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BAYESIAN ESTIMATION OF GENETIC PARAMETERS OF GROWTH TRAITS IN ZANDI SHEEP

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ABSTRACT

This study was conducted at Ramin agricultural and natural resources university in Khuzestan of Iran in 2012 to 2013. In order to estimate the (co) variance components and genetic parameters of growth traits in Zandi sheep, It was used a total of 6188 records of birth weight (BW), 5170 records of weaning weight(WW), 2994 records of 6 month weight (6MW), 2283 records of 9 month weight(9 MW) respectively which collected in the Khajir animal breeding station from Tehran city during 1994-2010. The SAS statistical software was used to determine the environmental factors that affect these traits and MTGSAM software was used to determine genetic parameters of growth traits under Bayesian method. Environmental factors include year of birth, lamb sex, type of birth and age of dam had a significant difference on all traits. It is entered the age of animal in to the model as covariate during the weigh. It is estimated the heritability and variance components of each trait with Bayesian method under the uni-trait animal model. By including or ignoring maternal genetic effector or common environmental effects due to dam to direct additive genetic effects of animal, six different model of analysis were fitted into each trait. To find the best model for each trait, it was considered the minimum residual variance. Mean and standard deviation of BW, WW,6MW and 9 MW were 4.24±0.72, 21.48±3.79, 30.98±4.7, 32.8±4.53 respectively. Results showed that for BW, model was included direct additive genetic effects, maternal additive genetic effects and maternal permanent environmental effects without considering the covariance between them. For WW, model was included direct additive genetic effects, maternal additive genetic effects with considering the covariance between them. For 6 MW, model was included direct additive genetic effects, maternal additive genetic effects and maternal permanent environmental effects with considering the covariance between them. For 9 MW, model was included direct additive genetic effects, maternal additive genetic effects and maternal permanent environmental effects without considering the covariance between them. The direct estimated heritability of BW,WW, 6MW with the best model were 0.124, 0.169, 0.258 and 0.163 respectively.

INTRODUCTION

In the world of agriculture, sheep breeding is one of the most important branches of livestock in terms of the number of animals and the value of the products. Sheep are important due to having several desirable features such as compromises in different environmental conditions, low demand for food, and value of sheep products (6). Sheep products constitute an important component of livestock production in Iran. There are nearly 50 million sheep with more than 20 breeds in Iran (31). The aims of breeding programs are to maximize the rate of genetic progress for economic traits of sheep. One of the most important breeds of Iranian sheep is Zandi sheep. Mutton is a traditional source of protein in Iran but meat production from the sheep does not cover the increasing consumer demand. In this case Yazdi *et al*. (34) pointed out that the improvement in efficiency of any sheep production enterprises can be achieved by enhancing economically important traits such as litter size of ewe and body weight of lamb. To determine optimal breeding strategies for increase the efficiency of sheep production, knowledge of genetic parameters for weight traits at various ages and also the genetic relationships between the traits are needed (5). Numerous studies have demonstrated that live body weight and growth rate of lambs of different breeds considerably are affected by maternal as well as the direct genetic effects (34; 21; 1; 5; 23; 19). Most of these studies concluded that ignoring maternal effects in genetic analysis of these traits, especially for pre-weaning ones, resulted in upward biases in estimation of direct heritability. Hence, to achieve optimum genetic progress in a selection program both the direct and maternal components should be taken into account (14; 12). Furthermore, it is important to try to characterize genetically indigenous breeds. Genes affecting polygenic traits and characterizing milk or meat productions are difficult to identify. However, several potential candidate genes have been recognized. They may be selected on the basis of a known relationship between physiological or biochemical processes and production traits, and could be tested as quantitative trait loci (QTLs) (28). The most important trait is body weight and also there was no information regarding (co)variance components and genetic parameters for such important traits in Zandi sheep. Thus, the objective of the present study was to estimate the genetic parameters of body weight traits in Zandi sheep.

MATERIALS AND METHODS

In general, animals were managed following semi-intensively. Natural pasture is the main source of feed. The quantity and quality of the pasture varies considerably during the year. With the dry season, the quantity and quality of the pasture decreases and supplemental feeding comprising dried alfalfa and barley grains has to be provided especially at the time of the flushing and late pregnancy. A controlled mating strategy was designed during mating period (Early September to mid-November) and ewes were mated to fertile rams at the rate of 20 ewes per ram. Lambing was in January and March. At birth time and / or within 24 h afterwards lambs were weighted and ear-tagged. Lambs were kept indoors from mid January to late April and manually fed afterwards lambs were grazed on pastures of low quality and productivity. The lambs were weaned about 3 months of age. The female lambs were exposed to the rams about 18 months of age.

Using pedigree information and body weight records which collected from 1994 to2010 at Zandi sheep breeding station (khojir station). Studied traits were birth weight (bw,n=6188), weaning weight (ww, n=5170), 6-month weight (n=2994) and 9-month weight (n=2283).The maximum of data which were available for analysis included lamb records born from 245 sires and 1919 dams (Table 1). Traits investigated were body weight at birth (BW), weaning (WW), six months of age (6MW), nine months of age (9MW). All body weights, except BW, were pre-adjusted for the effect of weighing age assuming a linear growth rate and weighing ages of 120, 180, 270 and 365 days for WW, 6MW and 9MW respectively. The structure of Pedigree information given in Table 1 and the records used in the analysis is given in Table 2.

Table1. Pedigree information

Item	**Number**
N. of records	6917

N. of sires	245
N. of animal with progeny	2164
N. of granddams	959
N. of dams	1919
N. of animalwithout progeny	4753

Table 2. The records used in the analysis

Fixed effect	BW	WW	6MW	9MW
Birth year				
1994	227	206	197	-
1995	187	116	103	-
1996	372	252	191	128
1997	307	259	130	115
1998	309	260	118	116
1999	243	194	185	156
2000	272	205	213	185
2001	361	260	201	191
2002	391	230	244	224
2003	365	273	159	116
2004	369	307	247	159
2005	494	432	293	260
2006	418	371	214	181
2007	451	426	198	175
2008	493	472	301	277
2009	406	406	-	-

2010	523	501	-	-
Birth type				
Single	4876	4113	2426	1894
Twin	1312	1057	568	389
Sex				
Male	3131	2599	1626	1321
Female	3057	2571	1368	962
Ewe age				
2	1358	1092	652	483
3	1294	1088	637	493
4	1117	959	517	425
5	1023	880	534	371
6	760	648	363	271
7	433	344	217	169
8	203	159	74	71

BW: birth weight, WW: weaning weight (three-month weight), 6MW: six-month weight and 9MW: nine-month.

The model accounting for environmental (fixed) effects were included year of lambing (1994-2010), sex of lamb (male and female), type of birth (single and twin) and age of ewe (2-8 years old).Test of significance for the fixed effects carried out using GLM procedure of SAS program(27). The interactions between the fixed effects were not significant and therefore excluded from the model. The SAS statistical software was used to determine the environmental factors that affect these traits and MTGSAM software was used to determine genetic parameters of growth traits under Bayesian method. Birth year, lamb's sex, type of birth and dam age had a significant effect on all traits($p<0.001$). It is entered the age of animal in to the model as covariate during the weigh. It is estimated the heritability and variance components of each trait with Bayesian method under the uni-trait animal model. By including or ignoring maternal genetic effect or common environmental effects due to dam to direct additive genetic effects of animal, six different model of analysis were fitted into each trait. To find the best model for each trait, It was considered the minimum residual variance:

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

$y = Xb + Z_a a + Z_{pe} pe + e$ Model 2

$y = Xb + Z_a a + Z_m m + e$ Model 3

$Cov(a, m) = 0$

$y = Xb + Z_a a + Z_m m + e$ Model 4

$Cov(a, m) = A\sigma_{am}$

$y = Xb + Z_a a + Z_m m + Z_{pe} pe + e$ Model 5

$Cov(a, m) = 0$

$y = Xb + Z_a a + Z_m m + Z_{pe} pe + e$ Model 6

$Cov(a, m) = A\sigma_{am}$

Where:

y: vector of records.

b: vector of fixed effects.

a: vector of direct additive genetic effects.

m: vector of maternal additive genetic effects.

pe: vector of permanent environmental effects due to ewe. X, Za, Zm and Zpe: corresponding design matrices relating the fixed effects, direct additive genetic effects, maternal additive genetic effects and permanent environmental effects due to ewe to vector of y, respectively.

e: vector of residual effects.

Cov(a, m): covariance between direct additive genetic and maternal additive genetic effects.

It is assumed that:

$$Var\begin{bmatrix} a \\ m \\ pe \\ e \end{bmatrix} = \begin{bmatrix} A\sigma_a^2 & A\sigma_{am} & 0 & 0 \\ A\sigma_{ma} & A\sigma_m^2 & 0 & 0 \\ 0 & 0 & I_d\sigma_{pe}^2 & 0 \\ 0 & 0 & 0 & I_n\sigma_e^2 \end{bmatrix}$$

It was assumed that the direct additive genetic effects, maternal additive genetic effects, permanent environmental effects due to ewe and residual effects to be normally distributed with mean 0 and variance $A\sigma_a^2, A\sigma_m^2, I_d\sigma_{pe}^2, I_n\sigma_e^2,$ respectively.

$\sigma_a^2, \sigma_m^2, \sigma_{pe}^2, \sigma_e^2$: direct additive genetic variance, maternal additive genetic variance, permanent environmental variance due to ewe and residual variance, respectively.

A: additive numerator relationship matrix.

Id and In: identity matrices that have order equal to the number of ewes and number of records, respectively.

σam: covariance between direct additive genetic and maternal additive genetic effects.

Total heritabilities were estimated according to formula of Willham (33):

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

In univariate analysis, the log likelihood values were applied to choose the most appropriate model for each trait (14). Estimation of genetic and phenotypic correlations was accomplished using multi-trait analysis applying the most appropriate model which was determined in univariate analysis. The fixed effects included in the multi-trait animal models were those in single-trait analyses.

RESULTS

Least square means for studied traits are shown in Table 3. The result of variance analysis showed that the year of birth had significant effects on all studied traits ($p<0.01$).Sex of lamb had significant effect on all traits ($p<0.01$). The significant effect of fixed factors in these characters could be assigned partly to the differences in the endocrine system of female and male lambs. Also, age of dam had significant effect on BW, 3MW, 6MW and 9MW($p<0.05$).Type of birth had a significant effect on weight changes in all traits ($p<0.01$). Single born lambs had higher body weights and pre-weaning growth rate than twins and triplets.

Table 3. Lease square means and standard errors for the studied traits

Fixed effect	BW	WW	6MW	9MW
Birth year				
1994	3.94^{J}±0.72	21.19^{f}±3.79	34.46^{a}±4.7	-
1995	4.27^{de}±0.72	24.17^{a}±3.79	31.12^{cd}±4.7	-
1996	4.01^{jl}±0.72	19.46^{g}±3.79	32.12^{b}±4.7	31.80^{c}±4.53
1997	4.35^{cd}±0.72	17.85^{h}±3.79	29.52^{fe}±4.7	28.99^{f}±4.53
1998	4.16^{gfh}±0.72	17.17^{l}±3.79	29.23^{ef}±4.7	30.16^{ed}±4.53
1999	4.08^{glh}±0.72	21.87^{e}±3.79	32.0^{cd}±4.7	30.72^{d}±4.53
2000	3.70^{k}±0.72	22.53^{cbd}±3.79	30.84^{d}±4.7	32.99^{b}±4.53
2001	4.1^{glh}±0.72	21.14^{f}±3.79	30.38^{ed}±4.7	29.40^{ef}±4.53
2002	4.04^{hl}±0.72	22.23^{ced}±3.79	29.68^{fe}±4.7	34.14^{a}±4.53
2003	4.05^{hl}±0.72	19.16^{g}±3.79	27.57^{g}±4.7	32.49^{bc}±4.53
2004	4.16^{gf}±0.72	21.08^{f}±3.79	30.99^{d}±4.7	34.17^{a}±4.53
2005	4.22^{fe}±0.72	23.03^{b}±3.79	31.29^{cbd}±4.7	34.33^{a}±4.53
2006	4.32^{cde}±0.72	22.59^{cbd}±3.79	32.07^{b}±4.7	34.43^{a}±4.53
2007	4.29^{de}±0.72	22.38^{cdel}±3.79	31.09^{cd}±4.7	34.0^{a}±4.53
2008	4.47^{b}±0.72	21.92^{e}±3.79	30.84^{d}±4.7	34.43^{a}±4.53
2009	4.67^{a}±0.72	22.75^{cb}±34.79	-	-
2010	4.39^{bc}±0.72	22.14^{de}±3.79	-	-
Birth type				
Single	4.39^{a}±0.72	22.01^{a}±3.79	31.46^{a}±4.7	33.09^{a}±4.53
Twin	3.68^{b}±0.72	19.47^{b}±3.79	28.94^{b}±4.7	31.45^{b}±4.53
Sex				
Male	4.10^{b}±0.72	20.01^{b}±3.79	29.55^{b}±4.7	31.45^{b}±4.53
Female	4.37^{a}±0.72	22.28^{a}±3.79	32.68^{a}±4.7	34.68^{a}±4.53
Ewe age				
2	4.10^{c}±0.72	21.08^{c}±3.79	30.47^{bc}±4.7	32.63^{ab}±4.53

3	$4.26^{b}\pm0.72$	$21.63^{ab}\pm3.79$	$30.99^{abc}\pm4.7$	$32.94^{a}\pm4.53$
4	$4.39^{a}\pm0.72$	$22.0^{a}\pm3.79$	$31.16^{ab}\pm4.7$	$33.04^{a}\pm4.53$
5	$4.30^{b}\pm0.72$	$21.58^{b}\pm3.79$	$31.38^{a}\pm4.7$	$32.88^{a}\pm4.53$
6	$4.32^{ab}\pm0.72$	$21.51^{b}\pm3.79$	$31.44^{a}\pm4.7$	$33.19^{a}\pm4.53$
7	$4.02^{b}\pm0.72$	$20.85^{c}\pm3.79$	$30.54^{bc}\pm4.7$	$32.0^{b}\pm4.53$
8	$4.01^{b}\pm0.72$	$20.70^{c}\pm3.79$	$30.29^{c}\pm4.7$	$31.91^{b}\pm4.53$

The means within the same column with at least one common letter, do not have significant difference($P>0.01$).

BW: birth weight, WW: weaning weight (three-month weight), 6MW: six-month weight, 9MW: nine-month weight.

Table 4. (Co)variance components, genetic parameters estimates for the studied traits with different models

Traits	Models	σ^2_a	σ^2_m	σ^2_{am}	σ^2_e	σ^2_p	h^{2*}_a	c^{2*}	h^{2*}_m
BW	1	0.098	-	-	0.278	0.376	0.261	-	-
BW	2	0.0529	-	-	0.269	0.370	0.142	0.127	-
BW	3	0.044	0.065	-	0.273	0.372	0.119	-	0.176
BW	4	0.045	0.066	-0.012	0.273	0.372	0.121	-	0.178
BW	5	**0.046**	**0.044**	**-**	**0.268**	**0.370**	**0.124**	**0.054**	**0.121**
BW	6	0.042	0.045	-0.010	0.273	0.371	0.115	0.053	0.121
WW	1	1.88	-	-	7.438	9.318	0.201	-	-
WW	2	1.603	-	-	7.332	9.278	0.172	0.036	-
WW	3	1.52	0.570	-	7.371	9.314	0.163	-	0.061
WW	4	1.578	**0.665**	**-0.246**	**7.327**	**9.325**	**0.169**	**-**	**0.071**
WW	5	1.458	0.542	-	7.397	9.300	0.156	0.003	0.058
WW	6	1.497	0.605	-0.194	7.368	9.306	0.160	0.003	0.065
6MW	1	4.420	-	-	12.618	17.039	0.258	-	-
6MW	2	3.823	-	-	12.193	16.924	0.225	0.05	-
6MW	3	4.442	1.863	-	11.909	17.0338	0.260	-	0.109
6MW	4	4.470	1.885	-1.211	11.893	17.038	0.261	-	0.110
6MW	5	4.382	1.591	-	11.731	17.036	0.256	0.027	0.093
6MW	6	**4.408**	**1.577**	**-1.168**	**11.679**	**17.042**	**0.258**	**0.031**	**0.092**
9MW	1	2.631	-	-	10.913	13.544	0.193	-	-
9MW	2	2.345	-	-	10.541	13.515	0.173	0.046	-
9MW	3	2.188	1.414	-	10.493	13.620	0.160	-	0.103
9MW	4	2.187	1.441	-0.487	10.484	10.626	0.160	-	0.105

9MW	5	**2.23**	**1.109**	**-**	**10.360**	**13.608**	**0.163**	**0.025**	**0.081**
9MW	6	2.210	1.168	-0.471	10.428	13.628	0.161	0.021	0.085

σ^2_a: direct genetic variance, σ^2_m: maternal additive genetic variance σ^2_e: residual variance, σ^2_p: phenotypic variance, σ^2_{am}: covariance between direct genetic and maternal additive genetic, h^2_a: direct heritability, h^2_m: maternal heritability, c^2: ratio of maternal permanent environmental effect to phenotypic variance.

BW: birth weight, WW: weaning weight (three-month weight), 6MW: six-month weight and 9MW: nine-month weight. The most appropriate model for each trait is shown in bold face.

DISCUSSION

Estimates of phenotypic variance using different models were generally similar for all considered traits. Residual variance was also similar in models 1 to 6. The most appropriate models for BW and 3MW were Model 5 and 4 respectively. The most appropriate models for 6MW and 9MW were Model 6and 5 respectively. Maternal permanent environmental effects had a considerable impact on variation for BW, 3MW, 6MW and 9MW. In general, the values observed in this study are in agreement with the estimates reported by the other researchers (38; 16).The significant influence of lambing year can be described by the variation in the climate conditions and dependence of sheep to pastures, management and breeding conditions of mothers and lambs feeding in various years. Significant effects of year on reproductive traits have been reported by several authors (32; 16; 4; 18).According to the previous reports, the growth rate of female lambs was slower than in male lambs, and thus their weight was less, respectively (17). Also, competition for milk consumption can be effective between twins and triplets particularly in pre-weaning period, which was consistent with other reports (22). Including of birth age as a correlated variable into the statistical model (covariate) had a significant effect on all traits ($p<0.01$).The estimate of direct heritability for BW in the current study (0.12) is lower than in the report of Mohammadi *et al.* (17) (0.15). Lower heritability of birth weight compared to the other weights is related to the following reasons. Fetal growth is influenced by genetic and environmental factors such as the placenta and the fetal nutrition by a dam. Therefore, environmental factors affecting dam growth, especially the quality and quantity of food and the storage of food for dam can influence the growth of the embryo. In the present research the estimate of direct heritability for 3MW (0.16) corresponds to the data of Jafaroghli *et al*. (11). Higher estimate (17; 0.19) have also been reported. The reason for low heritability is that the lambs are more affected by breast milk during infancy. The estimate of direct heritability for 6MW in this study (0.25) is higher than the estimate by Mohammadi *et al*. (17; 0.21) and is lower than by Ghafouri-Kesbi et al. (10). Also, the estimate of direct heritability for 9MW in this study (0.16) is approximately compatible with previous results in the Shal breed by Mohammadi *et al*. (17; 0.18). As it is explicit, direct heritability has had upward trend, which has been proved by different researchers. Also, maternal heritability for 6MW was estimated to be 0.07 (2), whilst in our study this parameter was estimated to be 0.092. The estimate of maternal heritability for 9MW in the present study (0.085) is higher than the estimate published by (10) -0.05. In addition, c***2*** for 6MW was estimated to be 0.03,that was lower than the results reported by others researches (17; 0.06). The rate of c***2*** for 9MW was estimated to be 0.02, which is in accordance with results of others researches (10; 0.02) (Table 4). The results indicate that maternal additive genetic effects, which regard to the growth of fetus, could have some beneficial effect on the post-natal growth traits too. In the other words, body weight from birth to 6MW of age is partly influenced by similar genes of the dam in terms of maternal genetic effects.

Several reports have been published on the contribution and importance of the maternal genetic variance, permanent environmental variance and direct-maternal genetic covariance in improving the fit of models for growth performance in sheep (30; 12; 1; 5; 23; 15). Based on the genetic parameters estimate fitting different models for body weight traits, direct heritability estimates with best models for body weight of lambs were relatively low to medium ranging from 0.12 for BW to 0.25 for 9MW. The direct additive heritability estimate (0.12) of BW in present study is low, but within the range reported by others. The range of direct heritability estimates for BW varies substantially from 0.04 (23) to 0.46 (9). The results in the present study were similar to the results reported by Mohammadi *et al*. (15) for Iranian Sanjabi lambs. Safari *et al*. (25), reported estimates of 0.19 and 0.15 for direct heritability of BW in dual-purpose and meat type breeds of sheep, respectively. These estimates were higher than our obtained value in the present study. The maternal additive genetic variances were low. Estimates of maternal heritability with appropriate models for BW and WW were 0.12 and 0.07, respectively. The estimated values for the maternal heritability of BW were well consistent with some of the published values (12; 5; 23). Safari *et a*l. (25) reported weighted mean of the maternal heritability estimated for BW of 0.18 in dual-purpose and 0.24 in meat type. Corresponding value for meat type ones was in general agreement with our estimated value. Birth weight is a trait of economical importance mainly due to its effect on pre-weaning growth of lambs and accordingly on economic success of lamb production (3). Estimate of direct heritability for WW (0.16) obtained in the present study was within the range of those published in the literature, which varied from 0.09 (20) to 0.33 (29). A decreasing trend in the maternal effects from birth to later ages has shown. Estimate of direct heritability for 6MW (0.25) obtained in the current study werein the range the estimates of Bahreini Behzadi *et al*. (5), Eskandarinasab *et al*. (7) and Mohammadi *et al*. (15). The direct heritability estimate of 9MW (0.16) was in the range of 0.03 (19) to 0.59 (29). The low estimates of maternal heritability for 6MW and 9MW were expected, because at these ages individuals do not depend on their mother and their weights should reflect only the direct effect of the genes on growth except for carry over maternal effects from before weaning. For animals raised on pasture, the length of time from birth to yearling is probably not enough that compensatory gain could buffer completely the maternal effect existing at birth. Robison

(1981) suggested that even if maternal effects tend to diminish with age, some adult traits will nevertheless contain this source of variation. In general, different estimates of the direct and maternal heritabilities of body weight traits in various studies can be due to model of analysis, sheep breed, data structure, different management of herds and different breeding strategies in sheep. The relatively low heritability estimates for the studied traits can be perhaps explained by the low nutritional management, low quality of pastures and harsh climatic conditions, which result in a high environmental variance. Sizeable effects of maternal influences on BW and WW traits suggest that these effects need to be considered in selection programs and exclusion of them may lead to biased estimations of direct heritability. When maternal effects are of high importance, total heritability values are more efficient than direct heritabilities for estimation of selection response based on phenotypic values (1).

CONCLUSION

The estimates of genetic parameters reported for the Zandi sheep were in general agreement with those reported in the literature. Maternal effects were significant sources of variation for BW and WW traits in Zandi sheep. Therefore, effects of genetic maternal need to be accounted for estimate the best linear unbiased predicted value (BLUP) of Zandi lambs. The estimates of direct heritability tended to increase from birth to weaning. These results indicated that selection for body weight traits on WW will be effective. The estimates of direct genetic and additive genetic maternal correlations between body weight traits were positive and high. So selection for any of these traits could result in genetic progress for the other traits.

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