Global Journal of Animal Scientific Research

Journal homepage: www.gjasr.com

Print ISSN:2345-4377 Online ISSN:2345-4385

Original Article

Genetic, Phenotypic and Environmental Trends for Growth and Reproductive Traits in Zandi Sheep

Kourosh Mohammadi[1,*] and Rostam Abdollahi-Arpanahi[2]

[1] Department of Animal Science, Faculty of Animal Science and Food Industries, Khuzestan Ramin Agricultural and Natural Resources University, Ahwaz, Iran
[2] Department of Animal Science, Faculty of Agricultural Science and Engineering, College of Agriculture and Natural Resources (UTCAN), University of Tehran, Tehran, Iran

ARTICLE INFO

Corresponding Author:
Kourosh Mohammadi
kouroshmhd@hotmail.co.uk

How to Cite this Article:
Mohammadi, K., and R. Abdollahi-Arpanahi. 2015. Genetic, Phenotypic and Environmental Trends for Growth and Reproductive Traits in ZandiSheep. *Global Journal of Animal Scientific Research.* 3(2):311-320.

Article History:
Received: 10 December 2014
Accepted: 25 December 2014

ABSTRACT

This paper reports the genetic, phenotypic and environmental trends for growth traits including birth weight (BW), weaning weight (WW), 6-month weight (6MW), 9-month weight (9MW) and yearling weight (YW). Reproductive traits namely, litter size at birth (LSB), litter size at weaning (LSW), total litter weight at birth (TLWB) and total litter weight at weaning (TLWW) were also investigated. The data were collected from the Khojir Breeding Station of Zandi sheep in Tehran, Iran from 1993 to 2008. Best linear unbiased prediction (BLUP) of breeding values was estimated by Restricted Maximum Likelihood procedure using multi-trait animal model. The most appropriate models were chose to predict breeding values of aforementioned traits. Genetic and phenotypic trends were obtained by regression of average breeding values and phenotypic least squares mean, respectively, on birth year. Direct genetic trends were significant for BW, WW, 6MW, 9MW, YW, TLWB and TLWW (5, 48, 21.5, 72, 65, −2.5 and11 g per year, respectively). Phenotypic ones were significant for WW, 6MW and TLWW (129.5, 238.3, and 187.3 g per year respectively). Environmental ones were significant for WW and 6MW (81.5, and 216.8 g per year, respectively). Both LSB phenotypic and environmental trends were −0.010 head per year. The results showed that selection program would relatively bring out genetic improvement especially for growth traits in mentioned breed. Environmental fluctuations ought to be modified with particular managing schedules to provide a susceptible field to express genes' additive effects.

Keywords: genetic trends, growth and reproductive traits, Zandi sheep.

INTRODUCTION

Economically, growth traits are one of the most pivotal traits in sheep production; especially in Iran that lamb sale is the main source of income for breeders; therefore it is important to add on weight in fast and efficient manner to increase livestock-producer's income. Investigation of the growth traits helps or even guides the breeders to determine the optimum management schemes in order to maintain the gain at optimum state, as well. On the other hand, the productivity of a ewe might be measured by litter size at birth (LSB), litter size at weaning (LSW) and total litter weight at weaning (TLWW); thus these traits are the most vital factors to determine reproductive efficiency.

The primary aim of animal breeders is to maximize the rate of genetic improvement through selection. In a meat sheep enterprise, this implies maximizing genetic improvement of meat production. Achieving this goal would depend mainly upon the accuracy of selecting superior parents for the next generation. To determine the effectiveness of genetic selection, genetic trends in the population under consideration must be monitored (Vanwyk *et al.*, 1993). The estimations of genetic, phenotypic, and environmental trends as a graphic perspective of a within-herd breeding program could convey a quick evaluation of a breeder's selection success in previous generations. These trends might be used to compare alternative procedures of selection or management for animal breeders involved with large flocks. They would improve selection and management aims established by a breeder. But such trends might also warn the need for changes in selection and/or management plan.

The Zandi sheep is one of the most important Iranian native breeds known for its high grazing ability, adapted to unfavorable climatic conditions and resistant to the common diseases in reared regions. As a matter of fact, genetic, phenotypic, and environmental trend estimations illustrate how much selection was effective. Such reports on trend estimates are scarce or lack for Zandi sheep. Thus, the aim of current study was to assess the genetic, phenotypic, and environmental trends in order to evaluate the current breeding program and develop strategies for future programs in Zandi sheep.

MATERIALS AND METHODS

Geographical Location and Flock Management

Data were collected on Zandi sheep maintained at Khojir Sheep Breeding Station, located between Tehran and Abali, over a period of 16 years (1993-2008). The station is located 1547 m above sea level at 35° 45′E longitude and 51° 40′N latitude in northern Iran and established in 1991. The starting animals were purchased from different sheep farms in the region. The climate at the location is moderate. Ewes and rams were herded and housed separately except during the breeding season. During the breeding season, ewes in estrus were detected using a teaser ram in morning and evening. One breeding ram was normally allowed to mate 15 ewes. Breeding rams were generally used for 2 years. New-born lambs were weighed at birth and/or 24 h afterwards, identified by an ear tag and suckled its mother until weaning at approximately 3 months of age. More details of the management of the flock have been described in our previous study (Mohammadi *et al.*, 2011; 2013).

Traits Studied

The traits investigated were growth traits comprising birth weight (BW), weaning weight (WW), 6, 9 and 12 months (6MW, 9MW and YW, respectively) and reproductive traits, namely, litter size at birth (LSB), litter size at weaning (LSW), total litter weight at birth (TLWB) and total litter weight at weaning (TLWW). The number of available records, mean, standard deviation, coefficient of variation, number of sires and dams of the traits studied are presented in Table 1.

Statistical and Genetic Analysis

The multi-trait animal model was fitted to estimate (Co) variance components for investigated traits by DFREML 3.1 computer program (Meyer, 2000).The most appropriate models that our previous studies indicated were used in the present multivariate analysis. The best models for the investigated traits were as follows:

$y = Xb + Z_1a + e$ (Model 1)

$y = Xb + Z_1a + Z_3c + e$ (Model 2)

$y = Xb + Z_1a + Z_2m + e$ with Cov (a, m) = 0 (Model 3)

$y = Xb + Z_1a + Wpe + e$ (Model 4)

where is a vector of observations, vector of fixed effects with incidence matrix X, a~N (0, $A\sigma^2_a$) and m~N (0, $A\sigma^2_m$) vectors of direct and maternal genetic effects with incidence matrixes Z_a and Z_m, respectively, c~N (0, $I_d\sigma^2_c$) a vector of random maternal permanent environmental effects with incidence matrix Z_c, pe~N (0, $I_d\sigma^2_{pe}$) a vector of random permanent environmental effects related to repeated records of the ewes with incidence matrix W_{pe} and e~N (0, $I_n\sigma^2_e$) is a vector of random residual (error) effects.

Also, σ^2_a is the direct genetic variance, σ^2_m the maternal genetic variance,σ^2_c the maternal permanent environmental variance, σ^2_{pe} the permanent environmental variance related to repeated records of the ewes, σ^2_e the residual variance, the additive genetic relationship matrix, and I_d and I_n are the identity matrices of order equal to the number of dams and number of records, respectively. Also, X, Z_1, Z_2, Z_3 and W stand for design matrices associating the corresponding effects with elements of y.

Table 1: Summary of descriptive statistics for the traits studied of Zandi sheep

Traits	No. of records	No. of sires	No. of dams	Mean	C.V (%)	Average no. of records per sire	Average no. of records per dam
Growth							
BW (kg)	4,309	273	1,378	4.23	19.15	15.78	3.12
WW (kg)	3,199	270	1,275	21.17	16.20	11.85	2.51
6MW (kg)	2,634	202	1,045	27.55	17.27	13.04	2.52
9MW (kg)	1,893	188	761	33.80	14.85	10.07	2.49
YW (kg)	1,115	156	448	36.13	16.22	7.15	2.49
Reproductive							
LSB (head)	2,588	147	577	1.12	29.46	17.60	4.48
LSW (head)	2,588	147	577	0.74	67.57	17.60	4.48
TLWB (kg)	2,588	147	577	4.81	28.27	17.60	4.48
TLWW (kg)	1,859	141	481	22.03	23.06	13.18	3.86

BW: birth weight, WW: weaning weight (3 months weight), 6MW: 6- month weight, 9MW: 9-month weight, YW: yearling weight, LSB: litter size at birth, LSW: litter size at weaning, TLWB: total litter weight at birth, TLWW: total litter weight at weaning, CV: coefficient of variation

For BW, WW and 6MW, the model included lamb sex, birth year, dam age, and birth type as fixed effects and mentioned ones with the exception of birth type for 9MW and YW. And lamb age at 3, 6, 9 and 12 months of age as a covariate for WW, 6MW, 9MW and YW, respectively.

The most appropriate model for BW included direct and maternal genetic effects (Model 3), and direct genetic and maternal permanent environmental effects (Model 2) for WW and 6MW whilst direct genetic effects (Model 1) for 9MW and YW, only. For all of the reproductive traits, lambing year and ewe age considered as fixed effects and lamb age at weaning as covariate for TLWW and the direct genetic and individual permanent environmental effects (Model 4) as random effects.

Genetic and phenotypic trends of mentioned traits were obtained as regression of breeding and phenotypic values mean on birth year, respectively. To assess the environmental trend, the subtraction of breeding value mean was computed from phenotypic mean, for the first step, and then the regression of obtained value on birth year was considered as environmental trend.

RESULTS AND DISCUSSION

Genetic, Phenotypic and Environmental Trends for Growth Traits

Predictions of breeding values mean for growth traits of Zandi sheep in each birth year are illustrated in Fig. 1. Over-one-trait information has been used to estimate breeding values, in multi-trait analyses; hence obtained breeding values are more accurate than single trait analysis. The genetic trend of growth traits shows a mild ascending change that had fluctuations over the course of study. However, there was overall increase in the magnitude, irrespective of the ups and downs in different years in all growth traits, as illustrated in Fig. 1.

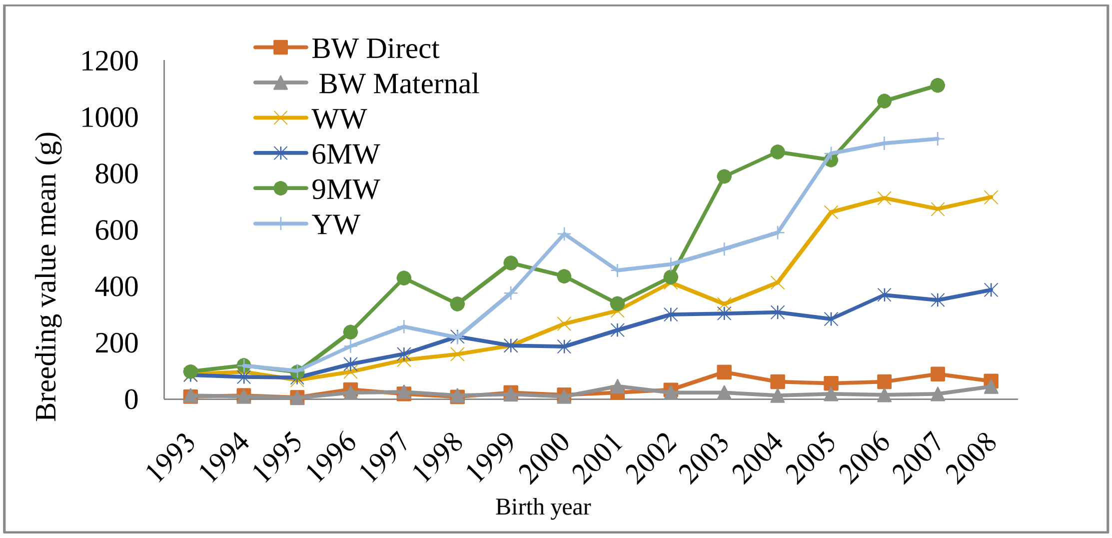

Fig. 1: Predictions of breeding values mean for growth traits of Zandi sheep by year of birth

Genetic, phenotypic and environmental trends (g per year) for growth traits have been demonstrated in Table 2. BW direct genetic trend (5 g per year) in current study was consistent with the obtained value of Klerk and Heydenrych (1990) in South African Dohne Merino sheep. Higher direct genetic trend for this trait (1 kg per year) was assessed by Hanford *et al.*, (2005), considerably. However, BW direct genetic trends attained of Arora *et al.*, (2010) and Di *et al.*, (2014) for Malpura and Chinese superfine Merino sheep, respectively, were insignificant. The low and insignificant BW maternal genetic trend in this study was conflicting with that obtained by Mokhtari and Rashidi (2010). There was little difference between direct and maternal genetic trend lines for BW, generally.

Table 2: Genetic, phenotypic and environmental trends (g per year) for growth traits

Growth Traits	GT ± SE	R^2(%)	PT ± SE	R^2(%)	ET ± SE	R^2(%)	MT ± SE	R^2 (%)
BW	5 ± 0.9**	66.2	12.8 ±11.6ns	8.0	7.8 ± 11.6ns	3.1	1 ± 0.6 ns	17.3
WW	48 ± 4.1**	90.7	129.5 ± 31.2**	55.2	81.5 ±29.5*	35.3	-	-
6MW	21.5 ± 1.4**	94.2	238.3 ± 64.5**	49.4	216.8 ± 64.6**	44.6	-	-
9MW	72 ± 7.1**	88.9	222.7 ± 146.2ns	15.1	150.7 ± 147.4ns	7.4	-	-
YW	65 ± 5.6**	91.7	268 ± 149.9ns	21.0	203 ± 149.4 ns	13.3	-	-

GT: genetic trend, PT: Phenotypic trend, ET: environmental trend, MT: maternal trend, R^2: regression fit, *, **: Significant effect at $p < 0.05$ and $p < 0.01$, ^{ns} non-significant ($p > 0.05$).
For trait abbreviations see footnote of Table 1.

The genetic trend for WW had an ascending pattern with mild slope from 1995 to 2002, but genetic improvement was not gained in 2003. The cause of this decrease could due to culling of many superior ewes in previous years because of elderly and entrance of many new ewes with less breeding value in flock. The mean of breeding value for WW has been increased from 2004 afterward. Estimate of genetic trend for WW (48 g per year) was lower than those of the previous reports (Mansour *et al.*, 1977; Mokhtari and Rashidi, 2010). Shrestha *et al.*, (1996) also estimated genetic trends for Canadian sheep at 91 days of age as 23 and 25 g per year in Suffolk and Finnish Landrace sheep, respectively. The increase of breeding values mean for WW in Columbia- and Targee breeds reported by Hanford *et al.*, (2002, 2003) were 0.5 and 7.5 kg per year, respectively, during a 49-year period.

The genetic trend for 6MW (21.5 g per year) was less than WW and it was the lowest among the post-weaning traits studied, since the animals grazed in range and during this stage of growth nutritional level was poor, therefore, it has been more affected by environmental factors and climate condition. Scilicet, the environmental conditions are getting unfavorable after trimester period and the rate of growth is declined, subsequently. Similar finding was reported by Shaat *et al.,* (2004) in Ossimi sheep, as well. However, higher estimated values achieved by others (Klerk and Heydenrych, 1990; Arora *et al.,* 2010; Mokhtari and Rashidi, 2010). Yapi-Gnaore *et al.* (1997) reported genetic trend of 180-day-weight trait was 11 g per year for Dyallonke sheep, during an 8-year period.

The genetic trend value estimated for 9MW (72 g per year) was lower than that of the previous report (Mokhtari and Rashidi, 2010). Also, an estimate of 0.95 kg annually for 9MW genetic trend was reported by Arora *et al.*, (2010). Our estimate for YW genetic trend (65 g per year) was generally consistent with the reported value by Klerk and Heydenrych (1990). Higher estimates were documented in the literature for other sheep breeds (Cloete and Scholtz, 1998; Arora *et al.,* 2010; Mokhtari and Rashidi, 2010). However, Yapi-Gnaore *et al.*, (1997) obtained a lower estimate. In general, these genetic trend estimates provide a good picture of the selection program for Zandi sheep although unfavorable environmental conditions affected upon breeding values prediction and caused decreased genetic improvement of traits in selected programs.

Phenotypic least squares mean for growth traits of Zandi sheep by year of birth are portrayed in Fig. 2. It had remarkable fluctuations in different years and does not follow of an especial trend. There was partially phenotypic improvement in growth traits over the years; however, it is not consistent, in most cases. WW and 6MW phenotypic trends were significant (129.5 and 238.3 g per year, respectively). However, 3MW and 6MW phenotypic trends reported by Arora *et al.*, (2010) were 0.31 and 0.37 kg annually. Our obtained values for WW and 6MW environmental trend were 81.5 and 216.8 g per year, respectively. Phenotypic and environmental trends for other growth traits were non-significant in current study. Arora *et al.,* (2010) found negative and significant environmental trends for BW, 3MW, 6MW, 9MW and 12MW (–0.07, –0.27, –0.24, –0.88 and –0.42 kg per year, respectively).

Usually, the cause of low-genetic improvement is due to more use of rams with low breeding value, lack of breeding objectives, non-use of appropriate selection criteria, inaccuracy in traits recording and non-execution of predicted programs in the aspect of flock size and replacement (Vatankhah *et al.,* 2004).

Genetic, Phenotypic and Environmental Trends for Reproductive Traits

Genetic, phenotypic and environmental trends for reproductive traits have been showed in Table 3.

Predictions of breeding values mean for LSB and LSW of Zandi sheep in each year of birth have been illustrated in Fig. 3. Selection for litter size would not be effective for increasing lamb production, since it does not include the weaning weight of individual lambs (Snyman *et al.,* 1997).

As indicated in Fig. 3, severe fluctuations were observed during the period of study, but LSB and LSW genetic trends were insignificant near to zero (–0.0002 and 0.0004 head per year, respectively) and maintained at the level of base year. The obtained results were into his line of Vatankhah *et al.,* (2007) findings. However, Sakul *et al.,* (1999) reported a mild genetic improvement for LSB in Targee sheep, over a 30-year period. Also, higher estimates for LSB and LSW genetic trend reported by Hanford *et al.*, (2002; 2005) were 0.4 and 0.3 head per year in Columbia, and 0.4 and 0.4 head per yearin Rambouillet sheep, during 1950-1998.

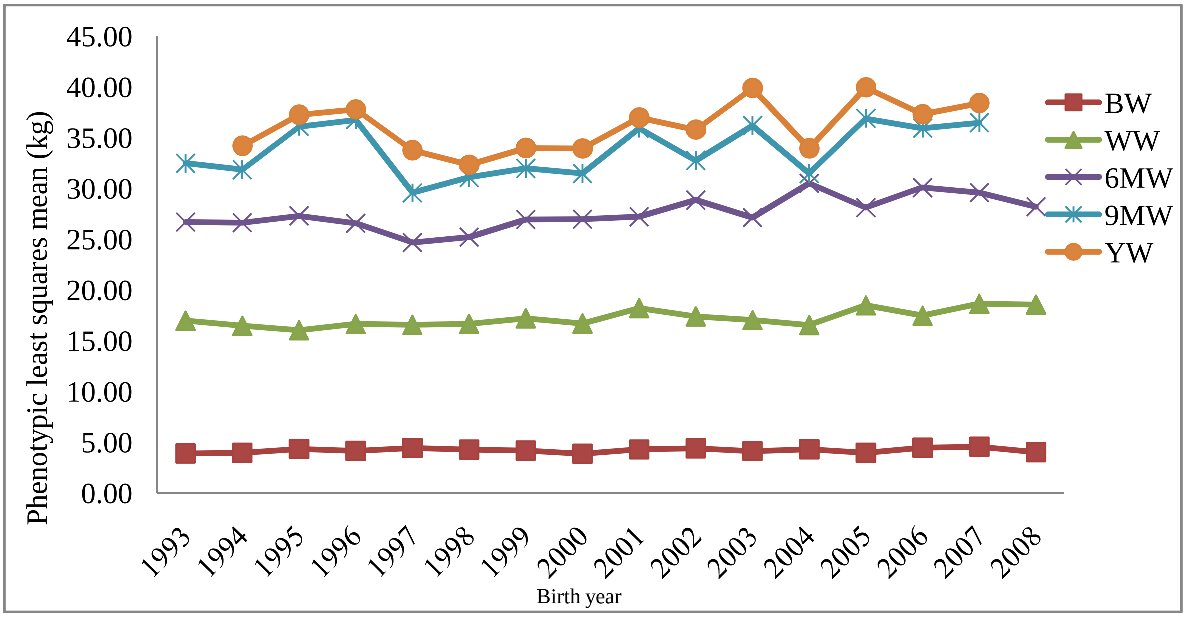

Fig. 2: Phenotypic least squares mean for growth traits of Zandi sheep by year of birth

Table 3: Genetic, phenotypic and environmental trends for reproductive traits

Reproductive Traits	GT ± SE	R^2 (%)	PT ± SE	R^2(%)	ET ± SE	R^2(%)
LSB (head per year)	−0.0002 ± 0.0011ns	0.8	−0.010 ±0.002**	57.9	−0.010 ± 0.002**	63.8
LSW (head per year)	0.0004 ± 0.0009ns	1.2	0.006 ± 0.009ns	3.0	0.006 ± 0.009ns	2.7
TLWB (g per year)	−2.5 ± 1.0*	30.3	42.5 ± 23.9ns	19.5	45 ± 24.2ns	21.0
TLWW (g per year)	11 ± 2.1**	67.1	187.3 ± 85.8*	26.8	176.2 ± 86.9ns	24.0

GT: genetic trend, PT: Phenotypic trend, ET: environmental trend, R^2: regression fit, *, **: Significant effect at $p < 0.05$ and $p < 0.01$, Ns: non-significant (p > 0.05).
For trait abbreviations see footnote of Table 1.

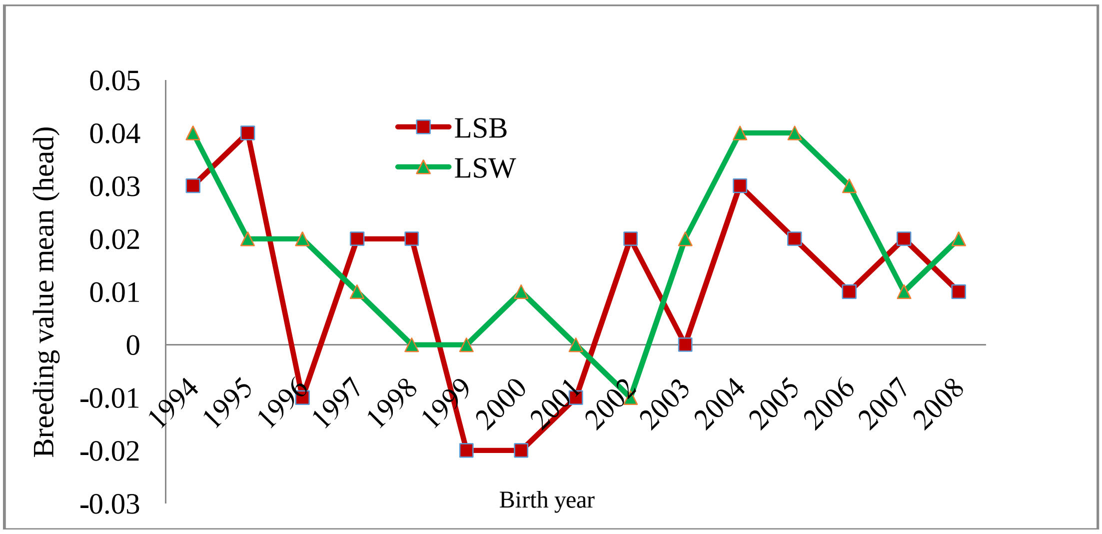

Fig. 3: **Predictions of breeding values mean for LSB and LSW of Zandi sheep by year of birth**

In Fig. 4, substantial fluctuations were observed in yearly predictions of breeding values mean for TLWB and TLWW; there were abrupt declines in some years. Negative and significant genetic trend was observed for TLWB (−2.5 g per year), which was converse both in sign and significance level with the study of Vatankhah *et al.*, (2007). However, negative and insignificant TLWB genetic trend was documented in the literature for Moghani sheep (Savar Sofla *et al.*, 2010).

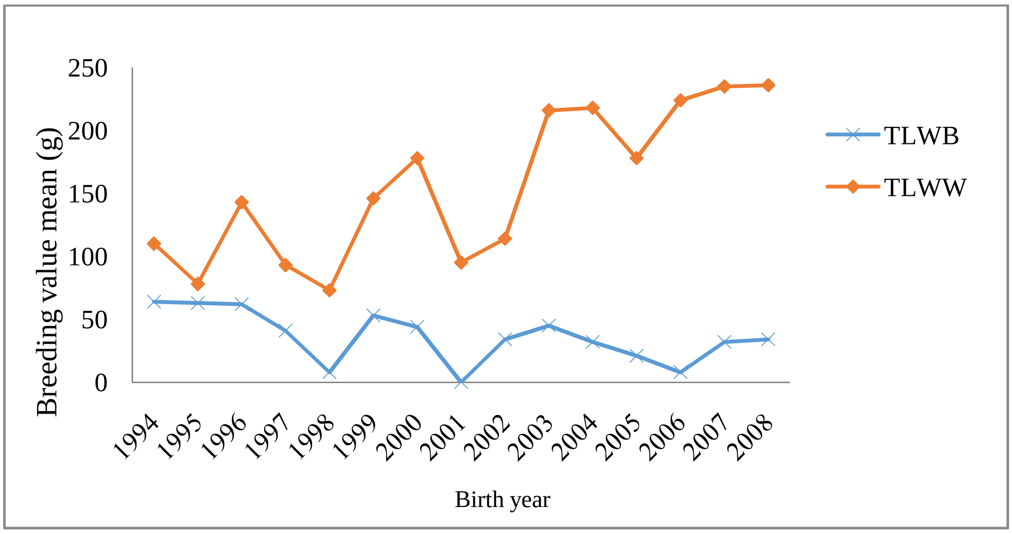

Fig. 4: Predictions of breeding values mean for TLWB and TLWW of Zandi sheep by year of birth

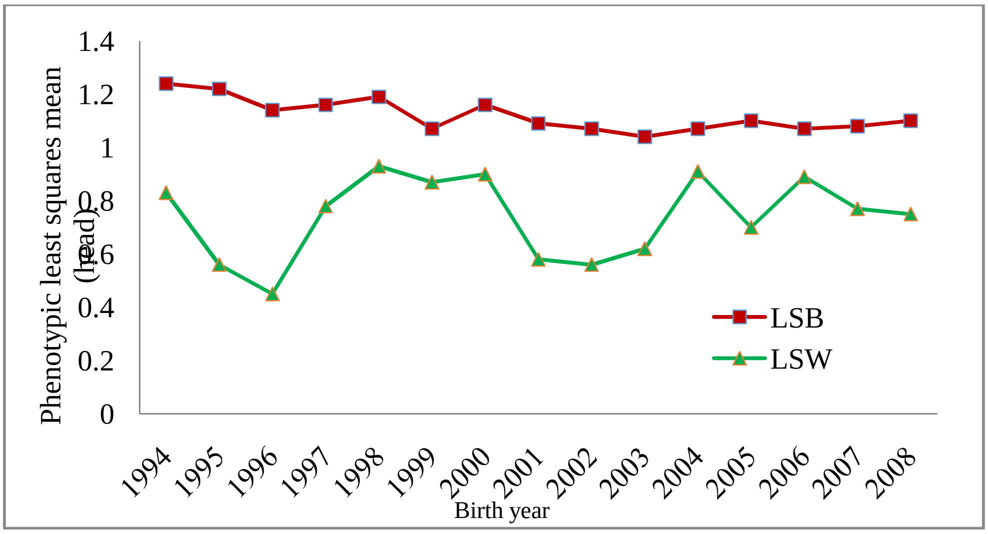

Fig. 5: Phenotypic least squares mean for LSB and LSW of Zandi sheep by year of birth

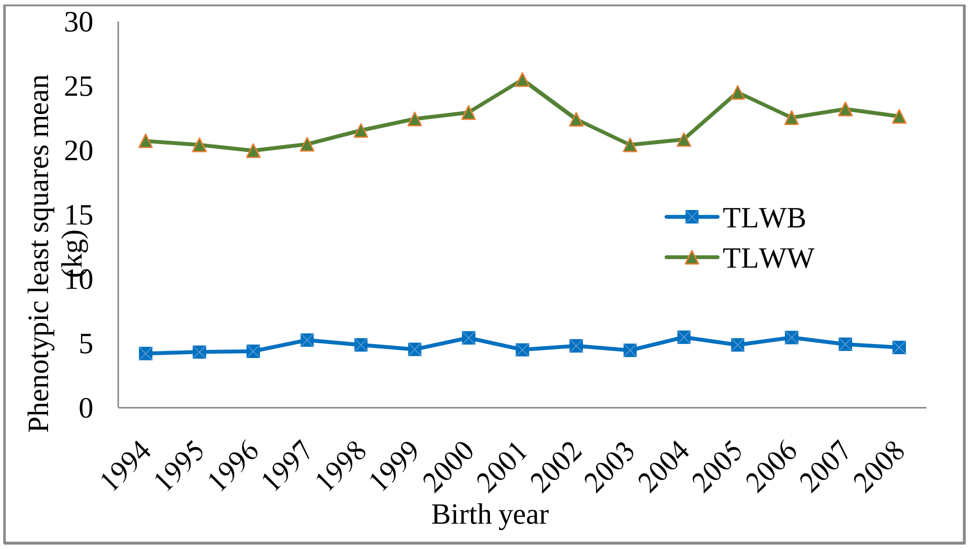

Fig. 6.Phenotypic least squares mean for TLWB and TLWW of Zandi sheep by year of birth

Genetic trend is varied from 0.5 to 3 percent of phenotypic mean through selection within-breed in each year (Smith, 1984). Nevertheless, the gained genetic trend is even not in the level of 0.5 percent of phenotypic mean for neither growth nor reproductive traits, in current study. Genetic trend of TLWW should have more than 110 g per year if the least of genetic improvement was considered as 0.5 percent of phenotypic mean for this trait. However, TLWW genetic trend (11 g per year) was in accordance with the previous reports of Savar Sofla *et al.* (2010), relatively. Higher obtained value (23 g per year) was documented in the literature for Lori-Bakhtiari sheep (Vatankhah *et al.,* 2007). There are few reports about genetic trend for reproductive traits in the sheep.

Phenotypic least squares mean for reproductive traits of Zandi sheep by year of birth are illustrated in Figs. 5 and 6. Similar to growth traits, noticeable fluctuations were observed for mentioned traits in different years. Corresponding to the obtained values by Savar Sofla *et al.* (2010), LSB and TLWW phenotypic trends were significant (−0.01 head per year and 187.3 g per year, respectively). In contrast to the value reported by Vatankhah *et al.*, (2007), LSW and TLWB phenotypic trends were non-significant. In agreement with the study of Savar Sofla *et al.,* (2010), LSW phenotypic trend was non-significant in our study. Environmental trend was only significant for LSB (−0.01 head per year). Phenotypic and environmental trends for other traits were non-significant. However, positive and significant environmental trend estimates was reported by Vatankhah *et al.*, (2007) for LSW, TLWB and TLWW. In current study, the obtained results shows that environmental fluctuations were higher than breeding value ones, during these years.

Performing animal breeding programs before any carrying out, optimal environmental conditions should be provided to obtain more genetic potential in order to coincidence of phenotypic trend with genetic one.

CONCLUSION

In current study, genetic trend was positive and significant for majority of traits, but phenotypic and environmental ones just for some of them. The main cause of genetic non-improvement in reproductive traits in current study could be related to factors such as lack of breeding objectives, non-using of appropriate selection criteria and emphasis on that over the different years and also environmental and managing fluctuations. Also, high-standard error and severe fluctuations of breeding value mean are the causes of being insignificant of genetic trend for reproductive traits. It is seemed that there was no especial breeding program and correct selection criteria so as to improve genetically traits on benefits of Zandi sheep in recent years. Therefore, performing more review of breeding ones for these sheep seemed to be necessary.

ACKNOWLEDGEMENTS

The authors would like to appreciate National Animal Breeding Center and Promotion of Animal Products, Karaj, Iran and the contribution of all Zandi sheep Breeding Station staff, for farm management and on farm data collection.

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