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Morphology of the dorsal lingual papillae in the lesser mouse deer, *Tragulus javanicus*

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ABSTRACT

The dorsal lingual papillae of the lesser mouse deer were studied morphologically using light and scanning electron microscopy. Four types of papillae, filiform, fungiform, vallate and foliate, were observed. Filiform papillae consisted of larger main papillae with smaller secondary papillae on their anterolateral aspects. Secondary papillae were well distributed over the anterior two-thirds of the tongue, but were very rare or absent in the posterior third. Fungiform papillae were distributed among the filiform papillae, being larger and more abundant on the tip of the tongue. Vallate papillae were round–flat or long–flat, surrounded by a prominent circular groove and a thin annular pad. An important finding was the presence of distinct and prominent foliate papillae on the posterolateral sides of the tongue. Keratinisation of the covering stratified squamous epithelium was relatively weak. Taste buds were observed in the epithelium of the fungiform, vallate and foliate papillae. The lingual papillae of the lesser mouse deer showed some characteristics that differed from those reported for domestic ruminants. These may be related to the feeding habits and the type of food eaten by this species.

Key words: Ruminants; tragulina; tongue.

INTRODUCTION

The suborder Ruminantia consists of two infraorders, the Pecora and the Tragulina. The Pecora infraorder consists of more than 100 species, including domestic ruminants such as cattle, sheep, goat and buffalo, while the Tragulina infraorder contains only 4 species. One of these, the lesser mouse deer (*Tragulus javanicus*), weighing only 1.6–2 kg, has the distinction of being the smallest ruminant (Langer, 1988).

The papillae of the ruminant tongue have been studied by scanning electron microscopy in the goat (Qayyum & Beg, 1975; Yamada et al. 1983), cattle (Yamada et al. 1983; Chamorro et al. 1986; de Paz Cabello et al. 1988; Steflik et al. 1983) and buffalo (Scala et al. 1993). Similar studies have not so far been reported for the lesser mouse deer.

MATERIALS AND METHODS

The tongues of 3 young adult *Tragulus javanicus* weighing 1.65–1.79 kg, which were captured and killed under licence, were used. The samples were fixed in Karnovsky's solution, washed with 0.01 M phosphate buffered saline (pH 7.2) and postfixed with 2% tannic acid and 1% osmium tetroxide (Murakami, 1973). After dehydration through a graded ethanol series, the specimens were dried using the *t*-butyl alcohol freeze-drying method (Inoue & Osatake, 1988), mounted on metal stubs, coated with platinum and observed at various different angles with a scanning electron microscope (JEOL JSM 6031-F) at accelerating voltages of 5 or 10 kV. For histological observations, tissue samples were dehydrated through ethanol–xylene and embedded in paraffin wax. Sections (5 μm) were cut transversely or longitudinally and stained with haematoxylin and eosin.

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RESULTS

The tongue of the lesser mouse deer measured ~ 5.5 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) but no torus linguae or fossa linguae.

Scanning electron microscopy

Four different types of papillae were observed: filiform, fungiform, vallate and foliate (Fig. 1).

Filiform papillae were the most numerous, extending over the whole dorsal surface of the tongue up to the root. They were tongue or leaf-like in shape with pointed tips which were directed posteriorly. Filiform papillae consisted of larger main papillae and smaller secondary papillae (Fig. 2*c–d*). In general, each main papilla was accompanied by 2 or, in some instances, 3 secondary papillae on the anterolateral side of its base. This pattern was observed from the anterior third of the tongue as far as junction of the middle and posterior thirds. The secondary papillae were of similar height to the main ones in the lateral regions (Fig. 2*c*), but their height decreased towards the midline (Fig. 2*d*). The height of the main papillae decreased more posteriorly. Secondary papillae were rare or absent in the posterior third of the tongue. In this region, the groove surrounding each filiform papilla became more pronounced. The papillae also showed an increased posteriorly directed inclination and displayed a shallow longitudinal groove, running from the base to the tip in their central portion (Fig. 2*e*).

Fungiform papillae (Fig. 2*a*, *b*) were rounded and larger than the filiform papillae. They were distributed irregularly among the filiform papillae, being more numerous in the anterior than in the posterior part of the tongue. At the tip of the tongue, the papillae were larger and abundant.

A pair of long-flat vallate papillae (Fig. 3*a*) were observed in 2 of the 3 tongues examined, and 5 round–flat vallate papillae (Figs 1, 3*b*) in 1 tongue. The papillae were located on both sides of the midline in the caudal part just rostral to the root of the tongue. Each papilla was surrounded by a prominent circular primary groove and a thin annular pad. Posterior to these papillae was an area of lingual tonsil.

Several foliate papillae (Figs 1, 3*c*) were observed on both posterolateral sides, ventral to the vallate papillae. The papillae were distinct and prominent. They were arranged in an interdigitating pattern and were separated from each other by small furrows.

At higher magnification, the epithelium of the filiform papillae showed a smooth surface (Fig. 4*a*), while that of the interpapillar regions and the fungiform (Fig. 4*b*), vallate (Fig. 4*c*) and foliate (Fig. 4*d*) papillae possessed microridges. Taste pores were observed on the dorsal surface of fungiform papillae (Fig. 4*b*).

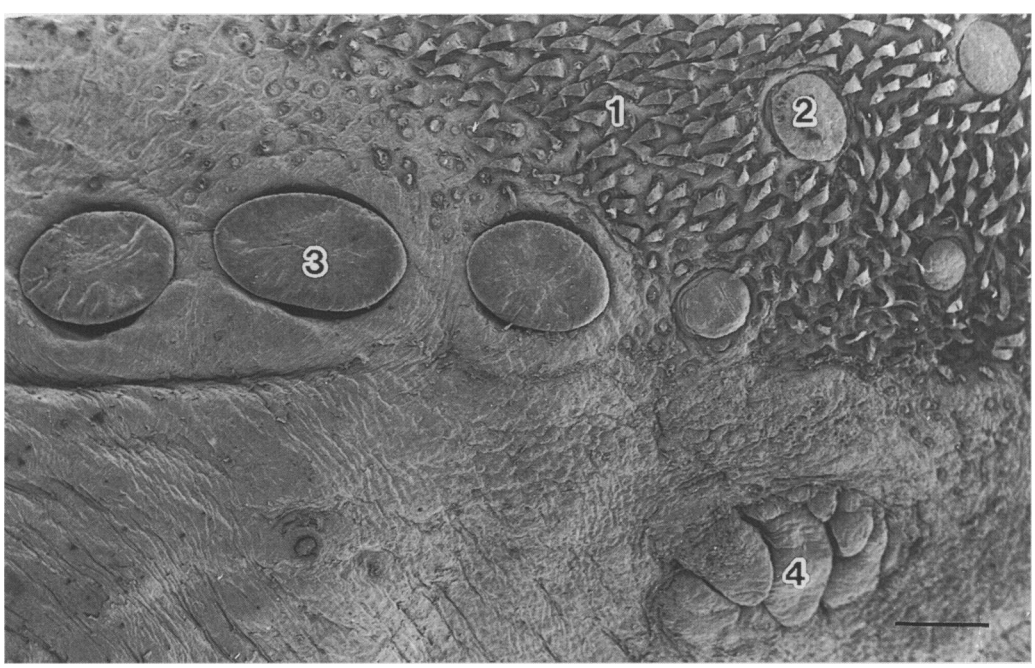

Fig. 1. Scanning electron micrograph of the posterior third of the tongue showing 4 types of lingual papillae, filiform (1), fungiform (2), vallate (3) and foliate (4) papillae. Bar, 500 μm.

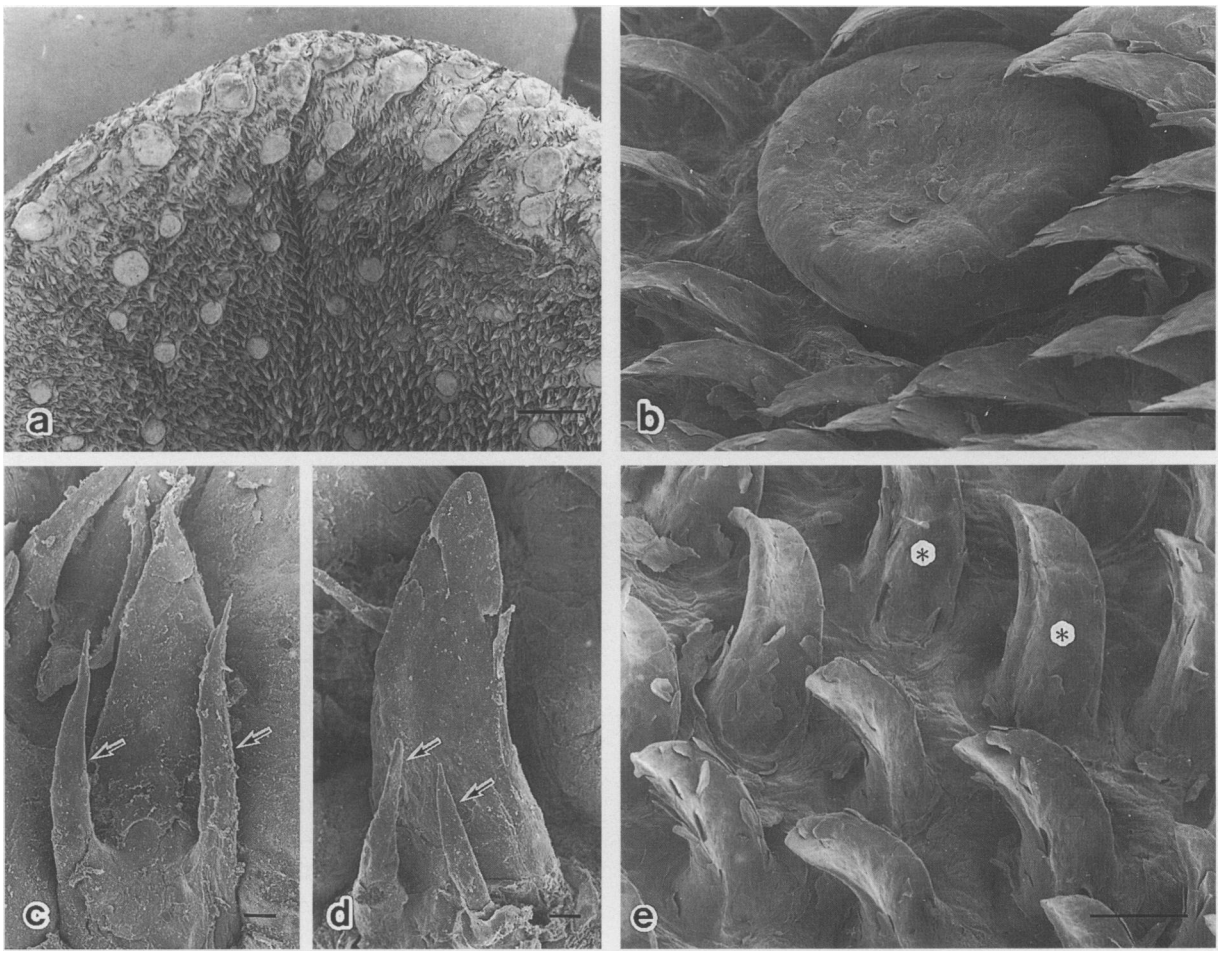

Fig. 2. Scanning electron micrographs. (*a*) Fungiform papillae are relatively large and numerous at the tip of the tongue. (*b*) A fungiform papilla among filiform ones. (*c*) Filiform papillae in the lateral and (*d*) medial parts of the tongue. The secondary papillae (arrows) are relatively tall in the lateral part, but short medial. (*e*) Filiform papillae in the posterior region. Note absence of secondary papillae, more prominent surrounding grooves, more posteriorly inclined tips and the presence of a shallow groove at the centre of each papilla (asterisks). Bars: (*a*) 500 μm; (*b*, *e*) 100 μm; (*c*, *d*) 10 μm.

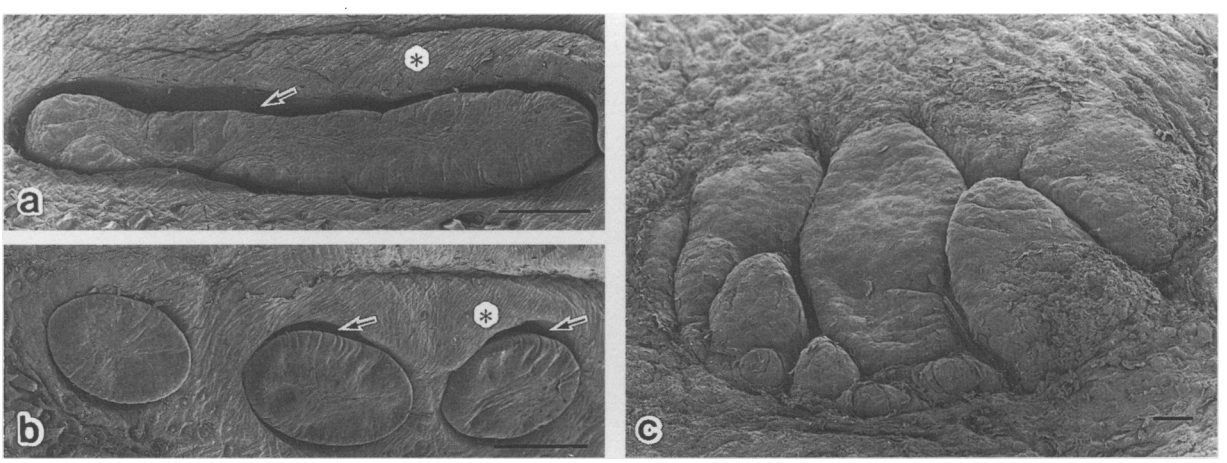

Fig. 3. Scanning electron micrographs showing the vallate (*a*, *b*) and foliate (*c*) papillae. The vallate papillae are long flat (*a*) or round flat (*b*) in form, each of which is surrounded by a prominent primary groove (arrows) and a thin annular pad (asterisks). The foliate papillae (*c*) are distinct and prominent. They are arranged in an interdigitating manner and are separated from each other by small furrows. Bars: (*a*, *b*) 500 μm; (*c*) 100 μm.

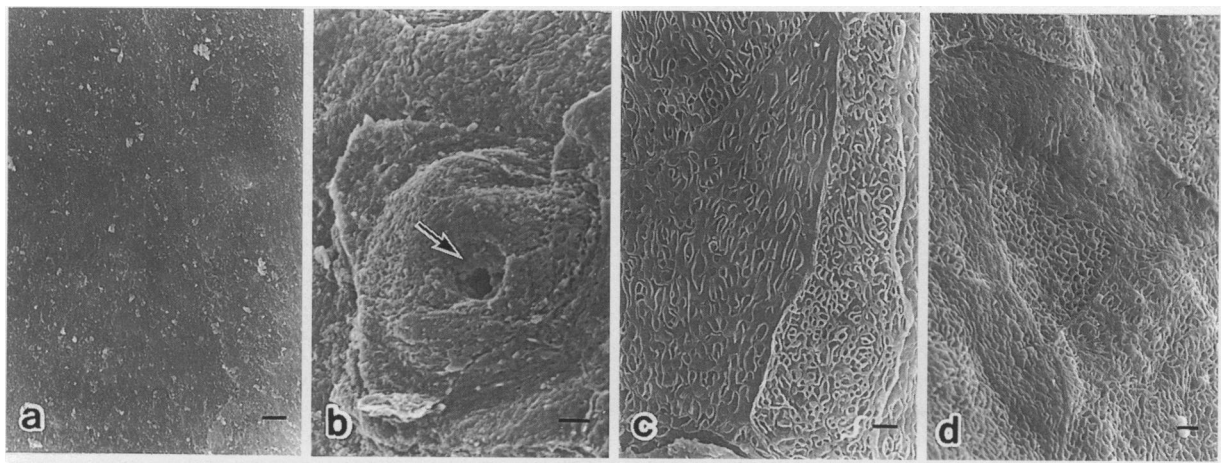

Fig. 4. Scanning electron micrographs showing the epithelial surfaces of filiform (*a*), fungiform (*b*), vallate (*c*) and foliate (*d*) papillae at higher magnification. Arrow, taste pore on the dorsal surface of a fungiform papilla. Bars: (*a*, *c*, *d*) 1 μm; (*b*) 2 μm.

Light microscopy

Each type of lingual papilla was covered by stratified squamous epithelium and had a core of connective tissue (Fig. 5). Keratinisation of the covering epithelium was only weak. In the filiform papillae, epithelial cells on their anterior aspect consisted of clear cells with weakly stained cytoplasm in the dorsal part, their precursor cells in the ventral part showing keratohyalin granules. On their posterior aspect the predominant epithelial cells lacked keratohyalin granules and culminated in a keratin spine (Fig. 5*a*).

Taste buds were found in the epithelium of the dorsal parts in the fungiform papillae (Fig. 5*b*) and the lateral parts of the vallate (Fig. 5*c*) and foliate (Fig. 5*d*) papillae. Submucosal and intermuscular serous glands were observed in the ventral part of vallate (von Ebner's glands) and foliate papillae. The glands had openings into the depth of the groove.

DISCUSSION

The present study has demonstrated four types of dorsal lingual papillae, filiform, fungiform, vallate and foliate, in the lesser mouse deer.

Filiform papillae, which are considered to have a mechanical function (Nickel, 1979) have been reported to vary considerably in shape and structural organisation from one species to another (Yamada et al. 1983; Iwasaki et al. 1987; Kullaa-Mikkonen et al. 1987). The arrangement of the filiform papillae provides the tongue with a rough surface suited for the movement and grinding of food (Svejda & Skach, 1975; Yamada et al. 1983). In addition to filiform papillae, conical and lenticular papillae can be found in the lingual torus of domestic ruminants, goats and cattle (Nickel et al. 1979). Conical and lenticular papillae were not observed in the present study. This finding suggests a more simple structure for the lingual mechanical papillae in the lesser mouse deer as compared with goats or cattle. The absence of conical and lenticular papillae is probably related to the absence of the lingual torus in the lesser mouse deer. When compared with the goat and cattle (Yamada et al. 1983), the structure and organisation of the filiform papillae in the lesser mouse deer are generally more similar to those of the goat. However, the presence of 2 or 3 secondary papillae in the lesser mouse deer is less in comparison with the 2–6 observed in the goat. Moreover, the distribution of the secondary papillae in the lesser mouse deer, being present from the anterior part of the tongue to the end of the middle third and rare or absent in the posterior part, is relatively restricted. Keratinisation of the epithelium covering the filiform papillae was weak in the lesser mouse deer. This finding differs from cattle and cats, which have strongly keratinised papillae (Nickel, 1979). Farbman (1970) was the first to observe two distinct type of epithelial cells in the filiform papillae of rat tongue, one producing hard and the other soft keratin. In the lesser mouse deer, the epithelial cells on the anterior aspect of these papillae consisted of cells possessing keratohyalin granules in their ventral part as precursors for clear cells with soft keratin in their dorsal part, whereas those on their posterior aspect consisted of the predominant cells that culminated in a keratin spine. These histological appearances resemble those of cattle (Steflik et al. 1983) but not those of the pig (Boshell et al. 1980).

The presence of taste buds in the fungiform papillae of the lesser mouse deer resembles cattle, horse (Chamorro et al. 1986), man, monkey (Arvidson,

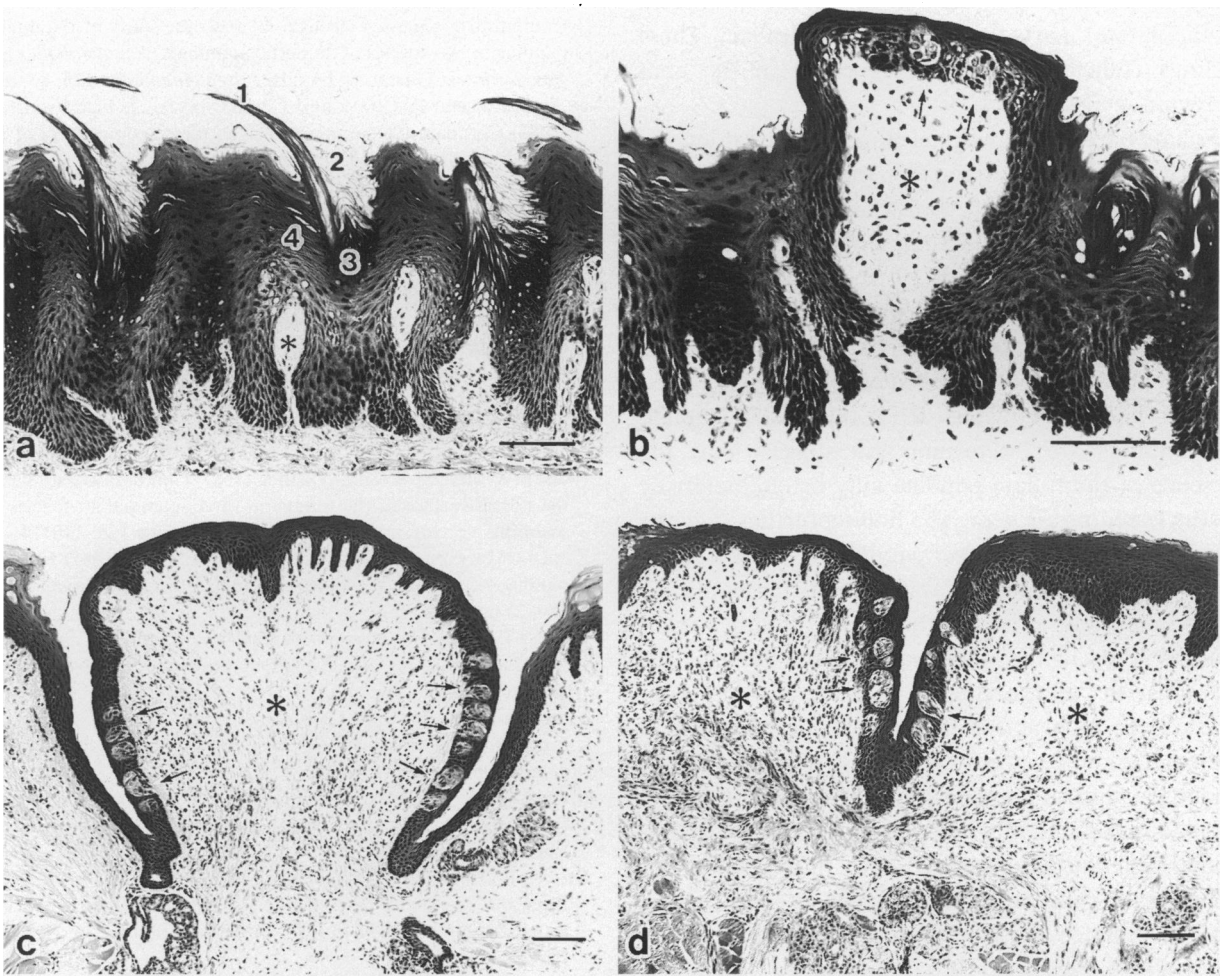

Fig. 5. Light micrographs showing histological structure of the filiform (*a*), fungiform (*b*), vallate (*c*) and foliate (*d*) papillae. Each type of papilla has a core of connective tissue (asterisks). Taste buds (arrows) are present in the epithelium of the dorsal surface in the fungiform papilla (*b*) and in the epithelium of the lateral surface in the vallate (*c*) and foliate (*d*) papillae. (*1*), keratin spine; (*2*) clear cells; (*3*), cells rich in keratohyalin granules; (4) predominant cells lacking keratohyalin granules. Bars, 1 mm.

1976) and rat (Mistretta & Baum, 1984), which further reconfirms the gustatory function of this type of papilla. The characteristics of the fungiform papillae in the lesser mouse deer, being larger and distributed in abundance at the tip of the tongue, coincides with the reports on goats (Qayyum & Beg, 1975) and several species of primates (Hofer et al. 1993). The tip of the tongue can therefore be considered as a special sense organ, transmitting several kinds of sensory information.

The number of vallate papillae varies with the species. Ruminants such as cattle, sheep or goats possess 8–17, 18–24 and 12–18 papillae respectively. Pigs and horses have a single pair while carnivores have 4–6 (Nickel, 1979). Based on the number of these papillae, the lesser mouse deer is more similar to the pig, horse and carnivores than to other ruminants. Another important aspect concerning this type of papilla is its morphology. We observed two types of vallate papilla, a long-flat type and a round-flat type. The round-flat type, termed the circumvallate, is commonly found in ruminants (Qayyum & Beg, 1975; Nickel, 1979; Chamorro et al. 1986; Tichý, 1992; Scala et al. 1993) whereas the long-flat type, has not so far been reported. Whether these two morphological types of vallate papilla represent developmental stages or whether they are indeed peculiar to the lesser mouse deer, is not yet clear. The primary groove surrounding the vallate papillae is compressed by a thick and prominent annular pad in cattle (Chamorro et al. 1986), sheep (Tichý, 1992) and the camel (Qayyum et al. 1988). Conversely, we found that the annular pad was thin in the lesser mouse deer, revealing a more prominent primary groove. These features may suggest differences in access and retention of saliva produced by von Ebner's glands between cattle, sheep and camels, and the present species. Chamorro et al. (1986) reported the presence of taste buds in the epithelium of the dorsal and lateral parts in the vallate papillae of cattle. In the present

study, taste buds were observed only in the epithelium of the lateral parts in the vallate papillae. These findings coincide with those reported in the goat (Qayyum & Beg, 1975).

Foliate papillae are well developed in the rabbit, pig and horse, but extremely small in the dog, rudimentary in the cat (Nickel, 1979; Stinson & Calhoun, 1993) and completely absent in ruminants except for cattle which have rudimentary forms (Nickel, 1979; Chamorro et al. 1986). Our observations, however, reveal the presence of foliate papillae in the lesser mouse deer which were well developed and showed the morphology characteristic for this type of papilla. The findings are interesting and suggest that the presence of the foliate papillae may be characteristic for the lesser mouse deer. The finding further suggests that the function of foliate papillae in this species is probably the most remarkable among ruminants.

In conclusion, although the present findings show features typical for the mammalian tongue, the characteristic of the lingual papillae in the lesser mouse deer such as the absence of the conical and lenticular papillae, the restricted distribution of the secondary filiform papillae and the presence of foliate papillae makes the morphology of the tongue of this animal different as compared with those known for the domestic pecoran ruminants such as sheep, goats, cattle or buffalo. The lesser mouse deer feeds on easily digestible forages such as young leaves, vegetables, potatoes and fruits (Langer, 1988; Richardson et al. 1988). The above differences may be related to the feeding habits and the kind of food eaten by this animal.

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