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Evaluation of Holstein cattle by a complex of traits in the breeding farm of the Russian Federation

Natalia Fedoseeva
The Department of Zootechnics, Production and Animal Products Processing
Russian State Agrarian Correspondence University
Balashikha, Russia
NFedoseeva0208@yandex.ru

Zoya Sanova
Research branch - Animal breeding
Kaluga Research Institute of Agriculture
Kaluga, Russia
sanova.zoya@yandex.ru

Maya Myshkina
The Department of Zootechnics, Production and Animal Products Processing
Russian State Agrarian Correspondence University
Balashikha, Russia
studmen2@yandex.ru

Leonid Kiselev
The Department of Zootechnics, Production and Animal Products Processing
Russian State Agrarian Correspondence University
Balashikha, Russia
NFedoseeva0208@yandex.ru

***Abstract*— The cattle were evaluated on the basis of productivity and reproduction indices both individually and in the terms of their genealogical groups. As a result of the correlation data analysis with the milk yield from 4.000 to 12.000 kg, a mathematical relationship between the individual and group values of the reproductive function parameters and the milk production was obtained. It was established that the correlation coefficient (g) between fat and protein was not as the standard and averaged up to +0.188. This means that when selecting animals with a high content of protein in milk, only in 20% of the cases will have a fat increase. It is noted that the age of the first insemination and the body weight at the 1st insemination are quite close to the standard indicators that are typical for this breed, which are 14-15 months and 370-380 kg, respectively. The productivity of first-calf heifers of the line Vis Back Ideal 933122 exceeded on average by 99 kg of milk on the first lactation; by the second lactation of the Reflection Sovereing 198998 cattle exceeded the productivity of other lines by 135 kg of milk.**

Keywords*— breed, productivity, genetic potential, age of the 1st insemination, line, bulls

I. INTRODUCTION

Currently, Russia is the fifth largest milk producer in the world, while the United States, with a population of 9 million cows and a productivity of 10 thousand kg per cow, has the first place [1].

The effectiveness of dairy cattle breeding is due to the high productivity of cows and the duration of their use. Farms that are breeding highly productive cows with a yield of 8–10 thousand kg of milk per lactation have appeared in Russia in the recent years. At the same time, an increase in the population of highly productive cows is carried out mainly due to the import of cattle. In many regions, the acquisition of pedigree cattle remains one of the ways to create highly productive livestock [2].

II. LITERATURE REVIEW

The increase of milk production can be achieved by increasing the genetic potential of productivity, improvement of the feed and feeding management, technological modernization of the industry and a full use of the latest scientific and practical achievements. Such a strategic direction of development of the industry is typical for the whole country and individual regions and is consistent with the experience of developed Western countries [3].

When it comes to the genetic level of the dairy cattle, breeders often mean the highest possible productivity. However, currently, a high genetic potential is becoming increasingly associated with the maximum possible profit obtained under certain conditions. In this regard, the very concept of genetic potential becomes relative. It is related to the specific production conditions, where the level of productivity is often not the decisive factor, because the milk production can be beneficial when the productivity of 5.000 kg per cow in the conditions of the extensive technology of New Zealand and balance on the verge of unprofitability when productivity of 10.000 kg in Western Europe due to high costs for veterinary services, imported concentrates and for the rearing of young stock [15].

Nevertheless, the production of milk is the main goal of dairy cattle management, and therefore it is not surprising that an increase in productivity was the essence of stock breeding throughout almost the entire history of dairy cattle breeding. During the last 50 years, stock breeding has met unprecedented success – productivity in developed countries has doubled, while the genetic potential of productivity has steadily increased by 50-100 kg of milk per year for most breeds in countries with developed dairy cattle breeding.

Historically, the Nordic countries (Sweden, Norway, Denmark and Finland) devoted great importance to the use of health and reproduction indices in the selection of dairy cattle; the United States used only the dairy productivity indices [12, 13, 14].

R. Reder, referring to the opinions of Patov, Schubert, Abel and Langlet, indicates that there is a general opinion about necessity of calculating the milk yield using relative indicators with certain milk productivity. The feasibility of using this method is confirmed by the practice of such countries as Sweden, Finland, Germany and the USA [9, 10, 11].

The transfer of dairy cattle breeding to new industrial technologies gives new challenges for improving cattle breeds. It is necessary to work with animals adapted to modern production technology, "repaying" for the feed by the highest yield of high-quality products [4, 7].

The average milk yield was and remains the main breeding and economic characteristic in dairy cattle breeding. However, against the background of its growth and the achievement in some cases of European and world levels,

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in recent years there have been trends in the deterioration of the parameters of reproduction and a decrease in the productive longevity of cows. Therefore, the need to achieve methodological innovations for a more objective comprehensive group assessment of cattle is becoming the main task. Evaluation of animals on a complex of traits is practiced all around the world, with the use of different techniques and methods.

According to our research, it has been established that an increase of the calving interval over 370 days makes a loss of average annual milk productivity by an amount equal to 0.3-0.4% of the actual annual milk yield [5, 6, 8].

The experience of the past decades has shown that ignoring the indicators of reproduction and health in breeding work irreversibly leads to their serious degradation. Therefore, almost all countries with developed dairy cattle breeding use reproduction and health indicators in breeding at the present [18].

According to A.G. Nezhdanov and V.P. Inozemtsev insufficient increase of the body weight causes reproductive immaturity, delay in physiological maturity and development in most animals. Therefore, the introduction of heifers older than 20-24 months into the herd is accompanied by the mass manifestation of pathological changes in the body.

The goal is to conduct a comprehensive assessment of animals using one of the methods for assessing cattle on the basis of productivity and reproduction indices to identify the best genotypes, bulls and lines.

The scientific novelty of the research consists in the fact that for the first time in conditions of the region, Holstein cows have been assessed by a complex of traits for a number of lactations and the influence of genetic and paratypical traits, with the aim of identifying the best genotypes that are exceeding the numbers all around the world. For more efficient use of imported livestock in our region and increasing the genetic potential of animals, the optimization of the genealogical structure of breeds and individual herds is of great importance. The work carried out is relevant not only in Russia, but also abroad, as animals are used by import selection with the forefathers of genealogical lines known to the whole world.

III. METHODS

The studies used abstract-logical and statistical methods, as well as comparative analysis.

The range of evaluated traits: the milk production (milk yield, fat, protein) and the reproductive abilities of animals (age of first calving, body weight at the 1st insemination, service period, interlactation period).

High-productive Holstein animals on the dairy complex of one of the farms in the region served as the research material. The herd was formed of purchased first-calf heifers from Hungary, America and Denmark [4]. All animals are purebred and have certificates confirming their breeding status. The choice of these countries is dictated, first of all, by productive qualities. Highly productive animals were from America, with the high milk production, and from Denmark, with high fat and protein level and high life longevity. Zootechnical and pedigree data were the sources of this information. This database was created in Excel. All calculations of the milk productivity of the cows are given of January 1st, 2016. The digital material of the experimental data was processed by the method of variation statistics. The total number of daughters of first-calf heifers in the studied population was 366 animals, of which 228 were evaluated by the first completed lactation. The milk production of cows on average in the herd was 9.914 kg of milk, the fat level was 3.60 kg and the protein level was 3.22 kg. All cows were purebred, class elite record.

IV. RESULTS AND DISCUSSION

Data on the milk production for 305 days of lactation are presented in Table 1. The first first-calf heifers have a very high productivity potential – the average milk yield for the 1st lactation was almost 10.130 kg, the percentage of fat and protein is on average 3.62 and 3.22%, respectively, that conforms to the breed standard. However, there are 158 cows (23%) with the fat level less than 3.60%. In first-calf heifers, as in the previous analyzed groups, there is a low consolidation of animals.

Only 54.8% belongs to the calculated modal class, the milk yield interval for the actual modal class (2σ), as well as in all previous analyzed groups, exceeds the recommended ± 10% and is 13.5%. 58 animals (25.4%) belong to the left (calculated) class, 45 animals (19.7%) belong to the right class.

TABLE I. GENERAL CHARACTERISTICS OF THE MILK PRODUCTION OF FIRST-CALF HEIFERS FOR 305 DAYS OF LACTATION

Trait	Yield of the 1st lactation	Fat, kg	Protein, kg
Average, kg	10130	365	325
Standard error (±)	90	1.8	1.6
σ	1364	48	43
Inaccuracy, kg	8428	302	272
Min., kig	5585	202	179,6
Max., kg	14013	504	451.6
Modal class:			
Actual interval, kg	8766-11494	317-413	282-368
Animals in the modal class	161	476	474
animals in the modal class (%)	70.6	69.3	69.0
Calculated interval (±10% of the average value), kg	9117-11143	329-402	293-356
Animals in the calculated modal class	125	389	380
animals in the calculated modal class (%)	54.8	56.6	55.3
n	228	687	687

The fact that about 75 of first-calf heifers belongs to the right calculated class, is a very good indicator on the one hand, since about 20% of first-calf heifers have a productivity significantly higher than the average values (11.250 kg and higher), but on the other hand it should be remembered that the high average milk yield of the first first-calf heifers (10.130 kg of milk) is mainly provided by these animals, or, in other words, by 75 highly productive first-calf heifers there are as many (45 animals) relatively low-producing (for a given herd) animals (less than 9.000 kg).

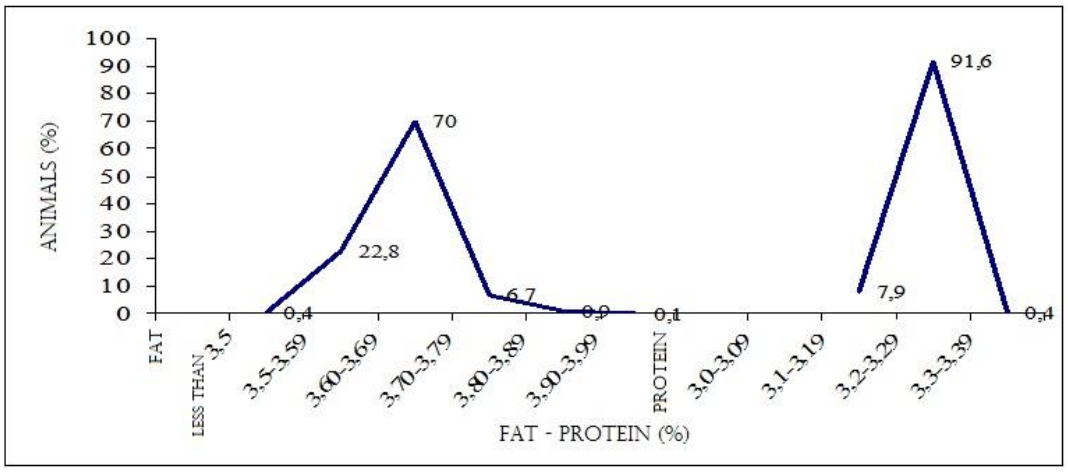

Fig. 1. Variation curve for fat and protein level in the milk

Milk yield for first-calf heifers accounted for: first part (the first 100 days) - 31.6%; second part (the second 100 days; - 34.9%); third part (the third 105 days) - 33.5%.

The variation curve of the distribution of animals in terms of fat level corresponds to the classical form, namely: there is a pronounced peak, only two points fall into the modal class – this indicates a high consolidation of animals; the left side is steep and the right side is flatter – this indicates that there are practically no animals with a low trait indicator, and animals with high indicators of the percentage of fat in the herd are there and this is a reserve for improving the indicator.

In the studies of domestic and foreign scientists noted that between the percentage of fat and the percentage of protein in milk, there is a high positive correlation, which is within +0.50…+0.75, the correlation between milk yield and total fat (kg) is also a high positive value of +0.90. In our studies, the correlation coefficient (r) between fat and protein was not standard and averaged +0.188, but the correlation coefficient between milk yield and fat in this herd is very close to the ideal and is +0.996, which coincides with the data of domestic and foreign researchers.

This means that, selecting animals with a high level of protein in milk, only in 20% of cases there will be increased fat level.

Similar data are given in the works of M.P. Libizov – in all cases there is no displacement of animals within the variational series, but their redistribution in the new variational series.

In terms of protein level in milk, the range of the modal class is narrow and amounts to ± 0.03 (σ), σ does not go beyond the permissible 5% and is only 0.93% of the average; about 87% of animals are included in the actual modal class (Figure 1).

The variation curve for the quantitative protein content (kg), as well as for the quantitative content of fat, is also similar to the variation curves for milk yield over 305 days of lactation. Therefore, breeding measures to increase the milk yield and consolidate animals, proposed above, will make the desired adjustments not only in indicators of milk yield and total fat (kg), but also in indicators of total protein (kg).

As a result, there is heterogeneity of animals on the basis of milk yield and, thereby, consolidation decreases. In confirmation of this, the nature of the variation curve of the milk yield is a broad base, gently sloping (especially on the left); the top of the peak has an anterior plateau (Figure 3).

This means that at least for the first 100 days of lactation, the animals were not sufficiently stimulated for the milking. The calculation was made taking into account the fact that milk yield Holstein breed cows corresponds to 40-45% in the first 100 days of lactation of the total milk yield for 305 days of lactation.

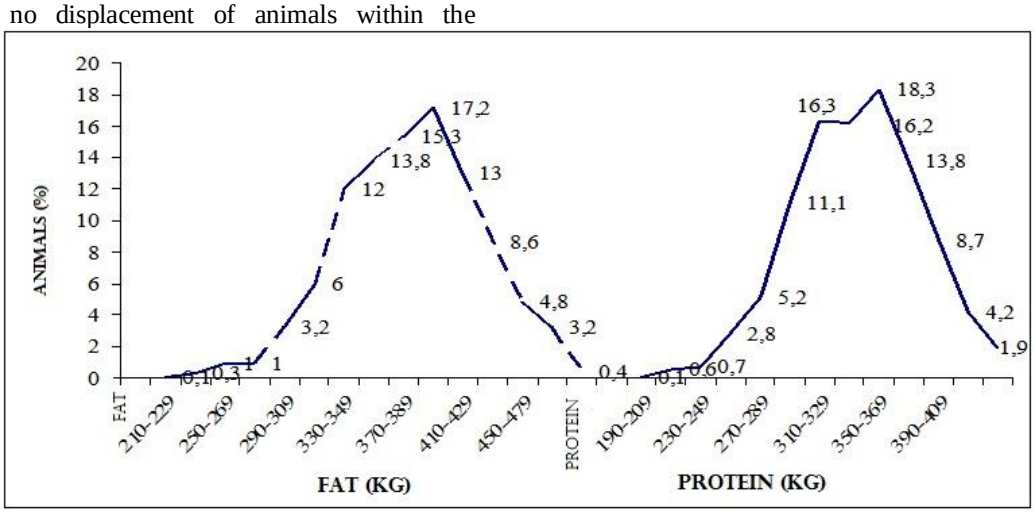

Fig. 2. Variation curve of total fat and protein in the milk, kg

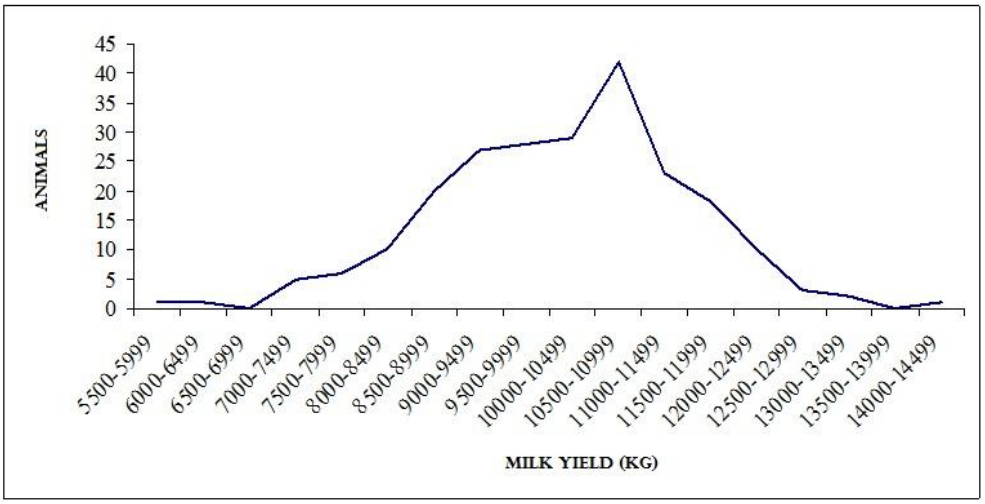

Fig. 3. Variation curve of first-calf heifer milk yield for 305 days

At the first glance, the potential of the first-calf heifer milk productivity was fully realized, since the milk yield for the first 100 days was 3.198 kg, when the milk yield for the entire lactation should be 7.106-7.995 kg, and an average of 7.550 kg, but in fact it was 11.030 kg.

However, the classic view of the lactation curve includes a peak at 3 months of lactation, and then there is a gradual decrease in the milk yield, which we do not observe in the studied herd. The lactation curve looks like a straight line, the values of which vary between 31.6-34.9%.

At the first first-calf heifers there are certain problems with the implementation of genetic potential. The lactation period can be divided into three parts: the first 90-100 days of lactation, the second 90-100 days of lactation and the third 105-125 days of lactation.

The main yield occurs on the first and the second part of lactation; therefore, it is usually these that are taken into account as the "first 100 days" and "first 200 days" of lactation. Physiologically justified milk yield on average during these periods should be: 1st part (the first 100 days) 40-50%; 2nd part (the second 100 days) 30-35%; 3rd part (the third 105 days) 20-25%.

In addition, there is a coefficient of lactation stability (C. stab.), which is the ratio of milk yield for the second 100 days of lactation to the milk yield for the first 100 days of lactation, expressed in percentage. In cows with exceptionally high productivity, the stability coefficient can reach 98-99%, but normally it does not exceed 100%; the lactation stability coefficient on the farm averages 112%.

The data presented in Figure 4 once again confirms that the cows in the farm are not distributed correctly in the first three months of lactation.

A similar situation is observed not only in first-calf heifers, but also in cows of the second and third lactation. According to physiological norms, milk yield over the last 100 days of lactation should not exceed 20% of the total milk yield. Consequently, the first first-calf heifers were either poorly distributed in the first part of lactation, and this, as a rule, indicates poor feeding and management of animals, or there could be informational errors in the database.

One of the first signs by which one can judge about high genetic potential of the future milk productivity of cows are indicators of age and body weight of first-calf heifers at the 1st insemination. The optimal parameters for the 1st insemination are: age – 14-15 months; body weight – 380-390 kg.

Only 60.2% of animals makes into the actual modal class of cows, whereas the first-calf heifers makes it up to 85.7%. However, the interval of the actual modal class of cows is rather wide – 1.94 months; whereas the first-calf heifers is up to 1.59 months, which significantly exceeds the theoretically calculated interval (1.4 months).

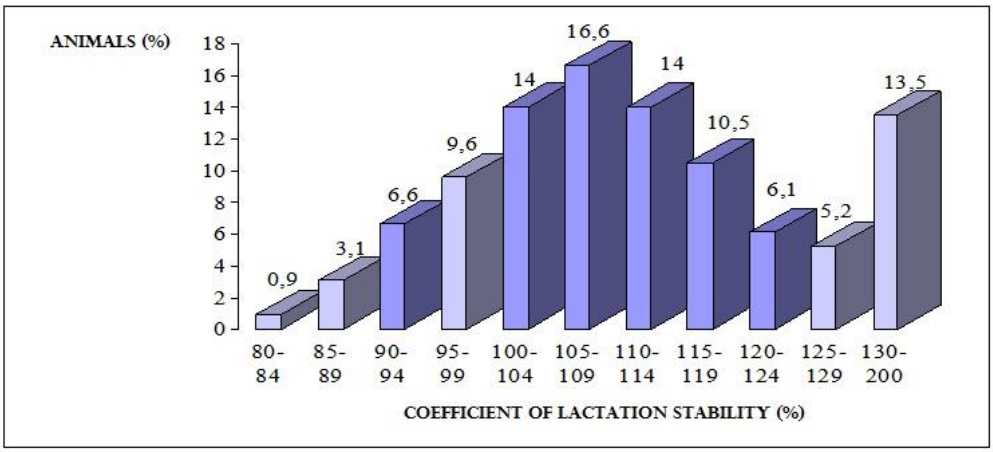

Fig. 4. Variational curve of the coefficient of lactation stability

TABLE II. GENERAL CHARACTERISTICS OF AGE AT THE 1ST INSEMINATION

TRAIT	Age of the 1st insemination		Body weight at the 1st insemination	
	*Cows**	*First-calf heifers*	*Cows**	*First-calf heifers*
Average. months	14.1	14.0	389	398
Standard error (±)	0.06	0.09	0.9	1.7
σ	1.94	1.59	28	28
Inaccuracy. motnhs	18	10	282	284
Min.. months	8	11	218	276
Max.. months	26	21	500	560
n	1030	343	854	287
Modal class:				
Actual interval. months	12-16	12.4-15.6	361-417	370-426
Animals in the actual modal class	620	294	637	232
animals in the actual modal class (%)	60.2	85.7	74.6	80.8
Calculated interval (±5% of the average age). months	13.4-14.7	13.4-14.7	350-428	358-438
Animals in the calculated modal class	507	206	763	251
animals in the calculated modal class (%)	49.2	60.1	89.3	87.5

[a.] imported as heifers

The age of the 1st insemination belongs to low-variable trait and σ should not exceed ± 5%. Consequently, the calculated modal class should be within 13.4-14.7 months, and only 49% of cows and 60% of first-calf heifers fit into this interval. In a herd of 118 cows and 25 first-calf heifers had a 1st insemination age of 17 months and above, which is 11.8% and 7.3%, respectively (Table 2).

Indicators of the average body weight of animals at the 1st insemination are quite close to the standards of this breed (370-380 kg). According to this trait, the animals in the herd are well consolidated. The interval of the calculated modal class (σ = 28 kg, or 7.0-7.2%) turned out to be wider than the interval of the actual (± 39 kg). 75% of the animals among cows of the 2nd lactation and older make it in the actual modal class, as well as 81% of the first-calf heifers; and almost 90% of animals (87-89%) makes it into the calculated modal class.

Amount of cows, weighing less than 350 kg, is 16 animals of the all herd (1.9%), and first-calf heifers – 6 animals (2.1%). Amount of cows, weighing more than 430 kg at the 1st insemination, is 75 animals (8.8%), and first-calf heifers – 29 (10%). As for animals that have not gained weight for the 1st insemination, there can be two reasons: either very young animals are inseminated at the age of 10-12 months, or – it is undernourished animals. As for animals with excess weight for the 1st insemination – the reason lies, as a rule, in several consecutive non-productive inseminations.

The milk productivity of animals belonging to different genotypes is presented in Table 3. No significant differences in the productivity of the lines were revealed. This indicates a good uniformity of the herd, despite the animals import from different countries. The selection of bulls of American and Canadian breeding ensured the uniformity of the herd by productivity and by type.

The productivity of first-calf heifers of the line Vis Back Ideal 933122 exceeded on average by 99 kg of milk; the Reflection Sovereing 198998 exceeded the productivity of other lines by 135 kg by the second lactation. The productivity of cows of the third lactation and older did not have much difference. First-calf heifers and cows of the second calving are animals obtained and raised in a breeding farm.

TABLE III. THE PRODUCTIVITY OF COWS, DEPENDING ON THE LINE

Line	1st lactation				2nd lactation				3rd lactation and older		
	n	*Milk yield, kg*	*fat, %*	*± yield of the herd*	*n*	*Milk yield, kg*	*fat, %*	*± yield of the herd*	*n*	*Milk yield, kg*	*fat, %*
Reflection Sovereing 198998	78	9801	3.60	-129	80	11507	3.61	+179	54	10967	3.60
Montwick Chieftein 95679	21	9748	3.58	-182	25	11390	3.60	-62	10	11622	3.60
Vis Back Ideal 933122	165	10024	3.60	+94	130	11286	3.60	-42	75	10651	3.60
Pabst Governor 882933	2	9859	3.59	-71	-	-	-	-	-	-	-
+, - of lactation	263	9930	3.60	-	235	11328	3.60	-	140	10726	3.60

V. CONCLUSION

The abovementioned activities that form a targeted system for selecting animals with the rational use of the genetic potential of the outstanding lines, make it possible to quickly achieve herd productivity at 9.000-10.000 kg of milk and more from each cow by complete lactation under conditions of intensive technologies.

Evaluation of cows by a complex of traits of milk productivity (milk yield, fat and protein level in the milk) and reproductive abilities allows one to select and use the best animals for raising bulls with high breeding value not only in Russia, but also abroad. This is important for the proper selection of bulls, which determines the characteristics of future offspring, high milk production, reproduction and life longevity.

The highly positive correlation between milk yield and total fat and protein content suggests that all breeding activities carried out to consolidate animals for milk yield will also make the desired adjustments to the total fat and protein content (kg), and vice versa.

One of the defining aspects of the effectiveness of the technologies used in the dairy cattle breeding is the optimization of the body weight increase, which is associated with the age of the 1st insemination of heifers. As a complex, it characterizes the specifics of the regional gene pool of the cattle population, its acclimatization and, in general, the quality of breeding products.

Therefore, in our opinion, in view of the intensive use of the genomic assessment of stud bulls, which today is one of the most reliable, it is necessary to focus on a more detailed and scrupulous relation to the assessment of herd stock. This will provide an opportunity to more reliably assess the order of interrelationships of the productivity traits, as well as improve the accuracy of predicting the breeding value of the offspring. This is especially important for the quality indicators of milk, such as fat and protein milk content, the heritability of which is quite high.

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