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Comparative Morphological and Histological Analysis of Buffalo and Goat Tongues in Comparison to the Human Tongue

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ABSTRACT

Background: The upper surface of the tongue is distinguished by a quartet of papillary types: filiform, fungiform, circumvallate, and foliate. The filiform, lenticular, and conical varieties are mainly associated with mechanical operations. At the same time, the fungiform, foliate, and circumvallate categories, which house gustatory receptors, are integral to the sensory function of taste. This study seeks to evaluate the structural and cellular composition of the tongues of buffaloes and goats compared to that of humans.

Methods: Tissue samples collected from specified tongue regions were preserved in Bouin's solution and then processed through paraffin embedding. Subsequent sectioning provided thin slices for microscopic analysis, stained using hematoxylin and eosin to accentuate histological details.

Results: Findings indicate a pronounced elongation of the anterior segment of the buffalo's tongue. Both buffalo and goat tongues feature an intermolar prominence. In humans, the tongue's upper side is sectioned into oral and pharyngeal territories demarcated by the V-like sulcus terminalis, with the oral region being substantially longer. Observations revealed the presence of taste buds within the circumvallate, foliate, and most of the fungiform papillae in these species.

Conclusion: The study underscores distinct morphological variances in the tongues of humans, buffaloes, and goats, focusing on the distribution of papillae and their taste-related adaptations. These findings expand the scope of our anatomical knowledge regarding the tongue across different species.

Key-words: Human Tongue, Papillae, Intermolar eminence, Sulcus terminalis, Bouin's fluid

INTRODUCTION

The mammalian tongue, an organ of remarkable versatility, showcases a range of common and unique features that mirror the varied diets of different species [1].

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These features, including changes in shape and size, have evolved to adapt to the specific ecological habitats of the animals. Such diversity in tongue morphology highlights the extraordinary ways nature customizes organisms for their environmental roles.

Central to the mammalian tongue's anatomy are the papillae on its dorsal surface, divided into four main categories: filiform, fungiform, circumvallate, and foliate. Each type serves distinct functions. Filiform, lenticular, and conical papillae protect the tongue and assist in food manipulation. On the other hand, fungiform, foliate, and circumvallate papillae, which contain taste buds, are

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crucial for taste, allowing organisms to identify various flavors in their diet.

Interestingly, while foliate papillae in humans are somewhat basic, they play a significant role in the taste perception of many other animals [2,3]. These papillae act as major sites for taste receptors, providing animals with a nuanced sense of taste that matches their dietary needs. Taste buds, the flavour detectors, are specialized groups of epithelial cells located within the stratified squamous epithelium of the fungiform, circumvallate, and foliate papillae. This arrangement enables direct interaction with food, aiding in the complex process of taste perception. Moreover, the tongue contains glands categorized into three main groups based on structure and location [4]. These glands perform various functions, from producing saliva, which helps digestion, to secreting mucus, ensuring the tongue remains moist for efficient food processing.

As a critical sensory organ, the tongue plays key roles in feeding and speech and demonstrates significant adaptations. These include diverse papillae types and specialized taste receptors, finely adjusted to each species' dietary and environmental needs. This blend of form and function illustrates the profound diversity and complexity of natural evolutionary processes [5].

This investigation offers insights into mammalian tongues' macroscopic and microscopic characteristics, focusing on papillae distribution and their taste-related roles. The findings deepen our comprehension of the sophisticated attributes that dictate this vital organ's functionality across different species.

MATERIALS AND METHODS

Human Tongue

Macroscopic Observations- Examination of the human tongue reveals a division into anterior (oral) and posterior (pharyngeal) parts by the V-shaped sulcus terminalis. The oral section is notably longer, with a rich presence of lingual papillae types such as filiform, fungiform, circumvallate, and foliate distributed on its surface. The anterior portion is densely populated with filiform papillae, while fungiform papillae are more abundant near the tip and edges. Circumvallate papillae, numbering 8-10, are arranged in a V-pattern, and foliate papillae are found near the palatoglossal fold. The pharyngeal section shows smooth lingual tonsils, with a smooth ventral surface featuring a frenulum linguae.

Microscopic Observations- The oral mucosa displays stratified squamous keratinized epithelium, with a lamina propria filled with dense connective tissue supporting the papillae. Circumvallate papillae are encircled by a trench, with serous glands (Von-Ebner's) opening at the base. Foliate papillae appear as leaf-like folds. Lymphoid tissues and mucous gland ducts are prevalent in the pharyngeal lamina propria.

Buffalo Tongue

Macroscopic Observations- The buffalo tongue's anterior section significantly surpasses the pharyngeal section in length. Filiform, fungiform, and circumvallate papillae are found anterior to the torus linguae, with giant conical papillae featured prominently. Circumvallate papillae, numbering 13-20, mark the posterior boundary of the torus linguae. The pharyngeal section is smooth and lacks papillae, similar to the unpapillated ventral surface, which also displays a frenulum linguae.

Microscopic Observations- The anterior oral mucosa consists of a heavily keratinized stratified squamous epithelium, with the lamina propria forming the papillae core. Various filiform papillae types are noted alongside fungiform papillae. Circumvallate papillae, surrounded by trenches, and foliate papillae are distinguished by their leaf-like folds. Serous-secreting acini are abundant in the pharyngeal region.

Goat Tongue

Macroscopic Observations- Circumvallate papillae partition the goat tongue into longer anterior and shorter pharyngeal parts. The smooth ventral surface contrasts with the dorsum, which displays an intermolar eminence and a variety of papillae types, including filiform, fungiform, and circumvallate, densely populated especially towards the tip and edges.

Microscopic Observations- Both anterior and posterior mucosa are characterized by a heavily keratinized stratified squamous epithelium. The lamina propria supports an array of papillae types, with a special emphasis on the diversity of filiform papillae. Circumvallate papillae feature a surrounding trench, highlighting the structural complexity of the tongue's surface in goats.

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Ethical Clearance- This comparative observational study received ethical clearance from the Institutional Ethical Committee (IEC).

RESULTS

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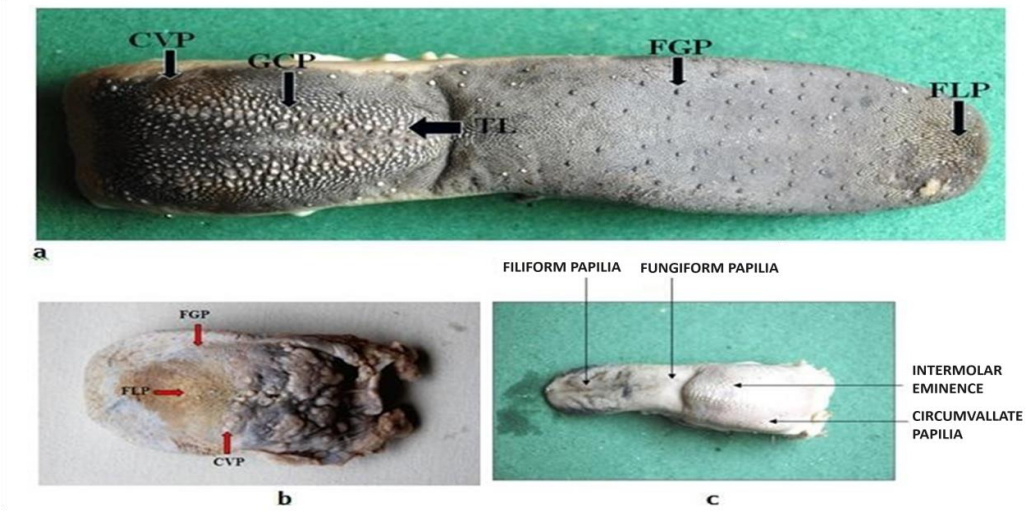

Fig. 1: Comparative Illustration of a. Buffalo, b. Human, c. Goat

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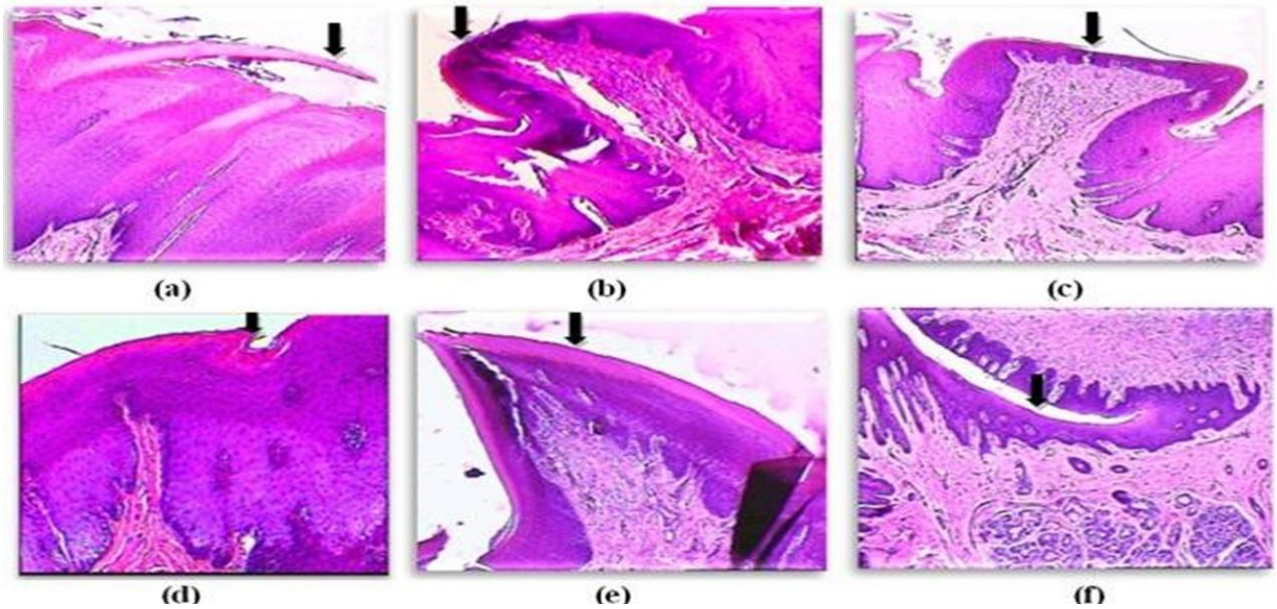

Fig. 2: Microscopic Images of Buffalo Tongue Depicting Lingual Papillae Using H&E Staining: (a) Filiform Papillae, (b) Fungiform Papillae, (c) Circumvallate Papillae, (d) Simple Conical Papillae, (e) Giant Conical Papillae, (f) Trenches in Circumvallate Papillae

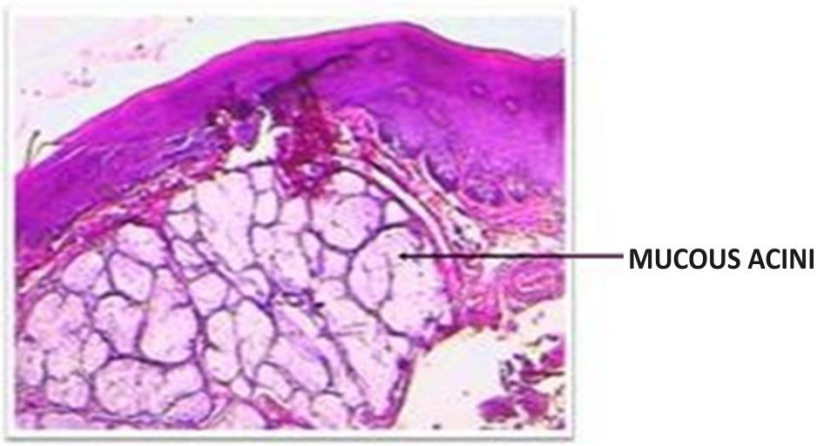

Fig. 3: Microscopic Image of Mucous Acini in the Pharyngeal Part of Buffalo Tongue at 10x Magnification (H&E Stain)

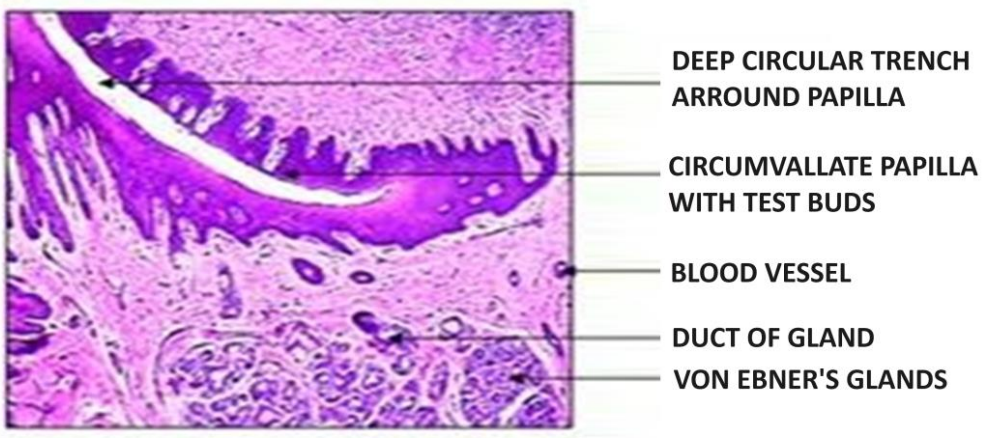

Fig. 4. Microscopic Image of Von Ebner's Glands in the Buffalo Tongue at 10x Magnification (H&E Stain)

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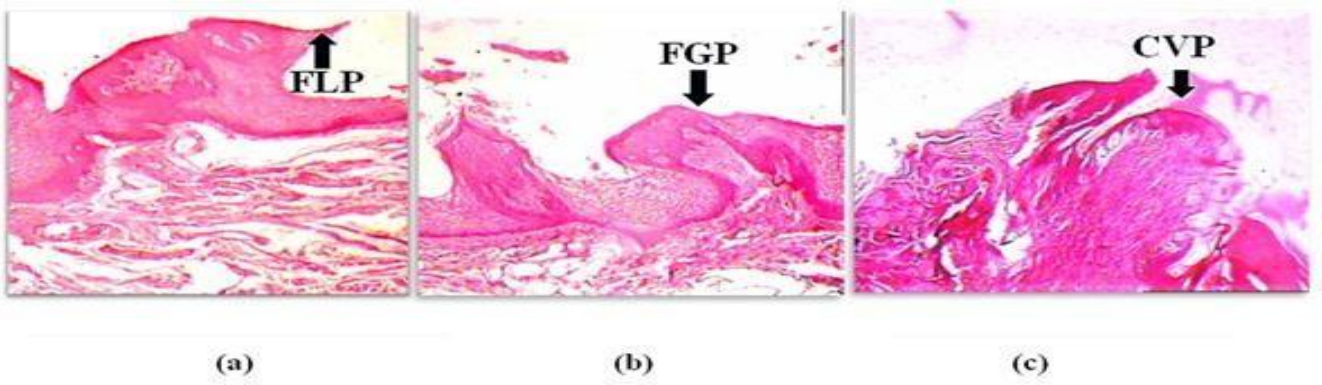

Fig. 5. Microscopic Images of Human Tongue Depicting Lingual Papillae at 10x Magnification (H&E Stain): (a) Filiform Papilla (FLP), (b) Fungiform Papilla (FGP), (c) Circumvallate Papilla (CVP)

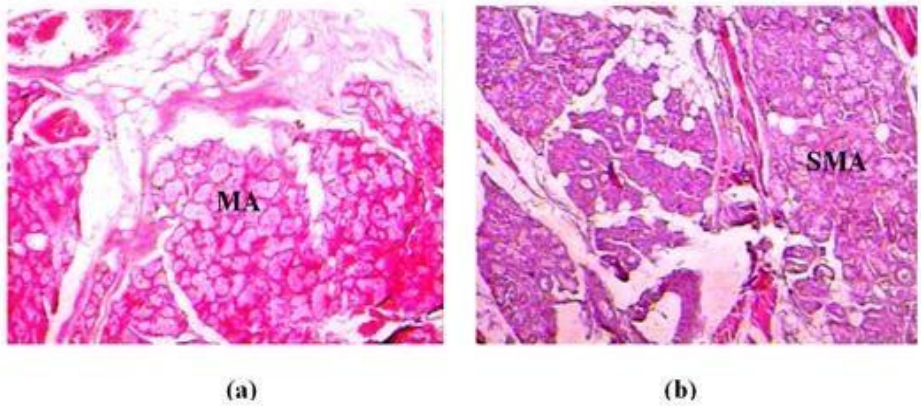

Fig. 6. Microscopic Images of Human Tongue Depicting Lingual Glands at 10x Magnification (H&E Stain): (a) Mucous Glands -Pharyngeal Part, (b) Apical Lingual Glands/Glands of Nuhn

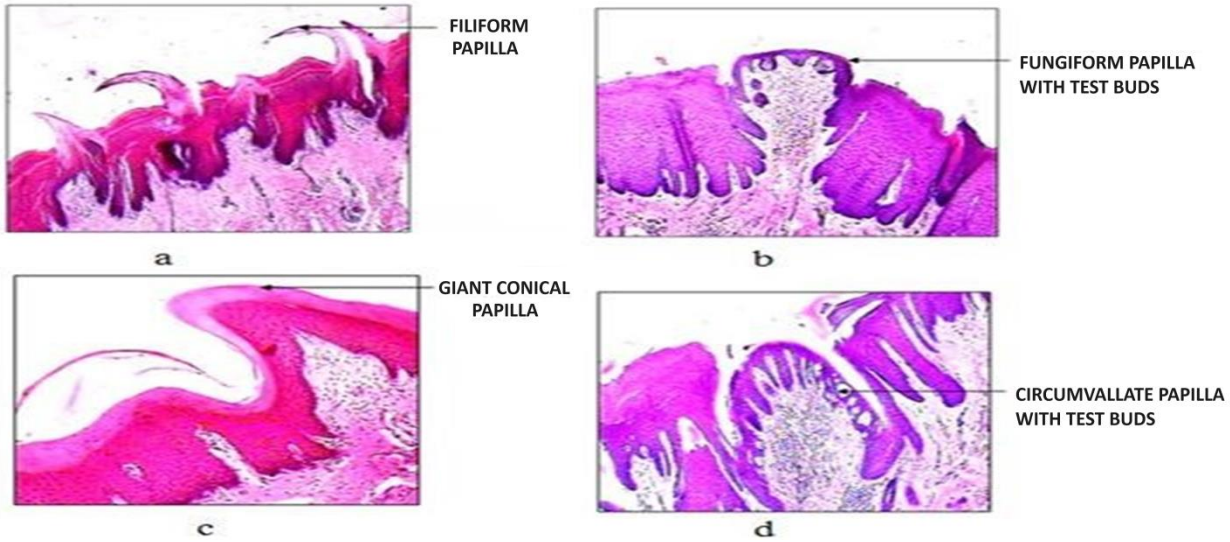

Fig. 7: Microscopic Views of Goat Tongue: (a) Filiform Papilla, (b) Fungiform Papilla, (c) Giant Conical Papilla, (d) Circumvallate Papilla with Associated Taste Buds at 10x Magnification (H&E Stain)

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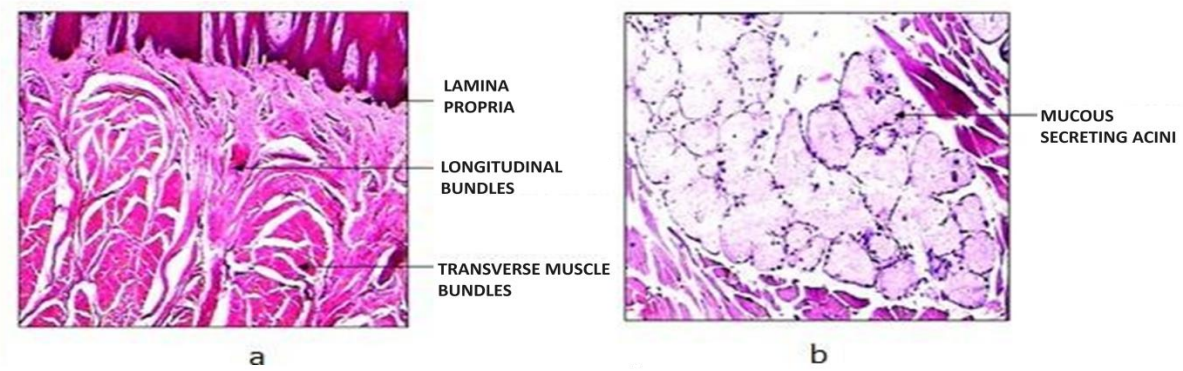

Fig. 8: Cross-Sectional Microscopic Image of Mucous Acini in the Pharyngeal Part of Goat Tongue at 10x Magnification (H&E Stain)

DISCUSSION

Variations in the segmentation of the tongue into anterior and posterior regions are evident across species. In line with the observations of Dotiwala and Samra [6], it's been noted that the oral portion of the tongue is significantly longer in certain mammals like buffaloes and goats, with a notable 4:1 ratio. This pronounced oral section is possibly an evolutionary trait for enhanced food-grasping capabilities [6,7]. Goats exhibit a distinctive intermolar eminence, contrasting with the human tongue, which typically presents a 2:1 ratio between the oral and pharyngeal parts, corroborating with other scholarly findings [8]. The sulcus terminalis is distinctly pronounced in humans, forming a V-shaped demarcation, as detailed by Bloom and Fawcett. However, such a feature is absent in buffalo tongues, which is consistent with Dotiwala and Samra's research [6]. These findings agree with multiple scholarly observations [8].

The oral cavity's structural complexity underscores its vital role in survival, facilitating key physiological functions crucial for health and well-being [9]. The diverse forms of vertebrate tongues, shaped by diet, specialization, and environmental factors, underscore their adaptability for various survival functions such as swallowing, hydration, food manipulation, grooming, and suckling in mammals [1,10-12]. For instance, the lingual prominence noted in the Egyptian buffalo, characteristic of grass-eating artiodactyls, is absent in carnivores and pigs, indicating an anatomical specialization for herbivorous diets [13-15].

The absence of lenticular papillae in the tongues of reeves, barking deer, and mazama species marks a unique anatomical adaptation, suggesting variations in papillae distribution among species [16-18].

Such conical and lenticular papillae are instrumental in the physical breakdown of plant materials, a necessity for herbivores like the Egyptian buffalo, where keratinized lenticular papillae are prominent on the lingual prominence [19]. The specific arrangement of vallate papillae in buffalo also points to specialized feeding behaviors [19].

In goat fetuses, the apex of the tongue forms a spatula-like shape crucial for initial food manipulation [20]. Early developments of lingual papillae are suggested by epithelial thickenings in goat fetuses around 50 days old [21]. Observations of circumvallate papillae in buffalo fetuses at 77 days of gestation indicate gestational and species-specific developmental timelines [22]. The dorsal surfaces of tongues in Bengal Goats and Garole Sheep feature a distinct ridge and a notable arrangement of circumvallate papillae, which evolve with age [23].

At 12-13 weeks of gestation, Sahel Goats demonstrate circumvallate papillae encircled by vallums. By 90 days, an extensive array of filiform and fungiform papillae emerges, along with circumvallate papillae arranged in rows, signifying developmental progress [24]. The diversity of filiform papillae, conical and lenticular papillae on the lingual torus, and taste buds in fungiform and vallate papillae reveal intricate lingual anatomy [25].

Goat tongues, with their thickly keratinized cell layers, differ markedly from human tongues, which lack the intermolar eminence found in buffaloes—a feature that Dotiwala and Samra [5] suggest compensates for the reduced mastication ability due to incomplete dental structures.

The current study confirms the diversity in the number and distribution of circumvallate papillae, with humans typically displaying 8 to 10 in a posteriorly directed V-shape.

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CONCLUSIONS

Analyzing the anatomical features of the tongue across species reveals the functional significance of its morphological characteristics. The division of the tongue into anterior and posterior sections based on circumvallate papillae, the notable length of the anterior part, and the presence of specialized structures like the intermolar eminence elucidate the adaptive nature of this organ.

The absence of foliate papillae across the specimens examined further emphasizes interspecies variation. This detailed examination of lingual morphology enhances our understanding of anatomical adaptations linked to dietary and environmental interactions across species.

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CONTRIBUTION OF AUTHORS

Research concept- Fulse A.C
Research design- Fulse A.C., Kolte S.P
Supervision- Fulse A.C.
Materials- Paikrao V.M.
Data collection- Fulse A.C., Paikrao V.M.
Data analysis and Interpretation- Paikrao V.M.
Literature search- Paikrao V.M.
Writing article- Fulse A.C., Paikrao V.M.
Critical review- Fulse A.C., Kolte S.P.,
Article editing- Fulse A.C.
Final approval- Fulse A.C.

REFERENCES

[1] Iwasaki S. Evolution of the structure and function of the vertebrate tongue. J Anat., 2002; 201(1): 1–13.
[2] Guimaraes GC, Miglino MA. Anatomic study and distribution of the vallate papillae in domestic cats. Brez J Vet Res Anim Sci., 2007; 44: 82-88.
[3] Vinubal S. Foliate Papillae of Human Tongue - A Microscopic study. India J App Res., 2016; 6(10), 18-21.
[4] Ghannam MG, Singh P. Anatomy, Head and Neck, Salivary Glands. Treasure Island (FL): Stat Pearls Publishing; 2024 Jan Bookshelf; ID: NBK538325; PMID: 30855909.
[5] Mistretta CM, Kumari A. Tongue and Taste Organ Biology and Function: Homeostasis Maintained by Hedgehog Signaling. Annu Rev Physiol., 2017; 79: 335–56.
[6] Dotiwala AK, Samra NS. Anatomy, Head and Neck, Tongue, StatPearls Publishing LLC.: 2024; Bookshelf ID: NBK507782 PMID: 29939559.
[7] Chen J, Jacox LA, Saldanha F, Sive H. Mouth development. Wiley Interdiscip Rev Dev Biol., 2017; 6(5): e275.
[8] Dawson DV, Drake DR, Hill JR, Brogden KA, Fischer CL, et al. Organization, barrier function and antimicrobial lipids of the oral mucosa. Int J Cosmet Sci. Int J Cosmet Sci., 2013; 35(3): 220–23.
[9] SoukupV. Horacek I, Cerny R. Development and evolution of the vertebrate primary mouth. J Anat., 2013; 222: 79–99.
[10] Kilinc M, Erdogan S, Ketani S, Ketani MA. Morphological study by scanning Electron Microscopy of the lingual papillae in the Middle East Blind Mole Rat (Spalax ehrenbergi, Nehring, 1898). Anat Histol Embryol., 2010; 39: 509–15.
[11] Pastor JF, Barbosa, M. De Paz Fj, Garcia M, Ferrero, E. Functional and Comparative study of lingual papillae in four species of bear (Ursidae) by scanning electron microscopy. Microsc Res Tech., 2011; 74: 910–19.
[12] Mancanares CAF, Santos AC, Piemonte MV, Vasconcelos BG, et al. Macroscopic and Microscopic analysis of the tongue of the common opossum (Didelphis marsupialis). Microsc Res Tech., 2012; 75: 1329–33.
[13] Kumar S, Bate LA. Scanning electron microscopy study of the tongue papillae in the pig (*Sus scrofa*). Microsc Res Tech., 2004; 63: 253–58
[14] Tadjali M, Pazhoomand R. Tongue papilla in lambs: a scanning electron microscopic study. Small Rumin Res., 2004; 54: 157–64.
[15] Emura S, Okumura T, Chen H, et ai. Morphology of the lingual papillae in the raccoon dog and fox. Okajimas Folia Anat Jpn., 2006; 83: 39–44.
[16] Zheng J, Kobayashi K. Comparative morphological study on the lingual papillae and their connective tissue cores (CTC) in reeves' muntjac deer (Muntiacus reevesi). Ann Anat., 2006; 188: 555–64.
[17] Adnyane IKM, Zuki AB, Noordin MM, Agungpriyono S. Morphological study of the lingual papillae in the barking deer, Muntiacus muntjak. Anat Histol Embryol., 2011; 40: 73–77.

DOI: 10.21276/SSR-IIJLS.2024.10.1.28

[18] Emura S and Bakary NERE. Morphology of the lingual papillae of Egyptian buffalo (Bubalus bubalis) Okajimas Folia Anat. Jpn., 2014; 91(1): 13–17.

[19] Kokubun HS, Zanatta Esper GV, Rezende Franciolli Al, de Oliveira Silva FM, et al. Estudo histologico comparative das papillas linguais dos cervideos Mazama Americana Mazama gouzoubira por microscopia de luz e electronica de varredura. Pesq Vet Bras., 2012; 32: 1061–66.

[20] Dar Y, Sarma K, Devi J. Studies on gross morphological development of the tongue in goat foetii (*Capra hircus*). Ruminant Sci., 2013; 2(2): 175-78.

[21] Igbokwe CO, Okolie C. The Morphological Observations of some Lingual Papillae in the Prenatal and Prepuberal Stages of Red Sokoto Goats (*Capra hircus*). Int J Morphol., 2009; 27(1): 145-50.

[22] Verma D, Uppal V, Bansal N, Anuradha. Differentiation and Development of Fungiform Papillae in Buffalo Tongue. Indian J Vet Anat., 2014; 26 (1): 7-9.

[23] Hemram S, Ray S. Comparative anatomical study of tongue in Black Bengal goat and Garole sheep. J Interacademicia, 2009; 13(3): 311-14.

[24] Shawulu JC, Kwari HD, Abgyal AY. Pre-Natal Growth of the Tongue and Development of the Lingual Papillae in Sahel Goats (Capra hircus). Agricu J., 2012; 7(1): 5-9.

[25] Mahdy MAA, Abdalla KEH, Mohamed SA. Morphological and scanning electron microscopic studies of the lingual papillae of the tongue of the goat (*Capra hircus*) Microsc Res Tech., 2021; 84(5): 891-901.