STUDY ON PRODUCTIVITY LEVEL AND DEGREE OF GENETIC IMPROVEMENT IN A PRIVATE SECTOR DAIRY COW HERDS

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Abstract

The aim of present paper is to estimate the improvement value by the BLUP methodology - the repeatable animal model of Fleckvieh breeders whose semen was used by AI in females of the same breed. The following statistical estimators were determined: the arithmetic mean ($\bar{X}$), the error of the arithmetic mean ($\pm s_x$), the standard deviation (s), the coefficient of variability (V%), the genetic parameters. The graphical representation of the regression line was drawn up, the Pearson correlation, Chi-Square Tests, ANOVA Test, p Significance Test, confidence interval (CI) and breeder impovement value were estimated. After comparing the main productive characters between ancestry (M- 8155.45 kg milk) and descendance (6735.27 kg milk) it was observed that the latter have lower productions even if their genetic potential is high. It can be concluded that the influence of environmental factors related to growth technology, feeding and climate has an important role in the phenotypic manifestation of production characters influencing the productive level. If it is desired to improve the milk production in the herd analyzed, the bull with registration number 73869 should be used for reproduction, for which the best improvement value of 129.8073 kg was estimated for the character milk quantity milk. The bull is also a breeder for other traits of milk production.

Keywords: *BLUP, Fleckvieh, milk, descendance, bull*

INTRODUCTION

Animals are exploited as a source of high-quality protein, lipids and micronutrients necessary for humans to survive, as they have the ability to convert forage unsuitable for human consumption (eg. grass) into meat, milk and eggs.

It is known that the productions of animals are the expression of the interaction between genes and the environment (Georgescu et al. 1988).

The selection of animals involves their testing, the finality being the prediction of the breeding value, which is not a goal in itself in the character improvement process, but the obtained values are decisive in the breeding process (Pipernea, 1979).

In the entire process of breeding livestock, three major sources of inducing genetic progress are used:

- the selection of primiparous by testing according to their own performance - induces a 20% progress;
- selective reform - determines a genetic progress of 10%;
- breeding bulls that are the most important source of genetic progress that can reach a percentage of 61-70% (43-52% through sons and 18% through daughters) (Maciuc, 2006).

The BLUP methodology is based on the phenotypic records of the selection candidates but also on the matrix of additive relationships between the individuals in the population, information obtained from genealogical records (Grosu et al. 1997).

Regarding the BLUP methodology – the animal model with repeatability, it was applied to estimate the breeding value of a breeder bull according to descendant performance, for a quantitative trait that repeats phenotypically several times in the

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productive life of cows such as the amount of milk with all other related characters (% fat and % protein, amount of fat and protein etc.). With the help of this calculation model, a bull can be tested and his transmission capacity / breeding value can be reassessed whenever daughters are born.

MATERIAL AND METHOD

The farm whose batch of cows was the object of the study is located in the mountainous area of Suceava county. The production technology is adapted to the mountain area and the fact that the farm has a small herd of animals: stables during the cold season (October 1 – May 15) and during the grazing period, which starts on May 15, the animals graze on natural meadows from the area.

The cows for which the primary data was processed in order to estimate the breeding value of bulls, belong to Fleckvieh breed and are animals of known origin attested with a certificate, being registered in the official production control.

Data for 3 total and normal lactations were processed. The highest production of cows was recorded in the 2nd lactation when an average total lactation production of 9140.45 kg of milk was achieved, with a minimum of 7704 kg and a maximum of 10967 kg.

The statistical processing of the primary data was carried out using the following computer programs: SAVC (Statistical Analysis of Variance and Covariance) respectively SPSS 16.00 for WINDOWS. It was possible to determine the following statistical estimators: arithmetic mean ($\overline{X}$), error of the arithmetic mean ($\pm s_{\overline{x}}$), standard deviation (s), coefficient of variability (V%), genetic parameters (heritability, character correlations). Also, the graphical representation of the regression line was drawn up, the Pearson correlation, Chi-Square Tests, ANOVA Test, p Significance Test, confidence interval (CI) and improvement value were calculated for milk production traits.

The formula for calculating *the arithmetic mean* ($\overline{X}$) is well known, being the ratio of the sum of the values of the observations relative to their number: $\overline{X} = (\sum X)/N$.

The formula for calculating the *variance* S^2 is:

$$\left(S^2\right) = \frac{\Sigma x^2 - \frac{\left(E_X\right)^2}{N}}{N-1}$$

The standard deviation is expressed in the same unit as the corresponding variable and the relationship by which it is determined in the following: $s = \sqrt{S^2}$.

The standard deviation of the mean is calculated according to the formula:

$$s_{\overline{x}} = \sqrt{\frac{S^2}{N}} = \frac{s}{\sqrt{N}}$$

The coefficient of variation (V%) has the following calculation formula:

$$V\,\% = \frac{s}{\overline{\overline{X}}} \times 100$$

The REML (Restricted or residual, or reduced Maximum Likelihood) method is a statistical data processing method and was used to determine the values of the genetic parameters. This method is based on an iterative process of maximizing a function (Maciuc et al. 2003; Ivancia, 2020). For an efficient evaluation it is expected that the number of iterations required is also high. In our case, the final convergence was 100% and the number of iterations was 130.

The animal linear mixed model with repeatability is as follows:

$$Y_{ijkm} = r_i + f_i + a_k + p_k + e_{ijkm}$$

where:

-Y_{ijkm} - measured performance of cow k achieved within the farm combination - year j, lactation i;

-r_i - fixed effect of lactation rank;

-f_i - the fixed effect of the firm-year combination;

-a_k - additive (random) genetic effect of the individual;

-p_k - the permanent (random) environmental effect of the cow;

-e_{ijkm} - random error (Grosu et al. 1997; Robinson, 1991).

RESULTS AND DISCUSSIONS

Table 1. Statistics of milk production in the ancestry of the cattle herd studied

The ascendancy	Characters	n	$\overline{X}$	$\pm s_{\bar{x}}$	S	V%	Minimum	Maximum
M[1]	Milk Kg	11	8155.45	120.707	716.963	27.576	996	12277
	fat %	11	4.09	0.162	0.538	13.134	3.2	4.95
	Fat Kg	11	334.55	45.073	149.491	44.685	32	498
	Protein %	11	3.45	0.057	0.19	5.502	3.13	3.71
	Protein Kg	11	277.18	39.341	130.481	47.074	32	439
	F+P[4] Kg	11	611.73	83.167	275.835	45,091	64	879
FM[2]	Milk Kg	11	11986.45	244.159	809.785	6.756	10816	13544
	fat %	11	4.32	0.165	0.549	12.711	3.7	5.64
	Fat Kg	11	516.45	20.632	68.427	13.249	431	677
	Protein %	11	3.4	0.042	0.14	4.115	3.2	3.66
	Protein Kg	11	408.09	10.728	35.579	8.718	346	465
	F+P Kg	11	924.55	27.853	92.378	9.992	803	1116
MM[3]	Milk Kg	11	9242.82	471.252	926.289	24.087	5479	13554
	fat %	11	4.16	0.124	0.412	9.91	3.2	4.74
	Fat Kg	11	383.91	29.52	97.907	25.503	241	537
	Protein %	11	3.42	0.079	0.263	7.686	2.97	3.9
	Protein Kg	11	314.36	22.886	75.906	24.146	212	469
	F+P Kg	11	698.27	51.669	171.366	24.541	453	1006

[1]Mother; [2] Father's Mother; [3] Mother's Mother; [4]Fat + Protein

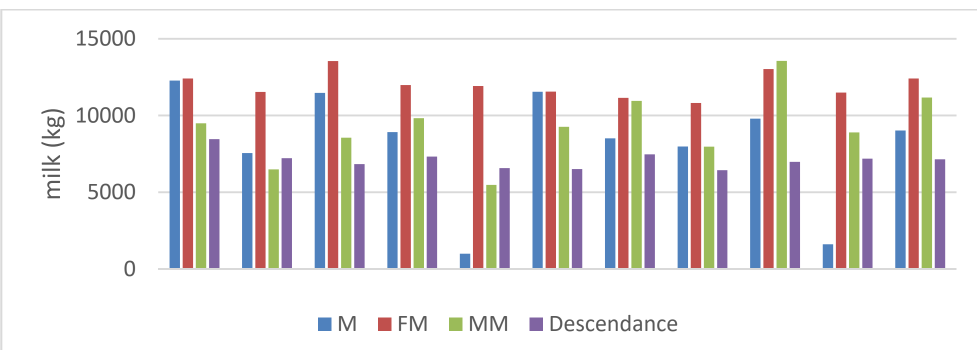

Fig. 1. Comparative representation of milk production for ancestry and descendance

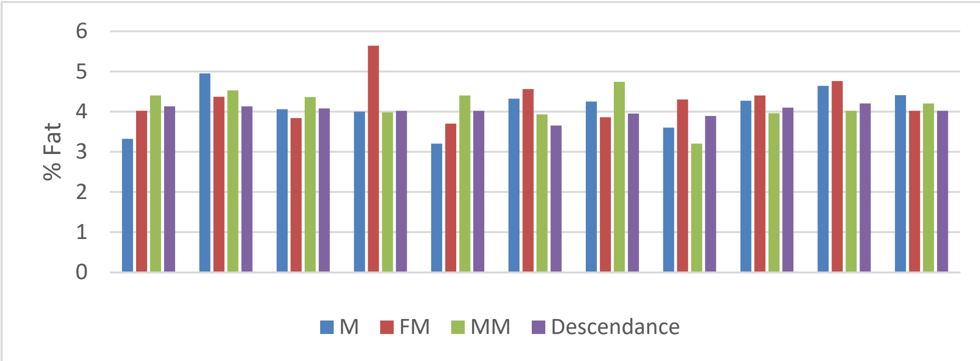

Fig. 2. Comparative representation of milk fat percentage for ancestry and descendance

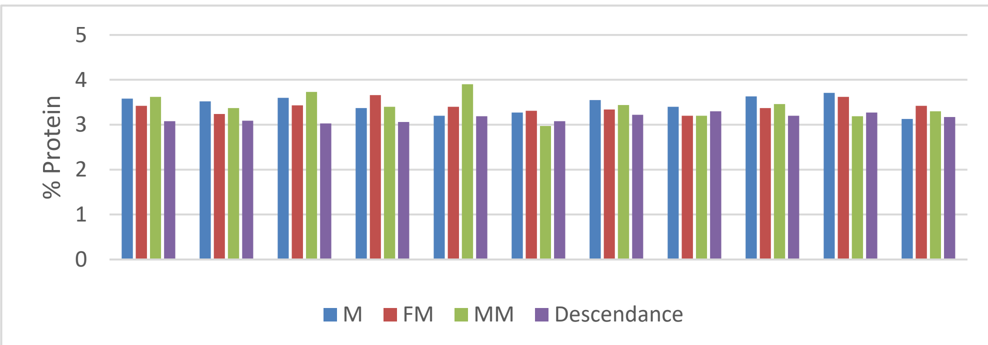

Fig. 3. Comparative representation of milk protein percentage for ancestry and descendance

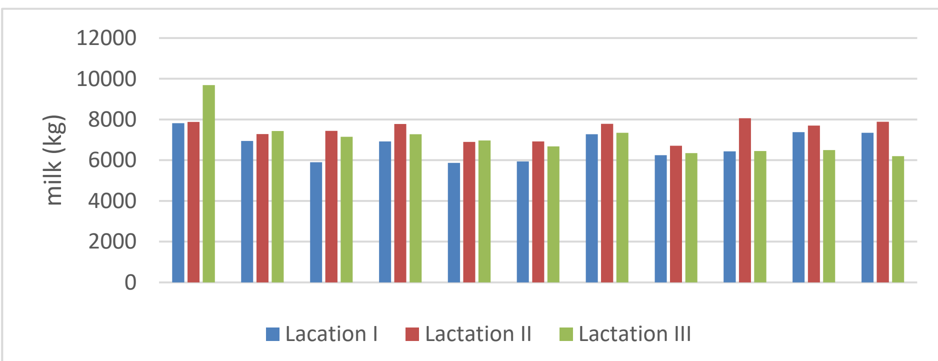

Figure 4. Representation of the quantitative evolution of milk production in normal lactations for each descendent

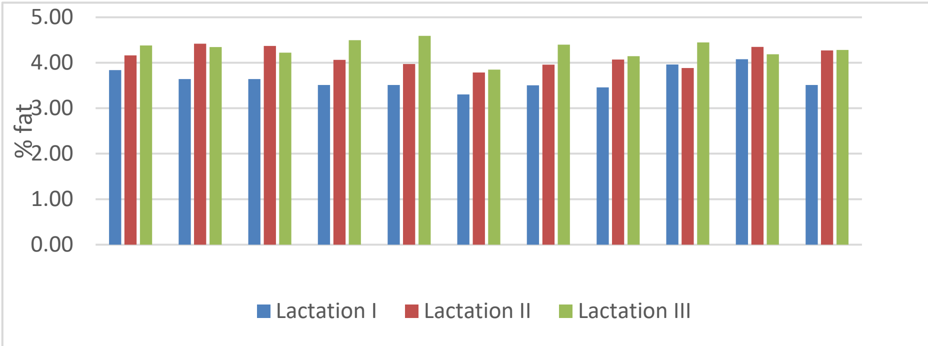

Figure 5. Representation of % fat for normal lactations of each descendent

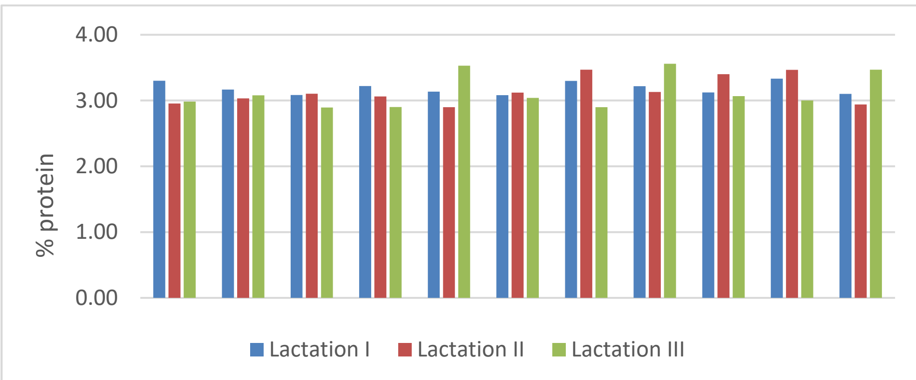

Figure 6. Representation of % protein for normal lactations of each descendent

The processing of the primary data also involved the calculation of the estimators: the arithmetic mean, the standard deviation, the standard deviation of the mean and the coefficient of variation. The last estimator gives us clues about the homogeneity of the population. In the case of mother cows, we have the following situation:
-for the % protein character, the sample is homogeneous;
-for % fat, the sample is medium homogeneous;
-for the rest of the characters considered, the sample is heterogeneous.
In the case of cows that are paternal grandparents:
-the homogeneity of the sample is observed in the case of milk production, then for % and the amount of protein as well as for the total amount of F+P (kg).
-average homogeneity is observed in the case of the amount of fat.
-the sample is not characterized by heterogeneity for any character.

If we analyze the group of maternal grandparents, we can conclude that:
-homogeneity is in the case of the characters % fat and % protein and for the rest of the characters the sample is characterized by heterogeneity.

Regarding the arithmetic averages calculated for milk production, percentage and amount of fat, it can be seen from table 1 that:
-the average amount of milk, which is 8155.45 kg in the case of mothers, is lower in value than the average in the case of maternal grandmothers (9242.82 kg) and paternal grandmothers (11986.45 kg).

The mean milk fat and protein percentages are approximately the same in the ancestry for the mentioned generations: M-4.09%, MM-4.16%, FM-4.32% and respectively M-3.45%, MM-3.42%, FM-3.4%). Regarding the amount of fat and protein, the average with the highest value is in the case of the paternal grandmother: 516.45 kg and 408.09 kg respectively. Quantitatively, milk protein and fat, estimated by the synthetic index „F+P" (kg) being correlated with milk production, has the same evolution as milk production.

In the case of the progeny, statistical data processing was done for the first three total and normal lactations. Although the ancestry is very valuable for the production characters (milk quantity, fat and protein percentage) and the values are good, they are still inferior to the mothers and grandmothers: 6735.27 kg of milk is the average production in the first normal lactation (total: 6968.27 kg), 7486.64 kg of milk in the second (9140.45 kg) and 7095.27 kg of milk in the third lactation (total: 8179.45 kg). The average fat percentage is also lower: 3.63% (min. 3.3% and max. 4.08%), 4.12% (min. 3.79% and max. 4.42%) and 4.3% (min. 3.85% and max. 4.59%) compared to the average values expressed in ascendancy: M-4.09%, FM-4.32% and MM-4.16%.

The same situation is also observed when we compare the percentage values for protein which, in the case of cows in the batch, has the following values: 3.19% in the first lactation, 3.14% in the second and 3.13% in the third lactation.

In addition to milk production and the other characters for which the statistical processing of the data in the ancestry was done, estimators for the duration of total and normal lactation, age at first calving AFC, Service period SP, Calvin interval CI and mammary rest were also calculated.

The age at first calving – AFC, has an optimal value: 833.64 days≈27.79 months. In the case of the Service period, it has an optimal average value of 568.64 days in the case of heifers and 84.27 days for the second lactation, but having a high value in the case of females in the third lactation: 126.36 days.

-Calvin Interval is another reproductive index for which we have an optimal average value of 374.27 days in the 2nd lactation and a higher value of 417.18 days after the 3rd lactation.

-Breast rest is on average higher at the end of the second lactation (which is also the largest quantitatively) having a value of 73.36 days, falling within the optimal range of recommended days for the third lactation: 55.64 days.

From the analysis of the values of the coefficient of variation v% regarding the homogeneity of the batch for the characters considered in the case of normal lactations, we conclude:

- it is homogeneous for the characters % fat and % protein for all three lactations but also for the amount of milk and fat in the case of the second lactation;
- it is a homogenous environment for all three lactations in terms of the amount of protein but also the production of milk and the amount of fat in the case of the first and third lactations.

The batch of cows is homogeneous for VP characters, homogeneous medium for SP values in the 1st lactation and heterogeneous for the 2nd and 3rd lactations. Also, it is homogeneous for CI in the 2nd lactation and heterogeneous in the case of the 3rd lactation.

Table 2. Genetic parameters for the properties of milk production in the herd studied
(G matrix convergence – 99.99 %, R matrix convergence – 99.98 %, No. of iterations 170)

The character	Heritability (h^2)	Variance due to additive genes	Intralot variance	Total variance
Milk Kg	0.20	62918.581	398198.25	461116.83
Duration of lactation days	0.25	88.5571	503.8833	415.3262
fat %	0.61	0.0019	0.0119	0.0138
Fat Kg	0.25	73.4716	677.8188	751.2904
Protein %	0.55	0.0011	0.0025	0.0036
Protein Kg	0.24	95.724	482.575	578.299
AFC[1]	0.27	3108.3559	7215.7688	10324.125

[1]age of first calvin

In the case of the group of descendants, it is observed that for most of the characters related to milk production the heritability coefficient h^2 has low values, the genetic determinism being therefore weak, with the exception of % fat and % protein which are highly heritable characters.

It can also be observed that of the total phenotypic variance, the one due to individual variability (intralot variance) is very high for all characters, but especially in the case of milk production and duration of lactation in days.

The analysis of correlation and covariance between characters are contained in table 3. Thus:

-milk production is strongly positively correlated with the amount of fat and protein;

-are moderately positively correlated: the duration of lactation with % fat and with the amount of fat and protein respectively, then the percentage of fat with the amount of fat, % protein, the amount of protein but also the character amount of fat with % protein and the percentage of protein with the amount of protein.

The analysis of the values obtained through statistical processing was done for error probabilities $p < 0.05$ and $p < 0.01$, which means that there are significant statistical links.

Based on the values obtained through the statistical processing of the data for the correlation coefficient (Pearson coefficient) by which the linear correlation between two variables is expressed, a very strong positive association between the characters resulted:

- milk production and the amount of fat and protein,
- the duration of lactation and the amount of protein,
-the percentage of fat from the first lactation and the amount of protein,
-the amount of fat and the percentage and amount of protein,
-the percentage of protein and the amount of protein,
-age at first calving and Service Period calculated for heifers.

There is strong association between the following characters:

- the duration of lactation and the amount of fat and % protein;
- the percentage of fat and the percentage and amount of milk protein;
- the amount of protein and breast rest.

Weak and moderate negative correlations are between characters:

-the amount of milk and the percentage of fat and protein;
- mammary rest and the amount of milk, the duration of lactation, the amount of fat, the percentage of protein.

Table 3. Phenotypic, genetic and environmental correlations for milk production characteristics in the studied herd (G matrix convergence – 99.99 %, R matrix convergence – 99.98 %, no. of iterations 170)

Character 1	Character 2	Phenotypic correlation	Genetic correlation	Environmental correlation	Genetic covariance	Intralot covariance	Total covariance
Milk	Duration of lactation	0.27	0.23	0.31	115.0204	7675.3458	7560.3254
Milk	fat %	-0.22	-0.20	-0.23	-9.7994	14.0544	-23.8537
Milk	Fat Kg	0.98	0.99	0.98	2124.4674	16151.273	18275.74
Milk	Protein %	-0.20	-0.19	-0.22	-1.2341	-5.5289	-6.763
Milk	Protein Kg	0.89	0.83	0.93	2216.9061	13754.442	15971.348
Milk	AFC	-0.24	-0.22	-0.27	-25889.76	25276.473	-613.2834
Duration of lactation	fat %	0.40	0.37	0.45	0.1039	1.1908	1.0869
Duration of lactation	Fat Kg	0.49	0.32	0.57	6.7743	257.9625	264.7368
Duration of lactation	Protein %	0.29	0.24	0.30	0.0135	0.0755	0.089
Duration of lactation	Protein Kg	0.58	0.43	0.60	23.5764	253.1917	276.7681
Duration of lactation	AFC	0.23	0.17	0.24	-230.2704	717.7792	487.5087
fat %	Fat Kg	0.41	0.39	0.39	0.2975	0.0872	0.3847
fat %	Protein %	0.34	0.27	0.37	0.0011	0.0006	0.0017
fat %	Protein Kg	0.29	0.25	0.31	0.2268	0.4637	0.6905
fat %	AFC	-0.16	-0.13	-0.24	-2.2179	0.1267	-2.0912
Fat Kg	Protein %	0.39	0.35	0.41	0.0798	0.2818	0.3617
Fat Kg	Protein Kg	0.96	0.79	0.99	79.2608	561.0667	640.3275
Fat Kg	AFC	-0.15	-0.18	-0.23	-1150,804	1075.7438	-75.0601
Protein %	Protein Kg	0.47	0.39	0.48	0.0814	0.3148	0.3962
Protein %	AFC	-0.18	-0.17	-0.23	-2.2916	1.1779	-1.1137
Protein Kg	AFC	-0.19	-0.18	-0.21	-900.8395	913.35	-12.5105

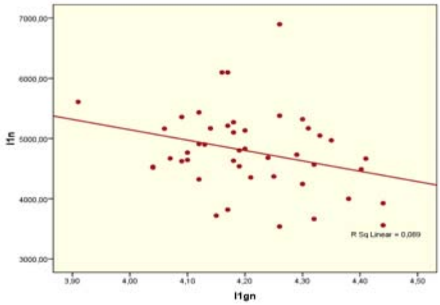

Figure 7. Regression line for milk quantity and fat percentage

According to the orientation of the regression line in figure 7, we have a negative and significant relationship between the amount of milk and the percentage of fat. So, when the amount of milk increases, the percentage of fat or the quality of the milk will decrease. The confidence interval is 95%.

From the representation of the regression line in figure 8, it emerges that between the amount of milk and the amount of fat we have a positive and very significant relationship (82%).

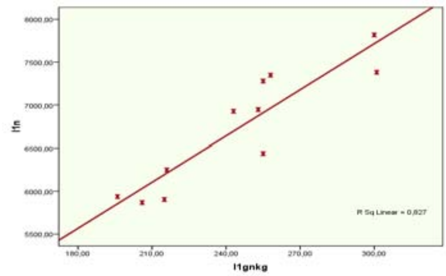

Figure 8. Regression line for milk amount and fat amount

So, when the amount of milk increases, so will the amount of fat. The link is very close as it indicates the coefficient obtained and the points in the graph that are arranged along and on the right of the regression. The confidence interval is 95%.

The solutions of the system of linear equations solved by the BLUP methodology, animal model with repeatability, for the tested bulls represent the transmission capacity of each one, respectively the deviation of the mean of the offspring from the mean. Based on the transmission capacity of the characters, the improvement value of the male is calculated according to which, separately for each character, their ranking was made as shown in the following table.

Table 4. Centralizer of breeding values for the studied herd

Registration number	Milk production	% fat	Fat (kg)	% protein	Protein (kg)	AFC	CI
73869	**129.8073**	0.0718	7.9355	0.0389	**6.8655**	-10.4727	-5.3718
53439	77.4873	**0.1546**	**8.0805**	**0.0492**	4.9455	-10.4727	5.8382
940100513	73.5273	-0.042	1.8455	-0.0301	2.0655	-10.4727	-4.0418
4677522	65.1273	-0.0455	1.4105	0.0389	3.9855	-3.2727	**14.0082**
52033	25.2873	0.0028	1.1205	-0.006	0.7855	3.9273	-2.7118
54548	22.8873	-0.042	-0.3295	0.0113	1.2655	**47.1273**	2.7982
894501519	-35.7927	0.1132	1.4105	-0.0232	-2.2545	-3.2727	-1.7618
554074222	-58.4727	-0.0593	-4.2445	0.0113	-2.2545	-10.4727	0.1382
948300739	-95.7929	-0.1145	-7.1445	-0.037	-5.1345	-17.6727	-3.6618
947291829	-99.8727	0.0028	-4.3895	-0.037	-5.2945	11.1273	-3.0918
573845918	-104.1927	-0.042	-5.6945	-0.0163	-4.9745	3.9273	-2.1418

After estimating the breeding value for the milk production character, 6 of the 11 bulls are improvers, the most valuable bull being the one with the registration number 73869 which has the transmission capacity of 64.9036 kg.

To improve the milk fat percentage, 5 of the 11 bulls tested and ranked according to the values in the table can be used.

For the trait „Kg milk fat”, the bull with registration number 53439 is the breeder whose breeding value is the highest among the 6 breeding bulls.

Conversely, if improvement in milk protein percentage is sought, then the semen of bull number 53439 should be used, as this breeder has the highest breeding value for this trait. In addition to this bull, there are 4 more bulls.

To improve the amount of protein (Kg) in the milk, 6 of the 11 bulls can be used, the bull with registration number 73869 having the highest breeding value.

CONCLUSIONS

The average productions of the progeny are good but are inferior to any of the ancestry (mother and grandparents). In the second lactation, milk production is the highest. The fact that the analyzed quantitative characters have a low heritability coefficient means that the influence of the environment largely determines their phenotypic manifestation.

Considering the fact that the ancestry is very valuable, the productions with lower values in the descent are explained by the influences of the environmental factors related to the applied technology and the macro- and microclimate conditions.

To improve the performances of these females, it is recommended:

- reformulation of fodder rations depending on the physiological state especially;
- monitoring environmental factors and especially microclimate factors that can be a source of stress: temperature in the stable, humidity, air currents, etc.;
- compliance with mammary rest.

Regarding the improvement value of the tested bulls, if it is desired to improve the milk production in a herd, the bull with the registration number 73869 will be used for AI, for which the best improvement value for this character was estimated, namely 129.8073 kg of milk.

Even if it does not have the highest improvement value in the grid for milk production, the bull with registration number 53439 can be considered the best option among all males for improving milk production but also for the other characters considered.

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