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Review Article

An Overview of Kashmir Merino Sheep: A Synthetic Strain Developed in Jammu and Kashmir

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Abstract | Small ruminant rearing is the core activity of the economically weaker sections in Jammu and Kashmir, India. The state has a rich diversity of sheep genetic resources. However, concerning wool traits, the production potential of these breeds was poor. Accordingly, crossbreeding was taken up the breeding policy to improve the genetic worth of these breeds. As a result, a fast-growing and fine wool-producing sheep strain Kashmir Merino was developed. The present article summarizes the performance of this important synthetic sheep strain in the temperate region of Jammu and Kashmir. The overall least square means (inch) of 9.90±0.15, 4.35±0.03, 2.72±0.06, 24.07±0.11, 27.68±0.12, 33.70±0.16, 38.92±0.09 and 13.33±0.10 for FL (face length), EL (ear length), EB (ear breadth), BL (body length), WH (height at withers), HG (chest girth), PG (paunch girth) and TL (tail length), respectively. Was reported the maximum average body weight at birth, weaning, 6, 12, and 24 months of age reported was 3.66±0.05, 21.80±0.15, 20.46±0.09, 28.41±0.13, and 28.07±0.49 kg, respectively. Kashmir Merino sheep was seen to produce 2.72 kg of greasy fleece per annum with a fiber diameter of 18-22 µ. The estimates of greasy fleece yield of first clip (GFY-1), staple length (SL), fiber diameter (FD), crimps per cm (CPC), and medullation were 0.82±0.03 to 1.20±0.02 kg, 3.43±0.10 to 5.22±0.11 cm, 20.04±0.02 to 20.99±0.08 µ, 4.35±0.02 to 4.87±0.20 and 0.10±0.01%, respectively for Kashmir Merino sheep. The average age and body weight at first mating were 493.54±11.17 days and 29.52±0.28 kg, respectively. Fasciolosis, sheep pox, brucellosis, and gastrointestinal parasitism were reported to be among the main threats responsible for high economic losses in Kashmir Merino sheep. The fodders scarcity during winters, lack of awareness among farmers, non-availability of proven sires, small flock size, lack of infrastructure, and non-availability of digital records were reported among major constraints in exploiting the genetic worth of Kashmir Merino sheep. However, owing to the high production potential of this breed, its conservation, and selective breeding are highly recommended and there is a need for further research to understand the potential of this breed more comprehensively.

Keywords | Kashmir Merino, Sheep, Growth, Performance, Reproduction

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INTRODUCTION

Jammu and Kashmir have a rich diversity of sheep genetic resources. Among the 44 registered sheep breeds in India, Jammu and Kashmir contributes six breeds, viz. Bhakarwal, Changthangi, Gaddi, Gurez, Karnah, Poonchi, and many other non-registered breeds like Malluk, Purgi, Purik, etc. (Rather et al., 2019a). The overall sheep population of Jammu and Kashmir is 3.24 million (Anonymous, 2020). The native breeds play an important

role in the economy of Jammu and Kashmir where thousands of poor marginal farmers and landless laborers depend upon sheep and goat farming for their livelihood (Anonymous, 2021a). The production of pashmina shawls, carpets, and blankets of Kashmir earn a handsome foreign exchange. The native sheep breeds of Jammu and Kashmir possess traits of adaptation to the harsh prevailing agro-climatic which include bitter winters, lack of green fodders in winters, lack of resources available with poor and marginal farmers associated with sheep rearing (Shah et al., 2017). Native breeds have better adaptability to such conditions along with better resistance to diseases (FAO, 2020). In addition, the native breeds are easy to manage on low input in terms of feed/fodder, housing, and health care. Further, these convert low-quality feeds/fodder into good quality animal products (meat, milk, etc.) efficiently (Shah et al., 2020a) and preserve the cultural and historical values hence sustain the inheritance value of livestock (Ganai et al., 2011).

The productivity of native breeds in terms of wool and mutton was low due to their poor genetic potential (Dixit et al., 2006). Therefore, crossbreeding program was taken up as a breeding policy to improve the genetic potential of sheep for wool traits to meet the rising demand for good quality apparel wool. Further, the worldwide success of crossbreeding was another reason for taking up the program (Rather, 2019). Crossbreeding of native sheep genetic resources of Jammu and Kashmir with exotic breeds has been in practice for a long to bring the improvement in production and reproduction traits in the native sheep. In 1942, Tasmanian Merino rams were imported from Australia and crossed with native ewes of Poonchi, Gaddi, and Bhakerwal breeds, and F1 ewes so produced were bred to Delain rams (imported from the U.S.A). Inter-se mating of the F2 generation was continued till 1960 and a strain Kashmir Merino with steady and uniform characters was evolved at Government Sheep Breeding Farm, Reasi, Jammu, and Kashmir (Anonymous, 2004). The level of exotic inheritance in the foundation stock for evolving the Kashmir Merino was 50-75 (Acharya, 1982). The Kashmir Merino sheep were maintained at six government sheep breeding farms and used for the up-gradation of native sheep breeds. The farms had adopted a closed nucleus breeding policy for up-gradation of native sheep from the early 1960s particularly to improve apparel wool production (Rather et al. 2019a). Due to the superior characteristics (fast growth rate and fine wool production), Kashmir Merino sheep is now distributed in every nook and corner of the Kashmir Valley (Rather, 2019). However, these are more commonly found in the districts of Anantnag, Badgam, Bandipora, Kulgam, Shopian, Pulwama, Srinagar, Ganderbal, Baramulla, and Kupwara with an overall population of 11 lakhs. Kashmir Merino sheep are adapted to the harsh agro-climatic conditions of Jammu and Kashmir and reared by the rural farmers as a source of food and cash (Want et al., 2020a, b). Keeping in view its importance and demand in Kashmir an effort is being made in this article to compile the research efforts of different researchers about Kashmir Merino sheep.

Morphometric traits

The morphometric traits of sheep are important for establishing breed standards (Riva et al., 2002; Verma et al., 2016) and are used in developing suitable selection criteria. These traits also provide information about the morphological structure, developmental ability of sheep and were also used for estimation of average live body weight (Ravimurugan et al., 2015). The Kashmir Merino is a highly variable sheep concerning its morphometric traits owing to the involvement of several native and exotic sheep breeds (Dixit et al., 2006). It varies to a considerable extent in skin folds, body size, shape, and size of dewlap. Head, tail, and ventral regions remain covered with skirting (Low-quality wool). However, ears, lower limbs, and lower face were devoid of wool and remained covered with white hair. Although, eyes remain covered with wool in some animals, therefore, cause wool blindness. The overall least square means (inches) of 24.47±0.18, 27.37 ±0.18, 37.03±0.03, 39.61 ±0.32, 10.10±0.08, 4.10 ±0.08, 2.73 ±0.05, and 13.74±0.25 for body length (BL), body height (BH), heart girth (HG), paunch girth (PG), face length (FL), ear length (EL), ear breadth (EB), and tail length (TL), respectively with age and sex having significant effects on all these traits (Rather et al., 2021). The head profile in a majority of Kashmir Merino sheep is narrow and long with a convex nasal bridge (51.65 %) and the coat color was white in all animals (Manzoor et al., 2019). Concerning the presence or absence of horns, Kashmir Merino males are horned whereas females are polled. Among horned sheep, horn orientation was curved first backward and then forward (Rather et al., 2020b). The majority of sheep have broad, slightly droopy, and long ears whereas a small proportion of animals possess rudimentary to short and erect tubular, triangular and long ears too (Manzoor et al., 2019). The teats in all ewes are small and conical. The color of hooves for all the animals is brown and black (Want, 2016). The limited information on morphometric traits suggested that Kashmir Merino is a highly variable and medium-sized sheep in comparison to the native sheep genetic resources of Jammu and Kashmir viz: Changthangi (Ganai et al., 2011), Gurez (Ganai et al., 2010), Karnah (Ganai et al., 2009), Purgi (Baba, 2013) and Purik sheep. The morphological traits of native sheep genetic resources of Jammu and Kashmir as reported by various researchers are reflected in Table 1.

Growth performance

The performance of an animal or breed in a particular environment is judged by its body weights at different

Table 1: Morphometric traits of Native sheep genetic resources of Kashmir.

Genetic group	Sex	BL	CG	BH	References
Gurez sheep	Male	60.24±0.58	67.93±0.54	57.99±0.56	Ganai *et al*. (2010)
	Female	59.94±0.36	67.90±0.34	57.34±0.36	
Bakharwal sheep	Male	81	108	77	Anonymous (2021)
	Female	67	88	68	
Poonchi	Female	56.7	72.6	57	Anonymous (2021)
Gaddi	Male	70.41	67.97	59.05	Anonymous (2021)
	Female	69.52	65.90	57.83	
Karnah Sheep	Male	72.9±1.11	63.1±0.91	62.5±1.04	Ganai *et al*. (2009)
	Female	68.5±0.45	61.7±0.34	58.3±0.27	
Changthangi sheep	Male	76.0±0.77	97.5±1.28	69.0±0.71	Acharya (1982)
	Female	75.2±0.89	89.0±0.80	67.0±0.65	

ages. Fast growth rate and higher body weight are the main considerations for profitable meat production. Growth, one of the most essential traits in farm animals, is defined as an increase in the tissues and organs of the animals per unit time and is affected by genetic and environmental factors (Tariq et al., 2011). Growth is an important measure of the fitness of a genotype and is measured as body weight at a specific age. Further, the growth in domestic animals is a reflection of the adaptability and economic viability of the animal and hence can being used as criteria for the selection of breeds and individuals within breeds (Singh et al., 2006). The study on body weights at different ages helps the breeders to determine the optimum managemental practices for optimum gains. Early growth of the animal influences the mature body weight, lifetime performance, sexual maturity, reproduction, and survivability of sheep. Therefore, growth traits are good indicators of the adaptability of an animal and are essential for production, reproduction, and survivability (Lalit et al., 2017).

The growth traits of Kashmir Merino sheep as reported by different researchers over time are summarized in Table 2. Birth weight, the earliest available trait is a measure of prenatal growth (Lalit et al., 2016). It is an important component of overall productivity because of its effect on survival, growth rate, and therefore, total market weight and value (Iman and Slyter, 1996). The least-squares mean of birth weights for the Kashmir Merino sheep strain varied from 3.50±0.03 to 3.66±0.05 kg. Weaning weight is highly correlated with the mothering ability (milk yield and maternal instinct to care) of ewe as the lamb meets most of its requirements through milk. Average weaning weights of Kashmir Merino lambs varied from 8.93±0.14 to 21.80±0.15 kg. The variations in weaning weight are essentially the reflections of mothering ability as well as the inherent difference in growth (Lalit et al., 2016). The yearling body weight varied between 22.08±1.30 and 28.41±0.13. Rather et al. (2021) reported average adult body weights of 36.32 ±0.27 kg (females) and 45.65± 0.79 kg (males) in Kashmir Merino sheep. Khan et al. (2017) reported body weights of 4.73±0.37, 12.00±0.59, 16.00±0.55, 20.90±0.40, 25.60±0.29, 31.00±0.31 and 41.30±0.34 at 0 to 3 months, 4-6 months, 7-12 months, 13-24 months,25-36 months, 37-48 months and > 48 months, respectively in Purik sheep. The adult body weights of Purgy sheep varied between 10.21±0.47 to 26.39±0.68 kg (Baba, 2013). Similarly, the average adult body weights of Changthangi sheep were 38.64±0.57 in males and 34.0±0.62 kg in females (Acharya, 1982). The body weights of native sheep genetic resources of J and K are reflected in Table 2. by comparing Kashmir Merino sheep with native genetic resources of J and K. it can be perceived that Kashmir Merino has better growth potential than native sheep genetic resources; however, the performance of Kashmir Merino concerning growth as well as wool has decreased over the years from 1974 to 2021 (Hamadani et al., 2021). Further, the individual animals of Kashmir Merino attain more than 65 kg at 2 years age which reflects that selective breeding will improve the body weights of this sheep.

As most of the studies were mostly undertaken at farms and the farm had adopted a closed nucleus breeding system with unidirectional gene flow for up-gradation of native sheep populations. Further, the capacity of all the farms was not increased over time. Therefore, inbreeding at farms might have increased and accumulated over time thus causing a decrease in performance concerning growth traits. Further, from body weights at different ages, it could be concluded that the Kashmir Merino sheep have good growth up to 6 to 9 months of age and it is almost static or very slow from 9 months to yearling period. The slow growth from 9 to 12 months of age may be attributed to the harsh winters. Therefore, it is recommended that for good economic returns, the lambs that are kept for feedlot purposes should be sold at the ages of 6 to 9 months. Body weights of different sheep genetic resources of Jammu and Kashmir are given in Table 3.

Table 2: Body weight of Kashmir Merino sheep at different stages of growth.

Stage of growth	Body weight(kg)	Reference
Birth	3.60±0.06	Khan and Singh (1974)
	3.23±0.03	Sheikh and Dhillon (1985)
	3.50±0.03	Sheikh and Dhillon (1986)
	2.82±0.05	Das *et al.* (2014)
	3.45±0.06	Want (2016)
	3.34±0.05	Rather (2019)
	3.66±0.05	Rather *et al.* (2020f)
Weaning	21.80±0.15	Khan and Singh (1974)
	18.30±0.16	Sheikh and Dhillon (1986)
	20.96±0.11	Shiekh *et al.* (1986)
	8.93±0.14	Want (2016)
	11.54±0.18	Rather *et al.* (2020f)
Six months	19.33±0.45	Rather (2019)
Nine months	21.46±0.09	Rather *et al.* (2021)
Yearling	26.94±0.17	Sheikh and Dhillon (1985)
	28.41±0.13	Shiekh *et al.* (1986)
	22.44±0.46	Rather (2019)
18 months	53.29±0.16	Shiekh *et al.* (1986)
24 months	28.07±0.49	Want (2016)

Wool production and quality traits

Wool is a versatile sheep product and is in demand mainly because of its physical characteristics that directly influence wearer comfort (Hatcher et al., 2010). The wool traits are important for economic returns in the sheep production system. The greasy fleece yield (GFY) is a measure of the production potential of sheep. Greasy fleece yield, staple length and fiber diameter of wool are important traits for the selection of rams for breeding. Staple length and fiber diameter bear a positive correlation with market prices of wool. Khan and Singh (1974) and Rather et al. (2019a) reported the average GFY of the first clip (GFY-1) of Kashmir Merino as 1.20±0.02 and 0.82±0.03 kg, respectively (Table 4). The average GFY of the second clip (GFY-2) of Kashmir Merino was 0.80±0.02 kg (Rather et al., 2019a). Rather et al. (2021b) reported an average lifetime wool yield of 1.36±0.01 kg/shearing in Kashmir Merino sheep, thus producing 2.72 kg of wool annually. The variation in the production of greasy fleece in terms of quality and quantity is also due to complicated interactions of genetic and environmental factors. Ganai et al. (2010) reported an average annual wool yield of 0.62 -1.5 kg in Gurez sheep. Bakharwal and Poonchi sheep produce greasy fleece of 1.600 kg per annum (Anonymous, 2021) whereas Karnah sheep produce 1.000 to 1.250 kg per annum (Ganai et al., 2009). Therefore, as a perusal of the performance of sheep genetic resources (concerning greasy fleece yield) of Jammu and Kashmir, it is concluded that Kashmir Merino sheep have far higher production potential as compared to other sheep genetic resources.

The wool quality traits of Kashmir Merino are presented in Table 4. Staple length (SL) is the length of a group of fibers of any composition, which generally determines its end-use i.e., whether it will be used in weaving or knitting. The trait is linked with wool processing performance. The longer wools, generally around 51mm or above are processed to versatile yarn. Wool fiber staple length is becoming an increasingly important determinant of wool quality and value (Valera et al., 2009). Wool with long SL is commercially more desirable as it tends to be easier to spin, give fewer stoppages, and ultimately can form stronger and more even yarn (Holman and Malau-Aduli, 2012). The staple length in Kashmir Merino sheep varied from 3.43±0.10 cm (Rather et al., 2019a) to 5.22±0.11 cm (Das et al., 2014). The wool of shorter staple length produced by Kashmir Merino can't be used to manufacture versatile yarn. Therefore, necessary steps are required to be incorporated in the breeding policy of Kashmir Merino to improve wool staple length. Fiber diameter (FD) refers to the average width of a single cross-section of wool fiber (Holman and Malau-Aduli, 2012) and is widely established as the most important wool trait for assessing wool quality and cost. FD value is an indicator of the fineness with which a yarn can be spun. Low FD wools (or finer wools) can be processed into yarns which are suited for high-value apparel textile end uses (Warn et al., 2006; Holman and Malau-Aduli, 2012). The average FD in Kashmir Merino wool was observed that it varied from 20.04±0.02 (Baba et al., 2020a) to 20.99±0.08 μ (Rather et al., 2019b).

Table 3: Body weights of different sheep genetic resources of Jammu and Kashmir.

Genetic group	Sex	BW (kg)	WW (kg)	6 MW (kg)	>1 year	References
Gurez	Male	2.54±0.02	8.73±0.08	21.28±0.25	28.60±0.28	Ganai *et al.* (2010)
	Female	2.47±0.01	8.70±0.05	21.54±0.19	28.59±0.19	
Bakharwal	Male				42	Anonymous (2021)
	Female				33	
Poonchi	Overall				27	Anonymous (2021)
Karnah	Male	2.8±0.02	7.6 ± 0.06	21.1± 0.56	21.3 ± 0.79	Ganai *et al.* (2009)
	Female	2.7 ± 0.02	7.8 ± 0.07	21.4±0.39	20.4 ± 0.23	

The origin of the crimping of individual fibers resides in the follicle, but the precise mechanism is still under discussion. Doggy wool is a condition characterized by loss of crimp; its cause is not known but the incidence increases with age (Khan, 2012). Staple crimp, both concerning frequency and amplitude has traditionally been used as an indicator of fiber fineness. However, while the relationship with fineness frequently applies, it is by no means invariable (Khan, 2012). The overall estimates of 4.35±0.02 to 4.87±0.20 crimps/ cm was observed in the Kashmir Merino sheep (Baba et al., 2020a; Rather et al., 2019b). In wool, a major factor reducing its value is contamination with coarse, medullated fibers. Wool has a high medullation percentage is regarded as low-quality wool. However, fortunately, Kashmir Merino sheep maintained at government breeding farms produce medullation-free wool. However, sheep (Kashmir Merino) produce wool with 0.10±0.01% medullated fibers (Baba et al., 2020a). Baba et al. (2020a) reported a clean wool yield of 67.19±0.02% in Kashmir Merino sheep suggesting that wool from Kashmir Merino sheep contains a high quantity of grease, vegetable matter, etc. Kashmir Merino sheep produce wool which is at par with fine wool breeds of the world. Further, Kashmir Merino sheep produce the finest wool as compared to the native and imported sheep genetic resources maintained by farmers and government breeding farms of Kashmir.

Reproductive performance

Reproductive efficiency is assessed by age at first lambing, lamb crop per year, and inter lambing period and is one of the most important factors affecting production in sheep breeding. The reported measures for reproductive performance in Kashmir Merino sheep are present in Table 5. In

Table 4: Fiber diameter (μ) and staple length (cm) in different sheep breeds.

Breed	Average ±S.E					References
	FD (μ)	SL(cm)	Crimps	Medullation (%)	scouring yield	
Russian Merino	20.80±0.16	-				Khan and Singh (1974)
Gaddi	24.95±0.90	6.06±0.42		4.11±0.86		Gupta (2000)
Corriedale	26.30±0.55	4.75±0.16				Sarkar *et al.* (2008)
Poll Dorset	25.18±1.28	4.04±0.51				Sarkar *et al.* (2008)
South Down	20.64±0.60	2.80±0.27				Sarkar *et al.* (2008)
rossbred	25.21±1.16	3.65±0.21				Sarkar *et al.* (2008)
Poonchia	27.93±584	7.89±0.584				Qureshi *et al.* (2013)
Rambouillet	20.02±0.65	9.00±00.650				Qureshi *et al.* (2013)
Kashmir Merino	20.95±0.07	5.22 ±0.11				Das *et al.* (2014)
Rambouillet	21.27±0.03	5.64±0.04				Khan *et al.* (2015)
Rambouillet	21.30±0.02	5.26±0.03				Mahajan *et al.* (2018)
Kashmir Merino	20.95±0.07					Das *et al.* (2014)
Kashmir Merino	20.04±0.02	5.22±0.11	4.35±0.02	0.10±0.01	67.19±0.02	Baba *et al.* (2020a)
Kashmir Merino	20.33±0.05	3.86±0.14				Rather *et al.* (2019a)
Kashmir Merino	20.99±0.08	4.87±0.20				Rather *et al.* (2019b)
Changthangi	31.19 ± 0.71	11.34 ± 0.55	4.13±0.36	11.37± 0.97	81.06±0.94	Malik *et al.* (2021)
Gurez	29.25±0.41	4.69±0.17	5.27±0.28	6.61±0.79	76.73±0.33	Rather *et al.* (2021c)
	21.20±0.05	3.88±0.05	4.16±4.37	0.24±0.06	683.46±1.19 g/kg	Baba *et al.* (2020)

Table 5: Reproduction performance of Kashmir Merino sheep.

Trait	Mean±SE	Reference
Age at sexual maturity (months)	20.81±0.46 (Field) - 33.00±0.60 (Farm)	Want (2016)
Weight at sexual maturity (kg)	31.15±0.31(Farm) - 32.85±0.59 (Field)	Want (2016)
Age at first service (months)	14.74±0.04	Das *et al.* (2014)
Age at first lambing (months)	25.23±0.57 (Field) - 37.24±0.60 (Farm)	Want (2016)
Weight at first lambing (kg)	32.50±0.37 (Field) - 36.97±0.56 (Farm)	Want (2016)
Lambing interval (months)	10.84±0.19 (Field) - 13.96±0.47(Farm)	Want (2016)
Litter size (no.)	1.08±0.03	Rather *et al.* (2019b)

farm conditions, Want (2016) reported age at sexual maturity, weight at sexual maturity, age at first lambing, weight at first lambing and lambing 33.00±0.60 month, 31.15±0.31kg, 37.24±0.60 month, 36.97±0.56 kg, and 13.96±0.47 month, respectively. The corresponding values under field conditions were 20.81±0.46 month, 32.85±0.59 kg, 25.23±0.57 month, 32.50±0.37 kg, and 10.84±0.19 month, respectively. Less age at first mating and at first lambing are prerequisites for maximum economic returns and genetic gain as there will be low generation interval. However, it was observed that Kashmir Merino sheep have higher estimates for age at first lambing, inter lambing interval thus indicating high generation interval and low economic returns. The data management at organized farms should incorporate information about the culling of ewes along with maximum age at first lambing. Efforts should be undertaken to reduce the age at first lambing to international standards.

Genetic parameters and breeding value estimates

Genetic improvement of traits can be increased with the knowledge of their genetic parameters. Accurate estimates of genetic parameters are essential to design and develop efficient improvement programs for economically decisive traits of sheep. Shiekh et al. (1985) reported a heritability of 0.03±0.02 in Kashmir Merino for birth weight. Rather et al. (2020d) reported that heritability estimates for cumulative mortalities from birth to 12 months were low (0.04±0.27 to 0.25±0.22). In Kashmir Merino, Rather (2019) reported breeding values of 3.33±0.07 kg, 18.82±0.18 kg, 21.20±0.27 kg, 0.75±0.01 kg, 0.85±0.02 kg, 21.20±0.21 µ, 4.40±0.05 cm, 1098.68±6.28 days, and 395.46±7.71 for birth weight, six months weight, yearling body weight, GFY-1, GFY-2, fiber diameter, staple length, age at first lambing and inter-lambing period, respectively. The genetic trends / period for corresponding traits were -0.012 kg, -0.024 kg, 0.190 kg, 0.001 kg, -0.003 kg, 0.024 µ, -0.045 cm, -12.411 days and 2.383 days, respectively. Rather (2019) reported heritability estimates of 0.61±0.08, 0.47±0.04, 0.23±0.04, and 0.66±0.10 for GFY-1, GFY-2, fiber diameter, and staple length, respectively along with favorable genetic and phenotypic correlations among these traits. Similarly, low to high heritability estimates and genetic correlations among different growth, wool and reproductions were observed by Rather (2019) and Rather et al. (2020b). Hamadani et al. (2020) reported biannual trends for fiber diameter, staple length, and GFY-1 and GFY-2 as 0.0126±0.0028, –0.052±0.0203, 0.00228±0.00618, –0.01945±0.0119, respectively. Rather et al. (2020c) estimated the overall breeding values of 3.47±0.03, 11.07±0.14, 17.46±0.16, 20.09±0.16, and 25.18±0.18 kg for weight at birth, weaning, 6, 9, and 12-month bodyweight, respectively. They also observed low to moderate (0.15±0.03 to 0.56±0.02) product-moment correlations between different production traits of Kashmir Merino sheep.

Diseases prevalence

Shah et al. (2020b) observed incidence of sheep pox as 6.74, 2.81, 42.31, 8.01, 2.24, 4.44, 2.03, 2.98, 28.44% in Budgam, Srinagar, Anantnag, Pulwama, Shopian, Kulgam, Bandipora, Baramullah, respectively in Kashmir Merino sheep. The morbidity, mortality, and case fatality was 35.50, 4.31, and 13.26% (Rather et al., 2020g) and 19.44, 3.34, and 17.19% (Ahanger et al., 2020a), respectively reported due to sheep pox in Kashmir Merino sheep. Gastrointestinal tract parasitism has a highly detrimental effect on sheep production. Abdullah et al. (2020) reported a 23.54% prevalence of fasciolosis among sheep in Kashmir Merino sheep. Baba et al. (2020b) found the prevalence of 22.54, 10.84, 9.11, 9.11, 0.14, 2.56, and 0.88 for *Haemonchus/Nematodirus*, *Strongyloides*, *Moniezia*, *Eimeria*, *Fasciola*, *Trichotrongylus,* and *Trichuris* infection, respectively. Bashir et al. (2020) found an 8.75% prevalence of *Coenurus cerebralis* in Kashmir Merino sheep at an organized farm. On seroprevalence, Bhat et al. (2020) reported a 73.87% prevalence of *Mycobacterium avium* in Kashmir Merino sheep flocks of Central Kashmir valley. The abortions in the Kashmir valley are mostly caused by brucellosis. The overall seroprevalence of ovine brucellosis to the tune of 14.14, 35.87, 7.38, and 20.17% was reported by Lone et al. (2013), Hussain et al. (2017), Ahanger et al. (2020b), and Rather et al (2020e), respectively in Kashmir Merino sheep. Hussain et al. (2017) reported that seroprevalence of ovine brucellosis was non-significantly higher in females (37.82%) than males (23.33%).

Rather et al. (2020d) reported overall least-squares means of pre-weaning (0–3 months) and post-weaning (3–6, 6–9, and 9–12 months) survivability 88.33±1.38, 95.69±11.03, 97.96±0.56, and 98.28±0.00%, respectively in Kashmir Merino sheep. The overall mean lamb mortality rate was 18.43±2.17% from birth to 12 months of age. Sheep mortality is a drag on litter size and the number of lambs sold per ewe. Further, it is not possible to save every lamb born at the farm. However, it is possible to decrease lamb mortality and increase lamb marketing significantly by establishing facts relating to cause and time of morality. The survival rates of lambs up to weaning and beyond determine the economics and profitability of sheep farmers. While it is not possible to save every single lamb, there is huge scope to reduce mortality percentage for economic sheep production through the development of sheep flock health programs. These flock health programs require information on diseases and their predisposing factors causing mortality and thus huge economic losses. Therefore, the information about losses through deaths needs to be in

the form of a profile indicating the importance of disease and predisposing factors in terms of susceptible age group, the seasonal incidence of the disease, and the annual variation in its occurrence.

Reasons of low genetic improvement

Currently, there is a severe deficiency of accurate pedigree data on Kashmir Merino sheep. Further, the minimum period required for a genetic improvement program has to be at least 10 to 15 years and such programs require strong institutional support. Closed flocks of small size maintained at sheep breeding farms suffer from inbreeding depression and genetic drift. Inbreeding is usually associated with the appearance of genetic defects and a general decline in vigor and performance (Mandal et al., 2004; Ceyhan et al., 2011), decrease lamb survival (Lamberson and Thomas, 1984), and deleterious effect on additive genetic variance as well as on phenotypic values (Falconer and McKay, 1996). The amount of genetic improvement in the breeding program depends on the accuracy of selection, the intensity of selection, and the generation interval. However, in small populations, there is low genetic variation, reproductive efficiency, intensity and accuracy of selection. In addition to lack of awareness, non-availability of proven sires, small flock size, lack of infrastructure, high mortality, and non-availability of digital records are some reasons for slow genetic progress. In Jammu and Kashmir, small flock sizes, large fluctuations in rearing conditions and management between flocks, and over time within a flock, lack systematic livestock identification, inadequate recording of livestock performances and pedigrees and constraints related to the subsistence nature of livestock rearing (where monetary profit is not the most important consideration), the accuracy of selection will be much lower, resulting in lower rates of genetic gain.

Measures to be taken to enhance animal productivity

Genetic progress can be achieved by combining traditional knowledge with science. Continued improvement and conservation Kashmir Merino is highly recommended at farms and farmers' flocks through an open nucleus breeding system. Using proper and simple techniques and targeted investment by establishing units of 25 to 100 ewes in community organizations with technical guidance and logistic support by concerned government organizations is recommended. Modern breeding techniques (ranking of sires and BLUP) and biotechnological tools (MOET, AI, and embryo transfer technology) can be utilized to develop highly productive Kashmir Merino populations, which can sustain the modern economic pressures. However, for modern breeding techniques, reliable and accurate data is required. Therefore, the data recording system at all farms should be uniform and digital. The data management in the farms should be done with the help of ICT-based Management Information Systems and modern breeding tools to warrant reliable and accurate data recording and analysis. The progressive farmers should be linked with government farms. The surplus female stock at government farms should be used for establishing mini sheep farms. Accelerated lambing/out-season breeding and introgression of the *FecB* gene can be practiced by increasing lambing percentage and number of lambs born per ewe. However, an increasing number of lambs born per ewe per year is not sufficient for improving the production potential of Kashmir Merino sheep. Therefore, a multidimensional program should be framed and strictly adopted for augmenting its productivity and genetic improvement. Therefore, a fodder nursery should be established to increase fodder production. Transplantation of improved varieties of legumes and herbs should be tried. Seed production stations should be developed for self-sufficiency in seed availability. Provision for clean drinking water facilities, proper hygiene, disease control programs through adaptation of proper and timely dosing. Vaccination regimes need to be adopted for increasing production of quality animal products. The establishment of effective diagnostic centers and the identification of effective medicines for treatment requires top priority. Non-conventional feed and fodder resources should be utilized. The establishment of effective feed banks and database information centers is highly recommended. Wastelands should be used for fodder production. Afforestation and silvipasture development and productivity of land should be increased. Self-help groups and co-operatives specifically livestock-based should be developed. Extension activities should be strengthened, and desired information should be provided to the farmers in the form of printed leaflets and mass media. Educating the farmers regarding the importance of balanced feeding, disease control, and breeding should be a routine practice. The development of entrepreneurship among rural youth should be encouraged. A marketing facility should be developed for livestock and livestock-related products.

CONCLUSIONS AND RECOMMENDATIONS

The Kashmir Merino is a superior wool breed that has been evolved to produce high-quality apparel wool. This breed also shows good meat production qualities. This is the reason for the popularity of this breed. However, improper management at the grass-root level is leading to indiscriminate crossbreeding which is leading to the dilution of the superior characteristics of this breed. This is also leading to the breed dilution of indigenous breeds of Jammu and Kashmir. However, the presence of high variability in the phenotypes of this sheep is a promising

opportunity. The fodders scarcity during winters, lack of awareness among farmers, non-availability of proven sires, small flock size, lack of infrastructure, and non-availability of digital records are among major constraints in exploiting genetic worth of Kashmir Merino sheep. However, owing to the high production potential of this breed, its conservation, and selective breeding are highly recommended and there is a need for further research to understand the potential of this breed more comprehensively.

NOVELTY STATEMENT

Little work has been done for the important synthetic breed; Kashmir Merino and this paper provides a comprehensive review important research for the breed which was hitherto unavailable.

AUTHOR'S CONTRIBUTION

1st, 2nd and 3rd Author conducted research on this breed. 4th and 5th authors compiled the research. 6th and 7th authors prepared the manuscript and proofread it.

Conflict of interest

The authors have declared no conflict of interest.

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