Comparative Anatomical Study on the Dorsal Surface Structure of the Tongue of Two Birds with Different Feeding Habits

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Abstract:

The lingual dorsal surface of the adult little owl (Athene noctua) and fowl (Gallus gallus) were examined by light and scanning electron microscopy. The tongue of the fowl has an elongated triangular shape with pointed hard tip and flat dorsal surface. The tongue of the owl is conical in shape with a bifid tip that is covered by desquamated cells and its dorsal surface has a middle groove. Three parts were distinguished in the tongue of the two birds: the apex, the body, and the radix of the tongue. At the end of lingual body of the owl tongue there are large conical papillae. Where in the fowl a giant conical papillae are represented. The surface of the giant conical papillae adorn by flattened scales. In the tongue of the owl, the lingual glands are fewer than those in the fowl. The region of the orifices of the lingual glands occupies a wide area in the tongue of fowl. Taste and Merkel corpuscles are represented in the tongue of the fowl but not observed in the owl. The present comparative study of the tongues of the carnivorous little owl (Athene noctua) and the granivorous fowl (Gallus gallus) reflects a close relationship between the structures of the tongue and their feeding habits.

Introduction:

Most birds can fly (owl) but some cannot (fowl), and all are adapted to their different environments with respect to food sources, the seashore, ponds, small rivers, fields, or mountains. Reflecting their different life styles, birds have different feeding habits, with corresponding differences in the structures of their bills and tongues.

The studies of the structure of the tongue in birds have been conducted on few species; Homberger and Brush (1986) in the African grey parrot, Iwasaki et al. (1997) in Middendorff's bean goose, Jackowiak and Godynicji (2005) in white tailed eagle, Jackowiak et al. (2006) in cormorant, Emura (2008 a&b) in black kite and common pheasant, Emura et al. (2008 b) in tree sparrow. On the other hand, a comparative scanning electron microscope and histological studies of the tongues in relation to feeding habits have received insufficient attention.

To find out a correlation with the specific food diets of bird's concerned, the present work, described by light and scanning electron microscopy the structure of the dorsal lingual epithelium of the little owl (carnivorous) and the fowl (granivorous).

Material and Methods:

Tongue from ten owls and fowls were used. Animals were killed by neck dislocation and tongues were removed and immediately immersed in 10% neutral formalin, dehydrated and embedded in paraffin wax. Histological sections of 5 µm thickness were done and stained with hematoxylin-eosin.

For scanning electron microscopy, the tongue was cut into small pieces after prefixation with 2% gluteraldehyde in 0.2 M phosphate buffered (pH 7.3) at 4°C for 4 hours, rinsed in 0.2 M phosphate buffered solution and post-fixed in phosphate buffered (pH 7.3) 1% osmium tetroxide at 4°C for 4 hours. The specimens were then washed in 0.2 M phosphate buffer solution for several times before treatment with 3N hydrochloric acid at 60°C for 30 minutes in order to remove the mucus from the tongue surface. The samples were dehydrated in an ascending series of ethanol. After critical
RESULTS:

**Little owl (Athene noctua):**

The tongue of the adult little owl is conical in shape with bifid tip. Its length is about 1.6 cm, and its width is 0.5 cm. Three regions are distinguished in the dorsal surface of the tongue: the lingual apex, the lingual body, and the lingual radix. There is a conical wide area between the lingual apex and lingual radix. Conical papillae are situated at the end of the lingual body and are inclined toward the posterior end of the tongue. A median groove is found along the dorsal surface of the tongue and gradually expands backwardly. This median groove divides the body of the tongue into two symmetrical parts which are characterized by their convex folded surface. The tongue is connected with the bottom of the bill with a short frenulum in the posterior part of the lingual body at the level of the crest of the conical papillae (Fig. 1A).

At low magnification of scanning electron microscope, desquamated cells are observed in the dorsal surface of the tip of the lingual apex (Fig. 2). The rest of the dorsal surface of the lingual apex and the anterior part of the lingual body are armed by densely thread-shaped papillae (Fig. 3). The small and large conical papillae are adorning the dorsal surface of the posterior part of the lingual body (Fig. 4). The ventral surface of both the apex and the lingual body has smooth texture.
annular pad. At higher magnification, the papillary surface revealed irregular microplicae (Fig. 5).

Fig. 5. Scanning electromicrograph of the dorsal surface of the anterior part of the lingual body of the owl showing: fungiform papillae (FP) the arrow show its pore and the orifices of lingual glands (O).

The orifices of the lingual glands are characteristic structures of the tongue of the owl. On the dorsal surface of the posterior half of the lingual body, up to the conical papillae, the orifices of the anterior lingual glands are few and are located in a small bulge of the mucosa, resembling craters. Orifices of the posterior lingual glands are located evenly on the whole dorsal surface of the lingual radix (Fig. 6).

Fig. 6. Scanning electromicrograph of the dorsal surface of the lingual radix of the owl showing: the orifices of the posterior lingual glands (LG) partly filled with mucus.

Microscopic observations revealed that the mucosae of the lingual apex, body, and radix are covered with stratified squamous non keratinized epithelium. Its thickness is decreased gradually backwards. Numerous taste buds are found amongst the stratified squamous epithelium. They are concentrated on the dorsal surface of the anterior half of the lingual body. The taste buds are consisted of a number of spindle-shaped taste cells; each has a taste pore at its apical end (Fig. 7). Thread-shaped filiform papillae with pointed edge cover the whole dorsal surface of the tongue except the tip region of the lingual apex. The fungiform papillae are distinguished and housed predominantly in the anterior part of the lingual body (Fig. 8). The connective tissue fills almost the entire cavity of both the filiform and fungiform papillae.

Fig. 7. Photomicrograph of a T.S. of the anterior part of the lingual body of the tongue of the owl showing: taste buds (TB), connective tissues (CT), and stratified squamous epithelium (SSE). × 200

Fig. 8. Photomicrograph of a T.S. of the anterior part of the lingual body of the tongue of owl showing: filiform papillae (F), fungiform papillae (FP), and connective tissue (CT). × 300

The fowl (Gallus gallus):

The tongue of Gallus gallus (fowl) has an elongated triangular shape with a pointed hardened texture tip and flat dorsal surface. Its length is about 3 cm and its width is 0.6 cm. Giant conical papillae are observed at the marginal area between the end of the lingual body and the lingual radix. These papillae are increased in length and size towards the postero-lateral side and are arranged transversely in a row. These giant conical papillae are slightly inclined towards the posterior end of the tongue (Fig. 1B).

Investigation by scanning electron microscope revealed that the dorsal surface of the giant conical papillae are covered with overlapping flat, irregularly-shaped lamellar structures, viz scales of different sizes (Fig. 9). Many fine filiform papillae are observed...
densely distributed over the dorsal surface of the lingual apex and lingual body of the tongue (Fig. 10). At higher magnification these papillae present a flattened and slightly twisted aspect (Fig. 11). Fungiform papillae are densely distributed among the filiform ones along the dorsal surface of the lingual body. These papillae appear as rose-bud shaped structures; each has a central pore (Fig. 12). The anterior and posterior lingual glands are well developed and are densely distributed on the dorsal surface of the lingual body and the lingual radix. Its orifices are numerous and wide (Fig. 13).

Histologically, the whole surface of the tongue is strongly cornified; the cornification reaches its maximum at the tip and decreases gradually towards the base. Taste corpuscles are occurring amongst the cells of the stratified squamous epithelium. They are more abundant on the dorsal surface of the apex (Fig. 14). Numerous taste buds are located on the dorsal surface of the stratified squamous epithelium of the anterior part of the lingual body (Fig. 15). The connective tissue of the lamina propria penetrates deeply into the epithelium of the tip of tongue, forming connective tissue papillae.

In the connective tissue, immediately under the stratified squamous epithelium, a cluster of clear, oval-shaped cells is detected. These cells are identified as Merkel corpuscles. Each consists of 4-8 Merkel cells (Fig. 16).
DISCUSSION:

In the present work, the owl (_Athene noctua_ ) and the domestic fowl (_Gallus gallus_) were chosen for studying their lingual morphology; these two species live in different habitats and have different feeding habits. The results of the present study make it possible to distinguish species-specific features in the morphology of the tongue and in the microscopic structure of the lingual papillae and the correlation between the structure of the tongue and the feeding habits.

The macroscopic morphology of the tongue of these two species differs significantly. The tongue of the fowl is long in the antero-posterior direction and is triangular in shape, with a pointed apex. This description of the fowl’s tongue agrees with that of many granivorous birds; Salem (1978) in the pigeon, Iwasaki and Kobayashi (1986) in chicken, Iwasaki _et al._ (1997) in Middendorf’s bean goose, and Rossi _et al._ (2005) in partridge. However, Homerber and Brush (1986) recorded that the tongue of the African gray parrot (granivorous) is relatively rounded profile. This structure of parrot is different completely from the tongues of species cited in the present study.

The tongue of the owl (carnivorous) is conical in shape with bifid apex. This description is similar in structure to that of the northern fur seal (Emura _et al._, 2001), in beaver (Shindo _et al._, 2006) and in _Otus scops_ (Emura _et al._, 2009). Salem (1990) described that the tip of _Carduelis_ tongue possess very fine hairy outgrowth and in (1984) the same author studied 19 species belonging to order passeriforms with different feeding habits and recorded such hairy structures that are characteristic features for order passeriforms. However, in the nectar eating birds, Dubale and Thomas (1978) in _Sturnus pagodarum_ and Bock (1972) in _Ciridops anna_ mentioned that the hairy structures of the tongue form a closed tube to suck the nectar.

Kooloos (1986) pointed out, from the observations of the pecking mechanism of the mallard that all movements of epidermal structures can be interpreted as causing the transportation of food. Iwasaki _et al._ (1997) added that the shape of the tongue is most important for performing this function.


Giant conical papillae are found in the marginal region between the lingual body and
lingual radix of the tongue of the fowl. These papillae are arranged transversely in a row. This description agrees with Iwasaki and Kobayashi (1986) in chicken and Iwasaki et al. (1997) in Middendorff's bean goose. In the owl, these large conical papillae are located at the end of lingual body. This agrees with Jackowiak and Godynicki (2005) in the white tailed eagle; Emura (2008a) in black kite and Emura et al. (2001) in northern fur seal.

However, Jackowiak and Ludwig (2008) in their study on the ostrich tongue recorded that there are no conical papillae between the body and the root of the tongue. The authors described the presence of the flat fold with lateral processes sliding over the tongue root.

The dorsal surface of the giant conical papillae of the fowl is covered with overlapping flat scales of different sizes that provide a protective surface for the rough seeds. This agrees with Salem (1990) in upupa (insectivorous) and Dubal and Thomas (1978) in Motacilla (insectivorous). They mentioned that there are no spinelets over the giant papillae but the surface is covered with numerous scales. These scales act as pad-like structures and provide a firm hold over the insects preventing their escape.

The present study indicated that the filiform papillae are widely distributed over the lingual apex and lingual body of the dorsal surface of the fowl's tongue. In the owl, the filiform papillae are distributed on the whole dorsal surface of the tongue except in the tip of the lingual apex. Small and large conical papillae also are observed at the posterior part of the lingual body and radix of the owl's tongue, aiding in the transfer of the swallowed food towards the esophagus and at the same time preventing its regurgitation. Guimaraes et al. (2009) recorded that the dorsal surface of the tongue of ostrich is smooth without lingual papillae. Many authors recorded that the filiform papillae are distributed over the entire anterior 2/3 of the dorsal surface of the tongue (Bailey et al., 1997) in bustards, (Iwasaki and Kobayashi, 1986) in chicken, and (Emura et al., 2008a) in peregrine falcon and common kestrel. Also, Iwasaki and Kobayashi (1986) mentioned that the fluffy dorsal lingual surface coated with mucus fluid, seems to be suitable for retaining various foods. Furthermore, (Kobayashi et al., 1998) said that the filiform papillae are useful for holding food, such as fish, within the mouth.

The present study indicated that in the fowl, numerous and wide orifices of well developed anterior lingual glands are found in the entire dorsal surface of the lingual body and posterior lingual glands. Also, they are found on the dorsal surface of the lingual radix of the tongue. In the owl, the lingual glands are detected at the posterior part of the lingual body and the dorsal surface of the lingual radix.

However, Jackowiak and Godynicki (2005) in the white tailed eagle reported that the orifices of the anterior lingual glands are situated on the lateral surface of the posterior part of the lingual body, whereas the posterior lingual glands open on the entire surface of the lingual root. Jackowiak et al. (2006) recorded that the lingual glands are absent in cormorants. Emura et al. (2008a) described that in the tongues of the peregrine falcon and common kestrel, many openings of the lingual glands existed in the entire surfaces of the lingual body and lingual root.

The sense of taste is one of the chemical senses elicited by taste stimuli called tastants or taste buds located in the oral epithelium (smith and Margolskee, 2001). In the present study, the taste buds are more numerous in the stratified squamous epithelium of the anterior part of the lingual body and are less numerous in the lingual radix of the tongue of the fowl (granivorous). In the owl (carnivorous) the taste buds are fewer and occur only at the anterior part of the lingual body. These may be closely related to the type of food; the bird picks up all type of seeds, then repels most of them and swallows preferable seeds. The taste buds of the present birds consist of a number of spindle-shaped taste cells. Kinnamon (1991) recorded that the taste bud consists of 50-100 spindle-shaped taste cells, and has an opening to the oral cavity termed the taste pore at its apical end.

Merkel corpuscles are located in the connective tissue immediately under the stratified squamous epithelium of the fowl tongue. These cells are not observed in the owl. Several workers have demonstrated the constant existence of Merkel cells in the subepithelial and subepidermal connective tissue (Düring, 1975; Toyoshima, 1989; Toyoshima and shimamura, 1991; Toyoshima et al., 1993; Fujita et al., 1988). Yoshie et al. (1999) described that Merkel cells are a member of the paraneuron family.

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دراسات تشريحية مقارنة على تركيب السطح الظهري للسابان طائرين مختلفين

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هدف هذا البحث إلى دراسة السطح الظهري للسابان طائر أم فوق (أكل حبوب) والدجاج المنزلي (أكل حبوب). باستخدام الميكروسكوب الضوئي والكهربائي الماسي. أوضحت الدراسة أن السبان في الدجاج المنزلي ظهر متماثلاً وطريقه مدبب وصلب، ومدجج بالأحجار اللسانية. يوجد تجميع وسطي على السطح الظهري للسابان أم فوق، طرف اللسان مشوق وسطحه الظهري مغطى بلحاء حرشفي، يتمر السبان في كلا الطائرين إلى ثلاثة أجزاء: الجزء الخارجي وحجم اللسان والمدة. يوجد حلمات مخروطية كبيرة عند نهاية الجزء الجسمى للسابان أم فوق، بينما في الدجاج المنزلي تكون هذه الحلمات مخروطية وعمقها وسطحها الظهري مغطي بحراشف مسطحة.

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