

## Genetic analysis of performance traits in Harnali sheep

Sandeep Kumar\*, S.P. Dahiya, Z.S. Malik, C.S. Patil and Ankit Magotra

Department of Animal Genetics and Breeding,

Lala Lajpat Rai University of Veterinary and Animal sciences, Hisar-125 004, Haryana, India.

Received: 27-06-2016

Accepted: 30-08-2016

DOI: 10.18805/ijar.v0iOF.7827

### ABSTRACT

Harnali sheep is a new synthetic strain developed for superior carpet wool, better growth and adaptability. The present investigation was undertaken to evaluate the Harnali sheep for seven performance traits namely birth weight (BW), weaning weight (WW), six month body weight (SMW), yearling body weight (YBW), adult body weight (ABW), age at first lambing (AFL) and grease fleece weight (GFW) with a mixed model methodology. The overall least squares means for BW, WW, SMW, YBW, ABW, GFW and AFL were estimated as  $3.51 \pm 0.58$  kg,  $13.61 \pm 0.22$  kg,  $19.45 \pm 0.24$  kg,  $27.26 \pm 0.31$  kg,  $37.90 \pm 0.34$  kg,  $1662.65 \pm 35.46$  gm and  $789.98 \pm 10.40$  days, respectively. The period of birth had significant effect on all the performance traits except GFW. The effect of sex was found significant on all the performance traits. The male lambs were significantly heavier than females at all ages. The effect of dam's age at lambing was found non-significant on all the performance traits but dam's weight at lambing significantly influenced all the performance traits and indicated heavier lambs born from heavier ewes. Heritability estimates were high for BW, WW, SMW, YBW, ABW and GFW as  $0.68 \pm 0.19$ ,  $0.49 \pm 0.17$ ,  $0.65 \pm 0.15$ ,  $0.44 \pm 0.17$ ,  $0.42 \pm 0.17$  and  $0.54 \pm 0.17$ , respectively while moderate estimates was obtained for AFL as  $0.38 \pm 0.16$ . The phenotypic correlations of WW and SMW were significant and positive with BW, YBW and ABW with moderate to high in magnitude ranging from  $0.22 \pm 0.04$  to  $0.71 \pm 0.07$ . The phenotypic correlation between BW and SMW was high and positive ( $0.71 \pm 0.07$ ). The genetic correlations among performance traits were low to high ranging from  $-0.03 \pm 0.04$  to  $0.61 \pm 0.12$ . Keeping in view the heritability and genetic correlations among performance traits it is concluded that SMW can serve as a good selection criterion in sheep at early age as it has high heritability and positive and high correlations with body weights at later ages and favourable correlation with age at first lambing.

**Key words:** Genetic and phenotypic correlations, Harnali sheep, Heritability, Performance traits.

**Abbreviations:** BW : birth weight, WW : weaning weight, SMW : six month weight, YBW : yearling body weight, ABW : adult body weight, GFW : grease fleece weight, AFL : age at first lambing.

### INTRODUCTION

India is rich repository of sheep genetic resources having 42 descript breeds of sheep which are distributed in various agro-climatic zones of the country (NBAGR, 2015). Majority of these breeds have been defined in terms of phenotypic characteristics which distinguish them from other populations. Crossbreeding of native sheep with exotic breeds has been in practice since long to bring about improvement in both wool and mutton production. The aim of sheep breeders is to bring out genetic changes in animals, with a view of increase in profitability, sustainability and ease of management at production level. Harnali sheep is a new synthetic strain evolved by cross breeding for superior carpet wool, better growth and adaptability. The crossbreds having 62.5 per cent exotic inheritance from Russian Merino and Corriedale and 37.5 per cent from local Nali breed were mated inter-se for several generations for stable performance. Harnali population has now become stable (Sehrawat, 2005) and stability is one of the most desirable properties of a genotype to be released as a breed for wider utilization.

The growth rate is an economic trait of interest in sheep as growth of the lambs is a reflection of the adaptability and economic viability of the animal and hence may be used as criteria for the selection among breeds and the individual within breeds (Singh *et al.*, 2006). Slow growth rate causes low market weight and has been identified as one of the limiting factors affecting the profitability of any production system. To increase economic returns from these animals, genetic improvement of performance related traits is required and the selection objective should concentrate on these traits (Tosh and Kemp, 1994). Further, for designing the effective selection programs to increase the efficiency of sheep production, the knowledge of genetic parameters of lamb weights at various ages and the genetic relationships among the traits are of utmost importance (Jafari *et al.*, 2014). In addition, estimates of genetic parameters can aid in determination of selection criterion, prediction of the response to selection, and construction of selection indexes. Therefore, the present investigation was aimed to estimate the genetic parameters of performance traits in Harnali sheep.

\*Corresponding author's e-mail: sandyverma5539@gmail.com

## MATERIALS AND METHODS

The information were recorded on seven performance traits namely Birth weights (BW), Weaning weight (WW), Six month body weight (SMW), Yearling body weight (YBW), Adult body weight (ABW), Age at first lambing (AFL) and Grease fleece weight (GFW). The data on 349 Harnali sheep were collected from the history cum pedigree sheets of the Department of Animal Genetics and Breeding of LUVAS, Hisar for the period 1998 to 2015. Hisar is located at 29°09'22 N, 75°42'22 E, altitude 215 m with average rainfall 490.6 mm and average temperature ranges between 17.6 and 32.5°C. All animals were kept under semi intensive housing system. The flock was a closed type and no new animal was introduced from outside. All animals were provided with same management and concentrate supplement in addition to 6-8 hours grazing.

In order to overcome non-orthogonality of the data due to unequal subclass frequencies, least-squares and maximum likelihood computer programme of Harvey (1990) using mixed linear model with dam's weight at lambing as covariate for estimation of various tangible factors on various performance traits were used. The following mathematical model was used:

$$Y_{ijklm} = \mu + S_i + P_j + B_k + A_l + b(X_{Dj} - \bar{X}) + e_{ijklm}$$

Where  $Y_{ijklm}$  is the observation on  $m^{\text{th}}$  animal belonging to  $l^{\text{th}}$  age group of dam, of  $k^{\text{th}}$  sex born in  $j^{\text{th}}$  period of birth, of  $i^{\text{th}}$  sire;  $\mu$  is the overall mean;  $S_i$  is the random effect of  $i^{\text{th}}$  sire;  $P_j$  is the fixed effect of  $j^{\text{th}}$  period of birth ( $j = 1, 2, 3, \dots, 6$ );  $B_k$  is the fixed effect of  $k^{\text{th}}$  sex ( $k = 1, 2$ );  $A_l$  is the fixed effect of  $l^{\text{th}}$  age group of dam ( $l = 1, 2, \dots, 7$ );  $b$  is the linear regression coefficient of trait on dam's weight at lambing;  $X_{Dj}$  is the dam's weight at lambing;  $\bar{X}$  is the mean dam's weight at lambing and  $e_{ijklm}$  is the random error component. Modified Duncan's multiple range test was used for comparing subgroup means (Kramer, 1957). Heritability estimates for different traits were obtained from sire component of variances using paternal half-sib correlation method. The standard errors of heritability estimates were obtained using the formula given by Swiger *et al.* (1964). Genetic correlations among different traits were calculated from sire components of variances and co-variances. The standard errors of genetic

correlations were estimated using the formula given by Robertson (1959). Phenotypic correlations among various traits were calculated from total variances and covariances. The standard error of phenotypic correlation was computed using the formula given by Snedecor and Cochran (1968).

## RESULTS AND DISCUSSION

Sex of lamb was found to have significant effect on all the performance traits. The effect of dam's age at lambing was non-significant on all the performance traits. However, Dam's weight at lambing significantly ( $P < 0.01$ ) influenced all the performance traits. The least squares means for birth weight (BW), weaning weight (WW), six month body weight (SMW), yearling body weight (YBW), adult body weight (ABW), Grease fleece weight (GFW) and age at first lambing (AFL) were estimated as  $3.51 \pm 0.58$  kg,  $13.61 \pm 0.22$  kg,  $19.45 \pm 0.24$  kg,  $27.26 \pm 0.31$  kg,  $37.90 \pm 0.34$  kg,  $1662.65 \pm 35.46$  gm and  $789.98 \pm 10.40$  days, respectively (Table 2). The period of birth of lamb had significant ( $P < 0.01$ ) effect on all the performance traits except GFW (Table 1).

High heritability estimates for BW, WW, SMW, YBW, ABW and GFW were obtained as  $0.68 \pm 0.19$ ,  $0.49 \pm 0.17$ ,  $0.65 \pm 0.15$ ,  $0.44 \pm 0.17$ ,  $0.42 \pm 0.17$  and  $0.54 \pm 0.17$ , respectively while moderate estimate was obtained for AFL as  $0.38 \pm 0.16$  (Table 3). The phenotypic correlations among all the performance traits were positive except that phenotypic correlations of BW, WW and ABW were negative with AFL (Table 3). The phenotypic correlation between BW and SMW was highly positive ( $0.71 \pm 0.07$ ). The phenotypic correlations of WW and SMW were significant and positive with BW, YBW and ABW with moderate to high in magnitude ranging from  $0.22 \pm 0.04$  to  $0.71 \pm 0.07$ . The Phenotypic correlations of GFW were positive and significant with SMW, YBW and ABW. The phenotypic correlation of AFL was significant and positive with SMW but negative with WW. The genetic correlation of BW was found positive with WW and SMW but negative with other traits. The genetic correlations of WW and SMW were found positive and moderate to high in magnitude with YBW and ABW ranging from  $0.25 \pm 0.16$  to  $0.61 \pm 0.12$ . The genetic correlations of YBW and ABW were estimated

**Table 1:** Analysis of variance for performance traits in Harnali sheep

Source of variation	D.f.	Mean sum of squares						
		BW	WW	SMW	YBW	ABW	GFW	AFL
Sire	95	0.37	6.04	9.07	13.89	15.08	17828.78	15571.75
Period	5	0.31**	20.55**	15.09**	34.06**	25.39**	215988.91	38743.55**
Sex	1	0.30**	50.15**	712.73**	3195.11**	7674.73**	734907.05**	-
Dam's age at lambing	6	0.09	4.03	11.83	9.87	22.11	172971.67	24206.02
Dam's weight at lambing (linear regression)	1	9.71**	168.75**	61.86*	14.66**	375.45**	922447.04**	20628.18**
Error	240	0.20	4.36	9.87	12.91	14.12	123353.69	16216.32

\*\* Significant at  $P < 0.01$ , \* Significant at  $P < 0.05$

**Table 2 :** Least squares means along with standard error for performance traits in Harnali sheep

Effects	No. of observations	Traits						
		BW(kg)	WW(kg)	SMW(kg)	YBW(kg)	ABW(kg)	GFW(gm)	AFL(days)
<b>Overall (<math>\mu</math>)</b>	349	3.51 $\pm$ 0.58	13.61 $\pm$ 0.22	19.45 $\pm$ 0.24	27.26 $\pm$ 0.31	37.90 $\pm$ 0.34	1662.65 $\pm$ 35.46	789.98 $\pm$ 10.40
<b>Period</b>								
1	18	3.88 <sup>c</sup> $\pm$ 0.38	10.95 <sup>a</sup> $\pm$ 1.76	19.25 <sup>c</sup> $\pm$ 2.63	32.60 <sup>e</sup> $\pm$ 3.10	43.48 <sup>f</sup> $\pm$ 3.77	1575.99 $\pm$ 146.36	724.91 <sup>a</sup> $\pm$ 58.39
2	56	3.53 <sup>d</sup> $\pm$ 0.16	12.08 <sup>c</sup> $\pm$ 0.72	17.87 <sup>b</sup> $\pm$ 1.06	24.84 <sup>b</sup> $\pm$ 1.26	39.10 <sup>e</sup> $\pm$ 1.52	1512.71 $\pm$ 118.69	748.37 <sup>b</sup> $\pm$ 42.60
3	106	3.10 <sup>a</sup> $\pm$ 0.14	11.40 <sup>b</sup> $\pm$ 0.60	16.53 <sup>a</sup> $\pm$ 0.89	23.78 <sup>a</sup> $\pm$ 1.06	34.05 <sup>a</sup> $\pm$ 1.27	1609.43 $\pm$ 100.56	722.30 <sup>a</sup> $\pm$ 30.00
4	33	3.17 <sup>b</sup> $\pm$ 0.15	15.94 <sup>d</sup> $\pm$ 0.68	21.51 <sup>e</sup> $\pm$ 0.99	29.65 <sup>d</sup> $\pm$ 1.18	35.49 <sup>b</sup> $\pm$ 1.42	1797.13 $\pm$ 120.57	931.03 <sup>d</sup> $\pm$ 39.81
5	77	3.30 <sup>c</sup> $\pm$ 0.16	15.84 <sup>d</sup> $\pm$ 0.73	21.54 <sup>e</sup> $\pm$ 1.08	26.36 <sup>c</sup> $\pm$ 1.28	37.11 <sup>e</sup> $\pm$ 1.55	1733.49 $\pm$ 120.57	844.90 <sup>c</sup> $\pm$ 43.31
6	59	3.21 <sup>b</sup> $\pm$ 0.25	16.41 <sup>e</sup> $\pm$ 1.15	20.03 <sup>d</sup> $\pm$ 1.72	26.26 <sup>c</sup> $\pm$ 2.03	38.16 <sup>d</sup> $\pm$ 2.46	1748.32 $\pm$ 139.72	833.38 <sup>c</sup> $\pm$ 48.78
<b>Sex</b>								
1	78	3.77 <sup>b</sup> $\pm$ 0.08	14.00 <sup>b</sup> $\pm$ 0.31	22.69 <sup>b</sup> $\pm$ 0.41	32.11 <sup>b</sup> $\pm$ 0.51	47.79 <sup>b</sup> $\pm$ 0.59	1792.84 <sup>b</sup> $\pm$ 52.47	–
2	271	3.25 <sup>a</sup> $\pm$ 0.06	13.21 <sup>a</sup> $\pm$ 0.23	16.22 <sup>a</sup> $\pm$ 0.26	22.69 <sup>a</sup> $\pm$ 0.34	28.01 <sup>a</sup> $\pm$ 0.37	1532.47 <sup>a</sup> $\pm$ 38.89	–
<b>Dam' age at lambing (months)</b>								
<36	134	3.45 $\pm$ 0.84	13.91 $\pm$ 0.33	19.02 $\pm$ 0.39	27.67 $\pm$ 0.48	37.84 $\pm$ 0.50	1605.52 $\pm$ 51.68	828.47 $\pm$ 14.17
37-48	65	3.48 $\pm$ 0.92	14.19 $\pm$ 0.39	19.33 $\pm$ 0.50	27.92 $\pm$ 0.60	36.94 $\pm$ 0.62	1602.73 $\pm$ 61.74	819.66 $\pm$ 16.28
49-60	53	3.39 $\pm$ 0.10	14.06 $\pm$ 0.43	18.74 $\pm$ 0.57	26.85 $\pm$ 0.67	36.45 $\pm$ 0.70	1500.42 $\pm$ 71.25	796.48 $\pm$ 13.45
61-72	51	3.51 $\pm$ 0.10	13.25 $\pm$ 0.42	18.64 $\pm$ 0.56	26.88 $\pm$ 0.66	36.79 $\pm$ 0.69	1567.64 $\pm$ 67.45	811.54 $\pm$ 14.68
73-84	31	3.48 $\pm$ 0.12	13.80 $\pm$ 0.52	19.95 $\pm$ 0.72	28.05 $\pm$ 0.84	38.68 $\pm$ 0.81	1548.83 $\pm$ 51.89	817.62 $\pm$ 15.45
85-90	7	3.37 $\pm$ 0.19	14.21 $\pm$ 0.89	19.20 $\pm$ 0.96	26.77 $\pm$ 0.87	36.49 $\pm$ 0.85	1562.04 $\pm$ 87.55	806.81 $\pm$ 17.78
>90	8	3.62 $\pm$ 0.20	14.81 $\pm$ 0.91	22.09 $\pm$ 0.91	29.07 $\pm$ 0.91	39.85 $\pm$ 0.89	1201.88 $\pm$ 91.65	666.51 $\pm$ 18.61
<b>Regression of Dam's weight at lambing</b>		0.05 $\pm$ 0.01	0.26 $\pm$ 0.03	0.32 $\pm$ 0.05	0.36 $\pm$ 0.06	0.47 $\pm$ 0.71	14.03 $\pm$ 5.45	0.26 $\pm$ 1.99

Means with different superscripts for an effect differed significantly ( $P < 0.05$ )

**Table 3:** Estimates of heritability (diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations along with standard error among performance traits

Traits	BW	WW	SMW	YBW	ABW	GFW	AFL
<b>BW</b>	<b>0.68<math>\pm</math>0.19</b>	0.38 $\pm$ 0.13	0.11 $\pm$ 0.16	-0.03 $\pm$ 0.15	-0.19 $\pm$ 0.15	-0.03 $\pm$ 0.04	-0.28 $\pm$ 0.15
<b>WW</b>	0.22 <sup>**</sup> $\pm$ 0.04	<b>0.49<math>\pm</math>0.17</b>	0.38 $\pm$ 0.15	0.25 $\pm$ 0.16	0.26 $\pm$ 0.16	0.10 $\pm$ 0.08	-0.47 $\pm$ 0.16
<b>SMW</b>	0.71 <sup>**</sup> $\pm$ 0.07	0.42 <sup>**</sup> $\pm$ 0.05	<b>0.65<math>\pm</math>0.15</b>	0.61 $\pm$ 0.12	0.25 $\pm$ 0.18	0.19 $\pm$ 0.17	-0.16 $\pm$ 0.18
<b>YBW</b>	0.03 $\pm$ 0.01	0.26 <sup>**</sup> $\pm$ 0.03	0.51 <sup>**</sup> $\pm$ 0.06	<b>0.44<math>\pm</math>0.17</b>	0.59 $\pm$ 0.11	0.57 $\pm$ 0.13	-0.21 $\pm$ 0.18
<b>ABW</b>	0.06 $\pm$ 0.02	0.25 <sup>**</sup> $\pm$ 0.04	0.69 <sup>**</sup> $\pm$ 0.05	0.50 <sup>**</sup> $\pm$ 0.07	<b>0.42<math>\pm</math>0.17</b>	0.28 $\pm$ 0.15	-0.03 $\pm$ 0.17
<b>GFW</b>	0.03 $\pm$ 0.01	0.09 $\pm$ 0.02	0.10 <sup>*</sup> $\pm$ 0.01	0.21 <sup>**</sup> $\pm$ 0.03	0.13 <sup>*</sup> $\pm$ 0.02	<b>0.54<math>\pm</math>0.17</b>	0.13 $\pm$ 0.16
<b>AFL</b>	-0.03 $\pm$ 0.01	-0.15 <sup>**</sup> $\pm$ 0.03	0.17 <sup>**</sup> $\pm$ 0.02	0.04 $\pm$ 0.01	-0.03 $\pm$ 0.01	0.08 $\pm$ 0.02	<b>0.38<math>\pm</math>0.16</b>

\*\* Significant at  $P < 0.01$ , \* Significant at  $P < 0.05$

positive with all performance traits with moderate to high in magnitude ranging from -0.25 $\pm$ 0.16 to 0.61 $\pm$ 0.12 except with BW and AFL. AFL was found to have negative genetic correlations with all growth traits ranging from -0.03 $\pm$ 0.17 to -0.47 $\pm$ 0.16.

The overall least squares means of birth weight (BW), weaning weight (WW), six month body weight (SMW) and yearling body weight (YBW) were on the higher side than those reported by Sehrawat (2005), Dangi *et al.* (2006) and Singh *et al.* (2006) in crossbred sheep. However, Momoh *et al.* (2013), Vivekanand *et al.* (2014), Nirban *et al.* (2015) and Mallick *et al.* (2015) reported higher estimates in different indigenous sheep breeds. Higher weaning weight (13.61 $\pm$ 0.22 kg) in Harnali lambs reflects better mothering ability and milk producing ability of Harnali ewes as compared to other breeds. The overall least squares mean of adult body weight

by Afolayan *et al.* (2006) in Yankasa sheep and Otoikhian *et al.* (ABW) was obtained as 37.90 $\pm$ 0.34 kg. The estimates obtained in the present study were higher than those reported by Afolayan *et al.* (2006) in Yankasa sheep and Otoikhian *et al.* (2008) in Ouda sheep, but lower than those found by Petrovie *et al.* (2012) in Merinolandschaf sheep and Borg *et al.* (2009) in western sheep.

The overall least squares mean of age at first lambing (AFL) was obtained as 789.98 $\pm$ 10.40 days which was higher than those reported by Mane *et al.* (2014) and Lakew *et al.* (2014) but lower than those found by Dey (2004) in different indigenous breeds of sheep. The overall least squares mean for grease fleece weight (GFW) was obtained as 1662.65 $\pm$ 35.46 gm. The estimate obtained in the present study was higher than that reported in the literature.

The period of birth had significant ( $P < 0.01$ ) effect on all the performance traits except GFW. Similar findings were reported by Singh *et al.* (2006) in crossbred sheep, Kushwaha *et al.* (2010) in Chokla sheep and Balasubramanyam *et al.* (2012) in Madras Red sheep. However non-significant effect of period on BW was reported by Mishra *et al.* (2008), Gowane *et al.* (2011) and Das *et al.* (2014). The differences due to period of birth on body weights of the lambs are the reflections of varying climatic conditions affecting the availability of fodder and natural pastures.

The effect of sex was found significant on all the performance traits. Significant sex difference on performance traits were also reported by Prince *et al.* (2010), Balasubramanyam *et al.* (2012), Chikurdekar *et al.* (2012), Momoh *et al.* (2013), Singh *et al.* (2013), Vivekanand *et al.* (2014) and Mane *et al.* (2014) in different Indian breeds of sheep. The male lambs were significantly heavier than females at all ages. This difference of body weights between the two sexes may be due to hormonal influences.

The effect of dam's age at lambing was found non-significant on all the performance traits. Similar finding was also reported by Abd-Allah *et al.* (2012) in crossbred sheep. However, Rahimi *et al.* (2014) found significant effect of dam's age on body weights in crossbred sheep.

Dam's weight at lambing significantly ( $P < 0.01$ ) influenced all the performance traits and indicated heavier lambs were born from heavier ewes. The present results were in accordance with the findings of Dey (2004), Mishra *et al.* (2008), Prince *et al.* (2010) and Singh *et al.* (2013) in different breeds. Present results showed that dam's weight at lambing has favourable effect on weight of lamb at different ages..

**Heritability estimates for performance traits:** The estimates of heritability in the present study for WW, SMW and YBW were somewhat higher than those reported in literature. The heritability estimates of BW reported in the literature for different breeds of sheep ranged from  $0.02 \pm 0.01$  in Iran Black sheep (Rashidi *et al.*, 2013) to  $0.33 \pm 0.05$  in Sangsari sheep (Miraei-Asthaini *et al.*, 2007). However, Ganeshan *et al.* (2013) reported higher estimates of heritability for WW and YBW as  $0.508 \pm 0.1602$  and  $0.651 \pm 0.190$ , respectively in Madras Red sheep.

The estimates of heritability for ABW in the present study was higher than 0.38 as estimated by Borg *et al.* (2009) in Western sheep but lower than  $0.58 \pm 0.03$  as estimated by Snyman *et al.* (2012) in Angora goats.

The estimate of heritability for AFL in the present study was higher than  $0.14 \pm 0.07$  and  $0.11 \pm 0.05$  as estimated by Gowane *et al.* (2014) in Malpura sheep. However, the heritability estimate of AFL was lower than  $0.70 \pm 0.19$  as estimated by Sehrawat (2005) in the synthetic sheep and  $0.44 \pm 0.11$  estimated by Akhtar *et al.* (2008) in Hissardale sheep.

The estimate of heritability for GFW was higher than  $0.49 \pm 0.08$  as estimated by Khan *et al.* (2015) in Rambouillet crossbred. Lower estimates of heritability for GFW than that found in the present study were also reported by Kumar *et al.* (2005) and Jafari and Hashemi (2014) in different breeds of sheep. Higher estimates of heritability for performance traits in present study pointed towards the availability of genetic variability in these traits which can be exploited for further improvement in the growth and reproductive performance of Harnali sheep.

**Correlations among performance traits:** From the phenotypic correlations of body weights at different ages it was observed that magnitude of association was more among body weights at adjoining ages but lower between weights of more distant ages. High phenotypic correlations among BW, WW, SMW and YBW were also found by Singh *et al.* (2006) in crossbred and Gowane *et al.* (2011) in Garole  $\times$  Malpura sheep. The Phenotypic correlation of GFW was positive and significant with SMW, YBW and ABW. The phenotypic correlation of AFL was significant and positive with SMW but negative with WW.

The genetic correlation of BW was found positive with WW and SMW but negative with other traits. The genetic correlations of WW and SMW were found positive and moderate to high in magnitude with YBW and ABW ranging from  $0.25 \pm 0.16$  to  $0.61 \pm 0.12$ . The genetic correlations of YBW and ABW were found positive with GFW as  $0.57 \pm 0.13$  and  $0.28 \pm 0.15$ , respectively. Positive genetic correlations between GFW and growth traits were also reported by Singh *et al.* (1998) in Marwari sheep. AFL was found to have negative genetic correlations with all growth traits ranging from  $-0.03 \pm 0.17$  to  $-0.47 \pm 0.16$ . Similar results were also reported by Singh *et al.* (1998), Gowane *et al.* (2011) and Ganeshan *et al.* (2013) in different breeds of sheep but Singh and Manuja (2000) observed positive genetic correlation between BW and AFL in Gaddi sheep. The negative association between AFL and growth traits at different ages indicates that fast growing female lambs sexually mature early and lamb at early age as compared to slow growing females.

The results of present study clearly pointed towards the availability of genetic variability in growth traits of Harnali sheep which indicate the scope of further improvement in this strain through selection. Further veering around the genetic parameters it is inferred that six month weight can be a good selection criterion at early age as it has high heritability and positive and high correlations with body weights at later ages and favourable correlation with age at first lambing.

#### ACKNOWLEDGMENT

The authors are indebted to the Vice Chancellor, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana for providing the infrastructure facilities that enabled the successful completion of the research.

## REFERENCES

- Abd-Allah, M., Hassan, H.A. and Al-Baroady, M.A. (2012). Growth performance of Rahmani and F1 cross (Chios x Rahmani) lambs under the environmental conditions of Upper Egypt. *J. Anim. Sci. Adv.* **2**: 287-295.
- Afolayan, R. A., Adeyinka, I.A and Lakpini, C. A. M. (2006).The estimation of live weight from body measurements in Yankasa sheep. *Czech J.Anim.Sci.* **51**: 343-348.
- Akhtar, P., Ali, S., Hussain, A., Mirza, M.A., Mustafa, M.I. and Sultan, A.I. (2008). Heritability estimates of post-weaning performance traits in Hissardale sheep in Pakistan. *Turk. J. Vet. Sci.* **32**:275-279.
- Balasubramanyam, D., Raja, T. V., Kumarasamy, P. and Sivaselvam, S. N. (2012). Estimation of genetic parameter and trends for body weight traits in Madras Red sheep. *The Indian Journal of Small Ruminants.*, **18** : 173-179.
- Borg, R.C., Notter, D.R. and Kott, R.W. (2009). Phenotypic and genetic associations between lamb growth traits and adult ewe body weights in western range sheep. *J. Anim. Sci.* **87**:3506-3514.
- Chikurdekar, A.A., Mandakmale, S.D., Birari D.R., Bhoite, U.Y., Sakhare P.S. (2012). Effect of factors affecting growth performance of Sangammeri strain of Deccani sheep. *The Indian Journal of Small Ruminants.* **18**: 256-257.
- Dangi, P.S. and Poonia, J.S. (2006). Factors affecting weaning weight and six month body weight in crossbred sheep. *Indian J. Anim. Res.* **40** (2): 161-163.
- Das, A.K., Chakraborty, D., Kumar, N., Gupta, P., Khan, N.N. and Bukhari, S. (2014). Effect of non-genetic factors on performance traits of Kashmir Merino sheep. *Indian J. Anim. Res.* **48** : 106-108.
- Dey, B. (2004). Genetic studies on reproduction and production traits of Nali sheep. M.V.Sc. Thesis., CCS Haryana Agricultural University, Hisar, Haryana, India.
- Ganeshan, R., Dhanavanthan, P., Balasubramanyam, D., Kumarasamy, P. and Kiruthika. (2013). Estimation of genetic parameters of growth traits in Madras Red sheep. *Journal of Agriculture and Veterinary Science.* **3**: 69-73.
- Gowane, G.R., Chopra, A., Prince, L.L.L., Mishra, A.K. and Arora,A.L. (2011). Genetic analysis for growth traits of prolific Garole × Malpura (GM) sheep. *Trop. Anim. Health Prod.* **43**: 299–303.
- Gowane, G.R., Prince, L.L.L., Paswan C., Mishra, S.S., Sharma, R.C. and Naqvi, S.M.K.(2014). Genetic analysis of reproductive and fitness traits of Malpura sheep in semi-arid tropics of india. *Agricultural Research.* **3**: 1-8.
- Harvey, W. R. (1990). Mixed model least squares and maximum likelihood computer program, January.
- Jafari, S. and Hashemi, A. (2014). Estimation of genetic parameters for body measurements and their association with yearling liveweight in the Makuie sheep breed. *S. Afr. J. Anim. Sci.* **44**: 141–147.
- Jafari, S., Hashemi, A., Darauishzadeh, R. and Manafiazlo, G. (2014). Genetic parameters for live weight, body measurements, greasy fleece weight and reproduction n traits of Makuie sheep. *Spanish J. Agri. Res.* **12**: 653-663.
- Khan, N. N., Kumar, N., Das, A.K., Chakraborty, D., Taggar R.K. and Gupta, P. (2015). Genetic studies on wool production traits in Rambouillet crossbred sheep in J & K State, India. *Indian J. Anim. Res.* **49**: 40-43.
- Kramer, C.Y. (1957). Extension of Multiple range tests to group correlated adjusted means. *Biometrics.* **13**: 13-18.
- Kumar, R., Singh, C.V. and Mehta, B.S. (2005). Genetic parameter estimates for the weight and fleece traits in Chokla sheep. *Indian Journal of Animal Sciences.* **75**: 1073-1079.
- Kushwaha, B. P., Mandal, A., Kumar, R. and Kumar, S. (2010). Environmental & genetic effects on growth traits of Chokla sheep. *Indian Journal of Animal Sciences.* **80** : 346-349.
- Lakew, M., Haile-Melekot, M., Mekuriaw, G., Abreha, S. and Setotaw, H. (2014). Reproductive performance and mortality rate in local and Dorper x Local crossbred sheep following controlled breeding in Ethiopia. *Open Journal of Animal Sciences.* **4**: 278-284.
- Mallick, P.K., Pourouchottamane, R., Rajapandi, S., Thirumaran, S.M.K. and Rajendiran A.S. (2015). Performance of Bharat Merino x Bannur (Mandya) crossbreds in Kolar and Chikballpur districts of Karnataka. *The Indian Journal of Small Ruminants.* **21** : 28-31.
- Mane, P. M., Pachpute S.T., and Nimase, R.G. (2014). Growth and reproductive performance of Deccani sheep in an organized farm. *The Indian Journal of Small Ruminants.* **20**: 23-27.
- Miraei-Ashtiani, S. R., Seyedalian, A. R. and Moradi- shahrbabak, M. (2007). Variance components and heritabilities for body weight traits in Sangsari sheep, using univariate and multivariate animal models. *Small Rumin. Res.* **73**:109-114.
- Mishra, A.K., Arora, A.L., Prince, L.L.L. and Kumar, S. (2008). Performance evaluation of Garole×Malpura half-bred sheep evolved in semiarid region of Rajasthan. *Indian Journal of Animal Sciences.* **78**: 746–750.
- Momoh, O. M., Rotimi E. A., and Dim, N.I. (2013). Breed effect and non-genetic factors affectin growth performance of sheep in semi-arid region of Nigeria. *Journal of Applied Biosciences.* **67**: 5302-5307.
- National Bureau of Animal Genetic Resources, (2015). Animal Genetic Resources, Karnal. [www.nbagr.res.in](http://www.nbagr.res.in)
- Nirban, L.K., Joshi, R.K., Narula, H.K., Singh, H. and Bhakar, S. (2015). Genetic and non genetic factors affecting body weights in Marwari sheep. *The Indian Journal of Small Ruminants.* **21** : 106-108.
- Otoikhian, C.S.O., Otoikhian, A.M., Akporhwarho, O.P. and Isidahoman, C. (2008). Correlation of body weight and somebody measurement parameters in Quda sheep under extensive management system. *Afr. J. Gen. Agric.* **4**(3): 129-133.
- Petrovic, M.P., Petrovic, V.C., Muslic, R.D., Iliæ, Z., Spasiæ, Z., Stojkoviæ, J. and Makshimovic, N. (2012). Genetic and phenotypic of the body measured traits in Merinolandschaf breed of sheep. *Biotechnology in Animal Husbandry.* **28** : 733-741.
- Prince, L.L.L., Chopra, A., Gowane, G.R. and Arora, A.L. (2010). Factors affecting growth in Avikalin sheep. *Indian Vet. J.*, **87**: 1104-1108.
- Rahimi, S. M., Rafat, S. A. and Jafari, S. (2014). Effects of environmental facotors on the growth traits of Makuie sheep. *Biotechnology in Animal Husbandry.* **30**: 185

- Rashidi, A. (2013). Genetic parameter estimates of body weight traits in Iran-Black sheep. *Journal of Livestock Science and Technologies.*, **1**: 50-56.
- Robertson, A. (1959). The sampling variation of genetic correlation coefficient. *Biometrics.* **15**: 469-485.
- Sehrawat, V. (2005). Studies on genetic architecture of the synthetic sheep population. M.V.Sc. Thesis. College of Animal Sciences, CCS Haryana Agricultural University, Hisar, Haryana, India.
- Singh, D., Kumar, R., Pander, B.L., Dhaka, S.S. and Singh, S. (2006) Genetic parameter of growth traits in crossbred sheep. *Asian-Aust. J. Anim. Sci.* **19**: 1390-1393.
- Singh, H., Pannu, U., Narula, H.K., Chopra, A., and Murdia, C.K. (2013). Influence of genetic and non-genetic factors on pre-weaning growth in Marwari sheep. *The Indian Journal of Small Ruminants.* **19**: 142-145.
- Singh, U. and Manuja, N.K. (2000). Genetic and phenotypic correlations of reproductive and productive traits in exotic and their crosses with Gaddi sheep in Himachal Pradesh. *Indian Journal of Animal Sciences.* **70**: 63-64.
- Singh, V.K., Dass, G., Mehta, S.C. and Sharma, P.R. (1998). Selection in Marwari sheep: performance of selection line. *Journal of Animal Sciences.* **4**: 1-4
- Snedecor, G.W. and Cochran, W.G. (1968). *Statistical Methods*, Oxford & IBH Publ. Co., New Delhi, India.
- Snyman, M.A. (2012). Genetic analysis of body weight in South African Angora kids and young goats. *South African Journal of Animal Science.* **42**: 146-155.
- Swiger, L.A., Harvey, W.R., Everson, D.O. and Gregory, K.E. (1964). The variance of interclass correlation involving groups with one observation. *Biometrics.* **20**: 818-826.
- Tosh J.J., and Kemp R.A. (1994). Estimation of variance components for lamb weights in three sheep populations. *J Anim.Sci.* **72**:1184-1190
- Vivekanand., Joshi, R. K., Narula, H. K., Singh, H. and Chopra, A. (2014). Effect of genetic and non genetic factor on growth of Magra sheep in arid region of rajasthan. *The Indian Journal of Small Ruminants.* **20**: 19-22.