



Estimation of genetic trends for body weight traits in Markhoz goat at different ages

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Abstract

The objective of the present study was to estimate genetic trends for body weight at different ages in Markhoz goat, including birth weight (BW, $n = 4758$), weaning weight (WW, $n = 3685$), 6-month weight (6MW, $n = 3420$), 9-month weight (9MW, $n = 3032$) and 12-month weight (12MW, $n = 2697$). Data and pedigree information were collected from 1992 until 2014 at the Breeding Center of Markhoz goat, Sanandaj, Iran. The GLM procedure of SAS was used for selecting the variables and identifying significant fixed effects in the equation of model. Various animal models were applied for genetic analysis and the best model was determined based on Akaike information criteria (AIC). Breeding values of animals were predicted using Wombat program. Genetic trends were obtained by regressing the average predicted breeding values on birth year for each trait. Based on the best model, direct estimated genetic trends were positive and significance for WW, 6MW, 9MW and 12 MW were 15.51, 26.28, 58.36 and 76.70 g/year, respectively ($p < 0.001$). Maternal genetic trend for BW and WW were 0.61 and 5.47 g/year, respectively ($p < 0.01$). The low and moderate generic trends obtained in the present study, indicated the possibility of growth traits improvements through genetic selection at all ages in Markhoz goat.

Additional keywords: breeding value; growth traits; animal model.

Abbreviations used: AIC (Akaike information criteria); BW (birth weight); WW (weaning weight); 6MW (6-month weight); 9MW (9-month weight); 12MW (12-month weight).

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Introduction

The Markhoz goat is an indigenous breed originating from Kurdistan Province and west Azerbaijan province in Iran. These goats are small-sized with a wide range in brown, white and black coat color. The range of coat color characters is a unique between goats in the world. Most income for farmers is obtained from sale of kids and meat production (Rashidi *et al.*, 2011, 2015).

The profitability of goat production for meat and increasing of meat production in goats depend on kid's weight as the growth performance and production of more kids per doe. Accurate prediction of breeding value of animals is one of the best tools available to maximize response to selection programs and the success of a breeding program can be assessed by examining the actual change in breeding value expressed as a proportion of expected theoretical

change of the breeding value mean for the trait under selection (Jurado *et al.*, 1994). The accuracy of genetic evaluations depends on how well the assumptions of the model match the data (Wiggans & VanRaden, 1991). Selection methods and management can be evaluated by estimating genetic and environmental trend. However, few researches have reported evaluation of genetic trends for body weight traits in goat (*e.g.*, Snyman, 2012; Hassan *et al.*, 2013; Hasan *et al.*, 2014).

Several studies have been conducted on Markhoz goat including the estimation of genetic parameters or inbreeding effects (Rashidi *et al.*, 2008; Kheirabadi & Rashidi, 2016; Mahmoudi *et al.*, 2017), but there is not any information about genetic trends for body weight traits at different ages in this breed. Therefore, the objective of this study was to determine the best models of genetic analysis for body weight of Markhoz goat kids at different ages and estimation

of genetic trends in body weight traits over a 23-year period.

Material and methods

Data collection and management

The data used in this study were collected between 1992 and 2014 from Breeding Center of Markhoz goat in Sanandaj, Kurdistan, Iran (1373 m asl and 35°20' N latitude and 47° E longitude). The studied traits were birth weight (BW), weaning weight (WW), 6-month weight (6MW), 9-month weight (9MW) and 12-month weight (12MW). Details on the climatic conditions and herd management are presented by Rashidi *et al.* (2015). Briefly, in the station, does were mated with selected bucks at about 18 months of age in breeding pens. Each buck was randomly mated to ~20 does from early October to late November. Kidding was in February and March and kids were weaned until ~4 months of age. The kids were weighed and ear tagged after birth. The number of records, mean, standard deviation, coefficient of variation, number of sires and dams for the body weight traits are presented in Table 1.

Statistical and genetics analysis

The GLM procedure (SAS, 2001) was used for identifying fixed effects that had significant influence on the investigated traits. This was performed on a model including fixed effects of year of birth (23 levels from 1992 to 2014), age of doe (6 classes from 2 to 7 years old), kid's gender (2 classes of male and female) and birth type (singles, twins and triplets). All of these fixed effects were significant ($p \leq 0.001$) for all body weight traits (BW, WW, 6MW, 9MW and 12MW) and therefore these effects were considered in the model. Age of kid at weighing (in days) was considered as covariate for all analyzed traits except BW.

(Co)variance components and corresponding genetic parameters were estimated using Wombat program

(Meyer, 2013). Six different animal models were used for genetics analysis for each trait, by ignoring or including maternal additive genetic effect, permanent environmental effect and covariance between direct-maternal additive genetic effects.

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{Z}_1\mathbf{a} + \mathbf{e} \quad (1)$$

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{Z}_1\mathbf{a} + \mathbf{Z}_3\mathbf{pe} + \mathbf{e} \quad (2)$$

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{Z}_1\mathbf{a} + \mathbf{Z}_2\mathbf{m} + \mathbf{e} \quad \text{cov}(\mathbf{a}, \mathbf{m}) = 0 \quad (3)$$

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{Z}_1\mathbf{a} + \mathbf{Z}_2\mathbf{m} + \mathbf{e} \quad \text{cov}(\mathbf{a}, \mathbf{m}) = \mathbf{A}\sigma_{am} \quad (4)$$

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{Z}_1\mathbf{a} + \mathbf{Z}_2\mathbf{m} + \mathbf{Z}_3\mathbf{pe} + \mathbf{e} \quad \text{cov}(\mathbf{a}, \mathbf{m}) = 0 \quad (5)$$

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{Z}_1\mathbf{a} + \mathbf{Z}_2\mathbf{m} + \mathbf{Z}_3\mathbf{pe} + \mathbf{e} \quad \text{cov}(\mathbf{a}, \mathbf{m}) = \mathbf{A}\sigma_{am} \quad (6)$$

where \mathbf{y} is a vector of observations of the studied traits; \mathbf{b} , \mathbf{a} , \mathbf{m} , \mathbf{pe} and \mathbf{e} are vectors of fixed effects, direct additive genetic effects, maternal, permanent environmental effects and the residual effects, respectively. \mathbf{X} , \mathbf{Z}_1 , \mathbf{Z}_2 and \mathbf{Z}_3 are incidence matrices relating these effects to the records. \mathbf{A} is the additive numerator relationship matrix, and σ_{am} is the covariance between direct additive genetic and maternal additive genetic effects. Assumptions for variance (V) and covariance (Cov) matrices involving random effects were:

$$\begin{aligned} V(\mathbf{a}) &= \mathbf{A}\sigma_a^2, V(\mathbf{m}) = \mathbf{A}\sigma_m^2, V(\mathbf{pe}) = \mathbf{I}_d\sigma_{pe}^2, V(\mathbf{e}) = \mathbf{I}_n\sigma_e^2 \\ &\text{and Cov}(\mathbf{a}, \mathbf{m}) = \mathbf{A}\sigma_{am} \end{aligned}$$

where, \mathbf{I}_d and \mathbf{I}_n are identity matrices that have order equal to the number of dams and records, respectively, and σ_a^2 , σ_m^2 , σ_{pe}^2 and σ_e^2 are variance of additive genetic values, maternal additive genetic variance, maternal permanent environmental variance and residual variance, respectively.

Model comparison criteria

Akaike information criteria (AIC) were applied to choose the best-fit model amongst all six models (Akaike, 1974). It is defined as $AIC = -2 \log L + 2p$, where $\log L$ is the maximized likelihood and p is the number of parameters in the model. The model with the

Table 1. Descriptive statistics for body weight traits in Markhoz goat.

Items	Traits ^a				
	BW (kg)	WW (kg)	6MW (kg)	9MW (kg)	12MW (kg)
No. of records	4758	3685	3420	3032	2697
Average weight (SD)	2.48 (0.45)	15.60 (4.11)	17.79 (4.15)	20.92 (5.03)	25.38 (6.59)
Coefficient of variation (%)	18.37	26.38	23.32	24.06	26.06
Number of sire with records	235	220	219	211	209
Number of does with records	1475	1286	1274	1217	1161

^aBW: birth weight, WW: weaning weight, 6MW: 6-month weight, 9MW: 9-month weight, 12MW: 12-month weight.

smallest AIC is considered as the best model for each trait.

Predicted breeding values of individual animals were obtained with Wombat (Meyer, 2013). Genetic trends of the studied traits were obtained by regression of average predicted breeding values on birth year of animals for each trait. Genetic trend analyses were carried out with the regression procedure (Proc Reg) of SAS program (SAS, 2001).

Results and discussion

The most appropriate model for each trait and parameter estimates are given in Table 2. The results obtained in this study indicate that the most appropriate models for BW, WW, 6MW, 9MW and 12 MW were (6), (5), (1), (2) and (1), respectively. Therefore, these models were selected for parameter estimates and prediction of breeding value for each trait.

The average of direct and maternal predicted breeding values by year of birth during the study period

(1992-2014) are illustrated in Fig. 1. The estimates of genetic and maternal trends (g/year) for investigated traits are reported in Table 2. As illustrated in Fig. 1, the direct genetic trend of BW between 1992 and 2014 appeared to be constant, but generally showed an increase over time for the other studied traits (WW, 6MW, 9MW and 12MW). The average of annual genetic trends were positive from 1998 onward, and had irregular variation over the years. The annual direct genetic trends were positive and significant ($p < 0.001$) for all growth traits except BW over the years (Table 2). Fig. 1 shows that the maternal genetic trend appeared to be constant and fluctuated for BW and WW traits, respectively. The annual maternal genetic trends were positive and significant for BW ($p < 0.01$) and WW ($p < 0.001$) over the years (Table 2).

Estimates of direct genetic trends for BW, WW, 6MW, 9MW and 12 MW were 1.08, 15.51, 26.28, 58.36 and 76.70 (g/year), respectively. The direct genetic trend for birth weight in the current study (1.08 g/year) was low ($p > 0.05$) and generally agrees with that reported by Ghavi Hossein-Zadeh (2012) in Moghani sheep (1.63 g/year), Hassani *et al.* (2009) in Baluchi sheep (0.7 g/year) and Zishiri *et al.* (2010) in Ile de France sheep (1 g/year). However, higher

Table 2. The most appropriate models, parameter estimates and estimates of genetic trends (g/year) for body weight traits in Markhoz goat.

Trait	Best Model	σ_p^2	h_a^2	h_m^2	r_{am}	pe^2	DGT \pm SE	R^2 (%)	MGT \pm SE	R^2 (%)
BW	6	0.15	0.25 \pm 0.05	0.09 \pm 0.03	-0.57 \pm 0.11	0.10 \pm 0.02	1.08 ^{NS} \pm 0.58	14.24	0.61* \pm 0.26	20.99
WW	5	10.39	0.09 \pm 0.03	0.04 \pm 0.02	-	0.07 \pm 0.03	15.51** \pm 2.41	66.32	5.47** \pm 1.24	48.02
6MW	1	10.62	0.17 \pm 0.03	-	-	-	26.28** \pm 2.96	78.91	-	-
9MW	2	13.81	0.25 \pm 0.04	-	-	0.02 \pm 0.02	58.36** \pm 5.85	82.54	-	-
12MW	1	21.87	0.31 \pm 0.04	-	-	-	76.70** \pm 8.19	80.66	-	-

BW, Birth weight. 6MW, 6-month weight. 9MW, 9-month weight. 12MW, 12-month weight. σ_p^2 , phenotypic variance. h_a^2 , direct heritability. h_m^2 , maternal heritability. r_{am} , direct-maternal additive genetic correlation. pe^2 , maternal permanent environmental effect. DGT, direct genetic trend. MGT, maternal genetic trend. R^2 , coefficient of determination for the regression fit of genetic trends. NS: $p > 0.05$, * $p < 0.01$ level of significance, ** $p < 0.001$ level of significance.

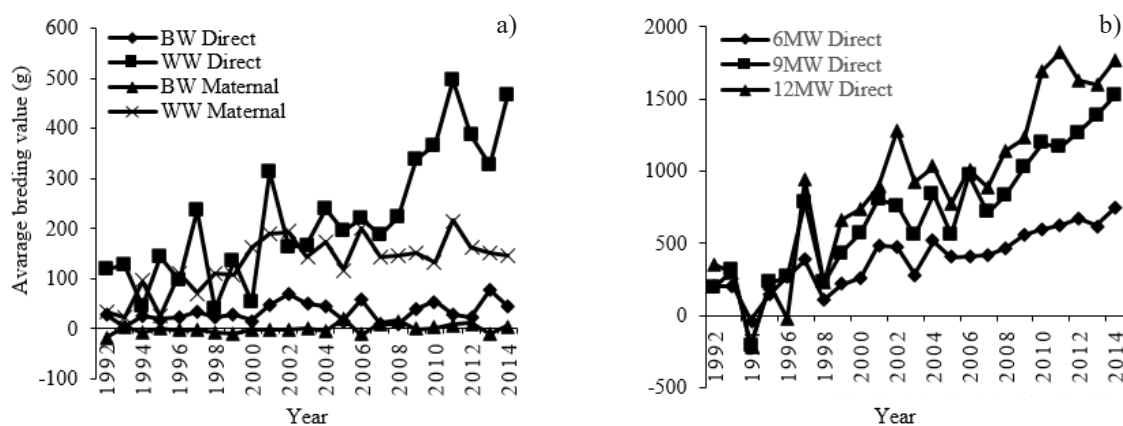


Figure 1. Direct and maternal genetic trends of mean breeding values by year of birth observed for body weight traits of Markhoz goat.

estimates of genetic trends for BW in various other goat and sheep breeds were reported by Snyman (2012) in Angora goat (4 g/year), Hasan *et al.* (2014) in Ettawa Grade goat (20 g/year), Kariuki *et al.* (2010) in Dorper sheep (6 g/year) and Supakorn *et al.* (2013) in sheep population in Thailand (20 g/year). This difference in genetic trends can be explained by dissimilarity in breeding strategies for different breeds and models used for analysis.

Estimate of direct genetic trend for WW in the present study was 15.51 g/year ($p < 0.001$). Also, estimate of direct genetic trend for WW was lower than those reported by Snyman (2012) in Angora goat (56.7 g/year), Hasan *et al.* (2014) in Ettawa Grade goat (60 g/year) and Shrestha *et al.* (1996) in Suffolk (23 g/year) and Finnsheep (25 g/year) sheep. Lower estimate (7 g/year) was reported by Gholizadeh & Ghafouri-Kesbi (2015) in Baluchi sheep.

The direct genetic trend estimate for 6MW in the current study (26.28 g/year) was greater than those reported by Hasan *et al.* (2014) in Ettawa Grade goat (-0.10 g/year), and Gholizadeh & Ghafouri-Kesbi (2015) in Baluchi sheep (4 g/year). Higher estimates of 91 g/year were reported by Mokhtari & Rashidi (2010) in Kermani sheep, 79.4 g/year in Moghani sheep (Ghavi Hossein-Zadeh, 2012) and 72 g/year was reported by Hassani *et al.* (2009) in Baluchi sheep.

The direct genetic trend value estimated for 9MW (58.36 g/year) in the present study was higher than those of 35 g/year reported by Snyman (2012) in Angora goat at eight month body weight, 7 g/year was reported by Gholizadeh & Ghafouri-Kesbi (2015) in Baluchi sheep and it was lower than those of 81 g/year in Kermani sheep (Mokhtari & Rashidi, 2010) and 66.83 g/year was reported by Ghavi Hossein-Zadeh (2012) in Moghani sheep.

The genetic trend value estimated for 12MW obtained in the present research (70.76 g/year) was higher than those of -0.30 g/year and 14 g/year reported by Hasan *et al.* (2014) in Ettawa Grade goat and Gholizadeh & Ghafouri-Kesbi (2015) in Baluchi sheep, respectively.

Also, estimate of genetic trend for 12MW in the present study was lower than the estimates of 156 g/year and 110.2 g/year reported by Mokhtari & Rashidi (2010) and Ghavi Hossein-Zadeh (2012), respectively. In the present study an increasing trend was observed for direct genetic trend value from birth weight to 12MW. The increasing direct genetic trend value of body weight at later ages might be explained by attributed to the relatively higher additive genetic variation. Also, Shaat *et al.* (2004) reported that higher genetic trend may be explained by the higher additive genetic variation.

Also, maternal genetic trends for BW (0.61 g/year) and WW (5.47 g/year) were positive ($p < 0.01$ and $p < 0.001$, respectively). Results of the current study showed that maternal effects influences on pre-weaning traits in Markhoz goat and this effect need to be considered in selection programs. Maternal genetic trend estimates for BW and WW are rarely reported in literature. The maternal genetic trends for BW in current study were low and generally in agreement with estimates of 1 and 2.36 g/year reported by Snyman (2012) and Ghavi Hossein-Zadeh (2012), respectively. Estimate of maternal genetic trend for WW was lower than those observed by Snyman (2012) in Angora goat (9 g/year) and Ghavi Hossein-Zadeh (2012) in Moghani sheep (49.2 g/year). The estimate of maternal trends for BW and WW were low and these values were lower than direct trends. These may be due to the larger direct effects on BW and WW than maternal genetic effects in Markhoz goat. Rashidi *et al.* (2008) reported lower maternal heritabilities estimates than direct heritabilities for BW and WW traits in Markhoz goat.

Results indicate the positive and significant genetic trends for weight traits of Markhoz goat. The low and moderate genetic trends obtained in Markhoz goat indicated that it can be possible the improvement of growth traits through genetic selection at all ages considered.

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