ТЕХНОЛОГІЯ ВИРОБНИЦТВА І ПЕРЕРОБКИ ПРОДУКЦІЇ ТВАРИННИЦТВА

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Significance of breeding value indicators for prediction of milk yield

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A comparative assessment of the significance of various indicators of the breeding value of breeding bulls for predicting milk yield in the highly productive herd of the farm economy "Alfa" was carried out. The milk yield of cows, whose bulls-fathers were evaluated in Ukraine and abroad, was studied. It was established that in the period from 2009 to 2014, the milk yield of first-calf heifers increased by 23.9 % and reached 5894.3 kg. Accordingly, during the specified period, most of the quantitative indicators of the breeding value and milk productivity of the bulls' daughters also increased: the breeding value of the parent bulls in terms of milk yield increased from +245.3 kg in 2009 to +540.4 kg in 2014; the breeding value of parent bulls in terms of the total amount of milk fat per lactation increased from +10.2 kg to +29.7 kg. A correlation analysis of the relationships between various indicators of breeding value of parent bulls and the milk yield of their daughters was carried out. It was established that the actual milk yield of first-calf heifers in FE "Alfa" most (correlation coefficients r higher than 0.8) and most significantly ($p<0.001$) depended on the average milk yield and amount of milk fat yield of bull's daughters in the herds where the breeding value of these bulls was evaluated. The breeding value of the sire bulls by the amount of milk fat yield was also characterized by high ($r=0.675$) and significant ($p<0.01$) relationship with the actual milk yield of the first-calf heifers (daughters of these sires). The variance analysis of the influence of the breeding value estimation method of breeder bulls (BV, ETA, ZW, DRV, RPC) on the actual milk yield of their daughters during the first lactation established that this influence was significant ($p=0.001$), and the power of influence was $\eta^2=0,59$. Significant differences were mostly observed between milk yields of first-calf heifers whose parent bulls were evaluated abroad and in Ukraine. The biggest difference in terms of actual milk yield was revealed between the daughters of bulls evaluated by the ETA method (Canada) and by the "daughter-of-the-same-age (DRV)" method (Ukraine). This difference was 2640 kg of milk ($p<0.01$) in favor of first-calf heifers from Canadian bulls.

Key words: breeding bulls, breeding value, milk productivity, daughters of bulls, milk yield, selection index, evaluation method.

Problem statement and analysis of recent research. Ukrainian catalogs of breeder bulls list more than a dozen different indicators of their breeding value in terms of milk productivity. Each of these indicators characterizes quantitative, qualitative or complex aspects of evaluation [1–4]. In particular, among the breeding value indicators there is a block of indicators that evaluate exactly breeding value by milk productivity, i.e. the potential advantage of the assessed bull's daughters compared to daughters of other bulls (for example, plus-minus according to the milk yield of daughters).

The second block of indicators is characteristics of average milk productivity of daughters, by which the sire was evaluated (for example, the average milk yield of his daughters per lactation).

Each block usually includes 5 indicators. Based on them, it is possible to additionally deter-

mine several more complex characteristics of milk productivity.

In addition, the catalogs have certain indexes and categories of breeding value, which characterize sires simultaneously by several breeding traits. They act as integral criteria for assessing the breeding value. In countries where breeding work is carried out at a high level, the calculation of the breeding value index is carried out simultaneously based on 4–6 economic and 17–18 breeding indicators. Usually such indicators in numerical form characterize the genetic potential of livestock from the point of view of its influence on the complex of economic and useful traits of offspring [4–11].

Breeding indexes mostly include the most significant indicators of productivity, reproductive capacity, technological, genomic and other characteristics of animals in a certain ratio in the way that it is convenient to achieve breeding goals with their help [12–18].

It should be noted that all indicators of breeding value, which are given in the catalogs, were determined on animals that are kept in certain conditions. And these conditions do not always correspond to the level that occurs in a specific domestic farm [19–21]. So, today most of the sperm of parent bulls used in Ukrainian farms have foreign origin. In particular, the cows on which the breeding value of sires was evaluated are characterized by milk yield of 7–12 thousand kg per lactation. And this implies the appropriate level and quality of feeding and comfort for animals. The vast majority of Ukrainian farms have not yet reached this level.

Thus, the comparative assessment of the significance of various indicators of breeding value for predicting milk yield of cows in low-yielding herds simultaneously faces several methodological obstacles regarding the correctness of such an assessment. First of all, we are talking about the additional impact of the non-compliance of farm conditions with those that took place during the evaluation of bulls.

In view of this, the **goal of the conducted research** is quite relevant. It consists in a comparative assessment of the significance of bull's breeding value indicators for predicting the milk yield of their daughters in such Ukrainian farms, the level of milk yield in which corresponds to foreign ones, and the quality of feeding and comfort of keeping can be compared with those that took place in the process of evaluating bulls abroad.

Material and methods of research. The research was conducted on the basis of data obtained at the farming economy "Alfa" (FE "Alfa") of Zolochiv District, Kharkiv Region. In this farm, the milk productivity of cows was increasing significantly for a long time. In 2010–2021, milk productivity of cows in FE "Alfa" reached the level that occurred when assessing the breeding value of most breeding bulls used in this farm.

FE "Alfa" is a dairy cattle breeding specializes farm. Ukrainian Black-And-White dairy cattle are bred here. They use tethered and untethered keeping of animals. The technologies of keeping different sex-age groups of animals, as well as keeping them in different seasons of the year, are somewhat different.

About 300 dairy cows were kept in the farm. The milk yield of dairy cows in the period 2007–2009 was 5545–6497 kg (an average of 6062 kg). In the period of 2012–2014, milk yield was 7503–8010 kg, that is, it increased on average to 7838 kg. Milk yield per cow during these controlled periods is significantly different ($p = 0.005$).

The average daily growth of heifer's mass during the considered years of research ranged from 616 to 872 g. This is a fairly high level. In this regard, and in view of the results of our previous studies [22], the level of daily growth of heifer's mass unlikely effects significantly on the results of evaluating of various breeding value characteristics of sires.

The material for the research was the data on the milk yield (MY) of the first-calf heifers, born from the use of sperm production of different breeder bulls in different periods. In addition, available indicators of breeding value of sires used in FE "Alfa" were selected from breeding bull's catalogs, 1-mol cards and other sources. In particular, the following indicators of breeding value of sires were monitored:

- Selection index of bull (SI), points;
- Pedigree index of bull (PI), points;
- Breeding value of bull by milk yield per lactation (BVMY), kg;
- Breeding value of bull by fat content in milk (BV%F), %;
- Breeding value of bull by amount of milk fat per lactation (BVFat), kg;
- Breeding value of bull by protein content in milk (BV%P), %;
- Breeding value of the bull by amount of milk protein per lactation (BVProt), kg;
- Average milk yield of bull's daughters per lactation in herds where the breeding value evaluation of the sire was carried out (ADMY), kg;
- Average fat content in milk of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (AD%F), %;
- Average amount of milk fat per lactation of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (ADMF), kg;

• Average protein content in the milk of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (AD%P), %;

• Average amount of milk protein per lactation of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (ADMP), kg.

In addition, two more complex indicators were calculated on the basis of these breeding value indicators:

• Breeding value of bulls by total amount of milk fat and milk protein per lactation (BVFatPr), kg;

• The average total amount of milk fat and milk protein per lactation of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (ADMFP), kg.

The dynamics of indicators of breeding value and milk yield of first-calf heifers in FE "Alfa" at 2009 and 2014 were analyzed.

The relationships between the above parameters of breeding value of sires and the milk yield of first-calf heifers were investigated using correlation analysis. Statistical processing was carried out in three variants:

– using data for the entire period of research;

– with the involvement in the processing of only indicators determined as of 2009;

– with the involvement in the processing of only indicators determined as of 2014;

The package of applied computer statistical programs SPSS-22, the procedures "Correlation – Pairwise" and "General linear model – Univariate" were responsible for software support.

The correlation coefficients between various indicators of breeding value of sires and the actual milk yield of first-calf heifers (their daughters) in FE "Alfa" was compared. At the same time, the most significant and most important correlations were highlighted. This made it possible to determine the characteristics of breeding value of sires, which are most significant for predicting future milk yields.

In addition, trends of changing these correlation coefficients over time were monitored. At the same time, significant trends in the validity of the use of bulls' semen with certain indicators of breeding value were highlighted.

Results and discussion. It was established that the average milk yield of first-calf heifers in FE "Alfa" (table 1) during the entire period of research was M = 5306.7 kg. The mean square (standard) deviation of milk yields between daughters of different sires was σ = 1023.0 kg. At the same time, it should be noted that as of 2009, this average milk yield was significantly lower (M = 4759.1 kg) and less variable (σ = 694.0 kg). At 2014 it had increased by 23.9 % to 5894.3 kg. Milk yield variability between daughters of different bulls in 2014 is significantly higher compared to 2009: mean square (standard) deviation increased by 45.5 %.

Accordingly, most of the quantitative indicators of breeding value of sires and milk productivity of their daughters increased during the specified period. In particular, the breeding value of bulls by milk yield in 2014 reached +540.4 kg, by the total amount of milk fat per lactation of their daughters +29.7 kg, against +245.3 kg and +10.2 kg, respectively, in 2009.

The average milk yield of bulls' daughters per lactation in the herds, where the evaluation of breeding value of the sire was carried out, increased from 2009 to 2014 by 2582.3 kg, reaching 7487.6 kg. Accordingly, the average amount of milk fat per lactation of bulls' daughters in the herds where breeding value was evaluated increased by 59.9 % over the same period and reached 286.3 kg in 2014.

A correlation analysis of the relationships between the characteristics of the breeding value of bulls and the milk yield of first-calf heifers (their daughters in FE "Alfa") was carried out (table 2). It was established that the actual milk yield of first-calf heifers in FE "Alfa" most (correlation coefficients r higher than 0.8) and most significantly ($p<0.001$) depended on the average milk productivity (milk yield and amounts of milk fat) of their parent bull's daughters in the herds where the evaluation of the bulls' breeding value was carried out.

From the direct indicators of the breeding value of bulls, the breeding value of the sire bull by the amount of milk fat was characterized by a slightly lower ($r=0.675$), but also significant ($p<0.01$) relation with the actual milk yield of first-calf heifers (daughters of these sires) in FE "Alfa".

In addition, a considerable and significant relationship between the actual milk yield of first-calf heifers and the values of the selection indexes of parent bulls SI and PI was revealed.

All the given regularities are fully consistent with the conclusion we made earlier in the studies conducted on the database, which consisted of animals from many breeding farms of Ukraine [16].

If we analyze the correlations between different indicators of the breeding value, it is worth paying attention to the positive and significant relationships between the direct indicators of the breeding value of the sires and the average milk productivity of their daughters in the herds where the breeding value of these bulls was assessed. This indicates a parallel improvement over time in both the sires' breeding values of the themselves and the milk productivity of the dams on which these sires are tested.

Table 1 – **Characteristics of the variability of breeding value indicators of bulls-fathers in FE "Alfa"**

Indicators	Mean, M	Standard deviation, σ	Number of assessed bulls, heads
Breeding value of bull by milk yield per lactation (BVMY), kg	+436,2	428,5	17
Breeding value of bull by fat content in milk (BV%F), %	+0,071	0,211	17
Breeding value of bull by amount of milk fat per lactation (BVFat), kg	+22,8	23,5	17
Breeding value of bull by protein content in milk (BV%P), %	+0,099	0,127	7
Breeding value of the bull by amount of milk protein per lactation (BVProt), kg	+33,7	11,1	7
Breeding value of bulls by total amount of milk fat and milk protein per lactation (BVFatPr), kg	+77,0	24,0	7
Average milk yield of bull's daughters per lactation in herds where the breeding value of the sire evaluation was carried out (ADMY), kg	6576,2	2329,0	17
Average fat content in milk of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (AD%F), %	3,771	0,246	17
Average amount of milk fat per lactation of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (ADMF), kg	248,4	95,2	17
Average protein content in the milk of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (AD%P), %	3,341	0,220	7
Average amount of milk protein per lactation of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (ADMP), kg	300,9	28,9	7
The average total amount of milk fat and milk protein per lactation of bull's daughters in the herds where the breeding value evaluation of the sire was carried out (ADMFP), kg	652,7	66,6	7
Selection (SI) or pedigree (PI) index of bull, points;	639,4	479,0	15

A dispersion analysis of the effect of the breeding value estimation method of breeder bulls (BV, ETA, ZW, DRV, RPC) on the actual milk yield of their daughters during the first lactation in FE "Alfa" was carried out. It was found that this effect was significant ($p=0.001$), and the power of influence was $\eta^2 = 0.59$. Significant differences were mostly observed between milk yields of first-calf heifers whose parent bulls were evaluated abroad and in Ukraine.

Thus, the biggest difference by milk yields was recorded between the daughters of bulls evaluated by the ETA method (Canada) and by the "daughter-of-the-same-age (DRV)" method (Ukraine). This difference was 2640 kg of milk ($p<0.01$) in favor of first-calf heifers from Canadian bulls. In FE "Alfa" the average milk yield of first-calf heifers from Canadian sires evaluated by the ETA method was 7,503 kg against the milk yield of 4,863 kg in first-calf heifers that were daughters of bull sires evaluated in Ukraine by the DRV method.

In the rest of the researched options, first-calf heifers obtained from sires who were evaluated abroad prevailed in terms of milk yield of first-calf heifers, whose parents were evaluated in Ukraine, by 1173–2245 kg. All but one of these differences at milk yields were significant.

A comparison of the milk yield of the first-calf heifers of FE "Alfa" obtained from bulls of different breeding value categories was carried out. A significant ($p<0.05$) difference was established between the milk yields of first-calf heifers whose parent bulls had "P5" and "H+" breeding value categories. This difference was 1571 kg in favor of the "P5" category.

Table 2 – **Correlation between the milk yields of first-calf heifers and indicators of breeding value of their parent bulls for the entire monitored period**

Indicators		BVMY	BV%F	BVFat	BV%P	BVProt	BVFatPr	ADMY	AD%F	ADMF	AD%P	ADMP	ADMFP	SI/PI	MY
BV	r	1,00	–0,27	0,47	–0,60	0,46	–0,37	0,49*	–0,03	0,45	–0,52	–0,35	–0,52	0,26	0,38
MY	p		0,29	0,06	0,15	0,29	0,41	0,05	0,91	0,07	0,23	0,45	0,23	0,34	0,13
BV	r	–0,27	1,00	0,71**	0,67	–0,26	0,67	0,38	0,66**	0,50*	0,28	0,56	0,73	0,50	0,43
%F	p	0,29		0,00	0,10	0,57	0,10	0,14	0,00	0,04	0,54	0,20	0,06	0,06	0,09
BV	r	0,47	0,71**	1,00	0,65	0,03	0,89**	0,70**	0,56*	0,78**	0,00	0,61	0,78*	0,67**	0,68**
Fat	p	0,06	0,00		0,12	0,95	0,01	0,00	0,02	0,00	1,00	0,15	0,04	0,01	0,00
BV	r	–0,60	0,67	0,65	1,00	0,42	0,76*	–0,15	0,75	0,43	0,67	0,26	0,37	0,77*	0,60
%P	p	0,15	0,10	0,12		0,34	0,05	0,75	0,05	0,34	0,10	0,58	0,42	0,05	0,16
BV	r	0,46	–0,26	0,03	0,42	1,00	0,49	–0,07	–0,10	–0,15	0,08	–0,03	–0,10	0,24	0,43
Prot	p	0,29	0,57	0,95	0,34		0,27	0,88	0,83	0,76	0,87	0,96	0,84	0,60	0,34
BV	r	–0,37	0,67	0,89**	0,76*	0,49	1,00	0,39	0,28	0,69	0,03	0,52	0,63	0,50	0,58
FatPr	p	0,41	0,10	0,01	0,05	0,27		0,39	0,55	0,09	0,94	0,23	0,13	0,25	0,18
AD	r	0,49*	0,38	0,70**	–0,15	–0,07	0,39	1,00	0,33	0,98**	–0,66	0,86*	0,82*	0,61*	0,81**
MY	p	0,05	0,14	0,00	0,75	0,88	0,39		0,20	0,00	0,11	0,01	0,02	0,02	0,00
AD	r	–0,03	0,66**	0,56*	0,75	–0,10	0,28	0,33	1,00	0,52*	0,85*	–0,15	0,02	0,67**	0,43
%F	p	0,91	0,00	0,02	0,05	0,83	0,55	0,20		0,03	0,02	0,74	0,97	0,01	0,09
AD	r	0,45	0,50*	0,78**	0,43	–0,15	0,69	0,98**	0,52*	1,00	–0,11	0,90**	0,98**	0,71**	0,83**
MF	p	0,07	0,04	0,00	0,34	0,76	0,09	0,00	0,03		0,82	0,01	0,00	0,00	0,00
AD	r	–0,52	0,28	0,00	0,67	0,08	0,03	–0,66	0,85*	–0,11	1,00	–0,19	–0,15	0,61	0,26
%P	p	0,23	0,54	1,00	0,10	0,87	0,94	0,11	0,02	0,82		0,69	0,75	0,15	0,57
AD	r	–0,35	0,56	0,61	0,26	–0,03	0,52	0,86*	–0,15	0,90**	–0,19	1,00	0,97**	–0,15	0,77*
MP	p	0,45	0,20	0,15	0,58	0,96	0,23	0,01	0,74	0,01	0,69		0,00	0,76	0,04
AD	r	–0,52	0,73	0,78*	0,37	–0,10	0,63	0,82*	0,02	0,98**	–0,15	0,97**	1,00	–0,03	0,71
MFP	p	0,23	0,06	0,04	0,42	0,84	0,13	0,02	0,97	0,00	0,75	0,00		0,96	0,07
SI /	r	0,26	0,50	0,67**	0,77*	0,24	0,50	0,61*	0,67**	0,71**	0,61	–0,15	–0,03	1,00	0,62*
PI	p	0,34	0,06	0,01	0,05	0,60	0,25	0,02	0,01	0,00	0,15	0,76	0,96		0,02
MY	r	0,38	0,43	0,68**	0,60	0,43	0,58	0,81**	0,43	0,83**	0,26	0,77*	0,71	0,62*	1,00
	p	0,13	0,09	0,00	0,16	0,34	0,18	0,00	0,09	0,00	0,57	0,04	0,07	0,02	

* – $p \leq 0,05$; ** – $p \leq 0,01$.

Conclusions. 1. It was established that in the period from 2009 to 2014, in FE "Alfa" the average milk yield of first-calf heifers increased by 23.9 % and reached 5894.3 kg. Accordingly, during the specified period, mean square (standard) deviation increased by 45.5 %.

2. Most of the quantitative indicators of the breeding value and milk productivity of the bulls' daughters from 2009 to 2014 also increased: the breeding value of the parent bulls in terms of milk yield increased from +245.3 kg in 2009 to +540.4 kg in 2014; the breeding value of parent bulls in terms of the total amount of milk fat per lactation increased from +10.2 kg to +29.7 kg.

3. The actual milk yield of first-calf heifers in FE "Alfa" most (correlation coefficients r higher than 0.8) and most significantly ($p<0.001$) depended on the average milk yield and amount of milk fat yield of bull's daughters in the herds where the breeding value of these bulls was evaluated.

4. The breeding value of the sire bulls by the amount of milk fat yield was characterized by high ($r=0.675$) and significant ($p<0.01$) relationship with the actual milk yield of the first-calf heifers (daughters of these sires).

5. The variance analysis of the influence of the breeding value estimation method of breeder bulls (BV, ETA, ZW, DRV, RPC) on the actual milk yield of their daughters during the first lactation established that this influence was significant ($p=0.001$), and the power of influence was $\eta^2 = 0$, 59. Significant differences were mostly observed between milk yields of first-calf heifers whose parent bulls were evaluated abroad and in Ukraine.

6. The biggest difference in terms of actual milk yield was revealed between the daughters of bulls evaluated by the ETA method (Canada) and by the "daughter-of-the-same-age (DRV)" method (Ukraine). This difference was 2640 kg of milk ($p<0.01$) in favor of first-calf heifers from Canadian bulls.

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Значущість показників племінної цінності для прогнозування надоїв

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Проведено порівняльне оцінювання значущості різних показників племінної цінності бугаїв-плідників для прогнозування надоїв у високопродуктивному вітчизняному стаді фермерського господарства «Альфа». Досліджено надої корів, батьками яких були бугаї, оцінені в Україні та за кордоном. Встановлено, що за період з 2009 до 2014 рік надої первісток збільшилися на 23,9 % і сягнули 5894,3 кг. Зросла також більшість кількісних показників племінної цінності та молочної продуктивності дочок бугаїв: племінна цінність бугаїв-батьків за надоєм зросла зі +245,3 кг у 2009 році до +540,4 кг у 2014 році; племінна цінність бугаїв-батьків за сумарною кількістю молочного жиру за лактацію – збільшилася з +10,2 кг до +29,7 кг. Здійснено кореляційний аналіз зв'язків між різними показниками племінної цінності бугаїв-батьків і надоями їхніх дочок. Встановлено, що фактичні надої первісток у ФГ «Альфа» найбільше (коефіцієнти кореляції r вищі за 0,8) і найвірогідніше ($p<0,001$) залежали від середніх надоїв і кількості молочного жиру дочок бугаїв у стадах, на яких проводили оцінювання племінної цінності цих бугаїв. Суттєвим ($r=0,675$) і вірогідним ($p<0,01$) зв'язком із фактичним надоєм первісток (дочок цих плідників) у ФГ «Альфа» характеризувалася також племінна цінність бугая-батька за кількістю молочного жиру. Дисперсійним аналізом впливу методу оцінювання племінної цінності бугаїв-плідників (BV, ETA, ZW, ДРВ, РПЦ) на фактичні надої їхніх дочок за першу лактацію встановлено, що цей вплив був вірогідним ($p=0,001$), а ступінь впливу становив $\eta^2 = 0,59$. Статистично значущі різниці здебільшого спостерігали між надоями первісток, батьки яких оцінені за кордоном і в Україні. Найбільшу різницю за фактичними надоями зафіксовано між дочками бугаїв, оцінених за передавальною здатністю методом ETA (Канада) і методом «дочки-ровесниці (ДРВ)» в Україні. Ця різниця становила 2640 кг молока ($p<0,01$) на користь первісток від канадських бугаїв.

Ключові слова: бугаї-плідники, племінна цінність, молочна продуктивність, дочки бугаїв, надій, селекційний індекс, метод оцінювання.

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