

## Tongue structure in the long-eared hedgehog (*Hemiechinus auritus*): A scanning electron microscopic study

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Article Info	Abstract
<p><b>Article history:</b></p> <p>Received: 10 December 2016 Accepted: 17 April 2018 Available online: 15 September 2018</p> <p><b>Key words:</b></p> <p>Lingual papillae Long-eared hedgehog Scanning electron microscope Tongue</p>	<p>The aim of this study was to investigate the dorsal surface of the long-eared hedgehog tongue using scanning electron microscopy. The tongue of the long-eared hedgehog is rectangular-shaped with an elongated body and a widened root and a marked deep median groove can be seen on its dorsal surface. A characteristic feature of the lingual root is presence of two huge laterally situated folds. These anatomical structures have never been described with regard to other small mammals studied so far. According to their anatomical appearances, the lingual papillae can be distinguished as filiform, conical, fungiform, circumvallate and foliate papillae. The filiform papillae covering the body of the tongue are longer and wider than those on its apex and have an apparent fork-like appearance. Fungiform papillae are evenly distributed on the dorsal surface of the apex and body of the tongue. The triangular area of the lingual root contains small caudally directed conical papillae with single processes. Foliate papillae are situated on both lateral surfaces of the lingual root medial to the huge lateral lingual folds as three large obliquely situated parallel folds. There are three circumvallate papillae, two of which are obliquely situated on both sides of the rostral part of the lingual root, while the third one is situated in the midline of the caudal part of the lingual root. The results show that the tongue structure of the long-eared hedgehog is more complex in comparison with other mammals which is related to its phylogeny and feeding habits.</p> <p>© 2018 Urmia University. All rights reserved.</p>

### ساختار زبان در جوجه تیغی دراز گوش (همی/کینوس آوریئوس): مطالعه‌ای در سطح میکروسکوپ الکترونی نگاره

#### چکیده

هدف این مطالعه بررسی سطح پستی زبان جوجه تیغی دراز گوش با استفاده از میکروسکوپ الکترونی نگاره بود. زبان جوجه تیغی دراز گوش مثلثی شکل با بدنه‌ای کشیده و ریشه‌ای عریض می باشد و بر روی سطح پستی آن شیار میانی عمیق آشکاری قابل مشاهده است. مشخصه بارز ریشه زبان وجود دو تاخوردگی وسیع مستقر در سطح جانبی می باشد. چنین ساختارهای آناتومیکی تاکنون در دیگر پستانداران کوچکی که مورد مطالعه قرار گرفته اند، توصیف نشده‌اند. بر اساس ظواهر آناتومیکی پرزهای زبانی به صورت پرزهای نخی شکل، مخروطی شکل، قارچی شکل، جامی شکل و برگی شکل قابل تشخیص می باشند. پرزهای نخی شکلی مفروش کننده بدنه زبان طویل تر و عریض تر از این پرزها بر روی رأس اندام می باشند و ظاهر چنگالمانند مشهودی دارند. پرزهای قارچی شکل بر روی سرتاسر سطح پستی رأس و بدنه زبان پراکنده شده اند. ناحیه‌ی مثلثی شکل ریشه زبان حاوی پرزهای مخروطی شکلی کوچک در راستای خلفی با زوائد منفرد می باشد. پرزهای برگی شکل به شکل سه تاخوردگی موازی مورب طویل بر روی هر دو سطح جانبی ریشه زبان در موقعیت میانی نسبت به تاخوردگی‌های جانبی وسیع جای گرفته‌اند. سه پرز جامی شکل وجود دارند که دو پرز، به‌طور مورب بر دو سوی بخش قدامی ریشه‌ی زبان جای گرفته اند، درحالی که پرز سوم در خط میانی بخش خلفی ریشه زبان استقرار یافته است. نتایج نشان می دهند که ساختار زبان جوجه تیغی گوش دراز در مقایسه با دیگر پستانداران از پیچیدگی بیش تری برخوردار است که در ارتباط با تبارشناسی و عادات تغذیه‌ای حیوان قرار می گیرد.

**واژه های کلیدی:** پرزهای زبانی، جوجه تیغی دراز گوش، زبان، میکروسکوپ الکترونی نگاره

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## Introduction

The shape and surface structure of the tongue differ considerably among animal species, reflecting the various functions of each respective organ.<sup>1</sup> The tongue as a particularly important organ in digestive process participates in food intake, mastication and deglutination and due to the presence of various gustatory papillae, it also participates in the perception of taste stimuli. The tongue has become an important object of many anatomical and histological studies aimed at presenting the dependence between its gross and microscopic structure and diverse animal adaptations to the environment and food.<sup>2,3</sup> Research has shown that the overall anatomical and histological structure of the tongue is similar in all mammalian species. Differences however exist between the species concern lingual shape and size and the structural organization of the lingual mucous membrane particularly in the dorsal area of the organ.<sup>1</sup>

The studies on morphological features of the tongue and lingual papillae have been conducted in most vertebrate classes including mammals.<sup>1,4,5</sup> The results of these studies conducted so far have indicated a close correlation of the morphological features of the tongue with the method of food intake, type of food, habitat and the environmental conditions of different species. The purpose of this study was to describe the morphological structure of tongue in long-eared hedgehog using scanning electron microscopy in order to compare the results with those previously reported in other small mammals.

## Materials and Methods

Tongues of six adult long-eared hedgehogs of both sexes (3 males and 3 females) within the weight range of 400-520 g were used in the investigations. No animal was sacrificed in this study. All the procedures of this study were approved by the Institutional Ethics Committee of University of Shahrekord, Iran (No. 1394.1623, Date: Jan 07 2016). The tongues used in this study were obtained from hedgehogs that died due to different causes, but their tongues were not affected. The tongues were dissected from the mandible and surrounding soft tissues and their lengths were measured using caliper. The tongues were rinsed with 0.10 M phosphate buffer at pH of 7.30. Post-fixation was made in 1.00% osmium tetroxide solution (Merck, Darmstadt, Germany) for two hr at 4 °C. The specimens were dehydrated through graded series of ethanol and infiltrated by hexamethyl disilazane (Merck). The dried specimens were then mounted on aluminum stubs and coated about 20 sec with gold-palladium (Merck). The specimens were observed under a scanning electron microscope (Stereoscan 360; Leica Cambridge Ltd., Cambridge shire, UK). The measurement was provided automatically by the SEM unit.

## Results

The tongue of the long-eared hedgehog has a rectangular shape with a clearly elongated body and a widened root. The total length of the tongue is 24.50 mm, while its width, depending on the area, is as follows: 5.50 mm in the apical part, 7.00 mm in the anterior part of the body, 7.20 mm in its middle and 8.80 mm at the root. A marked deep median groove of 12.20 mm extending from the apex nearly up to middle point of the organ can be seen on its dorsal surface. A characteristic feature of the lingual root is presence of two large laterally situated folds (Figs. 1A and 3B). The surface of the caudal part of the lingual root is obviously lowered towards the pharynx. Five distinct types of lingual papillae can be distinguished on the dorsal surface of the organ including filiform, fungiform, conical, circumvallate and foliate papillae.

**Filiform papillae.** The most numerous papillae on the entire dorsal surface of the apex and body of the tongue are filiform papillae. These papillae have one, two or three apical processes tilted posteriorly toward the root of the organ. The shapes of the filiform papillae vary depending on their situation on the tongue. The average length of the filiform papillae on the apical part of the tongue is  $125.48 \pm 12.20 \mu\text{m}$  with the width in the range of  $40.50 \pm 8.42 \mu\text{m}$ . The filiform papillae covering the body of the tongue are longer ( $210.64 \pm 22.48 \mu\text{m}$ ) and wider ( $92.18 \pm 10.12 \mu\text{m}$ ) than those on its apex and have apparent fork-like appearances (Figs. 1B and 2A).

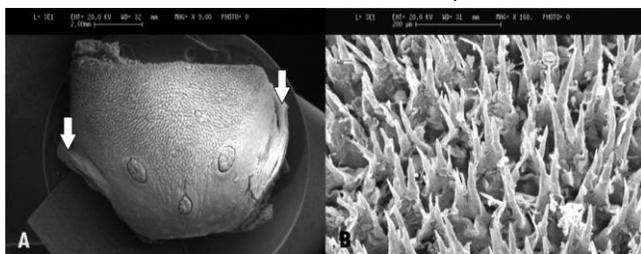
**Fungiform papillae.** Fungiform papillae are evenly distributed on the entire dorsal surface of the apex and body of the tongue between filiform papillae (Fig. 2B). They are dome-shaped structures and their average diameter is  $188.50 \pm 18.44 \mu\text{m}$  in the apex of the tongue up to  $218.24 \pm 22.48 \mu\text{m}$  in the body of the organ.

**Conical papillae.** The triangular area of the lingual root formed between the circumvallate papillae contains small caudally directed conical papillae with single processes (Fig. 3A) and their respective dimensions are as follows: length:  $185.24 \pm 12.48 \mu\text{m}$  and width:  $85.64 \pm 8.68 \mu\text{m}$ . The largest conical papillae are in the middle part of the above-mentioned triangular area, whereas on the lateral parts of the area they gradually become smaller.

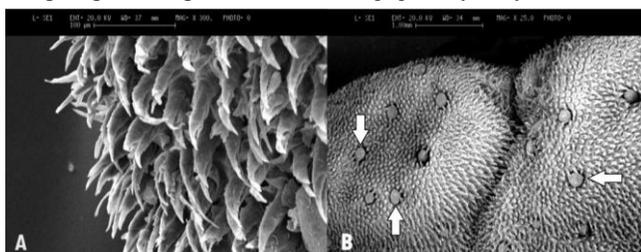
**Foliate papillae.** Foliate papillae are situated on both lateral surfaces of the lingual root medial to the large lateral lingual folds and adjacent to the palatopharyngeal arches. They are arranged in three large obliquely situated parallel folds with  $820.40 \pm 46.22 \mu\text{m}$  average height and  $64.00 \pm 8.44 \mu\text{m}$  average width separated by shallow wide grooves (Fig. 3B).

**Circumvallate papillae.** There are three circumvallate papillae, two of which are obliquely situated on both sides of the rostral part of lingual root, while the third one is situated in the midline of the caudal part of lingual root (Fig. 4A). The papillae are egg-shaped and their free dorsal

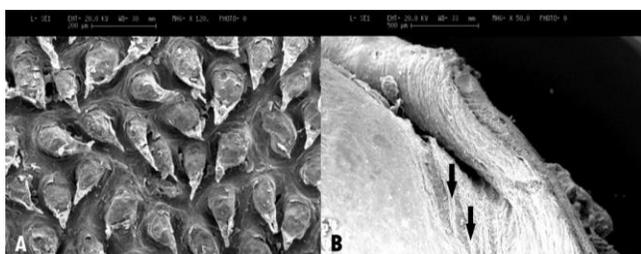
surfaces are clearly irregular and lobulated (Fig. 4B). The rostral part of the caudal papilla and the medial parts of the rostral papillae are surrounded by conical papillae, whereas the caudal part of the caudal papilla and the lateral parts of the rostral papillae are adjacent to bare flat mucosa of the lingual root (Fig. 4A). These gustatory papillae are surrounded by distinct continuous fissures (Fig. 4B). The rostral papillae with caudally directed points are apparently larger than the caudal papilla and the average diameter of their larger axis is 994.88  $\mu\text{m}$ , while that of their smaller one is 620.48  $\mu\text{m}$ .



**Fig. 1.** **A)** SEM micrograph of the root of the tongue in the long-eared hedgehog. A characteristic feature of the lingual root is presence of two large laterally situated folds (arrows; 9 $\times$ ); **B)** SEM micrograph of the body of the tongue in the long-eared hedgehog with large fork-like filiform papillae (160 $\times$ ).



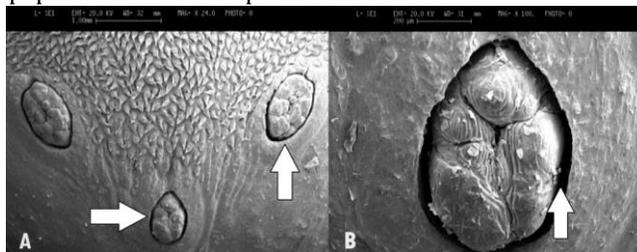
**Fig. 2.** **A)** SEM micrograph of the filiform papillae of the apex of the tongue in long-eared hedgehog. These papillae are more slender and less branched than those on the body of the organ (300 $\times$ ); **B)** SEM micrograph of the dorsal surface of apex and body of the tongue in the long-eared hedgehog. Dome-shaped fungiform papillae (arrows) are evenly distributed on the entire dorsal surface of the apex and body of the tongue between filiform papillae (25 $\times$ ).



**Fig. 3.** **A)** SEM micrograph of the triangular area of the lingual root formed between the circumvallate papillae in the long-eared hedgehog containing caudally directed conical papillae (120 $\times$ ); **B)** SEM micrograph of the foliate papillae (arrows) situated on lateral surface of the lingual root medial to the large lateral lingual folds in the long-eared hedgehog. Note that the foliate papillae are arranged in obliquely situated parallel folds separated by shallow wide grooves (50 $\times$ ).

The dimensions of the caudal papilla with a rostrally directed point are as follows: large axis = 760.50  $\mu\text{m}$  and the smaller one = 442.86  $\mu\text{m}$ .

It seems neither the morphological features nor the morphometric characteristics of the tongue and the lingual papillae showed sex-specific differences.



**Fig. 4.** **A)** SEM micrograph of the root of the tongue in the long-eared hedgehog. Note the presence of three large circumvallate papillae (arrows; 24 $\times$ ); **B)** SEM micrograph of a circumvallate papilla situated on the root of the tongue in the long-eared hedgehog. The papilla is egg-shaped and its free dorsal surface is clearly irregular and lobulated. Note the presence of a distinct continuous fissure around the papilla (arrow; 100 $\times$ ).

## Discussion

The results obtained from the present investigation showed that morphological characteristics of the tongue in the long-eared hedgehog are similar to those of the tongue in the other small mammals investigated previously. This study also revealed some species-specific features in the surface of tongue in the long-eared hedgehog.

The length of long-eared hedgehog tongue in this investigation (24.50 mm) is in agreement with Jabbar, who stated that the length of the tongue of the Iraqi hedgehog was about 27 mm and Taha who reported that the length of tongue in long-eared hedgehog was about 19 mm.<sup>6,7</sup>

A marked deep median groove which divides the rostral half of the tongue into two symmetrical parts can be seen on the dorsal surface of the tongue of the long-eared hedgehog. The median groove on the rostral part of the tongue is a characteristic feature in some small mammals investigated previously confirming our observation, although its length can be considered as a species-specific feature.<sup>8-10</sup> The groove however is absent in the guinea pig<sup>11</sup> as well as Egyptian fruit bat.<sup>12</sup>

The present study showed that unlike the rodents, lagomorphs and ruminants, the intermolar prominence is not present on the dorsal surface of long-eared hedgehog tongue.<sup>5,6,8,13</sup> The presence of a lingual prominence is regarded as a characteristic of herbivores and this muscle-rich prominence with filiform papillae allows herbivores to grind food by crushing it between the tongue and the upper palate.<sup>14</sup> A characteristic feature of the tongue in the long-eared hedgehog is the presence of two huge caudolaterally situated lingual folds. These two folds may help to prevent saliva accumulation in the oral cavity and its flow towards the alimentary canal. More researches

may be needed to confirm this statement. These huge anatomical structures have never been described with regard to other small mammals studied so far.

Lingual papillae show considerable differences regarding their shape, dimensions, number, orientation and distribution among different mammalian species. These differences depend on dissimilarities in diet, feeding habits and handling of the food in the mouth.<sup>1</sup>

The results of the present study on the lingual papillae of long-eared hedgehog showed that the most numerous papillae on the entire dorsal surface of the apex and body of the tongue are filiform papillae. The appearance and dimensions of the filiform papillae depend on their anatomical position on the tongue, so that the filiform papillae covering the body of the tongue are longer and wider than those on its apex and have apparent fork-like appearances. The filiform papillae in the long-eared hedgehog have one, two or three apical processes tilted posteriorly toward the root of the organ. The presence of two distinct types of filiform papillae has been reported in other small mammals, however unlike the long-eared hedgehog, the filiform papillae in these animals have only one process.<sup>15,16</sup> This finding may indicate that the filiform papillae in the long-eared hedgehog are more differentiated in shape in comparison with those in other small mammals. The filiform papillae as highly keratinized mechanical papillae are involved in the passage of food toward the alimentary canal.<sup>1</sup>

The results obtained from the present investigation also showed that another type of mechanical papillae called conical papillae with single processes can be seen in the small triangular area of the lingual root formed between the circumvallate papillae. These mechanical papillae have never been described in hedgehog species so far. These papillae may be an anatomically modified type of the filiform papillae in the long-eared hedgehog. More investigations on this type of papillae may be needed to confirm this statement and find whether the anatomical structure of these papillae is related to the phylogeny and/or the feeding method of the long-eared hedgehog. The conical papillae have been also found on the root of the tongue in small mammals such as hazel dormouse.<sup>17</sup> The presence of this type of mechanical papillae in the majority of rodents is confined to the intermolar prominence.<sup>8,15,16</sup> These papillae mechanically prevent retraction of the chewed food during its passage through the oral cavity towards the alimentary canal.<sup>1</sup>

The present study also showed that three types of gustatory papillae are found in the tongue of the long-eared hedgehog including numerous fungiform papillae scattered throughout the lingual surface, foliate papillae on the caudolateral margins of the tongue and three huge circumvallate papillae on the root of the tongue.

Fungiform papillae in the long-eared hedgehog are evenly distributed on the entire dorsal surface of the apex

and body of the tongue between filiform papillae and they are absent in the root of the organ. The distribution of fungiform papillae varies among the vertebrates. In the guinea pig, fungiform papillae are found merely on the apex of the tongue on the lateral margins of the body of the tongue and the dorsal surface of the body of the organ is completely devoid of this type of gustatory papillae.<sup>11</sup> In the gerbil, on the other hand, fungiform papillae are distributed on the body and also on the root of the organ.<sup>8</sup> In rats, mice and nutria, the fungiform papillae are densely distributed on the lingual apex and their frequency diminishes towards the body of the organ.<sup>9,18,19</sup>

Another type of gustatory papillae in the long-eared hedgehog is circumvallate papillae. There are three circumvallate papillae, two of which are obliquely situated on both sides of the rostral part of the lingual root, while the third one is situated in the midline of the caudal part of the lingual root. The number of circumvallate papillae also varies in small mammals. Circumvallate papillae are absent in the guinea pig.<sup>11</sup> As reported by Iino and Kobayashi, a single circumvallate papilla is present in the medial line of the tongue in the rat and mouse.<sup>15</sup> Sonntag and Emura *et al.* have stated that in the nutria, two oval circumvallate papillae can be found on the root of the tongue,<sup>4,20</sup> while in the flying squirrel there are three circumvallate papillae.<sup>21</sup> The number of the circumvallate papillae can be related to the taxonomic position as well as the environment and feeding habits of the species. The dorsal surfaces of the circumvallate papillae were clearly irregular and lobulated in the present study. This finding is similar to that reported in dog and fox, while it was smooth in Japanese marten.<sup>22,23</sup> In European bat, between the two circumvallate papillae, there was an area without papillae, while in our study, between the two circumvallate papillae, there was an area of triangular filiform papillae.<sup>24</sup>

The third type of gustatory papillae found in the long-eared hedgehog is foliate papillae located on both lateral sides of the lingual root medial to the large lateral lingual folds and adjacent to the palatopharyngeal arches and arranged in three large obliquely situated parallel folds separated by shallow wide grooves. The location and anatomical structure of these papillae are both similar to those in the gerbil, rat and mouse.<sup>8,15,25</sup> The number of ridges in some small mammals may be higher. Emura *et al.* have stated that in the flying squirrel, each foliate papilla consists of as many as 34 ridges.<sup>18</sup> According to Shindo *et al.*, the degree of foliate papillae development correlates with the type of food and the manner of its processing inside the oral cavity of the animal.<sup>25</sup>

In conclusion, the results obtained from the present investigation indicated the close similarity of the distribution and surface anatomical structure of the lingual papillae in the long-eared hedgehog with those in the small mammals so far studied.

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## Conflict of interest

The authors do not have any particular conflicts of interest to declare.

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