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ECONOMIC AND BIOLOGICAL CHARACTERISTICS OF THE FIRST-CALVING HOLSTEIN HEIFERS OF DIFFERENT ORIGIN DURING ACCLIMATIZATION ON A FARM IN CENTRAL RUSSIA

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A b s t r a c t

Making the most of the genetic potential of dairy cattle imported to the Russian Federation is an important and urgent task which requires a detailed study of animals' acclimatization and adaptation under the conditions at regional livestock enterprises. The aim of the work was to assess body scores, productive and reproductive performance, blood biochemical parameters and composition in the Holstein black-and-white first calving cows (a herd of OOO Molochnik, Bolshesoldatsky District, Kursk Province, 2019-2020). We compared performance of 15 imported heifers of European selection from Denmark (group 1) and 15 heifers from pre-adapted mother cows born on the farm (group 2). The groups were in identical feeding and housing conditions. On average, the cows calved in 23.6 (group 1) and 24.6 months (group 2), having bodyweight of 509.2 and 516.9 kg, respectively. For 305-day lactation, total milk production was 8667 kg with 3.73 % fat for group 1 and 121 kg more with 3.80 % fat for group 2 (the differences are insignificant). Milk yield adjustment to 3.4 % milk fat increased the difference to 314 kg (P > 0.95). In group 1, the milk fat yield was 323.6 kg, or 10.3 kg less compared to group 2 (the differences are insignificant). The difference in milk proteins was also small (3.27 vs. 3.28 %). Total milk protein yield was 283.4 kg vs. 288.2 kg, the milk production coefficients (i.e., fat-corrected milk yield per unit bodyweight) was 1867 kg vs. 1900 kg. Therefore, these findings confirm 93.1 % vs. 93.0 % realization of genetic potential for milk production, 99.5 % vs. 100.7 % for milk fat, and 100.0 % vs. 99.3 % for milk protein. All cows were quite tall, their height at the withers averaged 137.5 cm vs. 135.4 cm, at the sacrum 145.3 vs. 142.4 cm. The total exterior scores, including strong body constitution, well-developed milk traits, and leg condition, in group 1 were higher (P > 0.95) compared to group 2. According to a 100-point evaluation, the cows of group 1 had a slight advantage. Of the classification traits, the score of trunk volume was 0.9 points higher, of udder — 0.9 points higher, of general appearance — 0.8 points higher compered to group 2 (the differences are insignificant). The animals of both group had body type Good+ with 83.0 points vs. 81.7 points for five classification traits compared (the difference is insignificant). At month 6 of lactation, the total blood protein level averaged 83.11 g/l vs. 83.78 g/l. Other biochemical blood parameters (albumin, globulins, glucose, cholesterol, calcium, phosphorus, magnesium, activity of transamination enzymes and alkaline phosphatase) were within the physiological limits. An increased counts of blood leukocytes occurred in the European cows. The hematocrit index in group 1 was significantly higher than in group 2 (P > 0.95), which is apparently due to intensified metabolism. Thus, in the conditions that meet the biological needs of animals, the acclimatization of European breeding cows is quite successful.

Keywords: Holstein cows, first-calf heifers, genetic potential, exterior, body scores, linear body measurements, blood biochemical parameters, total protein, albumin, globulins, aminotransferases, alkaline phosphatase

The study of the implementation of the genetic potential of growth, development and productivity, acclimatization and adaptive qualities of dairy cattle imported to the Russian Federation from abroad remains an important and urgent problem [1, 2]. In connection with the culling of animals for various reasons [3-6], the selection of cows of the first calving for herd repair is an important direction in selection and breeding work both in Russia and abroad. For example, in Canada, 34-36 replacement heifers are raised annually per 100 cows [7, 8].

The import of breeding stock does not completely solve the problems of dairy cattle breeding. There are risks during transportation and quarantine of animals, difficulties in adapting to new technological conditions, as a result, the duration of the productive use of cows is significantly reduced, their genetic potential is not fully realized [9, 10]. As per H.A. Amerkhanov [11], internal reserves for increasing the milk productivity of cows are the full realization of the genetic potential of animals, the improvement of feeding regimes, the use of innovative technologies for keeping and reproducing herds.

Russia ranks 6th in the world in terms of milk production. In January-September 2020, gross milk yield in farms of all categories amounted to 24.9 million tons and increased by 2.7% compared to 2019. At agricultural enterprises, milk yield per cow amounted to 6156.0 kg, or 6.5% more compared to the same period in 2019. The intensification of domestic dairy cattle breeding in Russia is carried out on the basis of a qualitative transformation of domestic cattle breeds and the creation of highly productive dairy herds that meet the requirements of modern milk production technologies. For this purpose, highly productive animals of the Holstein breed, which have a high genetic potential, are imported into the Russian Federation from Europe and North America [12]. According to the Ministry of Agriculture of Russia, for the period from 2008 to 2018, the number of Holstein cattle in Russia increased by 4.3 times, from 121.23 thousand animals, or 3.4% of probonitated individuals to almost 525 thousand heads. With loose housing and balanced feeding, the yield of Holstein cows is 8000-10000 kg of milk with a mass fraction of fat of 3.5-3.6% [13, 14]. When breeding dairy cattle, much attention is paid to the assessment of animals according to their exterior and constitutional features [15-17].

Here, we present the results of assessing the acclimatization qualities of animals imported and born on the farm, based on a comprehensive comparison of their conformation, physiological and productive indicators. Under conditions that meet the biological needs of animals, the successful acclimatization of first-calf heifers of European selection has been confirmed.

The purpose of the work is to study the economic and biological characteristics of cows of the first calving of the black-and-white Holstein cows of different origin in a dairy farm.

Materials and methods. The studies were carried out in 2019-2020 on a population of highly productive black-and-white Holstein cows (Molochnik LLC, Bolshesoldatsky District, Kursk Province). The dairy herd of the enterprise was completed with the livestock of heifers imported from the breeding farms of European countries and the USA. Information about the productive indicators of animals, their production use was borrowed from the card index of breeding cows of the archive of the program for zootechnical and breeding accounting AWP "SELEKS" (LLC Regional Center for Information Support of Pedigree Livestock Breeding of the Leningrad Region, PLINOR). For the study, we used two test groups, each of 15 randomly assigned first-calf heifers. Group 1 included imported animals of European selection (Denmark), group 2 consisted of animals that descended from mothers born on the farm and passed adaptation. Animals during the experiment were in identical conditions of feeding and maintenance.

The coefficient of milk yielding (MY, kg) was determined by the formula reducing the milk yield to the basic rate of milk fat content equal to 3.4%:

$$MY = (Y_{305} \times MFF) \times 3.4^{-1} \times LW^{-1} \times 100,$$

where Y_{305} is milk yield for 305 days, kg; MFF is mass fraction of fat, %; LW is live weight, kg.

The degree of realization of the genetic potential (RGP, %) of animals was calculated as $RGP = OP \times EP^{-1} \times 100\%$, where OP is observed productivity, EP is expected productivity according to the parental index of cows (PCI), kg. PCI was calculated by the formula of N.A. Kravchenko (1969):

$$PCI = \frac{1}{4} (2M + MM + FM),$$

where M is mother's productivity, kg, MM is productivity of mother's mother, kg, FM is productivity of father's mother, kg.

The measurements of the main body parts of the animals were determined on the 3rd-5th month after calving, body indexes were calculated based on the ratio of the corresponding measurements [18]. To study the physique, a linear assessment method was used, which makes it possible to obtain an objective assessment of individual animals, groups of animals and herds as a whole, to conduct a corrective selection to eliminate the identified shortcomings in the exterior of animals and thus influence the type of physique. Each of the features used in linear estimation and has an independent value and was evaluated separately from others on a scale from 1 to 9 points: the average value of the trait is 5 points. In assessing the trait, biological extremes (–, +) of development were taken into account. Seventeen exterior traits were evaluated, and in the complex assessment of individuals on a 100-point scale, 5 traits were used. In addition to the traits included in the linear type score, conformation deficiencies that affect health and milk production were accounted [17, 19-21].

The health and metabolic state of the animals was assessed by morphological and biochemical parameters of blood. In 5 individuals from each group, at the 6th month of lactation, blood samples were taken into vacuum tubes (from the caudal vein in the morning before feeding). Total protein and its fractions, glucose, total cholesterol, enzymes alanine aminotransferase (AlAT), aspartate aminotransferase (AsAT), alkaline phosphatase, calcium, phosphorus, magnesium were determined in blood serum in accordance with the manufacturer's instructions (a biochemical automatic analyzer BioChem FC 120 and the supplied reagents, High Technology, Inc., USA). Complete blood count was performed on a Mindray BC-2800 Vet automatic hematology analyzer with Vet 2.3 software for animals (Mindray Medical International, Ltd., China). The resulting digital material was subjected to biometric processing [22] using the standard package of the Data Analysis program in the Microsoft Excel system for WINDOWS. Means (*M*), standard errors of means (±SEM), coefficients of variation (Cv, %) are presented. To assess the significance of differences between groups, the Student-Fisher test was used. Differences were statistically significant at $P > 0.95$.

Results. The intensity of animal rearing to a certain extent affects the completeness of the implementation of their genetically determined productive qualities. For optimal formation of glandular tissue in the udder, heifers should receive 300-350 kg of milk during the milking period, feeding on balanced, complete diets with a moderate amount, but high quality of feed [23]. Analyzing the data, it can be stated that in LLC Molochnik, rearing of replacement young animals is well-organized. Heifers from group 2 were effectively inseminated at the age of 15.5±2.8 months upon reaching a live weight of 391.8±20.9 kg. It should be noted that the animals that came from Europe were also grown intensively. So, in heifers of group 1, the age of the first insemination was 29 days less than in the animals of group 2, and the live weight was 0.4 kg more, the animals calved on average at about the same age (Table 1). The live weight of cows from group 2 at the first calving was 7.7 kg more than that of cows from group 1 (differences are not significant).

1. Growth and milk yield in black-and-white Holstein replacement heifers of various origin (*M*±SEM, LLC Molochnik, Kursk Province, 2020)

Index	Group 1 (*n* = 15)	Group 2 (*n* = 15)
Age of the 1st insemination, months	14.6±1.5	15.5±2.8
Live weight at the 1st insemination, kg	392.2±15.7	391.8±20.9
Age at 1st calving, months	23.6±1.4	24.6±2.7
Live weight at the 1st lactation, kg	509.2±15.4	516.9±25.1
Milk yield for 305 days of lactation, kg	8667±94	8788±128
Milk yield adjusted for 3.4% fat content, kg	9508±86*	9822±97
Mass fraction of fat (MFF),%	3.73±0.11	3.80±0.07
Milk fat, kg	323.6±19.1	333.9±16.8
Mass fraction of protein (MFP), %	3.27±0.06	3.28±0.04
Milk protein, kg	283.4±17.4	288.2±4.4

N o t e. Imported animals of European selection (Denmark) were group 1, heifers derived from mothers born at the farm and subjected to adaptation were group 2.
* Differences between groups are statistically significant at P > 0.95.

The evaluation of the productive indicators of first-calf heifers indicates a high genetic potential of animals, that is, all individuals are selected for abundant milk production. The milk yield of cows for 305 days of lactation in group 1 averaged 8667±94 kg, in group 2 it was 121 kg higher. When the milk yield was adjusted to the normalized milk fat content, the difference increased to 314 kg and became significant (P > 0.95). At the first calving, the cows from group 2 also differed from the imported peers by a higher content of fat in milk (3.80±0.07 vs. 3.73±0.11%). As a result, the difference between the groups in milk fat yield was more significant. So, in group 2, the milk fat yield was 10.3 kg more than in group 1 (differences are not significant). We did not reveal any noticeable difference in the mass fraction of protein in milk (see Table 1). The yield of milk protein in cows in group 2 was 4.8 kg more than in group 1 (differences are not significant) (see Table 1). In group 1, the coefficient variability was 27.2% for milk yield, 2.8 and 1.6% for the mass fraction of fat and protein, respectively, and 15.7% for milk fat; in group 2, these indicators accounted for 22.4%, 2.9% and 1.8%, 22.1%, respectively.

The live weight of dairy cows is an important breeding trait that characterizes the development of animals and is associated with their productive qualities. One of the objective indicators in assessing the milk productivity of cows is the milk yield coefficient, which shows the amount of milk produced per lactation per 100 kg of live weight. The coefficient of milk production makes it possible to judge the constitutional orientation of animals. In our studies, animals in group 2 were had a higher indicator, 1900±30.7 kg vs. 1867±23.5 kg. Given these data, it can be concluded that in terms of productivity, all experimental heifers belonged to the dairy type.

2. Values of PCI (parental indices of cows) **and RGP** (realization of genetic potential) **in replacement black-and-white Holstein replacement heifers of various origin** (*M*±SEM, Molochnik LLC, Kursk Province, 2020)

Index	Group 1 (*n* = 15)	Group 2 (*n* = 15)
PCI for milk yield, kg	9309±171	9437±134
PCI by mass fraction of fat (MFF),%	3.75±0.14	3,77±0,11
PCI by mass fraction of protein (MFP), %	3.27±0.05	3,30±0,07
Actual milk yield (MY), kg	8667±94	8788±128
Actual MFF, %	3.73±0.11	3,80±0,07
Actual MFP, %	3.27±0.06	3,28±0,04
RGP for milk yield, %	93.1	93,0
RGP for MFF, %	99.5	100,7
RGP for MFP, %	100.0	99,3

N o t e. Imported animals of European selection (Denmark) were group 1, heifers derived from mothers born at the farm and subjected to adaptation were group 2.

Animals of groups 1 and 2, as descendants of highly valuable parents, inherited high productive indicators. The calculation of parental indices of mothers of experimental cows showed that, with the exception of milk yield, they differed insignificantly in other traits, that is, the phenotypic realization of their genetic inclinations turned out to be approximately at the same level. Realization of the genetic potential was somewhat higher by MFF (100.7%) in first-calf heifers of group 2, by MFP in group 1 (100.0%) (Table 2).

The genetic potential of animal productivity is realized under the influence of paratypic factors in specifically created conditions for growing, keeping, feeding and exploitation. The body type of Holstein cattle, along with productive indicators, is one of the selected traits used in the selection improvement of animals. The practice of breeding dairy breeds has shown the existence of a positive relationship between the productivity and duration of the economic use of cows with a well-developed physique.

3. Linear scores of exterior in replacement black-and-white Holstein replacement heifers of various origin (*M*±SEM, Molochnik LLC, Kursk Province, 2020)

Linear trait	Group 1 (*n* = 15)		Group 2 (*n* = 15)	
	M±SEM	*Cv*, %	*M*±SEM	*Cv*, %
Linear score A, points				
Trunk depth	5.7±0.3	20.2	5.4±0.3	22.5
Fortress physique	5.3±0.2*	22.1	4.6±0.2	21.8
Dairy cow stature	5.6±0.2	22.8	5.2±0.2	22.0
Sacrum length	4.5±0.2	25.6	4.2±0.2	26.5
Pelvic position	5.2±0.3	14.4	4.8±0.2	23.2
Pelvis width	5.4±0.3	21.0	5.1±0.2	21.4
Muscularity	5.0±0.2	17.7	4.8±0.1	16.8
Position of the hind legs	4.8±0.2	24.7	5.0±0.1	24.2
Hoof angle	4.8±0.2	15.0	4.3±0.	17.0
Attachment of the front udder	4.8±0.2	20.7	4.5±0.2	22.8
Length of front udder	5.4±0.2	21.6	5.1±0.1	28.3
Height of udder attachment	5.3±0.3	21.5	4.9±0.2	21.6
Rear udder width	5.7±0.3	20.8	5.3±0.2	19.4
Udder furrow	5.4±0.3	24.2	5.3±0.1	18.6
Udder bottom position	5.9±0.2	19.5	5.6±0.2	20.4
Location of the anterior nipples	5.1±0.2	24.6	4.9±0.1	27.1
Nipple length	5.3±0.1	15.8	5.3±0.1	20.7
Comprehensive assessment according to system B (100-point scale)				
Body volume	83.1±0.5	5.2	82.2±0.6	8.1
Expression of milk traits	83.8±0.7*	6.4	81.7±0.5	7.8
Limbs	84.9±0.4*	5.1	83.5±0.4	7.2
Udder	82.5±0.6	5.5	81.6±0.5	7.5
General appearance	82.7±0.5	7.0	81.9±0.5	6.4
Overall score	83.0±0.4	3.7	81.7±0.5	3.6

Note. Imported animals of European selection (Denmark) were group 1, heifers derived from mothers born at the farm and subjected to adaptation were group 2.
* Differences between groups are statistically significant at $P > 0.95$.

A linear assessment of animal physique [24, 25] objectively determines the individual constitution in dairy cattle based on independent indicators for each parameter [26-28]. Table 3 shows linear measurements of the exterior of first-calf heifers. We found significant differences in favor of animals of group 1 for body strength by 0.7 points (significance criterion td = 2.13), milking characteristics by 1.1 points (td = 2.13), limbs by 1.4 points (td = 2.13). The angle of the hoof formed by the front wall of the hoof of the hind limb with the floor plane was close to ideal (5 points, 45°). An acute angle leads to rapid wear of the heel of the hoof, a blunt (more than 50°, "butt hoof") poorly amortizes the load on the joints of the hind legs. It should be noted that other indicators, except for the setting of the hind legs, were higher in the animals of group 1, although the observed differences were not significant.

Cows of group 1 showed high variability for the sacrum length (25.6%), setting of the hind legs (24.7%), location of the front teats (24.6%), udder furrow

(24.2%), of group 2 — for the length of the anterior udder lobes (28.3%), the location of the anterior nipples (27.1%), the sacrum length (26.5%), the position of the pelvis (23.2%).

As per the set of features in the 100-point system, animals of group 1 had a slight advantage (see Table 3). The volume of the body was higher by 0.9 points, the classification score of the udder was higher by 0.9 points, and the general appearance was higher by 0.8 points vs those in cows of group 2 (differences are not significant). According to five classification features, animals of group 1 had a total score of 83.0 points, of roup 2 81.7 points. A difference of 1.3 points tended to be close to significant (td = 1.75, P > 0.90). The complex assessment data showed that all animals were of the good+ body type, the difference between the groups was not significant, and the variability of the indicators was low.

4. Body measurements in replacement black-and-white Holstein replacement heifers of various origin (*M*±SEM, Molochnik LLC, Kursk Province, 2020)

Measurement, cm	Group 1 (*n* = 15)		Group 2 (*n* = 15)	
	M±SEM	*Cv*, %	*M*±SEM	*Cv*, %
Height at the withers	137.5±1.3*	3.00	135.4±2.1	2.77
Rump height	145.3±1.4*	2.81	142.4±1.7	3.02
Chest depth	73.8±0.7	2.97	73.7±0.4	4.88
Chest width	46.4±0.4*	8.06	43.3±0.4	8.00
Width in hook bones	54.4±0.8*	4.34	51.1±0.9	3.66
Width at ischial tuberosities	37.1±0.5*	6.12	35.1±0.4	5.89
Oblique torso length with a stick	164.4±0.5	4.08	163.1±0.4	3.87
Chest girth	197.5±0.8	5.07	195.7±1.1	5.75
Pastern girth	19.2±0.4	6.00	19.2±0.4	5.68

N o t e. Imported animals of European selection (Denmark) were group 1, heifers derived from mothers born at the farm and subjected to adaptation were group 2.
* Differences between groups are statistically significant at P > 0.95.

Comparative analysis of body measurements revealed differences between groups (Table 4). At the age of the 1st calving, the animals were quite tall, in group 1 and group 2, the height at the withers averaged 137.5±1.29 cm and 135.4±2.09 cm, respectively, in the sacrum 145, 3±1.4 and 142.4±1.7 cm, respectively. Moreover, the difference between individuals in height at the withers and rump (respectively 2.1 cm and 2.9 cm) was significant (td = 2.46 and td = 2.20). The width of the chest, the width in the hook bones and the width in the ischial tuberosities in the first heifers from group 1 were significantly higher, by 3.1 cm (td = 4.07), 3.3 cm (td = 2.13) and 2.0 cm, respectively (td = 2.95). It should be noted that, according to other measurements (except for the girth of the metacarpus), first-calf heifers from group 1 were characterized by higher rates. Despite somewhat lower body measurements, the animals of group 2 also had a fairly good physique.

In contrast to the comparative characteristics of measurements expressed in absolute values, the use of physique indices makes it possible to obtain relative numerical indicators characterizing the exterior type of dairy cattle in the relative harmony of all articles [29]. Dairy cattle have a lower stretch index. In our studies, in cows in group 1, it was within 119.6%, in group 2, it was 2.7% higher (differences are not significant, Table 5). The pelvic-thoracic and thoracic indices testify to the pronounced milk type of the evaluated animals. Thus, the chest index in cows from group 1 was 3.7% higher than in individuals in group 2 (differences are not significant). The overrun index (compactness, index of general development and, in particular, live weight) was higher in first-calf heifers from group 1. The difference (3.2%) tended to be significant (td = 1.75, P > 0.90). Heifers from group 2 were characterized by a higher overgrowth index. According to the bone index, the differences between the groups were insignificant, 14.0% in group 1 vs. 13.9% in group 2.

5. Body indexes (%) in black-and-white Holstein replacement heifers of different origin (Molochnik LLC, Kursk Province, 2020)

Index	Group 1 (n = 15)		Group 2 (n = 15)	
	M±SEM	*Cv*, %	*M*±SEM	*Cv*, %
Leggy	46.30±0.19	4.5	45.20±0.88	6.7
Lengthiness	119.60±0.24	6.6	122.30±2.97	8.6
pelvic-thoracic	85.30±0.33	9.9	84.70±1.05	7.5
Thoracic	62.90±0.31	5.4	59.20±0.96	7.1
Downed	120.10±1.18	8.0	116.90±1.04	8.3
Overgrowth	105.70±1.41	4.7	106.70±2.11	4.4
Bonyness	14.00±0.07	5.3	13.90±0.06	6.2

N o t e. Imported animals of European selection (Denmark) were group 1, heifers derived from mothers born at the farm and subjected to adaptation were group 2.

Commercial dairy farming provides for the intensive exploitation of animals, as a result of which their body is constantly exposed to a wide variety of stressors. Stress negatively affects many physiological functions, the intensity of metabolic processes, which affects the health and productivity of cows. Metabolic disorders are one of the main factors hindering the realization of the genetic potential of animals [30, 31].

The results of a biochemical analysis of the blood of first-calf heifers of both groups indicated a properly organized, complete and balanced feeding. At the 6th month of lactation, all the studied biochemical parameters of the blood of animals varied within the physiological norm. The concentration of total protein in the blood serum in group 1 averaged 83.11±5.62 g/l, in group 2 it was higher by 0.67 g/l (differences are not significant) (Table 6), which indicates the compliance of protein nutrition with current standards.

6. Biochemical parameters of blood serum in black-and-white Holstein replacement heifers of different origin (*M*±SEM, Molochnik LLC, Kursk Province, 2020)

Parameter	Group 1 (n = 5)	Group 2 (n = 5)
Total protein, g/l	83.11±5.62	83.78±6.04
Albumins (A), g/l	27.80±1.73	27.17±1.82
Globulins (G), g/l	54.02±3.94	55.75±5.02
A/G	0.51±0.06	0.49±0.07
Glucose, mmol/l	3.74±0.11	3.71±0.16
Total cholesterol, mmol/l	3.63±0.28	3.76±0.22
Alanine aminotransferase, IU/l	27.02±2.06	25.19±1.93
Aspartate aminotransferase, IU/l	80.86±5.72	81.95±6.64
Alkaline phosphatase, IU/l	128.02±8.47	127.16±8.18
Ca, mmol/l	2.16±0.09	2.20±0.12
P, mmol/l	2.28±0.17	2.34±0.19
Ca/R	0.95±0.13	0.94±0.16
Mg, mmol/l	0.98±0.06	0.94±0.08

N o t e. Imported animals of European selection (Denmark) were group 1, heifers derived from mothers born at the farm and subjected to adaptation were group 2.

Aminotransferases belong to a group of enzymes indicative of the functional state of the liver, an organ involved in all metabolic processes [32], including the balance of protein nutrition. We found out that in the examined animals the activity of AlAT, AsAT and alkaline phosphatase was within the physiological norm, the differences in the indices between the groups were insignificant. The same can be said about the content of calcium and phosphorus in the blood serum (2.16-2.20 mmol/l and 2.28-2.34 mmol/l, respectively) and the ratio of these elements characterizing the state of calcium-phosphorus metabolism (0, 95±0.13 and 0.94±0.16).

Blood is the connective tissue of the internal environment of the body, participating in all processes occurring in it, while changing both qualitatively and quantitatively. Morphological parameters of blood vary and take values that are optimal for the adaptation of an individual to changing environmental conditions [33]. We noted a slight increase in the number of leukocytes in the blood of cows of European selection, which may be due to the protective and adaptive reactions of their body (Table 7), while the number of erythrocytes and the level of hemoglobin were slightly lower (see Table 7).

7. Hematological parameters in black-and-white Holstein replacement heifers of different origin (*M*±SEM, Molochnik LLC, Kursk Province, 2020)

Parameter	Group 1 (*n* = 5)	Group 2 (*n* = 5)
Leukocytes, $\times 10^9$/l	8.37±1.99	8.19±1.43
Erythrocytes, $\times 10^{12}$/l	7.33±0.88	7.54±1.05
Hemoglobin, g/l	99.86±3.27	101.00±3.44
Hematocrit, %	32.60±1.11*	26.60±1.16

N o t e. Imported animals of European selection (Denmark) were group 1, heifers derived from mothers born at the farm and subjected to adaptation were group 2.
* Differences between groups are statistically significant at P > 0.95.

The number of red blood cells in the blood of cattle is determined by sex, age, productivity, feeding and housing conditions. The ratio of the volume of formed elements to the total volume of blood characterizes the hematocrit. The sizes of erythrocytes, as a rule, are inversely related to their number per unit volume of blood and the metabolic activity characteristic of the body [34, 35].

Our data on the acclimatization features and productive qualities of dairy cattle are consistent with the results of other researchers. Thus, it is reported about the successful adaptation of Holstein cattle of domestic and American selection in the conditions of the Kabardino-Balkarian Republic [36, 37]. It is important to assess the state of cattle of various selections in conditions of ecological trouble. Realization of the genetic potential of black-and-white Holstein first-calf heifers of Hungarian selection of different lines is shown (from 78.9 to 91.42%, an average 305-day milk productivity of 6957 kg, a fat content of 3.75% and protein content of 3.06%) [38].

The study of blood parameters is an objective method for assessing the functional state of an animal's body in conditions of adaptation to technology and environmental factors [2, 39]. For example, it was noted that in Holstein animals brought to the Samara region from Holland, each new generation improved blood morphology and biochemical parameters, and elevated the level of cellular and humoral factors of natural resistance. As a result, adaptation to new natural-ecological, fodder and technological conditions took place [40].

Large-scale studies of economically useful features of Holstein heifers imported from the USA, Denmark, Germany and Australia to the Lower Volga region showed that animals of American and German origin had a higher level of natural resistance and adaptability to the natural and climatic conditions of the region. They also had higher productivity and improved reproductive function compared to their peers of Danish and Australian selection. A comparative study of economically useful traits of black-and-white heifers of the Leningrad and Danish selection in the conditions of the Rostov region showed that Danish heifers had a higher resistance to changing environmental conditions compared to their peers of the Leningrad selection. In the conditions of the Central Non-Black Earth Region, imported black-and-white Holstein animals realize their high genetic potential of milk productivity, significantly exceeding domestic breeds in terms of milk yield [41-44].

So, in our studies, we compared animals of European selection (Denmark) (group 1) and those derived from mothers born at the farm and undergone adaptation (group 2), according to the age of the 1st calving, milk productivity, milk fat and protein yield, body measurements, exterior signs, biochemical parameters and blood morphology. Significant (P > 0.95) differences occurred only in milk yield normalized to standard fat content (by 134 kg in favor of animals born at the farm), in exterior, i.e., in the strength of the physique, milking characteristics, the condition of the legs in favor of imported animals. Hematocrit was also higher in imported animals. Animals of group 1 and group 2 realized their genetic potential for milk yield by 93.1 and 93.0%, for mass fraction of fat by 99.5 and 100.7%, of protein by 100.0 and 99.3%. When comparing the type of physique according to five classification criteria, the scores for the groups were 83.0 and 81.7 points. A slight increase in the number of leukocytes occurred in first-calf heifers of European selection. It can be assumed that in this group, the ongoing adaptation led to more intense metabolic processes. Thus, under conditions that meet the biological needs of animals, the acclimatization of cows of European selection is quite successful.

REFERENCES

1. Strekozov N.I., Pogodaev S.F. *Zootekhniya*, 1999, 8: 6-9 (in Russ.).
2. Shevkhuzhev A.F., Ulimbashev M.B., Smakuev D.R., Tekeev M.A. *Sovremennye tekhnologii proizvodstva moloka s ispol'zovaniem genofonda golshtinskogo skota* [Modern milk production technologies based on Holstein cattle gene pool]. Moscow, 2015 (in Russ.).
3. Van Schyndel S.J., Bauman C.A., Pascottini O.B., Renaud D.L., Dubuc J. Kelton D.F. Reproductive management practices on dairy farms: the Canadian national dairy study 2015. *Journal of Dairy Science*, 2019, 102(2): 1822-1831 (doi: 10.3168/jds.2018-14683).
4. Edwards-Callaway L.N., Walker J., Tucker C.B. Culling decisions and dairy cattle welfare during transport to slaughter in the United States. *Frontiers in Veterinary Science*, 2019, 5: 343 (doi: 10.3389/fvets.2018.00343).
5. Hadley G.L., Wolf C.A., Harsh S.B. Dairy cattle culling patterns, explanations, and implications. *Journal of Dairy Science*, 2006, 89(6): 2286-2296 (doi: 10.3168/jds.S0022-0302(06)72300-1).
6. Chiumia D., Chagunda M., Macrae A., Roberts D. Predisposing factors for involuntary culling in Holstein-Friesian dairy cows. *Journal of Dairy Research*, 2013, 80(1): 45-50 (doi: 10.1017/S002202991200060X).
7. Abylkasymov D., Sudarev N.P., Chargeishvili S.V. *Effektivnost' ispol'zovaniya vysokoproduktivnykh korov raznoi selektsii v usloviyakh intensivnoi tekhnologii proizvodstva moloka* [Efficiency of using highly productive cows of different selection in intensive dairy farming]. Tver', 2020 (in Russ.).
8. Roche S.M., Renaud D.L., Genore R., Shock D.A., Bauman C., Croyl S., Kelton D.F., Barkema H.W., Dubuc J., Keefe G.P. Canadian national dairy study: describing Canadian dairy producer practices and perceptions surrounding cull cow management. *Journal of Dairy Science*, 2020, 4(103): 3414-3421 (doi: 10.3168/jds.2019-17390).
9. Dunin I.M., Amerkhanov Kh.A. *Zootekhniya*, 2017, 6: 2-8 (in Russ.).
10. Dippel S., Dolezala M., Brenninkmeyerb C. Risk factors for lameness in cubicle housed Austrian Simmental dairy cows. *Preventive Veterinary Medicine*, 2009, 90: 102-112 (doi: 10.1016/prevetmed.2009.03.014).
11. Amerkhanov Kh.A. *Molochnoe i myasnoe skotovodstvo*, 2017, 1: 2-5 (in Russ.).
12. Miglior F., Muir B.L., and Doormaal B.J. Selection indices in Holstein cattle of various countries. *Journal of Dairy Science*, 2005, 88(3): 1255-1263 (doi: 10.3168/jds.S0022-0302(05)72792-2).
13. Morozova N.I., Musaev F.A., Ivanova L.V. *Fundamental'nye issledovaniya*, 2012, 6(2): 405-408 (in Russ.).
14. Wielgosz-Groth Z., Groth I. Quality of colostrums in cows milked twice or three times daily during the first six days after calving. *Annals of Animal Science*, 2001, 1(1): 25-37.
15. Abugaliev S.K. *Zootekhniya*, 2017, 10: 2-5 (in Russ.).
16. Konstandoglo A., Foksha V., Stratan G., Stratan D. Evaluation of the exterior of Holstein and Simmental primiparous cows. *Scientific Papers. Series D. Animal Science*, 2017, 60: 35-39.
17. Loginov Zh.G., Prokhorenko P.N., Popova N.V. *Metodicheskie rekomendatsii po lineinoi otsenke ekster'ernogo tipa v molochnom skotovodstve* [Guidelines for linear assessment of the exterior in dairy cattle breeding]. Moscow, 1994 (in Russ.).
18. Borisenko E.Ya., Baranova K.V., Lisitsyn A.P. *Praktikum po razvedeniyu sel'skokhozyaistvennykh zhivotnykh* [Workshop on breeding farm animals]. Moscow, 1984 (in Russ.).
19. *Pravila otsenki teloslozheniya docherei bykov-proizvoditelei molochno-myasnykh porod* [Rules for assessing the physique of the daughters of bulls-producers of dairy and meat breeds]. Moscow, 1996 (in Russ.).
20. Kharitonov S.N., Yanchukov I.N., Ermilov A.N. *Izvestiya Timiryazevskoi sel'skokhozyaistvennoi akademii*, 2011, 4: 103-113 (in Russ.).
21. Shi C., Zhang J.L., Teng G.H. Mobile measuring system based on LabVIEW for pig body components estimation in a large-scale farm. *Computers and Electronics in Agriculture*, 2019, 156: 399-405 (doi: 10.17632/3b8t3689yw.1).
22. Merkur'eva E.K. *Biometriya v selektsii i genetike sel'skokhozyaistvennykh zhivotnykh* [Biometrics in

breeding and genetics of farm animals]. Moscow, 1970 (in Russ.).
23. Barnev V. *Zhivotnovodstvo Rossii*, 2008, 1: 51 (in Russ.).
24. Halachmi I., Polak P., Roberts D.J., Klopcic M. Cow body shape and automation of condition scoring. *Journal of Dairy Science*, 2008, 91(11): 4444-4451 (doi: 10.3168/jds.2007-0785).
25. Hewitt A., Olchowy T., James A.S., Fraser B., Ranjbar S., Soust M., Alawneh J.I. Linear body measurements and productivity of subtropical Holstein-Friesian dairy calves. *Aust. Vet. J.*, 2020, 98(7): 280-289 (doi: 10.1111/avj.12950).
26. Lukuyu M.N., Gibson J.P., Savage D.B., Duncan A.J., Mujibi F.D.N., Okeyo A.M. Use of body linear measurements to estimate live weigh to crossbred dairy cattle in smallholder farms in Kenya. *SpringerPlus*, 2016, 5: 63 (doi: 10.1186/s40064-016-1698-3).
27. Broster W.H., Broster V.J. Body score of dairy cows. *Journal of Dairy Research*, 1998, 65(1): 155-173 (doi: 10.1017/s0022029997002550).
28. Kazarbin D.R. *Lineinaya otsenka ekster'era molochnykh korov i ee primenenie v skotovodstve Rossii. Avtoreferat doktorskoi dissertatsii* [Linear assessment of the exterior of dairy cows in cattle breeding in Russia. DSc Thesis]. Dubrovitsy, 1997 (in Russ.).
29. Adushinov D.S. *Molochnoe i myasnoe skotovodstvo*, 2006, 3: 17-19 (in Russ.).
30. Seifi H.A., Leblanc S.J., Leslie K.E., Duffield T.F. Metabolic predictors of post-partum disease and culling risk in dairy cattle. *Vet. J.*, 2011, 188(2): 216-220 (doi: 10.1016/j.tvjl.2010.04.007).
31. Donadeu F.X., Howes N.L., Esteves C.L., Howes M.P., Byrne T.J., Macrae A.I. Farmer and veterinary practices and opinions related to the diagnosis of mastitis and metabolic disease in UK dairy cows. *Frontiers in Veterinary Science*, 2020, 7: 127 (doi: 10.3389/fvets.2020.00127).
32. Mitra V., Metcalf J. Metabolic functions of the liver. *Anaesthesia & Intensive Care Medicine*, 2012, 13(2): 54-55 (doi: 10.1016/j.mpaic.2011.11.006).
33. Viana M.T., Perez M.C., Ribas V.R., de Martins G.F., de Castro C.M. Leukocyte, red blood cell and morphological adaptation to moderate physical training in rats undernourished in the neonatal period. *Rev. Bras. Hematol. Hemoter.*, 2012, 34(4): 285-291 (doi: 10.5581/1516-8484.20120073).
34. Pretorius E. The adaptability of red blood cells. *Cardiovasc. Diabetol.*, 2013, 12: 63 (doi: 10.1186/1475-2840-12-63).
35. Bogdanova A., Kaestner L. The red blood cells on the move! *Frontiers in Physiology*, 2018, 9: 474 (doi: 10.3389/fphys.2018.00474).
36. Ulimbashev M.B., Alagirova Zh.T. Adaptive ability of Holstein cattle introduced into new habital conditions. *Sel'skokhozyaistvennaya biologiya* [*Agricultural Biology*], 2016, 51(2): 247-254 (doi: 10.15389/agrobiology.2016.2.247eng).
37. Sulyga N.V., Kovaleva G.P. *Zootekhniya*, 2010, 2: 4-6 (in Russ.).
38. Donnik I.M., Shkuratova I.A. *Veterinariya Kubani*, 2009, 5: 16-17 (in Russ.).
39. Triwutanon S., Rukkwamsuk T. Patterns of blood biochemical parameters of peripartum dairy cows raised in either smallholder or semi-commercial dairy farms in Thailand. *Veterinary World*, 2021, 14(3): 649-655. (doi: 10.14202/vetworld.2021.649-655).
40. Karamaev V.S., Asonova L.V., Grigor'ev V.S. *Izvestiya Orenburgskogo gosudarstvennogo agrarnogo universiteta*, 2013, 1(39): 77-80 (in Russ.).
41. Gorlov I.F., Komarova Z.B., Serdyukova YA.P. *Vestnik Rossiiskoi akademii sel'skokhozyaistvennykh nauk*, 2014, 2: 53-54 (in Russ.).
42. Gorlov I.F., Bozhova S.E., Shakhbasova O.P., Gubareva V.V. Productivity and adaptation capability of Holstein cattle of different genetic selections. *Turkish Journal of Veterinary and Animal Sciences*, 2016, 40(5): 527-533 (doi: 10.3906/vet-1505-82).
43. Mokhov A.S. *Politematicheskii setevoi elektronnyi nauchnyi zhurnal Kubanskogo GAU im. I.T. Trubilina*, 2016, 122(08): 774-784 (doi: 10.21515/1990-4665-122-054) (in Russ.).
44. Petkevich N.S., Kurskaya Yu.A., Ivanova A.I. *Dostizheniya nauki i tekhniki APK*, 2015, 29(3): 48-50 (in Russ.).