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ADAPTIVE ABILITY OF HOLSTEIN CATTLE INTRODUCED INTO NEW HABITAL CONDITIONS

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Abstract

Use of artificial insemination technologies and a purebred animal international trading led to global spreading commercial American and West-European breeds, which possess high productivity potential, but are very demanding to the feed quality, stuff experience and zoohygiene conditions. The highest genetic potential is characteristic of the Holstein cattle from the USA and Canada. Wide use of the Holstein breed in the Russian Federation resulted in rise of dairy productivity and improvement of dairy cattle technological parameters, but some problems of imported animals' health and adaptation have been revealed. The high dairy productivity inevitably leads to the weakening immunity, decreased fertility and less stress resistance. Disease susceptibility, in its turn, also ultimately decreases the productivity, fertility and the time of farming use in highly-productive cows. Nowadays a great importance is given to breeding for production traits, while the lack of resistance to the external factors as a cause of diseases and reduced performance is still remaining less studied. Our main aim was to study the adaptive abilities of the Holstein cattle of Russian and the US origin which were moved to Kabardino-Balkarian Republic in comparison with Black-motley animals long reared under the local conditions of Kabardino-Balkaria. The investigations were carried out on the farms of a pre-mountain zone (Agro-Concern Golden Kolos LLC, Soyuz-Agro LLC). The heifers were divided into 3 groups, 30 animals per each, with regard to age, physiological state, origin and productivity. The Black-motley heifers were the control group, the Russian Holstein heifers were the group 1, and the American Holstein heifers were the group 2. In the groups we studied blood bactericidal, lysozyme, complement and phagocyte activity. The dairy production was estimated monthly during the first two lactations. Fat and protein levels in milk, and cow weight were recorded, and the milkiness index was calculated. The superiority of Black-motley heifers and first-calf cows in blood bactericidal activity (by 5.7-8.3 %, $P > 0.999$, and 5.4-7.5 %, $P > 0.999$, respectively), blood lysozyme activity (by 2.2-3.1 %, $P > 0.999$, and 1.8-4.5 %, $P > 0.999$, respectively), blood complement activity (by 0.4-0.6 %, $P > 0.95$-0.99, and 3.2-5.0 %, $P > 0.99$-0.999) was found, whereas the Russian and American Holsteins were shown to possess more intensive phagocytosis (i.e., 4.9-7.7 % higher in heifers, $P > 0.99$-0.999, and 2.6-3.8 % higher in first-calf cows, $P > 0.95$-0.99). There was a true milk yield priority of 2227 kg ($P > 0.999$) in the first lactation and 2465 kg ($P > 0.999$) in the second lactation in the Holsteins originated from the US when compared to domestic Black-motley cows of the same age. However, the Black-motley cows surpassed the Holstein coevals of foreign origin due to higher milk fat and protein. Note, for the whole observation in all breeds studied the milk fat and protein were higher compared to the breed standards. Though milk quality was higher in the Black-motley cows, the total milk fat and protein yield was higher in the Holsteins, so that during the first lactation the difference in milk fat and protein output between the first-calf cows averaged 47.9-74.8 kg ($P > 0.999$) and 41.0-63.3 kg ($P > 0.999$), respectively, and the same trend was found in the second lactation. The maximum milking index was observed in Holstein cows of the US breeding which were superior to Black-motley cows and Russian Holstiens of the same age on average by 366-373 kg ($P > 0.999$) and 135-141 kg ($P > 0.95$), respectively. Thus Holstein cows bred in Russia and the US are quite successfully adapted to the conditions of Kabardino-Balkaria.

Keywords: Black-motley cattle, selection, adaptation, dairy productivity

The criteria for cows' adaptation to milk production technology are the realization of the genetic potential of productivity and its retaining under extreme stimuli, the ability to reproduce healthy offspring, the time of economic use, and the resistance to diseases [1].

Identification of commercially valuable individuals, introduction of modern reproduction techniques (artificial insemination, embryo transplantation, genetic engineering) and international trade of breeding material resulted in the global spread of a number of so-called commercial American and West-European breeds [2-4]. They possess a high productivity potential, but are very demanding to the feed quality, stuff experience, zoohygienic factors (temperature, humidity, light conditions), the environment, and veterinary services [5-6].

The diets imbalanced for essential nutrients, inconsistency of animal living conditions with the physiological needs of the organism under increasing productive potential lead to appearing and developing reproductive pathological processes, violation of reproductive function, and early culling [7]. The greatest losses of offspring (57 %) are associated to embryo death, and the problems of placentation (16 %) are in the second place [8].

Close interrelation of the reproductive function of highly productive cattle with a genetic component, adequate nutrition and a positive energy balance has been shown in the research of foreign authors [9-11]. Their studies examine the dependence of herd reproduction on particular factors, but the problem necessitates a comprehensive approach [12, 13]. One of the main causes of the problem of highly productive cattle reproduction is so-called long-term negative energy balance, at the peak of lactation especially [14, 15].

It is believed that increasing natural resistance of dairy cows is a way to increase their long-term use [16]. This is based on the understanding of the role of genetic factors in determining diseases and the possibility of a corresponding change in the genetic structure of farm populations. In this, the complex relationship between the productivity and resistance (adaptability) must be accounted for which complicates the direct estimation and forecasting the manifestations of the specified traits [17].

Wide use of imported Holstein bulls in Russia resulted in a rise of dairy productivity in crossbred milk cows, but at the same time, previously absent hereditary diseases appeared [18] as associated with a high milk production genes [19, 20]. According to N.P. Sudarev et al. [21], importing breeding stock indicates the limited own resources in Russia due to low herd reproduction.

Assessing adaptive qualities of Holstein cattle when moving it in different ecological and geographical conditions, domestic and foreign scientists disagree on the adaptive abilities, productive qualities, duration of economic use, and lifetime milk production.

Breeding cattle is based historically on the selection of phenotypes, that is a set of genes is selected that contribute to the particular phenotype manifestation. Strong returns require higher body resources which are not endless. High milk yielding inevitably results in the immunity and fertility weakening, a decrease in stress resistance, diseases, and a reduction of productive longevity [22, 23].

Among dairy cows, the highest genetic potential is characteristic of the Holstein cattle from the USA and Canada [24]. However, an introduction and continued use of highly productive cattle under new climatic, environmental and feeding conditions necessitate estimation of their adaptation ability [25, 26].

For the first time, we studied the productive features and immunobiological mechanisms of resistance in imported Holstein cattle under the conditions of Kabardino-Balkarian Republic, and confirmed its high acclimatization.

In this paper we summarize obtained data on the adaptive abilities of Holstein cattle of Russian and American origin introduced to Kabardino-Balkarian Republic versus Black-motley cows long reared under the local conditions of the area.

Technique. The research was performed in 2013-2015 at the farms of the pre-mountain Kabardino-Balkarian Republic area (Agro-Concern Golden

Kolos LLC, Soyuz-Agro LLC) specialized in breeding Black-motley and Holstein cattle. Three heifer groups were formed, 30 animals per group regarding age, physiological state, origin, and productivity, with calving occurred during the experiment. Black-motley heifers were the control group, Russian-bred Holstein heifers were group I, American-bred Holstein heifers were group II.

The cellular and humoral factors of immunity was studied at the republican blood transfusion station (RSPK KBR, Nalchik) using conventional methods. We assessed blood bactericidal, lysozyme, complement activity, and neutrophil phagocytic activity [27, 28]. Dairy production (milk yield, milk fat and protein) was estimated monthly during the first two lactations. Milk fat and protein levels were estimated as described [29]. Live weight was monitored. Milking index was calculated as the ratio of the milk yield to the animal live weight.

Blood was sampled from 20 animals of each group at the time when the animals were heifers, and during lactation. Milk productivity values were evaluated in all cows of each group.

Within the study, the animals were kept under the similar feeding and living conditions. Feeding was carried out using conventional farm diets regarding the actual feed nutritional value, lactation period, milk productivity, body weight, and physiological state [30].

The data were processed biometrically [31].

Results. Experimental groups of animals differed in their immunity parameters in different age periods (Table 1).

Blood bactericidal activity (BBA) characterizes the humoral immunoreactivity. BBA maximum was reported in experimental livestock during pregnancy and averaged 54.5-62.8 % which was 5.6-6.4 % greater (P > 0.99) compared to first-calf cows. Higher BBA in Black-motley cows compared to Holsteins was apparently due to their lasting breeding in the climatic and feeding conditions of the area.

1. Humoral and cellular immunity parameters (%) in Black-motley and Holstein heifers and first-calf cows of different origin ($X \pm m_x$, Kabardino-Balkarian Republic, 2013-2015)

Parameter	Group		
	control (n = 20)	experimental I (n = 20)	experimental II (n = 20)
Heifers			
BBA	62.8±1.0	57.1±1.2	54.5±1.4
BLA	27.3±0.3	25.1±0.4	24.2±0.4
NPA	65.7±1.2	70.6±1.4	73.4±1.3
BCA	13.6±0.1	13.2±0.2	13.0±0.2
First-calf cows			
BBA	56.4±0.8	51.0±0.9	48.9±1.1
BLA	28.2±0.4	26.4±0.3	23.7±0.4
NPA	54.0±0.7	56.6±0.9	57.8±1.0
BCA	13.3±0.2	12.4±0.2	11.9±0.2

Note. BBA - blood bactericidal activity, BLA - blood lysozyme activity, NPA - neutrophil phagocytic activity, BCA - blood complement activity. Group description is given in the Methods section.

Lysozyme is an important humoral nonspecific immunity factor, in particular it has a stimulating effect on phagocytosis and bactericidal effects on some microorganisms. Depending on the physiological state of the animals, they differed in lysozyme activity. Thus, while in Russian-bred Black-motley and Holstein cows this value increased somewhat during lactation compared to pregnancy (by 0.9 % at P <0.95 and 1.3 % at P > 0.95, respectively), then it decreased by 0.5 % (P < 0.95) in American animals of the same age. Irrespective of age, the highest lysozyme activity was characteristic of Black-motley animals, as during pregnancy they surpassed Holsteins of the same age of different origin by an average of 2.2-3.1 % (P > 0.999), and in the milk production period by 1.8-4.5 % (P > 0.999).

Phagocytosis is one of the efficient cellular defense mechanisms. Blood phagocytic activity was higher in American-bred Holsteins which provided them with the protection from adverse environmental factors when moving into new agroclimatic, technological, and feeding conditions. The differences versus Black-motley heifers characterized by minimum indexes, amounted to 7.7 % during pregnancy

(P > 0.999) and 3.8 % (P > 0.99) during lactation. It should be noted that domestic Holsteins were intermediate for this trait. Along with the breed differences, we observed an age-related decline of phagocytosis, mostly notable in Holstein cattle (14.0-15.6 %, P > 0.999) and the lowest in the same age Black-motley animals (11.7 %, P > 0.999).

Blood complement activity and neutrophil phagocytic activity decreased with age, with the greatest decline in Holstein cows — by 0.8-1.1 % (P > 0.99-0.999). During pregnancy and lactation, this value in Black-motley cows was greater compared to American-bred Holstein cows by 0.6 and 1.4 % (P > 0.99 and P > 0.999), respectively.

For a more complete characterization of Holstein cattle adaptive abilities, we studied the dairy traits in the experimental herds (Table 2).

In the first lactation, the milk yields were by 2227 kg (P > 0.999) and 1381 kg (P > 0.999) greater in American-bred and domestic first-calf Holsteins compared to Black-motley cows of the same age. Similar differences were observed in the 2-nd lactation: in Holstein cattle, it was by 2465 (P > 0.999) and 1532 kg (P> 0.999) greater, respectively. Higher coefficients of variation in milk yields in Black-motley cows (*Cv* = 16-17 %) compared to Holsteins of different breeds (*Cv* = 13.6-14.9 %) are noteworthy, which indicates the possibility of increasing milk production in Black-motley cattle populations through the appropriate screening and selection of animals.

2. Milk productivity and weight in Black-motley and Holstein animals of different origin ($X \pm m_x$, Kabardino-Balkarian Republic, 2014-2015)

Parameter	Group		
	control (n = 30)	experimental I (n = 30)	experimental II (n = 30)
1-st lactation			
Yield of milk within 305 days of lactation in kg	5937±184	7318±198	8164±217
Fat level in milk in %	3.73±0.02	3.68±0.02	3.63±0.03
Protein level in milk in %	3.39±0.02	3.31±0.02	3.24±0.02
Milk fat yield in kg	221.40±6.80	269.30±7.30	296.20±7.80
Milk protein yield in kg	201.20±6.20	242.20±6.50	264.50±6.90
Weight at the 2-nd to 3-rd months of lactation in kg	526.00±4.10	538.00±3.80	546.00±3.40
Milking index in kg	1129±34.6	1360±36.8	1495±38.7
2-nd lactation			
Yield of milk within 305 days of lactation in kg	6724±195	8256±211	9189±232
Fat level in milk in %	3.76±0.02	3.71±0.03	3.65±0.03
Protein level in milk in %	3.41±0.02	3.34±0.02	3.27±0.02
Milk fat yield in kg	252.80±7.20	306.30±7.70	335.40±8.40
Milk protein yield in kg	229.30±6.50	275.70±6.90	300.50±7.50
Weight at the 2-nd to 3-rd months of lactation in kg	554.00±4.30	571.00±4.00	579.00±3.70
Milking index in kg	1214±35.2	1446±36.9	1587±39.5

Age-related changes in milk yields demonstrated the greatest increase in Holstein cows (average of 938-1025 kg), that is, the environmental conditions were comfortable to realize high productive qualities. However, greater milk fat yields were characteristic of Black-motley cows that were superior to Holsteins of foreign origin of the same age by an average of 0.10 % (P > 0.99) in the 1-st lactation and by 0.11 % (P > 0.99) in the 2-nd lactation, indicating lower milk fat yields in the ancestors of American-bred Holstein bulls. Total milk protein yields were by an average of 0.07-0.15 % (P > 0.95-0.999) higher in Black-motley cattle than in Holsteins. An increase of fat and protein levels of an average of 0.02-0.03 % was observed in experimental groups in the 2-nd lactation versus the 1-st one.

The daughters of Black-motley and Holstein bulls exceeded the minimum requirements for milk production parameters. Thus, in the 1-st lactation, milk yields exceeded standard values by 2437 kg in Black-motley cows, by 2818 kg in domestic Holstein cows, and by 3664 kg in American-bred Holsteins; in the

2nd lactation the exceeding amounted 2924, 3256, and 4189 kg, respectively. However, the 13.3 % increase in milk production from the 1-st to the 2-nd lactation was the greatest in Black-motley cows while it was 12.8 % in domestic cows of Holstein origin and 12.5 % in North American animals. Different increases in milk yields in experimental cows was apparently due to different realization of the productive traits in Holstein cattle in the new geographical, technological and feeding conditions.

Fat and protein levels in milk in all lactations studied exceeded standards for the respective cattle breeds. The qualitative parameters of milk exceeded the minimum requirements in domestic-bred Holsteins greater than in the population of foreign origin which indicates the use of the bulls of domestic origin of higher fat-and-protein lines in the breeding process.

Despite the higher milk characteristics in Black-motley cows, milk fat and protein yields were higher in the groups of Holstein origin which was due to their higher milk productivity. So, the milk fat yield differences between the first-calf cows of the control and experimental groups averaged 47.9-74.8 kg ($P > 0.999$), and milk protein yield differences were 41.0-63.3 kg ($P > 0.999$). The similar tendency was in the second lactation.

The body weight is important parameter in cow breeding. This breed and constitutional trait characterizes animal development and is associated with milk and meat productivity. The body weight of experimental foreign-bred cows at the 2-nd to 3-rd months of lactation was by 20-25 kg ($P > 0.999$) higher as compared to that in domestic Black-motley cattle. This parameter was intermediate in Holstein cows of Russian origin and close to American-bred cows of the same age.

Milking index is a parameter of milk production per center of cow body weight. The maximum milking index was observed in Holstein cows bred in USA that were superior to Black-motley cows and Russian Holstiens of the same age by 366-373 kg ($P > 0.999$) and 135-141 kg ($P > 0.95$) on average, respectively. The obtained milking index characterize all experimental cows as a herd of dairy production type.

Thus, Holstein cows bred in Russia and USA are quite successfully adapted to the conditions of Kabardino-Balkarian Republic. In particular, the lack of humoral protective factors in Holsteins compared to Black-motley cows is compensated by more intense phagocytosis which is a compensatory response to the new agro-climatic, technological and feeding conditions. The high qualities of both domestic- and American-bred Holstein cattle is proved by their considerable superiority over local Black-motley cows of the same age in milk yields, milk fat yields, and milkling indices

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