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INVESTIGATIONS CONCERNING THE POLYMORPHISM OF BLOOD GROUP STRUCTURES IN THE BOTOŞANI KARAKUL BREED IN RELATION TO THE COLOUR VARIETIES OF SHEEP

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In the international fur trade a new preferential trend appeared in the clothing industry field. This refers to the lamb pelt production of Karakul type of different colours of hairy coating thereof, as well as to the many shades of these colours. Thus, the sheep farming of Botoşani Karakul breed was focused lately in accordance with the market requirements relating to fur production. In this context, this paper describes the genetic structure of blood groups in Botoşani Karakul sheep as regards the colour varieties (black, greyish, brown, grey, pink and white) of this breed. The immunogenetic analysis envisages the quantification of phenotypic, allelic and genotypic frequencies at the determinant loci of blood group factors for each colour variety, the immunogenetic equilibrium status, as well as the immunogenetic endowment degree with red cell antigens. At the same time, the paper reveals the immunogenetic similarities and differentiations among these infrabreed entities. Based on this information, there are analyzed the associations of blood group factors with chromatic characteristics of colour varieties, as well as the relationship between the immunogenetic endowment status of these subpopulations and their inbreeding degree. Depending on the correlational panel configuration of colour varieties with blood formulae of animals, the discussions highlight the opportunity to use the blood group factors as genetic markers in early selection of animals for their improvement to strengthen the lamb pelt colours and to diversify the shades of these colours on the one hand, and a predictability analysis is made on the genetic and physiological homeostasis degree within these infrabreed entities as well as their evolutionary trends, on the other hand; from this perspective, the blood groups in the Botoşani Karakul sheep constitute a really useful tool for phenotypic and genetic strengthening of these taxonomic entities and for prevention of excessive inbreeding of the colour variety subpopulations.

INTRODUCTION

The nobleness and beauty of Karakul type sheep are conferred, in particular, by the colour variety beneath which the individuals appear in subpopulations, which, beside the morphological and histological characteristics of lamb pelt curling, make of them a completely different sheep category compared to other breeds [1–5].

Moreover, a very important factor for the commercial effect of lamb pelts is the colour of hair fibres. Colour quality and especially its uniformity throughout the curling contribute greatly to increasing the value of lamb pelts, imprints thereof pleasant reflexes and gives them nobility, even if the curling drawing is less suitable[1, 4]. In the colour framework not only its uniformity matters, but also the colour shade is an essential parameter for defining the aesthetic profile of lamb pelt. Colour shade makes possible the breed differentiation in smaller taxonomic groups, for example in specialized production types, and their use in various mating combinations of individuals in the reproduction process [6]. In most Karakul ecotypes, the black lamb pelts are prevalent, the greyish lamb pelts are in a moderate quantity and the brown, grey, pink and white lamb pelts are less common on the fur market [4]. Each colour variety has multiple shades. The shade spectrum is very limited for the black colour, instead an extremely large variation occurs for the other colours. The diversity of these colours and shades is determined by the presence of combined fibres of black, white, brown, brownish colours or the fibres are bizonally coloured; each colour variety is characterized by the pigment arrangement in hair fibre and by the proportion of these fibres within the curls [2, 4].

In the Botoşani Karakul sheep the selection processes are focused on increasing the number of individuals belonging to all six colour varieties of breed and obtaining a more diverse range of colour shades within each variety. Besides the strengthening of various qualitative morphological and histological traits of hair fibres of lambs, the improvement option of chromatic palette of lamb pelts of Karakul type is one of the priority objectives of this breed farming[2, 3, 7–10]. In the same context, the heterogenization of morphological and histological qualitative characteristics of lamb pelts, as well as the diversification of colours and of their shades in the Botoşani Karakul sheep contribute decisively to enhance the macroscopic biodiversity within the breed, but also in the ovine species in general[11].

The need to increase the production of coloured lamb pelts became a more recent preference of sheep farmers. This requirement occurred as a result of a new trend in the international trade of Karakul garments and handicrafts which is given by the buyer preferences for lamb pelts of different colours (brown, grey, pink and white) and shades thereof that are 3–5 times more expensive than the black or greyish lamb pelts. Also, the white lamb pelts are in high demand because they show a high pretability to be painted in any desired colour [12–17]. However this trend has the effect of changing the structure of sheep populations in terms of colour varieties[2, 3, 6, 11, 15, 16], but mostly regarding the genetic substrate of sheep in general [18, 19, 20, 21] and of those of Karakul type in particular [22, 23, 24].

Unlike the other qualitative features of lamb pelts (type, size and shaping of curls, hair length, skin thickness, smoothness, quality and lustre of hair fibres, closing mode and degree of hair curl etc.) which are determined by genetic factors, but they can be influenced by technological factors[2–5, 25–28], the colour of hair fibre hair has mostly genetic determinism. Of the colour characteristics (shade, uniformity, intensity, melanocytic type, the pigment production, the pigment arrangement in hair fibre) only the colour intensity can be influenced by nongenetic factors to a limited extent (*e.g.* type of diet may influence the melanin amount located along the hair fibre). Of all these qualitative features, the hair colour has the highest heritability, reaching a median value of 0.7 [2, 3, 29].

Like any qualitative character, the hair fibre colour is the phenotypic result of interaction of a certain number of genes [14, 21, 24, 25, 29]. In this context, the determinant loci of blood group factors can establish correlations with other loci responsible for exteriorization of biochemical systems or other morphological and physiological features through linkage or can influence them by their pleiotropic effect [20, 23, 30–32]. As such, this study tries to make an important contribution to the identification of some “marker genes” by immunoserological methods, on the one hand, but also to clarify certain association aspects of genes determining the antigenic erythrocyte structures with chromatic characteristics in the colour varieties of Botoşani Karakul breed for accelerating the improvement process of these infrabreed entities.

MATERIALS AND METHODS

The biological material on which the immunogenetic investigations were undertaken was represented by sheep of Botoşani Karakul breed of all six colour varieties: black, greyish, brown, grey, pink and white (Figs. 1–6). The black and greyish sheep constituted two independent subpopulations; the brown, grey, pink and white sheep formed a single population, taking into account their low incidence within the breed and the genetic similarities among them. Samples of 71 individuals of black variety, 42 individuals of greyish variety and 51 individuals of coloured varieties have formed three sub-populations of sheep constituted according to individual appurtenance to the colour varieties.

Typological identification of erythrocyte antigens was performed by haemolytic test method. In the immunoserological reaction there were used red blood cells (as antigens) from individuals which had to be immunogenetically typified and eight monovalent isoimmune reagents (as antibodies): *anti-Aa*, *anti-Bb*, *anti-Bc*, *anti-Bd*, *anti-Bf*, *anti-Bi*, *Ca* and *anti-Ma*; for the normal carrying out the haemolytic test the rabbit complement adsorbed on red blood cells of sheep was added in the reaction medium [33, 24].

The distributions of all erythrocyte factors and the averages of phenotypic, allelic and genotypic structures at the loci of these factors were calculated within each colour variety.

RESULTS AND DISCUSSION

GENETIC STRUCTURE AT THE BLOOD FACTOR LOCI DEPENDING ON THE COLOUR VARIETIES OF SHEEP

By the immunoserological reaction between the red blood cells of examined sheep and the eight monospecific sera in the presence of rabbit complement it was possible to identify eight blood group factors in sheep belonging to the colour varieties of colour of Botoşani Karakul breed; the eight erythrocyte factors are classified into four blood group systems: *Aa* (system A), *Bb*, *Bc*, *Bd*, *Bf*, *Bi* (system B), *Ca* (system C) and *Ma* (system M) that outline the blood formulae of immuno-genetically typified animals.

The haematic lysis degree has been revealed by contacting the red blood cells with specific reagents. The sheep which presented positive reactions of haemolytic test are individuals that possess erythrocyte factors in manifest status (dominant) and in the other individuals whose the haemolytic was negative the erythrocyte factors are in hidden status (recessive, "silent"). In fact, by such reactions the manifest and "silent" phenotypes of blood factors are determined. Usually, in the animal husbandry and veterinary practice only the manifest phenotypes are used as operating tool. On the basis of phenotypic configuration, the allele frequencies and genotypic variants can be determined in accordance with the complete dominance phenomenon that controls the genetics of blood groups in sheep species [24].

Figure 1. Botoşani Karakul sheep – black variety.

Figure 2. Botoşani Karakul sheep – greyish variety.

Figure 3. Botoşani Karakul sheep – brown variety.

Figure 4. Botoşani Karakul sheep – grey variety.

The results of haemolysis reactions highlighted the very emphasized polymorphism of blood factors in the colour varieties of Botoşani Karakul breed reflected in the very rich and heterogeneous mosaic of antigenic structures from the surface of red blood cells of animals. The red blood cells have reacted in a significant proportion with complementary reagent sera to antigens contained therein, for most erythrocyte factors, the margin representation of manifested phenotypes ranging between 50% and 80%; the remaining red cells showed negative reactions when they were brought into contact with specific antisera (Figs. 7, 10, 13).

Figure 5. Botoşani Karakul sheep – pink variety.

Figure 6. Botoşani Karakul sheep – white variety.

Beside the common fact (richness and emphasized polymorphism of antigenic structures), the three sheep subpopulations have some own characteristics, concerning the erythrocytic factors distributions, which customizes them as regards the genetic structure of blood groups.

In the black variety the manifest blood phenotypes are well accounted for most erythrocytic factors (Fig. 7). The highest frequencies are recorded by *Bf* and *Ma* factors. At the level of some factors their incidence fluctuates around 50% (*Bb*) or even below this threshold (*Bc*, *Bi*). The other factors have a middle representation within the mentioned limits (*Aa*, *Bd*, *Ca*).

Although the manifest phenotypes are relatively more frequent than those of "silent" type, the recessive gene recorded frequencies 2–3 times higher than their dominant alleles at the level of all factors (Fig. 8). The only more balanced ratios between the two genes, but still sub unitary, are at the level of *Bf* and *Ma* factors, *i.e.* where the factor representation is the best. As such, in the genotypic aspect, the dominant homozygotes are poorly represented, the recessive homozygotes and heterozygotes being predominant (Fig. 9). At the level of *Bb*, *Bc* and *Bi* factors the recessive homozygotness is more present than heterozygosity and at the level of *Aa*, *Bd* and *Ca* factors the heterozygosity is higher than recessive homozygosity. A character segregation that is closer to the Mendelian pattern can be seen at the level of factors *Ma* and *Bf*.

On average, across all blood group systems, although the manifest phenotypes (57.39%) are relatively more frequent than the hidden ones (42.61%), the recessive genes (64.80%) are almost twice more common than the dominant genes (35.20%). Accordingly, the dominant homozygotes record a low frequency (13.00%), while the two other genetic statuses are well represented and balanced, the heterozygosity being slightly higher (44.39%) than the recessive homozygosity (42.61%) (Figs. 7–9).

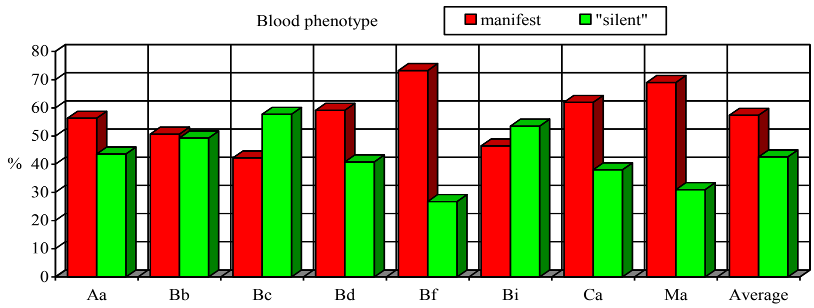

Figure 7. Phenotypic frequencies of blood group factors
in the black variety sheep of Botoşani Karakul breed.

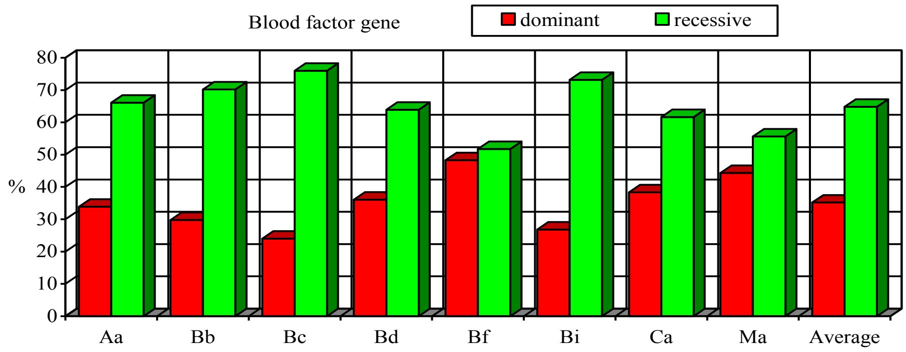

Figure 8. Gene frequencies of blood group factors in the black variety sheep of Botoşani Karakul breed.

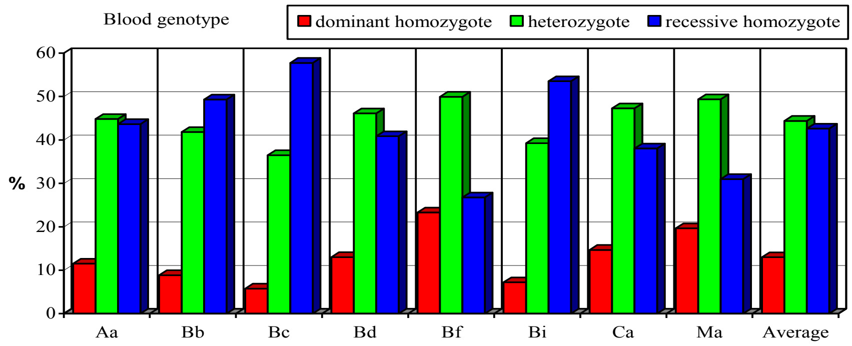

Figure 9. Genotypic frequencies of blood group factors in the black variety sheep of Botoşani Karakul breed.

In the greyish variety the mosaic of red cells is much richer in antigenic determinants in comparison with the subpopulation belonging to black variety. At all factor level the presence of manifest blood phenotypes is higher than 50% (Fig. 10). Also here, the most common antigenic determinants are *Bf* and *Ma* factors. Unlike the black variety, the lowest frequencies are recorded by *Aa* and *Bb* factors, the other factors being situated in the average plane of this variability range. The higher frequency of erythrocytic factors in this variety determines a reduction of percentage gaps between the two types of genes compared to black variety; however the recessive genes are generally still more spread than their dominant alleles (Fig. 11). At the level of *Bf* and *Ma* factors, the dominant genes are quite well represented in subpopulation, being even most commonly spread than their recessive alleles. More nuanced distributions of manifest blood phenotypes in greyish variety compared to black variety have as a result increasing the number of dominant homozygotes to the detriment of the recessive ones (Fig. 12). Thus, at the level of *Bf* and *Ma* factors the dominant homozygote incidence is higher than of the recessive homozygotes. However, for most factors, the dominant homozygosis is lower than the recessive one (*Bc*, *Bd*, *Bi*, *Ca*), but the differences between the two homozygous statuses are much lower as in the black variety. Larger gaps are found only at the *Aa* and *Bb* factor level. Increasing the frequency of positive reactions has the effect, at the same time, increasing the heterozygosis at loci of erythrocytic factors. In most cases, the heterozygosity is more developed compared to both homozygous statuses except the factors *Aa* and *Bb* to which the recessive homozygotness is slightly higher than heterozygosity.

Higher frequencies of erythrocytic factors detected (67.26%) than those of the hidden blood phenotypes (37.74%) determines a better spread of dominant alleles (43.32%) but no more than that of recessive genes (56.68%). In genotype terms these allelic distributions involve an increase of heterozygosity (47.88%), but especially of dominant homozygosity (19.38%) to the detriment of recessive homozygosity (32.74%) compared to the black variety. It is ascertained that the heterozygotness in the grayish variety is significantly higher compared to both homozygous statuses (Figs. 10, 11, 12).

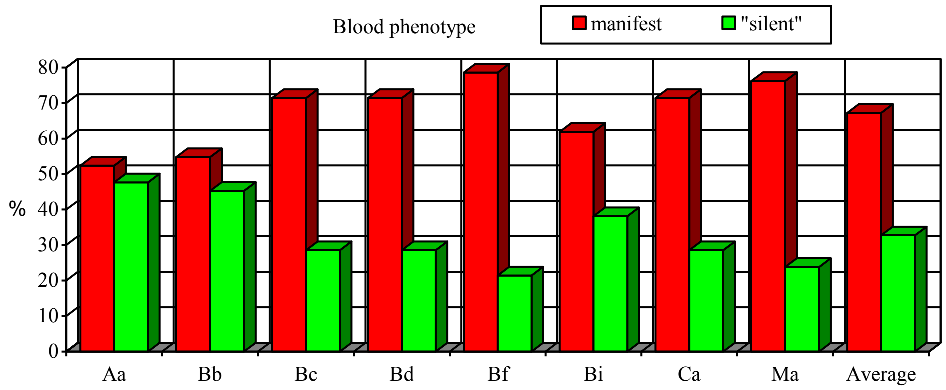

Figure 10. Phenotypic frequencies of blood group factors in the greyish variety sheep of Botoşani Karakul breed.

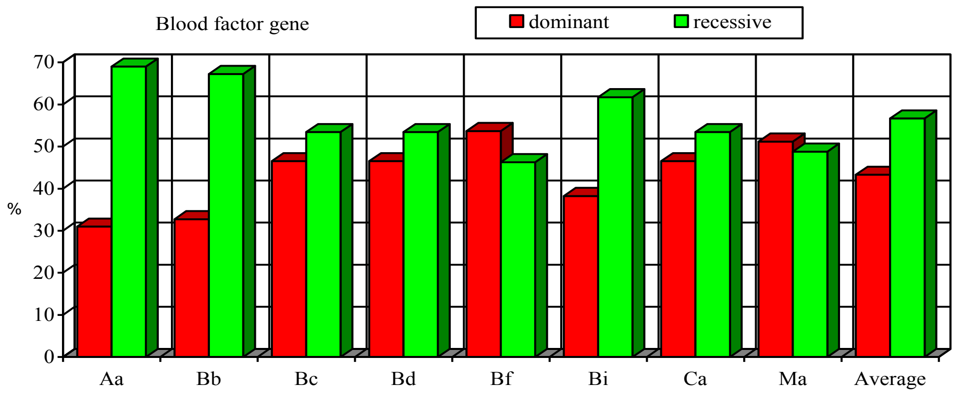

Figure 11. Gene frequencies of blood group factors in the greyish variety sheep of Botoşani Karakul breed.

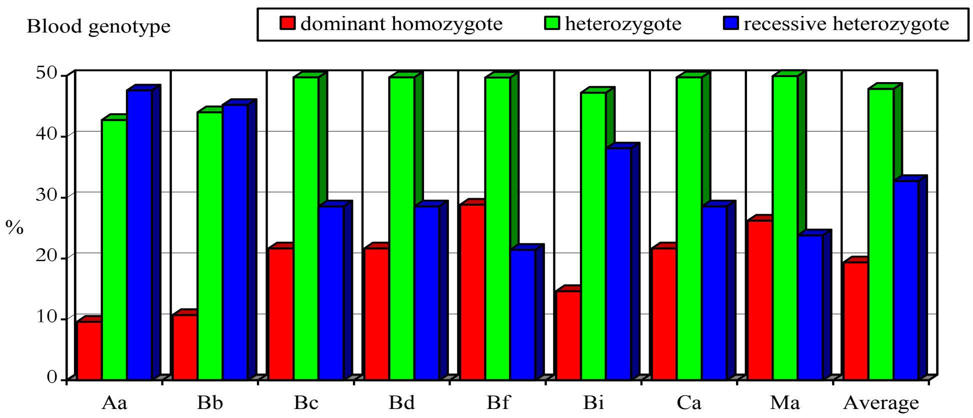

Figure 12. Genotypic frequencies of blood group factors in the greyish variety sheep of Botoşani Karakul breed.

In the coloured varieties the manifest phenotypes have intermediate distributions between those of black and greyish varieties (Fig. 13). The *Bc* and *Bi* factors recorded the lowest frequencies (like in black variety) of approximately 50%, the other factors having an upper spread to this percentage. If in the other two colour varieties the factors *Bf* and *Ma* are the most widespread, in the coloured varieties the highest incidence is registered by the *Ca* factor. At the same time, the factors *Aa* and *Bb*, which in other two varieties have lower frequencies (especially in greyish variety), in the coloured varieties their representation is much more relevant. The ratios between dominant and recessive genes are generally below par for most blood factors, except the factor *Ca*, where this ratio is almost unitary (Fig. 14). This distribution of genes makes that the dominant homozygotness to be lower than the recessive one, but not so categorical like in the black variety; instead, the heterozygosity is quite well represented (Fig. 15). At the level of *Bc* and *Bi* factors, apart from the fact that the dominant homozygosity is very low, the heterozygosity is lower than the recessive homozygosity. For the other factors the heterozygosity is much better represented than the recessive homozygosity. The only blood factor at which level there is a character segregation according to the classical Mendelian pattern (1/2/1) is the factor *Ca*.

Generally, the spread by almost 1.5 times of manifest phenotypes (63.73%) than that of the "silent" ones (36.27%) makes the recessive genes (59.81%) to be more frequent only with 20% compared to dominant genes (40.19%). In general, the spread with almost 1.5 times higher of manifest phenotypes (63.73%) than that of those of "silent" type (36.27%) makes that the recessive genes (59.81%) to be more frequently only with 20% compared to dominant genes (40.19%). As such, on all systems, in the genotypic aspect, in the coloured varieties the dominant homozygosity (16.66%) is higher than in black variety, but lower than in greyish variety, and in the case of recessive homozygosity (36.27%) the phenomenon is reversely. The heterozygosity (47.07%) is similar to the greyish variety and higher than of the black variety (Figs. 13–15).

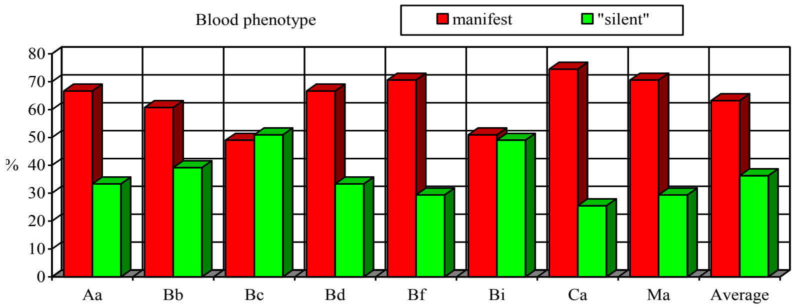

Figure 13. Phenotypic frequencies of blood group factors in the coloured variety sheep of Botoşani Karakul breed.

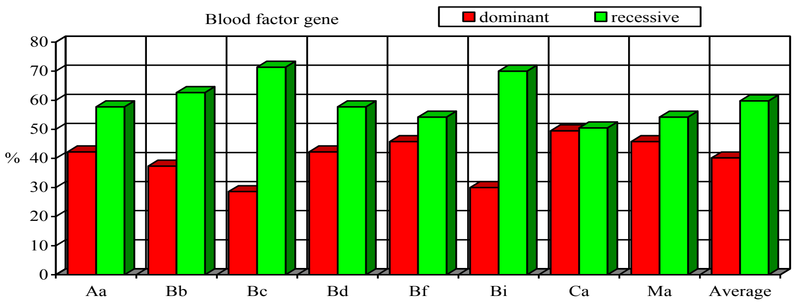

Figure 14. Gene frequencies of blood group factors in the coloured variety sheep of Botoşani Karakul breed.

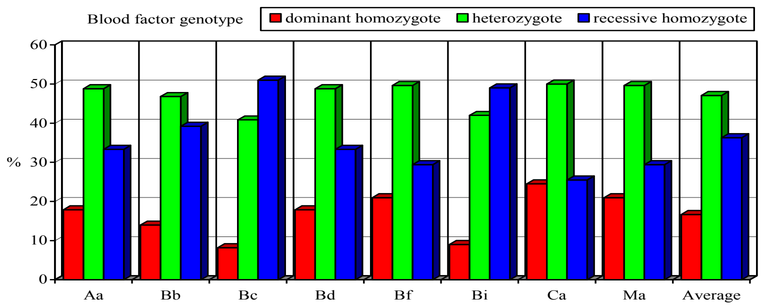

Figure 15. Genotypic frequencies of blood group factors in the coloured variety sheep of Botoşani Karakul breed.

So, a certain antigenic structure is characteristic to each colour variety, this subpopulations being distinguished among them, both in terms of their whole blood factor dowry and of preponderance sequence of each factor in the blood panel within these varieties. The selection system used for obtaining of the colour varieties and of various shades within those [2, 7–11] influences in a different manner the genetic structure of these sheep subpopulations, including their immunogenetic status.

ASSOCIATIONS BETWEEN BLOOD GROUPS AND COLOUR VARIETIES OF SHEEP

The associative analysis of blood groups with colour varieties derived from incidences of erythrocytic factors as well as from the genetic structure at thereof loci for each colour variety (Figs. 7, 10, 13). Experimental and statistics data show that association differences of colour varieties with blood group factors arise from the distinct immunogenetic profiles described for the three subpopulations.

The black variety is associated in a higher degree with blood factors *Bf* and *Ma* in manifest status and *Bc* and *Bi* in hidden (recessive) status (Fig. 7).

The greyish variety is associated more with the presence of erythrocyte antigens from the level of all blood factors than with their absence, but, by their incidences, the factors *Bc*, *Bd*, *Bf*, *Ca* and *Ma* present a higher association degree with this colour variety; only for factors *Aa* and *Bb* the association degree is lower (Fig. 10).

In the coloured varieties the best association with erythrocyte antigens is carried out with the factors in manifest status from the loci *Aa*, *Bd*, *Bf*, *Ca* and *Ma* and with the factor in hidden status at the *Bc* locus level (Fig. 13).

The phenotypic structure analysis at determinant loci of blood factors show different degrees of endowment with antigenic elements of the colour varieties (Fig. 16). Thus, the black variety is associated with the lowest immunogenetic dowry compared to greyish variety that, in its turn, is associated with the highest endowment degree with blood factors, and the coloured varieties present a intermediary immuno-genetics dowry between the two varieties mentioned above. The greyish variety is genetically the most endowed with antigenic determinants and the black variety is the poorest in this regard, the coloured Karakul hovering between the two varieties on the incidence of erythrocytic factors.

The overall antigen formulae found on the surface of red blood cells of sheep represent the phenotypic expression of general blood genotype structure of all immunogenetic elements. (Fig. 17). Thus, the black variety is associated with an important immunogenetic heterozygosity, but also with an appreciable recessive homozygosity, while the dominant homozygosity records relatively low values. In the greyish variety, due to more massive presence of erythrocyte antigens, the heterozygosity is the best represented of all varieties: also the dominant homozygosity is more developed, but it is below the recessive homozygosity. In the coloured varieties, although the heterozygosity is not significantly lower as in the greyish variety, the recessive homozygosity is twice more present than the dominant homozygosity.

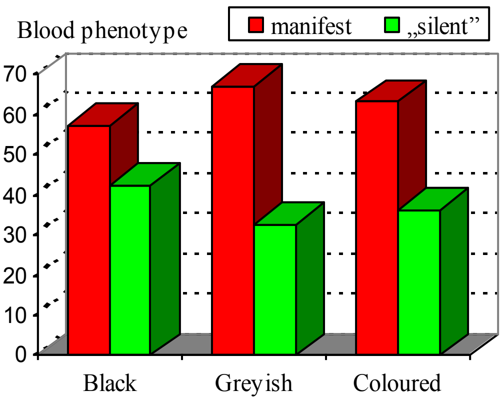

Figure 16. Average distributions of blood group factors in the colour variety sheep of Botoşani Karakul breed.

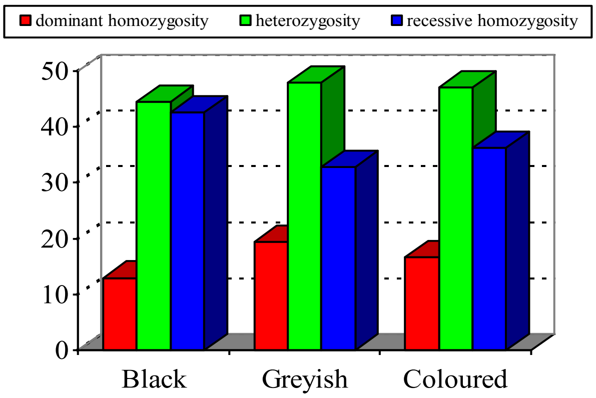

Figure 17. Average distributions of immunogenetic zygosity at the blood group factor loci in the colour variety sheep of Botoşani Karakul breed.

Among the three immunogenetic zygosity statuses, all colour varieties are associated to the highest degree with heterozygosity than with the two homozygous statuses, and in terms of homozygotness status the association is more obvious with recessive homozygosity than with dominant homozygosity. The most frequent dominant homozygosity is met in the greyish variety, and the most weakly represented is in the black variety, between these limits hovering the dominant homozygosity in the coloured varieties. But if in the black variety the recessive homozygotness has a representation close to the incidence of heterozygosity, in the other colour varieties the heterozygosity occurs much more frequently than the recessive homozygotness. Although in the coloured varieties the heterozygosity is imperceptible lower like in the greyish variety, the ratios between the two homozygous statuses are not identical; thus the differences between the two homozygous statuses are more evident in the subpopulation of greyish Karakul, the dominant homozygotness being higher, and the recessive one less spread than in the coloured Karakul.

The associative issue configuration of the colour varieties within the Botoşani Karakul breed with immunogenetic structures bears the imprint of the selection criteria used and of priority objectives pursued in improving of this sheep breed. The Botoşani Karakul sheep being a specialized breed for lamb pelt production, to strengthen the different morphological features of this production parameter the homogeneous mating are practiced, on the one hand, and to diversify other qualitative traits the heterogeneous mating are used, on the other hand, both mating types giving the intensity measure of inbreeding phenomenon [2, 3]. Occurrence of such phenomena throughout several historical stages of these taxonomic entities could affect their genetic substrate, inclusive at the blood group factor loci [24]. This analysis shows that statistically there is a relationship of inverse proportionality between the inbreeding intensity and the endowment degree with antigenic factors of the colour varieties; the more the inbreeding is more pronounced, the more their endowment is more reduced, and the more the inbreeding is less intense, the more their genetic heritage is richer. Consequently, if the inbreeding is stronger, the dominant homozygotness and heterozygogotness are lower and the recessive homozygotness is higher; if the inbreeding is less emphasized, the dominant homozygotness and heterozygotness are higher and the recessive homozygotness is lower.

In the black variety the sheep farming on the basis of breeding lines requires a more frequent practicing of homogeneous mating for improving the morphological and histochemical characteristics of lamb pelts (7, 8, 10); therefore, the dominant homozygotnes and heterozygotnes decrease and the recessive homozygotnes increases. In the greyish variety the heterogeneous matings are practiced very much for avoiding the hereditary anomalies and the homogeneous matings and are used only to strengthen the colour shades of this variety (7, 8, 10); as such, in comparison with black variety, the heterozygotness and dominant homozygotness have higher incidences and the recessive homozygotnes records a lower frequency. In the coloured varieties the selection is directed both to strengthen the colours, but especially their shades and to prevent the lethal factor; these objectives are achieved by alternating using both homogeneous mating and heterogeneous those (2, 3); as a result, the immunogenetic zygotness statuses of the coloured varieties present intermediary distributions between the black and greyish varieties, but much closer to those of the greyish variety.

In terms of heterozygosity, the coloured varieties are well represented, being similar to the greyish variety, but upper to the black variety. The fact that in the coloured Karakul we are witnessing a lower dominant homozygosity and a more increased recessive homozygosity compared to the greyish Karakul it may be because the inbreeding phenomenon was used more intensively for obtaining and strengthening of the coloured Karakul. The fact is even more relevant in the black variety, where the inbreeding phenomenon is even more pronounced due to farming of this variety on the basis of breeding lines, in which there is a more obvious decrease, both of dominant homozygosity and of heterozygosity and a more emphasized increase of recessive homozygosity compared to the other colour varieties. Although in the greyish Karakul too the selection for colour homozygosity is intensively practiced, the good enough heterozygosity of this variety at the blood factor loci can be correlated with the heterogeneous matings between individuals of greyish variety and individuals of black variety for avoiding the lethal factor; from this point of view many greyish individuals are heterozygous at the locus of the gene which determines the colour of hair fibres. Viewed from the association perspective of blood group makers with colour varieties, the distribution panel of the three immunogenetic zygosity statuses indicates that the inbreeding phenomenon has the highest intensity in the black variety, is more subdued in the coloured varieties, in order to in the greyish variety to be isolated.

Finalization of such analysis type offers the opportunity to estimate the endowment with antigenic determinants of individuals belonging to different colour varieties, quantifying the homozygosity and heterozygosity degree of these subpopulations, the ratios among these statuses, as well as their immunogenetic equilibrium status at a given moment. It also allows the development of new conclusions on kinship and differences between colour varieties, as well as on the genetic variability within them. On the other hand, this analysis represents a good opportunity to use the blood group factors as genetic markers in early selection of farm animals for their improvement in a faster pace in order to strengthen the colours of lamb pelts and to diversify the shades of these colours. At the same time, the populational dynamics of colour varieties can be evaluated over generations and the effects of a prolonged and exaggerated endogamy with negative repercussions on heterosis in populations may be anticipated. Based on these estimates the preventive measures can be applied when genetic imbalances caused by excessive endogamy are foreseeable so that to lead to installing of genetic and physiological homeostasis by triggering of feedback mechanisms.

CONCLUSIONS

The haemolytic test method revealed a very emphasized polymorphism of colour varieties belonging to the Botoşani Karakul sheep breed at erythrocyte factor loci being detected eight antigenic determinants included into four systems blood groups: *Aa* (system A), *Bb*, *Bc*, *Bd*, *Bf*, *Bi* (system B), *Ca* (system C) and *Ma* (system M) expressed in different frequencies.

In general, for each colour variety the manifest phenotypes are more common than the "silent" phenotypes in various degrees for each blood group factor; the incidences of dominant alleles are lower than those of their recessive; in the genotypic respect, the dominant homozygosity is lower than the recessive one and heterozygosity is better represented than both homozygous statuses.

The colour varieties of Botoşani Karakul breed are distinguished among them in immunogenetic aspect, each having an own antigenic structure and different associative particularities of blood group factors with hairy coating colour of sheep.

The dominant homozygosity is more common in greyish Karakul to coloured Karakul but mostly to black Karakul, the ratios among these statuses being reversed in the recessive homozygosity case; the heterozygosity incidence is almost similar in greyish and coloured Karakul having a considerable value and higher than that of the black Karakul.

In the Botoşani Karakul breed the most obvious associations of blood group factors with colour varieties are observed in the black variety with manifest factors *Bf* and *Ma* and with hidden factors *Bc* and *Bi*, in the greyish variety with manifest factors *Bc*, *Bd*, *Bf*, *Ca* and *Ma* and with hidden factors *Aa* and *Bb* and in the coloured varieties with manifest factors *Aa*, *Bd*, *Bf*, *Ca* and *Ma* and with hidden factor *Bc*.

The greyish variety is immunogenetically the most endowed and the black variety is the weakest equipped with erythrocyte antigens; the coloured varieties are associated with an intermediate immunogenetic dowry, but that is closest to that of the greyish variety with regard to blood factor distributions.

All colour varieties are more obvious associated with heterozygosity, at medium level with recessive homozygosity and the association with dominant homozygosity is weaker; there are differences among colour varieties concerning their association with the immunogenetic zygosity statuses according to their endowment with antigenic structures.

There is an inverse proportionality ratio between the immunogenetic endowment of the colour varieties and intensity of their inbreeding phenomenon.

The correlational panel configuration of the colour varieties with blood formulae indicates the degree of genetic and physiological homeostasis within these infrabreed entities, as well as their evolutionary trends, being a helpful tool for phenotypic and genotypic enhancing of these taxons and to prevent their excessive inbreeding.

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