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Functional Morphology of the Tongue and Lingual Epithelium of the Laughing Dove in Relation to Feeding Habit

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Abstract: *The aim of the present study was to investigate the morphological structure of the tongue of the Laughing dove, Streptopelia senegalensis (granivorous) in relation to feeding habits and to compare the present results with those reported in other avian species. Three adult birds were used in this study. Three parts were distinguished in the dorsal surface of the tongue of each bird: the apex, the body and the root. The mucosa of the dorsal surface of the tongue apex is covered with a thick nonkeratinized stratified squamous epithelium while, the lateral and ventral surfaces of the apex is covered with keratinized stratified squamous epithelium. SEM revealed that the epithelium of the whole dorsal surface of the lingual apex presents the lamellar-shaped aspect while smooth on the tongue body. The lingual salivary glands extend through the dorsal surface from the lingual apex and the lingual body.*

Keywords: *tongue- Laughing dove- Functional morphology- epithelium - Feeding*

1. INTRODUCTION

Feeding mechanism is important to determines the adaptation and persistence of vertebrates to their environment [1].The tongue plays an important role in feeding mechanism in vertebrates especially in birds. Differences in shape and size allowing the tongue to function as a specialized tool for obtaining, manipulation, swallowing and processing food. Many authors has been studied the morphology of the tongue in vertebrates [2, 3, 4, 5, 6, 7,]. Reflecting to their lifestyle, birds have different feeding habits, with corresponding differences in the structures of their bills and tongues. As birds are spread out through the different habitats such as the air, the land and the water, many authors stated that the shape and structure of the tongue differ according to the type of food and method of food intake [8, 9, 10, 11]. The avian tongues are adapted for the collection, manipulation and swallowing of foods. The shape of the tongue is triangular and elongated in many birds [12, 13] and relatively small in other [14, 15, 16]. Keratinization of the lingual epithelium, the distinct median sulcus, convex lateral parts, different types of papillae, distribution of lingual glands are common characteristic features of bird's tongue. Morphological and functional studies of various avian species indicated a close relations of the histological structure of the tongue with their feeding habits [17, 18, 19]. Many authors described structure of lingual mucosa, type and distribution of mechanical papillae and the degrees of keratinization of the lingual epithelium [20, 21, 22, 23, 24].

The aim of this study is to describe the morphology of the tongue of Laughing dove, *Streptopelia senegalensis* and to characterize the microscopic structure of the lingual mucosa using light and scanning electron microscopy. Also, the relationship between the tongue structure with food and feeding habits of the bird in order to compare the results with those previous reports in other birds.

2. MATERIALS AND METHODS

2.1. Experimental Animals

The experimental animals of the present work included adult and healthy birds. Three adult Laughing dove, *Streptopelia senegalensis* (Granivorous) were used in the present study. Birds were killed and tongues were dissected free from the mandible, then lengths and widths of tongues were measured quickly. For routine light microscopy, two tongues from two birds were

fixed in 10% buffered paraformaldehyde for histological investigation and one tongue from one bird was prepared for investigation by scanning electron microscope.

2.2. Histological and Morphometrical Studies

The freshly removed tongues were washed under running tape water to remove any food debris and immediately fixed in 10% neutral formalin. The tissue was washed in tap water then dehydrated in ascending series of ethyl alcohols, cleaned in xylene and finally embedded in paraffin wax at 60°C. The transverse paraffin sections at 5-6µm in thick were prepared. For routine histological investigation, sections were stained with Haematoxylin and Eosin according to [25]. For morphometrical study, Four slides of each region of the tongue of each individual (15 sections per slide) were measured. For each section, three measurements of thickness of the epithelium of different regions of the surfaces of the tongue were measured. Histological sections were studies by using a research microscope equipped with digital camera and connected to a PC based image analysis system. Sigma Scan Pro (version 4.0, Jendel Scientific, SPSS Inc., Chicago, USA) was used for image analysis and morphometrical data acquisition.

2.3. Scanning Electron Microscopy

One tongue of each bird was fixed in 5% gluteraldehyde, washed in cocodylate buffer for one hour and post fixed in a buffered solution of 1% osmium tetroxide at 37°C for two hours. Then, specimens were followed by dehydration in ethanol; complete dehydration in amyleacetate for two days, dried in carbon dioxide at sputter coated with gold. The specimens were examined in a JEOL scanning electron microscope (JSM-5400LV).

3. RESULTS

3.1. Macroscopic Observations

The tongue (Fig. 1) of the adult the Laughing dove is about 2.1 cm long and appears thin and triangular in shape. The anterior tip of the tongue is slightly tapered. The tongue is composed of two parts; the free portion of the tongue is distinguished on the dorsal surface into two portions, the apex and the body. The other part is the caudal part that is the root of the tongue. The width of the tongue become larger from the anterior to the posterior region. The width of the most posterior region is about 0.5 cm. There is a shallow groove at the median half part of the tongue. Small conical papillae appeared in a conical shape with a sharp tips that was directed caudally and present on the posterior dorsal surface of the free portion of the tongue.

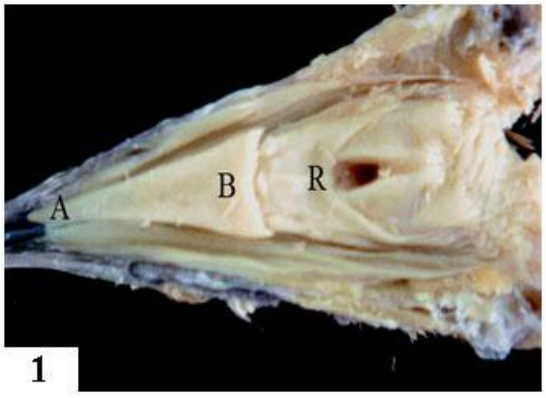

Fig1. *Floor of the oropharynx of the Laughing dove showing the tongue apex (A), the body (B), the root (R). Scale bar = 1 cm.*

3.2. Microscopic Observations

The tongue (Fig.2) is supported by paraglossum which is a cartilage enous, single and oval in shape through the apex and it is double at the body region of the tongue. Lingual muscle fibers were seen in a cross section of the tongue are transversely sectioned indicating that the orientation of these muscles are parallel to the long axis of the tongue.

Dorsal lingual surface is covered by a multilayered stratified squamous non-keratinized epithelium, while the ventral and lateral surfaces of the tongue is covered with a keratinized stratified squamous epithelium. The connective tissue beneath the epithelium of the dorsal surface

penetrated the epithelium in form of connective tissue of lamina propria forming lamina propria ridges but this was lacking in the ventral epithelial layer.

The epithelium is thicker at the dorsal surface of the tongue than that in the ventral one. Also, the epithelium of the anterior region of the tongue is thicker than that in the posterior one. The lingual glands (Figs.2,3) are present laterally along the free portion of the tongue. The lingual glands are formed from tubuloalveolar type beneath the dorsal lingual epithelium and lined with connective tissue. The ducts of the lingual glands opened onto the dorsal surface of the tongue (Fig. 6).

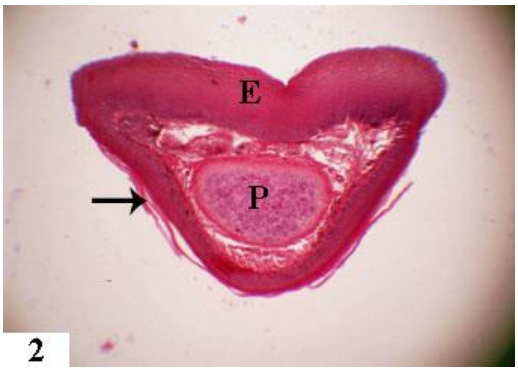

Fig2. *Photomicrograph of a T.S. of the of the tongue apex of the Laughing dove showing a single paraglossum (P), non-keratinized multilayered stratified squamous epithelium of the dorsal surface (E) and lateral and ventral keratinized layers (arrow). (H&E, X 40)*

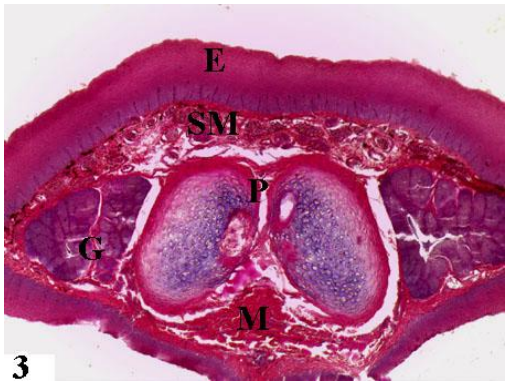

Fig3. *Photomicrograph of a T.S. of the tongue body of the Laughing dove showing double paraglossum(P), non-keratinized multilayered stratified squamous epithelium of the dorsal surface (E), the lingual glands (G), submucosa (SM), Muscle bundles(M). (H&E, X 100)*

3.3. Scanning Electron Microscopy

SEM revealed that the dorsal surface of the apex of the lingual epithelium is covered with thick and compact layer which composed of thick plates overlapped with each others and separated by clear fissures (Fig.4). At the posterior part of the tongue, the epithelium is covered with smooth slighely folded layer without clear fissure appeared (Fig.5).

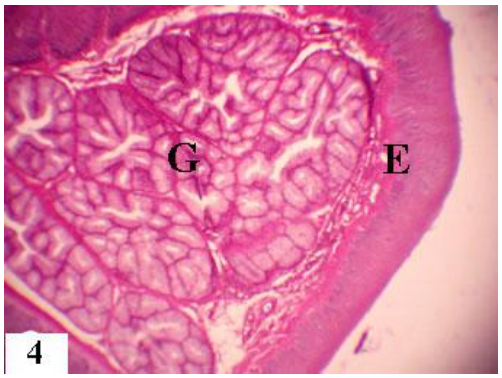

Fig4. *Photomicrograph of a T.S. of the of the tongue body showing lingual glands (G) and lingual epithelium (E). (H&E, X 400)*

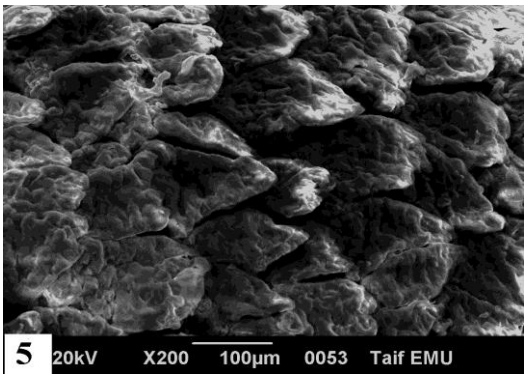

Fig5. *Scanning electron micrograph of the dorsal surface of the lingual apex of the Laughing dove showing that the lingual epithelium is covered with thick overlapped compact layer which composed of thick plates separated by clear fissures.*

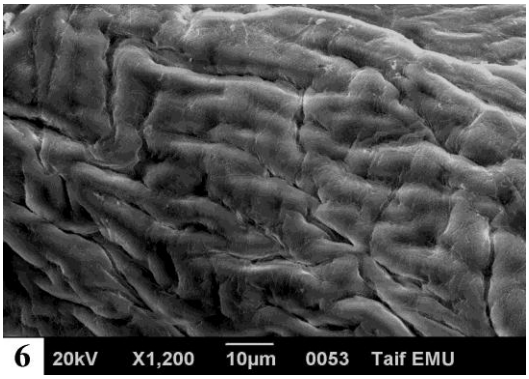

Fig6. *Scanning electron micrograph of the dorsal surface of the lingual body of the Laughing dove showing that the epithelium is covered with smooth slightly folded layer without clear fissure appeared.*

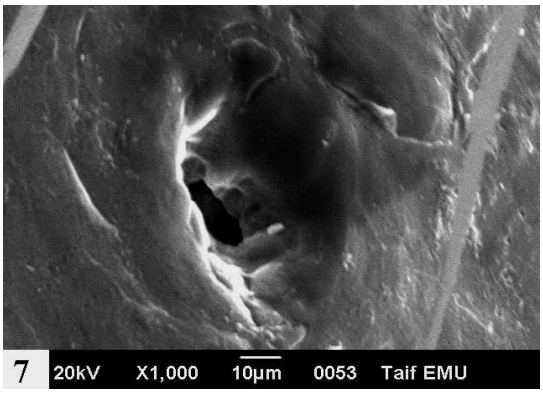

Fig7. *Scanning electron micrograph of the dorsal surface of the lingual body of the Laughing dove showing the opening of the lingual gland.*

4. DISCUSSION

Morphological and microscopic structure of the tongue of birds may be directly associated with feeding habit and food intake of the bird [26, 27]. Data obtained from the present study showed that the tip of the tongue was pointed and there is a groove in the dorsal surface of the tongue. Presence of the median groove is in accordance with [28] who stated that the tongues of white tailed eagle, ducks and geese have a median groove and this features indicate the adaptation of the tongue to help swallowing the grains as a whole items to the oesoohagus. [7] Stated that during adaptation from a wet to a dry habitat in vertebrate, stratification and keratinization are the most important changes in the lingual epithelium. Thickness of lingual epithelium and keratinized layer of birds are differ according to the type of food intake [10]. In most birds, anterior tip of the tongue is directly contact with food and may expose to injuries during feeding. In the present study, lingual epithelium is thick and has compact plates because it exposed to hard grains and seeds during feeding. Lateral borders and ventral surface of the tongue may exposed more to

grains and seeds during manipulation and when storage in the buccal cavity. Thus, epithelium is covered with a keratinized layer.

In birds, the lingual papillae play an important role in feeding. Birds that eat hard foods use papillae as teeth which act co-operatively during feeding and mastication [7].The conical papillae aid in the transfer of the food towards the alimentary canal and prevent its regurgitation [22]. Presence of conical papillae between the body and root of the tongue in the Laughing dove are in agreements with [21, 29]. Conical papillae of the tongue in the present study are not well developed. On the contrary, papillae are well developed in birds such as White tailed eagle and owl which feed on fish or small animals and absent in birds such as woodpecker and ostrich which feed on insects or plants [19, 22, 30]. The presence of lamina propria ridges may adapted for mechanical protection of the organ and may give more support for attachment between the lamina propria and the lingual epithelium against injuries during feeding. This finding is similar to the tongue of the emu [14]., ostrich [10]. and Muscovy duck [31]. In this study, Lingual glands are well developed and present along the whole length of the free portion of the tongue with numerous openings. The lingual glands are generally well developed in granivorous species that feed on dry food like grains and seeds, less developed in birds of prey, poorly developed in piscivores and absent in the Anhinga and Grea Cormorant [32, 33] 34].In some birds, the glands may be restricted to certain areas of the tongue [8, 34].lack lingual glands entirely as in cormorant, in white-tailed eagle and in chukar partridge [9, 28, 35].

In conclusion, this study has shown that the there is a functional morphological relationship between structural features of the tongue of the Laughing dove and food intake.

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