Indian Journal of Animal Sciences **85** (3): 258–261, March 2015/Article

Genetic studies on growth and wool production traits in crossbred sheep of India

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Received: 26 September 2013; Accepted: 5 November 2014

Key words: Birth weight, Fiber diameter, Greasy fleece weight, Heritability, Rambouillet

ABSTRACT

Data on 5,435 lambs pertaining to 166 rams of Rambouillet and their crosses over the 13 years (1998–2010) at Government Sheep Breeding and Research Farm, Reasi, Jammu, were studied. The averages of birth weight (BWT), weaning weight (WWT), litter size (LS), greasy fleece weight (GFW), staple length (SL) and fiber diameter (FD) were 3.034±0.010 kg, 22.644±0.061 kg, 1.052±0.009, 1.520±0.009 kg, 5.599±0.019cm and 21.310±0.014 μ, respectively. The highest co-efficient of variation (CV) percentage was observed for greasy fleece weight whereas the lowest CV was observed for fiber diameter. The least-squares means were 3.088±0.023 kg, 22.578±0.148 kg, 1.046±0.007, 1.533±0.021 kg, 5.719±0.045cm and 21.315±0.034 μ for BWT, WWT, LS, GFW and FD, respectively. The effect of year of lambing was significant for all the traits under present study, whereas, the effect of season of lambing was nonsignificant for all the traits. The effect of sex was significant for growth traits and greasy fleece weight only. However, no systematic trend was observed over the year, season of lambing and sex for all the traits studied. The estimates of heritability were high for BWT (0.351), medium for WWT (0.301), GFW (0.401) and SL (0.453), whereas for FD and LS, it was low as 0.272 and 0.132, respectively. The genetic and phenotypic correlations were either negative or low. These estimates revealed that there is a scope for genetic improvement of these traits through appropriate selection methods.

Key words: Birth weight, Fiber diameter, Greasy fleece weight, Heritability, Rambouillet

Crossbreeding trails in India were undertaken from 1938 to 1949 on regional basis (NCA 1976). During the fourth Five Year Plan, Central Sheep Breeding Farms were established in Jammu and Kashmir (Acharya 1982). Rambouillet is intensively used for crossbreeding programme in India for improving the productivity of native sheep (Acharya 1978). Rambouillet, an excellent fine wool sheep breed and also well known for its meat, is adaptable to wide variety of arid range conditions.

Early growth traits are important factors influencing profitability in any meat producing enterprise. The birth weight of an animal and its early growth rate are highly influenced by genetic potential of sheep. Wool quality and quantity traits are the first indicators of wool production potential of the animal. Greasy fleece weight evaluates the quantity of clean wool. Staple length of the fibre indicates quality and fineness of wool. Fibre diameter is important physical attribute of wool fibre and is responsible for fineness of the wool. Production traits are the main criterion for selection of animals which are influenced by many non-genetic factors like period, season, sex etc. Therefore, the present study was undertaken to investigate the effect of various non-genetic factors on body weights and production traits in Rambouillet crossbred sheep and also to estimate the genetic parameters for improving the traits so that proper selection criteria can be applied to improve the crossbred sheep.

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MATERIALS AND METHODS

The data were obtained from the records of 5,435 Rambouillet crossbred sheep maintained at Government Sheep Breeding and Research Farm, Reasi, Jammu, India. The Farm is located at 33° 05" N latitude and 74° 5" E longitudes. The farm follows semi-migratory production system. In mid- April the sheep are shifted to alpine pastures, viz. Zaban, located at about 6,000–8,000 feet altitude above sea level and allowed to graze there up to the end of September. At alpine pastures sheep are kept open and allowed to graze during day time for 12 h without any supplementary feeding. During winter (mid-December to the end of February) the sheep were housed in concrete sheds with batton floors, provided with hay racks and feeding channels. From mid-March to mid April and October to mid December the flocks are grazed at sub-alpine pastures. First shearing of lambs is normally conducted in November on return of flocks from high land pastures. Second shearing is conducted after an interval of 6 months of first shearing.

The data were spread over a period of 13 years i.e. from 1998 to 2010. The growth traits studied were birth weight (BWT) and weaning weight (WWT). The season of lambing was divided into 2 seasons, winter (December-February) and spring (March–May). The production traits, viz. greasy fleece weight (GFW), staple length (SL) and fibre diameter (FD) were included in the present study.

The mean, standard errors and coefficient of variations (CV) were computed statistically (Snedecor and Cochran 1994). The effects of non-genetic factors such as years, seasons and sex on these growth traits and various normalized production traits were analyzed by least squares analysis using the technique developed by Harvey (1990). The following model was used for present investigation with assumptions that the different components being fitted into the model were linear, independent and additive.

$$Y_{ijklm} = m + R_i + Y_j + S_k + C_l + e_{ijklm}$$

where,

Y_{ijklm}, m^{th} record of individual of i^{th} Ram lambed in j^{th} year, k^{th} season and l^{th} sex;m , overall population mean; R_i, random effect of i^{th} ram ;Y_j, fixed effect of j^{th} year of lambing; S_k , fixed effect of k^{th} season of lambing; C_l, fixed effect of l^{th} sex; e_{ijklm}, error associated with each observation and assumed to be normally and independently distributed with mean zero and variance (0, σ^2_e). The least squares means of significant effects were compared using Duncan's multiple range test (DMRT) as modified by Kramer (1957).

Paternal half sib correlation method (Becker 1975) was used to estimate the heritability of different characters and their genetic correlations. Half-sib family sires (126) with 5 or more than 5 progenies were included for the estimation of heritability. The data adjusted for significant effects of non-genetic factors were used for estimation of heritability.

RESULTS AND DISCUSSION

The growth and wool production traits considered in present study were BWT, WWT, LS, GFW, SL and FD along with standard errors (SE), standard deviations (SD) and coefficient of variation (CV %) are presented in Table 1. The mean for birth weight (BWT), weaning weight (WWT), litter size (LS), greasy fleece weight (GFW), staple length (SL) and fiber diameter (FD) were 3.034±0.010 kg, 22.644±0.061 kg, 1.052±0.009, 1.520±0.009 kg, 5.599±0.019 cm and 21.310±0.014 μ with CV 25.31%, 19.69%, 21.00%, 42.30%, 24.66% and 4.67%, respectively. Coefficient of variations among traits under study were low to medium indicating that the traits had low to medium variability with the highest CV (%) for greasy fleece weight. This showed that GFW had maximum variability hence there is scope for its improvement.

The least squares means for growth and production traits along with their standard errors are presented in Table 2. Dixit *et al.* (2011) reported lower least squares means for SL and FD with higher CV (%) for these traits in Bharat Merino Sheep which is 3/4th crossbreds of Rambouillet and Russian Merino with Chokla, Jaisalmeri, Malpura and Nali breeds. The birth weight of lambs was the highest in 2010. This may be due to the ongoing breeding strategy or managemental practices followed. However, no definite trend was found across the year. The highest weaning weight was observed in year 2003. This may be due to the fact that the number of lambs was comparatively less in that particular year and lambs got plenty of fodder compared to other years.

Table 1. Average estimates along with standard errors of growth and production traits in Rambouillet crossbred sheep

TRAITS	Number of observations	Mean±SE	Standard deviation	CV (%)
BWT (kg)	5435	3.034±0.010	0.768	25.313
WWT (kg)	5435	22.644±0.061	4.459	19.692
LS	5435	1.052±0.009	0.221	21.008
GFW (kg)	5435	1.520±0.009	0.643	42.303
SL (cm)	5435	5.599±0.019	1.381	24.665
FD (microns)	5435	21.310±0.014	0.997	4.679

Year of lambing showed a highly significant (P<0.01) source of variation in this study. The effect of year was highly significant (P<0.01) on litter size. The highest greasy fleece weight was found in the year 2002. The significant differences between years for all the traits may be due to variations in physical environmental conditions, availability of inputs in terms of feeding, forage availability prevailing in different years for grazing resources, which directly affects health of the animal, selection of rams during those years and also due to difference in the management practices in different years. Singh *et al.* (2006) in crossbred sheep and Khan *et al.* (2013) in Rambouillet crossbred sheep also reported the significant effect of year of lambing on birth weight and weaning weight. Lambs born in spring season had slightly lower greasy fleece weight which did not differ significantly from those born in winter.

The effect of season was nonsignificant on all the traits under study. Lambs born in spring were heavier than those born in winter may be due to better grazing resources. But, winter born lambs were slightly heavier than spring born lambs at weaning weight. Balasubramanyam *et al.* (2010) also reported nonsignificant effect of season of lambing on birth weight in Madras Red sheep.

Sex of lamb had significant effect on birth and weaning weight. Males were significantly heavier than females at birth and at weaning. The significant difference between sexes may be due to reflection of physiological difference (hormonal effects) in the growth of both the sexes. The effect of sex was nonsignificant on litter size. The performances of females were better than the males for all the traits although it was significant (P<0.01) for GFW only. Chopra *et al.* (2010) also reported a significant effect of year of

Table 2. Least squares means (±SE) for non-genetic factors influencing growth and production traits in Rambouillet crossbred sheep

Particulars	Number of observations	BWT (Mean±SE) (kg)	WWT (Mean±SE) (kg)	LS (Mean±SE)	GFW (Mean±SE) (kg)	SL (Mean±SE) (cm)	FD (Mean±SE) (μ)
Overall mean	5435	3.088±0.023	22.578±0.148	1.046±0.007	1.533±0.021	5.719±0.045	21.315±0.034
Year		**	**	**	**	**	**
1998	503	3.176±0.034^{d}	22.104±0.222^{de}	1.072±0.011^{ef}	1.200±0.031^{a}	4.849±0.067^{a}	21.007±0.050^{a}
1999	556	2.961±0.034^{c}	23.634±0.218^{f}	1.067±0.011^{e}	1.240±0.031^{a}	4.960±0.066^{a}	21.473±0.049^{def}
2000	518	2.634±0.037^{a}	21.011±0.237^{a}	1.095±0.012^{f}	1.331±0.033^{b}	5.351±0.072^{b}	21.339±0.054^{c}
2001	388	2.669±0.040^{a}	21.304±0.260^{b}	1.026±0.013^{abc}	1.458±0.036^{c}	5.356±0.079^{b}	21.431±0.059^{d}
2002	428	2.824±0.039^{b}	24.821±0.249^{g}	1.043±0.013^{abcde}	1.978±0.035^{h}	6.066±0.076^{ef}	21.314±0.057^{c}
2003	232	2.891±0.049^{bc}	25.255±0.319^{g}	1.025±0.016^{abc}	1.471±0.045^{cd}	6.020±0.097^{e}	21.196±0.073^{b}
2004	405	2.578±0.039^{a}	22.480±0.256^{e}	1.052±0.013^{bcde}	1.687±0.036^{g}	5.841±0.078^{cd}	20.997±0.058^{a}
2005	418	2.892±0.039^{bc}	22.639±0.250^{e}	1.027±0.013^{abc}	1.627±0.035^{fg}	6.000±0.076^{e}	21.509±0.057^{fg}
2006	411	3.162±0.038^{d}	22.667±0.245^{e}	1.052±0.013^{bcde}	1.477±0.034^{cd}	5.964±0.075^{e}	21.218±0.056^{b}
2007	327	3.673±0.043^{f}	21.480±0.279^{c}	1.035±0.014^{abcd}	1.694±0.039^{g}	6.093±0.085^{ef}	21.187±0.064^{b}
2008	466	3.311±0.037^{e}	21.765±0.241^{cd}	1.041±0.012^{abcd}	1.538±0.034^{d}	5.907±0.073^{d}	21.496±0.055^{ef}
2009	519	3.336±0.036^{e}	21.346±0.235^{bc}	1.048±0.012^{bcde}	1.573±0.033^{ef}	5.803±0.071^{c}	21.561±0.054^{g}
2010	264	4.036±0.046^{g}	22.011±0.303^{d}	1.020±0.015^{a}	1.662±0.043^{g}	6.143±0.092^{f}	21.360±0.069^{c}
Season		NS	NS	NS	NS	NS	NS
Winter (Dec-Feb)	5202	3.059±0.010	22.713±0.061	1.048±0.003	1.542±0.009	5.658±0.019	21.298±0.014
Spring (March-May)	233	3.120±0.045	22.444±0.289	1.044±0.015	1.525±0.041	5.780±0.087	21.331±0.066
Sex		**	**	NS	**	NS	NS
Male	2807	3.169±0.025	23.875±0.159	1.044±0.008	1.464±0.022	5.654±0.048	21.293±0.036
Female	2628	3.007±0.025	22.281±0.161	1.049±0.008	1.604±0.023	5.785±0.049	21.336±0.037

Means with same superscript do not differ significantly; ** P<0.01.

Table 3. Estimates of heritability, genetic and phenotypic correlations for different body weight and wool production traits in Rambouillet crossbred sheep

	BWT	WWT	LS	GFW	SL	FD
BWT	0.351±0.109	0.313±0.095**	0.135±0.118**	0.089±0.099*	0.284±0.092**	0.183±0.102**
WWT	–0.014±0.014	0.301±0.045	0.005±0.131	0.221±0.106**	0.008±0.109	–0.302±0.109**
LS	–0.099±0.014**	0.008±0.014	0.132±0.027	–0.331±0.119**	–0.400±0.114**	–0.101±0.132**
GFW	0.011±0.014	0.044±0.014**	–0.018±0.014	0.401±0.055	0.709±0.062**	–0.074±0.112**
SL	0.037±0.014**	0.013±0.014	–0.032±0.014*	0.123±0.014**	0.453±0.060	0.062±0.111**
FD	–0.003±0.014	–0.041±0.014**	–0.014±0.014	–0.012±0.014	–0.004±0.014	0.272±0.042

The estimates of heritability are on the diagonal, while as genetic and phenotypic correlations are above and below the diagonal respectively.

birth and nonsignificant effect of sex of lamb on FD and SL in Bharat Merino sheep, which is similar to present findings.

The estimates of heritability were low to high for different body weight and production traits of the present study (Table 3). The heritability estimates of body weight traits were medium 0.351 and 0.301 for birth weight and weaning weight, respectively. Therefore, the genetic differences in these traits can be exploited through mass selection for genetic improvement of these traits in Rambouillet crossbred sheep.

The estimate of heritability of LS was low (0.132) indicating that the most of the variation in this trait was non-genetic in nature. Thus, this trait could be improved through managemental intervention.

Staple length had higher estimate of heritability (0.453). High estimates of heritability for GFW (0.401) and SL indicated that there is an existence of considerable additive genetic variance in GFW and SL. Dixit *et al.* (2011) reported higher estimates of heritability for GFW, SL and FD in Bharat Merino sheep.

The lowest genetic correlation was observed for LS and SL whereas the highest value obtained for GFW and SL. Litter size has negative genetic correlations with production traits. The birth weight showed medium genetic correlation with weaning weight which is desirable one. The genetic correlations of FD with other traits were negative except for birth weight and all the phenotypic correlations were nonsignificant and near to zero except for weaning weight. Negative genetic correlation between GFW and FD is a desirable one. Any effort at environment level to improve GFW and SL will improve FD. Ozcan *et al.* (2005) also reported the positive genetic correlation among growth traits and wool traits in Turkish Merino. Dixit *et al.* (2011) reported higher estimates of genetic correlation between GFW and WWT, GFW and FD and lower value for genetic correlation between GFW and SL in Bharat Merino sheep.

Phenotypic correlation between BWT and WWT was very low and negative. The phenotypic correlation of litter size with all the traits was low negative except weaning weight, which was low positive. Phenotypic correlations indicated that heavier lambs produce heavier greasy fleece weight with less fibre diameter. So, any effort at environment level to improve growth of the lambs will also improve the greasy wool yield with more staple length and less fibre diameter. Dixit *et al.* (2011) reported positive phenotypic correlation between GFW and WWT, FD and SL in Bharat Merino sheep.

In conclusion, low to medium coefficient of variation for BWT, WWT, LS, SL and FD indicating that the traits had low to medium variability. The highest CV% for greasy fleece weight showed that GFW had maximum variability hence there is a scope for its improvement. The significant difference between years was observed in BWT, WWT, LS, GFW, SL and FD. Sex showed significant effect on growth traits and greasy fleece weight and nonsignificant effect on staple length and fibre diameter. The heritability estimate of BWT, WWT, LS, GFW, SL and FD were low to medium indicating that most of the variation in these traits was non-genetic in nature thus could be improved through managemental intervention. Highly significant genetic and phenotypic correlation indicates that with suitable selection and breeding strategy traits can be improved.

ACKNOWLEDGEMENT

Authors are thankful to the In-charge and staff of Government Sheep Breeding and Research Farm, Reasi, Jammu for providing facilities and help for the present study.

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