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Original Article

Direct and maternal genetic trend estimates for body weight traits of Iran-Black Sheep using multivariate animal models

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Abstract

The objective of the present study was to estimate direct and maternal genetic trends for body weight traits in Iran-Black sheep using data which were collected for 24 years. The investigated traits were birth weight (BW), weaning weight (WW), 6-month weight (6MW), 9-month weight (9MW) and yearling weight (YW). A multivariate animal model analysis was applied to predict the breeding values of individual for the studied traits. For each trait, genetic trends were obtained by regressing the means of predicted breeding values on year of birth. Direct genetic trends were positive and highly significant (P<0.01) for BW, WW, 6MW, 9MW, and YW and were 0.93, 43.74, 81.72, 87.29, and 137.61 g/year, respectively. Also, maternal genetic trend for BW and 6MW was significant and were 4.60 and -14.38 g/year, respectively. The results showed that improvement of body weight traits of Iran-Black sheep seems to be possible in selection programs.

Keywords: Iran-Black sheep, growth traits, multivariate animal models, genetic trend

1. Introduction

To maximize the response to selection programs, an accurate predicted breeding value of candidate animals is one of the best tools. There are many factors that determine the success of a breeding program. In such case, the actual change in breeding value expressed as a proportion of expected theoretical change of the mean breeding value for the trait under selection can be used to assesses the success of a breeding program (Jurad *et al.*, 1994). Over a span of time, regarding experiments in different environmental conditions is difficult. On the other hand, genetic trend estimate is problematic over time because changes in performance must reflect both environmental and genetic changes (Shaat *et al.*, 2004). In order to solve the problem, Hill (1972) proposed that removing the effect of environmental change is possible by simultaneously maintaining a control population, but over a long period of time it is not cost-effective (Shaat *et al.*, 2004) To take into account the relationship among the traits and increased the effectiveness of selection, multivariate genetic evaluation is an excellent method available. The positive and significant direct and maternal genetic trends for body weight at different ages in some Iranian sheep breeds have been investigated (Mokhtari and Rashidi, 2010; Ghavi Hossien-Zadeh, 2012). However, due to an increased demand for meat from sheep in Iran, litter size, body conformation, and lamb weight traits are used in breeding programs to increase the efficiency of sheep production (Yazdi *et al.*, 1997). Iran-Black sheep, principally reared for meat production, is a composite breed developed in 1975 at the Abbasabad sheep breeding station located in the northeast of Mashhad, Razavi Khorasan province. This sheep has reasonable production performance because of their adaptation to harsh conditions, the same as of Balouchi sheep (Rashidi, 2012). The breeding station

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fulfills two main activities, namely improvement of production efficiency and dissemination of superior animals into local flocks. There are several reports regarding estimates of direct and maternal genetic trends of sheep breeds (Shrestha *et al.*, 1996; Shaat *et al.*, 2004; Hanford *et al.*, 2005; Rashidi and Akhshi, 2007). But there is no published report of direct and maternal genetic trend for body weight at different ages of Iran-Black sheep. The aim of the present study was to estimate direct and maternal genetic trends for body weight traits of Iran-Black sheep.

2. Materials and Methods

2.1 Data set

Iran-Black sheep, originating from a crossing of Balouchi ewes with Chios rams and vice versa, is the synthetic breed in Iran. This sheep is well adapted to the arid and hot climates. Matings generally occurred from mid-August till September. Rams were used for five years and ewes could be used for up to six years. Selection was based on six-month weight and, to some extent, body conformation. Mating ratio is one breeding ram to 10-12 ewes. The lambing is started in mid-January and ends in February (Kamjoo *et al.*, 2014). The lambs were weighed and ear-tagged shortly after. From birth to 12 months of age, the lambs were weighed at three months intervals, and the date of each weight was recorded. In this study, data and pedigree information were collected at the breeding station of Iran-Black sheep from 1981 to 2004. The investigated traits were: birth weight (BW), 3-month weight (3MW), 6-month weight (6MW), 9-month weight (9MW), and yearling weight (YW). Pedigree structure and descriptive statistics of traits are given in Table 1.

2.2 Statistical analysis

To estimate genetic parameters, random and fixed effects, which were found significant in the primary analysis, were included in the final model. The GLM procedure (SAS 2002; SAS Institute Inc., Cary, NC) was firstly used to determine the fixed effects that had significant influence on the traits studied. There was no evidence of significant influence for interaction effects. For the inclusion of fixed effects into the final model of analysis, the significance level was declared at $p<0.05$. The fixed effects included in the model were sex (male and female), year of birth (24 classes), age of dam at lambing (2, 3, 4, 5, 6, and 7 years old), type of birth (single, twin and more) and age of weaning (in days) were considered as covariate for W9 and YW ($P<0.05$). (Co)variance components were obtained by AI-REML algorithm fitting a five-trait animal model analysis (WOMBAT; Meyer, 2007).

The significant random effects for each trait were those of reported by Kamjoo *et al.* (2014) in this breed for the same data set. They found significant both maternal genetic and permanent environmental effects for BW, WW, and 6 MW, whereas the most appropriate model for 9MW and YW was model that consisted of direct additive genetic and maternal permanent environmental effects.

The following five-trait animal model was fitted to estimate (Co)variance components of studied traits:

$$\mathbf{y}_i = \mathbf{X}_i\mathbf{b}_i + \mathbf{Z}_{i1}\mathbf{a} + \mathbf{Z}_{i2}\mathbf{m} + \mathbf{Z}_{i3}\mathbf{c} + \mathbf{e}_i$$

where $\mathbf{y}_i$ is a n×1 vector of observations for trait i; $\mathbf{b}_i$, $\mathbf{a}_i$, $\mathbf{m}_i$, and $\mathbf{c}_i$ are vectors of fixed effects (birth year, sex of lamb, birth status of lamb, and age of dam), direct additive genetic effects, maternal additive genetic effects, and permanent environmental effects due to dam, for trait i respectively; $\mathbf{X}_i$, $\mathbf{Z}_{i1}$, $\mathbf{Z}_{i2}$, $\mathbf{Z}_{i3}$ are the corresponding incidence matrices relating these effects to **y** of ith trait; e_i is the vector of residual effects for trait i. It is assumed that:

$$V(\alpha) = \mathbf{A}\sigma^2_\alpha; V(m) = \mathbf{A}\sigma^2_m; V(c) = \mathbf{I}_d\sigma^2_c; V(e) = \mathbf{I}_n\sigma^2_e; Cov(\alpha, m) = \mathbf{A}\sigma_{\alpha m} = 0$$

where **A** is numerator relationship matrix; σ^2_α direct additive genetic variance; σ^2_m maternal additive genetic variance; $\sigma_{\alpha m}$ direct-maternal additive genetic covariance; σ^2_c maternal permanent environmental variance; σ^2_e residual variance; $\mathbf{I}_d$, $\mathbf{I}_n$ identity matrices of an order equal to the number of dams and records, respectively (Ekiz, 2005).

Best linear unbiased prediction (BLUP) methodology was used to predict breeding values of individual animals. Genetic trends based regressing the means of predicted breeding values on year of birth were achieved. Genetic trend analyses were performed with the regression procedure (Pros Reg) of the SAS (SAS 2002; SAS Institute Inc., Cary, NC). Direct (and maternal) genetic progress was calculated by the difference between mean of direct (and maternal) predicted breeding values for the first and last birth year.

3. Results and Discussion

As given in the Table 1, there was a decreasing rate for number of records per trait by aging from birth to yearling. It may be due to culling or death of animals and sale of some males. The coefficients of variation for body weights ranged from 17.2% to 23.45% and were similar to those of reported by Miraei-Ashtiani *et al.* (2007), Mandal *et al.* (2008), and Vatankhah and Talebi (2008).

Estimates of direct and maternal genetic trends (grams per year) and genetic progress for body weight traits at different ages in Iran-Black sheep obtained from multi-trait analyses are shown in Table 2. Direct genetic trend estimates were positive and highly significant ($p<0.01$) for all investigated traits. Estimated direct genetic trend displayed that selection would be effective for the enhancement of genetic potential of body weight traits in this breed.

To improve traits of interest in an animal breeding program, traditional selection procedures should be capable. There have been findings reported when data from other

Table 1. Statistical characteristics of data used for body weight at different ages in Iran-Black sheep.

Trait	Animals in pedigree	No. of records	No. of sires	No. of dams	Mean (kg)	SD (kg)	CV (%)
BW[a]	4923	4607	135	1227	3.61	0.83	22.88
WW	4480	4220	155	1213	22.13	5.19	23.45
6 MW	3881	3636	152	1147	29.17	5.67	19.43
9 MW	3392	3196	133	1075	33.20	5.71	17.20
YW	3149	2955	132	1055	39.39	7.05	17.89

[a]BW, birth weight; WW, weaning weight; 6 MW, 6-month weight; 9 MW, 9-month weight; YW, yearling weight

Table 2. Genetic progress and average breeding values by year of birth for body weight traits of Iran-Black sheep at different ages.

Trait	DT[a]±S.E.	MT± S.E.	DGP (gr)	MGP (gr)
BW	0.93**±0.31	4.60**±0.97	25.220	90.375
WW	43.74**±7.63	-1.59ns±3.85	776.353	147.000
6 MW	81.72**±17.43	-14.38**±3.44	1595.480	-134.779
9 MW	87.29**±13.12	-	2024.719	-
YW	137.61**±21.56	-	2335.037	-

[a]DT: Direct Genetic Trend, MT: Maternal Genetic Trend, DGP: Direct Genetic Progress, MGP: Maternal Genetic Progress

species were evaluated (Akbas and Oguz, 2000; Lewis and Brotherstone, 2002).

The results show that the selection on birth weight was at least compared with the other traits. Both direct and maternal genetic trends seem to be flat for this trait. The estimate of direct genetic trend for birth weight (0.93 g/year) was positive and significant (P<0.01). This value was low and relatively in accordance with those reported by Bahreini Behzadi and Aslaminejad (2010) in Kermani sheep (1 g/year), and Zishiri *et al.* (2010) in Ile de France sheep (1 g/year) but was lower than the reports of Shrestha *et al.* (1996) in Finnsheep breed (7 g/year) and Kariuki *et al.* (2010) in Dorper sheep (6 g/year). On the other hand, estimate of maternal trend for BW was moderate (4.60 g/year) and in agreement with finding of Rashidi and Akhshi (2007). Higher maternal genetic trend estimates of BW in other sheep breeds have been reported by several authors (Shrestha *et al.*, 1996; Gizaw *et al.*, 2007; Bosso *et al.*, 2007). A lower direct than maternal genetic trend for birth weight show that greater proportion in genetic variation of birth weight is expected to be due to maternal effect. Robison (1981) showed that maternal genetic effects for measurements of weight at younger ages are important and reduce by ageing. Decreasing maternal genetic effect on lamb weight over time has also been reported by others (Al-Shorepy and Notter, 1996; Näsholm and Danell, 1996).

Our estimate of direct genetic trend for WW (43.74 g/year) was similar to the ones observed by Khojastehkey and Aslaminejad (2013) in Zandi sheep (34 g/year), and Hassani *et al.* (2010) in Balouchi sheep (55 g/year). Also, this estimate was lower than the reports of Shaat *et al.* (2004) in Rahmani breed (92 g/year), Rashidi and Akhshi (2007) in Kurdi sheep (128 g/year), and Mokhtari and Rashidi (2010) in Kermani sheep (125 g/year), respectively. Higher estimates of genetic trend (620 g/year) of 90 days lamb weight have been reported by Lax *et al.* (1979). As illustrated in Table 2, maternal genetic trend for WW was negative but not significant.

We found a positive and highly significant direct genetic trend for 6MW (81.72 g/year) that agrees with those reported by Ghavi Hoseein-Zadeh (2012) in Moghani sheep (79.38 g/year) but was lower than the reports of Rashidi and Akhshi (2007) in Kurdi sheep (129 g/year) and Shaat *et al.* (2004) in Rahmani sheep (135 g/year). On the other hands, lower estimates have been reported by Khojastehkey and Aslaminejad (2013) in Zandi sheep (28 g/year), Klerk and Heydenrych (1990) in South African Dohne Merino sheep (59 g/year), and Shaat *et al.* (2004) in Ossimi sheep (21 g/year). In the current study, maternal genetic trend (-14.38 g/year) for 6MW was negative and significant (P<0.01). This may be affected by the antagonism between direct and maternal genetic effects. The negative correlation between genetic direct and maternal effects for body weight traits in sheep have been reported by some authors (Maria *et al.*, 1993; Tosh and Kemp, 1994; Miraei-Ashtianietal *et al.*, 2007). The estimate of maternal genetic trend was lower than that of reported by Ghavi Hossein-Zadeh (2012) in Moghani sheep (37.30 g/year).

The estimation of direct genetic trend for 9MW (87.29 g/year) was close to the results displayed by Kariuki *et al.* (2010) in Dorper sheep (96 g/year), Mokhtari and Rashidi (2010) in Kermani sheep (81 g/year), and Mohammadi *et al.* (2011) in Zandi sheep (72 g/year).

The estimated direct genetic trend value for YW in our study (137.61 g/year) was the highest among the post-weaning traits investigated and was higher than the reports of Mohammadi and Moradi Shahrebabak (2011) in Zandi sheep (89.63 g/year), Bosso *et al.* (2007) in Djallonke sheep (90 g/year), and Klerk and Heydenrych (1990) in South African Dohne Merino sheep (59 g/year). For genetic trends of YW in other sheep breeds, higher estimates have been reported by various authors (Gizaw *et al.*, 2007; Mokhtari and Rashidi, 2010; Kariuki *et al.*, 2010). In general, as a result of selection, the positive genetic trends must mainly constitute a correlated response by increased body mass.

In this study, the direct and maternal genetic progress for all studied traits, except maternal genetic progress for 6 MW, was obtained positive (Table 2). The values for direct genetic effect ranged from 25.220 g for BW to 2335.037 g for YW. The results showed that there was a relatively low genetic enhancement in birth weight for this breed. On the other hands, due to attribution to the relatively higher additive genetic variation in investigated traits, the direct genetic trends were higher for 6MW, 9MW, and YW than BW and WW. In according to the higher estimates of direct heritabilities for 6MW, 9MW, and YW than those of BW and WW in Iran-Black sheep, that could be imputable (Kamjoo *et al.*, 2014). However, higher genetic trend may be explained by the higher additive genetic variation (Shaat *et al.*, 2004). The results generally showed that selection for body weight traits at different ages in Iran-Black sheep was effective, and highly significant genetic enhancement was achieved. Therefore, it seems that selection for 6 and 9 months weight could be more impressive than the other body weights in the breeding program of Iran-Black sheep flock.

The direct and maternal trend of mean breeding values over the years of birth for body weight traits are shown in Figure 1 and Figure 2, respectively. In general, maternal genetic trend was more regular than that of direct genetic. Also, BW showed the slight changes for both direct and maternal trends. As indicated, direct trend of mean breeding values for traits investigated has increased during the last 12 years. This is in agreement with the positive correlation of breeding values for traits reported by Kamjoo *et al.* (2014). Due to positive direct genetic trend for all body weight traits in this breed, there was a general tendency for the improvement of body mass. From 1980 to 1991, relatively constant yearly mean breeding values could indicate that introduction of external sires was based particularly on phenotypic characteristics (Mokhtari and Rashidi, 2010). From 1992 onwards, all traits have increasing trend that indicate seriously selection program for this flock. Among the traits, maternal effect for WW is in the same direction of direct one. Therefore, it can be said that these effects are not independent for this trait. Also, the decreasing trend for maternal effect of WW till 1990 is probably because of lack of strong selection schemes for both direct and maternal effects. Importing the external sires can be another reason for that. That can be assigned to the forfeiture of proper selection criteria and breeding objective of this breed. Negative maternal genetic trend for WW and 6MW in the present study demonstrates that selection for improved growth traits could be effective but leads to decreased maternal abilities in a breeding system.

Also, maternal genetic trend estimates was negative, whereas it was positive and significant for BW. Irregular fluctuations were obtained in maternal trend of yearly mean predicted breeding values of individual animals for WW, and 6MW. Maternal genetic trend estimates were lower than those of correspond direct genetic trends. The template of change in the first nine years was similar for maternal genetic trend

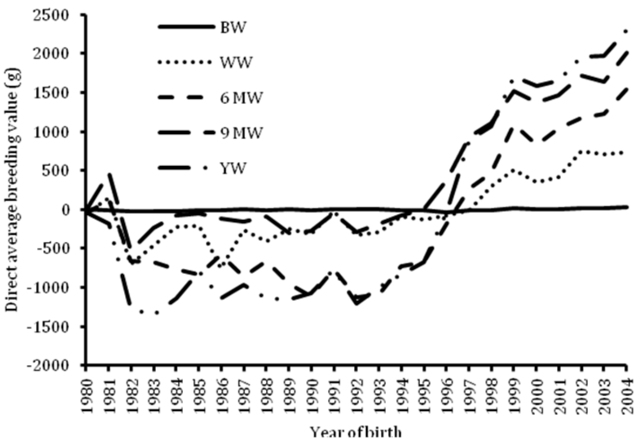

Figure 1. Direct genetic trends for body weight traits in Iran-Black sheep.

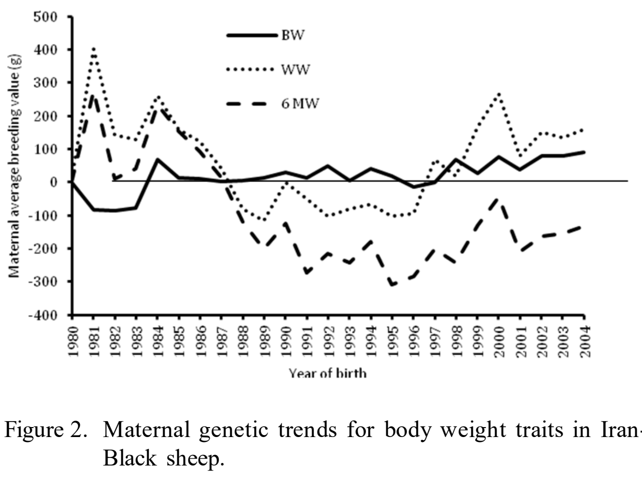

Figure 2. Maternal genetic trends for body weight traits in Iran-Black sheep.

of WW and 6MW. From 1984 to 1989, maternal trend was absolutely decreasing and the means of maternal breeding values were very close for these traits. But, the difference between their mean of predicted maternal breeding values began and increased afterward. The results indicated that may be selection in the breed have been done only to improve lambs merit and has reduced the maternal potential for lambs growth.

4. Conclusions

In the current study, we have found positive direct genetic trend for body weight traits at different ages of Iran-Black sheep. Also, maternal genetic trend for BW was positive and highly significant. Due to the higher additive genetic variation, the greatest genetic trend value was obtained for YW. On the other hands, from birth to 6MW, there was a decreasing maternal genetic trend for body weight traits. For BW, the maternal genetic trend was higher than direct genetic trend in Iran-Black sheep. The results generally showed that improvement of body weight traits at different ages of Iran-Black sheep seems to be possible in selection programs. Due to decreasing in the maternal genetic potential simultaneously with increasing direct genetic trend, it can be noted that there are an antagonism effect between direct and maternal genetic effect. Hence, it is strongly recommended to consider the maternal effect in breeding scheme of this breed to maximize the response to selection for growth trait.

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