HISTOLOGICAL FEATURES OF THE TONGUE OF THE COMMON PIGEON (*Columba livia*)

IGWEBUIKE, Udensi M., UGWUOKE, Wilfred I. and UDOUMOH, Anietie F.
Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Enugu State, Nigeria.

Corresponding Author: Igwebuike, U. M. Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Enugu State, Nigeria. **Email:** abuchi2002@yahoo.com or udensi.igwebuike@unn.edu.ng **Phone:** +234 8038726150

ABSTRACT

The study evaluated the histological characteristics of the tongue in ten adult common pigeons, with a view to highlighting the relationship between structure and function of the tongue in the common pigeon. The results showed that the entire dorsal surface of the tongue was covered by a non-keratinized stratified squamous epithelium, while the ventral surface of the tongue exhibited a keratinized stratified squamous epithelium in the tongue body and apex. In addition, intraepithelial taste buds occurred in the dorsal epithelium of the tongue body and apex. The dense fibrous sub-epithelial connective tissue of the tongue root and body showed presence of mucus-secreting lingual glands and solitary lymphoid nodules. These were absent in the tongue apex. Furthermore, skeletal muscle fibres were abundant in the root and body of the tongue but not in the tongue apex. A paraglossum composed of hyaline cartilage was situated in the core of the tongue, extending from the tongue body to the tongue apex. In longitudinal section, the papillary crest appeared as evaginations of the dorsal lingual epithelium at the boundary between the root and body of the tongue. The evagination, composed entirely of epithelial cells lacked a connective tissue core. It was concluded that these histological features are essential adaptations that support the functions of the tongue during food intake, especially in the common pigeon which feeds mainly on grains and seeds.

Keywords: Common pigeon, *Columba livia*, Tongue, Lingual Epithelium, Lingual gland, Intraepithelial taste bud

INTRODUCTION

Pigeons have been domesticated for many centuries, and have been used for several different purposes such as 'carrier pigeons' used for delivering brief written messages, and 'release doves' for ceremonies. In recent times, there has been growing attention to the use of pigeons as mini-livestock, a source of meat-protein, especially among poor rural dwellers in parts of Africa. The common pigeon is a member of the family columbidae, and feeds mainly on seeds and grains. The tongue of most birds functions as a prehensile organ that plays important roles in procurement, transportation and swallowing of food. In-depth knowledge is available on the morphology of the tongue of many domestic and wild birds; Chicken (Iwasaki, 2002), white-tailed eagle (Jackowiak and Godynicki, 2005), emu (Crole and Soley, 2008, 2010), ostrich (Jackowiak and Ludwig, 2008), zebra finch (Dehkordi *et al.,* 2010), African pied crow (Igwebuike and Eze, 2010), European magpie and common raven (Erdogan

and Alan, 2012), Chukar partridge (Erdogan *et al.,* 2012), Guinea fowl (Igwebuike and Anagor, 2013a) and Muscovy duck (Igwebuike and Anagor, 2013b), but the information on the morphology of the tongue of the common pigeon is apparently scanty.

Generally, the tongue is composed of three parts namely; the tongue apex, the tongue body and the tongue root. A papillary crest forms the boundary between the body and root of the tongue. However, available data from the studies cited above reveal that lingual features exhibit great variability in relation to the type of food consumed by the birds and the adaptation of birds to environmental conditions. Knowledge of the biology of the common pigeon is needful for veterinarians because it will enable adequate medical and nutritional management of the bird. Thus, the present study seeks to provide information on the histological features of the tongue of the common pigeon in relation to its functions during food intake. Furthermore, our results will offer a good foundation for recognition of pathological lesions in the tongue of the common pigeon.

MATERIALS AND METHODS

Animals: All protocols involving animal experimentation and disposal of animal carcass were conducted according to the guidelines for animal experimentation, protection and animal welfare of the University of Nigeria, Nsukka. The ten adult common pigeons (325.4 ± 6.12 g) used for this study were obtained from local markets in Nsukka Local Government Area, Enugu State, Nigeria. The birds were sacrificed by euthanasia using intravenous injection of ketamine (1 ml / 100 g body weight of bird).

Histological Preparations: The tongue was dissected from the oral cavity, and specimens taken from different parts of the organ (apex, body and root) were fixed by immersion in Bouin's fluid for 48 hours. Later, these specimens were dehydrated in increasing concentrations of ethanol, cleared in xylene, and embedded in paraffin wax. The 5µm thick sections were cut, mounted on glass slides, and stained routinely with Haematoxylin and Eosin (H&E) for light microscopy (Igwebuike and Eze, 2010). Photomicrographs were captured using a Moticam Images Plus 2.0 Digital Camera (Motic China Group Limited).

RESULTS

Tongue Apex: The dorsal surface of the tongue apex was lined by very thick non-keratinized stratified squamous epithelium, while the ventral surface exhibited a relatively thin keratinized stratified squamous epithelium. The core of the tongue apex was composed of hyaline cartilage. Neither glands nor skeletal muscle fibres were encountered in the connective tissue of the tongue apex (Figure 1). Dense irregular fibrous connective tissue underlies both epithelial surfaces. The connective tissue beneath the epithelium of the dorsal surface penetrated the epithelium in form of richly vascularized connective tissue papillae, but this was lacking in the ventral epithelial layer. Moreover, intraepithelial taste buds were present in the dorsal surface epithelium (Figure 2).

Tongue Body: Longitudinal section of the tongue body (Figure 3) showed that the thickness of the non-keratinized stratified squamous epithelium covering the dorsal surface shrank abruptly towards the caudal part of the tongue body, while a keratinized stratified squamous epithelium covered the ventral surface of the tongue body. The fibrous connective tissue beneath the dorsal surface epithelium contained solitary lymphoid nodules and lingual glands (Figure 3). Connective tissue papillae extended from this layer to penetrate the ventral surface of the dorsal epithelium (Figure 4). The hyaline cartilage, which formed the core of the tongue body, appeared butterfly-shaped in cross section (Figure 4). Whereas skeletal muscle fibres occupied a position ventro-lateral to the hyaline cartilage, the lingual glands present in the tongue body were situated in a dorso-lateral position beneath the dorsal epithelial lining (Figure 4). Each glandular unit was surrounded by a dense connective tissue sheath, from which arose

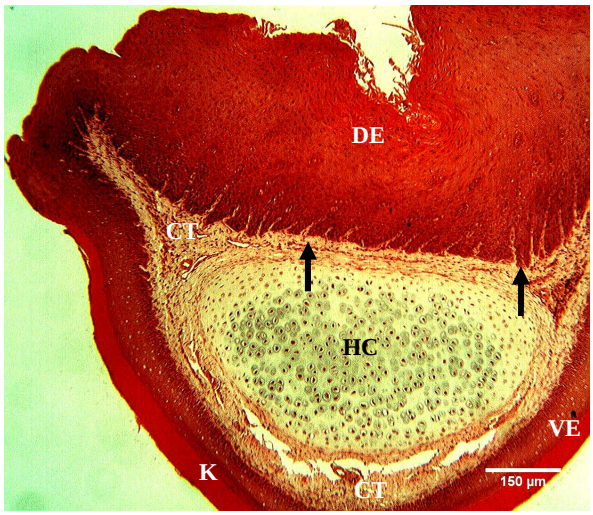

Figure 1: Transverse section of tongue apex showing dorsal epithelium (DE), sub-epithelial connective tissue (CT), connective tissue papillae (arrows), hyaline cartilage (HC), ventral epithelium (VE) with keratin (K). H & E stain, scale bar = 150 µm

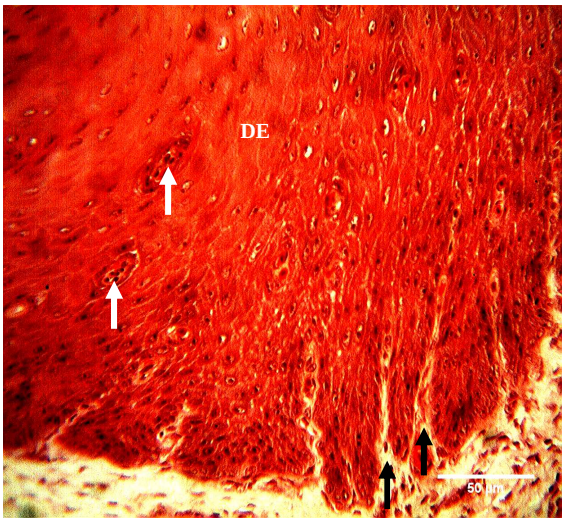

Figure 2: Dorsal epithelium of tongue apex (DE) showing intraepithelial taste buds (white arrows) and connective tissue papillae (black arrows). H & E stain, scale bar = 50 µm

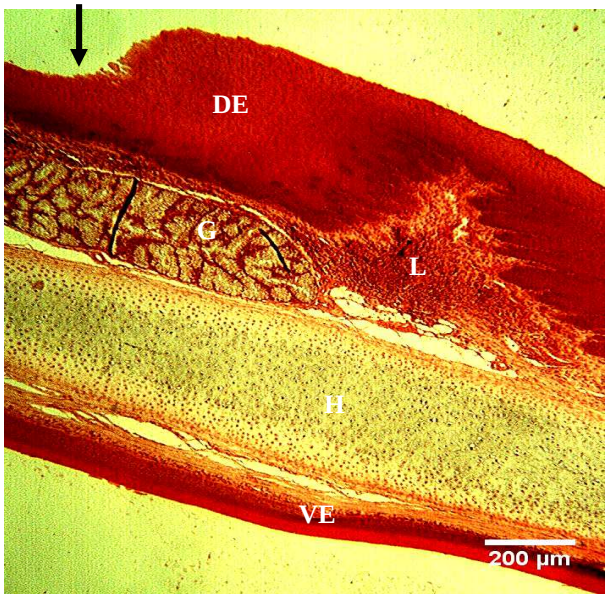

Figure 3: Longitudinal section of the tongue body showing thick dorsal epithelium (DE), abrupt reduction in epithelial thickness (arrow), lymphoid nodule (L), gland (G), hyaline cartilage (H), ventral epithelium (VE). H & E stain, scale bar = 200 µm

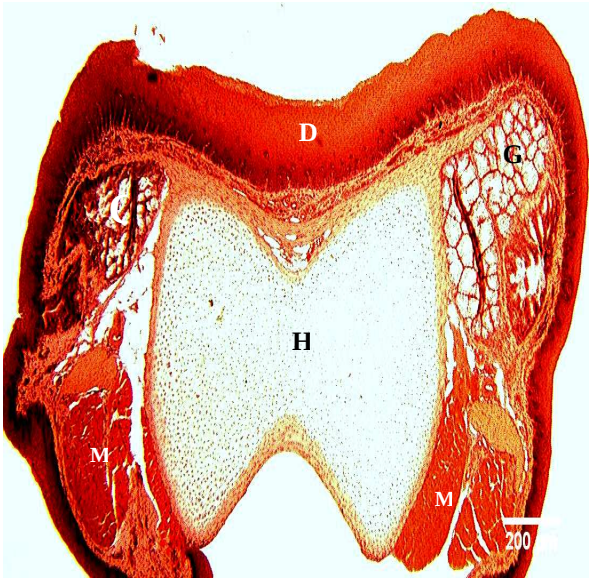

Figure 4: Transverse section of the tongue body showing dorsal epithelium (D), butterfly-shaped hyaline cartilage (H), glands (G) in dorso-lateral position, skeletal muscle fibres (M) in ventro-lateral position. H & E stain, scale bar = 200 µm

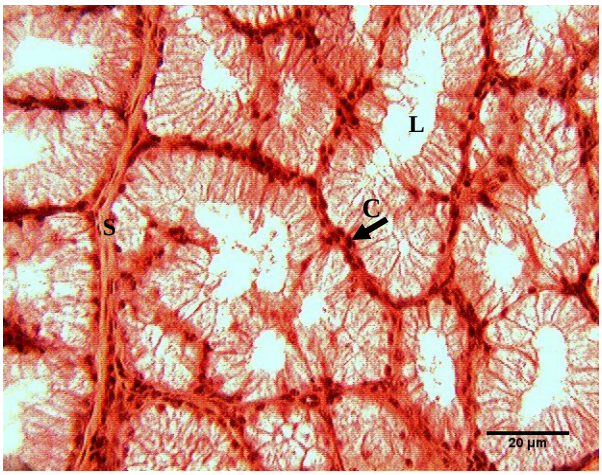

Figure 5: Section of lingual gland showing lumen of acinus (L), lightly stained cytoplasm (C), basally displaced dark nucleus (arrow) and dense connective tissue sheath (S). H & E stain, scale bar = 20 µm

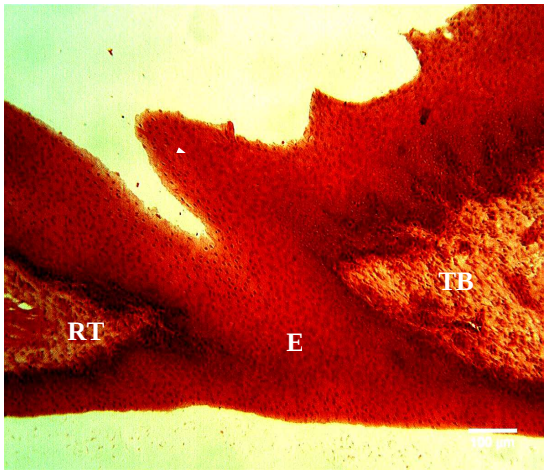

Figure 6: Longitudinal section of tongue showing caudally pointed papilla of the papillary crest (asterisk), connective tissue of tongue body (TB), connective tissue of tongue root (RT), epithelium (E). H & E stain, scale bar = 100 µm

Figure 7: Transverse section of the root of tongue showing dorsal epithelium (D), glands (G), surrounded by connective tissue sheath (arrow), connective tissue (CT), and skeletal muscle fibres (M). H & E stain, scale bar = 100 µm

connective tissue septa that separated individual secretory acini. The acini contained mucus-secreting cells characterized by lightly stained 'foamy' cytoplasm and basally displaced dark nuclei (Figure 5).

Papillary Crest and Tongue Root: In longitudinal section, the papillary crest that demarcates the tongue body from the root of the tongue appeared as caudally pointed epithelial evaginations on the dorsal surface of the tongue (Figure 6). The evagination lacked a connective tissue core and was composed of epithelial cells only. Indeed, the connective tissue of the tongue body and that of the tongue root were not continuous, but were separated by epithelial cells at the level of the papillary crest (Figure 6). In this region, the epithelia of the dorsal and ventral surfaces of the tongue unite. The epithelial covering on both dorsal and ventral surfaces of the tongue root was non-keratinized stratified squamous epithelium (Figures 6 and 7). The dense sub-epithelial connective tissue layer was richly vascularized, and contained mucus-secreting glands and solitary lymphoid nodules. The bulk of the root of the tongue was composed of many bundles of skeletal muscle fibres (Figure 7).

DISCUSSION

Morphological differences and variations that appear in the microscopic structure of the tongue of bird species may be directly

associated with dietary specialization and food type consumed by the particular bird and/or adaptation of the bird to its environmental conditions. The thick epithelial covering on the dorsal surface of the tongue apex and body in the common pigeon may signify significant involvement of the tongue in food manipulation resulting in the need for adequate mechanical protection of the organ. Although the dorsal surface epithelium of the tongue is non-keratinized in the common pigeon, the ventral lingual epithelium is keratinized throughout the tongue apex and body. This is similar to the tongue of the white-tailed eagle (Jackowiak and Godynicki, 2005), African pied crow (Igwebuike and Eze, 2010) and guinea fowl (Igwebuike and Anagor, 2013a), but differs from the tongue of the emu (Crole and Soley, 2008), ostrich (Jackowiak and Ludwig, 2008) and Muscovy duck (Igwebuike and Anagor, 2013b) which do not show any lingual epithelial keratinization. In the Chukar partridge, only the dorsal lingual epithelium is keratinized (Erdogan *et al.,* 2012). Thus, it is evident that the extent and pattern of lingual epithelial keratinization varies greatly among avian species. Iwasaki (2002) demonstrated that a relationship exists between the extent of lingual epithelial keratinization and avian habitat and type of food consumed by the bird.

Occurrence of connective tissue papillae that penetrate the ventral surface of the dorsal lingual epithelium of the common pigeon may serve to firmly anchor the epithelium to the underlying tissues. Since these connective tissue papillae are richly vascularized, they may further serve to bring nutrient supply closer to the cells of the relatively thick epithelium. Intraepithelial taste buds are evident in the dorsal epithelium of the tongue apex and body in the common pigeon. This is akin to the reports in bulbul (Al-Mansour and Jarrar, 2004), white-tailed eagle (Jackowiak and Godynicki, 2005), chicken (Kudo *et al.,* 2008), African pied crow (Igwebuike and Eze, 2010), Chukar partridge (Erdogan *et al.,* 2012) and guinea fowl (Igwebuike and Anagor, 2013a). This suggests that birds may exhibit some degree of taste discrimination, which may play an important role in food selection. The acuity of taste may vary among avian species, but this capacity for taste discrimination should be an important consideration when administering therapeutic drugs via the oral route. The papillary crest, which demarcates the tongue body from the tongue root, is a common feature of the tongue of most birds (Iwasaki and Kobayashi, 1986; Jackowiak and Godynicki, 2005; Igwebuike and Eze, 2010; Dehkordi *et al.,* 2010). Histologically, the papillary crest of the tongue in the common pigeon is composed of epithelial cells only. There are neither connective tissue cores nor gustatory cells associated with the papillary crest. Erdogan and Alan (2012) suggested that there is no precise correlation between the existence of papillary crest and the type of diet consumed by the bird. The papillary crest may facilitate unidirectional movement of food towards the oesophagus, and their mechanical aid prevents regurgitation (Jackowiak and Godynicki, 2005).

Glandular acini occur in both the body and root of the tongue in the common pigeon. There is no consensus as regards the localization and naming of avian lingual glands (Crole and Soley, 2010). However, in the present study, as in the chicken (Nickel *et al.,* 1977), quail (Capacchietti *et al.,* 2009) and Chukar partridge (Erdogan *et al.,* 2012), glands located in the tongue body are referred to as anterior lingual glands, while glands located in the tongue root are called posterior lingual glands. Lingual glands of the common pigeon are mucus-secreting glands that contribute to the secretion of saliva. The saliva lubricates and protects the oropharyngeal cavity from the activities of microorganisms (Gargiulo *et al.,* 1991). Furthermore, secretions of lingual glands may aid in swallowing of food by lubricating the caudal part of the oropharynx and probably, the initial part of the oesophagus (Igwebuike and Eze, 2010). Such lubrication is important especially because birds lack teeth and are unable to adequately masticate their food. Solitary lymphoid aggregates encountered in the sub-epithelial connective tissue of the tongue in the common pigeon constitute a component of the gut-associated lymphoid tissues (GALT) of avian oropharynx. These aggregates are composed mainly of densely stained lymphocytes, which are known to be very

important in immune responses. Their strategic location, just beneath the epithelium, makes them easily accessible sites for immune response surveillance. Hyaline cartilage that forms the paraglossum of the tongue in the common pigeon may provide for firmness, in addition to its function as a skeletal element for attachment of muscles of the tongue. Furthermore, skeletal muscle fibres present in the tongue of the pigeon enable voluntary control of tongue movements, and are thus, a very important histological feature that aids the functions of the tongue as a prehensile organ involved in procurement, transportation and swallowing of food.

Conclusion: The study has demonstrated that the histological features of the tongue of the common pigeon are important adaptations to support its functions as a prehensile organ. In addition, the information provided in this study will be useful in recognizing pathological lesions in the tongue, as well as in adequate medical management of the common pigeon by veterinarians.

ACKNOWLEDGEMENTS

The technical assistance of Mr. Okezie Agbakwu of the Department of Veterinary Anatomy, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria is gratefully acknowledged.

REFERENCES

AL-MANSOUR, M. I. and JARRAR, B. M. (2004). Structure and secretions of the lingual salivary glands of the white-cheeked bulbul (*Pycnontus leucogenys*). *Saudi Journal of Biological Science,* 11: 119 – 126.

CAPACCHIETTI, M., SABBIETI, M. G., AGAS, D., MATERAZZI, S., MENGHI, G. and MARCHETTI, L. (2009). Ultrastructure and lecithin cytochemistry of secretory cells in lingual glands of the Japanese quail (*Coturnix coturnix japonica*). *Histology and Histopathology,* 24: 1087 – 1096.

CROLE, M. R. and SOLEY, J. T. (2008). Histological structure of the tongue of the emu (*Dromaius novaehollandiae*). *Proceedings of the Microscopy Society of Southern Africa,* 38: 63.

CROLE, M. R. and SOLEY, J. T. (2010). Surface morphology of the emu (*Dromaius novaehollandiae*) tongue. *Anatomia Histologia Embryologia,* 39: 355 – 365.

DEHKORDI, R. A. F., PARCHAMI, A. and BAHADORAN, S. (2010). Light and scanning electron microscopic study of the tongue in the zebra finch (*Carduelis carduelis*). *Slovenian Veterinary Research,* 47: 139 – 144.

ERDOGAN, S. and ALAN, A. (2012). Gross anatomical and scanning electron microscopic studies of the oropharyngeal cavity in the European magpie (*Pica pica*) and the common raven (*Corvus corax*). *Microscopy Research Technique*, 75: 379 – 389.

ERDOGAN, S., SAGAOZ, H. and AKBALIK, M. E. (2012b). Anatomical and histological structure of the tongue and histochemical characteristics of the lingual salivary glands in the Chukar partridge (*Alectoris chukar*). *British Poultry Science*, 53: 307 – 315.

GARGIULO, A. M., LORVIK, S., CECCARELLI, P. and PEDINI, V. (1991). Histological and histochemical studies on the chicken lingual glands. *British Poultry Science,* 32: 693 – 702.

IGWEBUIKE, U. M. and ANAGOR, T. A. (2013a). Gross and histo-morphological assessment of the oropharynx and tongue of the Guinea fowl (*Numida meleagris*). *Animal Research International*, 10(2): 1739 – 1746.

IGWEBUIKE, U. M. and ANAGOR, T. A. (2013b). Morphology of the oropharynx and tongue of the Muscovy duck (*Anas platyrhynchos*). *Veterinarski Arhiv,* 83: (in press).

IGWEBUIKE, U. M. and EZE, U. U. (2010). Anatomy of the oropharynx and tongue of the African pied crow (*Corvus albus*). *Veterinarski Arhiv,* 80: 523 – 531.

IWASAKI, S. (2002). Evolution of the structure and function of the vertebrate tongue. *Journal of Anatomy,* 201: 1 – 13.

IWASAKI, S. and KOBAYASHI, K. (1986). Scanning and transmission electron microscopical studies on the lingual dorsal epithelium of chickens. *Acta Anatomica (Nippon),* 61: 83 – 96.

JACKOWIAK, H. and GODYNICKI, S. (2005). Light and scanning electron microscopic study of the tongue in the white-tailed eagle (*Haliaeetus albicilla,* Accipitridae, Aves). *Annals of Anatomy,* 187: 251 – 259.

JACKOWIAK, H. and LUDWIG, M. (2008). Light and scanning electron microscopic study of the ostrich (*Strutio camelus*) tongue. *Zoological Science,* 25: 188 – 194.

KUDO, K., NISHIMURA, S. and TABATA, S. (2008). Distribution of taste buds in layer-type chickens: scanning electron microscopic observations. *Animal Science Journal,* 79: 680 – 685.

NICKEL, R., SCHUMMER, A. and SEIFERLE, E. (1977). *Anatomy of the Domestic Birds.* Volume 5, Verlag Paul Parey, Berlin.