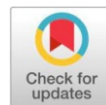


Original Research Article

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Age related gross anatomical studies on the tongue of non-descript goats of Jammu region with special emphasis on lingual papillae



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ABSTRACT

The tongue of the non-descript goats was spatula-shaped and divided into apex, body, and root. Dorsal surface of the tongue of adult goats showed patches of deep to light black pigmentation. Apex was notched in the centre. Longitudinal groove on the dorsal surface was more apparent in the young and senile groups. Caudo-dorsal portion of the body presented torus linguae, in front of which was transverse fossa linguae. Dorsal surface of the tongue was covered by filiform, fungiform, conical, lenticular, and circumvallate papillae. Filiform papillae were pointed, thread-like, and directed caudally and were the most abundant. Fungiform papillae were mushroom-shaped. Filiform and fungiform papillae were also present on the ventral surface of the tongue tip in 'V' configuration in all three age groups. Lenticular papillae were less developed in young goats. In adults, these were arranged in two parallel rows whereas in the senile group, the arrangement was irregular. They were found on the torus linguae. The largest lenticular papillae were placed along the midline of the prominence. Conical papillae were found lateral to lenticular papillae and orientated caudally. They were greater in the center and smaller in the caudal and lateral aspects. In comparison to young goats, the adult and senile groups had a denser distribution of lenticular and conical papillae. Circumvallate papillae were spherical and encircled by a deep moat which was surrounded by a slightly higher mucosal ring. They were arranged in two rows. Weight and volume of the tongue was significantly ($P < 0.05$) greater in senile group followed by adults and least in the young age group. In all three age groups, the length of the body was the longest part whereas the root was the shortest. Width and thickness of the tongue was maximum at the level of torus linguae in all the age group. Width at apex and body showed a significant difference ($P < 0.05$). Thickness at the apex and torus linguae showed significant difference ($P < 0.05$). Distance between the lingual fossa and tip of the tongue varied significantly ($P < 0.05$) with advancing age. Similarly, distance between lingual fossa and root of the tongue showed a significant difference ($P < 0.05$) with advancing age. Total number of vallate papillae were the highest in adult group but the difference was non-significant ($P > 0.05$). The length of median longitudinal groove showed a significant difference ($P < 0.05$) among various age groups. It was longest in the senile followed by young and shortest in the adult group.

Keywords: Goat, Gross anatomy, Lingual papillae, Tongue, Torus linguae

Introduction

The union territory of Jammu and Kashmir is generally equipped with an environment and socio-cultural system that promotes small ruminant production. Goats are important livestock species in developing countries and are sometimes referred to as "Poor Man's Cow" in India and 'wet nurse' of infants in Europe (Iqbal *et al* 2008). Goats are important because of their ability to convert forages, crops and household residues into meat, fiber, skin and milk. A number of large and small farmers rear goat for their livelihood (Singh *et al* 2006). On the basis of foraging behavior, ruminants can be classed as grazers, browsers, or intermediate grazers (Gordon 2003). Goats generally prefer to browse (Mosavat and Chamani 2013). The feeding habits of ruminants, according to Hofmann and Stewart (1972), can induce physical changes in their digestive systems.

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The oral cavity is mainly concerned with food prehension, selection and mastication. The tongue is a mobile organ occupying the greater part of oral cavity and consisting of apical, corpus and radix parts with a characteristic mucous membrane in the digestive system (Dursun 2008). In herbivores, the tongue is used as a prehensile organ that is involved in grasping diet items (Meier *et al* 2016). It is capable of both vigorous and precise movements as in prehension, lapping, grooming, and manipulation of food within the mouth on the one hand and speech articulation on the other, while in some animals the tongue participates in the heat loss by panting as in the dog (Dyce *et al* 2010). Any alteration and impairment of the tongue in farm animals, both in structure and function has a profound effect on the performance of the animals (Dyce *et al* 2010).

There is scant information on the specific structure of the tongue in small ruminants, particularly goats which prompted to undertake this study to gain a better understanding of the anatomical features of the tongue of non-descript goats of the Jammu region.

Materials and Methods

The present study was conducted in the Division of Veterinary Anatomy, F.V.Sc. & A.H., SKUAST-J, R.S. Pura.

Heads of freshly slaughtered goats were collected from local slaughter houses in and around Jammu city and immediately brought to the laboratory. Goats were divided into three age groups (young: below 1 year; adult: 2-3 years and senile: 4 years and above) as per the dentition. Six samples from each group of non-descript goats were collected. The tongue was removed to study gross morphological features. For morphometric analysis, different measurements (in cm) were done on the freshly collected tongue using a scale, Vernier calliper and non-stretchable thread. The following biometrical parameters were recorded.

- Weight (g) of head
- Weight (g) and volume (ml) of the tongue using a sensitive electronic balance
- Relative weight (%) of tongue
- Total length (cm) of the tongue
- Length (cm) of apex, body, torus linguae and root
- Width (cm) of tongue at apex, body, torus linguae and root
- Thickness (cm) of tongue at apex, body, torus linguae and root
- Distance (cm) of lingual fossa from apex and root
- Number of vallate papillae on right side and left side
- Total number of vallate papillae
- Width of lingual groove
- Length (cm) of median longitudinal groove
- Number of transverse ridges

The data of the tongue obtained was expressed as mean \pm SEM (Standard Error of Mean) and subjected to Statistical Analysis (Snedecor and Cochran 1994). Values of $P \leq 0.05$ were considered significant.

Results and Discussion

Gross morphology

The tongue of all the non-descript goats under study rested on the floor of the oral cavity, supported mostly by intrinsic and extrinsic lingual muscles. The colour of the tongue was mainly whitish, however, patches of deep or light black pigmentation were seen on the dorsal surface in adult goats (Fig. 1), as also previously observed by Kadhimi (2016). Ghafil and Khaleel (2023) noticed pinkish tongues with speckled black pigments in adult Gazelles. The tongue of the non-descript goats was divided into three parts: apex, body, and root (Fig. 1), as also reported by Kadhimi (2016) in rams and goats and Delibas *et al* (2023) in Norduz sheep. However, Jackowiak *et al* (2017) found that the tongue in fallow deer was divided into four parts: the apex, the body, the torus linguae, and the root. The tongue in non-descript goats of all age groups was spatula-shaped as earlier described by Kadhimi (2016) in goats. The apex was free and dorso-ventrally flattened, with dorsal and ventral surfaces. It was notched in the centre (Fig. 1). The dorsal surface of the apex had a shallow longitudinal groove, which was more apparent in the young and senile groups (Fig. 1). It extended from the centre of the notch to the front of the fossa linguae. Murad *et al* (2010) reported a shallow median longitudinal groove in mature rams. The body of the tongue was attached to the floor of the mouth and was wider than the apex. Its lateral surfaces were almost flat for the majority of the part. The cauda-dorsal portion of the body developed an elliptical protrusion, the torus linguae, in front of which was transverse fossa linguae (Fig. 1) as reported earlier by Delibas *et al* (2023) in Norduz sheep and Madkour *et al* (2023) in Rahmani sheep. The lingual prominence is a characteristic morphological character in mammals, especially those that eat fibrous vegetation such as grass, as noted in the

present study and in rabbits (Nonaka *et al* 2008), Egyptian water buffalo (Emura and El Bakary 2014), cattle (Ding *et al* 2016), fallow deer (Jackowiak *et al* 2017), and most artiodactyls (Goździewska-Harłajczuk *et al* 2015). The lingual prominence is important in the process of food mastication because it presses the food against the hard palate (El-Bakary and Abumandour 2017). As per Hofmann (1989), all ruminant tongues are distinguished by the torus linguae. Its pushing interaction with the hard palate could be a functional correction for an incomplete dentition. Tongue of carnivores, omnivorous monkeys and pigs was devoid of lingual prominence (Kumar and Bate 2004; Emura *et al* 2006). The root was narrow and sloped caudo-ventrally with a smooth dorsal surface.

The dorsal surface of the tongue, from the apex to the root, was covered by different types of papillae. However, the root part looked smooth and had fewer number of papillae. The free rostral region of the ventral side of the tongue was smooth, and the mucous membrane was pigmented in the adult goats (Fig. 2).

The tongue was studded with five different types of lingual papillae: filiform, fungiform, conical, lenticular, and circumvallate papillae, which varied in distribution across the tongue. Murad *et al* (2010) in adult rams, Goodarzi and Shah Hoseini (2014) in goats, Ding *et al* (2016) in cattle, El-Bakary and Abumandour (2017) in buffalo, and Thanvi *et al* (2020) in camels have all reported these five forms of papillae. However, Adnyane *et al* (2011) found four forms of lingual papillae in barking deer: filiform, conical, fungiform, and circumvallate. Bats have three varieties of papillae (filiform, fungiform, and circumvallate), but haematophagous bats only have two types (filiform and fungiform) (Masuko *et al* 2007).

Filiform papillae were the most abundant. They were pointed, thread-like, and directed caudally (Fig. 3), as described by Parvez and Rahaman (2005) in cows, Khan *et al* (2006) in goats, and Murad *et al* (2010) in adult rams. Musk deer had soft filiform papillae, giving the tongue a smoother appearance (Khan *et al* 2006). They were densely packed on the apex. They were also found on the body of the tongue, albeit in smaller numbers than at the apex. The filiform papillae provided the mucosa a velvety appearance (Fig. 3).

The fungiform papillae were less numerous but larger than the filiform papillae. They were mushroom-shaped and increased in size antero-posteriorly (Fig. 3), as previously also observed by Murad *et al* (2010) in adult rams. These papillae were somewhat elevated from the dorsal surface. Similar findings were also reported by Mahabady *et al* (2010) in Iranian buffaloes. Again, Parvez and Rahaman (2005) described club-shaped fungiform papillae in cows. They were irregularly scattered over the lateral margin of the tongue, extending beyond the lingual fossa. In contrast, Raghavan (1964) in ox found that fungiform papillae were confined from the tip to the lingual fossa. Fungiform papillae were spherical in cattle but elliptical in European bison (Plewa *et al* 2022).

Filiform and fungiform papillae were also found on the lateral margin of the ventral surface of the tongue tip in all three age groups. The papillae were organized in a 'V' configuration (Fig. 2). Murad *et al* (2010) also found filiform and fungiform papillae on the ventral side of the tip of the tongue in adult ram. According to El-Bakary and Abumandour (2017), the five types of lingual papillae in Egyptian water buffaloes play a significant role in the detection and selection of various nutrients present in Egyptian fields.

Lenticular papillae were less developed in young goats.

In adults, these were placed in two parallel rows with flat or convex surfaces (Fig. 4), whereas in the senile group, the arrangement was irregular. They were found on the torus linguae, notably in its rostral region. The size of the lenticular papillae varied, with the largest ones being placed along the midline of the prominence and the smallest at the edges (Fig. 4). Adult ram lenticular papillae were lens-shaped (Murad *et al* 2010). Conical papillae were found on the torus linguae, lateral to lenticular papillae and orientated caudally. They were greater in the center and smaller towards the caudal and lateral aspects (Fig. 4), as previously reported by Thanvi *et al* (2020) in camels. The tips of these papillae were pointed. In comparison to young goats, the adult and senile groups had a denser distribution of lenticular and conical papillae. The existence of a lingual prominence with filiform, conical, and lenticular papillae enables herbivores to grind food by crushing it between the tongue and the upper palate (Shao *et al* 2010).

The circumvallate papillae were spherical and encircled by a deep moat which was surrounded by a slightly higher mucosal ring. They were arranged in two rows (Fig. 4). However, in camels, circumvallate papillae were arranged in a single row (Thanvi *et al* 2020). Murad *et al* (2010) observed round to oval-shaped circumvallate papillae in adult rams. The dorsal surface of the root of the tongue showed few papillae only in adult goats, but the tongues of young and senile goats were devoid of any papilla. Khan *et al* (2006) in goats and Jackowiak *et al* (2017) in fallow deer found that the root of the tongue was free of lingual papillae. The distribution of the different types of papillae on the surfaces of the tongue plays a vital role in the taxonomic ranking (Pastor *et al* 2011).

Biometry

The biometrical parameters of the tongue of young, adult and senile non-descript goats have been depicted in Table 1. The weight of the tongue was significantly ($P<0.05$) greater in senile (89.02 ± 6.32 gm) followed by adult (74.95 ± 7.49 gm) and least in the young (44.85 ± 5.98 gm) age group. A similar pattern was observed for volume. Our data corroborate with the findings of Mahmud *et al* (2021) in adult Uda ram where the weight of tongue was recorded as 72.83 ± 8.15 gm. The tongue was significantly ($P<0.05$) longer in adult goats (16.18 ± 1.02 cm). Length of tongue was 19.77 ± 0.334 cm in adult ram (Murad *et al* 2010), 15.54 ± 1.56 cm in Billy goats, and 17.24 ± 1.43 cm in Awasi ram (Kadhim 2016), 47.00 ± 1.2 cm in adult buffalo (El-Bakary and Adumandour 2017) and 16.40 ± 1.02 cm in Uda ram (Mahmud *et al* 2021). The average length of the tongue of Norduz sheep was 15 cm (Delibas *et al* 2023). In all three age groups, length of the body was the longest part whereas root was the shortest.

Table 1. Age related biometrical parameters of tongue of non-descript goats of Jammu region

Parameters	Age group		
	Young	Adult	Senile
Total length (cm)	$12.72^a \pm 0.45$ (11.40-14.00)	$16.18^b \pm 1.02$ (13.00-19.00)	$15.96^b \pm 0.47$ (14.70-18.00)
Length of the apex (cm)	$3.45^a \pm 0.18$ (3.10-4.30)	$4.66^b \pm 0.23$ (4.00-5.70)	$5.03^b \pm 0.28$ (4.00-6.00)
Length of the body (cm)	$6.31^a \pm 1.08$ (1.20-8.90)	$9.38^a \pm 1.12$ (5.20-12.30)	$6.89^a \pm 0.32$ (5.70-7.80)
Length of torus linguae (cm)	$5.63^a \pm 0.19$ (4.80-6.00)	$5.98^a \pm 0.67$ (3.00-7.20)	$6.08^a \pm 0.42$ (4.50-7.40)
Length of the root (cm)	$2.03^a \pm 0.37$ (0.90-3.40)	$2.13^a \pm 0.38$ (1.00-3.40)	$2.91^a \pm 0.15$ (2.40-3.50)

Similar observation was made by Murad *et al* (2010) in adult ram. However, in adult Uda ram, apex was the longest and root was the shortest (Mahmud *et al* 2021). However, only the length of apex showed significant difference ($P<0.05$). In all three age groups, width and thickness of the tongue was maximum at the level of torus linguae which was similar to the findings of Mahmud *et al* (2021) in adult Uda ram. Width at apex and body showed a significant difference ($P<0.05$). Thickness at apex and torus linguae showed significant difference ($P<0.05$). Distance between lingual fossa and tip of the tongue varied significantly ($P<0.05$) with advancing age. It was maximum in adults (8.26 ± 0.64 cm) followed by senile (7.80 ± 0.39 cm) and least in young (6.08 ± 0.30 cm) age group. Similarly, the distance between lingual fossa and the root of the tongue showed a significant difference ($P<0.05$) with advancing age. Madkour *et al* (2023) reported that torus linguae was 69.95 ± 4 mm away from the tip of the tongue of Rahmani sheep. Total number of vallate papillae was the highest in the adult group but the difference was non-significant ($P>0.05$). It was 33.50 ± 4.35 in young, 35.16 ± 3.07 in adult and 33.00 ± 0.93 in senile group. In cow, the number of vallate papillae ranged from 25-38 (Parvez and Rahaman 2005). Length of median longitudinal groove showed a significant difference ($P<0.05$) among various age groups. It was longest in senile (4.76 ± 0.21 cm) followed by young (3.33 ± 0.08 cm) and shortest in adult group (1.88 ± 0.74 cm). In adult ram, the length of the median longitudinal groove was 3.75 ± 0.26 cm (Murad *et al* 2010). The groove measured 23 to 26 mm in both sexes of fallow deer (Jackowiak *et al* 2017).

Conclusion

The present study extended the knowledge regarding the age-related morphology of tongue of non-descript goats of the Jammu region which further adds to the literature. Tongue was spatula shaped. Dorsal surface of tongue of adult goats showed patches of deep to light black pigmentation. Filiform papillae were pointed, thread-like, and fungiform papillae were mushroom-shaped. Filiform and fungiform papillae were also present on the ventral surface of the tongue tip in 'V' configuration in all three age groups. Lenticular papillae were less developed in young goats. In adults, these were arranged in two parallel rows whereas in the senile group, the arrangement was irregular. Weight and volume of the tongue were significantly greater in senile group followed by adult and least in the young age group. Total number of vallate papillae was the highest in the adult group but the difference was non-significant.

Conflicts of interest: The authors declare that there is no conflict of interest.

Width at the tip (cm)	2.26 ^a ±0.06 (2.00-2.40)	3.08 ^b ±0.31 (2.30-4.30)	2.60 ^{ab} ±0.06 (2.40-2.89)
Width at the body (cm)	2.50 ^a ±0.10 (2.20-2.80)	3.27 ^b ±0.22 (2.57-4.10)	3.05 ^b ±0.14 (2.56-3.60)
Width at the torus linguae (cm)	3.30 ^a ±0.11 (3.00-3.60)	3.88 ^a ±0.24 (2.90-4.70)	3.64 ^a ±0.25 (2.81-4.60)
Width at the root (cm)	3.28 ^a ±0.22 (2.70-4.20)	3.73 ^a ±0.13 (3.40-4.30)	3.45 ^a ±0.09 (3.12-3.80)
Thickness at the tip (cm)	0.85 ^b ±0.11 (0.45-1.34)	0.63 ^a ±0.03 (0.56-0.78)	0.57 ^a ±0.00 (0.56--0.60)
Thickness at the body (cm)	1.43 ^a ±0.07 (1.23-1.67)	1.37 ^a ±0.23 (0.89-2.52)	1.72 ^a ±0.05 (1.50-1.89)
Thickness at the torus linguae (cm)	2.15 ^a ±0.19 (1.56-2.89)	1.96 ^a ±0.09 (1.78-2.34)	2.58 ^b ±0.08 (2.25-2.89)
Thickness at the root (cm)	1.33 ^a ±0.14 (0.89-1.89)	1.58 ^a ±0.25 (0.89-2.34)	1.60 ^a ±0.27 (0.89-2.88)
Distance of fossa linguae from the tip (cm)	6.08 ^a ±0.30 (5.00-6.90)	8.26 ^b ±0.64 (6.40-10.00)	7.80 ^b ±0.39 (6.60-9.30)
Distance of fossa linguae from the root (cm)	6.66 ^a ±0.29 (6.00-7.90)	7.91 ^b ±0.42 (6.60-9.00)	7.93 ^b ±0.19 (7.40-8.70)
Weight of the tongue (gm)	44.85 ^a ±5.98 (30.60-68.40)	74.95 ^b ±7.49 (45.00-94.70)	89.02 ^b ±6.32 (63.60-107.00)
Relative weight (%)	3.36 ^a ±0.27 (2.70-4.65)	3.78 ^a ±0.21 (2.96-4.56)	3.22 ^a ±0.24 (2.59-4.01)
Volume (ml)	43.33 ^a ±5.42 (30.00-65.00)	73.33 ^b ±7.49 (45.00-95.00)	83.00 ^b ±5.06 (63.00-100.00)
Shape index (%)	19.72 ^a ±0.92 (16.42-21.70)	21.35 ^a ±1.24 (16.85-26.15)	19.11 ^a ±0.50 (16.84-20.20)
No. of vallate papillae on right side	16.50 ^a ±2.27 (12.00-25.00)	17.33 ^a ±2.15 (12.00-26.00)	17.00 ^a ±0.73 (15.00-20.00)
No. of vallate papillae on left side	17.00 ^a ±2.14 (11.00-24.00)	17.83 ^a ±1.27 (13.00-22.00)	16.00 ^a ±0.57 (14.00-18.00)
Total No. of vallate papillae	33.50 ^a ±4.35 (23.00-48.00)	35.16 ^a ±3.07 (25.00-46.00)	33.00 ^a ±0.93 (30.00-36.00)
Total weight of head (kg)	1.32 ^a ±0.11 (0.90-1.63)	1.96 ^b ±0.16 (1.52-2.62)	2.80 ^c ±0.22 (2.06-3.60)
Width of lingual groove (cm)	1.95 ^a ±0.22 (1.40-3.00)	2.56 ^a ±0.32 (1.80-3.90)	2.36 ^a ±0.17 (1.70-3.00)
Median longitudinal groove length (cm)	3.33 ^b ±0.08 (3.00-3.60)	1.88 ^a ±0.74 (0.00-4.10)	4.76 ^c ±0.21 (4.20-5.50)
No. of transverse ridges	13.83 ^a ±0.30 (13.00-15.00)	13.16 ^a ±0.47 (12.00-15.00)	14.66 ^a ±0.49 (13.00-16.00)

Mean value with same superscript (a, b, c) within row do not differ significantly ($p>0.05$)



Fig. 1 Gross morphology of dorsal surface of tongue of young (a), adult (b) and senile (c) non-descript goats of Jammu region showing apex (A), body (B), torus linguae (T), root (R) and fossa linguae (*). Dorsal surface is pigmented in adult age group. Apex is notched (white arrow head). Median longitudinal groove (arrow) is prominent in young and senile age group.

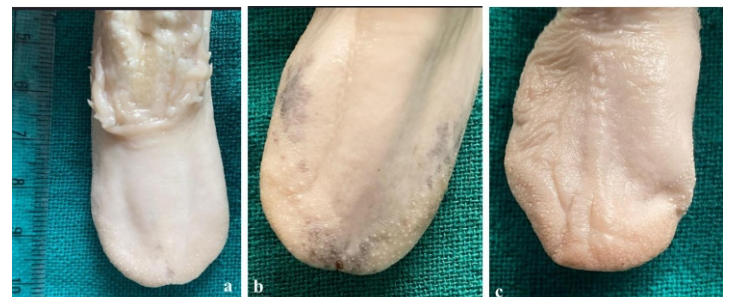


Fig. 2 Gross morphology of ventral surface of tongue of young (a), adult (b) and senile (c) non-descript goats of Jammu region showing arrangement of filiform and fungiform papillae along the lateral margin of tip of the tongue in 'V' arrangement. Tongue of adult group showed patches of pigmentation

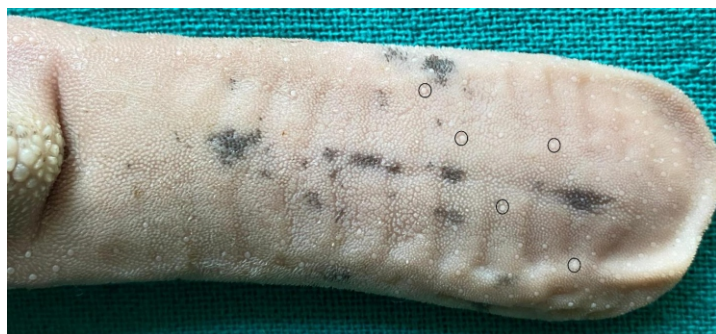


Fig. 3 Dorsal surface of tongue of adult goat showing distribution of filiform and fungiform papillae (encircled). Filiform papillae are numerous giving velvety appearance to the tongue.



Fig. 4 Dorsal surface of tongue of adult goat showing distribution of lenticular (L) and conical (C) papillae over the torus linguae. Conical papillae are directed caudally. Circumvallate papillae (V) are arranged in two rows on either side. Few fungiform papillae (F) are also visible

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