Influence of genetic and non genetic factors on growth traits of Bharat Merino sheep in sub-temperate climate of Kodai hills of Tamil Nadu, India

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ABSTRACT

In the present study, the data on 1649 Bharat Merino (BM) lambs; progeny of 144 sires over the year from 2000 to 2014 available at Southern Regional Research Centre (SRRC), Central Sheep and Wool Research Institute, Mannavanur were considered for the analysis. The different economic growth traits used for the analysis were birth weight (BWT), weaning weight (3MWT), 6 month weight (6MWT), 12 month weight (12MWT) and greasy fleece yield (GFY). The overall least-square means for weights (in kg) were 3.28±0.02, 19.08±0.23, 25.00±0.35, 34.79±0.59 and 2.13±0.07 for BWT, 3MWT, 6MWT, 12MWT and GFY respectively. Different non genetic factors such as year, sex, type of birth and dam's age had significant (P<0.01) influence on BWT and 3MWT. Season influenced the BWT (P<0.05) while it had no significant effect on 3MWT. Six month weight was also significantly (P<0.05) influenced by all non-genetic factors taken under present study. Twelve month weight was significantly affected by year (P<0.01), sex and season (P<0.05). Similarly, analysis of variance showed that the year, sex of the lambs (P<0.01) and season (P<0.05) were important sources of variation on GFY of Bharat Merino sheep. Lambs born single had higher values of BWT and 3MWT than that of the lambs born as twins. The trend of the increase in BWT and 3MWT of the lambs is being observed up to the period when the age of their corresponding dams is 4-5 years. The findings of the present study showed that non - genetic factors play an important role in the expression of genetic potential in the lambs as well as growth performance of Bharat Merino sheep under sub temperate conditions of Kodai hills of Tamil Nadu, India. The genetic parameters estimated of 6MWT indicate that it is most suitable for use as selection criterion. Improvement of body weight of BM sheep seems feasible in selection programs, as some of the related traits are moderately heritable and those traits specially are well correlated, which could suggest that these traits are useful in selection programs.

Key words: Bharat Merino sheep, Genetic Correlation, Genetic factors, Heritability, Non-genetic factors.

INTRODUCTION

Bharat Merino (BM) is a strain of fine apparel wool sheep comprising of 75% exotic inheritance of Rambouillet/ Russian Merino, 12.5% Indian carpet wool sheep Nali/ Chokla and 12.5% Indian mutton sheep Malpura/ Jaisalmeri, evolved at ICAR – Central Sheep and Wool Research Institute (CSWRI), Avikanagar, Rajasthan, India. R.M. Acharya was the pioneer worker involved in the genesis of BM strain (Singh *et al.*, 2006). BM sheep were brought from the semi-arid climate zone of Avikanagar, Rajathan to the sub-temperate climate zone of Mannavanur (Kodaikanal, Tamil Nadu) to study their adaptability as well as to study their performance in new environment. Growth traits of lambs reflect the economic viability of animals, which play an important role in a good sheep production (Petrovic *et al.*, 2011). Hence, they are used as a selection criterion along with production and reproduction traits. Information on the birth weight of lambs is of interest to the farmers as well as

to the animal breeders. There are many non-genetic factors, which influence the phenotypic expression of the growth. Identification of such factors is important for adjustment to analyze for genetic parameters and better planning for herd management (Dixit *et al.*, 2011; Das *et al.*, 2014). Hence, the present study was carried out with the objective to investigate the effect of various non-genetic factors on growth and production traits of Bharat Merino sheep under organized farm in sub-temperate conditions of SRRC, Mannavanur, Tamil Nadu, India, and to estimate genetic parameters for different growth traits.

MATERIALS AND METHODS

The data for the present study were collected from sheep farm, Southern Regional Research Centre, ICAR-CSWRI, Mannavanur, Kodaikanal situated at a longitude of 77º-78ºE, latitude of 10º-11ºN and an altitude of 2030 m above mean sea level in the hilly region of South India. The climate of this region is essentially sub-temperate. The

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highest temperature prevails from April to June when mean monthly temperature is about 25ºC. Winter season is from mid November to mid March. The minimum and maximum ambient temperature range from 0°C to 5°C and from 26°C to 30°C, respectively, while the mean relative humidity varies between 15 and 90 %. The rainfall is erratic and round the year with an annual mean rainfall of 1055 mm.

Data and management: The records of growth and production performance of 1649 BM lambs; progeny of 144 sires spread over 15 years starting from 2000 to 2014 were obtained from the Bharat Merino flock of SRRC, Mannavanur were considered for analysis. The data were classified according to period, season, sex, type of birth and dam's age to observe the effect of different non-genetic factors on the traits under study. The lambing is restricted to the spring (January – May) and the autumn (September – November) seasons only. The traits under study were birth weight (BWT), Weaning weight (3MWT), 6 month weight (6MWT), 12 month weight (12MWT) and grease fleece wool yield (GFY).

Seasons were considered to be one of the main environmental factors that affect the performance of sheep, as there is a wide variation in meteorological conditions and availability of fodder during different seasons of the year. Sheep were grazed together during the day for about 6-8 hours. In addition a supplementary concentrate ration of 250-500 g/animal/day, depending on season and physiological status, was fed to animals in the morning before grazing and in the evening after grazing.

Statistical analysis: The general linear model was used to obtain the least squares constants for non-genetic factors viz., periods, seasons, sex, type of birth and dam's age. All traits were analyzed using the following model:

$$Y_{ijklmn} = \mu + Y_i + S_j + P_k + T_l + D_m + e_{ijklmn}$$

Where,
Y_{ijklmn} was the observed trait,
μ was the population mean,
Y_i was the effect of year (with 15 year from 2000-2014),
S_j was the effect of season (with 2 levels: Spring and Autumn),
P_k was the effect of sex (male and female)
T_l was the effect of type of birth (with two levels: single and twin)
D_m was the effect of dam's age (with 6 level: <2yrs, 2-3yrs, 3-4yrs, 4-5yrs, 5-6yrs and >6yrs)
and e_{ijklmn} was random error.

All the interactions were found to be non-significant and hence were ignored. Comparison of the means of the different subgroups was performed by Duncan's multiple range tests as described by Kramer (1957). Co variance components for different growth traits were obtained by restricted maximum likelihood method using an animal model. The mixed model used was

$$Y = Xb + Za + e$$

Where, 'Y' is a N x 1 vector of records, 'b' denotes the fixed effects in the model with association matrix X, 'a' is the vector of additive genetic effects with association matrix Z. Fixed effects used were those found to be significant in the initial least square analysis. Bivariate analyses were used for estimation of genetic correlations among different growth traits. The standard errors of genetic parameters were estimated through approximations as described by Meyer (2007). REML analyses were done using WOMBAT software (Meyer, 2007).

RESULTS AND DISCUSSION

Descriptive statistics for various production traits are presented in Table 1. The coefficient of variations (CV) (%) of all these traits had medium variability. The highest CV for GFY (42.55%) showed that GFY had the maximum variability among all the traits under study. On the other hand, moderate CV for BWT, 3MWT, 6MWT and 12MWT indicated that there are scope for improvement of these traits through proper selection procedures and managemental practices. Das *et al*. (2014) reported moderate value of CV in BWT (18.75%) and GFY (23.61%) for Kashmir Merino Sheep.

The least square means were 3.28±0.02kg, 19.08±0.23kg, 25.00±0.35kg, 34.79±0.59kg and 2.13±0.07 kg for BWT, 3MWT, 6MWT, 12MWT and GFY, respectively (Table 2). The least square mean of birth weight of Bharat Merino sheep was in close agreement with the results of Chopra *et al*. (2010), Nehera and Singh (2006), Dey and Poonia, (2005) and Dixit *et al*. (2001).The lower estimate of 3MWT and 6MWT in BM sheep under semi-arid zone could be due to the effect of scarce availability of grass and pasture on the traits considered in the present study. However, lower estimate of BWT was reported by Das *et al*. (2014) in Kashmir Merino sheep, which could be due to the reason that they might have included only ewe lambs. When compared to the findings of the present study, Singh *et al*. (2006) reported lower value of BWT, 3MWT, 6MWT and 12MWT in crossbred sheep and this could be due to the breed effect. Similarly Tomar *et al*. (2000) also reported lower estimates of GFY in Bharat Merino sheep under semi-arid climatic zone of Rajasthan, when compared with the

Table 1: Average performance for different growth and production traits of Bharat Merino sheep

Character	Mean ± SE	Standard Deviation	CV (%)
BWT	3.73±0.01(1699)	0.64	17.49
3MWT	20.76±0.08(1159)	3.03	14.69
6MWT	26.83±0.13(891)	4.11	15.32
12MWT	35.92±0.23(579)	5.06	15.61
GFY	2.26±0.05(350)	0.96	42.55

Figures in the parenthesis indicates number of animals in that group
BWT= Birth weight, 3MWT= Weaning weight, 6MWT= Six months weight, 12MWT=Twelve month weight, GFY= Grease fleece yield

Table 2: Least square means (± SE) and test of significance for effect of season, sex, type of birth and dam's age in Bharat Merino sheep.

Character	N	BWT	3MWT	6MWT	12MWT	GFY
Overall(μ)	1649	3.289±0.02	19.08±0.23	25.00±.35	34.79±0.59	2.13±0.07
Season		**	NS	*	*	*
Spring	704	3.12±0.03[a]	18.81±0.25	25.58±0.37[a]	32.84±0.61[a]	1.96±0.78[a]
Autumn	945	3.43±0.03[b]	19.31±0.25	24.51±0.38[b]	36.39±0.70[b]	2.29±0.09[b]
Sex		**	**	*	*	**
Male	819	3.40±0.03[a]	19.95±0.24[a]	26.82±0.37[a]	38.08±0.64[a]	2.48±0.08[a]
Female	830	3.17±0.03[b]	18.21±0.24[b]	23.18±0.36[b]	31.51±0.60[b]	1.78±0.07[b]
Type of birth		**	**	*	NS	NS
Single	1539	3.68±0.01[b]	20.46±0.10[a]	26.84±0.14[a]	35.85±0.31	2.22±0.04
Twin	110	2.88±0.05[b]	17.70±0.45[b]	23.16±0.67[b]	33.74±1.12	2.04±0.14
Dam's Age		**	**	*	NS	NS
<2year	105	2.94±0.06[a]	17.86±0.40[a]	23.51±0.57[a]	34.49±0.91	2.13±0.12
2-3year	279	3.19±0.04[b]	18.85±0.29[ab]	24.63±0.44[ab]	34.64±0.74	2.15±0.09
3-4year	340	3.30±0.03[bc]	19.27±0.28[ab]	25.26±0.40[b]	34.62±0.66	2.11±0.08
4-5year	292	3.43±0.04[d]	19.79±0.28[bc]	25.62±0.43[b]	35.09±0.72	2.27±0.09
5-6year	286	3.44±0.04[d]	19.70±0.28[c]	25.75±0.41[b]	35.23±0.67	2.07±0.08
>6year	347	3.40±0.03[cd]	19.02±0.27[ab]	25.21±0.41[ab]	34.68±0.68	2.05±0.08

For traits abbreviations see footnote Table 1. ** p<0.01, * p<0.05 and NS-Non significant

present study. Different estimates could be due to differences in breeds and genetic merit of sires or could be due to differences in climate and managemental practices.

Effect of year of lambing : Year effect was significant on BWT, 3MWT, 6MWT, 12MWT and GFY (Table 3). The variability in different traits due to years could be due to variation in physical environmental conditions, feeding forage availability prevailing in different years for grazing and selection of rams.

Effect of season of lambing: The season of lambing had significant effect on BWT (P<0.01), 6MWT, 12MWT and GFY (P<0.05), but no effect on weaning weight (Table 2). Earlier reports indicate that season of birth had highly significant (P<0.01) effect on all the above mentioned traits as observed by Mandakmale *et al*. (2014) in Madgyal sheep and Dass *et al*. (2014) in Mujaffarnagari sheep. Lambs born in autumn were heavier than the lambs born in spring (Table 1). Results indicated that at SRRC, Mannavanur, autumn season is highly conducive for the lambing as there is plentiful availability of good pasture. The similar results also reflected in the effect of season where in autumn born lambs were heavier than the spring born lamb reported by Singh *et al*. (1987) in Nali and crossbred lambs under semi-arid conditions.

The present study indicated that during winter season, at SRRC, Mannavanur the prevalence of low

Table 3: Least square means (± SE) and analysis of variance for period effect on production traits of Bharat Merino sheep.

Character	N	BWT	3MWT	6MWT	12MWT	GFY
Overall(μ)	1649	3.28±0.02	19.08±0.23	25.00±.35	34.79±0.59	2.13±0.07
Period		**	**	*	**	**
2000	169	3.68±0.04[e]	18.28±0.34[abc]	26.11±0.56[cd]	39.25±0.81[de]	3.78±0.10[f]
2001	98	3.71±0.06[e]	19.88±0.37[de]	23.88±0.65[abc]	33.01±0.9[bc]	3.14±0.11[ef]
2002	84	3.36±0.07[d]	19.85±0.43[bcd]	22.93±0.56[a]	31.09±2.33[a]	2.47±0.29[bcd]
2003	91	3.31±0.06[cd]	16.61±0.55[a]	21.60±0.77[ab]	29.73±2.21[ab]	1.93±0.28[cd]
2004	47	2.66±0.08[a]	16.82±0.51[a]	21.90±0.47[ab]	30.23±2.01[ab]	1.97±0.26[cd]
2005	146	3.30±0.05[cd]	17.34±0.37[ab]	25.24±0.53[cd]	38.71±0.81[e]	2.48±0.10[de]
2006	82	3.40±0.06[d]	18.14±0.42[bc]	25.02±0.92[bcd]	37.66±1.47[cde]	2.40±0.19[bcd]
2007	55	3.70±0.07[e]	21.98±0.41[f]	28.04±0.55[ef]	36.15±0.77[de]	1.88±0.09[abc]
2008	73	3.23±0.08[bc]	20.01±0.50[cd]	27.10±0.66[de]	36.15±1.04[cde]	1.54±0.13[a]
2009	150	3.07±0.05[b]	18.17±0.35[bc]	25.04±0.50[cd]	33.29±0.79[bcd]	1.77±0.10[ab]
2010	140	3.22±0.05[bcd]	18.82±0.34[cd]	23.01±0.48[abc]	33.59±0.81[cde]	1.88±0.10[bcd]
2011	147	3.29±0.05[cd]	19.50±0.34[de]	25.97±0.49[cd]	34.54±0.76[bcd]	1.83±0.09[ab]
2012	138	3.18±0.05[bcd]	20.82±0.32[ef]	25.97±0.49[cd]	35.58±0.74[cde]	1.91±0.09[abc]
2013	151	3.24±0.05[bcd]	20.19±0.31[de]	25.61±0.46[cd]	35.53±0.72[cd]	1.67±0.09[ab]
2014	78	3.16±0.06[bc]	18.89±0.35[bcd]	29.15±0.65[f]	-	-

For traits abbreviations see footnote Table 1. ** . p<0.01, * p<0.05 and NS-Non significant

temperature (from 3^0 C to zero degrees Celsius) and frost rendered the pasture land dry. The lower body weight of spring born lambs could be due to the reason that in spring season there was scarcity of green fodder owing to adverse climatic conditions. The spring born lambs emphasized the need to provide supplementary feed and adequate managemental practices to the lambs so as to protect them from the variance inducing factor.

Effect of sex of the lamb: The sex of the lamb had highly significant effect on BWT, 3MWT and GFY (P<0.01) and significant effect on 6MWT and 12MWT (P<0.05) (Table 2). Similar results of significant effect on sex of the lamb on BWT and 3MWT were reported by Chopra *et al.* (2010) in Bharat Merino and Dass *et al.* (2014) in Mujaffarnagari sheep.

The weights, *viz.* BWT, 3MWT, 6MWT, 12MWT and GFY of male lambs were greater (3.40±0.03, 19.95±0.17, 26.82±0.37, 38.08±0.64 and 2.48±0.08 kg respectively) than female lambs (3.17±0.03, 18.21±0.24, 23.18±0.36, 31.51±0.60 and 1.78±0.07 kg respectively).

The results pertaining to heavier weight of the male lambs in comparison to the female lambs were also reported in Iranian Baluchi sheep (Abbasi *et al.*, 2012), indigenous Serbian breeds of sheep (Petrovic *et al.,* 2011) and Farafra lambs (Roshanfekr *et al.*, 2011). This is mainly due to the physiological differences between the two genders and male and female endocrine system that males are always heavier and grew faster than female as reported in many studies by Mousa *et al.* (2010).

Effect of type of birth at lambing: The type of birth at lambing had highly significant effect on BWT and 3MWT (P<0.01) and significant effect on 6MWT (P<0.05) where as it had no effect on 12MWT and GFY (Table 2). Lambs born as twins had lower BWT, 3MWT, 6MWT, 12MWT and GFY as compared to those born as single. Singles had higher values than twin values (3.68±0.01 against 2.88±0.05, 20.46± 0.10 against 17.70±0.04, 26.84±0.14 against 23.16±0.67, 35.85±0.31 against 33.74±1.12 and 2.22±0.04 against 2.04±0.14 for BWT, 3MWT, 6MWT, 12MWT and GFY, respectively) (Table 2). This is in agreement with the results of Mousa *et al.* (2013) in Farafara sheep, Abbasi *et al.* (2012) in Iranian Baluchi sheep, Roshanfekr *et al.* (2011) in Arabi lambs and Petrovic *et al.* (2011) in indigenous

Serbian breeds of sheep. The growth advantage of single born lambs could be due to the fact that there is no competition in suckling of milk from its dam when compared to the twins and triplets. At weaning, the difference in weight between single and twin lambs could be attributed to that singles were more capable of suckling the milk from their mothers than twins. Lower body weight of twin lambs at weaning may be due to low birth weights and the competition between twins for the limited quantity of milk available in their udder.

Effect of dam's age at lambing: The dam's age at lambing had highly significant effect on BWT and 3MWT (P<0.01) and significant effect on 6MWT (P<0.05) where as it had no effect on 12MWT and GFY (Table 2). Similar results were also reported by Chopra *et al.* (2010 and Dixit *et al.* (2001) in Bharat Merino sheep in semiarid zone. Negi *et al.* (1987) also found out that effect of Dam's age on Birth weight in Gaddi sheep and its crosses was highly significant (P<0.01) in temperate zone. Dam's age on 3MWT may be due to the fact that the older dams have more milk production and good mothering ability. The trend of the increase in BWT (3.43±0.04kg) and 3MWT (19.79±0.28kg) of the lambs is being observed up to the period when the age of their corresponding dams is 4-5 years. Similar results were obtained by Mousa *et al.* (2013) in Farfara, Abbasi *et al.* (2012) in Iranian Balichi, Petrovic *et al.* (2011) in Svrljig and Roshanfekr *et al.* (2011) in Arabi lambs. Due to ewes' body development, limited uterine space, inadequate availability of nutrients during pregnancy, enhancement of milk quality and quantity and improvement in maternal ability of the ewes with age, it is expected that litters born in the first parity would have significantly lower weight than those of later parities. For above 6 year old ewes, tooth decay results in grazing problems followed by reduction in milk production and maternal care for lambs. For this reason, the birth weights of lambs from the very old ewes (beyond 6 years of age) are less than the lambs born from 4-5years old ewes.

Heritability estimates: Heritability (h^2) estimates, genetic and phenotypic correlations with their standard error are presented in Table 4. Birth weight had moderate estimate of heritability suggesting that there is considerable scope of improvement in this trait by mass selection. Heritability estimates for body weights in various sheep breeds ranged

Table 4: Estimates of heritability (diagonal), Genetic correlation (above diagonal) and phenotypic correlation (below diagonal) of different economic traits of Bharat Merino sheep.

Traits	BWT	3MWT	6MWT	12MWT	GFY
BWT	**0.29±0.06**	1.00±0.20	0.84±0.21	0.23±0.21	0.05±0.04
3MWT	0.37±0.02	**0.16±0.05**	0.44±0.65	-0.59	0.99
6MWT	0.36±0.03	0.76±0.01	**0.17±0.06**	0.98±0.17	-
12MWT	0.24±0.04	0.55±0.03	0.72±0.02	**0.15±0.08**	1.00±0.35
GFY	0.05±0.04	0.19±0.44	-	0.41±0.04	**0.02±0.06**

For traits abbreviations see footnote of Table 1

from 0.04 to 0.39 at birth and from 0.09 to 0.39 at weaning (Al-Shorepy, 2001). Estimate of heritability for BWT in the current study was higher than those obtained by Matika *et al*. (2003) for Turkish Merino sheep (0.25), Mousa. *et al*., 2013 for native Farafra sheep (0.25), Parkash *et al*. (2012) for Malpura sheep (0.21) Rashidi *et al*. (2008) for Kermani sheep (0.04) and Abbasi *et al*. (2012) for Iranian Baluchi sheep (0.12). However, h^2 estimate for BWT was lower than those reported by El-Awady *et al*. (2011) and Miraei *et al*. (2007) which were 0.40 for Rahmani lambs and 0.33 for Sangsari sheep, respectively.

Heritability estimate of 0.16 for 3MWT in the current study is close to that reported by Miraei *et al*. (2007) for Iranian Baluchi sheep (0.17) and higher than those obtained by Abbasi *et al*. (2012), Singh *et al*. (2006) and Matika *et al*. (2003) which was 0.10 in Sangsari sheep, 0.13 in Corriedale and Russian Merino with Nali sheep and 0.11 for Sabi sheep, respectively; and lower than those reported by Parkash *et al*. (2012) in Malpura sheep (0.24), El-Awady *et al*. (2011) in Rahmani sheep (0.42), Rashidi *et al*. (2008) in Kermani sheep (0.27). The estimate of heritability for 12MWT was 0.15 which was lower than the findings of Singh *et al*. (2006) this could be due to high degree of genetic variability in this trait. The moderate estimate of heritability for all growth traits suggests that performance of Bharat Merino sheep can be improved through selection for economic mutton production. These above traits, therefore, can be used effectively as a selection criterion in multi-trait selection programs that will lead to an improved biological efficiency of a flock. The heritability estimate for GFY was very low and could be due to lower additive genetic variance with a large environmental variation.

Genetic correlations: In general, genetic correlations among different growth traits in this flock were positive and high (Table 4). Birth weight had high values of genetic correlation with later body weight traits. With higher value of heritability and the trait being available immediately after birth, there is scope to improve body weight at later ages by indirect selection on birth weight. Very high values of genetic correlation found for 3 MWT and 6 MWT with 12MWT would be very useful to improve 12MWT through indirect selection. However, weaning weight at 3 months age is more influenced by maternal effects. Six months body weight is the first weight available after weaning until which maternal influence could play a major role. Hence, it could be used as a selection criterion. Further studies on influence of maternal

genetics and permanent environmental influence on these traits would reduce the biasness due to maternal influence. Estimation of genetic correlation among 3WT, 6MWT and 12MWT in the present study are in agreement with the findings of Kushwaha *et al*. (1996) and Singh *et al*. (2006).

Phenotypic correlations: The phenotypic correlations of BWT with other traits were positive and ranged from low to high (0.05 to 0.72) (Table 4). The range of phenotypic correlation estimates for BWT and 3MWT in literature varied from 0.25 (Jafaroghli *et al*., 2010) to 0.49 (Prakash *et al*., 2012). Three month weight had negative phenotypic correlation with 12MWT probably could be due to environmental and managemental variations. This is in agreement with the results of Miraei *et al*. (2007) and Zhang *et al*. (2009). Phenotypic correlations of 12MWT with other traits were positive except for 3MWT.

CONCLUSIONS

Non-genetic factors included in the study *viz.* period, season, sex, type of birth and age of dam at lambing had significant influence on most of the traits. Results indicated that at SRRC, Mannavanur, autumn season is highly conducive for the lambing as there is plentiful availability of good pasture. Spring born lambs emphasized the need to provide supplementary feed and adequate management, so as to protect them from the variance inducing factor. Heritability estimates of growth traits were moderate indicating an acceptable response to genetic selection for the studied traits. Although BWT had better heritability and positive genetic correlations with subsequent body weights, it is not prudent to select on the basis of BWT alone because of the presence of maternal effect. Therefore, a sequential selection procedure should be adopted for improvement of growth rate. The estimates of genetic parameters of 6MWT indicate that it is most suitable for use as selection criterion. Improvement of body weight of Bharat Merino sheep seems feasible in selection programs, as some of the related traits are moderately heritable and those traits specially are well correlated, which could suggest that these traits are useful in selection programs.

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