ANALYSIS OF GENETIC PARAMETERS AND GENETIC TRENDS FOR EARLY GROWTH TRAITS IN IRANIAN AFSHARI SHEEP

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Abstract: The purpose of the present study was estimation of genetic parameters and genetic trends of early growth traits using Bayesian approach by Gibbs3f90 software in Iranian Afshari sheep. The data set [birth weight (BW), weaning weight (WW) and pre-weaning daily weight gain (PWDG)] were collected during the period 1999 to 2010 from Agriculture Jahad of Zanjan province, Iran. The fitted fixed effects were herd–year–season as interactions, sex (male, female), birth type (single, multiple) and age of dam. Based on Derivative Information Criteria (DIC), for studied traits the most appropriate model was determined. Therefore, based on the most appropriate fitted model, the direct additive heritabilities estimate for BW, WW and PWDG were 0.32±0.02, 0.05±0.01 and 0.24±0.02, respectively. The estimates of maternal heritabilities were 0.17±0.04, 0.07±0.02 and 0.12±0.05 and total heritabilities 0.11±0.05, 0.08±0.02 and 0.08±0.03 for BW, WW and PWDG, respectively. Direct genetic trends were positive for all traits but only significant for BW 0.75±0.31 g/year (P <0.05). Also, maternal genetic trends were for all traits negative and was significant for BW -0.63±0.27 g/year (P <0.05). The moderate estimates of heritabilities for early growth traits indicate that in Afshari sheep faster genetic improvement through selection is possible for these traits. Furthermore, the results genetic trends in this current study indicated that genetic improvement through selection is suitable only for BW in Afshari sheep.

Keywords: Afshari sheep, early growth, heritability, genetic trend

Introduction

An advantage of a breeding program can be assessed by change in breeding value expressed as a proportion of expected theoretical change of the mean breeding value for the trait under selection (*Mokhtari and Rashidi, 2010*).

Sheep meat production is one of the most important parts of Iranian livestock industry. However, improving growth performance by selection programs is an important method to increase meat production in lamb breeding herds (*Gholizadeh and Ghafouri-Kesbi*, *2015*). In this regard, one of the heavy, fat-tail, meat and high lamb growth rate breeds in Iran is Afshari sheep. This sheep has high potentials of growth and reproduction and adapt to cold climate and must be considered in breeding program (*Ghavi Hossein-Zadeh, 2012; Mohammadi et al., 2009*). Afshari breed is distributed in the origins of harsh environmental condition Zanjan province and in some parts of Eastern and Western Azarbayjan and Kordistan of Iran. The purpose of Afshari sheep breeding were selection for increasing body weight and phenotypic characteristics. However, in Afshari sheep faster genetic improvement through selection is possible for body weight (*Eskandarinasab et al., 2010*).

Body size varies between 45 and 57 kg in adult ewes and frequency of ewes lambing is 65 to 75 percent *(Mohammadi et al., 2009)*. The birth weight (BW) of Afshari sheep breed were reported 4.3 and 4 kg, weaning weight (WW) 29.6 and 26.5 kg for male and female lambs, respectively *(Monem et al., 2005)*. Estimates of genetic parameters of various traits of Iranian Afshari sheep have been reported in different studies, such as: Litter size *(Mohammadi et al., 2011)*, direct heritability of BW, and post average daily gain 0.231 and 0.07, respectively (*Khorsand et al., 2014*). Also, direct heritability of kleiber ratio at weaning and kleiber ratio at 6 months of age 0.13 and 0.06, respectively reported by *Eskandarinasab et al. (2010).* Moreover, in literature several were used for growth traits in others Iranian breeds of sheep. Such as; Mehraban sheep (*Zahamin and Mohammadi, 2008*); Makuei sheep (*Ghafouri-Kesbi and Baneh, 2012*); Baluchi sheep (*Gholizadeh and Ghafouri-Kesbi, 2015*); Kermani sheep (*Bahreini Behzadi et al., 2005*).

The main objective of the current study was to estimate the genetic parameters and genetic trends for early growth traits in Afshari sheep, by fitting different six models, including direct and maternal additive genetics and maternal permanent environmental effects.

Materials and methods

Data recording and management

The Afshari sheep is mostly local breed and kept on extensive production. The Jahad of Agriculture in Iran put in place a breeding program to enhance the efficiency of output by improving growth traits, wool production and milk yield that are economically important (*Mokhtari and Rashidi, 2010*). The data set include birth weight (BW), weaning weight (WW) and pre-weaning daily weight gain (PWDG) records available of Afshari sheep. The records were retrieved of 6912 lambs that descended from 3116 dams and 201 sires were collected between 1999 and 2010 from Agriculture Jahad of Zanjan province, Iran. The descriptive statistics of the data structure are summarized in Table 1.

Table 1. The characteristics of the data structure for early growth traits of Afshari sheep

Item	Traits		
	BW (g)	WW (g)	PWDG (g)
No. of records	6912	4511	4511
Average weight	3.81	25.15	213.80
No. of sires with record	201	159	159
No. of dams with record	3116	2555	2555
Standard deviation (SD)	0.90	4.63	59.39
Coefficient of variation, % (CV)	23.75	18.42	27.78

BW: birth weight; WW: weaning weight; PWDG: pre-weaning daily weight gain.

Statistical analysis

The GLM procedure of SAS software was applied to identify the fixed effects have significant influences on traits (*SAS, 2004*). The fitted fixed effects were herd–year–season as interactions, sex (male, female), birth type (single, multiple) and age of dam (2-7 years old). The variance components were estimated with six different univariate animal models as follows: (1)

$$Model\ 1: y = Xb + Z_1a + e$$
$$Model\ 2: y = Xb + Z_1a + Wc + e$$
$$Model\ 3: y = Xb + Z_1a + Z_2m + e \qquad Cov\,(a,m) = 0$$
$$Model\ 4: y = Xb + Z_1a + Z_2m + e \qquad Cov\,(a,m) = A\sigma_{am}$$
$$Model\ 5: y = Xb + Z_1a + Z_2m + Wc + e \qquad Cov\,(a,m) = 0$$
$$Model\ 6: y = Xb + Z_1a + Z_2m + Wc + e \qquad Cov\,(a,m) = A\sigma_{am}$$

Where y; is the vector of observations; b, is vector of fixed effects; a and m are vectors of random direct and maternal additive genetic effects; c, is the vector of random maternal permanent environmental effects; e is vector of residual effects and X, Z_1, Z_2 and W are incidence matrices for b, a, m and c, respectively. $Cov\,(a,m)$; indicates whether covariance between direct and maternal additive genetic effects was considered. Generally, the (co)variance structure for studied traits will be as follows:

$$(2)$$

$$var \begin{bmatrix} a \\ m \\ pe \\ e \end{bmatrix} = \begin{bmatrix} A\sigma_a^2 & A\sigma_{am} & 0 & 0 \\ A\sigma_{am} & A\sigma_m^2 & 0 & 0 \\ 0 & 0 & I\sigma_{pe}^2 & 0 \\ 0 & 0 & 0 & I\sigma_e^2 \end{bmatrix}$$

Where, $\mathbf{A}$ is the additive numerator relationship matrix coefficients among animals; σ_a^2, σ_m^2, σ_{pe}^2 and σ_e^2 are direct additive genetic, maternal additive genetic, maternal permanent environmental and residual variances, respectively, $\boldsymbol{\sigma_{am}}$ is the covariance between direct and maternal effects and $\mathbf{I}$ is the identity matrix. The (co)variance components were estimated using Gibbs sampling methodology using Bayesian approach by Gibbs3f90 software (*Mistzal 2002*). The number of samples, length of burn-in and sampling interval were 300000, 30000 and 100, respectively.

Estimates of total heritability (h_t^2) are of value to predict phenotypic response to selection. Total heritability estimates were calculated according to *Willham, (1972)* as: (3)

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

1. Model comparison criteria

Goodness of fit for the models was examined using Deviance Information Criterion (DIC), as follows: (4)

$$DIC = 2 \times \overline{D(\theta)} - D(\bar{\theta})$$

Where $\overline{D(\theta)}$ is the posterior expectation of Log-likelihood and $D(\bar{\theta})$ is Log-likelihood evaluated at the posterior mean of the parameters.

Results and Discussion

Among traits studied, PWDG (27.78) had the maximum coefficient of variation (CV %). Standard deviation (SD) for BW, WW and PWDG in this current study, were observed 0.90, 4.63 and 59.39, respectively (Table 1). Maximum growth rate observed in the PWDG, Similarly, *Prince et al. (2010)* in Avikalin sheep and *Ghafouri-Kesbi et al. (2011)* in Zandi sheep. The reason of less CV % for WW and BW may be due to effect of outside environmental in these traits. Also, due to that during the final months of the maintenance and in the winter, the ewes are fed inside. These results are in agreement with those reported by *Miraei Ashtiani et al. (2007)*; *Boujenane; Diallo (2017)*.

The least square means and standard errors for fixed effect of studied traits are presented in Table 2. Herd-year-season as interactions significantly affected all studied traits ($P < 0.001$). Gender and birth type had a significant effect on BW,

WW and PWDG traits (P <0.001). All traits were significantly influenced by age of dam (P <0.001). These fixed effects also were shown to be significant in previous studies, such as: Abbasi et al. (2012), in Baluchi sheep; *Boujenane; Diallo (2017)*, Sardi sheep; *Eskandarinasab et al. (2010)*, Afshari sheep; *Jafari and Razzagzadeh (2016)*, Makuie sheep. In this research, six model different were compared for better fitting performance of WW, BW and PWDG traits in Afshari sheep. These results comparison of the models are in agreement with those reported by *Khorsand et al. (2014); Ghafouri-Kesbi and Baneh (2012).*

Table 2. Number of observations and least square means ±SE of early growth traits

Fixed effects	Traits		
	BW	WW	PWDG
Herd*Year*season	**	**	**
Gender	**	**	**
Male	3.61±0.02[a]	25.31±0.11[a]	211.57± 1.48[a]
Female	3.43±0.02[b]	24.73±0.09[b]	207.25± 1.42[b]
Birth type	**	**	**
single	3.87±0.01[a]	25.62±0.10[a]	214.26±1.21[a]
twin	3.17±0.02[b]	24.42±0.16[b]	204.54±1.86[b]
Age of dam (Year)	**	**	**
2	3.44±0.02[a]	24.62±0.16[c]	204.22±1.88[b]
3	3.51±0.02[a]	25.14±0.16[a]	209.21±1.85[ab]
4	3.54±0.01[a]	25.40±0.15[a]	211.28±1.83[a]
5	3.57±0.03[a]	25.33±0.17[ab]	212.03±1.90[a]
6	3.56±0.02[a]	25.01±0.18[abc]	210.64±2.15[ab]
7	3.52±0.02[a]	24.64±0.22[bc]	209.04±2.66[ab]

*: Significant at P < 0.05.
**: Significant at P < 0.001.
A same letter in each column means not-significant differences of least square means in letters are not significant at
P < 0.05.

Selection of a best model depends partly on the DIC that fitted on the data. For analyze BW, WW and PWDG, 4th, 3rd and 6th models had the lowest DIC values and were selected the most appropriate model (Table 3).

Table 3. Deviance information criteria (DIC) values for early growth traits under six models (The most appropriate model in bold)

Model	Traits		
	BW	WW	PWDG
1	11225.26	24640.54	46927.05
2	11222.84	24491.91	46635.49
3	10401.10	**24366.13**	46924.60
4	**9416.53**	24676.14	46266.31
5	11378.09	24401.93	46534.08
6	10217.70	24492.76	**41249.34**

Estimates of (co)variance components, based on the most appropriate model for each trait are shown in Table 4. The direct additive genetic variance was highest at PWDG (534.10) and lowest in BW (0.11). The direct additive heritabilities (h_a^2) estimate for BW, WW and PWDG were 0.32±0.02, 0.05±0.01 and 0.24±0.02, respectively. An estimate of direct additive heritability for BW was in agreement with reported by *Boujenane and Diallo (2017)* in Sardi sheep; *Abbasi et al. (2012)* in Baluchi sheep and *Eskandarinasab et al. (2010)*, in Afshari sheep; *Jafaroghli et al. (2010)* in Moghani sheep. Whereas, finding by *Gizaw et al. (2007)*, in Menz sheep (0.46) for direct additive heritability were higher than this results present study in the case BW trait. Various estimates of the WW trait have been reported at other Iranian sheep's, such as: Mehraban sheep 0.22 (*Zamani and Mohammadi, 2008*); Makooei sheep 0.28 (*Ghafouri-Kesbi and Baneh. 2012*); Kermani sheep 0.19 (*Bahreini Behzadi et al., 2005*); Moghani sheep 0.07 (*Jafaroghli et al., 2010*). Different values reported by this study can be due to different breeds, fitted statistical models, data structure and different environmental conditions. The estimates of direct additive heritability for PWDG were also similar to range of published estimates, as *Zamani and Mohammadi (2008)* and *Khorsand et al. (2014).*

Furthermore, the estimates of maternal heritabilities of BW, WW and PWDG were 0.17±0.04, 0.07±0.02 and 0.12±0.05, respectively. Based on obtained results, magnitude of maternal heritabilities declined from birth to weaning. The regarding to results available in this study, maternal heritabilities were in accordance with other reports (*Jafaroghli et al., 2010; Mohammadi et al., 2015*; for BW and WW 0.18 and 0.06; 0.11 and 0.03, respectively). Estimated maternal permanent environmental effect (c^2) were 0.08±0.02 for PWDG by best model for this trait. Maternal permanent environmental effect was estimated to be lower than direct and maternal heritabilities for PWDG trait by best model. The maternal permanent environmental effect estimates for PWDG agreeing with the finding presented by *Zamani and Mohammadi (2008)* and *Zamani and Almasi (2017)* in Mehraban sheep, *Gholizadeh and Ghafouri-Kesbi (2015)* in Baluchi sheep.

Table 4. Estimates of (co)variance components and genetic parameter estimates for early growth traits

Trait	σ_a^2	σ_m^2	σ_{pe}^2	σ_e^2	σ_p^2	σ_{am}	$h_a^2 \pm$ SE	$h_m^2 \pm$ SE	c^2	r_{am}	$h_T^2 \pm$ SE
BW	0.11	0.06	-	0.18	0.36	-0.07	0.32±0.02	0.17±0.04	-	-0.76	0.11±0.05
WW	0.59	0.94	-	11.65	13.18	-	0.05±0.01	0.07±0.02	-	-	0.08±0.02
PWDG	534.10	252.23	165.34	1235.20	2186.87	319.40	0.24±0.02	0.12±0.05	0.08±0.02	-0.77	0.08±0.03

σ_a^2: additive genetic variance, σ_m^2: maternal additive genetic variance, σ_{pe}^2: maternal permanent environmental variance, σ_e^2: residual variance, σ_p^2: phenotypic variance, σ_{am}: direct-maternal genetic covariance, respectively; h_a^2: direct additive heritability, h_m^2: maternal heritability, c^2: maternal permanent environmental effect, r_{am}: correlation between direct and maternal genetic effects and h_T^2: total heritability

The fitting the direct and maternal genetic covariance resulted to estimates of correlation between direct and maternal genetic effects (r_{am}) of -0.76 and -0.77 for WW and PWDG, respectively. *Boujenane and Diallo (2017)* in Sardi sheep reported that correlation between direct and maternal genetic effects -0.67 and -0.1 for BW and WW, respectively. That is close to our results in this regard, which estimates may be attributed to the data structure and due to natural selection for an intermediate optimum (*Tosh and Kemp, 1994*).

The estimates of total heritabilities for BW, WW and PWDG were obtained 0.11±0.05, 0.08±0.02 and 0.08±0.03, respectively. The estimates of direct and maternal annual genetic trends for early growth traits (g/year) in this current study were given in Table 5. Estimates of total heritability for all traits are low, suggesting that mass selection would not be very effective in improving these traits. With regard to published estimates, the total heritability obtained in this current study was comparable with the results of several studies (e.g. *Boujenane and Diallo (2017)* in Sardi sheep*; Zamani and Almasi (2017)* in Mehraban sheep; *Rashidi et al. (2008)* in Kermani sheep). However, these results were inconsistent with the results of some studies (*Ekiz et al., 2004; Mandal et al., 2006*) in different breeds of sheep.

Table 5. Estimates of genetic trends (g/year) for early growth traits of Afshari lambs from 1999 - 2010

| Trait	DGT±SE	R^2	MGT±SE	R^2
BW	0.75[*]± 0.31	36.36	-0.63[*]± 0.27	34.87
WW	0.71[ns]± 0.41	23.42	-1.87[ns]± 0.94	28.43
PWDG	1.82[ns]± 17.96	0.01	-5.90[ns]± 13.35	0.02

DGT, MGT and R^2: Direct genetic trend, Maternal genetic trend and regression fit for genetic trend, respectively.
*: Significant at P < 0.05.
Ns: Not significant.

Positive genetic trend was observed for BW 0.75±0.31 and significant (*P* <0.05), and for WW and PWDG not significant. Generally, plots of the mean predicted breeding values on year of birth (1999-2010) of studied traits for direct and maternal are given in Figure 1. As indicated in Figure 1. for BW-Maternal mean breeding value since the beginning of study period positive were observed (from 1999 year of birth) then sudden drop in 2003 year of birth and again trend increase showed the end (close to zero). BW-Direct mean breeding value at early of period was negative genetic trend and then trend increased. For WW-Direct and maternal mean breeding values at early of period were positive and high and at the end of the period it was low and close to zero. In addition to, for PWDG-Direct and maternal mean breeding value it has been various slopes over the years. Estimate of direct genetic trend for BW obtained in the present research (0.75 g/year) was low and generally agrees with that reported by *Mokhtari and Rashidi (2010)* in

Kermani sheep (2 g/year); *Hanford et al. (2005)* in Rambouillet sheep (0.4 g/year). However, higher estimates for genetic trends of BW in other sheep breeds were reported by several authors (0.23, 20, 25 and 128 g/year were reported by *Shrestha et al. (1996)* in Suffolk, and Finn sheep; *Shaat et al.* (2004) in Ossimi breed, *Rashidi and Akhshi, (2007)* in kurdi sheep, respectively). The direct genetic trends for WW and PWDG were not significant similar to the *Boujenane and Diallo (2017)* in Sardi sheep. Further, maternal genetic trend was negative for all traits this percent study, and only significant for BW ($P <0.05$). Our results of maternal genetic trend for BW were close to *Boujenane and Diallo (2017)*; in Sardi sheep. A higher value for maternal genetic trend (3 g/year) was reported in Iranian Kermani sheep (*Mokhtari and Rashidi, 2010*). Also, the estimated maternal genetic trend for WW was consistent with estimates of *Boujenane and Diallo (2017)* in Sardi sheep (-0.26 g/year). The low annual genetic trends for studied traits in this study could be attributed mainly to the low heritability estimates that it depends mostly on phenotypic characteristics instead of additive genetic values. Also, due to the low nutritional level and harsh climate condition of Afshari sheep that is not very favorable for the expression of sheep's genetic potential. These results were similar to those reported by *Boujenane and Diallo (2017)*, *Mokhtari and Rashidi (2010)*. The obtained results of the mean breeding values during the year of birth (Maternal and direct) of BW, WW and PWDG were consistent with the results by *Boujenane and Diallo (2017), Mokhtari and Rashidi (2010).*
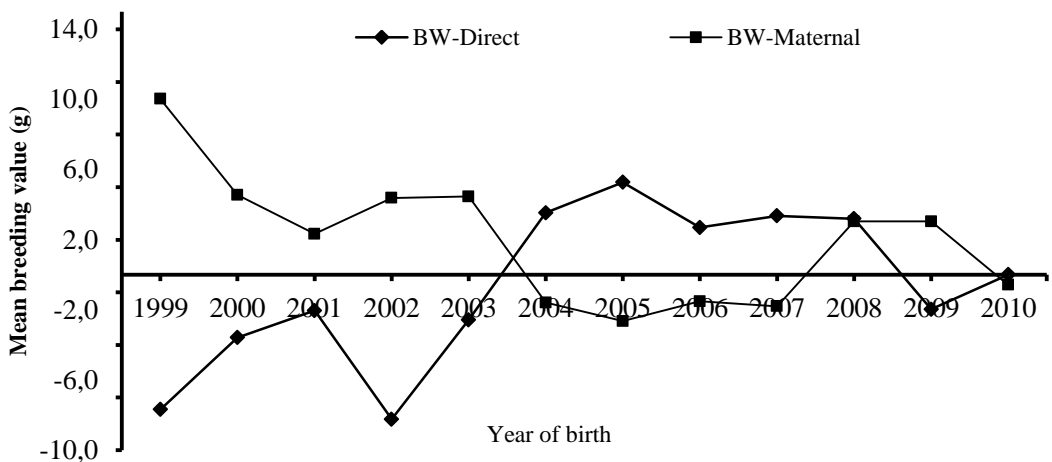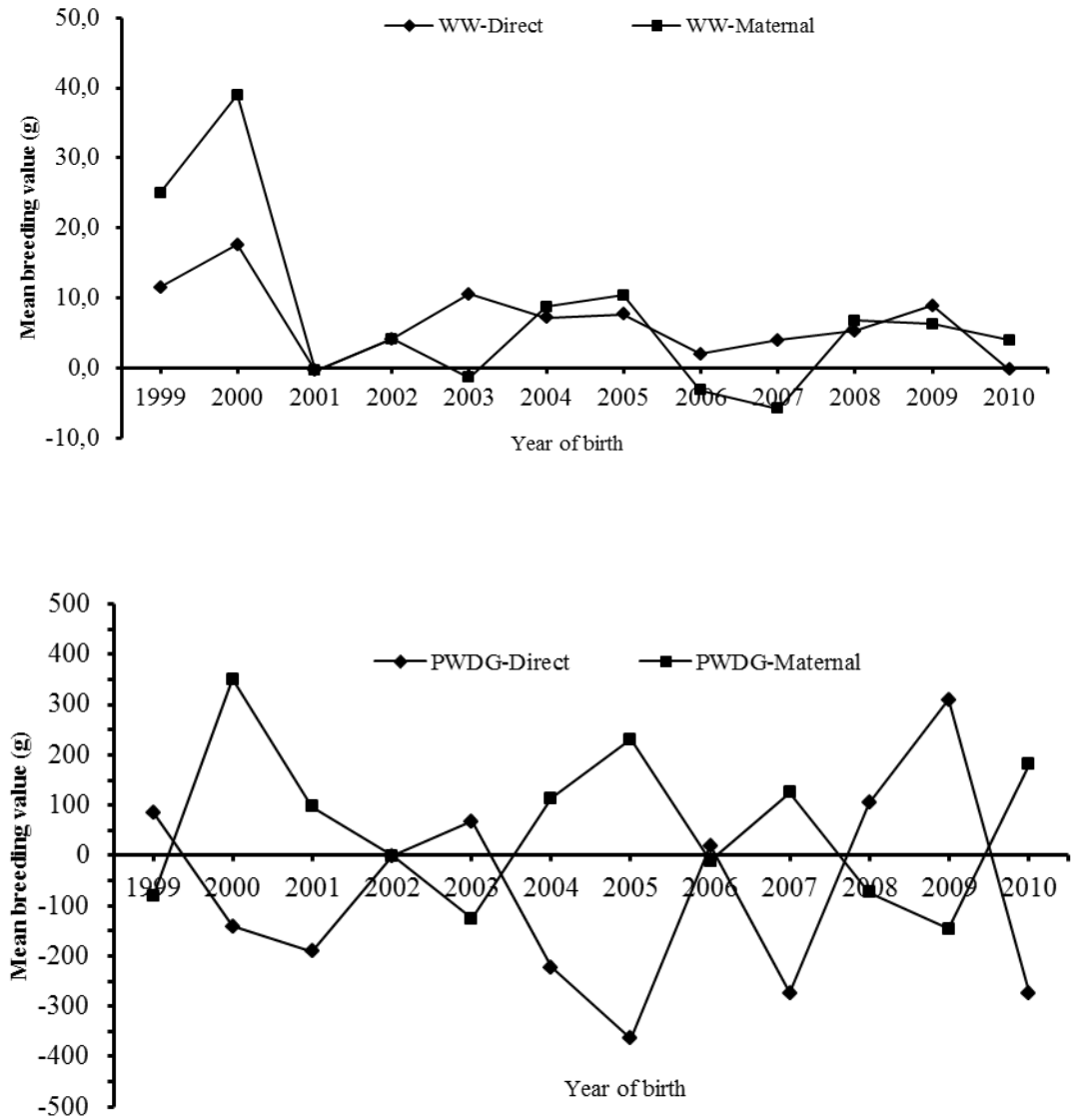
Figure 1. Means of predicts of breeding values BW, WW and PWDG at year of birth.

Conclusion

The low heritability estimates obtained for investigated traits in this research suggest that mass selection based on these traits may result in slow genetic progress for growth traits. Also, only BW was affected by genetic and maternal trends. Generally the low annual genetic trends for studied traits were observed. Eventually, recommended to improve the management of flock and also to select males based on their genetic merit.

Analiza genetskih parametara i trendova za osobine ranog porasta iranske afshari ovce

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Rezime

Svrha ove studije bila je procena genetičkih parametara i genetskih trendova osobina ranog porasta korišćenjem Baiesov-og pristupa sa softverom Gibbs3f90 kod iranske afshari ovce. Skup podataka (težina na rođenju (BW), težina na odbijanja (WW) i dnevni prirast telesne težine pre odbijanja (PWDG)) su sakupljeni u periodu od 1999. do 2010. godine od strane poljoprivrednog jahada pokrajine Zanjan, Iran. Prilagođeni fiksni efekti bili su zapat-godina-sezona kao interakcije, pol (muški, ženski), vrsta rođenja (jedinac, blizanci) i starost majke. Na osnovu Kriterija izvedenih informacija (Derivative Information Criteria - DIC), za ispitivane osobine određen je najprikladniji model. Prema tome, na osnovu najprikladnijeg prilagođenog modela, procena neposrednih aditivnih heritabilita za BW, WW i PWDG bila je 0,32±0,02; 0,05±0,01 i 0,24±0,02; respektivno. Procene heritabiliteta sa majčinske strane su 0,17±0,04; 0,07±0,02 i 0,12±0,05 i ukupnog heritabiliteta 0,11±0,05; 0,08±0,02 i 0,08±0,03 za BW, WW i PWDG, respektivno. Direktni genetski trendovi bili su pozitivni za sve osobine, ali samo za BW 0,75±0,31 g/godišnje (P<0,05). Takođe, genetski trendovi sa majčinske strane bili su negativni za sve osobine i značajan za BW -0,63 ± 0,27 g/godišnje (P<0,05). Umerene procene heritabiliteta za osobine ranog porasta pokazuju da je kod afshari ovaca brže genetsko poboljšanje kroz selekciju moguće za ove osobine. Osim toga, genetski trendovi u ovoj studiji ukazali su na to da je genetsko poboljšanje kroz selekciju pogodno samo za BW kod afshari ovaca.

Ključne reči: afshari ovce, rani porast, heritabilitet, genetski trend

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