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Genetic Parameters of Direct and Maternal Effects for Growth Traits of Afshari Sheep

Research Article

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ABSTRACT

The genetic parameters and (co) variance components of body weight at birth (BW), weaning (WW) and six months of age (BW6) and average daily gain (ADG) pre and post-weaning of Afshari sheep were estimated using restricted maximum likelihood (REML) methodology and animal model implemented in DFREML software. The likelihood ratio test (LRT) was used to compare the models. Year of birth, age of mother, sex of lamb and type of birth showed significant effects on studied traits, so they were considered as fixed effects in analyzing models. The direct heritability (h^2) of BW, WW and BW6 and pre and post-weaning ADG were 0.231, 0.164, 0.246, 0.118 and 0.07, respectively, based on the best model. The maternal effects significantly influenced the pre-weaning traits. The maternal heritability (m^2) of BW and the permanent maternal environment effects (c^2) of WW and pre-weaning ADG were 0.219, 0.078 and 0.079, respectively. The direct additive genetic (r_a) and phenotypic (r_p) correlations between studied traits were positive in all cases and ranged from 0.425 to 0.990 and from 0.013 to 0.990, respectively. The maternal permanent environmental correlation (r_c) between WW and pre-weaning ADG was 0.984.

KEY WORDS Afshari sheep, genetic parameter, growth traits.

INTRODUCTION

Protein is one of the major nutrients which play vital roles in human health. Protein deficiency causes much range of physical and mental disorders. Every mature person needs about 29 g/d of animal protein. Therefore, based on this estimation, the overall production of animal protein must be 793, 875 tons per year in Iran. While the total animal protein produced in Iran can just secure about 65% of required protein. Therefore, the protein from animal source must be increased. There are two ways for increasing production: improving environmental condition and improving the structure of animal genetics. If these two conditions are realized, the maximum promotion of performance would be achieved. The first step to improving the structure of animal genetics is to consider suitable breeding goals for each breed and each production system and then use of a proper statistical model to estimate genetic parameters of production traits. Development of effective genetic evaluation and improvement programs requires knowledge of the genetic parameters (genetic variance of each trait and covariance among traits) for economically important production traits (Safari *et al*. 2005).

Estimates of genetic parameters of various production traits of sheep have been reported in different studies (Abegaz *et al*. 2002; Bromeley *et al*. 2000; Ekiz, 2004; Gizaw *et al*. 2007; Snowder *et al*. 2003; Mokhtari and Rashidi, 2010). In Iranian sheep category, the Afshari sheep belonged to the class of heavy weight breeds and has high fatten ability and high lamb growth rate. Fattening and meat production is the main goal of rearing Afshari sheep. Authors did not find any report about genetic parameters of growth traits (body weight at different ages and post- and pre-weaning growth rate) and genetic correlation between them in Afshari sheep. The objective of present study was to estimate the genetic parameters for body weight at different ages and post- and pre-weaning growth rates. Furthermore, the r_a, r_p and r_c between studied traits were estimated.

MATERIALS AND METHODS

Zanjan province is located in central part of Iran. There are 11 types of climates from dry cold to Mediterranean-cold and the average yearly raining is about 360 mm in Zanjan. Afshari is dominant sheep breed of Zanjan. In studied sheep population, mating is done late of November for three estrus cycles and one ram was randomly used for every ten ewes. In mating season, the estrus ewes were detected and then were placed in mating boxes together with interested ram for 48-72 hours.

The data and records of studied population were registered in special paper including lambs and their parent's number, date of birth, sex, type of birth and body weight at birth, weaning, different ages and weight gain at pre- and post-weaning. In the studied population, 38.8% of 1496 born lambs were twins and the male / female proportion was 50%. The 44% and 66% of lambs were born in August and September, respectively.

The average weaning age was 120 days. The preparing and saving of records of body weight at birth, weaning and six months of age and pre- and post-weaning ADG were done using excel 2003 and access 2003 softwares. Then desultory and abnormal data were removed and pedigree file was constructed. The descriptive information of studied traits is shown in Table 1. Since the dates of lambs' weaning were not similar, the weaning weights were adjusted for 120 days with following model:

Adjusted WW= ((WW-BW)/age weaning) × 120 + BW

Where:
BW: birth weight.
WW: real weaning weight.
AGE weaning: weaning age.

Also, the following model was used to calibrate the records of BW6 for 180 days of age:

Adjusted BW6= ((W6 actual-WW)/age 6-age weaning) × (180-age weaning) + WW

Where:
W6 actual: registered BW6 of lambs.
Age 6: weaning age.

The pre- and post-weaning ADG were adjusted using following models:

ADGb= (W6 adjusted-WW adjusted) / 60
ADGa= (WW adjusted-BW) / 120

Where:
ADGb and ADGa: average daily gain pre and post-weaning, respectively.

Before DFREML analysis, the effects of fixed elements such as sex, age of mother, type of birth and year of birth on studying traits were calculated with GLM procedure of SAS software package (SAS, 2004) then significant effects ($P<0.05$) were entered in DFREML models.

Table 1 Descriptive information of studied traits in Afshari sheep

Item	Trait				
	BW	WW	BW6	ADGb	ADGa
N of records	1496	1396	1095	1396	1095
N of animal	1731	1628	1386	1628	1386
N of ram with record	29	29	22	29	22
N of ewe with record	311	303	214	303	214
Average lamb per ram	31.70	29.60	25.90	29.60	25.90
Average lamb per ewe	2.90	2.80	2.50	2.80	2.50
Mean (kg)	4.82	28.35	34.56	0.20	0.10
SD	0.65	5.42	0.99	0.042	0.036

SD: standard deviation.

Statistical model for univariate analysis

In order to select the best model, six types of models were assigned in which one or both maternal effect (additive genetic and permanent environment) with or without genetic covariance between additive direct genetic effects and maternal additive genetic effects were considered as following models:

$Y= Xb + Z_1a + e$
$Y= Xb + Z_1a + Z_2c + e$
$Y= Xb + Z_1a + Z_3m + e$, Cov (a and m)= 0
$Y= Xb + Z_1a + Z_3m + e$, Cov (a and m)= $A\sigma_{am}$
$Y= Xb + Z_1a+ Z_2c + Z_3m + e$, Cov (a and m)= 0
$Y= Xb + Z_1a + Z_2c + Z_3m + e$, Cov (a and m)= $A\sigma_{am}$

Where:
Y: observation vector of studied trait.
b: unknown vector of fixed effects.
a: unknown vector of genetic and direct additive effects.
c: unknown vector of permanent maternal environmental effects.
X: matrix of obvious coefficient of fixed effects.
Z_1: coefficient matrix, relates genetic effects to observation.

Z_2: coefficient matrix that relates permanent environmental maternal effects to observations.

Z_3: coefficient matrix that relates additive genetic effects to observations.

Generally, the following variance-covariance matrix was constructed for studied traits:

$$V = \begin{bmatrix} a \\ m \\ c \\ e \end{bmatrix} = \begin{bmatrix} A\sigma^2_a & A\sigma_{am} & 0 & 0 \\ A\sigma_{am} & A\sigma^2_m & 0 & 0 \\ 0 & 0 & I_c\sigma^2_c & 0 \\ 0 & 0 & 0 & Ie\sigma^2_e \end{bmatrix}$$

Where:

A: matrix of additive genetic relations (inbreeding matrix).

I: identity matrix.

σ^2_a: direct additive genetic variance.

σ^2_m: maternal additive genetic variance.

σ_{am}: covariance of additive genetic between direct and maternal random effects.

σ^2_c: variance of permanent maternal effects.

σ^2_e: residual variance.

The 3.1 version of DFREML package (Meyer, 2000) in dfuni option was used to calculate (co)variance component and estimate heritability of different traits. The simple algorithm of DFREML and convergence index of 10^{-8} was used in analysis.

Statistical model for multivariate analysis

The multivariate model was similar to univariate model, but in multivariate model, two traits were simultaneously analyzed. In the present study the dxmux option of DFREML software was used. The average information algorithm (AI-REML) was used to maximize likelihood function (Gilmour *et al.* 1995) with convergence index of 10^{-8}.

Test of likelihood logarithm

In univariate analysis, each trait was analyzed in six forms of models. Therefore, the likelihood logarithm test was used in order to assign the most appropriate model. Meyer (1992) suggested that each model that has maximum likelihood logarithm function and its differentiation from other models was significant can be selected as best model. The ki-square (X^2) test was used to determine of best appropriate model for univariate analyses:

$$X^2 = -2 \log (\log L \text{ tested model} - \log L \text{ based model})$$

Where:

Log L: logarithm of likelihood.

The calculated X^2 was compared with table X^2 to find the best model.

RESULTS AND DISCUSSION

Single trait analyses

According to different amount of log L for each model, the model 3 was selected as appropriate model to analyze BW. The h^2 estimate of BW was 0.231 in Afshari sheep (Table 2). The m^2 of BW was 0.219 which was nearly equal to direct h^2 estimate. In Afshari sheep population, the effect of permanent maternal environment on BW was lower than the effect of maternal additive. The model 2 was the best fitted model for pre-weaning ADG in our study. The h^2 and c^2 estimates of WW for Afshari sheep were 0.164 and 0.078, respectively. The estimated Log L for model 1 was greater than other models, thus the model 1 was the best fitted model for BW6 analysis. According to model 1 the h^2 of BW6 was estimated about 0.246 in present study. The pre and post-weaning ADG of Afshari sheep were 196 and 100 g/d with h^2_s as of 0.118 and 0.071, respectively (Tables 1 and 2). Estimated c^2 for pre-weaning ADG was 0.079 in present study (Table 2). Whereas, (co)variance components especially their proportions are not constant even in one breed, so the new estimation of parameters are required for beginning of a new breeding program. The (co) variance components and genetic parameters estimates of studied traits are shown in Table 2. Comparison of different models of parameters for additive genetic and permanent maternal environment effects (models 2 and 3) showed that maternal additive genetic effects on BW was greater than permanent maternal environment effects. The body weight at early age is influenced by lambs' genetic potential (direct additive genetic), maternal genetic potential (maternal additive genetic) and effects of maternal common environment (Ekiz, 2005). Because of litter size of sheep, the role of maternal effects on birth of lambs is important and should be included in models of parameter estimation (Bradford, 1972). According to above mentioned reason and different amount of Log L for each model, the model 3 was selected as appropriate model to analyze BW. The h^2 estimate of BW was 0.231 (model 3) in Afshari sheep. Bromeley *et al.* (2000) reported the h^2_s as of 0.18, 0.16, 0.19 and 0.22 for Columbia, Pplypay, Rambouillet and Targhee sheep, respectively. Also, Safari *et al.* (2005) after collecting reported genetic parameters of productive traits of different breeds, showed the h^2_s as of 0.15, 0.21 and 0.19 for BW of meat, wool and dual purpose sheep, respectively. Differences in genetic parameter estimates between different breeds can be due to discrepancy in breeds, family relationship in pedigree, structure of data, statistical model and diversity of climates (Hanford *et al.* 2002). Tosh and Kemp (1994) reported the direct h^2_s as of 0.07 and 0.39 for BW of Romanov and Hampshire sheep, respectively. The direct h^2 of BW was 0.48 for Lori sheep (Lavvaf and Noshary, 2008). In our study, the direct h^2 of BW estimated by model 1 was nearly two times greater than that estimated by model 3 (best model). In present study, the m^2 of BW was 0.219, which was nearly equal to direct h^2 estimate. Between Iranian sheep populations, the maximum and minimum m^2 were estimated about 0.65 for Sangsari sheep and 0.07 for Balouchi sheep (Yazdi *et al.* 1997). The effect of permanent maternal environment on BW was lower than effect of maternal additive genetic in present study. This parameter was 0.37 for Hampshire sheep (Tosh and Kemp, 1994). The model 2 was the best fitted model for pre-weaning ADG in our study. The pre-weaning ADG of Afshari sheep was 196 g/day with h^2 as of 0.118 (model 2). The previous reports about h^2 of this trait were from 0.03 in Spanish Merino (Jurado *et al.* 1994) to 0.78 in Awasi × Menz crossbred sheep (Gizaw and Joshi, 2004). According to the previous studies the pre-weaning ADG is influenced by maternal effects (Yazdi *et al.* 1997; Bromeley *et al.* 2000; Ekiz, 2005; Szwaczkowski *et al.* 2006; Kolmosi, 2008). Estimated c^2 for pre-weaning ADG was 0.079 in present study. This parameter was reported from 0.01 for Hungarian merino and Ill dofrance (Kolmosi, 2008) to 0.09 for Targhee (Bromeley *et al.* 2000) and Turkish Merinus (Ekiz, 2005). The estimated h^2 of WW for Afshari sheep was 0.164. Ekiz (2004) and Gizaw and Joshi, (2004) reported the h^2_s as of 0.057 and 0.47 for WW of Turkish Merino and Menz sheep, respectively. Safari *et al.* (2005) also reported the h^2_s as of 0.18, 0.21 and 0.16 for WW of meat, wool and dual purpose sheep, respectively. When the direct additive genetic effect was just as a random effect in analyzing model (model 1), the h^2_s of WW was over estimated. But insertion of maternal effects in model estimated the real amount of h^2_s of WW (0.164). Ekiz (2004) showed that insertion of maternal environment effects in analyzing model caused decreasing h^2 estimation of WW of Turkish merino sheep from 0.12 to 0.05. The c^2 of WW in our study was 0.078 that was lower than those reported for meat (0.19), wool (0.1) and dual purpose (0.09) sheep (Safari *et al.* 2005). The m^2 of WW of Afshari sheep was estimated about 0.074.

The highest and lowest reported m^2 were 0.3 for Badana sheep (Carolino *et al.* 2002) and 0.01 for Romanov sheep (Maria *et al.* 1993), respectively. The small impact of maternal effects on WW in our study is due to rearing method of lamb.

In studied population the lambs were separated from their mother during lactation period and a few times of day can fed from their mother's milk. So the impact of maternal genetic potential on body weight gain of lambs was decreased and the lamb's phenotype was more related to lamb's additive genetic effects. The h^2 of BW6 was estimated about 0.246 in present study (model 1). The estimated Log L for model 1 was greater than other models, so the model 1 was the best fitted model for BW6 analysis.

The h^2 of BW6 of Afshari sheep was nearly in average of previous reports.

This parameter estimate was 0.1 for Muzaffarnagari sheep (Mandal *et al.* 2006), 0.16 and 0.18 for Horro sheep (Abegaz *et al.* 2002; Abegaz *et al.* 2005), 0.43 for D'man sheep (Boujenane and Kerfal, 1990), 0.47 for Afrino sheep (Snyman *et al.* 1995) and 0.51 for Menz sheep (Gizaw *et al.* 2007).

The h^2 of post-weaning ADG was estimated about 0.071 in our study. Also, the c^2 was decreased from 0.04 at birth to 0.01 at one year of age. Mousa *et al.* (1999) reported that c^2 was decreased from 0.07 at birth to 0.00 at 31 months of age in a hybrid population of sheep (Columbia ram×hybrid ewe of Hampshire and Suffolk). The decline of maternal effects on lamb's growth rate after weaning can be due to excision of lamb and mother relation, so the growth of lamb is based on its genetic potential.

Two trait analyses

The r_a between growth traits all were positive and were in range from 0.425 to 0.99. Also the r_p between different traits were in range from 0.013 to 0.99 (Table 3). In the present study, the r_c between WW and pre-weaning ADG was positive and high (0.984). The residual correlations (r_e) between BW, WW and pre-weaning ADG with post-weaning ADG were negative and between other studied traits were positive and were in range from 0.15 to 0.99 in Afshari sheep (Table 3).

Two trait analyses were used to detect genetic and phenotypic correlation between studied traits (Table 3). The r_a between growth traits all were positive and in range from 0.425 (between BW and post-weaning ADG) to 0.99 (between WW and pre-weaning ADG). Maria *et al.* (1993) reported the r_a as of 0.12 and 0.24 between BW with WW and weight at three months of age (BW3) for Romanov sheep, respectively.

For the Balouchi sheep the r_a estimates between BW with WW and BW6 were 0.6 and 0.64, between WW with BW6 and weight at 12 month of age (BW12) were 0.76 and 0.6, and between BW6 with BW12 was 0.74, respectively (Yazdi *et al.* 1997). Also the r_p between different traits were in range from 0.013 (between pre-weaning ADG and post-weaning ADG) to 0.99 (between WW and pre-weaning ADG).

The r_p was estimated about 0.6 and 0.34 between BW with WW and BW6, 0.76 and 0.6 between WW with BW6 and BW12 and 0.74 between BW6 and BW12 for Balouchi sheep, respectively (Yazdi *et al.* 1997).

In the present study the r_c between WW and pre-weaning ADG was positive and high (0.984). The residual correlations between BW, WW and pre-weaning ADG with post-weaning ADG were negative in Afshari sheep (Table 3).

Table 2 (Co) variance components and genetic parameter estimates for studied trait of Afshari sheep

Trait	Model*	σ^2a	σ^2_m	σ^2_c	σ_{am}	σ^2_e	σ^2_p	h^2	m^2	c^2	r_{am}	log L
BW	3	0.073	0.070	-	-	0.175	0.319	0.231	0.219	-	-	178.522
WW	2	2.432	-	1.163	-	11.222	14.818	0.164	-	0.078	-	-2559.057
BW6	1	4.301	-	-	-	13.187	17.489	0.246	-	-	-	-2087.093
ADGb	2	109.2	-	73.9	-	741.6	924.8	0.118	-	0.79	-	-5416.102
ADGa	1	68	-	-	-	886.0	954.0	0.070	-	-	-	-4259.162

* Best fitted model.
ADGb: pre-weaning ADG; ADGa: post-weaning ADG; σ^2_p: phenotypic variance and r_{am}: maternal-direct additive genetic correlation.
BW: body weight at birth; WW: weight weaning and BW6: body weight at six months of age.

Table 3 Results of two-trait analyses

Trait 1	Trait 2	r_a	r_p	r_c	r_e
BW	WW	0.693	0.418	-	0.271
BW	BW6	0.671	0.400	-	0.251
BW	ADGb	0.588	0.289	-	0.150
BW	ADGa	0.425	0.091	-	-0.003
WW	BW6	0.978	0.904	-	0.837
WW	ADGb	0.990	0.990	0.984	0.993
WW	ADGa	0.678	0.030	-	-0.110
BW6	ADGb	0.966	0.889	-	0.866
BW6	ADGa	0.745	0.456	-	0.409
ADGb	ADGa	0.610	0.013	-	-0.102

ADGb: pre-weaning ADG and ADGa: post-weaning ADG.
BW: body weight at birth; WW: weight weaning and BW6: body weight at six months of age.

The residual correlations (r_e) between other studied traits were positive and in range from 0.15 (between BW and pre-weaning ADG) to 0.99 (between WW and pre-weaning ADG). In a study by Hanford *et al.* (2003), the r_a and r_c between BW and WW of Targhee sheep were 0.52 and 0.35, respectively.

In regard to positive correlations between body weights at different age, it can be concluded that selection of lambs with higher weight at any age will increase the body weight at other ages. The low correlations between body weight traits indicate that we cannot select a lamb according to its early age records. The positive and high generic correlations between growth traits in present study can be a useful tool to correlate selection in a selection index. For example, the WW with medium h^2 and high r_a with other studied traits can be used as selection index to improve of growth performance of Afshari sheep. The results of the present study showed that body weight at early growth stages is influenced by direct maternal genetic and direct maternal environment effects and so ignoring of maternal effects will lead to biased estimation of direct heritability. Therefore in addition to direct effects the maternal effects should be considered in statistical model in order to exactly estimate such parameters. At older age, the importance of maternal effect will be decreased, so these effects can be ignored in animal evaluation.

CONCLUSION

The (co)variance components, genetic and phenotypic correlations of five growth related traits were estimated in present study. The highest and lowest h^2_s were 0.246 and 0.070 for BW6 and pre-weaning ADG, respectively. The positive and high genetic correlation between WW and other studied traits concluded that WW can be used as a selection index to improve post-weaning traits.

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