University of Duhok

College of Education – Akre

Department of Biology

TONGUE OF THE BIRDS

- The domestic duck is an example -

Research Project

Submitted to the Department of (Biology) in partial fulfillment of the requirements for the degree of **BSc.** in **Biology**

By

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CERTIFICATE

This research project has been written under my supervision and has been submitted for the award of the **BSc.** degree in **Biology** with my approval as a supervisor.

Signature
Name:

Date:

DEDICATION

We dedicate this work:

- We dedicate this work to my cherished parents, who have shown us so much love, care and patience.
- To our beloved parents for their endless love, support and encouragement for us.
- To our uncles, sisters and brothers.
- To all our relatives and friends.

Ramzia M. Saied

Awara Moawi Rauf

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ABSTRACT

A biometric study was conducted on the tongue of twenty-five (25) adult domestic ducks collected from the poultry market in Akreh city, over a period of seven days. A pair of scissors, a scalpel and a blade were used to cut, excise, separate or shatter different parts of the oral cavity to expose the organ for research. The results showed that the tongue is characterized by an elongated triangular shape. At some point, approximately two-thirds of the length of the lingual body has a pronounced depression, separating the caudal one-third of the lingual body from the rostral two-thirds. There is a median groove on the dorsal surface of the condyle and body of the tongue. A unique feature of the tongue in domestic ducks is the presence of many fine, overlapping needle-shaped processes on both lateral sides of the caudal lingual crest. One row of large conical papillae is symmetrically observed in the marginal region between the body and root of the tongue, a biometric being the median dimension.

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1. INTRODUCTION

The morphological structure of the tongue in birds is characterized by an abundance of structures resulting from a number of factors such as taxonomic affiliation, type of food intake, method of diet collection and the birds' occupied environment. Harrison (1964) identified three groups of tongues with specialist structural adaptations to enhance the performance of their functions. The first tongue group are those used to capture and intake food utilizing a highly developed hyoid apparatus. The second functional group comprises of tongues with numerous, stiff papillae on the dorsal surface, adapted to holding and/or manipulating food. The third functional group is composed of tongues which are organs employed for retaining food in the oral cavity prior to swallowing.

The process of feeding in vertebrates is complex and generally is distinguished three stages: ingestion, intra-oral transport and swallowing (Schwenk 1989).

Birds have adapted to their environments with respect to food sources. Reflecting their specific lifestyles, birds have various feeding habits, with corresponding versatility in the structures of their tongues. The tongue is a muscular hydrostat on the floors of the mouths of most vertebrates which manipulates food for mastication. It is the primary organ of taste (gustation), as much of the upper surface of the tongue is covered in papillae and taste buds (Whittow, GC. 2000: 299-300.). It is sensitive and kept moist by saliva, and is richly supplied with nerves and blood vessels. A considerable number of papers have been published on the lingual structure in domestic mammals (Kumar, P; Kumar, S and Singh, Y., 1998: 355-357). The studies on the structure of the tongue in birds, however, have been conducted on a small number of avian species, i.e.

The behavioral observations of feeding mechanism revealed the presence of phylogenetic different between paleognathous and neognathous birds (Tomlinson 2000). In paleognathous birds, feeding behavior is based on the catch and throw mechanism, described as cranioinertial mechanism in which food is moved directly into the esophagus, without using the tongue. The neognathous birds use lingual feeding mechanism related to the complex movements of the beak and hyolingual apparatus. Sometimes neognathous birds use catch and throw mechanism, but it is used only during ingestion of large food particles and still requires complex movements of hyolingual apparatus. The exception among neognathous birds is toucan, hornbills and southern cassowary in which develops the so-called ballistic transport (Harte et al. 2012).

The hypothesis of this study is that feeding mechanisms of the domestic duck, typical for both aquatic and terrestrial life style, influenced on numerous structural adaptations of lingual mucosa. To verify this hypothesis, detailed observations were made on the morphology of the tongue in domestic ducks, with particular emphasis on macro- and microstructures of the lingual mucosa including the lingual papillae, lingual glands and mucosal epithelium in specific areas of the tongue.

2. Materials and methods

The study was conducted on eight tongues of adult female domestic ducks (aged 6 months, average weight 3.5 kg) collected from a local slaughterhouse. The study was conducted in accordance with the guidelines set out by the Ethics Commission at the Poznan University of Life Sciences, and the national guidelines, Poland.

Immediately after slaughter, tongues were rinsed in saline and immersed in 10 % neutralized formalin. After a 24-hour fixation period, macroscopic photographic documentation was made using a digital camera.

In order to perform light microscopy and scanning electron microscopy (SEM) analysis, tissue samples were collected from the apex, body, lingual prominence, root and mechanical papillae from each tongue.

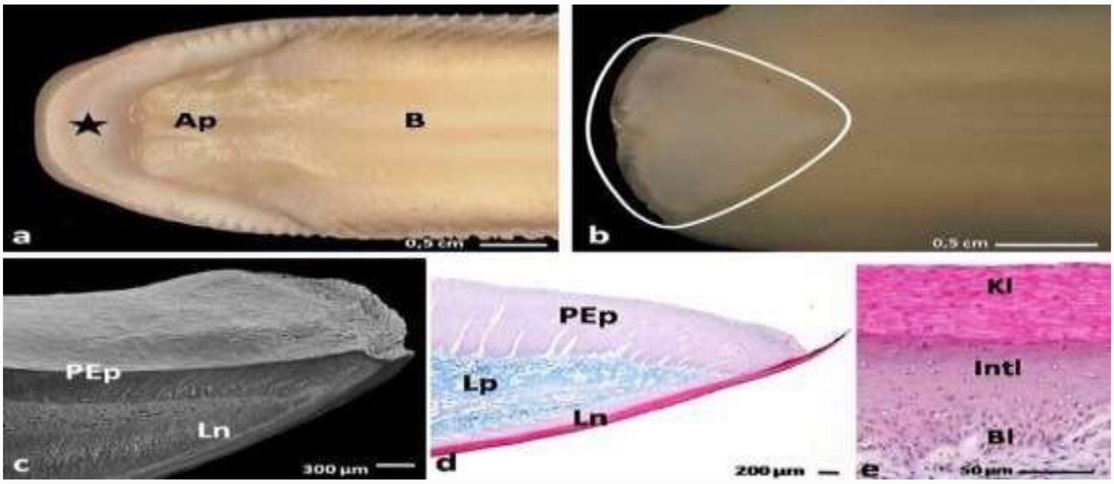
Tissue samples undergoing SEM analysis were dehydrated in increasing concentrations of ethanol (70–96 %) and acetone (100 %). The samples were dried at the critical point using CO_2 (Critical Point Dryer EM CPD300, Leica, Germany), mounted on aluminum tables covered with carbon tabs and coated with a gold layer measuring 15–30 nm in thickness (Gold Sputter S 150B, Edwards, England). Observations and photographic documentation were performed under a ZEISS 435 VP scanning electron microscope, at an accelerating voltage of 10-15 kV. On eight tissue samples, three measurements were made in order to determine a total of 24 measurements of the height and width of mechanical papillae, using a Multiscan computer morphometric system (ver. 10.2, CSS, Warsaw, Poland).

Histological measurements were statistically analyzed using Statistica (ver. 12.5, StatSoft, Poland) software. For each morphological feature, the following parameters were calculated: the mean value (X) with standard deviation (SD), the minimum value (min) and the maximum value (max).

3. Macroscopic observations

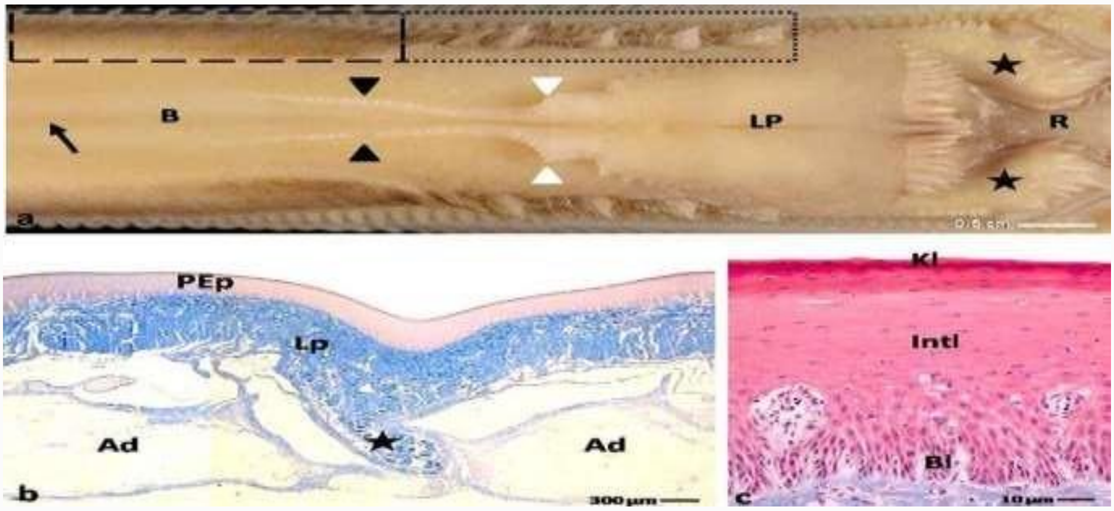
The domestic duck tongue comprised of the apex, the body with the lingual prominence and the root (Figs. 1a, 2a). Tongues were attached to the bottom part of the bill by the frenulum. The tongue strictly occupied the oral cavity with the exception of the free tip of the rostral part of the bill (Fig. 1a).

Fig. 1



a Dorsal view on the rostral part of the tongue and the beak in the domestic duck. *Asterisk* shows the free tip of the beak. *A* apex of the tongue; *B* body of the tongue. **b** Ventral view on the apex of the tongue. *Continous line* marks the *triangular shape* of the lingual nail. **c** Dorsal view on the apex of the tongue with lingual nail protruding to the side of the apex. *PEp* parakeratinized epithelium on the dorsal surface of the apex; *Ln* lingual nail; SEM. **d** Sagittal cross section through the apex of the tongue. *PEp* parakeratinized epithelium on the dorsal surface of the apex; *Ln* lingual nail; *Lp* lamina propria; LM. **e** Cross section through the orthokeratinized epithelium of the lingual nail. *Bl* basal layer; *Int* intermediate layer; *Kl* keratinized layer; LM

Fig. 2



a Dorsal view on the body of the tongue and lingual prominence in the domestic duck. *Dashed line* shows small conical papillae. *Dotted line* points the large conical papillae. *Black arrows* show median groove of the body. *Black arrowheads* point the lingual comb. *White arrowheads* show turned up lingual comb. *Asterisk* point papillae on the lateral sides of the root. *B* body of the tongue; *LP* lingual prominence; *R* root of the tongue. **b** Cross section through the body. *Asterisk* shows connective tissue septum. *Ad* adipose tissue; *PEp* parakeratinized epithelium; *Lp* lamina propria; LM. **c** Cross section through the parakeratinized epithelium on the body. *Bl* basal layer; *Intl* intermediate layer; *Kl* keratinized layer; LM

The tongue in the domestic duck was narrow and elongated (Figs. 1a, 2a). The total length of the tongue averaged 6.3 cm, of which the apex averaged 0.8 cm in length, the body with the lingual prominence was 4.9 cm, and the root had a mean length of 0.6 cm. The average width of the tongue was 1.6 cm on the apex, 1.7 cm on the body, varied between 0.8 and 1.8 cm on the lingual prominence and 0.5 cm on the root.

i. The apex of the tongue

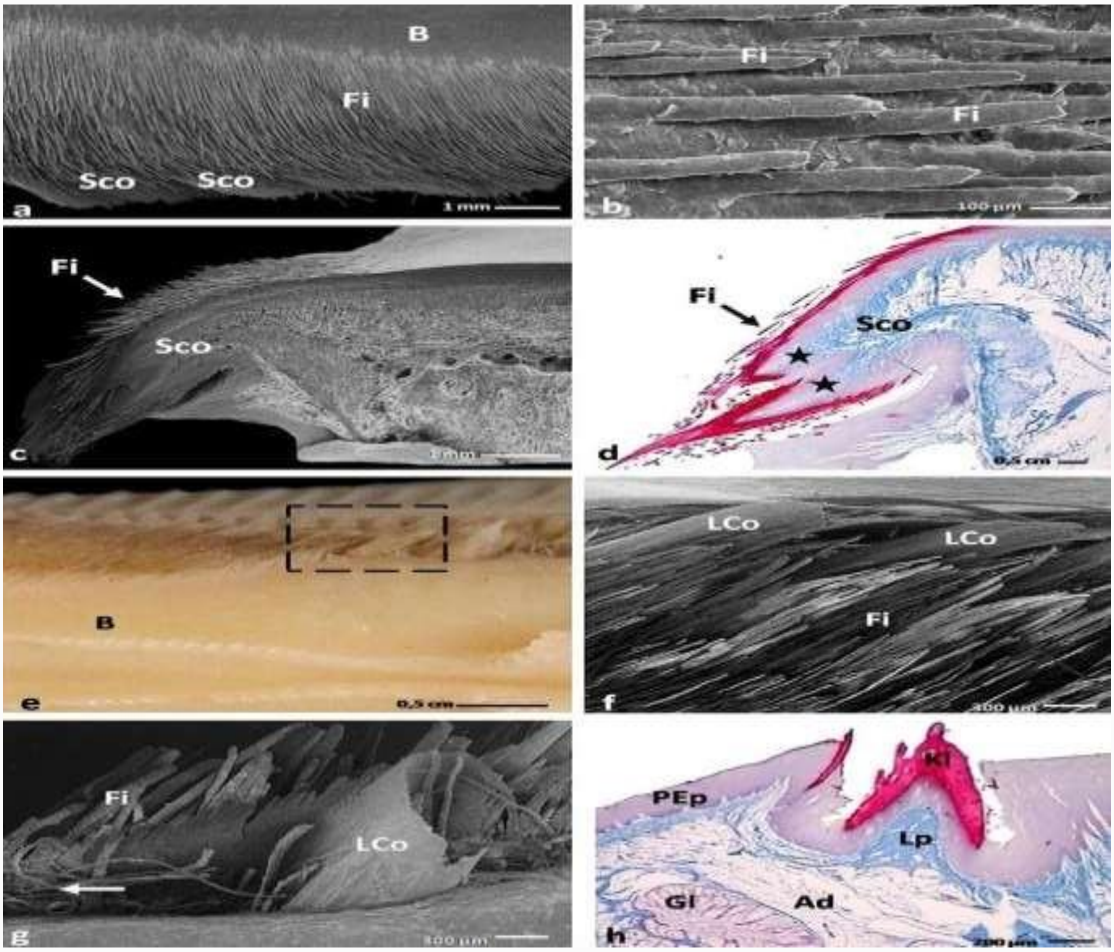
The apex of the domestic duck tongue was spatula-shape, and its dorsal surface presented as smooth and free of lingual papillae (Fig. 1a). On the ventral surface of the apex, there was a flat, triangular, white plate of the lingual nail and the edges of the structure stood out to the front and sides (Fig. 1b, c). The average length and width of the lingual nail through the middle was 1.3 and 1 cm, sequentially.

ii. The body of the tongue

The dorsal surfaces of the tongue bodies were divided into two symmetrical parts by the shallow median groove (Fig. 2a). In the caudal part of the body, symmetrically on the sides of the median groove, two elevations of the mucosa were observed, which formed the left and right lingual combs with jagged edges (Figs. 2a, 4b). In front of the lingual prominence, the lingual comb turned up and subsequently merged with the rostral edges of the lingual prominence (Figs. 2a, 4b).

Symmetrically, along both edges of the body, there were three types of mechanical papillae–large and small conical papillae and filiform papillae (Figs. 2a, 3a, e, f, g). On the smooth lateral surfaces of the body of the tongue, 16–18 openings of the rostral lingual glands were linearly arranged. The average distance between openings was between 0.9 and 1.8 mm.

Fig. 3



a Dorsal view on the dorso-lateral surface of the body of the tongue in the domestic duck. *B* body of the tongue; *Fi*, filiform papillae; *Sco*, small conical papillae; SEM. **b** Magnification of the filiform papillae, as keratinized processes of the epithelium. *Fi* filiform papillae; SEM. **c** Magnification of the small conical papillae covered with the brush of filiform papillae. *Fi* filiform papillae; *Sco* small conical papillae; SEM. **d** Cross section through the small conical papillae. *Asterisks* show ventral and dorsal connective tissue cores. *Fi* filiform papillae; *Sco* small conical papillae; LM. **e** Dorsal view on the dorso-lateral part of the body of the tongue in the domestic duck. *Dashed line* points the two large conical papillae in the caudal part of the lingual body. *B* body of the tongue. **f** Magnification of the two conical papillae with frayed tips. *Fi* filiform papillae; *Lco* large conical papillae; SEM. **g** Magnification of the large conical papillae in shape of a fountain pen. *Arrow* shows twisted processes of the filiform papillae. *Fi* filiform papillae; *Lco* large conical papillae; SEM. **h** Cross section of the large conical papillae. *Ad* adipose tissue; *Gl* rostral lingual glands; *Lp* lamina propria; *Kl* keratinized layer of the orthokeratinized epithelium; *PEp*, parakeratinized epithelium; LM

iii. Small conical papillae of the body

In the rostral part of the body, 14 pairs of the small conical papillae were observed. Each papilla had the shape of a flattened plate with jagged ends (Fig. 3a). The papillae were directed toward the bottom of the tongue at an angle of 40–45°.

iv. Large conical papillae of the body

In the caudal part of the body, six pairs of large conical papillae of different shapes were present directly behind the small conical papillae. The first four pairs of these papillae were found in the form of slightly flattened cones with a caudal concave surface resembling the shape of the nib of a fountain pen (Fig. 3g). Two other pairs of large conical papillae took the form of cones with frayed tips (Fig. 3e, f). These papillae lay directed caudally to the root of the tongue and were arranged at an angle of 20–30° to the lingual body.

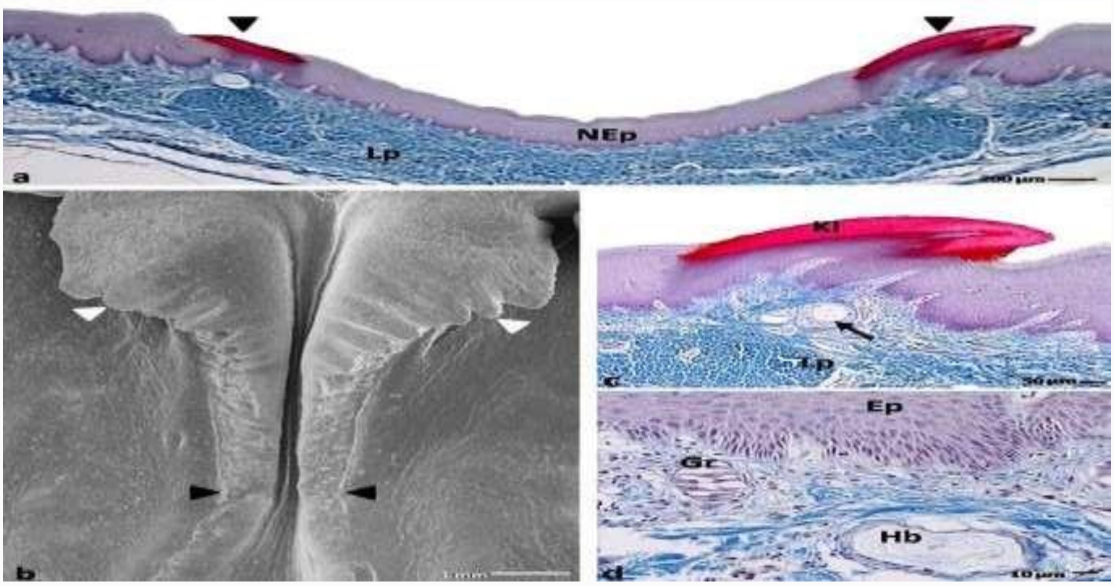
v. Filiform papillae of the body

Filiform papillae in the rostral part of the lingual body formed a dense covering overlapping small conical papillae, which were located underneath the filiform papillae (Fig. 3a, c). The filiform papillae on the caudal part of the body presented on the medial side of the large conical papillae and formed twisted processes (Fig. 3g), while filiform papillae between large conical papillae formed densely arranged, simply structured long processes (Fig. 3f, g).

vi. The lingual prominence

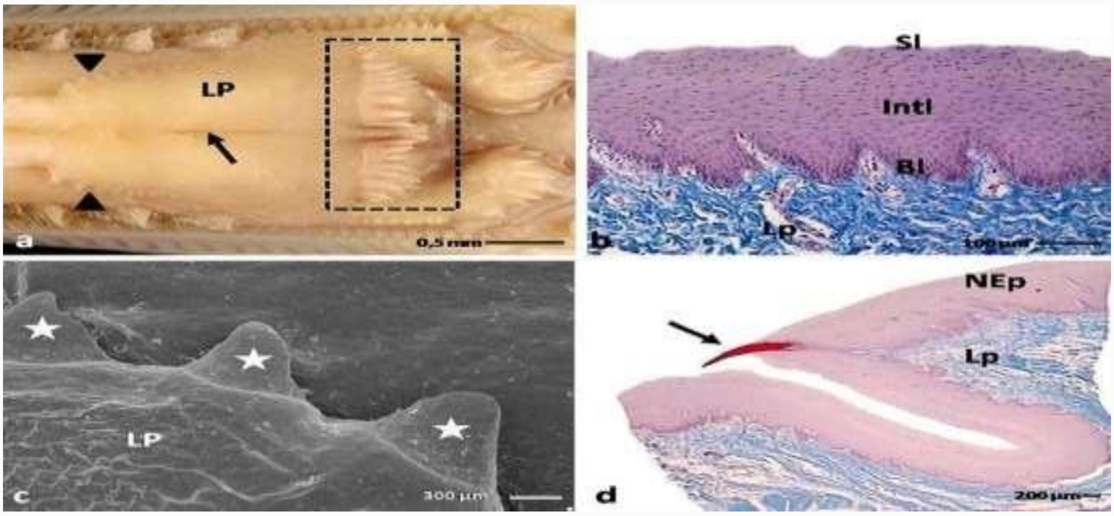
The lingual prominence had the shape of a triangle, the base of which was directed toward the root of the tongue (Fig. 2a). The lingual prominence was divided into two symmetrical parts by a slight median groove (Fig. 5a). The rostral serrated edges of the prominence raised above the lingual body (Fig. 5a). On the caudal edge of the prominence, rows of conical papillae had formed (Fig. 5a). On the caudo-lateral surfaces of the prominence, there were 2–3 openings of the caudo-lateral lingual glands.

Fig. 4



a Cross section through the caudo-median part of the lingual body in the domestic duck. *Arrowheads* point the *right* and *left* lingual combs of the mucosa. *NEp* nonkeratinized epithelium; *Lp* lamina propria; LM. **b** Magnification of the caudo-median part of the body. *Black arrowheads* show right and left lingual combs. *White arrowheads* point the serrated turned up lingual combs; SEM. **c** Cross section through the right lingual comb in the domestic duck. *Arrow* points the Herbst corpuscle. *Lp* lamina propria; *Kl* keratinized layer of the orthokeratinized epithelium; LM. **d** Magnification of the mechanoreceptors beneath the lingual comb. Ep. epithelium; *Gr* Grandry corpuscle; *Hb* Herbst corpuscle; LM

Fig. 5

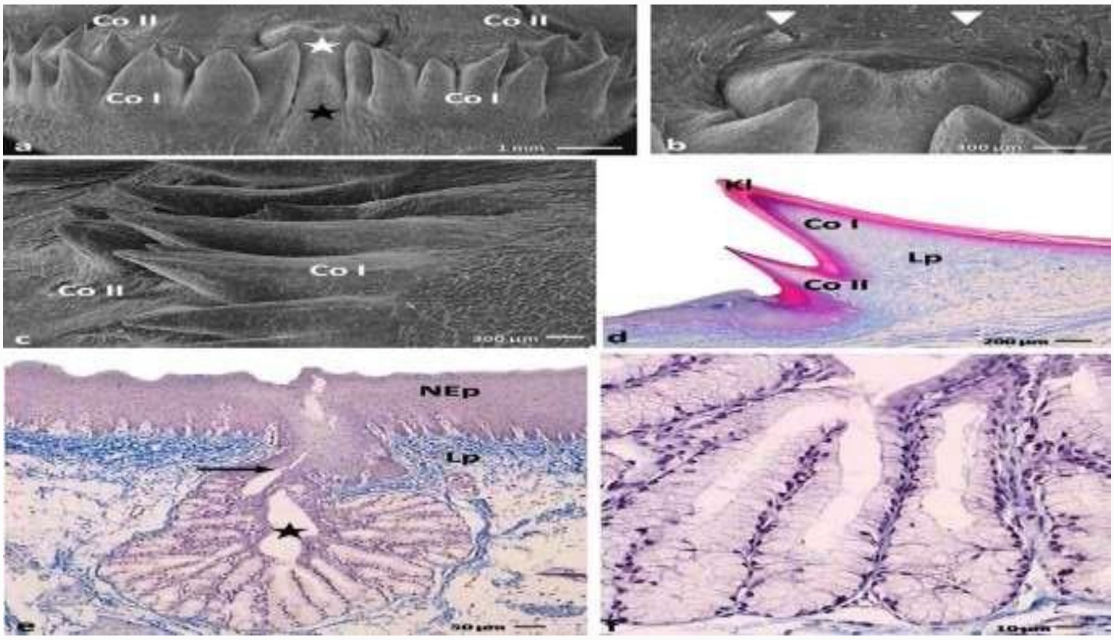


a Dorsal view on the surface of the lingual prominence and the root of the tongue in the domestic duck. *Dashed line* points rows of conical papillae on the caudal border of the lingual prominence. *Arrow* shows median groove. *Arrowheads* show serrated rostral part of the lingual prominence. *LP* lingual prominence; *R*, root of the tongue. **b** Cross section through the nonkeratinized epithelium of the lingual prominence. *Bl* basal layer; *Int* intermediate layer; *Sl* superficial layer; *Lp* lamina propria; LM. **c** Dorsal view on the border of the rostral part of the lingual prominence. *Asterisks* point serration. *LP* lingual prominence; SEM. **d** Cross section through the rostral part of the lingual prominence with keratinized processes (*arrow*). *NEp* nonkeratinized epithelium; *Lp* lamina propria; LM

vii. Conical papillae of the lingual prominence

The conical papillae of the lingual prominence were arranged in two rows directed obliquely and caudally (Fig. 6a). Additionally, papillae in the first and second rows were divided into two left and right groups, in the midline of the prominence a distinct mucosa elevation was observed with its base located at the second rows of papillae (Fig. 6a).

Fig. 6



a Dorsal view on the caudal part of the lingual prominence in the domestic duck. *Black asterisk* shows median elevation of the mucosa. *White asterisk* points two conical papillae with a common base. *Co I* conical papillae in the first row; *Co II* conical papillae in the second row; SEM. **b** Magnification of the surface of the root behind conical papillae of the lingual prominence. *Arrowheads* point openings of the caudo-median lingual glands; SEM. **c** Lateral view on the caudally pointed conical papillae. *Co I* conical papillae in the firs row; *Co II* conical papillae in the second row; SEM. **d** Cross section through the conical papillae of the lingual prominence. *Co I* conical papillae in the firs row; *Co II* conical papillae in the second row; *Kl* keratinized layer of the orthokeratinized epithelium; *Lp* lamina propria; LM. **e** Cross section through the caudo-median lingual glands in the root of the tongue. *Asterisk* points the wide collecting chamber. *Arrows* shows short secretory duct. *Ad* adipose tissue; *Lp* lamina propria; LM. **f** Magnification of the caudo-median lingual glands arranged in lobules; LM

In the first row, 16 conical papillae were observed, with 8 papillae on each of the right- and left-hand sides of the prominence. Similarly, in the second row there were 12 conical papillae, with 6 papillae on each side. The tips of the conical papillae of the lingual prominence were pointed and bent over the flat surface of the root (Fig. 6c).

viii. The root of the tongue

The area of the root tongue, adjacent to the laryngeal prominence, was the smallest part of the tongue. Its surface was located below the lingual prominence (Fig. 2a). On both sides of the root, two round papillae with smaller spinal processes were detected (Fig. 2a). In the median part of the root, three pairs of the glandular openings of the caudo-median lingual glands arranged linearly were observed (Fig. 6b).

4. Result and Discussion

a. Result:

From the result, the tongue of the adult domestic duck is characterized by an elongated triangular format for both sexes (Fig. 7), conforming to the shape of the lower beak within which it lies. This is in accordance with many scholars who highlighted that, the tongue in many species of birds is a triangular organ that fills the whole lower part of the bill (Vollmerhaus, B and Sinowatz, F. Verdauungsapparat. 1992.). It is an elongated tubular organ in woodpeckers (Emura, S; Okumura, T and Chen, H. 2009; 86: 31-35.) and elongated flat in geese and ducks (Iwasaki, S. et al, 1997: 147-163.). The tongue of the cormorant is only a small, mushroom-shaped connective tissue structure joined with the hyoid cartilage and the lingual root is nonexistent (Jackowiak, H; Andrzejewski, W and Godynicki, S., 2005; 23: 161-167.). Results obtained from the present study show that the tongue of the adult domestic duck like that of many other birds is a well-developed elongated triangular organ with three distinct anatomical parts, i.e., apex, body and root.

Fig. 7

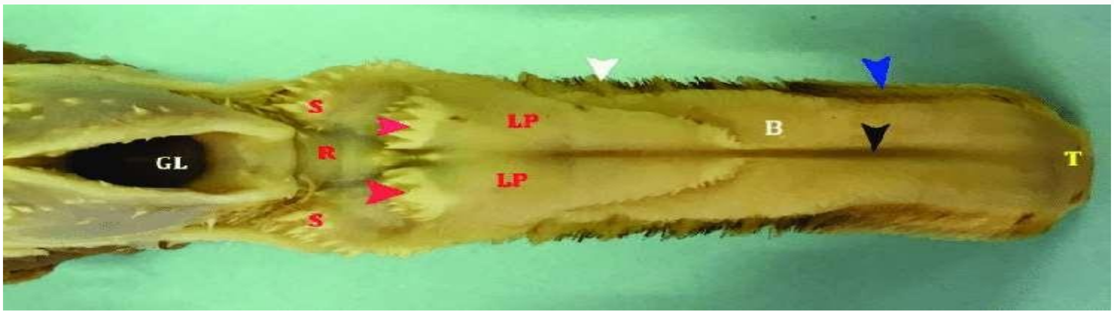


Fig 7 (Plate I): Photograph showing the dorsal view of adult domestic duck tongue with the Root (R), Body (B) and Tip (T)

The results of morphological studies conducted in this specie contain references regarding the size and shape of the various portions of the digestive tract so far, indicate a close correlation of the shape of the tongue with the method of food intake and the type of food and habitat. (Witt, M. & Reutter, K. 1997: 601-12) Therefore, the present study was aimed at establishing a base-line data on the normal dimensions of the tongue of the adult domestic duck (Anas platyrhynchos domestica) in this part of the countries breed.

Owing to their different lifestyles, birds show considerable differences in the structures of their bills and tongues. A unique feature of the tongue in domestic duck is the presence of many fine overlapping needle-shaped processes at both lateral sides of the anterior lingual apex, the apices of which are directed rostrally (Fig. 8). A single row of large conical papillae is observed symmetrically in the marginal region between the body and root of the tongue, the apices of which are pointed towards the posterior part of the tongue. The sizes of these mechanical papillae varied according to their location within the tongue.

Fig. 8

Fig 8 (Plate II): Photograph showing the dorsal view of adult domestic duck tongue with the lower Bill (Green arrow), Tongue (Blue arrow) and prenular (Red arrow).

b. Discussion

Literature dealing with the feeding behavior in wild birds shows that Anseriformes were distinguished by three ways of gathering food: pecking, grazing and filter-feeding (Van der Leeuw et al. 2003). These studies showed that, between Anserinae and Anatidae, there are also differences in the transportation of food into the esophagus.

After analyzing the three methods of feeding and the two types of transport, and on the basis of the conducted detailed macro- and microscopic observations of the tongue in the duck, it was possible to determine the functional adaptation of individual parts of the tongue.

The first type of food intake in Anatidae is pecking which starts with grabbing the grains by the front part of the beak. The main structure involves in this feeding behavior is the apex with the lingual nail. The lingual nail stands out to the front and side of the apex and can act as a spoon for lifting grains. Similar observations have been made by Jackowiak et al. (2011) in the domestic goose. Although the lingual nail is a hard keratinized structure, it is very flexible and efficient in collecting food (Homberger and Brush 1986). Microscopic observations of the cross section of the apex showed that in the mid-length of the apex it did not have an entoglossal cartilage and was built of loose connective tissue. The lingual nail, which comprised of the orthokeratinized epithelium with a thick keratinized layer, may play an important role as the external skeleton supporting the apex of the tongue. This statement is supported by the results of morphometric measurements, which showed that the keratinized layer is up to one-third of the height of the epithelium.

The second type of food intake in Anatidae is grazing. The wild duck uses the lateral rims of the beak to grab the leaves of grass, which are then broken off and blades of grass are hold by pressing the lingual prominence to the palate (Van der Leeuw et al. 2003). The morphological structures directly linked to grazing in the domestic duck are the large conical papillae. They have shape of cones directed to the root of the tongue and are located at the latero-caudal part of the lingual body. They are compatible to the lamellae in bottom part of the beak and act like scissors. The small conical papillae have a shape of plate directed to the bottom of the tongue and do not take part in the grazing. Comparing current data with observations made in the domestic goose (Jackowiak et al. 2011), we can state the tongue in the domestic duck is less well adapted for cutting grass, because only the conical papillae in the caudal part of the body of the tongue are involved in this action. What may be due to the fact that grazing is not the main mechanism of feeding.

The unique type of food ingestion in Anatidae is filter-feeding. Behavioral studies performance by Kooloos et al. (1989) and Zweers et al. (1997) showed that the water is pumped into the oral cavity when the beak is open, the tongue is retracted, and the lingual body is raised. When the beak is closing, the tongue is retracted and the lingual body is depressed, the water and food are forced to move on the dorsal surface of the tongue, just before lingual prominence. During another retraction of the tongue, the lingual body is raised what causes that the water with the food samples is moved on the lateral sides of the lingual prominence. The water is then removed outside. The current research demonstrates that the first barrier stopping large items of food is the serrated edge of the lingual prominence. The second barrier is the so-called filtering apparatus, which is formed by small and large conical papillae of the body and the filiform papillae. Based on observations, it appears that the effectiveness of filtration for large conical papillae in the domestic duck is smaller compared to the small conical papillae, due to the shape of the papillae, their caudal orientation and a less dense arrangement of the filiform papillae. The filiform papillae in the rostral part of the body can act as a brush retaining even the smallest food items, which is adapted as a dense filtering apparatus, efficiently stocking finer particles as compared to those structures in the goose (Jackowiak et al. 2005).

In the wild duck has been preserved catch and throw transport of grains, diameter of which is smaller than that of a pea, and is also utilized to move grass blades (Zweers et al. 1997). These birds feed mainly on food immersed in water by using the filter-feeding mechanism (Kooloos 1986). During filtration, duck use typical for neognathous bird, lingual feeding mechanism and under tongue transport (Tomlinson 2000). This method of food transport has decided about formation of the specific structures of the lingual mucosa. The present study revealed that mucosal structures involved in the transportation of food in the domestic duck are midline groove, which acts as a gutter in which food is transported, the lingual comb, which is engaged in the division of food particles into two parts, and raised serrated edges of the rostral part of the lingual prominence facilitate the under-tongue transport. The conical papillae of the lingual prominence help in the transport of food into the esophagus, both during catch and throw transport and under tongue transport, while two papillae on the sides of the root may be used to re-direct food onto one track, forming a bite of food and protection from falling out from the oral cavity.

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