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Estimation of genetic and phenotypic trends for wool traits in Kashmir Merino sheep

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ABSTRACT

A study was planned to estimate genetic, heritability and phenotypic trends for Kashmir Merino sheep of J&K. The present study was carried out to study the genetic and phenotypic trends of various wool traits of this breed to understand its progress over the years. Phenotypic, genetic as well as heritability trends were generated for fibre diameter, staple length, greasy fleece weight for clip 1 and greasy fleece weight clip 2 from Government Sheep Breeding Farms Kralpathri (1997–2016) and Goabal (2013–2016). Trend lines were generated as linear regression coefficients of mean breeding values, phenotypic values and heritability for animal's year of birth. Trends obtained for phenotypic values for fibre diameter and greasy fleece weight at clip one were positive. For staple length and greasy fleece weight at second clip slope was found to be negative. Trends were significant for fibre diameter and staple length and insignificant for all other traits. Slopes for fibre diameter, staple length and greasy fleece weight for first clip and greasy fleece weight for second clip were 0.0126±0.0028, –0.052±0.0203, 0.00228±0.00618, –0.01945±0.0119 respectively. It may, therefore, be concluded the genetic progress may have more or less stagnated over the years and that an effective selection strategy considering the genetic merit of animals may be adopted to sustain the sheep breeding programs for Kashmir Merino breed.

Keywords: Genetic trends, Heritability, Kashmir Merino, Wool

The Kashmir Merino breed of sheep was developed by crossing Gaddi, Bhakarwal and Poonchi in the 1960s. The breed was primarily developed to improve the genetic potential of local breeds for wool quality and quantity to meet the rising demand for good quality apparel wool. This breed is now being maintained at multiple farms across Jammu and Kashmir. Kashmir Merino is seen as an important genetic resource for the country and therefore understanding the changes in its wool traits over the years is important. BLUP makes use of the mixed model methodology for predicting the individual breeding value (BV) of the animals which takes both random and fixed effects into consideration and is being used for evaluation of breeding programs worldwide since the mid-1970's (Strandberg and Malmfors, 2006).

Several studies (Singh *et al.* 2006, Das *et al.* 2014, Sudan 2017 and Khan *et al.* 2017) have been conducted on sheep breeds to evaluate their performance under Indian conditions. Khan *et al.* (2013) estimated various genetic parameters for wool traits in Rambouillet sheep while Ganai *et al.* (1990) studied the factors affecting some traits in Rambouillet and its crosses with Australian Merino. However, the BLUP methodology for the estimation of heritability and breeding values is largely unexploited for this breed under the specific agro climatic conditions of J&K. Keeping this in view, a study was undertaken to estimate genetic, heritability, and phenotypic trends for wool traits in Kashmir Merino sheep in Jammu and Kashmir.

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MATERIALS AND METHODS

Data collection and herd description: The data concerning 4,165 lambs born to a total of 271 sires was collected for Kashmir Merino was collected from Government Sheep Breeding Farm, Kralpathri from 1997–2016 and from Government Sheep Breeding Farm, Goabal from 2013–2016 for fibre diameter, staple length, greasy fleece weight for clip 1 and greasy fleece weight clip 2. The fibre diameter is estimated by projectile microscope method in microns and staple length is measured as per the standard procedures of Bureau of Indian Standards in cm. The greasy fleece weight of animals is estimated in kilograms.

Farm locations: Government Sheep breeding farm, Kralapathri is located at 33p 53′ latitude N and 74p 37′ longitude E and is about 45 km from Srinagar. Sheep breeding farm Goabal is located at 34p 16′ latitude N and 53p 49′ longitude E.

Management and health cover: Both farms under the study follow the same management practices. The animals are stall-fed from 15th November to 1st April. They are grazed in the nearby forest areas from 15th May to 15th August and for the rest of the year, they are taken to highland pastures. The sheep are regularly vaccinated against multiple diseases like enterotoxaemia, PPR, foot and mouth disease and sheep pox as per schedule. Parasitic control measures are also followed meticulously. Dipping is practiced twice a year. The animals are machine shorn twice a year.

Breeding: Mating takes place in late summer and early autumn. Ewes are separated into groups based on weight, wool yield and quality traits, each group consisting of about 100 ewes. Rams are similarly selected while avoiding close breeding. The brisket region of selected rams is painted before putting them into the allotted pens. Weaning takes place at 4–5 months and all weaners were reared in together.

Mean phenotypic values: R programming language was used for the estimation of two yearly mean phenotypic values for fibre diameter and staple length. For greasy fleece weight at clip one and two, 4 yearly estimates were made from 1997 to 2016.

Heritability estimation: Heritability was estimated two yearly for fibre diameter and staple length for Kashmir Merino breed. For greasy fleece weight at clip one and greasy fleece weight at clip two, 4 yearly estimates were made from 1997 to 2014. These estimations were done using 'Smart Sheep Breeder', a Farm Management Information System cum breeding tool developed at SKUAST-Kashmir (Hamadani, 2018). Generalized Linear Mixed Models were used for the estimation of heritability.

A linear mixed model was used (Mrode 2005) for each of the traits considered under the model, sex and year were taken as fixed effects. Animal effect, sire effect and dam effects are taken as random effects in the mixed model. Farm effect was considered from the years 2013–2016.

Estimated breeding values: The breeding values were also estimated using scripts developed for Smart Sheep Breeder, a Farm Management Information System developed at SKUAST-Kashmir (Hamadani 2018).

Smart Sheep Breeder estimates breeding values using best linear unbiased prediction and uses the model in matrix and mixed model solutions is given as (Mukherjee *et al.* 2017).

$$Y = Xb + Zu + e$$

$$\begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + AA^{-1} \end{bmatrix} \begin{bmatrix} b \\ u \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \end{bmatrix}$$

where, Y, selected trait; b, fixed vector for all non-genetic factors assumed to influence the traits; u, random vector for the breeding values to be predicted; e, represents random errors. X and Z represent incidence matrices. λ equals $(4-h^2)/h^2$ and A is the numerator relationship matrix (Mrode 2005).

Sex and year of birth, farm was taken as fixed effects while animal effect was taken as random effect. Farm effect was considered from the years 2013–2016. Two yearly mean breeding values for fibre diameter and staple length for Kashmir Merino breed were estimated to generate the trend of breeding values from 1997 to 2016 for Government Sheep Breeding Farm, Kralpathri and from 2013 to 2016 for Government Sheep Breeding Farm, Goabal. For greasy fleece weight at clip one and greasy fleece weight at clip two, 4 yearly estimates were made from 1997 to 2014.

Trend generation: The trends for phenotypic values, heritability as well as breeding values were generated as linear regression coefficients of mean phenotypic, heritability and average breeding values respectively for the animal's birth year for every trait under study (Lui *et al.* 2017).

RESULTS AND DISCUSSION

Phenotypic trends: The mean phenotypic values for fibre diameter, staple length along with their standard deviations and the number of animals the estimate are shown in Table 1 and average values for greasy fleece weights are shown in Table 2. The lesser number of animals in the second clip may be attributed to disposal of animals from the farm.

The values obtained are similar to Turkish Malya sheep which is a Merino Crossbreed (Cilek 2015).

Trends obtained for phenotypic values for fibre diameter and greasy fleece weight at clip one were positive. For staple length and greasy fleece weight at clip two, slope was found to be negative. Trends for fibre diameter and staple length were significant while trends for all other traits were insignificant. Bappaditya and Poonia (2006) also reported non-significant phenotypic trends for fibre diameter in Nali sheep of India.

Slopes for fibre diameter, staple length and greasy fleece

Table 1. Mean phenotypic values for wool quantity traits

Year	Clipping 1 (kg)			Clipping 2 (kg)		
	N	Mean	SE	N	Mean	SE
1997–2000	611	0.91	0.02	106	1.53	0.11
2001–2004	562	0.85	0.01	235	1.25	0.02
2005–2008	402	0.80	0.03	101	1.05	0.04
2009–2012	390	0.76	0.01	257	1.21	0.02
2013–2014	933	0.85	0.02	571	1.16	0.02

Table 2. Mean phenotypic values for wool quality traits in Kashmir Merino

Year	Fibre diameter (micron)			Staple Length (cm)		
	N	Mean	SE	N	Mean	SE
1997–98	364	20.31	0.02	364	4.16	0.05
1999–00	258	20.30	0.03	260	5.06	0.08
2001–02	351	20.31	0.03	351	4.26	0.07
2003–04	404	20.32	0.03	404	3.98	0.04
2005–06	295	20.39	0.02	295	3.70	0.03
2007–08	386	20.49	0.03	387	3.40	0.05
2009–10	183	20.34	0.04	184	3.64	0.08
2011–12	456	20.49	0.02	456	3.68	0.03
2013–14	346	20.50	0.02	340	3.81	0.04
2015–16	452	20.50	0.02	550	3.68	0.04

Table 3. EBV's for wool quality traits

Year	Fibre diameter			Staple length		
	N	Mean	SE	N	Mean	SE
1997–98	666	0.00109	0.0004	667	–0.00611	0.0017
1999–00	537	0.00267	0.0021	540	–0.00031	0.0025
2001–02	1257	–0.00185	0.0006	664	–0.00022	0.0012
2003–04	761	0.00176	0.0009	761	0.00141	0.0010
2005–06	599	–0.00039	0.0006	599	–0.00001	0.0008
2007–08	779	0.00034	0.0009	781	–0.00320	0.0018
2009–10	1133	0.00083	0.0004	392	0.00080	0.0016
2011–12	853	0.00037	0.0004	853	–0.00137	0.0011
2013–14	709	–0.00015	0.0010	691	0.00031	0.0008
2015–16	940	0.00111	0.0006	1107	0.00017	0.0013

Table 4. EBV's for wool quality traits

Year	Clip 1			Clip 2		
	N	Mean	SE	N	Mean	SE
1997–2000	1067	–0.00618	0.0008	235	–0.00008	0.0030
2001–2004	1017	0.00113	0.0002	503	0.00039	0.0004
2005–2008	809	0.00055	0.0005	240	–0.00225	0.0025
2009–2012	761	0.00007	0.0003	522	–0.00089	0.0015
2013–2014	1757	–0.00031	0.0004	1128	–0.00427	0.0016

weight for first clip and greasy fleece weight for second clip were 0.0126±0.0028, –0.052±0.0203, 0.00228± 0.00618, –0.01945±0.0119 respectively. The average phenotypic trends of staple length for Kashmir Merino showed significantly declining trends. Similar trends were reported by Cloete *et al.* (2004) for fleece weight in South African Merino. The average phenotypic trends for greasy fleece weight at clip 2 had a declining trend. Similar results were reported by Ozgul *et al.* (2009) in Soay sheep, Malik (2017) for birth, weaning, 6-month and 12-month bodyweight of Munjal sheep and Nirban *et al.* (2016) for greasy fleece weight at clip 1 in Marwari sheep parallel. This indicates negligible genetic improvement for the said traits and this may form a practical basis for designing optimal breeding schemes for the future. A major contributing factor may be environmental change which can generate a quick phenotypic response (Ozgul *et al.* 2009) therefore phenotypic performance could be improved through improved management and nutrition (Gunawan *et al.* 2012). Average phenotypic trend for fibre diameter was significantly positive. Similar trends have been reported by Cloete *et al.* (2004) for reproduction, Roshanfekr *et al.* (2015) for litter size at weaning of Arabi sheep, fleece weight and live weight in South African Merino. Again it is inferred that selection may not be taking place for fibre diameter even though this breed was principally developed for wool quality and quantity. The phenotypic value for greasy fleece weight at first clip and birth weight in Kashmir Merino also tended upwards. Nirban *et al.* (2016) for 3-month, 6 month and 12-month body weight in Marwari sheep also reported similar trends.

Breeding values: Two yearly mean breeding values for fibre diameter and staple length (Table 3) along with their standard deviations and the number of animals were estimated. Four yearly mean breeding values for greasy fleece weight at clip one and greasy fleece weight at clip two along with their standard deviations and the number of animals were also estimated (Table 4).

Trends obtained for breeding values for fibre diameter, staple length and greasy fleece weight for first clip and greasy fleece weight for second clip for Kashmir Merino were positive. Slopes for fibre diameter, staple length and greasy fleece weight for first clip and greasy fleece weight for second clip were 0.0007±0.004, 0.0002±0.0001, 0.0003±0.0001, 0.400±0.2261 respectively. Trends obtained for all traits were insignificant. The genetic trends for fibre diameter, staple length, greasy fleece weight for clip 1 and greasy fleece weight for clip 2 were close to zero, and positive in the present study. Such results have also been reported by Cloete *et al.* (2004) for fleece weight in South African Merino sheep, Roshanfekr *et al.* (2015) for reproductive traits in Arabi sheep, Gizaw *et al.* (2013) for weight and survival in Menz lambs, Khojastehkey and Aslaminejad (2013) for body weights in Zandi sheep, Mallick *et al.* (2016) for greasy fleece weight in Bharat Merino sheep, and Liu *et al.* (2017) for silver blue mink. Venkataramanan (2013) also reported positive trends for body weight.

Non-significant trends give the indication that effective selection might not have taken place for the breed under study. This was also concluded by Roshanfekr *et al*. (2015) in their respective study. The absence of clear and effective selection criteria for these traits could possibly have led to low genetic improvement (Khojastehkey and Aslaminejad 2013). In order to estimate breeding values at any farm, the availability of records and computation through statistical designs and genetic models is essential. Ineffective breeding strategies may therefore have contributed to the current trend. High inbreeding at the farms could also have an effect on the breeding value trends. Closed Nucleus Breeding Systems result in a lower genetic gain than Open Nucleus Breeding Systems. Inbreeding was also reported to be a causative factor in the negative genetic trends reported by Malik (2017) in his study on Munjal sheep. A positive trend for breeding values of fibre diameter was observed, implying that selection might be taking place against fibre diameter trait for Kashmir Merino.

Our results suggest that an optimal selection strategy that considers both genetic merits and coancestry of mates is required to sustain the Kashmir Merino breeding programs in the State.

Heritability: The average heritability values for fibre diameter, staple length, greasy fleece weight at clip 1 and greasy fleece weight at clip 2 are presented in Tables 5 and 6. Mass Selection can be suggested to provide genetic improvement in the herd according to these low heritability results were reported by Cilek (2012). Heritability applies to a specific trait measured in a specific population of animals at a specific point in time (Cassel, 2009). Estimates

Table 5. Heritability estimate for wool quality (Kashmir Merino)

Year	Fibre diameter			Staple length		
	h^2		Range	h^2		Range
1997–1998	0.13	0.02	0.29	0.17	0.03	0.44
1999–2000	0.40	0.05	0.88	0.21	0.03	0.48
2001–2002	0.10	0.01	0.19	0.14	0.04	0.28
2003–2004	0.15	0.03	0.33	0.13	0.02	0.29
2005–2006	0.15	0.03	0.33	0.14	0.02	0.33
2007–2008	0.16	0.02	0.40	0.18	0.02	0.48
2009–2010	0.09	0.02	0.18	0.15	0.02	0.36
2011–2012	0.11	0.02	0.23	0.14	0.03	0.31
2013–2014	0.28	0.03	0.68	0.16	0.02	0.39
2015–2016	0.17	0.03	0.39	0.17	0.04	0.36

Table 6. Heritability estimates for wool quantity traits (Kashmir Merino)

Year	Clip 1			Clip 2		
	h^2		Range	h^2		Range
1997–2000	0.12	0.02	0.26	0.20	0.02	0.52
2001–2004	0.08	0.02	0.16	0.18	0.02	0.4
2005–2008	0.12	0.02	0.26	0.56	0.13	0.94
2009–2012	0.16	0.02	0.40	0.52	0.14	0.94
2013–2014	0.14	0.03	0.29	0.56	0.24	0.88

of heritability also vary from flock to flock. Changes in heritability may be due to both the change in variance in genetic values or environmental factors (Wray and Vissher, 2008, Cilek, 2012)

Trends obtained for heritability for fibre diameter and staple lengths were negative. For greasy fleece weight for first clip and greasy fleece weight for second clip, slope was found to be positive.

The slopes for heritability for birth weight, 6-month body weight and 12-month body weights were 0.002±0.002, 0.003±0.002 and 0.009±0.005 respectively. Slopes for fibre diameter, staple length and greasy fleece weight for first clip and greasy fleece weight for second clip were –0.004±0.011, –0.002±0.003, 0.0034±0.002 and 0.0266±0.009 respectively. All trends were insignificant suggesting that though heritability results change for the same trait but these changes are generally not abrupt (Hamadani *et al.* 2019).

Heritability estimates for the breed under study correlated with those reported by Umeel *et al.* (2018), Jawasreh *et al.* (2018), Nirban *et al.* (2015) and Venkataramanan (2013) in their respective studies. Heritability trends for greasy fleece weight at first clip and greasy fleece weight at second clip for Kashmir Merino were found to be positive and close to zero. Heritability trends were near zero for fibre diameter and staple length in Kashmir Merino. This is in agreement with the fact that estimates of heritability for a trait can differ between breeds and may change slowly over time (Visscher *et al.* 2008). As heritability is a function of both the genetic and environmental variances, management and environment may both be contributing to the trends obtained in the present study. Inbreeding in a closed flock of sheep may also have contributed to the near static variance in the flock. Increasing trends in heritability have also been reported by Berry *et al.* (2003) in their respective study.

It is concluded that an effective selection strategy that considers the genetic merit of animals should be adopted to sustain the sheep breeding programs in J&K for Kashmir Merino breed. Selection methodologies like multi-trait BLUP and selection indices may be employed taking the correlations between traits into consideration (Rather *et al.* 2019).

From the current research, it may be concluded that there is a need for effective directional selection strategy for rapid genetic improvement of sheep which may have stagnated over the years. In this regard, an effective selection strategy that considers the genetic merit of animals should be adopted to sustain the sheep breeding programs in J&K for Kashmir Merino breed and Selection methodologies like multi-trait BLUP and selection indices may be employed.

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