Indian Journal of Animal Sciences **94** (5): 435–441, May 2024/Article
https://doi.org/10.56093/ijans.v94i5.131099

Estimation of genetic parameters as well as trends for growth traits in Harnali sheep

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Received: 6 December 2022; Accepted: 14 March 2024

ABSTRACT

The current study focussed on the growth traits pertaining to Harnali sheep maintained at Sheep Farm, LUVAS, Hisar and data were recorded from pedigree sheets of 1278 animals. Growth traits considered were birth weight (BW), weaning weight (WW), six-month weight (6MW), yearling weight (YW), and pre-weaning average daily gain (PRWDG) and least-squares means for corresponding traits found to be 3.28±0.02 kg, 12.89±0.07 kg, 17.06±0.06 kg, 24.36±0.06 kg, and 106.74±0.61 g, respectively. Effect of different factors like period of birth, sex of animal and dams' weight at lambing was studied on growth traits. Except YW, significant effect of period of birth was observed on all the growth traits. Sex had significant influence on BW only however, dams' weight at lambing affected significantly all the considered growth traits except YW. By leveraging the sire component of variance and covariance from mixed model analysis, the paternal half-sib correlation method was used to estimate genetic as well as phenotypic parameters. Estimates of heritability for BW, WW, 6MW, YW and PRWDG were 0.28±0.07, 0.33±0.07, 0.31±0.07, 0.12±0.04 and 0.27±0.06, respectively. Genetic as well as phenotypic trends for WW and PRWDG were found to be positive. Moderate range of genetic variability at weaning weight and its positive genetic and phenotypic correlations with growth traits specially six month's weight indicated that genetic improvement could be possible through early selection at weaning weight in Harnali sheep.

Keywords: Breeding value, Genetic parameters, Genetic trend, Growth, Harnali sheep

Sheep play a significant role in meeting the basic needs of rural populations by providing meat, milk, and wool. Sheep farming is vital to the economy in India's rural areas. According to Livestock Census (2019), with 44 recognized breeds having a total of 74.26 million sheep, India has the third-highest number of sheep in the world and is a major source of sheep genetic resources. In both India and rest of the world, demand for meat and meat products is rising quickly, which has piqued academics' interest in finding ways to improve meat production using marker-assisted selection and selective breeding. Harnali sheep has been devolved through cross-breeding for producing superior carpet wool, improved growth and adaptability. Crossbreds with 62.5% exotic inheritance from Russian Merino and Corriedale and 37.5% from local Nali breed were crossed *inter se* for numerous generations to attain stable performance. The stability of the Harnali population is now recognized and a genotype's stability is the most desired property before its release as a breed for widespread use.

Animals go through a critical stage of development that might have an impact on eventual production of products including milk, meat, wool, and other products. Growth qualities are more economically significant in sheep breeding (Thiruvenkadan *et al*. 2011) because larger lambs with faster growth rates would generate more income in a shorter amount of time than weaker lambs would. Fast-growing lambs are in high demand due to the market's escalating mutton pricing. A key factor in flock production is a faster growth rate and for optimum survivability, reproduction and production, better growth is essential (Singh 2012).

The study of genetic trends in a population is important in monitoring the genetic progress as it corresponds to observed changes in the average breeding values of animals for the traits concerned during the selection process. Knowledge of genetic variation and correlations among traits is required for designing effective sheep breeding programmes as well as for accurate prediction of genetic progress. Nevertheless, in depth research on genetic trends of economically important traits of Harnali sheep is lacking. Therefore, the aim of the current study was to assess the genetic parameters as well as genetic change in growth traits of Harnali sheep.

MATERIALS AND METHODS

Data and farm management: The present study made use of data on the growth characteristics of Harnali sheep

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kept at animal farm of AGB Department, LUVAS, Hisar, Haryana under sheep breeding project. Collection of data was done from history cum pedigree sheets of 1278 animals of Harnali sheep developed under project entitled, Estimating the cross combining ability of Corriedale and Russian Merino rams with Nali ewes. The animals were housed in loose housing system with brick floor. Animals were permitted to graze on natural pastures for roughly six hours each day, with the addition of concentrate feeding and grown fodder. In the shed, clean water was made available to the animals all the time. At three months of age, lambs were vaccinated against PPR, sheep-pox and enterotoxaemia. The flock was routinely dewormed every four months.

Recording of information: In order to evaluate the impact of non-genetic factors on the growth traits under consideration, 14 years' duration (2001-2014) data were classified according to birth period (07 periods, each lasting two years), sex of the lamb (Male/Female), and weight of the dam at lambing (DW 1: 23.0 kg, DW 2: 23.01-26.00 kg, DW 3: 26.01-29.00 kg, DW 4: >29.0 kg). Growth traits studied were birth weight (BW), weaning weight (WW), six-month weight (6MW), yearling weight (YW) and pre-weaning average daily gain (PRWDG). After lambing, birth weight and dam's weight at lambing were recorded within 16 h duration. Weaning weight, six-month body weight and one-year body weight were taken at 90 days, 180 days and 365 days of age, respectively.

Statistical analyses: To analyse the impacts of various factors on the traits under consideration, least-squares mixed model as given below with maximum likelihood computer programme (Harvey 1990) was used. Using Kramer's modified DMRT, least-squares means were compared (Kramer 1957).

$$Y_{ijklm} = \mu + S_i + P_j + B_k + D_l + e_{ijklm}$$

Here, Y_{ijklm}, observation on m^{th} sheep from l^{th} dam weight group, having k^{th} sex, born in j^{th} period and having i^{th} sire; μ, overall mean; S_i, random effect of i^{th} sire; P_j, fixed effect of j^{th} period of birth (j = 1 to 7); B_k, fixed effect of k^{th} sex (k = 1, 2); D_l, fixed effect of l^{th} weight group of dam (l = 1 to 4) and e_{ijklm}, random residual error.

Using the sire component of variance and covariance from mixed model analysis, genetic as well as phenotypic parameters were evaluated using the paternal half-sib correlation approach. Standard errors of phenotypic correlations were computed by the formula given by Snedecor and Cochran (1980). Single trait animal model was considered to estimate the breeding values with WOMBAT software (Meyer 2007) as under:

$$Y = X\beta + Zu + e$$

where, Y, vector of observations for growth traits; X & β, design matrix and vector for fixed effects; Z & u, design matrix and vector for random animal effects; and e, vector of associated random residual errors. Assumptions of model were:

$$E(Y) = Xb \quad E(u) = 0, \ E(e) = 0$$

$$V(\mu) = A\,\sigma^2_a \quad V(e) = I\,\sigma^2_e$$

where, A, numerator relationship matrix; I, identity matrix of order equal to number of records; σ^2_a, additive genetic variance and σ^2_e, residual variance.

Breeding as well as phenotypic values of growth traits were regressed on the birth year for estimation of genetic as well as phenotypic trends by using the regression technique of SPSS (2007).

RESULTS AND DISCUSSION

Least-squares means for birth weight (BW), weaning weight (WW), six-month body weight (6MW), yearling

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

Trait	BW (kg)	WW (kg)	6MW (kg)	YW (kg)	PRWDG (g)
Overall mean	3.28±0.02(1278)	12.89±0.07(1278)	17.06±0.06(1278)	24.36±0.06(1048)	106.74±0.61(1278)
Period of birth					
P1	3.02^a±0.04(159)	12.04^a±0.1(159)	16.45^a±0.1(159)	23.14±0.14(132)	100.16^{ab}±1.02(159)
P2	3.02^a±0.03(226)	11.89^a±0.09(226)	16.36^a±0.08(226)	23.76±0.12(185)	98.49^a±0.89(226)
P3	3.32^b±0.05(155)	12.48^b±0.13(155)	16.82^b±0.11(155)	24.32±0.17(125)	101.76^b±1.18(155)
P4	3.86^d±0.03(209)	13.98^d±0.10(209)	17.89^e±0.08(209)	25.54±0.15(170)	112.42^c±1.09(209)
P5	3.54^c±0.03(201)	14.00^d±0.09(201)	17.75^{de}±0.08(201)	24.99±0.17(165)	116.26^d±0.92(201)
P6	3.38^b±0.03(153)	13.54^c±0.1(153)	17.37^c±0.1(153)	24.12±0.14(127)	112.89^c±0.93(153)
P7	3.32^b±0.04(188)	13.36^c±0.1(188)	17.51^{cd}±0.1(188)	24.34±0.18(152)	111.65^c±0.91(188)
Sex					
Male	3.32^a±0.02(626)	12.90±0.08(626)	17.04±0.07(626)	24.72±0.16(396)	106.53±0.72(626)
Female	3.25^b±0.02 (652)	12.87±0.08(652)	17.07±0.07(652)	24.12±0.15(652)	106.96±0.72(652)
DWL					
D1	3.10^d±0.05 (109)	12.47^d±0.14(109)	16.87^c±0.13(109)	24.15±0.24(89)	104.13^d±1.4(109)
D2	3.21^c±0.03 (309)	12.83^c±0.09(309)	16.87^c±0.08(309)	24.06±0.18(246)	106.84^c±0.89(309)
D3	3.37^b±0.03 (394)	13.01^b±0.09(394)	17.12^b±0.08(394)	24.49±0.17(329)	107.18^b±0.82(394)
D4	3.45^a±0.03 (466)	13.25^a±0.08(466)	17.37^a±0.07(466)	24.97±0.17(384)	108.82^a±0.79(466)

Figures within parenthesis are number of observations, means with different superscripts within a column for each trait differ significantly.

body weight (YW) and pre-weaning average daily gain (PRWDG) were estimated as 3.28±0.02 kg, 12.89±0.07 kg, 17.06±0.06 kg, 24.36±0.06 kg and 106.74±0.61 g, respectively (Table 1). Chauhan *et al*. (2021) reported similar least-squares means for BW, WW and 6MW in Harnali sheep. The overall least-squares mean of birth weight in Harnali lambs was comparatively more than the reports of Gowane *et al*. (2011) in Garole × Malpura. In the present study, weaning weight as obtained was in correspondence with earlier reports in different sheep breeds (Lalit *et al*. 2016, Reddy *et al*. 2017 and Bangar *et al*. 2020). On contrary, Kannojia *et al*. (2016) as well as Mallick *et al*. (2017) reported higher estimates of weaning weight in different sheep breeds. Overall least-squares mean as obtained for six-month body weight (6MW) in the current study was similar to the findings of various researchers (Kannojia *et al*. 2016, Mallick *et al*. 2017 and Narula *et al*. 2017) in other sheep breeds. Conversely, Lalit *et al*. (2016) and Bangar *et al*. (2020) reported comparatively lower and higher 6MW in Harnali sheep, respectively. In current study, least-squares mean of one-year body weight (YWT) in Harnali sheep was obtained as 24.36±0.06 kg which was higher than the findings of Lalit *et al.* (2016). On the contrary, Bangar *et al.* (2020) in Harnali (26.78±0.36 kg) reported higher body weight at one year of age.

Effect of non-genetic factors: Period of birth had significant ($p<0.01$) effect on all the growth traits except yearling weight (YW). Similar significant influence of birth period on BW was observed by Kumar *et al*. (2022) in Harnali sheep, however, birth period had no significant influence on BW as observed by Das *et al*. (2014). Corresponding to the present findings, significant effect of period of birth on WW was also reported by Nirban *et al*. (2015) however, Kumar *et al*. (2022) observed non-significant influence of period on WW. In this study, 6MW significantly varied in different periods and an increasing trend was obtained from period 2 to period 4 for 6MW, which might be the result of continuous selection as this trait was the basis of selecting rams for breeding. Significant period differences were also reported by Hussain *et al*. (2014) and Nirban *et al*. (2015) in different sheep breeds. Differences due to period of birth were observed as non-significant for YWT, however, significant period differences were reported by various workers (Kannojia *et al*. 2016, Narula *et al*. 2017 and Kumar *et al*. 2022) in sheep. The variations because of period of birth on BW of lambs might be attributed to the diverse weather conditions determining accessibility of fodder as well as natural pastures during various periods. Greater availability of pastures leads to more chances of heavier and healthier lambs. Variation in management practices also contributed towards period effect on birth weight of lambs during different periods.

Birth weight was significantly ($p<0.01$) affected by sex while other traits had no effect of sex in current study. Birth weight of male lambs (3.32±0.02 kg) was significantly higher than female lambs (3.25±0.02 kg). Similar significant influence of sex on birth weight was also observed by earlier researchers in different Indian breeds of sheep (Vivekanand *et al*. 2014, Kumar *et al*. 2018). Hormonal influences play a vital role in the difference between birth weights of males and females. Superiority of male over female lambs was also observed with advancement of age. Males were somewhat heavier (17.06±0.06 kg) than females (16.87±0.13 kg) at the age of six months and these results were in correspondence with the findings of Nirban *et al*. (2015) and Kumar *et al*. (2018) in different breeds of sheep. Males (24.72±0.16 kg) had significantly higher weight than the females (24.12±0.15 kg) at the age of one year and the findings were supported by previous studies in sheep (Nirban *et al.* 2015, Narula *et al*. 2017 and Kumar *et al*. 2018). The faster growth rate and early culling of males than their counterparts, i.e. females might be the reason for this finding. Culling was more intense in males than females specifically after six months of age. The significant differences in body weights of both sexes indicated that selection standards of male and female lambs should be fixed for future use. Contrary to present findings, Assan (2020) reported significant effect of sex of the lamb on pre-weaning growth.

In this study, weight of dam at lambing had significant effect on all growth traits except yearling weight (YW). Similar to the present study, weight of dam at lambing had significant influence on birth weight in sheep as reported by Kumar *et al*. (2018). These results indicated that ewes with higher body weight at lambing delivered heavier lambs. This might be due to the reason that the well-fed ewes with good body weight, provides better intra uterine environment and nutrients to the foetus. Consequently, the breeder should take care of feeding ewes cautiously in advance pregnancy to get a healthier lamb crop. Weight of dam at lambing also affected WW significantly ($p<0.01$) and results were supported by earlier studies (Nirban *et al.* 2015, Kumar *et al.* 2018). Dams having higher body weights yielded heavier lambs with enhanced growth and vigour. This can be ascribed to the fact that well fed dams produced additional milk to feed their lambs till weaning.

Table 2. Estimates of heritability (diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations along with standard error among growth traits

Trait	BW	WW	6MW	YW	PRWDG
BW	0.28±0.07	0.58±0.12	0.77±0.09	0.44±0.21	0.29±0.17
WW	0.43*±0.03	0.33±0.07	0.58±0.12	0.50±0.20	0.95±0.02
6MW	0.51*±0.01	0.51*±0.03	0.31±0.07	0.27±0.21	0.38±0.15
YW	-0.02±0.03	0.04±0.03	-0.01±0.04	0.12±0.04	0.41±0.21
PRWDG	0.10±0.03	0.94**±0.03	0.38*±0.04	0.05±0.04	0.27±0.06

Also, 6MW was significantly influenced by weight of dam at lambing and this was in concordance with the study of Kumar *et al*. (2022), however, contrary to present findings they reported significant influence of dam's weight at lambing on one-year body weight. The results revealed that the effect of mothering ability was also reflected in market weight of lamb. Weight of dam at lambing did not affect body weight at one year of age and in Avikalin sheep, similar findings were observed by Prince *et al*. (2010).

Estimates of heritability and correlations: Heritability estimates for BW, WW, 6MW, YW and PRWDG were 0.28±0.07, 0.33±0.07, 0.31±0.07, 0.12±0.04 and 0.27±0.06, respectively as presented in Table 2. Heritability estimates were moderate for BW, WW, 6MW and PRWDG while low for YW. Heritability value as obtained for BW in current study was in correspondence with the findings of Mallick *et al*. (2017) in Bharat Merino sheep and Kumar *et al*. (2022) in Harnali sheep however, it was comparatively less than the reports of Gowane *et al*. (2011) in Garole × Malpura and Kumar *et al*. (2018) in Harnali sheep. Estimates of heritability for WW in current study were higher than those reported by Chauhan *et al*. (2021) in Harnali sheep and lesser than the reports of Kumar *et al*. (2018) in Harnali sheep and Oyeing *et al*. (2022) in Pure Red Massai sheep. Heritability estimate obtained for 6MW were in close agreement with the reports of Bangar *et al*. (2020) in Harnali sheep and lower than those reported by Jafari and Hashemi (2014) in Makui sheep. Chauhan *et al*. (2021) also found similar estimate for YW in Harnali sheep though; earlier studies (Narula *et al*. 2017, Kumar *et al*. 2022 and Kumar *et al*. 2018) reported comparatively higher heritability estimates for YW. It is evident from Table 2 that genetic correlations among different considered traits varied from 0.27 (6MW & YW) to 0.95 (WW & PRWDG) and phenotypic correlations ranged from -0.01 (6MW & YW) to 0.94 (WW & PRWDG).

Breeding values for growth traits: Estimated breeding values (EBV) of top ten sires for considered growth traits are shown in Table 3. It was found that out of 10 top-ranked Harnali sires, sire number 81 had highest EBV for BW as 3.83 kg and lowest estimated breeding value was observed for sire no. 87 as 3.58 kg. Further, sire number 81 was ranked second and sixth for 6MW and YW. Sire no. 81 also had highest EBV for WW as 14.01 kg and lowest EBV was observed for sire no. 49 as 13.59 kg. Sire no. 131 had highest EBV for 6MW as 17.89 kg and lowest EBV was observed for sire no. 120 as 17.591 kg. Also Sire no. 87 had highest EBV for YW as 26.614 kg and lowest EBV was observed for sire no. 72 as 25.447 kg. Results of the current study were in line with findings of the Vivekanand (2013) who reported 14.80 kg breeding value for WW in Magra sheep, however, higher breeding value was reported for YW by Vivekanand (2013). For BW, Rather *et al*. (2019) reported comparatively lower BV estimate as 2.97 kg in Kashmir Merino. Hussain (2006) reported that breeding value of sires ranged between -0.447 to 0.216 for birth weight, -1.357 to 2.440 for six-month body weight and -1.686 to 2.089 for yearling body weight in Thalli sheep.

On perusal of Table 4, it is evident that estimated breeding values (EBV) of sires for considered traits had product moment correlations varying from -0.03 to 0.71. For WW-6MW (0.71), WW-BW (0.66) and BW-6MW (0.69), correlations among EBV of sires were highly positive as well as significant. However, correlations among EBV of sires for YW and other growth traits were low in magnitude. In Munjal sheep, correlations among EBV of sires for different growth traits varied from 0.01 to 0.80 (Umeel *et al*. 2018). Product moment correlations amongst estimated breeding values of sires between production traits ranging from 0.15±0.03 (between WW and 12MW) to 0.56±0.02 (between 6MW and 9 MW) were observed in Kashmir Merino sheep (Rather *et al*. 2019). Sudan *et al*. (2020) estimated product moment correlation between estimated breeding values among performance traits of Rambouillet rams and reported high positive product

Table 4. Product moment (above diagonal) and Spearman's rank (below diagonal) correlations between the EBVs among growth traits

Trait	BW	WW	6MW	YW
BW		0.66**	0.69**	0.05
WW	0.48**		0.71**	-0.03
6MW	0.63**	0.66**		-0.01
YW	0.06	0.00	0.07	

Table 3. Estimated breeding values and ranking of top ten sires for growth traits in Harnali sheep using single trait animal model

BW		WW		6MW		YW	
Sire no.	BV	Sire no.	BV	Sire no.	BV	Sire no.	BV
81	3.83	81	14.010	131	17.893	87	26.614
114	3.67	71	14.005	81	17.877	44	25.826
121	3.63	114	13.805	62	17.874	112	25.822
59	3.62	80	13.731	123	17.813	114	25.797
123	3.61	61	13.714	80	17.753	1	25.642
131	3.60	112	13.658	87	17.699	81	25.595
69	3.60	119	13.619	56	17.661	83	25.476
80	3.60	73	13.607	61	17.632	60	25.471
72	3.59	75	13.599	70	17.598	105	25.451
87	3.58	49	13.592	120	17.591	72	25.447

Table 5. Index weighing factors (b) and accuracy (r_{IH}) of the indices for improving growth traits in Harnali sheep

Index	Trait included	b-value			r_{IH}
		WWT (1)	6WT (2)	YWT (3)	
I_1	1	0.0074			0.278
I_2	2		0.0043		0.151
I_3	3			0.1204	0.347
I_4	1,2	0.0073	0.0003		0.278
I_5	1,3	0.0096		-0.0044	0.308
I_6	2,3		0.0044	0.1209	0.380
I_7	1,2,3	0.0068	0.0007	0.1172	0.437

moment correlation between BW and YW (0.66).

Ranking of sires was done as per their genetic merit based on EBV. Rank correlations among the sire's EBV of considered growth traits varied from low (0.00) to high (0.66). For WW-6MW (0.66), BW-WW (0.48) and BW-6MW (0.63), rank correlations amongst sire's EBV were observed as significantly positive. All correlations were positive and significant and similar findings were reported by Umeel *et al*. (2018) in Munjal sheep. A moderate to high degree of similarity among rankings was revealed by moderate to high rank correlations between the various growth traits. Rather *et al*. (2020) reported that Kashmir Merino sheep had moderate to high rank correlation among several body weight traits, ranging from 0.25±0.03 (6MW and 12MW) to 0.78±0.01 (WW and 9MW).

Estimation of genetic and phenotypic trends: Genetic and phenotypic trends for body weights at different ages are presented in Figs. 1 and 2. Genetic trends for WW and PRWDG were positive and obtained as 0.013960 kg/year and 0.192387g/year, respectively. Genetic trends for BW, 6MW and YW were negative with corresponding values as -0.005731 kg/year, -0.014175 kg/year and -0.005664 kg/year. Positive phenotypic trends for WW as well as PRWDG were observed with corresponding values as 0.044600 kg/year and 0.702142 g/year, respectively. Phenotypic trends for BW, 6MW and YW were negative and obtained as -0.018608 kg/year, -0.046325 kg/year and -0.047204 kg/year, respectively. Balasubramanyam *et al*. (2012) and Mallick *et al*. (2016) observed progressive

Table 6. Expected direct and indirect genetic gain (ΔG_i) for individual growth traits in Harnali sheep

Index	ΔG_i		
	WWT	6WT	YWT
I_1	0.412	(0.223)	(0.010)
I_2	(0.238)	0.377	(0.005)
I_3	(0.127)	(0.065)	0.012
I_4	0.412	0.233	(0.010)
I_5	0.472	(0.256)	0.011
I_6	(0.0213)	0.212	0.013
I_7	0.349	0.199	0.0154

Figures within parenthesis represents indirect genetic gain.

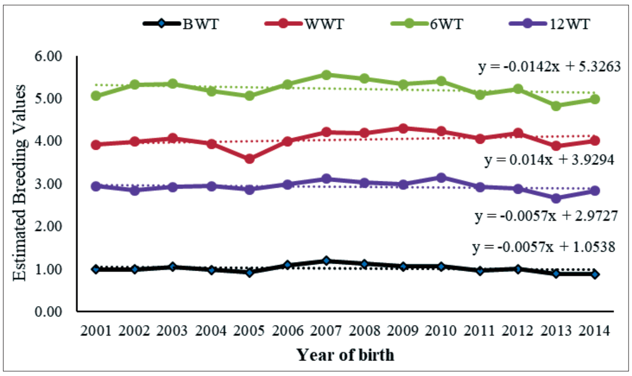

Fig. 1. Genetic trends of body weights in Harnali sheep.

genetic trend for traits, viz. birth weight, weaning weight, six-month body weight and yearling body weight in Madras Red and Bharat Merino sheep, respectively. Hamadani *et al*. (2021) observed desirable genetic trend for birth weight whereas negative trends for phenotypic values of 6-month and 12-month body weights. Oyieng *et al*. (2022) reported positive genetic gain for BW and WW in pure Red Maasai, pure Dorper and 50% Dorper sheep. Rather *et al*. (2019) reported negative genetic trend for BWT and 6-MWT whereas positive genetic trends for 12-MWT in Kashmir Merino sheep.

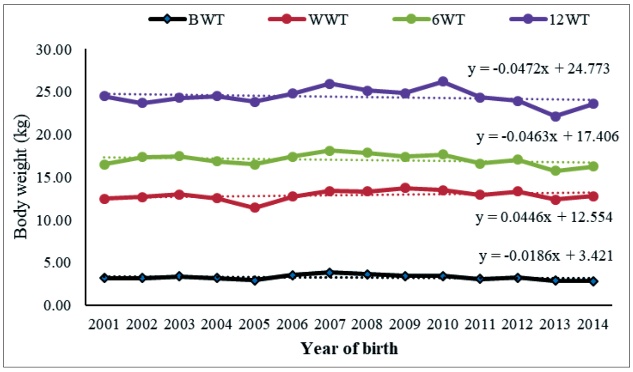

Fig. 2. Phenotypic trends of body weights in Harnali sheep.

Selection criterion for improvement of growth traits: Index selection is reported to be the most efficient method of genetic selection for multi traits with maximum accuracy. In present study, seven indices were formulated by taking different combinations of three important traits, i.e. WW, 6MW and YW for improving yearling weight. Index weighing factors (b) and accuracy (r_{IH}) of the indices for improving yearling body weight is presented in Table 5. The most suitable selection index was I_7 by taking weaning weight (WW), weight at 6 months of age (6MW), and weight at one year of age (YW) into consideration with r_{IH} value 0.437. For improving yearly body weight, I_7 facilitates us to perform selection for improvement of growth traits. Kannojia (2015) constructed selection index in Marwari sheep using 6 traits (3WT, 6WT, 9WT, 12WT, GFW1 and GFW2) and obtained accuracy of r_{IH} = 0.499. Kandalkar *et al*. (2016) in Deccani sheep reported combination of W3 and W6 as most useful index with accuracy of selection as 0.656. Expected genetic gain (ΔG_i) in individual traits is given in Table 6. The response per generation in WW, 6WT and YWT for index I_7 were expected to be 0.349 kg, 0.199 kg, and 0.154 kg, respectively. The response per generation (ΔG_i) in WWT, 6WT and YWT were lesser as compared to the previous studies (Kannojia 2015, Kandalkar *et al*. 2016).

In conclusion, moderate additive genetic variability was found for the considered growth traits except one-year body weight indicating scope of improvement through selection. Sire breeding values for various traits under study indicated genetic variability and it is recommended to use top-ranking sires for further genetic improvement in these traits. The moderate range of genetic variability at weaning weight and its positive genetic and phenotypic correlation with later growth traits specially 6 month's weight indicated that genetic improvement could be possible through early selection at weaning weight in Harnali sheep.

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