Relationship between the natural resistance of cows of different genotypes and their dairy productivity

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Abstract. The article considers the regularities of the adaptive ability of cows of different genotypes. The study is based on traits of natural resistance and biochemical analyses of blood serum. Crossbred animals in Group III have been found to have higher indices of the natural resistance of the organism. The metabolism intensity in the animal body was indicated a high immunological status, i.e. the bactericidal activity of blood serum (BABS) of crossbred first-calf heifers was 83.1%, which was higher by 7.4% than the analogs’ indices in Group II and by 5.8% than indices in Group I. Similar results were recorded in terms of the lysozyme activity of blood serum. The highest phagocytic activity (PhA) was also found in crossbred heifers. The increased metabolism in the body of crossbred heifers can be explained by the effect of heterosis.

1. Introduction
The dairy subcomplex of the agro-industry is one of the main life-supporting sectors of the agricultural economy and is the most efficient animal protein industry. Today, milk protein remains the cheapest dietary protein of animal origin. Therefore, it is the dairy sector of the agro-industry that has a decisive influence on the food supply in the country and determines the health of the nation.

At present, the population's need for milk and dairy products in the country is not satisfied by its own production. Russia is the world's largest importer.

In solving the “dairy” problem, of great importance is the selection work aimed at improving livestock breeds. At the present stage of breeding work, objective immunogenetic and biochemical tests that make it possible to comprehensively determine and predict the breeding value of animals are particularly important [1].

The study of the available research results published allowed us to conclude that the parameters of the natural resistance of cattle of various breeds in the conditions of different natural-ecological zones and technologies have not been sufficiently studied.

Modern milk production technologies apply narrow requirements to animals in highly mechanized industrial complexes and demand high milk productivity to be complemented with a strong constitution, high viability of animals, and a long term of their productive use [4, 6].

Intensive milk production technology and its economic efficiency depend on the creation of highly productive animals with high adaptability, disease resistance, and long-term economic use. On the other hand, the intensification of animal husbandry and a significant increase in the productivity of animals determine the functional stress of all organs and systems of the body, which often leads to a decrease in its resistance to unfavorable environmental conditions and occurrence of infectious diseases. The
increased concentration of animals in industrial complexes contributes to the spread of infectious agents [2].

Therefore, the study of natural resistance parameters of the animal organism and its dependence on productive qualities under specific natural and climatic conditions is of great scientific and practical interest.

In this regard, an urgent task is to study nonspecific protective forces of an animal organism.

2. Research results
The studies were conducted in the conditions of the agricultural production cooperative “50 year October” in the Neklinovsky rayon of the Rostov region.

The research object was the cattle of the Red Steppe and Holstein breeds and their first generation crosses. For this purpose, three groups of cows were formed, i.e. Red Steppe purebred cows formed Group I; Holstein purebred cows formed Group II; and their half-blood hybrid cows formed Group III. Each group consisted of 20 first-calf heifers calved in different seasons of the year. The factors of natural resistance of first-calf heifers of different genotypes in different periods of lactation and the physiological state of cows from 1st to 2nd calving were studied.

The animals were fed with balanced diets in accordance with the detailed VIZH norms.

The hemoglobin content and the numbers of erythrocytes and leukocytes were determined on a Medonic CA 530 hematological analyzer. The total protein in the blood serum and protein fractions were found on a StatFaks 1904 automatic biochemical analyzer.

The natural resistance and immune status of the animal body were assessed with respect to the bactericidal activity of blood serum (the Smirnova and Kuzmina’s method modified by Bukharin and Sozykin (1979), lysozyme activity of blood (according to Grant), phagocytic activity and phagocytic index (according to Kostenko).

The resulting digital material was subjected to statistical processing, using the Microsoft Excel data analysis package.

The average indices of milk yield and humoral and cellular factors of nonspecific body defense of the first-calf heifers are shown in table 1.

| Trait | Group I | Group II | Group III |
|-------|---------|----------|-----------|
| Milk yield for 305 days of first lactation, kg | 2930±42 | 3355±54 | 3545±41 |
| Fat content in milk, % | 3.6±0.05 | 3.6±0.03 | 3.68±0.05 |
| Milk fat, kg | 105.48±0.05 | 120.78±0.05 | 130.45±0.05 |
| BABS, % | 77.3±1.7 | 75.7±1.6 | 83.1±1.6 |
| LABS, % | 25.5±0.9 | 24.3±0.8 | 28.1±0.6 |
| PhA, % | 44.1±0.9 | 42.0±1.2 | 47.6±1.2 |
| FI | 6.6 | 6.6 | 7.3 |
| Total protein, g/L | 75.8±1.8 | 72.4±1.6 | 81.9±1.0 |
| Albumins, % | 38.9±0.3 | 40.3±0.4 | 38.6±0.3 |
| Globulins, %: | 61.1±1.5 | 59.7±1.2 | 61.4±1.3 |

* a - P>0.95; b - P>0.99; and c - P>0.999.

The data obtained in the studies of the defense of the cow organism indicated good health of animals in all groups.

According to the indices of the cellular and humoral immunity of cows of different breeds, there were certain differences found in the periods under study, which confirmed different body burdens resulted in good fitness of hybrid animals ensured by these resistance factors in specific environmental conditions [3, 5].
The research found that crossbred cows in Group III had higher indices of the natural resistance of the organism. The metabolism intensity in the animal body was indicated by a high immunological status, i.e. the BABS in hybrid first-calf heifers was 83.1%, which was by 7.4% higher than the analogs’ indices in Group II and by 5.8% higher than indices in Group I. Similar results were recorded for the lysozyme activity of blood serum. The highest PhA was also found in crossbred heifers. The increased metabolism of hybrid first-calf heifers can be explained by the effect of heterosis.

Comparing the breeds found that Red steppe first calf heifers (Group I) had higher indices of humoral and cellular factors of nonspecific defense of the organism than Holstein heifers (Group II) that possessed a higher potential for milk production, but were particular about keeping conditions and were adapting to the conditions of the North Caucasus.

The metabolism intensity in the cow body positively correlates with the milk productivity. In the first lactation, the crossbred cows had the average milk yield of 3545 kg, which was by 21% higher than in Group I and by 5.7% higher than in Group II. Similar results were observed with respect to the amount of milk fat at a high percentage confidence.

The study of the relationship between the natural resistance indices and milk productivity found that the degree and direction of the correlation depended on the lactation period.

For 305 days of lactation, the BABS was found to have a weak negative correlation ($r = -0.11-0.14$) in all groups, with a moderately negative correlation ($r = -0.31-0.33$) in the 1st month of lactation, a weak negative correlation ($r = -0.12-0.15$) in the 3rd month of lactation, and a weak positive correlation at the end of lactation ($r = 0.17-0.19$) all groups.

On the first day after calving and during the 1st month of lactation, the LASK had a moderately negative correlation with milk yield ($r = -0.30-0.33$) in all groups. Further, from the 3rd month of lactation, the correlation became positive and remained to the start ($r = 0.15-0.17$). The correlation between the LASK and milk yield for 305 days was weakly positive ($r = 0.0.9-0.13$).

The correlation between the PhA and milk yield for 305 days of lactation was moderately negative ($r = -0.29-0.32$). After calving, the correlation between the indices in all groups was moderately negative ($r = -0.32-0.34$). One month after calving, a strong negative relationship between the indices ($r = -0.45-0.50$) was established. During the lactation, the correlation dependence between the parameters became slightly negative ($r = -0.12-0.13$). At the end of lactation, the correlation between the parameters was positive ($r = 0.11-0.12$).

The correlations between the weight fraction of milk fat and the BABS, LABS, and PhABS was slightly negative ($r = -0.09-0.12$) in all groups.

The humoral factors that characterize the natural resistance of the organism were very labile; they can decrease or increase both in parallel and compensating each other.

Thus, Holstein first-calf heifers and their crosses had higher rates of the milk production and natural resistance. The Holstein breed was selected in quite different climatic and feeding conditions; so, the animal organism was deprived of the self-preservation instinct and was fully dedicated to milk production. Therefore, imported animals required the feeding and keeping technology applied in countries, importing livestock, to be satisfied.

Modern data, characterizing the correlations between the most probable resistance markers and productivity indicated the possibility of simultaneous selection for these traits. Breeding for resistance is becoming a necessary element of modern animal selection programs.

For the animal immune status being objectively characterized, we assessed the natural resistance, using a genetic-statistical indicator—the resistance index (RI). Humoral and cellular factors, reflecting the body's immune status, were used for calculating this index. It was important to determine the statistical weight of each breeding trait. In general terms, the index represented the following equality:

$$RI = K_1 * X_1 + K_2 * X_2 + \cdots + K_n * X_n;$$

where $K$ is the weight number of the trait and $X$ is the value of the trait.
The weight number of a trait depends on many factors and is determined by the heritability estimate, variation degree, and selection differential.

There should be no more than 6-7 traits included in the index. The index also should not include traits of low breeding value. When calculating the resistance indices, we took into account 5 traits, i.e. bactericidal activity of blood serum, lysozyme activity of blood serum, phagocytic activity of blood serum, phagocytic index, and phagocytic number.

The scheme for calculating the resistance indices of animals is shown in Table 2.

**Table 2.** Scheme for calculating the indices of animal resistance.

| Biometrics | Bactericidal activity of blood serum | Lysozyme activity of blood serum | Phagocytic activity of blood serum | Phagocytic index | Phagocytic number |
|------------|------------------------------------|---------------------------------|-----------------------------------|-----------------|------------------|
| \( V_i \)  | \( V_{max} \)                      | \( V_{max} \)                   | \( V_{max} \)                     | \( V_{max} \)   | \( V_{max} \)    |
| \( V_{min} \) | \( V_{min} \)                      | \( V_{min} \)                   | \( V_{min} \)                     | \( V_{min} \)   | \( V_{min} \)    |
| \( V_{max} - V_{min} \) | \( V_{max} - V_{min} \)          | \( V_{max} - V_{min} \)         | \( V_{max} - V_{min} \)           | \( V_{max} - V_{min} \) | \( V_{max} - V_{min} \) |
| \( C_v \)  | \( C_v \)                          | \( C_v \)                       | \( C_v \)                         | \( C_v \)       | \( C_v \)        |
| \( k = \frac{C_v}{\Sigma C_v} \times 100 \) | \( k_1 \)                        | \( k_2 \)                        | \( k_3 \)                       | \( k_4 \)       | \( k_5 \)        |
| \( X_i = \frac{V_{max} - V_{min}}{V_{max} - V_{min}} \) | \( X_1 \)                       | \( X_2 \)                        | \( X_3 \)                       | \( X_4 \)       | \( X_5 \)        |

The resistance index is: \( RI = K \times X \),
where: \( V_i \) is the individual value of the trait;
\( V_{max} \) is the maximum individual value of the trait;
\( V_{min} \) is the minimum individual value of the trait;
\( V_{max} - V_{min} \) is the difference between the maximum and minimum individual values of the trait; and
\( C_v \) is the variation coefficient.

The analysis of the results obtained showed that the resistance index of cows was high. An interesting fact was that this indicator was slightly lower in Group III (96.7-97.1) than in Groups I and II (98.7), although the Group III cows surpassed their peers in terms of absolute indices of humoral and cellular defense of the body.

This was probably due to the fact that these cows were less adapted to natural conditions than others, but surpassed them in productivity and suitability for the intensive milk production technology, the research was performed in. These animals, as a rule, require closer attention of the veterinary service.

### 3. Conclusions

The analysis of natural resistance indices of cattle of various breeds and the relationship between the breed and productive properties confirmed that they are insufficiently studied and indicated the need to apply different integral factors to assess the immune status in further breeding.

The calculation of the resistance index as an integral indicator and the use and regular control as interior tests for selection in breeding farms allowed obtaining more reliable information on the resistance of young cattle at early stages of ontogenesis and thereby increasing the efficiency of selection in terms of the economic traits.
Modern data characterize the correlations between the most probable markers of resistance and productivity and indicate the possibility of simultaneous selection for these traits. Breeding for resistance is becoming a necessary element of modern animal selection programs.

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References
[1] Gorlov I F, Fedotova G V, Mosolova N I et al. 2019 Assessment and the current state of the dairy production in Russia Izvestia of Nizhnevolzskiy agrouniversity complex: science and higher vocational education 2(54) 189-97
[2] Gorlov I F, Komarova Z B and Serdyukova Ya P 2014 Adaptation of black-and-white cattle of different ecological and genetic Vestnik of the Russian Agricultural Science 2 53-4
[3] Gorlov I F, Shahbazova O P, Radjabov R G, Ivanova N V, Randelin A V, Mosolova N I and Sherstyuk B A 2019 Using a resistance index model for breeding work on the adaptive ability of cows Research Journal of Pharmaceutical, Biological and Chemical Sciences 10(1) 1460-7
[4] Kolosov Yu A, Chamurliev N G and Illarionova N F 2019 Problems of intensive development of dairy farming at the regional level Izvestia of Nizhnevolzskiy agrouniversity complex: science and higher vocational education 1(53)
[5] Mikhailov N V, Ganzha A, Mikhailova A et al. 1986 Procedures for constructing selection indices in pig breeding. In: Breeding, feeding, and pig keeping technology (Rostov-on-Don: Persianovka) p 92-6
[6] Slozenkina M I, Gorlov I F, Kholodova M A, Kholodov O A, Shahbazova O P and Mosolova D A 2020 Beef and dairy cattle breeding: development trends of small agribusiness in conditions of state support IOP Conf. Ser.: Earth and Environmental Science 548 82037