Morphology of the lingual papillae of the polar bear (*Ursus maritimus*)

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**Summary:** We examined the dorsal lingual surfaces of a newborn and an old polar bears by using scanning electron microscopy. In the newborn polar bear, the filiform papilla on the lingual apex was cylindrical in shape. The connective tissue core of the filiform papillae was needle-shaped and that of the fungiform papillae was funnel-shaped. The filiform papillae on the lingual body was dome-shaped. The connective tissue core of the filiform papillae was U-shaped and that of the fungiform papillae was column-shaped. On the lingual apex and body, there could not distinguish the filiform from fungiform papillae. The connective tissue core of the filiform papilla was different from the fungiform papilla. The vallate papillae were surrounded by a groove and pad and the surface was smooth. In the old bear, the filiform papilla on the lingual apex had several pointed processes. The processes of the filiform papilla on the lingual body were larger than those of the lingual apex. The vallate papillae were surrounded by a groove and pad and the surface was rough. There are no foliate papillae.

Many studies report the structures of the lingual surfaces of various animals. Some scanning electron microscopy (SEM) studies have been performed on the tongues of animals in the order Carnivora, including the cat (Boshell et al., 1982), dog (Iwasaki and Sakata, 1985), mongoose (Iwasaki et al., 1987), Japanese weasel (Furubayashi et al., 1989), sea otter (Shimoda et al., 1996), Japanese black bear (Inatomi and Kobayashi, 1999), bush dog (Emura et al., 2000), panther, Asian black bear (Emura et al., 2001), lion (Emura et al., 2003), tiger (Emura et al., 2004), jaguar (Emura et al., 2013), fishing cat (Emura et al., 2014), and black-backed jackal (Emura et al., 2014). These studies have revealed variations in the morphology and distribution of papillae on the dorsal lingual surface among animal species.

However, no SEM study of the tongue of the polar bear (*Ursus maritimus*) has been performed. Therefore, this study examined the dorsal lingual surface of the polar bear and compared the features with those of other mammals.

**Materials and Methods**

The tongues of a newborn and an old polar bears of the family Ursidae were used in this study. The tongues were fixed in 10% formalin. Small blocks containing papillae were cut with a razor blade and post-fixed with 1% osmium tetroxide for 1 h. The specimens were subsequently dehydrated through a graded series of acetone and critical point-dried. To show the three-dimensional connective tissue structure of the lamina propria of the mucosa, some of the samples were washed in distilled water after fixation and macerated in 3.5 N HCl at 35°C for 2 days. After maceration, the tissues were washed in distilled water, post-fixed in 1% osmium tetroxide for 1 h, and dehydrated in a series of acetone and critical point-dried. All specimens were sputtered with platinum–palladium before being examined by SEM (Hitachi S-3500N, Tokyo, Japan) at an acceleration voltage of 10 kV.

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Results

Macroscopically, the tongue of the newborn polar bear was approximately 5 cm long (Fig. 1a). That of the old polar bear was approximately 25 cm long (Fig. 1b). The tongues of those bears had a median groove (Fig. 1a, b). There were no foliate papillae. Vallate papillae were located on both sides of the posterior end of the lingual body.

New born polar bear

SEM showed that filiform papilla on the lingual apex was cylindrical in shape (Fig. 2a). The connective tissue core of the filiform papillae was needle-shaped and that of the fungiform papillae was funnel-shaped (Fig. 2b). The filiform papilla on the lingual body was dome-shaped (Fig. 3a). The connective tissue core of the filiform papilla was U-shaped and that of the fungiform papilla was column-shaped (Fig. 3b). On the lingual apex and body, there could not distinguish the filiform from fungiform papillae (Fig. 2a, 3a). However, the connective tissue core of the filiform papilla was different from the fungiform papilla (Fig. 2b, 3b). The vallate papillae were surrounded by a groove and pad and the surface was smooth (Fig. 4).

Old polar bear

SEM showed that the filiform papilla on the lingual apex had several pointed processes (Fig. 5a). The connective tissue core of the filiform papilla was finger-shaped (Fig. 5b). The fungiform papilla was round in shape and the connective tissue core was bud-shaped (Fig. 5b). The processes of the filiform papilla on the lingual body were larger than those of the lingual apex (Fig. 6a). The connective tissue core of the filiform papillae had many vertical grooves and that of the fungiform papilla was honeycomb-shaped (Fig. 6b). The vallate papilla was surrounded by a groove and pad and the surface was rough. (Fig. 7).

Discussion

In the newborn dog (Kobayashi et al., 1987), the filiform papillae are seen as ovoid protrusions. In the newborn panther (Emura et al., 2001), the filiform papillae of the central region of the lingual body are cylinder-shaped papillae rather than conical papillae. The vallate papilla is surrounded by a groove and a pad. In the newborn Asian black bear (Emura et al., 2001), the filiform papillae of the central region of the lingual body are bud-shaped papillae. Some vallate papillae are composed by a primary papilla which is divided into several secondary papillae by intermediate grooves. In the present study of the tongue of the
Fig. 3. SEM micrographs of the lingual body of the new born polar bear. (a) The filiform papillae on the lingual body was dome-shaped. (b) The connective tissue core of the filiform papillae was U-shaped and that of the fungiform papillae was column-shaped. Fu: fungiform papilla.

Fig. 4. SEM micrograph of the vallate papillae of the new born polar bear. The vallate papillae were surrounded by a groove and pad and the surface was smooth V: vallate papillae. P: pad.

Fig. 5. SEM micrographs of the lingual apex of the old polar bear. (a) The filiform papilla on the lingual apex had several pointed processes. (b) The connective tissue core of the filiform papillae was finger-shaped. Fu: fungiform papillae.

Fig. 6. SEM micrographs of the lingual body of the old polar bear. (a) The processes of the filiform papilla on the lingual body were larger than those of the lingual apex. (b) The connective tissue core of the filiform papillae had many vertical grooves and that of the fungiform papillae was honeycomb-shaped. Fu: fungiform papillae.
newborn polar bear, the filiform papillae on the lingual apex was cylindrical in shape and that of the lingual body was dome-shaped. In the adult Asian black bear (Inatomi and Kobayashi, 1999), the structure of the tongue is very similar to that of the other Carnivora having numerous large conical papillae on the dorsal surface of the radix. On the other hand, the tongue structure of the Asian black bear is also similar to that of the crab-eating monkey, an omnivorous animal, which has similar filiform papillae and foliate papillae.

In the tiger (Emura et al., 2004), the filiform papillae are distributed over the entire dorsal surface of the tongue. The filiform papillae on the midpoint of the anterior 1/3 giant club-shaped papillae. The fungiform papillae are present rounded bodies, and more densely distributed on the lingual apex. There are no foliate papillae. In the jaguar (Emura et al., 2013), the filiform papillae on the lingual apex comprise one larger main papilla and some secondary papillae. The filiform papillae on the anterior part of the lingual body are large and cylindrical. The filiform papillae on the central part of the lingual body are large conical papillae. There are no foliate papillae. In the fishing cat (Emura et al., 2014), the filiform papillae on the lingual apex have several pointed processes. The filiform papillae on the anterior part of the lingual body are large and cylindrical. The filiform papillae on the central part of the lingual body are large and conical. There are no foliate papillae.

In the cat (Boshell et al., 1982), lion (Emura et al., 2003), tiger (Emura et al., 2004), jaguar (Emura et al., 2013), and fishing cat (Emura et al., 2014), the filiform papillae on the anterior part of the lingual body are large and cylindrical; this is a characteristic of the filiform papillae in the family Felidae.

In the family Canidae, the filiform papillae of the beagle dog (Iwasaki and Sakata, 1985), are closely distributed over the entire dorsal surface of the tongue. On the apical surface, some twigs form a semicircle around baso-frontal dome-shaped bulge from the back. Towards the middle area of the body, the bulge of filiform papillae gradually becomes smaller and flatter; only the central twig gradually becomes larger, while the other twigs become smaller. In the bush dog (Emura et al., 2000), the filiform papillae on the apical surface of the tongue have several conical processes; those on the midpoint are larger than those on the apex. In the region of the vallate papillae, the filiform papillae do not have conical processes and are larger than those on the midpoint of the tongue. The fungiform papillae have rounded bodies and are more densely distributed on the tip of the lingual apex. The vallate papillae are located on the both sides of the posterior end of the lingual body. Each papilla is surrounded by a groove and crescent pad. Small conical papillae are present on the dorsal surfaces of the papillae. In the silver fox (Jackowiak and Godynicki, 2004), the filiform papillae on the anterior part of the tongue are divided into 1 main and 10–12 accessory processes; there are fewer accessory processes on the papillae on the posterior part of the body of the tongue. Conical papillae are located in the area of the vallate papillae. The wall surrounding each papilla and its gustatory trench form 6–8 partly connected conical papillae. In the raccoon dog and fox (Emura et al., 2006), the filiform papillae are distributed over the entire dorsal surface of the tongue. The filiform papillae on the apical surface of the tongue have several pointed processes. The filiform papillae of the lingual body consist of one main papilla and some secondary papillae. The fungiform papillae exhibit rounded bodies and are more densely distributed on the lingual apex. Foliate papillae are found on the dorsolateral aspect of the tongue. The vallate papillae are located on both sides of the posterior end of the lingual body. Each papilla is surrounded by a groove and crescent pad. Large conical papillae are found on the periphery of the papillae. In the black-backed jackal (Emura et al., 2014), the filiform papilla on the lingual apex exhibits a crown-like shape with several pointed processes. The filiform papilla on the lingual body has several pointed processes.

In the present study of the tongue of the old polar bear, the filiform papilla on the lingual apex had several pointed processes. The fungiform papilla was round in shape. The processes of the filiform papilla on the lingual body were larger than those of the lingual apex. The vallate papillae were surrounded by a groove and pad and the surface was rough. There were no foliate papillae.

In conclusion, the major morphological characteristic of the lingual surface of the polar bear is a lack of the cylindrical papilla on the lingual body like other canines. The tongue of the polar bear resembles that of the dog family than that of the cat family. There were no foliate papillae in the polar bear. These anatomical characteristics may enhance understanding of its feeding behavior adaptations.
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