

# The distribution and structure of the lingual papillae on the tongue of the bank vole *Clethrionomys glareolus*

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*The distribution and three-dimensional structure of the lingual papillae were studied by means of scanning electron microscopy. The elongated tongue in the bank vole is about 12 mm in length and about 3 mm in width. The characteristic features of the tongue are the median sulcus on the apex of the tongue, considerable narrowing in the body of the tongue and a well developed intermolar 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 intermolar prominence of the tongue is covered with conical and saw-like filiform papillae. On the posteriolateral margin of the intermolar prominence two foliate papillae were found.*

*A single oval vallate papilla was situated in the median line of the anterior part of the root of the tongue. The posterior part of the lingual root is flat without papillae. The distribution and types of the lingual papillae found in the bank vole are similar to those in species of the Microtinae family.*

**Key words:** lingual papillae, tongue, bank vole, scanning electron microscopy (SEM)

## INTRODUCTION

The morphology of the tongue in vertebrates, and especially the structure of the mucosa with the lingual papillae on the dorsal surface of the tongue, shows considerable variability [1, 10, 18, 19]. Studies on the tongue microstructure conducted so far in rodents using light and electron microscopy were carried out primarily on laboratory animals, mainly the rat, mouse and guinea pig [7–9, 11, 12, 14, 15, 17].

From studies conducted on breeding species and species living in the wild, observations need to be mentioned concerning the three-dimensional structure of the lingual papillae in the Japanese grass vole (*Microtus montebelli*), the Manchurian chipmunk (*Tamias sibiricus asiaticus*), the gerbil (*Meriones unguiculatus*), in the large vesper mouse (*Calomys cal-*

*losus*, in the flying squirrel (*Petaurista leucogenys*), and in the nutria (*Myocastor coypus*) [2–5, 13, 20].

Characteristic features of the tongue in rodents are the elongated body of the tongue and the presence in the posterior part of the tongue 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 behaviour and mastication mode. The authors of the above-mentioned studies in rodents distinguish among the mechanical papillae filiform and conical papillae and among the gustatory papillae three types of papillae found in vertebrates, namely fungiform, vallate and foliate papillae.

The aim of our scanning electron observations of the dorsal surface of the tongue was to describe the distribution and three-dimensional structure of the lingual papillae in the bank vole and to compare the results with data obtained from other rodents.

## MATERIAL AND METHODS

The observations were conducted on 7 tongues of adult bank voles (3 females and 4 males). The tongues, fixed in 10% neutral formaldehyde, were dissected from the mandible 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<sub>2</sub> (Critical Point Dryer K850, Emitech).

The specimens were carefully mounted on aluminium 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 LEO 435 VP (Zeiss) at the accelerating voltage of 15 kV. The size and density of the lingual papillae were measured and calculated with the help of a computer system Multiscan 6.01 (CSS Warsaw).

## RESULTS

The tongue in the bank vole is elongated with a widened apical part (Fig. 1). It is 11–13.5 mm in length. On the surface of the lingual apex there is a deep median sulcus of 1–1.2 mm in length. The width of the lingual apex is approx. 3–4 mm, while the anterior part of the lingual body is narrower, reaching approx. 2 mm. A characteristic structure of the

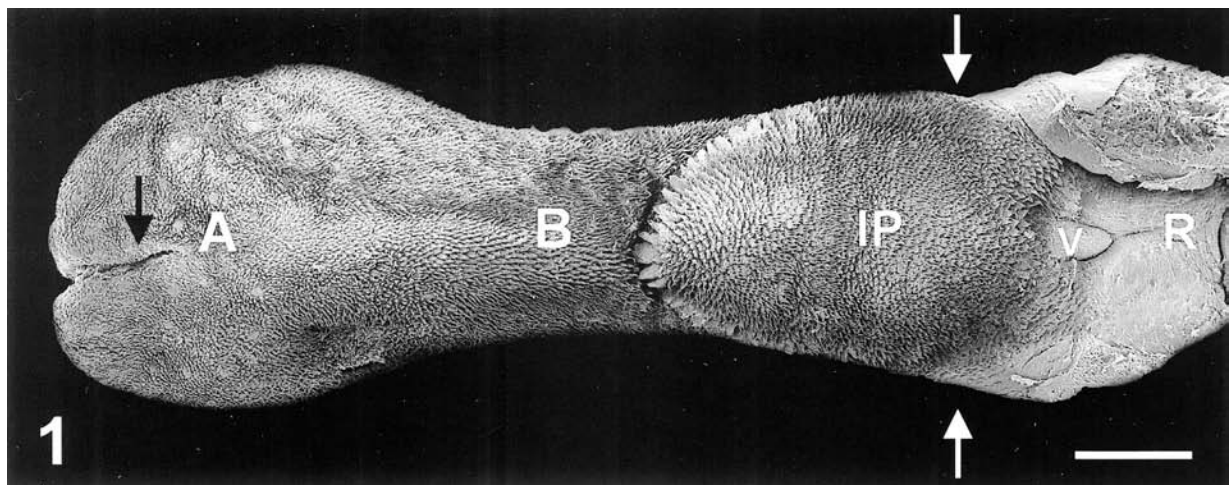
posterior part of the lingual body is the torus, occupying the whole width of the lingual body, and referred to as the intermolar prominence (Figs. 1, 7). The anterior margin of the prominence is semicircular and rises over the lingual body. This part of the tongue widens to 3 mm. The surface of the posterior part of the intermolar prominence and the root of the tongue is gradually lowered towards the pharynx.

Observation under the scanning electron microscope made it possible to distinguish 5 types of lingual papillae in the mucosa-covered dorsal surface of the tongue.

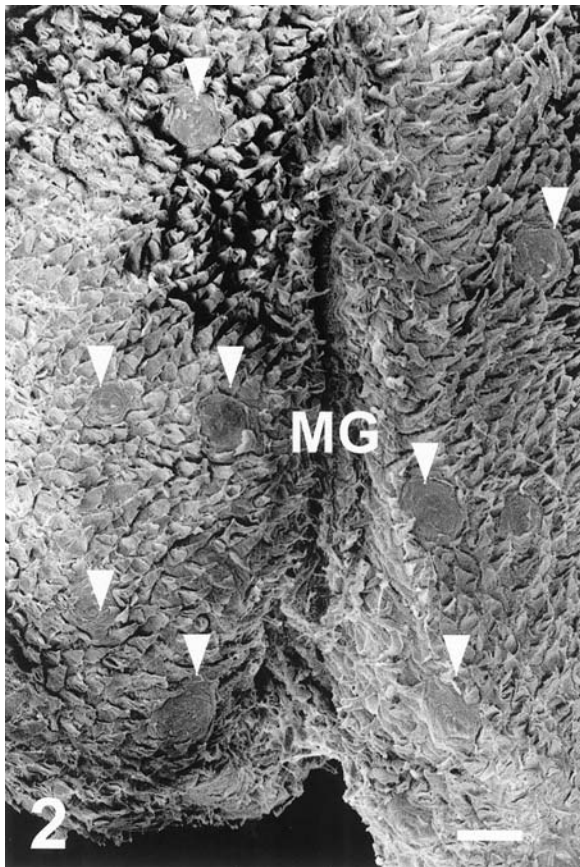
Filiform papillae with a single flat elongated process, tilted towards the posterior part of the tongue, are found on the lingual apex (Figs. 2, 3). The bases of the papillae are approx. 20–30  $\mu\text{m}$  in width, whereas the posterior single processes are 60–75  $\mu\text{m}$  in length. The density of the papillae ranges from 380 to 464 per 1 mm<sup>2</sup>. The second type of lingual papilla on the apex of the tongue is the fungiform papilla (Figs. 2, 3). These papillae are uniformly distributed between filiform papillae. The density of the fungiform papillae is 3.5–5 per 1 mm<sup>2</sup>. Each fungiform papilla is a round structure with a diameter ranging from 96 to 120  $\mu\text{m}$ . On the flat surface of each papilla is situated a single pore of the gustatory bud.

The distribution of the fungiform papillae in the posterior part of the body is irregular as far as the base of the intermolar prominence.

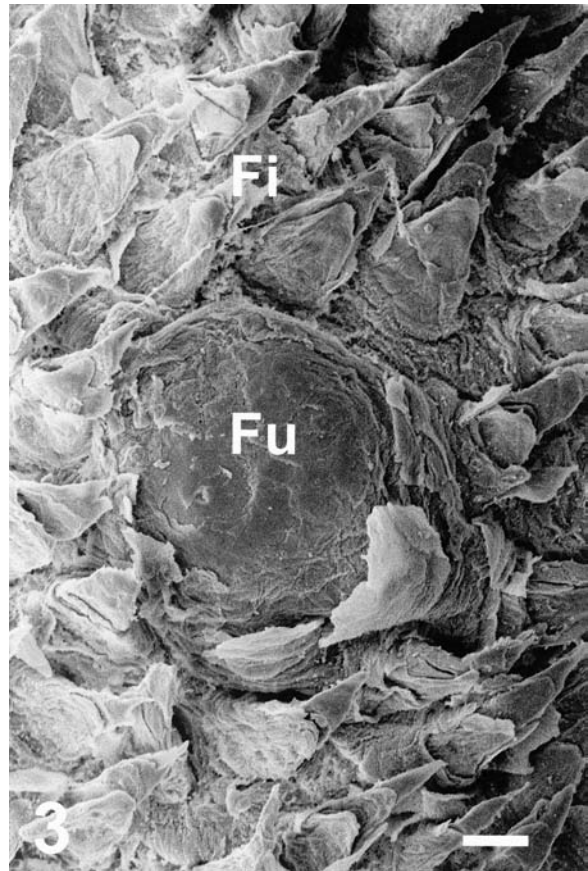
On the SEM images of the narrowing of the lingual body mainly filiform papillae, composed of one flat process, are observed (Fig. 4). There are two sub-



**Figure 1.** The scanning electron micrograph of the dorsal view of the tongue in the bank vole. The black arrow shows the median groove on the wide apex of the tongue; the white arrows show the position of the foliate papillae. A — apex of the tongue; B — body of the tongue; IP — intermolar prominence; R — root of the tongue, V — vallate papilla. Mag.  $\times 28$ , bar = 1 mm.



**Figure 2.** A higher magnification of the surface of the apex of the tongue in the bank vole. The round fungiform papillae (arrow-heads) are scattered among filiform papillae. MG — median groove. Mag.  $\times 155$ , bar =  $100 \mu\text{m}$ .



**Figure 3.** A higher magnification of fungiform papillae with a flat surface (Fu). Fi — filiform papillae with a single keratinised process. Mag.  $\times 871$ , bar =  $20 \mu\text{m}$ .

types of these papillae. On the medial line of the body of the tongue these papillae overlap and form a flat band (Figs. 4, 5). The bases of the papillae are approx.  $40\text{--}50 \mu\text{m}$  in width, while the keratinised processes are  $90\text{--}130 \mu\text{m}$  long. The density of the filiform papillae is lower than on the lingual apex, amounting to  $190\text{--}230$  per  $1 \text{mm}^2$ .

At both margins of the narrow part of the lingual body the filiform papillae are slim (Figs. 4, 6). The bases of these papillae are  $20 \mu\text{m}$  in width, while the length of the narrow process is approx.  $130\text{--}140 \mu\text{m}$ . The density of the papillae on the margins of the tongue is on average  $331$  per  $1 \text{mm}^2$ .

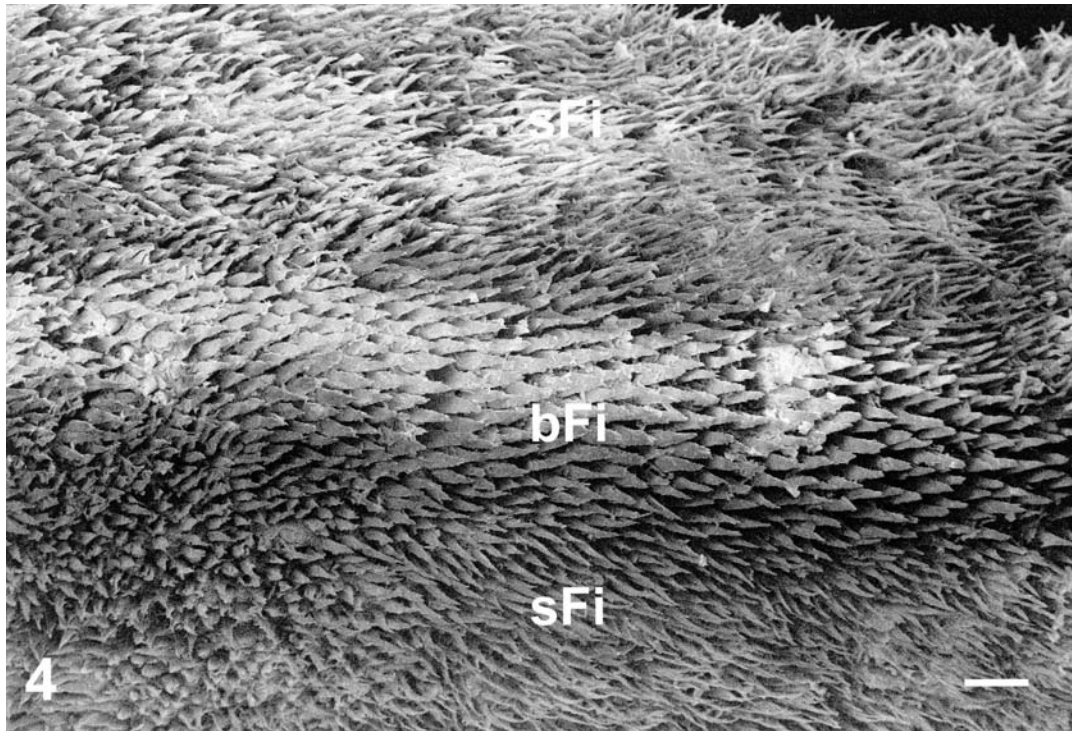
The SEM images of the intermolar prominence show large conical papillae, frequently known as giant conical papillae, on their frontal margin and the tips of these are directed to the apex of the tongue (Figs. 1, 7). The largest conical papillae are in the medial part of the intermolar prominence, whereas on the lateral margins of this they gradually become smaller (Fig. 8). The bases of the largest conical

papillae measure approximately  $180\text{--}200 \mu\text{m}$  in width, whereas the processes are  $100\text{--}135 \mu\text{m}$  long.

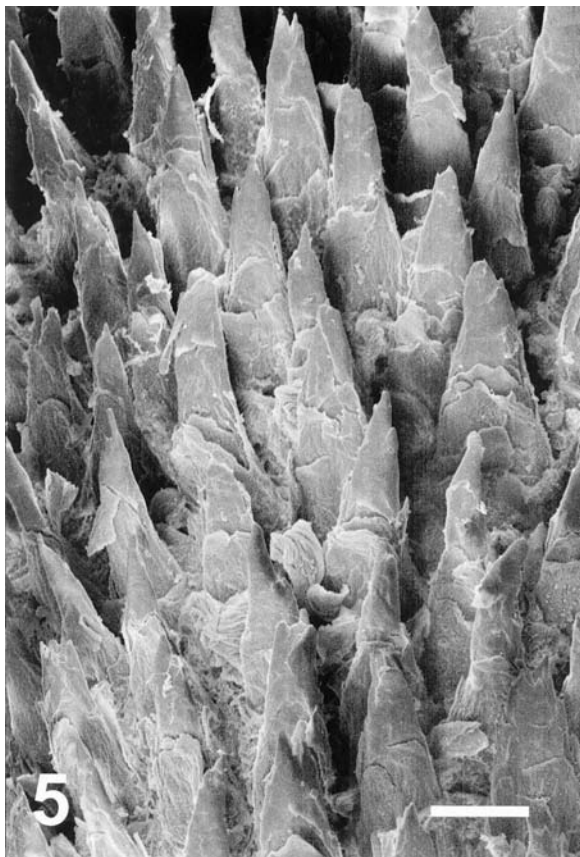
The whole dorsal surface of the intermolar prominence is covered by saw-like filiform papillae with one broad keratinised process tilted towards the posterior part of the tongue (Fig. 7–9). On the apical margin of the processes one or two deep incisions were found (Fig. 8). The width of the base of the papillae was approx.  $40\text{--}50 \mu\text{m}$ , while the length of processes was approx.  $60 \mu\text{m}$ . The density of the papillae was  $120$  per  $1 \text{mm}^2$ .

In the posterior part of the intermolar prominence, on the lateral surfaces adjacent to the pharyngeal-palatine arch, 4–5 fissures of foliate papillae were situated bilaterally (Figs. 1, 7, 10). The width of each papilla was approx.  $300 \mu\text{m}$ .

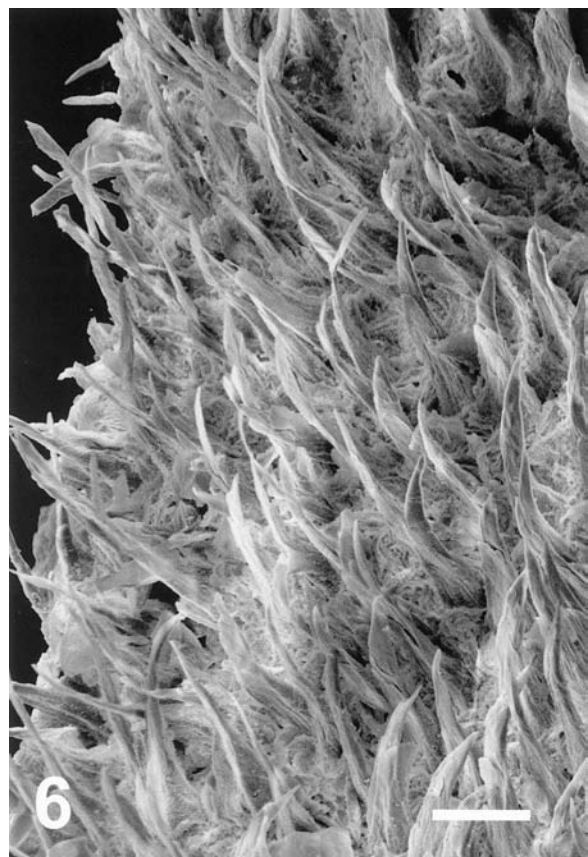
Immediately behind the intermolar prominence, a single vallate papilla, located on the medial line of the tongue, was found on the root of the tongue (Figs. 1, 11). This oval gustatory papilla was surrounded by a distinct continuous fissure. The anterior part



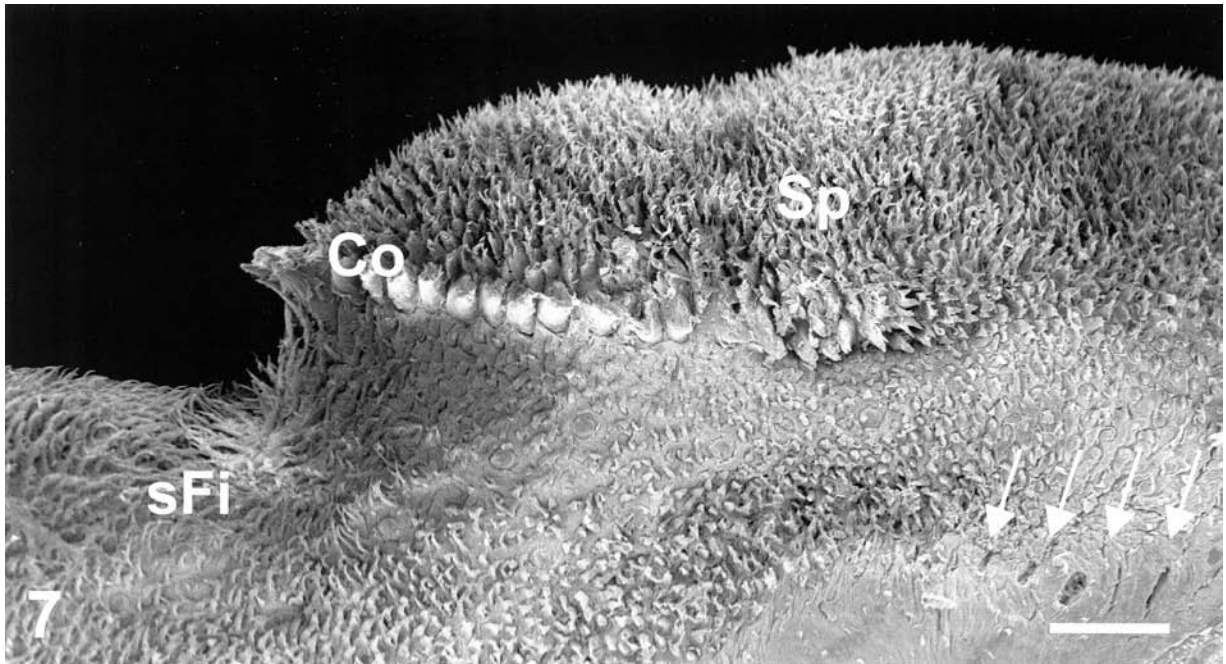
**Figure 4.** The scanning electron micrograph of the narrowing of body of the tongue. The whole surface of the tongue is covered by the filiform papillae, the processes of which are tilted posteriorly. The middle part of the body of the tongue is covered by larger filiform papillae (bFi), whereas the lateral parts are covered by slim filiform papillae (sFi). Mag.  $\times 85$ , bar =  $200 \mu\text{m}$ .



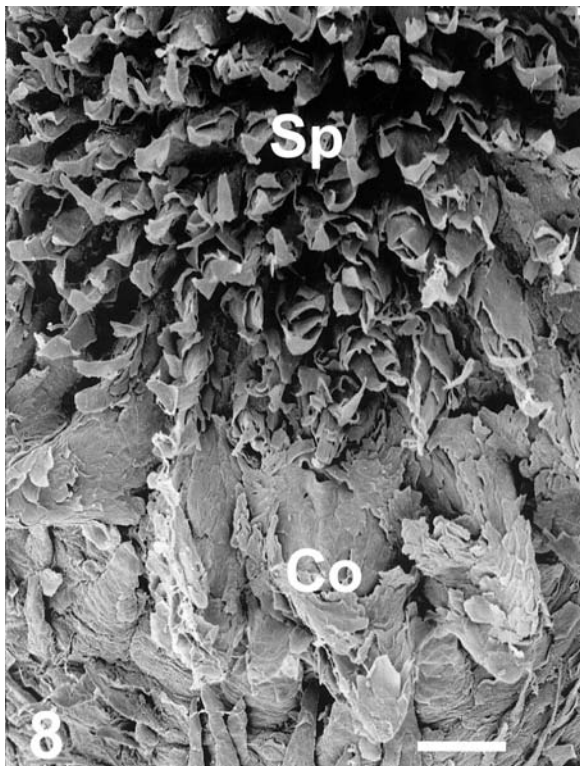
**Figure 5.** A higher magnification of the larger filiform papillae, the processes of which overlap each other. Mag.  $\times 562$ , bar =  $30 \mu\text{m}$ .



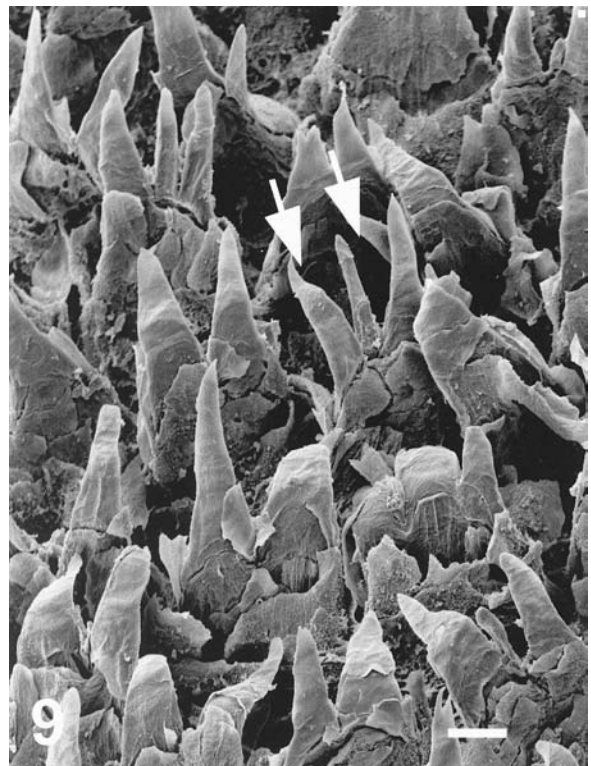
**Figure 6.** A higher magnification of the slim filiform papillae. Mag.  $\times 562$ , bar =  $30 \mu\text{m}$ .



**Figure 7.** Scanning electron micrograph of the lateral view of the intermolar prominence of the bank vole tongue. The slim filiform papillae (sFi) disappear near the base of the prominence and on the margin of the prominence conical papillae (Co) are present. The convex surface of the prominence is covered by numerous saw-like papillae (Sp). Arrows show the openings of the foliate papillae. Mag.  $\times 84$ , bar =  $200 \mu\text{m}$ .

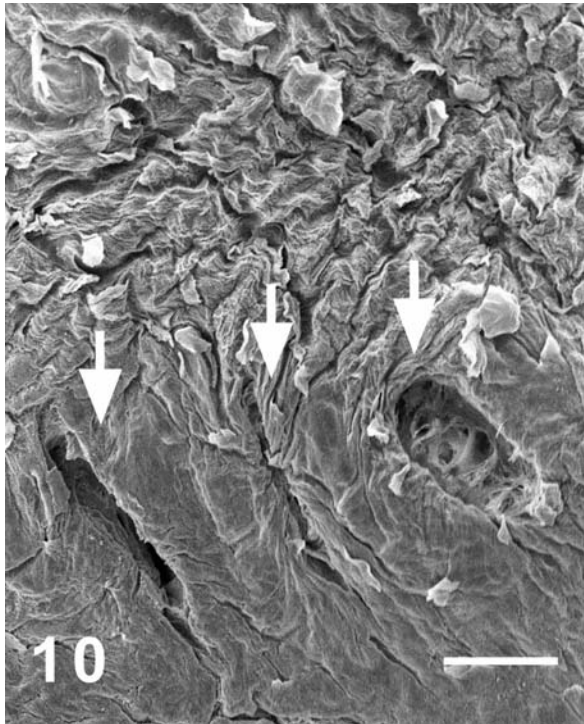


**Figure 8.** Scanning electron micrograph of the dorsal view of the apex of the intermolar prominence in the bank vole. The tips of the conical papillae (Co) are directed to the anterior part of the tongue. Sp — saw-like filiform papillae. Mag.  $\times 435$ , bar =  $30 \mu\text{m}$ .

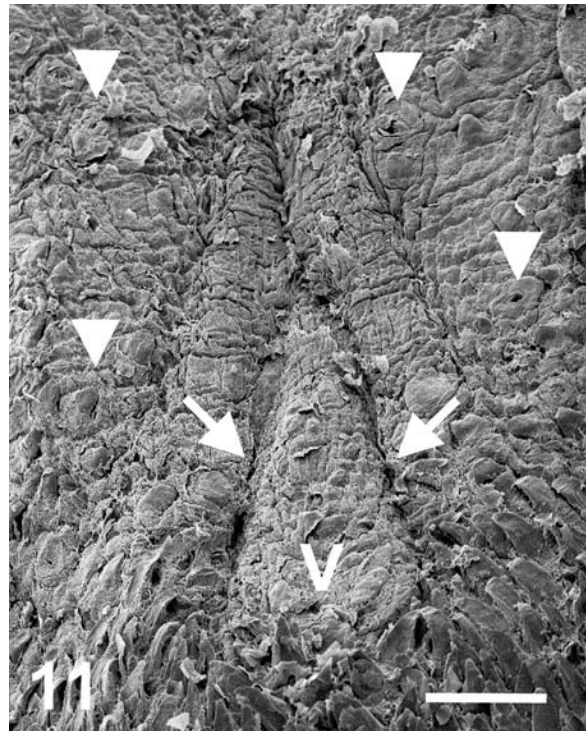


**Figure 9.** A higher magnification of the saw-like papillae on the surface of the intermolar prominence of the tongue in the bank vole. The arrows show the deep incision of the border of the saw-like papilla. Mag.  $\times 1007$ , bar =  $10 \mu\text{m}$ .





**Figure 10.** A higher magnification of part of the foliate papillae in the posteriolateral part of the bank vole tongue. The arrows show the fissures of the papillae. Mag.  $\times 476$ , bar =  $30 \mu\text{m}$ .



**Figure 11.** Scanning electron micrograph of the surface of the root of the bank vole tongue with a single vallate papilla (V). Arrows show the fissure of the papilla. Arrowheads indicate openings of the lingual glands on the flat surface of the root of the tongue. Mag.  $\times 225$ , bar =  $120 \mu\text{m}$ .

of the vallate papilla was surrounded by filiform papillae, whereas the posterior part is adjacent to the flat mucosa. The maximum diameter of the vallate papillae is  $650\text{--}720 \mu\text{m}$ , while the minimum is  $240\text{--}255 \mu\text{m}$ , respectively. The posterior part of the root of the tongue is flat with no papillae (Figs. 1, 11). The openings of the lingual papillae are seen on the surface of the mucosa (Fig. 11).

## DISCUSSION

The results of the present study facilitate a description of the topography and the microscopic structure of the dorsal surface of the tongue in the bank vole. General morphological features of the tongue in the bank vole show a considerable similarity to the structure of the tongue in the rodent species investigated previously. However, the results of the present studies make it possible to distinguish species-specific features in the morphology of the tongue and in the microscopic structure of the lingual papillae.

In the elongated tongue of the bank vole the characteristic features are a distinct median sulcus, which divides the wide shovel-shaped apex of the

tongue into two parts, and a considerable narrowing of the lingual body, found behind the apex. The median sulcus on the apex of the tongue is a characteristic feature found in many rodents, although its length and width are species-specific [5, 8, 9]. As reported by Kobayashi [12], the sulcus is absent in the guinea pig. The width of the lingual body in rodents is usually similar or slightly smaller than that of the other parts of the tongue. The morphology of the posterior part of the lingual body with its high intermolar prominence is similar in the bank vole to that in all rodents, as well as lagomorphs and ruminants [5, 18, 19].

The results of the microscopic observations of the lingual papillae in the bank vole indicated that the most numerous lingual papillae are the filiform papillae. As was shown on the SEM images, the three-dimensional structure of the filiform papillae, their dimensions and their density change depending on their location on the tongue, so that was possible to distinguish morphological subtypes of papillae. These highly keratinised papillae, covering the whole surface of the tongue except for the root, are involved, together with the palate, in the securing, passage

and partial mastication of bites of food, crushed previously with the teeth.

Characteristic features of the bank vole are a flat band of highly keratinised filiform papillae with overlapping processes, found in the medial line of the lingual body, and distribution of the giant conical papillae and saw-like papillae on the intermolar prominence. These results, showing the variety of filiform papillae with one keratinised process, are consistent with the observations conducted on other rodents [4, 6, 11, 16, 20]. Results for the distribution of lingual papillae closely resembling these were obtained by Emura et al. [2] in *Microtus montebelli*, a member of the Microtinae family. In the mouse, rat, gerbil and guinea pig the intermolar prominence is covered by conical papillae [5, 6, 11, 12]. The presence of saw-like papillae was also found in the gerbil [5].

Our findings have shown that three types of gustatory papilla are found in the bank vole, namely numerous fungiform papillae in the anterior part of the tongue, two foliate papillae distributed symmetrically on the lateral margins of the posterior part of the tongue and a single vallate papilla on the root of the tongue. Such a pattern of gustatory papillae has been found in *Microtus montebelli*, as well as in the rat, mouse and gerbil [2, 5, 6, 11, 14].

Fungiform papillae in the bank vole are situated on the apex and body of the tongue. An accumulation of fungiform papillae on the apex of the tongue was observed in *Microtus montebelli* [2] and in the rat, mouse and nutria [4, 15]. A comparison of the density of fungiform papillae on the apex of the tongue in the bank vole with the results obtained by Miller and Preslar [15] in the rat indicates considerable similarity. In other rodents the distribution of fungiform papillae varies. As reported by Kobayashi [12] in the guinea pig and Emura et al. [3] in the flying squirrel, fungiform papillae are found on the apex of the tongue and also on the lateral margins of the body of the tongue. In the gerbil fungiform papillae are evenly distributed on the body and also on the root of the tongue [5]. It also needs to be added that in the bank vole the fungiform papillae have, as in other rodents, a single taste bud on the apex of the papillae [5, 15].

Another type of gustatory papilla in the bank vole is, as in the rat and the mouse, represented by a single vallate papilla located in the medial line of the tongue [6, 11]. The number of vallate papillae found on the root of the tongue varies in rodents. As reported by Emura et al. [3, 4] and Sonntag [18] in the nutria, two oval vallate papillae are present on the root of the

tongue, while in the flying squirrel there are three vallate papillae. In the guinea pig vallate papillae are absent and in their place the so-called posterior foliate papillae are observed [12]. In the rodents investigated, including the bank vole, the oval body of the vallate papilla is separated from a more or less flat wall of a furrow by a continuous deep trench.

The third type of gustatory papilla in the bank vole are two foliate papillae, located on the posterolateral margin of the body of the tongue, and composed of 4–5 ridges separated by deep grooves. Both the location and the structure of these papillae in the bank vole are similar to those in the gerbil, the rat and the mouse [5, 6, 11]. The number of ridges in some species may be higher. As reported by Emura et al. [3], in the flying squirrel each foliate papilla consists of as many as 34 ridges.

The results obtained of the observation of the surface of the tongue in the bank vole indicated the close similarity of the distribution and structure of the lingual papillae tongue with the tongue of the *Microtus montebelli* and leads to the conclusion that the morphological features of the tongue are most probably typical for the other species belonging to the Microtinae.

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