Iranian Journal of Applied Animal Science

Phenotypic and Genetic Factors Affecting on Reproductive Lifetime of Lori-Bakhtiari Ewes

Research Article

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Received on: 7 Jun 2014
Revised on: 10 Oct 2014
Accepted on: 15 Nov 2014
Online Published on: Mar 2016

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Online version is available on: www.ijas.ir

ABSTRACT

In this study phenotypic and genetic factors affecting the reproductive efficiency of Lori-Bakhtiari ewes were determined using 8202 reproductive records of 2478 ewes collected at Shooli research station in the southwestern part of Iran (Shahrekord) during 1989 to 2012. Reproductive efficiency over all consecutive lambing opportunities were calculated by adding the total reproductive efficiency traits per ewe joined for all of the parturition opportunities. Reproductive traits included in the current study were: number of parity (NP), total number of lambs born (TNLB), total number of lambs weaned (TNLW), total of lambs birth weight (TLBW), total of lambs weaning weight (TLWW), total of lambs weaning weight per kg ewe body weight (TLWW/EBW) and total of lambs weaning weight per kg metabolic ewe body weight (TLWW/MEBW). The data set analyzed with multi-trait animal model included the fixed effects of birth year of ewe, number of parturition in ewe's lifetime, ewe body weight as covariate and random effects direct additive genetic and residual. The overall mean of NP, TNLB, TNLW, TLBW, TLWW, TLWW/EBW and TLWW/MEBW were 3.31, 3.31, 3.21, 16.51 kg, 87.31 kg, 1.51 and 4.16, respectively. The effect of non-genetic factors were significant for all investigated traits in this study (P<0.01). The heritability estimates were medium (0.30) for NP and low (0.08 to 0.11) for other reproductive efficiency traits. The estimates of genetic and phenotypic correlations between the traits were high (0.72 to 0.99) or medium to high (0.57 to 0.99). Thus, improving environmental effects could make significant improvements in reproductive efficiency traits at first. The low to medium heritability estimate and high genetic correlations obtained between reproductive efficiency traits in ewe's lifetime and high phenotypic standard deviation from them indicated that improvement by selection of all of traits, especially NP can be improved TLWW as net reproductive efficiency trait in Lori-Bakhtiari ewes.

KEY WORDS ewe's lifetime, genetic parameters, reproductive efficiency.

INTRODUCTION

Improved ewe productivity is a major objective in the sheep industry and could be achieved by increasing the number of lambs weaned and weight of lambs weaned per ewe per year (Duguma *et al.* 2002). Evaluating the cumulative lifetime production of a group of ewes presents a good measure of the entire flock operation and improving the reproductive rate of the ewe flock offers one of the greatest single opportunities for increasing the efficiency of lamb production (Iman and Slyter, 1996). Improving reproductive performance increases productivity of the breeding ewe unit, more efficient use is made of available feed (proportionately less of the feed consumed is used for maintenance), more surplus animals are available for sale and greater selection pressure is available, increasing the potential for genetic gains (Langford *et al.* 2004). Different strategies, such as frequent lambing and high prolificacy of ewes or rapid growth rate of lambs, may be applied to increase sheep productivity. According to Snyman *et al.* (1997), the total weight of lamb weaned per year is the best single measure of a flock's productivity. There is relatively large phenotypic variation in total weight of lamb weaned regardless of the reproductive rate of the flock. They indicated that this variation may have a genetic basis and could, therefore, be exploited to genetically increase lifetime reproductive efficiency in any flock. Additionally, these individual traits can be combined by the total number of parturition to express the total apparent biological productivity in a ewe's lifetime. The lifetime ewe efficiency was reported as different indices such as total of lambs born and weaned in a lifetime, total of weight of lambs weaned in a lifetime and the ratio of lamb's weight to ewe weight (Qureshi, 1997; Duguma *et al.* 2002; Eküz *et al.* 2004; Lee *et al.* 2009; Mishra *et al.* 2009; Lobo and Lobo, 2010).

The Lori-Bakhtiari sheep breed is one of the most common native fat-tailed breeds in the southwestern parts of Iran (Zagros Mountains), with a population size of more than 1.7 million head. In this area, the animals are mostly kept in villages under semi intensive system with low productive efficiency. Due to this fact that reproductive traits are one of the most economically important traits in all sheep production systems (Gallivan, 1996; Vatankhah, 2005), therefore, any increase in these traits would have a detrimental impact on the success of sheep production. The phenotypic and genetic factors affecting on different reproductive ewe efficiency traits in total lifetime are necessary to improve profitability in rearing sheep under village system. Thus, this study was conducted to obtain such estimates for Lori-Bakhtiari ewes.

MATERIALS AND METHODS

Data and management

The data set used in this study consisted of 8202 records of reproductive traits during the lifetime of 2478 Lori-Bakhtiari ewes from 1989 to 2012 provided by Shooli research station in the southwestern part of Iran (Shahrekord). The pedigree information of the animals are summarized in Table 1.

The flock being managed under semi-migratory or village system (Vatankhah and Talebi, 2008) and were kept indoors at the station from December to May. During this period, the flock was fed with alfalfa, barley and wheat stubble (Vatankhah and Talebi, 2008). For the rest of the year the ewes were grazed on the range and cereal pastures. The breeding period extended from late August to late October, with a ratio of 20 to 25 ewes to each ram. The ewes typically begun lambing in late January. The lambs suckle their dams until 15 days of age and are then given *ad-libitum* access to creep feed and were weaned at a mean age of 90 ± 5 days.

Post weaning male and female lambs were separated and the female lambs were kept on the pasture of cultivated alfalfa, where as the male lambs were kept indoors until six months of age and fed an *ad-libitum* a ration composed of 45% alfalfa hay, 39% barley grain, 7% beet pulp, 8% cottonseed meal, 1% salt and mineral supplements which containing 13.5% crude protein (CP) and 2.5 Mcal ME/kg DM. The ewes were shearing in the second half of June and were selected on criteria generally related to the weaning weight of lambs (growth traits, total weaning weight per ewe expose and Kleiber ratio).

Traits

The traits evaluated in this study were reproductive efficiency over the lifetime of ewes, by adding up the total numbers of lambs weaned per ewe joined on all of consecutive lambing parturition opportunities (1 to 8). Ewes that failed to a lamb or did not wean a lamb, received zero for that year. The cumulative reproduction traits were evaluated for each ewe exposed to the ram during her lifetime included, number of parity (NP), (0 to 8), total number of lambs born per ewe (TNLB), (0 to 10), total number of lambs weaned per ewe (TNLW), (0 to 10), total of lamb birth weight (TLBW), total of lamb weaning weight (TLWW), total lamb weaning weight per kg of ewe body weight (TLWW/EBW) and total of lamb weaning weight per kg metabolic ewe body weight ($EBW^{0.75}$) in ewe's lifetime (TLWW/MEBW).

Statistical analysis

The GLM procedure of SAS (2004) was applied to identify important fixed effects affecting on reproductive efficiency traits in a ewe's lifetime using the following model.

$$y_{ijk} = \mu + A_i + B_j + B(EBW_{ijk} - EBW_{000}) + e_{ijk}$$

Where:
y_{ijk}: each of the observations.
μ: overall mean.
A_i: was the ith year of ewe birth (i=1988 to 2011).
B_j: effect of jth parturition in a ewe's lifetime (j=1 to 8) for all of the traits except number of parities in total ewe's lifetime.
b: linear regression coefficient of ewe body weight.
EBW_{ijk}: mean body weight of each ewe (kg).
EBW_{000}: overall mean for ewe body weight.
e_{ijk}: residual effects.

Least squares means were calculated for each trait and differences were compared using the multiple t-test with a

95% confindence interval and significances were stated at $P < 0.05$.

The lamb birth weight and weaning weight were corrected for gender of each lamb and the number of days to weaning.

Table 1 Summary of animal information available from pedigree records

Classification	Number	Classification	Number
Original	2752	Unknown sire	764
Post pruning	2721	Unknown dam	743
No records	243	Parents unknown	734
Records	2478	Sire	241
No offspring	1256	Dam	1224
With offspring	1465	Maternal grandsire	1529
With offspring and records	1222	Maternal granddam	1547

All of the significant (P<0.05) effect were and hence they were included in the animal model. (Co)variance components and genetic parameters of reproductive traits in a ewe's lifetime were estimated using the restricted maximum likelihood method (Meyer, 2013), fitting a multi-trait animal model as follows:

$$y_i = X_i b_i + Z_i a_i + e_i$$

Where:

y_i, b_i, a_i and e_i: vectors of observations, fixed effects, direct additive genetic effects, and residual random effects for the i^{th} trait, respectively.

Xi and Z_i: observations of the i^{th} trait to the respective fixed effects and additive genetic effects, respectively.

The average information (AI) REML algorithm was used to maximize the likelihood (convergence criterion was 10^{-8}) and additional restarts were performed until no further improvement in log likelihood occurred. The heritability estimated as the additive genetic variance divided by the phenotypic variance. The phenotypic and genetic correlations estimated as follows:

$$r_{px_ix_j} = \frac{\sigma_{px_ix_j}}{\sigma_{px_i}\sigma_{px_j}} \quad r_{gx_ix_j} = \frac{\sigma_{BVx_ix_j}}{\sigma_{BVx_i}\sigma_{BVx_j}}$$

Where:

$r_{px_ix_j}$, $\sigma_{px_ix_j}$, σ_{px_i} and σ_{px_j}: phenotypic correlation between i^{th} and j^{th} traits for $i \neq j$, phenotypic covariance between i^{th} and j^{th} traits, phenotypic standard deviation of the i^{th} trait and phenotypic standard deviation of the j^{th} trait, respectively.

$r_{gx_ix_j}$, $\sigma_{BVx_ix_j}$, σ_{BVx_i} and σ_{BVx_j}: genetic correlation between i^{th} and j^{th} traits for $i \neq j$, covariance between breeding values of the i^{th} and j^{th} traits, standard deviation of breeding values for the i^{th} trait and standard deviation of the breeding values for the j^{th} trait, respectively.

All the standard errors of the phenotypic and genetic parameters estimated as formulas described in the WOMBAT program manual (Meyer, 2013).

RESULTS AND DISCUSSION

The greatest frequency and percentage of ewes were first (1) and lowest in 8^{th} parity over their lifetime (Table 2). More than one half of the ewes (55.4%) completed three or fewer parities and 21.1 percent of the ewes that had only one parity over their lifetime before leaving the flock. The number of animals leaving the flock decreased continually between second and sixth parity, until only 0.5% of ewes remained in the flock on the eighth parity.

Table 2 Frequency and percentage of animals according parity number

Pariry (No.)	Frequency	Percent	Cumulative frequency	Cumulative percent
1	522	21.1	522	21.1
2	441	17.8	963	38.9
3	410	16.5	1373	55.4
4	406	16.4	1779	71.8
5	351	14.2	2130	86.0
6	261	10.5	2391	96.5
7	75	3.0	2466	99.5
8	12	0.5	2478	100

The overall mean of NP (No.) and TNLB (head) over the lifetime of the ewes (Table 3) were similar (3.31), due to survival rate below one between birth and weaning, whereas the TLNW decreased by 0.1 and was 3.21. The overall mean for TLWW as net reproductive efficiency was 87.3 kg. The ratio of kg of TLWW per kg ewe body weight was 1.5 and per kg metabolic ewe body weight calculated was 4.2. The variability (standard deviation) for all of the variables assessed was high, but was greatest for especially TLWW. All the ewe efficiency traits assessed were affected (P<0.01) by non-genetic factors such as year of birth, number of parity (except for NP) and body weight as covariate. The effect of year of birth was not presented, because there was no clear trend and it considered to be of less. All the ewe efficiency traits increased with increasing parity number. TNLB did not differ between ewes in their sixth and seventh, and seventh and eighth parities. Regression coefficients indicated that body weight of the ewes significantly (P<0.01) increased all the variables measured with the exception of TLWW/EBW and TLWW/MEBW (Table 3). The greatest coefficient of variation occurred in NP (45.6%) ranging from 28.2% to 33.8%, while the fixed model itself accounted for 30% of the variation in NP and between 74% and 82% of the variation in all other variables.

Table 3 Least squares means of different levels of some fixed factors in different ewe's reproductive efficiency traits

Trait	NP	TNLB	TNLW	TLBW	TLWW	TLWW/EBW	TLWW/MEBW
Overall Mean±SD	3.31±1.79	3.31±2.17	3.21±2.20	16.51±11.04	87.31±63.93	1.51±1.06	4.16±2.95
Year of birth	**	**	**	**	**	**	**
No. of parity	-	**	**	**	**	**	**
1	-	0.99±0.06^{g}	0.98±0.05^{g}	5.19±0.24^{g}	24.37±1.51^{g}	0.35±0.03^{g}	1.02±0.07^{g}
2	-	1.82±0.06^{f}	1.69±0.05^{f}	8.86±0.24^{f}	44.74±1.51^{f}	0.78±0.03^{f}	2.13±0.07^{f}
3	-	3.11±0.06^{e}	2.98±0.06^{e}	15.18±0.24^{e}	80.62±1.54^{e}	1.43±0.03^{e}	3.92±0.07^{e}
4	-	4.11±0.06^{d}	3.96±0.06^{d}	20.12±0.24^{d}	108.40±1.54^{d}	1.90±0.03^{d}	5.22±0.07^{d}
5	-	5.32±0.06^{c}	5.11±0.06^{c}	26.02±0.26^{c}	140.25±1.63^{c}	2.46±0.03^{c}	6.75±0.08^{c}
6	-	6.02±0.07^{b}	6.08±0.07^{b}	31.46±0.30^{b}	171.70±1.92^{b}	2.96±0.03^{b}	8.16±0.09^{b}
7	-	6.28±0.13^{b}	7.30±0.13^{a}	37.58±0.55^{a}	209.86±3.47^{a}	3.55±0.06^{a}	9.84±0.16^{a}
8	-	6.97±0.32^{a}	7.42±0.31^{a}	40.07±1.35^{a}	220.69±8.50^{a}	3.77±0.15^{a}	10.42±0.40^{a}
EBW (Co) variate	0.121±0.005**	0.017±0.004**	0.019±0.004**	0.164±0.017**	0.733±0.110**	-0.010±0.002**	-0.012±0.005*
R^2	0.30	0.74	0.77	0.82	0.79	0.78	0.78
% CV	45.56	33.79	33.13	28.18	33.46	33.09	33.06

NP: number of parity; TNLB: total number of lambs born in ewe's lifetime; TNLW: total number of lambs weaned in a ewe's lifetime; TLBW: total of lamb birth weight in a ewe's lifetime; TLWW: total of lambs weaning weight in a ewe's lifetime; TLWW/EBW: total of lambs weaning weight per ewe body weight (EBW) in a ewe's lifetime and TLWW/MEBW: total of lambs weaning weight per metabolic EBW ($EBW^{0.75}$) in a ewe's lifetime.
* (P<0.05) and ** (P<0.01).
SD: standard deviation and CV: coefficient of variation.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).

Table 4 Estimates of heritability (diagonal) and correlations (genetic under diagonal, phenotypic above diagonal) between ewe's reproductive efficiency traits

Trait	NP	TNLB	TNLW	TLBW	TLWW	TLWW/EBW	TLWW/MEBW
NP	**0.30±0.04**	0.80±0.01	0.83±0.01	0.87±0.01	0.84±0.01	0.85±0.01	0.85±0.01
TNLB	0.94±0.03	**0.08±0.03**	0.67±0.01	0.69±0.01	0.57±0.01	0.58±0.01	0.58±0.01
TNLW	0.92±0.03	0.98±0.10	**0.10±0.03**	0.81±0.02	0.80±0.01	0.80±0.01	0.80±0.01
TLBW	0.95±0.02	0.84±0.12	0.73±0.10	**0.08±0.03**	0.80±0.01	0.79±0.01	0.98±0.01
TLWW	0.93±0.02	0.75±0.15	0.74±0.09	0.74±0.11	**0.10±0.03**	0.98±0.01	0.99±0.01
TLWW/EBW	0.93±0.03	0.72±0.15	0.73±0.10	0.75±0.11	0.99±0.01	**0.11±0.03**	0.98±0.01
TLWW/MEBW	0.93±0.02	0.73±0.15	0.73±0.10	0.75±0.11	0.99±0.01	0.98±0.01	**0.11±0.03**

NP: number of parity; TNLB: total number of lambs born in ewe's lifetime; TNLW: total number of lambs weaned in a ewe's lifetime; TLBW: total of lamb birth weight in a ewe's lifetime; TLWW: total of lambs weaning weight in a ewe's lifetime; TLWW/EBW: total of lambs weaning weight per ewe body weight (EBW) in a ewe's lifetime and TLWW/MEBW: total of lambs weaning weight per metabolic EBW ($EBW^{0.75}$) in a ewe's lifetime.

The heritability was estimates as medium (0.30) in number of parity (NP) and low (0.08 to 0.11) for other reproductive efficiency traits (Table 4). The genetic correlation between NP and other lifetime reproductive efficiency traits were high (0.92 to 0.95). The estimates of genetic correlations between TNLB and TNLW were high (0.98), but lower 0.72 to 0.75 between TLNB and TNLW with other traits related to total of lamb birth weight and lambs weaning weight. The genetic correlation between TLBW with traits related to TLWW were lower than unity (0.74 to 0.75), while between TLWW and TLWW per kg ewe body weight and kg metabolic ewe body weight were near to 1 (0.98 to 0.99). The phenotypic correlations between all of considered traits were similar to genetic correlations and positive, but lower than genetic correlation which from medium to high (0.57 to 0.99).

The more than one half of the ewes (55.4%) achieved three parities or less in a total lifetime, indicating the potential to increase the NP that a ewe can complete in a lifetime. It has been reported that Kajli ewes replaced just after their first parturition imbalance of lambing frequency in this study and implies that there is potential to improve NP over a ewe's lifetime.

This pattern of frequency distribution which most of the ewes were replaced just after their first parturition (Qureshi *et al.* 1997) and the data in this study showed that 35% of the Kajli ewes were replaced after first parturition, and that, from second parity onwards, the rate of ewe replacement decreas up until 6th parity, followed by which were replaced at a faster rate mainly due to older age. This indicates that the cause of ewe culling, especially in first parity animals is worth investigation to eliminate factors that could be applied to increase ewe longevity above the mean NP found in this study (3.31). The mean number of parities Najdi and Awassi ewes complete have been reported to be 3.3 and 4.1 parities respectively (Abdelqader *et al.* 2012) indicating similar and greater longevity to the Lori-Bakhtiari ewes in this study. One possible interpretation is that Awassi ewes could utilize the opportunity of multiple exposures better than Lori-Bakhtiari ewes in accelerated lambing systems, because the number of parities over a ewe's lifetime could be improved by increased longevity and out of season lambing. The overall means TNLB (3.31) and TNLW (3.21) obtained in this study were higher than a TNLB of 2.22 and TNLW of 1.88 reported for the Carnarvon Merino flock (Snyman *et al.* 1997) over three lambing opportunities, but were lower than a TNLB of 5.2 and TNLW of 4.1 reported in Merino ewes (Duguma *et al*. 2002) and it was reported that multiple born ewes were superior to singles in both the TNLB and TNLW.

The mean TLBW reported by Eküz *et al*. (2005) for Turkish Merino ewes was 25.61 kg, while the TLBW in this study as lower at 16.51 kg and the mean TLWW of 87.31 kg, used as a net reproductive efficiency was also lower than the 198 kg reported in Rambouillet and Targhee ewes (Ercanbrack *et al*. 1989), 121.97 kg (Snyman *et al*. 1997) and 92.6 kg reported in Merino ewes, over four lambing opportunities (Duguma *et al*. 2002) and 162.47 kg from Turkish Merino ewes (Eküz *et al*. 2005). This greater production is due to a greater number of lifetime parturition opportunities and greater litter size at birth and weaning in these breeds compared with Lori-Bakhtiari ewes. However, the ratio of kg of litter weaning weight per kg ewe body weight (TLWW/EBW) and kg metabolic ewe body weight (TLWW/MEBW) are better measures of the lifetime efficiency of ewes. While, a number of variations of this ratio have been adopted, the most commonly used has been the metabolic weight, which favors smaller ewes. This is important because heavier ewes produce heavier lambs at birth and at weaning (Ray and Smith, 1966) and the selection for litter weaning weight increases the mature weight of ewes. However, large ewes such as Lori-Bakhtiari present a most expensive maintenance cost.

The differences between years may be attributed to variation in the environmental conditions, affecting feed availability and other management factors. Whereas, the effects of the birth year of ewe, number of parturitions (except for NP) and ewe body weight on reproductive efficiency have been reported for Merino ewes (Duguma *et al*. 2002; Eküz *et al*. 2005) and were found in ewes in this study to be significant. The significant influence of ewe live weight on productivity traits, confirm earlier suggestion by Cloete and Heydenrych (1986); Cloete and Heydenrych (1987b). They indicated that selection of an increased two-tooth ewe live weight (at about 1.5 yrs of age) may be associated with an increase in reproduction rate in Merino sheep. The lack of significant differences observed in this study for most of the considered traits, with the except of NP between the sixth and seventh parity and seventh and eighth parity can be attributed to the large standard errors due to the low number of ewes in these groups.

In Mule ewes (Mekkawy *et al*. 2009) reported 0.27, which was similar to heritability estimated for NP. 30) in this study, but higher than 0.08 to 0.10 from multiple trait analyses with other traits in Polypay (Borg, 2007). Heritability estimates for TNLB (0.08) and TNLW (0.10) found in the current study were close to 0.08 and 0.04 in Dorset (Brash *et al*. 1994a), 0.06 and 0.04 in Corriedale (Brash *et al*. 1994b), 0.09 and 0.04 in Hyfer (Fogarty *et al*. 1994), but lower than 0.26 and 0.17 found in Afrino (Snyman *et al*. 1998b), 0.23 and 0.17 in Merino (Olivier *et al*. 2001), 0.23 and 0.17 in Merino (Duguma *et al*. 2002). Cloete and Heydenrych (1987a) reported estimates ranging between 0.29 and 0.36 for total number of lambs born and weaned per ewe that conceived over four lambing opportunities in a flock of Tygerhoek Merino, using half-sib analysis. Fogarty (1995) indicated that REML estimates of heritability were lower, but might be regarded as more reliable than earlier estimates for these traits. In his review, Fogarty (1995) reported a mean lifetime heritability estimate of 0.14 for total number of lambs born per lambing opportunity using REML procedures and fitting an animal model. Heritability estimates for TLWW of 0.06 in Hyfer (Fogarty *et al*. 1994) and 0.13 in Merino (Snyman *et al*. 1998a; Snyman *et al*. 1998b), which were similar to that (0.10) found in this study, but were lower than 0.22 in Merino (Snyman *et al*. 1997), 0.17 in Afrino (Snyman *et al*. 1997), 0.19 in Merino (Olivier *et al*. 2001), 0.21 in Merino (Olivier *et al*. 2001), 0.15 in Merino and 0.20 in Merino (Duguma *et al*. 2002). The heritability estimated by Lobo and Lono (2010) reported for TLWW/EBW and TLWW/MEBW of 0.10, which was close the 0.11 found in this study. In general, the heritability estimates obtained in the present study indicate that there is low scope for genetic improvement if selection is based on either of the traits considered.

The high genetic correlation (0.92 to 0.95) between NP and other reproductive efficiency traits would be expected due to the fact that NP forms part in the calculation of all other traits. There are however no comparative estimates between NP and other considered traits could be found in the literature. These high genetic correlations indicated that increasing NP by lambing in out of season and improving longevity of ewes could improve reproductive efficiency in a ewe's lifetime. The genetic correlation close to unity between TNLB and TNLW obtained in this study was higher than the value (0.62) reported by Duguma *et al*. (2002). This high genetic correlation between them could be expected because the twinning rate in this breed of sheep was not high and the survival rate of lambs born up to weaning was high. The estimated genetic correlation between TNLW and TLBW, TLWW, TLWW/EBW and TLWW/MEBW were high (0.73 to 0.74) and positive. These estimates were lower than those ranging from 0.97 to 0.98 reported between the TNLW and TLWW by Olivier *et al*. (2001) for the Grootfontein and the Carnarvon Merino flocks and the estimate of 0.84 reported by Snyman *et al*. (1998b) for Afrino ewes. The lower estimates for genetic correlations between TNLW and TLWW from the values reported in the literature could be attributed to low twinning rate in Lori-Bakhtiari ewes. The high genetic correlations close to unity between TLWW, TLWW/EBW and TLWW/MEBW indicate that TLWW/MEBW could be used as selection criteria to indirectly improve both TLWW and TLWW/EBW without increasing EBW and energy requirements for ewe's maintenance. The estimate of high and positive genetic correlation (0.74) between TLBW and TLWW indicated that selection for one of them was likely to affect the other one, but due to estimate of genetic correlation lower than unity between them, there was an opportunity to improve TLWW without large improvement in TLBW for avoiding dystocia. The medium to high and positive phenotypic correlations between considered traits indicate that phenotypic changes between traits were similar to genetic changes but by slightly lower rate. In general, the high genetic and phenotypic correlations obtained between these reproductive efficiency traits in a ewe's lifetime indicated that improvement from selection of all traits, especially NP can be achieved in TLWW as net reproductive efficiency trait in this flock.

CONCLUSION

The reproductive efficiency traits were low due to low lambing and the twining rates during the lifetime of ewes. Factors, other than genetic variation, accounted significant variation in reproductive efficiency and improvement in nutrition and management (environmental effects) could increase reproductive efficiency significantly. Low to medium heritability estimates obtained in this study indicated that there was little scope for improvement ewe performance through genetic selection based on the majority of traits considered. However, medium heritability estimate for NP and high genetic and phenotypic correlations and standard deviation indicated that improvement reproductive efficiency traits especially NP could be improve TLWW.

ACKNOWLEDGEMENT

I am grateful to the head and all of the coworker in Sholi station to collect the data and allowed me to use them.

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