Genetic analysis of performance traits in Harnali sheep

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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±0.58 kg, 13.61±0.22 kg, 19.45±0.24 kg, 27.26±0.31 kg, 37.90±0.34 kg, 1662.65±35.46 gm and 789.98±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±0.19, 0.49±0.17, 0.65±0.15, 0.44±0.17, 0.42±0.17 and 0.54±0.17, respectively while moderate estimates was obtained for AFL as 0.38±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±0.04 to 0.71±0.07. The phenotypic correlation between BW and SMW was high and positive (0.71±0.07). The genetic correlations among performance traits were low to high ranging from -0.03±0.04 to 0.61±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.


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 crossbreeding 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.

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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’ N, 75°42’ 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:

\[ Y_{ijklm} = \mu + S_i + P_j + B_k + A_l + b(X_p) + \bar{X}_d + e_{ijklm} \]

Where \( Y_{ijklm} \) is the observation on \( m \)th animal belonging to \( l \)th age group of dam, of \( k \)th sire; \( \mu \) 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; \( B_k \) is the fixed effect of \( k \)th period of birth; \( A_l \) is the fixed effect of \( l \)th sex (\( k = 1, 2 \)); \( b \) is the linear regression coefficient of trait on dam’s weight at lambing; \( X_p \) is the dam’s weight at lambing; \( \bar{X}_d \) 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 calculated from sire components 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 Cocharan (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), Greece fleece weight (GFW) and age at first lambing (AFL) were estimated as 3.51±0.58 kg, 13.61±0.22 kg, 19.45±0.24 kg, 27.26±0.31 kg, 37.90±0.34 kg, 1662.65±35.46 gm and 789.98±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±0.19, 0.49±0.17, 0.65±0.15, 0.44±0.17, 0.42±0.17 and 0.54±0.17, respectively while moderate estimate was obtained for AFL as 0.38±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±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±0.04 to 0.71±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±0.16 to 0.61±0.12. The genetic correlations of YBW and ABW were estimated

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

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D.f.</th>
<th>Mean sum of squares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BW</td>
<td>SMW</td>
</tr>
<tr>
<td>Sire</td>
<td>95</td>
<td>0.37</td>
</tr>
<tr>
<td>Period</td>
<td>5</td>
<td>0.31**</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.30**</td>
</tr>
<tr>
<td>Dam’s age at lambing</td>
<td>6</td>
<td>0.09</td>
</tr>
<tr>
<td>Dam’s weight at lambing</td>
<td>1</td>
<td>9.71**</td>
</tr>
<tr>
<td>Linear regression</td>
<td>240</td>
<td>0.20</td>
</tr>
</tbody>
</table>

** 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

<table>
<thead>
<tr>
<th>Effects</th>
<th>No. of observations</th>
<th>BW(kg)</th>
<th>WW(kg)</th>
<th>SMW(kg)</th>
<th>YBW(kg)</th>
<th>ABW(kg)</th>
<th>GFW(gm)</th>
<th>AFL(days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall (µ)</td>
<td>349</td>
<td>3.51±0.58</td>
<td>13.61±0.22</td>
<td>19.45±0.24</td>
<td>27.26±0.31</td>
<td>37.90±0.34</td>
<td>166.65±35.46</td>
<td>789.98±10.40</td>
</tr>
<tr>
<td>Period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>3.88±0.38</td>
<td>10.95±1.76</td>
<td>19.25±2.63</td>
<td>32.60±3.10</td>
<td>43.48±3.77</td>
<td>157.59±146.36</td>
<td>724.91±58.39</td>
</tr>
<tr>
<td>2</td>
<td>56</td>
<td>3.53±0.16</td>
<td>12.08±0.72</td>
<td>17.87±1.06</td>
<td>24.84±1.26</td>
<td>39.10±1.52</td>
<td>1512.71±188.69</td>
<td>748.37±42.60</td>
</tr>
<tr>
<td>3</td>
<td>106</td>
<td>3.10±0.14</td>
<td>11.40±0.60</td>
<td>16.53±0.89</td>
<td>23.78±1.06</td>
<td>34.05±1.27</td>
<td>1609.43±100.56</td>
<td>722.30±30.00</td>
</tr>
<tr>
<td>4</td>
<td>33</td>
<td>3.17±0.15</td>
<td>15.94±0.68</td>
<td>21.51±0.99</td>
<td>29.65±1.18</td>
<td>35.49±1.42</td>
<td>1797.13±120.57</td>
<td>931.03±39.81</td>
</tr>
<tr>
<td>5</td>
<td>77</td>
<td>3.30±0.16</td>
<td>15.84±0.73</td>
<td>21.54±1.08</td>
<td>26.36±1.28</td>
<td>37.11±1.55</td>
<td>1733.49±120.57</td>
<td>844.90±43.31</td>
</tr>
<tr>
<td>6</td>
<td>59</td>
<td>3.21±0.25</td>
<td>16.41±1.15</td>
<td>20.03±1.72</td>
<td>26.26±2.03</td>
<td>38.16±2.46</td>
<td>1748.32±139.72</td>
<td>833.38±48.78</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Traits</th>
<th>BW</th>
<th>WW</th>
<th>SMW</th>
<th>YBW</th>
<th>ABW</th>
<th>GFW</th>
<th>AFL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW</td>
<td>0.68±0.19</td>
<td>0.38±0.13</td>
<td>0.11±0.16</td>
<td>-0.03±0.15</td>
<td>-0.19±0.15</td>
<td>-0.03±0.04</td>
<td>-0.28±0.15</td>
</tr>
<tr>
<td>WW</td>
<td>0.22±0.04</td>
<td>0.49±0.17</td>
<td>0.38±0.15</td>
<td>0.25±0.16</td>
<td>0.26±0.16</td>
<td>0.10±0.08</td>
<td>-0.47±0.16</td>
</tr>
<tr>
<td>SMW</td>
<td>0.71±0.07</td>
<td>0.42±0.05</td>
<td>0.65±0.15</td>
<td>0.61±0.12</td>
<td>0.25±0.18</td>
<td>0.19±0.17</td>
<td>-0.16±0.18</td>
</tr>
<tr>
<td>YBW</td>
<td>0.03±0.01</td>
<td>0.26±0.03</td>
<td>0.51±0.06</td>
<td>0.44±0.17</td>
<td>0.59±0.11</td>
<td>0.57±0.13</td>
<td>-0.21±0.18</td>
</tr>
<tr>
<td>ABW</td>
<td>0.06±0.02</td>
<td>0.23±0.04</td>
<td>0.69±0.05</td>
<td>0.50±0.07</td>
<td>0.42±0.17</td>
<td>0.28±0.15</td>
<td>-0.03±0.17</td>
</tr>
<tr>
<td>GFW</td>
<td>0.03±0.01</td>
<td>0.09±0.02</td>
<td>0.10±0.01</td>
<td>0.21±0.03</td>
<td>0.13±0.02</td>
<td>0.54±0.17</td>
<td>0.13±0.16</td>
</tr>
<tr>
<td>AFL</td>
<td>-0.03±0.01</td>
<td>-0.15±0.03</td>
<td>0.17±0.02</td>
<td>0.04±0.01</td>
<td>-0.03±0.01</td>
<td>0.08±0.02</td>
<td>0.38±0.16</td>
</tr>
</tbody>
</table>

** 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±0.16 to 0.61±0.12 except with BW and AFL. AFL was found to have negative genetic correlations with all growth traits ranging from -0.03±0.17 to -0.47±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±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 Otokhian et (ABW) was obtained as 37.90±0.34 kg. The estimates obtained in the present study were higher than those reported by Afolayan et al. (2006) in Yankasa sheep and Otokhian 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±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±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 Balasubramaniam 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), Balasubramaniam 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±0.01 in Iran Black sheep (Rashidi et al., 2013) to 0.33±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±0.1602 and 0.651±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±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±0.07 and 0.11±0.05 as estimated by Gowane et al. (2014) in Malpura sheep. However, the heritability estimate of AFL was lower than 0.70±0.19 as estimated by Sehrawat (2005) in the synthetic sheep and 0.44±0.11 estimated by Akhtar et al. (2008) in Hissardale sheep.

The estimate of heritability for GFW was higher than 0.49±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 × 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±0.16 to 0.61±0.12. The genetic correlations of YBW and ABW were found positive with GFW as 0.57±0.13 and 0.28±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±0.17 to -0.47±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.

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