Scanning electron microscopic study on the tongue in the scarlet macaw (*Ara macao*)

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Summary: The dorsal lingual surface of scarlet macaw (*Ara macao*) was examined by scanning electron microscopy. Macroscopically, the lingual apex of the scarlet macaw had a lip-like shape. Three parts were distinguished in the dorsal surface of the tongue: the apex, body, and root of the tongue. The surface of the lingual apex was relatively smooth. The central surface of the papillary layer in the lingual apex after removal of the epithelium consisted of numerous dermal papillae, but the papillae were not observed in the lateral region. A pair of openings of the lingual glands was observed in the posterolateral region of the lingual body. The opening of the lingual gland after removal of the epithelium showed more clear structure than before removal. Many conical papillae in the posterior region of the lingual body were observed. The structure of the tongue of the scarlet macaw was different from that of the rainbow lorikeet.

Introduction

Studies on the structure of the tongue in birds have been conducted on some species, i.e., chicken, African grey parrot, Middendorff’s bean goose, white-tailed eagle, cormorant, ostrich, peregrine falcon, common kestrel, Ural owl, Oriental scops owl, Japanese white-eye, nutcracker and rainbow lorikeet (Iwasaki and Kobayashi, 1986; Homberger and Brush, 1986; Iwasaki et al., 1997; Jackowiak and Godynicki, 2005; Jackowiak et al., 2006; Jackowiak and Ludwig, 2008; Emura et al., 2008a; Emura and Chen, 2008; Emura et al., 2009a,b; Emura et al., 2010; Jackowiak et al., 2010; Emura et al., 2011). Results of morphological studies conducted until date indicate a close correlation between the shape of the tongue and the method of food intake, the type of food, and bird’s habitat.

However, a scanning electron microscopic (SEM) study on the tongues of the scarlet macaw has not been carried out. Therefore, the purpose of this study is to examine three-dimensionally the dorsal lingual surface of the scarlet macaw in order to compare results with those from previous reports on other birds.

Materials and Methods

The tongue of an adult scarlet macaw (*Ara macao*) of the family Psittacidae were used in this study. The tongue was fixed in 10% formalin. The specimens were washed in distilled water and post-fixed in 1% osmium tetroxide for 1 h, dehydrated in a series of acetone dilutions, and then 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 3.5N HCl at 35°C for 2 days. After maceration, tissues were washed in the distilled water and 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 Pt-Pd before being examined under SEM (Hitachi S-3500N, Tokyo, Japan) at an accelerating voltage of 10 kV.

Results

Macroscopically, the lingual apex of the scarlet macaw has a lip-like shape (Fig. 1). Three parts are distinguished...
in the dorsal surface of the tongue: the apex, body, and root of the tongue (Fig. 1). The surface of the lingual apex has many grooves toward lingual root (Fig. 1).

The surface of the lingual apex is relatively smooth (Fig. 2b). The central surface of the papillary layer in the lingual apex after removal of the epithelium consists of numerous dermal papillae, but the papillae are not observed in the lateral region (Fig. 2a,b). A pair of openings of the lingual glands is observed in the posterolateral region of the lingual body (Fig. 3a,b). The opening of the lingual gland after removal of the epithelium shows more clear structure than before removal (Fig. 3a). Many conical papillae in the posterior region of the lingual body are observed (Fig. 3b).

Discussion

The tongues of the white-tailed eagle, black kite, and northern goshawk which feed on fish or small animals were elongated with a sharp-ended apex (Jackowiak and Godynicki, 2005; Emura 2008a; Emura et al., 2008b). The characteristic morphological features observed on the tongue included a distinct median groove dividing the mucosa into two symmetrical, convex lateral parts and a single crest of large conical papillae in the posterior part of the lingual body, extending over the surface of the flat root of the tongue (Jackowiak and Godynicki, 2005; Emura, 2008a; Emura et al., 2008b).

The tongues of the Middendorff’s bean goose, swans and spot-billed duck which feed on seeds of water plants or water plants were elongated with a sharp-ended apex (Iwasaki et al., 1997; Emura, 2008c; Emura, 2009a). Those tongues were elongated in the anteroposterior direction, and the apical regions of the tongues were round (Iwasaki et al., 1997; Emura, 2008c; Emura, 2009a). The lingual body had a distinct median groove. On both the lateral sides of the lingual body lingual hairs were compactly distributed and small numbers of cylindrical papillae were arranged between these hairs (Iwasaki et al., 1997; Emura, 2008c; Emura, 2009a).

The tongues of the chicken and common pheasant which feed on grains appeared as an elongated triangle with a pointed tip (Iwasaki and Kobayashi, 1986; Emura, 2008b). The dorsal surfaces of the tongues were flat, but differences in structure were distinguishable between the anterior tongue and posterior tongue, and a median groove was not observed in the tongue (Iwasaki and Kobayashi, 1986; Emura, 2008b).

The tongue of the brown-eared bulbul which feeds on nectar and fruit had a spear-like shape (Emura, 2009b). The characteristic morphological features observed on the tongue included many conical processes in the tip of the tongue (Emura, 2009b).

The tongue of the Japanese pygmy woodpecker which feeds on insects had a toothpick-like shape (Emura et al., 2009b). On both the lateral sides of the anterior lingual apex, some conical processes were observed (Emura et al., 2009b).

The tongues of the little egret, black-crowned night heron, and green-backed heron which feed on fish and frog were needle-like or had a spearhead-like shape (Emura, 2009b). The characteristic morphological features observed on the tongue included many conical processes in the tip of the tongue (Emura, 2009b).

In this study, the lingual apex of the scarlet macaw which feeds on seed and fruit showed a lip-like shape and has many grooves toward lingual root. Furthermore, the
Fig. 2. Scanning electron micrographs of the surfaces of the lingual apex. (a) The surface of the connective tissue core in the lingual apex after removal of the epithelium. (b) The dorsal surface of the lingual apex.

Fig. 3. Scanning electron micrographs of the surfaces of the lingual body. (a) The opening of the lingual gland (asterisk) after removal of the epithelium. (b) The conical papillae in the posterior region of the lingual body. C = conical papillae. Arrow = opening of the lingual gland.
surface of the lingual apex has many grooves toward lingual root and a pair of openings of the lingual glands is observed in the posterolateral region of the lingual body. A large opening of the lingual gland in central part of the lingual root is observed in both rainbow lorikeet (Emura et al., 2011) and scarlet macaw. However, many processes observed in the lingual apex of the rainbow lorikeet (Emura et al., 2011) of the family Psittacidae which feeds on nectar are not showed in the scarlet macaw. This finding is not reported so far. All birds adapted to their environment with respect to food sources. Corresponding to their lifestyles they have different feeding habits, with corresponding differences in the structures of their bills and tongues.

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References