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Dibyendu Chakraborty
Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu
R.S. Pura, Jammu,
Jammu and Kashmir, India

Vikas bin Zaffer
Assistant Manager
Suguna Poultry Farm Ltd.,
Punjab, India

Parul Gupta
KVK. Rajouri, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India

Pallavi Khajuria
College of Veterinary Sciences,
Rampura Phul
Bathinda, Punjab, India

VP Singh
Central Artificial Breeding Station, Hakkal Jammu,
Jammu and Kashmir, India

RK Taggar
Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu
R.S. Pura, Jammu,
Jammu and Kashmir, India

Corresponding Author:
Dibyendu Chakraborty
Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu
R.S. Pura, Jammu,
Jammu and Kashmir, India

Genetic studies on growth rate traits and Kleiber ratios in Rambouillet Sheep

Dibyendu Chakraborty, Vikas bin Zaffer, Parul Gupta, Pallavi Khajuria, VP Singh and RK Taggar

Abstract
In the present study data on 300 animals were collected from history sheet maintained at Government Sheep Breeding Farm Panthal, Reasi, J&K, India, over a period of 11 years (2002-2012). The traits included in the study were average pre-weaning daily weight gain (ADG1-birth to weaning), average post-weaning daily weight gain (ADG2-weaning to yearling), pre-weaning kleiber ratio (KR1) and post-weaning kleiber ratio (KR2). The statistical analysis was carried out using LSMLMW computer programme. Least-squares means for various growth rate traits under study were 68.82±1.05 gm, 44.69±1.18 gm, 8.85±0.06 and 4.17±0.10 for ADG1, ADG2, KR1 and KR2, respectively. Period of lambing had significant effect on ADG2 and KR2. Sex of lambs had significant effect on ADG1, KR1 and KR2. Ram had highly significant effect on all the traits under study. The heritability ranged from 0.09±0.12 (KR1) to 0.24±0.22 (KR2). The highest genetic and phenotypic correlations were calculated between ADG2 and KR2. Ram code 11 and 12 are better for growth rate traits and these rams can be used for breeding purpose if alive.

Keywords: Average daily weight gain, Kleiber ratio, Rambouillet, Heritability, India

1. Introduction
Growth rate is one of the most important factors in sheep husbandry and it is directly related to the economy of the farmers. With the rising prices of mutton in the market, fast growing and heavier lambs are in great demand (Narula *et al*., 2009) [13]. Feed efficiency is a major component in the profitability of the small ruminant enterprise. Growth rate and feed efficiency are two traits of great economic importance in sheep production. The Kleiber ratio, defined as growth rate/metabolic weight, has been suggested to be a useful indicator of growth efficiency and an indirect selection criterion for feed conversion (Kleiber, 1947) [8]. Growth rates and Kleiber ratios are derived traits and they involve no extra cost recording. For any breed improvement programme for economic traits knowledge of genetic parameter is essential, along with the different non-genetic factors which are influencing the traits. Therefore, the present investigation was undertaken with objectives to estimate the effect of various genetic and non-genetic factors on different growth rate traits and Kleiber ratios and to estimate the genetic parameters in Rambouillet sheep.

2. Materials and Methods
Growth data on 300 animals, pedigree of 12 Rams used in the present study were collected from history sheet maintained at Government Sheep Breeding Farm Panthal, Reasi, J&K, India over a period of 11 years from 2002 to 2012. The Government Sheep Breeding Farm, Panthal, is located 52 kms on north-east of Jammu and lies between 33^0 05" N latitude and 74^0 5" E longitude. The farm follows semi-migratory production system. In middle of April the sheep are shifted to highland alpine pastures, at an altitude of 6000-8000 feet above sea level and allowed to graze there up to end of September. Ewes were mated in the month of August and October when ewes were flushed on nutritive highland pastures. The ewes were divided into groups, each group consisting of about 50 ewes. The performance data maintained at farm from 2002 to 2012 were classified into three different periods for present study.
Traits included in the study were average weight gain of individual lamb during birth to weaning (ADG1), average weight gain of individual lamb during weaning to yearling (ADG2), kleiber ratio during birth to weaning (KR1) and kleiber ratio during weaning to yearling (KR2).

The ADGs were calculated as weight gain during particular period divided by duration of that period in days. Kleiber ratio (KR) for the pre-weaning (birth to weaning) and post-weaning (weaning to yearling) periods were calculated as follows as recommended for measuring growth efficiency (Kleiber, 1947) [8]:

$KR = ADG/W^{0.75}$

Where, ADG, average daily gain for the period expressed in g/day; $W^{0.75}$, metabolic body weight at the older age of the period for which KR is calculated.

The effects of non-genetic and genetic factors such as periods, sex and rams on various normalized traits were analyzed by least squares analysis using the technique developed by Harvey (1990) [6]. The following model was used for analyzing data for Rambouillet sheep with assumptions that the different components being fitted into the model were linear, independent and additive.

$Y_{ijkl} = \mu + P_i + S_j + R_k + e_{ijkl}$

Where,

Y_{ijkl} = l^{th} record of individual lambed in i^{th} year, j^{th} season and of k^{th} sex

μ = Overall population mean

P_i = Fixed effect of i^{th} period of lambing

S_j = Fixed effect of j^{th} sex of lamb

R_k = Random effect of k^{th} Ram

e_{ijkl} = Error associated with each observation and assume to be normally and independently distributed with mean zero and variance $(0, \sigma^2_e)$

Data were analyzed by paternal half-sib correlation methods for all the growth traits (Beacker, 1975) [2]. Rams with five or more number of progenies for each trait were included in the analysis. The standard error of phenotypic correlations was calculated by Panse and Sukhatme (1961) [4].

3. Results and Discussions

The descriptive statistics for different traits under study in Rambouillet sheep have been presented in Table 1. The overall means were 69.86 gm, 44.80 gm, 8.90 and 4.17 for DG1, ADG2, KR1 and KR2, respectively. The coefficient variations (CV) (%) for different traits are low to moderate. The highest CV (%) was calculated for ADG2 (52.28%). The low to moderate CV indicate that there are low to moderate variation among the traits and these traits can be improved by proper breeding, selection and management practices or importing good rams from other herds.

Table 1: Overall mean performances of growth rate traits in Rambouillet sheep

	ADG1 (Pre-weaning)	ADG2 (Post-weaning)	KR1 (Pre-weaning)	KR2 (Post-weaning)
Mean	69.86	44.80	8.90	4.17
SD	21.76	23.42	1.34	2.02
SE	1.26	1.35	0.08	0.12
CV (%)	31.15	52.28	15.06	48.44

Least-squares means for various growth rate traits under study were 68.82±1.05 gm, 44.69±1.18 gm, 8.85±0.06 and 4.17±0.10 for ADG1, ADG2, KR1 and KR2, respectively (Table 2). Higher estimates were reported by Jeichitra and Rajendran (2014) [7] on pre-weaning and post weaning KRs in Mecheri sheep, Venkataramanan *et al*. (2016) [7] on KR1 in Nilagiri and Sandyno sheep, Kumar *et al*. (2017) [10] for pre-weaning, post weaning ADGs and KRs in Deccani Sheep and Kumar *et al*. (2018) [11] on ADG1 and KR1in Nellore sheep On the other hand, lower estimates were reported by Venkataramanan *et al*. (2016) [7] on KR2 in Nilagiri and Sandyno sheep, Kumar *et al*. (2018) [11] on ADG2 & KR2 in Nellore sheep. Higher ADG values were reported in Rambouillet sheep (Anamika *et al*., 2019) [1].

Table 2: Least squares means for growth rate traits in Rambouillet sheep (in gm)

	ADG1 (Pre-weaning)	ADG2 (Post-weaning)	KR1 (Pre-weaning)	KR2 (Post-weaning)
Overall (300)	68.82 ± 1.05	44.69 ± 1.18	8.85 ± 0.06	4.17 ± 0.10
Period	NS	**	NS	*
2002-2004 (125)	72.08 ± 1.61	47.64^{b} ± 1.80	8.98 ± 0.10	4.33^{b} ± 0.15
2005-2008 (103)	71.75 ± 1.82	39.92^{a} ± 2.04	9.04 ± 0.11	3.79^{a} ± 0.17
2009-2012 (72)	62.64 ± 3.09	46.51^{b} ± 3.47	8.54 ± 0.18	4.39^{b} ± 0.28
Sex	**	NS	*	*
Male (151)	72.55 ± 1.44	46.40 ± 1.64	9.00 ± 0.09	4.38 ± 0.13
Female (149)	65.09 ± 1.46	42.97 ± 1.62	8.71 ± 0.09	3.96 ± 0.13

Period had significant effect on ADG2 and KR2 (Table 2). Significant effect of period of lambing were reported on pre-weaning and post weaning KRs in Mecheri sheep (Jeichitra and Rajendran, 2014) [7], on KR1 in Arabi sheep (Roshanfekr, 2014) [16]. On contrary to the present findings Kumar *et al*. (2018) [11], Mallick *et al*. (2019) [12] and Anamika *et al*. (2019) [1] reported significant effect of period on all growth rate traits and Kleiber ratios in Nellore sheep, Bharat Merino sheep and Rambouillet sheep, respectively. The significant differences in body weight among lambs born in different year may be attributed to differences in management, selection of rams, variation in availability of foraging material in pasture during different years and environmental conditions such as the ambient temperature, humidity and rainfall.

Sex of lambs had highly significant effect on ADG1, KR1 and KR2 in Rambouillet sheep (Table 2). Males had higher ADG and KR values as compared to females at all ages. The results were in conformity with earlier estimates in Avikalin sheep (Prince *et al*., 2010), in Nellore sheep (Kumar *et al*., 2018) [11], in Bharat Merino sheep (Mallick *et al*., 2019) [12] and in Rambouillet sheep (Anamika *et al*., 2019) [1]. Significant effect of sex reported on pre-weaning and post weaning KRs in Mecheri sheep (Jeichitra and Rajendran, 2014) [7], on KR1 in Arabi sheep (Roshanfekr, 2014) [16], on KR1 and KR2 in Nilagiri and Sandyno sheep (Venkataramanan *et al*., 2016) [7] and post weaning ADG & pre-weaning, post weaning KRs in Deccani Sheep (Kumar *et al*., 2017) [10]. Chakraborty *et al*. (2015) [3] reported non-significant effect of sex in Dorper

crossbred sheep. The differences in body weights between males and females might be due to the differences in the endocrine systems i.e., in the secretion of growth and sex hormones between males and females.

Rams had highly significant effect on all the traits under study. The least-squares means for different traits under study have been depicted in Figure 1. It was found that Ram code 11 and 12 were better for ADG2 and KR2 in Rambouillet sheep. The ADG2 and KR2 are post-weaning traits and therefore, less influenced by the maternal effect. Hence, the Ram code 11 and 12 are better for growth rate & Kleiber ratio traits and these rams can be used for breeding purpose if alive.

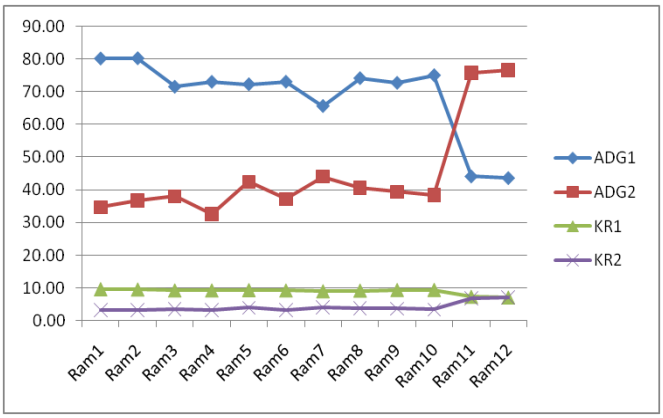

Fig 1: Least squares means for growth rate traits for different Rambouillet Rams

The estimates of heritability along with genetic and phenotypic correlations are presented in Table 3. The estimates of heritability values were low for all the traits under study and ranged from 0.09±0.12 (KR1) to 0.24±0.22 (KR2). Similar estimate of heritability was reported in Bharat Merino sheep for ADG1 (Mallick *et al*., 2019) [12]. Higher estimates of ADG1 (0.23) and KR1 (0.22) were reported in Iranian fat-tailed Afshari sheep (Eskandarinasab, 2010). Lower estimate of heritability was reported in Zandi sheep for ADG1 (0.11), ADG2 (0.10) & KR2 (0.07) (Ghafouri-Kesbi *et al*., 2011) [5]; in Arabi sheep for KR1 (0.11) (Roshanfekr, 2014) [16]; in Nilagiri and Sandyno sheep (Venkataramanan *et al*., 2016) [7] for KR1 (0.106 & 0.109) and KR2 (0.103 & 0.003). Lower Estimates for heritability were reported for KR1 (0.10) in Zandi sheep (Ghafouri-Kesbi *et al*., 2011) [5]. Chakraborty *et al*. (2015) [3] reported higher estimates of ADGs in Dorper crossbred sheep. Low estimate of heritability indicates that low additive genetic variation for growth rate and Kleiber ratio present in this population of Rambouillet sheep and these traits are controlled by non-additive gene action and environment play important role in controlling the traits. The increasing heritability of growth rate traits at the later stages of life indicates that environmental factors had more influence on growth traits before weaning compared to later stage of life. After weaning at six months, maternal effects are reduced considerably and there is also similar plane of nutrition for all individuals in the flock. This might have helped to reduce the environmental variability resulting in higher heritability values.

Table 3: Estimates of heritability (diagonal), genetic (above diagonal) and phenotypic correlations (below diagonal) for growth rate traits of Rambouillet sheep

	ADG1	ADG2	KR1	KR2
ADG1	**0.14 ±0.15**	-0.10 ± 0.06	0.99** ±0.01	-0.21* ± 0.06
ADG2	-0.38**±0.05	0.24 ± 0.22	-0.44 ± 0.06	0.99** ± 0.01
KR1	0.88**±0.03	-0.70**±0.04	0.09 ± 0.12	-0.55** ± 0.06
KR2	-0.53**±0.05	0.96**±0.02	-0.53**±0.05	0.19 ± 0.18

* $P<0.05$ ** $P<0.01$

The genetic correlation values ranged from -0.55±0.06 (KR1 & KR2) to 0.99±0.06 (ADG1 & KR1; ADG2 & KR2). All the genetic correlations values under present study were significant except between ADG1 and ADG2, where the genetic correlation was non-significant and negative. Genetic correlations within pre-and post- weaning traits were positive but between pre- and post-weaning traits these were negative. Similarly to the present investigation, positive genetic correlations were reported between ADG1 & KR1 and ADG2 & KR2 in Nilagiri and Sandyno sheep (Venkataramanan *et al*., 2016) [7]. On the other hand negative correlations between ADG1 & KR2 and positive genetic correlations between ADG2 & KR1 were reported in Nilagiri and Sandyno sheep (Venkataramanan *et al*., 2016) [7]. Negative genetic correlations between KR1 and KR2 similar to the present findings were also reported in Nilagiri and Sandyno sheep (Venkataramanan *et al*., 2016) [7].

Phenotypic correlations values were ranged from -0.70±0.04 (ADG2 & KR1) to 0.96±0.02 (ADG2 & KR2). All the phenotypic correlations values under present study were highly significant ($P< 0.01$). Phenotypic correlations within pre-and post- weaning traits were positive but between pre- and post-weaning traits these were negative. Similar to the present findings negative correlation was reported in Zandi sheep for ADG1 and KR2 (-0.49) (Ghafouri-Kesbi *et al*., 2011) [5]. Chakraborty *et al*. (2015) reported negative phenotypic correlations of pre-weaning ADG with all the post-weaning ADGs in Dorper crossbred sheep.

4. Conclusions

It can be concluded from the present study that genetic and non-genetic factors are significantly affecting the growth rate traits and Kleiber ratios in Rambouillet sheep. The Ram code 11 and 12 are better for growth rate & Kleiber ratio traits and these rams can be used for breeding purpose if alive. The estimates of genetic parameters indicate that selecting for improved growth rate or Kleiber ratio in Rabmouillet sheep would generate a relatively slow genetic progress.

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