Journal of Animal and Veterinary Advances 10 (15): 1906-1913, 2011
ISSN: 1680-5593

Light and Scanning Electron Microscopic Study of the Dorsal Lingual Papillae of the Goitered Gazelle (*Gazelle subgutturosa*)

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Abstract: The morphology of the dorsal lingual papillae of the adult Goitered gazelle was examined by scanning electron microscopy and light microscopy. On the dorsal surface of the lingual mucosa, three types of mechanical papillae and two types of gustatory papillae were observed. Numerous filiform papillae covered the entire surface of the lingual apex and body except for the lingual torus of the dorsal lingual surface. The structure and size of filiform papillae vary in the apex and body parts of the tongue. Two types of lenticular papillae were observed including rounded type papillae in the anterior median portion and half-cut pyramid shaped papillae in the posterior median portion of the lingual torus. Conical papillae were distributed on all parts of the lingual torus excluding the median plane and were also observed on the root of the tongue. Fungiform papillae, dispersed the lingual apex and body and the lateral sides of the lingual torus, display regional variation in structure and size. The smaller papillae on the lingual apex and body were mainly located along the sides of the tongue among filiform papillae while the larger papillae on the lateral and posterior parts of the lingual torus were located among conical papillae and had a convex surface. Large fungiform papillae lacked taste buds. The number of vallate papillae was 26 in the caudolateral region of the lingual torus. These papillae were observed to have a compact structure and to possess shallow grooves. No foliate papillae were seen on the dorsal surface.

Key words: Dorsal lingual papillae, goitered gazelle, light microscopy, scanning electron microscopy, tongue, taste buds

INTRODUCTION

The lingual mucosa of animals presents a highly differentiated papillary system with mechanical and gustatory functions. Yet, the structure of the mammalian tongue has evolved for specialized functions and the papillae present on the lingual surfaces tell about the animal's diet, habit and taxonomy (Iwasaki, 2002).

Ruminantsare considered to be the most advanced artiodactyls and they are certainly the most numerous and widespread of the world's modern-day ungulate fauna. Their great success is due to a very specialized digestive tract which allows these ungulates to thrive on relatively poor vegetation. So much research has been published on the three-dimensional structure of the lingual surfaces of the ruminant tongue (Tadjalli and Pazhoomand, 2004). Several studies have been conducted on the tongue of the lamb (Tadjalli and Pazhoomand, 2004), Barbary sheep (Emura *et al*., 2000), Bighorn sheep (Takayuki *et al*., 2002), goat (Kumar *et al*., 1998; Kurtul and Atalgin, 2008), Blackbuck (Emura *et al*., 1999), lesser mouse deer (Agungpriyono *et al*., 1995), Reeves muntjac deer (Zheng and Kobayashi, 2006), Formosan serow (Atoji *et al*., 1998), Japanese serow (Funato *et al*., 1985; Takayuki *et al*., 2002), cow (Chamorro *et al*., 1986; Cabello *et al*., 1988; Steflik *et al*., 1983), buffalo and camel (Eerdunchaolu *et al*., 2001; Qayyum *et al*., 1988).

Goitered gazelles were formerly widespread from the Arabian Peninsula to southern Mongolia. In their natural habitat, they most commonly eat grasses, halophytes, composites, legumes, caltrops, ephedras, borages, gourds, leadwort and tamarisks. In agricultural areas, goitered gazelles eat fruits or shoots of barley, chick peas, cotton, dates, maize, melons, onions, sugar cane and wheat (Kingswood and Blank, 1996). The present study was aimed at the investigation of the dorsal lingual papillae of the goitered gazelle which belongs to sthe Ruminantia suborder, Bovidae superfamily and

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Antilopinae subfamily by light and scanning electron microscopy and the establishment of morphostructural differences with other ruminant species.

MATERIALS AND METHODS

The tongues of 3 males 3-4 years old gazelles obtained from the Ceylanpinar State Farm constituted the material of the study. Firstly, the tongues were washed in physiological saline. Tissue specimens taken from the apex, body, root and torus regions of the dorsal lingual surface for light microscopy were fixed in 10% formaldehyde solution and subjected to routine histological processing before being embedded in paraffin wax. The resultant blocks were cut into sections 6 μm thick and were applied Mallory's modified trichrome staining technique to determine the histological structure of the papillae. The sections were examined under light microscope (B X 51, Olympus, Japan) and photographed with a digital camera system (DP71, Olympus, Japan). Specimens taken from the same regions for scanning electron microscopy were fixed in FAA fixative (85% Ethanol-10% Formalin-5% Acetic acid). The tissue specimens were dehydrated through a series of graded alcohol, chemically dried in Hexamethyl-Disilazane (HMDS) (Braet *et al*., 1997) and observed under scanning electron microscope (EVO50, ZEISS, Germany).

RESULTS AND DISCUSSION

The tongue of the goitered gazelle measured approximately 12 cm in length. It could be divided into three regions, the apex linguae (tip), corpus linguae (body) and the radix linguae (root). It showed a sulcus medianus linguale (median dorsal groove) on the apex linguae and well-developed torus linguae on the posterior portion of the dorsal surface of the tongue on which large lenticular and conical papillae are distributed (Fig. 1a). At the posterior portion of the tongue, several vallate papillae are distributed on both sides of the lingual torus. Fungiform papillae were distributed on the lingual apex and body and along the lateral surface of the lingual torus (Fig. 1b).

Filiform papillae: Numerous filiform papillae were distributed on the dorsal surface of the apex and body of the tongue. Due to the presence of centrally located longitudinal grooves running from the basal to the apical region, these papillae were shovel-like in shape and their surface was covered with microplicae. The height of these shovel-like shaped papillae was 180-200 μm in the apex region (Fig. 2a) and 450-500 μm in the body region of the tongue (Fig. 2b). The tips of the filiform papillae which

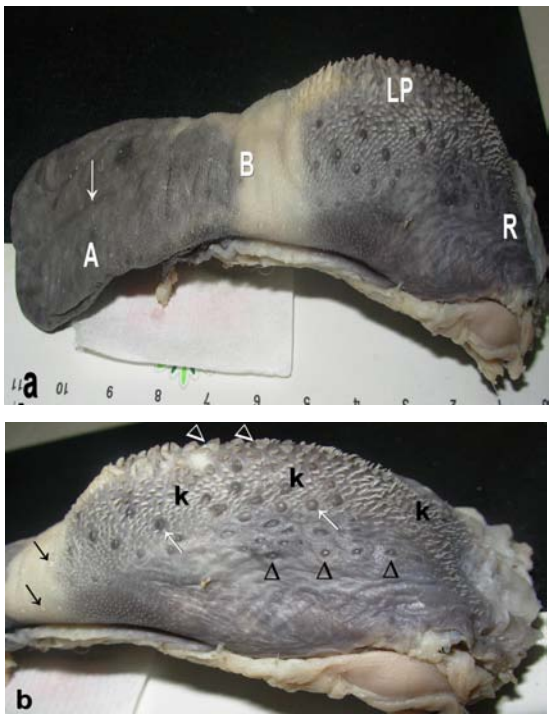

Fig. 1: a) Dorso-lateral view of a Goitered gazelle tongue. A: Apex, B: Body, R: Root, LP: Lingual torus, arrow: median groove; b) Caudo-lateral view of Goitered gazelle tongue. Note the presence of numerous vallate papillae (black arrowheads) on the posterior lateral tongue. Black arrows: The fungiform papillae on the body of the tongue, white arrows: The fungiform papillae on the lingual torus of the tongue, white arrowheads: The lenticular papillae on the median lingual torus, k: conical papillae

were distributed on the apex linguae, displayed 3-6 sharp-pointed, thread-like projections (Fig. 2a). Those that were distributed on the body generally had two sharp-pointed projections which stemmed bilaterally from the main body. The projections at the conically shaped free end were determined to shorten and become blunt. One and occasionally two very small secondary papillary projections were determined to grow from the base of some of these papillae (Fig. 2b). Light microscopic examination revealed the projections of filiform papillae to form keratin spines which were distributed along the surface of the epithelial layer. It was determined that filiform papillae were supported by a connective tissue core (Fig. 2c and d).

Fungiform papillae: Two types of fungiform papillae were distinguished according to their localization in the goitered gazelle. The first type included small (240-300 μ

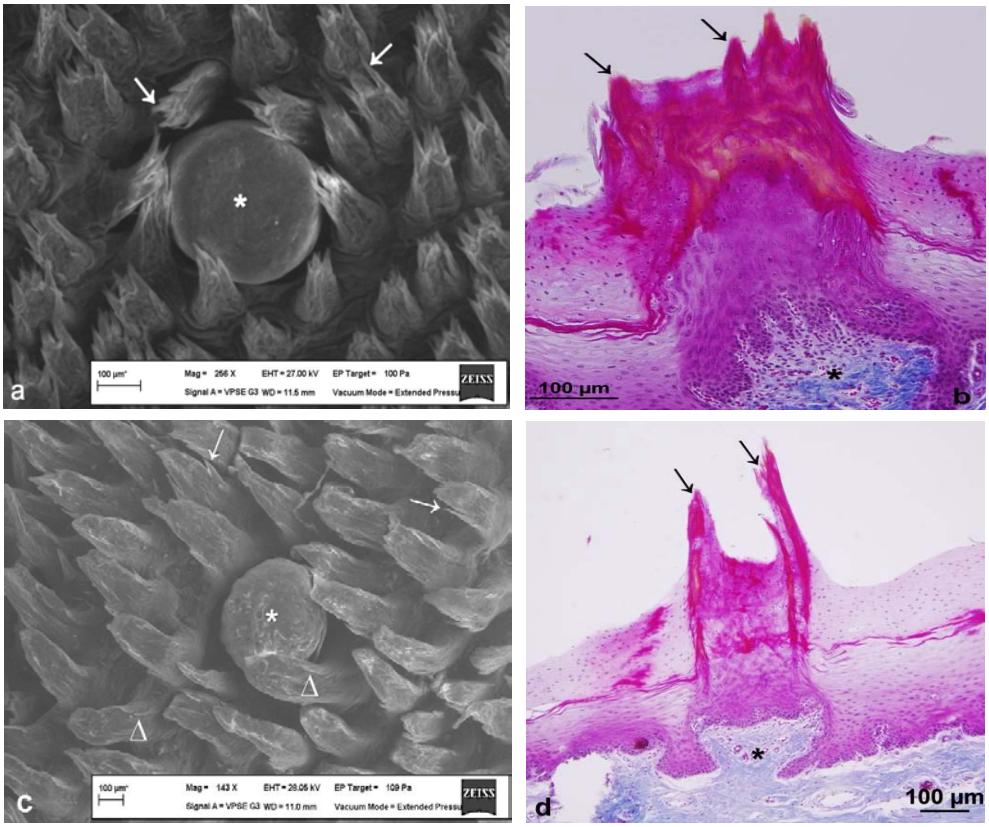

Fig. 2: a) Scanning electron micrograph showing filiform papillae with sharp pointed projections (arrows) at the free end on the apex of the tongue. Asterisk: a fungiform papillae; b) Light micrograph showing histological feature of filiform papillae on the apex of the tongue. Arrows: keratin spine, asterisk: connective tissue core. Mallory's modified trichrome staining; c) Scanning electron micrograph showing filiform papillae with small projections (arrows) at the free end on the body of the tongue. Small secondary papillae (arrow head) at the base of papillae. Asterisk: A fungiform papillae; d) Light micrograph showing histological feature of filiform papillae on the body of the tongue. Arrows: keratin spine, asterisk: connective tissue core. Mallory's modified trichrome staining

in diameter) and rounded fungiform papillae which were distributed on the lingual apex and body (Fig. 1b). These were distributed among filiform papillae particularly along the sides of the tongue. Scanning electron microscopic examination demonstrated that the surface of these papillae had a scaly appearance due to their composition of stratified squamous epithelium (Fig. 3a). Histological examination revealed these papillae to have taste buds situated in the epithelium of the upper surface and further demonstrated that the outer surface of the papillae was covered with a moderately thick keratin layer (Fig. 3b). The second type of fungiform papillae was distributed along the lateral sides of the lingual torus among conical papillae and was larger (800-1000 µ) with a convex surface (Fig. 1b). The outer surface of these papillae was observed to have a vesicular appearance (Fig. 3c). Light microscopic examination revealed that these vesicular structures were supported by a connective tissue core (Fig. 3d). The epithelium of these papillae lacked taste buds.

Vallate papillae: These were compact papillae, 26 in total number which were distributed along the caudo-lateral side of the lingual torus (Fig. 1b). Vallate papillae which were mostly rounded and 800 microns in diameter were determined to have an irregular surface encircled by a shallow papillary groove by scanning electron microscopy. This groove was limited by a superficial annular pad originating from the lingual mucosa. Cap-like reliefs were observed to be scattered on this pad (Fig. 4a). Histologically, the epithelium of vallate papillae was determined to be covered with a moderately thick keratin layer and numerous taste buds were ascertained to be present in the epithelium lining the lateral side which faced the papillary groove (Fig. 4b).

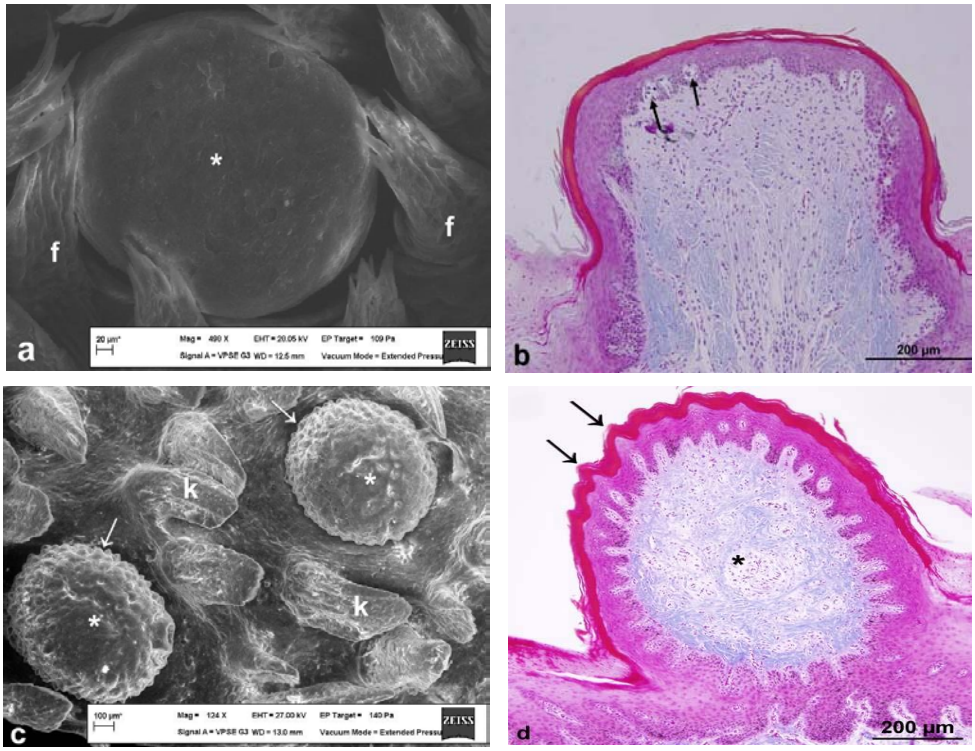

Fig. 3: a) Scanning electron micrograph showing a fungiform papillae (asterisk) on the apex of the tongue f: filiform papillae; b) Light micrograph showing a number of taste buds (arrows) are present in the epithelium of the dorsal surface in the fungiform papillae on the apex of the tongue. Mallory's modified trichrome staining; c) Scanning electron micrograph showing two fungiform papillae (asterisk) on the lateral sides of the lingual torus with a convex surface and vesicular structures (arrows) among conical papillae (k); d) Light micrograph showing fungiform papillae (asterisk) on the lateral sides of the lingual torus. Arrows: vesicular structures, asterisk: connective tissue core. Mallory's modified trichrome staining

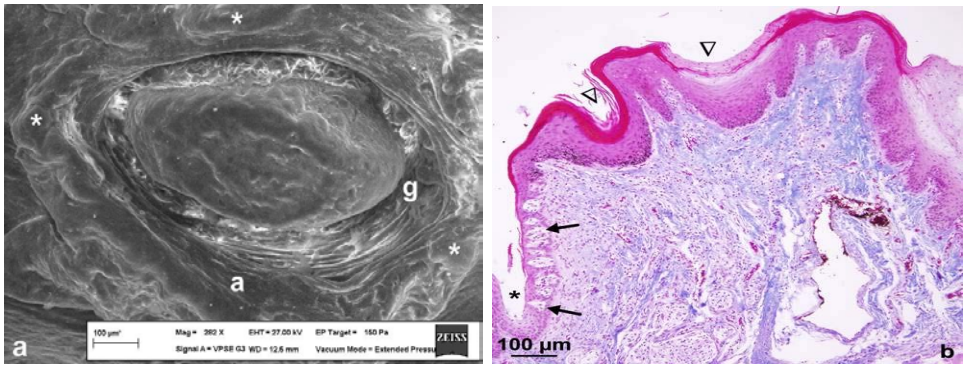

Fig. 4: a) Scanning electron micrograph showing a vallate papillae. g: papillary groove, a: annular pad, asterisk: cap-like reliefs; b) Light micrograph showing taste buds (arrows) are present in the epithelium of the lateral surface in the vallate papilla. Arrowhead: depressions, Asterisk: papillary groove. Mallory's modified trichrome staining

Lenticular papillae: These papillae which are distributed only on the median plane of the lingual torus (Fig. 1b) were of two types that differed in both shape and size. Those distributed on the anterior median portion of the lingual torus were the largest and had a rounded shape. Since they were not very high, they had a flattened appearance. Their surface exhibited dermal projections resembling papillae (Fig. 5a). Histological examination revealed these papillae to be supported by a connective tissue core and their surface to be covered with a thick

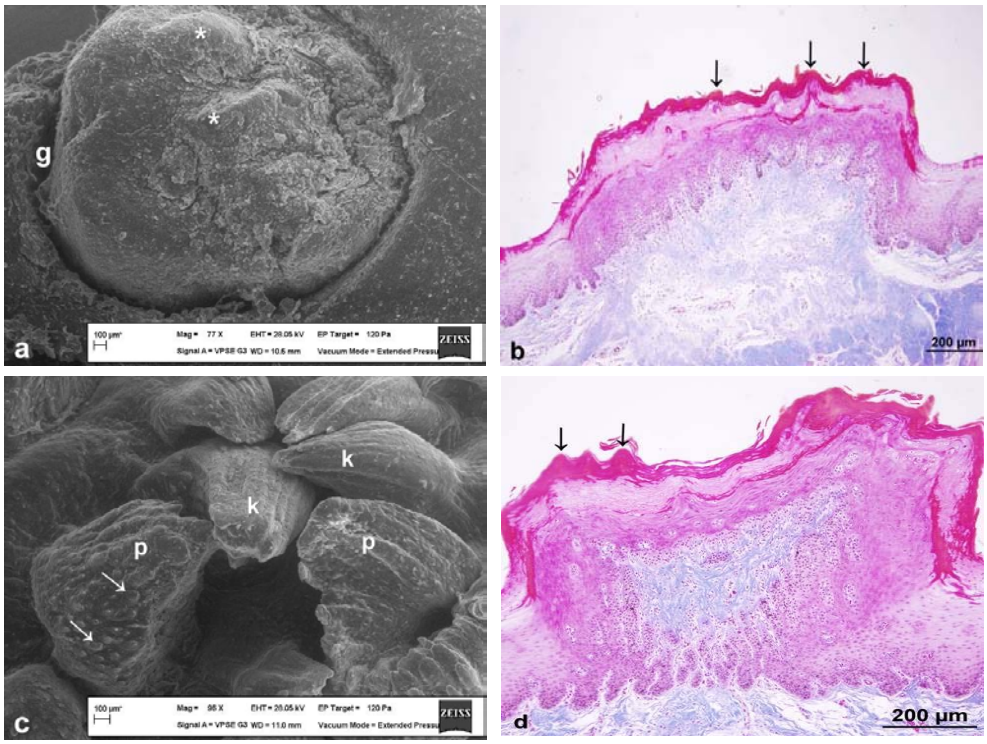

Fig. 5: a) Scanning electron micrograph of the round-shaped lenticular papillae on the anterior median portion of lingual torus. asterisk: dermal projections resembling papillae, g: papillary groove; b) Light micrograph of the round-shaped lenticular papillae Arrows: dermal projections resembling papillae. Mallory's modified trichrome staining; c) Scanning electron micrograph of the a half-cut pyramidal shaped lenticular papillae (p) on the lateral sides of the lingual torus. arrows: pseudopapillary projections, k: conical papillae; d) Light micrograph of a half-cut pyramidal shaped lenticular papillae. Arrows: pseudopapillary projections. Mallory's modified trichrome staining

keratinized layer (Fig. 5b). The shorter type of lenticular papillae with a half-cut pyramid shape was distributed on the posterior median and lateral portions of the lingual torus. Small, irregular shaped dermal projections, resembling pseudopapillae were observed on their surface (Fig. 5c and d).

Conical papillae: Excluding the median plane, all parts of the lingual torus were covered with these papillae which were larger in the anterior part of the lingual torus (Fig. 1b). Conical papillae differed from filiform papillae in that they did not possess any projection or secondary papillae. Conical papillae which were also distributed on the root of the tongue had a round base and blunt tip. Those that covered the lateral parts of the lingual torus had pointed tips (Fig. 6a). Histological examination revealed the surface of conical papillae to be covered with a very thick keratin layer and further demonstrated that these papillae were supported by a connective tissue core (Fig. 6b-d).

The lingual torus (lingual prominence) appears to be a characteristic structure which has developed primarily in grass eating animals (Zheng and Kobayashi, 2006). Similar to other grass eating artiodactyls (e.g., cattle, goat, sheep, deer and serow), a well-developed lingual torus was present on the posterior part of the dorsal lingual surface in the goitered gazelle. The length of the tongue in the goitered gazelle was measured as 12 cm, similar to the blackbuck (Emura *et al*., 1999) which belongs to the same subfamily namely antilopinae.

Filiform papillae which are considered to have a mechanical function are arranged to provide the tongue the rough surface suited for the movement and grinding of food (Agungpriyono *et al*., 1995). In mammals there are marked variations in the structure of the dorsal surface of the tongue especially in the size and shape of the filiform papillae (Kullaa-Mikkonen and Sorvari, 1985).

The caudal orientation reported to exist in the goat (Kumar *et al*., 1998), buffalo and cow (Cabello *et al*., 1988) was not observed in the lingual apex of the goitered gazelle where filiform papillae were observed to be irregularly inclined. The body of these papillae was reported to be conical in the goat (Kumar *et al*., 1998), Saanen goat (Kurtul and Atalgin, 2008) and buffalo

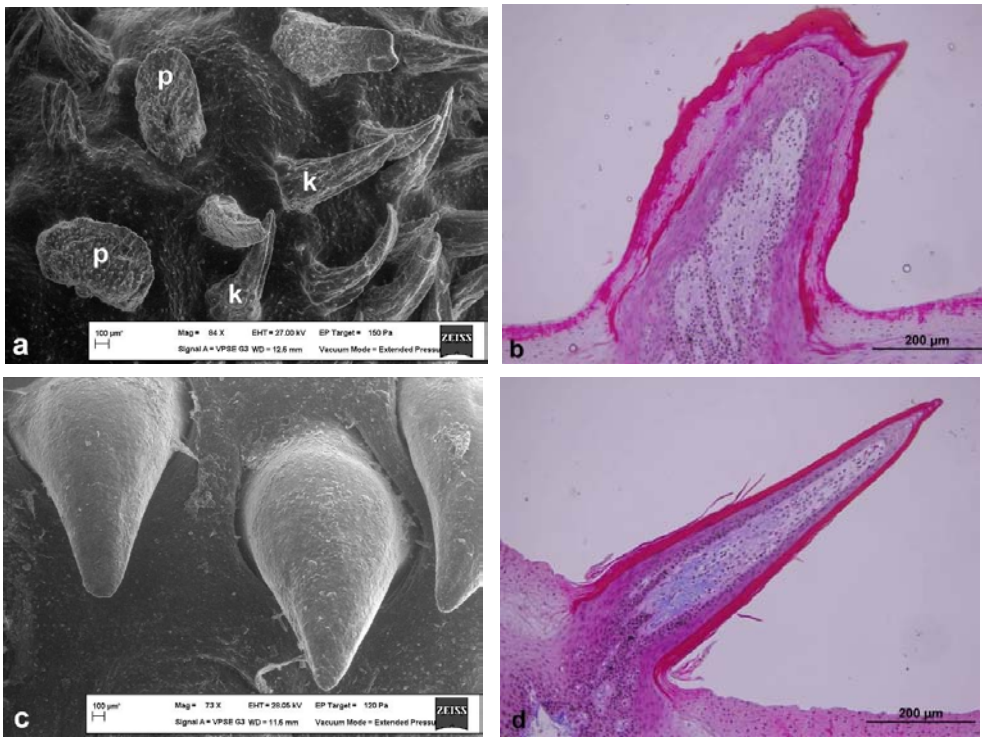

Fig. 6: a) Scanning electron micrograph of a half-cut pyramidal-shaped lenticular papillae (p) and conical papillae (k) posterior median portion of the lingual torus, arrows: mikropapillar uzantýlar; b) Light micrograph of a conical papillae at the sideward on the lingual torus. Mallory's modified trichrome staining; c) Scanning electron micrograph of the conical papillae on the lingual root; d) Light micrograph of a conical papillae on the lingual root. Mallory's modified trichrome staining

tongue-like in the cow (Cabello *et al*., 1988; Funato *et al*., 1985) and rod-shaped in Reeve's muntjac deer (Zheng and Kobayashi, 2006). In the goitered gazelle, the main body of the filiform papillae on the lingual apex was determined to have a shovel-like appearance due to the centrally located longitudinal groove. The number of projections stemming from the main body and protruding from the free end of the papillae was 3-6 in the goat (Kumar *et al*., 1998), 6-9 in the Saanen goat (Kurtul and Atalgin, 2008) and 1 in the one humped camel (Qayyum *et al*., 1988) while several small slender accessory processes grew from the main body of the papillae in the Japanese serow (Takayuki *et al*., 2002), Reeve's muntjac deer (Zheng and Kobayashi, 2006) and bighorn sheep (Takayuki *et al*., 2002). The number of secondary papillae was reported as 6-8 in the goat (Kumar *et al*., 1998), 3-6 in the Saanen goat (Kurtul and Atalgin, 2008) and 2 in the Formosan serow (Atoji *et al*., 1998). In the present study, the filiform papillae on the lingual apex and body of the goitered gazelle were determined to vary in shape, similar to the muntjac deer. While the papillae on the lingual apex had 6-8 projections stemming from the main body and lacked secondary papillae, the papillae on the lingual body had fewer projections, a conically-shaped main body and occasionally 1 secondary papilla stemming from the body. In the Saanen goat, the filiform papillae on the ventro-lateral aspect of the free tip of the tongue lacked secondary papillae (Kurtul and Atalgin, 2008). The absence of secondary papillae in this region which is subject to less mechanical impact, suggests that secondary papillae demonstrate a pattern of presence in parallel with the degree of mechanical impact that they are exposed to. Therefore, taking into consideration the structural properties of filiform papillae in the goitered gazelle, it could be concluded that the mechanical function of these papillae is weaker than that reported for other ruminant species.

Fungiform papillae are reported to be mushroom-like in the goat (Kumar *et al*., 1998) and round in the Barbary sheep (Emura *et al*., 2000), blackbuck (Emura *et al*., 1999) and Formosan serow (Atoji *et al*., 1998), similar to the goitered gazelle. Similar to the goitered gazelle, two types of fungiform papillae are distinguished in the Formosan serow (Atoji *et al*., 1998) and muntjac deer (Zheng and Kobayashi, 2006). In the goitered gazelle while the smaller

type of papillae is distributed on the lingual apex and body, the larger type of papillae is distributed on the torus linguae. The presence of taste buds in the smaller fungiform papillae was indicative of their gustatory function. However, the fungiform papillae on the lingual torus lacked taste buds or pores. In the muntjac deer both types of fungiform papillae were reported to have taste buds (Zheng and Kobayashi, 2006). Similar to those of the Saanen goat (Kurtul and Atalgin, 2008) and the lamb (Tadjalli and Pazhoomand, 2004), the surface of the smaller fungiform papillae in the goitered gazelle had a scaly appearance. The shallow groove which was reported to exist in the goat (Kumar *et al*., 1998), Saanen goat (Kurtul and Atalgin, 2008), cow (Chamorro *et al*., 1986) and one humped camel (Qayyum *et al*., 1988) was determined not to be present in the fungiform papillae of the goitered gazelle.

The number of vallate papillae which extend bilaterally along the caudolateral side of the tongue varies among species. The number of vallate papillae was reported as 30 in the Barbary sheep (Emura *et al*., 2000) and blackbuck (Emura *et al*., 1999), 23 in the Formosan serow (Atoji *et al*., 1998), 20 in the Japanese serow and bighorn sheep (Takayuki *et al*., 2002) and 26 in the Saanen goat (Kurtul and Atalgin, 2008) and was determined as 26 in the goitered gazelle. While the papillary surface was reported to be smooth in the goat (Kumar *et al*., 1998), cow (Chamorro *et al*., 1986) and one humped camel (Qayyum *et al*., 1988), some papillae in the goitered gazelle were determined to have an irregular surface, similar to those of the Bactrian camel (Eerdunchaolu *et al*., 2001) and Saanen goat (Kurtul and Atalgin, 2008). The vallate papillae of the goitered gazelle which have a shallow papillary groove were determined to be surrounded by a weak annular pad, similar to those of the Formosan serow (Atoji *et al*., 1998). Chamorro *et al*. (1986) reported that annular pads regulate access and retention of saliva in the groove by means of their smooth muscular fibres. Therefore, it can be concluded that a thick annular pad and well-developed smooth muscle are not required for the discharge of the saliva which accumulates in the shallow papillary groove.

The lenticular papillae could serve as a complementary protection of the tongue surface (Tadjalli and Pazhoomand, 2004). Lenticular papillae which are reported to exist in bactrian camel (Eerdunchaolu *et al*., 2001), cow (Cabello *et al*., 1988), goat (Kumar *et al*., 1998), Japanese serow (Funato *et al*., 1985), lesser mouse deer (Agungpriyono *et al*., 1995), Saanen goat (Kurtul and Atalgin, 2008) and to be absent in Barbary sheep (Emura *et al*., 2000), the Formosan serow (Atoji *et al*., 1998) and blackbuck (Emura *et al*., 1999) were determined to be distributed along the median plane of the lingual torus in the goitered gazelle. The papillary surface is reported to be rough in the goat (Kumar *et al*., 1998), Saanen goat (Kurtul and Atalgin, 2008) and cow (Cabello *et al*., 1988) with a ridge-like appearance in the goat and a scaly appearance in the cow and Saanen goat.

CONCLUSION

In the present study, the papillary surface was determined to be rough in the goitered gazelle. Similar to those of the Saanen goat there were two types of lenticular papillae which differed in shape. While the surface of round-shaped lenticular papillae was irregular, those that had a half-cut pyramid shape possessed a cut-like surface with numerous pseudopapillary projections. The groove reported to exist in the cow (Cabello *et al*., 1988) and goat (Kumar *et al*., 1998) was determined to be shallow in the goitered gazelle. Conical papillae which are reported not to exist in the Bactrian camel (Eerdunchaolu *et al*., 2001) and one humped camel (Qayyum *et al*., 1988) have evolved into the laminari papillae which are located on the lateral sides of the torus linguae in the buffalo. In the present study, the conical papillae of the goitered gazelle were determined to be distributed mainly on the lingual torus, similar to those of the blackbuck (Emura *et al*., 1999), Barbary sheep (Emura *et al*., 2000) and Japanese serow (Takayuki *et al*., 2002) as well as on the lingual root.

Upon the review of previously conducted studies, it was observed that in the blackbuck which is considered as the closest species to the goitered gazelle, the dorsal lingual papillae were reported to be composed of four types including filiform, conical, fungiform and vallate papillae (Emura *et al*., 1999). The goitered gazelle, in addition to these four types of papillae also possessed lenticular papillae. A similar case is true for the Formosan serow and Japanese serow which belong to the same genus (capricornis).

The lenticular papillae which are reported to exist in the Japanese serow (Funato *et al*., 1985) are indicated to be lacked by the Formosan serow (Atoji *et al*., 1998). Therefore, it is suggested that the structure of the papillae distributed on the lingual surface in mammals varies with diet, habits and taxonomic peculiarities as well as with genetic differences.

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