.33%) (fig. 4).

Considering the low values of the χ^2 test, the differences between the observed distributions and the expected ones are unsignificant, so that the Carpathian breed is in Hardy-Weinberg genetic equilibrium, both in the respect of genotype repartition (χ^2= 2.5137) and in the one of ratio between homozygotness and heterozygotness (χ^2= 2.2083) (fig. 3, 4).



χ^2= 2,2083; L.D.=1; p>0,05

Figure 4. Zygosity status at the Hb locus in the Carpathian breed

From the viewpoint of the genetic structure from the Hb locus, the Carpathian breed belongs to the group of goats in which all haemoglobin types are expressed. The Carpathian breed resembles with the Nigerian breed, Red Sokoto [7], both breeds having the three normal haemoglobin types with almost the same incidences in the haemoglobin table. Moreover, in the Red Sokoto goats, the allele Hb^C was detected (in combination with the allele Hb^A), having however a very low frequency; this allele, that determines the synthesis of an abnormal haemoglobin (HbC), has always been associated with incidence of anaemia due to illness and environmental stress in small ruminants. The German goat breed, Edelziegen weiss, has the three haemoglobin types, too, but in this breed the HbA type is prevalent in comparison with the heterozygous type, while the HbB type is sporadically met [1] (tab. 1).

Table 1
Genetic structure at the Hb locus in some goat breeds

Rasa	Genotype Hb				Allele Hb		
	Hb^AHb^A	Hb^AHb^B	Hb^BHb^B	Hb^AHb^C	Hb^A	Hb^B	Hb^C
Carpathian	12.31	35.33	52.36		30.87	69.13	
Red Sofoto	13.33	36.00	50.00	0.67	31.67	68.00	0.33
Edelziegen weiss	85.62	13.75	0.63		92.49	7.51	
Edelziegen grün	95.20	4.80			97.60	2.40	
Dhofari	34.00	66.00			67.00	33.00	
Batinah	100.00				100.00		
Jebel Akhdar	100.00				100.00	0.00	
Damascus			100.00			100.00	

In other goat breeds, two haemoglobin types appear: always homozygotes Hb^AHb^A and heterozygotes Hb^AHb^B and never the homozygotes Hb^BHb^B. But, while the haemoglobin of HbA type is prevalent in the Edelziegen grün breed [1], the fenotype HbAB is two times more frequent toward the fenotype HbA in the Dhofari goats [3]. However, in both breeds, the allele Hb^A has higher frequencies than the allele Hb^B (tab. 1).

In the third group of goats, only one haemoglobin type is expressed, usually one

of the homozygous genotypes, either homozygote for the Hb^A allele (Batinah and Jebel Akhdar breeds from Oman) [3] or homozygote for the Hb^B allele (Damascus goat) [2] (tab. 1).

The genetic similarity at the Hb locus between the Carpathian and Red Sokoto breeds can be explained by their common origin: the Prisca goat breed (*Capra Prisca*), whose habitat is placed in Greece. In fact, the Prisca goat is considered the ancestor of more European and African goat breeds [5].

The polymorphism degree of haemoglobin system of each goat breed is defined by the number of alleles, the ratio between them, the interallelic combinatory capacity, the number of genotypes expressed, their distributions, the grouping mode, the variability ranges, the dispersion degree etc.

Therefore, the cases discussed until now demonstrate that, generally, the extreme temperatures (acute cold or sultry heats), the extreme forms of relief (dessert or mountain) or precarious nutrition and breeding conditions favour the fixing of the allele Hb^A and the temperatures situated in the biological comfort zone, the moderate forms of relief (forest steppe, hill etc.) or the optimal breeding technologies are correlated with a more emphasized fixing of the allele Hb^B. Thus, in the biological respect, as in the case of sheep too, the allele Hb^A is characterized by a great selection advantage in comparison with the allele Hb^B. In a great measure, the selective advantage of the allele Hb^A is due to the biophysical, biochemical and physiological peculiarities of the haemoglobin molecule of type A (saturation capacity with oxygen, dissociation curve of oxyhaemoglobin, erythrocyte load with haemoglobin, metabolic profile of the erythrocyte) [6]. It is possible that, sometimes, the profile of haemoglobin system in some goat breeds could be due to the reproduction isolation phenomenon.

CONCLUSIONS

1. The Carpathian goat breed presents a middle polymorphism at the Hb locus with a structure of binary type.

2. The haemoglobin polymorphism is defined by expression of the three genotypes: two homozygotes, Hb^AHb^A and Hb^BHb^B, and one heterozygote, Hb^AHb^B. The phenotypization of the haemoglobin variants is determined by two co-dominant alleles, Hb^A and Hb^B.

3. The allele Hb^B registers a higher frequency than the allele Hb^A. Consequently, in the haemoglobin table, the homozygotes Hb^BHb^B reach a high incidence, the heterozygotes Hb^AHb^B have a middling frequency and the homozygotes Hb^AHb^A are less present.

4. On the whole, the haemoglobin homozygotness is a little higher than the haemoglobin heterozygotness.

5. The goat population of the Carpathian breed is in Hardy-Weinberg genetic equilibrium at the determinant locus of haemoglobin.

REFERENCES

Journal articles

[1] Fésüs L., Várkonyi J., Áts Ágnes: Biochemical polymorphisms in goats with special reference to the Hungarian Native breed, Anim. Genetics, 1983, 14, 1: 1-6.

[2] Güney O., Özuyanik O., Torun O., Görgülü, Darcan N.: Relationship between some polymorphic parameters and performances in Damascus goats, Pakistan J. of Biol. Sci., 2003, 6, 8: 738-740.

[3] Johnson E.H., Nam D., Al-Busaidy R.: Observations on Haemoglobin Types in Three Breeds of Omani Goats. Vet. Res. Communic., 2002, 26, 5: 353-359.

[4] Menrad M, Stier C. H., Geldermann H., Gall, C. F.: A study on the Changthangi pashmina and the Bakerwali goat breeds in Kashmir: I. Analysis of blood protein polymorphisms and genetic variability within and between the populations, Small Rumin., Res., 2002, 43, 1: 3-14.

[5] Pourlis A. F., Christodoulopoulos G.: Morphology of the Hairs in the Goat-Breed *Capra Prisca*, J. of Anim. And Vet. Adv., 2008, 7, 9: 1142-1145.

[6] Raushenbach Yu O., Kamenek V.M.: The rol of biochemical polymorphism in ecogenetic differentiation of animals and its signifiance for selection for rezistence to extreme environmental conditions. XVI-th Intern, Conf. on Anim. Blood Groups and biochem. Polymorph., Leningrad, 1978: 128.

[7] Salako A.E., Ijadunola T.O., Agbesola Y.O.: Haemoglobin polymorphism in Nigerian indigenous small ruminant populations – preliminary investigation, Afric. J. of Biotechn., 2007, 6, 22: 2636-2638.