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Full Length Research Paper

Genetic and phenotypic parameters of body weight in Zandi sheep

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The purposes of this study were to estimate genetic parameters for growth traits and to develop a suitable model for the data set used. Data were collected in the Zandi sheep breed from 1992 to 2007 from the Khojir Sheep Breeding Station, Tehran, Iran. Number of observation were 5711 for birth weight (BW), 4619 for weaning weight (WW) , 2801 for body weight at 6-months of age (W6), 2124 for body weight at 9 months of age (W9) and 2113 for yearling weight (W12). (Co) variance components and corresponding genetic parameters were obtained with univariate and multivariate analyses fitting animal models using restricted maximum likelihood (REML) methods that accounted for fixed effects of sex, birth type, age of dam, year of birth and month of birth. Three different animal models were fitted. Based on the most appropriate model fitted, direct heritability, maternal heritability and maternal permanent environmental effect were estimated to range from 0.155 at BW to 0.357 at WW, 0.069 at WW to 0.157 at BW and 0.161 at W9 to 0.171 at W6, respectively. Phenotypic and genetic correlations between all traits were positive, demonstrating the effectiveness of the implemented breeding programs.

Key words: Sheep, body weight, genetic parameters, maternal effects.

INTRODUCTION

The sheep population in Iran is mainly composed of fat tailed carpet-wool native breeds. A high percentage of the sheep population is managed under a migratory system, utilizing the ranges as the major source of feed (Bahreini Behzadi et al., 2007). Ways to increase meat production in sheep, in any system are likely to be 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). Body weight and growth traits in sheep are known to be influenced by direct and maternal genetic effects as well as by environmental effects (Szwaczkowski et al., 2006). Since direct and maternal effects are generally confused, there are some difficulties in the estimation of maternal effects and their covariance components. The availability of restricted maximum likelihood (REML) algorithms for analyses fitting an animal model has simplified the estimation of (co)variance components due to maternal effects (Maria et al., 1993; Tosh and Kemp, 1994). Moreover, the heritability and genetic relationship between traits is needed for planning an efficient breeding system and development of effective genetic evaluation (Rashidi et al., 2008). The aims of the present paper were to investigate the importance of direct and maternal effects on body weight at different ages of Zandi lambs and to develop a suitable model for the data set used.

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Table1. Characteristics of the data structure.

Trait^a					Item
W12	**W9**	**W6**	**WW**	**BW**	
489	489	489	489	490	Number of base animals
2113	2124	2801	4619	5711	Number of records
117	118	217	478	937	number of animals without known sire
26	30	50	73	64	number of animals without known dam
134	156	160	186	183	Number of sires with progeny record
800	1053	1188	1450	1519	Number of dams with progeny record
164	205	210	237	239	Number of grandsires with progeny record
497	684	726	875	906	Number of granddams with progeny record
34.19	32.56	31.42	20.78	4.13	Mean, kg
6.35	5.89	5.70	4.41	0.74	SD, kg
18.57	18.09	18.14	21.22	17.91	CV, %

^{a}BW - birth weight; WW - weaning weight; W6- body weight at 6 months of age
W9 - body weight at 9 months of age; W12 – yearling weight

MATERIALS AND METHODS

Animals and management

Zandi sheep are fat tail breed adapted to the dry and harsh climatic conditions. They are primarily raised for mutton, with milk and wool being of secondary importance. The birth weight is around 3 - 4 kg and the adult weight is 30 - 40 kg. The average height is 55 - 65 at withers. Natural pasture is the main source of feed all the year except for cold (winter) as well as mating (commenced in August) seasons. At these times supplemental feeding has to be provided. Young ewes were exposed to rams at an average age of 1.5 years. No culling was performed among the dams except for infertility, old age, and health problems. Rams were used for 3 or 4 breeding years and kept separated from ewes, except in the mating season. In the mating season, artificial insemination (AI) was initially performed, but animals that did not conceive by AI were allocated to natural service. In the latter case, each group of ewes (detected in oestrus) was allotted to one fertile ram in a separate mating pen. At birth, lambs were weighed, tagged, sexed and identified to their parents. Birth date was also recorded. During the suckling period, lambs were kept indoors and allowed to nurse their mothers twice a day. The suckling stage lasted for 90 days on the average (Ghafouri-Kesbi and Eskandarinasab, 2008).

Data collection and traits description

The data used in the present study, were collected from Khojir Sheep Breeding Station, Tehran, Iran from 1992 to 2007. The traits analyzed were birth weight (BW), weaning weight (WW), body weight at 6 months of age (W6), body weight at 9 months of age (W9) and yearling weight (W12). Numbers of observation were 5711 for BW, 4619 for WW, 2801 for W6, 2124 for W9 and 2113 for W12. Data structure is shown in Table 1.

Statistical analysis

The GLM procedure of SAS (SAS, 1999) was used to identify important fixed effects to be considered in the final model. The statistical model included sex (male and female), birth type (single, twin and multiple), age of dam (2 - 10 years old), year of birth (15 years) and season of birth (winter and spring). All the effects were significant ($p < 0.05$) and hence they were included in the animal model. (Co) variance components and corresponding genetic parameters for all traits were estimated by restricted maximum likelihood (REML) method fitting an animal model. For this purpose, DFREML 3.1 computer program was used (Meyer, 2000). As described by Ekiz et al., 2004 univariate models (shown below) were used to estimate genetic parameters. All models included an additive direct effect and this was the only random factor in model 1. Model 2 included the maternal permanent environmental effect, fitted as an additional random effect, uncorrelated with all other effects in the model. Model 3 included an additive maternal effect fitted as a second random effect.

Model 1: $Y = X ß + Z_a a + e$
Model 2: $Y = X ß + Z_a a + Z_c c + e$
Model 3: $Y = X ß + Z_a a + Z_m m + e$ with $Cov (a,m) = 0$

Where, Y = vector of observations; ß = sex, birth type, age of dam, year of birth and season of birth as fixed effects; a = vectors of direct additive genetic effects; m = maternal genetic effects; c = permanent environmental effect of dam; e = residual; A = numerator relationship matrix; X, Z_a, Z_m and Z_c are the incidence matrices relating observations to ß, a, m and c, respectively.

Total heritability $(\sigma^2_a + 0.5 \sigma^2_m + 1.5 \sigma_{am}) / \sigma^2_p$), is as defined by Willham (1972). To determine the most appropriate model, likelihood ratio tests were used for each trait. An effect was considered to have a significant influence when its addition caused a significant increase in log likelihood, in comparison with the model in which it was ignored. When log likelihoods did not differ significantly ($P > 0.05$), the model that had fewer parameters was selected as the most appropriate. Genetic and phenotypic correlations were estimated using multi-trait analysis. The fixed effects included in the multi trait animal models were those in single trait analyses direct additive genetic effects, maternal additive genetic effects and environmental residual random effects for the *i*th trait were also included in the multi trait animal models. A variance of 10^{-8} of simplex function

Table 2. Least squares means ± of growth traits at different ages.

Trait						
W12 (Kg)	**W9 (Kg)**	**W6 (Kg)**	**WW (Kg)**	**BW (Kg)**	**Item**	
34.19 ± 6.35	32.56 ± 5.79	31.42 ± 5.20	20.78 ± 4.41	4.13 ± 0.74		Overall Mean
32.50 ± 0.74	31.22 ± 4.80	31.75 ± 5.10	21.90 ± 4.40	4.21 ± 0.47	Single	Birth Type
30.15 ± 5.40	28.55 ± 4.70	28.60 ± 4.45	20.20 ± 4.60	3.43 ± 0.52	Twine	
32.35 ± 5.23	31.75 ± 4.20	32.85 ± 4.55	22.13 ± 4.71	4.20 ± 0.85	Male	Gender
30.90 ± 5.34	30.29 ± 4.35	29.90 ± 5.22	20.73 ± 4.14	3.90 ± 0.74	Female	
33.90 ± 5.19	31.85 ± 5.33	31.60 ± 4.35	21.72 ± 3.85	4.23 ± 0.70	2	Dam Age
32.80 ± 6.12	30.80 ± 4.25	31.50 ± 4.25	22.20 ± 3.95	4.0 ± 0.65	3	
34.50 ± 5.50	32.10 ± 4.10	31.70 ± 4.15	21.65 ± 4.22	4.11 ± 0.36	4	
33.33 ± 5.90	32.20 ± 4.70	30.90 ± 3.95	21.85 ± 4.13	4.21 ± 0.79	5	
33.85 ± 4.80	32.10 ± 4.50	29.85 ± 4.00	21.76 ± 4.65	4.30 ± 0.71	6	
34.35 ± 5.60	31.10 ± 4.20	30.00 ± 4.50	20.97 ± 4.55	4.01 ± 0.45	7	
31.80 ± 6.40	30.80 ± 3.90	29.90 ± 3.80	20.75 ± 4.45	4.00 ± 0.55	8	
38.33 ± 6.11	37.85 ± 4.70	34.58 ± 5.42	23.70 ± 4.13	3.55 ± 0.38	1992	Birth Year
36.65 ± 5.45	39.60 ± 5.35	33.45 ± 5.15	23.35 ± 4.12	3.92 ± 0.43	1993	
32.74 ± 4.80	34.36 ± 5.30	32.65 ± 4.37	22.28 ± 3.58	4.12 ± 0.45	1994	
31.82 ± 5.12	29.95 ± 6.50	31.35 ± 4.12	25.42 ± 4.20	4.11 ± 0.39	1995	
31.45 ± 4.02	29.92 ± 6.70	32.67 ± 4.95	20.65 ± 3.28	4.80 ± 0.28	1996	
30.25 ± 4.50	27.65 ± 4.48	30.27 ± 4.20	19.00 ± 3.90	4.16 ± 0.64	1997	
31.87 ± 5.30	28.80 ± 5.31	29.71 ± 3.84	17.78 ± 3.92	3.90 ± 0.70	1998	
32.25± 6.50	29.43 ± 4.20	32.55 ± 5.75	23.12 ± 4.11	4.01 ± 0.65	1999	
29.80 ± 5.60	31.62 ± 5.20	31.67 ± 5.35	23.72 ± 4.15	3.95 ± 0.55	2000	
30.75 ± 6.80	35.50 ± 5.70	30.92 ± 5.20	22.38 ± 4.12	3.90 ± 0.44	2001	
36.65 ± 5.41	32.82 ± 5.20	30.22 ± 3.90	23.35 ± 4.27	3.93 ± 0.33	2002	
32.22 ± 4.85	31.10 ± 4.90	29.11 ± 3.84	20.97 ± 4.21	3.90 ± 0.32	2003	
31.53 ± 6.72	32.92 ± 5.30	31.50 ± 5.70	22.19 ± 3.91	3.91 ± 0.51	2004	
32.42 ± 6.23	33.00 ± 6.45	31.80 ± 5.63	24.24 ± 5.05	4.08 ± 0.38	2005	
34.50 ± 5.80	33.08 ± 5.45	32.60 ± 5.55	23.80 ± 5.17	4.13 ± 0.78	2006	
34.75 ± 6.01	32.56 ± 4.18	31.66 ± 4.12	23.52 ± 4.11	4.05 ± 0.46	2007	

RESULTS

Data structure and analysis under different model

As seen in Table 1, the coefficient of variation for BW was less than that of the other traits, which is an indication of the smaller effect of environment on BW than on the other ones. Moreover, as expected, the number of records decreased with age and this decline was due to the harvest/culling and losses of lambs at different ages. The least squares means and standard errors for BW, WW, W6, W9 and W12 are presented in Table 2. Estimates of (co)variance components and genetic parameters based on the most appropriate model for each trait are given in Table 3. The most appropriate model for BW and WW was model 3, which included direct and maternal additive genetic effects. The most appropriate model for W6 and W9 was model 2, which included direct additive genetic as well as maternal permanent environmental effects, whereas the most appropriate model for W12 had only the direct additive genetic effects (model 1).

Heritability estimates

Heritability estimates for weight traits were generally moderate in magnitude and ranged from 0.155 to 0.357 with very low standard errors (range 0.047 – 0.061) (Table 3). With the simple animal model (Model 1), h^2 estimates were overestimated; but when maternal effects were included in the models, h^2 decreased. Direct h^2 estimates with appropriate models for body weight decreased with age from 0.357 at birth to 0.155 at weaning.

Correlation estimates

Multivariate analyses results are presented in Table 4. Genetic correlation estimates between traits were positive,

Table 3. Estimates of (co) variance components and genetic parameters for growth traits based on the most appropriate model.

W12	W9	W6	WW	BW	item
1	**2**	**2**	**3**	**3**	**The most appropriate model**
-2916.32	-2209.63	-2209.69	-2024.58	-88.51	Log L
3.52	2.30	3.10	1.93	0.136	б^{2}a
-	2.44	3.047	-	-	б^{2}c
-	-	-	0.851	0.06	б^{2}m
15.69	12.76	14.635	9.46	0.25	б^{2}e
19.18	15.07	17.74	12.39	0.38	б^{2}p
0.052± 0.184	0.051± 0.156	0.047± 0.174	0.061± 0.155	0.051± 0.357	h^2a ±S.E.
-	0.035± 0.161	0.042± 0.171	-	-	c^2 ±S.E.
-	-	-	0.069 ± 0.052	0.157 ± 0.082	h^2m ± S.E.
-	-	-	0.190 ± 0.043	0.436 ± 0.070	h^2T ± S.E.
12.81	21.74	24/56	21.05	16.05	CV

Table 4. Genetic correlations (upper triangle) and phenotypic correlations (lower triangle) among live weight traits1

W12	W9	W6	WW	BW	Trait
0.56±0.16	0.58±0.09	0.73±0.06	0.79±0.08		BW
0.68±0.12	0.71±0.11	0.85±0.05		0.89±0.08	WW
0.70±0.09	0.79±0.12		0.81±0.06	0.87±0.06	W6
0.72±0.08		0.79±0.11	0.82±0.07	0.83±0.07	W9
	0.85±0.13	0.86±0.08	0.82±0.09	0.79±0.08	W12

1- Live body weight at birth (BW), weaning (WW), 6 months (W6), 9 months (W9) and yearling weight (YW).

moderate to high, and ranged from 0.56 for BW-W12 to 0.85 for WW-W6. The estimates of phenotypic correlations were generally higher than those of genetic correlations and varied from 0.79 for BW - W12 and W6 - W9 to 0.89 for BW - WW.

DISCUSSION

The results of some investigations summarized by Vatankhah et al. (2005) in different Iranian breeds, showed that the range of heritability estimate was between very low (about 0.05) and high (above 0.5). The results obtained in this study conformed to previous results from the same population, but based on smaller data sets (Ghafouri-Kesbi1 and Eskandarinasab, 2008). Several factors such as breed, genetic variation within population, management and environmental conditions, method of estimating parameters, among others would have affected the differences between estimations (Miraei-Ashtiani et al., 2007). The range of direct heritability estimates for BW in literature varies substantially from 0.04 (Maria et al., 1993) to 0.46 (Gizaw et al., 2007). Al-Shorepy (2001) and Bosso et al. (2007) reported a heritability of 0.39 and 0.38 for BW in Djallonké sheep and local sheep in United Arab Emirates, respectively. Miraei-Ashtiani et al. (2007) found a heritability of 0.33 for BW in Sangsari sheep. The estimate of the direct heritability of WW was consistent with reports for comparable traits (Tosh and Kemp, 1994; Nasholm and Danell, 1996; Ligda et al., 2000; Simm et al., 2002; Hanford et al., 2005; Miraei-Ashtiani et al., 2007; Ghafouri-Kesbi and Eskandarinasab, 2008). In contrast to some reports (Tosh and Kemp, 1994; Yazdi et al., 1997; Simm et al., 2002; Bahreini Behzadi et al., 2007), observation on increase in the heritability of body weight at the later age was not made. A tendency for direct heritability to rise with increasing age is frequently attributed to the waning influence of the maternal milk supply on the variability of food intake and performance in the young lamb; although this trend was not also observed (Larsgard and Olesen, 1998). The heritability estimates of post-weaning weights have also been reported for many breeds of sheep for different conditions. Vatankhah and Talebi (2008) in their study on Lori-Bakhtiari (Iranian fat-tailed breed of sheep), using REML procedure and multi-trait animal model, reported a heritability of 0.19 ± 0.03 for W6. Bahreini Behzadi et al. (2007) on their study on Kermani sheep breed (a fat-tail breed in eastern Iran), using single and two-trait animal models, reported heritability estimates of 0.09 ± 0.06, 0.13 ± 0.08 and 0.14 ± 0.08 for W6, W9 and W12, respectively. Miraei-Ashtiani et al. (2007) in their study on Sangsari sheep, using a Derivative Free, Restricted Maximum Likelihood (DFREML) approach, reported the heritability estimates of W6, W9, and W12 as being 0.49 ± 0.07, 0.08 ± 0.05, 0.10 ± 0.05, respectively. The derived results of current study fairly are in agreement with the mentioned reports.

Genetic correlation between various traits in this study was positive and varied from moderate to high. The present results are in agreement with those reported by Ozcan et al. (2005) in Turkish Merino sheep, Rashidi et al. (2008) in Kermani sheep, and Gizaw et al. (2007) in Menz sheep. The genetic correlation between BW and W12 was lower than that between WW and W12, indicating that selection for W12 would not quickly result in increased BW. The genetic correlations between WW and later weights were high, indicating that selection for increased WW in Zandi sheep will also result in genetic change for W6, W9, and YW. So, it is rational to recommend that the traits to be included in the sheep breeding scheme could be limited to the traits expressed early in life of the lambs. The chronologically adjacent weight traits showed the largest positive relationship rather than non-adjacent ones. Mousa et al. (1999) indicated that an autocorrelation would exist among the genetic and environmental effects associated with the successive measurements.

The magnitude of the maternal heritability estimate of BW (0.157) in this research was greater than direct heritability and was within the range reported in literature from 0.09 by Snyman et al. (1995) to 0.59 by El Fadili et al. (2000). Robison (1981) showed that maternal effects in mammals are substantial in young animals but diminish with age. In this study, estimates of maternal heritability tended to decline from BW to W12. Maternal heritability estimates of BW and WW in this study were lower than values reported by Nasholm and Danell (1996), Ligda et al. (2000), Ekiz et al. (2000) and Rashidi et al. (2008). In general, the trend of decreasing maternal heritabilities with age in Zandi sheep was similar to the average trends reported for other breeds. The maternal heritability estimates for lamb body weights found in the present study were within the range of those presented in literature.(Simm et al., 2002, Hanford et al., 2005; Miraei-Ashtiani et al., 2007; Ghafouri-Kesbi and Eskandarinasab, 2008).The phenotypic correlation estimates between all traits were positive in this study ranging from 0.79 for BW - W12 and W6 - W9 to 0.89 for BW - WW. Positive phenotypic correlations between these traits were reported in literature (Miraei-Ashtiani et al., 2007; Ghafouri-Kesbi and Eskandarinasab, 2008). However Maria et al. (1993) reported an estimate of -0.58 and -0.37 for phenotypic correlation between BW-WW and BW - ADG, respectively.

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