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Full Length Research Paper

Estimation of genetic parameters for body weight at different ages in Mehraban sheep

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The objective of the present study is to estimate genetic parameters of birth weight (BW, n = 3005), weaning weight (WW, n = 2800), 6 months weight (6 MW, n = 2600), 9 months weight (9 MW, n = 1990) and yearling weight (YW, n = 1450) of Mehraban sheep, collected during 1995 - 2007 at Mehraban sheep Breeding Station in Hamedan province, Iran. (Co)variance components and genetic parameters were estimated with univariate and multivariate animal model using restricted maximum likelihood (REML) procedure. Effect of herd, lamb's sex, and year of birth were significant on all traits ($P < 0.05$). The estimates of direct heritability for BW, WW, 6MW, 9MW and YW were 0.30±0.05, 0.30±0.04, 0.35±0.05, 0.37±0.04 and 0.43±0.04 respectively. Maternal heritability estimates for mentioned traits were 0.17±0.03, 0.18±0.03, 0.14±0.03, 0.12±0.03 and 0.10±0.02, respectively. The estimates of the direct genetic correlation between BW-WW, BW-6MW, BW-9MW, BW-YW, WW-6MW, WW-9MW, WW-YW, 6MW-9MW, 6MW-YW and 9MW-YW were 0.287±0.09, 0.305±0.09, 0.249±0.03, 0.136±0.07, 0.825±0.34, 0.713±0.05, 0.845±0.52, 0.862±0.06, 0.596±0.09 and 0.712±0.02 respectively. The estimates of the phenotypic correlation between traits were positive and ranged from 0.152 for BW-9MW to 0.835 for 9MW-YW.

Key words: Mehraban sheep, heritability, genetic correlation, body weight traits.

INTRODUCTION

Body weight and growth traits are one of the economically important traits in sheep production, specially in Iran that lamb sale is the main source of income for breeder while other products are in secondary importance. Although mutton is the most important source of protein in Iran, meat production from the sheep does not cover the increasing consumer demand (Rashidi et al., 2008). On the other hand, increase in sheep number for more meat production has been limited by low quality and quantity of forage range. Therefore enhancing meat production should be achieved by selecting the animals that have maximum genetic merit as future generation parents. To design an efficient improvement program and genetic evaluation system for maximization response to selection for economically important traits, accurate estimates of the genetic parameters and the genetic relationships between the traits are necessary (Safari et al., 2005; Baneh, 2009).

Mehraban sheep is one of Iranian fat-tailed breed that are raised in Hamadan province, western Iran. The region's average annual rainfall is between 300 and 500 mm with mean temperature, 19℃; and average elevation, 1747 m (Bathaei and Pascal, 1998). In this province, the predominant breed is Mehraban, numbering approximately 2.1 million heads (Aghaali Gamasaee, 2009). They are well adapted to the cold condition. Though Mehraban sheep have high performance of milk, wool and repro-duction efficiency, mutton is the most important productive trait in this breed. Nowadays, meat is the main source of income for producers.

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Abbreviations: BW, Birth weight; **WW,** weaning weight; **6 MW,** weight at six months of age; **9 MW,** weight at nine months of age; **YW,** yearling weight.

Table 1. Descriptive data used in the analysis.

Trait	No of records	Mean	S.D	Minimum	Maximum	C.V (%)
Birth weight	3005	3.38	0.82	1.20	8.01	24.24
Weaning weight	2800	22.21	5.80	9.00	30.00	26.12
6 months weight	2600	35.73	9.29	13.10	59.00	26.00
9 months weight	1990	46.90	9.99	14.04	62.00	21.30
Yearling weight	1450	55.48	7.97	25.29	69.25	14.37

Observations have shown that only a few attempts have been made to estimate genetic parameters in Mehraban sheep with no published result on the genetic parameters estimation of body weight traits using animal models for this breed. In a previous study, the genetic parameters for growth traits in Mehraban sheep were estimated using least-squares procedure analysis by Bathaei and Pascal (1998).

The objective of the present study is to investigate the environmental effects (herd, lamb's sex, birth type and year of birth) as well as estimate the (Co)variance components and genetic parameters for birth weight (BW), weaning weight (WW), weight at six months (6 MW), weight at nine months (9 MW) and yearling weight (YW) in Mehraban sheep using animal model methodology. In addition, genetic and phenotypic correlations between traits were estimated.

MATERIALS AND METHODS

Data and management

Data and pedigree information of Mehraban sheep collected at Mehraban sheep Breeding Station in Hamedan Province, over a 12-years period (1995 - 2007), was used in this study. Number of records for birth weight, weaning weight, 6 months weight, 9 months weight and yearling weight were 3005, 2800, 2600, 1990 and 1450, respectively. The structure of data set used in this research are presented in Table 1.

Lambs were ear-tagged and pedigree information (animal code, sire and dam) and birth information (date of birth, lambs' sex, birth type) were registered for each lambs separately at birth time. Lambs were weighed at birth, 3, 6, 9 and 12 months of age. Ewes were exposed to the rams at about 18 months of age. Mating period for all ewes started from 15th of September and continued to the beginning of November each year. Lambing commenced from 15th of February to April. Mating was controlled and each mating groups including 10 – 15 ewes were set aside to a ram. The lambs were weaned at around 90 days of age. Flocks were grazed during the daytime and housed at night. Lambs were kept indoors and fed manually during winter.

Statistical models

Investigation of environmental effects was carried out using general linear model (GLM) procedure of SAS software package (SAS, 1996). Statistical model utilized for investigation of studied environmental factors was:

$$y_{ijklm} = \mu + Y_i + S_k + T_l + H_m + e_{ijklm}$$

Where, y_{ijklm} is each of the records, μ the overall mean, Y_i the effect of ith birth year in 12 class (1995-2007), S_k the effect of kth sex in 2 class (male and female), T_l the effect of lth type of birth in 4 class (single, twin, triplet and quadruplet), H_m, the effect of mth herd in 17 class and e_{ijklm} is the residual effect.

As ewes had different mating times and lambs were given birth to during the lambing period, all lambs weighed at the same day had different age. Therefore the age was used as covariate for phenotype observation of age adjustment on all traits except birth weight.

Co-variance components and corresponding genetic parameters for the various traits were estimated with a univariate and multivariate animal model. For this purpose, data were analyzed by restricted maximum likelihood (REML) method using ASREML (Gilmour et al., 2002). The following model was fitted to the data:

$$y = Xb + Z_1a + Z_2m + e \quad \text{with } Cov(a,m) = 0$$

Where, y is a vector of observations for different traits; b, a, m and e are vectors of fixed effects, direct additive genetic effects, maternal additive genetic effects and the residual effects, respectively. X, Z1 and Z2 are corresponding design matrices associating the fixed effects, direct additive genetic effects and maternal additive genetic effects to vector of y.

Total heritability was calculated according to Willham (1972) as:

$$h^2_T = (\sigma^2_a + 0.5\,\sigma^2_{m})/\,\sigma^2_p$$

RESULTS

Environmental effects

The results from general linear model analysis for investigation of environmental effects, means and standard error for different traits are presented in Table 2. The effects of sex, year of birth and herd on the all traits were significant ($p < 0.05$). Type of birth was significant on BW, WW, 6MW, 9MW, but had no effects on YW ($p < 0.05$). At all ages, male lambs were significantly heavier than females ($p < 0.05$).

Heritability estimates

The estimates of variance component, direct heritability and maternal heritability for all traits are given in Table 3. Total heritability estimates of all traits were moderate,

Table 2. Least squares means ± S.E. of body weight traits.

Fixed effects	Traits				
	BW	WW	6MW	9MW	YW
Sex	*	*	*	*	*
Male	3.59^{a} ±0.32	23.03^{a}±0.09	39.94^{a}±0.25	49.19^{a}±0.35	57.20^{a}±0.85
Female	3.43^{b}±0.34	22.26^{b}±0.55	37.60^{b}±0.46	45.73^{b}±0.62	54.72^{b}±0.23
Type of birth	*	*	*	*	ns
Single	4.46^{a}±0.55	23.05^{a}±0.41	53.78^{a}±0.02	55.81^{a}±0.45	57.53^{a}±0.24
Twin	3.02^{c}±0.02	22.03^{b}±0.80	42.72^{b}±0.51	51.40^{b}±0.23	57.44^{a}±0.67
Triplet	3.74^{b}±0.81	21.48^{b}±0.96	38.55^{c}±0.12	48.01^{c}±0.78	55.33^{a}±0.53
Quadruplet	2.76^{d}±0.04	-	37.49^{c}±0.09	44.56^{d}±0.29	53.03^{a}±0.42
Year of birth	*	*	*	*	*
Herd	*	*	*	*	*

Means with similar letters within a column do not differ from another at $p < 0.05$. BW: birth weight, WW: weaning weight, 6MW: 6 months weight, 9MW: 9 months weight, YW: yearling weight, * $p < 0.05$.

Table 3. Estimates of variance components, genetic, maternal and total heritability for body weight traits.

Trait	BW	WW	6MW	9MW	YW
σ^2_a	0.06422	4.215	5.521	8.961	12.61
σ^2_m	0.03602	2.456	2.234	2.906	2.960
σ^2_e	0.1109	7.301	8.246	12.352	13.73
σ^2_p	0.2112	13.97	16	24.22	29.30
h^2_a	0.30±0.05	0.30±0.04	0.35±0.05	0.37±0.04	0.43±0.04
h^2_m	0.17±0.03	0.18±0.03	0.14±0.03	0.12±0.03	0.10±0.02
h^2_T	0.38	0.39	0.42	0.43	0.48

BW: birth weight, WW: weaning weight, 6MW: 6 months weight, 9MW: 9 months weight, YW: yearling weight, σ^2_a: direct additive genetic variance, σ^2_m: maternal additive genetic variance, σ^2_e: residual variance, σ^2_p: phenotypic variance, h^2_d: direct heritability, h^2_m: maternal heritability, h^2_T: tolal heritability.

and ranged from 0.38 for BW to 0.48 for YW. Direct heritability for BW, WW, 6MW, 9MW and YW were estimated as 0.30, 0.30, 0.35, 0.37 and 0.43, respectively. Maternal heritability was lower than direct heritability for all traits. This parameter for BW, WW, 6MW, 9MW and YW were estimated as 0.17, 0.18, 0.14, 0.12, and 0.10, respectively.

Correlation estimates

The estimates of phenotypic correlations, direct genetic correlations and maternal genetic correlations between body weight traits are shown in Table 4. All phenotypic correlation estimates were positive and ranged from 0.152 for BW-9MW to 0.835 for 9MW-YW. Direct genetic correlation estimates except for BW-YW and 9MW-YW were generally higher than those of phenotypic correlation and varied from 0.136 for BW-YW to 0.862 for 6MW-9MW. The maternal additive genetic correlations between all studied traits were positive and ranged from 0.160 for 9MW-YW to 0.840 for 6MW-YW.

DISCUSSION

The studied environmental factors showed significant sources of variation on growth traits in Mehraban sheep. Male lambs were heavier than female at all ages. Differences in sexual chromosomes, physiological characteristics and endocrinal system (type and measure of hormone secretion especially sexual hormones) can lead to significant influences of sex factor. Also, effect of lamb's sex on body weight traits at different ages have been reported in various breeds of sheep (Baneh and Hafezian, 2009; Rashidi et al., 2008; Mokhtari et al., 2008; Kalantar, 2003; Vatankhah and Talebi, 2008b; Dixit et al., 2001).

Birth type was significant on all traits except YW. Order of body weight traits for single and other type of birth were single > twin > triplet > quadruplet. The significant

Table 4. Estimates of phenotypic, direct genetic and maternal correlations between traits.

Trait 1	Trait 2	r_p	r_d	r_m
BW	WW	0.272±0.18	0.287±0.09	0.412±0.05
BW	6MW	0.273±0.04	0.305±0.09	0.345±0.11
BW	9MW	0.152±0.01	0.249±0.03	0.180±0.13
BW	YW	0.191±0.02	0.136±0.07	0.180±0.08
WW	6MW	0.705±0.20	0.825±0.34	0.812±0.02
WW	9MW	0.552±0.01	0.713±0.05	0.748±0.13
WW	YW	0.452±0.08	0.845±0.52	0.702±0.05
6MW	9MW	0.707±0.05	0.862±0.06	0.745±0.06
6MW	YW	0.405±0.02	0.596±0.09	0.840±0.03
9MW	YW	0.835±0.05	0.712±0.02	0.160±0.08

BW: Birth weight, WW: weaning weight, 6MW: 6 months weight, 9MW: 9 months weight, YW: yearling weight, r_p: phenotypic correlation, r_d: direct genetic correlation, r_m: maternal genetic correlation.

effect of birth type on body weight can be explained by limited uterine space during pregnancy, nutrition of dam especially during last pregnancy and competition for milk suckling between multiple birth lambs during birth to weaning.

In addition, high correlation between pre-weaning weight with 6MW and 9MW is probably the reason for significant effect of type of birth on post-weaning traits in this study.

Significant effect of birth type on body weight has been reported in other breeds such as Zandi (Kalantar, 2003), Merino (Dixit et al., 2001), Lori-Bakhtiari (Vatankhah and Talebi, 2008a, b) and Kermani (Rashidi et al., 2008). However, Mokhtari et al. (2008) reported that birth type has no significant effect on post-weaning weights in Kermani sheep.

Also, significant influences of herd and birth year on studied traits can be explained by differences in management, food availability, diseases, climatic condition (rate of rainfall, humidity and temperature that had effect on the quality and quantity of pasture forages) and raising systems in different years and different herds. Our results on birth year showed that significant effect were similar with those reported by Dixit et al. (2001), Ozcan et al. (2005), Abegaz et al. (2005), Rashidi et al. (2007), Kalantar (2003), Baneh and Hafezian (2009). In addition, the same results were shown by the researchers who investigated the effects of herd on body weight (Yazdi et al., 1998; Nourian, 2000; Neser et al., 2001; Baneh and Hafezian, 2009).

Direct heritability estimates increased with age from 0.30 at birth to 0.43 at yearling, but the estimates of maternal heritability reduced with increase in age. The direct additive heritability estimate (0.30) of BW in the present study is within the range reported from 0.04 in Kermani (Rashidi et al., 2008) and Romanov (Maria et al., 1993) breeds to 0.46 in Menz breed (Gizaw et al., 2007). The estimate of direct additive heritability of birth weight in the present study was similar to that reported by Hanford et al. (2002), for Columbia breed (0.27), Hanford et al. (2005), for Ramboullet breed (0.27), Miraei-Ashtiani et al. (2007), for Sangesari breed (0.33) and Vatankhah and Talebi (2008 b), for Lori-Bakhtiari (0.31).

Our estimate of maternal heritability (0.17) for BW was higher than those reported for Dorper (Neser et al., 2000), Sabi (Matika et al., 2003), Horro (Abegaz et al., 2005) and Merino (Ozcan et al., 2005) breeds. This estimate is in agreement with the findings of Mousa et al. (1999) (0.17 for Compound), Bromley et al. (2000) (0.18 and 0.19 for Ramboullet and Targhee respectively), Hanford et al. (2005) (0.19 for Rambouillet) and Maxa et al. (2007) (0.17 and 0.19 for Shropshire and Danish Texel respectively). However, estimates reported by Tosh and Kemp (1994), Larsgard et al. (1998), El Fadili et al. (2000) and Miraei-Ashtiani et al. (2007) were higher than the present estimate.

Estimate of direct heritability for WW (0.30) obtained in the present study is within the range of those published in the literature, which varied from 0.07 in Polypay (Notter, 1997) and Elsenburg Dormer (Van Wyk et al., 2003) to 0.48 in Menz sheep (Gizaw et al., 2007) and is in agreement with the finding of Rashidi et al. (2008) in Kermani sheep. Lower direct heritability estimates were reported by Tosh and Kemp (1994) in Romanov sheep, Snyman et al. (1996) in Merino sheep, Larsgard et al. (1998) in Norwegian sheep, Ligda et al. (2000) in Chois sheep, Ozcan et al. (2005) in Turkish Merino sheep, Abegaz et al. (2005) in Horro sheep, Hanford et al. (2006) in Polypay sheep, Vatankhah and Talebi (2008a, b) in Lori-Bakhtiari sheep. However, estimates reported by Maria et al. (1993) in Romanov, Tosh and Kemp (1994) in Hompshire and Gizaw et al. (2007) in Menz sheep were higher than our estimates.

Also the obtained maternal heritability for WW (0.18) in this research is in agreement with those reported by Tosh and kemp (1994) (0.19 for Hampshire), Larsgard et al (1998) (0.17 for Norwegian) and Vatankhah and Talebi (2008b) (0.16 for Lori-Bakhtiari), However published results of estimates in Chios (Ligda et al., 2000), Columbia

(Hanford et al., 2002), Sabi (Matika et al., 2003) and Turkish Merino (Ozcan et al., 2005) were lower than our estimates.

Direct heritability estimated for 6MW (0.35) was lower than those reported by Gizaw et al. (2007) and Miraei-Ashtiani et al. (2007), but was greater than the estimates reported by Snyman et al. (1996), Abegaz et al. (2005), Vatankhah and Talebi (2008a, b). Estimate of maternal heritability for 6MW (0.14) obtained in the present study was close to those published by Snyman et al. (1996) for Merino sheep 0.10) and Miraei-Ashtiani et al. (2007) for Sangesari sheep (0.11); however, our estimate was greater than those reported by Abegaz et al. (2005), Vatankhah and Talebi (2008b).

Estimate of direct additive heritability for 9MW (0.37) in the present study is relatively high and is in the range reported by other researchers. The range of direct heritability estimate for 9MW in literature vary from 0.03 (Mokhtari et al., 2008) to 0.59 (Snyman et al., 1995). In addition, our estimate was higher than that of 0.08 reported by Miraei-Ashtiani et al. (2007) in Sangsari lambs.

Estimate of direct heritability for YW (0.43) obtained in the present study was within the range reported from 0.10 by Miraei-Ashtiani et al. (2007) to 0.58 by Snyman et al. (1995) in literature, and was higher than those published by Bahreini Behzadi et al. (2007) in Kermani sheep (0.14), by Ozcan et al. (2005) in Turkish Merino sheep (0.25) and by Abegaz et al. (2005) in Horro sheep (0.33), but lower than those of 0.56 reported by Gizaw et al. (2007) in Menz sheep.

Our estimate of maternal heritability for 9MW was 0.12. Abegaz et al. (2005) reported an estimate of 0.06 for maternal heritability for body weight at 8 months of ages in Horro sheep. Maternal heritability estimated for YW in this study (0.10) was higher than those reported by Ozcan et al. (2005) for Turkish Merino sheep (0.03) and Matika et al. (2003) for Sabi sheep (0.00).

Estimates of direct genetic correlation between traits in this study were positive and varied from 0.136 for BW-YW to 0.862 for 6MW-9MW. Our direct genetic correlation estimates between BW-WW and BW-6MW were lower than those reported by Miraei-Ashtiani et al. (2007) in Sangesari sheep (0.46 for BW-WW and 0.50 for BW-6MW). Also genetic correlation estimated for BW-9MW (0.249) and BW-YW (0.136) were low and these magnitudes were lower than that reported by Mokhtari et al. (2008) in Kermani sheep. Estimates of direct genetic correlation for WW-6MW, WW-9MW and WW-YW were relatively high and were 0.825, 0.713 and 0.845, respectively. The results published by Mokhtari et al. (2008) in Kermani sheep were higher than the present estimates. Direct genetic correlation between post-weaning traits varied from 0.596 for 6MW-YW to 0.862 for 6MW-9MW.

All phenotypic correlation estimates among studied traits were positive and changed from 0.152 for BW–9MW to 0.835 for 9MW–YW. In addition, these estimates except for BW-YW and 9MW-YW were lower than those of the genetic correlation estimates. Phenotypic correlations between weaning and post-weaning traits were positive and relatively high estimates.

The positive maternal genetic correlations obtained between all investigated traits varied from 0.160 (for 9MW-YW) to 0.840 (for 6MW-YW).

The results of the present investigation showed that due to positive genetic and phenotypic correlation, selection for any of the studied traits can result in an increase of phenotypic magnitudes and genetic potentials for other body weight traits.

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