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Evaluation of Bulls and Related Groups of the Jersey Breed on Dairy Productivity and Reproductive Capacity of Offspring

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Abstract. The article presents the results of research on the influence of paternal origin and belonging to a related group on the level of milk productivity of cows and the reproductive capacity of Jersey cows in the farm "Dan-Milk" of the Zhytomyr Region. The purpose of this study is to establish the influence of paternal origin and belonging to a related group on the level of milk productivity and reproductive capacity parameters of Jersey cows. The study established a substantial level of differentiation in the main economically useful features between groups of half-sisters by father. The best quantitative indicators of milk productivity were noted among the daughters of bulls DJ Jante 302761 (P<0.001) and Headline 114114336 (P<0.001), the worst indicators – among daughters of Karl 67037285. The highest indicators of fat and protein content in milk were noted in the cows bred from the bull Legal 61929249, the lowest – from the bull Karl 67037285. The influence of the origin of cows by father on the variability of milk yield and yield of milk fat and protein was 20.3–30.3% (up to P<0.001), the content of fat and protein in milk decreased to 13.2-20.0% (P<0.01 and P<0.05), and according to the reproductive capacity features – to 7.8-19.0% with an unreliable level of statistical significance. Prepotent as to milk yield are bulls Legal 61929249 and Headline 114114336, as to the content and yield of milk protein – Legal 61929249. Cows of the related group bred from the bull Observer 553236 are characterised by the highest milk yield and yield of milk fat and protein for both the first and best lactation, and cows of the related group bred from Surville 604694 are characterised by the worst yield. The influence of belonging to a related group on the studied features was several times lower (0.2-10.5%) compared to the influence of paternal origin. With an increase in the milk yield of cows over the first lactation, there is a stable and substantial decrease in the reproductive capacity coefficient due to the lengthening of the service period between the first and second calving. Such natural antagonism does not imply the goal of increasing the duration of the service period to obtain maximum milk yields for firstborn cows, since this will lead to a decrease in the yield of calves and render timely replenishment of the herd impossible. It is optimal to milk the firstborn up to 8 tonnes over 305 days of lactation while maintaining a satisfactory reproductive level

Keywords: Jersey cattle, bull, short line, yield, reproduction, consolidation

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INTRODUCTION

Jersey cattle are described by high productive qualities and are the world's best dairy breed in terms of fat and protein content in milk. This breed is quite common in England, New Zealand, Australia, Denmark, and several other countries [1-3]. The world has accumulated a certain positive practice of purebred breeding of Jersey cattle and its cross-breeds with other dairy breeds [4; 5]. The Jersey breed has been a source of valuable heredity, which determines exceptionally high levels of fat and protein content in milk and payment for feed with products, which depends on the correct choice of the breeding bull [4; 6].

The use of biotechnological methods of sperm cryopreservation and artificial insemination substantially expands the opportunities for unleashing the potential of breeding bulls of any breed. One breeding bull can yield over 50 thousand offspring, while high-value cows can yield 7-10 offspring in a lifetime. The decisive role in the breeding process belongs precisely to breeding bulls, since they account for about 90% of the breeding effect [7].

The extensive use of improver bulls evaluated by the offspring allows creating highly productive herds, consolidated in terms of milk productivity, fertility, and duration of economic use. Therewith, breeding bulls are described by unequal stability of transmitting economically useful features to their daughters in their certain mutual combination, and even more so – in the desired one [8; 9].

Current trends in milk production require constant work to improve the genetic potential of cattle, which is achieved by increasing the level of milk yield, as well as its fat and protein content. Animals with modern milk production technology should have good reproductive capacity and long-term productive use. To achieve these goals, modern breeding programmes focus on functional compliance and productive life of the cow. One of the most effective methods of improving the breeding and productive qualities of dairy cattle is the use of prepotent improver bulls [10; 11].

Important elements of the intra-breed breeding structure are lines or related groups. The dynamism and replacement of some genealogical formations of the breed with others that are more promising and more valuable in breeding terms allows adjusting the breeding process with each herd individually. The development and improvement of any breed is largely conditioned upon its genealogical structure, the use of bulls from different related groups. Breeding along lines is considered the highest form of stock breeding and one of the methods of genetic improvement of herds and breeds. It enables an effective use of breeding bulls with high breeding value, which steadfastly transmit the desired manifestation of economically useful features to their offspring [12-14].

The purpose of this study is to establish the influence of paternal origin and belonging to a related group (short line) on the level of milk productivity and reproductive capacity parameters of Jersey cows.

MATERIALS AND METHODS

The object of this study is population-genetic patterns of inheritance of economically useful features of Jersey cows. The subject of this study is indicators of milk productivity and reproductive capacity of cows.

The study was conducted at the farm "Dan-Milk" of the Zhytomyrska Oblast. The farm fully maintains livestock and breeding records, and has implemented an automated information system called Uniform Agri. Cows are milked at the "Parallel" milking unit. The cattle are housed in yards with rest boxes. Diets are developed depending on the physiological state and productivity of cattle.

The genealogical structure of the herd is represented by the offspring of a considerable number of breeding bulls of the Jersey breed. Among the breeding stock imported from Denmark, the most numerous were the groups of half-sisters bred from bulls Headline 114114336 (n=55), Legal 61929249 (n=15), DJ Jante 302761 (n=15), Karl 67037285 (n=20), and Vernon 115863998 (n=28). The vast majority of cows and heifers are genealogically assigned to related groups bred from bulls Fallneva 593883, Surville 604694, and Observer 553236, represented by the offspring of at least three breeding bulls.

Milk productivity was recorded by performing control milking (every decade during the first three months and monthly until the end of lactation) and monthly determination of the fat and protein content (%) in milk (using the Ecomilk KAM-98.2A device). The study calculated lactation duration and milk production over 305 days, or reduced lactation.

The degree of phenotypic consolidation of related groups and prepotency of breeding bulls based on the studied features was evaluated according to the coefficients proposed by the authors of this study in [14] C_1, C_2, C_{avg} with their calculation using the following formulas:

$$C_1 = 1 - \sigma_g/\sigma_h,\ C_2 = 1 - Cv_g/Cv_h \quad (1)$$

$$C_{avg} = (C_1 + C_2): 2 \quad (2)$$

where σ_g and Cv_g are the standard deviation and variability coefficient of the estimated group of animals for a particular feature; σ_h and Cv_h are the standard deviation and variability coefficient of the general population (herd).

The degree of influence of various factors (paternal origin, belonging to a related group, milk yield level) on economically useful features was determined through the correlation of factorial and total variances using single-factor analysis of variance. Three standard levels of statistical significance were indicated using alphabetic superscripts (^{a} – P<0.05, ^{b} – P<0.01, ^{c} – P<0.001).

Calculations were performed using mathematical statistics methods using the STATISTICA-13.0 software package on a personal computer.

RESULTS AND DISCUSSION

Breeding indices in bull catalogues do not always coincide with the results of evaluation in farm conditions [15-17].

Breeding progress can be achieved proceeding exclusively from the evaluation results of breeding bulls in the conditions of a particular herd. Regularities of correlated variability of features in the cows bred from breeding bulls allow identifying improvers both in terms of milk productivity and reproductive capacity [9; 12].

The farm "Dan-Milk" has established an intensive milk production technology, which ensures increasing the productivity of cows while neglecting extensive production factors, namely increasing the number of breeding stock at the expense of its herd replacements. The study established that the intergroup difference between half-sisters after the father was not identified only regarding lactation duration, which is quite natural because this feature is largely determined by paratypical factors. Similar patterns were established in the studies of other Ukrainian and foreign authors [13; 18; 19].

In the herd of the farm "Dan-Milk", the study established a substantial differentiation level in the main economically useful features between groups of cows (paternal half-sisters) bred from different bulls (Table 1).

***Table 1**. Reproductive capacity and productivity of cows bred from different bulls*

Feature		Group of half-sister cows bred from:				
		Headline 114114336	**Legal 61929249**	**DJ Jante 302761**	**Karl 67037285**	**Vernon 115863998**
First lactation						
Number of cows monitored		55	15	15	20	28
Duration of periods, days:	Second pregnancy	279.9±0.45	278.8±0.80	278.4±1.20	278.1±1.14	280.3±0.57
	Service period	142.4±9.25	147.6±19.96	129.5±15.69	133.2±13.47	153.8±19.22
	Lactation	361.3±9.28	365.2±19.70	348.1±15.48	352.5±13.88	372.7±18.92
	Interlactation period	61.0±0.63	61.2±0.92	59.7±1.14	58.8±1.08	61.4±0.93
	Between I and II calving	422.3±9.23	426.4±19.90	407.8±15.45	411.4±13.72	434.1±19.31
Reproductive capacity coefficient (RCC)		0.88±0.017	0.89±0.038	0.91±0.031	0.90±0.029	0.88±0.035
Milk yield, kg	Over lactation	9738±286.7^{c}	9044±518.2^{b}	10008±808.5^{b}	7240 ± 310.3	9556±516.6^{c}
	Over 305 days	8217±206.4^{c}	7433±301.6^{c}	8579±531.3^{c}	6211±137.2	7800±301.8^{c}
Milk fat:	%	4.70±0.073	4.76±0.122	4.72±0.150	4.43±0.131	4.58±0.066
	kg	388.9±13.6^{c}	353.8±17.11^{c}	401.9±25.84^{c}	273.9±7.52	357.4±14.91^{c}
Milk protein:	%	3.73±0.043	3.74±0.071	3.74±0.089	3.55±0.096	3.69±0.058
	kg	308.0±9.17^{c}	278.7±12.86^{c}	317.9±19.19^{b}	219.5±5.95	287.9±11.96^{c}
Higher lactation						
Milk yield over 305 days, kg		8660±242.3^{c}	7890±369.5^{b}	9419±582.5^{c}	6790±149.8	8420±347.9^{c}
Milk fat:	%	4.63±0.081	4.92±0.097^{a}	4.66±0.213	4.94±0.120^{a}	4.71±0.126
	kg	399.3±12.45^{c}	389.2±20.73^{b}	431.9±27.47^{b}	336.0±12.63	392.1±15.60^{c}
Milk protein:	%	3.68±0.051	3.85±0.047^{b}	3.67±0.109	3.87±0.075^{a}	3.70±0.066
	kg	317.2±9.41^{c}	303.6±14.75^{b}	343.5±21.48^{b}	263.1±7.94	310.6±12.91^{c}

***Notes**: ^{a} – P<0.05, ^{b} – P<0.01, ^{c} – P<0.001*

In general, a statistically reliable difference in various levels of significance (from P<0.05 to P<0.001) in milk productivity features between the cows of the best bulls and the coevals of a worse breeder was found in 17 cases out of 35, which is 49% of the total number of compared pairs.

Milk productivity is the main breeding feature of dairy cows, which forms an integral component in the calculation of selection indices [14; 20]. Therefore, the study investigated the effect of paternal ancestry on milk productivity features. A general biological pattern was discovered – intergroup differentiation of cows of individual breeder bulls. Moreover, the highest milk yield is associated with the lowest indicators of fat and protein content in milk, which is consistent with literature data – an increase in milk yield often entails a decrease in fat and

protein content in milk and reproductive capacity [21-23]. The best milk productivity is noted among the cows bred from bulls DJ Jante 302761, Headline 114114336 and Vernon 115863998, who in terms of milk yield, milk fat and protein yield for the first and best lactation reliably (up to P<0.001) outperformed their coevals bred from Karl 67037285, the worst bull according to these features. In particular, the milk yield for the first lactation of the cow bred from DJ Jante 302761 dominated its coevals from Karl 67037285 by 2768±866.0 kg or 38.2%, over its first 305 days – by 2368±548.7 kg or 38.1%, according to the yield of milk fat over 305 days of the first lactation – by 128.0±26.91 kg or 46.7%, milk protein – by 98.4±33.58 kg or 44.8%. Over 305 days of better lactation, this milk yield advantage reached 2629±601.5 kg or 38.7%, milk fat yield – 95.9±30.23 kg or 28.5%, protein yield – 80.4±22.90 kg or 30.6%.

According to the quality indicators of milk, the intergroup difference for various lactation periods turned out to be multidirectional. As for fat and protein content in milk over 305 days of the first lactation of the cow bred from the worst breeder in terms of firstborn's milk yield Karl 67037285 are inferior to their coevals from the rest of the compared bulls at a close to statistically significant level. In particular, the cows bred from Headline 114114336 are superior in fat content by 0.27±0.15% and in protein content – by 0.18±0.105% for P<0.1. But on the other hand, for the best lactation in terms of milk yield, cows bred from Karl 67037285 have the highest content of fat and protein in milk with a statistically significant (P<0.05) difference over their coevals from Headline 114114336. Among the firstborns, the cow bred from the bull Legal 61929249 is characterised by the highest content of fat and protein in milk. In most cases, comparison of group averages confirms the inverse correlation variability of quantitative and qualitative features of dairy productivity of cows.

The highest indicators of fat and protein content in milk were noted in the cows bred from the bull Legal 61929249, the lowest – from the bull Karl 67037285. That is, it was not possible to simultaneously identify the improver in both qualitative and quantitative features because, quite naturally, an increase in the level of milk yield entails a decrease in milk quality features. Therewith, the cows bred from the bull Karl 67037285 are described by both the lowest milk yield and the lowest fat and protein content in milk, which indicates the inexpediency of reusing this bull (P<0.05, P<0.01, P<0.001). The results obtained indicate a substantial difference between the cows bred from different bulls of the farm "Dan-Milk" and allow identifying the best concerning milk productivity. The best indicators of milk productivity were noted among the cows bred from bulls DJ Jante 302761 and Headline 114114336 of the Observer 553236 line. Therefore, it is promising to use breeding bulls of this line in the selection plans for the breeding stock of the herd under study, provided that close inbreeding is avoided.

The best indicators of milk productivity for higher lactation were noted among the cows bred from bulls DJ Jante 302761 and Headline 114114336, who reliably (P<0.001) outperformed the cows bred by Karl 67037285 in terms of milk yield (by 2.628 and 1.870 kg, respectively), milk fat (by 95.9 and 63.3 kg) and protein (by 80.4 and 54.1 kg). In turn, the cows bred from the bull DJ Jante 302761 are also reliably superior (P<0.05) to the cows bred from the bull Legal 61929249 in terms of milk yield by 1.528 kg. The cows bred from the bull Headline 14114336 had the lowest rates of fat and protein in milk, demonstrating general biological feedback between milk yield and fat content in milk. Therewith, they were inferior (P<0.05, P<0.01) to the cows bred from the bulls Legal 61929249 (0.29% against 0.17%) and Karl 67037285 (0.31% against 0.19%) in these features.

Apart from milk productivity, the authors of this study have investigated the features of reproductive capacity of the offspring of various breeding bulls as an essential aspect of the development of modern dairy cattle breeding. Several authors [24-27] report an increase in the duration of lactation and a deterioration in the reproductive capacity of cows due to the lengthening of the service period. This is quite natural because animals need more time to restore the functions of the genitals and the normal course of their sexual cycle. The dependence of reproductive qualities on paratypical factors is confirmed by other authors [28-30]. This study also confirms the low level of genetic determination of cows' reproductive capacity features. This is conditioned upon the lower heritability of these features compared to dairy productivity.

There was no statistically significant difference between the paternal half-sister groups in terms of reproductive features (P>0.05). However, the cows bred from the bull DJ Jante 302761 combine high milk productivity with satisfactory reproductive features (Table 1), which is confirmed by the result of its assessment according to the quality of offspring (6.031 cows, the reliability of the assessment is 99%, NTM – 5), given by the Jersey Cattle Association [31; 32]. That is, this breeder is an improver of milk yield and reproductive capacity.

Univariate analysis of variance confirms the effect of the parental origin of cows on individual features of reproductive capacity investigated by comparison of group averages (Table 2).

***Table 2**. Impact of (η_x^2±S.E., %) origin by father on the studied features of cattle*

Feature		F.	P	η_x^2±S.E., %
Number of degrees of freedom:	Factorial		21	
	Random		145	
First lactation				
Duration of periods, days:	Second pregnancy	1.62	0.0517	19.0±0.14
	Service period	0.72	0.8066	9.5±0.14
	Lactation	0.71	0.8224	9.3±0.14
	Interlactation period	1.21	0.2471	15.0±0.14
	Between I and II calving	0.72	0.8110	9.4±0.14
Reproductive capacity coefficient		0.58	0.9237	7.8±0.14
Milk yield, kg	Over lactation	1.76	0.0286	20.3±0.14
	Over 305 days	3.00	<0.0001	30.3±0.13
Milk fat:	%	1.05	0.4040	13.2±0.14
	kg	2.53	<0.0001	26.8±0.13
Milk protein:	%	1.47	0.0951	17.6±0.14
	kg	2.97	<0.0001	30.0±0.13
Higher lactation				
Milk yield over 305 days, kg		2.35	0.0010	25.4±0.14
Milk fat:	%	1.73	0.0321	20.0±0.14
	kg	1.60	0.0558	18.8±0.14
Milk protein:	%	1.60	0.0568	18.8±0.14
	kg	1.79	0.0247	20.6±0.14

***Notes**: F is Fisher's criterion, P is probability*

The basis of selection is to assign the evaluated improver bulls to the breeding stock to obtain highly productive offspring. In most cases, the conducted studies revealed a statistically significant level of intergroup differentiation of paternal half-sisters based on the features of cows' milk productivity, which proves the effectiveness of breeding Jersey cattle by using the identified improvers to obtain highly productive offspring in the next generation.

A higher (20.3-30.3%) and statistically significant (up to P<0.0001) level of heredity was observed in the firstborn by milking and yield of milk fat and protein, as well as by milking the best lactation over 305 days. As for fat and protein content in milk, the strength of the paternal influence decreases to 13.2-20.0% with a lower level of confidence (P<0.1 and P<0.05). According to the reproductive capacity features, an even lower level of heredity was established (7.8-19.0%) with an unreliable level of statistical significance. Greater breeding value is represented by the improver bulls with stable transmission of breeding qualities to offspring (prepotency), which is realised through a relative narrowing of variability (consolidation) in groups of paternal half-sisters [33; 34].

According to the features under study, the breeders used in the herd are described (Table 3) according to varying degrees of prepotence (up to C=0.684) or are yeld (up to C= -0.336).

***Table 3**. Consolidation of paternal half-sister groups (breeder prepotence)*

Feature			Coefficient	Breeder prepotence: Headline 114114336	Legal 61929249	DJ Jante 302761	Karl 67037285	Vernon 115863998
Duration of periods, days:	Second pregnancy		C_1	0.133	0.011	-0.215	-0.150	0.206
			C_2	0.136	0.010	-0.219	-0.155	0.209
			C_{avg}	0.134	0.011	-0.217	-0.152	0.207
	Service period		C_1	0.104	-0.169	0.204	0.316	-0.332
			C_2	0.104	-0.128	0.124	0.270	-0.233
			C_{avg}	0.104	-0.148	0.164	0.293	-0.282
	Interlactation period		C_1	-0.026	0.092	0.019	0.069	-0.096
			C_2	-0.014	0.106	0.010	0.046	-0.076
			C_{avg}	-0.020	0.099	0.015	0.058	-0.086
	between I and II calving		C_1	0.104	-0.164	0.218	0.305	-0.336
			C_2	0.106	-0.150	0.191	0.288	-0.297
			C_{avg}	0.105	-0.157	0.205	0.296	-0.317
Coefficient of reproducibility			C_1	0.089	-0.204	0.149	0.209	-0.288
			C_2	0.083	-0.206	0.168	0.218	-0.302
			C_{avg}	0.086	-0.205	0.158	0.213	-0.295
Over 305 days of the first lactation	Milk yield, kg		C_1	0.061	0.172	-0.263	0.674	0.020
			C_2	0.130	0.152	-0.120	0.600	0.044
			C_{avg}	0.095	0.162	-0.192	0.637	0.032
	Milk fat	%	C_1	-0.082	-0.092	-0.164	-0.016	0.304
			C_2	-0.068	-0.065	-0.144	-0.064	0.295
			C_{avg}	-0.075	-0.079	-0.154	-0.040	0.300
		kg	C_1	0.050	0.047	-0.031	-0.117	0.075
			C_2	0.058	0.059	-0.020	-0.165	0.074
			C_{avg}	0.054	0.053	-0.025	-0.141	0.075
	Milk protein	%	C_1	-0.096	0.169	-0.087	0.684	0.143
			C_2	0.002	0.168	0.042	0.591	0.151
			C_{avg}	-0.047	0.168	-0.023	0.637	0.147
		kg	C_1	-0.002	0.153	-0.095	0.660	0.068
			C_2	0.083	0.143	0.029	0.564	0.087
			C_{avg}	0.041	0.148	-0.033	0.612	0.077

As for pregnancy duration, a notable prepotence was observed in breeder bulls Head-line 114114336 and Vernon 115863998, while DJ Jante 302761 and Karl 67037285 were yeld. According to the coefficient of reproducibility, the duration of the service period between 1st and 2nd calving, the bulls Karl 67037285 and DJ Jante 302761 can be attributed to prepotent, while Vernon 115863998 and Legal 61929249 – to yeld ones. In terms of the duration of the interpreg-nancy period, all producers had low prepotency coefficients, which confirms its low genetic conditionality from the standpoint of the planned regulation of the cows dry-off by the livestock owner.

According to milk yield of the firstborn, the improver bull DJ Jante 302761 is characterised by a higher-than-average phenotypic variability of this feature in cows bred from it, that is, it turned out to be yeld. Positive coefficients of milk yield consolidation are inherent

in groups of paternal half-sisters bred from bulls Legal 61929249 and milk yield improver Headline 114114336, which gives an additional selection advantage to the latter. According to the content and yield of milk protein, the bull Legal 61929249 can be considered prepotent, and according to the content and yield of milk fat and protein – milk yield improver Vernon 115863998. The highest level of prepotency in terms of milk yield, milk protein content and yield, as well as the duration of the service period between the 1st and the 2nd calving, was observed in bull Karl 67037285. However, given the lowest milk yield of its cows for the first and highest lactation and the lowest content and yield of milk fat and protein of the firstborn (Table 1), that is, the high prepotence of the aggravator, makes it highly undesirable to continue using this breeder in the herd under study. According to the reproductive features, the breeding bull DJ Jante 302761 is recommended for further use in the herd, which produces an improving effect on RCC, the duration of the service period between calving with a distinctive level of prepotency.

Phenotypic and genetic specificity constitutes an important component of testing and further genetic progress of breeds and intra-breed formations (lines, families, types) [33]. The study estab-lished a slightly lower, compared to the paternal origin, but a significant effect of belonging to a related group on the features of milk productivity for both the first and highest lactation. The obtained results are consistent with the literature data on the statistically significant influence on the economically useful features of paternal origin and linear affiliation on the variability of features of live weight, milk productivity and reproductive capacity of cows [34; 35].

Of particular interest is the average level of prepotency of breeding bulls used in the herd according to individual characteristics. The average level of consolidation of the five investigated groups of paternal half-sisters for the duration of the second pregnancy was -0.003, the service period – 0.026, the interlactation period – 0.013, the interpregnancy period – 0.026, and the reproductive capacity coefficient – -0.009. On average, according to these features, which to a certain extent describe the reproductive capability of animals, the prepotence of the evaluated producers was 0.011. This confirms the low level of consolidation of intra-breed selection groups according to reproductive features. According to the milk productivity features, the degree of consolidation of the related groups under study, as well as groups of paternal semi-sisters, was higher. According to the milk yield of firstborns, the average level of prepotency of the offspring was 0.147, according to the fat content in milk – -0.010, its yield – 0.003, protein content in milk – 0.176, milk protein yield – 0.169 (Table 3). On average, per five milk productivity features of cows over 305 days of the first lactation, the level of consolidation of groups of paternal half-sister cows was 0.097, which exceeded that for reproductive features by 8.8 times. This can be explained by the priorities of selection for dairy productivity.

A certain proportion of variability in the breed should be determined by intergroup variability between homogeneous and differentiated structural elements of the breed. The offspring of a certain breeder belonging to lines or certain related groups should be described not only by a common origin, but also by the uniformity of the manifestation of economically useful features [14; 15; 17]. Therefore, when evaluating cows of a particular herd according to milk productivity features, it is necessary to consider their genealogical structure [14].

Among the related groups whose breeders were used in the herd under study, the most numerous in terms of breeding stock were the offspring groups bred from progenitor bulls Fallneva 5938833, Observer 553236, and Surville 604694. The comparison of group averages established a statistically significant level of intergroup differentiation according to features of milk productivity, and a considerably lower level, unreliable in all cases – according to considered fea-tures of reproductive capacity (Table 4). Cows of the related group bred from Observer 553236 are characterised by the highest milk yield and yield of milk fat and protein for both the first and best lactation. They outperformed cows of the worst related group bred from Surville 604694 for the first lactation in milk yield by 1321±281.0 kg or 19.1% (t_d=4.70, P<0.001), by milk fat yield – by 68.2±16.79 kg or 21.3% (t_d=4.06, P<0.001), protein – by 54.0±12.30 kg or 21.3% (t_d=4.39, P<0.001).

***Table 4**. Reproductive capacity and productivity of cows of different related groups*

Feature		Related Group:		
		Fallneva 5938833	Observer 553236	Surville 604694
Number of cows monitored		**35**	**74**	**35**
First lactation				
Duration of periods, days:	Second pregnancy	280.1±0.52	279.5±0.43	278.5±0.68
	Service period	154.0±16.91	137.8±7.62	141.5±12.68
	Interlactation period	60.9±0.84	60.6±0.53	60.2±0.72
	Between I and II calving	434.1±16.95	417.3±7.60	420.0±12.70
Reproductive capacity coefficient		0.88±0.03	0.89±0.01	0.89±0.02

Table 4, Continued

Feature			Related Group:		
			Fallneva 5938833	Observer 553236	Surville 604694
Number of cows monitored			**35**	**74**	**35**
First lactation					
Over 305 days:	Milk yield, kg		7559±262.4[a]	8230±189.3[c]	6909±207.7
	Milk fat:	%	4.58±0.07	4.69±0.06[b]	4.62±0.09
		kg	346.0±12.88	387.8±11.52[a]	319.6±12.22
	Milk protein:	%	3.68±0.06[a]	3.73±0.04[b]	3.66±0.06
		kg	278.1±10.40	307.3±7.98[b]	253.3±9.18
Higher lactation					
Over 305 days:	Milk yield, kg		8183±297.7[a]	8768±218.3[c]	7419±237.3
	Milk fat:	%	4.69±0.12	4.64±0.08[b]	4.93±0.07
		kg	380.6±14.33	403.8±10.97[a]	366.4±13.63
	Milk protein:	%	3.68±0.06[a]	3.68±0.05[b]	3.86±0.04
		kg	300.6±11.58	320.8±8.33[b]	286.2±9.61

***Notes**: [a] – P<0.05, [b] – P<0.01, [c] – P<0.001*

For higher lactation – by 1349±322.4 kg or 18.2% (t_d=4.18, P<0.001), 37.4±17.50 kg or 10.2% (t_d=2.14, P<0.05), 34.6±12.72 kg or 12.1% (t_d=2.72, P<0.01). As for fat and protein content in milk for the first lactation, the difference between cows of these related groups was insignificant (+0.07%), and for the best milk lactation, animals of the related group bred from Surville 604694, on the contrary, prevailed over coevals of the related group bred from Observer 553236 in terms of fat content by 0.29±0.106% (t_d=2.74, P<0.01) and protein – by 0.18±0.064% (t_d=2.81, P<0.01). Cows of the related group bred from Fallneva 5938833 occupied an intermediate position in most features of milk productivity for the first and highest lactation.

Cows of related groups bred from Fallneva 593883 and Observer 553236 scored the best indicators of milk productivity. There was no essential difference in the features of milk productivity between them, which can be explained by the commonality of their origin (Fallneva 593883 is bred from Observer 553236). This gives grounds to recommend using breeders of both related groups specified. Cows of the related group bred from Observer 553236 have the shortest service and interpregnancy periods and a higher reproductive capacity coefficient, while cows of the related group bred from Fallneva 593883 have longer service and interpregnancy periods, and a lower reproductive capacity coefficient. But the intergroup difference in reproductive features was non-essential and did not reach a statistically significant level.

Among the cows of the related group bred from Observer 553236, the most numerous were the offspring of Headline 114114336 and DJ Jante 302761 bulls, in the related group bred from Fallneva 593883 – the breeder bull Vernon 115863998, and in the related group bred from Surville 604694 – breeder bulls Karl 67037285 and Legal 61929249.

Variance analysis confirms the non-essential effect of belonging to a related group on the reproductive features established by comparison of group averages (Table 5). According to these signs, only the effect on the phenotypic variability of pregnancy duration was reliable or approached such – over the duration of the interlactation period. Belonging to a related group also has a low (2.0-2.4%) and unreliable (P>0.1) effect on the fat and protein content in milk for both the first and best lactation.

The specified genetic factor has a more substantial (7.7-10.5%) and statistically significant (P<0.01… P<0.001) effect on milk yield, milk fat and protein yield in firstborn cows. According to these features, for higher lactation, the effect decreases to 3.0 … 6.5%. In general, the influence of belonging to a related group on the features under study was several times lower compared to the influence of paternal origin.

The main feature of a line or related group is the consolidation inherent in their representatives regarding the economically useful features due to kinship and directional selection, which makes them different from others to a certain extent [16]. The authors of this study have established that the values of the coefficients of phenotypic consolidation of animals of various related groups of the herd under study are described mainly by positive values with slight variability. Ukrainian authors have established the influence of leading genealogical formations on the degree of phenotypic consolidation coefficients, which directly affects breeding work with the herd and provides the necessary uniformity and trend of desired traits [16; 36].

***Table 5**. Impact of (η_x^2±S.E., %) belonging to a related group on the variability of features in cattle*

Feature		F.	P	η_x^2±S.E., %
Number of degrees of freedom:	Factorial		2	
	Random		151	
First lactation				
Duration of periods, days:	Second pregnancy	5.47	0.0051	6.8±0.01
	Service period	0.17	0.8409	0.2±0.01
	Lactation	0.19	0.8302	0.2±0.01
	Interlactation period	2.89	0.0587	3.7±0.01
	Between I and II calving	0.28	0.7585	0.4±0.01
Reproductive capacity coefficient		0.17	0.8479	0.2±0.01
Milk yield, kg	Over lactation	6.28	0.0024	7.7±0.01
	Over 305 days	8.41	0.0003	10.0±0.01
Milk fat:	%	1.52	0.2230	2.0±0.01
	kg	7.19	0.0010	8.7±0.01
Milk protein:	%	1.89	0.1548	2.4±0.01
	kg	8.82	0.0002	10.5±0.01
Higher lactation				
Milk yield over 305 days, kg		5.28	0.0061	6.5±0.01
Milk fat:	%	1.77	0.1741	2.3±0.01
	kg	2.3	0.1033	3.0±0.01
Milk protein:	%	1.72	0.1818	2.2±0.01
	kg	3.21	0.0432	4.1±0.01

***Notes**: F is Fisher's criterion, P is probability*

A certain selection interest is the degree of consolidation of the evaluated related groups based on the features under study. I was established (Table 6) that on average, the related group Observer 553236 demonstrates the greatest consolidation (C_{avg}=0.058), slightly lower – in the related group Surville 604694 (C_{avg}=0.038), and the related group Fallneva 593883 demonstrates the intra-group variability even slightly higher (C_{avg}= -0.008) than the total variability across the herd. The degree of phenotypic consolidation of the related groups under study substantially differs by groups of features describing the reproductive capacity or milk productivity. According to the reproductive features, the related group bred from Observer 553236 also demonstrates a higher level of consolidation (C_{avg}=0.084), the smallest (C_{avg} = -0.143) – in the group bred from Fallneva 593883, and in the related group bred from Surville 604694 the intra-group phenotypic variability is almost identical to the total (C_{avg}=0.001).

***Table 6**. Degree of phenotypic consolidation of related groups*

Feature		Coefficient	Breeder prepotence:		
			Fallneva 5938833	Observer 553236	Surville 604694
Duration of periods, days:	Second pregnancy	C_1	0.195	0.037	-0.049
		C_2	0.198	0.038	-0.051
		C_{avg}	0.196	0.038	-0.050
	Service period	C_1	-0.310	0.142	0.018
		C_2	-0.212	0.113	0.011
		C_{avg}	-0.261	0.127	0.014

Table 6, Continued

Feature			Coefficient	Breeder prepotence:		
				Fallneva 5938833	Observer 553236	Surville 604694
Duration of periods, days:	Interlactation period		C_1	-0.096	-0.009	0.058
			C_2	-0.085	-0.003	0.057
			C_{avg}	-0.090	-0.006	0.057
	Between I and II calving		C_1	-0.311	0.145	0.017
			C_2	-0.273	0.136	0.014
			C_{avg}	-0.292	0.140	0.016
Coefficient of reproducibility			C_1	-0.258	0.119	-0.034
			C_2	-0.273	0.122	-0.030
			C_{avg}	-0.266	0.121	-0.032
Over 305 days of the first lactation	Milk yield, kg		C_1	0.047	0.000	0.246
			C_2	0.041	0.076	0.169
			C_{avg}	0.044	0.038	0.208
	Milk fat	%	C_1	0.216	-0.087	-0.095
			C_2	0.206	-0.075	-0.100
			C_{avg}	0.211	-0.081	-0.097
		kg	C_1	0.172	-0.077	0.214
			C_2	0.153	0.017	0.129
			C_{avg}	0.162	-0.030	0.172
	Milk protein	%	C_1	0.018	0.013	-0.054
			C_2	0.014	0.021	-0.065
			C_{avg}	0.016	0.017	-0.059
		kg	C_1	0.093	-0.012	0.199
			C_2	0.081	0.072	0.109
			C_{avg}	0.087	0.030	0.154

As for dairy productivity, a higher level of consolidation was observed, on the contrary, in the related group Fallneva 593883 (C_{avg}=0.104), slightly lower – in the related group Surville 604694 (C_{avg}=0.076), and in the related group Observer 553236 it decreases on average to negative values (C_{avg}= -0.005). Therefore, with further expanded use of cows of the most productive related group Observer 553236, herd consolidation should not be expected according to milk productivity features. It can be achieved by searching for and using prepotent improvers among the producers of this related group.

Of certain interest is the average degree of consolidation of the related groups under study based on their separate features. For three related groups, the duration of the second pregnancy was 0.061, the service period – -0.040, the interlactation period – -0.013, the interpregnancy period – -0.045, and the reproductive capacity coefficient – -0.059.

On average, according to these reproductive features, the phenotypic consolidation amounted to -0.019. This confirms the low level of consolidation of intrabreed selection groups according to reproductive features. According to the milk productivity features, the degree of consolidation of the related groups under study, as well as groups of semi-siblings by father, was higher. The average milk yield of firstborn was 0.097, the fat content in milk – 0.011, its yield – 0.101, the protein content in milk – -0.009, the yield of milk protein – 0.090 (Table 6). On average, per five milk productivity features of cows over 305 days of the first lactation, the level of phenotypic consolidation of related groups was 0.058, which substantially exceeded that for reproductive features. The authors of this study tend to explain this by the priorities of breeding for dairy productivity.

An essential biological and at the same time economic criterion for the effectiveness of animals is their

reproductive capacity [37-39]. This is a complex feature that depends mainly on the duration of the service period and the generalising indicator – the reproductive capacity coefficient. It was proved that the factual parameters of the reproductive capacity of firstborn cows are somewhat inferior to the optimal ones. Considering the established natural antagonism of the milk productivity and reproductive features, the study compared the group average features describing the reproductive capacity at different levels of milk yield of firstborns (Table 7).

Table 7. *Reproductive capacity of Jersey cows with different milk yield of firstborns*

Group according to milk yield of firstborns, kg	Number of cows monitored	Duration of the period, days:				Reproductive capacity coefficient
		II pregnancy	Service period	Interlactation period	Between I and II calving	
Up to 7,000	31	276.9±0.78	93.5±5.81	58.2±0.81	370.4±5.85	0.99±0.015
7,001-8,000	34	279.9±0.56^{b}	112.5±10.10	60.6±0.90	392.4±10.19	0.95±0.021
8,001-9,000	41	279.5±0.63^{b}	127.6±9.95^{b}	60.5±0.69^{a}	407.1±9.93^{c}	0.91±0.020^{c}
9,001-10,000	29	279.7±0.65^{b}	162.0±13.26^{c}	61.3±0.78^{b}	441.7±13.10^{c}	0.85±0.023^{c}
Over 10,000	32	279.8±0.61^{b}	219.7±13.93^{c}	60.9±0.64^{a}	499.4±13.79^{c}	0.75±0.020^{c}

Notes: *^{a} – P<0.05, ^{b} – P<0.01, ^{c} – P<0.001*

An increase in the duration of biological reproductive periods led to a decrease in the reproductive capacity coefficient. It was found that the increase in milk yield of cows during the first lactation practically does not affect the duration of pregnancy and the dry period, except for their smaller value in animals with milk yield up to 7,000 kg. This is conditioned upon the high biological constancy of the pregnancy duration and the planning of the duration of the interlactation period by the livestock owner. Therewith, a stable and substantial decrease in the reproductive capacity coefficient due to the lengthening of the service period between the first and second calving was confirmed. Starting with milking more than 8 tonnes, the deterioration of reproductive features in firstborns acquires a statistically significant level (P<0.01... P<0.001). Such natural antagonism does not imply the goal of increasing the duration of the service period to obtain maximum milk yields for firstborn cows. The authors of this study believe that it is optimal to milk the firstborn up to 8 tonnes over 305 days of lactation while maintaining a satisfactory reproductive level.

Notably, cows with the lowest milk yield level among the general sample were also described by a shorter pregnancy duration compared to more productive animals (P<0.01, P<0.001). With an increase in the milk yield level, there is a likely increase in the duration of biological reproduction periods (service and interpregnancy). It was established [40] that apart from the milk productivity level, the reproductive features of cows are affected by the management decisions of each particular husbandry. Similar conclusions were also obtained in studies by other authors [41].

Regression analysis confirmed a direct correlation between the milk yield of cows (Y) and the duration of the service period (X), which is described by a linear equation of the form $y = 6443 + 18.3\ x$ (Fig. 1) by the coefficient of determination R^2=0.974. This equation describes 97.4% of cases. The presented histogram and graph illustrate a stable direct correlation between milk productivity and the reproductive capacity of cows. According to the established regression coefficient, the extension of the service period of cows by one day causes an increase in milk yield by 18.3 kg. The inverse regression equation (x over y) gives grounds to expect an extension of the service period by 29 days, with an increase in milk yield for every 1,000 kg. The trend line is reliable and demonstrates a high degree of approximation (coincidence) to the factual data, expresses the share of variation of the dependent variable determined by the correlation coefficient, i.e., how accurately the linear equation describes the data obtained in the experiment [42].

A linear model of milk yield changes over 305 days with an increase in the duration of the service period is also calculated. The equation has the form $y = 8107 - 3.5x$ for the determination coefficient R^2=0.980. This equation describes 98.0% of the sample cases.

As previously noted, increasing the milk yield for lactation by extending the service period cannot be considered a selection purpose, since this entails a decrease in the yield of calves and renders the timely herd replacement impossible. Variance analysis confirmed a substantial (up to 35.2%) and reliable (p<0.0001) effect of milk yield of firstborn cows on the phenotypic variability of the duration of service and interpregnancy periods and the reproductive capacity coefficient (Table 8).

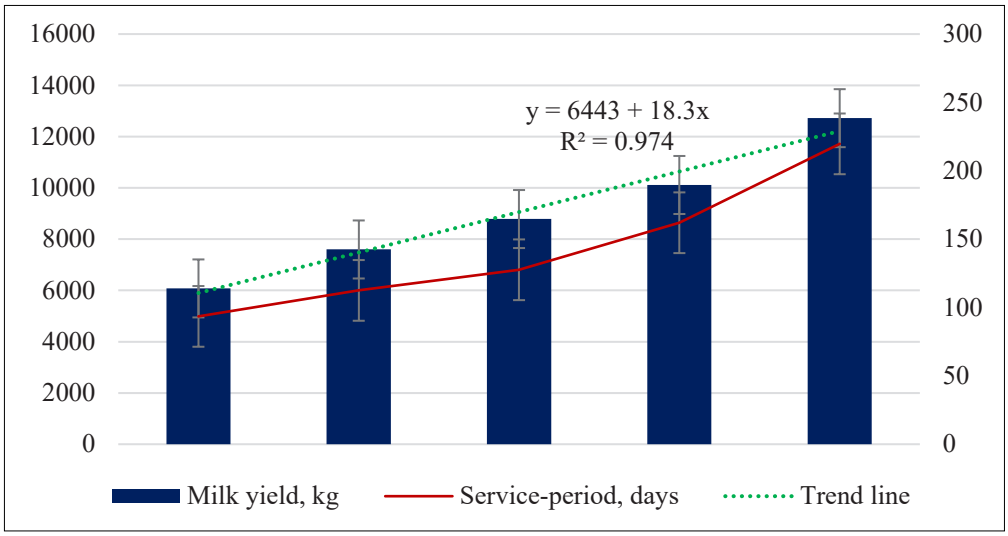

Figure 1. *Correlation between milk yield of cows during lactation and the service period*

Table 8. *The strength of the milk productivity effect on the reproductive capacity of cows*

Feature		F.	P	η_x^2 ± S.E., %
Number of degrees of freedom:	Factorial		4	
	Random		162	
Duration of periods, days:	Second pregnancy	3.65	0.0071	8.3±0.02
	Service period	20.01	<0.0001	33.0±0.02
	Interlactation period	2.27	0.0637	5.3±0.02
	Between I and II calving	20.77	<0.0001	33.9±0.02
Reproductive capacity coefficient		21.97	<0.0001	35.2±0.02

Notes: *F is Fisher's criterion, P is probability*

CONCLUSIONS

The substantial influence of breeding bulls on the economic utility features of the cows bred from them is proved, as evidenced by a statistically significant intergroup difference. Cows bred from DJ Jante 302761 (P<0.001) and Headline 114114336 (P<0.001) were described by the best quantitative indicators of milk productivity, while cows bred from Karl 67037285 were the worst. The highest indicators of fat and protein content in milk were noted in the cows bred from the bull Legal 61929249, the lowest – from the bull Karl 67037285. Paternal half-sisters bred from the bull Karl 67037285 are described by both the lowest milk yield and the lowest fat and protein content in milk, which indicates the inexpediency of further use of this bull (P<0.05, P<0.01, P<0.001). A substantial intergroup difference between half-siblings and fathers was also confirmed by univariate analysis of variance – the strength of the effect on milk fat and protein yield was 20.3-30.3% (up to P<0.001), for the content of fat and protein in milk – 13.2-20.0% (P<0.1 and P<0.05), for reproductive capacity features – 7.8-19.0% with an unreliable level of statistical significance.

Positive coefficients of potency for milking are inherent in bulls Legal 61929249 and milk yield improver Headline 114114336, which gives an additional selection advantage to the latter. According to the content and yield of milk protein, the bull Legal 61929249 can be considered prepotent, and according to the content and yield of milk fat and protein – milk yield improver Vernon 115863998. The highest level of prepotency for most features was the aggravator bull Karl 67037285, which makes it highly undesirable to continue using this breeder in the herd. The generalised consolidation coefficient for milk productivity features was 0.097, which is 8.8 times more than for reproductive features. This indicates the priority of selecting animals in this herd based on the features of milk productivity.

The study established a statistically significant level of differentiation of related groups according to features of milk productivity, and considerably lower level, unreliable in all cases – according to features of reproductive capacity. Cows of the related Observer 553236 group are characterised by the highest milk yield and

yield of milk fat and protein for both the first and best lactation, and cows of the related Surville 604694 group are characterised by the worst yield. The influence of belonging to a related group on the studied features was several times lower compared to the influence of paternal origin. The well-known antagonism between dairy and reproductive dominants was proved – there is a stable and substantial decrease in the coefficient of reproductive capacity due to the extension of the duration of service period and the period between the first and second calving, with a simultaneous increase in the milk yield.

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Оцінка плідників і споріднених груп джерсейської породи за молочною продуктивністю та відтворювальною здатністю потомства

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Анотація. У статті наведено результати досліджень щодо впливу походження за батьком та належності до спорідненої групи на рівень молочної продуктивності корів і відтворювальної здатності корів джерсейської породи в умовах ДП «Дан-Мілк» Житомирської області. Метою наукової роботи є встановлення впливу походження за батьком та належності до спорідненої групи на рівень молочної продуктивності та параметри відтворювальної здатності корів джерсейської породи. Встановлено істотний рівень диференціації за основними господарськи корисними ознаками між групами напівсестер за батьком. Кращими кількісними показниками молочної продуктивності відзначилися дочки бугаїв DJ Jante 302761 (P < 0,001) та Headline 114114336 (P < 0,001), найгіршими – Karl 67037285. Найвищими показниками вмісту жиру і білка у молоці відзначилися дочки бугая Legal 61929249, найнижчими – Karl 67037285. Вплив походження корів за батьком на мінливість надою і виходу молочного жиру і білка становив 20,3–30,3 % (до P < 0,001), вмісту в молоці жиру та білка знижувався до 13,2–20,0 % (P < 0,01 і P < 0,05), а за ознаками відтворювальної здатності – до 7,8–19,0% за недостовірного рівня статистичної значущості. Препотентними за надоєм є бугаї Legal 61929249 і Headline 114114336, за вмістом і виходом молочного білка – Legal 61929249. Найвищим надоєм і виходом молочного жиру і білка як за першу, так і за кращу лактацію характеризуються корови спорідненої групи Observer 553236, найгіршим – спорідненої групи Surville 604694. Вплив належності до спорідненої групи на досліджувані ознаки виявився у рази нижчий (0,2–10,5 %) порівняно зі впливом походження за батьком. Зі зростанням надою корів за першу лактацію спостерігається стабільне та істотне зниження коефіцієнта відтворювальної здатності через подовження тривалості сервіс- і періоду між першим та другим отеленнями. Такий природний антагонізм не означає мети збільшення тривалості сервіс-періоду задля отримання максимальних надоїв первісток, оскільки це призведе до зменшення виходу телят і унеможливить своєчасний ремонт стада. Оптимальним вбачається роздоювання первісток до 8 тонн за 305 днів лактації зі збереженням задовільного рівня відтворення

Ключові слова: джерсейська худоба, бугай-плідник, коротка лінія, надій, відтворення, консолідованість