



Estimation of heritability and breeding values for performance and body conformation traits in Harnali Sheep

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ABSTRACT

The present study was conducted to evaluate the effect of non-genetic factors on performance and body conformation traits along with estimation of heritability and breeding values of these traits in Harnali sheep. Non-genetic factors had significant effect on the performance and body conformation traits in Harnali sheep. Heritability estimates varied from low to moderate for performance traits indicating the presence of genetic variability which could be used for further improvement of these traits. Comparatively higher heritability estimates for body conformation traits in the present study indicated towards the presence of genetic variability which might be due to the reason that linear type traits were not included in the selection criterion of Harnali sheep so far. High genetic variability in these traits noticeably indicated the scope of improvement in these body dimensions through selection. Breeding value estimates for different performance and body conformation traits pointed the variability between the genetic merit of individuals which can be exploited through selection for making improvement in the considered traits in Harnali sheep.

Keywords: Body conformation, Breeding value, Harnali sheep, Heritability

Sheep rearing has great contribution towards agricultural economy particularly in areas wherever crop and dairy farming are not cost-effective. Sheep rearing plays a vital role in the livelihood of a large proportion of small and marginal farmers along with landless labourers. In developing countries, sheep serves as an important source of meat, milk and wool. Thus, it is important to improve the growth, production and reproduction performance of sheep breeds. India has vast genetic diversity of sheep in form of 44 breeds (NBAGR 2021). India ranks third in the world sheep population with 74.26 million sheep (Livestock Census 2019). In addition to registered 44 breeds of sheep, India has developed a number of synthetic sheep strains for various purposes. Harnali sheep is a new synthetic strain which has been evolved through cross breeding for superior carpet wool, better growth and adaptability (Verma *et al.* 2016). The crossbreds having 62.5% exotic inheritance from Russian Merino and Corriedale and 37.5% from Nali breed were mated *inter se* for several generations for stable performance of Harnali sheep. Harnali population has stabilized and stability is one of the most desirable characteristics of a genotype for distribution as a breed for widespread use. Measurements of body conformation

indicate breed characteristics and are of value in judging the quantitative characteristics of meat in sheep and also helpful in developing suitable selection criterion (Kumar *et al.* 2018, Dahiya *et al.* 2018). The main objective of animal breeder is to improve the performance of animals through selection and breeding. Various environmental factors affect the performance of animals. Therefore, it is important to assess the effect of different factors on the performance traits. The knowledge of genetic parameters is a pre-requisite for formulating any breeding programme. Additionally, expected breeding value of the individual for a particular trait defines the net genetic worth of the individual. Estimation of breeding value constitutes an important part of breeding programs to carry the genetic progress in economic traits. Thus, the present study was conducted to assess the effect of non-genetic factors on performance and body conformation traits in addition to estimation of heritability and breeding values of these traits in Harnali sheep.

MATERIALS AND METHODS

In the present study, data were recorded on 110 Harnali sheep kept at the Sheep Breeding Farm, Department of Animal Genetics and Breeding, LUVAS, Hisar, Haryana, India. Different performance traits, viz. birth weight (BWT), weaning weight (W-WT), six-month body weight (6 M-WT), one-year body weight (Y-WT), adult body weight

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(A-WT), age at first service (AFS), weight at first service (WFS), age at first lambing (AFL), weight at first lambing (WFL) and annual grease fleece weight (GFW) along with four body conformation traits, viz. body length (BL), body height (BH), heart girth (HG) and paunch girth (PG) were considered in the present study. Data were standardized firstly and to study the effect of various genetic and non-genetic factors, least-squares and maximum likelihood computer programme of Harvey (1990) using mixed linear model was used with the following statistical model:

$$Y_{ijklm} = \mu + S_i + P_j + (Se)_k + D_l + e_{ijklm}$$

where Y_{ijklm} , observation on m^{th} animal which is progeny of i^{th} sire belonging to j^{th} period of birth, having k^{th} sex and l^{th} group of dam's weight at lambing; μ , overall mean; S_i , random effect of sire; P_j , fixed effect of j^{th} period of birth ($j = 1, 2$); $(Se)_k$, fixed effect of k^{th} sex ($k = 1, 2$); D_l , fixed effect of l^{th} dam's weight at lambing ($l = 1, 2, 3$) and e_{ijklm} is random error component NID ($0, \sigma_e^2$). Heritability estimates for different traits were obtained from sire component of variances using paternal half-sib correlation method. Single trait animal model including significant fixed effects from GLM and random effects of sire was used for estimation of breeding values using WOMBAT

software (Meyer 2007) as:

$$Y = Xb + Zu + e$$

where Y , vector of observations on considered traits; X , design matrix of fixed effects; b , vector of fixed effects; Z , design matrix corresponding to random animal effects; u , vector of random animal effects; e , vector of random residual errors.

RESULTS AND DISCUSSION

The effect of period of birth was highly significant ($p < 0.01$) on BWT, Y-WT, WFL and GFW and significant ($p < 0.05$) on A-WT in Harnali sheep (Tables 1, 2). Similar findings were reported by Lalit *et al.* (2016) and Kumar *et al.* (2018a) in Harnali sheep, Kannoja *et al.* (2016) in Marwari sheep, Narula *et al.* (2017) in Magra sheep, Reddy *et al.* (2017) in Nellore brown sheep and Mallick *et al.* (2017) in Bharat merino sheep. Period of birth had non-significant effect on AFS and present findings were in agreement with those reported by Baber and Javed (2009) in Lohi sheep. However, Gowane *et al.* (2014) in Malpura sheep and Reddy (2015) in Nellore brown sheep found significant effect of period of birth on age at first service. Period of birth had non-significant effect on W-WT and 6

Table 1. Least-squares means along with standard error for growth traits in Harnali sheep

Factor		BWT (kg)	WWT (kg)	6 M-WT (kg)	Y-WT (kg)	A-WT (kg)
<i>Period of birth</i>	N	**	NS	NS	**	*
I (2011–2013)	44	3.33 ^a ±0.10	15.10±0.45	18.26±0.51	23.40 ^a ±0.47	28.00 ^a ±0.61
II (2014–2016)	66	3.68 ^b ±0.82	15.32±0.36	18.99±0.41	25.89 ^b ±0.37	31.12 ^b ±0.49
<i>Sex</i>		NS	NS	**	**	**
Male	14	3.67±0.16	14.81±0.77	24.07 ^b ±0.83	32.11 ^b ±1.04	44.92 ^b ±1.22
Female	96	3.68±0.08	14.66±0.29	18.81 ^a ±0.32	22.52 ^a ±0.40	30.19 ^a ±0.47
<i>Dam weight at lambing (kg)</i>		*	**	**	**	*
≤27	39	3.63 ^{ab} ±0.11	13.64 ^a ±0.43	17.79 ^a ±0.51	20.72 ^a ±0.46	28.47 ^a ±0.63
>27–30	32	3.47 ^a ±0.12	14.40 ^{ab} ±0.48	18.44 ^{ab} ±0.56	22.52 ^a ±0.51	30.48 ^{ab} ±0.70
>30	39	3.72 ^b ±0.11	15.92 ^b ±0.45	20.95 ^b ±0.53	24.91 ^b ±0.53	32.14 ^b ±0.66

BWT, Birth weight; A-WT, adult body weight (kg); N, number of observations; NS, non-significant; WWT, weaning weight; 6 M-WT, six month body weight; Y-WT, one year body weight; ** and * represents significant at 1% and 5% level of significance; Mean values with different superscripts differ significantly.

Table 2. Least-squares means along with standard error for performance traits in Harnali sheep

Factor		AFS (days)	WFS (kg)	AFL (days)	WFL (kg)	GFW (g)
<i>Period of birth</i>	N	NS	NS	NS	**	**
I (2011–2013)	38	541.85±6.91	26.49±0.56	738.77±7.41	30.05 ^b ±0.56	1532.00 ^a ±44.55
II (2014–2016)	58	555.51±5.51	27.09±0.44	731.47±5.91	27.51 ^a ±0.45	1865.81 ^b ±35.54
<i>Sex</i>		NS	NS	NS	NS	**
Male	—	—	—	—	—	2285.71 ^b ±98.06
Female	—	—	—	—	—	1736.06 ^a ±37.85
<i>Dam weight at lambing (kg)</i>		NS	**	NS	**	NS
≤27	35	549.54±7.19	25.66 ^a ±0.54	720.27±7.63	23.76 ^a ±0.28	1778.48±53.88
>27–30	30	548.07±7.95	26.56 ^{ab} ±0.59	739.70±8.42	28.88 ^{ab} ±0.30	1675.18±59.57
>30	31	553.83±7.54	28.47 ^b ±0.56	732.00±7.99	32.26 ^b ±0.28	1810.00±56.51

AFS, Age at first service; WFS, weight at first service; AFL, age at first lambing; WFL, weight at first lambing; GFW, grease fleece weight; N, number of observations; NS, non-significant; ** and * represents significant results at 1% and 5% level of significance; Mean values with different superscripts differ significantly.

Table 3. Least-squares means along with standard error for body conformation traits in Harnali sheep

Effect		BL (cm)	BH (cm)	HG (cm)	PG (cm)
<i>Period of birth</i>	N		**	**	**
I (2011–2013)	44	65.54±0.62	66.80 ^b ±0.64	73.68 ^a ±0.83	73.85 ^a ±1.00
II (2014–2016)	66	65.16±0.95	64.35 ^a ±0.51	76.66 ^b ±0.66	80.12 ^b ±0.80
<i>Sex</i>		**	**	**	**
Male	14	75.71 ^b ±1.08	73.41 ^b ±1.06	86.75 ^b ±1.37	88.78 ^b ±1.86
Female	96	65.30 ^a ±0.42	65.45 ^a ±0.41	75.56 ^a ±0.53	77.55 ^a ±0.53
<i>Dam's weight at lambing(kg)</i>		**	**		
≤27	39	63.52 ^a ±0.62	63.43 ^a ±0.43	75.67±0.90	78.45±1.71
>27–30	32	65.70 ^{ab} ±0.69	65.52 ^{ab} ±0.71	75.22±0.99	77.15±1.29
>30	39	67.23 ^b ±0.54	67.16 ^b ±0.67	76.56±0.94	77.33±1.22

BL, Body length; BH, body height; HG: heart girth; PG, paunch girth; ** represents significant results at 1% level of significance; Mean values with different superscripts differ significantly.

M-WT in Harnali sheep in the present study, however, several researchers (Kannoja *et al.* (2016) in Marwari sheep, Narula *et al.* (2017) in Magra, Mallick *et al.* (2017) in Bharat merino and Kumar *et al.* (2018a) in Harnali sheep) reported significant effect of period of birth on these traits. In the current study, AFL was not significantly affected by the period of birth, however, Lakew *et al.* (2014) found significant effect of period of birth on AFL. In the present study, the performance of Harnali sheep for growth traits in general was higher in 2nd period. The variation might be due to varying environmental conditions and as a result of continuous selection for body weight at the sheep farm. Sex of lamb had highly significant effect ($p<0.01$) on 6 M-WT, Y-WT, A-WT and GFW in Harnali sheep. Significant sex difference in body weight was also reported by Lalit *et al.* (2016) in Harnali, Narula *et al.* (2017) in Magra and Reddy *et al.* (2017) in Nellore brown sheep. The males were having higher estimates for all body weights than females. The superiority of males was observed right from 3 months of age to adult age and increased with the advancement of age. Better prenatal and post-natal growth of male lambs might be due to differences in their endocrine profiles. Dam's weight at lambing showed highly significant effect ($p<0.01$) on W-WT, 6 M-WT, Y-WT, WFS and WFL and significant effect ($p<0.05$) on BWT and A-WT in Harnali sheep in present study. Significant effect on dam's weight at lambing was also reported by Singh *et al.* (2013), Devendran *et al.* (2014) and Nirban *et al.* (2015) in different breeds of sheep. The heavier lambs were born out of heavier dams and tend to maintain their better vigour and growth. This might be due to the reason that well fed heavy dams were expected to produce more milk to feed their lambs up to weaning besides providing better environment during fetus growth. Three body conformation traits, viz. BH, HG and PG were significantly ($p<0.01$) affected by period of birth in Harnali sheep (Table 3). HG and PG was higher in 2nd period as compared to 1st period in Harnali sheep which might be due to variation in availability of feed and fodder and management fluctuations in different periods. The significant effect of period of birth on body conformation was also reported by Petrovic *et al.* (2012) in Merinol and

Schaf sheep, and Jafari and Hashemi (2014) in Makuie sheep. Sex of lamb had significant effect ($p<0.01$) on all conformation traits (Table 3). The males were having higher estimates for all body measurements than females. This variation might be due to hormonal influences and higher body weight in males. Similar findings were also reported by Petrovic *et al.* (2012) in Merinol and Schaf sheep, and Jafari and Hashemi (2014) in Makuie sheep. Dam's weight at lambing showed significant effect ($p<0.01$) on BL and BH in present study. It indicated that body condition score of dam at the time of lambing was very important factor for body conformation of lambs in the adult age. Higher body weight score of dams at lambing reflected better nourishment of the lambs before and after birth. Similar findings were also reported by Chopra *et al.* (2010) and Jafari and Hashemi (2014) in different breeds of sheep. Kumar *et al.* (2019) reported significant association among different body conformation traits in Harnali sheep.

Heritability estimates for various performance traits in Harnali sheep (Table 4) were low to moderate. Heritability estimates for BWT, W-WT, 6 M-WT, Y-WT, A-WT, AFS, WFS, AFL, WFL and GFW were 0.29±0.02, 0.27±0.08, 0.27±0.04, 0.34±0.07, 0.26±0.09, 0.23±0.05, 0.19±0.04,

Table 4. Estimates of heritability along with standard error for performance and body conformation traits in Harnali sheep

Trait	Heritability±SE
Birth weight (kg)	0.29±0.02
Weaning weight (kg)	0.27±0.08
Six month body weight (kg)	0.27±0.04
One year body weight (kg)	0.34±0.07
Adult body weight (kg)	0.26±0.09
Age at first service (days)	0.23±0.05
Weight at first service (kg)	0.19±0.04
Age at first lambing (days)	0.26±0.07
Weight at first lambing (kg)	0.07±0.01
Grease fleece weight (g)	0.01±0.01
Body length (cm)	0.32±0.13
Body height (cm)	0.39±0.11
Heart girth (cm)	0.25±0.11
Paunch girth (cm)	0.25±0.14

Table 5. Breeding values of performance and body conformation traits in Harnali sheep

Trait	Breeding value			Range
	Average	Minimum	Maximum	
Birth weight (kg)	0.006	-0.441	0.430	0.872
Weaning weight (kg)	-0.02	-2.93	2.413	5.346
Six month body weight (kg)	0.05	-2.356	2.015	4.370
One year body weight (kg)	-0.070	-2.356	1.456	3.812
Adult body weight (kg)	-0.01	-2.83	2.312	5.142
Age at first service (days)	0.0936	-2.014	1.498	3.512
Weight at first service (kg)	-0.167	-8.081	7.420	15.501
Age at first lambing (days)	-0.414	-23.915	74.373	98.289
Weight at first lambing (kg)	0.018	-0.751	0.635	1.386
Grease fleece weight (g)	1.002	-4.012	7.123	11.135
Body length (cm)	-0.053	-3.350	6.766	10.116
Body height (cm)	-0.012	-3.117	4.464	7.582
Heart girth (cm)	-0.259	-5.582	5.844	11.427
Paunch girth (cm)	0.159	6.069	11.601	17.670

0.26±0.07, 0.07±0.01 and 0.01±0.01 respectively. The heritability estimates for birth weight reported in literature ranged from 0.09±0.08 (Reddy *et al.* 2017) in Nellore brown sheep to 0.76±0.14 (Dey 2004) in Nali sheep. The estimates of heritability in the present study for BWT, W-WT, 6 M-WT, Y-WT and A-WT were in close agreement with those reported in literature. However, Ganeshan *et al.* (2013) reported higher estimates of heritability for W-WT as 0.51±0.16 in Madras Red sheep. Heritability estimate for BWT in the present study was lower than those reported by Dey (2004) in Nali sheep (0.76) and Kumar *et al.* (2018a) in Harnali sheep (0.68). Chauhan *et al.* (2021) reported comparatively lower (0.10) heritability of weaning weight in Harnali sheep using univariate animal model. Higher heritability estimates of Y-WT than those found in the present study were also reported by Ganeshan *et al.* (2013) in Madras red (0.65) and Narula *et al.* (2017) in Magra sheep (0.59). The estimate of heritability for A-WT in the present study (0.26±0.09) was comparatively lower than the finding of Snyman (2012) in Angora goats (0.58±0.03). Chauhan *et al.* (2021a) reported low to moderate heritability estimates for average daily gain from birth to 3 months of age, 3 months to 6 months of age and 6 months to 12 months of age in Harnali sheep. The estimate of heritability for AFL in Harnali sheep was higher than 0.11±0.05 as reported by Gowane *et al.* (2014) in Malpura sheep but it was lower than 0.44±0.11 as estimated by Akhtar *et al.* (2008) in Hissardale sheep. Heritability of GFW in current study was lower than the estimates obtained by Khan *et al.* (2015) in

Rambouillet crossbred (0.49±0.08). Higher estimate of heritability for GFW than that found in the present study was also reported by Jafari and Hashemi (2014). The variability in heritability values of various traits as estimated by different workers might be due to number of observations in each study and level of selection pressure in different flocks. Moderate to higher estimates of heritability for some performance traits in present study pointed towards the availability of genetic variability for these traits which could be exploited for further improvement in the growth and reproductive performance of Harnali sheep. In the present study, heritability estimates for various body conformation traits in Harnali sheep were moderate and estimates for BH, BL, HG and PG were 0.39±0.11, 0.32±0.13, 0.25±0.11 and 0.25±0.14, respectively (Table 4). High heritability estimates for BH and HG as 0.80±0.02 and 0.80±0.01, respectively were reported by Waheed *et al.* (2011) in beetal goats. Fadare *et al.* (2014) reported estimates of heritability for BL and HG as 0.67 and 0.71 in the West African sheep. The heritability estimates of BL, BH, HG and PG lower than those found in present study were reported by Mandal *et al.* (2010), Panda *et al.* (2014) and Bakhshalizadeh *et al.* (2015) in Muzaffarnagri, Ekda and Moghani sheep, respectively. Higher estimates of heritability for body measurement traits in present study indicated towards the presence of genetic variability in these traits which might be due to the reason that linear type traits were not included in the selection criterion of Harnali sheep so far. High genetic variability in these traits clearly indicated the scope of improvement in these body dimensions through selection.

The breeding values of performance and body conformation traits of Harnali sheep are presented in Table 5. The estimates of breeding value ranged from -0.441 to 0.430 kg, -2.93 to 2.413 kg, -2.356 to 2.015 kg, -2.356 to 1.456 kg, -2.83 to 2.312 kg, -2.014 to 1.498 days, -8.081 to 7.420 kg, -23.915 to 74.373 days, -0.751 to 0.635 kg and -4.012 to 7.123 g for BWT, W-WT, 6 M-WT, Y-WT, A-WT, AFS, WFS, AFL, WFL and GFW respectively in Harnali sheep (Table 5). More variability was observed in weaning weight in Harnali sheep. The range of breeding values for different performance traits indicated variability between the genetic worth of different individuals for these traits. This variability can be harnessed through selection for making further improvement in the considered traits. Javed *et al.* (2013) reported that estimated breeding values (EBVs) for birth weight, weaning weight and yearling weight for Lohi sheep ranged between -0.25 to 0.33, -0.99 to 1.30 and -1.26 to 1.51 kg, respectively. Jeichitra *et al.* (2015) estimated the breeding values for BWT, W-WT, 6 M-WT and Y-WT of Mecheri lambs ranging from -0.15 to 0.23, -0.61 to 0.85, -1.12 to 0.91 and -1.50 to 4.31, respectively. Mallick *et al.* (2016) estimated the breeding value of Bharat merino sheep for performance traits by mixed model using WOMBAT software and reported the EBVs as 0.067 for BW, 0.008 for WW, 0.036 for SMW and -0.003 for GFW. The estimates of breeding value (cm) ranged from -0.028 to 0.036, -0.035 to 0.025, -0.026 to

0.032 and -0.498 to 0.653 for BH, BL, HG and PG, respectively in Harnali sheep (Table 5). Negligible work has been done on breeding values of body conformation traits in sheep. The range of breeding values for these conformation traits pointed towards the availability of variability among individuals for these traits.

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