RESEARCH ON THE ESTIMATION OF GENETIC PARAMETERS FOR PRODUCTION TRAITS IN THE ROMANIAN SPOTTED CATTLE BREED – SIMMENTAL TYPE

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Abstract

The objective of this study is to estimate the genetic parameters of the production traits in a population of cattle from the Romanian Spotted Cattle breed-Simmental type. Genetic parameters refer to the heritability and genotypic correlations between traits. Knowing them is essential for optimizing cattle breeding programs.

To estimate genetic parameters, the REML methodology was used, applied to a BLUP animal model, for five traits, analyzed simultaneously (milk quantity/fat quantity/protein quantity/fat percentage/protein percentage).

The obtained results revealed an intermediate genetic determinism, with heritability values in the range of 0.18-0.34. Thus, for lactation I, heritability values were 0.253 (milk quantity); 0.226 (amount of fat); 0.177 (amount of protein); 0.258 (fat percentage) and 0.252 (protein percentage). For the second lactation, heritability values were 0.339 (milk quantity); 0.306 (amount of fat); 0.312 (quantity of protein); 0.326 (fat percentage) and 0.262 (protein percentage). For the third lactation, the corresponding values were the following 0.215 (milk quantity); 0.208 (amount of fat); 0.176 (quantity of protein); 0.198 (fat percentage) and 0.213 (protein percentage).

Regarding the genetic correlations between the traits, their values were closely correlated between the amount of milk and the amounts of fat and protein (> 0.70), which shows that the respective traits are controlled by the same genes, in the same direction. Between the quantity of milk and its quality (percentage of fat and protein), the genetic correlations were negative (-.0162/-0.382), which highlights the fact that selection for high milk quantity means counter-selection for milk quality.

***Key words**: REML, BLUP, variances, heritability, genetic correlations*

INTRODUCTION

Milk is an important food both for humans and animals. Dairy farming is an important branch of agriculture in many countries and it has many problems mainly where small farms are the basic producing units [1] (Adams, R.S., & Ishler, V.A. (2009). Trouble-shooting problems with low milk production. Dairy and Animal Science, 4(1), 98–16. Retrieved June 3, 2018. www.das.psu.edu/teamdairy)

Milk production is on the second position in Romania's agriculture after meat, in 2007 representing 21% of animal production value [2].

To estimate the variance, heritability, genetic and phenotypic correlations between milk production, fat production, protein production and fat and protein percentages, 1425 records were evaluated over an 8-year period between 2010 and 2018.

Although the knowledge of productive performances should not be a problem

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relatively difficult to establish, even if there are a multitude of factors that can load it with errors, knowledge of genetic parameters (heritability, genetic correlations) as well as some estimation of phenotypic, genotypic and environmental correlations, such as repeatability, show us the complexity of the factors involved in animal breeding decisions.

MATERIALS AND METHODS

The data collection, sampling and analysis of the milk taken in the study were taken from a number of 241 farms, which have signed contracts for the provision of services, for the Official Control of milk performance, with the Sărmașului Obstea Agricultural Cooperative from the town of Sarmas, Harghita county, located in the central area of Romania, namely in the east of Transylvania.

Data records were extracted from 1425 dairy cows of the Romanian Spotted Cattle breed-Simmental type, in lactations 1 and 2, these being selected from the total herd registered in the association.

The cows were housed and maintained according to the applicable recommendations of the European Council. Animal care involved the use of the I.C.A.R norms protocol for milk, fat and protein production. Cows were milked mechanized (barrel milking machine, pipe milking machine, or milking robot) twice a day for a full lactation of at least 305 days. Milk sampling was performed twice (morning and evening), when the amount of milk was measured. The genetic parameters were estimated using the REML (Restricted Maximum Likelihood) method, applied to pairs of two traits each.

The multi-character animal model is the optimal way of genetic evaluation of individuals, as it utilizes three categories of information:

a) The candidate's own performances for the selection, plus those of his relatives (by considering the kinship coefficients);

b) Genotypic and environmental correlations between traits;

c) The relative economic values of the traits included in the improvement objective.

The main effect of using this procedure is the increase in selection accuracy. The gain in accuracy depends on the absolute difference between genotypic and environmental correlations.

For the case where each animal has performance recorded for each character and the traits are influenced by the same environmental factors (equal incidence matrices), the biometric model used for the statistical analysis of the data can be written as follows [3]:

$$\mathbf{P_i = X_i b_i + Z_1 a_i + e_i}$$

in which:

Pi = vector of observations for character i;
bi = vector of fixed effects for character i;
ai = vector of random effects for character i;
ei = vector of residuals for character i.

For two traits the BLUP system of equations is:

$$\begin{bmatrix} X_1'\cdot r^{11}\cdot X_1 & X_1'\cdot r^{12}\cdot X_2 & X_1'\cdot r^{11}\cdot Z_1 & X_1'\cdot r^{12}\cdot Z_2 \\ X_2'\cdot r^{21}\cdot X_1 & X_2'\cdot r^{22}\cdot X_2 & X_2'\cdot r^{21}\cdot Z_1 & X_2'\cdot r^{22}\cdot Z_2 \\ Z_1'\cdot r^{11}\cdot X_1 & Z_1'\cdot r^{12}\cdot X_2 & Z_1'\cdot r^{11}\cdot Z_1 + A^{-1}\cdot g^{11} & Z_1'\cdot r^{12}\cdot Z_2 + A^{-1}\cdot g^{12} \\ Z_2'\cdot r^{11}\cdot X_1 & Z_2'\cdot r^{22}\cdot X_2 & Z_2'\cdot r^{21}\cdot Z_1 + A^{-1}\cdot g^{21} & Z_2'\cdot r^{22}\cdot Z_2 + A^{-1}\cdot g^{22} \end{bmatrix} \begin{bmatrix} \tilde{b}_1 \\ \hat{b}_2 \\ \hat{a}_1 \\ \hat{a}_2 \end{bmatrix} = \begin{bmatrix} X_1'\cdot r^{11}\cdot P_1 + X_1'\cdot r^{12}\cdot P_2 \\ X_2'\cdot r^{21}\cdot P_1 + X_2'\cdot r^{22}\cdot P_2 \\ Z_1'\cdot r^{11}\cdot P_1 + Z_1'\cdot r^{12}\cdot P_2 \\ Z_2'\cdot r^{21}\cdot P_1 + Z_2'\cdot r^{22}\cdot P_2 \end{bmatrix}$$

where, the matrices G and R contain the genotypic and environmental variances and covariances:

$$G^{1} = \begin{bmatrix} \sigma^2_{a1} & \sigma_{a12} \\ \sigma_{a21} & \sigma^2_{a2} \end{bmatrix}^{-1} = \begin{bmatrix} g^{11} & g^{12} \\ g^{21} & g^{22} \end{bmatrix}; R^{1} = \begin{bmatrix} \sigma^2_{e1} & \sigma_{e12} \\ \sigma_{e21} & \sigma^2_{e2} \end{bmatrix}^{-1} = \begin{bmatrix} r^{11} & r^{12} \\ r^{21} & r^{22} \end{bmatrix}$$

Additive genetic and environmental variances, for traits i and j, are calculated based on the following formulas:

$$\sigma^2_{a\,ii} = \frac{\hat{a}_i'\cdot A^{-1}\cdot \hat{a}_i + tr(A^{-1}\cdot C_{ii})}{q}$$

$$W = [X_1 \oplus X_2 \quad Z_1 \oplus Z_2] \; ($$

$$B = W\cdot C\cdot W' = \begin{bmatrix} B_{ii} & B_{ij} \\ B_{ji} & B_{jj} \end{bmatrix}$$

$$e_i = P_i - W\cdot [\tilde{b}_1 \quad \tilde{b}_2 \quad \hat{a}_1 \quad \hat{a}_2]$$

$$\sigma^2_{a\,jj} = \frac{\hat{a}_j'\cdot A^{-1}\cdot \hat{a}_j + tr(A^{-1}\cdot C_{jj})}{q}$$

$$\sigma_{aij} = \frac{\hat{a}_i'\cdot A^{-1}\cdot \hat{a}_j + tr(A^{-1}\cdot C_{ij})}{q}$$

$$\sigma^2_{e\,ii} = \frac{\hat{e}_i'\cdot \hat{e}_i + tr(B_{ii})}{n}$$

$$\sigma^2_{e\,ij} = \frac{\hat{e}_i'\cdot \hat{e}_j + tr(B_{ij})}{n}$$

$$\sigma^2_{e\,jj} = \frac{\hat{e}_j'\cdot \hat{e}_j + tr(B_{jj})}{n}$$

in which:

$$W = [X_1 \oplus X_2 \quad Z_1 \oplus Z_2] \; ($$

$$B = W\cdot C\cdot W' = \begin{bmatrix} B_{ii} & B_{ij} \\ B_{ji} & B_{jj} \end{bmatrix}$$

$$e_i = P_i - W\cdot [\tilde{b}_1 \quad \tilde{b}_2 \quad \hat{a}_1 \quad \hat{a}_2]$$

RESULTS AND DISCUSSIONS

Data utilized for this study consisted of first, second and third lactation, from 1425 dairy Romanian Spotted Cattle breed-Simmental type, with records of standard lactation period of 305 days of milk.

In order to study the genetic determinism of the five traits (milk quantity, fat quantity, protein quantity, fat percentage and protein percentage) the main statistics were estimated, separately for each lactation, as follows:

From the data presented in table 1, it can be seen that the average values of the traits under study are 5571 kg of milk, 216 kg of fat and 178 kg of protein. Regarding the percentage of fat and the percentage of protein, the average is 3.2% and 3.9%, respectively. 476 cows were analyzed.

On average, each individual value deviates from the average in terms of the amount of milk with 1230.5 KG of milk; regarding the amount of fat with 419.5 KG of fat; and with 41 KG of protein. For all the five traits studied, the coefficient of variability is between 9%-23%, thus we have the representative average. Regarding the average production of fat and protein, the values obtained for the first lactation are lower compared to those obtained by Macciotta et al [4] for Simmental cows from Italy (224 kg fat and 196 kg protein) or to those obtained by Trivunovic S., Plavsic M. [5] and Glamocic D. (2008) [6] also in Simmental cows (254 kg, respectively 215 kg).

Moreover, in this analysis, the percentages of fat and protein came close to the values obtained by other authors, such as Gorjanc et al. [7] for Brown Swiss cows (fat 3.9% and protein 3.2%) and for Simmental cows from Slovenia (fat 3.9% and protein 3.3%).

Table 1. Average performances of the traits milk quantity, fat quantity, protein quantity, fat percentage and protein percentage, for lactation I.

Trait	n	U.M	$\overline{X} \pm S_{\overline{x}}$	s	v%	Min-Max
Milk quantity	476	kg.	5571,57	1230,5	22%	3500 -17,830
Fat quantity	476	kg.	216,2	419,5	23%	96 - 419,553
Protein quantity	476	kg.	178,24	41	23%	105 - 352,019
Fat percentage	476	%	3,2	0,3	11%	2,31 - 5,54
Protein Percentage	476	%	3,89	0,44	9%	2,17 - 4.16

Table 2. Average performances of the traits milk quantity, fat quantity, protein quantity, fat percentage and protein percentage, for lactation II

Trait	n	U.M	$\overline{X} \pm S_{\overline{x}}$	s	v%	Min-Max
Milk quantity	471	kg.	5641,4	1313,3	23%	3502 - 10831
Fat quantity	471	kg.	221,4	55,1	25%	3,579 - 455
Protein quantity	471	kg.	184,6	45,7	25%	370 – 92,758
Fat percentage	471	%	3,9	0,5	12%	2,185 – 5,35
Protein Percentage	471	%	3,3	0,3	9%	2,36 – 4,26

From the data presented in table 2, it can be seen that the average values of the traits under study are 5641 kg of milk, 221 kg of fat and 184 kg of protein. Regarding the percentage of fat and percentage of protein, the average is 3.9% and 3.3%, respectively. 471 cows were analyzed.

On average, each individual value deviates from the average in terms of the amount of milk by 1313.3 KG of milk; regarding the amount of fat with 55.1 KG of fat; and with 45.7 KG of protein. For all the five traits studied, the coefficient of variability is between 9%-25%, thus we have the representative average. It should be taken into account that both the amount of milk and the amount of fat and protein have a medium spread of data, while the percentage of protein and fat have a very small spread of data, being very homogeneous.

For the second lactation, the average milk production falls within the average range of 4459-6907 kg obtained by Persic et al [8] between 2004 and 2006, for the Simmental breed from different countries in Europe, such as Hungary, Slovenia, Austria, Norway and others. Macciotta et al [4] obtained slightly higher average values for milk production 6225 kg, fat production 243 kg and protein production 212 kg. The average percentage of fat, for the second lactation, is lower than that obtained by Hauns et al [9] for the Holstein breed from the Czech Republic (3.5 kg). Pesek et al [10], studied the Simmental breed from the Czech Republic and obtained an average percentage of fat of 4.6%, which is a very high value compared to the results obtained in this paper.

Table The heritability values for lactation I

Nr. crt	Trait	$h^2 \pm S_{h^2}$
1	Milk quantity (A)	0,253 ± 0,221
2	Fat quantity (B)	0,226 ± 0,221
3	Protein quantity (C)	0,177± 0,221
4	Fat percentage (D)	0,258 ± 0,221
5	Protein Percentage (E)	0,262± 0,221

Table 4. The heritability for lactation II

Nr. crt	Trait	$h^2 \pm S_{h^2}$
1	Milk quantity (A)	0,339 ± 0,221
2	Fat quantity (B)	0,306 ± 0,221
3	Protein quantity (C)	0,312 ± 0,221
4	Fat percentage (D)	0,327± 0,221
5	Protein Percentage (E)	0,262 ± 0,221

Analyzing the data in table 3, we can conclude the following:

The amount of milk registers a heritability value of 0.253, from which it appears that this character falls into the category of intermediately heritable traits.

The amount of fat registers a heritability value of 0.226, from which it appears that this character falls into the category of intermediately heritable traits.

The amount of protein records a heritability value of 0.177, from which it appears that this character falls into the category of weakly heritable traits.

The percentage of fat records a heritability value of 0.258, from which it appears that this character falls into the category of intermediately heritable traits.

The protein percentage records a heritability value of 0.262, from which it appears that this character falls into the category of intermediately heritable traits.

Also, in the past years, these aspects were followed and it was found out that the heritability estimates, phenotypic correlations for the first lactation, as given in table 8, respectively table 10, were higher for the Simmental breed in the case of fat yield and fat percentage, compared to the results obtained for the Iranian Holstein (0.36). Heritability estimates of milk production and composition can increase as herd production levels increase [11]. Boichard and Bonaiti [12] found for first lactation milk yield higher heritability close to 0.30 for Normande and Montbeliarde and 0.37 in Holstein. Toit J. et al. [13] also reported a heritability greater than 0.35 for milk production in first lactation Jerseys from South Africa. For fat and protein percentages, they found closer heritability of 0.57 and 0.58, respectively.

Rothschild and Henderson [14] similarly reported a heritability of 0.41 in American Holstein for first lactation milk production.

The estimated heritability for milk, fat and protein yield in this study using the best fit model are similar to the estimated values for Simmental cattle in Germany, Austria and Switzerland [15]. In Germany and Austria (joint evaluation) the estimates ranged from 0.27 to 0.36, and in Switzerland the estimates ranged from 0.25 to 0.31

Amaya et al. [2] obtained the estimates values heritability for milk production for 60 days, 150 days and 305 days ranged from 0.20 to 0.27, 0.25 to 0.52, 0.30 to 0.35 and 0.20 to 0.23. For 150 days, the value heritability of 0.52 for milk yield was higher than in the study herein. Yang et al. [16] reported heritability for milk yield for 305 days 0.34 in Simmental cows from China. Kaps and Spehar [17] obtained 0.36 heritability for milk yield in Croatian Simmental. The heritability for fat test-day yield in our study was low the values ranged between 0.117 and 0.236, the heritability for 305 days in milk was 0.136. The heritability for protein test-day yield was medium values ranged between 0.308 and 0.372, the heritability for 305 days in milk was 0.356. Nistor et al. [18] reported the heritability for Romanian Spotted Cattle breed-Simmental type for fat yield 0.287 higher than our study and for protein yield was 0.280 lower than studied here. Kaps and Spehar [19] obtained higher heritability for fat yield for 305 days 0.31 and lower heritability 0.27 for protein yield for Simmental cattle than in our study. Cho et al. [20] reported low test–day heritability estimates ranged from 0.08 to 0.15 for milk, 0.06 to 0.14 for fat, 0.08 to 0.12 for protein according to days in milk in Holstein breed cows. Kheirabadi and Razmkabir [21] observed low heritability estimates for milk 0.204, fat 0.096 and protein 0.047 to Holstein cattle.

As reported in Table 4, the heritability found in the Romanian Spotted Cattle breed-Simmental type for milk production were higher than the estimate recorded by Nixon et al. [21] in Canadian Holstein (0.26), while a lower heritability was recorded for fat percentage (0.708). For fat yield, the heritability was closer to 0.38, the value reported in the Holstein breed [24]. The heritability value for protein yield exceeded that estimated from paternal correlation values between 0.13 and 0.20 in the literature. A lower heritability value of 0.25 for protein yield in Holstein was found by Hardie et al. [22] and Nixon et al. [23] in Canadian Holstein (0.21). Chauhan and Hayes [23] found in Canadian Holsteins a lower heritability for milk production (0.29), but similar for fat production (0.31) and lower for protein production (0.25).

Chauhan and Hayes [24], found nearly double heritability values for milk fat percentage (0.65) and milk protein percentage (0.61). Hallowell et al. [25] reported in the Holstein breed a much higher heritability for milk (0.57) and for fat percentage (0.37). The estimated heritability in Iranian Holstein found by Mashhadi et al. [27] were higher for milk production (0.35), but lower than those reported for the Romanian Simmental breed for: fat yield, protein yield, fat percentage and protein percentage.

In addition, Strabel and Misztal [26] in Poland in Black and White breeds found a lower heritability for milk production of 0.14. Dedkova and Wolf [27] estimate heritability of 0.28 to 0.30 for milk production in Holstein and 0.21 to 0.26 for Czech Pied cattle in the first three lactations, which are slightly lower than the heritability for milk production of milk found in the present study. Heritability indicates what percentage of the total variation for a trait is the result of genetic differences between animals and is an important factor in the rate of genetic change [28]. The higher the heritability, the greater the genetic control over the trait and the more rapid will be the selection for genetic progress. In general, fat and protein percentages (first lactation) have high heritability.

Most dairy producers are aware that increasing percentages of milk components tend to be associated with reduced milk volume. The genetic correlation between percentages of milk components and milk yield underpins this rule of thumb. Genetic correlation measures the link between two traits that are controlled by the same genes. Values from 0.4 to 1.0 indicate that two traits will progress strongly in the same direction if selection is on only one of the traits. This expected decrease in protein content suggests the definition of a new selection objective, which maximizes fat and protein production while maintaining protein content [29]. The possible decrease in protein content, which would have negative technological consequences, cannot be totally neglected, even with a selection based solely on solid yields.

CONCLUSIONS

In general, the results obtained from the research were extracted from 1425 dairy cows of the Romanian Spotted Cattle breed-Simmental type, in the 1st and 2nd lactations, which unfortunately did not confirm the data from previous literature, the correlations obtained in this study being generally lower, but this is probably also due to the environmental and climatic conditions, specific to the county. The results for milk and fat confirm the well-established choice of selection on fat yield to increase it as much as possible while maintaining or improving fat percentage.

Heritability indicated that there was a considerable amount of variation in milk yield, similar to that found for fat. The genetic correlation between yields was found to be high, but the negative correlation between milk and protein percentage (second lactation) will not allow rapid genetic change under divergent selection. To meet the human population's demand for milk, yogurt, cheeses, and other derived products, the desired breeding goal would seem to be to increase milk production while keeping the fat percentage constant. The negative genetic association between milk yield and protein percentage suggests that this trait should be included in selection programs if its level were to be maintained while increasing milk yield.

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