



Growth performance of Rambouillet sheep up to weaning age in an organized farm

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ABSTRACT

Data and pedigree information obtained from 4,186 birth records of Rambouillet Sheep collected from the Government Sheep Breeding and Research Farm, Reasi, Jammu and Kashmir were analyzed. The objective was to evaluate the performance and to estimate the genetic parameters of growth performance traits of Rambouillet Sheep. The mean of BW, WW, ADG, $WW^{0.75}$, and KR were 2.86 ± 0.04 kg, 13.85 ± 0.26 kg, 122.11 ± 2.94 gm/day, 7.18 ± 0.09 kg and 17.01 ± 0.11 , respectively. The coefficient of variations (CV%) of all these traits under study were low ranging from 9.48 to 25.39% indicating that the traits had low variability. The effect of year and season was highly significant and non-significant, respectively on all the traits under study. Effect of sex was significant on BW, WW, ADG and $WW^{0.75}$. 0.15 kg, 0.26 kg, 1.22 gm/day and 0.10 kg for BW, WW, ADG and $WW^{0.75}$, respectively was observed in favour of male lambs. The effect of birth type was significant on BE and WW only. The heritability estimates were moderate for all traits and the genetic correlations ranged from -0.11 ± 0.12 (between BW and WW) to 0.96 ± 0.01 (between ADG and $WW^{0.75}$). The overall breeding values for BW, WW, ADG, $WW^{0.75}$, and KR were 2.80 ± 0.04 kg, 13.86 ± 0.23 kg, 122.89 ± 2.58 kg/gm, 7.18 ± 0.07 kg and 17.11 ± 0.10 , respectively. All correlations were significant whereas the trends were non-significant. The study indicated existence of genetic variability which can be harvested through selection.

Keywords: Breeding values, Correlations, Heritability, Kleiber ratio, Rambouillet

Rambouillet is well-known for its excellence in maternal ability as well as its fine wool and quality mutton production. It is the largest fine wool breed and is adaptable to wide range of conditions. It also has well developed flocking instinct and is pretty long lived. The breed, although originally developed in France as a wool breed (Dickson *et al.* 1933), was developed into a dual-purpose breed in the US (Hultz *et al.* 1931). Rambouillet is intensively used for cross breeding programme in India for improving the productivity of native sheep. For the same reason, this sheep breed was imported into J&K in 1952 and is being maintained at Reasi Sheep Breeding Farm.

The accurate estimates of the genetic parameters from time to time are vital for prediction of breeding value and selection response. This is also important to understand the performance of a breed under certain environmental conditions and the evaluation of strategies that may be employed for its genetic improvement. Kleiber (1947) identified the $\frac{3}{4}$ power of body weight called metabolic mass as a suitable unit for the metabolic body size. The

metabolic mass signifies the portion of feed intake used by animal for its maintenance needs. The body condition score and Kleiber ratio (Kleiber 1947, Scholtz and Roux 1988) were developed as an alternative ratio to select animals for breeding (Arthur *et al.* 2001). The Kleiber ratio (KR) is a good indicator of feed conversion and selection criterion for growth efficiency (Koster *et al.* 1994) and is independent of body size (Kleiber 1961). Flock feed conversion could be improved through selection based on KR owing to its high heritability (Bergh 1994). Therefore, present study was designed to estimate genetic parameters of growth performance of Rambouillet sheep in an organized farm of J&K.

MATERIALS AND METHODS

The data for present study were collected from history sheets of Rambouillet sheep maintained at Government Sheep Breeding and Research Farm, Reasi, Jammu and Kashmir. The Farm is located 80 km on north-east of Jammu and lies between $33^{\circ} 05' N$ latitude and $74^{\circ} 5' E$ longitude. The farm is spread over a total area of about 418 acres with a surrounding of abundant green vegetation. The temperature ranges from $5^{\circ}C$ to $45^{\circ}C$ in winter to summer season, respectively.

The farm follows semi-migratory production system. In middle of April the sheep are shifted to alpine pastures,

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viz. Zaban situated at an altitude of 6,000–8,000 meters ASL and allowed to graze there up to end of September. At alpine pastures sheep were kept open and allowed to graze during the day for 12 h. During this time, supplementary feeding is not provided. During winter (mid-December to the end of February) the sheep were housed in concrete sheds with batten floors, with hay racks and feeding channels. The sheds are also provided with good cross-ventilation. During winters, the sheep are stall-fed and are let out in the paddocks, attached with sheds, for exercise. Sheep are also given an exercise by making them to walk up to a nearby freshwater stream for drinking water at mid-day. From mid-March to mid-April and from October to mid-December the flocks are allowed to graze at sub-alpine pastures.

During the stall feeding period, the sheep were given 1–1.5 kg of hay/sheep/day in addition to ISI marked pellet feed which includes wheat, maize, molasses, rice polish, limestone powder, rice bran, cotton seed extraction, mustard extraction, sunflower extraction, mineral mixture, salt, urea, vitamins, etc. Concentrate ration was given @ 500–600 gm/day/adult male and ewes were fed @ 500 gm/head/day. However, pregnant ewes were given @ 600 gm/day for 6 weeks prior to lambing and 6 weeks after lambing and the pure ram were given pellet feed @ 800 g respectively. Young lambs above 3 weeks of age were given @ 50–100 gm/day. Sheep were not provided any concentrate from February to November. However the common salt @ 10 gm/head/week up to lambing were given to these animals. The animals were machine shorn twice a year.

The sheep were vaccinated periodically against various infectious diseases, like enterotoxaemia, PPR, foot and mouth disease and sheep pox. The sheep were dozed regularly and flocks were dipped twice a year in butox solution. Flocks were also provided veterinary aid as and when needed. Cleaning of sheds was done regularly.

Ewes were mated in the month of August. The ewes were divided into groups, each group consisting of about 45 ewes. Rams were selected based on their body weight, wool yield and quality. Close breeding was avoided. The brisket region of rams was marked using paint before being put into pens with allotted group of ewes for day and night. Topping was recorded in the morning. The breeding was allowed for 45 days. The lambing commenced in January and terminated in the middle of March. Lambs were weaned at an age of 4–5 months. The male and female weaners were reared in separate groups.

Data were collected on animal number, sire, dam number, date of birth, type of birth, birth weight (BW), weaning weight (WW) from flock books and body weight registers. The generated traits included average daily gain from birth to 90 days (weaning) (ADG), metabolic weight at 90 days ($WW^{0.75}$), Kleiber ratio from birth to 90 days. Descriptive statistics of growth performance traits were computed by SPSS Software by Snedecor and Cochran, 1994 method. The body weights at different ages were corrected to constant age by simple multiplicative procedure as:

$$W_c = W_x (C/D)$$

where W_c , estimated body weight at a constant age; C , constant age; W , body weight of an animal at particular age and D , age of animal at the time of weighing. The generated traits were computed by using formulae: $ADG = (WW - BW)/90$ and $KR = ADG/WW^{0.75}$ (Talebi 2014).

The data was classified based on years (1997 to 2007), sex (male and female) and birth type (single and multiple). The data were analyzed as per Harvey (1990) to assess the random effect of sire and fixed effects of year, sex and type of birth using following statistical model:

$$Y_{ijklm} = \mu + R_i + G_j + Y_k + T_l + e_{ijklm}$$

where, Y_{ijklm} , observation of m^{th} lamb, born in l^{th} birth type, in l^{th} year, having j^{th} sex and born to i^{th} sire; μ , population mean; R_i , random effect of i^{th} sire ($R=1$ to 109) and G_j , Y_k , and T_l are the fixed effect of the j^{th} sex ($G=1$ to 2), k^{th} year ($Y=1$ –10) and l^{th} type of birth ($T=1$ to 2), respectively and e_{ijklm} , random error associated with each observation and assumed to be normally and independently distributed with mean zero and variance σ_e . F test was used to determine statistical significance of various fixed effects in the least squares model using SPSS software. For significant effects, the differences between any pairs of levels of effects of years were subjected to Duncan's multiple range test (DMRT) as modified by Kramer (1957). Paternal half sib correlation method (Becker 1975) was used to estimate the heritability by using following model:

$$Y_{ij} = \mu + s_i + e_{ij}$$

where, Y_{ij} , observation of the j^{th} progeny of the i^{th} sire; μ , overall mean; s_i , effect of the i^{th} sire, NID ($0, \sigma_s^2$) and e_{ij} , random error NID ($0, \sigma_e^2$). s_i and e_{ij} were assumed to be independent of each other. The phenotypic and genetic correlations were also estimated by previous analysis. The observations were sire number, dam number or animal number and similarly the sires having three or less than three progenies were not used for estimation of genetic parameters. The statistical significance of correlations was tested by 't' test as given by Snedecor and Cochran (1967). The standard error of phenotypic correlations was obtained according to formula given by Panse and Sukhatme (1961):

$$S.E. (r_p) = \frac{1 - r_{p(xy)}^2}{\sqrt{N-2}}$$

where, $r_{p(XY)}$, phenotypic correlation between the traits X and Y in the same individual; $N-2$, degree of freedom. The statistical significance of correlations was tested by 't' test as given by Snedecor and Cochran (1967). Breeding values of sires were estimated by Best Linear Unbiased Prediction (BLUP) procedure described by Henderson (1973) using the following mixed model.

$$Y = Xb + Zu + e$$

The genetic and phenotypic trends were calculated by regression of average predicted breeding values and average phenotypic values respectively with the year of birth of lamb. The subtraction of sire's breeding value means was

computed from phenotypic values, and the regression of obtained values on period of birth was considered as environmental trend. The regression analysis was performed by Minitab Statistical Software.

RESULTS AND DISCUSSION

The averages 2.91 ± 0.01 kg, 13.75 ± 0.07 kg, 120.40 ± 0.78 , 7.14 ± 0.02 gm/day, 7.14 ± 0.02 kg and 16.87 ± 0.03 were for birth weight (BW), weaning weight (WW), average daily gain (ADG), metabolic weight at 90 days ($WW^{0.75}$) and Kleiber ratio from birth to 90 days (KR), respectively (Table 1). The coefficient of variations (CV %) of all these traits under study were low (9.48 to 25.39%) indicating that the traits had low variability. The highest CV (%) for BW (25.39%) showed that birth weight had the maximum variability among all the traits under study. Low variability for growth traits was also reported by Rather (2019a) in Kashmir Merino sheep.

The least squares mean of growth performance traits up to weaning in Rambouillet Sheep are presented in Table 2.

Table 1. Average performance for different growth performance traits in Rambouillet sheep

Trait	N	Mean $\pm$ SE	SD	CV (%)
BW (kg)	4186	2.91 ± 0.01	0.74	25.39
WW (kg)	4186	13.75 ± 0.07	2.70	19.64
ADG (g/day)	4186	120.40 ± 0.78	27.36	22.72
$WW^{0.75}$	4186	7.14 ± 0.02	1.06	14.85
KR	4186	16.87 ± 0.03	1.60	9.48

More or less similar estimates for BW and WW were also reported by Mohammadi *et al.* (2010), Ghafouri-Kesbi *et al.* (2011) in Zandi, Prakash *et al.* (2012) in Malpura, Jeichitra and Rajendran (2014) in Mecheri and Venkataramanan *et al.* (2016) in Nilagiri and Sandyno sheep. The least squares means for BW and WW were more or less similar to those reported by Lalit *et al.* (2016) in Harnali sheep. However, higher values were reported by Talebi (2014) in Karakul, Anil (2017) in Deccani sheep for KR1, by Mallick *et al.* (2019) in Bharat Merino for and lower estimate for ADG1 by Anil (2017) in Deccani sheep. The effect of year was highly significant ($P < 0.01$) on all traits under study whereas effect of season was non-significant on all the traits under study. The significant variation in growth performance due to years may be due to variation in availability and difference in quality of feed and fodder and also due to difference in climatic conditions in different years. Significant variation in growth traits and ADG up to weaning was also reported by Lalit *et al.* (2016) in Harnali sheep. However, Talebi (2014) in Karakul sheep reported a non-significant effect of year of birth on growth performance traits up to weaning. The effect of sex was significant ($P < 0.05$) on all traits except KR. The sexual dimorphism of 0.15 kg, 0.26 kg, 1.22 gm/day and 0.10 kg for BW, WW, ADG and $WW^{0.75}$, respectively were observed in favour of male lambs. However, sexual dimorphism of 0.07 was observed for KR in favour of female lambs. The sexual dimorphism in favour of male lambs may be due to physiological variation. Talebi (2014) in Karakul sheep also reported significant effect of sex on BW, WW, average daily gain ADG and $WW^{0.75}$. Rather

Table 2. Least squares means ($\pm$ SE) for production traits in Rambouillet sheep

	N	BW (kg)	WW (kg)	ADG (g/day)	$WW^{0.75}$ (kg)	KR
<i>Year</i>	4144	2.86 ± 0.04	13.85 ± 0.26	122.11 ± 2.94	7.18 ± 0.09	17.01 ± 0.11
	P. Value	0.000**	0.000**	0.000**	0.000**	0.000**
1998	500	3.00 ± 0.07^d	13.27 ± 0.48^{abc}	114.11 ± 5.35^{bc}	6.65 ± 0.16^{abc}	16.41 ± 0.20^b
1999	543	2.73 ± 0.07^c	14.48 ± 0.45^d	130.55 ± 5.06^e	7.42 ± 0.16^d	16.59 ± 0.19^c
2000	515	2.40 ± 0.06^a	13.46 ± 0.43^{abc}	122.88 ± 4.85^{bcd}	7.03 ± 0.15^{abc}	16.49 ± 0.18^{de}
2001	384	2.47 ± 0.06^a	12.85 ± 0.43^a	115.33 ± 4.80^{ab}	6.79 ± 0.15^a	16.99 ± 0.18^{bcd}
2002	428	2.81 ± 0.06^b	15.04 ± 0.39^e	155.89 ± 4.33^f	7.64 ± 0.13^e	20.41 ± 0.16^f
2003	222	3.00 ± 0.07^{bc}	14.95 ± 0.46^e	135.89 ± 5.12^f	7.60 ± 0.16^e	17.87 ± 0.19^f
2004	402	2.67 ± 0.06^a	13.55 ± 0.40^{bc}	132.78 ± 4.45^{de}	7.06 ± 0.14^c	18.80 ± 0.17^e
2005	417	2.83 ± 0.07^{bc}	13.68 ± 0.44^{cd}	120.89 ± 4.91^{cde}	7.11 ± 0.15^{bcd}	17.00 ± 0.18^{cde}
2006	407	2.99 ± 0.07^d	13.91 ± 0.48^{cd}	120.56 ± 5.38^{bcd}	7.20 ± 0.17^{cd}	16.74 ± 0.20^{bc}
2007	326	3.65 ± 0.08^e	13.91 ± 0.52^{ab}	121.33 ± 5.87^a	7.20 ± 0.18^{ab}	16.85 ± 0.22^a
<i>Season</i>	P. Value	0.0683 ^N	0.4476 ^N	0.3056 ^N	0.4676 ^N	0.1661 ^N
Spring	3942	2.81 ± 0.03^a	13.92 ± 0.22^a	123.44 ± 2.47^a	7.21 ± 0.08^a	17.13 ± 0.09^a
Autumn	202	2.90 ± 0.06^a	13.72 ± 0.37^a	120.22 ± 4.14^a	7.13 ± 0.13^a	16.86 ± 0.15^a
<i>Sex</i>	P. Value	0.000**	0.002**	0.043*	0.002**	0.598 ^N
Male	2181	2.93 ± 0.04^b	13.98 ± 0.27^b	122.78 ± 3.01^b	7.23 ± 0.09^b	16.98 ± 0.11^a
Female	1963	2.78 ± 0.04^a	13.72 ± 0.27^a	121.56 ± 3.06^a	7.13 ± 0.09^a	17.05 ± 0.11^a
<i>Birth type</i>	P. Value	0.000**	0.043*	0.343 ^N	0.067 ^N	0.000**
Single	3916	3.03 ± 0.03^b	14.02 ± 0.23^a	122.11 ± 2.55^a	7.25 ± 0.08^a	16.85 ± 0.09^a
Multiple	228	2.69 ± 0.05^a	13.69 ± 0.36^b	122.22 ± 4.02^a	7.12 ± 0.12^a	17.17 ± 0.15^b

BW, birth weight; WW, weaning weight; ADG, average daily gain from birth to weaning; $WW^{0.75}$, metabolic weight at weaning; KR, Kleiber ratio from birth to weaning. Means having the same superscripts do not differ significantly at 5% level of significance.

Table 3. Genetic parameters of growth performance traits in Rambouillet sheep

Trait	BW	WW	ADG	WW ^{0.75}	KR
BW	0.49±0.11	-0.11±0.12**	-0.39±0.10**	-0.12±0.12**	-0.73±0.07**
WW	0.02±0.011**	0.27±0.05	0.96±0.01	1.00±0.00**	0.76±0.05**
ADG	-0.15±0.011**	0.98±0.002**	0.31±0.05	0.96±0.01**	0.92±0.02**
WW ^{0.75}	0.02±0.011**	1.00±0.000**	0.99±0.002**	0.27±0.05	0.76±0.05**
KR	-0.43±0.011**	0.89±0.010**	0.94±0.00**	0.89±0.00**	0.45±0.07

Values above the diagonal represent genotypic correlations, values on the diagonal (in bold letters) represent heritability estimates, values below the diagonal represent phenotypic correlations and values in parentheses represent environmental correlations; **, significant ($P<0.001$).

Table 4. Breeding values ($\pm$ SE) for production traits in Rambouillet sheep

Year	N	BW	WW	ADG	MWT	KR
Overall	4144	2.80±0.04	13.86±0.23	122.89±2.58	7.18±0.07	17.11±0.10
1998	500	3.04±0.05	13.30±0.33	114.02±3.71	6.98±0.11	16.37±0.14
1999	543	2.79±0.05	14.17±0.33	126.73±3.62	7.31±0.11	17.33±0.14
2000	515	2.44±0.05	13.45±0.32	122.36±3.72	7.02±0.12	17.42±0.14
2001	384	2.53±0.05	12.97±0.33	115.96±3.79	6.83±0.12	16.97±0.13
2002	428	2.72±0.05	15.07±0.33	137.24±3.67	7.65±0.11	17.94±0.14
2003	222	2.84±0.06	15.02±0.40	135.31±4.51	7.63±0.11	17.74±0.14
2004	402	2.50±0.05	13.60±0.34	123.36±3.70	7.08±0.11	17.42±0.14
2005	417	2.72±0.05	13.74±0.33	122.71±3.82	7.15±0.12	17.17±0.14
2006	407	2.97±0.06	13.90±0.35	121.47±3.89	7.20±0.12	16.87±0.14
2007	326	3.55±0.03	13.57±0.38	111.28±4.27	7.07±0.13	15.74±0.15

(2019) in Kashmir Merino also reported significant effect of sex on BW. The effect of birth type was significant ($P<0.05$) on BW and WW in the present study. Sexual dimorphism for body weight, growth rate and growth efficiency traits in favour of males was also reported by Devendran *et al.* (2009, 2010) in Madras Red, Talebi (2014) in Karakul, Albial Abed *et al.* (2014) in Nali and Anil (2017) in Deccani sheep. The single born lambs had higher birth weight and weaning and may be attributed to competition for uterine space and nutrients before birth and milk after birth, respectively among twins and triplets. Significant effect of birth type on BW and WW was also reported by Talebi (2014) in Karakul sheep.

The genetic parameters of growth performance traits up to weaning are presented in Table 3. The heritability of all the traits under study was moderate, ranging from 0.27±0.05 for WW and WW^{0.75} to 0.49±0.11 for BW. The findings were in consonance with Talebi (2014) in Karakul. The moderate h^2 suggest that the feed conversion could be improved through a selection process in the Rambouillet Sheep. The genetic and phenotypic association of BW with all other traits (except the phenotypic correlation with WW^{0.75}) was negative in direction and low to high in magnitude. The negative association of WW with BW may be due to reason that lambs having higher BW do not get milk as per their body requirements.

The overall breeding values of sire are presented in Table 4 and the trends (genetic phenotypic and environmental) are presented in Table 5. Similar breeding values for BW and WW were also estimated by Singh *et al.* (2016) in

Table 5. Trends (phenotypic, genetic and environmental) in Rambouillet sheep

Trait	Trend	Trend	P value	R ² (%)
BW	Phenotypic	0.0643	0.095	22.39
	Genetic trend	0.0441	0.239	6.42
	Environmental	0.0202	0.055	37.74
WW	Phenotypic	0.0430	0.759	0
	Genetic trend	0.0380	0.787	0
	Environmental	0.00530	0.529	5.14
ADG	Phenotypic	-0.24000	0.878	0
	Genetic trend	-0.30000	0.858	0
	Environmental	0.06200	0.812	0.75
WW ^{0.75}	Phenotypic	0.01670	0.731	1.56
	Genetic trend	0.00450	0.926	0
	Environmental	0.01218	0.077	33.96
KR	Phenotypic	-0.0470	0.445	7.47
	Genetic trend	-0.0523	0.459	0
	Environmental	0.0053	0.68	2.23

Marwari sheep. However, higher breeding values were observed by Yadav *et al* (2018) in Munjal sheep for BW and WW and Rather *et al* (2019b) in Kashmir Merino sheep for BW. All environmental trends were positive in direction. The genetic and phenotypic trends were positive for BW, WW and WW^{0.75} whereas negative for ADG and KR. The R² values were low for all trends. All trends were non-significant. Similar trends can be expected in flocks managed under random mating. Mokhtari and Rashidi (2010) in Kermani sheep, Balasubramanyam *et al.* (2012) in Madras red, Mohammadi and Rostam (2015) in Zandi

sheep and Mallick *et al.* (2016) in Bharat merino sheep reported the positive genetic trend for BW and WW. However, Yadav *et al.* (2018) in Munjal Sheep for BW and WW and Rather *et al.* (2019b) in Kashmir Merino sheep for BW found negative genetic trends. The environmental factors were significant sources of variation on growth traits that play an important role in expression of genetic potential. The study indicated the existence of moderate phenotypic and genetic variability in the flock which can be harvested through restricted selection index due to negative genetic association between BW and WW and KR can facilitate the selection of animals.

The performance of the Rambouillet breed under the agro-climatic conditions of J&K is remarkable and our study indicates the existence of genetic variability which can be harvested through selection. Therefore a robust breeding policy for this breed would go a long way in improving this important genetic resource.

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