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Estimation of Genetic Parameters of Body Weight Traits in Ghezel Sheep

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ABSTRACT: The present study was carried out to estimate genetic parameters for body weight traits in Ghezel sheep. The data set used was records of 9,221 lambs from 180 sires and 5,060 dams for birth weight (BW), 7,206 lambs from 167 sires and 4,497 dams for weaning weight (WW) and 6,112 lambs from 157 sires and 3,841 dams for 6-months weight (6 MW), which were collected from 1999 to 2007 (9-years) at Ghezel sheep Breeding Station in west Azarbaijan. Variance components and corresponding genetic parameters were obtained with univariate analyses fitting animal models using restricted maximum likelihood (REML) methods. The most suitable model for each trait was determined based on log likelihood ratio tests. Birth year, lamb gender, type of birth, age of dam and herd were significant sources of variation on BW, WW and 6 MW ($p<0.01$). Direct estimate of heritability for BW, WW and 6 MW was 0.24, 0.29 and 0.37, respectively. The estimate of maternal permanent environmental variance as a proportion of phenotypic variance was 0.09 and 0.05 for BW and WW, respectively. The results of this study showed that genetic progress for growth traits is possible by selection.
(**Key Words :** Variance Components, Heritability, Body Weight Traits, Ghezel Sheep)

INTRODUCTION

Ghezel sheep numbering about 2 million are raised in North Western of Iran. This breed is native, fat-tailed and large-sized (38.2 to 41.7 kg at yearling in female and male respectively). They are well adapted to mountainous and cold conditions (-22.8 to 38.3°C). They are raised primarily for meat, with milk and wool being of secondary importance (Baneh, 2009). Ways to increase meat production in sheep, in any system, are likely to be by producing more lambs per ewe and increasing growth performance of the lambs. The first objective can be achieved by increasing ewe productivity, including lambing rate and frequency, whereas the second objective requires enhancement of the growth potential and survival of lambs (Miraei-Ashtiani et al., 2007). Knowledge on genetic parameters and heritability are crucial for the genetic evaluation and for choosing the best selection schemes (Maxa et al., 2007). A number of studies have demonstrated that the inclusion of maternal effects in animal models has an important effect on the estimates of direct heritability (Nasholm and Danell, 1996; Maniatis and Pollott, 2002; Simm et al., 2002; Nasholm, 2004). There is no published data on the estimation of genetic parameters for body weight traits in this breed. Therefore, the objective of the present investigation was to obtain estimates of the genetic parameters for direct and maternal effects on body weight traits of Ghezel sheep by fitting three animal models, attempting to separate direct genetic, maternal genetic and maternal permanent environmental effects.

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MATERIALS AND METHODS

Data and management

Data and pedigree information on Ghezel sheep collected at the Breeding Station of Ghezel sheep, over the period from 1999 to 2007 (9-years), were used in this research. This information included pedigree information (animal, sire and dam code), birth information (date of birth, lamb sex, birth type) and performance records (birth weight (BW), weaning weight (WW), and 6-months weight (6 MW)). Data which were available for analysis included 9,221 lamb records born from 180 sires and 5,060 dams for BW, 7,206 lamb records born from 167 sires and 4,497 dams for WW, and 6,112 lamb records born from 157 sires and 3,841 dams for 6 MW. Mating was controlled and lambs were weighed and ear-tagged at birth and then pedigree and birth information of each lamb registered separately. Weaning was at approximately 3 months of age. Lambs were grazed during the day and housed at night in spring and summer. While in cold seasons they were fed manually. Feed intake included alfalfa, wheat straw, barley straw, barley barn and other extra forages.

Traits studied included birth weight (BW), weaning weight (WW) at 3 months of age and 6 months weight (6 MW). The structure of data used in the analysis is given in Table 1.

Statistical analysis

A univariate procedure of SAS software package (SAS, 1996) was used to edit the data (removing outlier observations) and check for normality. Data were analyzed by least squares analysis of variance using the general linear model (GLM) procedure of the SAS software package (SAS, 1996) to identify the fixed effects to be included in the final model. The statistical model included lamb gender in 2 class (male and female), birth year in 9 class (1999-2007), dam's age at lambing in 6 class (2-7 years old), birth type in 2 class (single and twin) and herd in 14 class. Because the lambs were not born at the same time but they were weighed together, they have different ages. The age at weighing (in days) was used as a covariate for WW and 6 MW. All these effects were significant ($p<0.01$) for all traits. The model used to estimate genetic parameters included random effect and all fixed effects that were found significant in least squares analysis. Variance components and corresponding genetic parameters of the various traits were estimated by the restricted maximum likelihood (REML) method fitting an animal model. For this purpose the DFREML 3.1 computer program was used (Meyer, 2000). Three univariate models (shown below) were used to estimate genetic parameters.

Model 1 $y = Xb+Z_1a+e$

Model 2 $y = Xb+Z_1a+Z_3c+e$

Model 3 $y = Xb+Z_1a+Z_2m+e$ $\quad Cov(a,m) = 0$

Where y is a vector of records on the different traits; b, a, m, c and e are vectors of fixed effects, direct additive genetic effects, maternal additive genetic effects, maternal permanent environmental effects and the residual effects, respectively; X, Z_1, Z_2 and Z_3 are corresponding design matrices associating the fixed effects, direct additive genetic effects, maternal additive genetic effects and maternal permanent environmental effects to vector of y.

It is assumed that direct additive genetic effects, maternal additive genetic effects, maternal permanent environmental effects and residual effects are normally distributed with mean 0 and variance $A\sigma^2_a$, $A\sigma^2_m$, $Id\sigma^2_c$ and $In\sigma^2_e$, respectively; where σ^2_a, σ^2_m, σ^2_c and σ^2_e are direct additive genetic variance, maternal additive genetic variance, maternal permanent environmental variance and residual variance, respectively; A is the additive numerator relationship matrix; Id and In are identity matrices that have order equal to the number of dams and number of records, respectively. Total heritability was calculated according to Willham (1972) as:

$$h^2_T = (\sigma^2_a+0.5\sigma^2_m+1.5\sigma_{a,m})/\sigma^2_p$$

Where h^2_T is total heritability; σ^2_a direct additive variance; σ^2_m maternal additive variance; $\sigma_{a,m}$ covariance between the animal effects; σ^2_p phenotypic variance. The most appropriate model for each trait was selected based on likelihood ratio tests (Meyer, 2000). An effect was considered to have a significant influence when its inclusion caused a significant increase in log-likelihood, compared to a model in which it was ignored. Significance was tested at $p<0.05$ by comparing differences in log-likelihood (-2 log L) to values for a chi-square distribution with degrees of freedom equal to difference in the number of (co)variance components fitted for two models. If -2 log L values were not significantly different ($p>0.05$) the model with fewest random terms was chosen.

Table 1. Description of data used in the analysis

	BW[1]	WW[1]	6 MW[1]
Number of animals (in pedigree)	13,299	11,200	9,539
Number of records	9,221	7,206	6,112
Number of sires	180	167	157
Number of dams	5,060	4,497	3,841
Mean (kg)	4.18	22.65	32.01
S.D (kg)	0.83	3.12	5.39
CV (%)	19.87	13.78	16.85

[1] BW = Birth weight, WW = Weaning weight, 6 MW = 6 months weight.

RESULTS

The least squares means and standard errors for BW, WW and 6 MW are presented in Table 2. Lamb gender, type of birth, age of dam, birth year and herd had significant influences on body weight traits ($p<0.01$). In all ages, the male and single lambs were heavier than female and twin lambs.

The log likelihood values under three different models with the most appropriate model (in bold) determined using log likelihood ratio tests are given in Table 3. The best model for BW and WW was model 2 and for 6 MW was model 1.

Table 2. Least squares means±SE of body weight traits

Fixed effects	BW[1]	WW[1]	6MW[1]
Gender	**	**	**
Male	3.88^a ±0.01	22.47^a±0.06	32.88^a±0.09
Female	3.67^b±0.01	21.57^b±0.05	31.49^b±0.09
Birth type	**	**	**
Single	4.22^a±0.01	22.63^a±0.04	33.21^a±0.07
Twin	3.33^b±0.01	21.40^b±0.07	31.17^b±0.12
Dam's age (year)	**	**	**
2	3.76^b±0.02	21.65^d±0.08	31.71^c±0.12
3	3.82^a±0.02	22.04^{bc}±0.07	32.17^b±0.11
4	3.74^b±0.02	22.15^b±0.07	32.55^a±0.11
5	3.81^a±0.02	22.03^{bc}±0.08	31.94^{bc}±0.13
6	3.67^c±0.02	21.84^{cd}±0.09	32.11^b±0.13
7 and more	3.84^a±0.02	22.39^a±0.09	32.65^a±0.13
Birth year	**	**	**
Herd	**	**	**
Regression coefficient on day of birth	-	0.014**±0.002	0.054*±0.004
R^2 of the model (%)	0.60	0.65	0.77

.[1] For traits abbreviations see footnote of Table 1. Means with similar letters within a column do not differ at $p<0.05$. *: $p<0.05$ **: $p<0.01$.

Heritability estimates fitting different models for various traits are presented in Table 3. Direct heritability estimates with appropriate models for body weight of lambs increased with age from 0.24 at birth and 0.29 at weaning to 0.37 at 6 months of age. Maternal permanent environmental effects had a significant effect on variation for BW and WW. Maternal permanent environmental estimates of 0.09 and 0.05 were obtained for BW and WW, respectively.

DISCUSSION

The overall least squares means for lamb weights at different ages were higher than those reported for Kermani (Rashidi et al., 2008) and Bharat Merino (Dixit et al., 2001) breeds. The environmental effects on body weight traits of Ghezel lambs were in close agreement with those reported in the literature (Dixit et al., 2001; Mandal et al., 2008; Rashidi et al., 2008; Vatankhah and Talebi, 2008b). The significant influences of environmental factors on body weight in the present study can be explained in part by differences in years (differences in environment, feeding and grazing resources), male and female endocrine system, limited uterine space, and inadequate availability of nutrients during pregnancy, competition for milk between the twins, maternal effects and maternal ability of dam at different ages (Rashidi et al., 2008).

The result of log likelihood ratio tests indicated that both additive genetic effect and maternal permanent

Table 3. Estimates of variance components, genetic parameters and log likelihood ratio with different models with best model in bold[1]

Traits	Models	σ_a^2	σ_m^2	σ_c^2	σ_e^2	σ_p^2	h^2_a±SE	h^2_m±SE	C^2±SE	h^2_T	Log L
BW[2]	Model 1	0.099	-	-	0.257	0.356	0.28±0.02	-	-	0.28	125.94
	Model 2	0.086	-	0.032	0.239	0.357	0.24±0.02	-	0.09±0.01	0.24	**147.92**
	Model 3	0.091	0.014	-	0.252	0.357	0.25±0.03	0.04±0.01	-	0.27	130.25
WW[2]	Model 1	1.55	-	-	3.31	4.86	0.32±0.03	-	-	0.32	-9,325.48
	Model 2	1.39	-	0.253	3.22	4.86	0.29±0.03	-	0.05±0.01	0.29	**-9,320.22**
	Model 3	1.50	0.046	-	3.31	4.86	0.31±0.03	0.01±0.01	-	0.31	-9,323.36
6MW[2]	Model 1	3.54	-	-	6.03	9.57	0.37±0.03	-	-	0.37	**-9,960.32**
	Model 2	3.44	-	0.236	5.90	9.58	0.36±0.03	-	0.03±0.01	0.36	-9,959.22
	Model 3	3.54	0.000	-	6.03	9.57	0.37±0.03	0.000	-	0.37	-9,960.32

[1] σ^2_a: direct additive genetic variance, σ^2_m: maternal additive genetic variance, σ^2_c: maternal permanent environmental variance, σ^2_e: residual variance, σ^2_p: phenotypic variance, h^2_d: direct heritability, h^2_m: maternal heritability, c^2: ratio of maternal permanent environmental effect, h^2_T: total heritability, log L: log likelihood, SE: standard error.

[2] For traits abbreviations see footnote of Table 1.

environmental effects had a significant effect on variation for BW and WW that were probably due to uterine environment, nutrition during pregnancy, milk production and maternal ability of dams in this breed. Therefore, the most appropriate model for BW and WW was model 2. Based on log likelihood ratio test direct additive genetic effect was significant for 6MW, so only model 1 was chosen as the best model for this trait.

The direct additive heritability estimate (0.24) for BW in the present study is within the range reported by other authors in recent research. The range of direct heritability estimates for BW in the literature varies substantially from 0.04 in Kermani (Rashidi et al., 2008) and Romanov (Maria et al., 1993) breeds to 0.46 in Menz breed (Gizaw et al., 2007). The estimate of direct additive heritability for birth weight in the present study were similar with the results reported by Snyman et al. (1995) for Afrino sheep, Larsgard et al. (1998) for Norvegian sheep, Bromley et al. (2000) for Targhee sheep, Hanford et al. (2002) for Columbia sheep, Matika et al. (2003) for Sabi Sheep, Abegaz et al. (2005) for Horro sheep and Hanford et al. (2005) for Rambouillet sheep.

Our estimate of maternal permanent environmental effects was 0.09 for BW which was higher than those observed in Norvegian (Larsgard et al., 1998) and Sangesari sheep (Miraei-Ashtiani et al., 2007). This estimate was in agreement with the findings of Ahmadi et al. (2004), Maria et al. (1993), Mousa et al. (1999), Bromley et al. (2000), Van Wyk et al. (2003) and Mandal et al. (2006). However, estimates reported by Tosh and Kemp (1994) in Hampshire, Polled Dorset and Romanov sheep, Snyman et al. (1995) in Afrino sheep, Nasholm and Danell (1996) in Swidish Finewool Sheep, Ligda et al. (2000) in Chois sheep, Matika et al. (2003) in Sabi Sheep, and Ozcan et al. (2005) in Turkish Merino lambs were higher than our estimate.

The estimate of direct heritability for WW (0.29) obtained in the present study is within the range of those published in the literature, which varied from 0.07 in Polypay (Notter, 1997) and Elsenburg Dormer (Van Wyk et al., 2003) to 0.48 in Menz sheep (Gizaw et al., 2007) and it was in agreement with the finding of Rashidi et al. (2008) in Kermani sheep. Lower direct heritability estimates were reported by Tosh and Kemp (1994) in Romanov sheep, Snyman et al. (1996) in Merino sheep, Larsgard et al. (1998) in Norwegian sheep, Ligda et al. (2000) in Chois sheep, Ozcan et al. (2005) in Turkish Merino sheep, Abegaz et al. (2005) in Horro sheep, Hanford et al. (2006) in Polypay sheep, and Vatankhah and Talebi (2008a) in Lori-Bakhtiari sheep. However, estimates reported by Maria et al. (1993) in Romanov, Tosh and Kemp (1994) in Hompshire, and Gizaw et al. (2007) in Menz sheep were higher than our estimates.

The estimate of maternal permanent environmental effects for WW (0.05) obtained in the present study was near to those published in the literature (Snyman et al., 1996; Matika et al., 2003; Van Wyk et al., 2003; Abegaz et al., 2005).

The direct heritability estimate for 6 MW (0.37) was lower than that reported by Gizaw et al. (2007) and Miraei-Ashtiani et al. (2007), but was greater than the estimates reported by Snyman et al. (1996), Abegaz et al. (2005), and Vatankhah and Talebi (2008a, b).

CONCLUSION

Environmental factors were significant sources of variation for body weight traits in Ghezel lambs. Therefore, effects of environmental factors need to be accounted for in estimates of the best linear unbiased predicted value (BLUP) and genetic evaluation of Ghezel lambs. The genetic parameter estimates obtained for body weight traits in the present investigation indicated that in the Ghezel breed of sheep, genetic progress for these traits is possible by selection.

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