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Genetic parameters for growth traits of Romanian Teleorman Black Head Tsigai sheep

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ABSTRACT

Estimation of genetic parameters for the local sheep for growth traits is necessary to estimate breeding value of the animals and to determine the breeding objectives. The purpose of this study was to estimate genetic parameters for lamb weight at different age and for average daily weight gain in a local Teleorman Black Head Tsigai population. Records of 545 lambs coming from 210 ewes and 18 rams, were used. Body weight at birth, 30 days and 60 days; the average daily weight gain from birth to 30 days, from 30 to 60 days and from birth to 60 days, were analized. The restricted maximum likelihood method with a model including the maternal genetic effects was used to estimate the genetic parameters.

The results revealed that direct and total heritability estimates were low for body weight at 30 days, moderate for birth weight, body weight at 60 days while high for average daily gain from birth to 30 days, 30 days to 60 days and birth to 60 days. The maternal heritability estimates were low for body weight at birth, 30 days and 60 days and moderate for average daily gain from birth to 30 days, 30 days to 60 days and birth to 60 days.

Key words: Average daily gain, Body weight, Genetic parameters, Lamb, Local breed

The Teleorman Black Head Tsigai sheep, a Romanian local breed reared especially in Teleorman County (Draganescu and Joitoiu 1998), has aptitudes for high milk and meat production and for prolificacy. The estimation of the genetic parameters for the Teleorman Black Head Tsigai is necessary to assess the breeding value of the animals and to determine the breeding objectives. A breeding program for meat production is also necessary for the Teleorman Black Head Tsigai. To estimate the genetic parameters for growth traits in local sheep breed many authors used restricted maximum likelihood (REML) method with different linear models (Fadili *et al.* 2000, Bahreini Behzadi *et al.* 2007, Shokrollahi and Baneh 2012) concluding that the model including the direct genetic effects, maternal genetic and permanent environmental effects can be considered the best.

The objective of our work was to estimate the genetic parameters for the body weight and weight gain at different ages of the Teleorman Black Head Tsigai lambs, in order to characterise this local breed sheep.

MATERIAL AND METHODS

Teleorman Black Head Tsigai population (545 lambs from 210 ewes and 18 rams) was studied. The live weight at birth, 30 and 60 days and average daily weight gain from birth to 30 days, 30 to 60 days and from birth to 60 days, measured and analyzed. The suckling period lasted 60 days.

Statistical analysis: The genetic parameters have been estimated using the Restricted Maximum Likelihood (REML) method using a Maternal Trait linear model in matrix notation (Mrode and Thompson, 2005)

$$y = Xb+Za+Wm+Spe+e$$

where y, the vector of observations; b, the vector of the fixed effects; a, the vector of the randomised animal effects; m, the vector of the randomised maternal genetic effects, pe, the vector of the permanent environmental effects and e, the vector of the random residual effects; X, Z, W and S are the incidence matrices referring to animal performance, fixed effects, direct effects, maternal effects and to the permanent environmental effects. It is assumed that:

$$\mathrm{var}\begin{bmatrix} a \\ m \\ pe \\ e \end{bmatrix} = \begin{bmatrix} \sigma_a^2 A & \sigma_{am} A & 0 & 0 \\ \sigma_{am} A & \sigma_m^2 A & 0 & 0 \\ 0 & 0 & I\sigma_{pe}^2 & 0 \\ 0 & 0 & 0 & I\sigma_e^2 \end{bmatrix}$$

where *A*, kinship matrix between animals; I, identity matrix; σ^2_a, additive genetic variance for the direct effects; σ^2_m, additive genetic variance for the maternal effects; σ_{am} additive genetic covariance between the direct and maternal

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effects; σ^2_{pe}, variance due the permanent environmental effects; σ^2_e, variance of the residual error.

The following parameters were estimated:

- Direct heritability

$$h_a^2 = \frac{\sigma_a^2}{\sigma_p^2}$$, where σ_p^2, the phenotypic variance

- Maternal heritability

$$h_m^2 = \frac{\sigma_m^2}{\sigma_p^2}$$

- Covariance between the direct and maternal effects as proportion of the phenotypic variance

$$\frac{\sigma_{am}}{\sigma_p^2}$$

- The total heritability (Willham 1972):

$$h_T^2 = \frac{\sigma_a^2 + 0.5\sigma_m^2 + 1.5\sigma_{am}}{\sigma_p^2}$$

where h^2_T is total heritability; σ^2_P is the phenotypic variance

- Proportion of the maternal permanent environment within the phenotypic variance (c^2).
- r_{am} genetic correlation between the direct and maternal effects,

$$r_{am} = \frac{\sigma_{am}}{\sqrt{\sigma_a^2 \cdot \sigma_m^2}}$$

In this study, the fixed part of the model includes the lactation rank effect levels (8), litter size effect levels (3) and lamb gender effect levels (2). The random effects have been the direct genetic effects, the maternal genetic effects and the permanent environmental effects.

The direct genetic correlations between traits were estimated by correlation of breeding values of lambs for these traits, maternal genetic correlations were estimated by correlation of maternal genetic effects for the studied traits. The phenotypic correlations were estimated by correlation between phenotypic values of the lambs for these traits.

RESULTS AND DISCUSSION

Estimation of variance and covariance, direct and maternal genetic heritability, correlation between direct and maternal genetic effects and proportion of permanent environmental effects within the total variance for the body weights and for the average daily weight gain traits are given in Table 1.

The direct heritability was moderate for the body weight at birth and for the body weight at 60 days, while the heritability for the body weight at 30 days was low. The direct heritability for the body weight at 60 days (weaning weight) was greater than the direct heritability for the weight at birth, showing a potential of the Teleorman Black Head Tsigai for the selection by the weaning weight. The direct heritability for these traits was higher than the maternal heritability. The covariance between the direct and maternal effects as proportion of the phenotypic variance was negative and low for body weight at different ages (–0.065, –0.044, –0.074) and for the average daily gains (–0.122, –0.123, –0.123). A negative covariance between direct and maternal effects was due to pleiotropy. The genetic correlation between the direct and maternal genetic effects for the body weight of the lambs at birth (r_{am},–0.340), 30 days (r_{am},–0.340) and 60 days (r_{am},–0.344) and for the average daily gains (r_{am},–0.351, r_{am},–0.354, r_{am},–0.350) was moderate and negative. The negative estimate for this parameter was due to the small number of data in the present study and to pleiotropy. The permanent maternal environmental variance, as proportion from the phenotypic variance c^2 was smaller having the same value for the weight at birth, at 30 days and at 60 days (0.049).

Table 1. Estimates of (co)variance components and genetic parameters

Item	Body weight			Average daily gain		
	birth	30 days	60 days	birth to 30 days	30 days to 60 days	birth to 60 days
σ^2_a	0.1940	1.2170	4.4750	0.0033	0.0052	0.0020
σ^2_m	0.1170	0.7310	2.6740	0.0020	0.0030	0.0012
σ_{am}	–0.0510	–0.3210	–1.1920	–0.0009	–0.0014	–0.0005
σ^2_{pe}	0.0390	0.3570	0.7900	0.0003	0.0005	0.0002
σ_e^2	0.4800	5.1900	9.2460	0.0026	0.0040	0.0015
σ_p^2	0.7790	7.1740	15.9930	0.0073	0.0113	0.0043
h_a^2	0.2490 ± 0.1200	0.1690 ± 0.1000	0.2790 ± 0.1300	0.4480 ± 0.1900	0.4600 ± 0.1900	0.4570 ± 0.1900
h_m^2	0.1500 ± 0.0900	0.1020 ± 0.0700	0.1670 ± 0.0900	0.2710 ± 0.1300	0.2650 ± 0.1300	0.2740 ± 0.1300
c^2	0.0490	0.0490	0.0490	0.0480	0.0490	0.0490
σ_{am}/σ_p^2	–0.0650	–0.0440	–0.0740	–0.1220	–0.1230	–0.1230
r_{am}	–0.3400	–0.3400	–0.3440	–0.3510	–0.3540	–0.3500
h_T^2	0.2300 ± 0.1100	0.1500 ± 0.1500	0.2500 ± 0.1200	0.4070 ± 0.1700	0.4070 ± 0.1700	0.4090 ± 0.1800

σ^2_a direct additive genetic variance, σ^2_m maternal genetic variance, σ_{am} direct–maternal additive genetic covariance, σ^2_{pe} maternal permanent environmental variance, σ_e^2 residual variance, h_a^2 direct heritability, h_m^2 maternal heritability, $c^2 = \sigma_{pe}^2/\sigma_p^2$ ratio of maternal permanent environmental variance to phenotypic variance, σ_{am}/σ_p^2 covariance between direct and maternal effects as proportion to phenotypic variance, r_{am} genetic correlation between direct and maternal effects, h_T^2 total heritability.

Table 2. Estimation of body weight and average daily gain: mean values with standard error, standard deviation, variation coefficients, and correlations between body weight at birth and growth traits [direct genetic (r_d), maternal (r_m) and phenotypic correlation (r_p)]

Item	Body weight (kg)			Average daily gain (kg)		
	birth	30 days	60 days	birth to 30 days	30 days to 60 days	birth to 60 days
Mean	5.0700	13.1200	19.6700	0.2700	0.2200	0.2400
Standard error	0.0390	0.1220	0.1710	0.0030	0.0040	0.0020
Standard deviation	0.9170	2.8670	4.0120	0.0800	0.0950	0.0610
Variation coefficient (%)	18.0900	21.8500	20.3900	30.1600	43.9000	25.2300
r_d		0.4230	0.0490	0.1650	–0.2420	–0.0940
r_m		0.4440	0.1840	0.1370	–0.1550	–0.0320
r_p		0.6000	0.4550	0.3310	0.0361	0.2460

The study showed that the direct heritability estimates for the body weight at birth of the lambs were similar to the one reported by Hanford *et al.* (2002) and by Van Vleck *et al.* (2003), were lower than those reported by Van Wik *et al.* (1993) and were larger than those reported by Tosh and Kemp (1994), Annalla and Serradilla (1998) and Reyes Lopez-Ordaz *et al.* (2012).

The maternal heritability for the body weight at birth was lower than the one reported by Tosh and Kemp (1994), Gamasaee *et al.* (2010) was similar with the one reported by Mousa *et al.* (1999) and by Janssens *et al.* (2000) and was greater than those reported by Mohammadi *et al.* (2010). In our study c^2 was lower than the value reported by Maria *et al.* (1993). Gamasaee *et al.* (2010) found out that the maternal heritability was lower than direct heritability for all traits.

The total heritability for the body weight at birth in our study was greater than those reported by Koyuncu and Duru (2009) and Shokrollahi and Baneh (2012).

Family structure is important when the maternal genetic effect is estimated, as reported by Maniatis and Pollot (2003). Snyman *et al.* (1995) and Yazdi *et al.* (1997) found out that the direct heritability tends to increase with the age of the lambs. In our study, the direct heritability for the body weight at 60 days was larger than the direct heritability for the body weight at birth. The value of the direct heritability estimated for the body weight at weaning was larger than the value reported by Annalla and Seradilla (1998) and by Rao and Notter (2000) and lower than the one reported by Fadili *et al.* (2000). The values of the direct heritability for the body weight traits of the lambs at different ages were larger than the values of the maternal heritability for the same traits in our study, supporting the observation of Hassen *et al.* (2003) that there is a trend that the values of the direct heritability are larger than the values of the maternal heritability for the traits of early growth. In our study and in other studies as well (Ligda *et al.* 2000, Hassen *et al.* 2003, Shokrollahi and Baneh 2012), a negative correlation was estimated between the direct genetic effects and the maternal genetic effects for the body weight at birth and the body weight at weaning. In our study, and in the study of Notter (1998), a negative correlation was estimated between the direct genetic effects and the maternal genetic effects, for the body weight of the lambs at 30 days. The value of the maternal heritability for the body weight at weaning at 60 days is similar with the value estimated by Annalla and Serradilla (1998).

The direct heritability for the average daily weight gain traits was higher than for the body weight traits. The values of the direct and maternal heritability were higher for the average daily weight gain from 30 days to 60 days, than the heritability for the average daily weight gain from birth to 30 days. The values of the direct and maternal heritability for the average daily body weight gain from birth to 60 days are larger than those reported by Maria *et al.* (1993) and by Hassen *et al.* (2003).

The values of the correlations between the direct and maternal genetic effects for the traits of the average daily weight gain were negative, like the values reported by Hassen *et al.* (2003) and Oczan *et al.* (2005).

The coefficient of variability for the body weight and for the average daily weight gain at different ages in the analysed population was high. These traits can be improved by selection.

The estimation of phenotypic correlations, of direct genetic correlations and of maternal genetic correlations between the traits are given in Table 2. The direct genetic correlation between body weight at birth and body weight at 30 days was moderate and positive (0.423), while the direct genetic correlation between body weight at birth and body weight at 60 days was small and positive, as was genetic correlation between body weight at birth and average daily weight gain from birth to 30 days. Negative genetic correlations were obtained between body weight at birth and average daily weight gain from 30 days to 60 days, and between body weight at birth and average daily weight gain from birth to 60 days.

Genetic correlation between maternal effects for body weight at birth and body weight at 30 days was moderate and positive, while maternal genetic correlation between body weight at birth and body weight at 60 days was small and positive, and so was maternal genetic correlation between body weight at birth and average daily weight gain from birth to 30 days.

Negative maternal correlations were obtained between body weight at birth and average daily weight gain from 30 days to 60 days (–0.242), and between body weight at birth and average daily weight gain from birth to 60 days (–0.032). These negative correlations may reflect differences in the animal responses to pre-weaning environmental conditions and may occur through pleiotropy.

Phenotypic correlation between body weight at birth and body weight at 30 days was positive and large (0.600), while the phenotypic correlation between the body weight at birth and the body weight at 60 days was positive and moderate, just like the phenotypic correlation between the body weight at birth and the average daily weight gain from birth to 30 days.

Total heritability for body weight at 60 days was moderate and this trait can be used for early genetic improvement of the Teleorman Black Head Tsigai sheep. In conclusion, the estimation of the genetic parameters for the Teleorman Black Head Tsigai is necessary for the breeding program of this local sheep breed.

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