Scanning electron microscopic study on the tongues of seven avian species

By

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Summary: The dorsal lingual surface of the grey crowned crane (Balearica regulorum), American flamingo (Phoenicopterus ruber), great egret (Ardea alba), mallard (Anas platyrhynchos), Himalayan monal (Lophophorus impejanus), black-necked stilt (Himantopus mexicanus) and green macaw (Ara militaris) were examined by scanning electron microscopy. In the grey crowned crane, the surface of the lingual apex was relatively rough. Many openings of the lingual glands in both lateral regions of the lingual body were observed. The surfaces of many conical papillae were smooth. Many openings of the lingual glands were observed in the region of the lingual root. In the American flamingo, the surface of the lingual apex was relatively smooth. The surfaces of many fang-like and mustache-like structures were smooth. In the great egret, the surfaces of the lingual apex, central part of the posterior lingual body and giant conical papilla were relatively smooth. Many openings of the lingual glands were observed on the lingual root. In the mallard, the surface of the lingual apex was relatively smooth. The thread-shaped and scale-shaped structures were observed on the anterolateral region of the lingual body. In the Himalayan monal, the dorsal surfaces of the lingual apex and body were relatively smooth. The saw-shaped papillae on the posterolateral region of the lingual body consisted of the thread-shaped structure and big processes. In the black-necked stilt, the surface of the lingual apex was relatively smooth. The dorsal surface of the lingual body was rough in comparison with that of the lingual apex. The posterior part of the lingual body consisted of several conical papillae. In the green macaw, the surface of the lingual apex had many grooves. The posterior part of the lingual body consisted of several conical papillae. These findings indicate a close correlation between the shape of the tongue and the method of food intake, the type of food, and bird’s habitat.

Many studies have reported on the structures of the lingual surfaces in various birds. In the order Gruiformes, there has been a scanning electron microscopy (SEM) study on the tongue of the common crane (Emura, 2012a). In the order Phoenicopteriformes, there have been some SEM studies on the tongues of the Chilean flamingo and lesser flamingo (Emura, 2011d, 2013b). In the order Ciconiiformes, there have been many SEM studies on the tongues of the little egret, black-crowned night heron, green-blackened heron, cattle egret, grey heron and intermediate egret (Emura 2009b, 2010, 2011b). In the order Anseriformes, there have been many SEM studies on the tongues of the tundra swan, whooper swan, spot-billed duck, northern pintail, Canada goose, Egyptian goose, mandarin duck, mute swan, swan goose and tufted duck (Emura 2008c, 2009a, 2011b,c, 2012). In the order Galliformes, there has been SEM study on the tongue of the common pheasant (Emura 2008). In the order Charadriiformes, there has been SEM study on the tongue of the red-necked phalarope (Emura 2011). In the order Psittaciformes, there has been SEM study on the tongues of the rainbow lorikeet and scarlet macaw (Emura et al., 2011, 2012). Results of morphological studies conducted until data indicates a close correlation between the shape of the tongue and the method of food intake, the type of food, and bird’s habitat.

However, SEM studies on the tongues of the grey crowned crane belongs to the order Gruiformes, American flamingo belongs to the order Phoenicopteriformes, great egret belongs to the order Ciconiiformes, mallard belongs to the order Anseriformes, himalayan monal belongs to the order Galliformes, black-necked stilt belongs to the order Charadriiformes and green macaw belongs to the order Psittaciformes have not been carried...
out. Therefore, the purpose of this study is thus to examine three-dimensionally the dorsal lingual surfaces of seven avian species in order to compare results with those from previous reports on other birds.

**Materials and Methods**

The tongues of an adult grey crowned crane (*Balaeniceps regulorum*) of the family Gruidae, American flamingo (*Phoenicopterus ruber*) of the family Phoenicopteridae, great egret (*Ardea alba*) of the family Ardeidae, mallard (*Anas platyrhynchos*) of the family Anatidae, Himalayan monal (*Lophophorus impejanus*) of the family Phasianidae, black-necked stilt (*himantopus mexicanus*) of the family Recurvirostridae and green macaw (*Ara militaris*) of the family Psittacidae were used in this study. The tongues were 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. 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**

**Grey crowned crane**

Macroscopically, the tongue of the grey crowned crane was an arrowhead-like shape. Many conical papillae of the lingual body were inclined toward the posterior of the tongue on the posterior end (Fig. 1a). Under SEM, the surface of the lingual apex was relatively rough (Fig. 1, inset 1). Many openings of the lingual glands in both lateral regions of the lingual body were observed (Fig. 1, inset 2). The surfaces of many conical papillae were smooth (Fig. 1, inset 3). Many openings of the lingual glands were observed in the region of the lingual root (Fig. 1, inset 4).

**American flamingo**

Macroscopically, the lingual apex of the American flamingo was a triangle shape. Many big fang-like structures were present in both lateral regions of the lingual body. Mustache-like structures were observed on the posterior lingual body (Fig. 2a). Under SEM, the surface of the lingual apex was relatively smooth (Fig. 2, inset 1). The surfaces of many fang-like and mustache-like structures were smooth (Fig. 2, inset 2, 3).

**Great egret**

Macroscopically, the tongue of the great egret was a needle-like shape. A pair of giant conical papillae was inclined toward the posterior of the tongue on the lateral side of the lingual body (Fig. 3a). Under SEM, the surfaces of the lingual apex, central part of the posterior lingual body and giant conical papilla were relatively smooth (Fig. 3, inset 1, 2, 4). Many openings of the lingual glands were observed on the lingual root (Fig. 3, inset 3).

**Mallard**

Macroscopically, the tongue of the mallard was elongated with a spatula-ended apex. There were saw-shaped papillae on the posterolateral region of the lingual body (Fig. 4a). Under SEM, the surface of the lingual apex was relatively smooth (Fig. 4, inset 1). The thread-shaped and scale-shaped structures were observed on the anterolateral region of the lingual body (Fig. 4, inset 2). The saw-shaped papillae on the posterolateral region of the lingual body consisted of the thread-shaped structure and big processes (Fig. 4, inset 3).

**Himalayan monal**

Macroscopically, the tongue of the Himalayan monal was an arrowhead-like shape (Fig. 5a). Under SEM, the dorsal surfaces of the lingual apex and body were relatively smooth (Fig. 5, inset 1, 2). The posterior part of the lingual body consisted of several conical papillae (Fig. 5, inset 3). Many openings of the lingual glands were observed on the lingual root (Fig. 5, inset 3).

**Black-necked stilt**

Macroscopically, the tongue of the black-necked stilt was a needle-like shape (Fig. 6a). Under SEM, the surface of the lingual apex was relatively smooth (Fig. 6, inset 1). The dorsal surface of the lingual body was rough to comparison with that of the lingual apex (Fig. 6, inset 2). The posterior part of the lingual body consisted of several conical papillae (Fig. 6, inset 3).

**Green macaw**

Macroscopically, the tongue of the green macaw was a lower lip-like shape (Fig. 7a). Under SEM, the surface of the lingual apex had many grooves (Fig. 7, inset 1). The posterior part of the lingual body consisted of several conical papillae (Fig. 7, inset 2).

**Discussion**

The tongue of the common crane which was omnivorous was a spearhead-like in shape. The surfaces of the lingual apex and body were smooth. The large conical papillae were inclined toward the posterior of the tongue on the posterior side of the lingual body. The many openings of the lingual glands existed in the lingual root (Emura, 2012a).

The tongues of the Chilean flamingo and lesser flamingo were equipped with many fang-like structures in both lateral sides of the lingual body that enable it to filter
Fig. 1. Macrograph of a grey crowned crane tongue. (a) The tongue is an arrowhead-like shape. Many conical papillae of the lingual body are inclined toward the posterior of the tongue on the posterior end. Under SEM, the surface of the lingual apex is relatively rough. Arrow=lateral side (inset 1). Many openings (arrows) of the lingual glands in both lateral regions of the lingual body are observed (inset 2). The surfaces of many conical papillae are smooth (inset 3). Many openings (arrows) of the lingual glands are observed in the region of the lingual root (inset 4).
Fig. 2. Macrograph of an American flamingo tongue. (a) The lingual apex is a triangle shape. Many big fang-like structures are present in both lateral regions of the lingual body. Mustache-like structures are observed on the posterior lingual body. Under SEM, the surface of the lingual apex is relatively smooth (inset 1). The surfaces of many fang-like and mustache-like structures are smooth (inset 2, 3).
Fig. 3. Macrograph of a great egret tongue. (a) The tongue is a needle-like shape. A pair of giant conical papillae is inclined toward the posterior of the tongue on the lateral side of the lingual body). Under SEM, the surfaces of the lingual apex, central part of the posterior lingual body and giant conical papilla are relatively smooth (inset 1, 2, 4). Many openings (arrows) of the lingual glands are observed on the lingual root (inset 3).
Fig. 4. Macrograph of a mallard tongue. (a) The tongue is elongated with a spatula-ended apex. There are saw-shaped papillae on the posterolateral region of the lingual body. Under SEM, the surface of the lingual apex is relatively smooth (inset 1). The thread-shaped and scale-shaped structures are observed on the anterolateral region of the lingual body (inset 2). The saw-shaped papillae on the posterolateral region of the lingual body consist of the thread-shaped structure and big processes (inset 3).
Fig. 5. Macrograph of a Himalayan monal tongue. (a) The tongue is an arrowhead-like shape. Under SEM, the dorsal surfaces of the lingual apex and body are relatively smooth (inset 1, 2). The posterior part of the lingual body consists of several conical papillae (inset 3). Many openings (arrow) of the lingual glands are observed on the lingual root (inset 3).
Fig. 6. Macrograph of a black-necked stilt tongue. (a) The tongue of the black-necked stilt is a needle-like shape. Under SEM, the surface of the lingual apex is relatively smooth (inset 1). The dorsal surface of the lingual body is rough in comparison with that of the lingual apex (inset 2). The posterior part of the lingual body consists of several conical papillae (inset 3).
Fig. 7. Macrograph of a green macaw tongue. (a) The tongue is a lower lip-like shape. Under SEM, the surface of the lingual apex has many grooves (inset 1). The posterior part of the lingual body consists of several conical papillae (C) (inset 2).
food (Emura, 2011d, 2013).

The tongues of the little egret, intermediate egret, black-crowned night heron, green-backed heron, cattle egret and grey heron that feed on fish and frog were a needle-like or a spearhead-like in shape. A pair of mantle-shaped giant conical papillae was inclined toward the posterior of the tongue on the lateral side of the lingual body. The many openings of the lingual glands existed in the lingual root (Emura, 2009b, 2010, 2011b).

The tongues of the spot-billed duck, northern pintail, mandarin duck and tufted duck, which feed on aquatic plants, were a spatula-like in shape. The posterolateral region of the lingual body had saw-shaped papillae. Many conical papillae were observed in the border region between the lingual body and root (Emura, 2009a, 2011b, 2012c).

The tongues of the common pheasant, Edward’s pheasant and Chinese bamboo partridge which were omnivorous were an arrowhead-like in shape. The surfaces of the lingual apex and body were smooth. The conical papillae of the lingual body were inclined toward the posterior of the tongue. The many openings of the lingual glands existed in the lingual root (Emura, 2008b, 2012c, 2013a).

The tongue of the red-necked phalarope, which feeds on large plankton, was a toothpick-like in shape. The lingual apex had a smooth surface and large conical papillae were observed in the border region between the lingual body and root (Emura, 2011a).

The tongue of the scarlet macaw, which feeds on fruits and seeds, was a toothpick-like in shape. The surface of the lingual apex had many grooves toward lingual root. The surface of the lingual apex was relatively smooth. A large opening of the lingual gland exists in central part of the lingual root (Emura, 2012).

In this study, the lingual apex of the grey crowned crane which was omnivorous showed an arrowhead-like shape. The surfaces of the lingual apex and body were smooth. The large conical papillae were inclined toward the posterior of the tongue on the posterior side of the lingual body. The many openings of the lingual glands existed in the lingual root. These findings are similar to the tongue of the common crane. The tongue of the American flamingo is equipped with many fang-like structures in both lateral sides of the lingual body that enable it to filter food. These findings are similar to the tongues of the Chilean flamingo and lesser flamingo. The tongue of the great egret was a needle-like shape. A pair of giant conical papillae was inclined toward the posterior of the tongue on the lateral side of the lingual body. Many openings of the lingual glands were observed on the lingual root. These findings are similar to the tongues of the little egret, intermediate egret, black-crowned night heron, green-backed heron, cattle egret and grey heron. The tongue of the mallard was elongated with a spatula-ended apex. There were saw-shaped papillae on the posterolateral region of the lingual body. The thread-shaped and scale-shaped structures were observed on the anterolateral region of the lingual body. The saw-shaped papillae on the posterolateral region of the lingual body consisted of the thread-shaped structure and big processes. These findings are similar to the tongues of the spot-billed duck, northern pintail, mandarin duck and tufted duck. The tongue of the Himalayan monal was an arrowhead-like shape. The posterior part of the lingual body consisted of several conical papillae. Many openings of the lingual glands were observed on the lingual root. These findings are similar to the tongues of the common pheasant, Edward’s pheasant and Chinese bamboo partridge. The tongue of the black-necked stilt was a needle-like shape. The dorsal surface of the lingual body was rough to comparison with that of the lingual apex. The posterior part of the lingual body consisted of several conical papillae. These findings are similar to the tongue of the red-necked phalarope. The tongue of the green macaw was a lower lip-like shape. The surface of the lingual apex had many grooves. The posterior part of the lingual body consisted of several conical papillae. These findings are similar to the tongue of the scarlet macaw.

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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