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Grounding the economic selection index for evaluation and selection of dairy cattle

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ABSTRACT

The aim of the research was to develop a selection index for the evaluation and selection of dairy cattle for increasing milk production and reproductive traits. Materials of the research were data on milk production and reproduction of cows of the Ukrainian Black-and-White dairy breed in commercial farm in Kharkiv region. Studies showed that there was a certain antagonism between milk productivity and reproduction of the Ukrainian Black-and-White dairy cow. The coefficients of phenotypic correlation between milk yield, fat and protein yield and the days open ranged from +0.284 to +0.293. Selection indexes were built, which included protein, fat yield, and days open. The developed selection indexes were characterized by a high relationship with the protein yield ($\alpha<0.001$), much lower – with the fat yield ($\alpha<0.05$), while the relationship of the selection indexes with the days open was almost absent. The calculated estimates of correlation and regression coefficients made possible to predict correlated responses of milk production and reproduction traits on selection index. The results showed that the developed selection indexes allow increase the milk production of cows and at the same time to prevent decrease in the level of reproduction.

Keywords: Correlated response, Dairy cows, Economic weight, Milk production, Reproduction.

INTRODUCTION

Evaluation and selection by selection indexes is an important tool in dairy cattle breeding, as it allows combine information on several traits into a single value, which is used to make selection decisions (Mancin *et al.,* 2022; Marašinskienė *et al.,* 2022). The ideal breeding goal for dairy cattle remains the main topic of researches, although consensus on this issue is problematic and is intensively discussed in the scientific literature (Miglior *et al.,* 2017; Cole and VanRaden, 2017; Cole *et al*., 2021). There is no unified breeding goal for dairy cattle that suitable for all populations or all herds within a single population, but there are general principles for constructing selection indexes (Hazel, 1943). These principles allow the development of selection indexes that meet economic (market) requirements, which depend on the characteristics of a particular country (Amaya *et al*., 2022; Matvieiev *et al*., 2023).

One of the main economic factors is pricing. The prices of agricultural products, including milk, can be market, partially market under certain governmental regulations, or fixed (contractual). An example of partial market pricing under government regulation is milk pricing in the United States. This pricing is very complex and is based on federal milk marketing orders (FMMO). Jesse and Cropp (2008) stated that the milk price in the United States depends on the region, end-product (fluid milk, production of cheese, butter, yogurt, or other products), as well as other factors (import restrictions, export subsidies, etc.). At the same time, the milk price in Israel is fixed. Each year, the Ministry of Agriculture of Israel establishes the price of milk -based on the recommendations of the Israel Dairy Board, which plans the milk market and determines quotas for farmers.

When determining the price of milk, the method of taking into account its composition is also important (Mucchetti and Zambrini, 2017). There are two methods of determining the milk price depending on its composition (Jesse and Cropp, 2008): percentage differential pricing and multiple component pricing.

It should be noted that in most developed countries multiple component pricing is used, as it allows take into account the price structure of the end-products more accurately. Milk quality indicators such as somatic cell count and bacterial contamination are also usually taken into account when determining the price of milk.

In recent decades, dairy cattle breeding was focused on milk production. This led to significant success and considerably increased milk yields and milk fat and protein, especially in Holstein cows (Guinan *et al*., 2023; Cole *et al*., 2021). These data indicate that the increase in milk production was achieved both through careful and well-organized breeding, which provided high genetic progress, as well as due to optimal conditions of nutrition, housing, and welfare of dairy cows (Berry, 2018; Ruban *et al*., 2022).

However, this progress led to deterioration in a number of economically important traits, including reproduction. Reproductive traits of cows are characterized by complex biological mechanisms determining them (Lucy, 2019), and they belong to the group of polygenic traits, which are determined by a large number of genes. According to (Ma[a] *et al*., 2019), who analyzed the results of 295 whole-genome association studies, only one QTL was found on chromosome 18, which significantly affects the reproduction of dairy cows. Heritability of reproductive traits is very low (from 0.01 to 0.20), which complicates their improvement through breeding programs (Shao *et al*., 2021), although the coefficients of genetic variability of fertility traits are not lower than those of milk production (Berry *et al*., 2016).

The experience of recent years shows that with the proper organization of recording, the use of modern methods of genetic (genomic) evaluation, and effective breeding programs it may be possible to achieve genetic improvement of reproduction. In the Nordic countries (Denmark, Sweden, and Finland) reproductive traits were included in the breeding programs of dairy breeds in the 1960s, which avoided their deterioration in line with increasing milk production (Muuttoranta *et al*., 2019). Today, two-thirds of Interbull member countries perform a genetic evaluation of dairy cattle for reproductive traits (Interbull, 2022).

Pregnancy rate is used in the United States for the genetic evaluation of dairy bulls and cows (Van Raden *et al*., 2004). In the period from 1960 to 2000 in the Holstein population of the United States, there was a steady decline in breeding values and actual (phenotypic) values of the pregnancy rate of cows. Since 2000, there has been a gradual increase in the actual values of the pregnancy rate of Holstein cows, and since 2010 (after the introduction of genomic evaluation of animals) some genetic progress is observed (Berry *et al*., 2018).

The tool for simultaneous genetic improvement of the economically important traits is the economic selection index (Hazel, 1943). It is very important to determine the economic weights of the traits correctly (Krupova *et al*., 2020). The economic weight of the trait is defined as the change in profit when increasing the trait per unit of its measurement at fixed values of other traits that are part of the breeding goal (Hazel, 1943). Due to the expansion of the range of genetic traits, the relative economic weight of milk productivity is now up to 50% (Cole and Van Raden, 2018. The relative economic weights of reproductive traits vary considerably from country to country. The relative economic weights of reproductive traits of dairy cows, depending on the breed are from 6.5% to 10.5% (Schmidtmann *et al.,* 2021). Sasaki *et al*. (2020) showed that in Japan the relative economic weight of days open depending on economic conditions can range from 10% to almost 50%.

The inclusion of functional traits, especially reproduction, in the economic selection indexes, which are used to evaluate and select dairy cattle, is important in terms of the profitability of milk production. For example, Chegini *et al.* (2019) compared different selection indexes and found that the index that provided the greatest genetic progress in milk yield did not maximize the profits of dairy cows. The authors concluded that the economic selection index for dairy cattle should include also reproductive traits and udder health. Cole *et al*. (2021) reported, the overall relative economic weight of reproduction in the selection indexes for dairy cattle should be about 10%. This study developed an economic selection index for the evaluation and selection of dairy cattle for milk production and reproduction.

MATERIALS AND METHODS

Materials of the research were data on milk production and reproductive traits of cows of the Ukrainian Black-and-White dairy cows in agricultural cooperative "Vostok" (AC "Vostok") in Kharkiv region for the period 2012–2022. The farm keeps 1,500 cows. They are housed in boxes with manure removal by mobile equipment and milking of cows on two "Parallel" milking parlors, 2×16. Cows are fed according to lactation phases (1 phase 1–120 days, 2 phase – 121–211 days, 3 phase 212 days, and more) using total mixed rations (TMR). With an average milk yield of 28–34 liters, cows are fed an average of 28-35 kg of silage, 12–15 kg of alfalfa haylage, 3 –6 kg of hay, and 8–12 kg of grain mixture with minerals. One kilogram of dry matter of the total mixed ration contains 11.8–12.3 MJ of metabolic energy, 12–14% of protein, 19–20% of acid-detergent fiber, and 35–38 % of neutral-detergent fiber.

The value of the heifer replacement on the farm is $1083. Milk from farms in Ukraine is sold according to the state standard DSTU 3662: 2018 (basic content of fat is 3.4% and of protein 3.0%). Thus, the purchase price (PP) per 1 kg of premium milk is calculated by the following:

$$PP = \left(\frac{PC}{3.0} \times 0{,}6 + \frac{FC}{3.4} \times 0{,}4\right) \times BP$$

where PP : purchase price (PP) of 1 kg of premium milk; PC : protein content, %; FC : fat content, %; BP: basic price of 1 kg of milk; 0.6 and 0.4 – correction factors for protein and fat contents, accordingly.

The basic price of 1 kg of milk is $0.475 according to the course of the National bank of Ukraine (National bank of Ukraine, 2022). The analysis of the existing tendencies in the farms of Ukraine made it possible to determine the values of replacement heifers in the domestic market. When modeling the results of the use of the selection index, we used the values of a replacement heifer $800, $1083, $1200, and $1400. The number of replacement heifers born per year is determined by the formula:

$$NH = 0{,}5 \times \frac{365}{GL + DO}$$

where NH: number of replacement heifers born per year, heads; 365: number of days in year; GL = 285 – gestation length, days; DO: days open, days.

The economic selection index (I) was:

$$I = (y_{PY} - M_{PY}) \times b_{PY} + (y_{FY} - M_{FY}) \times b_{FY} + (y_{DO} - M_{DO}) \times b_{DO}$$

where y_{PY}, y_{FY}, y_{DO}: protein yield, fat yield and days open of a cow; M_{PY}, M_{FY}, M_{DO}: average protein yield, fat yield and days open in herd; b_{PY}, b_{FY}, b_{DO}: index weights.

Index weights of traits were calculated by solving the system of equations (Hazel, 1943):

$$Pb = Gv$$

where b: vector of index weights of traits; P: phenotypic (co)variance matrix (3 × 3); G: additive genetic (co) variance matrix (3 × 3); v: vector of economic weights.

Coefficients of correlation and regression between traits and index values were calculated according to (Gibson and Dekkers, 2006). Coefficient of correlation between trait j and index values (r_{jI}) was calculated by the formula:

$$rjI = \frac{b`Gj}{Gjj \times \sqrt{b`Pb}}$$

where Gjj: j-th diagonal element of **G**.

Coefficient of regression of trait j on index values (RjI) was calculated by the formula:

$$RjI = \frac{b`Gj}{\sqrt{b`Pb}}$$

where Gj: j-th column of G.

Phenotypic (co)variance matrix P was calculated using data of AC "Vostok". Additive genetic (co)variance matrix G was calculated using estimates of genetic parameters in the Ukrainian Black-and-White dairy breed (Danshin *et al*., 2017).

Relative index weight of trait i (rw_i) was calculated by the formula (Gibson and Dekkers, 2006):

$$rw_i = \frac{|b_i| \times \sigma_{ai}}{\sum_j |b_j| \times \sigma_{aj}} \times 100\%,$$

Where b_i: absolute index weight of trait I; σ_{ai}: standard additive genetic deviation of trait I; Σ_j: summation on all traits in index.

Economic weight of 1 kg of protein yield was calculated by the formula:

$$v_{PY} = \frac{1000\ g}{amount\ of\ protein\ in\ 1\ kg\ of\ milk, g} \times PP,$$

Economic weight of 1 kg of fat yield (v_{FY}) was calculated by the formula:

$$v_{FY} = \frac{1000\ g}{amount\ of\ fat\ in\ 1\ kg\ of\ milk, g} \times PP,$$

where PP: purchase price of 1 kg of milk, $.

Economic weight of 1 day of days open was calculated by the formula:

$$v_{DO} = (NH_1 - NH_0) \times value\ of\ the\ replacement\ heifer, \$$$

where NH_0 the number of replacement heifers born per year with the average value of the days open, heads; NH_1 the number of replacement heifers born per year with the average value of the days open plus one day, heads.

Relative economic weight of trait i was calculated by the formula (Gibson and Dekkers, 2006):

$$ev_i = \frac{|v_i| \times \sigma_{ai}}{\sum_j |v_j| \times \sigma_{aj}} \times 100$$

where v_i: absolute economic weight of trait i; σ_{ai}: standard additive genetic deviation of trait i; Σ_j: summation on all traits in index.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 shows descriptive statistics on milk production (milk yield for 305 days of lactation, contents of fat and protein in milk, fat yield and protein yield), and reproduction (days open) of cows in AC "Vostok".

Animals of the studied herd are characterized by high milk production (milk yield for 305 days of lactation is in the range from 7800 kg to almost 9000 kg, with a fat content of 4.01–

Table 1. Characteristics (M±SE) of Milk Production and Reproduction Traits of Cows in AC «Vostok» (n=1677)

Milk Yield, kg	Fat Content, %	Fat Yield, kg	Protein Content, %	Protein Yield, kg	Days Open, days
		1st Lactation (n=694)			
7870.8±51.73	4.07±0.002	319.7±2.05	3.11±0.001	244.9±1.61	173±3.5
		2nd Lactation (n=459)			
8697.3±71.51	4.03±0.003	350.1±2.75	3.10±0.001	270.0±2.20	156±3.8
		3rd Lactation (n=287)			
8787.0±109.58	4.02±0.005	352.7±4.20	3.11±0.002	272.7±3.36	152±4.6
		4th Lactation (n=125)			
8854.6±146.46	4.02±0.007	355.5±5.62	3.11±0.002	275.0±4.52	158±7.1
		5th Lactation (n=59)			
8383.8±239.38	4.03±0.010	337.2±9.21	3.11±0.003	260.3±7.34	154±11.7
		6th Lactation (n=36)			
8763.1±304.84	4.02±0.014	351.7±11.52	3.11±0.004	271.9±9.30	165±14.5
		7th Lactation (n=10)			
7644.5±582.30	4.04±0.020	308.4±22.99	3.11±0.005	237.4±18.01	147±20.9
		8th Lactation (n=7)			
6594.2±640.25	4.01±0.037	266.2±24.36	3.11±0.009	207.0±19.95	119±17.7
		Herd Average (n=1677)			
8359.6±39.43	4.04±0.002	337.4±1.52	3.11±0.001	259.8±1.21	162±2.1

Table 2. Phenotypic Correlations Between Milk Production and Reproduction Traits of Cows in AC «Vostok» (n=1319)

Trait	Milk Yield	Fat Content	Fat Yield	Protein Content	Protein Yield	Days Open
Milk Yield	1	-0.476***	0.996***	-0.178***	0.999***	0.284***
Fat Content	-0.476***	1	-0.394***	0.290***	-0.465***	-0.04
Fat Yield	0.996***	-0.394***	1	-0.154***	0.996***	0.293***
Protein Content	-0.178***	0.29***	-0.154***	1	-0.135***	-0.02
Protein Yield	0.999***	0.465***	0.996***	-0.135***	1	0.285***
Days Open	0.284***	-0.04	0.293***	-0.02	0.285***	1

*** – α<0.001

4.07% and protein content of 3.10–3.11%). At the same time days open of cows is quite large (152–173 days), which causes a low level of reproduction (number of calves per 100 cows is 81), and an insufficient level of replacement of the herd.

The estimates of the coefficients of the phenotypic correlation between production and reproductive traits of cows (Table 2) indicate the presence of a traditionally negative relationship between milk yield and fat and protein contents in milk (-0.476 and -0.178, respectively), as well as a positive relationship between milk production (milk yield, fat and protein yields) and days open (from +0.284 to +0.293).

Such a relationship may result in a further reduction in the level of reproduction in the herd with increasing milk production of cows, which must be taken into account in breeding. Negative relationship between milk production and reproduction of dairy cows is well known (Lucy, 2019). In Israel annual means for conception status (the inverse of the number of inseminations to conception in percent) decreased from 55.6 for cows born in 1983 to 46.5 for cows born in 2018 (Weller *et al.*, 2022). Genetic nature of antagonism between fertility and milk production was confirmed in the study of (Ma[b] *et al.,* 2019). Authors compared two lines of Holstein cattle that were in the same conditions of environment and management since 1964. One line was selected for high milk performance, another one was control. It was shown that selection for milk production caused changes in frequencies of genes influencing reproduction of cows.

Based on the average milk composition of the herd, the price of 1 kg of milk in AC «Vostok» is $0.526. Analysis of the value (Table 3) and costs (Table 4) of replacement heifer rearing in specialized dairy farms of Ukraine allowed justifying possible changes in the breeding programs and, accordingly, the economic weights of traits in the economic selection index.

It should be noted that heifers are important not only for replacement of a herd, but also are a significant source of income (sales in both domestic and foreign markets). The average price of a heifer with high breeding values and certified pedigree ranges from $1900 to $2500 on the world market. In our calculations, such income is associated with days open – the less days open (optimum – 84–86 days) the more heifers can be born per 100 cows in a herd.

Economic Weights of Traits

Absolute and relative economic weights of traits are given in Table 5 and 6. They were calculated on the basis of the purchase price of 1 kg of milk, protein and fat contents in milk, and the value of a replacement heifer. Relative economic weights also take into account standard additive genetic deviations. Among of milk production traits, protein yield has the largest economic weight, less – fat yield, because the protein content in the milk of cows of the studied farm is much lower than the fat content (Table 1).

The economic weight of protein yield obtained in this work is greater than the fat yield, which is similar to the results of researchers (Komlósi *et al.,* 2010; Fuerst-Waltl *et al.,* 2016), who received economic weights for the market conditions of Hungary and Austria but differs from the results obtained for Iran's market conditions, where the smallest economic weight is

Table 3. Values of Replacement Heifers in Dairy Farms of Ukraine

Age, mo.	Average Value, $	Range of Values, $
Birth to 6 mo.	216.55	210–220
7–12 mo.	209.90	180–266
13–18 mo.	202.04	180–240
Older than 18 mo.	198.70	170–221
Pregnant Heifers (19–23 mo.)	255.70	230–277
Birth to 23 mo.	1082.89	970–1224

Table 4. Costs of Replacement Heifer Rearing

Costs	Portion, %
Variable Costs	93.0
Labor	22.1
Feeds	65.6
Electric Power	3.8
Fuel and Materials	1.5
Fixed Costs	7.0
Total	100

used in the index for the protein yield (-1.02 US dollars), and fat yield is most valued (1.36) (Sadeghi-Sefidmazgi *et al.,* 2012). Such differences could be explained by the different specificities of the dairy markets in these countries.

Days open has the lowest economic weight, which decreases with the increasing cost of a replacement heifer, due to the inverse relationship between days open and the level of reproduction in dairy cows. These data indicate minor changes in the relative economic weights of milk production traits with increasing cost of a replacement heifer, while the relative economic weight of days open increases from 2.8% to 4.8% with increasing cost of a replacement heifer from $800 to $1400.

For comparison in the US at prices of $6.9 for 1 kg of milk fat, $7.5 per 1 kg of milk protein (USDA[a], 2022) and $1363.0 for a replacement heifer (USDA[b], 2022), the economic weights of traits in the lifetime net merit index ($NM) are $9.2 for 1 kg of milk fat, $10.3 for 1 kg of milk protein and -$2.8 for 1 day of days open (Van Raden *et al*., 2021). The relative economic weights of these traits are 21.8%, 17.0% and 5.0%, respectively (Van Raden *et al*., 2021).

Selection Indexes

As a result of calculations, selection indexes were constructed for the selection of cows on milk production and reproduction depending on the values of a replacement heifer. The weights of the traits in the selection indices are shown in Table 7. Protein yield has the highest and positive index weight (from +27.08 to +27.60), which increases with increasing cost of a replacement heifer, while the index weights of fat yield and days open are negative.

The highest relative weights in the developed selection indexes were for protein yield due to the highest economic weight of this trait. The researchers (Komlósi *et al.,* 2010; Fuerst-Waltl *et al.,* 2016; Schmidtmann *et al.,* 2021) mentioned that the protein yield had a higher relative weight than the fat yield that conformed to the result obtained in the present investigation. The relative weights of days open were the lowest due to the low heritability of this trait and its negative relationship with milk production. The average values of the developed selection indexes of cows are presented in Table 8.

There is a tendency to gradually increase the values of selection indexes from 1st to 4th lactations and their further decrease due to the age dynamics of the level of milk production of cows. Table 9 shows the correlation coefficients between the milk production traits and days open and the values of selection indexes and the

Table 5. Absolute Economic Weights of Traits

Trait	Economic Weight, $
Protein Yield	16.91
Fat Yield	13.02
Days Open Depending on Value of a Replacement Heifer:	
800 $	-0.72
1083 $	-0.98
1200 $	-1.08
1400 $	-1.26

Table 6. Relative Economic Weights of Traits

Trait	Value of a Replacement Heifer, $			
	800	1083	1200	1400
	Relative Economic Weight, %			
Protein Yield	50.0	49.5	49.3	49.0
Fat Yield	47.2	46.7	46.5	46.2
Days Open	2.8	3.8	4.2	4.8

Table 8. Average Selection Index Values of Cows in AC «Vostok».

Lactation	Protein Yield, kg	Fat Yield, kg	Days Open, days	Value of a Replacement Heifer, $			
				800	1083	1200	1400
				Average Selection Index Value, $			
1	244.9	319.7	173	-113.8	-114.2	-114.5	-115.1
2	270.0	350.1	156	+67.8	+67.8	+68.0	+68.2
3	272.7	352.7	152	+99.1	+99.4	+99.7	+100.2
4	275.0	355.5	158	+113.0	+113.1	+113.4	+113.5
5	260.3	337.2	154	+19.5	+19.9	+20.0	+20.6
6	271.9	351.7	165	+89.7	+89.7	+89.8	+89.9
7	237.4	308.4	147	-121.1	-117.7	-120.2	-118.8
8	207.0	266.2	119	-235.9	-232.8	-232.7	-228.4

Table 9. Coefficients of Correlation and Regression Between Milk Production and Reproduction Traits and Selection Index Values

Trait	Value of a Replacement Heifer, $			
	800	1083	1200	1400
	Coefficient of Correlation			
Protein Yield	+0.7570***	+0.7604***	+0.7617***	+0.7640***
Fat Yield	+0.0879*	+0.0840*	+0.0825*	+0.0798*
Days Open	+0.0124	+0.0090	+0.0077	+0.0054
	Coefficient of Regression			
Protein Yield, kg/$	+0.0533	+0.0536	+0.0537	+0.0539
Fat Yield, kg/$	+0.0076	+0.0073	+0.0071	+0.0069
Days Open, days/$	+0.0012	+0.0008	+0.0007	+0.0005

* – $\alpha<0.05$, *** – $\alpha<0.001$

corresponding regression coefficients.

The highest relationship is between the values of selection indexes and protein yield (from +0.7570 to +0.7640, $\alpha<0.001$), much lower between the value of the selection index and fat yield ($\alpha< 0.05$), while the relationship between selection indexes and days open is almost absent (the corresponding correlation coefficients are not significant).The obtained values of regression coefficients allowed predict changes in selection traits depending on changes in the values of selection indexes (Table 10).

It can be seen from the results that increasing the values of selection indexes leads to an increase in protein and fat yields and a certain increase of days open. Also there is a tendency of increasing protein yield, decreasing fat yield and reducing days open with higher values of a replacement heifer. It should be noted that for the value of selection indexes of $300 the correlated response of fat yield with increasing value of a replacement heifer from $800 to $1,400 decreases from +2.28 kg to +2.07 kg, i.e. by 9.2%, while the similar response of days open decreases from +0.36 days to +0.15 days, i.e. by 58.3%. Thus, the selection of cows using the developed economic selection indexes will increase their milk production (mostly protein yield) and at the same time maintain the level of reproduction. This allows correct the direction of selection and to some extent to overcome the negative trend of declining fertility of cows due to unfavorable phenotypic and genetic correlations between protein and fat yields and days open and, consequently, support dairy herd replacement.

CONCLUSION

Table 10. Correlated Responses of Milk Production and Reproduction Traits on Selection Index Values (SIV).

SIV, $	Response											
	Protein Yield, kg				Fat Yield, kg				Days Open, days			
	Value of a Replacement Heifer, $											
	800	1083	1200	1400	800	1083	1200	1400	800	1083	1200	1400
-150	-8.0	-8.04	-8.06	-8.09	-1.14	-1.10	-1.07	-1.04	-0.18	-0.12	-0.11	-0.08
-100	-5.33	-5.36	-5.37	-5.39	-0.76	-0.73	-0.71	-0.69	-0.12	-0.08	-0.07	-0.05
+100	+5.33	+5.36	+5.37	+5.39	+0.76	+0.73	+0.71	+0.69	+0.12	+0.08	+0.07	+0.05
+150	+8.0	+8.04	+8.06	+8.09	+1.14	+1.10	+1.07	+1.04	+0.18	+0.12	+0.11	+0.08
+200	+10.66	+10.72	+10.74	+10.78	+1.52	+1.46	+1.42	+1.38	+0.24	+0.16	+0.14	+0.10
+250	+13.33	+13.40	+13.43	+13.48	+1.90	+1.83	+1.78	+1.73	+0.30	+0.20	+0.18	+0.13
+300	+15.99	+16.08	+16.11	+16.17	+2.28	+2.19	+2.13	+2.07	+0.36	+0.24	+0.21	+0.15

The economic and index weights of traits depend on cost of replacement heifer raising. The estimates of correlation and regression coefficients allowed statistical modeling, the results of which showed that the developed selection indexes make it possible to increase the milk production of cows while maintaining the level of reproduction. We recommend to use developed economic selection indexes for evaluation, selection and mating of bulls and cows of Ukrainian dairy breeds.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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