Relative Variability of Breeding Traits of the Dairy Cattle and the Breeding Process

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Соотносительная изменчивость селекционных признаков молочного скота и породообразовательный процесс

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Резюме

Соотносительная изменчивость многофакторных признаков продуктивности и воспроизводительной способности молочного скота, что формировалась при разных методах подбора в период породообразовательного процесса. Селекция на повышения жирномолочности в первые этапы генезиса украинской красной молочной породы обусловила уменьшение корреляции между надоем и содержанием жира в молоке от отрицательной ($r = -0,20$; $p < 0,001$) до позитивной ($r = +0,07$), а в пятом этапе выведение породы установлено отрицательную связь ($r = -0,31$; $p < 0,001$). Это стало следствием изменения направления селекции, а именно снижение отбора по признаку «содержание жира в молоке» и проведение интенсивного отбора по величине удоя и использованием для повышения молочности животных генофонда голштинской породы. Закономерной является высокая отрицательная корреляция между надоем и коэфициентом воспроизводительной способности в исследуемых животных V этапа ($r = -0,78$; $p < 0,001$). При разных методах подбора сохраняется общая тенденция позитивной корреляции между надоем и количеством молочного жира, слабая отрицательная корреляция между надоем и содержанием жира в молоке. Доказано закономерное изменение корреляционных связей селекционных признаков, что происходят под влиянием действия породообразовательного процесса. В отдельные периоды генезиса породы сила отрицательной корреляции между удоем, количеством молочного жира и коэффициентом воспроизводительной способности повышается. С увеличением гетерогенности подбора растет сила связи между признаками продуктивности и воспроизводительной способности. Установлено, что породообразовательный процесс и методы подбора вызывают значительную перестройку корреляционных связей между признаками продуктивности и воспроизводительной способности молочного скота, а их изменение возможно прогнозировать за установлениями закономерностями соотносительной изменчивости и благодаря этому целенаправлено руководить селекционным процессом.

Ключевые слова: крупный рогатый скот, породообразовательный процесс, подбор, признак, корреляция.

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Abstract

The relative variability of multifactorial traits of the productivity and reproductive capacity of dairy cattle through different selection methods during the breeding process. Breeding for increasing milk fat in the first stages of the genesis of the Ukrainian Red Dairy Breed caused a change in the correlation between milk yield and fat content in milk from negative ($r = -0.20$; $p < 0.001$) to positive ($r = +0.07$), and in the fifth stage of breeding, a negative link was established ($r = -0.31$; $p < 0.001$). This was due to a change in the direction of breeding, namely the reduction of pressure on the basis of "fat content in milk" and the intensive selection to increase the milk yield of animals of the Holstein gene pool breed. A high negative correlation between milking and the coefficient of reproductive ability in the study animals of stage V is natural ($r = -0.78$; $p < 0.001$). According to different selection methods, there is a general tendency for a positive correlation between milk yield and milk fat content, and a weak negative correlation exists between milk yield and fat content. A regular change in the correlation relationships of breeding traits occurring under the influence of the breed formation process has been proved. In certain periods of the genesis of the breed, the power of negative correlation between milk yield, milk fat content, and reproductive capacity increases. With increasing heterogeneity of selection, the strength of the link between performance traits and reproductive capacity increases. It has been established that the breeding formation process and selection methods cause significant restructuring of correlation relationships between the traits of productivity and the reproductive capacity of dairy cattle, and their change can be predicted according to the established patterns of relative variability and thus purposefully manage the breeding process.

Keywords: cattle, breeding formation process, selection, trait, correlation.

Introduction

Evolutionary changes in the development of economically useful traits in dairy cattle breeds occur under the influence of the directional action of the breeding process. This is first and foremost choosing good mother and father breeds and using heterogeneous selection productivity to obtain animals of the desired genotype. This process has been ongoing for many generations and is based on biological and statistical patterns that reflect the characteristics (qualities) of breed groups, types, lines, families, and even individual outstanding animals.

The intensification of the process of breeding new breeds using the best global gene pool, the method of reproductive crossing (breeding), effective inbreeding options, and factory lines have contributed to the acceleration in the first three generations of the genesis of specialized dairy and meat breeds of cattle (Zybets et al., 1997).

The traits that are used for breeding dairy cattle are interrelated. As in nature, the process of trait selection may have positive and negative correlations. Certain instances of such dependence may occur under certain environmental factors. However, most of them are nothing but a consequence of the combined influence of genetic and paratype factors (Ernst and Tsalitis, 1982).

A number of researchers have been studying the correlation between productive, technological, reproductive, anatomical, and physiological qualities of animals (Dynko, 2016; Fedorovich and Siratsky 2002; Demchuk, 2002; Kozyr, et al., 1999).

Determining the correlation between milk yield and fat content in milk has been the subject of a large number of studies (Demchuk, 2002; Kozyr et al., 1999; Kovtyukh, 2000).

We found there is a negative correlation between milk yield and fat content in milk (Kovtyukh, 2000) at low and medium levels (r = -0.599

± 0.030), between milk yield and milk content of major components (fat, protein, casein, non-fat skimmed milk residuals) a significant negative correlation relationships was determined when milk yield increased. Only lactose content correlates positively with milk yield (Chernyavska and Sklyarenko, 2017). Significant positive relationships were established between milk yield and individual blood biochemical parameters at all lactation periods and on average during all lactation (Fedorovich and Siratsky, 2002).

Previously, correlation indexes between mothers and their daughters of their milk productiveness were identified. Negative values of correlation coefficients are noted by the number of lactation days, the amount of milk yield for all lactation, and live bovine weight (Dynko, 2016). In cows of different lines the correlation coefficient between milk yield and fat content in milk is both negative (r = -0.013 and -0.205) and positive is (r = 0.083 and 0.195), between milk yield and live bovine weight is positive (r = 0.069...0,324), and between milk yield and the amount of milk fat is high positive (r = 0.832...0.977) (Lyubynskyy et al., 1999).

There is also ample accumulation of research findings to determine the correlation between lineal and economically beneficial features of dairy cattle (Kozyr et al., 1999; Khmelnytchiy and Vechorka, 2017; Alenda, 2002; Battagin et al., 2013). A positive correlation was found between the estimation of the exterior type of body structure, the quality of first-born udder and milk yield (Bashchenko and Khmelnytchiy, 2002), between individual measurements of external features and milk yield (Ladyka et al., 2010), between the measurements that form indices of body structure and milk yield for cows by lactation (Khmelnytchiy and Vechorka, 2015).

Of practical importance is the relationship between live bovine weight and the number of milk producing days, live bovine weight and milk yield during lactation, the number of milk producing days and milk yield during lactation, milk yield during lactation and fat content in milk, and so on. Although the correlation of these features is widely covered in the scientific literature (Dynko, 2016; Demchuk, 2002; Kuziv, et al. 2017; Poslavska et al. 2016), there is still no consensus. A positive correlation between milk yield for five lactations and service and intermittent periods, which prolongation causes productivity improvement, was revealed (Titarenko et al., 2012). There is a controversial negative correlation between milk yield and dry season duration (Savchuk et al., 1999; Kramar and Cheremysova, 2011), but there are reports of a positive correlation (Savchuk et al., 1999). Finding connecting relations between reproductive traits and indices of reproductive trait abilities requires further investigation as they can be used in breeding work with dairy cattle.

The existence of a high positive relationship between the duration of economic use of cows and the performance of milk production has also been previously demonstrated (Bashchenko et al., 2010; Polupan, 2014). Research of the relative variability of the type of stress resistance and indicators of economic use and lifelong productivity of cows found that the correlation ranges from 0.301 to 0.483 (Chernenko, 2014).

Knowledge of the patterns that determine the nature and magnitude of the relationship between traits make it possible to manage these relationships through breeding methods, achieving a significant improvement to correlation indicators (Kovtyukh, 2000).

Materials and methods

Scientific research was carried out in leading farms for breeding cattle of Ukrainian Red Dairy Breed – at private company "Zoria" in Kherson Oblast and Company of limited responsibilities "Colos 2011" in Mykolayiv Oblast. Breeding of the Ukrainian Red Dairy Breed was carried out over a long period of time, this was manifested in the peculiarities of the breeding process. The period during which the creation and consolidation of the Ukrainian Red Dairy Breed (URDB) took place is conditionally divided into 5 stages: Stage I – 1965–1975, Stage II – 1976–1985, Stage III – 1986–1995, Stage IV – 1996–2005, and Stage V – 2006–2015. For retrospective analysis, 1115 animals were selected, including cows by

stages: I – n = 248, II – n = 255, III – n = 156, IV – n = 232, and V – n = 224.

Material for the study was the data of dairy productivity of cows of the Ukrainian Red Dairy Breed. The reproductive capacity of the studied animals was evaluated through the duration of the length of service and the periods between calvings and by the coefficient of reproductive factor.

The heterogeneity of selection was determined by the level of milk yield and fat milk yield of the female ancestors of the studied animals. According to the difference, expressed by the mean square deviation (Pelechatyy et al., 2012) with the corresponding interval between the indicators for the highest lactation of the cow's mother (CM) and the cow's father's mother (FM), the selection was divided into: homogeneous – 0.4 σ or less; moderately heterogeneous – 0.5–1.4 σ; heterogeneous – 1.5–2.4 σ and high-heterogeneous – 2.5 σ or more.

Methods of retrospective analysis, zootechnical methods for evaluating the performance and reproductive capacity of cows, genetic-mathematical, variational statistics, correlation and variance analysis were used for the study (Kramarenko et al., 2019).

Results and discussion

In the process of breeding formation, the directional effect of breeding factors causes a change in the level of manifestation of economically useful traits of dairy cattle, which in turn causes a rebuilding of the correlation of relationships between them. The Ukrainian Red Dairy Breed was first (stages I–III) bred to increase milk fat (Red Steppe cows crossed with Angler breed), and then (stage IV–V) a change in direction took place. Breeding was then carried out for increasing milk yield using the Holstein breed. This, in turn, led to a restructuring of correlation between economically useful traits. Research of the relative variability of the five stages of Ukrainian Red Dairy Cattle Breeding showed that breeding traits were characterized by different values of correlation coefficients in the direction and strength of communication (Table 1).

Table 1. Dynamics of the relative variability of breeding traits during the period of breeding and consolidation of the Ukrainian Red Dairy Breed, $r \pm S_r$

Correlating Traits	Stages of selection and consolidation of breed				
	I, n = 248	II, n = 255	III, n = 156	IV, n = 232	V, n = 224
Milk yield for the first lactation-milk fat content	-0.03 ± 0.063	-0.20 ± 0.060[3]	0.07 ± 0.080	0.05 ± 0.066	-0.31 ± 0.605[3]
Milk yield for the first lactation-QMF	0.84 ± 0.019[3]	0.85 ± 0.017[3]	0.84 ± 0.024[3]	0.83 ± 0.020[3]	0.72 ± 0.032[3]
Milk fat content-QMF	0.36 ± 0.055[3]	0.15 ± 0.049[3]	0.24 ± 0.076[2]	0.25 ± 0.062[3]	-0.24 ± 0.063[3]
Days of lactation-SP	0.89 ± 0.013[3]	0.81 ± 0.021[3]	0.81 ± 0.028[3]	0.98 ± 0.003[3]	0.96 ± 0.005[3]
Days of lactation-PBC	0.90 ± 0.012[3]	0.75 ± 0.027[3]	0.83 ± 0.025[3]	0.98 ± 0.003[3]	0.98 ± 0.003[3]
Days of lactation-CRC	-0.88 ± 0.014[3]	-0.79 ± 0.023	-0.80 ± 0.029[3]	-0.94 ± 0.008	-0.92 ± 0.010[3]
Service period-PBC	0.91 ± 0.011[3]	0.81 ± 0.021[3]	0.92 ± 0.012[3]	0.99 ± 0.001[3]	0.97 ± 0.004[3]
Service period-CRC	-0.87 ± 0.015[3]	-0.80 ± 0.022[3]	-0.91 ± 0.014[3]	-0.94 ± 0.008[3]	-0.91 ± 0.011[3]
PBC-CRC	-0.97 ± 0.004[3]	-0.96 ± 0.005[3]	-0.98 ± 0.003[3]	-0.96 ± 0.005[3]	-0.95 ± 0.006[3]

Note: *QMF – quantity of milk fat, SP – service period, PBC – period between calvings, CRC – coefficient of reproductive capacity;* [1]*– $p < 0.05$;* [2]*– $p < 0.01$;* [3]*– $p < 0.001$*

The correlation between productive traits is the result of the directional action of breeding methods used to improve existing and produce new breeds. In this regard, the relative variability between milk yield and fat content of milk is important. Despite the sufficiently abundant research of the correlation between milk yield and fat content in milk and the general tendency for a negative correlation between them, it is proved that the nature and magnitude of the connection changed as a result of the breeding formation process. Gradually, the negative correlation ($r = -0.03$ and $r = -0.20$ at $p < 0.001$) changed and became positive ($r = 0.07$ and $r = 0.05$), so, the restructuring shifted to the desired direction. It was a result of redirected selection for increased milk fat and the action of stabilizing selection for milk production quantities.

However, in the fifth stage of Ukrainian Red Dairy Breeding, we noted a significant change. It was in the nature and strength of the relationship between milk yield and fat content in milk ($r = -0.31$ at $p < 0.001$). This was due to a change in the direction of breeding, namely the reduction of pressure on the basis of "fat content in milk" and the intensive selection of the largest milk yield and use of the gene pool of the Holstein breed to increase the milk yield of the animals of the created breed.

It has been reported (Demchuk, 2002) that in black-and-white cows with different proportion of Holstein breed heredity, the correlation coefficient between milk yield and fat content in the studied herds was $r = -0.220 \pm 0.04$ and $r = -0.599 \pm 0.03$ ($p < 0.05$).

Local animals (red steppe×red-and-white Holstein) of the experimental group were characterized by the absence of the well-known negative correlation between milk yield and fat content in milk ($r = 0{,}034$), but in the herd the correlation coefficient was -0,669 and this significantly complicates the breeding work for milk yield and fat content, so there is a need to select animals for a complex indicator such as milk fat content (Kozyr et al., 1999). In herds of Ukrainian black-and-white dairy breed, a significant correlative dependence ($r = 0.133$ to -0.402) was established between milk yield and fat content in milk, indicating the need for simultaneous breeding of dairy cattle on both traits or to consider milk fat as a threshold trait (Kovtyukh, S. I. (2000).

There is an antagonism between dairy productivity and reproductive capacity of cows (Polupan, 2014; Prokofiev et al., 2002), which is caused by the contradiction between lactation and sex dominance (Pryce et al. 1997), which is characterized by negative correlation coefficients between milking and reproductive capacity and the amount of fat milk and coefficient of reproductive capacity (Table 2). In some periods of the genesis of the breed, the negative correlation force between these traits changes. In the second stage, the correlation coefficient between milk yield and CRC was $r = -0.39$ ($p < 0.001$), between the amount of milk fat and CRC was $r = -0.16$ ($p < 0.01$), and in stage IV the latter was $r = -0.10$ ($p < 0.01$). The high negative correlation between milk yield and the reproductive factor was detected in the animals of stage V ($r = -0.78$; $p < 0.001$).

Other scientists (Titarenko et al., 2012) also found a negative correlation between the coefficient of reproductive capacity and milk yield, and they concluded that with increasing milk yield, the reproductive capacity of cows tends to decrease.

However, a positive correlation was established between productivity and reproductive traits such as lactation days, service-periods and period between calvings periods. The presence of a high positive correlation between milk yield and service- and inter-service periods ($r = 0.80$; $p < 0.001$ and $r = 0.81$; $p < 0.001$, respectively) characterizes the natural increase in milk yield, but this in turn may cause impaired reproductive capacity in animals. The coefficients of correlation between milk yield and CVC indicate this.

According to scientists (Titarenko et al., 2012), increasing productivity by prolonging lactation duration and the period between calvings is not a sufficiently effective solution to increase production output.

The relative variability, the nature, and the level, in the process of the genesis of the Ukrainian Red Dairy Breed change under the influence of various factors, foremost being breed-

ing methods, of which one is selection. Therefore, we investigated the change of correlative relationships between breeding traits relative to the selection methods. We found that the signs of productivity and reproductive capacity of the studied cows with different heterogeneity of selection (distribution=selecting by the milk yield level of the cow's mother (CM) and the cow's father's mother (FM) and were characterized by a strong positive and negative correlation dependence (Table 3). The general tendency of a positive correlation between milk yield and milk

Table 2. Correlation between productive and reproductive characteristics for the period of breeding and consolidation of breed, $r \pm S_r$

Correlating Traits	Stages of selection and consolidation of breed				
	I, n = 248	II, n = 255	III, n = 156	IV, n = 232	V, n = 224
Days of lactation-milk yield for the first lactation	0.70 ± 0.032[3]	0.58 ± 0.042[3]	0.59 ± 0.052[3]	0.66 ± 0.037[3]	0.84 ± 0.020[3]
Days of lactation-QMF	0.45 ± 0.051[3]	0.29 ± 0.057[3]	0.20 ± 0.077	0.21 ± 0.063[3]	0.29 ± 0.061[3]
SP lactation of milk yield	0.58 ± 0.042[3]	0.36 ± 0.055[3]	0.48 ± 0.062	0.60 ± 0.042[3]	0.80 ± 0.024[3]
SP-quantity of milk fat	0.31 ± 0.057[3]	0.10 ± 0.062	0.19 ± 0.077[1]	0.15 ± 0.064[2]	0.28 ± 0.062[3]
Milk yield for the first lactation-PBC	0.59 ± 0.041[3]	0.33 ± 0.056[3]	0.50 ± 0.060[3]	0.61 ± 0.041[3]	0.81 ± 0.023[3]
Milk yield for the first lactation-CRC	-0.58 ± 0.042[3]	-0.39 ± 0.053[3]	-0.49 ± 0.061[3]	-0.58 ± 0.044[3]	-0.78 ± 0.026[3]
QMF-PBC	0.33 ± 0.057[3]	0.10 ± 0.062	0.18 ± 0.078[1]	0.16 ± 0.064[2]	0.26 ± 0.062[3]
QMF-CRC	-0.36 ± 0.055[3]	-0.16 ± 0.061[3]	-0.21 ± 0.077[2]	-0.10 ± 0.065[2]	-0.30 ± 0.061[3]

Note: *[1] – $p < 0.05$; [2] – $p < 0.01$; [3] – $p < 0.001$*

Table 3. Correlation between plant breeding grounds for different methods of recruitment (distribution by level of yield), $r \pm S_r$

Correlating Traits	Selection Methods			
	Homogeneous, n = 119	Moderately heterogeneous, n = 165	Heterogeneous, n = 174	Highly Heterogeneous, n = 657
Milk yield for the first lactation-milk fat content	-0.24 ± 0.087[2]	-0.16 ± 0.076[1]	-0.28 ± 0.070[3]	-0.17 ± 0.038[3]
Milk yield for the first lactation-quantity of milk fat	0.90 ± 0.017[3]	0.90 ± 0.015[3]	0.94 ± 0.009[3]	0.89 ± 0.008[3]
Milk fat content- quantity of milk fat	-0.01 ± 0.092	0.05 ± 0.076	-0.17 ± 0.074[1]	-0.07 ± 0.039
Lactation days-SP	0.94 ± 0.011[3]	0.94 ± 0.009[3]	0.93 ± 0.010[3]	0.93 ± 0.005[3]
Lactation days-PBC	0.96 ± 0.007[3]	0.90 ± 0.015[3]	0.88 ± 0.017[3]	0.94 ± 0.004[3]
Lactation days-CRC	-0.91 ± 0.016[3]	-0.86 ± 0.020[3]	-0.88 ± 0.017[3]	-0.88 ± 0.009[3]
Service period-PBC	0.96 ± 0.007[3]	0.89 ± 0.016[3]	0.91 ± 0.013[3]	0.96 ± 0.003[3]
Service period-CRC	-0.89 ± 0.019[3]	-0.82 ± 0.025[3]	-0.89 ± 0.016[3]	-0.90 ± 0.007[3]
PBC-CRC	-0.96 ± 0.007[3]	-0.95 ± 0.008[3]	-0.97 ± 0.004[3]	-0.95 ± 0.004[3]

Note: *[1] – $p < 0.05$; [2] – $p < 0.01$; [3] – $p < 0.001$*

fat content remains (r = 0.89…0.94; p < 0.001); between lactation duration and service period (r = 0.93…0.94; p < 0.001) and intermittent period (r = 0.88…0.96; p < 0.001); between service and period between calvings (r = 0.89…0.96; p < 0.001).

Under different selection methods, there is a slightly negative correlation between milk yield and fat content in milk (r = -0.16... -0.28; p < 0.001); between the fat content of milk and the amount of milk fat (r = -0.01... -0.17; p < 0.05), except for a moderately homogeneous selection (r = 0.05).

Both the stages of the genesis of the breed and the different selection methods revealed a high negative correlation between the characteristics of reproductive capacity, in particular: lactation days, service period, period between calvings and reproductive capacity.

A similar interdependence of the characteristics of productivity and reproductive capacity of cows of Ukrainian Red Dairy Breed has been established by other scientists too (Kramar and Cheremysova, 2011). In particular, it is indicated that the service period correlates highly with the period between births and the coefficient of reproductive capacity, but with PBC the connection is positive, and with CRC it is negative.

The obvious possible links between productivity and reproductive traits, in turn, indicate that they also relate to each other, since lactation is a consequence of the reproduction process of a cow, milking occurs only after calving.

The results of evaluating the correlation between productive traits and reproductive performance, formed under the influence of different selection methods, are shown in Table 4. We found that the milk yield and amount of milk fat correlate positively with lactation duration, service and intermittent periods, but a negative correlation is manifested between the performance traits and the coefficient of reproduction capacity. The degree of correlation differs depending on the method of selection. The moderately heterogeneous values of the correlation coefficients are smaller than those of other selection methods. The values of the correlation coefficients for homogeneous selection are different from those for heterogeneous and highly heterogeneous selection.

With increasing heterogeneity of selection, the strength of the link between performance traits and reproductive capacity increases. For homoge-

Table 4. Correlation between productive and reproductive characteristics under different selection methods (distribution by level of milk yield), $r \pm S_r$

Correlating Traits	Selection Method			
	Homogeneous, n = 119	Moderately Heterogeneous, n = 165	Heterogeneous, n = 174	Highly Heterogeneous, N = 657
Days of lactation – milk yield for the first lactation	0.55 ± 0.064[3]	0.51 ± 0.058[3]	0.58 ± 0.050[3]	0.72 ± 0.019[3]
Days of lactation – quantity of milk fat	0.27 ± 0.085[2]	0.19 ± 0.075[2]	0.37 ± 0.066[3]	0.40 ± 0.033[3]
Service period – milk yield for the first lactation	0.46 ± 0.072[3]	0.47 ± 0.061[3]	0.52 ± 0.055[3]	0.65 ± 0.022[3]
Service period – quantity of milk fat	0.18 ± 0.089[1]	0.15 ± 0.076[1]	0.30 ± 0.069[3]	0.34 ± 0.034[3]
Milk yield for the I lactation – PBC	0.48 ± 0.071[3]	0.43 ± 0.064[3]	0.46 ± 0.016[3]	0.64 ± 0.023[3]
Milk yield for the I lactation –CRC	-0.49 ± 0.070[3]	-0.41 ± 0.065[3]	-0.47 ± 0.059[3]	-0.59 ± 0.025[3]
Quantity of milk fat – PBC	0.21 ± 0.088[1]	0.13 ± 0.077	0.26 ± 0.071[3]	0.33 ± 0.035[3]
Quantity of milk fat – CRC	-0.26 ± 0.086[2]	-0.15 ± 0.076[1]	-0.30 ± 0.069[3]	-0.34 ± 0.034[3]

Note: *[1] – p < 0.05; [2] – p < 0.01; [3] – p < 0.001*

neous selection, the correlation between lactation duration and milk yield for the first lactation is r = 0.55 ($p < 0.001$), and for highly heterogeneous r = 0.72 ($p < 0.001$); between the service period and the amount of milk fat r = 0.18 ($p < 0.05$) and r = 0.34 ($p < 0.001$), respectively. A similar trend is characteristic for the connection of the milk yield and the amount of milk fat with the coefficient of reproductive ability: with homogeneous selection r = -0.49 ($p < 0.001$) and r = -0.26 ($p < 0,01$), and for highly heterogeneous selection – r = -0.59 ($p < 0.001$) and r = -0.34 ($p < 0.001$).

Therefore, these results characterize the direction and the degree of correlation between the characteristics of productivity and reproductive capacity, which were formed during the genesis of Ukrainian Red Dairy Breed cattle.

However, our findings are inconsistent with indicators of the extent and directionality of the association between cow productivity and reproductive performance established by other researchers [20]. They determined that between the milk yield for 305 days and the duration of the service period, period between calvings, there is a negative average degree of correlation (r = -0,300; $p < 0.01$ and r = -0,320; $p < 0.01$). And conversely, between both milk yield for 305 days and the amount of milk fat and the reproductive ability coefficient, there is a positive average level of correlation r = +0.324 ($p < 0.01$) and r = +0.278 ($p < 0.01$).

The use of the methodical approach to determine the heterogeneity of the selection on the milk fat content of matrilineal ancestors (CM, FM) of the studied cows allowed us to evaluate the influence of different selection methods on the formation of correlative relationships between the traits of productivity, reproductive capacity (Table 5), and their interdependence (Table 6). Comparative analysis of the character and of the power of links between the studied traits proves a generally biological regularity in the existence of a negative correlation of low and moderate level between milk yield and fat content in milk, and a high connection between service-intermittent periods and a coefficient of reproductive ability, which manifests itself regardless of heterogeneity selection method.

A high positive correlation is established between reproductive traits, in particular: lactation days and service period (r = +0.93…+0.94; $p < 0.001$), lactation days and period between calvings r = +0.92…+0.94; $p < 0.001$), service period and period between calvings (r = +0.91…+0.97; $p < 0.001$). This indicates that with increasing lactation duration, service and period between calvings are prolonged.

A similar pattern has been found by other researchers (Kramar and Cheremysova, 2011), so it is believed that the question of the nature of the relationship between the productive and reproductive qualities of cows need further study (Savchuk et al., 1999), and the claim that the dependence of dairy productivity and reproductive capacity of cows only on their living conditions is groundless, since the highly probable influence of milk productivity indicators on the reproductive capacity of cows (83…85%, P > 0,999) was determined (Kramar and Cheremysova, 2011). Therefore, in order to increase the productivity of dairy cattle, it is advisable to carry out breeding by reproductive capacity, increasing the number of animals with CRC = 1 and treating the signs of productivity and reproductive capacity as relatively independent (Titarenko et al., 2012).

As a result of the analysis of correlation coefficients (Table 6), we found that in homogeneous, moderately heterogeneous, and heterogeneous selection, the links strengthened between the traits of productivity and reproducibility in comparison with the similar ones given in Table 4. So, if the selection method was determined by the fat milk content of the matrilineal ancestors of the studied cows, with the heterogeneous selection, the correlation coefficient between the traits: days of lactation and milk yield for the first lactation was r = 0.76 ($p < 0.001$), but less than its value (r = 0.58; $p < 0.001$) characterized a connection between indicated traits according to heterogeneous selection that was defined in terms of the milk yield of matrilineal ancestors (see Table 4).

The established pattern of increasing dependence manifests itself among the other traits studied and does not depend on the nature of correlation links. A heterogeneous selection between the milk yield for the first lactation and

Table 5. The correlation between plant breeding grounds for differentmethods of selection (for milk fat distribution), r ± Sr

Correlating Traits	Selection Method			
	Homogeneous, n=376	Moderately Heterogeneous, n=265	Heterogeneous, n=109	Highly Heterogeneous, n=365
Milk yield for the first lactation - milk fat content	-0.22 ± 0.049	-0.15 ± 0.060[2]	-0.28 ± 0.089[2]	-0.20 ± 0.050[3]
Milk yield for the first lactation-quantity of milk fat	0.90 ± 0.010[3]	0.89 ± 0.013[3]	0.88 ± 0.022[3]	0.91 ± 0.009[3]
Milk fat content - quantity of milk fat	-0.10 ± 0.051	0.07 ± 0.061	-0.12 ± 0.095	-0.06 ± 0.052
Days of lactation-service period	0.94 ± 0.006[3]	0.93 ± 0.008[3]	0.93 ± 0.013[3]	0.94 ± 0.006[3]
Days of lactation-PBC	0.94 ± 0.006[3]	0.93 ± 0.008[3]	0.94 ± 0.011[3]	0.92 ± 0.008[3]
Days of lactation-CRC	-0.90 ± 0.010[3]	-0.86 ± 0.016[3]	-0.85 ± 0.027[3]	-0.89 ± 0.011[3]
Service period-PBC	0.97 ± 0.003[3]	0.91 ± 0.010[3]	0.97 ± 0.006[3]	0.95 ± 0.005[3]
Service period-CRC	-0.92 ± 0.008[3]	-0.83 ± 0.019[3]	-0.86 ± 0.025[3]	-0.91 ± 0.009[3]
PBC-CRC	-0.96 ± 0.004[3]	-0.94 ± 0.007[3]	-0.94 ± 0.011[3]	-0.96 ± 0.004[3]

Note: *[2] – $p < 0.01$; [3] – $p < 0.001$*

Table 6. Correlation between productive and reproductive traits across different selection methods (fat milk distribution), r ± Sr

Correlating Traits	Selection Method			
	Homogeneous, n = 376	Moderately Heterogeneous, N = 265	Heterogeneous, n = 109	High Heterogeneous, N = 365
Lactation days – milk yield for the first lactation	0.67 ± 0.028[3]	0.68 ± 0.033[3]	0.76 ± 0.041[3]	0.66 ± 0.029[3]
Lactation days – quantity of milk fat	0.39 ± 0.044[3]	0.36 ± 0.053[3]	0.45 ± 0.077	0.37 ± 0.045[3]
Service period – milk yield for the first lactation	0.61 ± 0.032[3]	0.60 ± 0.039[3]	0.68 ± 0.052[3]	0.60 ± 0.033[3]
Service period – quantity of milk fat	0.33 ± 0.046[3]	0.29 ± 0.056[3]	0.36 ± 0.084[3]	0.32 ± 0.047[3]
Milk yield for the I lactation – PBC	0.60 ± 0.033[3]	0.58 ± 0.041[3]	0.68 ± 0.052[3]	0.57 ± 0.035[3]
Milk yield for the I lactation – CRC	-0.54 ± 0.036[3]	-0.55 ± 0.043[3]	-0.61 ± 0.060[3]	-0.54 ± 0.037[3]
Quantity of milk fat – PBC	0.32 ± 0.046[3]	0.2 ± 0.057[3]	0.37 ± 0.083[3]	0.29 ± 0.048[3]
Quantity of milk fat – CRC	-0.32 ± 0.046[3]	-0.31 ± 0.056[3]	-0.37 ± 0.083[3]	-0.31 ± 0.047[3]

Note: *[3] – $p < 0.001$*

the reproductive factor revealed a negative correlation ($r = -0.61$; $p < 0.001$), but this relationship was characterized by a smaller value ($r = -0.47$; $p < 0.001$), if the selection method is determined taking into account the level of milk yield of the ancestors of the studied animals (see Table 4). However, the exception is high-heterogeneous selection, since the strength of existing bonds, on the contrary, is weakened regardless of their direction.

Therefore, selection methods cause a significant restructuring of correlation links between the traits of productivity and reproductive capacity of dairy cattle, and their change can be predicted according to the established laws of relative variability. Thus the breeding process can be purposefully managed.

Conclusions

Regular changes in the correlation relationships of breeding traits occurring during the breed formation process have been proved. The peculiarity of the genesis of the Ukrainian Red Dairy Breed was in the focus shift during breeding, which led to the restructuring of correlation relationships between traits.

Breeding for increasing milk fat at the first stages of the genesis of the Ukrainian Red Dairy Breed caused a decrease in negative correlation ($r = -0.20$; $p < 0.001$) between milk yield and fat content in milk, which eventually became positive ($r = +0.07$). The introduction into the breeding process of the Holstein gene pool (during stages IV and V) dramatically changed the nature of the relationship between the main features of milk productivity – milk yield and fat content in milk ($r = -0.32$; $p < 0.001$).

In certain periods of the genesis of the breed, the power of negative correlation between milk yield, milk fat content, and reproductive capacity increases. A high negative correlation between milking and reproductive power in the study animals of stage V is a constant ($r = -0.78$; $p < 0.001$).

With increasing heterogeneity of selection, the strength of the link between performance traits and reproductive capacity increases. For homogeneous selection, the correlation between lactation duration and milk yield for the first lactation is $r = 0.55$ ($p < 0.001$), and for highly heterogeneous is $r = 0.72$ ($p < 0.001$); between the service period and the amount of milk fat is $r = 0.18$ ($p < 0.05$) and $r = 0.34$ ($p < 0.001$), respectively.

It has been established that selection methods cause a significant restructuring of correlation relationships between the traits of productivity and reproductive capacity of dairy cattle, and their change can be predicted according to established patterns of relative variability, and thus the breeding process can be purposefully managed.

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