Morphology of Lingual Papillae of Bear: 
Light Microscopic and SEM Study

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ABSTRACT

The morphology and histology of the tongue in two adult Asian bears were examined by light and scanning electron microscopy. Four types of papillae; filiform, conical, fungiform and vallate were observed on the dorsaum lingua. Numerous filiform papillae were visible on the lingual apex and body, while, fungiform papillae were scattered among them. The discoid-shaped fungiform papillae were more densely on the lingual apex. The filiform papillae were extended to the lateral margin of the lingual body. They were transformed into the conical papillae on the caudal part of the lingual body and root. Totally, 14-16 of spheroid and oval vallate papillae at different sizes were present on the root of the tongue. The foliate papillae were absent. Histological sections showed that the conical papillae represented a flat pyramidal shape with several slender accessory processes. The tongue was covered by a keratinized stratified squamous epithelium. A dense connective tissue composed the lamina propria and thick masses of striated muscles constituted the bulk of the tongue. The lamina propria didn’t penetrate completely into the filiform papillae of the lateral margin. Numerous forms of lingual salivary glands with seromucous secretions were intermingled with the lingual muscles in the lingual root.

INTRODUCTION

The tongue is a principle organ, has a direct functional role in the prehension, mastication, and swallowing of food and indirect effect in helping the animal to adapt to its environment (Darwish, 2012). The anatomical and morphological features of the tongue are determined by the feeding habits of a given animal species and habitat in which animal lives (McClung and Goldberg, 2000; Schwenk, 2000; Iwasaki, 2002; Darwish, 2012).

Lingual papillae, distributed on the dorsal surface of the tongue, are the most important features that can be investigated from an anatomical point of view. Generally, there are four types of lingual papillae on the dorsal lingual surface of mammalian species namely; filiform, fungiform, vallate and foliate papillae (Kobayashi et al., 1989). However, the shape, size, organization and presence of these papillae can be different among mammalian species (Jackowiak and Godinicki, 2005; Witt and Miller, 1992; Emura et al., 2000). For instance, foliate papillae are seen usually in equine species and lenticular papillae are a distinct feature of ruminant species (Goodarzi and Shahhoseini, 2015).

The tongue of various species of the order Carnivora such as cat (Boshel et al., 1982), dog (Iwasaki and Sakata, 1985), Bush dog (Emura et al., 2000), tiger (Emura et al., 2004), lion (Emura et al., 2003) and silver fox (Jackowiak and Godinicki, 2004) were subjected to anatomical
inspection.

The purpose of the present study was to examine the macroscopic and microscopic morphology of the lingual papillae of the bear and compare the results with those previously reported in other species.

**MATERIALS AND METHODS**

**Sampling**

The specimens of the present study were provided from two male individuals that were collected after dying due to shooting by hunters. The animals were found in a poor physical condition and referred to the Faculty of Veterinary Medicine, Razi University. The cooperation of Natural Resources Organization of the Kermanshah city is highly appreciated. Immediately after dying, the whole tongue was dissected and removed from the oral cavity and fixed in 10% neutral buffered formaldehyde.

**Gross examination**

For macroscopic observations, the tongues were examined using a stereomicroscope (UNICO, ZM191, USA) connected to a digital camera (Dinocapture V.2) and anatomical features on the dorsal surface of the tongues were photographed.

**SEM examination**

For scanning electron microscopy, the tongues were fixed in 2.5% glutaraldehyde for 48 h. The samples were then post-fixed with 1% osmium tetroxide solution. After dehydration in ascending concentrations of ethanol, the specimens were dried in a freeze dryer, mounted on the aluminum stubs and coated with gold. Finally, the specimens were examined under a scanning electron microscope (Quanta 450, FEI, USA) at accelerating voltages of 15 kV (Goodarzi, 2014).

**Light microscopy**

Following immediate dissection, the tongues were fixed in 10% neutral buffer formaldehyde for two weeks. Afterwards, the 1×1 cm specimens were removed from the apex, body and root and were processed and embedded in paraffin for light microscopic observations. The paraffin-embedded blocks were sectioned at 5µm thickness and stained with Masson’s trichrome method (Goodarzi et al., 2019).

**RESULTS**

In macroscopic observation, the filiform papillae covered the dorsal surface of the lingual apex and lingual body, while, fungiform papillae were scattered among them (Fig. 1a). The discoid-shaped fungiform papillae were more densely on the tip of the lingual apex. The filiform papillae were extended to the lateral margin of the lingual body (Fig. 2a). The filiform papillae were transformed into the conical papillae on the caudal part of the lingual body and lingual root (Fig. 3a). Totally, 14-16 of spheroid and oval vallate papillae at different sizes were present posteriorly on the root of the tongue (Fig. 4a). There were no foliate papillae on the lingual root. In SEM examination, the dorsal surface of the lingual apex was covered with numerous long and slender filiform papillae which their sharp tips directed caudally (Fig. 1b, 1c). The discoid fungiform papillae were scattered among the filiform papillae mainly on the lingual apex (Fig. 1b). At higher magnification, some taste pores could be seen between the shingle-like flattened cells of a stratified squamous epithelium covered the surface (Fig. 1b). The lateral surface of the tongue was covered with caudally-directed filiform papillae (Fig. 2b). The conical papillae on the lingual body were represented by a flat pyramidal shape with several slender accessory processes (Fig. 3b). On the lingual root, the body of the vallate papillae was encircled by a wide continuous gustatory groove and a thick annular pad of the lingual mucosa. The dorsal surface of the vallate papillae was highly irregular which appears to be lobulated and epithelial lining revealed irregular micropapillae (Fig. 4b, 4c).

Fig. 1. Light microscopical (a), scanning electron microscopic structure (b, c), and structure of the dorsal surface of the tongue of bear (d). Fup, fungiform papillae; red arrows, taste pores; Fip, filiform papillae; Lp, lamina propria; SM, striated muscles; yellow rectangles magnify the fungiform and filiform papillae in (b) and (c), respectively.
Light microscopic evaluation showed that the tongue was covered by a keratinized stratified squamous epithelium. A dense connective tissue composed the lamina propria and thick masses of striated muscles constituted the bulk of the tongue (Fig. 1d). The lamina propria didn’t penetrate completely into the filiform papillae of the lateral border (Fig. 2c). Some lingual gland were present in the lamina propria of the vallate papillae (Fig. 4d). Furthermore, numerous lingual salivary glands with seromucous appearance were intermingled with the lingual muscles in the lingual root (Fig. 4e).

**DISCUSSION**

The lingual prominence presents in many species such as rodents (Ciena et al., 2013; Kilinc et al., 2010) and ruminants (Zheng and Kobayashi, 2006), while it was not seen in carnivores and Pigs (Emura et al., 2006; Kumar and Bate, 2004). In general, lingual prominence is a characteristic feature of many herbivorous mammals which helps them to cellulose-rich materials against hard palate (Massoud and Abumandour, 2019). The tongue of the bear has no lingual prominence nor median sulcus.

Due to difference in feeding habits, diet, and handling of food inside the buccal cavity, the lingual papillae might be varied among species in their shape, size, number, orientation and distribution (Iwasaki, 1992; Iwasaki et al., 1996; Abumandour and El-Bakary, 2013; Emura et al., 2002).

In the present study, four types of lingual papillae were found on the lingual mucosa of the bear tongue. Two of them were mechanical type and represented by filiform and conical forms, while the other two represented the gustatory papillae which were fungiform and vallate papillae. Numerous types of the filiform papillae can be seen among mammalian species. Moreover, different shapes of filiform papillae may be present according to their location on the lingual mucosa (Yoshimura et al., 2009). Three types in rats and mice (Iwasaki et al., 1987a, b), and six types of filiform papillae in Egyptian fruit bat were reported previously (Abumandour and El-Bakary, 2013).

Emura et al. (2001) reported smooth finger-like projections as filiform papillae on the margin of the lingual apex of newborn Asian black bear, while, they were bud-shaped on the lingual body. In the present study, the filiform papillae had a long and slender appearance with caudally-directed sharp tips. These observations were similar to those reported in the tiger (Emura et al., 2004), fishing cat (Emura et al., 2014), raccoon dog and fox (Emura et al., 2006). The shape and number of the papillae showed a marked change from the lingual apex toward the lingual body. This finding is consistent with the observations in the cat (Bushell et al., 1982), newborn panther (Emura et al., 2001), and lion (Emura et al., 2003). The lingual papillae on the mid-portion of the tongue of the bear were
conical with several accessory processes, similar to those reported in the raccoon dog and fox (Emura et al., 2006).

The fungiform papillae can be different in their shape and distribution among mammalian species. The shape of the fungiform papillae has a wide variety of rectangle in Egyptian fruit bat (Abumandour and El-Bakary, 2013), dome-shape in dog and fox (Emura et al., 2006), Mushroom-shape in the rat (Nasr et al., 2012; Kurtul and Atalgin, 2008) and elliptical or circular in Sorex caecutiens (Park and Lee, 2009). Two types of fungiform papillae including hemispherical and club-shaped papillae were reported in the newborn black Asian bear (Emura et al., 2001), tiger (Emura et al., 2004) and jaguar (Emura et al., 2013). The fungiform papillae of the present study had a discoid shape and the existence of taste pores on the apical periphery of the papillae suggest that they have a gustatory role as revealed in other species (Kilinc et al., 2010; Chamorro et al., 1986; Goodarzi, 2014).

The fungiform papillae in the guinea pig (Kobayashi, 1990), goat (Kurtul and Atalgin, 2008), Persian squirrel (Goodarzi, 2014) and maned sloth (Benetti et al., 2009) are reported to be concentrated on the lingual apex and also on both lateral borders. However, fungiform papillae in the common shrew are restricted to the lingual corpus (Jackowiak et al., 2004). Nasr (2012) reported that fungiform papillae of Erinaceous auritus are populated on the apex of the tongue and form clusters of two or three papillae. The fungiform papillae of the bear were scattered on the dorsi lingua with a more population on the tip of the lingual apex.

The vallate papillae can be and absent in Cape hyrax (Emura et al., 2008) and hematophagous bats (Masuko et al., 2007), one in mouse, rat and hamster. (Kobayashi et al., 1989; Iwasaki et al., 1997), two in rabbit, guinea pig and opossum (Kulawik and Godynicki, 2007; Kobayashi, 1990; Krause and Cutts, 1982), three in common tree shrew, flying squirrel, Persian squirrel, American beaver and Egyptian fruit bat (Chunhabundit et al., 1992; Goodarzi, 2014; Abumandour and El-Bakary, 2013). 3–6 in the dog and cat (Boshell et al., 1982; Kobayashi et al., 1988) five in the bush dog (Emura et al., 2000) 10 in panther, 5-9 in the lion (Emura et al., 2003) and 4 papillae in the tiger (Emura et al., 2004). Conclusively, many species-specific characteristics in the morphology of the vallate papillae has been shown. For instance, small conical and filiform projection on the dorsal surface of the papillae in bush dog donkey (Emura et al., 2000) and multiple secondary papillae in giant panda (Pastor et al., 2008) were reported.

In this study, the bear showed 14-16 vallate papillae which were more than that was reported by Emura et al. (2001) in the newborn Asian black bear (7-8 papillae). The structure of the vallate papillae can be varied. The vallate papillae of the jaguar were surrounded by a discontinuous annular pad and a very shallow groove (Emura et al., 2013), while in the newborn Asian black bear (Emura et al., 2001) and equine (Chamorro et al., 1986) the vallate papillae were composed of a primary papilla which was divided into several secondary papillae by intermediate grooves.

In the tiger, the vallate papillae had an irregular surface with the openings of glandular ducts (Emura et al., 2004). Although observation of the this work such as the presence of lingual salivary glands in the connective tissue of the vallate papillae and opening of glandular ducts on the dorsal surface of this papillae indicated similarity between the tiger and bear, however, the structure of the vallate papillae in the bear was similar to that of the panther reported by Emura et al. (2001).

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Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Abumandour, M.A. and El-Bakary, R.M.A., 2013. Morphological and scanning electron microscopic studies of the tongue of the Egyptian fruit bat (Rousettus aegyptiacus) and their lingual adaptation for its feeding habits. Vet. Res. Commun., 37: 229-238. https://doi.org/10.1007/s11259-013-9567-9

Benetti, E.J., Picoli, L.C., Guimaraes, J.P., Motoyama, A.A., Miglino, M.A. and Watanabe, L.S., 2009. Characteristics of filiform, fungiform and vallate papillae and surface of interface tongue mucosa (Bradyus torquatus): Light and scanning electron microscopy study. Anat. Histol. Embryol., 38: 42-48. https://doi.org/10.1111/j.1439-0264.2008.00890.x

Boshell, J.L., Wilborn, W.H. and Singh, B.B., 1982. Filiform papillae of cat tongue. Acta Anat., 114: 99–105. https://doi.org/10.1159/000145583

Chamorro, C.A., De Paz, C.P., Sandoval, J. and Fernandez, J.G., 1986. Comparative scanning electron microscopic study of the lingual papillae in two species of domestic mammals (Equus caballus and Bos taurus) I. Gustatory papillae. Acta Anat., 125: 83-87. https://doi.org/10.1159/000146141

Chunhabundit, P., Thongpila, S. and Somana, R., 1992.
SEM study on the dorsal lingual surface of the common tree shrew, *Tupaia glis*. *Acta Anat.*, **143**: 253–257. https://doi.org/10.1159/000147257

Ciena, A.P., de Sousa Bolina, C., de Almeida, S.R., Grassi, R.E., Oliviera, M.F., Pereira da Silva, M.C., Miglino, M.A. and Watanabe, L.S., 2013. Structural and ultrastructural features of the agouti tongue (*Dasyprocta aguti* Linnaeus, 1766). *J. Anat.*, **223**: 152–158. https://doi.org/10.1111/joa.12065

Darwish, S.T., 2012. Comparative histological and ultrastructural study of the tongue in *Ptyodactylus guttatus* and *Stenodactylus petrii* (Lacertilia, Gekkonidae). *J. Am. Sci.*, **8**: 603-612.

Emura, S., Tamada, A., Hayakawa, D., Chen, H. and Shoumura, S., 2000. Morphology of the dorsal lingual papillae in the bush dog (*Speothos venaticus*). *Okajimas Folia Anat. Jpn.*, **77**: 137–142. https://doi.org/10.2535/ofaj1936.77.5_137

Emura, S., Tamada, A., Hayakawa, D., Chen, H. and Shoumura, S., 2001. Morphology of the dorsal lingual papillae in the newborn panther and asian black bear. *Okajimas Folia Anat Jpn.*, **78**: 173-178. https://doi.org/10.2535/ofaj1936.78.5_173

Emura, S., Hayakawa, D., Chen, H. and Shoumura, S. and Atoji, Y. and Wijayanto, H., 2002. SEM study on the dorsal lingual surface of the large flying fox, *pteropus vampyrrus*. *Okajimas Folia Anat. Jpn.*, **79**: 113-119. https://doi.org/10.2535/ofaj1936.78.5_113

Emura, S., Hayakawa, D., Chen, H. and Shoumura, S., 2003. SEM and gross study on the lingual surface of the lion (*Panthera leo*) in Japanes. *Mammal. Sci.*, **43**: 45-50.

Emura, S., Hayakawa, D., Chen, H. and Shoumura, S., 2004. Morphology of the lingual papillae of the tiger. *Okajimas Folia Anat. Jpn.*, **81**: 39-44. https://doi.org/10.2535/ofaj1936.81.39

Emura, S., Okumura, T., Chen, H. and Shoumura, S., 2006. Morphology of the lingual papillae in the raccoon dog and fox. *Okajimas Folia Anat. Jpn.*, **83**: 73-76. https://doi.org/10.2535/ofaj83.73

Emura, S., Okumura, T. and Chen, H., 2008. Morphology of the lingual papillae and their connective tissue cores in the Cape Hyrax. *Okajimas. Folia. Anat. Jpn.*, **85**:29-34.

Emura, S., Okumura, T. and Chen, H., 2013. Morphology of the lingual papillae in the jaguar. *Okajimas Folia Anat. Jpn.*, **89**: 93–97. https://doi.org/10.2535/ofaj89.93

Emura, S., Okumura, T. and Chen, H., 2014. Morphology of the lingual papillae in the fishing cat. *Okajimas. Folia. Anat. Jpn.*, **90**: 79–83.

Goodarzi, N. and Shah-Hoseini, T., 2015. Fine structure of lingual papillae in the markhoz goat (Iranian Angora): A scanning electron microscopic study. *Int. J. Zool. Res.*, **11**: 160-168. https://doi.org/10.3923/ijzr.2015.160.168

Goodarzi, N., 2014. Electron microscope structure of dorsal lingual epithelium of Persian squirrel *Sciurus anomalus*. *Online J. vet. Res.*, **18**: 132-144.

Goodarzi, N., Akbari Bazm, M., Naseri, L. and Hosseinipour, M., 2019. Histomorphometrical and stereological study of the esophagus in the adult male Persian squirrel (Sciurus anomalus). *Anat. Histol., Embryol.*, **48**: 444-448. https://doi.org/10.1111/ah.12465

Iwasaki, S. and Miyata, K., 1989. Fine structure of the filiform papilla of beagle dogs. *J. Morphol.*, **201**: 235–242. https://doi.org/10.1002/jmor.1052010303

Iwasaki, S. and Sakata, K., 1985. Scanning electron microscopy of the lingual dorsal surface of the beagle dog. *Okajimas. Folia Anat. Jpn.*, **62**: 1-13. https://doi.org/10.2535/ofaj1936.62.1_1

Iwasaki, S., 1992. Examination of the Dorsal Lingual Surface of the Crab-eating Monkey Macaca irus by Scanning Electron Microscope. *J. Mammal. Soc. Jpn.*, **17**: 49- 57.

Iwasaki, S., 2002. Evolution of the structure and function of the vertebrate tongue. *J. Anat.*, **201**: 1-13. https://doi.org/10.1046/j.1469-7580.2002.00073.x

Iwasaki, S., Miyata, K. and Kobayashi, K., 1987. Comparative studies of the dorsal surface the tongue in three mammalian species by scanning electron microscopy. *Acta Anat.*, **128**: 140-146. https://doi.org/10.1159/000146330

Iwasaki, S., Miyata, K. and Kobayashi, K., 1987b. The surface structure of the dorsal epithelium of tongue in the mouse. *Acta Anat. Nipp.*, **62**: 69-76.

Iwasaki, S., Yoshizaw, H. and Kawahara, I., 1996. Study by scanning electron microscopy of the morphogenesis of three types of lingual papilla in the mouse. *Acta Anat.*, **157**: 41-52. https://doi.org/10.1159/000147865

Iwasaki, S., Yoshizawa, H. and Kawahara I., 1997. Study by scanning electron microscopy of the morphogenesis of three types of lingual papilla in the mouse. *Acta Anat.*, **157**: 41-52. https://doi.org/10.1159/000147865
microscopy of lingual papillae in the common shrew, *Sorex araneus*, L. Anat. Histol. Embryol., 33: 290-293. https://doi.org/10.1111/j.1439-0264.2004.00551.x

Kilinc, M., Erdogan, S., Ketani, S. and Ketan, M.A., 2010. Morphological study by scanning electron microscopy of the lingual papillae in the Middle East blind mole rat (*Spalax ehrenbergi*, Nehring, 1898). Anat. Histol. Embryol., 39: 509–515. https://doi.org/10.1111/j.1439-0264.2010.01022.x

Kobayashi, K., 1990. Three-dimensional architecture of the connective tissue core of the lingual papillae in the guinea pig. Anat Embryol., 182: 205–213. https://doi.org/10.1007/BF00185514

Kobayashi, K., Miyata, K., Iwasaki, S. and Takahashi, K., 1988. Three dimensional structure of the connective tissue papillae of cat lingual papillae. Jpn. J. Oral. Biol., 30: 719–731. https://doi.org/10.2330/joralbiosci1965.30.719

Kobayashi, K., Miyata, K., Iwasaki, S. and Takahashi, K., 1989. Three dimensional architecture of the connective tissue papillae of the mouse tongue as viewed by scanning electron microscopy. Kaibogaku zasshi., 64: 523–538.

Krause, W.J. and Cutts, J.H., 1982. Morphological observations on the papillae of the opossum tongue. Acta Anat., 113: 159–168. https://doi.org/10.1159/000145551

Kulawik, M. and Godynicki, S., 2007. Fungiform papillae of the tongue in the rabbit (*Oryctolagus cuniculus*). Polish J. vet. Sci., 10: 25–27.

Kumar, S. and Bate, L.A., 2004. Scanning electron microscopy of the tongue papillae in the pig (*Sus scrofa*). Microsc. Res. Tech., 63: 253–258. https://doi.org/10.1002/jemt.20036

Kurtul, I. and Atalgin, S.H., 2008. Scanning electron microscopic study on the structure of the lingual papillae of the Saanen goat. Small Rum. Res., 80: 52-56. https://doi.org/10.1016/j.smallrumres.2008.09.003

Massoud, D. and Abumandour, M.M.A., 2019. Descriptive studies on the tongue of two micro-mammals inhabiting the Egyptian fauna; the Nile grass rat (*Arvicanthis niloticus*) and the Egyptian long-eared hedgehog (*Hemiechinus auritus*). Microsc. Res. Tech., 82: 1584–1592. https://doi.org/10.1002/jemt.23324

Masuko, T.S., Boaro, N., König-Jünior, B., Cabral, R.H. and Costa-Neto, J.M., 2007. Comparative scanning electron microscopic study of the lingual papillae in three species of bats (*Carollia perspicillata*, *Glossophaga soricina* and *Desmodus rotundus*). Microsc. Microanal., 13: 280-281.

McClung, J.R. and Goldberg, S.J., 2000. Functional anatomy of the hypoglossal innervated muscles of the rat tongue: A model for elongation and protrusion of the mammalian tongue. Anat. Rec., 260: 378-386. https://doi.org/10.1002/1097-0185 (20001201)260:4<378::AID-AR70>3.0.CO;2-A

Nasr, E., 2012. Surface Morphological structure of the tongue of the hedgehog, *Hemiechinus auritus* (Insectivora: Erinaceidae). J. Am. Sci., 8: 580-588.

Nasr, E., Gamal, A. and Elsheikh, E., 2012. Light and scanning electron microscopic study of the dorsal lingual papillae of the rat *Arvicanthis niloticus* (Muridae, Rodentia). J. Am. Sci., 8: 619-627.

Pastor, J.F., Barbosa, M. and De Paz, F.J., 2008. Morphological study of the lingual papillae of the giant panda (*Ailuropoda melanoleuca*) by scanning electron microscopy. J. Anat., 212: 99–105. https://doi.org/10.1111/j.1469-7580.2008.00850.x

Schwenk, K., 2000. *Feeding: Form, function and evolution in tetrapod vertebrates*. Academic Press, San Diego, CA, pp. 175-291. https://doi.org/10.1016/B978-012632590-4/50009-5

Witt, M. and Miller Jr, I.J., 1992. Comparative lectinhistochemistry on taste buds in foliate, circumvallate and fungiform papillae of the rabbit tongue. Histochemistry, 98: 173-182. https://doi.org/10.1007/BF00315876

Yoshimura, K., Shindo, J. and Kageyama, I., 2009. Light and scanning electron microscopic study on the tongue and lingual papillae of the Japanese badgers, *Meles meles* anakuma. Okajimas Folia Anat. Jpn., 85: 119–127. https://doi.org/10.2535/efaj.85.119

Zheng, J.H. and Kobayashi, K., 2006. Comparative morphological study on the lingual papillae and their connective tissue cores (CTC) in reeves’ muntjac deer (*Muntiacus reevesi*). Annls Anat., 188: 555–564. https://doi.org/10.1016/j.aanat.2006.05.014