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Full Length Research Paper

Evaluation of phenotypic and genetic parameters for ewe production traits of Lohi sheep in Pakistan

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The aims of the study were to investigate the fixed effects which are considered to influence ewe productivity and to estimate the genetic parameters for ewe productivity traits of Lohi sheep. Genetic parameters were estimated by restricted maximum likelihood (REML) procedure using the GENSTAT program. The effects of year and age of ewe were significant for fertility, litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB) and litter weight at weaning (LWW). The least squares means of fertility, LSB, LSW, LWB and LWW were 0.904, 1.422, 1.358, 6.689 kg and 41.577 kg, respectively. The means of total number of lambs born (TLB), total number of lambs weaned (TLW), total birth weight of lambs (TWB) and total weight of lambs weaned (TWW) per ewe over four lambing opportunities were 5.48, 5.25, 25.61 kg and 162.47 kg, respectively. Estimates of heritability for fertility, LSB, LSW, LWB and LWW were 0.0250, 0.0533, 0.0430, 0.0462 and 0.0255, respectively; and estimates of repeatability for these traits were 0.1242, 0.0787, 0.0772, 0.0882 and 0.0715, respectively. The low estimates of heritability and repeatability obtained in the current study for ewe productivity traits indicate that selection based on the ewe's own performance may result in slow genetic improvement.

Key words: Genetic parameter, litter size, ewe productivity.

INTRODUCTION

The Lohi breed is the biggest and most productive of all the breeds of sheep in Pakistan. It comprises some 40% of the Punjab and 15% of the national sheep production (Government of Pakistan, 2009). The Lohi breed belongs to the irrigated areas of the central Punjab but is wide-spread in other regions of the province also. There is a wide diversity in various production traits of this breed which suggests that there is a great scope for improvement of performance traits. This diversity in performance traits could be due to several genetic and environmental influences. The greatest part of the income in sheep farming is supplied through lamb production. Efficiency of lamb production is controlled by reproduction, mothering ability and milk production of the ewe, as well as growth rate and survival of the lamb (Rao and Notter., 2000).

Production of a ewe may be measured by litter size at birth, litter size at weaning or litter weight of lambs weaned per ewe lambing (More O'Farrell, 1975). The aim of lamb production is to produce slaughter lambs that can be marketed as soon as possible after weaning. 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). The litter weight of lambs weaned per ewe lambing combines ewe's fertility, litter size at birth, survival rate and growth performance of lambs from birth to weaning; therefore this trait is the most important factor in determining a ewe's productivity and the economic efficiency of a lamb enterprise (Deligiannis and Lainas, 2000).

The calculation of lifetime ewe productivity involves some difficulties, since the number of years used in production per ewe is different. Snyman et al. (1997) and Duguma et al. (2002) reported that that the first four

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lambing opportunities of a ewe could be taken as an indication of lifetime reproductive performance in ewes. Numerous genetic parameter estimates for ewe productivity traits have already been reported for several sheep breeds (Snyman et al., 1997; Duguma et al., 2002; Van Wyk et al., 2003).

However, it is essential to estimate genetic parameters accurately for use in the formulation of breeding plans for a specific flock. Reports on estimates of genetic parameters for ewe productivity of local sheep were limited, and were based on the paternal half-sib method Yalcin et al. (1972). The objectives of the current study were to evaluate the fixed effects which are considered to influence the ewe productivity, and to estimate the genetic parameters for ewe productivity traits in Lohi sheep.

MATERIALS AND METHODS

Data and pedigree information for Lohi sheep used in this study were collected at Livestock Production Research Institute, Bahadurnagar, Okara from 2004 to 2010. All ewes were bred to rams for the first time at an average age of 18 months. Hand mating was applied once a year between June 15th and July 30th in different years and continued for 40 to 45 days in individual years. All lambs were weighed and ear tagged within 12 h of birth. The lambs were kept together with their dams in individual boxes for the first three days after birth. Then a flock composed of suckling lambs and their dams was formed. All lambs were weaned on the same day (within each year), when lambs averaged approximately 90 days of age. Individual weaning weight was adjusted to 90 days of age, using individual birth weight and average daily gain from birth to weaning. The traits analysed were fertility, litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB) and litter weight at weaning (LWW). In addition, the first four lambing opportunities of a ewe were used to indicate lifetime reproduction, and total number of lambs born (TLB), total number of lambs weaned (TLW), total birth weight of lambs (TWB) and total weight of lambs weaned (TWW) per ewe; over four lambing opportunities were used as lifetime productivity traits.

The ewes used in the study were the progeny of 718 dams females and 142 sires males for fertility, and the progeny of 681 dams and 137 sires for LSB, LSW, LWB and LWW. A fertility score of 1 or 0 was assigned to ewes that lambed or did not lamb, respectively. LSB was the number of lambs born per ewe lambing (1, 2 or 3). LSW was the number of lambs weaned per ewe lambed (0, 1, 2 or 3). LWB was the sum of birth weights of lambs born for each ewe lambing. LWW was the sum of adjusted 90^{th} day weights of all lambs per ewe lambed. In the calculation of LWB and LWW for each ewe within specific lambing year, firstly, the contrast values for sex of lambs for birth and weaning weights of lambs were determined by least squares procedures. Individual birth and weaning weights of lambs were than corrected according to these values. Finally, these adjusted birth and weaning weights were used to calculate the LWB and LWW for each ewe within specific lambing year.

In the calculation of lifetime productive performance, only data from ewes, which had four consecutive lambing opportunities, were used. Least squares procedures were used to analyse data on ewe performance traits. The initial model used in the analyses of fertility, LSB, LSW, LWB and LWW included fixed effects of year, age and year-age interaction. The initial model used for LWB and LWW also included random effect of ram. Year-age interaction for LSB, LSW, LWB and LWW, and random effect of ram on LWW were not significant; therefore these effects were excluded from the final mathematical model used in the analyses. One-way ANOVA was used to analyses TLB, TLW, TWB and TWW. The significance controls of the differences between the sub-factors were determined by Duncan's test. SPSS was used for the analyses of phenotypic parameters. Genetic parameters for fertility, LSB, LSW, LWB and LWW were estimated by REML procedure using the GENSTAT Program. Since the number of animals with records for TLB, TLW, TWB and TWW was inadequate, genetic parameters for these traits could not be estimated. The animal model used to estimate the variance components was

$$Y = X\beta + Z_a a + Z_{pe} pe + e$$

where Y is the vector of observations; β, a, pe, and e(Error) are vectors of fixed effects (year, age), direct additive genetic effects (animal = ewe), permanent environmental effects and the residual effects, respectively; and X, Z_a, and Z_{pe} are incidence matrices relating observations to a and pe, respectively. Heritability was estimated by dividing direct additive genetic variance by phenotypic variance and repeatability was estimated from the ratio between the sum of direct additive genetic and permanent environmental variances and phenotypic variance (Matos et al., 1997; Analla et al, 1996).

RESULTS

The least squares means and standard errors of fertility, LSB and LSW, and LWB and LWW of Lohi sheep are presented in Tables 1 and 2, respectively. The effects of year and age of ewe were significant for fertility, LSB, LSW, LWB and LWW.

There was a less tendency for the productivity of ewes to improve with age, generally reaching a maximum between four and seven years of age for ewes. The effect of interaction between year and age of ewe on fertility was significant whereas it was non-significant for LSB, LSW, LWB and LWW. The random effect of ram was significant for LWB, but non-significant for LWW (El Fadili et al 2000; Kumar et al 1993; Lee et al., 2000).

The means and standard errors of TLB, TLW, TWB and TWW per ewe over four lambing opportunities of Lohi sheep are presented in Table 3. TLB, TLW, TWB and TWW for Lohi ewes were 5.48, 5.25, 25.61 kg and 162.47 kg, respectively. The effect of production years on TLB, TLW and TWW were significant and the lowest performances for these traits were recorded in production periods of 2004 to 2007. Estimates of variance components and genetic parameters for fertility, LSB, LSW, LWB and LWW of Lohi ewes are presented in Table 4. Estimates of direct additive genetic variance varied from 0.0023 in fertility to 5.5951 in LWW. Error variances were the most important source of variation for ewe productivity traits, and this result indicates that environmental factors have a highly significant effect on the expression of these traits. Estimates of heritability for fertility, LSB, LSW, LWB and LWW were 0.0250, 0.0533, 0.0430, 0.0462 and 0.0255, respectively, and estimates of repeatability for these traits were 0.1242, 0.0787,

Table 1. The least squares means (LSM) and standard errors (SE) of fertility, litter size at birth (LSB) and litter size at weaning (LSW) of Lohi Sheep.

Year	Factors investigated								
	Fertility			LSB			LSW		
	n	LSM	SE	n	LSM	SE	n	LSM	SE
2004	515	0.852^{d}	0.014	417	1.356^{d}	0.024	417	1.306^{bc}	0.026
2005	486	0.865^{cd}	0.015	417	1.354^{d}	0.024	417	1.292^{c}	0.026
2006	471	0.900^{bc}	0.016	421	1.406^{cd}	0.024	421	1.329^{b}	0.026
2007	518	0.947^{a}	0.017	478	1.424^{bc}	0.023	478	1.369^{ab}	0.025
2008	483	0.909^{ab}	0.016	436	1.472^{ab}	0.023	436	1.408^{a}	0.025
2009	474	0.921^{ab}	0.017	424	1.453^{abc}	0.024	424	1.369^{ab}	0.026
2010	489	0.938^{ab}	0.017	454	1.487^{a}	0.023	454	1.432^{a}	0.025
Age									
2	963	0.832^{c}	0.01	800	1.177^{c}	0.017	800	1.101^{c}	0.019
3	786	0.877^{b}	0.011	692	1.380^{b}	0.018	692	1.326^{b}	0.02
4	606	0.916^{a}	0.013	551	1.492^{a}	0.020	551	1.421^{a}	0.022
5	480	0.917^{a}	0.014	441	1.507^{a}	0.023	441	1.428^{a}	0.025
6	351	0.939^{a}	0.017	328	1.496^{a}	0.027	328	1.446^{a}	0.029
7	250	0.945^{a}	0.021	235	1.479^{a}	0.031	235	1.424^{a}	0.034
Year * Age		***			**			**	
Overall mean	3436	0.904	0.006	3047	1.422	0.009	3047	1.358	0.01

a, b, c, d : The differences among the means of groups carrying various letters in the same column are significant; ***, P < 0.001, **, P > 0.05.

Table 2. The least squares means (LSM) and standard errors (SE) of litter weight at birth (LWB) and litter weight at weaning (LWW) of Lohi sheep.

Year	Factors investigated					
	LWB (kg)			LWW (kg)		
	n	LSM	SE	n	LSM	SE
2004	413	6.492^{bc}	0.161	417	36.278^{e}	0.736
2005	416	6.389^{c}	0.162	417	39.232^{d}	0.739
2006	413	6.903^{ab}	0.142	421	41.322^{cd}	0.742
2007	475	6.588^{bc}	0.132	478	45.300^{a}	0.703
2008	431	6.968^{a}	0.139	436	43.478^{ab}	0.731
2009	417	6.501^{bc}	0.148	424	41.848^{bc}	0.742
2010	451	6.983^{a}	0.168	454	43.584^{ab}	0.722
Age						
2	789	5.187^{c}	0.087	800	32.465^{c}	0.534
3	685	6.447^{b}	0.091	692	40.584^{b}	0.574
4	547	7.033^{a}	0.099	551	44.000^{a}	0.64
5	438	7.222^{a}	0.108	441	43.783^{a}	0.715
6	323	7.224^{a}	0.123	328	45.361^{a}	0.828
7	234	7.022^{a}	0.14	235	43.272^{a}	0.981
Year * Age		**			**	
Ram (Random)					**	

a, b, c, d, e: The differences among the means of groups carrying various letters in the same column are significant; * P < 0.05; *** P < 0.001, **: P > 0.05.

Table 3. The means and standard errors (SE) of total number of lambs born (TLB), total number of lambs weaned (TLW), total birth weight of lambs (TWB) and total weight of lambs weaned (TWW) per ewe over four lambing opportunities of Lohi sheep.

Years	No.	Production							
		TLB		TLW		TWB		TWW	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
2004-2007	50	5.24^{b}	0.15	4.96^{b}	0.18	25.0^{b}	0.65	146.04^{b}	5.04
2005-2008	39	5.59^{ab}	0.15	5.51^{a}	0.16	26.41^{b}	0.65	146.04^{b}	4.75
2006-2009	47	5.32^{ab}	0.15	5.09^{ab}	0.15	24.82^{ab}	0.54	146.04^{b}	4.67
2007-2010	64	5.72^{a}	0.13	5.44^{a}	0.14	26.12^{a}	0.49	168.00^{a}	4.14
Total	**200**	**5.48**	**0.07**	**5.25**	**0.08**	**25.61**	**0.29**	**162.47**	**2.42**

$^{a,\,b}$: The differences among the means of groups carrying various letters in the same column are significant ($P < 0.05$).

Table 4. Estimates of variance components and genetic parameters for fertility, litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB) and litter weight at weaning (LWW).

Error	Fertility	LSB	LSW	LWB	LWW
σ^2_A	0.0023	0.0122	0.0116	0.1675	5.5951
σ^2_{PE}	0.0094	0.0058	0.0092	0.1524	10.0846
σ^2_E	0.0823	0.2107	0.2487	3.3068	203.622
σ^2_P	0.0942	0.2287	0.2694	3.6268	219.302
h^2	0.025 (0.021)	0.0533 (0.0269)	0.043 (0.0257)	0.0462 (0.0231)	0.0255 (0.022)
pe^2	0.1005 (0.0342)	0.0252 (0.0284)	0.0342 (0.0292)	0.042 (0.0267)	0.046 (0.0274)
r	0.1242	0.0787	0.0772	0.0882	0.0715

σ^2_A, Direct additive genetic variance; σ^2_{PE}, permanent environmental variance, σ^2_E, error variance; σ^2_P, phenotypic variance; h^2, heritability; pe^2, σ^2_{PE}/σ^2_P; r, repeatability.

0.0772, 0.0882 and 0.0715, respectively.

DISCUSSION

In the current study, in which the phenotypic and genetic parameters of ewe productivity traits were investigated, the effects of year and age of ewe on fertility, LSB, LSW, LWB and LWW were found to be significant.

The significant effects of year and age of ewe were also reported by Yalcin (1972) for LSB and LSW of Konya Merino ewes, by Boztepe (1994) for LSB of Karacabey Merino ewes and by Unal (1998) for LSB and LSW of Konya Merino ewes. Ozsoy and Vanlõ (1986), and Ozsoy et al. (1987) reported that the effects of both year and age of ewe were significant for LSB and LSW, whereas only the effect of year was significant for fertility. Effect of years and age of Eve were significant in the work done by Boujenane et al. (1991). The aforementioned study revealed that increased was noticed during age group young to intermediate. The peak increased was in intermediate age group and then towards decline. Several authors have reported a similar pattern of change in ewe productivity traits (Deligiannis and Lainas, 2000; Boujenane et al., 1991).

The LSB and LSW of Dormer ewes were reported to be 1.49 and 1.22, respectively (Van Wyk et al., 2003). The LSB obtained in the current study was in accordance with the reports of Cloete et al. (2003) and Van Wyk et al. (2003). The LSW of 1.358 obtained in the current study was higher than those reported by Cloete et al. (2003) and Van Wyk et al. (2003).

The LWW for South African Mutton Merino and Dohne Merino ewes were reported to be 37.3 and 35.5 kg, respectively. Cloete et al. (2003) and Van Wyk et al. (2003) reported LWW for Dormer ewes to be 25.9 kg.

The LWW of Rambouillet ewes were reported to be43.16 kg by Bromley et al. (2001) and 35.3 kg by

Ercanbrack and Knight (1998). The LWW of Lohi ewes reported by several authors were 28.9 to 42.20 kg (Bromley et al., 2001; Ercanbrack et al., 1998). The LWW obtained in the current study are higher than those reported for South African Mutton Merino, Dohne Merino and Dormer ewes, and within the range of those reported for Rambouillet and Targhee ewes.

Merino Eve exhibited over four lambing TLB, TLW and TWW values 5.2, 4.1 and 92.6 respectively as reported by Duguma et al. (2002). The means of lifetime productivity traits, particularly for TLW and TWW, obtained in the current study were higher than those reported for Merino ewes (Snyman et al., 1997; Duguma et al., 2002).

Yalcin et al. (1972) reported paternal half-sib h^2 of 0.14 and 0.16 for LSB, and 0.02 and 0.09 for LSW of Konya Merino ewes. Nagy et al. (1999) reported h^2 for LSB of Hungarian Merino ewes from 0.02 to 0.07 depending on the age of ewe. Van Wyk et al. (2003) estimated h^2 to be 0.059, 0.026, 0.107 and 0.038 for LSB, LSW, LWB and LWW, respectively. Estimates of repeatability for ewe productivity traits obtained in the current study ranged between 0.07 and 0.12, and were similar to previously reported estimates by Yalcin et al. (1972) for LSB (0.15) and LSW (0.09), by Analla et al, 1996 for fertility (0.13) and LSB (0.14), by Matos et al. (1997) for fertility (0.10-0.13) and LSB (0.11-0.21) and by Van Wyk et al. (2003) for LSB (0.133), LSW (0.098), LWB (0.168) and LWW (0.113).

Conclusion

In conclusion, the low estimates of h^2 and repeatability obtained in the current study for ewe productivity traits indicate that selection based on a ewes own performance may result in slow genetic improvement. Therefore, selection for ewe productivity traits of Lohi ewes should be based on female relatives of ewes or on correlated traits which have high and positive genetic correlation with ewe productivity traits.

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