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Genetic and phenotypic correlations among linear type traits in Harnali sheep

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Abstract
The measurements of body dimensions are very important indicators of growth pattern in meat animals. Data on 349 Harnali sheep for body length (BL), body height (BH), heart girth (HG), paunch girth (PG), tail length (TL), head circumference (HC), ear length (EL), ear width (EW) and face length (FL) were analyzed to study genetic and phenotypic correlations among linear type traits. The mixed linear model with dam's weight at lambing as covariate was used to study the effect of non-genetic factors on linear type traits. Genetic and phenotypic parameters were estimated by paternal half sib correlation method from mixed model analysis. The phenotypic correlations among various linear type traits ranged from 0.03± 0.01 to 0.81±0.04. Genetic correlations among linear type traits were low to high in magnitude ranging from -0.01±0.15 to 0.76±0.06. High genetic correlations among some of linear type traits indicated that these traits might be under the pleiotropic effect of common genes. High phenotypic and genetic correlations among linear type traits could be utilized while formulating selection criterion for genetic improvement of Harnali sheep with regards to growth pattern.

Keywords: Genetic correlations, Harnali sheep, linear type traits, phenotypic correlations.

Introduction
Sheep in India are reared mainly for mutton and wool production. With the introduction of synthetic fibre, the economy of sheep farming now a days depends mainly on production of lambs. Lamb production contributes 85-90 per cent of total income generation, whereas, wool contributes only 5-10 per cent and rest comes from manure (Arora *et al.*, 1986) [1]. 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 (Verma *et al.*, 2016) [21]. Harnali population has now become stable and stability is one of the most desirable properties of a genotype to be released as a breed for wider utilization. Information on body measurements is necessary not only to monitor the growth of the sheep but also to estimate genetic correlations among various body measurements. Genetic and non-genetic components for the growth parameters must be estimated for evolving better selection strategies relating to growth and development of sheep (Kumar *et al*, 2017a) [16]. Body measurements, an indicator of breed standards (Pesmen and Yardimci, 2008) [18], provides great convenience for the prediction of body weight without weighbridges (Afolayan *et al.*, 2006 [2]; Khan *et al.* 2006 [13]; Yakubu, 2009 [22]; Kumar *et al.*, 2017) [15]. To determine optimal breeding strategies to increase the efficiency of sheep production, knowledge of genetic parameters for various traits and also the genetic relationships between the traits in different breeds of sheep is needed (Bahreini-Behzadi *et al.*, 2007 [6]; Babar *et al.*, 2008 [4]; Komlosi, 2008 [14]; Gamasaee *et al.*, 2010 [9]). Genetic correlations among body measurement traits indicate the pleiotropic effect of some common genes. High phenotypic and genetic correlations among body measurements can be utilized while formulating selection criterion for genetic improvement of sheep with regards to the body dimensions and growth pattern. Hence the present study was carried out to determine genetic and phenotypic correlations among some linear type traits of Harnali sheep.

Materials and Methods
All the procedures have been conducted in accordance with the guidelines laid down by the Institutional Ethics Committee.
Data recording: The data for the present study were recorded on 349 Harnali animals maintained in the Department of Animal Genetics and Breeding, Lala Lajpat Rai University of

Veterinary and Animal sciences, Hisar. The adult animals above 2 years of age were recorded for body measurements using a graduated measuring tape. All body measurements were taken when the animal was in standing position with head raised and weight on all four feet without body movement. Physical restraint was sometimes applied to limit movement. Pregnant females were excluded from sampling to remove the effect of pregnancy on some of body parameters. Following nine body measurements were taken on each animal.

Body length (BL): distance from base of tail to the base of the neck (first thoracic vertebrae); Body height (BH): distance from the surface of the platform on which the animal stands to the withers; Heart girth (HG): body circumference around the chest just behind the front legs and withers; Paunch girth (PG): circumference of body measured just before the hind legs; Head circumference (HC): circumference of head above the eyebrows and ears and around the back of the head; Face length (FL): distance from the beginning of the upper lip to the external occipital protuberance; Ear length (EL): length of ear from base of ear; Ear width (EW): width of ear at the middle of ear and Tail length (TL): length of tail from base of tail.

Statistical analysis: Least-squares and maximum likelihood computer programme of Harvey (1990) [10] using mixed linear model with dam's weight at lambing as covariate for estimation of various tangible factors on linear type traits was used. The following model was used:

$$Y_{ijklm} = \mu + S_i + P_j + B_k + A_l + b\,(X_D - \overline{X}) + e_{ijklm}$$

Where Yi_{jklm} is the observation on m^{th} animal belonging to l^{th} age group of dam, of k^{th} sex born in j^{th} period of birth, of i^{th} sire; **μ** is the overall mean; S_i is the random effect of i^{th} sire; P_j is the fixed effect of j^{th} period of birth (j =1,2,3,….6); B_k is the fixed effect of k^{th} sex (k = 1, 2); A_l is the fixed effect of l^{th} age group of dam (l = 1,2,….7); b is the linear regression coefficient of trait on dam's weight at lambing; X_D is the dam's weight at lambing; $\overline{X}$ is the mean dam's weight at lambing and e_{ijklm} is the random error component. The genetic correlations among different traits were estimated from sire component of variance and covariance. The phenotypic correlations were obtained from sire and within sire components of variances and covariances.

Results and Discusion

Effect of non- genetic factors: The effect of various factors viz; period of birth, sex, dam's age and weight at lambing on linear type traits was studied to standardize the data for estimation of genetic parameters (Table 1). The period of birth had significant (P<0.01) effect on BL, BH, HC and FL but was non-significant on other body measurements. The effect of period of birth might be due to variation in availability of feed and fodder in different periods. The significant effect of period of birth on linear type traits was also reported by Tadesse and Gebremariam (2010) [20] in Highland sheep, Petrovic *et al.* (2012) [19] in Merinolandschaf sheep and Jafari and Hashemi (2014) [12] in Makuie sheep.

The effect of sex was found significant (P<0.01) on all linear type traits except ear length and ear width. The males were having higher values for all linear type traits than females. Similar findings were also reported by Petrovic *et al.* (2012) [19] in Merinolandschaf sheep, Jafari and Hashemi (2014) [12] in Makuie sheep and Lalit *et al.* (2016) [17] in Harnali sheep. The effect of dam's age at lambing was non-significant on all linear type traits. This might be due to the reason that weight of dam at lambing was taken as covariate in the model and weight of dam generally corresponds to the age. Similar findings were also reported by Abbasi and Ghafouri-Kesbi (2011) [1] in Makuie sheep and Cilek and Gotoh (2014) [8] in Malya sheep. However, significant effect of dam's age at lambing on body measurements was reported by Jafari and Hashemi (2014) [12] in Makuie sheep.

Dam's weight at lambing significantly (P<0.05) influenced all linear type traits indicating that body condition score of dam at the time of lambing is very important factor for body conformation of lambs in the adult age. Higher body condition score of dams at lambing reflected better nourishment of the lambs before and after birth. Similar observations were also noticed by Jafari and Hashemi (2014) [12] in Makuie sheep and Petrovic *et al.* (2012) [19] in Merinolandschaf sheep.

Table 1: Analysis of variance for body measurement traits in Harnali sheep

Source of variation	D.f.	Mean sum of squares								
		L	H	HG	PG	TL	HC	EL	EW	FL
Sire	95	16.04	8.85	13.87	23.70	45.04	8.08	8.57	1.91	2.52
Period	5	34.91**	44.24**	10.34	48.78	22.93	12.74**	6.31	1.32	14.25**
Sex	1	3003.37**	1905.09**	4340.43*	5419.07**	463.62**	1602.27**	5.09	0.77	319.22**
Dam's age at lambing	6	12.44	7.35	14.10	23.31	7.46	3.89	1.76	0.54	1.04
Dam's weight at lambing (linear regression)	1	36.92*	112.41**	92.02**	373.02**	445.07**	1.04**	27.57*	14.19**	10.71*
Error	240	10.68	9.94	15.33	46.06	22.32	5.72	6.45	1.02	2.44

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

Genetic parameters

The phenotypic correlation of BL was found positive and significant with all linear type traits ranging from 0.14±0.05 (TL) to 0.46±0.04 (BH) (Table 2). However, medium to high correlations between body length and other morphometric traits were observed by Baffour *et al.* (2000) [5], Cam *et al.* (2010) [7] and Jafari and Hashemi (2014) [12] in different breeds of sheep. The phenotypic correlation of BH was found positive and significant with HG, EL and FL with moderate to high in magnitude ranging from 0.22±0.04 to 0.81±0.08. The Phenotypic correlation of HG was found positive and significant with BL, BH, PG, HC and FL with moderate to high ranging from 0.36±0.02 to 0.57±0.07. Similar findings were also reported by Cam *et al.* (2010) [7], Iyiola-Tunji *et al.* (2011) [11], Petrovic *et al.* (2012) [19] and Jafari and Hashemi (2014) [12]. The phenotypic correlation of HC was found positive and significant with BL, HG, and FL with moderate to high ranging from 0.27±0.04 to 0.42±0.04. The phenotypic correlation of EL was found highly positive and significant with BH (0.81±0.04) and EW (0.69±0.04).

The genetic correlation of BL was found positive with all body measurements with low to high in magnitude ranging from 0.01±0.17 (FL) to 0.70±0.10 (BH). The genetic correlation of HG was found high and positive with PG (0.76±0.14) and HC (0.64±0.11). High genetic correlations among BL, BH and HG were also reported by Abbasi and Ghafour-Kesbi (2011) [1], Petrovic *et al.* (2012) [19] and Jafari and Hashemi (2014) [12]. The genetic correlation of PG was found positive with all body measurement traits except TL and BH. The genetic correlation of EW was high with BH (0.69±0.17) and EL (0.76±0.06). The genetic correlation of TL was moderate to high and negative with HG, PG, HC and FL. The genetic correlation of HC was positive with all body measurement traits with low to high in magnitude ranging from 0.14±0.16 (BH) to 0.75±0.16 (PG) except TL, EL and EW. The positive correlation of HC with most of the body measurements indicates that animals with broad head are genetically higher in other body dimensions also. The genetic correlation of EL was found high and positive with TL (0.41±0.11) and EW (0.76±0.06). The genetic correlation of FL was positive with BH, PG and HC but negative with BH, TL, EL and EW.

Table 2: Genetic (above diagonal) and phenotypic (below diagonal) correlations along with standard error among linear types traits in Harnali sheep.

Traits	L	H	HG	PG	TL	HC	EL	EW	FL
L	-	0.70±0.10	0.27±0.15	0.25±0.19	0.12±0.13	0.26±0.13	0.14±0.14	0.17±0.13	0.01±0.17
H	0.46**±0.04	-	0.08±0.19	-0.16±0.25	0.16±0.16	0.14±0.16	0.09±0.18	0.69±0.17	-0.13±0.19
HG	0.36**±0.02	0.39**±0.05	-	0.76±0.14	-0.22±0.17	0.64±0.11	-0.06±0.18	0.21±0.16	0.27±0.18
PG	0.26**±0.06	0.15**±0.03	0.57**±0.07	-	-0.52±0.20	0.75±0.16	0.05±0.22	0.34±0.20	0.10±0.25
TL	0.14**±0.05	0.04±0.01	-0.21**±0.02	-0.06±0.01	-	-0.37±0.13	0.41±0.11	0.28±0.12	-0.49±0.16
HC	0.27**±0.04	0.17**±0.03	0.42**±0.04	-0.07±0.02	-0.24**±0.05	-	-0.27±0.15	-0.53±0.14	0.44±0.13
EL	0.16**±0.01	0.81**±0.04	-0.18**±0.05	0.34**±0.04	0.39**±0.02	-0.14**±0.03	-	0.76±0.06	-0.32±0.17
EW	0.20**±0.05	0.06±0.07	0.10*±0.02	0.03±0.01	0.26**±0.03	0.10*±0.04	0.69**±0.04	-	-0.01±0.15
FL	0.19**±0.04	0.22**±0.08	0.38**±0.04	0.10*±0.03	-0.20**±0.04	0.41**±0.06	-0.12*±0.02	0.09±0.01	-

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

Conclusions

The phenotypic correlations among various body measurements were quite varying ranging from 0.03± 0.01 to 0.81±0.04. Genetic correlations among body measurement traits were low to high in magnitude ranging from -0.01±0.15 to 0.76±0.06. High genetic correlations among some of body measurements indicated that these traits might be under the pleiotropic effect of common genes which could be utilized while formulating selection criterion for genetic improvement of Harnali sheep. Moderate to high genetic correlations of head circumference with body length, height, heart girth and paunch girth indicated that this trait can be used as an indicator for selection of superior animals.

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