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Research Article

Morphohistological and histochemical study of oropharynx and tongue of duck (*Anas platyrhynchos*), partridge (*Alectoris chukar*) and ostrich (*Struthio camelus*) birds

Iman Mousa KHALEEL[*1], Fatimah Swadi ZGHAIR[2], Mahdi Abdul-Kareem ATYIA[1]

[1]*Department of Anatomy and Histology, College of Veterinary Medicine, University of Baghdad, Baghdad, Iraq.*
[2]*Department of Anatomy and Histology, College of Veterinary Medicine, University of AL-Qadisiyah, Veterinary Collage, Baghdad, Iraq.*
[*]*Email: eman.m@covm.uobaghdad.edu.iq*

Abstract: The oropharynx and tongue of local duck (*Anas platyrhynchos*), partridge (*Alectoris chukar*), and ostrich (*Struthio camelus*) were studied to evaluate the morphological characteristics that influence nutrition, swallowing, and food intake. The findings revealed that a cartilaginous hard palate constituted the roof of the oropharyngeal cavity, with the exception of partridges, that it did not have any papillae on its mucosal surface. The median palatine ridge, a prominent longitudinal mucosal fold running along the middle of the mouth, was present in the studied birds. The lateral margins of the floor and roof of the oropharynx were formed by rows of lamellae. The tongue was situated on the oropharynx floor and featured a prominent dorsal median sulcus and many lateral brush-like projections on each side of the tongue. Except for the absence of the papillae in the ostrich, other characteristics of the organ were horned lingual papillae and a bell-shaped dorsal surface height, which served as the organ's foundation. The tongues have non-keratinized stratified squamous epithelial cells on lingual dorsal and ventral surfaces, a thick layer of connective tissue containing lingual glands, nerve fibers with blood vessels, central structure consisting of the paraglossum and its related striated muscle. In conclusion, the duck, partidage, and ostrich oropharynx and tongue show particular anatomical characteristics which were morphological modulations of this part of the digestive canal as an adaptation for the feeding habits of these birds.

Keywords: Digestive system, Birds, Anatomy, Morphology.

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Introduction

Birds have a variety of eating behaviors that reflect their diverse living patterns, with matching variations in the architecture of their bills and tongues. A small animal with nutritional benefits, ducks have the potential to be used to augment the rural people's protein requirements in Iraq and other countries. The ducks are robust creatures that are resistant to the majority of illnesses and environmental dangers. Local ducks are grown in Iraq in a "semi-enclosed system" with domestic fowl or in a "free-range system". They are well suited to hunting on grasses, seeds, insects, and water fleas (Hanna et al. 2011). The birds are classified according to their economic importance; fowl, goose, duck, turkey, pigeon, and guinea are the most significant (Igweubike & Eze 2010).

Knowledge of both the oropharynx and tongue anatomy is critical for identifying anatomical characteristics that may affect food consumption, nutrition, and swallowing and establishing a baseline for recognizing disease. A certain amount of research has been done regarding the features of birds' tongues and oropharynx (Jackowiak & Godynicki 2005;

Crole & Soley 2008; Igebuike & Eze 2010; Tivane et al. 2011; Erdogan & Alan 2012). Detailed knowledge of the oropharynx and tongue anatomy of ducks, partridges, and ostriches is still scarce. Therefore, this research aimed to examine the oropharynx and tongue morphology in ducks, partridge, and ostrichs based on gross anatomy and histology.

Materials and Methods

Thirty males of clinically healthy domesticated ducks, partridges, and ostriches of different ages were used in this study. Each bird was used to study the anatomy of the oral cavity grossly. Morphometric measurement was done using a Dazor Magnifier and the Vernier Caliber. The results were photographed by a Sony® digital camera 12.1MP, 4X). Sodium pentobarbitone (80mg/kg) was administered intraperitoneally to euthanize the birds (Reilly 2001). Bird heads were promptly dissected based on an accepted proposal issued by the Faculty of Veterinary Medicine, Al-Qadisiyah University's local ethical committee.

The tongues and oral cavity were rinsed in normal saline solution before being kept in 10% buffered formalin. The shape of the tongue and oral cavity were studied under a stereomicroscope, and its total length and breadth were examined (SMZ 1500 digital camera). The hard palate and tongues were removed and the histological slides of 6 µm were prepared based on Eagderi et al. (2013). For investigating general microstructures, staining was done using haematoxylin eosin and Massons Trichrome, In the case of acid mucin, and Alcian blue-PAS was used for both acid and neutral mucine (Humason 1972; Totty 2002). The slides were photographed using an Olympus microscope (BX 50) equipped with a digital camera (ME, M 13500).

Results

Gross morphology oral cavity: Cavum oris roof from the palatum: Palate length (Fig. 1A, B, C) was about 6.2cm in male duck, 4.2cm in ptridage, and 8cm in ostrich, with deep concave centrally with caudally fades. From its mucous membrane, the median palatine ridge (Fig. 1 A, B, C) arises as a median longitudinal ridge of 4cm in ostrich, 1.5cm in partridges, and 3.6cm in duck. It extends rostrally until about 0.3cm in ostrich, 0.5cm in partridges 0.6cm in duck behind the hard keratinized tip, and caudally terminates forming four main papillae (Fig. 1A, B, C). On both sides of the ridge of the rostral part, there were 4-5 caudally short, smooth transverse palatine ridges in ducks but absent in ostrich and partridge (Fig. 1A, B, C). In ducks another row of 38-40 long blade-shaped pigment lamellae (Fig. 1A) are found on palate lateral margins, but these are absent in ostrich and patridage. On the palate lateral margins on the ventromedial sides of the bill, there was a row of 22-24 stout lamellae of about 0.3cm rostrally and progressively increased caudally to reach 0.6cm in length, while in ostrich, 6-10 plates are found in lower jaw with about 0.4cm rostrally and decrease in number caudally. These lamellae are absent in patridage. The sulcus palatinus or choanal cleft (Fig. 1 A, B, C) was 2.6cm in duck, 2cm in patridage, and 3cm in ostrich dividing the patate into narrow short rostral and wide long caudal portions.

The mucous membrane edges have several irregular rows of papillae oriented caudally (Fig. 1A, B). Posterior to the choanal cleft, there was an infundibular crack (Fig. 1A, B, C) that represents the general narrow opening of pair auditory tubes in ostrich choana cleft as V-shape. A depression separated by a large mucosal ridge, runs along the midline of the body as follows: A series of the modest mucosal ridges separate the apertures of the internal nares on the dorsomedial aspect of the nares. Near the base of the pharynx in the pharynx caudal part, the infundibular slit extends from a crater-like depression to divide it into two overlapping layers of mucus. Each of the folds has rounded free borders that together form a deep depression before becoming continuous with the mucosa of the proximal part of the esophagus (Fig. 1).

Floor of the cavum oris: Lingua or tongue (Figs. 2, 3A, B, C) in ducks is thick, fleshy, and elongated

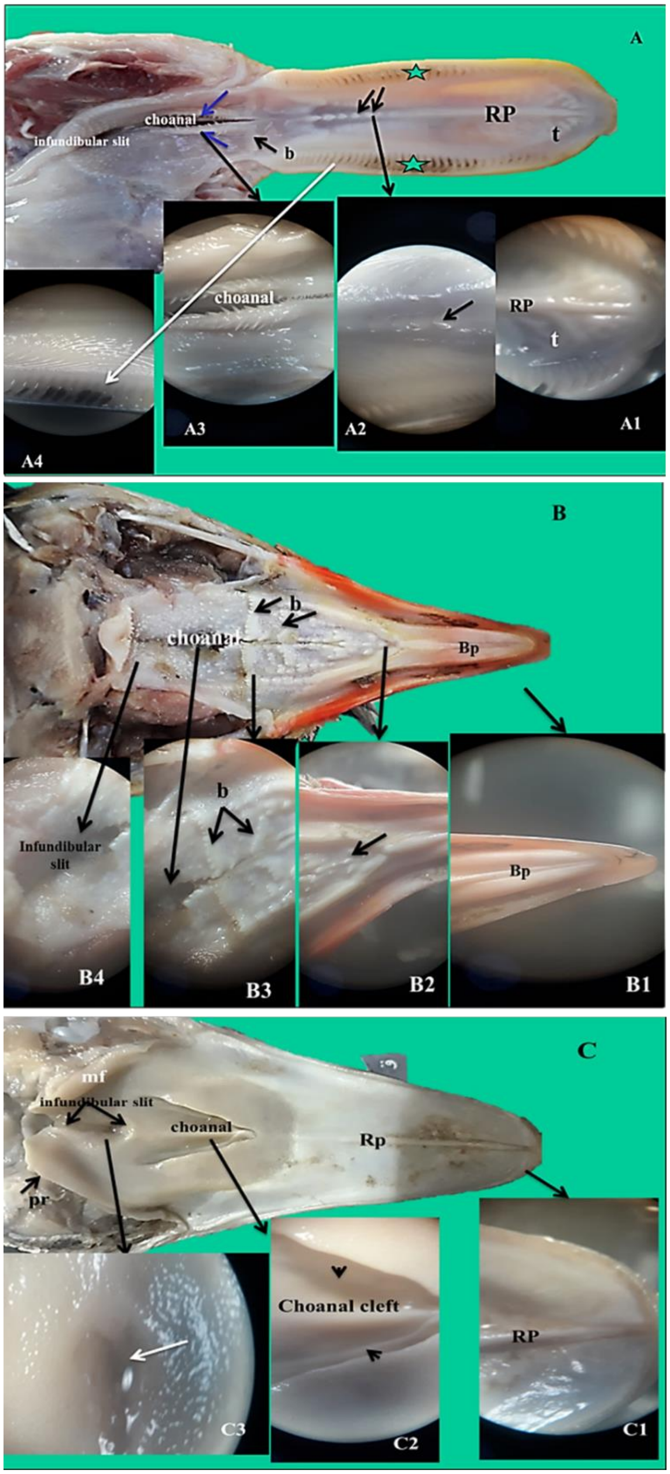

Fig.1. (A) The roof of oral cavity in duck (hard palate): Median palatine ridge (Rp), mucosal transverse folds (t), bilateral ridge (b), based papillae (black arrows), bill lamellae (green star), papillae (blue arrows), choanal, and infundibular slit (A1, A2, A3, and A4: under dissecting microscope. (B): The roof of oral cavity (hard palate) in ptridage: Median palatine ridge (Rp), bilateral ridge(b), based papillae (b), papillae (blue arrows), choanal, and infundibular slit. B1, B2, B3, and B4: under dissecting microscope. (C): The roof of oral cavity in duck (hard palate) in ostrich: Median palatine ridge (Rp), choanal cleft, infundibular slit., a crater-like depression (white arrow), pharyngeal folds (mf), at the base of the tongue, there are two tiny papillae that point caudally (arrowheads), retropharyngeal recess (pr). C1, C2, and C3: under dissecting microscope (X10).

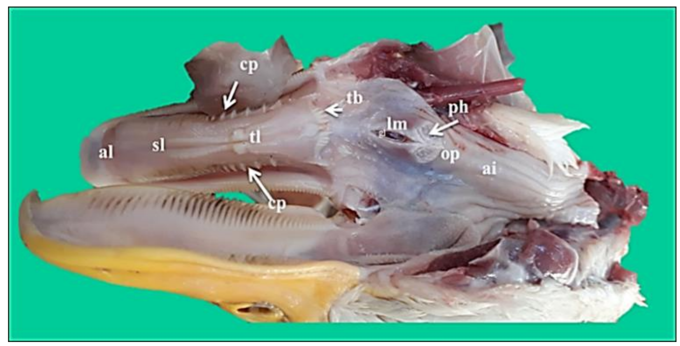

Fig.2. Floor of oral cavity floor in duck.

while in partridge has an elongated triangular shape with a pointed hardened texture tip and flat dorsal surface. In ostrich, the tongue appears conical in shape with a bifid tip, fully covers the oral cavity floor, and reaches about 5.2cm in length in duck, 4cm in partridge, 1cm in ostrich, width of 1.5cm in duck, 1cm in partridge, 1.75cm in ostrich and thickness of 1cm in duck, 0.5cm in partridge, and 0.75cm in ostrich. It consists of three portions the root, body, and apex. The tongue Apex in ducks is smooth, narrow, free of papillae, and extends to the tip of the lower bill, while in partridge, the apex of the tongue has a pointed hardened texture tip (Figs. 2, 3A, B), in ostrich to provide for accommodation between the rami of the jaw, the triangular internal area was formed, which served as the oral cavity's floor rostral to the tongue. It was wrapped about both the tongue and laryngeal mound on both sides, ultimately combining with the oesophageal mucosa to form a ring around the throat. Because of the variations in color, the mucosa of this area may be divided into two components. The rostral and rostro-lateral parts of the oral cavity were mostly filled by the biggest component, which was light in color (Fig. 3C). Tongue's body (Figs. 3A, 4) displays thick having two lateral, dorsal, and ventral surfaces; dorsum linguae marked by sulcus linguae (Figs. 2-4) which

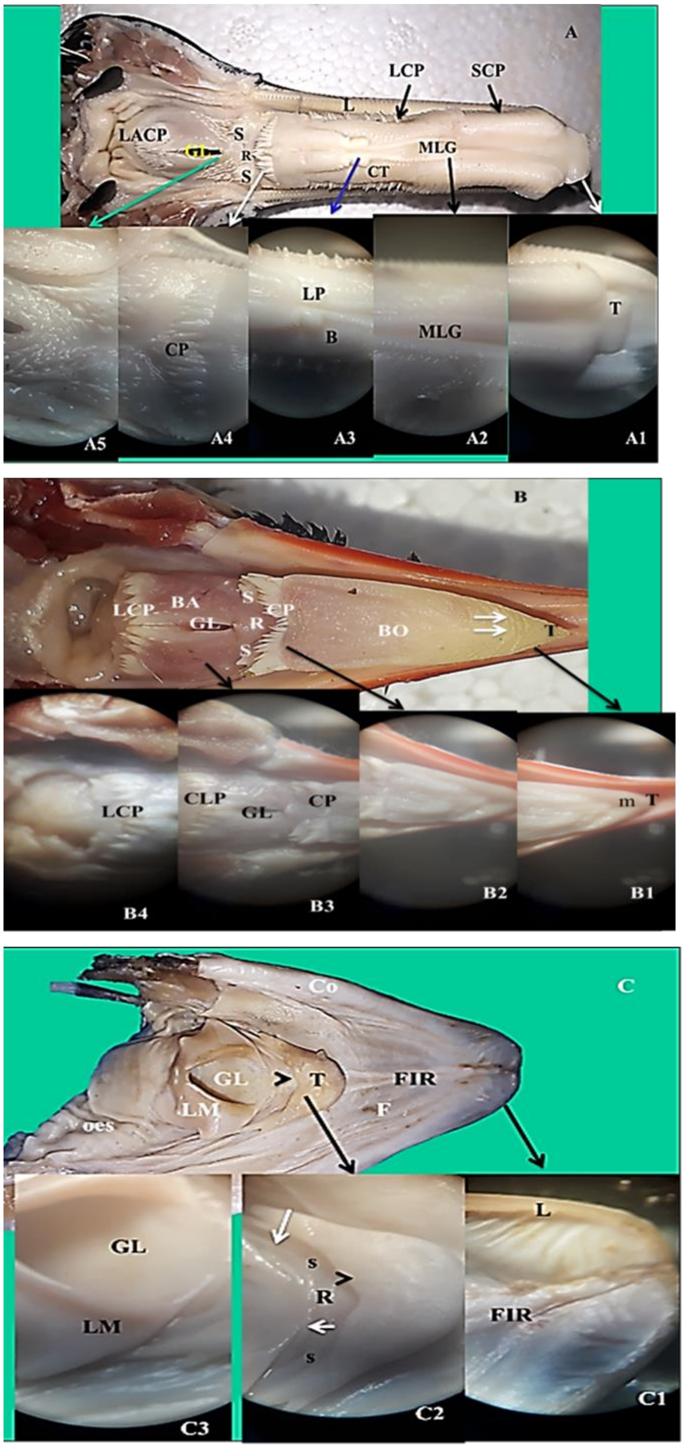

Fig.3. (A) The floor of oropharynx in duck: Make a note of the lingual tip (T), lingual body (B), bill lamellae (L), lingual prominence (L.P), mucosal swelling (S), median ridge (R), glottis (GL), median sulcus (MLG), conical papillae of lingual prominence caudal border (CP), smaller conical papillae (SCP (LCP). A1, A2, A3, A4, A5, and A6 under a dissecting microscope. (B) The floor of oropharynx and tongue in partidage. Notice tongue tip (T), lingual body (BO), mucosal swelling(S), median ridge (R), glottis (GL), conical papillae of the caudal border of body (CP), transverse line of conical papillae (white arrow), median longitudinal groove (m), lingual salivary glands' openings (white arrows), laryngeal conical papillae (LACP), B1, B2, B3, and B4 under dissecting microscope. (C) The floor of the oropharynx and tongue in ostrich. Note the tongue tip (T), lingual body (C2), mucosal swellings (S); Median ridge (R), glottis (GL), laryngeal mound (LM), high folded internal region (FIR), transverse line of the pharyngeal papillae (white arrow), lingual salivary glands' openings (white arrows), secondary tongue folds (head arrow) and oesphagus (Oes), C1,2,3 under dissecting microscope (X10).

has deep median longitudinal groove reaching between the apex and torus linguae in duck, and partridge, while in ostrich it is absent (Figs. 3A, B, C). lengths of about 2 and 1cm to adapt the hard palate median ridge during the closure of the oral cavity in duck and partridge. Arises from the ventrum linguae, a sickle -shape fold of mucous membrane represents frenulum linguae (Fig. 4A, B, C) and from the center of the tongue ventral surface to the oropharynx floor, the fold in duck, partridge, and ostrich are 1.6, 1.3, and 1cm, respectively.

Margo linguae were fringed with a large conical papilla (Fig. 4A, B) in duck and partridge, and in between them, there were many tiny thread-shaped papillae mixed with palate bill lamellae (Figs. 3A, B, 4A, B). The tongue root (Fig. 3A, B, C) affords rostrally a triangular wide ridge of mucous membrane. The torus linguae (Fig. 3A, B) has its base directed caudally, having rostrally two parallel curved rows of tiny papillae and the torus caudal basal side was separated by the sulcus linguae into two portions; each contains transverse caudally oriented papillae (Fig. 4A, B). At the floor of the pharynx, caudal to the lingual root, there was laryngeal prominence (Figs. 3, 4A, B) as median mucosal height that contains laryngeal inlet. It was restricted rostrally by a small papilla and many tiny pointed caudo-medially oriented papillae that were separated on a laryngeal mound terminal part in front of the esophageal inlet. The keratin covers most of the bill and it is leathery at the rostral end and there is a hard palate in the nail (Fig. 3A, B, C).

In ostrich three regions were distinguished in the lingual dorsal surface; apex, body, and radix.

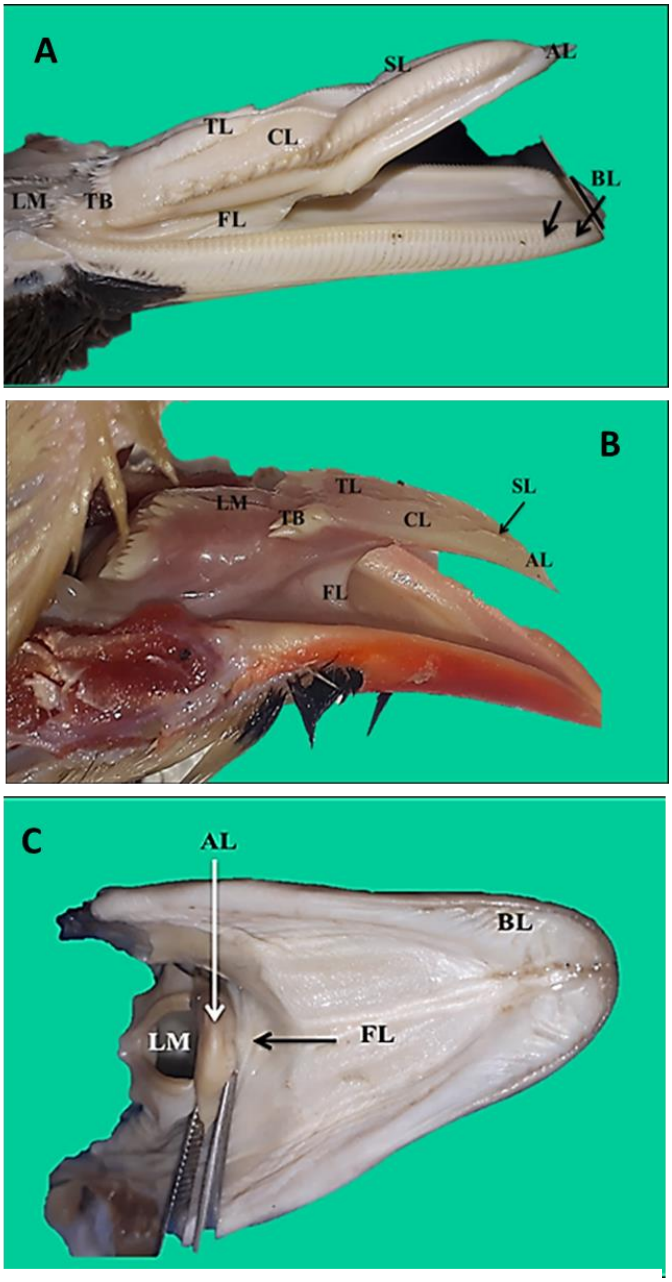

Fig.4. (A) The tongue and oral cavity floor of duck (lateral view), corpus linguae (CL), apex linguae (AL), sulcus linguae (SL), torus linguae (TL), frenulum (FL), bill lamellae (BL), transverse papillae (TB) and laryngeal mound (LM). (B) The tongue and oral cavity floor of partidage (lateral view), corpus linguae (CL), apex linguae (AL), sulcus linguae (SL), Torus linguae (TL), frenulum (FL), transverse papillae (TB) and laryngeal mound (LM). (C) The tongue and oral cavity floor of ostrich (anterior view), apex linguae (AL), frenulum linguae (FL) and laryngeal mound (LM).

Between the lingual apex and base, a wide area situated at the terminal of the lingual body is inclined toward the tongue's posterior end. A median groove was found along the tongue's dorsal surface and gradually expanded backward. The lingual body was separated into two symmetrical parts by this median furrow which were characterized by their convex folded surface. The tongue was connected with the bill bottom by a short frenulum to the tongue body posterior portion at the level of the conical papillary crest (Figs. 3C, 4C).

The tongue's strong conical papillae were angled backward between both the body and the base of the tongue, transversely placed. There was a larger one on each aspect of the body-base junction on each side, and a few additional papillae immediately. On the lingual base dorsal side, many lingual glands were opened (Fig. 3A, B, 4A, B). The tongue's ventrolateral surfaces featured solid plates (Fig. 3A, B, 4A, B). The row of pharynx conical papillae was oriented backward and placed transversally just below the laryngeal cleft, while another row of conical rudimentary papillae was positioned after the first row crossly (Fig. 3A, B).

Histological examination: According to the findings, in tongues of duck, partridge, and ostrich, the lamina propria, which contains mucous glands, lymphatic nodules, blood vessels, and nerve fibers, in addition to the core of paraglossum and related striated muscles are covered by epithelium. The lining epithelial cells of the ventral surface of the lingual rostral portion showed orthokeratinized and coated by many layers of cornified squamous epithelium including basal, intermediate, and keratinized layers forming the lingual nail (Fig. 5A, B, C). On the dorsum of the tongue, parakeratinized epithelial cells with the same three layers as the rest of the tongue were observed. There were non-keratinized stratified squamous epithelial cells lined both dorsal and ventral sides of the lingual root and certain regions on a lingual prominence, on the dorsal and ventral surfaces of the lingual root. The dorsal marginal epithelium is thicker than the ventral one. Beneath the surface epithelium of both dorsal and ventral surfaces of the lingual body, there was a dense irregular highly vascularized fibrous connective

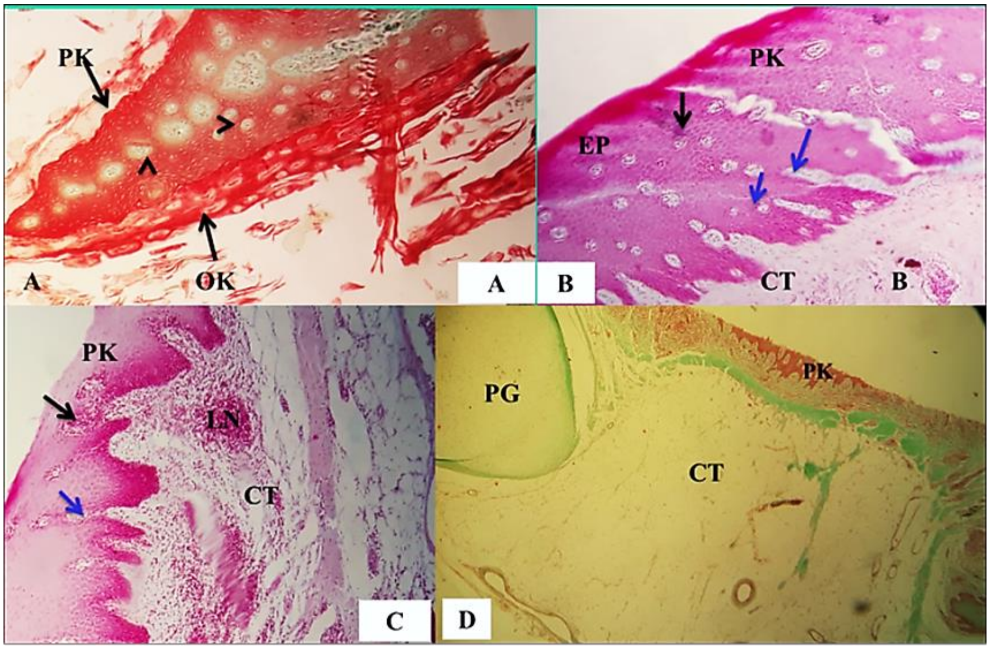

Fig.5A. The tip of the duck tongue, showing thick stratified squamous epithelium (EP), connective tissue (CT), parakeratinized layer (PK), taste buds (black arrowheads and black arrow), C.T papillae (blue arrowheads), hyaline cartilage (PG), lymphatic nodule (LN), orthokeratinized (OK) (A&D: Masson trichrome stain, X40; B&C: Combined alcian blue and PAS stain, X100).

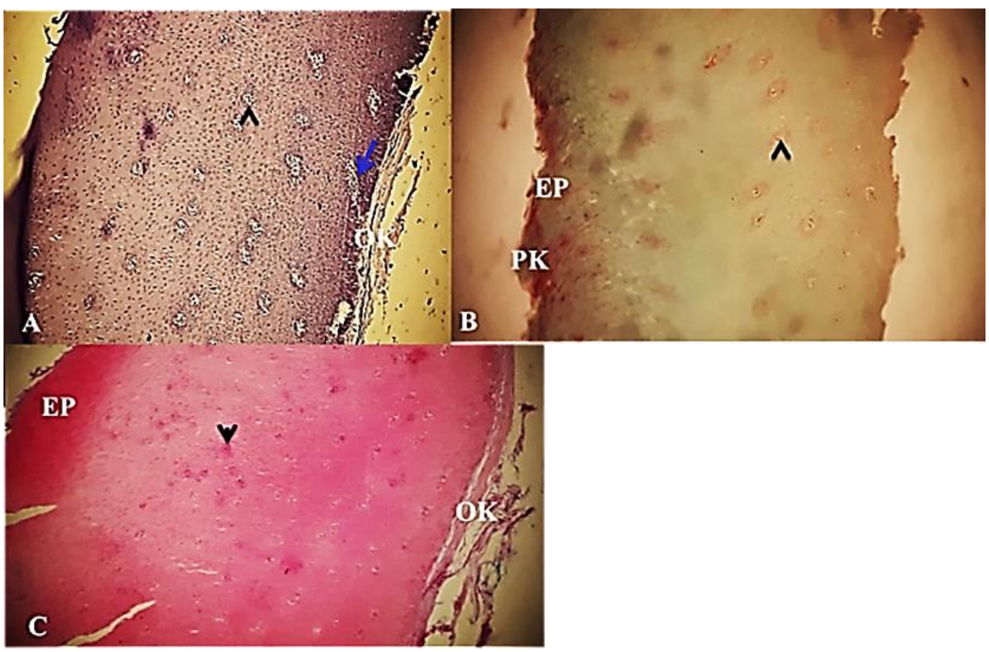

Fig.5B. The tongue tip of partidage reveals a thick stratified squamous epithelium. (EP), parakeratinized layer (PK), taste buds (Black arrowheads), C.T papillae (Blue arrowheads), ortho keratinized (OK) (A&B: H&E and Masson trichrome stain, X40; C: Combined alcian blue and PAS stain, X100).

tissue that penetrated the epithelial layers in the shape of papillary connective tissue. The lingual tip and ventral surface were free from any glandular structure except in ostrichs that have lingual salivary glands (Fig. 5A, B, C).

The lingual salivary glands were located at the lingual base and ventrolateral, respectively. The mucous glands were simple tubulo-alveolar. The cells of secretory units were represented as columnar cells with basally located nuclei (Fig. 5A, B, C). The

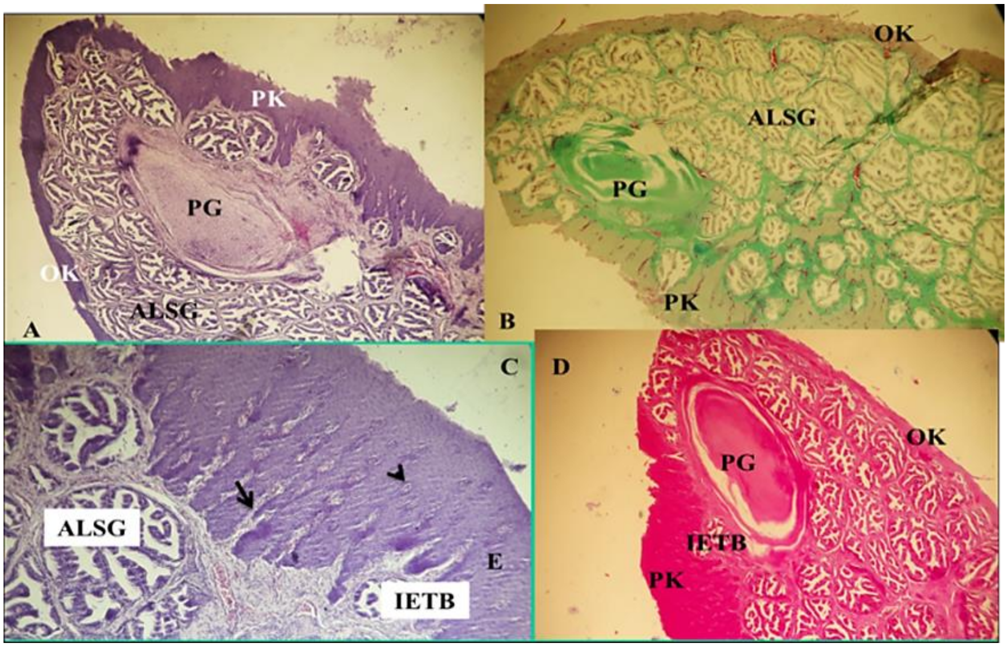

Fig.5C. The ostrich's tip of the tongue reveals a thick stratified squamous epithelium (EP), parakeratinized layer (PK), intraepithelial taste buds (black arrowheads and black arrow), orthokeratinized (OK) (A, B, and D: X40; C: X100) (H&E, Masson trichrome stain, Combined alcian blue and PAS stain).

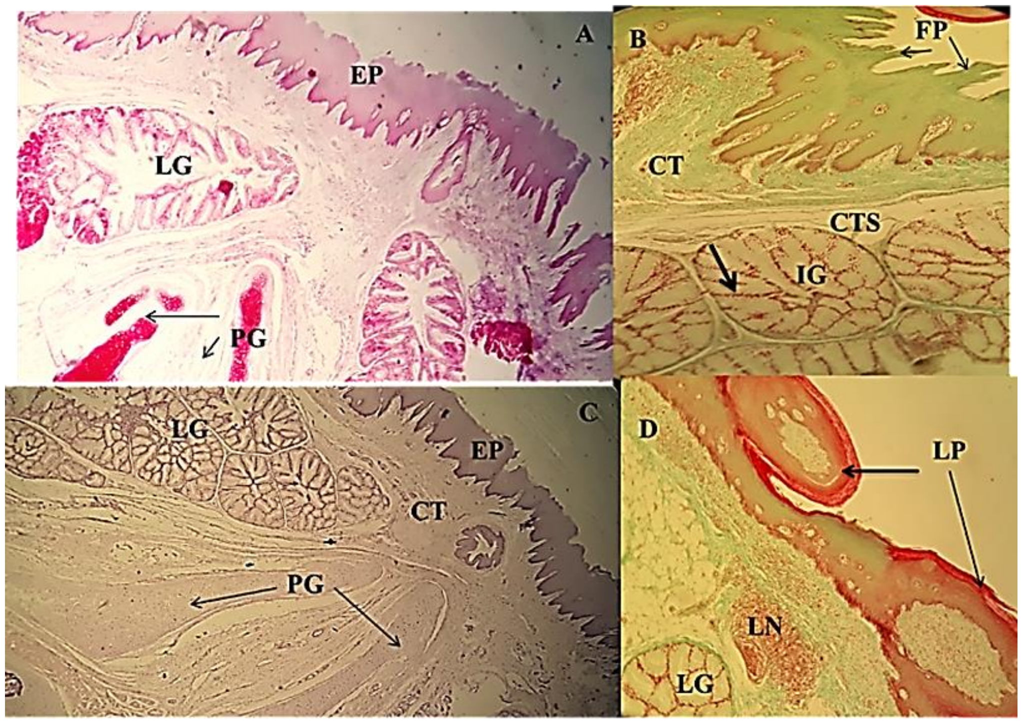

Fig.6A. The duck tongue base thick stratified squamous epithelium (EP), simple columnar epithelium lined lingual salivary gland (black arrow), lingual papillae (LP), hyaline cartilage (PG), connective tissue (CT), dense connective tissue sheath (CTS) (A and C: X40; B and D: X100; H&E, Masson trichrome stain, Combined alcian blue and PAS stain).

lingual salivary glands in the tongue frontal part were smaller than those of the caudal part. However, the mucin content of the anterior salivary glands exhibited variations following histochemical staining; the quantity of mucin in the medial group was higher than that of the lateral group (Fig. 6A, B, C). The posterior lingual glands are identical in appearance to the medial set in a portion near the base

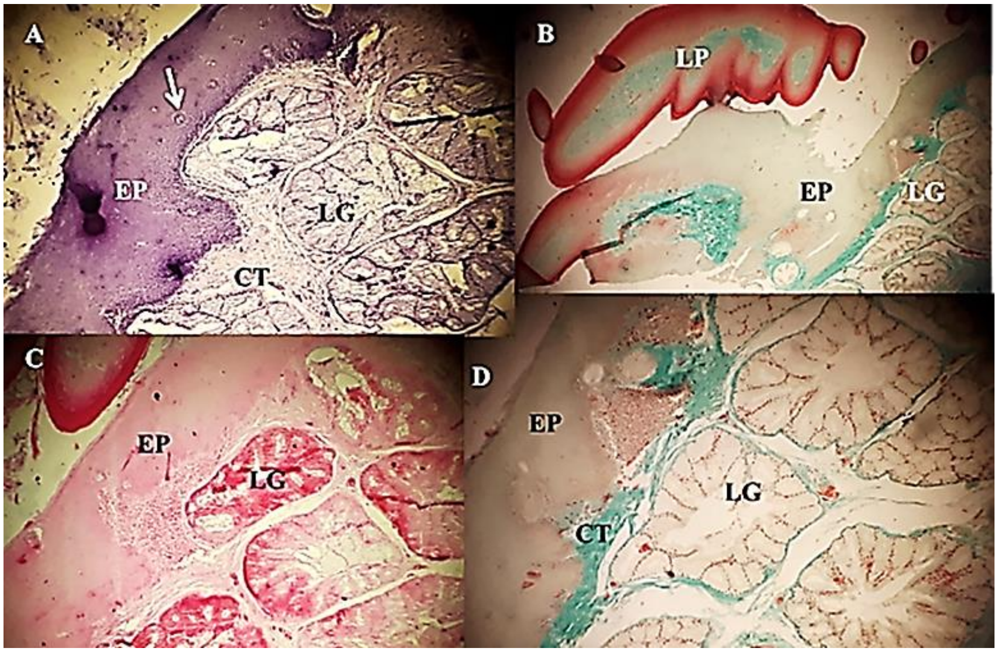

Fig.6B. The partidage tongue base thick stratified squamous epithelium (EP), lingual papillae (LP), connective tissue (CT), intraepithelial taste bud (white arrow) (A, B, C, and D: X40; H&E, Masson trichrome stain, Combined alcian blue and PAS stain).

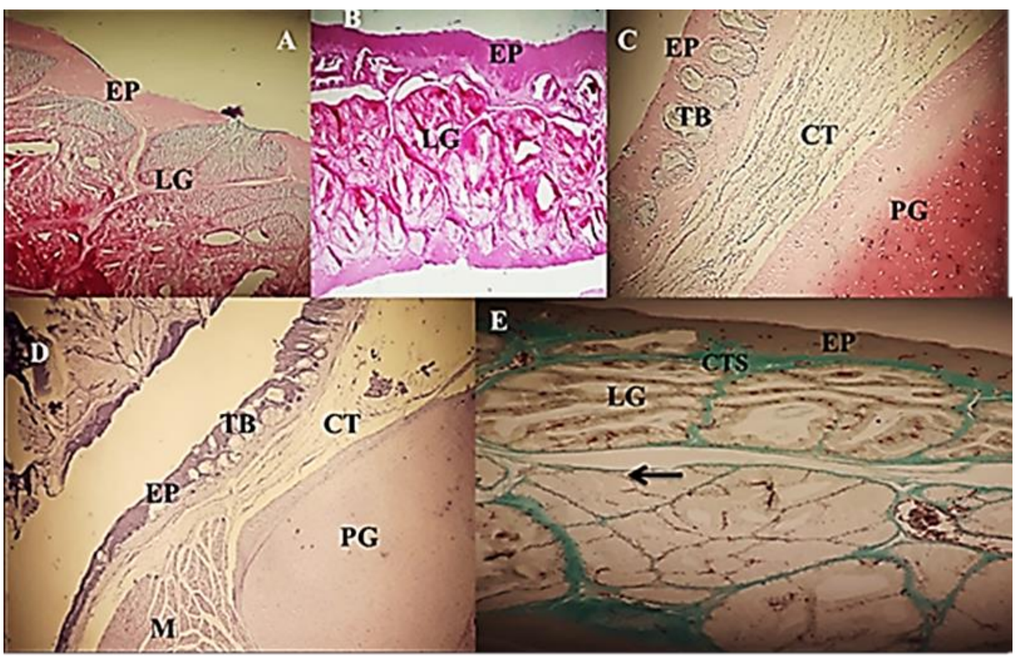

Fig.6C. The ostrich tongue base thick stratified squamous epithelium (EP), simple columnar epithelium lined lingual salivary gland (black arrow), hyaline cartilage (PG), connective tissue (CT), dense connective tissue sheath (CTS) (A, B, C, D and E: X100; H&E, Masson trichrome stain, Combined alcian blue and PAS stain).

of the tongue. Compared to the medial group of anterior lingual glands, the lateral group of anterior lingual glands responded to a moderate acid mucin reaction, whereas the medial group set did not. The anterior lingual glands were a collection of glands located in the lingual medial region. Mucin granules in the cytoplasm are present. The secretory cells were identified in both the posterior and anterior glands, while only one type of mucin was found in the lateral group.

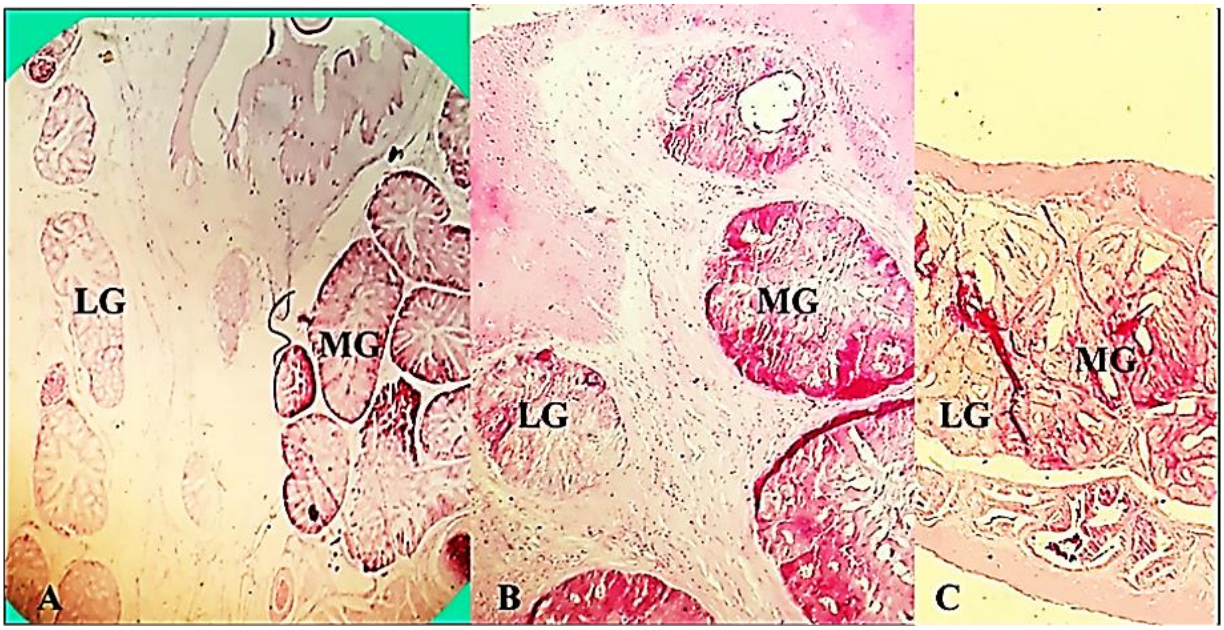

Fig.7. The duck, partridage, and ostrich tongue base (from left to right) as follows showing lateral glands group (LG) and medial gland group (MG) (A, B, and C: X100; Combined alcian blue and PAS stain).

Discussion

Gross morphology of the oral cavity: The results of the current study have similar results with previous studies' findings such as the absence of a soft palate, having a general oropharyngeal cavity, the hard palate acting as its roof which is directed via the choanal cleft followed by an infundibular slit, and the proximity of its floor occupied by the tongue. Our finding was in agreement with that of Hanna et al. (2011) on geese, Igweubike & Eze (2010) on crows, Dursun (2002) on fowls, Nickel et al. (1977) on fowls and pigeons, and McLelland (1968) in chickens. The tongue is composed of three parts; apex, body, and root. The torus linguae in the duck was a triangular broad ridge of mucous membrane with a caudally oriented base and two parallel curve rows of fine papillae marking its rostral sides. Torus linguae's caudal basal side was divided into two parts by a sulcus linguae, each one having caudally directed papillae. Hanna et al. (2011) showed the body of the tongue in a goose was ended by a lingual prominence. While Mally (2005) and McLelland (1990) pointed out that the tongue had fleshy caudal eminence; torus linguae in ducks, geese, and swans. McLelland (1968) noted that the terminal part of the tongue in ducks and geese contained a broad ridge of the mucous membrane while it was substituted by the caudal raised part in geese.

In our study, the tongues of ducks were long, meaty, thick, and completely filled the floor of the oral cavity. The tongue's apex was thin, smooth, and devoid of mechanical papillae. Hanna et al. (2011) described the goose tongue as a long narrow structure, while Igweubike & Eze (2010) described the African pied crow's tongue as arrow-shaped. In birds, Dyce et al. (2010) found the tongue had a triangular shape, whereas Catarina (2008) found that the ostrich tongue had a short, stubby, squat U-shaped structure with a blunt tip. Mally (2005) and McLelland (1990) noted that the tongues of ducks, geese, and swans were thick and meaty with rostral border transformed into a shovel, whereas the tongues of flamingos were piston-like. The tongue of the partidage was short, fleshy, and blunt. Nickel et al. (1977) showed the pigeon tongue was narrow, while it was broad and lancet-shaped in fowls. McLelland (1968) pointed out that the tongue's long free section was narrow at the rostral end in ducks, spatula-like with rounded rostral end in geese, and moderately hard triangular in chickens. The ventral surface of the tongue's body and oral cavity floor are where the frenulum lingua of the examined birds was insinuated. Similar results have been reported on the goose by Hanna et al. (2011), the pied crow by Igweubike & Eze (2010), the ostrich by Catarina (2008), the birds by Nickel et al. (1977), and the chicken by McLelland (1968). In the Current work, the tongue dorsum linguae was identified by a sound median sulcus that ran from its tip to its base. These results were in agreement with studies conducted on geese by Hanna et al. (2011), Egyptian geese by Hassan et al. (2010), and ducks, geese, and swans by Mally (2005) and McLelland (1990). However, Catarina (2008) found that the tongue's dorsal surface had a fold that had retracted to compose a large blind sac in ostriches.

Our results showed that in ducks, the margo linguae were bordered with big conical papillae, and between them, many small thread-like papillae are found mixed up with the bill lamellae of the palate. The present findings agreed with those reported by Hanna et al. (2010, 2011) for geese, Dyce et al. (2010) for ducks and geese, Mally (2005) and McLelland (1990) for ducks, geese, and swans, and McLelland (1968) for ducks.

Recent work revealed a ruga palatine mediana, also known as a median longitudinal ridge, was used to position the palate's mucous membrane. It is continued caudally to form four-based papillae after extending rostrally posterior to the firm keratin tip. According to Catarina (2008), the median palatine ridge, which separates the area into two portions is a prominent characteristic of the oropharynx in ostriches. Furthermore, the hard palate has a middle and two lateral palatine ridges, according to Nickel et al. (1977) in poultry and pigeon and McLelland (1968) in chicken. Additionally, the latter author noted that the rostral portion of the hard palate exhibited longitudinal median ridge in ducks and geese. Smooth rugae palatine laterales constituted the rostral portion of the ridge in the ducks. There was a row of long lamellae that were blade-shaped on a lateral border of the palate towards the ventromedial edge of the upper bill. The hard palate has middle and two lateral palatine ridges, in poultry and pigeon (Nickel et al. 1977) and in chicken (Mc Lelland 1968). The rostral portion of the hard palate exhibited a longitudinal median ridge in ducks and geese (McLelland 1968). Smooth rugae palatinae laterales form the rostral portion of the ridge in the ducks as reported in this study. There was a line or row of long lamellae that were blade-shaped on the lateral borders of the palate towards the ventromedial edge of the upper bill.

There was a line of prominent, thick lamellae rostrally oriented and gradually increased caudally reaching the ventromedial sides of the bill along the lateral edges of the palate. similar findings were reported by Nickel et al. (1977) on Lamellirostres and McLelland (1968) on ducks and geese. According to the findings, the choanal cleft in the studied birds was divided into long, wide caudal, and short, narrow rostral parts. The infundibular slit, a tiny opening connecting the two auditory tubes, was caudal to the preceding cleft and coated the mucous membrane of the cleft's borders in multiple irregular rows of caudally oriented papillae.

These remarks may be related to those mentioned in duck and goose by McLelland (1968). A longitudinal fissure that was separated into a thin rostral and an expanded caudal region agreed with the findings of Igweubike & Eze (2010) on pied crow, which was present in partridge's midline of the hard plate. The mucous membrane of the hard palate exhibited many papillae caudally oriented which were prominent at the palatine ridges and at the edges of an enlarged part of the choanal slit. According to Dyce et al. (2010), the palate of avis had a lengthy median choanal cleft that linked with the nasal cavity. Furthermore, according to Catarina (2008), the oropharynx of the ostrich has an inverted V-shaped depressed choana that is surrounded on the caudal side as a shallow crescent that delineates the median infundibular cleft. McLelland (1968) in chicken recorded the roof of the oral cavity also had papillae oriented caudally and were grouped on transverse rows, according to McLelland (1968) in a study on chickens. Two rows are positioned rostral to the choanal slit, pair rows at either side and two rows in between. There was a thin median longitudinal infundibular slit that split the pharynx's roof.

In the present study, birds' tongues were modified in accordance based on the type of their feeding (Pasand et al. 2010). Conical papillae were placed in a transverse row along the cell length. On the midline between the body and the base of the tongue where the tongue is located, these papillae are limited in duck and partridge (Iwasaki et al. 1997; Hassan et al. 2010). In the ostrich tongue, there were no papillae (Pasand et al. 2010). According to Emura et al. (2008), the caudal orientation of the papillae helps with food obtaining and swallowing. The pharyngeal papillae occur in two rows in the studied birds in the current work (Iwasaki & Kobayashi 1986) in chicken. However, it was just one row in the hue of jungle fowl's linguae (Khalid et al. 2011), this was the lingual shape in duck and partridge however, it is characterized by para keratinization of conical papillae and lingual ventrolateral side. It is coated by para-keratinized stratified squamous epithelial cells. The keratinization of lingual epithelium is mostly in birds that eat plants, such as herbivorous and granivorous birds, which have been shown to be highly cornified (Jackowiak & Ludwing 2008). A lower degree of keratinization occurs in birds that live in aquatic environments (Iwasaki 2002; Jackowiak et al. 2006). Although, the lingual glands were placed differently in the ostrich, where the salivary glands in the tongue were found on both dorsal and ventrallingual sides. However, the ostrich's lingual gland seems to be accurately located, while the ostrich's lingual gland appears to be inaccurately located (Pasand et al. 2010). The salivary glands on the tongue secreted mostly mucus. According to Rossi et al. (2005) in partridge, our finding was consistent with their findings. By contrast, cormorants' tongues lack lingual salivary glands (Jackowiak et al. 2006).

In the present work, there were no histological differences between both medial and lateral groups of anterior lingual salivary glands, in spite of the fact that similar differences have been noted before in some bird species. As shown in jungle chicken (Khalid et al. 2011), both anterior and posterior lingual glands exhibit considerable variation. Since the lateral group was situated more superficially, it perhaps subjected to more external pressure than the medial group, and therefore the former group may have altered in response to this influencing factor. As a consequence, mucous granules identified at the rear of the mouth have a neutral mucin content, comparable to the tongue of the tiny egret (Al-Mansour & Jarrar 2007). The anterior lingual glands' lateral group contains mostly neutral mucin, but the medial group and posterior lingual glands contain neutral and weak acid mucin. The present findings were consistent with those discovered in chickens (Suprasert & Fujioka 1987). Olmedo et al. (2000) showed significant variations in substructure within the same acinus and cell of the avian tongue.

The anterior lingual gland's medial group is unlikely to have acid mucin, while the posterior gland has moderate acid mucin containing both sulphated and corboxylated groups. These results agreed with those of Gargiulo et al. (1991) on chickens and Al-Mansour & Jarrar (2007) on tiny egrets. In addition to acting as a food lubricant to ease swallowing, neutral mucin also helps to keep the body hydrated by creating an environment that is hydrophilic. In addition, the acid mucin has a function in modulating calcium channel activity in the oral cavity (Slomiany et al. 1996). Based on the results of the current work, the unique characteristics of duck and partridge tongues were a lingual conical papillae arrangement and the presence of laryngeal papillae in two rows, while in ostrich the papillae were absent. Furthermore, there were different histochemical reactions of salivary gland components. However, there were no gender differences were observed in the current study.

Conclusions

The morphology and histology of the anterior and posterior lingual glands were examined in ducks, partidages, and ostriches. The lateral and medial zones in the anterior lingual glands were distinguished and each has its own morphological and tectorial characteristics. Secretory cells were mucous cells. The results of the current work showed that the tongue had distinct characteristics such as a lingual nail and mechanical papillae coated by an orthokeratinized and para keratinized epithelium and they were specialized for pecking, filtration, and transportation of foods to the esophagus and preventing food waste from the oral cavity.

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