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STUDY ON THE PERFORMANCE OF MILK PRODUCTION AND GENETIC PARAMETERS IN A HERD OF FLECKVIEH COWS EXPLOITED IN A FARM FROM THE NORTH-EAST OF ROMANIA

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Abstract. *The present study analyzes the level of productions achieved in a herd of Fleckvieh cows in normal lactations and the values of the genetic parameters. The statistical estimators were calculated with the S.A.V.C. computer program and the genetic parameters were estimated using the REML method. In the case of normal lactations, the highest production average is 7,122.91 kg reached in the third lactation, with 4.14% fat content and 2.99% protein. The heritability of milk production is 0.21 and this character is genetically correlated very strongly with the amount of fat and that of the protein, the coefficient value being 0.99 and respectively 0.88. The average productions of the cows are very good but all values are inferior compared to those in the ancestry, where for father's mother are the highest, 10,929.47 kg. Then cows do not phenotypically express their genetic potential due to the influence of external environmental factors.*

Keywords: Fleckvieh, phenotype, variability, heritability, correlations.

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1. Introduction

The improvement of dairy herds has been carried out for decades in order to increase the productive performance of dairy cows, but this has led to the worsening of many functional traits that are negatively correlated with milk production. Therefore, although increasing milk production and milk quality (fat

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and protein content) is a priority for the profitability of dairy farming, other traits are now also taken into account for selection such as mechanical milking capacity, udder health, resistance to disease (e.g. against mastitis and internal parasites) and heat stress, even the nutritional value of milk (e.g. fatty acid composition). New approaches in cattle selection are shifting the emphasis of selection traits away from milk production to include traits related to milk quality and other non-productive traits [6, 9].

In order to form the nucleus of selection, the superior genotypes in the population subject to selection are identified and the sources of phenotypic and genotypic information are used to estimate the breeding value of the breeding stock, after which the individuals in the population are ranked [8]. Phenotypic selection is routinely applied to cows and genotypic selection, due to high costs, is mainly applied to bulls used for artificial insemination.

Milk yield is a quantitative characteristic of milk production for which continuous selection has been and will continue to be carried out. Productive performance is the result of genetic selection, herd management and ensuring an optimal environment. In the case of specialized breeds, productions of 10,000 kg milk per lactation (305 days) or even higher are not uncommon under intensive animal husbandry conditions [11, 16].

For the efficient application of any breeding program the components of variance must be known and genetic parameters calculated and a prerequisite is the availability of reliable phenotypic data and pedigrees, which allow the estimation of accurate genetic parameters [15, 13].

Heritability, one of the genetic parameters, depends on genetic and phenotypic variation [14, 3]. For h^2 values above 0.5, the additive genetic variance plays a role in determining the respective traits, and as a result, their improvement by selection yields certain results. For traits with low heritability (30%), genetic progress can be achieved only if, in addition to one's own phenotype, the phenotype of one's own offspring, collateral relatives and offspring is taken into account in selection

Milk production parameters include quantitative (milk quantity, fat, protein and lactose) and qualitative (percentage of fat, protein and lactose) elements. International regulations stipulate that the milk production of bulls is expressed as milk quantity, pure fat and pure protein for 305 lactation days of the cow [7].

2. Materials and methods

The biological material consists of a herd of 43 primiparous and multiparous cows belonging to the mixed Fleckvieh breed (Simmental strain), which have completed their lactation between 01.01.2023 and 30.05.2024. These cows are exploited for milk production in a semi-intensive system on a farm located in Iași County, North-East Romania. The cows are kept in free stalls and feed from stock, with a monodiet ration (TMR), providing them with the necessary nutrients in accordance with their physiological condition and productive performance. Milking is carried out twice a day in the milking parlor.

The primary data related to the performance of the progeny are those obtained from the Herd Register and those related to the productive performance of the progeny were obtained from the bull association that carries out the official control of the production, from the National Agency for Animal Husbandry (ANZ) and from the management program Afimilk implemented on the farm. The progeny performance was analyzed for 5 lactations with the specification that the number of cows in 5th lactation is small and not statistically relevant.

All collected data were statistically processed by Prof. Vasile Maciuc from U.S.V. Iași. For this purpose, the computer program S.A.V.C. was used to determine the value of the main estimators: arithmetic mean ($\overline{X}$), arithmetic mean error ($s_{\bar{x}}$), standard deviation (s), coefficient of variation (CV%) [10, 5].

The arithmetic mean ($\overline{X}$) is the first and most important numerical characteristic of a set of observations. The value of the mean for a random variable is the quantity obtained by dividing the sum of the different values of the variable (Σx) by the number of corresponding observations (N). The arithmetic mean is given by the relation:

$$\left(\overline{X}\right) = \frac{\Sigma X}{n} \tag{1}$$

Variance (S^2) is one of the measures of variability that corresponds to the amount of variation in the trait or phenomenon under study. The number underlying this measure is the sum of the squares of the deviations from the mean resulting from the relation:

$$\sum\left(X - \overline{X}\right)^2 \tag{2}$$

The sum of squares is not used, as such, as a measure to express the size of the variance, but the mean square of the deviations (variance) S^2, calculated according to the relation:

$$\left(S^2\right) = \frac{\Sigma x^2 - \frac{(E_X)^2}{N}}{N-1} \tag{3}$$

Standard deviation (s) is the most widely used characteristic of dispersion, it is the main measure or estimate of the variability and the degree of dispersion of the variables around the mean. The standard deviation is an absolute figure and is measured with the same unit as the corresponding variable and is determined by the relation:

$$s = \sqrt{S^2} \quad (4)$$

Arithmetic mean error ($s_{\bar{x}}$) este valoarea care arată abaterea sau eroarea mediei aritmetice empirice $\overline{X}$ faţă de media adevărată teoretică. Este o cifră absolută şi, ca şi media şi abaterea satndard, se exprimă în unităţi de măsură şi se calculează după formula:

$$s_{\bar{x}} = \sqrt{\frac{S^2}{N}} = \frac{s}{\sqrt{N}} \quad (5)$$

Coefficient of variation (CV%) indică direct variabilitatea relativă a populaţiei faţă de medie, adică gradul de omogenitate a populaiei. Se calculează după relaţia:

$$CV\,\% = \frac{s}{\overline{X}} \times 100 \quad (6)$$

Genetic parameters were estimated by the R.E.M.L. (Restricted / residual / reduced Maximum Likelihood) method which is based on an iterative process of maximization of a function. In our case, the final convergence was 99.99% and the number of iterations 73. The statistical processing of the data was performed for the ancestry (M, MM and FM) and for the daughters forming the herd of offspring studied. Milk production statistics were also calculated for the main quantitative and qualitative parameters and the results are centralized in tables and graphically represented.

3. Results and discussions

Following the values obtained from the statistical processing of the primary data, the statistical values for the main characters of milk production in the case of the lineage, namely for the maternal cows and maternal and paternal grandmothers, respectively, are presented in Table 1.

Table 1. Statistics on milk production in the studied herd

Ancestry	Traits	N	$\overline{X}$	$\pm s_{\bar{x}}$	S	CV%	Min	Max
Mother (M)	Milk production-kg	41	7,388.76	165.559	1,060.097	14.347	4,607	10,057
	Fat - %	41	4.15	0.023	0.148	3.557	3.71	4.4
	Fat - kg	41	305.8	6.54	41.876	13.694	202	424
	Protein - %	41	3.29	0.05	0.32	9.732	2.56	3.64

	Protein - kg	41	237.05	7.411	47.456	20.019	24	301
	Total amount of fat + protein (kg)	41	544.27	12.359	79.136	14.54	316	703
Father' mother (FM)	Milk production-kg	32	10,929.47	241.339	1,365.217	12.491	9,290	13,270
	Fat - %	35	4.33	0.045	0.268	6.202	3.58	4.84
	Fat - kg	32	471.34	12.305	69.606	14.767	372	539
	Protein - %	35	3.5	0.021	0.123	3.503	3.11	3.86
	Protein - kg	32	379.72	7.701	43.566	11.473	327	421
	Total amount of fat + protein (kg)	32	851.06	19.753	111.74	13.129	711	960
Mother' mother (MM)	Milk production-kg	28	7,434.07	166.167	879.274	11.828	6,055	10,247
	Fat - %	38	4.2	0.038	0.234	5.566	3.62	4.88
	Fat - kg	28	310.43	7.808	41.316	13.309	249	438
	Protein - %	38	3.47	0.028	0.172	4.957	2.84	3.74
	Protein - kg	28	255.14	6.339	33.542	13.147	210	353
	Total amount of fat + protein (kg)	28	565.57	13.823	73.145	12.933	466	791

From the analysis of the average values obtained, it can be concluded that the milk yields are very good, being over 7,000 kg of milk with an average fat content between 4.15 - 4.33% and protein content between 3.29 - 3.5%.

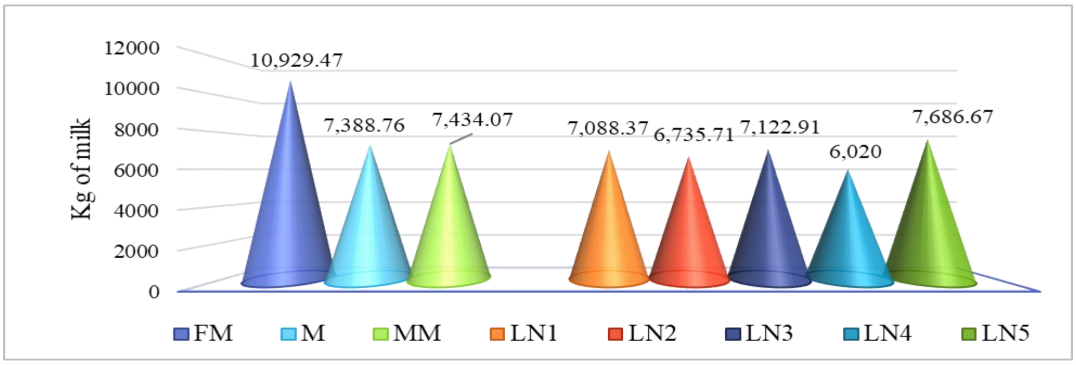
For the maternal grandmothers group the average milk yield is 7,434.07 kg with the maximum performance recorded for the plus variant of 10,247 kg. The average milk content is 4.2% fat and 3.47% protein. In the case of mothers, the average production is slightly lower at 7,388.76 kg milk with the maximum performance value of 10,057 kg milk.

The bulls whose semen was used for AI belong to the German and Austrian Fleckvieh breeds and have a very valuable pedigree. Milk production performs best in the paternal grandmothers group (MM), averaging 10,929.47 kg milk per lactation, plus variants having productions of 13,270 kg. Although the milk yields are the highest in the ancestry, the percentage fat and protein contents have the highest values of 4.33% and 3.5% protein respectively. In terms of fat and protein, they are again the highest at 471.34 kg and 379.72 kg respectively.

Fat and protein percentages are traits for which the ancestry is characterized by homogeneity, with coefficient of variability (CV%) values less than 10%. Milk yield, however, is a trait with medium variability, with CV% values ranging from a minimum of 11.828% for MM to a maximum of 14.347% for group M.

With regard to the amount of fat and protein per lactation, traits correlated with milk production, it can be observed that the groups of females are medium homogeneous, with a slightly higher degree of heterogeneity in the case of M for protein production.

The fact that the mean values of milk quantity and quality indicators are lowest in dams and that the variability of traits is higher in this group, draws attention to the influence of external environmental factors determined by the rearing and farming technology and also in terms of semen used in artificial insemination of MM.



LN – normal lactation

Fig. 1. Dynamic of milk productions in ancestry and descendance

In the Fleckvieh herd the average value of the normal lactation duration is increasing from the first to the third lactation which has an average duration of 302.64 days. The lowest average value is recorded for the fourth lactation and is 291 days.

The specialized literature specifies that the maximum lactation of this breed is the IV-Vth lactation and that the productive performance of the first lactation represents approx. 65-66% of maximum production [10, 1, 4]. The average production of the offspring has a sinuous evolution from one lactation to the next, the highest average value being in the third lactation, 7,122.91 ± 209.19 kg. The averages are lower than those of the cows of maternal ancestry and, compared to the FM group, the maximum production is 65.17% of the FM group.

The milk production is a characteristic with diverse variability, in the second lactation the offspring group is homogeneous, medium homogeneous in the first lactation and heterogeneous in the other lactations. The quality of the milk is very good, with an average milk fat content of between 4.14 and 4.24 % and protein content of between 2.99 and 3.20 %. The herd is homogeneous for these traits, except for the first lactation where, for the milk protein percentage, there is a higher variability for the value CV% = 12% in this case.

In the maximum lactation, when the average milk yield is also the highest, the highest values for fat and protein are recorded, 294.73 kg and 213.27 kg respectively. For these traits, the studied herd is average homogeneous for all lactations, except in the third lactation where the CV% = 9.741 for the fat content, which means that the herd is homogeneous.

In the second lactation the milk yield is lower than in the first lactation and the latter is close in average yield to the third maximum, of which it accounts for 99.56%.

As can be seen in the graphical representations in Fig. 2 and Fig. 3, for both fat and protein, the maximum values of the productions reached in the third lactation in the descendance are lower than any of the average values in the ancestry.

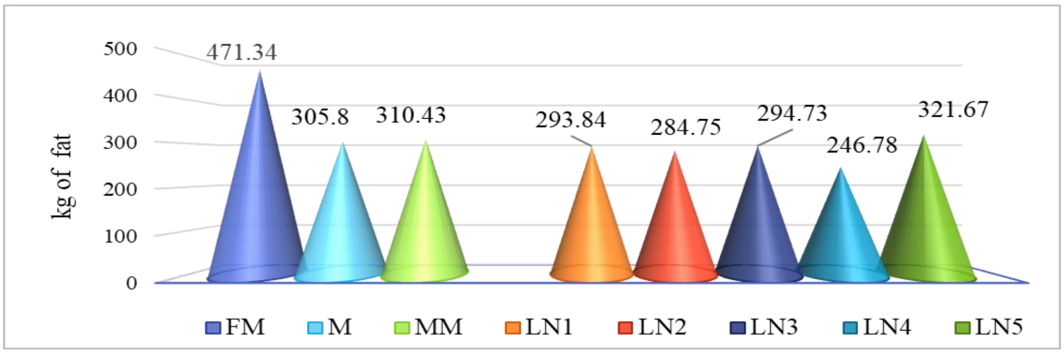


Fig. 2. Dynamic of quantities of fat produced in ancestry and descendance

Thus, in terms of fat content, daughter cows achieve an average of 294.73 kg in maximum lactation, a value close to that of group M but much lower than that of MF, 471.34 kg of which represents 62.53%. Similarly, a similar situation can be observed by analyzing Figure 3, which plots the performance achieved in terms of the amount of protein obtained throughout the lactations. In the third lactation the offspring have an average of 213.27 kg of protein, lower than the average of the mothers of 237.05 kg and much lower than that of the paternal grandparents of 379.72 kg of which they represent 62.43%.

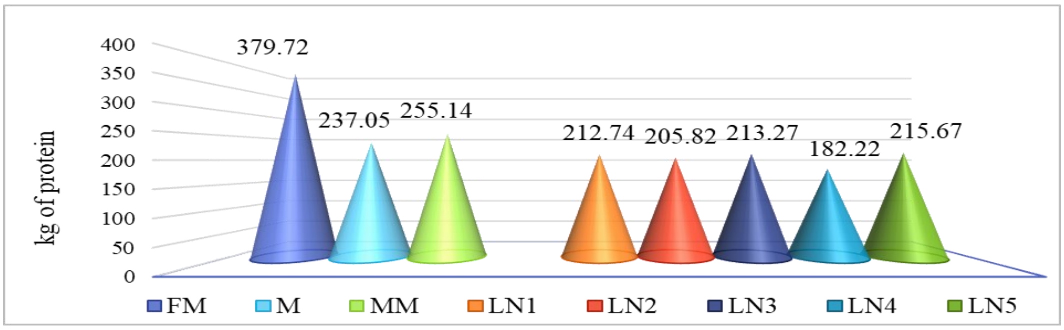


Fig. 3. Dynamic of quantities of protein produced in ancestry and descendance

The productive performance of the offspring is influenced by environmental factors related to their technology and maintenance so that the animals although they have genetic potential do not fully externalize it.

3.1. Heritabilities

Heritability expresses the proportion of phenotypic variance due to average gene effects or, in other words, the proportion of phenotypic variance that can be inherited [4].

Table 2. Coefficient of heritability (h^2) for the main milk production traits in the offspring line

Character	h^2	Variance due by aditive genes	"Intralot" Variance	Total variance
DNL – days	0.22	442.68	2,663.379	2,220.6993
Milk production - kg	0.21	423,611	2,874,120	2,450,509.4
% Fat	0.67	0.0653	0.4713	0.406
Fat amount – kg	0.24	630.235	5,045.005	4,414.7695
% Protein	0.59	0.0051	0.3378	0.3327
Protein amount - kg	0.23	168.635	2,200.595	2,031.9599

DNL – duration of normal lactation.

In Table 2 are shown the values obtained for the heritability coefficient h^2 and their variability. For the main milk production traits in the cows of the herd studied, traits such as fat percentage and protein percentage have strong genetic determinism, given h^2 values of 0.67 and 0.59 respectively with a high share of genetic variability in the total variability value. Milk yield is one of the quantitative traits for which genetic determinism is weak in the herd, with h^2 = 0.21 close to the value reported in the literature. For this trait, the variance due to genotype accounts for 5.78% of the total variance.

3.2. Repetability

Repeatability is expressed by the repeatability coefficient (R) and is the parameter of quantitative traits represented by their property of being affected by temporary environmental influences and is a measure of the constancy of repeated performance in the same individual and indicates the degree to which phenotypic expression is free from temporary environmental influences [12].

Table 3. Repeatability coefficient (R) for the main milk production traits

TRAIT	***R***
Milk production - kg	0.23
Fat - %	0.69
Fat - kg	0.27
Protein - %	0.64
Protein - kg	0.25

Characters with higher h^2 values are also those with higher repeatability coefficient values (Table 3). Milk fat percentage and milk protein percentage are two highly repeatable traits for which R has values of 0.69 and 0.64 respectively as can be seen in Table 4, which means that there is a high degree of probability that the phenotypic performance will be repeated in future lactations. The milk yields and the amount of fat and protein obtained in a lactation are not repeatable.

3.3. Correlations between traits

The simultaneous analysis of two or more traits shows that there are interdependent relationships between them. The causes of correlations between traits are genetic and environmental and the study of correlations is based on establishing the proportion of participation of the two causal sources in determining the phenotypic correlation.

Tabel 4). Phenotypic (r_P), genetic (r_G) and environmental (r_E) correlation coefficients for the main milk production traits.

Trait 1	Trait 2	r_P	r_G	r_E	Genetic covariance	”Intralot” covariance	Total covariance
Milk production Kg	DNL - days	0.37	0.33	0.39	9,755.3907	66,563.6008	56,808.2101
	Fat %	- 0.24	- 0.23	- 0.25	-101.1616	784.5888	683.4272
	Fat - kg	0.99	0.98	0.99	16,470.14	119,410.736	102,940.596
	Protein - %	- 0.22	- 0.19	- 0.23	-91.6542	411.6419	319.9877
	Protein - kg	0.88	0.98	0.96	12,455.954	74,885.4618	62,429.5081
DNL -days	Fat %	0.43	0.37	0.53	5.4489	33.3969	27.948
	Fat - kg	0.76	0.67	0.77	361.2009	2,756.2465	2,395.0456
	Protein - %	0.46	0.34	0.48	4.8552	20.9646	16.1094
	Protein - kg	0.69	0.48	0.75	304.4558	1,786.465	1,482.0092
Fat %	Fat - kg	0.69	0.67	0.7	3.4715	33.2315	29.76
	Protein - %	0.74	0.44	0.84	0.0581	0.3289	0.2707
	Protein - kg	0.7	0.41	0.75	2.9604	23.2824	20.3221
Fat - kg	Protein - %	0.33	0.31	0.43	3.4463	16.3564	12.9101
	Protein - kg	0.87	0.19	0.96	485.5413	3,107.2342	2,621.6929
Protein - %	Protein - kg	0.75	0.69	0.76	0.3971	16.4684	16.8655

For the improvement of traits, in addition to the heritability coefficient, it is necessary to know the correlations that exist between the different traits considered [4, 2]. Strong positive genetic correlations exist between milk yield and the amount of fat and protein realized per lactation (0.98). Milk yield is moderately positively correlated with lactation duration (0.33) and weakly antagonistically correlated with the percentage of fat and protein in milk.

Positive and strong genetic correlations are between the amount (kg) of fat and % fat (0.67) but also between the amount of protein and % protein (0.69).

Improving the herd to increase the number of days in lactation will lead to an increase in the amount of fat, these traits are strongly and positively genetically correlated (0.67) and to a lesser extent also the amount of protein (0.48).

Obtaining high milk yields is not dependent on lactation duration but increasing milk yield leads to a decrease in the percentage fat and protein content of milk. The amount of fat and protein in milk positively influence each other and each is determined as a phenotypic expression also by the percentage of these constituents contained in milk. Likewise, an increase in the percentage content of one of the milk components (fat, protein) leads to an increase in the percentage content of the other, as these two traits are genetically correlated in a positive genetic environment.

Conclusions

Based on the results obtained and presented in this study, it can be concluded:

(1) in maternal line ancestry, the mean for performances of quantitative characters are very good but, in case of M group, the values are lower compared to MM, traits being with medium variability for both groups.

(2) paternal ancestry is very valuable in terms of milk productions because the average of the FM group is 10,929.47 kg milk/lactation, with a fat content of 4.33% and 3.5% protein

(3) for quantities of fat and protein the group FM has the highest averages also in all ancestry, being 471.34 kg and respectively 379.72 kg.

For descendances we can conclude:

(4) the highest average for milk, fat and protein productions are reached in third lactation which is the maximum from the performances archived point of view.

(5) any value of averages for maximum milk, fat and protein productions are lower than those of any ancestry;

(6) the performances of third lactation for productions traits, reported to those of FM group, represent about 62-65% from it.

(7) the first normal lactation represents 99.56% of the maximum lactation (third one) and the average production of the second lactation is lower compared with first one.

(8) though the descendance has very good productions the cows in the herd do not realize their full genetic potential because environmental factors are those that influence their productive performance.

The following conclusions can be drawn from the analysis of genetic parameter values and correlations between traits:

(9) the heritability coefficient value for milk yield is low, $h^2 = 0.21$.

(10) characters such as duration of normal lactation, amount of fat and protein in milk, persistence of lactation have weak genetic determinism $h^2 = 0.22 - 0.24$.

(11) fat and protein percentages have strong genetic determinism, being highly inheritable (0.67; 0.59).

(12) the percentages of fat and protein in milk are two highly repeatable characters in the herd (R = 0.69; 0.64) while the rest of traits has low repeatability. ($R \leq 0.27$)

(13) highly genetic and positive correlated are the production traits: milk production with amount of fat and protein (0.98) whereas increased milk production leads to better fat and protein ones.

(14) number of days in lactation is a trait highly genetic correlated with amount of fat and there is a medium correlation with milk production and amount of protein.

(15) amount of fat and protein are highly genetic correlated each of them with percentages contained in milk in this constituents.

As a general conclusion it can be said that the cows from studied herd have genetic potential to achieve higher productions than those recorded which could be superior to the maternal ancestry. The influence of environmental factors related to the technology of rearing and maintaining the cows, the management measures applied on the farm are those that reduce the performances of the herd.

For the herd studied it is recommended:

- increase of productive performance by externalization of the genetic potential of the animals need managerial measures to improve environmental factors dependent on the technology of rearing and exploitation of cows;

- increasing heritability of production traits by increasing genetic variance and decreasing the environmental one.

- continuous improvement of milk yield and fat content, given the importance of these traits for the economic efficiency of dairy cow breeding.

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