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GENETIC PARAMETERS AND GENETIC GAINS FOR REPRODUCTIVE TRAITS OF ARABI SHEEP

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Original scientific paper

Abstract: The current study reports, for the first time, the genetic parameters and genetic, phenotypic and environmental correlations and trends of reproductive traits in Arabi sheep. Data were collected at Animal Science Research Station of Khuzestan Ramin Agricultural and Natural Resources University (ASRSKRANRU), south-west of Iran from 2001 to 2008. Litter size at birth (LSB), litter size at weaning (LSW), litter mean weight per lamb born (LMWLB), litter mean weight per lamb weaned (LMWLW), total litter weight at birth (TLWB) and total litter weight at weaning (TLWW) averaged 1.11 lambs, 1.01 lambs, 3.83 kg, 19.43 kg, 4.16 kg and 20.12 kg, respectively. Genetic parameters and correlations were estimated with univariate and bivariate models using restricted maximum likelihood, breeding values of animals were estimated with best linear unbiased prediction (BLUP) and genetic- and phenotypic trends by regression of ewes' average breeding values and phenotypic least square means on year of birth respectively. Random effects were fitted by additive direct genetic effects and permanent environment related to the ewe as well as service sire effects, in addition to fixed effects of ewe age at lambing and lambing year. Heritability estimates of 0.05, 0.02, 0.13, 0.12, 0.04, and 0.06, and repeatability estimates of 0.08, 0.06, 0.17, 0.16, 0.14 and 0.21 for the six traits, respectively. Genetic correlations between traits varied from −0.82 to 0.94. Phenotypic correlations were lower, ranging from −0.33 to 0.52. Estimated annual genetic progress was very low; −0.003 lambs for LSW and 15 g for TLWW. Annual phenotypic trend was only significant for LSW being 0.007 lambs. The study concluded that indirect selection based on total litter weight at weaning could be efficient for the traits studied.

Keywords: genetic parameters; genetic trends; reproductive traits; Arabi sheep

Introduction

Knowledge of genetic parameters is the basis of sound livestock improvement programs. Estimates of heritabilities and genetic correlations are essential population parameters required in animal breeding research and in design and application of practical animal breeding programs *(Imbayarwo-Chikosi, 2010)*. Moreover, repeatability is an important genetic parameter, which is frequently used to measure the animals' ability to repeat their level of production at successive intervals in time, although a high repeatability coefficient does not mean that the animals will strictly demonstrate the same performance in the next productive seasons; it could be predicted in the subsequent performance of the animals under stable environmental conditions *(Mohammadi et al., 2013).*

Ewe productivity defined as the total weight of lambs weaned by a ewe is one of the most important economic traits and has been proposed as a biologically optimum index to improve overall flock productivity *(Snowder, 2002)*. Also, ewe productivity is a key target in sheep breeding and could be improved by increasing the number of lambs weaned and weight of lambs weaned per ewe within a specific year *(Duguma et al., 2002).*

Arabi sheep is one of the most important dual-purpose sheep (meat and wool) native breeds of Iran. Most of these sheep are raised in Khuzestan province in southwest of Iran (numbering more than 1.8 million head). They are well adapted to humid-tropical environmental conditions *(Shokrollahi and Baneh, 2012)*. The Arabi breed is characterised as white, cream, black and dark/bright brown colour, horned rams and polled ewes, fat-tailed, medium-sized (mature weight of ewe and ram is 45-50 and 60-65 kg, respectively).

There is no published research on reproductive traits of Arabi sheep, to date. Thus, this paper analyzed data from Animal Science Research Station of Khuzestan Ramin Agricultural and Natural Resources University (ASRSKRANRU), and estimated genetic parameters, and correlations (genetic, phenotypic and environmental) for reproductive traits, providing a scientific evidence for breed selection on this station. In addition genetic-, phenotypic- and environmental trends were estimated.

Materials and methods

Geographical location and management

The data set used in the present study were collected from ASRSKRANRU in Mollasani town, located between Ahvaz and Shoushtar cities, from 2001 to 2008. Climate of Mollasani town is humid-tropical and the maximum temperature recorded is approximately 50 ° C in summer, while the temperature drops to 5 °C in winter. The mean annual rainfall is around 210 mm, mainly occurring during December – January. The animals were raised on pasture in spring and summer and with access to farm residual feeds during autumn and housed at night, typically. The environmental-, nutritional-, and management conditions were the same for all of the animals. Maiden ewes were exposed to rams at about 18 months of age and kept in the flock until death or apparent infertility. The selected rams were 3-4 years of age and kept separated from ewes, generally. During the breeding season, single-sire pens were used allocating 20-25 ewes per ram. The mating season was from early August to October. Lambing took place from early January to February, consequently. Lambs were weighed, ear-tagged early after birth. The date, sex and type of birth were recorded. Lambs were weaned from their mothers at an average age of 120 days. The ewes and young animals were kept on natural pastures as separate flocks, after weaning. Supplemental feeding was offered during mating and late pregnancy. Selection was based on weight at six months.

Studied traits

The traits analysed were classified as basic and composite. Basic traits were litter size at birth (LSB, the number of lambs born alive, coded by 1 or 2 for lamb alive at birth), litter size at weaning (LSW, the number of lambs weaned per ewe lambing, coded by 0 for lamb dead and 1 or 2 for lamb alive at weaning), litter mean weight per lamb born (LMWLB, the average weight of lambs at birth from the same parity), litter mean weight per lamb weaned (LMWLW, the average weight of lambs at weaning from the same parity), and composite traits were total litter weight at birth (TLWB, the sum of the birth weights of all lambs born per ewe lambed) and total litter weight at weaning (TLWW, the sum of the weights of all lambs weaned per ewe lambed). Summary statistics for reproductive traits is presented in Table1.

Table 1. Summary of descriptive statistics for reproductive traits of Iranian Arabi sheep

	Traits					
	LSB (lamb)	LSW (lamb)	LMWLB (kg)	LMWLW (kg)	TLWB (kg)	TLWW (kg)
No. of records	1690	1690	1690	1388	1690	1388
No. of ewes	473	473	473	408	473	408
No. of sires of the ewes	133	133	133	138	133	138
Mean	1.11	1.01	3.83	19.43	4.16	20.12
S.D.	0.31	0.46	0.77	3.27	1.33	5.16
C.V. (%)	27.93	45.54	20.10	16.83	31.97	25.65

LSB: Litter size at birth, LSW: litter size at weaning, LMWLB: litter mean weight per lamb born, LMWLW: litter mean weight per lamb weaned, TLWB: total litter weight at birth, TLWW: total litter weight at weaning

Statistical analysis

The general linear model (GLM) procedure of SAS *(SAS Institute, 2004)* was used to determine the fixed effects in the final models. These effects were included ewe age at lambing in 6 classes (2–7 years old) and lambing year in 8 classes (2001–2008). The lamb age at weaning (in days) was fitted as a covariate for LMWLW and TLWW traits. The interaction between fixed effects was not significant.

The traits were analyzed by WOMBAT software *(Meyer, 2006)* via AI-REML algorithm. The following models were applied to each trait:

Model 1 $\mathbf{y = Xb + Z_a a + e}$

Model 2 $\mathbf{y = Xb + Z_a a + Wpe + e}$

Model 3 $\mathbf{y = Xb + Z_s s + e}$

Model 4 $\mathbf{y = Xb + Z_a a + Z_s s + Wpe + e}$

where $\mathbf{y}$ is a vector of records on the respective traits; $\mathbf{b}$, $\mathbf{a}$, $\mathbf{pe}$, $\mathbf{s}$ and $\mathbf{e}$ are vectors of fixed effects, direct additive genetic effects, permanent environmental related to repeated records of the ewes, service sire, and residual, respectively. The $\mathbf{X}$, $\mathbf{Z_a}$, $\mathbf{W_{pe}}$ and $\mathbf{Z_s}$ stand for design matrices associating with the corresponding effects with elements of $\mathbf{y}$, as well. The (co)variance structure for the random effects was:

$$\mathrm{Var}\begin{bmatrix}\mathbf{a}\\ \mathbf{pe}\\ \mathbf{s}\\ \mathbf{e}\end{bmatrix}=\begin{bmatrix}\mathbf{A}\boldsymbol{\sigma}^2_{\mathbf{a}} & \mathbf{0} & \mathbf{0} & \mathbf{0}\\ \mathbf{0} & \mathbf{I_d}\boldsymbol{\sigma}^2_{\mathbf{pe}} & \mathbf{0} & \mathbf{0}\\ \mathbf{0} & \mathbf{0} & \mathbf{I_s}\boldsymbol{\sigma}^2_{\mathbf{s}} & \mathbf{0}\\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{I_n}\boldsymbol{\sigma}^2_{\mathbf{e}}\end{bmatrix}$$

It was assumed that the additive genetic effects, permanent environmental related to repeated records of the ewes, service sire, and residual to be normally distributed with a mean of zero and variances are $\mathbf{A}\boldsymbol{\sigma}^2_{\mathbf{a}}$, $\mathbf{I_d}\ \boldsymbol{\sigma}^2_{\mathbf{pe}}$, $\mathbf{I_s}\ \boldsymbol{\sigma}^2_{\mathbf{s}}$ and $\mathbf{In}\ \boldsymbol{\sigma}^2\mathbf{e}$, respectively. Also, $\boldsymbol{\sigma}^2_{\mathbf{a}}$, $\boldsymbol{\sigma}^2_{\mathbf{pe}}$, $\boldsymbol{\sigma}^2_{\mathbf{s}}$ and $\boldsymbol{\sigma}^2_{\mathbf{e}}$ are the direct additive genetic variance, permanent environmental related to repeated records of the ewes, service sire, and residual, respectively. $\mathbf{A}$ is the additive numerator relationship matrix. $\mathbf{I_d}$, $\mathbf{I_s}$ and $\mathbf{I_n}$ are identity matrices with the order equal to the number of ewes, sires and records, respectively.

Repeatability (r) was calculated using the following formula:

$$\mathbf{r} = \frac{\boldsymbol{\sigma}^2_{\mathbf{a}} + \boldsymbol{\sigma}^2_{\mathbf{pe}}}{\boldsymbol{\sigma}^2_{\mathbf{p}}}$$

In order to determine the most apposite model, Akaike’s information criterion (AIC) was used *(Akaike, 1974)*:

$$\mathrm{AIC}_i = -2 \log L_i + 2p_i$$

where log L_i is the maximised log likelihood of model i at convergence and p_i is the number of parameters obtained from each model; the model with the lowest AIC was chosen as the most suitable model.

Genetic-, phenotypic-, and environmental correlations were estimated using bivariate analysis with the same fixed effects as univariate models. Annual genetic and phenotypic trends of the traits were obtained as regression of ewes' means breeding and phenotypic values on their birth year, respectively. The subtraction of ewes' breeding value mean was computed from their phenotypic, and the regression of obtained value on birth year considered as environmental trend.

Results and discussion

Fixed effects

The least squares mean and standard errors of ewe age at lambing are presented in Table 2. The significant effect of ewe age was observed for all traits ($P<0.05$). The lowest reproductive performance was observed in 2- and 3-year-old dams. The significant influence of this effect could be explained by differences in maternal effects, nursing, and maternal behaviour of dams at different ages. All the studied traits were significantly influenced by lambing year ($P<0.05$). This effect may be explained by the variations in climate conditions and nutritional quality over the years.

Table 2. Least-squares mean ± standard errors for ewe age on reproductive traits

Fixed effects	Traits[a]					
	LSB (lamb)	LSW (lamb)	LMWLB (kg)	LMWLW (kg)	TLWB (kg)	TLWW (kg)
Ewe age (year)	*	*	*	*	*	*
2	$1.09^{bc} \pm 0.01$	$0.92^{b} \pm 0.07$	$3.50^{e} \pm 0.04$	$18.64^{c} \pm 0.19$	$3.71^{d} \pm 0.06$	$18.93^{c} \pm 0.27$
3	$1.08^{c} \pm 0.01$	$0.97^{ab} \pm 0.04$	$3.77^{d} \pm 0.04$	$18.49^{c} \pm 0.18$	$3.95^{c} \pm 0.06$	$18.59^{c} \pm 0.24$
4	$1.12^{abc} \pm 0.02$	$0.99^{ab} \pm 0.04$	$3.92^{bc} \pm 0.04$	$19.47^{b} \pm 0.24$	$4.28^{b} \pm 0.08$	$20.25^{b} \pm 0.39$
5	$1.14^{ab} \pm 0.01$	$1.07^{ab} \pm 0.05$	$4.02^{ab} \pm 0.05$	$19.45^{b} \pm 0.22$	$4.50^{ab} \pm 0.09$	$20.70^{ab} \pm 0.38$
6	$1.14^{ab} \pm 0.01$	$1.13^{a} \pm 0.04$	$4.06^{a} \pm 0.05$	$20.24^{a} \pm 0.23$	$4.51^{a} \pm 0.10$	$21.10^{ab} \pm 0.35$
7	$1.15^{a} \pm 0.03$	$1.12^{a} \pm 0.05$	$3.89^{cd} \pm 0.05$	$20.36^{a} \pm 0.20$	$4.37^{ab} \pm 0.11$	$21.26^{a} \pm 0.35$
Lambing year	*	*	*	*	*	*

Means with similar letters in each subclass within a column do not differ.

LSB: Litter size at birth, LSW: litter size at weaning, LMWLB: litter mean weight per lamb born, LMWLW: litter mean weight per lamb weaned, TLWB: total litter weight at birth, TLWW: total litter weight at weaning, *: $P < 0.05$

The significant effects ($P<0.01$) of lamb age at weaning demonstrated on traits included weaning weight (i.e. LMWLW and TLWW). Similar to our findings, significant effects of ewe age at lambing and lambing year on reproductive traits of sheep have been reported in literature *(Hanford et al., 2006; Vatankhah et al., 2008; Mokhtari et al., 2010, Rashidi et al., 2011; Mohammadi et al., 2012; Mohammadi et al., 2013; Amou Posht-e- Masari et al., 2013; Nabavi et al., 2014).*

Univariate analysis

Variance components and genetic parameters for reproductive traits are presented in Table 3. Response to direct selection for litter size is limited by low heritability of the trait, due to its discrete phenotypic expression *(Hill, 1985).* Heritability estimates for litter traits were low. They were 0.05 and 0.02 for LSB and LSW, respectively. Heritability estimates for litter traits obtained in the current study are close to those of *Ekiz at al. (2005)* for LSB in the Turkish Merino Sheep and *van Wyk et al. (2003); Cyhan et al. (2009)* and *Rashidi et al. (2011)* for LSW in Dormer, Sakiz and Moghani sheep breeds, respectively. However, they are lower than those reported for LSB in other sheep breeds, such as Katahdin *(Vanimisetti et al., 2007),* Boer *(Zhang et al., 2009),* Moghani *(Rashidi et al., 2011),* and Ghezel *(Nabavi et al., 2014).* Moreover, reported heritability for LSW in Turkish Merino, Lori-Bakhtiari, Boer and Makooei sheep reported by *Ekiz et al. (2005), Vatankhah et al. (2008), Zhang et al. (2009)* and *Mohammadi et al. (2012)* was 0.0430, 0.06, 0.10, 0.06, respectively. These findings indicate that, the loss of lambs from birth to weaning is mainly affected by environmental factors and lamb’s genotype rather than ewe’s genotype.

The value obtained for heritability of LMWLB (0.13) was in accordance with the study of *Mokhtari et al. (2010).* Nonetheless, higher estimates have been reported by some authors *(Vatankhah et al., 2008; Rashidi et al., 2011; Amou Posht-e- Masari et al., 2013).* Our finding for heritability of LMWLW (0.12) corresponded to those reported by *Vanimisetti et al. (2007); Vatankhah et al. (2008)* and *Mohammadi et al. (2013)*; also, lower and higher estimates were recorded by *Rashidi et al. (2011)* and *Mokhtari et al. (2010)*, respectively.

Without considering litter size at birth, the ewe capacity to produce lamb weight at birth is measured by total litter weight at birth per ewe lambing. The heritability of TLWB was estimated to 0.04, in consistence with the studies of *Ekiz et al. (2005)* and *Shiotsuki et al. (2014).* Higher values were reported by several authors *(Zhang et al., 2009; Mokhtari et al., 2010; Rashidi et al., 2011; Mohammadi et al., 2013; Nabavi et al., 2014)*, also. The combined influences of reproduction and pre weaning growth are considered as total litter weight at weaning. In agreement with the study of *Rashidi et al. (2011)*, the estimate of heritability of TLWW was 0.06. Heritability estimates for this trait varied from 0.0255 to 0.195 in different studies *(Rosati et al., 2002; Matika et al., 2003; vanWyk et al., 2003; Ekiz et al., 2005; Mokhtari et al., 2010; Amou Posht-e-Masari et al., 2013; Nabavi et al., 2014; Shiotsuki et al., 2014). Mohammadi et al.*

(2013) estimated heritability of this trait in Zandi sheep at 0.14 (i.e. higher than found in this study). Low heritability of reproductive traits is probably due to the greater proportional influence of environmental effects *(Turner and Young, 1969)*, thus their improvement by selection would be difficult even though they have great economic importance.

Table 3. Estimates of variance components and genetic parameters for reproductive traits.

Traits [a]	σ^2_a	σ^2_{pe}	σ^2_e	σ^2_p	h^2_d ± S.E.	pe^2 ± S.E.	r
LSB	1.152	0.711	19.771	21.634	0.05 ± 0.02	0.03 ± 0.01	0.08
LSW	0.587	1.129	25.673	27.389	0.02 ± 0.02	0.04 ± 0.01	0.06
LMWLB	5.146	1.595	32.468	39.209	0.13 ± 0.02	0.04 ± 0.01	0.17
LMWLW	2.247	0.761	15.420	18.428	0.12 ± 0.02	0.04 ± 0.02	0.16
TLWB	1.112	2.768	23.350	27.230	0.04 ± 0.02	0.10 ± 0.02	0.14
TLWW	2.250	5.088	27.879	35.217	0.06 ± 0.02	0.14 ± 0.02	0.21

σ^2_a: direct genetic variance, σ^2_{pe}: permanent environmental variance, σ^2_e: residual variance, σ^2_p: phenotypic variance, h^2_d: direct heritability, pe^2: ratio of permanent environmental variance on phenotypic variance, r: repeatability, S.E: standard error

LSB: Litter size at birth, LSW: litter size at weaning, LMWLB: litter mean weight per lamb born, LMWLW: litter mean weight per lamb weaned, TLWB: total litter weight at birth, TLWW: total litter weight at weaning

Similar to the findings reported by several authors *(Vatankhah et al., 2008; Mokhtari et al., 2010; Rashidi et al., 2011; Mohammadi et al., 2012; Amou Posht-e- Masari et al., 2013; Mohammadi et al., 2013)*, the most appropriate models in the current study included both direct genetic and permanent environmental effects related to the ewes.

The estimated fraction of variance due to permanent environmental effects were lower than the estimates of direct genetic effects, ranging from 0.03 to 0.14, suggesting that additive genetic effects are more important, totally. These fractions for reproductive traits in Zandi sheep reported by *Mohammadi et al. (2013)* ranged from 0.03 to 0.08. Our results were compatible with the reports of *Vatankhah et al. (2008)*, generally. Results showed that composite traits were more affected by permanent environmental effects and environmental factors such as nutrition and management. Consequently, the repeatability values observed in this study ranged from 0.06 to 0.21 that were congruent with the studies of *Vatankhah et al. (2008)*, *Mokhtari et al. (2010)* and *Mohammadi et al. (2013)*. Current findings indicate that environmental factors have a highly significant effect on the expression of reproductive traits.

Bivariate analysis

Estimates of correlations are presented in Table 4. The estimate of genetic correlation between litter traits was positive in sign, high in magnitude, despite the traits having low heritability; which is consistent with the studies of *Rashidi et al. (2011)* and *Mohammadi et al. (2012)*. Lower values were reported by some researchers *(Vatankhah et al., 2008; Mokhtari et al., 2010; Amou Posht-e- Masari et al., 2013).* Obtained negative genetic- and phenotypic correlations of both litter traits with litter mean weight traits indicate that lambs born as single tend to be heavier than twins and is an indication that selection for large litter size would be accompanied by a reduction in litter mean weight traits. Positive and high genetic correlations were observed between litter traits with composite traits, similar to those of Zandi sheep reported by *Mohammadi et al. (2013).* These findings could be explained by the fact that the ewes with more number of lambs born in each litter would have a heavier total weaning weight and indicate that indirect selection for each trait will cause an improvement in the other traits. The genetic correlation estimates between litter mean weight traits and composite traits were 0.83, 0.93 and 0.41, respectively, showing that the ewes having lambs with heavier mean birth weight are likely to produce more TLWB and TLWW. As TLWB has high genetic correlation with other reproductive traits (Table 4), selection for reproductive traits could be performed through it. The high genetic correlation (0.82) between composite traits showed that genes controlling the litter size and their weight at birth might control milk production and mothering ability of dams from birth to weaning, also. Similar results were obtained by the studies of *Vatankhah et al. (2008); Mohammadi et al. (2013)* and *Amou Posht-e- Masari et al. (2013).*

Table 4. Correlation estimates among reproductive traits

Trait[a] 1	Trait 2	r_{g12}[b]	r_{p12}	r_{pe12}	r_{e12}
LSB	NLAW	0.71	0.12	0.73	0.25
LSB	LMWLB	-0.45	-0.08	0.77	0.22
LSB	LMWLW	-0.82	-0.24	0.82	0.06
LSB	TLWB	0.94	0.52	0.95	0.14
LSB	TLWW	0.81	0.36	0.84	0.09
LSW	LMWLB	-0.64	-0.33	0.28	0.07
LSW	LMWLW	-0.31	-0.35	0.34	0.22
LSW	TLWB	0.37	0.15	0.85	0.04
LSW	TLWW	0.87	0.36	0.77	0.22
LMWLB	LMWLW	0.83	0.08	0.79	0.05
LMWLB	TLWB	0.93	0.25	0.93	0.12
LMWLB	TLWW	0.41	-0.06	0.84	0.12
LMWLW	TLWB	0.46	0.17	0.66	0.07
LMWLW	TLWW	0.51	0.11	0.86	0.13
TLWB	TLWW	0.82	0.34	0.81	0.31

r_{g12}: genetic correlation between trait 1 and trait 2, r_{p12}: phenotypic correlations between traits 1and 2, r_{pe12}: permanent environmental correlations between traits 1and 2, $r_{e\,12}$: environmental correlations between traits 1and 2.
LSB: Litter size at birth, LSW: litter size at weaning, LMWLB: litter mean weight per lamb born, LMWLW: litter mean weight per lamb weaned, TLWB: total litter weight at birth, TLWW: total litter weight at weaning

Low- and negative (in some cases) phenotypic correlations between studied traits were observed. Permanent environmental correlations between traits were positive and medium to high, but higher than genetic correlations, generally. The main objective of selection is to produce heavier lambs at weaning for the sheep meat industry. To reach this aim, the selection index should include litter traits and composite traits. Similar correlations for Moghani and Zandi sheep breeds were reported by *Rashidi et al. (2011)* and *Mohammadi et al. (2013)*, respectively.

Estimation of genetic gain

Predictions of breeding values mean for litter traits of Arabi sheep in each year of birth are illustrated in Figs. 1 and 2. Also, estimations of realised annual genetic progress for the traits are demonstrated in Table 5. Fluctuations were observed during the 8-year period, but annual genetic trend of LSB (0.00025 lambs) was insignificant.

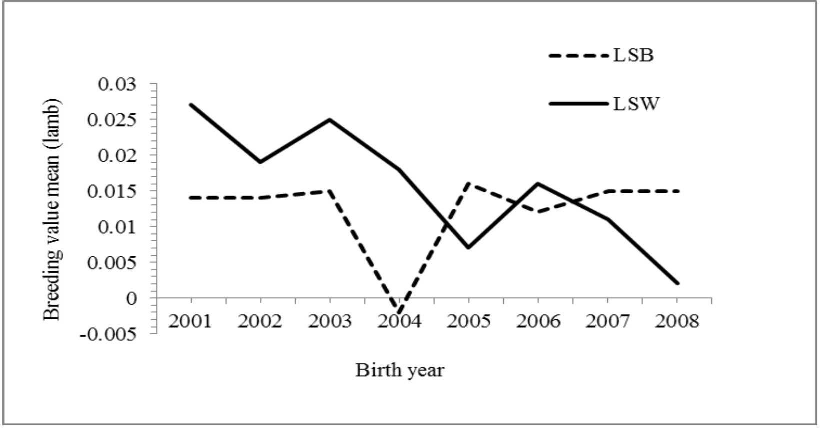

Fig. 1. Predictions of breeding values mean for litter traits of Arabi sheep by year of birth

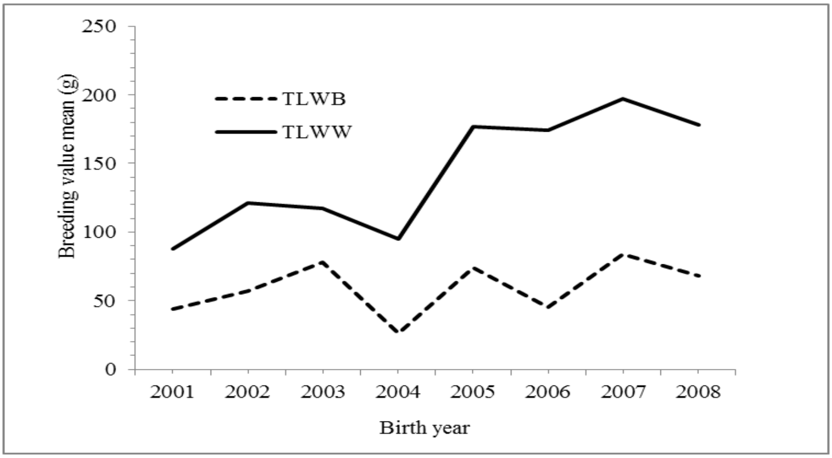

Fig. 2. Predictions of breeding values mean for composite traits of Arabi sheep by year of birth

This finding was compatible with the studies of *Vatankhah et al. (2007)* and *Savar Sofla et al. (2010).* Our estimate for annual genetic trend of LSW was negative and significant (-0.003 lambs. In contrast, an insignificant genetic trend was found by *Vatankhah et al. (2007).* However, *Hanford et al. (2002; 2005)* estimated the annual genetic trends of LSW as 0.3 and 0.4 head per year, for Columbia- and Rambouillet sheep breeds, respectively. In Fig. 2, substantial fluctuations were observed in annual genetic trend of composite traits. Positive and insignificant annual genetic trend was observed for TLWB (3 g), opposite to the study of *Savar Sofla et al. (2010).* Genetic trend varied from 0.5 to 3 per cent of phenotypic mean through selection within-breed in each year *(Smith, 1984).* In accordance with the aforementioned literature, annual genetic trend of TLWW should have become between 100 g to 600 g. Nonetheless, our estimate of genetic trend for TLWW (15.0 g) was higher than reported by *Savar Sofla et al. (2010).* There are few reports to compare the genetic trend of reproductive traits.

Table 5. Annual genetic, phenotypic and environmental trends for reproductive traits

reproductive traits	GT ± S.E.	R^2 (%)	PT ± S.E.	R^2 (%)	ET ± S.E.	R^2 (%)
LSB (lamb)	0.00025 ± 0.001 ^{ns}	1.0	0.007 ± 0.01 ^{ns}	5.8	0.007 ± 0.01 ^{ns}	4.8
LSW (lamb)	-0.003 ± 0.0007 *	73.8	0.007 ± 0.01 *	79.3	0.01 ± 0.01 ^{ns}	11.3
TLWB (g)	3 ± 3.1 ^{ns}	13.5	25.5 ± 72.0 ^{ns}	2.0	22.5 ± 74.0 ^{ns}	1.5
TLWW (g)	15 ± 3.6 *	74.5	-216.0 ± 267.4 ^{ns}	9.8	-231.1 ± 265.3 ^{ns}	11.2

GT: genetic trend, PT: phenotypic trend, ET: environmental trend, R^2: coefficient of determination, *: significant effect at $p < 0.05$, ^{ns}: non-significant ($p > 0.05$)
LSB: Litter size at birth, LSW: litter size at weaning, LMWLB: litter mean weight per lamb born, LMWLW: litter mean weight per lamb weaned, TLWB: total litter weight at birth, TLWW: total litter weight at weaning

Phenotypic least squares mean for reproductive traits are portrayed in Figs. 3 and 4 by year of birth. Phenotypic trend was only significant for LSW (0.007

lamb per year). Nevertheless, negative- and insignificant phenotypic trend was reported by *Savar Sofla et al. (2010)*. In contrast to our finding, phenotypic trend of LSB and composite traits were significant for Moghani sheep *(Savar Sofla et al., 2010)*. Annual environmental trends were non-significant for all traits.

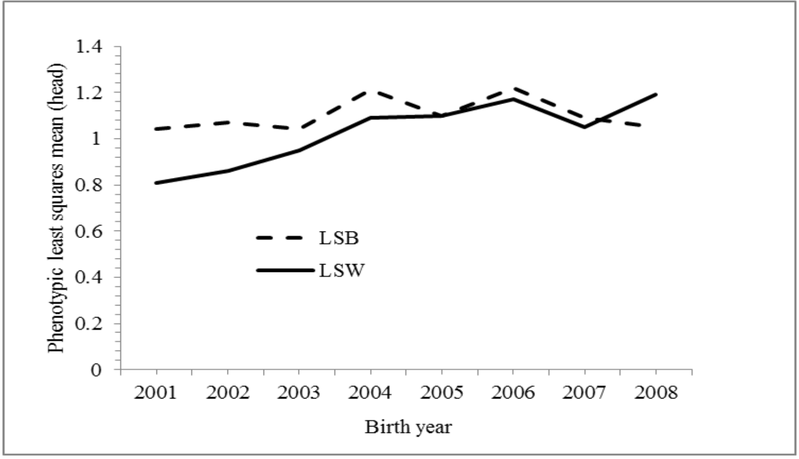

Fig. 3. Phenotypic least squares mean for litter traits of Arabi sheep by year of birth

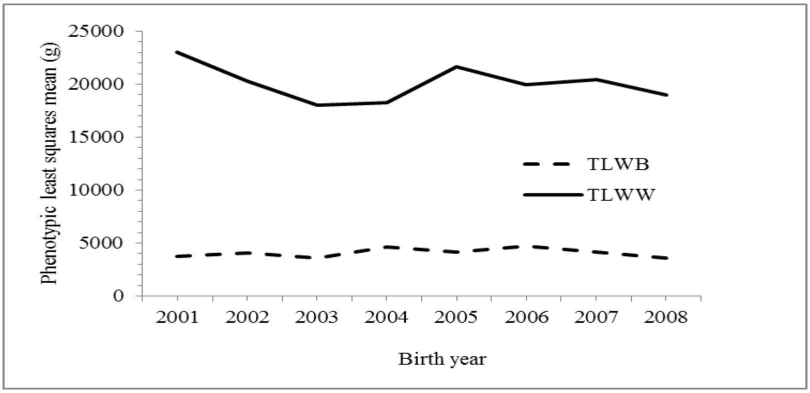

Fig. 4. Phenotypic least squares mean for composite traits of Arabi sheep by year of birth.

Conclusions

Low heritabilities for litter traits were found and might be partly attributed to their discontinuous distribution. A high coefficient of variation for LSW was found, suggesting that high selection differentials could be achieved in effective breeding programs. The genetic correlations between litter traits with composite traits were positive and moderate to high, indicating that selection would be done based on such traits. The insignificant or low genetic trends indicate that selection for the traits studied has been unsuccessful in Arabi sheep in recent years. There is room to improve the breeding program for Arabi sheep based on the genetic parameters estimated in this study.

Genetski parametri i genetski napredak reproduktivnih osobina arabi ovaca

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Rezime

Aktuelna studija, po prvi put, izveštava o genetskim parametrima i genetskim, fenotipskim i ekološkim korelacijama i trendovima reproduktivnih osobina ovaca rase arabi. Podaci su prikupljeni u Istraživačkoj stanici Khuzestan Ramin Univerziteta poljoprivrednih i prirodnih nauka (Animal Science Research Station of Khuzestan Ramin Agricultural and Natural Resources University - ASRSKRANRU), jugozapadno od Irana, u periodu od 2001. do 2008. godine. Veličina legla na rođenju (LSB), veličina legla na zalučenju (LSV), srednja masa legla po rođenom jagnjetu (LMVLB), srednja masa legla po zalučenom jagnjetu (LMVLV), ukupna težina legla na rođenju (TLVB) i ukupne težine legla na zalučenju (TLVV) u proseku su bile 1,11 jaganjadi, 1,01 jagnjadi, 3,83 kg, 19,43 kg, 4,16 kg i 20.12 kg, respektivno. Genetski parametri i korelacije su ocenjeni korišćenjem univarijatnog i bivarijatnog modela koji koriste ograničenu maksimalnu verovatnoću, priplodne vrednosti su procenjene korišćenjem BLUP-a i genetskih i fenotipskih trendova regresijom prosečnih priplodnih vrednosti ovaca i fenotipskih srednjih vrednosti najmanjih kvadrata u godini rođenja respektivno. Slučajnim uticajima su dodati aditivni direktni uticaj gena i stalnog okruženja ovaca, kao i uticaj oca, pored fiksnih uticaja starosti ovaca na jagnjenju i godine jagnjenja. Procena heritabiliteta od 0,05; 0,02; 0,13; 0,12; 0,04 i 0.06, i ponovljivosti od 0,08; 0,06; 0,17; 0,16; 0,14 i 0,21 za šest osobina, respektivno. Genetske korelacije između osobina su bile u rasponu od -0,82 do 0,94. Fenotipske korelacije su bile niže, u rasponu od -0,33 do 0,52. Procenjen godišnji genetski napredak je bio veoma nizak: -0.003 jagnjadi za LSV i 15 g za TLVV. Godišnji fenotipski trend je bio značajan samo za LSV, 0,007 jagnjadi. Zaključak istraživanja je da bi indirektna selekcija na osnovu ukupne težine legla na odbijanju mogla biti efikasna u slučaju ispitivanih osobina.

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