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## Lingual epithelium of the rock dove, *Patagioenas livia* (Columbidae): A morphometrical study

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The present study was designed to demonstrate the histomorphometry of the lingual epithelium of the rock dove, *Patagioenas livia*. The lingual epithelium of the rock dove, a granivorous bird, were examined morphometrically. Results obtained showed that the whole surface of the free portion tongue of the rock dove is covered by a keratinized epithelium. Data revealed that the tongue epithelium at the anterior region was thicker than in the posterior one. The thickness of the epithelium of the dorsal surface was greater than that in the lateral and ventral surfaces. Statistical analysis showed that there is a significant difference of thickness in the lingual epithelium and keratinized layer between different regions of the tongue. The dorsal epithelium of the preglottal area was thicker than that in the lateral one. Differences were not statistically significant between the epithelium thickness of the dorsal and lateral borders of the preglottal area.

**Keywords:** Lingual, epithelium, Morphometry, The Rock Dove, Feeding habits.

### INTRODUCTION

The thickness of the lingual epithelium of birds showing an obvious verity in relation to feeding habit. Several studies revealed that there is a nearby correlation of the shape of the tongues of birds and the histological structure of the lingual epithelium with the food intake method and the food content (Iwasaki et al., 1997; Hemberger and Brush, 1986; Shawki and Abdel-Rahman, 1998; Darwish, 2012; Taki-El-Deen, 2017). Keratinization appeared as the most important characteristic changes in the lingual epithelium during the evolutionary adaptation of birds from a wet to a dry habitat (Iwasaki, 2002). Many authors discussed the lingual mucosa structure, the degrees of keratinization of the stratified epithelium and of mechanical papillae distribution. (Zweers et al., 1977; Zweers, 1982; Iwasaki, and Kobayashi, 1986; Kooloose, 1986; Hombereger and Meyer, 1989; Kobayashi et al., 1998; Kumar et al., 1998). Tongues of the most birds are

covered with a keratinized layer in its dorsal surfaces (Jackowiak et al., 2010; Erdogan et al., 2012b). The epithelium at the dorsal surface of the tongue is thicker than the epithelium of the ventral surface (Jackowiak and Ludwig, 2008). Degree of keratinization of the tongue epithelium cover the tongue tip plays an important role to protect the tongue against hard food such as (Jackowiak and Godynicki, 2005) in white-tailed eagle, (Hombereger and Brush, 1986) in parrot, and (Jackowiak et al., 2010) in Nutcracker. Otherwise, thickness of the keratinized layer of the ventral and lateral surfaces of the tongue is reduced, as, in domestic birds (Erdogan et al., 2012b). Morphometrical studies on the tongue of birds, especially, histomorphometry are very rare and most of the studies included morphological and histological studies. The object of the this work is to demonstrate the histomorphometric measurements of the lingual epithelium of a granivorous bird, the rock dove in relation to

feeding habit of the bird.

## MATERIALS AND METHODS

### Experimental Animals:

Sex adult and healthy rock dove, *Patagioenas livia* were used in this work. Birds were sacrificed by cervical dislocation, and then tongues were removed immediately from the oropharyngeal floor. The tongues were washed by using running water.

### Histological Procedures:

Tongues were fixed in 10% neutral formalin. Next tongues were dehydrated through ascending series of ethyl alcohol and cleared in xylene. Embedding was done in paraffin wax. Sectioning was done at 6  $\mu$ m thickness using microtome and then subjected to routine staining Haematoxylin and Eosin (H&E) based on Carleton (1980).

### Morphometrical Procedures:

For morphometry, twenty sections of different regions from each bird were measured. Five measurements of thickness of the epithelial and keratinized layers of several parts were measured. Photomicrographs were viewed and captured by using a system of video camera coupled to an optical microscope and computer containing a software (the MOTIC Image Plus 2.0).

## RESULTS

### Microscopic investigation:

The apex and middle parts of the free portion of the tongue is supported by a cartilagenous oval paraglossale. Around the paraglossale, there are glandula lingualis and lingual muscles. The dorsal surface of the tongue is covered with a moderately stratification layer of squamous epithelium. The ventral tongue surface is covered with thin stratified squamous epithelium (Figs.1 and 2).

### Morphometrical measurements of the lingual epithelium

The thickness of the lingual epithelium (Table1) and (Figs. 1&2) vary depending on the region of the tongue. The epithelium of the anterior region of the tongue (1.005  $\pm$  0.036) mm was slightly thicker than that in the posterior one (0.964  $\pm$  0.032) mm. The thickness of the epithelium was greater at the dorsal surface of the tongue than that in the later (0.648  $\pm$  0.037) mm

and ventral (0.473  $\pm$  0.025) mm surfaces. At the ventral surface, the thickness of the epithelium was (0.473  $\pm$  0.025) mm.

### Morphometrical measurements of the preglotal area: (table 2)

The preglotal area is covered with non-keratinized epithelium (Fig. 3). The epithelium of the dorsal surface of the preglottal area (0.856  $\pm$  0.036) mm of the rock dove was thicker than that in the lateral one (0.846  $\pm$  0.036) mm.

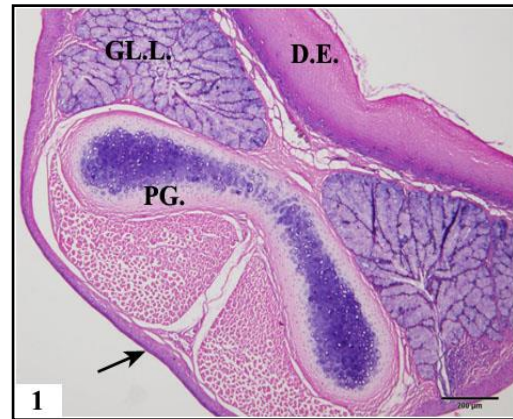


Figure1: Light micrographs of the middle part of the tongue of *Patagioenas livia*, showing the dorsal epithelium (D.E), the ventral epithelium (arrow), the paraglossale (PG.) and the lingual salivary gland (GL.L)

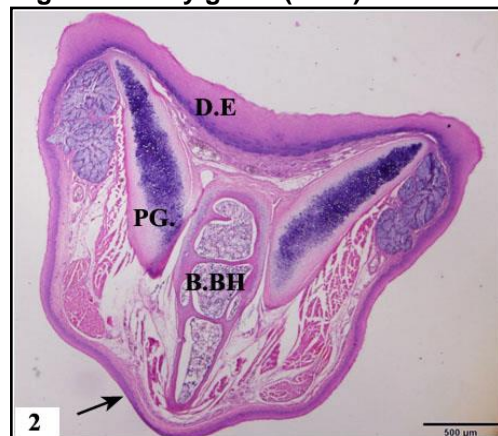
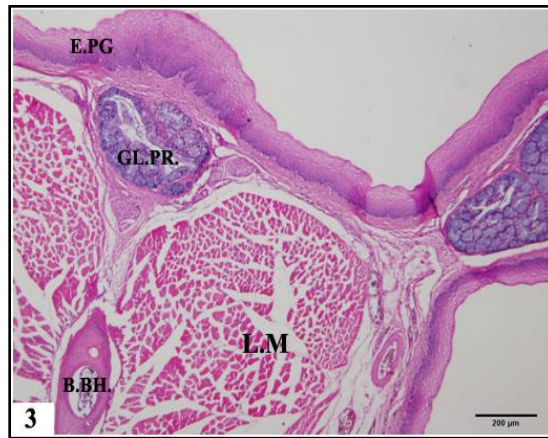


Figure2: Light micrographs of the posterior part of the tongue of *Patagioenas livia*, showing the dorsal epithelium (D.E), the ventral epithelium (arrow), the paraglossale (PG.), Bony basihyale (B.BH.)



**Figure3:** Light micrographs of the preglottal area of the tongue of *Patagioenas livia*, showing the dorsal epithelium of the preglottal region (E.PG.) which is characterized by non-keratinized epithelium, basihyale (B.BH), Glandula preglottalis (GL.PR.).

**Table 1:** Thickness of different regions of lingual epithelium of the rock dove (Values are means ± SD)

	Bird number			Means ±SD
	1	2	3	
<b>Antero-dorsal (mm)</b>	1.032 ± 0.063	0.989 ± .023	0.996 ± .024	1.005 ± 0.036
<b>Postero-dorsal* (mm)</b>	0.975 ± 0.043	0.956 ± 0.023	0.961 ± 0.031	0.964 ± 0.032
<b>Lateral (mm)</b>	0.642 ± 0.032	0.710 ± 0.043	0.594 ± 0.036	0.648 ± 0.037
<b>Ventral (mm)</b>	0.467 ± 0.021	0.521± 0.024	0.432 ± 0.032	0.473 ± 0.025

**Table 2:** Thickness of the epithelium of the preglottal area of the rock dove (Values are means ± SD)

	Bird number			Means ± SD
	1	2	3	
<b>Dorsal (mm)</b>	0.875 ± 0.045	0.912 ± 0.036	0.892 ± 0.028	0.856 ± 0.036
<b>Lateral (mm)</b>	0.815 ± 0.033	0.882 ± 0.042	0.842 ± 0.031	0.846 ± 0.036

**DISCUSSION**

The functional morphology of different avian species demonstrated approaching relation of the histological and morphometrical composition of the tongue epithelium in relation to food and feeding habits (Erdogan and Iwasaki, 2013; Emura et al., 2008). The keratinized lingual epithelium in birds is adapted to feeding hard food, such as granivorous birds to give a mechanical support for the tongue (Vollmerhaus and Sinowatz, 1992). Stratified squamous epithelium which covering the entire birds tongue surfaces are more or less a thick layer. It may be covered with keratin or non-keratinized, depending on food habit of birds. Thickness of tongue epithelial layer and keratinized layer is

probably differing according to the region of the tongue due to the degree of contact of this region with food. In many birds, anterior tip of the tongue epithelium is contact with intake food. If the food is hard such as grains it may cause injuries of the tongue through manipulation. Then, the part of epithelium in this region is in all tongue parts. The current investigation revealed that the tongue of the Rock Dove is covered with thick lingual epithelium. This is in accordance with Mohamed and Tobago (2019) who stated that the tongue apex of Muscovy duck is covered with parakeratinized epithelium on the dorsal surface. Data of the present work showed that thickness of lingual epithelium covering the dorsal surface of the tongue of the rock dove suggests a good adaptation for consuming hard food (grains and seeds) during feeding. The rock dove manipulate

grains and seeds and a part of this amount is storage in the buccal cavity throughout feeding. Lateral borders and ventral surface of the tongue may be exposed more to grains and seeds when storage in the buccal cavity. Thus, epithelium and keratinized layer of the lateral borders and ventral surface of the tongue are thicker than that in other regions. Non-keratinized epithelium, which covered the preglottal area of the rock dove, is may be due to less friction of food with this area. The above results are in accordance with (Shawki, 2016) about the lingual epithelium of the avian tongue. Different birds also show variations of the lingual structure for manipulating different types of food (Emura et al., 2009; Parchami et al., 2010a; Erdogan and Alan 2012; Erdoĝan and Iwasaki 2013). Several studies ((Crole and Soley, 2008, in the emu; Igwebuike and Anagor, 2013b) do not show any keratinization of the lingual epithelium. In ratites, tongue epithelium without keratinized layer on its dorsal or ventral surface (Jackowiak and Ludwig, 2008; Crole and Soley, 2009b; 2009; Santos et al., 2011). This is due to that food of these birds are wet and soft not hard. Many studies discussed lingual epithelium in reptiles. In case of snakes the lingual epithelium are adapted to dry terrestrial life, with strong keratinized layer (Mao et. al., 1991 and Iwasaki and Kumakura, 1994). In fresh water turtles, which are adapted to aquatic life, is non-keratinized (Iwasaki, 1992a). This may participate to the illustration of the relation between tongue structure of birds and food intake.

### CONCLUSION

The present work demonstrated the lingual epithelium morphometry of the tongue of the rock dove. Also, the relationship between the tongue epithelium structure with food intake and feeding habit.

### CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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### AUTHOR CONTRIBUTIONS

Fatma A. Al-Nefeyi designed the study, performed the experiments, prepared the Figures and wrote the manuscript. The authors read and approved the final version.

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