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Original Article

Multivariate genetic analysis on body weight traits in Ghezel sheep

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Abstract

The present study was carried out to estimate the genetic and phenotypic parameters for growth traits in Ghezel sheep, using pedigree information and body weight records which collected from 2000 to 2009 at Ghezel Sheep Breeding Station. Traits of interest were birth weight (BW, n=2,073), weaning weight (WW, n=1,663) and six-month old weight (6MW, n=1,315). The environmental factors were studied using GLM procedure in SAS software. (Co) variance components estimated based on multivariate animal model by REML method, using DMU-package. All traits were significantly influenced by birth year, lamb's sex, type of birth and dam age ($p<0.01$). Heritability estimates for BW, WW and 6MW were 0.16±0.05, 0.24±0.06 and 0.35±0.07, respectively. All genetic correlations between traits were estimated positive and ranged from 0.57 (BW-6MW) to 0.97 (WW-6MW). The phenotypic correlations among all traits were also positive. The results of this study indicate that because of high genetic correlation between traits, selection for each of these traits may result in improvement in other traits as well.

Keywords*:* Ghezel sheep, growth traits, heritability, genetic, phenotypic correlation

1. Introduction

Current meat production from sheep in Iran does not meet the increasing demand (Rashidi *et al.*, 2008). Mutton production in sheep depends on ewe reproduction performance (conception rate and litter size), lamb survival, growth traits and daily weight gain. Growth traits are economically important in sheep production, and directly affect the profitability of the production system. Moreover, body weight affects wool yield and survival particularly at birth.

One strategy for increasing mutton production can be the improvement of growth potential of the lambs. This objective can be achieved by selecting the individuals that have the highest genetic merit for growth traits as possible next generation parents (Miraei-Ashtiani *et al.*, 2007; Baneh, 2009). Therefore, knowledge on inheritance of economically important traits and genetic relationship among them are critical for accurate genetic evaluation, maximizing response to selection, and design the best breeding schemes (Maxa *et al.*, 2007a; Rashidi *et al.*, 2008; Baneh, 2009). Heritability estimates of growth traits have been widely reported for different sheep breeds ranged from 0.04 (Rashidi *et al.*, 2008) to 0.49 (Miraei-Ashtiani *et al.*, 2007). These variations may be aroused by breed differences, number of observations, pedigree and data structure, fitted models, rearing conditions, mating systems and selection intensity (El Fadili *et al.*, 2000; Baneh, 2009).

The Ghezel is one of the native fat-tailed breeds in the north-western part of Iran, populated approximately two million. This breed is well adapted to its geographical conditions. It also has high reproductive performance and milk and meat yield. Live lamb trade is the main income source for

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Ghezel sheep breeders (Baneh, 2009).However single trait analysis of body weight traits for this breed has been already studied by Baneh *et al.* (2010). But, there is no published information on the estimation of genetic parameters for such traits using multiple trait analysis in the Ghezel sheep. Therefore, this study aimed to estimating the genetic parameters for body weight traits of Ghezel sheep using a multivariate animal model. Genetic and phenotypic correlations among the studied traits were also estimated.

2. Material and Methods

2.1 Management and data set

The Ghezel Sheep Breeding Station (GSBS) is located at Miandoab City in Western Azerbaijan Province, at 46º06′E and 36º58′N. Temperature varies from -22.8°C (winter) to 38.3°C (summer). Average annual rainfall is 342 mm/year. All animals grazed during the day on natural pasture as far as weather conditions are suitable and housed at night. During cold seasons, they are fed manually. Ewes were first exposed to ram at 18 months old. Mating ewes with selected rams starts in October annually and continues for 51 days that is for three estrous periods. Lambing season is from March to May. The pedigree data for each lamb including animal ID, its sire and dam IDs, date of birth, sex, and type of birth was recorded at birth. All lambs weaned at approximately three months old. Body weight recorded at birth, three and six month's ages.

Data and pedigree information collected at the GSBS from 2000 to 2009 were used in for this study. Baneh *et al.* (2010) used both collected data at GSBS flock and flocks under supervision of GSBS, but in this study just the records of station flock were used. Investigated traits were birth weight (BW), weaning weight (WW) and six-months-old weight (6MW). Outliers (i.e. observations that were more than 3 s.d. above or below the observed trait mean); records from animals with unknown dam and observations with missing previous records were not considered in analysis.

After editing, all available data were included BW of 2,073 lambs from 65 sires and 899 dams, WW of 1,663 lambs from 63 sires and 829 dams and 6MW of 1,315 lambs from 48 sires and 710 dams. The data structure and descriptive statistics for studied traits are presented in Table 1.

2.2 Statistical analysis

The data were initially analyzed using the general linear model (GLM) procedure (SAS, 1996) to identify which the fixed effects should be included in the final model. The analysis of variance showed that effects of birth year (in 10 classes: 2000-2009), lamb's sex (in two classes: male and female), birth type (in two classes: single and twin), dam's age at lambing (in six classes: 2-7 years old) were significant for all traits. Consequently, for all traits, these significant effects were included in multi-trait mixed model. Age of weighting (in days) was only significant for WW and 6MW ($P<0.01$). Therefore, it was considered as a covariate for the mentioned traits.

(Co)variances components were estimated by restricted maximum likelihood (REML) with a multivariate individual animal model, using DMU-package (Madsen and Jensen, 2007). The following model was fitted on the data:

$$y_i = X_i b_i + Z_i \alpha_i + e_i \quad (1)$$

Where y_i is the vector of observations for trait *i*, b_i is the vector of fixed effects (include year of birth, lamb's sex, type of birth and age of dam at lambing that were found significant in the least square analysis) for trait *i* that were associated with design matrix X_i, α_i is the vector of random animal effects for trait *i* that were associated with design matrix Z_i and *e* is the vector of random residual effects for trait *I*, and X_i and Z_i are incidence matrices relating records for trait *i* to fixed and random animal effects, respectively.

3. Results

The analysis of variance and least square means and standard error of studied traits for each subclass of fixed effects (lamb's sex, birth type and age of dam) are given in Table 2. All traits were significantly different during various years ($p<0.01$). The body weight in males was higher than females ($p<0.01$). Single born lambs were significantly heavier than twins ($p<0.01$). The age of dam had significant effect on all studied traits ($p<0.01$). The least square means of ewe's age at lambing on lamb body weight indicate that it hasn't been changed corresponding to dam's age. However, the maximum means of birth weight of lambs occurred in 3 to 4 years old dams and, for WW and 6MW traits, in 4 years old ones.

(Co)variance components and heritabilities for the studied traits are given in Table 3. The heritability for birth weight, weaning weight, and 6–month weight were 0.16, 0.24, and 0.35, respectively. The genetic and phenotypic

Table 1. Description of data used in the analysis.

Item	Traits		
	BW	WW	6MW
No. of animals (in pedigree)	2,682	2,294	1,860
No. of records	2,073	1,663	1,315
No. of sire	65	63	48
No. of dams	899	829	710
Mean (kg)	4.34	23.78	34.52
S.D. (kg)	0.66	4.31	5.49
C.V (%)	15.23	18.11	15.92

BW: birth weight, WW: weaning weight,
6MW: 6–month weight.

Table 2. Least square means ±S.E. of studied traits.

Fixed effects	Traits		
	BW(kg)	WW(kg)	6MW(kg)
Birth year	**	**	**
Sex	**	**	**
Male	4.29±0.03a	24.01±0.17a	34.87±0.28a
Female	3.96±0.03b	22.01±0.18b	31.48±0.29b
Birth type	**	**	**
Single	4.44±0.03a	24.38±0.16a	34.89±0.25a
Twin	3.81±0.03b	21.65±0.22b	31.46±0.34b
Dam's age (year)	**	**	**
2	4.01±0.04c	22.16±0.22b	32.54±0.34c
3	4.18±0.04a	22.96±0.25a	33.25±0.39bc
4	4.17±0.04ab	23.43±0.24a	34.42±0.37a
5	4.15±0.04ab	23.19±0.28a	33.58±0.41ab
6	4.16±0.04ab	23.04±0.29a	32.51±0.46c
7 and more	4.08±0.04bc	23.29±0.27a	32.73±0.41bc
Regression coefficient on day of birth	-	0.039±0.009**	0.039±0.01**

BW: birth weight, WW: weaning weight, 6MW: 6–month weight, Means with the same superscripts for each subclass within a column are not significantly different from each other at ($p < 0.05$).
*: $p<0.05$ **: $p<0.01$. NS: Not significant.

correlations among traits are presented in Table 4. Genetic correlations for all traits were positive and varied from medium for BW-6MW (0.57) to very high for WW-6MW (0.97). Also, the phenotypic correlations were generally lower than those of genetic ones.

4. Discussion

The estimated effect of birth year could be resulted from annual climate and management conditions. Different climates (rainfall, humidity, and temperature) can affect the quality and quantity of pasture; and will subsequently alter body composition after weaning. The variation in body weight over time could also be resulted from various nutritional terms of lambs, particularly ewe's nutrition during last pregnancy, management and hygiene (ability to the farm manager, financial recourses and availability to veterinary services and feedstuff) (Dixit *et al.*, 2001; Baneh, 2009).

Differences in sexual chromosomes and probably in the position of genes related to growth, sexual difference in physiological characteristics and endocrinal system (type and quantity of hormone secretion especially sexual ones) lead to different animal growth rates between males and females (Vaez Torshizi *et al.*, 1992; Dixit *et al.*, 2001; Rashidi *et al.*, 2008). The birth type can significantly affect BW through an uterine space restriction. However, it can influence WW in two reasons. Firstly, twins are smaller at birth and secondly, competition for suckling from the same mother and consequently drinking less milk compared to single born lambs (Vaez Torshizi *et al.*, 1992; Rashidi *et al.*, 2008; Baneh, 2009).

Table 3. Estimates of variance components and heritability for studied traits.

Traits	σ^2_a	σ^2_e	σ^2_p	h^2
BW	0.045432	0.24403	0.28946	0.16±0.05
WW	2.7474	8.8415	11.589	0.24±0.06
6MW	7.1402	13.052	20.192	0.35±0.07

BW: birth weight, WW: weaning weight, 6MW: 6–month weight, σ^2_a : direct additive genetic variance. σ^2_e : residual variance; σ^2_p : phenotypic variance; h^2 : heritability

The significant effect of dam's age on body weight can be likely explained by differences in milk production, maternal ability of dam (nursing and maternal behavior) and variation in size of ewe's uterus and some physiological phenomena in different ages. Also younger ewes (less than 3.5 years old) utilize the energy for own growth and body development. It means that this energy will be commonly used by lamb and ewe. In contrast, older ewes entirely use it to forming of the lamb (Rashidi *et al.*, 2008; Baneh, 2009).

The effect of environmental factors on body weight at different ages has been reported in recent studies in several Iranian sheep populations. Baneh *et al.* (2010) obtained the same results in Ghezel sheep using more data. They stated that the environmental factors can significantly be accounted

Table 4. Estimate of genetic, environmental and phenotypic correlations between traits.

Traits		Pair Records[a]	σ_a	σ_e	σ_p	r_a	r_e	r_p
BW	WW	1663	0.22536	0.035986	0.26134	0.64±0.17	0.04±0.04	0.14
BW	6MW	1315	0.32417	0.12196	0.44613	0.57±0.16	0.07±0.06	0.19
WW	6MW	1315	4.3124	4.5332	8.8456	0.97±0.05	0.42±0.05	0.58

BW: birth weight, WW: weaning weight, 6MW: 6–month weight.athe number of animals having records for pairs of trait σ_a : additive genetic covariance between trait 1&2, σ_e : environmental covariance between trait 1&2, σ_p : phenotypic covariance between trait 1&2, r_a : additive genetic correlation between trait 1&2, r_e : environmental correlation between trait 1&2, r_p : phenotypic correlation between trait 1&2.

as a potential source for variation in body weight traits of Ghezel sheep and therefore should be considered in genetic evaluation of this breed. Rashidi *et al.* (2008) reported that both birth weight and weaning weight were significantly affected by lamb's sex, birth type, birth year and age of dam at lambing in Kermani sheep. However, Abegaz *et al.* (2005) observed that birth and weaning weights were not significantly affected by age of dam. Non-significant effect of birth type on weaning weight has also been reported in Sabi sheep by Matika *et al.* (2003). Vatankhah and Talebi (2008b) reported the significant effects of lamb's sex, birth type, birth year and age of dam on BW, WW and 6MW in another Iranian sheep that is Lori-Bakhtiari.

The reported heritabilities for of BW has ranged from 0.04 in Kermani sheep (Rashidi *et al.*, 2008) to 0.46 in Menz sheep (Gizaw *et al.*, 2007). However, our estimate was higher than that of Mandal *et al.* (2006) for Muzaffarnagari lambs (0.08) and near to Maxa *et al.* (2007) that is equal to 0.17 for Suffolk sheep in the Czech Republic.

The estimated direct heritability for WW (0.24) in this study was higher than 0.13 in Sabi sheep (Matika *et al.*, 2003) and 0.12 in Turkish Merino sheep (Ozcan *et al.*, 2005). However, our estimate of heritability for WW was in agreement with that reported by Duguma *et al.* (2002) in Merino sheep (0.25) and Rashidi *et al.* (2008) in Kermani sheep (0.27).

Heritability estimated for body weight of 6 months of age in this study (0.35) was generally higher than those in the other published reports, for instance, Abegaz *et al.* (2005) in Horro sheep (0.18), and Vatankhah and Talebi (2008a) in Lori-Bakhtiari sheep (0.19).

The estimated h^2 of 6MW (0.35) was near to that one (0.32) reported by Mokhtari *et al.* (2008) in Kermani sheep and another one (0.31) by Sadeghi (2001) for Sanjabi sheep.

The estimated heritability was to some extent higher than those of reported by Baneh *et al.* (2010). It can be due to more completed pedigree and lower missed sire in the current study. The resulted heritabilities were increasing with age of lamb from 0.16 (at birth) to 0.35 (at 6–month age). Rashidi *et al.* (2008) reported the same trend (from 0.04 at birth to 0.27 at weaning). It may be due to a declining in phenotypic variation after birth caused by a larger proportion of additive variance in phenotypic variance and/or an increasing in expression of genes that likely have additive effects on body weight. Also, a decreasing in maternal effects (maternal additive genetic and maternal permanent environmental effects) on body development with age can be another explanation (Snyman *et al.*, 1996; Yazdi *et al.*, 1997; Duguma *et al.*, 2002; Vatankhah and Talebi, 2008a).

Genetic correlations estimated in this study showed that this parameter decreases with increment in time intervals among traits (as mentioned above). Many authors have already reported the same patterns on genetic correlations in other sheep populations, for instance, Miraei-Ashtiani *et al.* (2007) reported estimate of 0.4 for genetic correlations of BW-6MW versus 0.946 for WW-6MW in Sangsari lambs. In addition, the similar values have been reported by Ozcan *et al.* (2005) in Turkish Merino sheep.

Rashidi *et al.* (2008) reported genetic correlation between BW and WW in Kermani sheep equals to 0.68, which is close to our estimate (0.64). The estimated genetic correlation of BW-6MW was (0.57) was in concordance with those of reported by Miraei-Ashtiani *et al.* (2007) in Sangsari sheep (0.50) and Mokhtari *et al.* (208) in Kermani sheep (0.53).

The positive and high estimate for the genetic correlation between WW and 6MW (0.97) in current study was in agreement with those reported by Vatankhah and Talebi (2008a) in Lori-Bakhtiari sheep (0.90) and Gizaw *et al.* (2007) in Menz sheep (0.98). Relatively high and positive estimates of genetic correlations indicated that selection for any one of the studied body weight traits could result in genetic progress for the other traits.

Also, an estimate of the phenotypic correlation between BW and WW (0.14) from the current study was similar to the value of 0.16 reported by EmamiMeibodi *et al.* (2001) in Balouchi sheep. In addition, Mokhtari *et al.* (2008) reported the estimates of 0.25 and 0.59 for phenotypic correlation between BW-6MW and WW-6MW, respectively, in Kermani sheep, which were in agreement with our findings (0.19 and 0.58, respectively).

5. Conclusions

The results indicate that growth traits in the Ghezel sheep are significantly influenced by environmental factors.

The estimates of heritability for the studied traits were moderate and increased with lamb's age. Genetic correlations among growth traits were positive and relatively high. Therefore, selection based on any of these traits may lead to the improvement in others. Both WW and 6MW are moderately heritable and genetically correlated together, but, since WW is recorded at lower age, it should be considered as a more suitable selection criterion in breeding schemes in order to enhancing body weights in the Ghezel sheep.

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