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Original scientific paper

GENETIC EVALUATION OF BODY WEIGHT TRAITS IN IRANIAN NATIVE GHEZEL SHEEP

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The aim of the current study was to estimate genetic parameters and trends for body weight traits at different ages in Ghezel lambs. Traits included were birth weight (BW), 3-month weight (3MW), 6-month weight (6MW), 9-month weight (9MW), and yearling weight (YW). Data and pedigree information used in the present study were collected at the Breeding Station of Ghezel sheep during 1986–2009. (Co) variance components were estimated using REML procedure and breeding values of animals were predicted with Best Linear Unbiased Prediction (BLUP) methodology under univariate analysis. Three different animal models were fitted. The models consisted of the direct additive genetic effect but differed in combinations of maternal additive genetic and maternal permanent environmental effects. Genetic trends for each trait were obtained by regressing the means of predicted breeding values on year of birth. The estimates of direct heritability were 0.285, 0.371, 0.388, 0.450 and 0.179, respectively. Also, the maternal heritability was estimated 0.113, 0.031, 0.021 and 0.030 for BW, WW, 6MW and 9MW, respectively. Direct genetic trends were positive and significant for BW, WW, 6MW ($p<0.01$), 9MW and YW ($p<0.05$) and were obtained 2.34, 46.20, 55.11, 33.40 and 24.01 (g/year), respectively. Also, maternal trends for BW, WW, 6MW and YW were positive and highly significant ($p<0.01$) and were 3.37, 17.05, 12.56 and 16.30 (g/year), respectively. The results indicated that considering maternal effects in the statistical model make accurate estimates of genetic parameters. Also, improvement of growth traits in Ghezel sheep seems to be likely in selection programs.

Key words: Best Linear Unbiased Prediction, Ghezel sheep, genetic parameters, genetic trends, growth traits

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INTRODUCTION

Ghezel sheep is mostly kept by small holder farmers under traditional management systems. It is estimated that its population is about 2 million and has been generally distributed in North Western parts of Iran. This breed is well adapted to mountainous climate and conditions (the temperature in the summer is about 38.3°C) (BANEH *et al*., 2010). Ghezel sheep were primarily used for meat (SATARI, 1999), milk and wool production. Due to a decreasing market demand for wool product over the recent years, considerable attention has been paid to meat production such other fiber breeds (CLOETE *et al*., 2002). In such case, depending on the management limitations within a production system, body weights at different ages may be considered as selection objectives for enhancing meat production and improvement of the growth potential and survival of lambs being of secondary importance (MIRAEI-ASHTIANI *et al*., 2007). A well tool available to improve response to selection for traits of interest is accurate predicted breeding value of animals. Real change in breeding value expressed as a proportion of expected theoretical change of the breeding value mean for the trait under selection can be used to assess a breeding program (JURADO *et al*., 1994). Depending on difficulty in conducting experiments in the same conditions over some generations, so that alteration in performance of a selected population may reflect, in part, both environmental and genetic changes, estimated genetic trends over time is problematic (SHAAT *et al*., 2004). Theoretically, removing the influence of environmental changes to simultaneously maintain a control population is possible but this is not cost-effective, especially over a long period of time (HILL, 1972). Genetic trend estimates for body weight at different ages in sheep have been reported by several authors (HANFORD *et al*., 2005; RASHIDI and AKHSHI, 2007; GIZAW *et al*., 2007; BOSSO *et al*., 2007). MOKHTARI and RASHIDI (2010) studied the genetic trends for body weight traits at different ages of Kermani sheep. The results showed that there has been a significant and positive genetic improvement in all studied traits and indicate that selection would be effective. HOSSEIN-ZADEH (2012) also showed that direct and maternal genetic trend for body weight traits of Moghani sheep were positive and significant. There are scarce reports on genetic and phenotypic trends of body weight traits in this breed. Therefore, the objective of this study was to estimate genetic parameters and trends for body weight at different ages of Ghezel sheep.

MATERIALS AND METHODS

Data set

Data and pedigree information were collected at the breeding station of Ghezel sheep during the period 1986–2009. The data was from the Ghezel sheep genetic evaluation program, in which, mating was controlled and lambs were weighed and ear-tagged at birth and then pedigree and birth information of each lamb registered, separately. Ewe lambs and ram lambs were bred at 18 months of age. Ewes could be used for up to 6 years. Weaning was at approximately 3 months of age. Due to type of production (meat), Body weight traits at different ages were considered as criteria in selection of replacements. Depend on season, lambs were grazed during the day and housed at night. They use alfalfa, wheat straw, barley straw, barley barn and other extra forages. Further details about flock management have been described by BANEH *et al*. (2010). The number of records, mean, standard deviation, coefficient of variation and skewness of the traits studied are presented in Table 1.

Table 1. Statistical Descriptive of data used in the analysis

Trait	No. of records	No. of sire	No. of dam	Mean	SD	CV (%)	Skew
BW (kg)	13347	254	6311	4.27	0.68	15.92	0.14
WW (kg)	14982	307	6846	23.37	4.12	17.62	0.09
6 MW (kg)	12358	218	5915	31.83	5.32	16.71	0.11
9 MW (kg)	3289	122	1887	35.49	9.87	27.81	0.04
YW (kg)	1932	100	1241	39.86	8.19	20.54	-0.05

BW, birth weight; WW, Weaning weight; 6MW, 6 months weight; 9MW, 9 months weight; YW, yearling weight; SD, standard deviation; CV (%), coefficient of variation and skew., skewness.

Statistical analysis

Preliminary least squares analyses were carried out for determining the fixed effects that had significant influence on the traits (SAS, 2002; SAS Institute Inc., Cary, NC). Significant fixed effects ($p<0.05$) as evidenced by GLM analysis were fitted in the subsequent models for estimating genetic parameters and consequently predict direct and maternal breeding values. All the fixed effects were significant ($p<0.01$) for all traits. However, to estimate genetic parameters, the model included random effects and the fixed class effects of year (23 levels), sex of lamb, birth type (single, twin, triplet) and age of dam (from 2 to 7 years old). Age of lamb at 3, 6, 9 and 12 months of age (in days) was used as a covariate for WW, 6MW, 9MW and YW, respectively. There was no evidence of significant influence for interaction effects and hence excluded from the final model. The (co)variance components and genetic parameters for the studied traits were estimated by restricted maximum likelihood (REML) method, using DMU 4.7 package (Madsen and Jensen 2007). To identify the impact of maternal effects to be included in the model analysis, three different animal models were fitted for the genetic analysis of body weight traits as follows:

Model 1) $y = Xb + Z_a a + e$

Model 2) $y = Xb + Z_a a + Z_m m + e$ $\quad$ $\mathrm{Cov}(a, m) = 0$

Model 3) $y = Xb + Z_a a + Z_m m + Z_c c + e$ $\quad$ $\mathrm{Cov}(a, m) = 0$

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**, $\mathbf{Z_a}$, $\mathbf{Z_m}$ and $\mathbf{Z_c}$ 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 to be normally distributed with mean 0 and variance $A\sigma_a^2, A\sigma_m^2, I_d\sigma_c^2$ and $I_n\sigma_e^2$, respectively. Where A is the additive numerator relationship matrix, σ_a^2, σ_m^2, σ_c^2 and σ_e^2 are direct additive genetic variance, maternal additive genetic variance, maternal permanent environmental variance and residual variance, respectively. I_d and I_n are identity matrices with orders equal to the number of dams and individual records, respectively. Total heritability (h_T^2) of the studied traits was estimated by the following formula (WILLHAM, 1972):

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

In which, σ_p^2 is the phenotypic variance of the trait. Log likelihood ratio tests were applied to choose the most appropriate model for each trait (MEYER, 1992). Breeding values of individuals were predicted from the model described as above. Based regressing the means of predicted breeding values on year of birth, genetic trends were obtained for each trait. The genetic trends were estimated by linear regression of the means of predicted breeding values on birth year using PROC REG in SAS (SAS, 2002; SAS Institute Inc., Cary, NC).

RESULTS

Genetic parameters

Estimation of genetic parameters for investigated traits is presented in Table 2. Fitting maternal effects, including maternal genetic and permanent environmental effects in Models 2 and 3 respectively, resulted in significantly higher log likelihood value in contrast to basic model (Model 1) which neglected the mentioned effects. It means that by considering maternal effects in the model analysis, more accurate estimate of genetic parameters will be obtained.

Table 2. Estimates of (Co) variance components, genetic parameters and log likelihood ratio with best model in bold for BW, WW, 6MW, 9 MW andYW with different models.

Trait$^{\psi}$	Models	σ_a^2	σ_m^2	σ_{pe}^2	σ_e^2	σ_p^2	h_a^2	h_m^2	c^2	h_T^2	LogL
BW	Model 1	0.154	-	-	0.247	0.401	0.384	-	-	0.384	-820.77
	Model 2	0.123	0.049	-	0.259	0.431	0.285	0.113	-	0.342	**-764.24**
	Model 3	0.117	0.038	0.003	0.253	0.411	0.284	0.092	0.007	0.331	-763.78
WW	Model 1	2.753	-	-	3.821	6.574	0.418	-	-	0.419	-27168.15
	Model 2	2.542	0.276	-	3.872	6.690	0.379	0.041	-	0.401	-25246.26
	Model 3	2.369	0.204	0.156	3.652	6.381	0.371	0.031	0.024	0.387	**-25234.68**
6 MW	Model 1	4.745	-	-	6.203	10.948	0.433	-	-	0.433	-26220.55
	Model 2	4.528	0.251	-	6.891	11.670	0.388	0.021	-	0.399	**-24417.19**
	Model 3	4.322	0.239	0.025	6.383	10.969	0.394	0.021	0.002	0.405	-24415.13
9 MW	Model 1	7.939	-	-	8.493	16.433	0.483	-	-	0.483	-8087.82
	Model 2	7.630	0.523	-	8.795	16.948	0.450	0.030	-	0.466	**-8082.64**
	Model 3	7.224	0.429	0.277	8.564	16.494	0.437	0.026	0.016	0.451	-8081.26
YW	Model 1	2.545	-	-	11.643	14.189	0.179	-	-	0.179	**-3570.33**
	Model 2	2.321	0.342	-	11.718	14.381	0.161	0.023	-	0.173	-3569.14
	Model 3	2.320	0.237	0.012	11.715	14.284	0.162	0.016	0.000	0.171	-3568.57

$^{\psi}$BW, birth weight; WW, Weaning weight; 6MW, 6 months weight; 9MW, 9 months weight; YW, yearling weight. σ_a^2; Direct additive genetic variance, σ_m^2; Maternal additive genetic variance; σ_{pe}^2; maternal permanent environmental variance, σ_e^2; residual variance, σ_p^2; phenotypic variance, h_a^2; direct heritability, h_m^2; maternal heritability, c^2; ratio of maternal permanent environmental effect, LogL; log likelihood.

The standard error of estimates was ranged from 0.001 to 0.08.

For all traits, direct heritability was the highest estimate by model 1. Fitting maternal effects decreased direct heritability for all traits. However, direct heritability for traits considered except of YW increased with age from birth to 9 months. Due to appropriate models (In bold) for body weight traits in Ghezel sheep, direct heritability for BW, WW, 6 MW, 9 MW and YW were 0.285, 0.371, 0.388, 0.450 and 0.179, respectively. Maternal genetic effect was significant ($P < 0.01$) for BW, WW, 6 MW and 9 MW traits. The values were 11.3, 3.1, 2.1 and 3 percent of phenotypic variance, respectively. Maternal permanent environmental effect estimate of 0.024 was achieved for WW.

Direct and maternal genetic trend

The estimates of direct and maternal genetic trend (g/year) for investigated traits are reported in Table 3. Also, Figs 1 and 2 show the plot of means of direct and maternal breeding value estimates by year of birth, respectively. From 1986 to 2009, an increasing was obtained over time for all studied traits of Ghezel lambs on the mean predicted breeding values. From 1998 onward, irregular variation over the years, the mean yearly genetic trends were positive. We found significant positive direct and maternal genetic changes for BW, 3MW, 6MW, 9MW and significant positive direct genetic change for YW over the years (Table 3). Patterns of change in the mean of both individual and maternal predicted breeding values over the years for all studied traits were the same (Fig. 1 and 2). The results showed that there were significant positive genetic enhancement in all studied traits and indicated that selection would be effective for enhancing growth traits of Ghezel sheep. On the other hand, there was more irregular variation in the yearly mean of predicted maternal breeding values for 3MW, 6MW and 9MW. In 1989, there was a sudden reduces yearly mean predicted breeding values of animals for WW (Fig. 2). Maternal genetic trends for BW, 3MW, 6MW and 9MW were lower in compare to direct genetic trends.

Table 3. Average breeding values for body weight traits of Ghezel sheep at different ages by year of birth.

Trait	DT±S.E.	R^2 (%)	MT±S.E.	R^2 (%)
Birth weight	$2.34^{**}\pm0.84$	36.43	$3.37^{**}\pm0.54$	63.50
Weaning weight	$46.21^{**}\pm2.76$	92.42	$17.05^{**}\pm1.61$	82.80
6 Month weight	$55.11^{**}\pm3.26$	92.49	$12.56^{**}\pm1.87$	65.90
9 Month weight	$33.40^{*}\pm2.05$	78.01	$16.30^{**}\pm1.25$	88.51
Yearling weight	$24.01^{*}\pm2.25$	83.02	-	-

DT, direct trend; MT, maternal trend; R^2, coefficient of determination for the regression fit of genetic trends. $^{*}p < 0.05$; $^{**}p < 0.01$.

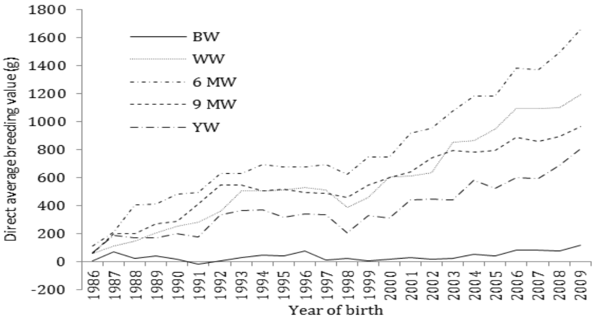

Figure 1. Direct trend of mean breeding values by year of birth for body weight traits in Ghezel sheep.

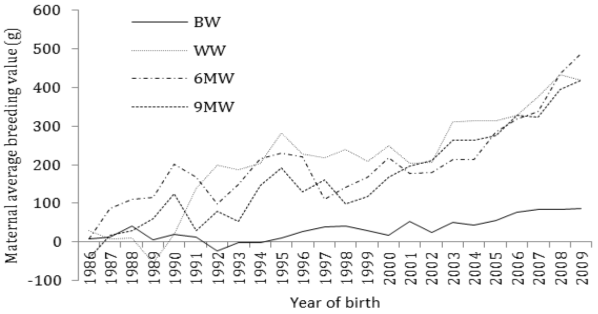

Figure 2. Maternal trend of mean breeding values by year of birth for body weight traits in Ghezel sheep.

DISCUSSION

There have been relatively few published articles on the estimates of genetic parameter and trend using different animal models (considering maternal effects) in sheep for growth traits. For Ghezel sheep, estimated direct heritability for BW and WW using the best fitted models were comparatively higher in compare to those reported by RASHIDI *et al.* (2008) for Kermani sheep (0.04 and 0.27), ABBASI *et al.* (2012) for Balouchi sheep (0.12 and 0.10) and BROMLEY *et al.* (2000) for Columbia sheep (0.18 and 0.07). However, they were close to those reported for Afrino sheep by SNYMAN *et al.* (1995) and for Norvegian sheep by LARSGARD *et al.* (1998). It was interesting that our estimates was higher than those of reported by BANEH *et al.* (2010) in this breed. It may be due to difference in number of records for interest traits as well as random effects affecting the traits. The estimates of direct heritability for 6 MW, 9 MW was also higher in compare to those reported by HOSSEIN-ZADEH and ARDALAN (2010) for Moghani sheep (0.14 and 0.10) using Bayesian procedure. Although, our estimate of direct heritability for YW (0.179) was lower than that of these researchers. It has been shown that the exclusion of the maternal permanent environmental effect, which has a significant influence, could make an overestimation of maternal heritability (EKIZ, 2005). Maternal heritabilities for BW, WW, 6 MW and 9 MW were 0.113, 0.041, 0.021 and 0.026, respectively. These results showed, while growing up lambs, the impact of maternal genetic effects on their growth reduces. In mammals, ROBISON (1981) indicated that maternal effects diminish with age. These results were comparatively in agreement with the estimates of maternal heritability reported by KHALILI *et al*. (2002) in Balouchi sheep and EKIZ (2005) in Turkish Merino lambs but were lower than those of BAHREINI-BEHZADI *et al*. (2007) for BW (0.27), WW (0.19) and 6MW (0.25) in Kermani lambs. Based on model 3, permanent environmental effect was 0.024 for WW which was higher than that observed in Moghani sheep (HOSSEIN-ZADEH and ARDALAN, 2010). The maternal permanent environmental effect due to the dam can be ascribed to multiple birth influences on milk yield, feeding level at late gestation and maternal ewe's behavior (MARIA *et al*., 1993; SNYMAN *et al*., 1995).

Breed direction as well as the rate of genetic improvement under breeding program can be indicated by the evaluation of genetic trend (BOSSO *et al*., 2007). As indicated in Fig. 1, positive genetic trends were observed from 1986 onwards for investigated traits. The decreased mean predicted breeding values of animals in the year 1998 was probably due to selection of sires with low breeding values (HOSSEIN-ZADEH, 2011). On the other hand, the low selection response could display that introduction of outside sires was based merely on phenotypic characteristics (MOKHTARI and RASHIDI, 2010). As the amount of data collected for 9MW and YW traits, the accuracy of predicted breeding values of animals would also decrease over time in compare to BW, WW and 6MW, results in lower genetic improvement for the mentioned traits at the end of 1998 and later. Based on a significant and positive genetic trend estimates in all investigated traits, selection for body weight traits would be effective in Ghezel sheep. Fig. 2 shows maternal genetic trends for BW, WW, 6MW and 9MW. For studied traits, irregular fluctuations were observed in yearly mean predicted maternal breeding values of lambs. Direct genetic trend estimate for BW in the current study (2.34 g/year) was low and in accordance with those reported by MOKHTARI and RASHIDI (2010) in Kermani sheep (2 g/year) and FAROKHAD *et al*. (2011) in Arman sheep (2 g/year). Also, estimate of maternal genetic trend for BW was low (3.37 g/year) but this estimate was higher than the direct genetic trend and this may be related to the larger maternal effects on BW than direct genetic effects in Ghezel sheep.

Estimated direct genetic trend for WW in this study (46.21 g/year) was in accordance with the estimates of 68 and 69 g/year were reported by SHRESTHA *et al*. (1996) in Rideau sheep and HOSSEIN-ZADEH (2012) in Moghani sheep, respectively. But it was lower than the estimates reported by SHAAT *et al*. (2004) in Rahmani breed (92 g/year) and RASHIDI and AKHSHI (2007) in Kurdi sheep (128 g/year). Also, maternal genetic trend for WW in the present study (17g/year) was higher than that reported by LOTFI-FARIKHAD *et al*. (2011) (7g/year) in Arman and lower than the estimate maternal genetic trend for WW (49.2) by HOSSEIN-ZADEH (2012) in Moghani sheep. Direct genetic trend estimate for 6MW in the present study (55.11 g/year) was lower than those in Kermani sheep (91 g/year) and Rahmani sheep (135g/year) reported by MOKHTARI and RASHIDI (2010) and SHAAT *et al*. (2004), respectively and was in agreement with estimate of 59 g/year reported by KLERK and HEYDENRYCH (1990) in South African Dohne Merino sheep. Low genetic trend estimate for 9MW in the current study may be due to the number of phenotypic records in compare to other traits considered or the accuracy of phenotypic measurements. Also, estimate of maternal genetic trend for 9MW (16.30 g/year) was in accordance to that (17.7 g/year) reported by HOSSEIN-ZADEH (2012) in Moghani sheep. Among the post-weaning traits investigated, genetic trend estimate for YW (81 g/year) was the lowest. This value was lower than those reported by BOSSO *et al*. (2007) in Djallonke sheep (90 g/year) and KLERK and HEYDENRYCH (1990) in South African Dohne Merino sheep (59 g/year). Low genetic trend estimate for YW in the present study may be due to mountainous conditions consequently the low nutritional (MOKHTARI *et al*., 2008). Based on the condition described, lambs have to walk more and need to get high energy. On the other hand, pastures are low in quality and quantity.

CONCLUSION

In the present study, positive direct and maternal genetic trends for growth traits of Ghezel sheep were obtained. The estimate of genetic trend for 6MW was the greatest among the body weight traits and this may be illustrated by the higher additive genetic variation for 6MW. By aging, the estimates of direct heritability tended to increase from birth to 9MW. Direct heritabilities were medium to high and show that selection would results in well selection response for growth traits of this breed. As the results showed that, considering maternal effects in the model analysis particularly to estimate genetic parameters for early growth is preferred.

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GENETIČKA EVALUACIJA OSOBINA POVEZANIH SA TEŽINOM KOD IRANSKE NATIVNE GHEZEL OVCE

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Izvod

Cilj ovog istraživanja bio je procena genetičkih parametara i trendova za osobine telesne težine u različitim uzrastima kod Ghezel jagnjadi. Uključene su osobine: težina na rođenju (BW=, težina posle 3 meseca (3MW), težina posle 6 meseci (6MW), težina posle 9 meseci (9MW) i težina posle jedne godine (YW). Podaci i informacije o pedigree su sakupljani u Oplemenjivačkoj stanici Ghezel ovaca tokom perioda od 1986–2009. Komponente co-varijanse su procenjene primenom Simplex procedure, a oplemenjivački nivo je predviđen BLUP metodologijom. Tri različita modela su se potvrdila odgovarajućim. Modeli su se sastojali od direktnog aditivnog genetskog efekta, ali su se razlikovali u kombinacijama materinskih aditivnih genetskih i materinskih stalnih efekata životne sredine. Genetski trendovi za svaku osobinu dobijeni regresijom sredina predviđenih oplemenjivačkih vrednosti u godini rođenja. Procenjene vrednosti direktne heritabilnosti bile su 0.285, 0.371, 0.388, 0.450 i 0.179. Procenjena materinska heritabilnost bila je 0.113, 0.031, 0.021 i 0.030 i BW, WW, 6MW i 9MW. Direktan genetički trend bio je pozitivan i značajan za BW, WW, 6MW ($p<0.01$), 9MW I YW ($p<0.05$) i iznosio je 2.34, 46.20, 55.11, 33.40 i 24.01 (g/godini). Takođe, materinski trend za BW, WW, 6MW i YW bio je pozitivan i visoko značajan ($p<0.01$) i iznosio je 3.37, 17.05, 12.56 i 16.30 (g/godini). Rezultati ukazuju da je proučavani materinski efekat u statističkom modelu pogodan za procenu genetičkih parametara. Takođe, poboljšanje u parametrima porasta kod Ghezel ovaca se može primeniti u selekcionim programima.

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