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Research Article

Histological study of lingual papillae on the tongue of the adult Iraqi domestic cat, *Felis catus*

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Abstract: The results of this study showed that the tongue of the adult Iraqi domestic cat is divided into three regions of apex, body and root. The dorsal surface of all regions possesses five types of lingual papillae, two mechanical which are filiform and cylindrical papillae, while the other three types are taste papillae which are foliate, fungiform and circumvallate papillae, while these papillae are absent on its ventral surface. The histological examination of all tongue areas revealed that it consisted of three tunica, the tunica mucosa and the tunica submucosa (the lamina propria) and the tunica muscularis. The tunica mucosa consisted of the epithelial lining, which is a stratified squamous epithelial tissue covering the lingual papillae, and it was keratinized in the filiform papillae, highly keratinized in the cylindrical papillae, small keratinized in the fungiform papillae, while non-keratinized in the circumvallate and foliate papillae. The tunica submucosa (the lumina) consisted of loose connective tissue containing lingual glands in the lingual root region only, which are of two types: mucous and serous glands. The tunica muscularis appears in the form of bundles of muscle fibers in three directions, in which connective tissue spreads, and fatty tissue may spread between the fibers in the body and the lingual root regions.

Keywords: Lingual Papillae, Domestic cat, *Felis catus*, Histological study.
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Introduction

The tongue in mammals differs in shape; and these differences are related to their collection and processing of food (grooming and vocal modulation), where the tongue is a taste organ. The dorsal surface of the lingual papillae plays an important role in digestion and food intake in many mammals. Studies on rabbits (Iwasaki 2002; Abuman dour & EL-Bakary 2013b) revealed a wide variation in the morphology and histological structure of the tongue, especially in the lingual papillae, showing a close relationship between the structure of these papillae with food habits and the vertebrate animal (Jackowiak & Godynicki 2005; Yoshimura et al. 2007).

Additionally, in other studies and depending on the area of the tongue, it is covered with either keratinized or non-keratinized squamous epithelial tissue (Ciena et al. 2013). There are also significant differences in the degree and time of keratinization (Iwasaki et al. 1999). Moreover, the muscle tissue constitutes the majority of the tongues in mammals (Doran & Baggett 1971), and within this tissue, there are lingual glands in the caudal part of the tongue, including the fungiform and circumvallate papillae (Nagato et al. 1997). Hence, this study aimed to examine the shape and distribution pattern of the lingual papillae on the dorsal surface of the tongue in the domestic cat, *Felis catus,* to compare it with previous findings on other carnivores.

Materials and Methods

The tongue of males and females from four domestic cats were used in this study. The samples were

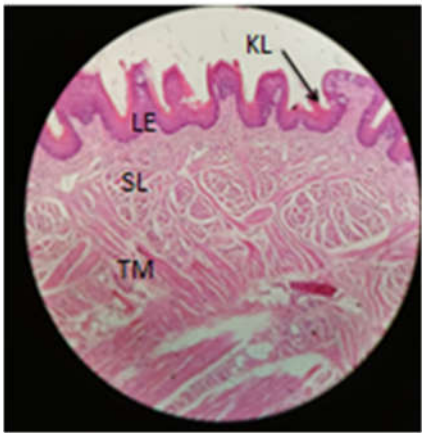

Fig.1. C.S. through lingual body showing: Keratinized Layer (KL), Linging Epithelium (LE), Tunica Submucosa-Lamina Properia (SL), and Tunica Muscularis (TM). H&E, 10X.

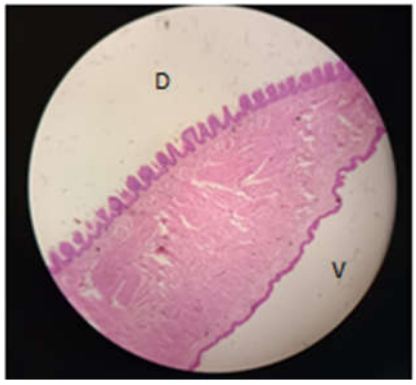

Fig.2. C.S. through lingual apex showing: Dorsal surface (D) and ventral surface (V). H&E, 10X.

Fig.3. C.S. through lingual root showing: Mucus gland (MG) & Serous Gland (SG). H&E, 40x.

collected from the local markets of the Baghdad governorate. All collected samples were then taken to the Comparative Anatomy Laboratory of the College of Education for Pure Sciences, Ibn Al-Haitham/University of Baghdad. The animals were anesthetized using chloroform, and the tongue was removed and washed with distilled water and dried using filter paper. Then, the tongue was quickly cut into three parts (apex, body and root) and fixed into a container containing 10% formalin for two days. After that, they were treated for embedding with paraffin, and a series of sections (longitudinal and transversal) with a thickness of 7 µm were prepared using rotating microtome; then the slides were stained using eosin-hematoclasin (H&E) (Bancroft & Stevens 2010).

Results

The results of the microscopic examination of the tongue sections in the domestic cat showed that it consists of three tunica, the tunica mucosa, the tunica submucosa (the lamina propria) and the tunica muscularis in all its regions (Fig. 1). The tunica mucosa consists of the epithelial lining, which is a stratified keratinized epithelial tissue (Figs.1, 5, 6, 7, 8). In addition, the dorsal surface of the tongue is thicker than the ventral surface, which appears non-keratinized in addition to the absence of lingual papillae. While the tunica submucosa (the lamina propria) consists of loose connective tissue in which blood vessels, lymphocytes, fibroblasts and nerves are spread, and the connective tissue penetrates into the papillae of the tunica mucosa (Fig. 2). This results also revealed that this tunica contains two types of the lingual glands, including mucous (Weber's glands) and serous glands (von Ebner's glands). The penetration of the mucous glands continues from the tunica mucosa to the tunica muscularis to reach the pulp of the tongue, as the lingual glands are located in the lingual root region, while they are absent in the apex and the lingual body.

The mucous glands are characterized by their low columnar cells and a relatively large cavity, and their nuclei are basal and compact, dark in color, and the cytoplasm is vacuolated and filled with mucous secretions (mucin) (Fig. 3). On the other hand, the serous glands were characterized by their cells are pyramidal in shape with a spherical basal nucleus that

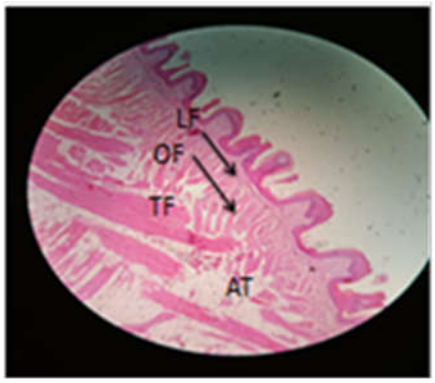

Fig.4. C.S. through lingual body showing: Longitudinal Fibers (LF), Obligue Fibers (OF), Transvers Fibers (TF) & Adipose tissue (AT). H&E, 10X.

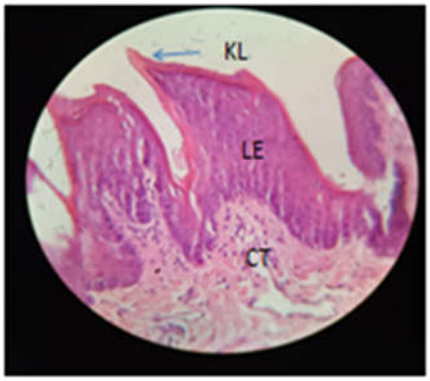

Fig.5. C.S. through lingual body showing: Keratinized Layer (KL), Linging Epithelium (LE) and Connective Tissue (CT). H&E, 40X.

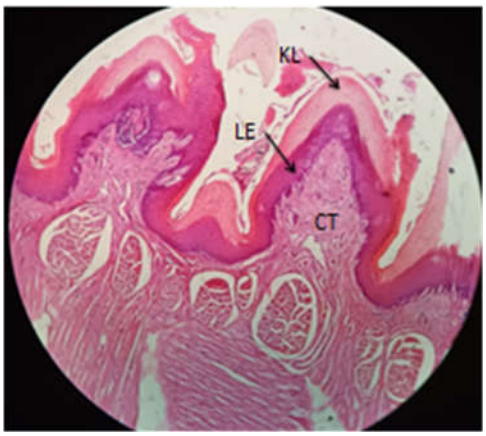

Fig.6. C.S. through lingual body showing: Keratinized Layer (KL), Linging Epithelium (LE) and Connective Tissue (CT). H&E, 40X.

is light in color, and zymogen granules assemble at the tops of the cells. The cavity of these glands is very small and is difficult to distinguish in most cases (Fig. 3). The fibers of tunica muscularis are arranged in bundles in three directions of longitudinal,

Fig.7. C.S. through lingual body showing: Keratinized Layer (KL), Taste Bud (TB), Linging Epithelium (LE) and Connective Tissue (CT). H&E, 40X.

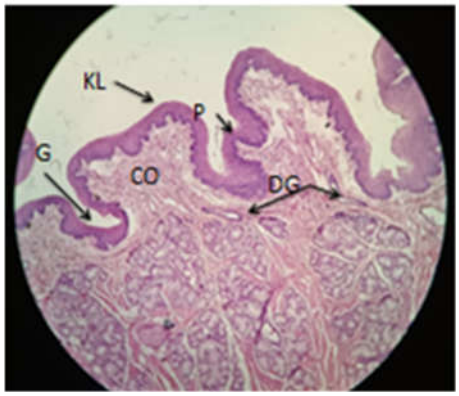

Fig.8. C.S. through lingual root showing: Keratinized Layer (KL), Pad (P), Groove (G),Gland Duct (GD) & Connective Tissue (CT). H&E, 40X.

transverse, and oblique, and connective tissue (containing blood vessels and nerves) is spread between the bundles of muscle fibers (Fig. 4). Furthermore, fatty tissue was found between the muscle bundles in the body section and the lingual root only, while it was absent in the apex region.

The microscopic examination showed that the dorsal surface of the tongue has two types of lingual papillae, mechanical and taste papillae. The mechanical papillae are represented by filiform and cylindrical papillae, while the taste papillae are represented by fungiform, foliate, and circumvallate papillae, while these types of papillae were absent on the ventral surface of the tongue. The filiform papillae are covered with stratified squamous keratinized epithelial tissue, and the pulp of the papilla contains loose connective tissue (Fig. 5). The

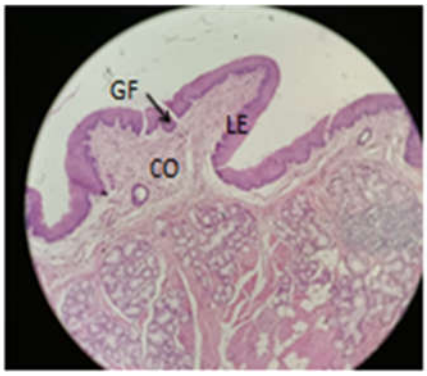

Fig.9. C.S. through lingual root showing: Gustatory Fissure (GF), Linging Epithelium (LE) and Connective Tissue (CT). H&E, 40X.

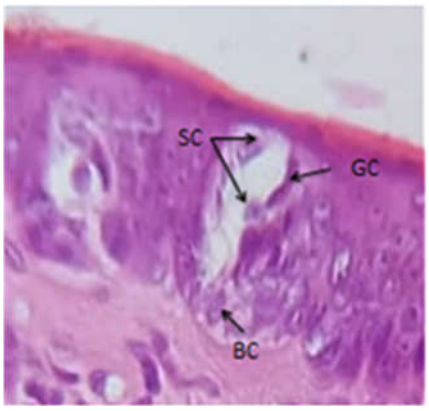

Fig.10. C.S lingual root showing taste bud structure: Gustatory Cell (GC), Supporting Cell (SC) and Basal Cell (BC). H&E, 100X.

cylindrical papillae are covered with stratified squamous and highly keratinized epithelium, and the pulp of the papilla contains loose connective tissue (Fig. 6). Additionally, the fungiform papillae are covered with a stratified squamous and slightly keratinized epithelial tissue, and the dorsal surface of the fungiform papillae contains taste buds, and the pulp of the papillae is also loose connective tissue (Fig. 7).

The results also revealed that the circumvallate papillae are surrounded by a pad and trench and are covered also with a non-keratinized stratified squamous epithelial tissue containing taste buds located at the dorsal and lateral surface of the circumvallate papilla, and the pulp of the papilla is loose connective tissue (Fig. 8). The foliate papillae are folds in the form of rows separated from each other by taste grooves located on both sides of the lingual root region and covered with stratified squamous non-keratinized epithelial tissue. The taste buds are located on the lateral walls of the leafy papilla and these buds open in the taste grooves; the pulp of the papilla is loose connective tissue (Fig. 9). The taste buds in the epithelial tissue of the taste papillae (fungiform, foliate, and circumvallate papillae) are barrel-shaped and consist of three types of cells: taste cells, supporting cells, and basal cells (Fig. 10).

Discussion

Several studies showed variations in the histological structure of the tongue in mammals, as it is composed of three tunica represented by the tunica mucosa, tunica submucosa, and tunica muscularis (Goodarzi & Azarhoosh 2016; Akbari et al. 2018). The observations of the current study are in line with previous findings in this regard, although it differs in some aspects. In our work, t the connective tissue located under the epithelial lining appears as a single layer, i.e. within one tunica, which is the tunica submucosa (the lamina propria), and this result is not consistent with other studies which described that the connective tissue in the lamina propria (Jabbar 2014; Wannaprasert 2017; Mutlk et al. 2017). This difference may be related to the structural construction based on the requirements of the function.

The tunica mucosa consists of the epithelial lining, which is composed of stratified squamous epithelial tissue that is keratinized on the dorsal surface of the tongue and non-keratinized on its ventral surface which lacks the papillae. This result is consistent with previous studies (Ghassemi & Jahromi 2013; Sadeghinezhad et al. 2018). Whereas the tunica submucosa (the lamina propria) consists of loose connective tissue interspersed with blood vessels, nerves, lymphocytes, and fibroblasts, and this tissue extends into the papillae present in the tunica mucosa, and this is consistent with studies of Al-Mahmodim (2012), and Sadeghinwzhad et al. (2018), while it does not agree with the results of

Wannapraset (2017) and AL-Jebori (2007), which indicated that the lamina propria was composed of dense connective tissue.

The current study showed the two types of lingual glands, the mucous (Weber's glands) and the serous (Von Ebner's glands) located in the tunica submucosa (the lamina propria) and penetrating into the tunica muscularis, and the presence of these glands is restricted to the lingual root region. This result is in agreement with the study of Ibrahim & AL-Jumaily (2020) while contradicting the results of Cizek et al. (2020) that the lingual glands in the Lesser hedgehog (*Echinopus telfairi*) are located in the tunica muscularis. The reason for this variation may be attributed to functional requirements and their relationship to the different feeding patterns in the animal.

Many studies have shown that the tunica muscularis consists of skeletal muscle fibers, and its fibers are arranged in three directions, longitudinal, transverse, and oblique. In addition, adipose tissue is spread between the muscle fibers in the root and lingual body regions and is absent at the apex of the tongue (Sadeghinezhad et al. 2017; Ibrahim & AL-Jumaily 2020). The results of the current study confirmed this tissue structure of the tongue in the domestic cat, while it contradicts the results of some studies that showed the presence of fibers arranged longitudinally and transversely and lacking oblique fibers (Ghassemi & Chesmi 2014). The reason for this observation is due to the nature of the animal's nutrition which requires moving the tongue in different directions since the muscle fibers constitute a basic mechanism in achieving different and accurate movements of the tongue during chewing. The dorsal surface of the tongue in the domestic cat contains several types of papillae including filiform, cylindrical, fungiform, circumvallate, and foliate papillae (Haligur & Ozkadif 2019). While the study of Emura et al. (2000) confirmed that *Speothos Venaticus* (bush dog) lacks foliate papillae in the tongue.

The histological examination revealed that the filiform papillae are covered with keratinized stratified squamous epithelial tissue, and the pulp of the papilla contains loose connective tissue (Jabbar 2014; Sadeghinezhad et al. 2018). The cylindrical papillae are covered with highly keratinized stratified squamous epithelial tissue, and the pulp of the papilla consists of loose connective tissue. This finding was consistent with the study of Emura et al. (2013) on Cheetah, while the study of Cizek et al. (2020) disagreed with the fact that the tongue of the lesser hedgehog (*Echinopus telfairi*) lacks the cylindrical papillae. The reason for the keratinization of these papillae is due to their mechanical function of holding food and preventing it from slipping (Nickel 1979), and to the fact that domestic cat food is rather soft.

This study showed that the fungiform papillae of the domestic cat are covered with stratified squamous epithelial tissue that is poorly keratinized with few taste buds, and the pulp of the papilla is loose connective tissue. This result is not consistent with the results of Torpak & Vlusoy (2011), which found no keratinization in the epithelium of fungiform papillae, while it is agreed with the study of Yoshimura et al. (2009), which indicated that the keratinization is weak in the epithelium of fungiform papillae in Japanese badgers (*Meles meles anakuma*) with few taste buds.

The foliate papillae are covered with stratified squamous non-keratinized epithelium. The pulp of the papilla is loose connective tissue, and taste buds are present on the dorsal and lateral surfaces of the papilla. The papilla is surrounded by the trench and pad. The structure of the circumvallate papilla in the domestic cat is similar to most mammals, such as the cheetah, the raccoon dog, and the fox (Emura et al. 2004, 2006) and also the American beaver (Shindo et al. 2006).

The leafy papillae are covered with stratified non-keratinized squamous epithelial tissue, and their lateral walls contain taste buds, and these buds open in the taste slit. The pulp of the papilla is loose connective tissue. This result does not agree with the

study of Ibrahim (2020) because *Herpestes javanicus* lacks foliate papillae. The microscopic examination of the taste buds spread in the epithelial tissue of the taste papillae (fungiform, foliate and circumvallate) showed that they are composed of three types of cells viz. basal, support, and circumvallate. These results are not consistent with the findings of Kanazawa (1993) which indicated the presence of five types of cells in the taste buds of the dog's tongue. Moreover, the study of Torpak & Vlusoy (2011) detected the presence of two types of cells forming the taste buds in the young lion (*Panthera leo*), which are light and dark-stained cells. In general, the histological composition of these buds is related to the function of taste, by receiving nutrients through their taste holes after dissolving the nutrients by the digestive enzymes of the serous glands (von Ebner's glands) to be then spread over the surface of the tongue, including the lingual taste papillae.

Conclusion

The histological study of the tongue in the domestic cat showed a similar general structure of the tunicates that make up the tongue in the rest of the order of predators; however, it showed that the location, structure, and distribution of lingual papillae in the domestic cat at the histological level differ in some aspects from other mammals, as these papillae adapted to the pattern of feeding in the domestic cat. In addition, the findings of this study may contribute to increasing the knowledge in this field of study.

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