

The morphology of the oropharynx and tongue of the muscovy duck (*Cairina moschata*)

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ABSTRACT

The morphology of the oropharynx and tongue of the muscovy duck was studied with a view to identifying structural features that may influence nutrition, food intake and ingestion, as well as to provide a foundation for the recognition of pathology of the bird in this region. The results illustrated that the roof of the oropharyngeal cavity was formed by a cartilaginous hard palate that lacked papillae on its mucosal surface, but exhibited a prominent median longitudinal mucosal fold, the median palatine ridge. Orderly arranged rows of notches, the lamellae, formed the lateral boundaries of both the roof and floor of the oropharynx. The tongue, which was located on the floor of the oropharyngeal cavity, was characterized by a prominent dorsal median sulcus, numerous lateral brush-like horny lingual papillae and a bell-shaped dorsal surface elevation, that formed the base (caudal 1/3) of the organ. This bell-shaped elevation may be similar to the torus linguae of ruminants. Histologically, the features of the tongue include a non-keratinized stratified squamous epithelial lining on both its dorsal and ventral surfaces, a wide connective tissue layer, containing lingual glands, blood vessels and nerves, and a core of paraglossum and associated striated muscles. In conclusion, the oropharynx and tongue of the muscovy duck exhibits certain anatomical features that are unique to this species, and the morphological modifications of this region of the digestive tract may be adaptations to the bird's habitat and mode of feeding.

Key words: duck, oropharynx, tongue, papillae, lingual gland, lingual epithelium

Introduction

Ducks are mini-livestock whose nutritional benefits may be useful to supplement the protein requirements of rural communities in Nigeria and other developing countries. Ducks are hardy and resistant to most common diseases and environmental hazards. In Nigeria, local ducks are raised either in a free-range system alongside domestic fowl or in a semi-enclosed system. They are highly adapted to scavenging conditions, and feed

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by foraging for a diet of grasses, seeds, invertebrates and water fleas. The muscovy duck (*Cairina moschata*) is the most prevalent breed of duck raised in Nigeria.

Knowledge of the anatomy of the oropharynx and tongue is important to identify structural features that may influence nutrition, food intake and ingestion, as well as to provide a foundation for recognition of pathology in this region. Some attention has been devoted to the study of the morphology of the avian oropharynx and tongue in recent times (JACKOWIAK and GODYNICKI, 2005; CROLE and SOLEY, 2008; IGWEBUIKE and EZE, 2010; TIVANE et al., 2011; ERDOGAN and ALAN, 2012). However, specific information on the anatomy of the oropharynx and tongue of the duck is still very scant. The present study seeks to investigate the morphology of the oropharynx and tongue of the muscovy duck, using gross anatomical and light microscopic techniques.

Materials and methods

Experimental animals. The ten adult muscovy ducks used for this study were obtained from local markets in Nsukka Local Government Area, Enugu State, Nigeria. The birds were sacrificed by euthanasia using an overdose intravenous injection of phenobarbitone.

Gross anatomy. Following death, the 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 48h. 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. Photomicrographs were captured using a Moticam Images Plus 2.0 digital camera (Motic China Group Ltd.).

Results

Gross anatomy. The mouth and pharynx of the muscovy duck lack a definite line of demarcation, and so constitute a common oropharyngeal cavity. The beak, which appears broad and shovel-shaped, consists of upper and lower beaks (Figs. 1, 2). The basis of the upper beak is formed by the incisive bone, while the basis of the lower beak is formed by the rostral part of the mandible. Both beaks are covered by hard horny sheaths, but the horny sheath of the upper beak extends beyond the borders of that of the lower beak. Thus, when the mouth is closed, the upper beak covers the lower beak, both laterally and rostrally.

The roof of the oropharynx (Fig. 1) is formed by the hard palate, which is predominantly cream-coloured, but shows some black patches. The rostral $\frac{2}{3}$ of the hard

palate is divided into left and right sides by a prominent median longitudinal mucosal fold, the median palatine ridge. Situated on the lateral borders of the hard palate there are numerous orderly arranged rows of notches, the lamellae. Many transversal narrow mucosal folds extend obliquely between the median longitudinal fold and the lamellae. Two transverse ridges, located on either side of the midline, demarcate the most-caudal aspects of the hard palate from the point of origin of the choanal slit. The choanal slit is visible as an oval depression in the caudal 1/3 of the roof of the duck's oropharynx (Fig. 1). It is characterized by a narrow rostral part and an enlarged caudal part. The choanal slit in the duck is a single opening whose lumen is partially separated into right and left compartments by a median ridge. Caudally-pointed papillae occur at the edges of the choanal slit.

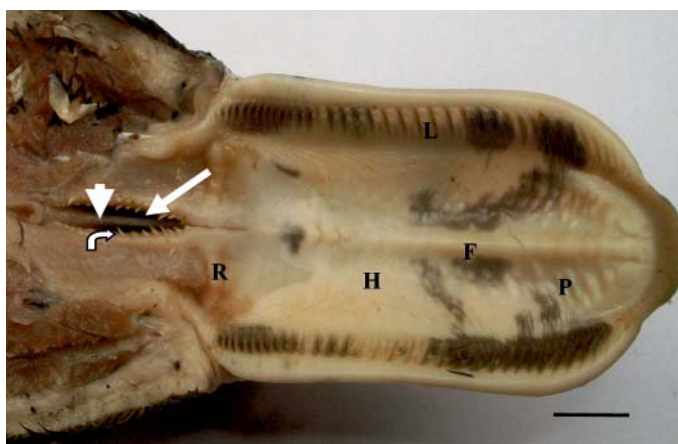


Fig. 1. The roof of the oropharynx of the duck. Hard palate (H), median palatine ridge (F), transversal mucosal folds (P), lamellae (L), bilateral transverse ridges (R). The choanal slit (arrow), median ridge (arrow head), caudally pointed papillae (curved arrow) on the edges of the choanal slit. Scale bar = 3 cm.

The floor of the oropharynx of the duck (Fig. 2) presents as a concave depression between the rami of the lower beak. The lateral edges of the floor of the oropharynx exhibit orderly arranged rows of lamellae, similar to those on the upper beak. The tongue of the duck is found on the rostral part of the floor of the oropharyngeal cavity. It is a long structure whose tip appears smooth and shovel-shaped. The tongue body is characterized by a prominent median sulcus, which is apparent on the dorsal surface of the organ. Whereas numerous long brush-like horny lingual papillae are situated at the lateral margins of the rostral half of the tongue body, the lateral margins of the caudal half of the tongue body exhibit fewer, but broader lingual papillae (Fig. 2). The gaps between these broad papillae are occupied by small thread-like papillae. A bell-shaped elevation

on the dorsal surface of the tongue forms the base of the organ. The caudal border of this elevation possesses a row of caudally-pointed broad papillae, which mark the caudal boundary of the tongue. In addition, small lingual papillae are evident at the rostral edge of the bell-shaped elevation. The median sulcus on the dorsal surface of the tongue body extends caudally on to the bell-shaped elevation.

Located on the floor of the oropharynx, just caudal to the base of the tongue, there are two lateral mucosal swellings, whose surfaces show the presence of filiform-like papillae (Fig. 2). These lateral mucosal swellings are separated by a median ridge, which extends from the base of the tongue towards the laryngeal mound. The median ridge bifurcates just rostral to the laryngeal mound, to form two caudal processes that appear to insert on the rostro-lateral margins of the laryngeal mound. The glottis, a large round opening, is apparent on the rostral surface of the laryngeal mound. The caudally directed papillae are obvious on the mucous membrane of the laryngeal mound and on the caudal processes of the median ridge.

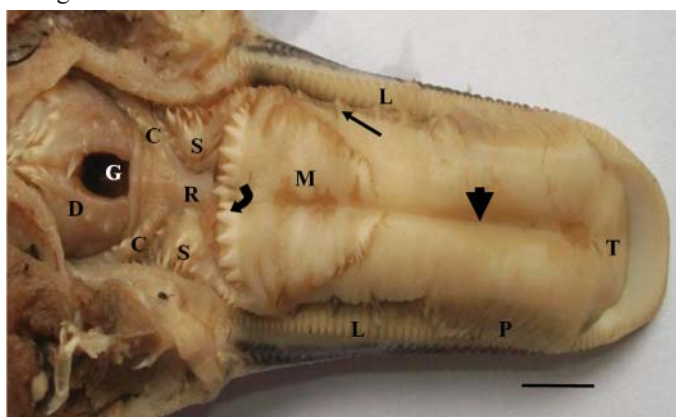


Fig. 2. The floor of the oropharynx of the duck. Lamellae (L), shovel-shaped tip of the tongue (T), median sulcus (arrow head), brush-like (P) and broad (arrow) horny lingual papillae, bell-shaped dorsal surface elevation (M), caudally pointed papillae (curved arrow), bilateral mucosal swellings (S), median ridge (R), caudal processes (C). The glottis (G), laryngeal mound (D). Scale bar = 3 cm

Histology. The histology of the tongue of the duck revealed that the organ consists essentially of an epithelial lining, a wide connective tissue layer containing lingual glands, blood vessels and nerves, and a core of paraglossum and associated striated muscles. The dorsal (Fig. 3) and ventral (Fig. 4) surfaces of the tongue body are lined by non-keratinized stratified squamous epithelium. However, the dorsal epithelium appears marginally thicker than the ventral epithelium. Beneath the epithelium on both the dorsal

and ventral surfaces of the tongue body there is dense irregular fibrous connective tissue, which penetrates the epithelial layers in the form of connective tissue papillae. Lingual papillae extend from the lateral margins of the tongue body as epithelial evaginations, with connective tissue cores. In contrast to the non-keratinized epithelial lining of the rest of the tongue body, these papillae are covered by heavily cornified stratified squamous epithelium (Fig. 5).



Fig. 3. The epithelium of the dorsal surface of the tongue. Non-keratinized stratified squamous epithelium (EP), sub-epithelial connective tissue (CT). H&E stain, objective $\times 10$, Scale bar = 60 μm .



Fig. 4. The non-keratinized stratified squamous epithelium (EP) on the ventral surface of the duck's tongue, sub-epithelial connective tissue (CT), glandular acini (GA). H&E stain, objective $\times 10$, Scale bar = 60 μm .

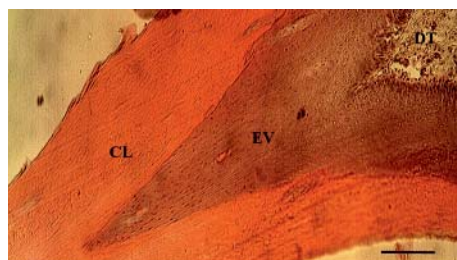


Fig. 5. Lingual papillae on the lateral margins of the duck's tongue. Epithelial evagination (EV), connective tissue core (DT), highly cornified epithelium (CL). H&E stain, objective $\times 10$, Scale bar = 60 μm .



Fig. 6. Intramural lingual glands in the tongue of the duck. Dense connective sheath (D), branched tubular acini (T), basally displaced dark nuclei (curved arrow), lightly stained cytoplasm (arrow). H&E stain, objective $\times 10$, Scale bar = 60 μm .

The lingual submucosa contains large numbers of simple branched tubular glands (Fig. 6) that occupy the full width of the layer. These structures appear as round, oval or pear-shaped profiles that account for the bulk of the tongue parenchyma. Surrounding each glandular unit there is a richly vascularized, condensed layer of connective tissue, from which connective tissue septa arise demarcating individual tubular secretory units. Each glandular acinus is composed of typical mucus-secreting cells, with basally-displaced dark nuclei and lightly stained 'foamy' cytoplasm.

Discussion

The boundaries of the oropharyngeal cavity of the duck, as described in this study, agree with the general pattern in most avian species (McLELLAND, 1993). Lack of any obvious morphological distinction between the oral cavity and the pharynx in the duck is also apparent in most avian species, probably due to the absence of the soft palate in birds (McLELLAND, 1993). However, it has been reported that some authors, who employed embryological data in their study of the oropharynx, suggest that the boundary between the oral and pharyngeal cavities in the duck may be at the level of the caudal lingual papillae (McLELLAND, 1993).

The broad, shovel-shaped beak of the muscovy duck is structured whereby the hard horny sheath of the upper beak covers that of the lower beak both laterally and rostrally. This is similar to other duck species, but differs from the fowl and pigeon, in which the beak is pointed, and the hard horny sheath of the upper beak extends in a hook beyond that of the lower beak (NICKEL et al., 1977). The present study shows that the mucosa of the hard palate on the roof of the duck's oropharynx exhibits a prominent median palatine ridge in the rostral $\frac{2}{3}$ of the palate. This feature is different from the anatomy of the hard palate in most birds (McLELLAND, 1979), but it is similar to what has been illustrated in the rhea (GUSSEKLOO, 2006), the emu (CROLE and SOLEY, 2008) and the ostrich (TIVANE et al., 2011). Furthermore, occurrence of horny lamellae on the lateral margins of both the upper and lower beaks is characteristic of the duck in the present study. NICKEL et al. (1977) suggested that, when the beak is closed, these lamellae may act as sieves that help to retain food particles taken up with the water during foraging.

Our study illustrates two transverse ridges that demarcate the caudal aspects of the hard palate from the choanal slit. This feature may be unique for the duck, and has not been described in other avian species. The choanal slit, which makes for communication between the nasal cavities and the oropharyngeal cavity in birds, appears in the muscovy duck as a single opening, whose lumen is partially separated into two compartments by a median ridge. Whereas similar compartmentalization of the choanal slit has been reported in the ostrich (TIVANE et al., 2011), the single choanal slit in the African pied crow showed no demarcation into compartments (IGWEBUIKE and EZE, 2010). It is remarkable that the

caudally pointed papillae that have been reported as a typical feature of the hard palate in most avian species (McLELLAND, 1979; IGWEBUIKE and EZE, 2010) are conspicuously absent on the mucosal surface of the duck's hard palate, except for the papillae on the edges of the choanal slit, as shown in the present study. This adaptation may be related to the duck's mode of feeding. A similar lack of papillae on the hard palate and roof of the oropharynx has been demonstrated in the rhea (GUSSEKLOO and BOUT, 2005) and ostrich (TIVANE et al., 2011).

The tongue of the duck appears to be adapted for prehension, transportation and swallowing of food. Its shape and size differ from those of the fowl and pigeon. Whereas the tongue is long and broad, with a shovel-shaped tip in the duck, the fowl's tongue is broad, lancet-shaped and does not extend to the full limit of the lower beak. In the pigeon, the tongue is narrow. Moreover, the bell-shaped dorsal surface elevation, that forms the base of the tongue, is unique to the duck, and may be likened to the torus linguae of ruminants. The prominent median sulcus on the dorsal surface of the tongue of the duck is lacking in the African pied crow (IGWEBUIKE and EZE, 2010). The tongue of the duck exhibits many lingual papillae, whose functions may vary depending on their location. The brush-like horny lingual papillae on the lateral margins of the tongue body may act as a filter that actively supplements the horny lamellae on the lateral margins of both the upper and lower beaks, while the other caudally pointed lingual papillae, on the dorsal surface of the caudal part of the tongue, may play important roles during food transportation and swallowing.

The stratified squamous epithelium lining both the dorsal and ventral surfaces of the tongue of the duck is non-keratinized. This may not be unconnected with the semi-aquatic habitat of the duck. Although this finding is a clear departure from the keratinized lingual epithelium reported for most birds (McLELLAND, 1975; KOBAYASHI et al., 1998), non-keratinized lingual epithelium is also present in the emu (CROLE and SOLEY, 2008) and the ostrich (JACKOWIAK and LUDWIG, 2008). Indeed, it has been documented that in some birds, such as the Japanese quail (WARNER et al., 1967), the white-tailed eagle (JACKOWIAK and GODYNICKI, 2005) and the African pied crow (IGWEBUIKE and EZE, 2010), the ventral lingual epithelium is keratinized, while the dorsal lingual epithelium is non-keratinized. A relationship has been demonstrated between the extent of lingual epithelial keratinization and avian habitat and the type of food consumed by the bird (IWASAKI, 2002).

The intramural lingual glands of the duck are simple branched tubular glands, similar to the lingual glands of the African pied crow (IGWEBUIKE and EZE, 2010). The morphological characteristics of the secretory cells of these glands in the duck, including the presence of basally displaced dark nuclei and lightly-stained 'foamy' cytoplasm, suggest that these are mucus-secreting glands. The presence of mucus-secreting lingual

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glands has been reported in other avian species (BACHA and BACHA, 2000; JACKOWIAK and GODYNICKI, 2005). GARGIULO et al. (1991) proposed that the main functions of the lingual salivary glands in birds include provision of a moist environment in the oropharynx, and protection of the cavity from microorganisms. In addition, the secretions of these glands may also aid in swallowing, by lubricating the caudal part of the oropharyngeal cavity and probably, the initial part of the oesophagus (IGWEBUIKE and EZE, 2010).

In conclusion, this study has demonstrated that the oropharynx and tongue of the muscovy duck exhibit certain anatomical features that are unique to this species, and the morphological modifications of this region of the digestive tract may be adaptations to the bird's habitat and mode of feeding.

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SAŽETAK

Istražena je morfologija orofarinksa i jezika mošusne patke s ciljem da se ustanove strukture koje mogu utjecati na hranidbu, unos hrane i probavu te da pruži temelj za prepoznavanje patoloških promjena u tom području. Rezultati su pokazali da je nepce orofaringealne šupljine građeno od hrskavičnog tvrdog nepca na čijoj sluznici nema bradavica. Ustanovljen je središnji uzdužni sluznični nabor odnosno središnji nepčani greben. Pravilno raspoređeni žljebovi, lamele oblikovali su lateralne granice nepca i dna orofarinksa. Na jeziku, smještenom na dnu orofaringealne šupljine, nalazi se dorzalno izražen središnji žlijeb s mnoštvom orožnjalih lateralnih jezičnih bradavica nalik na četku i zvonoliko dorzalno uzdignuće na bazi organa (kaudalna 1/3). To zvonoliko uzdignuće slično je torusu jezika u preživača. Dorzalna i ventralna površina histološki je građena od nekeratiziranoga slojevitoga skvamoznog epitela sa širokim vezivotkivnim slojem s jezičnim žlijezdama, krvnim žilama i živcima. Središnji dio građen je od prugastog mišićja. Može se zaključiti da orofarinks i jezik mošusne patke ima neka obilježja osebujna za vrstu. Morfološke modifikacije toga dijela probavnog trakta odraz su adaptacije ptičjem staništu i načinu hranidbe.

Cljučne riječi: patka, orofarinks, jezik, papile, lingvalne žlijezde, lingvalni epitel
