Light and scanning electron microscopic study of the dorsal lingual papillae of the rat *Arvicanthis niloticus* (Muridae, Rodentia)

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Abstract: The distribution and structure of the lingual papillae in rat tongue were studied by means of light and scanning electron microscopy. The tongue in the rat was about 27 mm in length and about 3 mm in width. The characteristic features of the tongue were the median sulcus on the apex, considerable narrowing in the body of the tongue and a moderately developed prominence. On the surface of the apex and body of the tongue three morphological types of the filiform papillae and fungiform papillae were observed. The prominence of the tongue was covered with forked and saw-like filiform papillae .Two oval vallate papillae were situated in the sides of the median line of root of the tongue. The posterior part of the lingual root is flat without papillae. Histological observation indicated keratinization of the dorsal surface of the tongue with variable degrees.
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1. Introduction

The morphology of the tongue in vertebrates, and especially the lingual papillae on the dorsal surface of the tongue, shows considerable variability (Sonntag, 1924 and Doran, 1975). Studies on the tongue microstructure in rodents using light and electron microscopy were carried out on rat ,mouse and guinea pig (Miller & Preslar, 1975; Liu & Lee, 1982; Iwasaki & Kobayashi, 1987; Sato *et al.,* 1988; Kobayashi, 1990; Iwasaki *et al.,* 1996; Iwasaki, 2002 and Park & Lee, 2009). Morphological studies of dorsal surface and lingual papillae using scanning and transmission electron microscope have been done on various mammalian species, including primates (Kobayashi *et al.,* 2004; Jackowiak, 2006; Kulawik & Godynicki, 2007a, b) and rodents (Iida *et al.,* 1985; Meisel *et al.,* 1987; Kobayashi, 1990; Iwasaki *et al.,* 1999). In mammals, four different types of tongue papillae (fungiform, circumvallate, foliate and filiform) can be found on the dorsal surface (Emura *et al*., 2006). But the structure of the tongue reveal a variability of morphological features related to the type of food, habit, and taxonomy (Jackowiak& Godinicki, 2005; Okada & Schraufnagel, 2005).

Characteristic features of the tongue in rodents are the elongated body of the tongue and the presence of a prominence known as the "intermolar" prominence. The dorsal surface of the mucosa of the tongue is covered by lingual papillae, which frequently show species-specific traits in terms of number and structure, depending on feeding behavior and mastication mode. The tongue papillae with its taste buds found in humans and mammals are the receptors for the sensation of taste (Stinson & Calhoun, 1993).

The aim of our scanning electron observations of the dorsal surface of the tongue was to describe the distribution and structure of the lingual papillae in the field rat and to compare the results with data obtained from other rodent.

2. Material and Methods

The observations were conducted on 7 tongues of adult rat females and males. The tongues were dissected from the mandible, fixed in 10% neutral formaldehyde, and routinely prepared for observation under a scanning electron microscope .The samples of the tongue were dehydrated in a series of ethanol (70–99.8%) and acetone, and subsequently dried at the critical point using CO_2 (Critical Point Dryer K850, Emitech).The specimens were carefully mounted on aluminum stages with double-sided carbon tape, sputtered with 15 nm thick gold coat (Sputter Coater S 150B, Edwards) and observed under the scanning electron microscope JEOL (JSM-5400 LV) in Regional Centre of Mycology, Al-Azhar University, Cairo Egypt.

Other dissected tongue specimens were fixed in 10% neutral buffered formalin and routinely prepared for normal histological observation under light microscope.

3. Results

3.1. SEM observations:

The tongue of the rat is about 2.7 cm long and 3-4mm width. The tongue occupies 2/3 length of the mouth cavity. The tip of the tongue is broad with a deep median sulcus of 1–1.2 mm in length (Figs.1a,b). Three parts are distinguished in the dorsal surface of the tongue: the apex, the body with a prominence and the root (Fig.1). The surface of the lingual apex is

rough and has a thickly keratinized epithelium (Fig.1 c). The anterior margin of the prominence is semicircular and rises over the lingual body (Fig.1d). The surface of the posterior part of the intermolar prominence and the root of the tongue is gradually lowered towards the pharynx (Fig.1e).

Observation under the scanning electron microscope made it possible to distinguish four types of lingual papillae in the mucosa-cover dorsal surface of the tongue. The lingual papillae were: filiform, fungiform, circumvallate and foliate papillae (Figs. 2-5).

The filiform papillae were the most numerous type and densely distributed all over the dorsal surface of the tongue. They were categorized into three types according to their shape. Type one was mainly observed in the front and middle section. They were cone-shaped with acuminate ends, and no observable flap or process as spotted in other types (Fig.2a). They were mostly short and bulky cones. The largest conical papillae are in front of the prominence and on both sides of the sulcus, whereas on its lateral margins ,they gradually become smaller. Cylinder-like base characterized with fork-shaped processes on the rear part directed posteriorly was the basic form of the type two filiform papillae (Figs.2 c-d). The number of processes in fork-shaped filiform papillae varied, some having one process with plain triangular shape, some having two processes looking like forceps and some having three processes resembling the shape of forks (Figs.2 d ,e). The filiform papillae situated in the front section usually had one or two processes , and the ones in the rear had two or three processes. The length of the processes also varied. The ones in front and central area had relatively short and flat processes while those in the rear sides showed long , sharp-looking processes. Type three filiform papillae were only seen near the posterior end of the tongue between two circumvallate papillae as well as on the prominence. They were in the form of giant conical saw-like papillae (Fig.3c).

Fungiform papillae are dome-shaped and wider in diameter than filiform ones (Figs.3a,b). On the apex of the tongue the fungiform papillae are regularly scattered and densely populated between filiform papillae. While ,in the middle and posterior part of the tongue they were few (Fig.3a). They were also seen throughout the whole tongue except the middle area and the rear end. Fungiform papillae located in the front were relatively smaller than those found in the middle (Figs.1b,c).

Two circumvallate papillae were observed in the posterior region of the tongue. They were circular, large, and dough-nut-shaped papillae. In the center of the vallate papilla, a minute pore could be seen (Fig. 3d).

In the postero- lateral surfaces of the intermolar prominence, adjacent to the pharyngeal-palatine arch, 4–5 ridges of foliate papillae were situated bilaterally (Fig. 1e).

3.2. Light microscopy observations:

The filiform papillae were characterized histologicaly by a curved shape, a keratinized stratified epithelium bordered by a basal generative layer , and a dermal papilla consisting of connective tissue which protrude into the centre of the filiform papillae. In the submucosal connective tissue, striated muscles were adjacent to the basal layer of the epithelium (Fig. 4). The surface layer of the epithelium at the rostral side of the filiform papillae stained strongly with haematoxylin-eosin, whereas the epithelium at the caudal side stained less intensely (Fig. 4a). The epithelium in the areas in between the filiform papillae was multilayered and thick (Fig.4f),whereas, that cover fungiform, vallate and foliate papillae was stratified squamous highly keratinized epithelium (Figs.4 c-e).

4. Discussion

The light and scanning electron microscope revealed the characteristics of the lingual mucosa of rat. The observation revealed that the dorsum of the rat tongues is covered by various types of papillae. Tongue papillae are differ in shape, size, number, nomenclature and distribution among different groups (Schwenk, 1986; Iwasaki, 1990, 1992; Toubeau & Bels, 1994; Iwasaki *et al.,* 1996; Wassif & El-Hawary, 1998; Lemell *et al.,* 2000). These differences depend on dissimilarities in diet, feeding habits and handling of the food in the mouth (Iwasaki & Miyata, 1985; Pianka, 1986; Mohammed, 1987; Mohammed, 1992). Furthermore, most of the papillae are covered by stratified squamous epithelium that differed only in thickness and degree of keratinization (Schwenk, 1986; Mohammed, 1991 a & b ; 1992; Wassif & El-Hawary, 1998). This observation is in agreement with the present investigation .

The distribution of filiform papillae was almost the same as in other mammals and reptiles reported by several authors (Iwasaki *et al.,* 1987). In mammals, the smaller papillae were in the anterior and lateral border while the taller ones were situated in the torus lingual; this arrangement could help the complex mastication pressing food against the palate. These aspects were related by Nagato *et al.* (1989) and Iwasaki *et al.* (1996) in the mouse and Watanabe *et al.* (1997) in the *Calomys callosus*. However, these authors describe giant conical papillae in the place while we found filiform papillae like a fork . In this study, the conical shaped filiform papillae on the dorsal surface of the tongue were observed to be regularly and densely distributed and directed caudally, as reported in the ruminants (Kobayashi *et al.,* 2005; Kurtul & Atalgın, 2008). The different shapes of the filiform papillae, which changed gradually from the apex to the

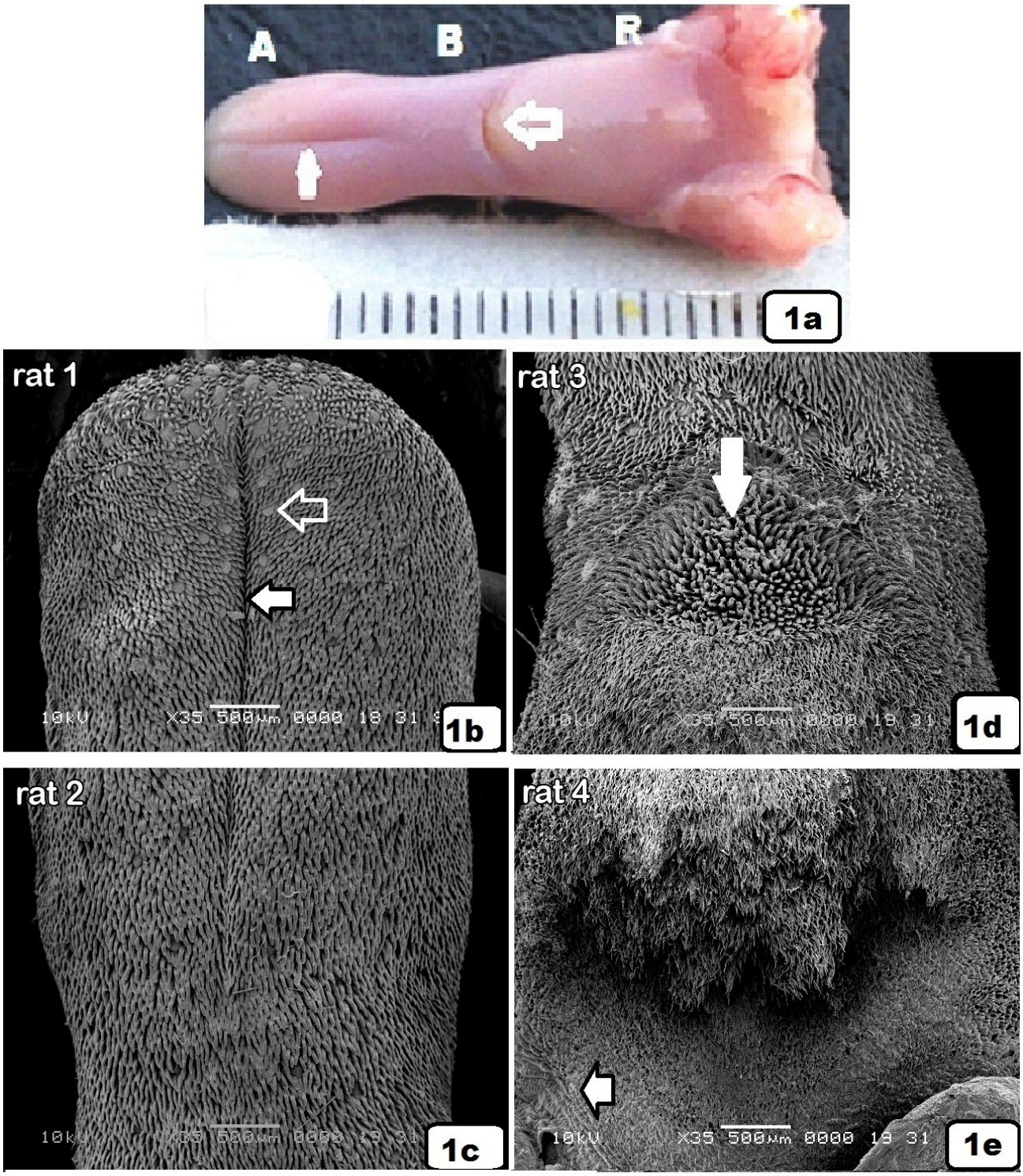

Fig. 1: photomicrograph (a), scanning electron micrograph(c-d) of the tongue of rat showing different anatomical regions: **a:** the apex (A) with the sulcus (solid arrow), the body(B) with the prominence(hollow arraw), and root (R). **b**: the apex with the sulcus (solid arrow) and fungiform papilla (hollow arrow). Scale bar=1µm. **c**: the body of the tongue showing extension of the sulcus on the slightly broad anterior end and more narrower posterior end with filiform papillae. Scale bar=1µm. **d:** the body showing the prominence (hollow arrow) covered by special type of filiform papillae. **e:** the root with its weakly developed foliate papillae (arrow). Scale bar=1µm.

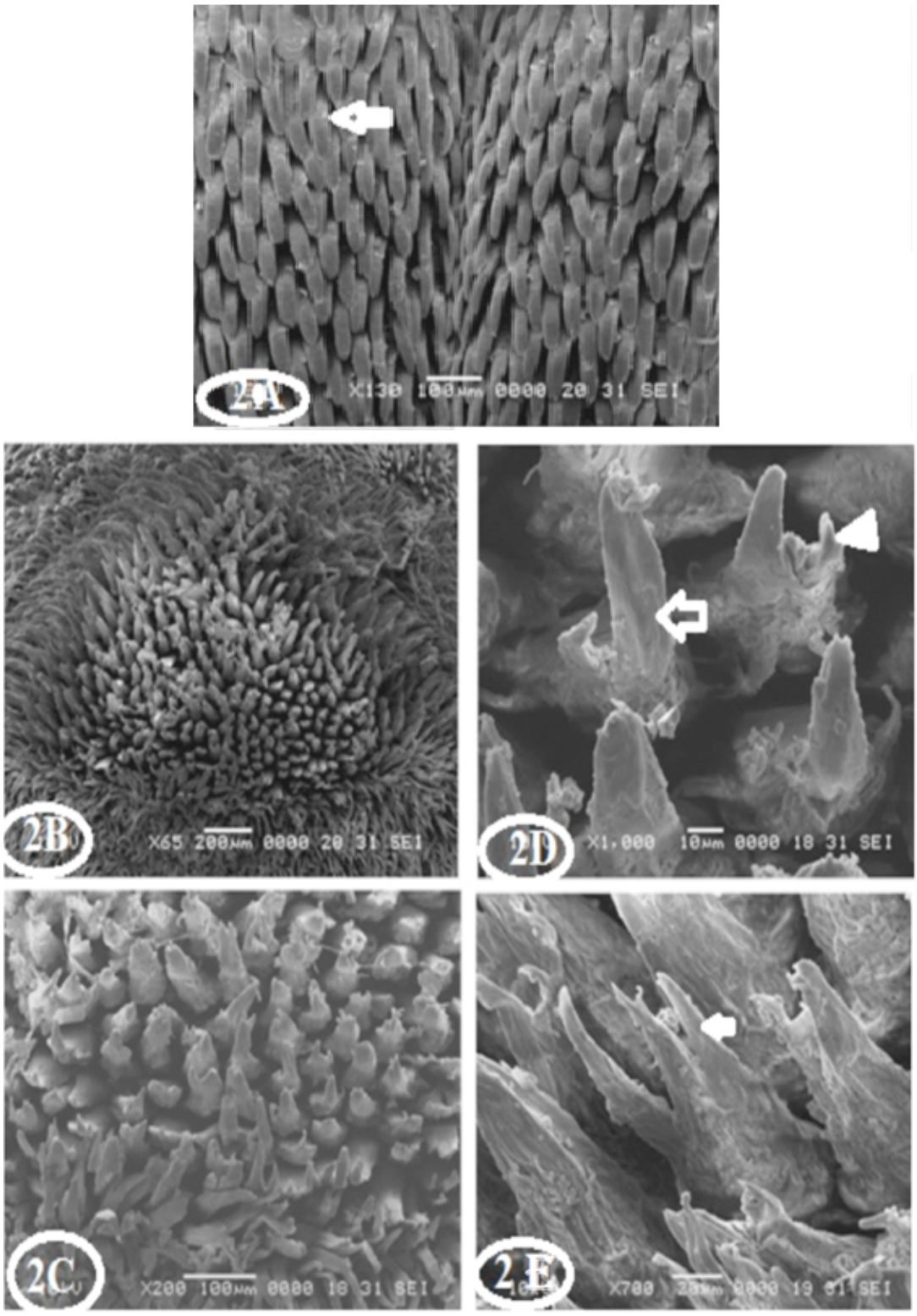

Fig. 2: Scanning electron micrograph of different shape filiform papillae. **a**: Cone-shaped filiform papillae with acuminate ends and no observable flap or processes extensively distributed around the sulcus Scale bar=100µm. **b** & **c**: Type 2 filiform papillae fork shaped processes on the rear and the prominence. Some having one process, other papillae looks like a forcep Scalebar=100µm. **d:** branched filiform papillae with two processes: pri. Scale bar=20µm ncipal (arrow) and accessory (arrowhead). Scale bar=10µm. **e**: three processes filiform papilla; one principal (arrow) and two accessory. Scale bar=20µm.

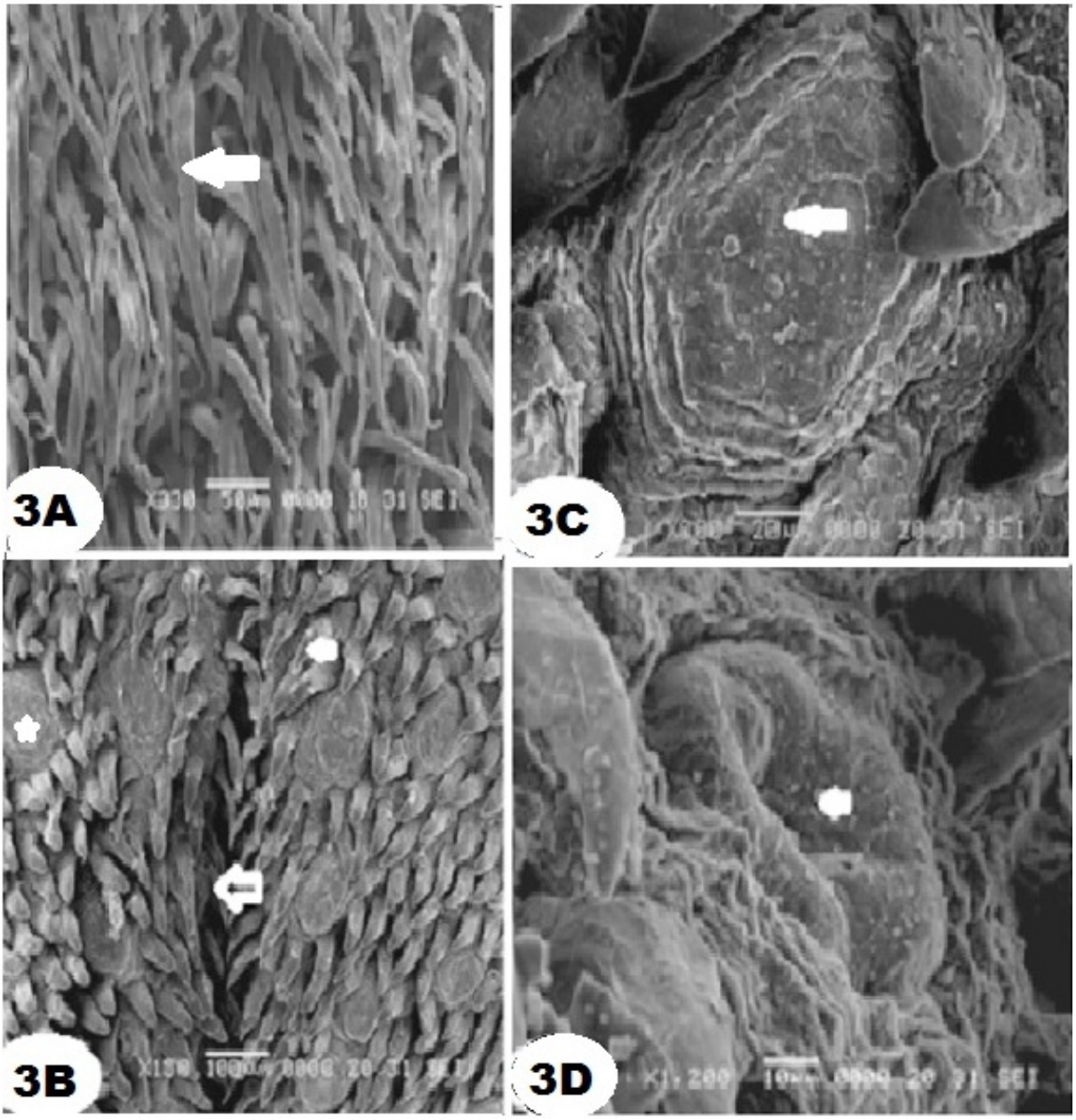

Fig. 3: Scanning electron micrograph of **a:** Saw-like filiform papilla with long sharp process (arrow) at the posterior end of the tongue as well as on the prominence and the root. Scale bar=50µm. **b:** Dome-shaped fungiform papillae (star) inbetween filiform ones (solid arrow) on the sides of the sulcus (hollow arrow). Scale bar=10µm. **c:** One mashroom-shaped fungiform papilla (arrow) with minute pores. Scale bar=20µm. **d:** Vallate papillae with central pore (arrow). Scale bar=20µm.

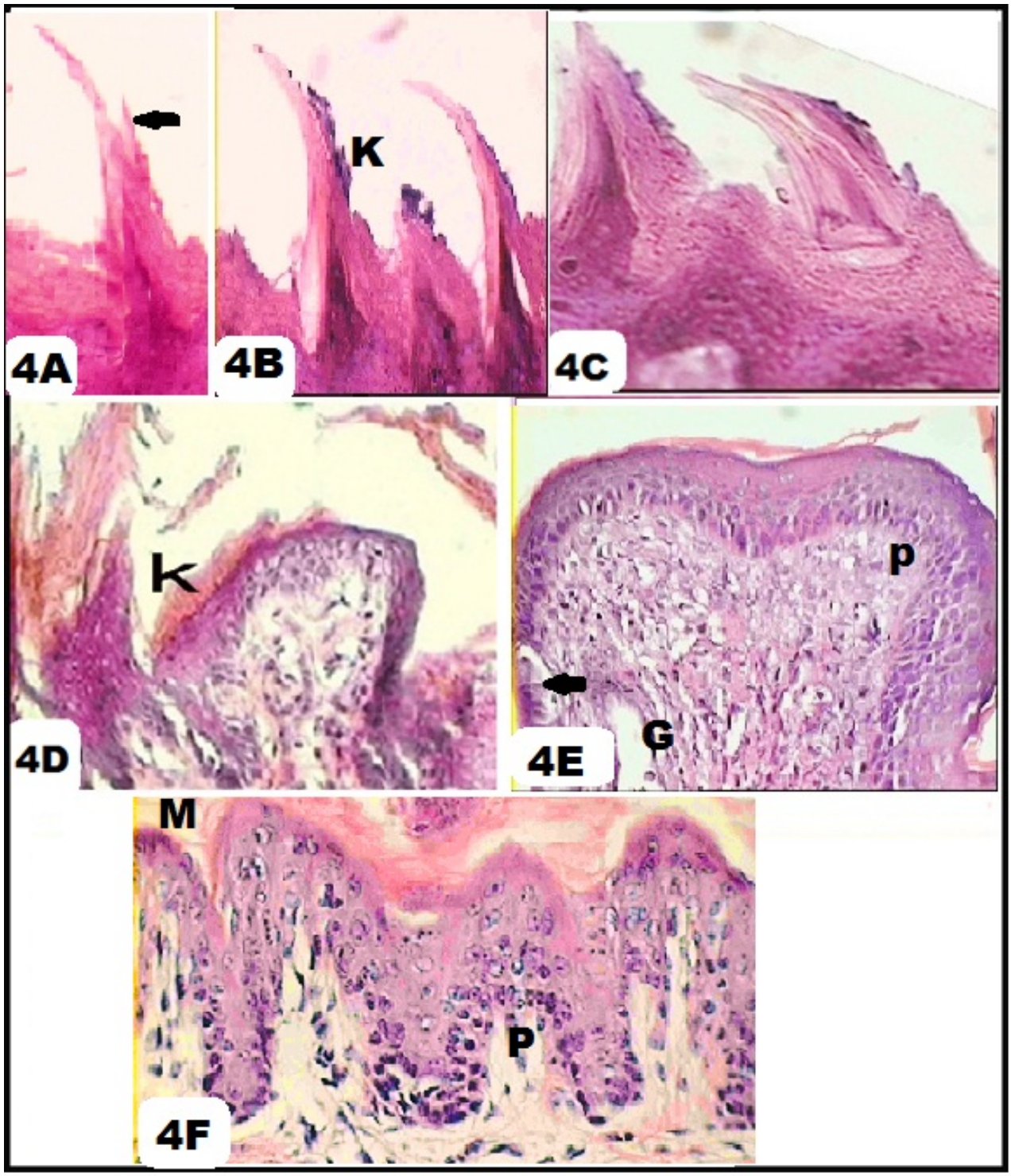

Fig. 4: a: H &E photomicrograph showing the fork shape filiform papilla with primary process and secondary (arrow) one. **b:** Saw-shaped filiform papilla with a layer of keratin (K). **c:** Cone-shaped filiform papillae appeared pended posteriorly. **d:** Fungiform papilla in-between two filiform papillae and covered by a thick layer of stratified squamous highly keratinized epithelium (K) and has a core of connective tissue. **e**: Circumvallate papilla with submucosal connective tissue core has dermal papilla (p), gland (G), and taste bud(arrow). **f:** five microredges of foliate papilla(m) covered with a thick layer of keratin and showing dermal papillae (P).

caudal part of the tongue, have also been observed by Iwasaki & Miyata (1990) in the mongoose. Filiform papillae, which are considered to have a mechanical function (Nickel, 1979); but Mistretta & Baum (1984) suggested the gustatory function of it. On the contrary, it forms the primary pathway for the transport of food come into contact with the palate during mastication and swallowing, thus the observed more intensive keratinized layer, which serves as a protective mechanism (Trzcielińska *et al.,* 2009). Filiform papilla provides the tongue with a rough surface suited for the movement and grinding of food Karan *et al.* (2010).

Fungiform papillae were localized in the anterior part of the tongue. They were elliptical or circular in shape embedded in between higher filiform papillae and bear taste buds. These characteristics were reported in guinea pigs (Kobayashi, 1990), in the *Paia gli*s (Kobayashi and Wanichanon, 1992), in the *Tragulus javanicus* (Agungpriyono *et al.,* 1995) and in rabbits (Ojima *et al.,* 1997).

Delheusy *et al.* (l994) mentioned that the role of these taste buds on the anterior papillae might be testing the palatability of the prey when contacts with the tongue occur during capture. In agamid lizard gustation may be used during mate selection (Mohammed, 1992). The presence of taste buds on the tongue tip and on the fore-tongue may play an important role in receiving chemical and mechanical information of food. Furthermore, papillae may considered as supporting structure for food uptake, mastication and swallowing. Mistretta and Liu (2006) suggested that gustatory papillae possess a receptor function

The characteristics of the fungiform papillae in the rat, being larger and distributed in abundance at the tip of the tongue, coincides with the reports on lesser mouse deer (Agungpriyono *et al.,* 1995).

The median sulcus of the apex tongue is a characteristic feature found in many rodents, although its length and width are species-specific (Jackowiak and Godynicki, 2005). The presence of a median lingual sulcus in the rostral and central parts of the rat is similar to findings in the guinea pig (Kobayashi, 1990), mouse (Iwasaki *et al.,* 1996), common quail (Parchami *et al.*, 2010) and blind mole rat (Kilinc *et al.,* 2010).

The presence of taste pores in the surface were described by Chamorro *et al.* (1986) in cows and horses and by Agungpriyono *et al.* (1995) in the *Tragulus javanicus* , in rabbit (Silva *et al.,* 2002).

The present study reveal the presence of foliate papillae in the rat tongue which were not well developed, but extremely small in the dog, rudimentary in the cat (Stinson & Calhoun, 1993) and completely absent in ruminants except cattles (Chamorro *et al.,* 1986).

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