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Immunogenetic Characteristics of Dairy Cattle of Different Populations in the Tyumen Region

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Abstract— **Modern dairy cattle breeding is based on the usage of various breeds of livestock. However, among this variety there are leading breeds. In Russia as well as in the world one of the most common breed is the Holstein breed. Besides, black-and-white and Simmental cattle are widely used. Each of them has its own characteristics; they relate not only to productivity, but also to the frequency of various blood groups. The study of the frequency of blood groups occurrence allows assessing the diversity of populations, the degree of genetic similarity of different populations and, as a consequence, correcting the breeding work with the livestock. The article presents the immunogenetic characteristics of dairy cattle breeds of different populations bred in the Tyumen region. The research allows obtaining the results that assert a high degree of homogeneity of the Holstein cattle belonging to different populations, while the black-and-white cattle retained some genetic diversity. The genetic similarity indices ranged from 0.815 to 0.873 and 0.568 to 0.791 according to the breed, respectively. In addition, the blood groups were revealed that were characteristic only of the black-and-white breed and only of Holstein cattle. The analysis of the frequency of blood groups occurrence among the Simmental cattle showed a relative similarity of the animals of the Austrian and German selection, the index of genetic similarity was 0.733. The results obtained will allow the adjustment of the subsequent breeding work in order to maintain the genetic diversity of breeds.**

Keywords — dairy breeds of catle, immunogenetic charateristics, blood group.

I. INTRODUCTION

Currently, dairy cattle breeding in Russia is increasingly using the potential of very diverse dairy livestock. Previously, the most common breed was the black-and-white one [1, 2]. Since the history of its breeding included several stages, and the breed itself was developed in different regions by different methods, a very peculiar group of cattle appeared, united almost only by the breed improver – the Dutch black-and-white cattle. Such peculiarities of breeding led, in turn, to the occurrence of different populations. Each of them was characterized by its own physical characteristics, productive qualities, and also immunogenetic characteristics [3, 4, 5]. In the Tyumen region the cattle of the Ural population were bred, and some part of such livestock remained at the stud farms, as the animals of this group were distinguished by the relatively high productiveness and productive longevity [6]. The subsequent selection process in the 1980s led to a slight "intake of blood" from the Holstein cattle, and later, after having obtained the cows' increased productivity, to the active usage of Holstein bulls. This caused the emergence of a large array of livestock with the high degree of Holsteinization, and as a result, the Ural type of black-and-white cattle was registered in the region; it was significantly different from the Ural population not only by its exterior and productive qualities, but also by breeding qualities [7]. That is, it became possible to ascertain the existence of a significant array of the Ural type of black-and-white cattle and the remaining small amount of Ural population [8, 9].

In addition to the changes occurring with the black-and-white cattle, the Holstein cattle were brought to the region. This was primarily conditioned by the insufficient number of the own breeding replacement young animals for the large industrial enterprises engaged in the milk production, which were actively built and are being built in the region. The Holstein cattle due to its adaptability and high productiveness suits the industrial production of milk in the best way [10, 11]. Due to the large needs for livestock, the delivery was carried out from many countries, but mainly from Europe. It should be mentioned that in every European country there is its own breeding program, although they are united by the usage of outstanding stud bulls. Therefore, livestock imported from abroad was characterized by a variety of body types, productive and adaptive qualities [12, 13].

Apart from the Holstein cattle the Simmentals cattle were delivered to the region, as they were stronger and more enduring, as well as they had high milking capacity, and their milk was suitable for making cheese [13, 14, 15]. Again, the delivery of animals came from several countries, mainly from Austria and Germany, whose breeding programs for the Simmental cattle differ. In Austria there is an emphasis on the strength of animals, combined with the high rates of both dairy and meat productiveness. In Germany, the main direction of

breeding is high milk capacity and only then strength and meat productiveness.

In this context, it can be concluded that at the present stage there is an array of dairy cattle of different breeds with different origin and, consequently, different genotypes in the region. However, the diversity of populations is mainly maintained by the mother stock, whereas, the stud bulls are genetically relatively similar due to the large-scale breeding. The adequate breeding work is possible only under the conditions of genetic diversity within populations, as it allows effective selection of the most successful genotypes. Reducing the level of genetic diversity leaves almost no choice [16]. Moreover, sometimes there is a need to work with a certain genetically isolated group of animals in order to maintain limited populations. Therefore, the study of blood groups in the existing population is necessary. Such a study will allow not only assessing the genetic diversity of the population, but also determining the possible direction of the subsequent breeding process [17].

Thus, the immunogenetic characteristics of the dairy cattle are relevant in view of determining the subsequent breeding work with the livestock in the region.

II. Material and Methods of Research

For the immunogenetic characteristics of the dairy cattle, the analysis of the animals' blood groups of different breeds was carried out by random sampling technique in several farms and populations.

With regard to the black-and-white cattle the animals of the Ural population had the quantity (n=143) and the Holsteinized black-and-white cattle – (n=154) in three breeding farms of the region. As to the Holstein cattle in three populations the quantities were: own breeding (n=60), Dutch selection (n=96), German selection (n=126).

With regard to the Simmental breed in two populations the quantities were as follows: Austrian breeding or AC (n=76) and German breeding or HC_C (n=50).

Immunogenetic characteristics of livestock is based on the study of the animals' blood groups, which were determined at the laboratory of the Siberian Research, Design and Technological Institute of Animal Breeding.

The genetic similarity indices were calculated based on the frequency of occurrence of erythrocyte antigens using the Mayal and Lingstrem formula [18].

III. Findings

A. Immunogenetic characteristics of the black-and-white cattle

Blood groups do not change in the ontogenesis process, therefore, they are a lifelong characteristic of each animal and form the structure of the population. When using blood groups and erythrocyte antigens, one can judge the dynamics of breeding processes. Since the modern process of breeding black-and-white cattle is based on the use of the Holstein stud bulls, the number of which is relatively small due to the large-scale breeding, this may lead to the diversity loss of the gene pool.

The frequency of blood groups occurrence among the cattle of the black-and-white breed selected in the stud farms is given in Table 1.

TABLE I. Frequency of some erythrocyte antigens among black-and-white cattle of different origin

Antigen	Ural Population instructional farm of TSACA (n=143)	Ural Type		
		instructio-nal farm of TSACA (n=77)	Flagman SJCS (n=32)	Uspens-koye SJCS (n=45)
J_2	0.300	0	0.419	0
Q'	0.200	0.309	0.302	0.711
B_2	0.238	0.269	0.232	0.156
O_2	0.153	0.173	0.256	0.133
I'	0.108	0	0.698	0.067
W	0.352	0.398	0.395	0.156
H"	0	0	0.093	0
S_1	0.138	0.134	0.186	0
U	0	0	0.232	0.289
U"	0.007	0	0.232	0
O_1	0.093	0	0	0.111
A'_2	0.091	0.103	0	0.200
E'_1	0.132	0.149	0	0.667
R_2	0.228	0.136	0	0.156
G"	0.089	0.101	0	0.289
L'	0.106	0.119	0	0.089
H'	0.354	0.560	0	0.956
K'	0.086	0	0	0.022
Y'	0.044	0	0	0.022
O_3	0.122	0.138	0	0
G_3	0.262	0.296	0	0

Since the Ural type representatives were characterized by different shares of pedigree with Holstein breed (from 75% to 93.7%) in different farms, the variations in the frequency of antigens occurrence were observed.

In general, it can be noted that the factor "farming" had a greater effect on the frequency of antigens occurrence than the belonging to the Ural population or type. This situation is explained by the fact that each enterprise had its own plan of breeding and within each herd it carried out work taking into account the characteristics of the breeding stock. The evaluation of the similarity of the analyzed groups by erythrocyte antigens allows characterizing the homogeneity of

the population of black-and-white cattle; the data of genetic similarity are shown in table 2.

TABLE II. INDICES OF THE GENETIC SIMILARITY OF BLACK-AND-WHITE CATTLE GROUPS HAVING DIFFERENT ORIGIN (R)

R		Ural Population instructional farm of TSACA	Ural Type		
			instructional farm of TSACA	Flagman SJCS	Uspenskoye SJCS
Ural Breed		-	0.925	0.709	0.791
Ural Type	instructional farm of TSACA	0.925	-	0.620	0.778
	Flagman SJCS	0.709	0.620	-	0.568
	Uspenskoye SJCS	0.791	0.778	0.568	-

The given data characterize the relationship between different groups of black-and-white cattle rather unusually. Thus, the representatives of the Ural population and the Ural type bred at the instructional farm of TSACA manifested the greatest similarity. At the same time, the degree of similarity between the Ural population and representatives of the Holsteinized cattle in other farms was rather high, it ranged from 0.709 to 0.791.

When analyzing the similarities indices of the representatives of the Ural type of different farms, it was revealed that they are relatively high (0.568-0.778), however, they are still lower than when compared with the Ural population. That is, in this case, it can be noted that a similar maternal basis – black-and-white cattle – still has a greater impact than that introduced by the Holstein cattle.

B. Immunogenetic characteristics of the Holstein cattle

Modern Holstein cattle have a large number of populations, as the representatives of this breed are bred around the world. To the Tyumen region they brought animals mostly of European genetics. Since the first limited deliveries were carried out in the 1980s, their descendants could be considered the Holsteins of own breeding. The next delivery began in 2006 and continues in small quantities at present. The frequency of occurrence of some erythrocyte antigens in the Holstein cattle of different populations is shown in Table 3.

In the majority of the countries, the Holstein cattle was bred according to the principle of absorption of local breeds, and, therefore, it is most often characterized by the initially different mother stock, gradually transformed into a fairly homogeneous breed array by using high-quality Holstein stud bulls. It is the different mother stock that allows maintaining some diversity.

TABLE III. FREQUENCY OF OCCURRENCE OF SOME ERYTHROCYTE ANTIGENS IN HOLSTEIN CATTLE OF DIFFERENT ORIGIN

Antigen	Cattle of own breeding (n=60)	Dutch selection (n=96)	German selection (n=126)
A_2	0.350	0.438	0.500
G_2	0.200	0.625	0.484
J'	0	0.125	0.219
B'	0.867	0.479	0.484
Q'	0.167	0.417	0.469
B_1	0	0.042	0
B_2	0.083	0.146	0.141
O_2	0.067	0.188	0.047
O_4	0	0	0.219
E'_3	0.167	0.479	0.469
O'	0.117	0.396	0.109
D'	0.067	0.125	0.094
G'	0.133	0.229	0.281
E'_2	0.117	0.354	0.531
I	0.283	0.104	0
I_2	0.050	0.250	0.281
X_2	0.600	0.458	0.703
W	0.150	0.188	0.219
R_1	0	0.188	0.016
C_2	0.483	0.542	0.641
C_1	0.083	0.229	0.438
L	0.100	0.229	0.219
H"	0.067	0.417	0.141
S_1	0	0	0.172
U	0.067	0.271	0.109
U"	0.067	0.250	0.125
Z	0.217	0.542	0.297
O_1	0.333	0.188	0.297
Y_2	0.567	0.521	0.500
E	0.083	0.167	0.453
I_1	0.167	0.021	0.063
S_2	0.033	0.146	0.094
K'	0.200	0.396	0
Y'	0.167	0.208	0

The values of the genetic similarity indices allow assessing the homogeneity of the breed, as well as the presence of connections between the members of different populations (Table 4).

TABLE IV. INDICES OF THE GENETIC SIMILARITY OF HOLSTEIN CATTLE HAVING DIFFERENT ORIGIN

R	Cattle of own breeding	Dutch selection	German selection
Cattle of own breeding	-	0.830	0.815
Dutch selection	0.830	-	0.873
German selection	0.815	0.873	-

The calculated indices indicate a significant genetic similarity of cattle groups of different origin, which is caused by the same direction of the breeding process and the use of affined stud bulls, which are the leaders of the breed. At the same time, if one compares female representatives of different origin, the most similar blood groups are among the German and Dutch cows (0.873); the lower index can be seen among the cows of own breeding and Dutch cows (0.830); the cows of own breeding and those imported from Germany are slightly more diverse.

However, in any case, such high indices of genetic similarity suggest that a highly productive herd of the Holstein cattle of own breeding was created in the region; it practically does not differ from the European representatives genetically, can actively progress using high-quality stud bulls and does not require adaptation.

When comparing erythrocyte antigens of the Holstein cattle and the black-and-white one, the lack of the following antigens among the Holstein cattle was determined: J_2, I', A'_2, E'_1, G", L', H', O_3, G_3.

The frequency of occurrence of B_2, O_2, E'_3, E'_2, W, S_1, R_2 antigens among the black-and-white cattle is 1.5-2 times higher than that of the Holstein cattle; however, the frequency of H", O_1, K' antigens is much lower.

At the same time, the antigens G3, J', O4, I, E, P' were not detected among the black-and-white cattle. That is, in the context of active Holsteinization of the black-and-white cattle, they can be used as the markers of the breed.

C. Immunogenetic characteristics of the Simmental cattle

The Simmental cattle are relatively new to the region, in contrast to the black-and-white and Holstein breeds. Its peculiar combined productiveness became attractive for farms and served as the basis for the importation of the representatives of this breed from different countries.

Due to the fact that such studies show the biological status of the herd, the study of the imported cattle by blood groups was initiated (Table 5).

TABLE V. FREQUENCY OF OCCURRENCE OF SOME ERYTHROCYTE ANTIGENS IN SIMMENTAL CATTLE OF DIFFERENT ORIGIN

Antigen	AC	HC_C	Antigen	AC	HC_C
A_2	0.526	0.600	O_2	0.132	0
A'_2	0.092	0.500	D'	0.026	0.200
O_1	0.171	0.340	K	0.105	0.200
E'_1	0.106	0.200	K'	0.105	0.300
E'_2	0.566	0	F'_2	0.013	0.400
E'_3	0.500	0.360	O'	0.197	0.200
B'	0.303	0.160	C_1	0.197	0.240
B"	0.053	0.260	C_2	0.395	0.160
G_2	0.263	0.540	R_2	0.145	0.400
Q	0.013	0.240	X_1	0.0260	0.100
Q'	0.526	0.360	X_2	0	0.300
G	0.026	0.200	L'	0.224	0.440
G'	0.539	0.200	W	0.895	0.860
G_3	0.158	0	F/F	0.618	0.600
G"	0.132	0.240	V/V	0.066	0
B_2	0.382	0.360	F/V	0.316	0.400
I'	0.105	0.440	L	0.145	0.300
I_1	0.237	0.100	U'	0.039	0.140
Y'	0	0.100	U"	0.026	0
Y_1	0.039	0.100	H'	0.329	0.800
Y_2	0.355	0.200	H"	0.092	0.100
I_2	0.211	0.160	S_1	0	0.500
T	0.026	0.200	S_2	0.605	0
T_1	0.039	0.240	Z	0.408	0.500
T_2	0.066	0.260	R'	0.053	0.200
O_1	0.171	0.360	T'	0.184	0

The use of blood groups provides information about the dynamics and shifts in the genetic structure of a population. It is possible to use some antigens as the marker ones, since the marker genes are either in the same linkage group with the genes controlling the selection trait or directly affect this trait themselves.

The frequency of antigens occurrence in the animals of different origin was similar for some of them and different for the others, which can be explained by multidirectional breeding work with the populations of the Simmental cattle from different countries.

If the animals are characterized as a whole, the following features can be identified:

1) medium and high antigens occurrence among cows of different selection with the difference in frequency between the groups of up to two times

a) in the system A – A2 (52.6–60.0%),

b) in the system B – E'3 (36.0 – 50.0%), G2 (26.3 – 54.0%), Q' (36.0 – 52.6%), B2 (36.0 – 38.2%), Y2 (20.0 – 35.5%),

c) in the system C – L' (22.4 – 44.0%), W (86.0 – 89.5%),

d) in the system FV – combination F/F (60.0 – 61.8%), combination F/V (31.6 – 40.0%),

e) in the system Z – Z (40.8 – 50.0%);

2) low antigens occurrence with the difference in frequency of up to two times

a) in the system B – E'1 (10.6 – 20.0%), B' (30.3 – 16.0%), G" (13.2 – 24.0%), Y1 (3.9 – 10.0%), I2 (21.1 – 16.0%), O1 (17.1 – 36.0%), K (10.5 – 20.0%), O' (19.7 – 20.0%), F'2 (1.3 – 40.0%),

b) in the system C – C1 (19.7 – 24.0%), C' (3.9 – 6.0%), X1 (2.6 – 10.0%),

c) in the system SU – U' (3.9 – 14.0%), H" (9.2 – 10.0%);

3) occurrence frequency with the difference of two or more times

a) in the system B – A'2 (9.2 – 50.0%), O1 (17.1 – 34.0%), B" (5.3 – 26.0), Q (1.3 – 24.0%), G (2.6 – 20.0%), G' (53.9 – 20.0%), I' (10.5 – 44.0%), I1 (23.7 – 10.0%), T (2.6 – 20.0%), T1 (3.9 – 24.0%), T2 (6.6 – 26.0%), D' (2.6 – 20.0%), K' (10.5 – 30.0%),

b) in the system C – C2 (39.5 – 16.0%), R2 (14.5 – 40.0%),

c) in the system L – L (14.5 – 30.0%),

d) in the system SU – U' (3.9 – 14.0%), H' (32.9 – 80.0%),

e) in the system R – R' (5.3 – 20.0%);

4) • antigens detected only in one of the studied groups

a) among the Simmental cattle of the Austrian breeding – E'2 (56.6%), G3 (15.8%), O2 (13.2%), F' (3.9%), E (3.9%), V/V (6.6%), U" (2.6%), S2 (60.5%), T' (18.4%);

b) among the Simmental cattle of the German breeding – Y' (10.0%), R1 (10.0%), X2 (30.0%), S1 (50.0%).

Despite the revealed differences, the index of the genetic similarity of the cows of these populations is quite high (0.733), which indicates the congeniality of these groups of Simmentals. Such features of animals different from the breeding point of view must be used in the subsequent breeding work with the herd.

IV. CONCLUSION

Thus, it can be concluded that in the course of carrying out the research of the immunogenetic characteristics of cattle used in the dairy production, some features of the animals from different populations were identified.

Thus, among the black-and-white cattle of the Ural population and the Ural type, there was a greater impact of the "farming" factor on the frequency of the blood groups occurrence. The relative diversity of the animals between the breeding farms and the similarity of the cattle differing by the degree of introduction of the Holstein breed in the same farm (the instructional farm of TSACA) is provided by the mother stock, which had a greater impact than the stud bulls of Holstein breed.

The Holstein cattle of different populations, despite the diverse origins: own breeding, Dutch selection, German selection, was characterized by a rather high genetic similarity. The genetic similarity indices varied insignificantly from 0.815 to 0.873. That is, even different breeding programs of different countries could not increase the genetic diversity of the breed due to the large-scale breeding and use of the same stud bulls.

Besides, when comparing erythrocyte antigens of the Holstein cattle and the black-and-white one, the following features were identified: there were no J_2, I', A'_2, E'_1, G", L', H', O_3, G_3 antigens among the Holstein cattle; no G_3, J', O_4, I, E, P' antigens were detected in the black-and-white cattle.

Thus, in the context of active Holsteinization of the black-and-white cattle, they can be used as the markers of the breed.

The analysis of the blood groups occurrence in different populations of the Simmental cattle revealed different frequencies of the following antigens: the Austrian Simmentals have A'_2, O_1, B", Q, G, I', T, D', K', R_2, L, U', H', R' antigens two or more times rarer than the German ones; the German Simmentals have G', I_1, C_2 antigens two or more times rarer than the Austrian ones; only the Austrian Simmentals have E'_2, G_3, O_2, F', E, V/V, U", S_2, T'; only the German Simmentals have Y', R_1, X_2, S_1. As a result, the genetic similarity index among the animals of the Simmental breed was lower and amounted to 0.733.

The identified differences can be used for the subsequent breeding of the Simmental cattle in order to maintain the genetic diversity of the breed.

References

[1] I.A. Paronyan, "Possibilities of Preserving and Improving the Gene Pool of Cattle Breeds of Domestic Breeding", Achievements of Science and Technology of Agrarian-Industrial Complex, 2018, vol. 32, no. 5, pp.63-66.

[2] M.A. Chasovshchikova, O.M. Sheveleva, M.A. Svjazhenina, N.I. Tatarkina, A.B. Satkeeva, "Relationship between the Genetic Variants of Kappa-Casein and Prolactin and the Productive-Biological Characteristics of Cows of the Black-Motley breed", Journal of Pharmaceutical Sciences and Research, 2017, vol. 9, no. 7, pp. 1038-1044.

[3] A. Zhmur, V.Bodnaruk, "Genetic Differentiation of Black-Spotted Breed by B-System of Blood Group", Scientific Herald of Lvov National Universit of the Veterinary Medicine named after S.Z. Gzhitski, 2016, vol. 18, no. 2-2 (67), pp. 94-96.

[4] M.A. Chasovshchikov, "The Effect of Erythrocyte Antigens on Longevity and Lifelong Productivity of Black-and-White Cows",

Bulletin of Orenburg State Agrarian University, 2013, no. 6 (44), pp. 81-83.

[5] M.E. Gontov, D.N. Koltsov, V.A. Onufrieva, V.I. Dmitrieva, S.A. Andreeva, "Characteristics of the Black-and-White Cattle of the Smolensk region by Blood Group Antigens", International Scientific Research Journal, 2018, no. 5 (71), pp.126-130.

[6] S.L. Gridina, G.A. Romanenko, F.A. Sagitdinova, "Breeding According to the Genotype of the Ural Black-and-White Cattle", Issues of Statutory Regulation in Veterinary Medicine, 2015, no. 2, pp.286-289.

[7] G.D. Halimullin, S.L. Gridina, G.D. Kipkaev, "New Ural Type of Black-and-White Cattle", Zootechny, 2003, no. 10, pp.5-6.

[8] V.S. Mymrin, S.L.Gridina, "Creation and Improvement of the Ural Type of Black-and-White Cattle", Niva Urala, 2008, no. S, pp.1-3.

[9] V. Mymrin, "Characterization of the State of Population of Black-and-White Cattle of the Ural type", Dairy and Beef Cattle Breeding, 2012, no. S1, pp.22-24.

[10] N.M. Kostomakhin, V.S. Yastrebova, "Adaptation Abilities and Productive Qualities of Holstein Cattle", Chief Zoo Technician, 2008, no. 1, pp.15-22.

[11] A.E. Belenkaya, "Productive and Reproductive Qualities of Holstein Cattle in the Conditions of the Northern Zauralye", Agrofood policy of Russia, 2017, no. 12 (72), pp.72-74.

[12] N.I. Kostomakhin, N.A. Popov, A.A.F.A. Isa, "Holstein-Breed Allelopool Delivered in Russia from Different Countries", Chief Zoo Technician, 2017, no. 3, pp. 3-12.

[13] E.B. Shukorova, "Immunogenetic Characteristics of Dairy Cattle Bred in the Khabarovsk Region", Bulletin of the Far Eastern Branch of the Russian Academy of Sciences, 2016, no. 2 (186), pp.101-107.

[14] A.I. Golubkov, M.M. Nikitin, "Simmental German Selection in the Conditions of Khakassia", Achievements of Science and Technology of Agriculture, 2013, no. 6, pp. 65-67.

[15] Kibkalo L. Simmental and Black-and-White Cattle - Reserve of Beef Production / L. Kibkalo, N. Goncharova // Dairy and Beef Cattle Breeding. 2010. №1. P.12-14.

[16] L.N. Prokopiv, S.S. Aleksandrova, "Monitoring of the Antigenic Structure of a Herd of Black-and-White Cattle Depending on the Linear Affiliation", Agrarian Bulletin of the Urals, 2014, no. 11(129), pp. 36-39.

[17] N.Ya. Kulumaeva, G.M. Goncharenko, "Genotypic Features of the Blood Groups of the Simmetal Cattle of Khakassia", Siberian Bulletin of Agricultural Science, 2007, no. 10(178), pp..59 - 64.

[18] V.K. Merkurieva, Z.V. Abramova, A.V. Bakai, I.I. Kocchish, Moscow: Agropromizdat, 1991, p. 446.