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RESEARCH ON THE ESTIMATION OF GENETIC PARAMETERS FOR PRODUCTION AND EXTERIOR TRAITS IN SUBPOPULATIONS OF THE TSURCANA BREED

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Abstract

The purpose of this work is to estimate the genetic parameters for the production and exterior traits of the 4 lines of the Turcana breed. The research was carried out on a herd of 16,196 Tsurcana sheep, structured on the 4 lines, of which: Belă, Brează, Bucălae and Oacheşă. 7 exterior traits were analyzed (conformation, wool yield, wool length, milk yield, The body weight at 60 days, The body weight at 120 days and average daily gain). For the estimation of the genetic parameters (Heritability and Genetic Correlation) the BLUP methodology was used. The heritability values recorded values from 0.116 (The body weight at 60 days in Bucălae), to 0.475 for milk yield (Belă). The values of genetic correlations achieved the full range of values, in the interval [-1, +1], with variations depending on the pair of traits and the population analyzed. Heritability and genetic correlation are useful parameters for substantiating the improvement programs of the analyzed populations.

Key words*: BLUP, exterior traits, genetic parameters, production traits.*

INTRODUCTION

The Ţurcană breed developed primarily through natural selection, becoming well adapted to a wide range of environmental conditions. Over the past 50 years, artificial selection has led to the emergence of a highly differentiated breed complex with an insular reproductive structure, comprising four subpopulations with distinct phenotypic and genetic characteristics currently undergoing consolidation (Ţurcana Brează, Bucălae, Belă, and Oacheşă). This genetic differentiation raises the need for separate breeding programs tailored to each subpopulation (Drăgănescu, 2003; 1995).

A series of studies have highlighted statistically assured differences between the four populations of the Ţurcană breed (Drăgănescu, 1979; 1994; Margetín et al., 2020). The more genetically different the populations are from each other, the more differentiated the genetic progress will be.

Results on the estimation of heritability of production traits for Valachian and Tsigai sheep were presented by Oravcová (2015). Also, Makovický (2018), obtained values within the limits of the specialized literature for the heritability of milk production and milk fat content in Valachian sheep populations.

In this analysis, the genetic differences between populations were established by the genetic determinism estimated at the level of each one. The genetic determinism of the traits expressed by heritability and genetic correlation is the basis for optimizing sheep breeding programs (El-Saied et al., 1998). The level of these indicators substantiates the genetic progress of the traits in the objective of sheep breeding.

The BLUP (Best Linear Unbiased Prediction) methodology, introduced by Henderson (1973), has become the standard tool for estimating breeding values and genetic parameters in livestock populations. Its application to sheep breeding has been validated in numerous studies, showing greater accuracy compared to classical selection methods, particularly in populations with complex family structures and multiple measured traits. The sire model, a simplified variant of the animal model, is especially useful in large-scale genetic

evaluations where full pedigree information is not available, as it allows estimation of additive genetic variance components from paternal half-sib families (Mrode & Thompson, 2005).
BLUP-based genetic evaluations have been applied to a wide range of sheep breeds and production systems across Europe. Studies on dairy breeds such as Lacaune, Awassi, and Merino-derived populations have shown that heritability estimates for milk yield, wool traits, and body weight obtained through BLUP are sufficiently stable to support selection decisions (Barillet, 2007; Komprej et al., 2012). The application of these methods to autochthonous breeds raised under extensive conditions - such as the Țurcană breed - is of particular interest, given the growing efforts to improve locally adapted genetic resources within national and European biodiversity conservation programs.
The research goal was to estimate the genetic parameters for production and exterior traits in subpopulations of the Tsurcană breed, in order to characterize them.

MATERIALS AND METHODS

Biological material studied

The research was carried out on a herd of 16,196 Tsurcană sheep, existing in the records of the Tsurcană-Dacia Sheep Breeders Association.
The total herd was structured on the 4 populations, as follows: Belă Line (4,567 females), Breză Line (1,035 females), Bucălae Line (3,288 females) and Oacheșa Line (7,306 females).
The genetic parameters were estimated for a number of seven traits included in the objective of improving the Tsurcană breed: The body weight at 60 days, The body weight at 120 days, average daily gain, wool yield, wool length, milk quantity and body conformation.
For the statistical analysis of the primary data, the following calculation methods were used: classical statistical indicators (mean, variance, standard deviation, standard error of the mean, and coefficient of variation). For the estimation of genetic parameters, the BLUP methodology (Best Linear Unbiased Prediction) was applied using the sire model for the 7 traits, according to the following biometric model:

Pi = Xibi + Ziai + ei
where:
Pi = vector of observations for character i;
Xi = Incidence matrix for fixed effects;
bi= vector of fixed effects for character i;
Zi= Incidence matrix for random effects;
ai = vector of random effects for character i;
ei= vector of residuals for character i.
To facilitate easier understanding of the BLUP equation system, it will be presented for the case of two traits, as follows (Grosu & Oltenacu, 2005):

$$\begin{bmatrix} X_1'\cdot r^{11}\cdot X_1 & X_1'\cdot r^{12}\cdot X_2 & X_1'\cdot r^{11}\cdot Z_1 & X_1'\cdot r^{12}\cdot Z_2 \\ X_2'\cdot r^{21}\cdot X_1 & X_2'\cdot r^{22}\cdot X_2 & X_2'\cdot r^{21}\cdot Z_1 & X_2'\cdot r^{22}\cdot Z_2 \\ Z_1'\cdot r^{11}\cdot X_1 & Z_1'\cdot r^{12}\cdot X_2 & Z_1'\cdot r^{11}\cdot Z_1+A^{-1}\cdot g^{11} & Z_1'\cdot r^{12}\cdot Z_2+A^{-1}\cdot g^{12} \\ Z_2'\cdot r^{11}\cdot X_1 & Z_2'\cdot r^{22}\cdot X_2 & Z_2'\cdot r^{21}\cdot Z_1+A^{-1}\cdot g^{21} & Z_2'\cdot r^{22}\cdot Z_2+A^{-1}\cdot g^{22} \end{bmatrix}$$

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

in which, the matrices G and R contain the genotypic and environmental variances and covariances of the considered traits:

$$G^{-1} = \begin{bmatrix} \boldsymbol{S_{I_X}^2} & \boldsymbol{Cov_{I_{XY}}} \\ \boldsymbol{Cov_{I_{XY}}} & \boldsymbol{S_{I_Y}^2} \end{bmatrix}^{-1} = \begin{bmatrix} g^{11} & g^{12} \\ g^{21} & g^{22} \end{bmatrix};$$

$$R^{-1} = \begin{bmatrix} \boldsymbol{S_{i_X}^2} & \boldsymbol{Cov_{i_{XY}}} \\ \boldsymbol{Cov_{i_{XY}}} & \boldsymbol{S_{i_Y}^2} \end{bmatrix}^{-1} = \begin{bmatrix} r^{11} & r^{12} \\ r^{21} & r^{22} \end{bmatrix}$$

The G and R elements were estimated using the formulas:

1) Interfamilial genetic variance (between paternal families), for the trait X $(\boldsymbol{S_{I_X}^2})$:

$$\boldsymbol{S_{I_X}^2} = \frac{\hat{a}_i'\cdot A^{-1}\cdot \hat{a}_i + tr(A^{-1}\cdot C_{ii})}{q}$$

2) Interfamilial genetic variance (between paternal families), for the Y trait $(\boldsymbol{S_{I_Y}^2})$:

$$\boldsymbol{S_{I_Y}^2} = \frac{\hat{a}_j' \cdot A^{-1} \cdot \hat{a}_j + tr(A^{-1} \cdot C_{jj})}{q}$$

3) Additive genetic covariance between traits X and Y ($\boldsymbol{Cov_{I_{XY}}}$):

$$\boldsymbol{Cov_{I_{XY}}} = \frac{\hat{a}_i' \cdot A^{-1} \cdot \hat{a}_j + tr(A^{-1} \cdot C_{ij})}{q}$$

4) Environmental variance (residual) for trait X ($\boldsymbol{S_{i_X}^2}$):

$$\boldsymbol{S_{i_X}^2} = \frac{\hat{e}_i' \cdot \hat{e}_i + tr(B_{ii})}{n}$$

5) Environmental variance (residual) for character Y ($\boldsymbol{S_{i_Y}^2}$):

$$\boldsymbol{S_{i_Y}^2} = \frac{\hat{e}_j' \cdot \hat{e}_j + tr(B_{jj})}{n}$$

6) Environmental covariance (residual) between traits X

$$\boldsymbol{Cov_{i_{XY}}} = \frac{\hat{e}_i' \cdot \hat{e}_j + tr(B_{ij})}{n}$$

$$W = \begin{bmatrix} X_1 \oplus X_2 & Z_1 \oplus Z_2 \end{bmatrix};$$

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

$\oplus$ = Direct sum (Searle & Hudson, 1982)

$e_i = P_i - W \cdot \begin{bmatrix} \widetilde{b}_1 & \widetilde{b}_2 & \hat{a}_1 & \hat{a}_2 \end{bmatrix}$, e represents the error vector.

Phenotypic variances and covariances are obtained by summing the intrafamilial and intrafamilial variances and covariances, as follows:

P=G + R

$$P = \begin{bmatrix} \boldsymbol{S_{F_X}^2} & \boldsymbol{Cov_{F_{XY}}} \\ \boldsymbol{Cov_{F_{XY}}} & \boldsymbol{S_{F_Y}^2} \end{bmatrix} = \begin{bmatrix} \boldsymbol{S_{I_X}^2} & \boldsymbol{Cov_{I_{XY}}} \\ \boldsymbol{Cov_{I_{XY}}} & \boldsymbol{S_{I_Y}^2} \end{bmatrix} + \begin{bmatrix} \boldsymbol{S_{i_X}^2} & \boldsymbol{Cov_{i_{XY}}} \\ \boldsymbol{Cov_{i_{XY}}} & \boldsymbol{S_{i_Y}^2} \end{bmatrix}$$

For the character "X", the heritability was obtained according to the formula:

$$h_X^2 = 4 \times \frac{\boldsymbol{S_{I_X}^2}}{\boldsymbol{S_{F_X}^2}}$$

Estimation of genotypic correlations and their errors

The genotypic correlation between traits X and Y ($r_{G_{XY}}$), was determined based on the observational components of the intrafamilial variances and covariances, according to the formula:

$$r_{G_{XY}} = \frac{\boldsymbol{Cov_{I_{XY}}}}{\sqrt{\boldsymbol{S_{I_X}^2} \cdot \boldsymbol{S_{I_Y}^2}}}$$

The genotypic correlation error was determined based on the formula:

$$S_{r_G} = \frac{1 - r_{G_{XY}}^2}{\sqrt{2}} \cdot \sqrt{\frac{S_{h_X^2} \cdot S_{h_Y^2}}{h_X^2 \cdot h_Y^2}}$$

where:

r_G = genotypic correlation error;

$S_{h_X^2}$ = heritability error of the trait X;

$S_{h_Y^2}$ = heritability error of the trait Y;

h_X^2 = heritability of the trait X;

h_Y^2 = heritability of the trait Y.

The heritability error was estimated using the formula:

$$S_{h^2} = 4 \cdot \sqrt{\frac{2 \cdot [1 + (k-1) \cdot t]^2 (1-t)^2}{k \cdot (k-1) \cdot (q-1)}}$$

where:

$t = \frac{S_I^2}{S_F^2}$

q = number of fathers;

k = average size of father's family (n/q), n=total number of offspring.

RESULTS AND DISCUSSIONS

Average performances of the Tsurcană breed

Establishing perspective objectives in improving the Tsurcană breed requires knowing the current leve l of average performances of the traits that are part of the improvement objective, for each population analyzed. Table 1 presents the average performances of the traits in the Tsurcană Belă.

For the first character, body conformation, an average performance of 8.7861 points is observed, with a variability of 7.5468%.

For the quantity of sheared wool, the average performance was 3.6708 kg with a variability of 10.0944%., compared to 3.95 kg obtained by Rotar et al. (2025).

The third analyzed character, the length of the wool strand, recorded an average value of 27.8362 cm with a variability of 8.8471%.
For milk production per lactation, the average performance was 40.62 kg with a variability of 13.7564% compared to 58.95 kg obtained by Rotar et al. (2025).

The body weight at 60 days, the achieved performance was 15.10 kg with a variability of 11.8097%. For The body weight at 120 days, the achieved performance was 32.28 kg with a variability of 20.6271%.
The average daily gain (ADG) recorded an average of 256.1122 g with a calculated variability of 13.9494% (Table 1).

Table 1. Average performances of the traits in the Tsurcana - Belă breed

Traits	N	U.M.	MEAN ± SEM	SD	CV %	Min	Max
conformation (1)	4567	Note	8.7861 ± 0.0098	0.6632	7.5478	8	10
wool yield (2)		kg	3.6708 ± 0.0055	0.3705	10.0944	2.74	5
wool length (3)		cm	27.8362 ± 0.0364	2.4627	8.8471	23.08	34
milk yield (4)		kg	40.6232 ± 0.0827	5.5883	13.7564	30.66	55.34
body weight at 60 days (5)		kg	15.1014 ± 0.0264	1.7834	11.8097	13	22.3
body weight at 120 days (6)		kg	32.2807 ± 0.0985	6.6586	20.6271	21	103
average daily gain (7)		g	256.1122 ± 0.5287	35.7261	13.9494	114.75	366.67

For the Breazã variety of the Tsurcanã breed, the same traits were analyzed on a population of 1035 individuals registered in the breed's genealogical register with the mention Breazã population. Thus, for conformation an average score of 8.7894 was obtained with a variability of 7.3206%.
For the wool yield, a value of 3.69 kg was obtained with a variability of 12.00%. The amount of milked milk had values of 42.17 kg compared to 59.14 kg mentioned by Rotar et al. (2017).

For the amount of sheared wool, an average quantity of 3.69 kg was achieved and had a calculated variability of 12.00%, compared to 2.77 kg obtained by Nistor (2007). The length of the wool had an average of 29.22 cm per strand with a variability of 7.17% compared to 28.49 cm (Nistor, 2007). Regarding the body weight at 60 days, an average the body weight G60 of 15.40 kg and a variability of 11.69% was obtained. For the body weight at G120, an average of 31.48 kg was calculated with a variability of 7.08%. The average daily gain was 257.58 g with a variability of 15.17% (Table 2).

Table 2. Average performances of the traits in the Tsurcanã - Breazã breed

Traits	N	U.M.	MEAN ± SEM	SD	CV %	Min	Max
conformation (1)	1035	Note	8.7894 ± 0,02	0.6434	7.3206	7	10
wool yield (2)		kg	3.6952 ± 0.0138	0.4437	12.0067	2.83	5.5
wool length (3)		cm	29.2217 ± 0.0652	2.0973	7.1772	23.08	34.5
milk yield (4)		kg	42.1713 ± 0.1651	5.3124	12.5973	31.29	53.65
body weight at 60 days (5)		kg	15.4021 ± 0.056	1.8018	11.6984	13	21.5
body weight at 120 days (6)		kg	31.4872 ± 0.0693	2.2297	7.0813	22	38
average daily gain (7)		g	257.586 ± 1.2147	3.079	1.,1712	116.67	366.67

For the Bucălae variety, a score of 8.8069 was obtained for conformation with a variability of 7.768%. For the quantity of sheared wool, an average value of 3.8352 kg was obtained and a calculated variability of 11.03%. The length of the wool strand had an average value of 29.83cm with a variability of 6.074%. For the milk quantity character, an average quantity of 45.27

kg was obtained and a variability of 7.60%. For The body weight, the following were obtained: for G60, an average value of 16.37 kg with a variability of 10.90%, and for G120, an average value of 32.24 kg with a variability of 6.94%. A ADG of 260.94 g was calculated with a variability of 17.43% (Table 3).

Table 3. Average performances of the traits in the Tsurcana - Bucălae breed

Traits	N	U.M.	MEAN ± SEM	SD	CV %	Min	Max
conformation (1)	3288	Note	8.8069 ± 0.0119	0.6841	7.768	7	10
wool yield (2)		kg	3.8352 ± 0.0074	0.423	11.0294	2.95	6
wool length (3)		cm	29.8287 ± 0.0316	1.8118	6.074	23.08	34.5
milk yield (4)		kg	45.2748 ± 0.0601	3.4447	7.6085	30.68	63.28
body weight at 60 days (5)		kg	16.3716 ± 0.0311	1.7852	10.9044	13	22.6
body weight at 120 days (6)		kg	32.2449 ± 0.0391	2.2397	6.9459	25	38
average daily gain (7)		g	260.9465 ± 0.7952	45.5966	17.4735	112.9	400

By analyzing the data of the individuals from the Oacheșă Variety, an average score of 8.6748 and a variability of 7.69% was obtained. For the character of wool yield, an average quantity of 3.76 kg was obtained with a variability of 9.65%. An average length of the wool strand of 29.46 cm and a variability of 5.10% was observed. For the quantity of milk, an average of 45.37 kg was obtained with a variability of 7.088%. For the body weight at 60 days the average performance was 16.15 kg with a variability of 11.23%, and for the body weight at 120 days the average was 32.76 kg and a variability of 16.19%. For ADG an average value of 261.15 grams was obtained with a variability of 16.99%.

Table 4. Average performances of the traits in the Tsurcana - Oacheșă

Traits	N	U.M.	MEAN ± SEM	SD	CV %	Min	Max
conformation (1)	7306	Note	8.6748 ± 0.0078	0.6676	7.6953	7	10
wool yield (2)		kg	3.7638 ± 0.0042	0.3631	9.6467	2.83	6
wool length (3)		cm	29.4677 ± 0.0176	1.5046	5.1061	23.08	34.5
milk yield (4)		kg	45.3676 ± 0.0376	3.2156	7.088	32.21	62.59
body weight at 60 days (5)		kg	16.1497 ± 0.0212	1.8132	11.2274	13	22.1
body weight at 120 days (6)		kg	32.7623 ± 0.062	5.3029	16.1861	21	101
average daily gain (7)		g	261.1537 ± 0.5191	44.3715	16.9905	114.75	400

Heritability of the analyzed traits

Heritability expresses the share of the total phenotypic variability attributed to the average effect of genes.

Given that the genetic structure differs from one population to another, it results that heritability is a property of each population in particular. And in the present analysis, heritability was estimated for each of the four populations considered.

From the analysis of the heritability of morphological traits for the studied herd belonging to the Belă line, it is observed that Wool length has an intense heritability (0.44) and Milk yield also has an intense heritability (0.475).

Average daily gain ADG (0.147), wool yield (0.182) and conformation (0.147) are weakly heritable traits.

For the Bucălae herd, we note that high heritability values were calculated for the milk yield trait (0.337).

For the other analyzed traits, conformation, wool yield, G60, G120, ADG, weak heritability values were obtained.

Lazăr et al. (2022) obtained the heritability of daily milk production in the first three lactations with values between 0.015 and 0.246.

Rotar et al. (2025) reported heritability values of 0.21 for milk production and 0.34 for wool production in the Tsurcana breed. Similarly, Popa et al. (2021) estimated heritability for test-day milk production in first-lactation ewes between 0.105 at 70 days and 0.270 at 115 days of lactation.

Table 5. Heritability and heritability standard error ($h^2 \pm SE$) for the traits analyzed in the Tsurcana breed populations

Traits	Tsurcana			
	Belă	Breazăă	Bucălae	Oacheșă
conformation (1)	0.15±0.039	0.140±0.111	0.128±0.045	0.124±0.027
wool yield (2)	0.18±0.041	0.194±0.112	0.239±0.050	0.199±0.030
wool length (3)	0.44±0.05	0.270±0.112	0.231±0.050	0.236±0.031
milk yield (4)	0.47±0.051	0.337±0.112	0.254±0.051	0.291±0.034
body weight at 60 days (5)	0.26±0.041	0.176±0.112	0.116±0.044	0.118±0.026
body weight at 120 days (6)	0.36±0.047	0.183±0.112	0.118±0.044	0.293±9.034
average daily gain (7)	0.15±0.039	0.141±0.112	0.117±0.044	0.102±0.026

Heritability values for sheep

Vatankhah & Talebi (2008) reported direct heritability estimates for body weight of 0.31 ± 0.02 at birth, 0.10 ± 0.02 at weaning, and 0.19 ± 0.02 at six months of age, while maternal heritability estimates were 0.22 ± 0.02, 0.16 ± 0.02, and 0.04 ± 0.02, respectively.

In the Bucălae subpopulation, weak heritability values were recorded for most traits, ranging from 0.116 for body weight at 60 days to 0.128 for conformation. Moderate heritability values were obtained for wool yield (0.239), wool length (0.231), and milk yield (0.254).

Following the analysis of the herd of sheep belonging to the Oacheșă variety, the heritability values fluctuate within narrow limits from 0.102 for ADG to 0.293 for G120, thus being weakly heritable. We note that different heritability values were calculated for the same production character in the analyzed herds of the 4 analyzed varieties. Average heritability values of 0.27 for milk production were obtained by (Pascal et al., 2007).

Genetic correlation between the analyzed traits

The values of the genotypic correlation coefficient (r_g) indicate the existence of variable relationships in terms of intensity and direction between the traits. It is observed that some combinations of traits show positive correlations, which indicates that an increase in one character is associated with an increase in the other. Conversely, negative correlation values signal an inverse relationship between the traits. It is also noted the existence of higher intensity correlations, which suggests a stronger genetic link between these traits, while low values indicate weak relationships. The correlation error shows the degree of precision of the estimates. We can conclude that there is no strong correlation between conformation and the other analyzed traits, moreover, negative values were also obtained.

Correlations with small negative values (-0.023) Belă and at (-0.062) Breazăă between conformation and wool length and weakly positive between the other traits.

In Bucălae, conformation is negatively correlated with milk quantity (-0.18) and with G60 (-0.014). In Oacheșa, conformation is negatively correlated only with milk yield (-0.072) and positively correlated with the others, from 0.022 to G120 and 0.227 to wool length (Table 6).

Table 6. Genotypic correlation

The combination of traits	Tsurcana							
	Belă		Breazǎ		Bucălae		Oacheșă	
	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}
conformation-wool yield	0.024	0.173	-0.131	0.469	0.042	0.191	0.023	0.127
conformation-wool length	-0.023	0.124	-0.062	0.408	0.221	0.184	0.227	0.113
conformation-milk yield	0.044	0.12	0.102	0.367	-0.18	0.181	-0.072	0.111
conformation - body weight at 60 days	0.066	0.151	0.031	0.499	-0.014	0.258	0.059	0.154
conformation-body weight at 120 days	0.015	0.134	0.034	0.49	0.208	0.245	0.022	0.111
conformation-ADG	0.118	0.187	0.06	0.552	0.188	0.247	0.143	0.161

Table 7 presents the genotypic correlations between wool yield and the other five production traits analyzed. Compared to the previous table, variations in the values of the correlation coefficients are observed, reflecting genetic differences between subpopulations. In Bela most correlations are of low to moderate intensity, but there are also stronger correlations for milk quantity with values between 0.179 in Oacheșă and 0.319 in Bucălae and for the wool length trait with values between 0.428 in Belă and 0.667 in Bucălae, indicating important genetic associations between certain traits. The presence of both positive and negative values shows that some traits evolve in the same direction, while others are antagonistic. The error associated with the coefficients indicates the level of confidence of these estimates.

The wool yield is strongly correlated in all lines with the length of the wool with limits of 0.427 in Belă and 0.667 in Bucălae.

The wool yield with the amount of milk is genetically intermediately correlated with limits of 0.179 in Oacheșă and 0.319 in Bucălae.

Wool yield and body weight at 60 days showed a moderate positive correlation in most subpopulations, with values ranging from 0.126 in Oacheșă to 0.381 in Breazǎ, while a weak negative correlation was recorded in the Bucălae line (-0.065).

Table 7. Genetic relationship between wool yield and the other 5 analyzed traits, in the Tsurcana breed

The combination of traits	Tsurcana							
	Belă		Breazǎ		Bucălae		Oacheșă	
	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}
wool yield-wool length	0.427	0.093	0.474	0.273	0.667	0.084	0.502	0.075
wool yield - milk yield	0.259	0.103	0.237	0.301	0.319	0.13	0.179	0.09
wool yield-G60	0.229	0.131	0.333	0.381	-0.065	0.199	0.126	0.128
wool yield-G120	-0.072	0.121	0.28	0.388	0.057	0.198	-0.094	0.092
wool yield-ADG	0.069	0.172	0.129	0.468	0.103	0.197	-0.051	0.137

Note: G60 - body weight at 60 days; G120 - body weight at 120 days; ADG - average daily gain

The genetic correlation between the wool yield and G120 is weakly negative in Bela (-0.072) and Oacheșă (-0.094) and intermediately positive in Breaza (0.28) and Bucălae (0.057).

For the character wool yield and ADG it is weakly positive with limits of (0.069) at Belă and (0.129) at Breazǎ. For the Oacheșa line the correlation was negative (-0.051).

Positive genotypic correlations between wool yield and wool length were consistently observed across all four subpopulations, while negative or low values were recorded for the trait combinations wool yield – body weight at 60 days, wool yield – body weight at 120 days, and wool yield – average daily gain. In a related context, Vatankhah & Talebi (2008) reported positive genetic correlations between lamb body weight and various reproductive traits, ranging from 0.06 to 0.98.

Table 8 presents the genotypic correlations obtained between the wool length trait and milk yield, the body weight at 60 days (G60), the body weight at 120 days (G120) and average daily gain (ADG).

The correlation values between wool length and wool yield were intermediately correlated with limits between 0.061 in Brează and 0.586 in Belă line. For the correlation between wool yield and G60, intermediate values were obtained between 0.21 in Brează and 0.514 in Belă and for the Bucălae line, negative values were obtained (-0.206). The correlation between wool length and G120 is negatively correlated (-0.046) in Belă line and weakly correlated in Bucălae (0.144) and in Brează (0.362). For the Correlation between Wool Length and ADG, weakly correlated values were obtained from 0.158 in Oacheșă and 0.248 in Bucălae. A high variability of the values of the correlation coefficients is observed, from negative values to high positive values.

Table 8. Genotypic correlations between wool length and milk yield, body weight at 60 days, body weight at 120 days, and average daily gain in the Tsurcana breed

The combination of traits	Tsurcana							
	Belă		Brează		Bucălae		Oacheșă	
	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}
wool length-milk yield	0.586	0.052	0.061	0.273	0.262	0.137	0.332	0.078
wool length-G60	0.514	0.073	0.21	0.352	-0.206	0.194	0.217	0.116
wool length-G120	-0.046	0.087	0.362	0.314	0.144	0.197	-0.13	0.086
wool length-ADG	0.175	0.12	0.218	0.389	0.248	0.189	0.158	0.126

Note: G60 - body weight at 60 days; G120 - body weight at 120 days; ADG - average daily gain

Some combinations of traits show positive correlations, which indicates a significant genetic link, but in general there are correlation values that show that there was no strong correlation between wool length and G60 except for the Belă population, and for the correlation between wool length and ADG low values were obtained, with a low correlation. Negative correlations also appear, indicating inverse relationships between traits. The correlation error must be taken into account in the interpretation of the results. Hanford et al. (2002) states that the estimate of the genetic correlation between wool the body weight and fiber length was positive (0.55).

Other authors (Naidoo et al., 2004), obtained high and positive genetic correlation values for wool yield and wool strand length from 0.45 to 0.60 in the samples tested.

Table 9. Genotypic correlations between milk yield and body weight at 60 days, body weight at 120 days, and average daily gain in the Tsurcana breed

The combination of traits	Tsurcana							
	Belă		Brează		Bucălae		Oacheșă	
	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}
Milk yield - G60	0.683	0.051	0.515	0.245	-0.142	0.192	0.16	0.111
Milk yield - G120	0.118	0.084	0.454	0.26	-0.145	0.19	-0.151	0.08
Milk yield - ADG	0.238	0.113	0.296	0.337	-0.025	0.195	0.051	0.12

Note: G60 - body weight at 60 days; G120 - body weight at 120 days; ADG - average daily gain

Table 9 highlights the various genotypic correlations between the traits Milk quantity and G60, G120 and ADG. Thus, higher values were obtained for the correlation between milk quantity and G60 for the Belă (0.683) and Breazã (0.515) populations and weakly correlated values for Oacheșă (0.16) and negative values for Bucălae (-0.142). For the correlation between Milk quantity and G120, the results were weakly correlated for Belă (0.118) and Breazã (0.454) and negative values for Bucălae (-0.145) and Oacheșă (-0.151). The correlation between Milk quantity and ADG is weakly correlated with values between 0.051 for Oacheșă and 0.296 for Breazã and negatively correlated for Bucălae (-0.025).

Table 10. Genotypic correlations of body weight at 60 days with body weight at 120 days and average daily gain (ADG) in the Tsurcana breed

The combination of traits	Tsurcana							
	Belă		Breazã		Bucălae		Oacheșă	
	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}
body weight at 60 day- body weight at 120 days	0.078	0.106	0.464	0.346	0.071	0.267	-0.075	0.113
body weight at 60 day - ADG	-0.051	0.15	-0.135	0.489	-0.579	0.178	-0.458	0.133

Table 10 presents the correlation values obtained by analyzing the data for the traits The body weight at 60 days and the body weight at 120 as well as ADG. Both positive and negative values were obtained. The highest positive value was obtained (0.464) between G60 and G120 in the Breazã sheep population, and the highest negative value (-0.579) was obtained between G-60 and ADG in Bucălae.

The correlation between G60 and G120 is weakly correlated with values between 0.071 in Bucălae and 0.464 in the Breazã line and negatively correlated (-0.075) in Oacheșa. For the correlation between G60 and ADG, negative values were obtained, -0.051 in the Belă Line and -0.579 in Bucălae. Mekuriaw & Haile (2014) obtained strongly positive values between 0.61 and 0.98 for the live the body weight trait.

In table 11 for the combination of the G-120 and ADG traits, we observe that only positive correlation values were obtained. High values were recorded for the Breazã (0.790) and Bucălae (0.763) populations. We can say that there is a fairly strong correlation between the two traits in the populations mentioned above. However, most of the correlation coefficient values are close to zero, which indicates weak genetic relationships between a large part of the traits.

Table 11. Genotypic correlation between the body weight at 120 days and average daily gain (ADG) in the Tsurcana breed

The combination of traits	Tsurcana							
	Belă		Breazã		Bucălae		Oacheșă	
	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}	r_G	S_{r_G}
body weight at 120 days -ADG	0.042	0.133	0.79	0.184	0.763	0.112	0.169	0.117

The genotypic correlation error values are relatively low, suggesting a good accuracy of the estimates. Overall, the results obtained highlight the existence of relevant genetic correlations, which can be exploited in the selection process.

CONCLUSIONS

The average performances recorded across all four Tsurcana subpopulations (Belă, Breazã, Bucălae, and Oacheșă) for the seven analyzed traits fall within the breed standards and are consistent with values reported in the literature. Heritability estimates varied considerably both across traits and across subpopulations. Milk yield and wool length showed the highest heritability values (up to 0.475 and 0.44, respectively, in the Belă subpopulation), while conformation and average daily gain were weakly heritable across all four lines. These

differences confirm that heritability is a population-specific parameter and should be estimated separately for each population.

Genotypic correlations between traits covered the full range of possible values, from strongly negative to strongly positive. The most consistent association across all subpopulations was observed between wool yield and wool length, while correlations involving body weight traits were generally weak and variable. Negative correlations were identified for several trait combinations, indicating antagonistic genetic relationships that must be considered when designing selection indices.

The results provide a quantitative basis for developing differentiated breeding programs for each Tsurcana subpopulation, adapted to their specific genetic structure and production objectives

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