

Morphological Study on the Dorsal Lingual Papillae of *Sorex caecutiens* Laxmann

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뒤쥐 (*Sorex caecutiens*) 혀유두의 형태학적 연구

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ABSTRACT

The dorsal lingual papillae of *Sorex caecutiens* were studied morphologically using scanning electron microscopy. Three types of lingual papillae were found: filiform papillae, fungiform papillae and circumvallate papillae. Filiform papillae were observed in most part of the tongue except on the lateral surface. There were basically three types of filiform papillae distinguished mainly by their morphological shape and structure. Numerous fungiform papillae were spread throughout the whole tongue, especially concentrated in lateral sides. The size varied according to the position of fungiform papillae, becoming larger as it reached to the rear. Strict pair-wise distribution was not observable, but fungiform papillae were mostly located in orderly manner. There were two large circumvallate papillae at the posterior region of the tongue. There were two thick pads around the center part where several bodies were gathered together. Overall research provided similar results with other close species such as common shrew (*S. araneus*). The circumvallate papillae of *S. caecutiens* were different from other *Sorex* species. They were circular, as in bats and other *Sorex* species, and had two distinguishable pads while others had only one.

Keywords : Tongue, Lingual papillae, *Sorex caecutiens*

INTRODUCTION

Morphological studies of dorsal surface and lingual papillae using scanning and transmission electron microscope have been done on various mammal species, including primates (Kobayashi et al., 2004), rodents (Fernandez et al., 1978; Iida et al., 1985; Kullaa-Mikkonen et al., 1987; Meisel et al., 1987; Kobayashi, 1990; Iwasaki et al., 1997, 1999;

Toprak, 2006), and Chiroptera (Emura et al., 2002; Hwang & Lee, 2007). There also has been some research done on the order Soricomorpha (Kobayashi et al., 1989; Jackowiak et al., 2004), but there is no serious morphologic research of lingual papillae of *Sorex caecutiens* Laxmann.

Sorex caecutiens, or Laxmann's shrew belongs to the family Soricidae which belongs to the order Soricomorpha, very different from common rats or hamsters which belong to the order Rodentia. An adult *S. caecutiens* has a weight

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Table 1. Comparison of the cell types, shapes, sizes and total numbers of the filiform, fungiform and circumvallate papillae of *Sorex caecutiens*

		Filiform papillae			Fungiform papillae			Circumvallate papillae
		Type			Region of tongue			
		(I)	(II)	(III)	Anterior	Middle	Posterior	
Shape	Flat cone	Fork	Cone	globular or oval			Oval	
Size (aver.)	Length	—			70 μ m	99 μ m	65 μ m	419 μ m
	Width	—			57 μ m	98 μ m	70 μ m	423 μ m
Amount	Uncountable			50 ~ 55			2	

Type I: Filiform papillae shaped like a flat cone, Type II: Filiform papillae shaped like a fork, Type III: Filiform papillae shaped like a cone

of 3 to 11 g and a body length of 4.8 to 7.8 cm, with the tail of 3.9 to 5.2 cm. Its habitats lies across northern Eurasia from Baltic to the East sea, including Hokkaido, Sakhalin and the Korean Peninsula. It usually favors high mountain forest, but is sometimes found in the lowland as well. *S. caecutiens* once belonged to the order Insectivora, which is now an abandoned term, and mainly prey upon various insects.

The main purpose of this research was to investigate the morphological characteristics of dorsal surface and lingual papillae of *S. caecutiens* by using scanning electron microscope. This study also aims to compare its results with those of other species of genus *Sorex*.

MATERIALS AND METHODS

Two adult individuals of *S. caecutiens* were captured for this study around Mount Muhak located in Masan, South Korea. After the sample has been anesthetized with ethyl ether, its tongue was excised and fixed in 3 % glutaraldehyde for three hours. It was then rinsed with buffer solution (Millonig's buffer, pH 7.4), and was fixed again in 1.33% OsO₄ for two hours afterward. To eliminate mucus and other non-tissue matters from the sample tongue, the mucus matter on the surface of tongue was dissociated in 8 N HCl at 60°C. After cleansing, it was dehydrated through graded series of alcohol (60, 70, 80, 90, 95, 99, 100%). Then, the alcohol inside the tissue was replaced with hexamethyldisilazane (HMDS). Finished tissue was coated with Pt for 90 seconds in ion sputter (E-1030, Hitachi), and was observed under scanning electron microscope (FESEM, S-4200, Hitachi).

RESULTS

The tongue of *S. caecutiens* was approximately 7 mm

long while 2.1 mm wide in the lower width and 1.6 mm wide in the upper width. Total of three types of lingual papillae were observed: filiform, fungiform and circumvallate papillae (Table 1, Fig. 1). The filiform papillae were observed in all areas except both edges (Fig. 1). They were categorized into three types according to their shape (Table 1). Type 1 was mainly observed in front middle section, with the shape of flat cone (Fig. 2A). Type 2 was located throughout both sides except on the very front. Cylinder-like base characterized with fork-shaped processes on the rear part directed toward the rear end of the tongue was the basic form of the type 2 (Fig. 2B). 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. 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 the ones in the rear sides showed long, sharp-looking processes. Type 3 filiform papillae were only seen near the rear end of the tongue between two circumvallate papillae. Type 3 papillae were cone-shaped with acuminate ends, with no observable flap or process as spotted in other types (Fig. 2C). They were mostly short and bulky with no crown or cylinder-like base.

The fungiform papillae were mainly located in sides (Figs. 1, 5). They were densely populated in the edge area (Fig. 5), and were also seen throughout the whole tongue except the middle area and the rear end. Total of approximately 50 ~ 55 fungiform papillae of the sample studied were distinguishable with round, flat shape. The fungiform papillae located in the front were relatively smaller than the ones found in the middle (Table 1).

Two circumvallate papillae were observed in the posterior region of the tongue. They were circular, large, and dough-

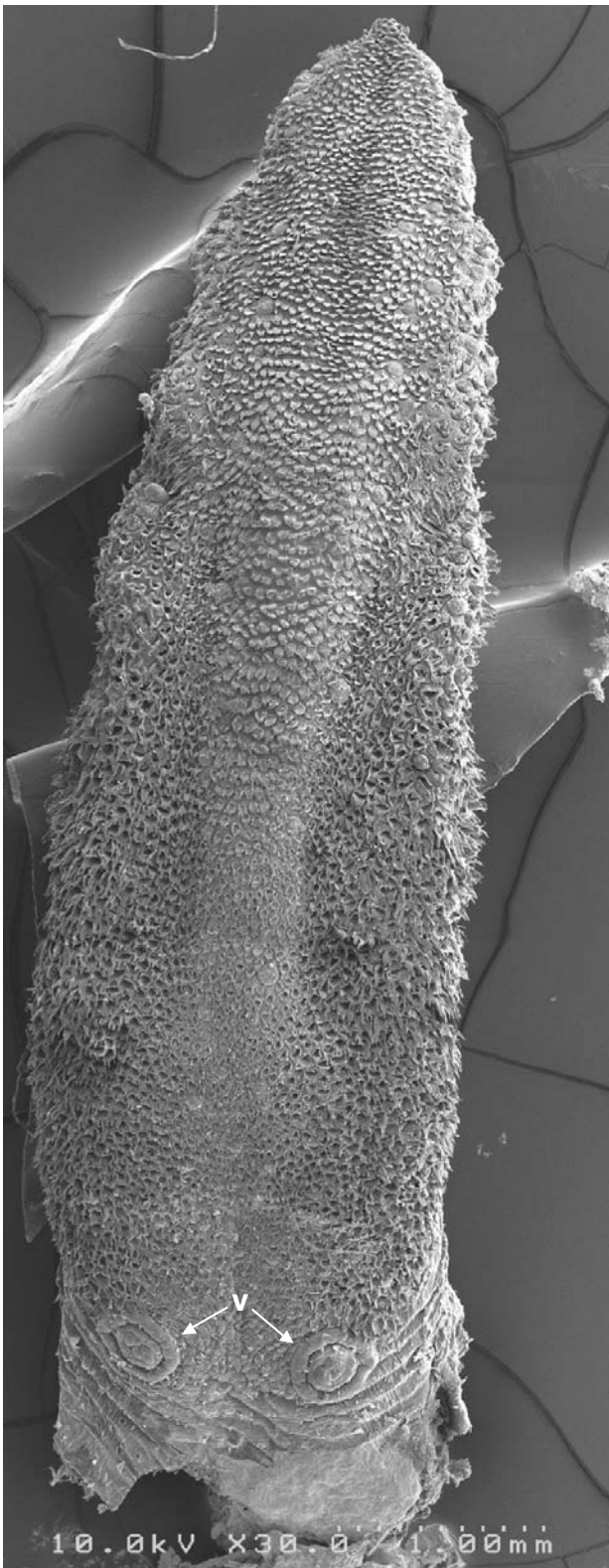


Fig. 1. SEM micrograph of the dorsal surface of the tongue of the *Sorex caecutiens*. The most of the surface is covered with filiform papillae (Fi), with occasional appearances of fungiform papillae (Fu). There are two circumvallate papillae (V) in the posterior region of the tongue.

nut-shaped papillae, with the length of approximately 430 μm and the width of approximately 410 μm . In the center of the vallate papilla, it was divided into two or three distinct bodies clumped together (Figs. 1, 4A, 4B). Two layers of thick pads encircled around the clumped bodies. Then, filiform papillae surrounded the anterior part of the vallate papilla while the posterior part met the lingual mucosa.

DISCUSSION

According to the former study on the lingual papillae of shrews belonging to the genus *Sorex* (Kobayashi, 1989; Jankowiak et al., 2004), three types of lingual papillae were found on the dorsal surface: filiform, fungiform and vallate papillae. Present research provided similar results with also three types of lingual papillae observed. The filiform papillae were distributed throughout the tongue of *S. caecutiens* as those of *S. araneus* did. The shape of the filiform papillae type 1 and 2 showed shared characteristic with other insectivores whose tips were bent toward the rear end of the tongue in order to prevent the escape of their food, or insects. The filiform papillae type 3 was relatively smoother than the rest, presumably due to their main function of gulping down the food. The special, middle portion, suggested by Pastor et al. (1993) and Son et al. (2000) where some filiform papillae were bent toward opposite direction in order to hold the food until they were swallowed was not observed in *S. caecutiens*. Additionally, there were few or no filiform papillae on the lateral side of the tongue, unlike *S. araneus* or other *Sorex* species.

The shape and distribution of fungiform papillae of *S. caecutiens* were also similar with those of other *Sorex* species (Kobayashi et al., 1989). The distribution of fungiform papillae is usually divided into four types: even distribution throughout the whole area of dorsal surface as found in dogs (type 1), focused distribution in the boundaries including side edges, tip and rear end section as in cats, moles and humans (type 2), concentrated distribution only in the tip and side edge areas as in rabbits (type 3), center and tip distribution as in mice (type 4) (Chung & Kwun, 1977).

In this research, fungiform papillae were occasionally found along the lateral margins of the tongue, although not so strictly paired in terms of location such as in the case of *S. araneus*. They were also found on the front tip of the tongue, as well as on the center of the posterior region. The fungiform papillae of *S. araneus* were symmetrical and were in pairs, but the ones of *S. caecutiens* did not exactly show those patterns although they were basically in line

along the side margin area. The overall distribution closely resembled that of the aforementioned type 2. The size of fungiform papilla increased as its position became closer to the middle area, and the ones located closer to the center were flatter than the ones found in the edges presumably because of frequent use and attrition. Approximately 50 to 55 fungiform papillae were found, whose shapes were mainly round or oval. This number is relatively smaller than other mammals such as dogs (700~800), cats (200~250), humans (180~220), mice (90~130), rabbits (90~120), moles (80~120) (Chung & Kwun, 1977). It is likely that the size of the tongue is proportional to its number of fungiform papillae present as Chung & Kwun (1977) suggested, but it is also possible that the number of fungiform papillae depends on the variety of food the species digests since omnivores such as dogs and humans tend to have relatively large number of fungiform papillae compared with their size. This further supports that the fungiform papillae serve mainly as taste sensors, which contain many taste buds.

The main morphological difference of lingual papillae between *S. caecutiens* and other *Sorex* species, especially *S. araneus* came from circumvallate papillae. The two valvate papillae of *S. caecutiens* were circular with thick layers of pad around the center where three (left) or two (right) distinguishable bodies were observed together. The number of pad layers around the circumvallate papillae varied among species. Those of mouse, rat and other rodents had only one layer of pads (Iwasaki et al., 1996, 1997). Those of primates had only one layer of pads, too (Kobayashi et al., 2004). Also, those of the close species such as *S. araneus* had one layer of pads. But, the circumvallate papillae of *S. caecutiens* had two distinct layers of pad. This may be considered a unique characteristic of this species. The circular shape of *S. caecutiens*' circumvallate papillae resembled those of bats or chiropters such as *Pteropus vampyrus* and *Myotis macrodactylus* (Emura et al., 2002; Hwang & Lee, 2007).

This study has provided morphological characteristic of each types of lingual papillae of *S. caecutiens*. It also showed distribution pattern of lingual papillae. Overall, the lingual papillae of *S. caecutiens* resembled many characteristics shared by many *Sorex* species, but some features, especially those of circumvallate papillae, were distinct from other species.

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< 국문 초록 >

뒤쥐 (*Sorex caecutiens*) 혀유두의 형태적 특징을 알아보기 위해 주사전자현미경을 이용하여 관찰하였다. 혀유두는 실유두, 버섯유두 그리고 성곽유두의 세 가지 유형으로 관찰되었다. 실유두는 혀 측면을 제외하고는 혀의 전역에 걸쳐 분포하고 있었으며, 형태와 구조적 특징을 기초로 하여 세 가지의 유형으로 구분되어졌다. 다수의 버섯유두는 혀 전체에 걸쳐 분포하였으며, 특히 혀의 양 측면

에 걸쳐 존재하고 있었으며, 혀의 앞쪽보다는 뒤쪽으로 갈수록 크기가 더 컸었다. 버섯유두는 쌍을 이루며 분포하지는 않았지만, 대부분 일정하게 분포하였다. 큰 2개의 성곽유두는 혀의 후방부의 끝 가까이에 존재하고 있었다. 성곽유두는 바깥쪽(측면)이 두꺼운 두 겹의 pad가 둥글게 둘러싸고 있었으며, 중앙에는 2개 혹은 3개 정도의 돌출된 둥글게 둘러싼 pad가 존재하고 있었다. 본 연구 종은 일반적인 뒤쥐류에서 볼 수 있는 혀의 형태와 거의 흡사한 구조를 가지고 있었음을 알 수가 있었다. 본 연구에서 성곽유두는 *Sorex* 종과는 차이가 있었다. 즉, 박쥐류와 *Sorex* 종에서와 같이 바깥쪽의 pad가 환상의 형태를 취하고 있다는 점에서는 동일하나 박쥐류와 *Sorex* 종의 경우는 바깥쪽의 pad가 한 겹인데 반해 본 연구 종은 두 겹의 환상 구조를 취하고 있다는 점에서 차이가 있었다.

FIGURE LEGENDS

Fig. 2. SEM micrographs of the dorsal lingual surface showing the filiform papillae. The figure 2A shows Type 1 filiform papillae of flat cone shape. The figure 2B shows Type 2 filiform papillae of fork-like shape. The figure 2C shows Type 3 filiform papillae of cone shape. The figure 2D presents another version of Type 2 filiform papillae.

Fig. 3. SEM micrographs of the dorsal lingual surface showing fungiform papillae (Fu). Both figures show fungiform papillae located in the middle part of the tongue.

Fig. 4. SEM micrographs of the dorsal lingual surface of the circumvallate papillae. The figure 4A shows the right vallate papilla. The figure 4B shows the left circumvallate papilla.

Fig. 5. SEM micrograph of the lateral surface of the tongue. Note the densely located fungiform papillae (Fu) and the lack of filiform papillae (Fi) on the lateral surface.

