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Productive qualities and their interrelation in Holstein cows of black-and-white breed

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Abstract. **Purpose.** Evaluation of Holstein cows according to economically useful characteristics and the establishment of indicators of the relationship between productive characteristics. **Methods.** Milk productivity was assessed by the method of control milking, milk quality indicators – by the instrument method on the Lactan-1M device, reproductive qualities – by conventional methods. We used the data of zootechnical and veterinary records of the IAS "SELEX-Dairy cattle" database, breeding cards of cows. **Results.** The highest indicator for milk productivity was established for full-age lactation. It was higher than the average by 1611 kg or 23.3 % ($P \leq 0.01$) and by 1141 kg or 15.4 % than the maximum lactation ($P \leq 0.01$). The duration of productive use of cows on the farm is 1.85 ± 0.07 lactation or 2.39 ± 0.07 calving, but the duration of use of individual animals is 9 lactation. MJ and MDB in milk, depending on the studied indicator, differ slightly and unreliably, but there is a tendency to increase these indicators for full-age lactation. Large coefficients of variability were determined by milk yield, and for lifetime milk yield it is more than 65.0 %, while for individual estimated lactation, the average, maximum and full-age coefficient of variability did not exceed 22.5 %. According to MJ and MDB in milk, the breeding stock is more equalized. Milk yield in cows increases up to 4 lactation, the largest increase in milk yield for 305 days of lactation was recorded in the second lactation – 937 kg or 14.5 %. Then the increase is 79–363 kg. Starting from the 5th lactation, there is a gradual decrease in milk yield for 305 days of lactation. There is no positive average and high correlation between milk yield and milk quality indicators, except for some data (6 lactation) and therefore they cannot be used when carrying out measures to improve the herd. Selection and selection for each indicator must be carried out separately. **The scientific novelty** of the work lies in the fact that new data have been obtained on the dairy productivity of modern Holstein black-and-white cattle with a high proportion of blood in the Holstein breed. The correlation coefficients between productive traits in cows with a share of blood in the Holstein breed over 94.0 % were calculated.
Keywords: Holstein black-and-white cattle, cows, milk yield, service period, correlation coefficient.

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Introduction

Ensuring the food security of the country is the most important task that must be solved by the workers of the agro-industrial complex of the country. This is due to the provision of the country's population with high-grade food [1, p. 12; 2, p. 78; 3, p. 21; 4, p. 10; 5, p. 2; 6, p. 4]. An increase in the production of agricultural products of own production, including livestock, is possible through the use of highly productive plant varieties and breeds of farm animals. In all this, great importance is attached to the development of dairy cattle breeding, as an industry from which are obtained valuable products such as milk and beef [7, p. 4; 8; 9, p. 9; 10, p. 50]. For this, there used highly productive dairy cattle with a high potential for milk productivity of both domestic and foreign breeds, such as the domestic black-and-white breed and Holstein [11, p. 37; 12, p. 560; 13, p. 133]. In the last few decades, Black-and-White cattle have been improved by using the worldwide Holstein gene pool, which has led to the creation of a large array of crossbred animals with high bloodlines for the Holstein breed. In most herds of black-and-white cattle, it reaches more than 94 %, which indicates that these animals, in terms of breed, are already purebred Holstein animals [14; 15, p. 317; 16]. Breeding within these herds is carried out with

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the continued use of purebred Holstein sires of domestic and foreign selection [17, p. 589; 18]. At present, a large number of highly productive Holstein black-and-white dairy cattle with a high proportion of bloodlines according to the Holstein breed is concentrated in the Sverdlovsk region [19, p. 294; 20, p. 512]. Evaluation of modern breeding stock for economically useful qualities is of scientific and practical interest, and is relevant.

The aim of the work was to evaluate Holsteinized cows according to economically useful traits and to establish indicators of the relationship between productive traits.

Methods

The research was carried out on the basis of one of the breeding plants for breeding Holstein black-and-white cattle of the Ural type in the Sverdlovsk region. We used data from the zootechnical and veterinary records of the database of the information and analytical system (IAS) "SELEKS-Dairy Cattle" for 2020. The sample included all cows that completed lactation. There were taken into account the milk yield for 305 days of lactation, mass fraction of fat (MFF) and mass fraction of protein (MFP) in milk by lactation, starting from the first to the last completed lactation. Calculated the coefficient of milk production, the amount of milk fat and milk protein for 305 days of lactation; the influence of the duration of the service period on the milk productivity of cows was evaluated. The milk productivity of cows was determined by control milkings once a month. The reproductive functions of cows were evaluated by the duration of the service and the intercalving period, there was taken into account the duration of lactation, and the coefficient of the reproductive ability of cows was calculated depending on lactation. Correlation coefficients were calculated between indicators of milk productivity depending on lactation, economically useful traits, taking into account their use in the selection of cows for their further improvement. The stability coefficient (SC) is the ratio of milk yield for 101–200 days of lactation (P2) to milk yield for 1–100 days of lactation (P1). Hence: SC = P2 / P1 * 100.

Results

The most important breeding trait in dairy cattle breeding is milk yield. Yield is taken into account for 305 days of lactation, for the last lactation, for the average lactation, for the maximum lactation and for life. We have carried out an assessment of the breeding stock of breeding cattle according to some of these indicators (Table 1).

From the data in the table it can be seen that milk yield varies depending on the period of evaluation of productive qualities. The highest rate was established for full-age lactation. It was higher than the average by 1611 kg or 23.3 % ($P \leq 0.01$) and by 1141 kg or 15.4 % than the maximum lactation ($P \leq 0.01$). This is most likely due to the fact that the sample for full-age lactation included cows that completed 3 and 4 lactations, and the rest of the indicators were calculated for the entire livestock. The duration of the productive use of cows on the farm is 1.85 ± 0.07 lactations or 2.39 ± 0.07 calving, but the duration of the use of individual animals is 9 lactations. In this regard, the average lifetime productivity is 20267 ± 1610.13 kg, and if we divide this milk yield by the average for lactations, then the number of lactations will be 2.93 lactations. This scoring is used in estimating productive longevity by pastoralists in the United States. However, it should be taken into account that some of the cows leave the herd without even finishing one lactation, as indicated the minimum milk yield, and the difference between the maximum and minimum milk yield is twice or more than the minimum milk yield. So for lifelong milk yield, this difference is 12.4 times.

MFF and MFP in milk, depending on the studied indicator, differ insignificantly and unreliably, but there is a tendency to increase these indicators for full-age lactation. It should be noted that the difference between these indicators in the studied animals is significant, especially in terms of MFF in milk.

Table 1

Indicators of milk productivity

Indicator	*Average*	*Average Fluctuation*		*Difference (Max – Min)*
		Min	*Max*	
Milk yield on average for all lactation, kg	*6913 ± 39.45*	*4237*	*9446*	*5209*
Milk yield for maximum lactation, kg	*7383 ± 54.38*	*4237*	*11097*	*10660*
Milk yield for full-age lactation, kg	*8524 ± 170.05*	*5089*	*16168*	*11079*
Lifetime milk yield, kg	*20267 ± 1610.13*	*5064*	*68405*	*63341*
MFF on average for all lactation, %	*4.00 ± 0.006*	*3.57*	*4.50*	*0.93*
MFF for maximum lactation, %	*4.04 ± 0.009*	*3.57*	*4.61*	*1.04*
MFF for full-age lactation, %	*4.05 ± 0.016*	*3.64*	*4.64*	*1.00*
MFF for lifetime milk yield, %	*4.00 ± 0.014*	*3.78*	*4.36*	*0.58*
MFP on average for all lactation, %	*3.05 ± 0.004*	*2.75*	*3.28*	*0.53*
MFP for maximum lactation, %	*3.06 ± 0.006*	*2.73*	*3.52*	*0.79*
MFP for full-age lactation, %	*3.10 ± 0.011*	*2.82*	*3.47*	*0.65*
MFP for lifetime milk yield, %	*3.08 ± 0.010*	*2.88*	*3.29*	*0.41*

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Table 2

Amount of milk fat and milk protein, kg

Indicator	*Average*	*Average Fluctuation*		*Difference (Max – Min)*
		Min	*Max*	
Milk fat on average for all lactation, kg	*276 ± 1.55*	*167*	*354*	*187*
Milk fat for maximum lactation, kg	*298 ± 2.27*	*187*	*456*	*269*
Milk fat for full-age lactation, kg	*330 ± 6.67*	*115*	*685*	*570*
Milk fat for life, kg	*813 ± 64.59*	*198*	*2714*	*2516*
Milk protein on average for all lactation, kg	*211 ± 1.23*	*128*	*268*	*140*
Milk protein for maximum lactation, kg	*226 ± 1.76*	*128*	*347*	*219*
Milk protein for full-age lactation, kg	*254 ± 5.14*	*87*	*515*	*428*
Milk protein for life, kg	*626 ± 50.05*	*153*	*2086*	*1933*

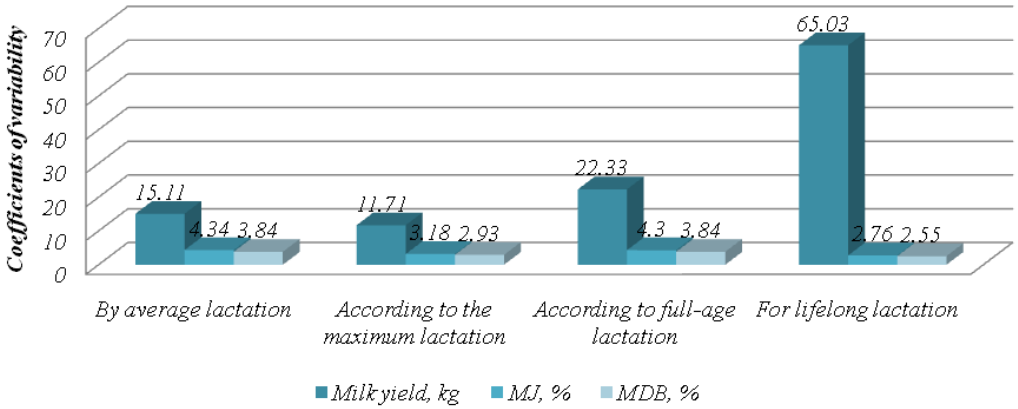


Fig. 1. Coefficients of variability of milk characteristics cows'

The second selection indicator that is important when grading cows according to their own productivity is the amount of milk fat obtained with milk for lactation. It is taken into account when determining the class of breeding value of cows. In our case, the average indicators for the amount of milk fat are higher than the requirements of the standard for Black-and-White and Holstein breeds (Table 2).

From the data presented in the table, it can be seen that the herd has a wide variety of animals in terms of such indicators as the amount of milk fat and milk protein, and more of these substances were obtained with milk for full-age lactation. It should be noted that according to the data presented in the previous table (Table 2), it was noted that in this lactation were established the highest average milk yield and the highest rates of MFF and MFP in milk. Fluctuations in the yield of nutrients with milk were significant, especially in lifetime productivity. The difference between the minimum and maximum values was 2516 kg of milk fat and 1933 kg of milk protein.

The coefficients of variability differed depending on the period of the assessment of milk production (Fig. 1).

The figure shows that the biggest coefficients of variability are determined by milk yield, and for lifelong milk yield from is more than 65.0%, while for individual indicative lactations, average, maximum and full-age coefficient of variability did not exceed 22.5 %. According to MFF and MFP in milk, the breeding stock is more even, which is confirmed by small coefficients of variability. Moreover, in terms of lifetime productivity, they turned out to be lower than in the studied lactations.

We analyzed the variability of milk yield by lactations. On the farm, animals are used up to 9 lactations and the dynamics of milk productivity depending on the age of the cows is of interest, especially since the average duration of the productive use of cows is much lower – 1.85 ± 0.07 lactations. An assessment of the possibility of increasing productive longevity is also possible by assessing the dynamics of milk yield (Fig. 2).

As a result of the analysis, it was found that milk yield increases up to 4 lactations, the largest increase in milk yield for 305 days of lactation was recorded in the second lactation – 937 kg or 14.5 %. Then the increase is 79–363 kg. Starting from the 5th lactation, there is a gradual decrease in milk yield for 305 days of lactation. This decrease was not constant and milk yield fluctuated by lactations, but slightly in one direction or another, which is most likely due not to the patterns of changes in lactation activity, but to the variability of the forage base on the farm.

There were similar changes in terms of milk yield for the entire lactation. The milk yield for lactation was higher, which is explained by its duration (Fig. 3).

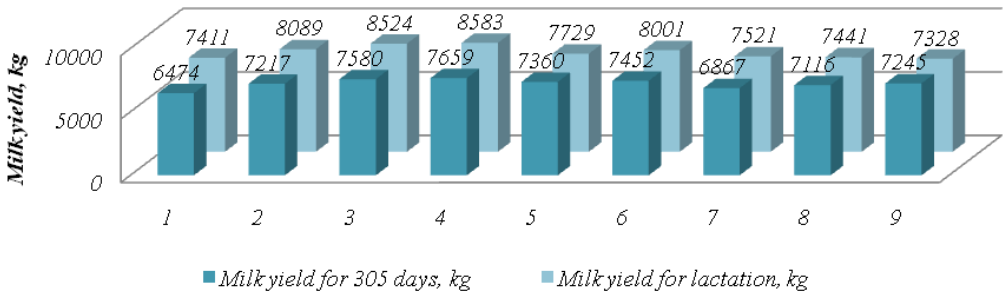


Fig. 2. Dynamics of milk yield cows' depending on age (lactation), kg

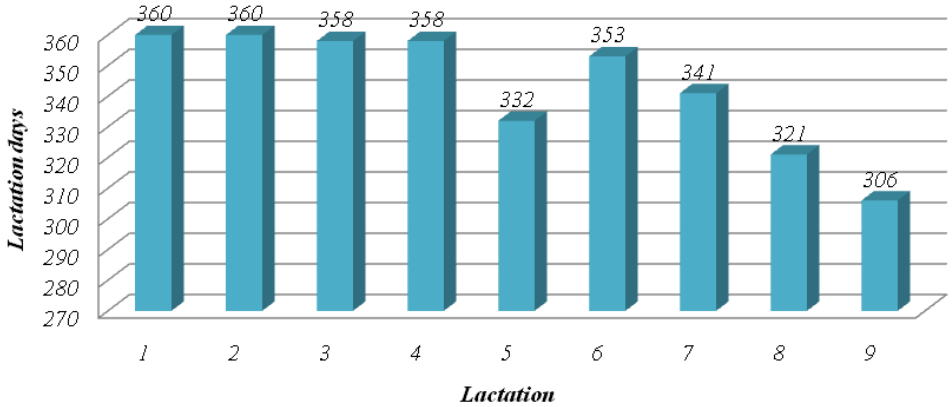
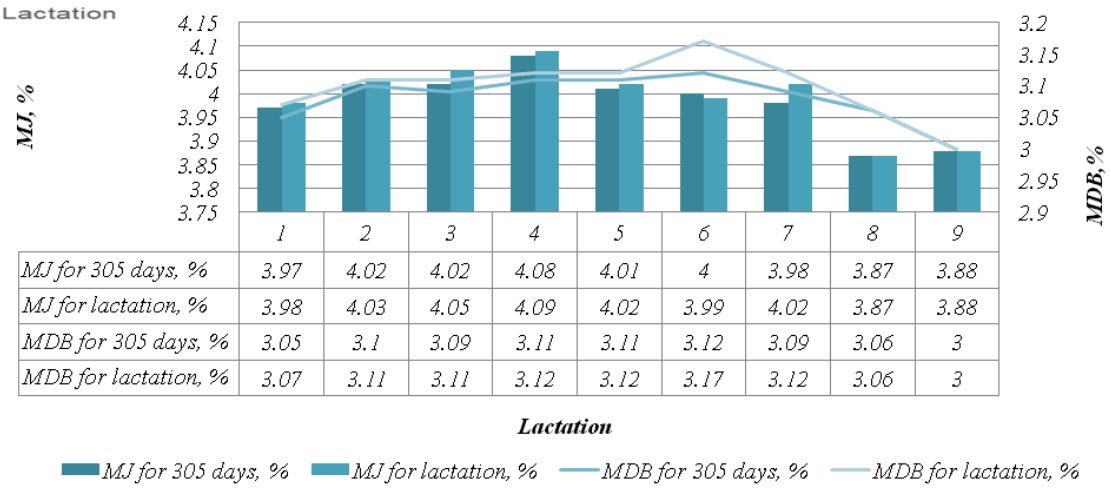


Fig. 3. Duration of lactation cows', days



	1	2	3	4	5	6	7	8	9
MJ for 305 days, %	3.97	4.02	4.02	4.08	4.01	4	3.98	3.87	3.88
MJ for lactation, %	3.98	4.03	4.05	4.09	4.02	3.99	4.02	3.87	3.88
MDB for 305 days, %	3.05	3.1	3.09	3.11	3.11	3.12	3.09	3.06	3
MDB for lactation, %	3.07	3.11	3.11	3.12	3.12	3.17	3.12	3.06	3

Fig. 4. Variability of milk quality indicators cows' by lactation, %

The figure shows that the duration of lactation exceeds the optimal indicators of 305 days, with the exception of the 9th lactation. It should be noted that in the first 4 lactations, the duration of lactation activity was almost the same and amounted to 358–360 days, that is, the increase in milk yield per lactation during this period did not depend on the duration of lactation activity, but was determined by the physiological patterns of changes in milk productivity of cows with age. Further, along with the feed factor, milk yield is also influenced by the duration of lactation. So milk yield for lactation for the fifth lactation was 7729 kg, which is less than for the fourth by 854 kg or 9.9 %, but the duration of lactation decreased by 26 days or 7.3 %. Further, with an increase in the duration of lactation, an increase in milk yield is observed and vice versa.

It is known that the quality indicators of milk (MFF and MFP) also change depending on age (Fig. 4).

The figure clearly shows that in the first 4 lactations there is an increase in MFF in milk both for 305 days of lactation and for the entire lactation. Since it is known that by the end of lactation, the MFF in milk increases, this also happens in our case. Starting from the 5th lactation, the indicators of MFF in milk stabilize, although their slight fluctuations in one direction or another are observed. The lowest fat content was found at 8 and 9 lactations. MFP in milk changes somewhat differently. This indicator constantly rises up to 6 lactations, and then sharply decreases, like MFF in milk.

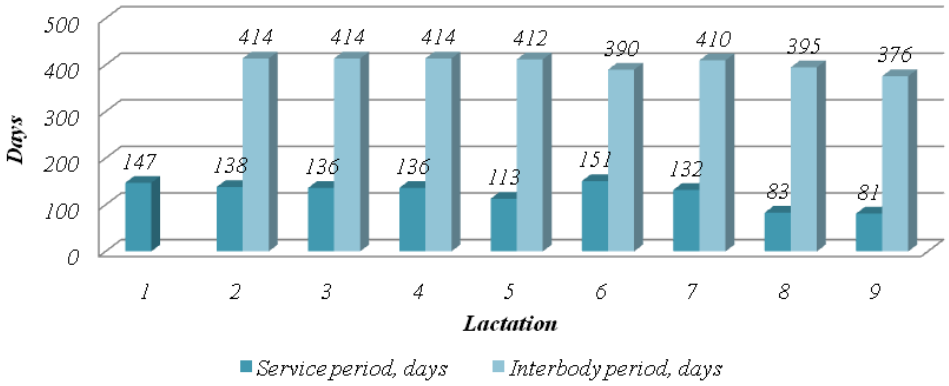


Fig. 5. The duration of the service and interbody period for lactation cows', days

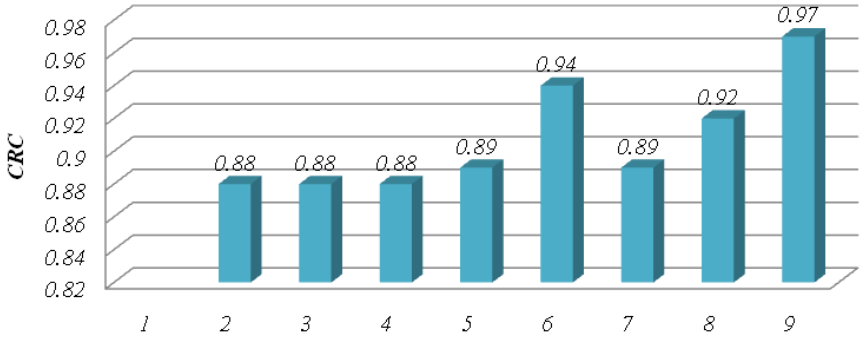


Fig. 6. Coefficient of reproductive cows' capacity

In the industrial production of milk, great importance is attached to the suitability of cows for use in industrial complexes, including the type of constitution. To assess the constitutional orientation of cows towards one or another productivity, the milk coefficient is often calculated, which in our case ranged from 750 to 1672 kg. On average, it was 1224 kg, which indicates that the cows were of the dairy direction of productivity.

Reproduction issues are currently in the first place. This is explained by the fact that milk productivity, namely the lactation activity of cows, is associated with reproduction. One of the indicators of the reproductive qualities of cows is the duration of the service period. It is believed that it should be 45-80 days. That is, with a favorable state of affairs with reproduction, a cow in the second hunt after calving can be fruitfully inseminated. With high rates of productivity and a good response of the animal to milking, insemination is carried out in the fourth cycle of estrus. However, due to the widespread Holsteinization and the achievement of high productivity indicators, an increase in the duration of the service period is observed. Often this is explained by the dominant milk production. However, this may also be related to the fertility haplotypes of the breeding stock and sires in terms of reproductive qualities.

An analysis of the duration of the service and intercalving periods showed that there are certain problems with reproduction in the herd (Fig. 5).

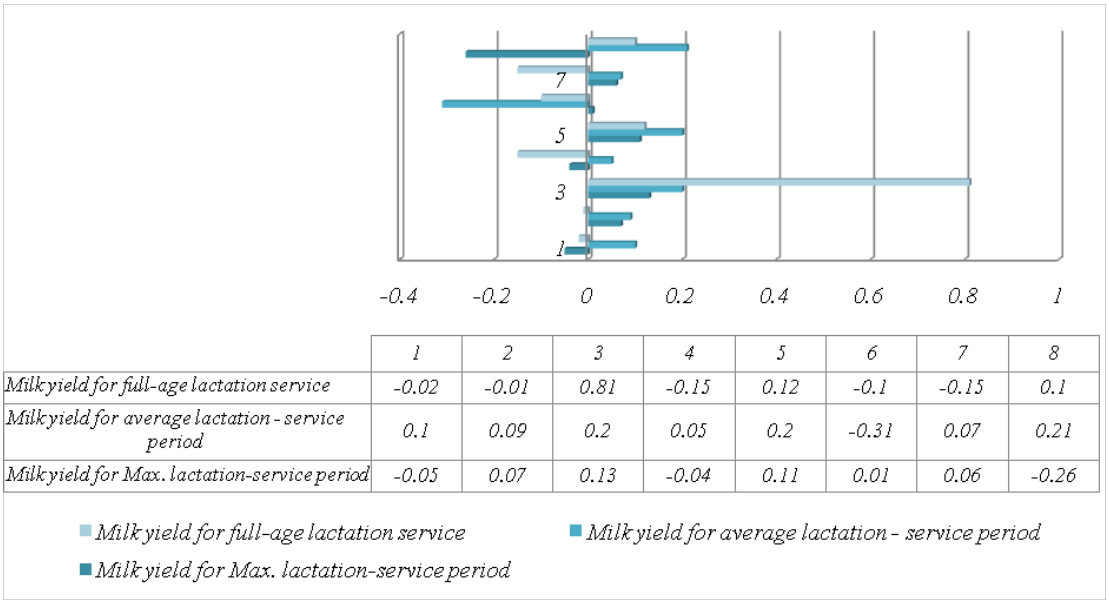
The figure shows that the duration of the service period for lactations varies slightly, especially in the first 4 lactations. In the fifth lactation, a decrease in this indicator was found with a further sharp increase. The optimal indicators of the duration of the service period are noted for 8 and 9 lactations. Most likely, this is explained by the fact that at this age only animals with good reproductive and productive qualities and in good health remain lactating.

This is also confirmed by the calculated coefficient of reproductive capacity (CRC), which should be at least 0.95 and tend to unity (Fig. 6).

The herd being assessed has reproductive problems. With age, reproductive functions improve due to the culling of cows, including for reasons of gynecological diseases and barrenness.

When planning breeding work with a herd, there are taken into account the correlation coefficients between economically useful traits. We have calculated the correlation coefficients between economically useful traits.

An assessment of the relationship between milk yield and the duration of the service and the intercalving period for lactations showed that there were no general patterns in the relationship between these indicators. They were, except for the correlation coefficient for the third lactation between milk yield for full-age lactation and the duration of the service period (Fig. 7).



	1	2	3	4	5	6	7	8
Milk yield for full-age lactation service	-0.02	-0.01	0.81	-0.15	0.12	-0.1	-0.15	0.1
Milk yield for average lactation - service period	0.1	0.09	0.2	0.05	0.2	-0.31	0.07	0.21
Milk yield for Max. lactation-service period	-0.05	0.07	0.13	-0.04	0.11	0.01	0.06	-0.26

Fig. 7. The conjugacy of milk yield cows' and the duration of the service period for lactation

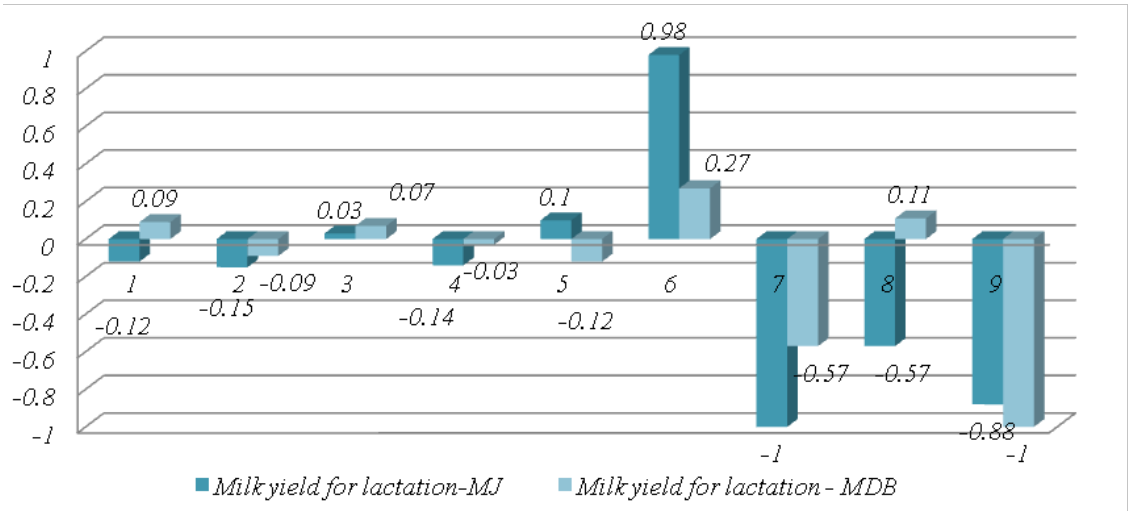


Fig. 8. Correlation coefficients between milk characteristics cows'

Thus, when carrying out breeding work with a herd, it is impossible to rely on indicators of the duration of the service period when selecting for milk productivity – milk yield.

The results of calculating the correlation coefficient between milk characteristics, milk yield for lactation and milk quality indicators are shown in Fig. 8.

Between milk yield and quality indicators of milk, a positive average and high correlation has not been established, with the exception of individual data (6 lactation), and therefore they cannot be used when carrying out measures to improve the herd. Selection and picking up for each indicator must be carried out separately.

Discussion and Conclusion

The farm uses highly productive dairy cattle of the Holstein Black-and-White breed. On the farm, individual animals are used up to 9 lactations, with an average duration of productive use of cows – 1.85 ± 0.07 lactations. Milk yields of cows change with age in accordance with the patterns of lactation activity. There are certain problems in reproduction in the herd. Between milk yield and quality indicators of milk, a positive average and high correlation has not been established, with the exception of individual data (6 lactation), and therefore they cannot be used when carrying out measures to improve the herd. Selection and picking up for each indicator must be carried out separately.

Similar data were obtained in the studies of A. V. Kolesnikova [4], O. V. Gorelik, O. E. Lihodeevskaya, N. N. Zezin, M. Ya. Sevostyanov and O. I. Leshonok [16], Mymrin V. O. Loretts [20] and others.

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