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Estimation of Breeding Values and Genetic Parameters for Milk Yield in Patch-Faced Maritza Sheep Breed

Horia GROSU[1], Petya ZHELYAZKOVA[2], Doytcho DIMOV[3] and Costin-Răzvan CERNITU[1]

[1] University of Agriculture and Veterinary Medicine Bucharest, Faculty of Animal Productions Engineering and Management, Romania;
[2] Breeding Association of Maritza Sheep Breeds, Plovdiv, Bulgaria,
[3] Agricultural University, Faculty of Agronomy, Plovdiv, Bulgaria.

Introduction

Estimation of breeding values and the genetic parameters are the main goals of any breeding program including the Patch-Faced Maritza sheep breed. They are the basic point of genetic gain, because the response to selection is just the average breeding values of selection candidates selected for reproduction.

The aims of this study

- Estimation of the heritability (h^2) and repeatability (R) for Milk Yield in Patch-Faced Maritza Sheep Breed
- Prediction of the breeding values for Milk Yield in Patch-Faced Maritza Sheep Breed

Material and methods

- The data used for this analysis were provided by the Breeding association of native Maritza sheep breeds;
- Database of 643 lactation records for 351 ewes of the Patch-faced Maritza sheep breed were used;
- The analyses includes data for the period 2018 – 2023;
- The pedgree data includes 586 animals, which 351 ewes had records, as daughters of 35 rams;
- Variance components for MY were estimated by using a single trait repeatability animal model (AM)
- All analyses were performed in R software environment, using the SOMMER package;
- Age and the Lactation Period clases were used fixed effects in the models.

Single Trait Repeatability Animal Model

$$y_{ijk} = Age_i + LP_j + a_k + p_k + e_{ijk}$$

The heritability of the traits was estimated as follows:

$$h^2 = \frac{\sigma_a^2}{\sigma_a^2+\sigma_p^2+\sigma_e^2}$$

The Repeatability of the traits was estimated as follows:

$$R = \frac{\sigma_a^2+\sigma_p^2}{\sigma_a^2+\sigma_p^2+\sigma_e^2}$$

Estimation of variance components

$$\sigma_e^2 = \frac{\left(y' \cdot y - \tilde{b}' \cdot X' \cdot y - \hat{a}' \cdot Z_a' \cdot y - \hat{p}' \cdot Z_p' \cdot y\right)}{N - rank(X)}$$

$$\sigma_a^2 = \frac{\left(\hat{a}' \cdot A^{-1} \cdot \hat{a} + \sigma_e^2 \cdot trace\left(C_{aa} \cdot A^{-1}\right)\right)}{q_1}$$

$$\sigma_p^2 = \frac{\left(\hat{p}' \cdot \hat{p} + \sigma_e^2 \cdot trace\left(C_{pp}\right)\right)}{q_2}$$

The Repeatability Animal Model

$$y = Xb + Za + Zp + e$$

$$\begin{bmatrix} X' \cdot X & X' \cdot Z_a & X' \cdot Z_p \\ Z_a \cdot X & Z_a \cdot Z_a + A^{-1} \cdot k_a & Z_a \cdot Z_p \\ Z_p \cdot X & Z_p \cdot Z_a & Z_p \cdot Z_p + I_p \cdot k_p \end{bmatrix} \cdot \begin{bmatrix} \tilde{b} \\ \hat{a} \\ \hat{p} \end{bmatrix} = \begin{bmatrix} X' \cdot y \\ Z_a \cdot y \\ Z_p \cdot y \end{bmatrix}$$

$$k_a = \frac{(1-R)}{h^2}; \qquad k_p = \frac{(1-R)}{R-h^2}$$

Table 1. The Structure of population for Patch-faced Maritza sheep.

Specification	Number
Total records (MILK)	643
Animals in pedigree	504
Animals (ewes) with records	351
Number of Sires	35
Number of Dams	200
AGE Clases	9
Lactation Period Clases	10

Table 2. Descriptive statistics of traits for Patch-faced Maritza sheep breed(n=643).

Trait/Effects	$\bar{X}$ ± SD	Min	Max	CV, %
Milk yield, L	115.57±34.43	51.02	293.34	29.79
Age, years	3.68±1.60	1.00	9.00	43.49
Age - Clases	5 ± 0.91	1	9	54.8
Lactation period, days	222.92±16.34	179.00	276.00	7.33
Lactation period - clases	5.5± 0.96	1	10	55

Table 3. Descriptive statistics for Age clases fixed effect

AGE_1	93.30	9.32	10.01	***
AGE_2	95.92	8.18	11.72	***
AGE_3	108.58	8.29	13.10	***
AGE_4	110.14	8.40	13.11	***
AGE_5	112.76	8.53	13.22	***
AGE_6	120.62	8.65	13.94	***
AGE_7	123.96	9.41	13.18	***
AGE_8	96.57	14.45	6.68	***
AGE_9	105.18	17.84	5.89	***

Table 4. Descriptive statistics for Lactation Period (LP) clases fixed effect

Age Fixed Effect Effects	$\bar{X}$	SD	t Statistic Test	Segnificati on
LP_1	27.22	8.95	3.04	**
LP_2	18.38	8.44	2.18	*
LP_3	18.50	8.55	2.17	*
LP_4	7.01	8.25	0.85	ns
LP_5	-0.43	8.15	-0.05	ns
LP_6	-1.34	8.25	-0.16	ns
LP_7	-1.59	9.01	-0.18	ns
LP_8	-3.95	11.32	-0.35	ns
LP_9	28.86	13.50	2.14	*

Table 5. Heritability (h2) and repeatability (R) of milk yield for Patch-faced Maritza sheep.

Traits	Value ± SE	h^2 ± SE	R± SE
Genetic Additive Variance (Va)	246.7 ± 135	0.219±0.115	0.515±0.045
Permanent Environmental Variance (Vpe)	333.97± 128.7		
Residual/Error Variance (Ve)	546.30 ± 45.30		
Phenotypic Variance (Vp	1126.97		

Table 6. Breeding and the Accuracy of Selection for the first 15 animalsValues for MY

No crt	ID_Animal	EBV	Accuracy
1	20121312	31.490	0.437
2	20151451	28.027	0.461
3	20191770	27.425	0.536
4	20161363	24.125	0.677
5	20200464	21.863	0.654
6	20181161	21.561	0.621
7	20190808	21.484	0.624
8	20151446	21.321	0.462
9	20191747	19.887	0.537
10	20171157	18.908	0.584
11	20200733	18.315	0.465
12	20171163	17.777	0.839
13	20110873	17.328	0.409
14	20171124	16.857	0.611
15	20210418	16.148	0.548

CONCLUSIONS

The estimated genetic parameters indicate a heritability for milk yield of h^2=0.262±0.024 and a repeatability of 0.525±0.049. These values fall within the ranges reported by other authors for various sheep populations.

The intermediate heritability value demonstrates that selection for this trait generates moderate genetic progress within the investigated population. The significant difference between heritability and repeatability underscores the importance of optimizing farm management factors, given the major impact of the permanent environment on productive performance. The use of modern algorithms from the sommer package allowed for an accurate genetic evaluation of all 504 animals, providing a rigorous basis for the ranking and selection of breeding stock.