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SINGLE TRAIT ANALYSIS FOR PREWEANING GROWTH TRAITS OF BUCHI SHEEP IN PAKISTAN

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ABSTRACT

Data on 3,564 Buchi sheep (55 males and 1,296 females; from 1986 to 2010) maintained at Livestock Experiment Station Jugaitpir District Bahawlpur Punjab, Pakistan were analyzed to assess preweaning growth traits and their genetic control. Means±SE were 2.84 ± 0.009 kg for birth weight, 7.64 ± 0.014 kg for weight at around 60 days of age, and 12.55 ± 0.03 kg for weaning weight adjusted to 120 days of age. Variance components corresponding to genetic parameters were estimated with single trait analysis using restricted maximum likelihood (REML) procedures, fitting model included direct additive genetic, maternal additive genetic, maternal permanent environmental effects and correlation between genetic direct and maternal effects by ASREML computer program. Study revealed that all preweaning traits were significantly ($P < 0.05$) affected by year, sex, interaction between year and season. Direct heritability estimated were 0.194±0.023 for birth weight, 0.20±0.025 for weight adjusted to60 days and 0.153±0.03 for weight adjusted to 120 days of age. Estimation of maternal heritability for birth weight, weight adjusted to 60 days and 120 days of age were 0.132± 0.025, 0.20± 0.028 and 0.12 ± 0.03, respectively. Negative correlation between direct and maternal heritability was estimated for all three preweaning traits (-0.517± 0.06, -1.013± 0.01, - 0.455± 0.004). These results indicate that selecting for improved maternal and/or direct effects in Buchi sheep would generate only slow genetic progress in early growth traits.

Key words: Buchi sheep, Heritability, Maternal, Preweaning, traits.

INTRODUCTION

Buchi sheep is the promising breeds of Pakistan, native to Cholistan; a desert area of Punjab Province, exceeding 1.8 million heads with a high degree of adaptability to hot and humid conditions. Breed is usually raised for the production of mutton but it has a great perspective in the production of wool as well. The massive potential of Buchi breed has led to a large number of genetic improvement strategies. In global food and leather perspectives there is a dire need of improving indigenous breeds. Selection of genetically superior parents is extremely improvement to have a highest genetic merit. The efficiency of sheep production enterprises can be improved by enhancing quantity and quality of lamb weight, milk and wool yield (Yazdi *et al.*, 1997). To improve meat production in farm animals, simultaneous improvements in environmental and genetic factors are critical. In addition, providing suitable conditions for expression of genetic potential is necessary to enhance and maximize the individual genetic merit. In order to obtain an optimum rate of genetic progress through selection, it is necessary to have high efficiency selection indices and a reliable heritability coefficient for each trait and high genetic correlations among those traits. Estimation of heritability is the basic requirement to predict the breeding values and to know how much improvement is possible through selection. The breeding values estimates are purposefully used for the comparative ranking of the animals. Therefore, next generation parents must be selected among the best current individuals, which have the highest genetic merit.

Growth traits particularly pre-weaning in mammalian are not only influenced by the genetic effect but some other effects such as direct maternal effect and permanent environmental effects (Rashidi *et al.*, 2008; Vatankhah and Talebi, 2008; Baneh *et al.*, 2010).These maternal effects reflect mainly the dam's milk production and mothering ability, though effects of the uterine environment and extra-chromosomal inheritance may also contribute. These maternal effects have three causes (Falconer, 1997): dam's own genotype for milking and mothering ability (maternal additive effects); those consistent among all lambs produced by a dam but not of additive genetic origin (permanent environmental effects); and those specific to individual lambs (temporary environmental effects). The genotype of the dam therefore affects the phenotype of the young one through a sample of half of her direct, additive genes for growth as well as through her genotype for maternal effects on growth. When some of these growth traits are included in the breeding goal, both the direct and maternal component should be taken into account to achieve optimum progress in a selection programme. The present study is designed to estimate the variance components corresponding direct additive, maternal heritability and genetic correlation between direct and maternal effects to improve the genetic performance of the existing pure bred Buchi flock. Traits included were: birth weight, weight adjusted to 60 days of age, weight adjusted to 120 days of age. The information thus generated would be helpful in formulating the effective breeding plan for the genetic improvement of the Buchi sheep breed in Pakistan.

MATERIALS AND M ETHODS

Animals and data: The animals and data, farm location, soil, climate characteristics, management and feeding practices used for the present were the same as described by Akhtar *et al.* (2012).

Model and statistical analysis: Estimates of variance components and heritability for various preweaning traits were obtained by restricted maximum likelihood (REML) procedure outlined by Patterson and Thompson (1971) fitting complete model using ASREML software (Gilmour, 2009). The model included fixed effects, direct additive genetic, maternal additive genetic, maternal permanent environmental effects and correlation between genetic direct and maternal effects. The fixed effects accounting for i.e., year of birth, season of birth, sex of lamb, type of birth, parity, age, and weight of dam at lambing and two way interactions between these environmental factors. The convergence criterion (variance of function values -2 log likelihood) for variance component estimation was 1 x 10^{-8}. The model in the matrix notation was as follow:

$$y = Xb + Z_a a + Z_m m + Z_c c + e \quad \text{with } Cov(a,m) = \mathbf{A}\sigma_{am}$$

$$V = \begin{bmatrix} a \\ m \\ c \\ e \end{bmatrix} = \begin{bmatrix} \mathbf{A}\sigma^2_a & \mathbf{A}\sigma_{am} & 0 & 0 \\ \mathbf{A}\sigma_{am} & \mathbf{A}\sigma^2_m & 0 & 0 \\ 0 & 0 & \mathbf{I_C}\sigma^2_c & 0 \\ 0 & 0 & 0 & \mathbf{I_R}\sigma^2_e \end{bmatrix}$$

Where y was a vector of observations on each trait; ***b***, ***a***, m, ***c*** and ***e*** were vectors of fixed effects (year of birth, season of birth, sex, type of birth, parity, age, weight of dam and interaction between these factors), direct additive genetic effects, maternal additive genetic effects, maternal permanent environmental effects and the residual effects, respectively. $\mathbf{X}$, $\mathbf{Z_a}$, $\mathbf{Z_m}$ and $\mathbf{Z_c}$ were corresponding design matrices associating the fixed, direct additive genetic, maternal additive genetic and maternal permanent environmental effects. It was also assumed that direct additive genetic, maternal additive genetic, maternal permanent environmental and residual effects were normally distributed with mean zero and variance σ^2. Where $\sigma^2 a$, $\sigma^2 m$, $\sigma^2 c$ and $\sigma^2 e$ were direct additive genetic variance, maternal additive genetic variance, maternal permanent environmental variance and residual variance, respectively.

Additive direct heritability (h^2_a), additive maternal heritability (h^2_m) and maternal permanent environmental effects (c^2) were estimated as ratios of additive direct, additive maternal and permanent environmental maternal variances to phenotypic variance, respectively. The direct-maternal genetic correlation (r_{am}) was computed as the ratio of the direct-maternal genetic covariance (σ_{am}) to the product of the square roots of $\sigma^2 a$ and $\sigma^2 m$. **A** was the additive numerator relationship matrix and **I** were identity matrices that had order equal to the number of dams and number of records, respectively and σ_{am} is the covariance between additive direct and maternal genetic effects. The (Co) variance structure for this model was:

$V(a) = A\ \sigma^2_{a,}$ $V(m) = A\ \sigma^2_{m,}$ $V(e) = I_R\ \sigma^2_{e,}$ $V(c) = I_C\ \sigma^2_{c,}$ $Cov(a,m) = A\ \sigma_{am}$

RESULTS AND DISCUSSION

The structure of data s et used for analysis is presented in Table 1. The twin births were 4% and the male-female sex ratio was 52:48. Means±SE for preweaning traits were 2.84±0.009 kg for birth weight, 7.64±0.014 kg for weight adjusted to 60 days of age and 12.55 ± 0.03 kg for weight adjusted to 120 days of age. Results of single-trait analysis to estimate additive gen etic variance (σ^2_a), maternal additive genetic variance (σ^2_m), permanent environmental variance (σ^2_c), additive and maternal additive genetic covariance (σ_{am}), residual variance (σ^2_e), phenotypic variance (σ^2_{pe}), direct heritability (h^2_a ± SE), maternal heritability (h^2_m ± SE) and correlation between direct and maternal additive genetic effects (r_{am} ± SE) for different traits are presented in Table 2.

Birth weight: In the current investigation, the values of direct heritability, maternal additive heritability and correlation between direct and maternal heritability were (0.194±0.023), (0.132±0.023) and (-0.517±0.06). The consistent results of direct additive heritability for birth weight were reported for different breeds of sheep in Pakistan. (Babar *et al*., 2003; Javed *et al*., 2013). Qureshi and Ghaffar, 2002; Farmanullah, 2011) reported that the estimates of 0.10 and 0.11 for Lohi, 0.13 and 0.15 for Kajli breeds of sheep. Hussian (2006), Ali *et al.* (2006) and Akhtar (1996) reported relatively low direct additive heritability estimates of 0.067, 0.07 and 0.08 for Thalli, Rambouillet and Hissaredale breeds of sheep in Pakistan. However, the estimates of 0.69 reported by Jabbar and Ahmad (1972), 0.34 by Chaudhry and Shah (1985) and 0.39 by Tariq *et al.* (2011) and for Rambouill et, Awassi, and Mangali breeds of sheep in Pakistan were highest and inconsistent with the findings of current study.

The estimates of 0.23 for Bharet Merino (Dixit *et al.*, 2001) in India, 0.19 for Tygerhoek Merino (Duguma *et al.*, 2002) in South Africa, 0.17 for Polybay sheep (Hanford *et al.* 2006) in USA, 0.22 and 0.24 for Dannish Mark and Finnish Landrace breeds of sheep (Norberg *et al.* 2005) in Denmark, 0.19 for Danish Texel, Shropshire and Suffolk breeds of sheep (Maxa *et al.*, 2007) in Denmark, 0.19 for Mehrban sheep (Kesbi *et al.* 2008) in Iran, 0.22 for Chokla (Kushwaha *et al.*, 2009) in India, 0.18 for Mecheri sheep (Thiruvenkadan *et al.* 2009) in India, 0.19 for Arabi sheep (Mohammadi *et al.*, 2010) in Iran, 0.21 for Avikalin (Prince *et al.* 2010) in India and 0.17 for Kurdish breeds of sheep (Shakoreallhai and Zandieh;2012) in Iran were in agreement with the present study. Contrary to those, relatively low direct heritability estimates of 0.051 (Senimari *et al.*, 2011) for Zandi in Iran , 0.08 (Ozcan *et al.*, 2005) for Turkish Merino in Turkey, 0.091 (Farokhad *et al.* 2010) for Arman sheep in Iran, 0.10 (Sofla *et al.*, 2011 and Behzadi *et al.*, 2007) for Moghani and Kermani sheep in Iran, 0.11 (Kesbi *et al.*, 2008) for Mehrban sheep in Iran, 0.11 (Naseer *et al.*, 2001) for Dorper sheep in South Africa and 0.12 (Cloete *et al.* 2003) for Merino Lines in South Africa were reported for different breeds of sheep. (Shakoorallahi and Baneh, 2010; Selvaggi *et al.* 2011; Gamasaee, *et al.*, 2010; Lobo *et al.*, 2009; Ashtiani *et al.* 2007; Mohammadi and Edriss, 2007; Mandal *et al.*, 2006; Hassen *et al.*, 2003) reported high estimates of direct heritability for birth weight ranged from 0.33 to 0.54 for Arabi, Puglia lamb, Mehrban, Multibreed meat sheep, Sangsari sheep, Muzaffernagri and Crossbred sheep in Iran, Italy, India, Brazil and Ethiopia under various environmental conditions.

The maternal heritability estimate (0.13) found in the present study were also in agreement with the previous results reported for different breeds of sheep for birth weight. The estimate of 0.15 for Mecheri sheep in India (Thiruvenkadan *et al.*, 2011), 0.11 for Barki sheep in Egypt (El-Awady, 2011), 0.15 for Avikalin in India (Prince *et al.*, 2010), 0.13 for Arman sheep in Iran (Farokhad *et al.*, 2010), 0.14 for Mehrban sheep in Iran (Mohammadi *et al.*, 2010), 0.15 for Oxford Down sheep in Denmark (Maxa *et al.*, 2007) and 0.17 for Mehrban in Iran (Gamasaee *et al.*, 2010). However, contrary to those very low maternal heritability estimates of 0.02, 0.03, 0.04, 0.05, 0.06 and 0.09 were also reported by Naseer *et al.* (2001) for Dorper sheep in South Africa, Hanford *et al.* (2005) for Rambouill et in USA, Baneh *et al.* (2010) for Ghezel in Iran, Bayeriyar *et al.* (2011) for Moghani sheep in Iran, Matica *et al.* (2003) for Sabi in Zimbabwe and Kushwaha *et al.* (2009) for Chokla breed of sheep in India, respectively. Moreover, some of the authors reported the better estimates of maternal heritability for different breeds of sheep. The estimates of 0.25 (Duguma *et al.*, 2002) for Tygerhoek sheep in South Africa, 0.23 (Cloete *et al.*, 2003) for Merino Lines in South Africa, 0.24 (Norberg *et al.*, 2005) for Spel sheep in Denmark, 0.65 (Ashtiani *et al.*, 2007) for Sangsari sheep in Iran, 0.33 (Behzadi *et al.*, 2007) for Kermani sheep in Iran and 0.24 (Shakoreallhai and Zandieh, 2012) for Kurdish breed of sheep in Iran. The differences between the heritability estimates obtained in the present investigation and literature could be correlated to differences in breeds, locations, and time periods, size of data s et or method of estimation along with other management practices.

Weight adjusted to 60 days of age: The direct and maternal heritability estimates (0.20 and 0.13) were found in the present study for weight adjusted to 60 days of age (about 2 months). Negative correlation between direct and maternal heritability was (-1.013± 0.01) estimated for this trait. The similar estimates of direct heritability for weight adjusted to 60 days of age (about 2 months) have been reported. Hussain (2006) and Tariq *et al.* (2011) reported the estimate of 0.12 for Thalli and Mangali sheep breed in Pakistan. Matica *et al.* (2003) reported the estimate of 0.13 for Sabi sheep in Zimbabwe and Mantiatis and Pollott (2003) reported 0.14 estimate for Suffolk sheep in USA. However, the finding of Mandal *et al.* (2006), Selvaggi *et al.* (2011), Neser *et al.* (2000), El- Fadali *et al.* (2000), Fossceco and Notter (1995) for Muzzafernagri sheep in India, Puglia lamb in Itlay, Mutton Merino in South Africa, Moroccan Timahdite and Dors et composite sheep breeds were reported different from the present study. They reported the better estimates of direct heritability for this trait as 0.36, 0.40, 0.27 to 0.37, 0.31 to 0.54 and 0.23 to 0.24, respectively. The low direct heritability estimates were also reported in different breeds of sheep. The estimates of 0.01 (Targhee), 0.04 (Dorset composite), 0.07 (Swedish Finewool), 0.02 to 0.07 (Timahdite). 0.06 to 0.11 (Belggian Texel), 0.07 to 0.08 (Polypay) breeds of sheep were reported by (Al-Shorepy and Notter, 1996; Nasholm and Danell, 1996; Benjenasne and Kansari, 2002; Janssens *et al.*, 2000; Notter, 1998).

Neser *et al.* (2000) and Janssens *et al.* (2000) reported the similar estimate (0.13) for South Africa Mutton Merino and Belgain breeds of sheep. Similar maternal estimates (0.10) for this trait were obtained by Neser *et al.* (2001), and Maniatis and Pollott (2003) for Dorper and Suffolk breeds of sheep. However contrary to those, the low estimates of maternal heritability were also reported by various workers for same type (wool and meat) of sheep breeds. The estimates of 0.02 (Mandal *et al.*, 2006), 0.03 (Fosceco and Notter, 1996), 0.04 (Al-Shorepy and Notter, 1996), 0.06 (Matica *et al.*, 2003), and 0.07 (Bonjenene and Kansari; 2002) were reported for Muzaffernagri, Dorset composite, Suffolk, Sabi and Timahdite breeds of sheep. El- Fedali (2000) and Nashloom and Danell (1996) reported the relatively high estimates of 0.38, 0.25 and 0.17 for Moroccan Timahdite, Romanov and Swedish Finewool breeds of sheep antagonistic to the results estimated in the present study.

Weight adjusted to 120 days of age: The estimates of direct (0.153±0.03) and maternal (0.12±0.029) heritability for weight adjusted to 120 days of age (about four months) were obtained in the present study. Negative correlation (-0.455±0.004) between direct and maternal heritability was estimated between the both traits. In those studies, the estimates of 0.12, 0.13, 0.14 0.17 were reported by Qureshi and Ghaffar (2002), Babar *et al.* (2003) and Shah and Khan (2004) for Kajli, Lohi, Kajli and Mangali breeds of sheep, respectively. The findings of Akhtar (1996), Hussain (2006), Ali *et al.* (2006) and Javed *et al.* (2013) and Farmanullah (2011) were slightly different but close to the present study. They reported heritability estimates of 0.10, 0.038, 0.04, 0.08 and 0.11 for Hissaredale, Thalli, Rambouillet, Lohi and Kajli breeds of sheep. Contrary to those, the high heritability estimates of 0.43, 0.49, 0.52, 0.69 and 0.89 were reported for Awassi, Kacchi, Rambouillet and Hissaredale breeds of sheep for different studies in Pakistan (Babar *et al.* 1989; Chaudhary and Shah, 1985; Jabbar and Ahmad, 1972).

The direct heritability estimates of 0.12 (Riggio *et al.* 2008) for Scotish Black sheep, 0.13 (Matica *et al.* 2003; Cloete *et al.* 2003; Farokhad, 2010) for Sabi, S.A. Mutton Merino and Arman breeds of sheep, 0.14 (Dixit *et al.* 2001) for Bhar et Merino, 0.16 (Vatankhah and Talebi, 2008) for Lori Bakhtiari, 0.17 (Ashtiani *et al*, 2007) and (Lobo *et al.* 2009) for Sangsari and Multibred breeds of sheep and 0.18 (Hanford *et al.*, 2006; Mohammadi *et al.* 2010) for Polybay and Mehrban breeds of sheep were in agreement with the results of present study. The low direct heritability estimates for this trait were reported 0.061 by Senimari *et al.* (2011) for Zandi sheep, 0.09 by Lawaf and Nowshary (2008) for Lori, 0.098 by Sofla *et al.* (2011) for Moghani, 0.09 by Farokhad *et al.* (2010) for Arman sheep breeds. Assan *et al.* (2011) reported 0.28. 0.38 and 0.48 estimates for Sabi, Dorper and Mutton Merino breeds of sheep in Zimbabwe. (Mohammadi and Edriss, 2007; Kesbi *et al.*, 2008; Gamasaee *et al.* 2010) reported the estimates of 0.18, 0.25 and 0.18 for three different flock of Mehrban sheep in Iran. The similar estimates of 0.23 and 0.31 were reported for Kurdish and Barbaine sheep breeds in Iran and Tunisia by Shakoorallhai and Zandi (2012) and Romdhani and Djemali (2006). Lobo *et al.* (2009) and Thiruvenkadan *et al.* (2009) for Multibreed and Mecheri breeds of sheep were reported the highest values of 0.81 and 0.48 for direct heritability estimates in Brazil and India

Table 1. Summary of data including numbers of records, sires, dams and means for preweaning traits in Buchi sheep

Traits	No. of animals	No. of sires	No. of dams	Mean ± SE	SD
Birth weight (kg)	3564	55	1296	2.84 ± 0. 009	0.515
Weight adjusted to 60 days of age (kg)	3496	55	1255	7.64 ± 0.014	0.829
Weight adjusted to 120 days of age (kg)	3349	55	1230	12.55 ± 0.03	1.946

SE: Standard error; SD: Standard Deviation.

Table 2. Estimates of (Co) variance components, direct heritability, maternal heritability and genetic correlation between direct and maternal effects of preweaning traits in Buchi sheep.

Traits	σ^2_a ± SE	σ^2_m±SE	σ^2_c± SE	σ^2_e± SE	σ^2_{pe}±SE	h^2_a± SE	h^2_m±SE	r_{am}
Birth weight	0.039± 0.001	0.027± 0.007	0.0008± 0.002	0.154± 0.003	0.204± 0.005	0.194± 0.023	0.132± 0.023	-0.517± 0.06
Weight adjusted to 60 days of age	0.721± 0.017	0.317± 0.008	0.004± 0.001	0.534	1.092± 0.026	0.201± 0.025	0.130± 0.025	-1.013± 0.01
Weight adjusted to 120 days of age	0.421± 0.01	0.329± 0.008	0.002± 0.004	2.168± 0.05	2.75± 0.06	0.153 ± 0.03	0.12± 0.029	-0.455± 0.04

σ^2_a : additive gen etic variance, σ^2_m : maternal gen etic variance, σ^2_c : permanent environment variance, σ^2_e : environmental variance, σ^2_{pe} : phenotypic variance, h^2_a : direct heritability, h^2_m : maternal heritability, r_{am} : correlation b etween direct and maternal gen etic effects.

Behzadi *et al.* (2007), Sofla *et al.* (2011), Mohammadi and Edriss (2007) and Mohammadi *et al.* (2010) reported 0.11 heritability estimates for Kermani, Moghani, Mehrban and Arabi sheep breeds of Iran in agreement to the present study. The estimates of 0.13, 0.14 and 0.15 were also reported for Scotish Black, Avaklain, Mehrban and Armani breeds of sheep by Riggo *et al.* (2008), Prince *et al.* (2010), Gamasaee *et al.* (2010) and Farokhad *et al.* (2010). Low estimates of maternal heritability were reported by different scientists in various studies. Baneh *et al.* (2010) in Ghazel sheep reported 0.01 and Ozcan *et al.* (2005) in Turkish Merino reported 0.04 estimate of heritability for this trait. The estimates of 0.06 were reported by Matica *et al.* (2003) for Sabi, Kesbi *et al.* (2008) for Mehrban, Senimari *et al.* (2011) for Zandi and Shakorallahi and Zandhi (2012) for Kurdish breeds of sheep. Assan *et al.* (2011) for Mutton Merino and Thiruvenkadan *et al.* (2011) for Mecheri breeds of sheep reported 0.44 and 0.23 maternal heritability estimates for this trait.

Conclusions: The findings of the present study confirmed the importance of implementing the correct model for estimation of variance components and genetic parameters for preweaning growth traits in Buchi sheep. For example, ignoring maternal effects in the model lead to overestimation of direct and total heritability, and exclusion of permanent environmental maternal effect result in overestimation of maternal heritability. The low estimates also suggest that there was a weak correlation between genotype and phenotype for various traits in this flock, and that if superior individuals had been used their offspring would not have been as good as when the heritability was high, and that the variation due to additive gene action was probably small. More attention must be paid to the performance of collateral relatives and progeny for gen etic improvement in Buchi sheep.

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