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RESEARCH

Morphological Characterization of Kage and Baruwal Sheep (*Ovis aries* Linnaeus, 1758) Breeds in Nepal

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Abstract

Sheep farming in Nepal is closely linked to its agricultural heritage and contributes to livelihoods and the socio-economic fabric. This study synthesizes the morphological characterization of Kage and Baruwal (*Ovis aries* Linnaeus, 1758) sheep, highlighting their genetic and functional attributes, including body size, conformation, coat color, horn morphology, and reproductive parameters. This study synthesizes the morphological characterization of Kage and Baruwal (*O. aries*) sheep, highlighting their genetic and functional attributes, including body size, conformation, coat color, horn morphology, and reproductive parameters. The analysis revealed a significant difference ($P \leq 0.01^{**}$) in quantitative traits between the two breeds. The Baruwal sheep exhibited higher mean values for tail length (12.96 ± 0.47 cm), ear length (10.67±0.20 cm), neck length (21.75±0.38 cm), chest girth (67.14±0.50), height at hip bone (64.78±0.44 cm), body weight (33.04±0.65 Kg), and height below withers (67.10±0.56). Additionally, correlation analysis of different quantitative traits was found to be significant at the 0.01 level on a two-tailed test. The study's results indicate significant quantitative variations, which suggest genetic adaptations and selective pressures. The analysis of qualitative traits highlights differences in horn presence, shape, fleece, head color, neckline, and tail shape, providing insights into genetic diversity and functional adaptations. The study concludes that comprehending such phenotypic traits helps with breed management, conservation, and sustainable agriculture. The preservation of genetic diversity and adaptability is underscored by indigenous sheep breeds, which requires further research to elucidate the genetic mechanisms underlying these traits.

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Statement of Sustainability: This research on the morphological characterization of Kage and Baruwal sheep breeds in Nepal contributes to our understanding of indigenous livestock diversity. It provides implications for sustainable agriculture, animal husbandry, and conservation efforts. The study highlights their unique adaptations to different ecological niches and climatic conditions in Nepal by documenting and analyzing the phenotypic traits of these sheep breeds. Such knowledge is essential for informed breed management practices, conservation strategies, and the promotion of sustainable agriculture.

1. Introduction

Sheep farming has long been an integral component of Nepal's agricultural and animal husbandry heritage, playing a pivotal role in supporting livelihoods, providing essential resources, and contributing to the country's socio-economic condition mainly in the sector of meat, fabric, and wool (Pandey and Gyawali, 2012). The diverse geographical and climatic conditions of Nepal have led to the evolution of a variety of strains of sheep breed uniquely characterized by the different ecological niches (Groeneveld et al., 2010). The phenotypic diversity observed in sheep breeds is a testament to the intricate interplay between natural selection, environmental pressures, and human intervention (Mariante et al., 2008). The indigenous breeds of Nepal such as Kage and Baruwal (*Ovis aries* Linnaeus, 1758) have developed distinct characteristics over centuries, enabling them to thrive in different agro-climatic zones across the country and resist different parasitic diseases such as haemonchus (Joshi, 2000). Nepal's topography, ranging from the lowland Terai to the highland Himalayas, has given rise to a multitude of microclimates that have directly influenced the morphology and physiology of different animals and wildlife in Nepal (Nepal, 2012). Understanding the phenotypic traits creates future implications for effective breed management, sustainable agriculture practices, and conservation (Rege, 2003). The challenges posed by altitude, temperature fluctuations, forage availability, and disease prevalence have contributed to the emergence of sheep with unique phenotypic adaptations (Gowane et al., 2017).

Moreover, the cultural and socio-economic aspects of sheep farming in Nepal have contributed a significant role in fulfilling human needs such as meat, wool, and other cultural rituals (Baker and Gray, 2004). Phenotypic characterization involves the diligent measurement and assessment of traits including body size, conformation, coat color, horn morphology, and reproductive parameters (Gatew, 2014). For instance, the large body size and robust conformation of certain Himalayan sheep breeds such as Baruwal and Bhyaglung can be linked to their ability to withstand harsh winters and traverse challenging terrains in search of forage. In this research, we study the morphological characterization of sheep breeds in Nepal. Moreover, the research aims to a deeper understanding of the relationship between environment, genetics, and human practices in shaping these invaluable genetic resources.

2. Materials and Methods

2.1. Study Area

Morphological characterization was carried out on two different Nepalese breeds of sheep i.e., Kage and Baruwal sheep (*O. aries*). Information on morphological characters (qualitative and quantitative Traits) was obtained from the Kage breed conserved by Farmers in its pocket area i.e., Bharatpur metro politician, Hupsekot VDC of Nawalpur district, Baudi kali VDC of Nawalpur Districts Similarly, different morphological data were generated from Baruwal maintained by farmers in different areas like Marsyangdi Rural Municipality of Lamjung, Annapurna VDC of Kaski District, Madi VDC of Kaski district and Purposive samples were collected randomly from various pocket areas of each breed. The data collection sites were selected to represent the natural habitat of the Kage breed and ensure random sampling (Figure 1).

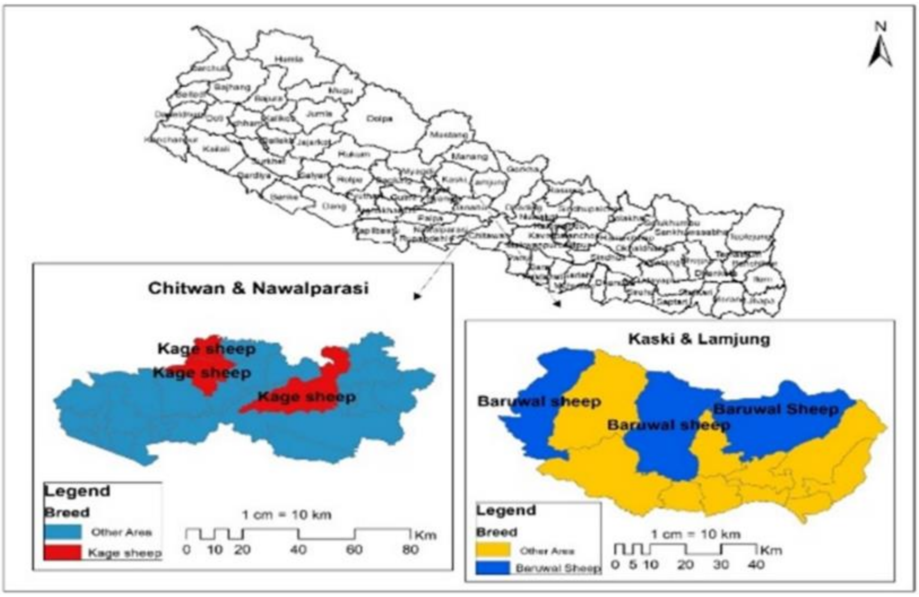

Figure 1. Map Showing Sample collection site.

2.2. Sampling and Data Collection

To ensure a representative sample, animals were selected based on detailed questionnaires and consultations with local animal owners. Closely related individuals were avoided to minimize bias in the dataset. Morphological measurements from 56 Kage Sheep and 56 Baruwal Sheep were taken by using standardized protocols under the guidelines of FAO phenotypic characterization of animals (FAO, 2011). The data was taken from October 2022 to January 2023 as given in Tables 1 and 2. The growth traits (quantitative variable) measured included tail length, body length, ear length, neck length, and phenotypic measurement considered in the characterization of sheep qualitative data were: Horn presence or absence, Horn Shape (if present), Fleece color, Head color, Neckline shape, and Tail Shape as shown in Figure 2 (Afolayan et al., 2006).

Figure 2. Measuring body length, body weight, and Chest girth in Kage and Baruwal sheep.

Table 1. Quantitative measures considered for Kage and Baruwal (*O. aries*) breed characterization.

Quantitative variable	Definition
Tail length (cm)	Distance from the root of the tail to the tip
Body length (cm)	The distance from the base of the tail to the base of the neck
Ear length (cm)	Distance from the base to the tip of the right ear, along the dorsal surface
Neck length (cm)	Distance from the throat to the tip of the shoulder in the medium
length of Head (cm)	Distance between the upper limit of the forehead to the tip of the nose
Chest girth (cm)	Maximum intercostal diameter at the level of the 6th rib, just behind the elbows
Height at Hip bone (cm)	Height from the top of the hip bone to the ground
Body weight in kg	Live Body weight
Height below withers (cm)	Height from the top of the withers to the ground

Table 2. Qualitative measures considered for Kage and Baruwal (*O. aries*) breed characterization.

Qualitative variable	Definition
Horn presence	Present, Absent
Horn Shape (if present)	Small Buddes, Short Curved, long Curved
Fleece colour	White Chalk, Brownish White
Head colour	White, White Speckled with fawn
Neckline shape	Straight, Curved
Tail Shape	Short, Long Below Shank

2.3. Statistical Analysis

The collected data were analyzed using appropriate statistical methods using R Studio (Verzani, 2011). Mean values and standard deviations were calculated for each growth trait for both the Kage and Baruwal breeds. Also, an independent sample T-test was done to check the level of significance and compare two sample means from Kage and Baruwal breeds.

3. Results and Discussion

3.1. Quantitative Trait Analysis

This study aimed to investigate and compare the quantitative growth traits of Kage and Baruwal sheep breeds. Table 3 provides the mean values of various growth traits, along with their standard deviations, for both populations. In terms of tail length, the average mean was found to be 11.53 ± 0.22 cm for Kage breeds and 12.96 ± 0.47 cm for Baruwal breeds. This difference might indicate genetic variations that could be linked to the sheep's adaptation to their specific environments (Fisher et al., 2004).

Table 3. Mean value of growth traits of two different sheep population

Growth Traits	Kage Breeds	Baruwal Breeds	P-Value
Tail length (cm)	11.53 ±0.22	12.96 ± 0.47	P ≤0.01**
Body length (cm)	60.1± 0.7	71.92± 0.56	P ≤0.01**
Ear length (cm)	7.11± 0.09	10.67±0.20	P ≤0.01**
Neck length (cm)	18.46±0.51	21.75±0.38	P ≤0.01**
length of Head (cm)	15.10±0.22	15.10±0.22	P ≤0.01**
Chest Girth (cm)	57.75±0.74	67.14±0.50	P ≤0.01**
Height at Hip bone (cm)	54.64±0.42	64.78±0.44	P ≤0.01**
Body weight in kg	20.73±0.70	33.04±0.65	P ≤0.01**
Height below withers (cm)	58.28±0.71	67.10±0.56	P ≤0.01**

**: Significantly different at P < 0.01.

For body length, Kage sheep had an average mean of 60.1 ± 0.7 cm, whereas Baruwal sheep displayed a significantly larger body length with an average mean of 71.92 ± 0.56 cm. Such variations may stem from differences in selective breeding for certain body proportions in the two breeds (Kalds et al., 2022). Ear length was another trait showing substantial differences. Kage sheep had an average mean ear length of 7.11 ± 0.09 cm, while Baruwal sheep exhibited longer ears, with an average mean of (10.67 ± 0.20 cm). Research conducted by Kalds et al. (2022) on different sheep breeds also found the ear length of the sheep to be different, these variations could be attributed to environmental influences and functional adaptations. Comparing neck length, Baruwal sheep demonstrated a greater average mean (21.75 ± 0.38 cm) than Kage sheep (18.46 ± 0.51 cm). This could be due to distinct husbandry practices or environmental pressures that have contributed to variations in neck length between the two breeds (Birteeb et al., 2012). The length of the head was consistent between the two breeds, both having an average mean of 15.10 ± 0.22 cm. This finding might suggest that head size is less influenced by breed-specific factors and more conserved across populations as per the research conducted by (Hailemariam et al., 2018; Marković et al., 2019). Chest girth was markedly larger in Baruwal sheep, with an average mean of 67.14 ± 0.50 cm, compared to Kage sheep's average mean of 57.75 ± 0.74 cm. This difference could be reflective of diverse breeding goals and natural adaptation processes in response to environmental conditions (Yilmaz et al., 2013). Height at the hip bone was another growth trait with significant differences. Baruwal sheep had an average mean of 64.78 ± 0.44 cm, while Kage sheep exhibited a lower average mean of 54.64 ± 0.42 cm. This variation may relate to body conformation and leg structure that are relevant to the respective environments these breeds have evolved (Salako, 2006).

In terms of body weight, the Baruwal sheep displayed substantially higher values, with an average mean of 33.04 ± 0.65 kg, in comparison to the Kage sheep's average mean of 20.73 ± 0.70 kg. This discrepancy in body weight might reflect different breeding practices and management strategies which is also reflected in the research conducted by (Shirzeyli et al., 2013). Finally, height below withers exhibited differences as well. Baruwal sheep had an average mean of 67.10 ± 0.56 cm, while Kage sheep had an average mean of 58.28 ± 0.71 cm. These variations in height might be influenced by factors such as skeletal structure and overall body proportions (Birteeb et al., 2012).

The results of this study emphasize the pronounced morphological differences between Kage and Baruwal sheep breeds. These differences highlight the complex interplay between genetic traits, environmental factors, and historical breeding practices. The variations observed in tail length, body length, and ear length can be attributed to genetic selection and environmental adaptation. Longer tails in Baruwal sheep might offer advantages in certain environments, while shorter tails in Kage sheep could be more suited to other conditions. Similarly, the larger body length in Baruwal sheep could indicate selective breeding for specific purposes, while the smaller body length in Kage sheep might reflect their adaptation to different geographic regions (Birteeb et al., 2012; Fisher et al., 2004; Hailemariam et al., 2018; Kalds et al., 2022; Le Boeuf et al., 2019; Marković et al., 2019; Salako, 2006; Shirzeyli et al., 2013). The substantial differences in body weight have implications for meat production and overall economic value. Baruwal sheep's greater body weight could be due to either improved management practices or genetic factors that promote higher weight gain (Irshad et al., 2013). The observed variations in neck length, chest girth, and height at hip bone may be related to differences in foraging behavior, feeding regimes, or physical adaptation to distinct environments. These differences could also impact the sheep's overall productivity and ability to thrive in specific husbandry conditions (Baneh and Hafezian, 2009). This study highlights the significant quantitative differences in growth traits between Kage and Baruwal sheep breeds. These variations provide valuable insights into the genetic diversity, adaptability, and potential uses of these breeds in different agricultural contexts.

Further research, including genetic analysis and functional studies, could provide deeper insights into the underlying mechanisms driving these differences and their potential implications for breed management and utilization. The observed differences in growth traits between the Kage and Baruwal breeds suggest variations in their adaptability, productivity, and potential uses (Gorkhali et al., 2016). The larger body size and higher body weight of the Baruwal breed indicate its suitability for meat production. On the other hand, the Kage breed's smaller size might be advantageous in resource-scarce environments.

3.2. Qualitative Trait Analysis

The results of the phenotypic characterization of Kage and Baruwal Sheep are presented in Table 4. A higher percentage of the horn was present in the males (89.28%) as compared to the females (16.07%). This might be due to sex-linked inheritance. The large horns are dominant in the males, and recessive in the females (Wood, 1909). Horn shape revealed the variations within the classes of the horn. A higher percentage of the Short-curved horn was found to be present in the male sheep (46%) and the female was characterized by a higher percentage of the long-curved horn (66.66%), moreover the small-budded horn was significantly found to be higher in the females (22.22%) (Table 4 and Figure 3). These variations reflect the intricate genetic diversity within sheep, with potential implications for functional and adaptive differences (Huang et al., 2017). Turning to the fleece color Female sheep were characterized by a higher percentage (48%) of white chalk fleece while the male was characterized by a higher percentage of brownish-white Fleece (52%). Although these differences are delicate, they could reflect historical breeding preferences or adaptation to environmental conditions.

Table 4. Frequency (%) of each class level for the qualitative traits recorded in Kage and Baruwal (*O. aries*) sheep.

Qualitative traits	Class	Female (%)	Male (%)
Horn	Present	16.07	89.28
	Absent	83.90	10.71
Horn Shape (if present)	Small (Budded)	22.22	18.00
	Short Curved	11.11	46.00
	Long Curved	66.66	36.00
Fleece colour	White chalk	48.00	38.70
	Brownish White	52.00	41.93
Head colour	White	83.00	85.00
	White speckled with fawn	17.00	15.00
Neckline shape	Straight	56.00	64.00
	Curved	44.00	36.00
Tail Shape	Short	100.00	100.00
	Long: Below shank	0.00	0.00

The prevalence of this trait is consistent across genders in both breeds, showing 85% of the white head in the males, and 17% of the white speckled head with fawn in the females. A minority of individuals in both breeds display White speckles with a fawn head color, providing a nuanced yet shared characteristic that might have limited genetic implications (Ijichi et al., 2018). Neckline shapes in the male sheep exhibited a higher percentage of the straight neckline and the curved neckline was found to be higher in the male sheep (44%). These differences in the Neckline shape could be due to the adaptation to distinct environments or potentially different breeding priorities and feeding styles during care and management (Zhang et al., 2014). The tail Shape trait demonstrates a consistent pattern within both breeds. Both male and female sheep exhibit a 100% prevalence of Short tail shape, with no instances of the Long: Below shank tail shape observed. This shared characteristic might be due to functional requirements or selective pressures acting on tail length (Li et al., 2020). The result revealed that the correlation of different quantitative traits is significant at the 0.01 level on 2 tailed tests. Most of the morphological traits were found to be highly correlated in two-tailed. All the parameters such as body length, height at wither, body weight, heart girth, neck length, and height at the hip bone correlate to each other except the Ear length which was not found to correlate with Tail length.

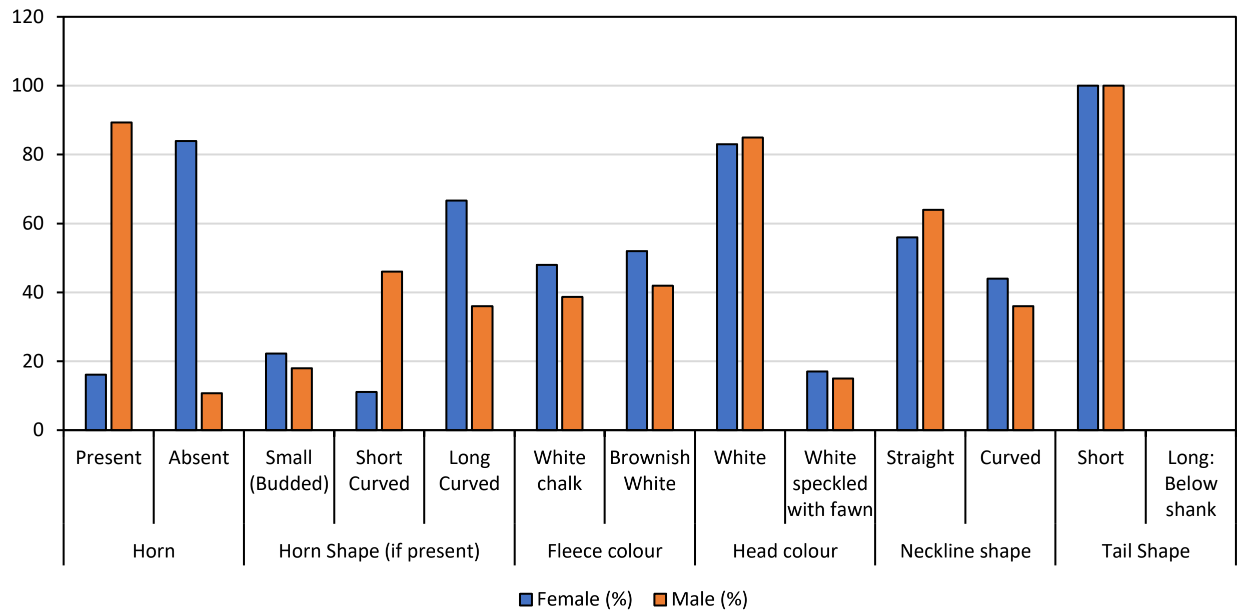

Figure 3. Bar Graph showing Frequency (%) of each class level for the qualitative traits.

Table 5. Correlation matrix of the quantitative traits of the Kage and Baruwal breeds of Sheep.

Parameters	Tail length (CM)	Body length CM)	Heart Girth (CM)	Head length (CM)	Body length n inch	Height at wither (CM)	Body weight (lbs)	Body weight in kg	Heart girth in inch	Neck length (CM)	Ear length (CM)	Height at the hip bone
Tail length (CM)	1											
Body length (CM)	.568**	1										
Heart Girth (CM)	.522**	.982**	1									
Head length (CM)	.482**	.952**	.918**	1								
Body length n inch	.568**	1.000**	.982**	.952**	1							
Height at wither (CM)	.557**	.985**	.967**	.940**	.985**	1						
Body weight (lbs)	.537**	.990**	.992**	.939**	.990**	.973**	1					
Body weight in kg	.537**	.990**	.992**	.939**	.990**	.973**	1.000**	1				
Heart girth in inch	.522**	.982**	1.000**	.918**	.982**	.967**	.992**	.992**	1			
Neck length (CM)	.479**	.781**	.777**	.749**	.781**	.789**	.792**	.792**	.777**	1		
Ear length (CM)	-0.145	-.621**	-.569**	-.706**	-.621**	-.542**	-.615**	-.615**	-.569**	-.319**	1	
Height at the hip bone	.342**	.869**	.850**	.848**	.869**	.820**	.864**	.864**	.850**	.602**	-.780**	1

**. Correlation is significant at the 0.01 level (2-tailed).

4. Conclusion

The variations were found to be observed in the growth traits such as body size, tail length, ear length, etc., and suggest selective pressure in response to changes in environment and genetic adaptations. Different phenotypic and morphological parameters of the sheep were found to be directly related to the body weight of the sheep. Moreover, different morphological parameters of the sheep were also found to be directly correlated with each other except for ear length and tail length. Thus, it is concluded that besides the body weight, other factors and parameters could also be considered as a major functional parameter for the genetic improvement program of the sheep breeds of Nepal. Moreover, the strong variation in the weight of the sheep between the two breeds also signifies that the breed is an important factor for the greater performance. Further genetic analysis and a marker-based study are required for the full sheep population and its genotypic features. The present information when complemented with the DNA microsatellites marker and functional markers may help in the animal genetic resources conservation of this indigenous breed of sheep.

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Data/Supplementary Information Availability: Not applicable.

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