The Bioscan 12(2): 913-917, 2017
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

ESTIMATES OF COVARIANCE COMPONENTS AND GENETIC PARAMETER FOR GROWTH TRAITS IN DECCANI SHEEP

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KEYWORDS
Deccani Sheep
Growth traits
Genetic parameters
Animal model

Received on :
27.04.2017

Accepted on :
27.05.2017

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ABSTRACT
The purpose of the study was to estimate the (co)variance components and genetic parameters for various growth traits in Deccani Sheep maintained at ICAR-Network Project on Sheep Improvement, MPKV, Rahuri, Maharashtra (India) using data records pertaining to 1736 lambs of 65 sires and 510 dams for the period of 2007 to 2014. The estimation was undertaken under restricted maximum likelihood procedure by accounting the direct and maternal effects in six univariate animal models. The estimates of direct heritability under the best model for growth traits viz. birth weight (BWT), weaning weight (3WT), weight at 6 (6WT), 9 (9WT) and 12 (12WT) months of age were 0.05, 0.20, 0.26, 0.22 and 0.17, respectively. The maternal effects or maternal permanent environmental effects had non-significant influence on growth traits. Genetic (ranged from 0.56 to 1.00) and phenotypic (ranged from 0.06 to 0.76) correlations ranged from moderate to high in positive direction. It is suggested that the current practice of selection at 6WT may be replaced by early selection at weaning weight (3WT) to order to improve the growth performance.

INTRODUCTION

Sheep are one of the major livestock species in India (65.06 million; 12.71% of the total livestock population) that considered as backbone of Indian rural economy especially in semi-arid region (Livestock Census, 2012). Sheep farming is an important farming system in India due to its multi-utility value such as meat, wool, skin and other by-products. The growth performance has been important topic in sheep industry due to necessity of understanding the mechanism of growth potential of lambs. This potential has been affected by several factors such as genetic and non-genetic factors, breeding strategy and flock management practices etc. (Chopra *et al.,* 2010 and Al-Bial *et al.,* 2012).

The direct genetic effects due to sire of lambs plays major role in growth performance. Besides sire effects, the components from mother effects are also influence the growth performance (Kushwaha *et al.,* 2009 and Boujenane *et al.,* 2015). The growth performance of lamb up to weaning age is mostly influenced due to inherited genes from parents, dam's milk yield and nutritional management of dam (Boujenane *et al.,* 2015). The maternal permanent environmental effects explain the effect due to dam for each lambing rather than the genetic influence. Furthermore, the direct-maternal additive genetic covariance explains the existing antagonistic mechanism (Prince *et al.,* 2010). The inclusion of both the direct and maternal components in a selection program is essential in order to accomplish optimal genetic improvement (Meyer, 1992 and Ekiz *et al.,* 2004).

Keeping under consideration the importance of genetic variability for genetic improvement, the present study was carried out to estimate (co)variance components for various growth traits in Deccani sheep by considering direct and maternal effects.

MATERIALS AND METHODS

Data

The data for the present study were obtained from the records maintained at ICAR-Network Project on Sheep Improvement (Deccani Farm Base Unit) located at Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Maharashtra (India). The reference period for collection of data records was 2007 to 2014. Various growth traits such as birth weight (BWT), weight at three (3WT), Six (6WT), nine (9WT) and twelve (12WT) months of age, were included in the study. The details of the data structure of growth traits along with number of records, sires and dams are given in Table 1. The birth and growth records of 1736 lambs of 65 sires and 510 dams were collected from various registers such as lambing register, inventory and weight registers. The weaning period for lambs was typically three months of age. The current practice of selection of rams for breeding purpose was based on their progeny's weight at 6 month of age.

Statistical analysis

General linear model in SAS 9.3 (SAS Institute Inc. 2013) was used to test if there was significant influence of fixed effects of period of birth (two levels), sex of lamb (male and female), season of birth (main season (October-March), off season (April-September)) and age of dam (four levels) on growth traits. The significant effects were subsequently included in animal models. The estimates of (co)variances and genetic parameters were estimated by the Average Information Restricted Maximum Likelihood method (AI-REML) using the WOMBAT software (Meyer, 2006), with univariate or bivariate traits animal models. The convergence was assumed if difference in log likelihood function between two consecutive iterations was lower than 5×10^{-4}.

The six univariate animal models which accounted for the direct and maternal effects were fitted as follows:

$$Y = X\beta + Z_a a + \varepsilon \quad (1)$$

$$Y = X\beta + Z_a a + Z_m m + \varepsilon \ \text{with} \ Cov(a, m) = 0 \quad (2)$$

$$Y = X\beta + Z_a a + Z_m m + \varepsilon \ \text{with} \ Cov(a, m) = A\sigma_{am} \quad (3)$$

$$Y = Xb + Z_a a + Z_c c + e \quad (4)$$

$$Y = Xb + Z_a a + Z_m m + Z_c c + e \ \text{with} \ Cov(a, m) = 0 \quad (5)$$

$$Y = Xb + Z_a a + Z_m m + Z_c c + e \ \text{with} \ Cov(a, m) = As_{am} \quad (6)$$

Where, Y is the vector of observations; â, a, m, c and å are vectors of fixed, direct additive genetic, maternal additive genetic, maternal permanent environmental effects and residual effects, respectively; with respective association matrices , Z_a, Z_m and Z_c; A is the numerator relationship matrix between animals; and σ_{am} is the covariance between additive direct and maternal genetic effects.

Assumptions for variance (V) and covariance (Cov) matrices involving random effects were:

$V(a)\ A\ {}^{2}_{a}\ V(m)\ \ A\ {}^{2}_{m}\ V(c)\ \ I\ {}^{2}_{c}$,

$V(e) = Is^{2}_{e}$ and $Cov(a, m) = As_{am}$

Where, I represents identity matrix; , σ^2_m, σ^2_c and σ^2_e are additive genetic variance, additive maternal, maternal permanent environmental and residual variances, respectively. The direct-maternal correlation (γ_{am}) was obtained for all the traits. Maternal across year repeatability for ewe performance was calculated for all the traits as: (Al-Shorepy 2001). The calculation of total heritability (h^2_T) was done as $h^2_T = (s^2_a + 0.5s^2_m + 1.5s_{am})/s^2_p$ (Willham,1972). The likelihood ratio test was used to find out most appropriate model for each trait (Meyer, 1992). If inclusion of particular effect showed significance increase in log-likelihood, then that model was considered as most suitable model. Otherwise, the model with fewest random terms was selected as most suitable model. Further, bivariate animal model was used to estimate genetic and phenotypic correlations between growth traits.

RESULTS AND DISCUSSION

The details of various growth traits under study are given in Table 1. The least square mean weight for weight at birth, three, six, nine and twelve months of age in Deccani sheep were 3.28 ± 0.01, 11.90 ± 0.07, 20.04 ± 0.10, 21.69 ± 0.10, 25.00 ± 0.10 kg, respectively. These estimates were in accordance with findings of Al-Bial *et al.* (2012) in Black Boni and Zaffer *et al.* (2015) in in Dorper Crossbred Sheep.

The estimates of (Co) variance components and genetic parameters for various growth traits of Deccani sheep are presented in Table 2. The most appropriate model decided on the basis of LRT test is given in bold. It was revealed that model 1 (with direct additive effects only) was most appropriate model for genetic parameter estimates of weaning and post-weaning traits.

(Co)variance components and genetic parameters

Birth weight (BWT)

The heritability for Birth weight under best model was 0.05 ± 0.03. The estimate was in agreement of Ozcan *et al.* (2005) in Turkish Merino, Gowane *et al.* (2010a) in Bharat Merino sheep and Boujenane *et al.* (2015) in D'man Sheep. However, it were lower than the estimates reported by Vatankhah and Talebi (2008) in Lori-Bakhtiari sheep, Baneh *et al.* (2010) in Ghezel, Prakash *et al.* (2012) in Malpura, Al-Bial *et al.* (2012) in Black Boni, Mohammadi *et al.* (2013) in Shal and Zishiri *et al.* (2014) in South African Dormer sheep. This low estimate of heritability indicated that the selection based on birth weight would be inefficient for improving growth traits.

The maternal additive genetic variance and corresponding maternal heritability was 0.009 and 0.05 under model 2 which leads to reduction in estimate of direct heritability. Similar findings also reported by Kushwaha *et al.* (2009) as the inclusion of maternal additive genetic effects decreased heritability estimate by half. However this maternal additive genetic effect was not enough to change log likelihood values significantly and remained negligible for the birth weight trait.

Weaning weight

Table 1: Details of growth traits in Deccani sheep

Trait	BWT	3WT	6WT	9WT	12WT
Number of records	1736	1608	1473	1313	1195
Number of Sires with progeny	65	64	63	61	60
Number of Dams with progeny	510	493	469	435	414
Least square mean weight (kg)	3.28 ± 0.01	11.90 ± 0.07	20.04 ± 0.10	21.69 ± 0.10	25.00 ± 0.10
CV%	13.71	22.78	18.65	16.90	15.29

Table 2: Estimates of parameters for different growth traits in Deccani sheep

Components	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Trait: BWT						
σ^2_a	0.01	0.005	0.005	0.005	0.005	0.005
σ^2_m		0.009	0.01		0.005	0.006
σ_{am}			-0.001			-0.001
σ^2_c				0.009	0.004	0.004
σ^2_e	0.18	0.18	0.18	0.18	0.18	0.18
σ^2_p	0.19	0.19	0.19	0.19	0.19	0.19
h^2	0.05 ± 0.03	0.02 ± 0.03	0.02 ± 0.03	0.03 ± 0.03	0.02 ± 0.03	0.03 ± 0.03
m^2		0.05 ± 0.02	0.05 ± 0.04		0.03 ± 0.04	0.03 ± 0.05
γ_{am}			-0.18			-0.15
c^2				0.05 ± 0.02	0.02 ± 0.04	0.02 ± 0.04
h^2_T	0.05	0.05	0.04	0.03	0.04	0.03
t_m	0.01	0.05	0.05	0.05	0.05	0.05
Log – L	550.79	552.52	552.53	552.53	552.60	552.60
Trait: 3WT						
σ^2_a	1.43	1.43	6.33	1.43	1.43	6.33
σ^2_m		0.00	2.05	0.00	0.00	2.05
σ_{am}			-3.58			-3.58
σ^2_c					0.00	0.00
σ^2_e	5.63	5.63	3.03	5.63	5.63	3.03
σ^2_p	7.06	7.06	7.83	7.06	7.06	7.83
h^2	0.20 ± 0.05	0.20 ± 0.05	0.81 ± 0.13	0.20 ± 0.05	0.20 ± 0.05	0.81 ± 0.13
m^2		0.00 ± 0.02	0.26 ± 0.06		0.00 ± 0.02	0.26 ± 0.06
γ_{am}			-0.99			-0.99
c^2				0.00 ± 0.02	0 ± 0.03	0.00 ± 0.02
h^2_T	0.20	0.20	0.25	0.20	0.20	0.25
t_m	0.05	0.05	0.007	0.05	0.05	0.007
Log – L	-2348.97	-2348.97	-2322.47	-2348.97	-2348.97	-2322.47
Trait: 6WT						
σ^2_a	2.83	2.83	8.59	2.83	2.83	8.58
σ^2_m		0.00	2.05		0.00	2.05
σ_{am}			-4.19			-4.19
σ^2_c				0.00	0.00	0.03
σ^2_e	8.06	8.06	5.26	8.06	8.06	5.23
σ^2_p	10.88	10.88	11.70	10.88	10.88	11.70
h^2	0.26 ± 0.05	0.26 ± 0.06	0.73 ± 0.13	0.26 ± 0.06	0.26 ± 0.06	0.73 ± 0.13
m^2		0.00 ± 0.03	0.18 ± 0.07		0.00 ± 0.04	0.18 ± 0.08
γ_{am}			-1.00			-1.00
c^2				0.00 ± 0.03	0.00 ± 0.04	0.003 ± 0.03
h^2_T	0.26	0.26	0.28	0.26	0.26	0.28
t_m	0.07	0.07	0.00	0.07	0.07	0.36
Log – L	-2457.90	-2457.90	-2440.16	-2457.90	-2457.9	-2440.16
Trait: 9WT						
σ^2_a	2.46	2.46	7.25	2.45	2.45	7.17
σ^2_m		0.00	1.98		0.00	1.92
σ_{am}			-3.79			-3.71
σ^2_c				0.12	0.12	0.14
σ^2_e	8.59	8.59	6.21	8.49	8.49	6.11
σ^2_p	11.05	11.05	11.65	11.06	11.06	11.63
h^2	0.22 ± 0.05	0.22 ± 0.05	0.62 ± 0.14	0.22 ± 0.05	0.22 ± 0.05	0.62 ± 0.14
m^2		0.00 ± 0.02	0.17 ± 0.07		0.00 ± 0.03	0.17 ± 0.07
γ_{am}			-1.00			-1.00
c^2				0.01 ± 0.03	0.01 ± 0.03	0.01 ± 0.03
h^2_T	0.22	0.22	0.22	0.22	0.22	0.22
t_m	0.06	0.06	0.00	0.07	0.07	0.01
Log – L	-2210.02	-2210.02	-2194.19	-2209.94	-2209.94	-2194.05

The direct additive genetic variance and direct heritability estimate for weaning weight (3WT) under best model was observed as 1.43 and 0.20, respectively. Similar estimates were reported by Mandal *et al*. (2006) in Muzaffarnagri, Gowane *et al*. (2010b) in Malpura, Al-Bial *et al*. (2012) in Black Boni, Mohammadi *et al*. (2013) in Shal and Boujenane *et al*. (2015) in D'man sheep. The estimates were higher than reports of Ozcan *et al*. (2005) in Turkish Merino, Vatankhah and Talebi (2008) in Lori-Bakhtiari sheep and Abbasi *et al*. (2012) in Iranian Baluchi sheep. However, the estimates were

Table 2: Contt..........................

Components	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Trait: 12WT						
σ_a^2	1.74	1.74	5.84	1.64	1.64	5.47
σ_m^2		0.00	1.38		0.00	1.27
σ_{am}			-2.84			-2.63
σ_c^2				0.43	0.43	0.44
σ_e^2	8.62	8.62	6.57	8.3	8.3	6.34
σ_p^2	10.36	10.36	10.96	10.38	10.38	10.88
h^2	0.17 ± 0.05	0.17 ± 0.06	0.53 ± 0.15	0.16 ± 0.05	0.16 ± 0.06	0.50 ± 0.15
m^2		0.00 ± 0.03	0.13 ± 0.07		0.00 ± 0.04	0.12 ± 0.07
γ_{am}			-1.00			-1.00
c^2				0.04 ± 0.03	0.04 ± 0.04	0.04 ± 0.04
h_T^2	0.17	0.17	0.21	0.16	0.16	0.20
t_m	0.04	0.04	0.00	0.08	0.08	0.04
Log−L	-1982.69	-1982.69	-1975.01	-1981.90	-1981.90	-1974.01

BWT: Birth weight; 3WT: Weaning weight; 6WT: Weight at 6 month; 9WT: Weight at 9 month; 12WT: Weight at 12 month; σ_a^2, σ_m^2, σ_c^2, σ_e^2 and σ_p^2 are additive genetic, maternal additive genetic, permanent environmental, residual variance and phenotypic variance, respectively; h^2, m^2, c^2 and h_T^2 are direct, maternal, maternal permanent environmental and total heritability respectively; σ_{am} and γ_{am} are direct-maternal covariance and correlation respectively; t_m is maternal across year repeatability for ewe performance, and log-L is log-likelihood for the best model obtained from Wombat (Meyer 2006).

Table 3: Estimates of genetic (above diagonal), phenotypic (below diagonal) and environmental (in parenthesis) correlations between various growth traits in Deccani sheep

Trait	BWT	3WT	6WT	9WT	12WT
BWT		1.00 ± 0.18	0.82 ± 0.21	0.65 ± 0.27	0.56 ± 0.57
3WT	0.08 ± 0.03(-0.06 ± 0.04)	0.91 ± 0.05		0.62 ± 0.13	0.59 ± 0.18
6WT	0.11 ± 0.03(-0.01 ± 0.04)	0.63 ± 0.02 (0.52 ± 0.03)		0.96 ± 0.04	0.76 ± 0.11
9WT	0.11 ± 0.03 (0.03 ± 0.04)	0.40 ± 0.03 (0.33 ± 0.04)	0.72 ± 0.01 (0.64 ± 0.03)		1.00 ± 0.15
12WT	0.06 ± 0.03 (0.03 ± 0.04)	0.23 ± 0.03 (0.14 ± 0.05)	0.52 ± 0.02 (0.48 ± 0.04)	0.76 ± 0.02 (0.77 ± 0.03)	

lower than the reports of Jafari *et al.* (2014) in Makuie sheep.

The additive maternal variance in model 2 was converged to zero which lead to maternal heritability as equal to zero. The direct-maternal additive covariance in model 3 was very high and negative (-3.58) which indicated some hidden mechanism underlying phenotypic relation (Prince *et al.* 2010). Similar result was observed in model 6. This negative covariance inflated the additive heritability estimate (0.81). The repeatability of ewe performance (tm) for weaning weight was observed very low (0.05), which was in accordance of results reported by Prince *et al.* (2010) in Avikalin sheep.

The direct additive genetic variance and corresponding heritability for weaning weight under best model indicated that further improvement in growth performance may be possible through selection.

Post-weaning traits

The estimates of direct heritability from the best model for weight at six, nine and twelve months of age were 0.26 ± 0.05, 0.22 ± 0.05 and 0.17 ± 0.05, respectively, which were in accordance with reports of Gowane *et al.* (2011) in Garole × Malpura (0.23 for 6WT, 0.27 for 9WT and 0.30 for 12WT) and Singh *et al.* (2016) in Marwari sheep (0.28 for 6WT, 0.30 for 9WT and 0.29 for 12WT).

The additive maternal variance (model 2) and maternal permanent environmental variances (model 4) were non-significant for post weaning traits. The estimates of repeatability of ewe performance (tm) for post-weaning traits were low (0.07 for 6WT, 0.06 for 9WT and 0.04 for 12WT), which were in accordance with results reported by Gowane *et al.* (2010b) in Malpura (0.07 for 6WT, 0.04 for 9WT and 0.03 for 12WT) and Prince *et al.* (2010) in Avikalin (0.07 for 6WT and 0.04 for 12WT).

Correlation estimates

The genetic, phenotypic and residual correlations among various growth traits are given in Table 3. Genetic and phenotypic correlations were positive and ranged between medium to high magnitude. The genetic correlation estimate of BWT with 3WT, 6WT, 9WT and 12WT were 1.00 ± 0.18, 0.82 ± 0.21, 0.65 ± 0.27 and 0.56 ± 0.57, respectively, which were higher than the findings reported by Ghafouri-Kesbi *et al.* (2008) in Mehraban and Gowane *et al.* (2010a) in Bharat Merino sheep. The estimates of genetic correlation of 3WT with 6WT, 9WT and 12WT were 0.91 ± 0.05, 0.62 ± 0.13 and 0.59 ± 0.18, respectively, which were in accordance with reports of Swain *et al.* (2004) in Bharat Merino sheep. The genetic correlation of 6WT with 9WT and 12WT were 0.96 ± 0.04 and 0.76 ± 0.11, respectively. The genetic correlation between 9WT–12WT was 1.00 ± 0.15. The phenotypic correlations of birth weight with other traits were low (0.08 ± 0.03 to 0.11 ± 0.03), which were lower than the reports of Gowane *et al.* (2010a) in Bharat Merino sheep. These low estimates may be due to improper care of new-born lambs in initial days. The phenotypic correlations between other traits were ranged between 0.23 ± 0.03 to 0.76 ± 0.02 (Singh *et al.,* 2016).

In conclusions, the estimates of direct heritability for weaning and post-weaning traits were found to be moderate, which indicated possibility of further genetic improvement in Deccani sheep. Genetic and phenotypic correlations showed positive relationship among growth traits. It is suggested that the current practice of selection at 6WT may be replaced by early selection at weaning weight (3WT) in order to bring improvement in growth performance in Deccani sheep.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, ICAR-Central Sheep and Wool Research Institute, Avikanagar (Rajasthan), India for providing necessary facility to conduct this study. The authors also express our gratitude to the learned referee and the Editor-in- Chief for their valuable comments on the original version of the paper.

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