



Research Article

Characterization of Salt Range Sheep Based on Various Quantitative and Qualitative Traits in Punjab, Pakistan

Hafiz Muhammad Bilal Akhtar¹, Ghulam Bilal², Fazle Ahad², Hafiz Muhammad Waheed², Andleib Qayyum², Muhammad Naeem Riaz¹, Bilal Javid¹

¹National Institute for Genomics and Advanced Biotechnology, NARC, Islamabad, Pakistan.

²Department of Animal Breeding and Genetics and National Center for Livestock Breeding Genetics and Genomics (NCLBG&G), PMAS Arid Agriculture University, Rawalpindi, Punjab, 46300, Pakistan.

*Correspondence: ghulam.bilal@uaar.edu.pk

Article History

Received: January 26, 2024

Accepted: March 4, 2024

Published: March 9, 2024

Abstract

The current study was conducted to characterize Salt Range sheep breed in arid region of Punjab, Pakistan on the basis of various quantitative and qualitative traits. Salt Range sheep breed in local culture is called as Latti sheep. The sample under study comprised of 252 female and 50 male animals having average age ranging between six to eight months. Data on sixteen traits were recorded at various locations, including University Research Farm in Koont, Gujjar Khan, Rawalpindi, Barani Livestock Production Research Institute in Kherimurat, Attock, and private herds nearby. Quantitative traits included live body weight (LBW), body length (BL), height at wither (HW), ear length (EL), head length (HL), heart girth (HG), tail circumference (TLC), mandibular circumference (MC), teat circumference (TC), teat length (TL), scrotal length (SL), and scrotal circumference (SC). Moreover, qualitative traits encompassed body wool color, body skin color, horn presence, and facial head profile. The data was organized based on sex and herd which was analyzed using a mixed linear model in SAS. The Phenotypic correlations between different traits were also estimated. The mean values \pm standard deviations of LBW, BL, HW, EL, HL, HG, TLC, MC, TC, TL, SL, and SC were as follows: 48.34 \pm 10.09 kg, 67.83 \pm 7.45 cm, 73.50 \pm 6.24 cm, 17.17 \pm 7.43 cm, 18.23 \pm 3.79 cm, 93.01 \pm 10.96 cm, 63.06 \pm 10.51 cm, 34.32 \pm 5.38 cm, 3.92 \pm 1.43 cm, 4.14 \pm 1.57 cm, 12.04 \pm 3.52 cm, and 20.10 \pm 7.21 cm, respectively. The study observed an effect of sex on LBW. Similarly, EL, HL, HG, TLC, and MC also significantly differed between males and females; however, body length (BL) and Height at wither (HW) did not exhibit significant differences ($P \geq 0.05$) between the two sexes. This study phenotypically characterized Salt Range sheep breed by investigating its various quantitative and qualitative traits, according to food and agriculture organization (FAO) breed characterization guidelines. The current study generated phenotypic information which highlighted the importance of Salt Range sheep for future conservation and application of genomics related to its breed improvement for various traits.

Keywords: Characterization; Genomics; Latti ; Quantitative; Qualitative



Copyright: © 2024 by the authors. Licensee Roots Press, Islamabad Pakistan.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Introduction

Sheep and goats are scientifically termed as *Ovis Aries*. Sheep and goats were domesticated by humans 10,000 years ago. Asia, Africa, and Europe, possess numerous sheep genetic resources which are climatically adapted to local temperatures and environments, meeting the needs and demand of local population in terms of meat and wool production, that are contributing to the food security of their respective countries (Taberlet *et al.*, 2011).

Pakistan boasts a vast and diverse sheep population, with approximately 31.9 million individuals distributed across different climatic zones (GOP, 2021-2022). The country's landscapes vary from the lush green pastures of Punjab to the arid lands of Baluchistan and Khyber Pakhtunkhwa, the picturesque mountainous regions of Azad Jammu and Kashmir and Gilgit Baltistan, and the renowned Thar Desert in the Sindh province. Livestock rearing, especially of sheep and goats, is a vital livelihood for most of the population residing in these regions. Pakistan is home to 25 sheep breeds and their wild relatives, including Urial, Bharal, Argali, and blue sheep (Khan *et al.*, 2007). These sheep breeds are phenotypically classified based on their tail type as thin-tailed and fat-tailed breeds, primarily raised for mutton and wool production (Khan *et al.*, 2007).

In the current era, marked by population growth and the effects of global warming and natural disasters like floods, elevated temperatures, and earthquakes, food security takes precedence. To meet the rising demand for food products, particularly meat from small ruminants, which serves as a valuable source of protein, it is crucial to conserve and characterize livestock species, especially sheep genetic resources. Unfortunately, sheep genetic resources in Pakistan face an identity crisis due to unplanned breeding, and there is a lack of criteria for sheep breeding and the conservation of local genetic resources in the country (Afzal and Naqvi, 2004). The characterization of local genetic resources represents an essential step in documenting and understanding selected phenotypic traits of interest (FAO, 2012). Regrettably, the aspect of animal breeding and genetics in sheep farming has been neglected in Pakistan. Quantitative and qualitative measurements play a vital role in comprehending various animal characteristics, leading to increased productivity and accurate animal identification (Nsoso *et al.*, 2004).

Keeping in view the scarcity of knowledge regarding the indigenous sheep breeds of Pakistan particularly the arid region of Punjab, Pakistan, the current study was designed to investigate the characterization of fat-tail Salt Range sheep breed based on quantitative and qualitative traits and to study the effect of sex and herd on these traits.

The importance of sheep and goats in the agricultural landscape of Pakistan cannot be overstated. These small ruminants not only serve as a significant source of meat and wool but also contribute to the livelihoods of numerous communities, particularly in the rural areas of the country. With a rich diversity of landscapes, from the fertile plains of Punjab to the rugged terrains of Baluchistan and the mountainous regions of Azad Jammu and Kashmir, Pakistan provides a range of climatic conditions ideal for various sheep breeds to thrive (Rafiq, 1995).

Among the 25 sheep breeds found in Pakistan, the Salt Range sheep breed holds a unique place, particularly for its fat-tailed characteristic, which is highly valued for its meat

production. Understanding the intricate details of this breed, including its physical traits and variations, is not only essential for its conservation but also for enhancing its productivity and adaptability to the changing environmental conditions (Mirza *et al.*, 1988).

In the current study, the focus on quantitative and qualitative traits of the Salt Range sheep breed is an integral part of broader efforts to characterize and conserve indigenous genetic resources. By examining how sex and herd factors influence these traits, researchers aim to shed light on the breed's unique attributes and potential for further development.

Phenotypic measurements, which encompass a range of physical characteristics, play a crucial role in this endeavor. They provide valuable data points for researchers and breeders to make informed decisions regarding breeding programs, conservation strategies, and overall breed improvement (Rafiq *et al.*, 2007).

This study's findings are expected to not only contribute to the existing body of knowledge about the Salt Range sheep breed but also provide actionable insights for the sustainable management and utilization of this breed within Pakistan's diverse agricultural landscape (Purdy *et al.*, 2018).

Methodology

Sampling region

The present study was carried out at University Research Farm Koont (Gujjar Khan, Rawalpindi), Barani Livestock Production Research Institute in Kherimurat, Attock, and private herds present near these locations. These areas represent the natural habitat of Salt Range sheep and are characterized by arid conditions, limited access to water for agricultural activities, the inability to cultivate crops and fodder, and a heavy reliance on annual rainfall to support agricultural operations. Inhabitants of this region predominantly engage in livestock rearing as their primary source of livelihood, owing to the ample availability of rangeland for livestock grazing.

Sample size and traits

Data pertaining to the Salt Range sheep breed were systematically gathered from the aforementioned regions during the timeframe spanning November to December 2022. A comprehensive proforma was meticulously designed to capture essential demographic information, as well as an extensive array of sixteen quantitative and qualitative traits on animals with age ranging between six to eight months. Nutrition is an important factor all animals were subject to open grazing in arid land of Attock and Gujjar Khan. Animals were kept in closed sheds to protect from weather calamities and attack from wild animals.

Phenotypic assessments were conducted on a sample size comprising 302 adult animals, encompassing both males and females, drawn from both public and private herds situated in the Potohar region (Table 1). Total number of adult animals with age ranging from six to eight months were selected in which data was collected from 242 animals from public herd and 60 animals from private herd. To provide a succinct overview, quantitative measurements were taken for attributes such as live body weight, body length, height at withers, ear length, head length, heart girth, tail circumference,

mandibular circumference, teat circumference, teat length, scrotal circumference, and scrotal length. Live body weight was recorded in kilograms, while other physical dimensions were quantified in centimeters.

Table 1. Quantitative measures considered for Salt Range sheep characterization in arid region of Punjab.

Sr. No.	Traits	Unit	Definition
1	Live body weight	Kg	Live body weight of sheep through weighing balance
2	Body length	Cm	The horizontal distance from point of shoulder to pin bone
3	Height at withers	Cm	The vertical height in cm from the bottom of the front foot to the highest point of shoulder between withers.
4	Ear length	Cm	Distance from base of ear to the tip of ear
5	Head length	Cm	Frontal distance from mouth to poll taken
6	Heart girth	cm	Measurement of circumference of chest
7	Tail circumference	cm	Circumference of tail
8	Mandibular circumference	cm	Circumference of Mandibular
9	Teat circumference	cm	Measurement of teat circumference
10	Teat length	cm	Length of teat
11	Scrotal length	cm	Length of Scrotum
12	Scrotal circumference	cm	Circumference of scrotum

Additionally, qualitative characteristics, encompassing body wool color, body skin color, horn presence, and facial head profile (nose), were meticulously documented. To ensure precision, live body weight measurements were obtained using a Salter Hanging weighing balance, with an accuracy of ± 0.5 kg. Body length was measured from the point of the shoulder to the pin bone in centimeters, while height at withers was determined from the bottom of the front foot to the highest point of the shoulder between the withers, also measured in centimeters. Ear length was gauged from the base to the tip of the ear in centimeters, and head length was assessed by measuring the distance between the mouth and the pole, also in centimeters. Chest girth was quantified by measuring the circumference of the chest using a measuring tape in centimeters. The total circumference of the fat-tail was recorded in centimeters, and mandibular circumference was assessed similarly. For female sheep, the circumferences and lengths of their teats were recorded in centimeters, while for male sheep, scrotal circumference and scrotal length were measured in centimeters, following the protocol detailed by Esquivelzeta *et al.* (2011).

Statistical analysis

Data were analyzed using mixed procedure in SAS On-Demand for Academics (www.oda.sas.com). The following **statistical model** was used to investigate the effect of sex and herd on various traits including LBW, BL, HW, EL, HL, HG, TLC and MC.

$$Y_{ijk} = \mu + \text{Sex}_i + \text{Herd}_j + E_{ijk}$$

Where,

- Y_{ijk} = a measurement on k^{th} animal in j^{th} herd and of i^{th} sex
- μ = Overall population mean
- Sex_i = Fixed effect of i^{th} sex ($i=1$ for female and 2 for male)

- Herd= Fixed effect of j^{th} herd ($j=1$ for public and 2 for private)
- E_{ijk} = Random error associated with a measurement on k^{th} animal in j^{th} herd and of i^{th} sex.

The following model of analysis was used for TL, TC, SL and SC

$$Y_{ij} = \mu + \text{Herd}_i + E_{ij}$$

Where,

- Y_{ijk} = a measurement on the j^{th} animal in i^{th} herd
- μ = overall population mean,
- Herd_i = Fixed effect of i^{th} herd ($i= 1$ for Public and 2 for Private)
- E_{ij} = Random error associated with a measurement on the j^{th} animal in i^{th} herd.

Correlations among various quantitative traits were estimated in using PROC CORR procedure in SAS.

Results

The statistical analysis of body measurements was conducted using SAS On-Demand for Academics, employing the "proc means" procedure in SAS. The trait definitions, computed means and standard deviations (SD) for various body measurements are presented in Table 1 and 2.

Table 2. Overall Mean \pm SD of various quantitative traits in Salt Range sheep.

Sr. No	Traits	No	Mean \pm SD	Min	Max	CV%
1	Live body weight(kg)	302	48.347 \pm 10.091	21	90	20.87
2	Body length(cm)	302	67.831 \pm 7.454	28	95	10.98
3	Height at withers(cm)	302	73.503 \pm 6.243	60	95	8.49
4	Ear length(cm)	302	17.175 \pm 7.437	9	100	43.30
5	Head length(cm)	302	18.231 \pm 3.794	11	68	20.81
6	Heart girth(cm)	302	93.016 \pm 10.967	19	115	11.79
7	Tail circumference(cm)	302	63.066 \pm 10.512	17	95	16.66
8	Mandibular circumference(cm)	302	34.321 \pm 5.384	13	46	15.68
9	Teat circumference(cm)	252	3.927 \pm 1.432	1	7	36.46
10	Teat length(cm)	252	4.146 \pm 1.577	1	8	38.03
11	Scrotal length(cm)	50	12.040 \pm 3.522	5	19	29.25
12	Scrotal circumference(cm)	50	20.100 \pm 7.211	6	35	35.87

Effect of sex

The analysis considered two distinct sexes, namely male and female, and the least square estimates of means for various quantitative traits are presented in Table 3. Notably, a significant disparity in weight was observed between the two sexes, with males averaging 45.6190 \pm 1.4831 kilograms and females 51.0507 \pm 0.7905 kilograms. It is worth noting that female animals exhibited slightly higher live body weight (LBW) in comparison to their male counterparts, while body length (BL) and height at withers (HW) displayed similar values in both male and female animals, with means of 18.3106 \pm 0.6075 and 73.503 \pm 6.243, respectively.

Ear length (EL) in female animals surpassed that of male sheep, with estimates of 16.1333

± 1.1399 and 18.5381 ± 0.5804 , respectively. Head length (HL) was notably higher in male animals (18.5381 ± 0.5804) compared to female animals (17.6150 ± 0.3093). Conversely, female sheep exhibited a higher heart girth (HG) with a mean of 92.6126 ± 0.8777 , while male sheep averaged 87.2333 ± 1.6468 .

Table 3. Effect of sex on body weight and various body measurements in Salt Range sheep in arid region of Punjab.

Sr.No	Traits	Male(N=50)	Female(N=252)	Overall P value
1	Live body weight(kg)	45.61 \pm 1.48	51.05 \pm 0.79	0.0014*
2	Body length(cm)	67.73 \pm 1.14	67.12 \pm 0.60	0.6358
3	Height at Withers(cm)	72.31 \pm 0.94	72.74 \pm 0.50	0.6900
4	Ear length(cm)	16.13 \pm 1.13	18.31 \pm 0.60	0.0929
5	Head length(cm)	18.53 \pm 0.58	17.61 \pm 0.30	0.1615
6	Heart girth(cm)	87.23 \pm 1.64	92.61 \pm 0.87	0.0042*
7	Tail circumference(cm)	58.40 \pm 1.58	63.39 \pm 0.84	0.0057*
8	Mandibular circumference(cm)	29.20 \pm 0.72	33.97 \pm 0.38	0.0001*

*Statistically significant ($P < 0.05$) and Non-significant ($P \geq 0.05$)

Tail circumference (TLC) measurements revealed a greater circumference in female sheep (63.3966 ± 0.8423) in contrast to male sheep (58.4048 ± 1.5804). Furthermore, mandibular circumference (MC) exhibited significant differences between the two sexes, with males averaging 29.2000 ± 0.7237 and females 33.9783 ± 0.3857 .

These findings highlight the distinct quantitative trait variations between male and female animals, underscoring the significance of sex as a contributing factor in the observed differences.

Effect of herd

The factor "herd" was categorized into two distinct classes: public, encompassing the university herd and livestock department herd, and private, representing all privately-owned farms raising Salt Range sheep. The least square estimates of herd effects are presented in Table 4, revealing noteworthy variations between these two classifications.

Private herds exhibited a higher mean live body weight (LBW) of 51.8778 ± 1.4328 kilograms, in contrast to public herds with an average LBW of 44.7920 ± 0.8783 kilograms. Moreover, public herds demonstrated higher values for body length (BL) at 68.9618 ± 0.6774 centimeters and scrotal circumference (SC) at 10.6143 ± 0.2593 centimeters compared to private herds, which recorded 65.9000 ± 1.1051 centimeters and 8.7333 ± 0.4230 centimeters, respectively. Similarly, the height at withers (HW) was found to be greater in public herds (74.4664 ± 0.5607 centimeters) compared to private herds (70.6000 ± 0.9146 centimeters).

However, private herds exhibited higher values for ear length (EL) at 18.1778 ± 1.1012 centimeters, tail circumference (TLC) at 61.1667 ± 1.5268 centimeters, and scrotal length (SL) at 6.3000 ± 0.2117 centimeters when compared to public herds. Additionally, test circumference (TC) was larger in private herds (2.1444 ± 0.1946 centimeters) in contrast to tail length (TL), which was higher in public herds at 2.0870 ± 0.1322 centimeters. Notably, mandibular circumference (MC) was observed to be higher in public herds at 32.7338 ± 0.4286 centimeters.

Table 4. Effect of herd on various body measurements and body weight in Salt Range sheep in arid region of Punjab.

Sr. No.	Traits	Herd1(public)	Herd2(private)	Overall P-value
1	Live body weight(kg)	44.79±0.87	51.87±1.43	0.0001*
2	Body length(cm)	68.96±0.67	65.90±1.10	0.0188*
3	Height at withers(cm)	74.46±0.56	70.60±0.91	0.0004*
4	Ear length(cm)	16.26±0.67	18.17±1.10	0.1399
5	Head length(cm)	18.68±0.34	17.46±0.56	0.0646
6	Heart girth(cm)	92.86±0.97	86.97±1.59	0.0018*
7	Tail circumference(cm)	60.63±0.93	61.16±1.52	0.7666
8	Mandibular circumference(cm)	32.73±0.42	30.44±0.69	0.0056*
9	Teat circumference(cm)	1.92±0.11	2.14±0.19	0.3357
10	Teat length(cm)	2.08±0.13	2.01±0.21	0.7645
11	Scrotal length(cm)	5.90±0.12	6.30±0.21	0.1083
12	Scrotal circumference(cm)	10.61±0.25	8.73±0.42	0.0002*

*Statistically significant ($P < 0.05$) and Non-significant ($P \geq 0.05$)

Furthermore, heart girth (HG) at 86.9778 ± 1.5909 centimeters and head length (HL) at 17.4667 ± 0.5607 centimeters were lower in private herds compared to their counterparts in public herds within the Pothohar region of Punjab, Pakistan. Additionally, scrotal length measurements exhibited statistical differences, with private herds having a higher scrotal length of 6.3000 ± 0.2117 centimeters compared to public herds with 5.9000 ± 0.1298 centimeters. Conversely, scrotal circumference was greater in public herds at 10.6143 ± 0.2593 centimeters in contrast to private herds, which recorded 8.7333 ± 0.4230 centimeters in the study. These findings underscore the significant variations in quantitative traits between public and private herds in the study region.

Phenotypic correlation estimates

The study explored the correlations between diverse body measurements, focusing on their relationships with live body weight (LBW), as detailed in Table 5. The analysis aimed to assess the degree of linear association between various variables, with correlation values ranging from 0 to 1.

Table 5 Correlation among different body measurements and body weight in Salt Range sheep in arid region of Punjab.

Sr.No		LBW	BL	HW	EL	HL	TLC	HG	MC	TC	TL	SL	SC
1	LBW(kg)	1.00											
2	BL(cm)	0.18	1.00										
3	HW(cm)	0.37	0.24	1.00									
4	EL(cm)	0.06	0.04	0.08	1.00								
5	HL(cm)	0.08	0.02	0.10	0.10	1.00							
6	TLC(cm)	0.38	0.02	0.09	0.04	0.06	1.00						
7	HG(cm)	0.41	0.18	0.20	0.24	0.43	0.20	1.00					
8	MC(cm)	0.22	0.05	0.01	0.05	0.18	0.41	0.29	1.00				
9	TC(cm)	0.14	0.11	0.16	0.00	0.03	0.25	0.14	0.45	1.00			
10	TL (cm)	0.18	0.04	0.16	0.01	0.04	0.36	0.20	0.53	0.85	1.00		
11	SL(cm)	0.07	0.07	0.07	0.07	0.07	0.17	0.14	0.38	0.71	0.69	1.00	
12	SC(cm)	0.04	0.06	0.10	0.07	0.05	0.13	0.12	0.36	0.69	0.68	0.94	1.00

LBW=Live body weight, BL= Body Length, HW= Height at Wither, EL= Ear Length, HL= Head Length, TLC= Tail circumference, HG= Heart Girth, MC= Mandibular Circumference, TC= Teat Circumference, TL= Teat Length, SL= Scrotal Length, SC= Scrotal Circumference

A robust and positive correlation (0.94) was observed between scrotal circumference and scrotal length, whereas a weak correlation (0.01) indicated the independent nature of mandibular circumference and height at withers, highlighting their limited interdependence.

Frequencies and percentages of qualitative traits

Observations pertaining to body wool color, body skin color, horn presence, and facial head profile (nose) are detailed in Table 6. Among these observations, 76% of animals exhibited white body coloration, while 6% displayed a slightly tan hue, and 18% had a pale coloration. Regarding body skin color, the majority (89%) featured non-pigmented skin, with a smaller portion (11.5%) showing a slightly tan coloration. Horn presence was noted in 25% of the animal population, while the remaining 75% were hornless. In terms of facial head profile (nose), 88% of animals had a straight nose, while 12% exhibited a concave nose structure.

Table 6. Qualitative observations in Salt Range sheep (N=302) of arid region of Punjab.

Sr. No.	Traits	Color	Frequency	Percentage (%)
1	Body wool color	a)White	a)227	a)76%
		b)Slightly tan	b)20	b)6%
		c)Pale	c)50	c)18%
2	Body skin color	a)Pigmented	a)267	a)0%
		b) Slightly tan	b)35	b)11%
3	Facial head profile(nose)	a)Straight	a)271	a)88%
		b)concave	b)31	b)12%
4	Horn presence	a)yes	a)76	a)25%
		b)no	b)226	b)75%

Discussion

Significant differences in weight were observed between male and female animals, possibly attributable to the heavier fat-tail in female animals, along with the presence of pregnant females during measurement. Fat-tail circumference measurements exhibited variations between male and female animals, with female sheep demonstrating a fat-tail circumference of (63.39±0.84), in contrast to male animals with (58.40±1.58), as indicated in Table 3. Additional distinctions in various body measurements were observed and are detailed in this study while considering the impact of both sex and herd on the Salt Range sheep Breed. It is noteworthy that prior research has already noted the influence of sex on various body measurements (Ibrahim et al., 2021).

Body measurements hold significant importance in genetic improvement programs for sheep and goats. However, there is a scarcity of data related to various sheep and goat breeds in the country. Previous studies have explored morphometric variations in AJK goat breeds, investigating the effects of age, breed, and sex on body weight and measurements in various AJK goat breeds, employing the mixed procedure in SAS 9.2 for data analysis (Moaeen-ud-Din et al., 2019). In Africa, phenotypic characterization of fat-tail sheep breeds considered both quantitative and qualitative traits for body measurements. It was noted that the sex of sheep had no effect on body weight, ear length, and rump length, while the age group significantly influenced various body

measurements, along with the location's impact on these measurements (Abera et al., 2014).

Phenotypic characterization studies of sheep breeds in different regions have yielded valuable insights. For instance, in the Gamogofa zone, higher body measurements and body weight were observed in rams, which increased with age. Moreover, positive correlations between body weight and most body measurements were identified across different sex and age groups (Hailemariam et al., 2018). Similarly, a study on the morphometric characteristics of Balami sheep breeds in Nigeria revealed that body weight exhibited a positive correlation with all body measurements except head length, indicating a shared genetic influence (Khan et al., 2017).

In the context of Simien sheep in mountainous regions of Ethiopia, phenotypic characterization indicated that the Simien breed attains its mature weight upon the eruption of three pairs of permanent incisors, implying an extended duration for the breed to achieve its target body weight (Melaku et al., 2019). These collective findings contribute to a comprehensive understanding of body measurements and their associations within various sheep breeds, facilitating informed genetic and breeding programs.

Phenotypic characterization studies have been conducted on various sheep breeds, contributing valuable insights into their qualitative and quantitative traits, with the aid of SAS software.

For instance, the Jaffna breed in Sri Lanka was characterized as having short hair and a medium-sized physique, with males possessing horns while females were polled. Notably, variations in ear length were observed within the breed (Rathnakumara et al., 2015).

In Saudi sheep, a phenotypic correlation analysis conducted in the Qassim region revealed the highest correlation coefficient between RH and WH traits (0.872) and the lowest between CC and HG traits (0.214) (Elzaree et al., 2021).

In the case of Vembur sheep, phenotypic characterization depicted them as tall animals with moderately long bodies, featuring white coat coloration with red or tan/fawn patches scattered across their bodies. Both sexes had medium-length heads with straight profiles and medium to broad foreheads exhibiting a slight bulge. Their coats were short, coarse, and bright in appearance (Selvakkumar et al., 2016).

Similar to the Salt Range sheep's phenotypic characterization, local Iraqi sheep breeds, including Awassi, Naimi, and Hamdani, underwent comprehensive characterization. For instance, Awassi males were identified by their white bodies, fine wool, long pendulous ears, and horns, while Awassi females shared white body color, carpet-like wool, long pendulous ears, but lacked horns and displayed higher litter sizes. Naimi breed males exhibited white bodies, carpet-like wool, long pendulous ears, and horns, whereas Naimi females had white bodies, carpet-like wool, shorter ears, no horns, and twins as their typical litter size. Hamdani males featured brown bodies, carpet-like wool, long pendulous ears, and no horns, while Hamdani females had white and brown body coloration, fine wool, long pendulous ears, no horns, and typically gave birth to twins (Al-Sabea et al., 2020).

Characterizing livestock genetic resources is a crucial component of breed conservation and enhancement strategies. In Ethiopia, research encompassed the phenotypic assessment of three fat-tailed and three thin-tailed local sheep breeds. Key measurements included live body weight, body length, height at withers, chest girth, chest depth, rump height, rump length, ear length, tail length, and pelvic width (Deribe *et al.*, 2021).

Conclusion

It was concluded that herd and sex play a significant role in investigating variation related to various body measurements in Salt Range sheep breed which may be considered while analyzing genetic parameters. The results from present study provide useful up to date information on breed characteristics of Salt Range sheep for long term conservation and running genetic improvement program. The current information obtained after characterization is also useful for genome wide association studies on various quantitative and qualitative traits of Salt Range sheep in Pakistan.

Conflict of Interest

There is not any conflict of interest to authors.

Authors Contributions

All the authors equally contributed to manuscript.

References

- Abera, B., K. Kebede, S. Gizaw and T. Feyera. 2014. On-farm phenotypic characterization of indigenous sheep types in Selale Area, Central Ethiopia. *Journal of Veterinary Science & Technology*, 5.
- Afzal, M. and A. Naqvi. 2004. Livestock resources of Pakistan: present status and future trends. *Quarterly Science Vision*, 9: 1-2.
- Al-Sabea, W. S., D. Al-Zwean and M. A. Al-Faham. 2020. Study of phenotypic distribution of local iraqi sheep. *Plant Archives*, 20: 6569-78.
- Deribe, B., D. Beyene, K. Dagne, T. Getachew, S. Gizaw and A. Abebe. 2021. Morphological diversity of northeastern fat-tailed and northwestern thin-tailed indigenous sheep breeds of Ethiopia. *Heliyon*, 7.
- Elzareei, M., E. Mousa and S. AL-Sharari. 2021. Phenotypic correlation between body measurements in Saudi sheep in Qassim region. *International Journal of Biology*, 13: 1-26.
- Esquivelzeta, C., M. Fina, R. Bach, C. Madruga, G. Caja, J. Casellas and J. Piedrafita. 2011. Morphological analysis and subpopulation characterization of Ripollesa sheep breed. *Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animales*, 49: 9-17.
- FAO. 2012. Phenotypic characterization of animal genetic resources. *FAO Animal Production and Health Guidelines No. 11*. Rome.
- Hailemariam, F., D. Gebremicheal and H. Hadgu. 2018. Phenotypic characterization of sheep breeds in Gamogofa zone. *Agriculture & Food Security*, 7: 1-7.
- Ibrahim, A., W. T. Artama, I. G. S. Budisatria, R. Yuniawan, B. A. Atmoko and R.

- Widayanti. 2021. Regression model analysis for prediction of body weight from body measurements in female Batur sheep of Banjarnegara District, Indonesia. *Biodiversitas Journal of Biological Diversity*, 22: 2723-30.
- Khan, K. M., N. Kumar, D. Chakraborty, I. Faried, R. Sharma, S. Bhatt, D. Kumar and R. Taggar. 2017. Phenotypic characterization of Purky sheep population of Kargil district. *Indian Journal of Animal Research*, 51: 625-29.
- Khan, M. S., M. Khan, S. Ahmad and S. Mahmood. 2007. Continuing education article genetic resources and diversity in Pakistani sheep. *International Journal of Agriculture and Biology*, 6: 941-44.
- Melaku, S., A. Kidane, S. Abegaz, A. Tarekegn and A. Tesfa. 2019. Phenotypic characterization of Simien sheep in Simien mountain region, Ethiopia. *International Journal of Agriculture and Biosciences*, 8: 178-85.
- Mirza, I., J. Jadoon, M. Naqvi and A. Ali. 1988. Performance of lambs fed urea molasses blocks vs concentrate. *Asian-Australasian journal of animal sciences*, 1: 27-31.
- Moaeen-ud-Din, M., G. Bilal, J. M. Reecy and M. Sajjad. 2019. Effect of breed, age and sex on body weight and various body measurements in Azad Jammu and Kashmir goat breeds. *Pakistan Journal of Agricultural Sciences*, 56.
- Nsoso, S. J., B. Podisi, E. Otsogile, B. Mokhutshwane and B. Ahmadu. 2004. Phenotypic characterization of indigenous Tswana goats and sheep breeds in Botswana: continuous traits. *Tropical Animal Health and Production*, 36: 789-800.
- Purdy, A., P. B. Pathare, Y. Wang, A. P. Roskilly and Y. Huang. 2018. Towards sustainable farming: Feasibility study into energy recovery from bio-waste on a small-scale dairy farm. *Journal of Cleaner Production*, 174: 899-904.
- Rafiq, M. 1995. Status and scope of small ruminants production in dry areas of Pakistan-Review. *Asian-Australasian Journal of Animal Sciences*, 8: 205-12.
- Rafiq, M., S. Mumtaz, N. Akhtar and M. Khan. 2007. Effect of strategic supplementation with multi-nutrient urea molasses blocks on body weight and body condition score of Lohi sheep owned by tenants of Pakistan. *Small Ruminant Research*, 70: 200-08.
- Rathnakumara, W., W. Abeygunawardena, M. Deepani, A. Amarasinghe, L. Lokugalappatti, L. Samaranayake, D. Rathnayake, P. Alexander and R. Rabel. 2015. Phenotypic Characterization of Jaffna Local Sheep, an Indigenous Livestock Breed of Sri Lanka. 67th Annual Scientific Sessions of the Sri Lanka Veterinary Association: 14.
- Selvakkumar, R., T. Sivakumar, S. M. Sundaram, K. T. P. Jawahar and T. T. Vanan. 2016. Phenotypic characterization of vembur sheep in its breeding tract. *Indian Veterinary Journal*, 93: 36-38.
- Taberlet, P., E. Coissac, J. Pansu and F. Pompanon. 2011. Conservation genetics of cattle, sheep, and goats. *Comptes Rendus Biologies*, 334: 247-54.