RESEARCH ARTICLE Indian Journal of Animal Research, Volume 55 Issue 2: 155-159 (February 2021)

Comparative Micrometrical Studies on the Lungs of Pashmina, Bakerwali and Non-descript Goats of the Union Territories of Jammu & Kashmir and Ladakh

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10.18805/ijar.B-3937

ABSTRACT

Background: The diversity of different climatic conditions and altitudes of UTs of Jammu and Kashmir and Ladakh (erstwhile J&K state) has given rise to differential adaptive mechanisms that enable goats to cope effectively with a variety of stressful environmental conditions. Jammu city (with an altitude of 327m to 412 m), like the rest of north-western India, features a humid subtropical climate. Ladakh is the dry temperate region and the highest plateau in the state of Jammu and Kashmir with much of it ranging from 3,000 m (9,800 ft) to 5,000-5,500 m (16,000-18,050 ft). There has been no systemic study on the probable comparative variation in micrometry of lungs in high altitude Pashmina goats of Ladakh and migratory Bakerwali and non-descript goats of Jammu and Kashmir, which live in regions with varied altitudes. Respiratory system plays a vital role in exchange of oxygen, olfaction, phonation and thermoregulation of the body. No literature on the comparative micrometry of the lungs in these three goat populations was found and such paucity of available literature prompted this present study.

Methods: The work was done in the lung samples of adult Pashmina, Bakerwali and non-descript goats (N=10 each) collected from slaughter houses of UT of Ladakh and in and around Jammu city of UT of J&K. The representative tissue samples from lungs of all the goats were preserved in 10% Neutral Buffered Formalin (NBF) solution, processed for paraffin block preparation, tissue sections of 5 µm thickness were obtained and stained with Hematoxylin and Eosin to record various micrometrical parameters.

Result: Our study revealed that significantly largest alveolar diameter and thinnest inter alveolar septal thickness was recorded in Pashmina goats followed by Bakerwali and non-descript goats. This might be due to the adaptive morphological phenomenon of the Pashmina goats which are natural habitants of high altitudes of the Himalayan regions for better utilization of the oxygen in hypoxic conditions.

Key words: Bakerwali, Lungs, Micrometry, Non-descript goats, Pashmina.

INTRODUCTION

The Union Territories of Jammu & Kashmir and Ladakh is blessed with unique land, environment and socio-cultural setup appropriate for the small ruminant production. The majority of people in Jammu and Kashmir are dependent on agriculture for their livelihood. Goats are kept by many rural people in small herds to serve as sources of financial stability and supply of meat. Goat rearing is the core activity of rural masses in the state of Jammu and Kashmir. It plays a vital role in socio- economic upliftment of weaker sections of the society *viz*. Gujjars and Bakerwals (Kuchai *et al*., 2011).

The diversity of different climatic conditions and altitudes within the Union Territories of Jammu & Kashmir and Ladakh has given rise to differential adaptive mechanisms that enable goats to cope effectively with a variety of stressful environmental conditions. Jammu city (with an altitude of 327m to 412 m), like the rest of north-western India, features a humid subtropical climate. Ladakh is the dry temperate region and the highest plateau in The Union Territories of Jammu & Kashmir and Ladakh with much of it ranging from 3,000 m (9,800 ft) to 5,000-5,500 m (16,000-18,050 ft). Both the regions have a considerable difference in altitude too (Jay, 2007).

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How to cite this article: Nabi, N., Sarma, K., Suri, S., Devi, J. and Chakraborty, D. (2021). Comparative Micrometrical Studies on the Lungs of Pashmina, Bakerwali and Non-descript Goats of the Union Territories of Jammu & Kashmir and Ladakh. Indian Journal of Animal Research. 55(2): 155-159. DOI: 10.18805/ijar.B-3937.

Submitted: 18-10-2019 **Accepted:** 30-05-2020 **Online:** 28-07-2020

Respiratory system plays a vital role in exchange of oxygen, olfaction, phonation and thermoregulation of the body. The respiratory portion, where gas exchange takes place, consists of respiratory bronchioles, alveolar duct and alveoli. The alveoli are the basic structural and functional unit for gas exchange in the lung parenchyma (Cormack, 1987).

There has been no systemic study on the probable comparative variation in micrometry of lungs in high altitude Pashmina goats, migratory Bakerwali goats and non-

descript goats, which are the habitats of low altitude regions. Such paucity of available literature prompted this present study.

MATERIALS AND METHODS

The work was done in the Division of Veterinary Anatomy, F.V.Sc. and A.H., R.S. Pura Jammu during 2018-2019. The lung samples from adult Pashmina goats were collected from slaughter houses of the U.T. of Ladakh. The samples of Bakerwali goats and non-descript goats were collected from slaughter houses in and around Jammu city. Minimum 10 samples from each breed of caprine were collected.

The representative tissue samples from lungs of all the goats were preserved in 10% Neutral Buffered Formalin (NBF) solution (Luna, 1968) and these tissues were processed for paraffin block preparation by alcohol-benzene schedule (Luna, 1968). Tissue sections of 5 μm thickness were obtained from these blocks on clean glass slides with the help of rotary microtome. The micrometrical observations were recorded on Hematoxylin and Eosin stained sections with the help of Ocular micrometer duly calibrated with stage micrometer. The micrometrical observations (Culling, 1974) included-

1. Alveolar diameter.
2. Number of alveoli per field.
3. Inter alveolar septal thickness.
4. Cross sectional diameter of the terminal bronchioles.

RESULTS AND DISCUSSION

Various micrometrical parameters *viz*., alveolar diameter, number of alveoli per field, inter-alveolar septal thickness and cross-sectional diameter of terminal bronchioles of all the lobes of the right and left lung of Pashmina, Bakerwali and non-descript goats recorded in this present study have been depicted in Table 1-4.

Alveolar diameter

The alveolar diameter of all the lobes of the right and left lung was found to be highest in Pashmina followed by Bakerwali and non-descript goats. Acute exposure to a simulated altitude of 4,270 m had been reported to increase surface tension in lung extracts of mice. Hence it may be that an animal continuously exposed to high altitude requires a persistent secretion of pulmonary surfactant.

The mean values for alveolar diameter of right apical lobe were recorded as 293.85±3.3μm, 253.50±4.8μm and 189.72±5.3μm for Pashmina, Bakerwali and non-descript goats, respectively. The mean values recorded for the diameter of alveoli of right cardiac lobe was 291.64±3.0μm, 251.70±2.8μm and 170.51±3.9μm in Pashmina, Bakerwali and non-descript goats, respectively. Again, the mean values recorded for the diameter of alveoli of right diaphragmatic lobe was 293.72±3.1μm, 237.70±3.8μm and 174.62±5.5μm in Pashmina, Bakerwali and non-descript goats, respectively. In the present study, the mean values recorded for the alveolar diameter of accessory lobe was 291.82±3.2μm, 257.99±3.7μm and 176.78±5.5μm in Pashmina, Bakerwali and non-descript goats, respectively. The mean values for the alveolar diameter of left apical lobe was 291.24±3.3μm, 246.34±6.1μm and 176.27±3.9μm in Pashmina, Bakerwali and non-descript goats, respectively. The mean values for the alveolar diameter of left cardiac lobe was 291.38±3.3μm, 231.70±3.2μm and 185.35±4.3μm in Pashmina, Bakerwali and non-descript goats, respectively. In the present study, the mean values recorded for the alveolar diameter of left diaphragmatic lobe was 291.55±3.2μm, 233.79±3.9μm and 179.84±4.2μm in Pashmina, Bakerwali and non-descript goats, respectively. It was observed in the present study that the alveolar diameter in regard to all the lobes of the lungs in Pashmina goat were significantly (P>0.05) more than the other goats (Table 1). Such larger alveoli might provide a comparatively larger surface area and capacity of the lung alveoli for effective oxygen intake during respiration process. In our study it had been observed that although the size of the lungs of Pashmina goat was lesser as compared to Bakerwali and non-descript goats, its alveoli were of large sized. This might be due to its morphological adaptive processes to cope up with hypoxic conditions of their high altitude habitats.

Micrometry of the alveolar diameter was also studied by Suman *et al.,* (2005) who found that the average alveolar diameter measured 45.06±6.18 μm in goats below one month and it increased to 54.61±4.45 μm in 2 to 3 months old goats and 55.78±10.71 μm in 7 to 9 months old goats., which were much lesser than our present findings and might be due to the much lesser age which they considered for their study. Also, Ochs *et al*. (2003) had reported that the alveoli comprised roughly of a diameter of 200μm in case of human lungs, which could be comparable to our findings in the goats. But in contrast, Baba and Choudhary (2008) found that the average alveolar diameter of the right and left lung of goat was 45.44±2.39 mm and 45.12±2.82 mm, respectively, which is much higher than our findings. This might be due to environmental factors or breed variations.

Number of alveoli per field

The number of alveoli is a key structural determinant of lung architecture. In the present study, the mean values of the number of alveoli per field of all the lobes of right and left lung were recorded. The mean values recorded for the number of alveoli per field of right apical lobe were 25.66±0.67, 22.76±1.04 and 34.16±1.17 in Pashmina, Bakerwali and non-descript goats, respectively. The mean values for the number of alveoli per field of right cardiac lobe were recorded as 27.06±0.69, 20.68±0.79 and 33.78±1.16 in Pashmina, Bakerwali and non-descript goats, respectively. The mean values recorded for the number of alveoli per field of right diaphragmatic lobe were 27.10±0.75, 21.36±1.0 and 35.86±1.0 in Pashmina, Bakerwali and non-descript goats, respectively. Again, the mean values recorded for the number of alveoli per field of accessory lobe were recorded as 25.32±0.69, 19.80±0.89 and

Table 1: Alveolar diameter (Mean±S.E.) in different lobes of the lungs of adult pashmina, bakerwali and non-descript goats.

	RAL	RCL	RDL	AC.L	LAL	LCL	LDL
Pashmina	293.85^{c}±3.3	291.64^{c}±3.0	293.72^{c}±3.1	291.82^{c}±3.2	291.24^{c}±3.0	291.38^{c}±3.3	291.55^{c}±3.2
Bakerwali	253.50^{b}±4.8	251.70^{b}±2.8	237.0^{b}±3.8	257.99^{b}±3.7	246.34^{b}±6.1	231.70^{b}±3.2	233.79^{b}±3.9
Non-descript	189.72^{a}±5.3	170.51^{b}±3.9	174.62^{a}±5.5	176.78^{a}±4.7	176.27^{a}±3.9	185.35^{a}±4.3	179.84^{a}±4.2

Means bearing similar superscript in a column do not differ significantly.

RAL: right apical lobe, RCL: right cardiac lobe, RDL: right diaphragmatic lobe, AC.L: accessory lobe, LAL: left apical lobe, LCL: left cardiac lobe and LDL: left diaphragmaticlobe.

Table 2: Number of alveoli per field (Mean ± S.E.) in different lobes of the lungs of adult Pashmina, Bakerwali and non-descript goats.

	RAL	RCL	RDL	AC.L	LAL	LCL	LDL
Pashmina	25.66^{b}±0.67	27.06^{b}±0.69	27.10^{b}±0.75	25.32^{b}±0.69	25.38^{b}±0.66	25.48^{b}±0.63	25.58^{b}±0.72
Bakerwali	22.76^{a}±1.04	20.68^{b}±0.79	21.36^{a} ±1.0	19.80^{a} 0.89	20.36^{a}±0.89	18.22^{a}±0.71	18.94^{b}±0.83
Non-descript	34.16^{c}±1.17	33.78^{c}±1.16	35.86^{c} ±1.0	37.56^{c}±1.16	36.10^{c}±1.27	36.78^{c}±1.14	36.10^{c}±1.09

Means bearing similar superscript in a column do not differ significantly.

RAL: right apical lobe, RCL: right cardiac lobe, RDL: right diaphragmatic lobe, AC.L: accessory lobe, LAL: left apical lobe, LCL: left cardiac lobe and LDL: left diaphragmaticlobe.

37.56±1.16 in Pashmina, Bakerwali and non-descript goats, respectively.

Similarly, the mean values recorded pertaining to the number of alveoli per field of left apical lobe were recorded as 25.38±0.66, 20.36±0.89 and 36.10±1.27 in Pashmina, Bakerwali and non-descript goats, respectively. The mean values recorded for the number of alveoli per field of left cardiac lobe were 25.48±0.63, 18.22±0.71 and 36.78±1.14 in Pashmina, Bakerwali and non-descript goats, respectively. In the present study, the mean values recorded for the number of alveoli per field of left diaphragmatic lobe were recorded to be 25.58±0.72, 18.94±0.83 and 36.10±1.09 in Pashmina, Bakerwali and non-descript goats, respectively. It was found that the number of alveoli was significantly (P>0.05) less in all the lobes of the lungs (barring the right cardiac and left diaphragmatic lobes in Pashmina goats and the same was significantly (P>0.05) more in non-descript goat as compared to other two breeds (Table 2). Such decreased number of lung alveoli in Pashmina goat may be attributed to their large sizes and vice versa in case of non-descript goats. Ochs *et al*. (2003) have reported that in case of human lungs, alveolar number was closely related to total lung volume, with larger lungs having considerably more alveoli. Again, Hyde *et al*. (2004) found that the number of alveoli in the rat lungs ranged from 17.3 -10^{6} to 24.6 -10^{6} and the right lobe contained 47% more alveoli than the left. The variation with respect to the total number of alveoli among lobes was 5 times larger than that of the total lung.

Inter-alveolar septal thickness

In the present study, the mean values recorded for the inter-alveolar septal thickness of right apical lobe were highest in Bakerwali (8.30±0.52µm), followed by non-descript (7.85±0.39µm) and Pashmina (7.05±0.35µm) goat. The mean values for the inter-alveolar septal thickness of right cardiac lobe were recorded as 7.20±0.36 µm, 8.15±0.54 µm and 8.30±0.44 µm in Pashmina, Bakerwali and non-descript goats, respectively. The mean values for the inter-alveolar septal thickness in regard to the right diaphragmatic lobe were found to be highest in Bakerwali (10.70±0.76µm), followed by Pashmina (9.18±2.02µm) and non-descript (8.25±0.43µm) goats. In the present study, the mean values recorded for the inter-alveolar septal thickness of accessory lobe were recorded as 7.35±0.33µm, 8.55±0.48µm and 9.04±1.07µm in Pashmina, Bakerwali and non-descript goats, respectively. The mean values for the inter-alveolar septal thickness of left apical lobe were found to be highest in Bakerwali (9.25±0.54µm), followed by non-descript (8.50±0.43µm) and Pashmina (6.95±0.31µm) goat, respectively. The mean values recorded pertaining to the inter-alveolar septal thickness of left cardiac lobe were recorded as 6.85±0.31µm, 9.45±0.57µm and 8.25±0.41µm in Pashmina, Bakerwali and non-descript goats, respectively. In the present study, it was found that the mean values for the inter-alveolar septal thickness of left diaphragmatic lobe were in the tune of 7.20±0.36µm, 8.85±0.52µm and 8.65±0.45µm in Pashmina, Bakerwali and non-descript goats, respectively (Table 3). Perusal to these measurements showed that the inter alveolar septal thickness was the least in Pashmina goat. This might be again due to morphological adaptive processes undergone by this breed for generations to cope-up with hypoxic conditions of high altitude environments. The thin inter alveolar septum of the lungs facilitates for more efficient gaseous exchange at the alveolar level. Banks (1986) also stated that the oxygenation of blood within the pulmonary capillaries was dependent upon varied factors like the amount of oxygen in the inspired air, the integrity of the blood air barrier, the amount of blood flowing within the pulmonary circulation, the quantity of O_2 dissolved in the blood and the amount of haemoglobin as well as its affinity for O_2. Such factors might be correlated with findings of this present study, as the haemoglobin concentration was recorded to be significantly (P>0.05) high in Pashmina goat

Table 3: Inter-alveolar septal thickness (Mean ± S.E.) in different lobes of the lungs of adult Pashmina, Bakerwali and non-descript goats.

	RAL	RCL	RDL	AC.L	LAL	LCL	LDL
Pashmina	7.05±0.35	7.20±0.36	7.18±2.02	7.35±0.33	6.95^{a}±0.31	6.85^{a}±0.31	7.20^{a}±0.36
Bakerwali	8.30±0.52	8.15±0.54	10.70±0.76	8.55±0.48	9.25^{b}±0.54	9.45^{b}±0.57	8.85^{b}±0.52
Non-descript	7.85±0.39	8.30±0.44	8.25±0.43	9.04±1.07	8.50^{b}±0.43	8.25^{b}±0.41	8.65^{b}±0.45

Means bearing similar superscript in a column do not differ significantly.

RAL: right apical lobe, RCL: right cardiac lobe, RDL: right diaphragmatic lobe, AC.L: accessory lobe, LAL: left apical lobe, LCL: left cardiac lobe and LDL: left diaphragmaticlobe.

Table 4: Cross-sectional diameter of terminal bronchioles (Mean±S.E) in different lobes of the lungs of adult Pashmina, Bakerwali and non-descript goats.

	RAL	RCL	RDL	AC.L	LAL	LCL	LDL
Pashmina	417.92^{c}±6.5	425.28^{c}±5.8	421.44^{b}±6.2	420.16^{b}±5.7	431.04^{b}±6.0	411.52^{b}±5.7	422.40^{b}±6.6
Bakerwali	385.60^{b}±6.6	385.60^{b}±6.3	384.84^{a}±9.4	371.92^{a}±11.3	387.20^{a}±6.6	381.00^{a}±9.2	376.84^{a}±9.4
Non-descript	368.32^{a}±4.8	368.00^{a}±5.0	372.48^{a}±4.7	367.68^{a}±4.9	375.36^{a}±4.6	366.40^{a}±4.8	371.52^{a}±4.8

Means bearing similar superscript in a column do not differ significantly.

RAL: right apical lobe, RCL: right cardiac lobe, RDL: right diaphragmatic lobe, AC.L: accessory lobe, LAL: left apical lobe, LCL: left cardiac lobe and LDL: left diaphragmatic lobe.

as compared to both Bakerwali and non-descript goats. In contrast to our findings, Baba and Choudhary (2008) reported much higher and values for inter-alveolar septal thickness being 6.56 ± 0.54 mm (right lung) and 6.72 ± 0.48 mm (left lung) with an overall value of 6.64 ± 0.35 mm in goats.

Cross sectional diameter of terminal bronchioles

In this study, the values in regard to cross sectional diameter of the terminal bronchioles varied among the different lobes of the lungs and the different goats. The mean values for the diameter of terminal bronchioles of right apical lobe were recorded as 417.92±6.5µm, 385.60±6.6µm and 368.32±4.8µm for Pashmina, Bakerwali and non-descript goats, respectively. The mean values for the diameter of terminal bronchioles of right cardiac lobe were found to be 425.28±5.8µm, 385.60±6.3µm and 368.00±5.0µm for Pashmina, Bakerwali and non-descript goats, respectively. Similarly, the mean values for the diameter of terminal bronchioles of right diaphragmatic lobe were recorded as 421.44±6.2µm, 384.84±9.4µm and 372.48±4.7µm for Pashmina, Bakerwali and non-descript goats, respectively. Again, the mean values for the diameter of terminal bronchioles of accessory lobe were found to be 420.16±6.2µm, 371.92±11.3µm and 367.68±4.9µm for Pashmina, Bakerwali and non-descript goats, respectively.

The mean values with regard to diameter of terminal bronchioles of left apical lobe were found to be 431.16±6.0µm, 387.20±6.6µm and 375.36±4.6µm for Pashmina, Bakerwali and non-descript goats, respectively. Again, the mean values for the diameter of terminal bronchioles of left cardiac lobe were found to be 411.52±5.7µm, 381.00±9.2µm and 366.40±4.8µm for Pashmina, Bakerwali and non-descript goats, respectively. Similarly, the mean values for the diameter of terminal bronchioles of left diaphragmatic lobe were recorded as 422.40±6.6µm, 376.84±9.4µm and 371.52±4.8µm for Pashmina, Bakerwali and non-descript goats, respectively (Table 4). It was found that the cross sectional diameter of the terminal bronchioles had the highest value in Pashmina goat followed by Bakerwali and non-descript goats. Bigger terminal bronchiolar diameter attributes to more air (oxygen) carrying capacity. So, such higher diameter of the terminal bronchioles found in Pashmina goats might be due to the morphological adaptive processes undergone by this breed for effective and optimum respiratory functions since generations to cope-up with hypoxic conditions of high altitude environments. However, paucity of available literature in this aspect restricted us from proper comparison and discussion.

CONCLUSION

The present study was conducted on the comparative micrometry of the lungs of three breeds of goats namely Pashmina, Bakerwali and Non-descript goats of The Union Territories of Jammu & Kashmir and Ladakh. From the study it was found that significantly largest alveolar diameter and thinnest inter alveolar septal thickness was recorded in Pashmina goats followed by Bakerwali and non-descript goats. This might be due to the adaptive morphological phenomenon of the Pashmina goats which are natural habitants of high altitudes of the Himalayan regions for better utilization of the oxygen in hypoxic conditions.

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