GROSS AND HISTOMORPHOLOGICAL ASSESSMENT OF THE OROPHARYNX AND TONGUE OF THE GUINEA FOWL (*Numida meleagris*)

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ABSTRACT

The study investigated the morphology of the oropharynx and tongue of the guinea fowl using gross anatomical and histological techniques. The results showed that the mouth and pharynx of the guinea fowl lacked a definite line of demarcation, and so formed a common oropharyngeal cavity. The roof of the oropharynx was formed by the hard palate and the choana. The hard palate was characterized by a broad v-shaped rostral mucosal swelling, a median palatine ridge that bifurcated caudally into left and right lateral palatine ridges, and para-median rows of caudally pointed conical papillae. The tongue of the guinea fowl was located on the floor of the oropharynx, but did not extend to the full limits of the lower beak. The caudal and rostral parts of the tongue were demarcated by a v-shaped row of papillae, the papillary crest. Histologically, the dorsal surface of the tongue was lined by a non-keratinized stratified squamous epithelium that contained intraepithelial taste buds, while the lining on the ventral surface of the tongue was a keratinized stratified squamous epithelium. Other features include a wide sub-epithelial connective tissue layer containing lingual glands, and a core of striated muscles. The lingual glands of the guinea fowl consisted of tubular secretory units made up of mucus-secreting cells. These findings may be important in nutritional and medical management of guinea fowls especially under the intensive system of production. Furthermore, our study has provided a foundation for recognition of pathology in the oropharynx and tongue of the guinea fowl.

Keywords: Guinea fowl, *Numida meleagris,* Gross anatomy, Oropharyngeal cavity, Hard palate, Tongue, Lingual gland

INTRODUCTION

Guinea fowl production is gaining some attention among smallholder farmers as an alternative source of meat protein, eggs and income (Abubakar *et al.,* 2008; Obike *et al.,* 2011). This is particularly because the guinea fowl has been reported to have some advantages over the chicken. Such advantages include greater disease resistance, greater ability to scavenge for food and higher meat-to-bone ratio (Kozaczynski, 1998). Intensive management of guinea fowl production is a relatively new enterprise in Nigeria, and efforts to position this emerging industry on a sound financial basis may be hamstrung by lack of basic knowledge of the biology of these birds. In the present time, most scientific studies are conducted on the chicken, while the same physiological responses are assumed in the guinea fowl. However, accumulation of knowledge on the biology of the guinea fowl, especially data on the morphology of components of the digestive tract would prove useful in relation to the nutritional and medical management of these birds. Furthermore, specific information on the anatomy of the oropharynx and tongue of the guinea fowl is important to identify structural features that may influence food intake and ingestion, as well as to provide a foundation for the recognition of pathology in this region of the bird.

Although many studies have attempted to describe the morphology of the avian oropharynx and tongue (Jackowiak and Godynicki, 2005; Crole and Soley, 2008; Igwebuike and Eze, 2010; Tivane *et al.,* 2011; Erdogan and Alan, 2012), specific information on the anatomy of the oropharynx and tongue of the guinea fowl is yet very scanty. The objective of the present study is to investigate the morphology of the oropharynx and tongue of the guinea fowl using gross anatomical and light microscopic techniques.

MATERIALS AND METHODS

Experimental Animals: All procedures involving animals were conducted according to the guidelines for the protection of animal welfare in the University of Nigeria, Nsukka. The ten adult guinea fowls used for this study were obtained from local small-holder farmers in Enugu-Ezike, Igbo-Eze North Local Government Area, Enugu State, Nigeria. The birds were sacrificed by euthanasia using overdose intravenous injection of ketamine (4 ml of ketamine per bird).

Gross Anatomy: Following death, components of the digestive tract located within the head region were dissected and studied in terms of their shape, physical appearance and *in-situ* topographical relationships. Gross photographs were captured using a Yashica 7.1 mega pixels digital camera.

Histological Preparations: Specimens of the tongue were cut and 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 5 μm thick sections were cut, mounted on glass slides, and stained routinely with Haematoxylin and Eosin (H&E) for light microscopy (Nickel *et al.,* 1977). Photomicrographs were captured using a Moticam Images Plus 2.0 digital camera (Motic China Group Limited).

RESULTS

Gross Anatomy: The mouth and pharynx of the guinea fowl did not show any definite line of demarcation, but formed a common oropharyngeal cavity. The oropharyngeal cavity was bounded dorsally by the oropharyngeal roof comprising the hard palate and choana, and ventrally by the tongue and floor of the oropharynx. The maxillary ramphotheca formed the lateral borders of the roof of the oropharyngeal cavity (Figure 1).

The right and left maxillary ramphotheca merged rostrally to form the maxillary rostrum. Immediately caudal to the maxillary rostrum was a broad v-shaped mucosal swelling on the hard palate. The two arms of the v-shaped mucosal swelling extended caudally to mark the lateral boundaries of the rostral ⅓ of the palate. A median palatine ridge situated in the median plane, separated the left and right arms of the v-shaped mucosal swelling.

Caudally, the median palatine ridge bifurcated into left and right lateral palatine ridges. A choanal slit (Figure 1) was apparent as a long single opening that extended from the middle to the caudal aspects of the oropharyngeal roof. This opening, which was in the median plane, was characterized by a narrow tubular rostral portion and a broad rounded caudal portion. The lumen of the choanal slit was partially demarcated into left and right compartments by a median ridge. Para-median rows of caudally pointed conical papillae occurred on the palatine mucosal surface between the choanal slit and the lateral palatine ridges. There were usually five or six rows of papillae on the left and right sides. The last row (the most-caudal row) contained numerous papillae that were especially large and prominent.

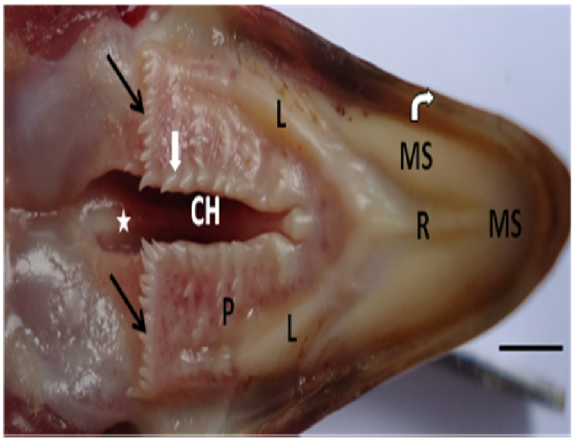

Figure 1: Roof of the oropharynx of a guinea fowl showing the maxillary ramphotheca (curved arrow), broad v-shaped rostral mucosal swelling (MS) on the palate, median palatine ridge (R), and lateral palatine ridges (L). The choanal slit (CH) is partially demarcated into two compartments by a median ridge (star). Caudally pointed papillae (white arrow) occur on the margins of the choanal opening. Note the rows of paramedian conical papillae (P). The most caudal row (black arrows) consists of especially prominent papillae. Scale bar = 3 cm.

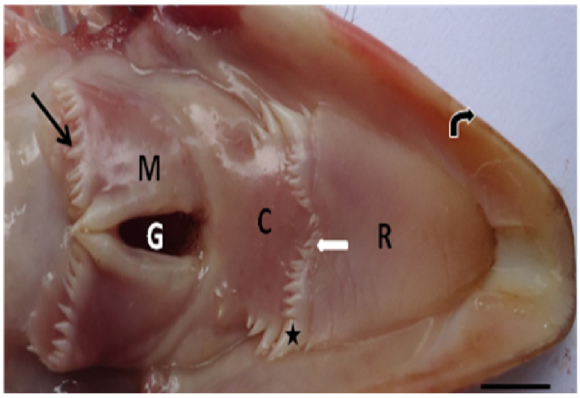

Figure 2: Floor of the oropharynx of a guinea fowl showing the mandibular ramphotheca (curved arrow), glottis (G) and laryngeal mound (M) whose caudal border exhibits a row of conical papillae (black arrow). The caudal (C) and rostral (R) parts of the tongue are separated by a v-shaped row of conical papillae (white arrow). Note different sizes of lateral lingual papillae (star) associated with the caudal part of the tongue. Scale bar = 3 cm.

Similarly, the margins of the tubular rostral portion of the choanal opening exhibited caudally pointed papillae, but these were absent in the broad, rounded caudal part of the choana.

The floor of the oropharyngeal cavity of the guinea fowl presented as a concave depression between the rami of the lower beak (Figure 2).

The mandibular ramphotheca that formed the lateral boundaries of the oropharyngeal floor followed the contours of the mandibular rami, and converged rostrally to form the mandibular rostrum. The tongue of the guinea fowl was located on the floor of the oropharynx. It was a relatively small organ that did not extend to the lateral and rostral margins of the lower beak. A v-shaped transverse row of caudally pointed conical papillae demarcated the rostral and caudal parts of the tongue. Whereas the rostral tongue body appeared arrow-shaped and lacked lingual papillae, the lateral margins of the caudal part of the tongue exhibited prominent conical lingual papillae of various sizes. The largest of these lateral lingual papillae were the most-rostral, while the smallest were the most-caudal (Figure 2).

The laryngeal mound was situated caudal to the tongue, and it was associated with a large opening, the glottis. A prominent row of caudally pointed papillae was evident on the caudal border of the laryngeal mound.

Histomorphology: The dorsal surface of the tongue of the guinea fowl was lined by a non-keratinized stratified squamous epithelium that exhibited many intraepithelial taste buds (Figure 3). In contrast, the epithelial lining on the ventral surface of the tongue was keratinized stratified squamous epithelium (Figure 4). Underneath these epithelial linings on both the dorsal and ventral surfaces of the tongue was a dense irregular connective tissue that formed the lingual submucosa. The lingual submucosa beneath the dorsal surface epithelium showed presence of numerous lingual glands (Figure 5). Each gland was characterized by tubular secretory units, and opened onto the dorsal surface of the tongue via a duct. Condensed connective tissue sheath surrounded each glandular unit. Connective tissue septa from this sheath demarcated individual tubular secretory acini (Figure 5).

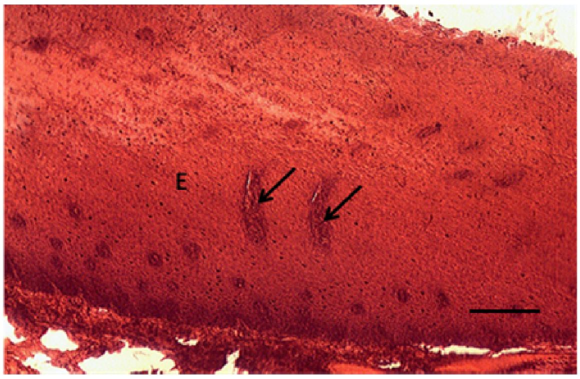

Figure 3: Non-keratinized stratified squamous epithelium (E) on the dorsal surface of the tongue in the guinea fowl. Note the occurrence of intraepithelial taste buds (arrows) in this epithelium. H&E stain, scale bar = 60 µm.

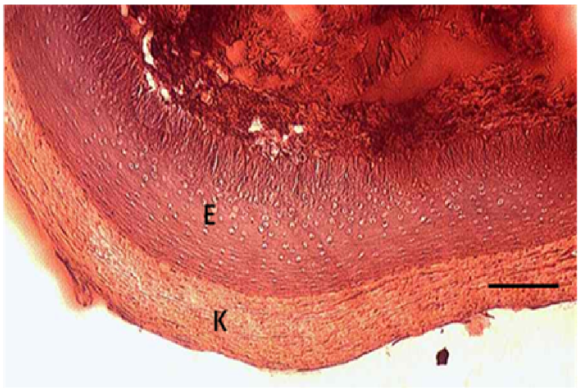

Figure 4: Presence of keratin (K) in the stratified squamous epithelial lining (E) of the ventral surface of the tongue in the guinea fowl. H&E stain, scale bar = 60 µm.

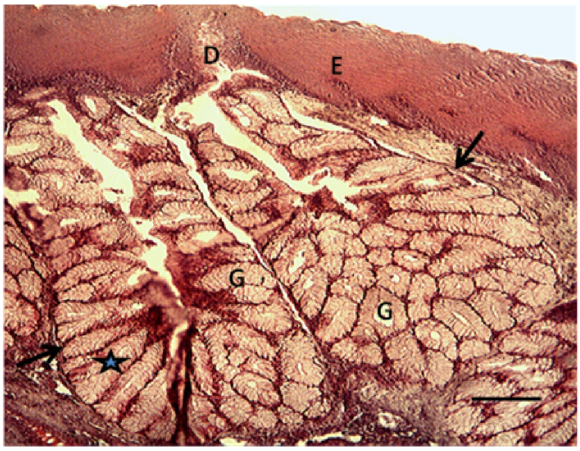

Figure 5: Lingual glands (G) are present in the sub-epithelial connective tissue beneath the dorsal surface epithelium (E) of the guinea fowl's tongue. The glands consist of tubular secretory units (star), and are surrounded by dense connective tissue sheaths (arrows). Note the ducts (D) that lead onto the surface of the tongue. H&E stain, scale bar = 60 µm.

DISCUSSION

Generally, phylogenetic relationships, adaptation to environmental conditions, dietary specialization and feeding habits are thought to determine morphological differences and variations in the anatomy of components of the avian digestive system including the oropharyngeal cavity and tongue. Occurrence of a common oropharyngeal cavity illustrated in the guinea fowl in this study reinforces previous reports in both domestic and wild species of birds (Bacha and Bacha, 2000; Gussekloo, 2006; Igwebuike and Eze, 2010). The ramphotheca is the stratum corneum of the epidermal covering of the beak (Clarke, 1993) and forms the lateral boundaries of the oropharyngeal cavity in the guinea fowl. Rostral convergence of the right and left maxillary ramphotheca in the upper beak, and a similar convergence of the left and right mandibular ramphotheca in the lower beak resulted in a bluntly tapered rostral extremity of the beak that functions as a prehensile organ, and may play significant roles in procurement, handling and incomplete break down of food materials.

The present study demonstrates a broad v-shaped mucosal swelling on the rostral part of the hard palate in the guinea fowl. This feature appears to be unique to the guinea fowl, and has not been reported in other birds. The median and lateral palatine ridges of the guinea fowl are similar to the palatine ridges of chicken (McLelland, 1979). In the rhea (Gussekloo, 2006), emu (Crole and Soley, 2010) and ostrich (Tivane *et al.,* 2011), only a prominent median palatine ridge is present and the lateral palatine ridges are absent.

Partial demarcation of the lumen of the single choanal opening of the guinea fowl into two compartments by a median ridge is comparable to the choana of ostrich (Tivane *et al.,* 2011), but differs from that of chicken (McLelland, 1979) and African pied crow (Igwebuike and Eze, 2010). However, unlike the ostrich (Tivane *et al.,* 2011), herons and ducks (McLelland, 1979) in which the choana is restricted to the caudal part of the roof of the oropharynx, the choanal slit in the guinea fowl is long and extends from the middle to the caudal aspects of the oropharyngeal roof. Thus, it is similar to what has been described for most birds including bustards (Bailey *et al.,* 1997). Whereas the conical papillae present on the lateral margins of the rostral part of the choanal cleft may serve to protect the choanal entrance (Nickel *et al.,* 1977), the caudally pointed conical papillae on the mucosal surface of the hard palate are thought to aid in unidirectional movement of food bolus towards the pharynx. These papillae are typical in most avian species (McLelland, 1979; Igwebuike and Eze, 2010), but are absent in the rhea (Gussekloo and Bout, 2005) and ostrich (Tivane *et al.,* 2011).

The shape of the tongue in birds is characteristically related to the form of the lower beak and the feeding habits of the particular species (Parchami *et al.,* 2010a,b; Erdogan *et al.,* 2012a). The arrow-shaped tongue of the guinea fowl does not extend to the full limits of the lower beak, and so resembles the tongue of the chicken (Iwasaki and Kobayashi, 1986), quail (Parchami *et al.,* 2010a) and white-tailed eagle (Jackowiak and Godynicki, 2005). Moreover, like the tongue of the chicken (Iwasaki and Kobayashi, 1986), European magpie (Erdogan and Alan, 2012) and penguin (Kobayashi *et al.,* 1998), the guinea fowl's tongue lacks a median sulcus on its dorsal surface. The median sulcus is reported to be prominent in the tongues of some birds such as the white-tailed eagle (Jackowiak and Godynicki, 2005), black kite (Emura, 2008), nutcracker (Jackowiak *et al.,* 2010) and goose (Hassan *et al.,* 2010), but vague and short in the raven (Erdogan and Alan, 2012).

The conical papillary crest that demarcates the rostral and caudal parts of the tongue in the guinea fowl may serve to facilitate movement of food towards the oesophagus, and to prevent regurgitation. A similar explanation may also be adduced for the prominent caudally pointed conical papillae located caudal to the laryngeal mound. The row of papillary crest on the guinea fowl's tongue is characteristically v-shaped in arrangement. Likewise, v-shaped arrangement of the papillary crest is observed in the partridge (Erdogan *et al.,* 2012b), white-tailed eagle (Jackowiak and Godynicki, 2005), quail (Parchami *et al.,* 2010a), goose (Hassan *et al.,* 2010) and zebra finch (Dehkordi *et al.,* 2010), but not in the African pied crow (Igwebuike and Eze, 2010) and raven (Erdogan and Alan, 2012). In addition to the row of papillary crest, laterally located papillae formed by large and small conical papillae were seen in the caudal part of the guinea fowl's tongue in the present study. Similar structures have been demonstrated in magpie and raven (Erdogan and Alan, 2012), golden eagle (Parchami *et al.,* 2010b), black kite (Emura, 2008), chicken (Iwasaki and Kobayashi, 1986) and cormorant (Jackowiak *et al.,* 2006).

Our study shows that in the guinea fowl, the dorsal surface of the tongue is covered by a non-keratinized stratified squamous epithelium, while the ventral surface is lined by a keratinized stratified squamous epithelium. The extent of lingual surface keratinization varies greatly among avian species, and it has been suggested that this may be related to the habitat and type of food consumed by the particular bird (Iwasaki, 2002). Whereas both dorsal and ventral tongue surfaces are covered by keratinized epithelium in the penguin (Kobayashi *et al.,* 1998), only the ventral surface epithelium is keratinized in the Japanese quail (Warner *et al.,* 1967), white-tailed eagle (Jackowiak and Godynicki, 2005) and African pied crow (Igwebuike and Eze, 2010). In contrast, both dorsal and ventral surfaces of the tongue are non-keratinized in the emu (Crole and Soley, 2008) and ostrich (Jackowiak and Ludwig, 2008). Intraepithelial taste buds observed in the dorsal surface epithelium of the guinea fowl's tongue in this study is akin to the reports in chicken (Kudo *et al.,* 2008), bulbul (Al-Mansour and Jarrar, 2004), white-tailed eagle (Jackowiak and Godynicki, 2005), African pied crow (Igwebuike and Eze, 2010) and partridge (Erdogan *et al.,* 2012b). Thus, it is most probable that these birds may exhibit some degree of taste discrimination, which may play an important role in food selection. Although the acuity of taste may vary among avian species, their capacity for taste discrimination may be an important consideration when administering therapeutic drugs via the oral route.

Lingual glands of the guinea fowl are simple branched tubular glands, and the histological features of these structures, including the lightly stained 'foamy' cytoplasm of the secretory cells suggest that these are mucus-secreting glands. It is thought that the most common configuration of avian lingual glands is simple tubular, but branched tubulo-alveolar, alveolar and compound alveolar glandular profiles have also been reported (Crole and Soley, 2010). Moreover, sero-mucous-secreting units were observed in the little egret (Al-Mansour and Jarrar, 2007), while glands composed of serous and sero-mucous units were demonstrated in the chicken (Gargiulo *et al.,* 1991), quail (Taib and Jarrar, 1998; Liman *et al.,* 2001) and chukar partridge (Erdogan *et al.,* 2012b). Obviously, avian lingual glands contribute to the secretion of saliva that provides for a moist environment in the oropharyngeal cavity, and protects the cavity from the activities of microorganisms (Gargiulo *et al.,* 1991). Saliva owes its function to its mucin content (Liman *et al.,* 2001). It has been proposed that salivary mucins establish a barrier between the oral mucosa and bacterial flora, and so forms a protective layer on the oral cavity against desiccation, mechanical damage, external toxic substances and microbial toxins (Samar *et al.,* 2002; Crole and Soley, 2011; Sagoz *et al.,* 2012). 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 as reported in the African pied crow (Igwebuike and Eze, 2010).

In conclusion, our study has provided information on the morphology of the oropharynx and tongue of the guinea fowl, and this may be important in nutritional and medical management of these birds especially under the intensive system of production. In addition, this study has offered a foundation for recognition of pathology in the oropharynx and tongue of the guinea fowl.

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