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Scanning Electron Microscopy Study of the Tongue in the Laboratory Mice *Mus musculus*

Estudio de la Lengua del Ratón de Laboratorio (*Mus musculus*) Mediante Microscopía Electrónica de Barrido

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SUMMARY: The tongue of the laboratory mouse (*Mus musculus*) serves as a valuable model for oral microscopic studies due to its structural similarities with those of other mammals. Understanding its surface morphology, particularly the lingual papillae, provides insights into both mechanical and sensory functions. This study aimed to describe the surface morphology of the mouse tongue using scanning electron microscopy, with emphasis on the types and distribution of lingual papillae. Tongues from healthy male and female mice were examined under scanning electron microscopy to document gross surface features and characterize papillary structures. The tongue appeared slender with a rounded anterior lingual apex, a relatively broad lingual body, and a caudal lingual root. A deep median sulcus extended from the apex to the body, dividing the tongue into two halves, while a lingual prominence was observed on the posterior third of the dorsal surface. The dorsal surface exhibited a rough texture due to the presence of two types of papillae: mechanical and gustatory. Filiform papillae (mechanical) exhibited three forms: cylindrical at the anterior apex, large conical at the lingual prominence and small conical at the posterior region. Fungiform papillae (gustatory) were bud-shaped, distributed between the apex and root, with a single vallate papilla surrounded by an incomplete groove. This study provides a detailed description of mouse tongue morphology, highlighting the structural diversity of papillae according to location and function. The findings support the use of mice as a valuable model in oral microscopic and anatomical research.

KEY WORDS: Tongue; *Mus musculus*; Scanning electron study; Lingual papillae.

INTRODUCTION

The survival and persistence of a vertebrate species in a given environment is closely related to its adaptation to that environment, primarily through feeding, which is largely dependent on the most important structure in the oral cavity, the tongue. Through its specialized lingual papillae, found on the dorsal surface in most vertebrates, the tongue functions as a part of digestion, food intake, and taste perception. Depending on its function, the shape and structure of the tongue differ, and the way it is devoted to the oral cavity varies between species (Abumandour & El-Bakary, 2013).

The tongue of the lamprey (Cyclostomata), for example, bears scattered teeth that serve to tear the skin of the prey, supported by strong muscles. The tongues of other fish are not as advanced as they are and consist of a fleshy fold formed by a slight elevation of the mucous membrane on the floor of the oral cavity (Kent & Carr, 2001). In amphibians, the tongue varies depending on the habitat. In some species it is immobile, while in others, such as frogs, it is mobile and contains voluntary muscles. Frogs also possess sticky tongues that act as prey capture organs, and several studies have focused on the mechanism of adhesion in frogs (Kleinteich & Gorb, 2018). The tongue in reptiles is different from that of other animals, with many gustatory and mechanical papillae being distributed on the dorsal surface of the apex and body of the tongue in geckos, while snakes lack lingual papillae and taste buds. Instead, it is highly keratinized and has strong muscles that allow it to extend into the environment for olfactory detection and localization of prey and, in cooperation with the vomeronasal organ, perform a purely olfactory function (AL-Fartwsy *et al*., 2016a,b; Rodrigues & Sartori, 2023).

In birds, the tongue differs depending on the diet. In insectivorous birds it is very long; in parrots it contains well-developed muscles, while in Galliformes the tongue muscles

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are reduced or completely absent (König *et al*., 2016). In mammals, the tongue is more developed than in other vertebrates and exhibits considerable diversity in form and function. It contains taste buds and various lingual papillae, both of which are involved in both mechanical and gustatory functions. Anteaters, for example, have a long, muscular tongue that is essential for food acquisition; cats use the tongue for licking and grooming, while in dogs it is also used for thermoregulation; in humans, the tongue is essential for speech, food intake and swallowing (Wilson & Reeder, 2005; Haddad *et al*., 2019). The oral cavity is occupied by the stratified squamous epithelium, which covers rodents, which has more than 2000 species belonging to 30 families (Abayomi *et al*., 2009). The tongue has various types of papillae, including gustatory papillae, foliate papillae, and vallate papillae, which have taste buds and taste pores, and mechanical papillae, which protect the tongue surface from abrasion and aid in grinding and chewing food. Several studies have described the morphological features of lingual papillae in various mammals, including the mouse (BALB/c strain) (Toprak, 2006), the vole (*Clethrionomys glareolus*) (Jackowiak & Godynicki, 2005), the Nile rat (*Arvicanthis niloticus*) (Nasr *et al*., 2012), the Wistar rat (Cheshmi & Ghassemi, 2014), the greater Japanese shrew (*Urotrichus talpoides*) (Yoshimura *et al*., 2013) and the brown-throated sloth (*Bradypus variegatus*) (dos Santos *et al*., 2024).

This study aims to evaluate the dorsal surface of the tongue of the laboratory mouse (*Mus musculus*) by analyzing it with scanning electron microscopic techniques and to identify the types of lingual papillae. The laboratory mouse is considered one of the most widespread rodents, characterized by a high adaptability to different environments and widely used in various scientific fields (Bancroft *et al*., 2012).

MATERIAL AND METHOD

Eight specimens of laboratory mice (*Mus musculus*) were obtained from the Animal House, Department of Biology, College of Education for Pure Sciences (Ibn Al-Haitham), University of Baghdad. The study was accompanied according to the following steps:

1. Excision of the tongue: The tongue was removed with a sharp scalpel after chloroform anesthesia was applied, which caused transverse opening of the oral cavity and separation of the lower and upper jaws.
2. Preparation of samples for gross examination: A dissecting microscope was used to inspect and take pictures of the tongue's dorsal surface after the recently removed tongues had been preserved in 10 % formalin.
3. Sample preparation for SEM (scanning electron microscopy).

The tongues were first treated with 3N hydrochloric acid at 60 °C for 20 min in order to remove mucus from the tissue surface and prepare the samples for SEM analysis. After that, the fresh samples were pre-fixed for one to two hours in 2 % glutaraldehyde made in 0.10 M cacodylate buffer. To guarantee that all of the glutaraldehyde was removed, tissues were washed in buffer solution (Sigma, St. Louis, USA) for an hour after fixation, changing the buffer every fifteen minutes. After that, samples were post-fixed for one hour at 4 °C in 1 % osmium tetroxide (TAAB) in 0.10 M phosphate buffered saline (PBS; Sigma) at pH 7.4. Tissues were dehydrated using a graded ethanol series following PBS washing. Following a gold sputter coating, the samples were examined under a scanning electron microscope to examine the dorsal lingual mucosa (Taha, 2013; Al-Shuwaili *et al*., 2022; Al-Fartwsy *et al*., 2023).

The Department of Electron Microscopy, College of Education for Pure Sciences (Ibn Al-Haitham), University of Baghdad, conducted the SEM examination.

RESULTS

According to this study, the laboratory mouse's (*Mus musculus*) tongue is an extended organ with a caudal end portion called the tongue root, a somewhat large middle portion called the lingual body, and a rounded anterior end called the lingual apex (Fig. 1).

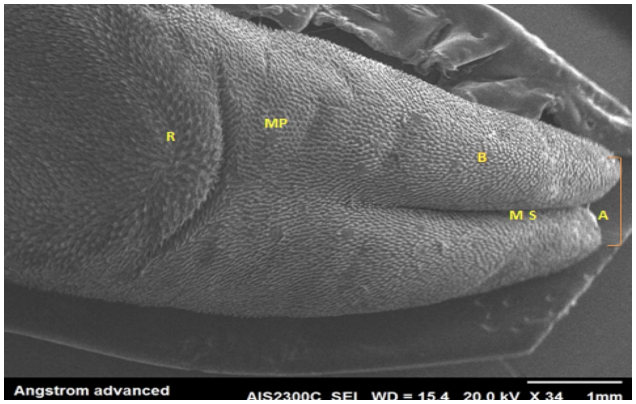

Fig. 1. Shows a scanning electron micrograph of the tongue's dorsal surface, highlighting its primary regions: the median sulcus (MS), median lingual prominence (MP), lingual apex (A), lingual body (B), and lingual root ®.

These areas are divided into two equal halves on the dorsal side by a deep median sulcus that runs from the start of the lingual tip to the lingual body. The lingual prominence is a prominent projection located in the posterior part of the dorsal surface (Figs. 1 and 2).

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The entire dorsal surface of the tongue is covered with papillae, which vary in type, shape and distribution depending on the region. The tongue contains mechanical papillae represented by filiform papillae, which have different shapes depending on their location on the tongue: Between the lingual prominence and the lingual apex, cylindrical filiform papillae have been seen. Individual projections on these cylindrical papillae are oriented toward the root area. The projections of these papillae stretch toward the median sulcus itself (Figs. 2 to 4).

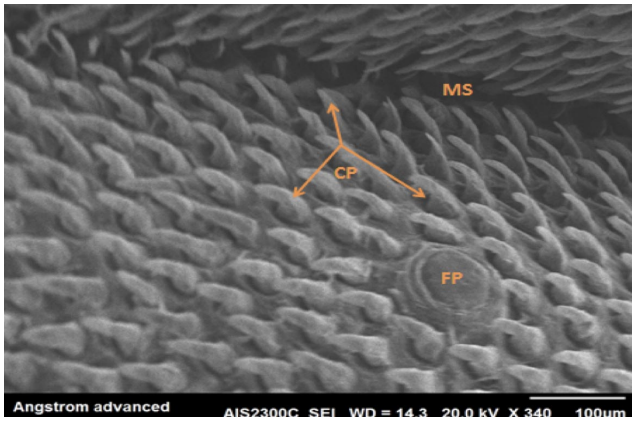

Fig. 2. A scanning electron micrograph of the tongue's dorsal surface displaying the cylindrical fungiform papillae (CP), filiform papillae (FP), and median sulcus (MS).

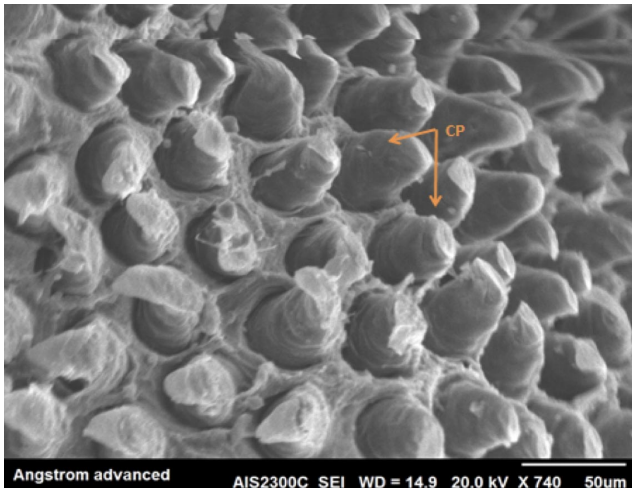

Fig. 3. Cylindrical filiform papillae (CP) are visible in this scanning electron micrograph of the tongue's dorsal surface.

In the region of the tongue protrusion, huge conical, thread-like papillae were found, arranged in dense clusters with different orientations and a flower-like appearance. Each papilla consists of an anterior part facing the papilla center and a posterior part, with two terminal projections at the tip of each papilla (Figs. 4 and 5).

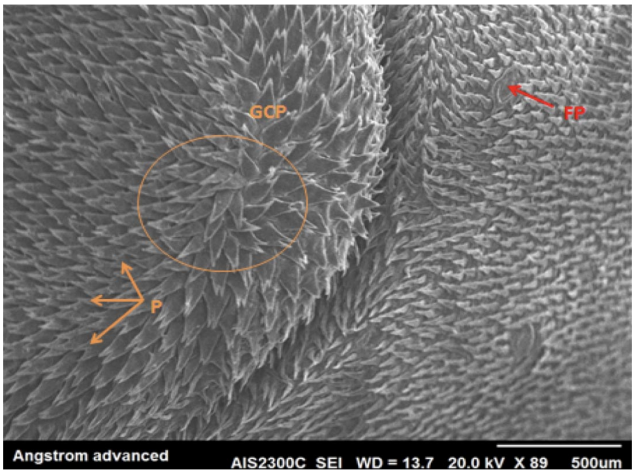

Fig. 4. Scanning electron micrograph of the tongue's dorsal surface displaying papillary projections (P), fungiform papillae (FP), and giant conical filiform papillae (GCP).

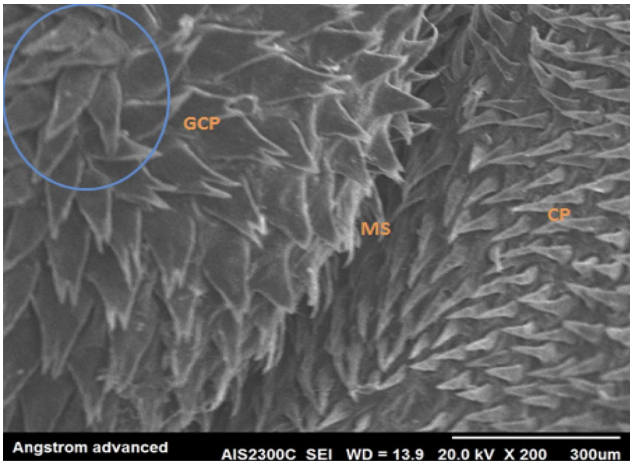

Fig. 5. A scanning electron micrograph of the tongue's dorsal surface displaying the median sulcus (MS), gigantic conical filiform papillae (GCP), and cylindrical filiform papillae (CP).

Fig. 6. Scanning electron micrograph of the tongue's dorsal surface displaying circumvallate papillae (CVP) and small conical filiform papillae (SCP).

Small, conical, filiform papillae were seen close to the anterior and lateral portions of the circumvallate papilla as well as in the back of the tongue. Near the circumvallate papilla, the papillae lose their branching and take on a cylindrical appearance, and their tips have two projections (Fig. 6).

The gustatory papillae were represented by fungiform and circumvallate papillae, while foliate papillae, which are characteristic of some mammals, were absent.

From the tip of the tongue to the anterior third, fungiform papillae are widely spaced and positioned in between filiform papillae.

Their number decreases while their size increases in the posterior two-thirds. They have a smooth, dome-shaped surface with a rounded apex, and the basal diameter is smaller than the apex (Fig. 7)

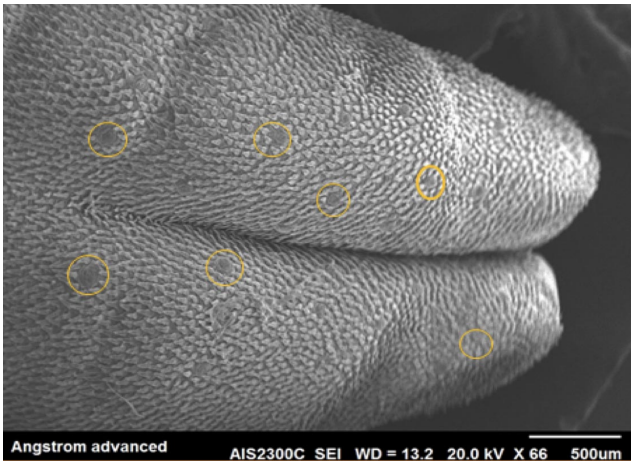

Fig. 7. Fungiform papillae (O) on the tongue's dorsal surface as seen in a scanning electron micrograph.

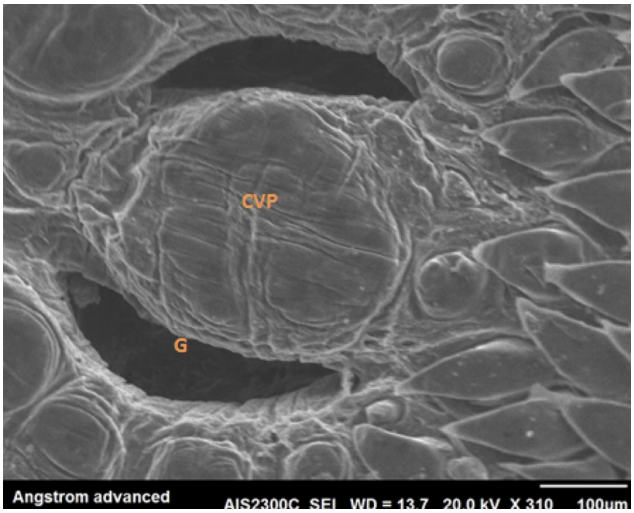

Fig. 8. Scanning electron micrograph of the tongue's dorsal surface displaying the groove (G) and circumvallate papillae (CVP).

A single circumvallate papilla was observed, disc-shaped with a shallow central groove surrounded by an incomplete surrounding groove (Fig. 8).

DISCUSSION

Animal tongues have morphological and histological traits that reflect behavioral variations and environmental adaptations (Abd AL-Rhman *et al*., 2016; Ibrahim *et al*., 2024). According to the current study's findings, the laboratory mouse's tongue is cylindrical in shape, with a rounded lingual apex at the front, a large lingual body in the center, and a lingual root at the back or caudal end. These results are in line with other studies on different mammals' tongues (Jabbar, 2014; Mutlak *et al*., 2017).

A deep median sulcus that separates the tip and body into two equal halves is a characteristic of the mouse tongue tip. This sulcus varies in length and depth among species, which is in line with earlier findings in the Nile grass rat (*Arvicanthis niloticus*) (Massoud & Abumandour, 2019), squirrel (*Sciurus vulgaris*) (Unsaldi, 2010) and New Zealand white rabbit (*Oryctolagus cuniculus*) (Abumandour & El-Bakary, 2017).

The tongues of the African pygmy hedgehog (*Atelerix albiventris*) (Cizek *et al*., 2022), the Egyptian fruit bat (*Rousettus aegyptianus*) (Abumandour, 2014) and the European hedgehog (*Erinaceus europaeus*) (Akbari *et al*., 2018), however, have not been shown to contain this type of sulcus. The largest portion of the tongue, the lingual body, frequently has a lingual projection on its dorsal surface, according to several studies (Goodarzi & Azarhoosh, 2016; Wannaprasert, 2018). These findings are supported by the current study's findings, whereas earlier investigations have reported no lingual protrusion (Ibrahim & Al-Jumaily, 2020).

SEM analysis showed that laboratory mice's tongues have a variety of papillae covering their dorsal surfaces, with a distinct regional distribution between the tongue body and the tongue root. While the gustatory papillae comprised fungiform papillae arranged from the apex to the body and a single circumvallate papilla situated in the root region, the mechanical papillae were represented by three different types of filiform papillae. These results differ from several previous studies in which four types of papillae were reported in the tongues of rats and New Zealand white rabbits (Masuko *et al*., 2007; Abumandour, 2014). However, it has been noted that haematophagous bats only have two kinds of papillae: filiform and fungiform (Park & Lee, 2009). The present findings, however, are in line with earlier findings in bats (Costa *et al*., 2013), which had three

different papillae types; filiform, fungiform, and circumvallate—that displayed a pattern resembling that of mice. Dietary practices and feeding behavior seem to be related to this variation in the quantity and kind of lingual papillae.

Our findings are in line with earlier research demonstrating that filiform papillae display significant morphological variations based on their functional purpose. For example, rodent tongues may have multiple subtypes of filiform papillae adapted to dietary requirements (Emura *et al*., 2012). Five subtypes have been identified in rousette bats (Reginato *et al*., 2014), four in frugivorous bats and New Zealand white rabbits, three in mice and just two in porcupines (Ciena *et al*., 2013). In the present study, laboratory mice exhibited filiform papillae with multiple posteriorly directed projections, lateral conical filiform papillae that aid in grasping and mixing food, and giant papillae with large projections in the anterior median region that facilitate the movement of food particles posteriorly to the pharynx. The orientation of all filiform papillae was along the tongue's longitudinal axis, which would aid in keeping food on the dorsal surface. The presence of multiple filiform papilla types emphasizes their functional importance in mammalian feeding, and despite the different types, no significant differences in their structure or location were observed in the different mammalian species (Kent & Carr, 2001).

Fungiform papillae of the laboratory mouse were dome-shaped, which is consistent with previous studies (Goz´dziewska-Har?ajczuk *et al*., 2018). They were distributed in the apex and root regions and interspersed with filiform papillae, consistent with observations in the capybara, where fungiform papillae covered the entire dorsal surface (Demirci *et al*., 2023). Other studies have reported their presence mainly in the anterior and middle regions between small filiform papillae, each with a single taste pore. Fungiform papillae were not present in the degum (Cizek *et al*., 2017).

The laboratory mouse examined in this study possessed a single circumvallate papilla in the root region, which appeared to be the largest lingual papilla. Although this result is in line with other research (Reginato *et al*., 2024), it deviates from findings of other rats where there are one to four circumvallate papillae. For instance, the giant pampas rat has two circumvallate papillae (Abumandour, 2014), but the Persian squirrel (*Sciurus anomalus*) has three in a V-shape (Sadeghinezhad *et al*., 2018). The circumvallate papillae's number and form seem to be in line with their functional role in taste perception, which is tailored to each species' feeding preferences.

CONCLUSION

The present study demonstrates that the tongue of the laboratory mouse (*Mus musculus*) exhibits distinct anatomical and morphological specializations, characterized by clear regional divisions (apex, body, root) and well-defined surface features, including the median sulcus and lingual prominence. The dorsal surface is covered by regionally distributed lingual papillae: filiform papillae (cylindrical, large conical and small conical) serving mechanical functions and gustatory papillae represented by fungiform papillae located at the apex and root, along with a single circumvallate papilla surrounded by an incomplete trench. This structural diversity reflects functional adaptations for food manipulation and taste perception. Overall, these findings underscore the laboratory mouse as a reliable model for comparative oral morphology and histology, as well as for preclinical and pharmacological studies targeting oral diseases and the development of novel therapeutic approaches.

AL-FARTWSY, A. R.; HUSSEIN, A. A. & ABED AL-SHUWAILI, E. H. Estudio de la lengua del ratón de laboratorio (*Mus musculus*) mediante microscopía electrónica de barrido. *Int. J. Morphol., 44(2)*:555-561, 2026.

RESUMEN: La lengua del ratón de laboratorio (*Mus musculus*) constituye un valioso modelo para estudios microscópicos orales debido a sus similitudes estructurales con las de otros mamíferos. La comprensión de su morfología superficial, en particular de las papilas linguales, aporta información sobre sus funciones mecánicas y sensoriales. Este estudio tuvo como objetivo describir la morfología superficial de la lengua del ratón mediante microscopía electrónica de barrido, con especial énfasis en los tipos y la distribución de las papilas linguales. Se examinaron lenguas de ratones sanos, machos y hembras, mediante microscopía electrónica de barrido para documentar las características macroscópicas de la superficie y caracterizar las estructuras papilares. La lengua presentaba una forma delgada con un ápice lingual anterior redondeado, un cuerpo lingual relativamente ancho y una raíz lingual caudal. Un surco mediano profundo se extendía desde el ápice hasta el cuerpo, dividiendo la lengua en dos mitades, mientras que se observaba una prominencia lingual en el tercio posterior de la superficie dorsal. Esta superficie presentaba una textura rugosa debido a la presencia de dos tipos de papilas: mecánicas y gustativas. Las papilas filiformes (mecánicas) presentaban tres formas: cilíndrica en el ápice anterior, cónica grande en la prominencia lingual y cónica pequeña en la región posterior. Las papilas fungiformes (gustativas) tenían forma de yema, distribuidas entre el ápice y la raíz, con una sola papila circunvalada rodeada por un surco incompleto. Este estudio proporciona una descripción detallada de la morfología de la lengua del ratón, destacando la diversidad estructural de las papilas según su ubicación y función. Los hallazgos respaldan el uso de ratones como un valioso modelo en la investigación microscópica y anatómica oral.

PALABRAS CLAVE: Lengua; *Mus musculus*; Microscopía electrónica de barrido; Papilas linguales.

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