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ORIGINAL ARTICLE

Gross Morphology and Scanning Electron Microscopic Structure of the Oropharyngeal Cavity of the Domestic Geese (*Anser anser domesticus*)

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Abstract
This study aimed to provide a full morphological description of the oropharyngeal cavity in the domestic geese with gross examination, morphometric analysis and scanning electron microscopy. Eight heads of adult healthy geese were used in this study. The oropharyngeal roof had a large rostral part with five palatine ridges; one median, two paramedian and two lateral longitudinal rows of blunt tubercles bounded laterally by transverse horny lamellae of the beak. The caudal papillary region exhibited choanal and infundibular clefts, surrounded by caudally directed conical papillae. In floor, an elongated tongue had a rounded apex with lingual nail and carried filiform papillae on its lateral edges. Each side of the lingual body carried 9 small conical papillae on the anterior part and 6 giant conical papillae on middle and posterior parts. These conical papillae were distributed among the filiform and hair-like papillae. The Posterior part of lingual body was thickened forming the lingual prominence with a transverse row of caudally directed 8-10 conical papillae forming a papillary crest. Lingual root consisted of a triangular surface surrounded by spinated borders. Caudally, an ovoid laryngeal mound with glottis is located in the pharyngeal floor, with conical papillae on its borders and transverse rows of large-sized pharyngeal papillae arranged linearly as 4-5 papillae on posterior part of the laryngeal mound. Openings of the salivary glands were observed in their corresponding region. In conclusion, the morphological characteristics of the oropharyngeal structures in geese confirmed their adaptation to the feeding habits and type of available food particles.

Keywords Anatomy; Domestic geese; Oropharyngeal cavity; Scanning Electron Microscopy (SEM); Tongue

1. Introduction
The domestic geese (*Anser anser domesticus*) are medium-sized birds that belong phylogenetically to subfamily Anserinae of Anatidae family (geese and ducks) in Anseriformes order of the class Aves **(Baumel et al. 1993; Hugo 2002).** There are about 96 breeds of domestic geese recognized around the world and it is thought that the geese were domesticated in Egypt about 3000 years ago or earlier **(Hugo 2002).** Commercially since ancient times, geese are bred for their meat, eggs, down and feathers.

In birds, due to the lack of the soft palate and glossopalatine folds, a combined cavity of the mouth and pharynx is referred to as the oropharynx that extends from the anterior tip of the beaks to the esophagus **(Konig et al. 2016).** Studying the morphology of the avian oropharyngeal cavity is essential for understanding the different structural adaptive mechanisms associated with food and water intake **(El-Said and El-Bakary 2015).** Therefore, many researchers are interested in the investigation of the structure of such particular region in many avian species to demonstrate its characteristic morphology-ical and functional features and their correlation with the surrounding natural environmental conditions and the various feeding habits **(Igwebuike and Eze 2010; Tivane et al. 2011; Igwebuike and Anagor 2013; Moussa and Hassan 2013; Ragab et al. 2014; Jayachitra et al. 2015; Gupta et al. 2018; Gewaily and Abumandour 2021).**

Based on the available published morphological studies about the investigation of the avian oropharynx, most of these studies focused on the tongue and its anatomical adaptation to the feeding habits such as food manipulation, filtering the food particles, and drinking of water **(Iwasaki et al. 1997; Rossi et al. 2005; Crole and Soley 2009; Hassan et al 2010; Jackowiak et al. 2011; Erdogan and Iwasaki 2014; Skieresz-Szewczyk and Jackowiak 2016; Ertas and Erdogan 2019; Abumandour and Kandyel 2020).** While few published researches described the morphological and adaptive structures of the laryngeal region or the palate depending on the birds' feeding lifestyle **(Santos et al. 2011; Erdogan and Alan 2012; Erdogan and Perez 2015; Abumandour and Gewaily 2019).**

Generally, there are scanty available data describe the characteristic morphology of the oropharyngeal cavity in different geese species except for the studies of **Hassan et al. (2010),** and **Khalaf and Ahmed (2020)** in the Egyptian geese, and **Jackowiak et al. (2011)** in the domestic geese. However their descriptions was limited on the morphological features of the pharyngeal roof and the tongue in these species. Therefore, the current study aimed to represent a full morphological description of the oropharynx including the palate, tongue, pharynx, and laryngeal prominence of the domestic geese (*Anser anser domesticus*) based on the macroscopic inspection, morphometric analysis, and scanning electron microscopic investigation to explain their structure and functional correlation throughout the feeding process in comparison with the available literature about the investigated region in different avian species.

2. Materials and Methods

2.1. Birds

A total number of eight adult domestic geese (*Anser anser domesticus*) of both sexes, weighing about 2.5 - 3.5 kg were used to conduct this study. The geese were purchased from local markets at Beni-Suef governorate, Egypt.

2.2. Gross morphological and morphometric examination

The head region of birds (n=8) was carefully inspected to exclude any abnormalities or injuries within the oral cavity and pharynx. The heads were collected immediately after slaughtering and the oropharynx was thoroughly washed with normal saline. Each head was carefully incised along the angle of the beak to expose different regions of the oropharyngeal cavity and photographic document-ation of the investigated macroscopic structures was done using a digital camera (Nikon Coolpix B500- 12 Megapixel). Morphometric measurements of different parts of the oropharyngeal cavity were obtained using a Vernier caliper and are presented in **Table (1)** as mean ± standard deviation (SD). Nomina Anatomica Avium (NAV) was used to adopt the nomenclatures in this study **(Baumel et al. 1993).**

2.3. Scanning electron microscopic investigation

Dissected head specimens (n=4) were used for scanning electron microscopy (SEM). The specimens were fixed in Glutaraldehyde solution (3%) in phosphate buffer at pH 7.2–7.4, post-fixed with osmium tetroxide (1%) in 0.1 M sodium cacodylate buffer at pH 7.2 at 4°C for 1h. Thereafter, graded series of ethanol was used to dehydrate the specimens, and the critical point dried with carbon dioxide. Then the specimens were covered with colloidal carbon tabs and attached with aluminum stubs facing upwards with sputtered gold-palladium over the specimens. A JEOL/EO-JSM-6510 LV SEM device was used to photograph the examined specimens at the unit of the electron microscopy, Faculty of Science, Beni-Suef University, Egypt.

3. Results

Gross examination of the head region of the domestic geese (*Anser anser domesticus*) revealed that there was no definite separation of the oral cavity and pharynx due to the absence of the glossopalatine folds and soft palate, producing a common oropharyngeal cavity consisted of a roof and floor **(Fig. 1).**

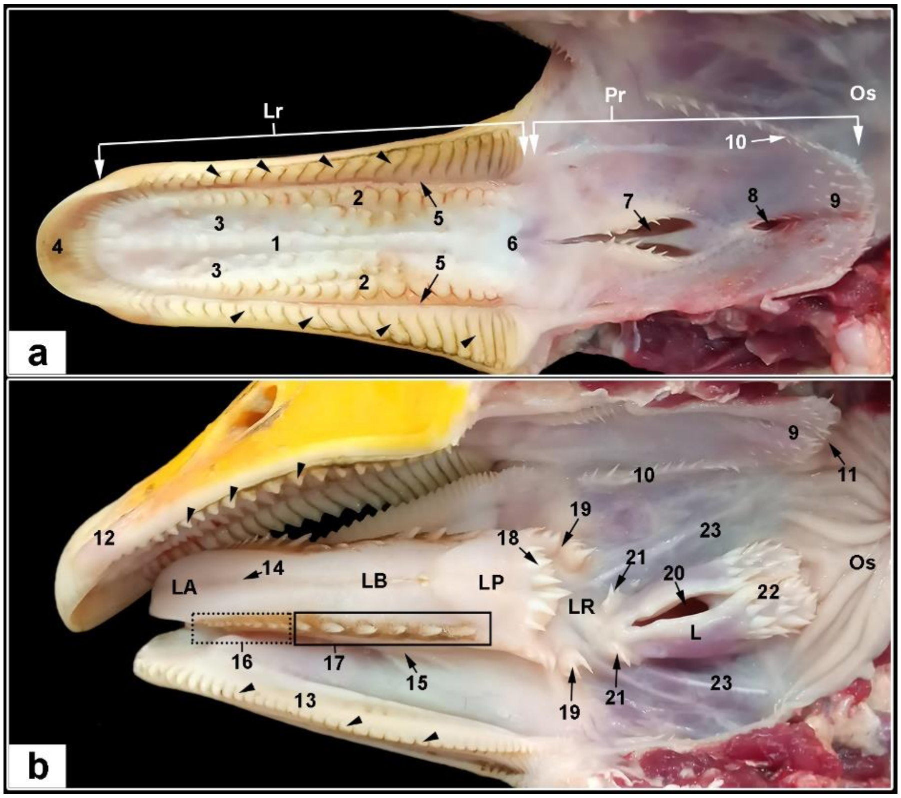

Fig 1. Macroscopic surface structures of the roof **(a)** and floor **(b)** of the oral cavity and pharynx of the Egyptian goose (opened and reflected) showing the lingual apex **(LA),** lingual body**(LB),** lingual root **(LR),** lingual prominence **(LP),** laryngeal prominence **(L),** esophagus **(Os),** lamellar region of the palate **(Lr),** papillary region of the palate **(Pr),** median longitudinal palatine ridge **(1),** two lateral longitudinal ridges formed by rows of rounded blunt tubercles **(2),** two paramedian longitudinal ridges at the middle third **(3),** premaxillary plate of the upper beaks **(4),** lateral longitudinal palatine grooves **(5)**; transverse ridge between the lamellar and papillary parts of the roof **(6),** the transversely oriented horny lamellae on the upper and lower beaks lateral edges **(arrowheads),** choanal cleft surrounded by the caudally directed papillae on its edges **(7),** infundibular cleft **(8),** caudally directed pharyngeal conical papillae **(9),** papillary rows **(10),** pharyngo-esophageal junction **(11),** upper beak **(12),** lower beak **(13),** median lingual groove **(14),** lingual frenulum **(15),** spiny keratinized bristles (papillae) arranged as nine small conical papillae at the anterior edge of the tongue **(16),** and six giant conical papillae at the middle edge of the lingual body **(17),** caudally directed conical papillae of the lingual prominence arranged as a transverse papillary row **(18),** elevation of the lingual root mucosa with 3 - 4 cone-shaped papillae, spinated border **(19),** aditus laryngis, or glottis **(20),** transverse fold with conical papillae between the laryngeal prominence and the lingual root **(21),** caudally directed transverse rows of the pharyngeal papillae on the caudal aspect of the laryngeal prominence **(22),** floor of the pharynx **(23)**

3.1. Roof of the oropharynx

The roof of the oropharyngeal cavity in the domestic geese was divided according to the existence of the papillae into two large regions: a rostral lamellar (Fig. 1a/Lr) and a caudal papillary (Fig. 1a/Pr). These two parts were markedly separated by a clear transverse elevated mucosal fold (Fig. 2b/1).

The large rostral lamellar part (Fig. 2a/Lr) was devoid of papillae and characterized grossly by the presence of five palatine ridges arranged longitudinally as one median, two paramedian, and two lateral palatine ridges. The rostral part of the median palatine ridge (Fig. 2a/9) had numerous transverse mucosal folds, while caudally it faded near the transverse mucosal fold. The paramedian ridges were incomplete and formed of small rounded tubercles in the middle third of the lamellar region (Fig. 2a/10) and separated from the median ridge by shallow grooves. Each of the lateral longitudinal ridges (Fig. 2a/4) consisted of a longitudinal row of rounded tubercles which decreased in size rostrally and consisted of two rows in the middle third of the lamellar region. Moreover, these two lateral longitudinal ridges were separated by deep longitudinal grooves (Fig. 2a/5) from the transverse horny lamellae of the upper beak (Fig. 2a/3).

By SEM examination, the lateral edges of the upper beak had transversely arranged rectangular horny lamellae (Fig. 2c,d/3) separated from each other by clear transverse grooves (Fig. 2d,e/6) and had an irregular surface with several layers of the cornified epithelium (Fig. 2e/7). The rounded blunt tubercles of the lateral longitudinal ridges are surrounded by intertubercular transverse horny plates (Fig. 2f/8) and separated by a bilateral longitudinal groove from the horny lamellae of the beak. Moreover, the anterior part of the upper beak contained a row of transverse lamellar ridges along its length and the horny premaxillary plate of the beak showed few openings of the horny tubules over its tip curvature (Fig. 2h).

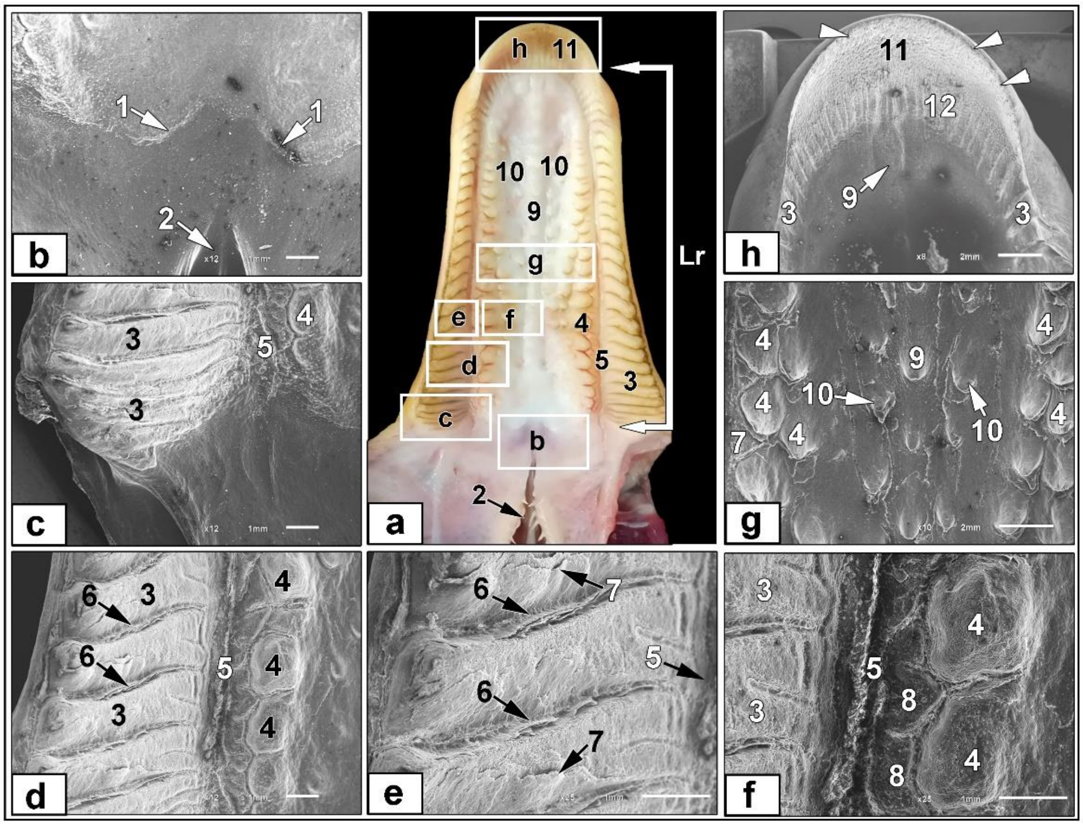

Fig 2. Gross image **(a)** and scanning electron microscopic micrographs **(b, c, d, e, f, g, h)** showing the lamellar region **(Lr)** of the oropharyngeal roof of the Egyptian goose. Gross image highlighted with white rectangles and corresponding letters of the SEM figures to show the examined area with SEM. **View (b)** Lamellar part of the oropharyngeal roof separated from the papillary region by a transverse elevated mucosal fold **(1)** rostral to the narrow area of the choanal cleft **(2)**. **View (c)** a transverse row of horny lamellae **(3)** and a lateral longitudinal row of rounded tubercles **(4)** separated by a longitudinal groove **(5). View (d)** horny lamellae of the upper beak separated by transverse grooves **(6). View (e)** a higher magnification of the horny lamellae showing multiple layers of the cornified epithelium **(7). View (f)** a higher magnification showing the lateral tubercles **(4)** surrounded by intertubercular transverse horny plates **(8). View (g)** at the middle third of the lamellar region showing five longitudinal rows of rounded blunt tubercles; the lateral palatine ridges **(4),** a median palatine ridge **(9),** two paramedian palatine ridges **(10). View (h)** inner side of the horny premaxillary plate distal rim of the upper beak **(11)**, small openings of the horny tubules **(arrowheads)** along the anterior curvature and the rostral tip of the upper beak included transverse lamellar ridges **(12).**

The papillary region of the oropharyngeal roof (Fig. 3) exhibited two median openings surrounded by numerous caudally directed conical papillae. These two openings were arranged longitudinally as the long choanal cleft (connected the oropharynx with the right and left nasal cavities) and the short infundibular cleft (connected the pharynx with the middle ear). The length of the rostrally located choanal cleft was about 16.38 ± 1.41 mm and its width was about 3.5 ± 0.53 mm. The infundibular cleft is located just caudal to the choanal cleft and measured about 8.13 ± 0.83 mm in length.

Using the SEM investigations, a median ridge (Fig. 3c,d/4) was found in the midline of the choanal cleft. The cleft consisted of two parts; a narrow rostral part (Fig. 3b/1) and a wide caudal part (Fig. 3c/3). Few small conical papillae directed backward were found on the edges of the narrow part (Fig. 3b/2). Furthermore, large conical papillae with pointed processes (Fig. 3b,c,e/2) were distributed caudally on the edges of the choanal and infundibular clefts. Some of these conical papillae were regularly arranged as papillary rows on the lateral sides of the papillary region (Fig. 3d,e,f/6) and other conical papillae (Fig. 3f/8) were randomly distributed on the caudal edges of the infundibular cleft. Employing a higher magnification, longitudinal folds of the mucosal surface were distinguished around the choanal and infundibular clefts (Fig. 3g,h/9) with numerous micropores represented the openings of the sphenopterygoid salivary glands (Fig. 3g,h/10) filled with the gland secretion (Fig. 3g,h/M).

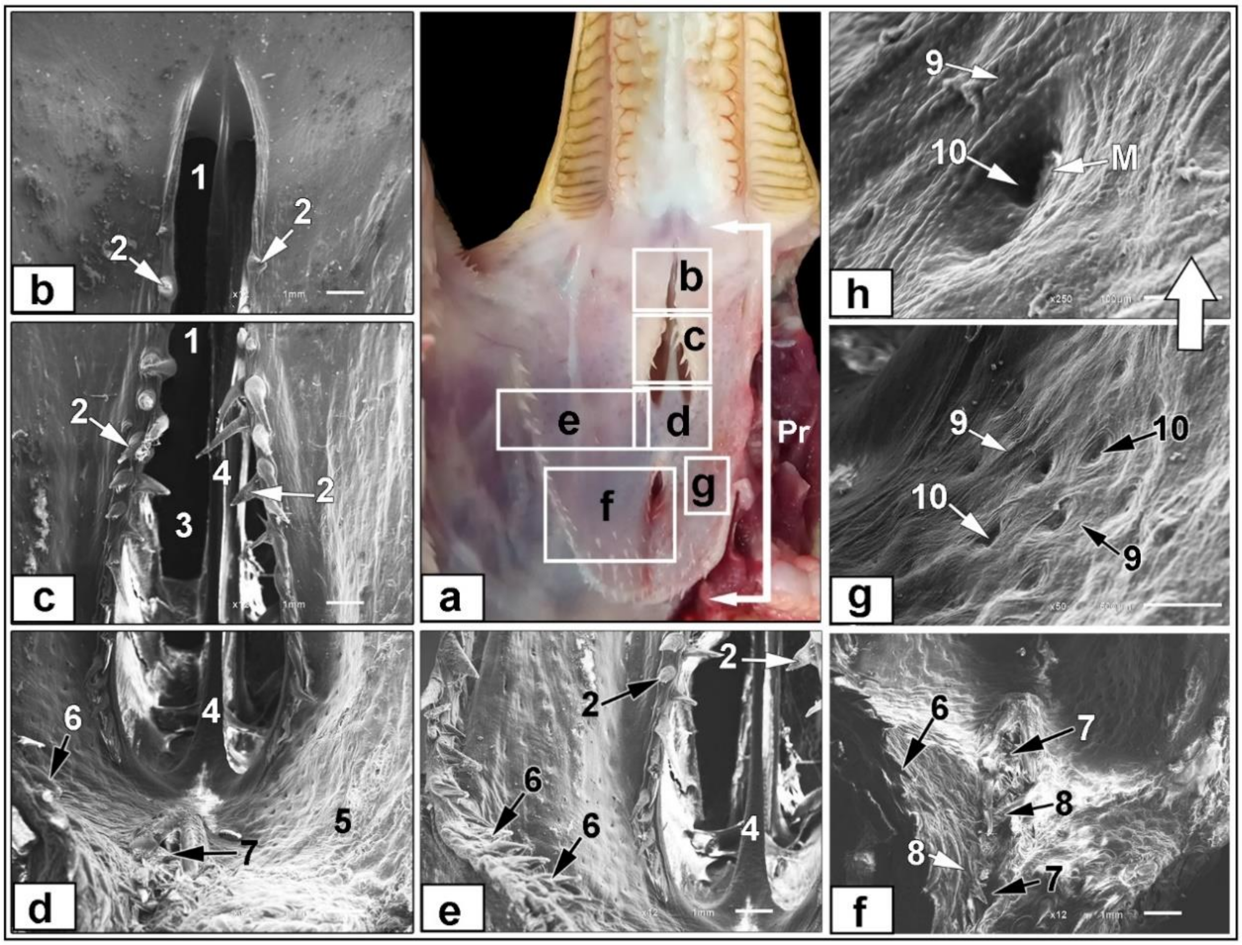

Fig 3. Gross image **(a)** and scanning electron microscopic micrographs **(b, c, d, e, f, g, h)** showing the papillary region **(Pr)** of the oropharyngeal roof of the Egyptian goose. Gross image highlighted with white rectangles and corresponding letters of the SEM figures to show the examined areas with SEM. **View (b)** the narrow rostral part of the choanal slit **(1)** with conical papillae **(2)** at its caudal part. **View (c)** the wide caudal part of the choanal cleft **(3)** surrounded by the conical papillae **(2). Views (d, e)** the median ridge **(4),** the wall of the pharynx **(5),** papillary row **(6),** and infundibular cleft **(7). View (f)** the infundibular cleft surrounded with irregularly distributed, caudally directed conical papillae **(8). Views (g, h)** a higher magnification of the mucosal surface around the choanal and infundibular clefts with longitudinal mucosal folds **(9),** and openings of the salivary glands **(10)** filled with gland secretion **(M).**

Table 1. Average measurements of the investigated anatomical structures in the oral cavity and pharynx (mm)

	Mean ± SD (mm)		Mean ± SD (mm)
Length of the whole tongue	56.38 ± 2.26	Thickness of the tongue root	8 ± 1.07
Length of the tongue apex	13.13±1.25	Length of the laryngeal mound	25 ± 1.85
Length of the tongue body	30.88±1.96	Width of the laryngeal mound	12.69 ± 1.14
Length of the tongue root	14.25 ± 1.28	Length of the glottis	13.38 ± 0.74
Width of the tongue apex	11.88 ± 0.99	Width of the glottis	4.38 ± 0.74
Width of the tongue body	13.25 ± 0.89	Length of the choanal cleft	16.38 ± 1.41
Width of the tongue root	17.13 ± 1.46	Width of the choanal cleft	3.5 ± 0.53
Thickness of the tongue apex	5 ± 0.76	Length of the infundibular cleft	8.13 ± 0.83
Thickness of the tongue body	7.88 ± 1.13		

3.2. Floor of the oropharynx

The rostral part of the oropharyngeal cavity floor was occupied by the tongue, while the caudal part had an elevated structure of the laryngeal mound with its midline entrance (glottis).

3.2.1. Tongue

In the domestic goose, the tongue was narrow and elongated (Fig. 1b). Its total length averaged about 56.38 ± 2.26 mm, of which the apex was about 13.13 ± 1.25 mm in length, the body with the lingual prominence was about 30.88 ± 1.96 mm in length, and the root was about 14.25 ± 1.28 mm in length. The average width of the tongue was 11.88 ± 0.99 mm on the apex, 13.25 ± 0.89 mm on the body, and 17.13 ± 1.46 mm on the lingual root. This non-protrusible elongated flat tongue conformed to the shape of the lower beak. Grossly, at the level of the anterior part of the lingual prominence, there was a short lingual frenulum attached the tongue to the floor of the oral cavity. The tongue was clearly distinguished into three regions: the lingual apex (anterior part), the lingual body (middle part), and the lingual root (caudal part). Lateral edges of the tongue were lined with spiny keratinized bristles (papillae) that were directed towards the pharynx (Fig. 1b).

The SEM examination of the free anterior area of the lower beak revealed transverse horny lamellae on both sides, and rows of horny tubule openings along the anterior curvatures of the horny bill tip (Fig. 4b). Moreover, the lingual apex terminated anteriorly by a rounded tip with a flat rounded lingual nail (Fig. 4c/Ln). The smooth dorsal surface of the lingual apex had no lingual papillae, but numerous extensive large filiform papillae on its lateral sides (Fig. 4c). By a higher magnification, stratification of the surface epithelium with numerous exfoliated superficial cells was observed on the dorsal surface of the apex of the tongue, with numerous micropores represented the openings of the anterior lingual salivary glands with mucous secretion (Fig. 4c1).

The SEM observation of the lingual body showed a shallow median lingual groove bounded with few hair-like papillae and conical papillae on the middle part of the dorsal surface of the body of the tongue (Fig. 4c,d,e). At the anterior part, nine small conical papillae were easily detected on each side with pointed processes directed laterally and slightly backward (Fig. 4c,d). While in the middle and posterior parts of the lingual body, six giant conical papillae were obvious on each side with caudally pointed processes (Fig. 4d,e). On lateral sides of the lingual body, dense filiform and hair-like papillae with twisted processes were distributed among the small and giant conical papillae (Fig. 4d1,e1). Moreover, the caudal third of the tongue was thickened forming an elevated triangular area termed the lingual prominence (torus linguae) (Fig. 4e,f/LP). This prominence had few conical papillae forming its apex. While its base contained 8-10 mechanical conical papillae created the caudally convex semicircular papillary crest, and the pointed processes of the conical papillae slightly overlapped over the rostral part of the lingual root (Fig. 4f,g). These conical papillae were distributed as a single row in all examined specimens.

The SEM observation of the lingual root showed that it consisted of a smooth middle triangular area surrounded by spinated lateral and caudal parts (Fig. 4f/S). Two lateral elevations of the lingual mucosa marked the smooth triangular area. Each of these elevations was formed of 3-4 cone-shaped papillae protruded from a basal part (Fig. 4g/arrows). The lingual root connected caudally with the laryngeal entrance. By a higher magnification of the lingual root, its mucosal surface showed irregular longitudinal folds with micro-ridges and micropores represented the openings of the posterior salivary glands of the tongue (Fig. 4g1).

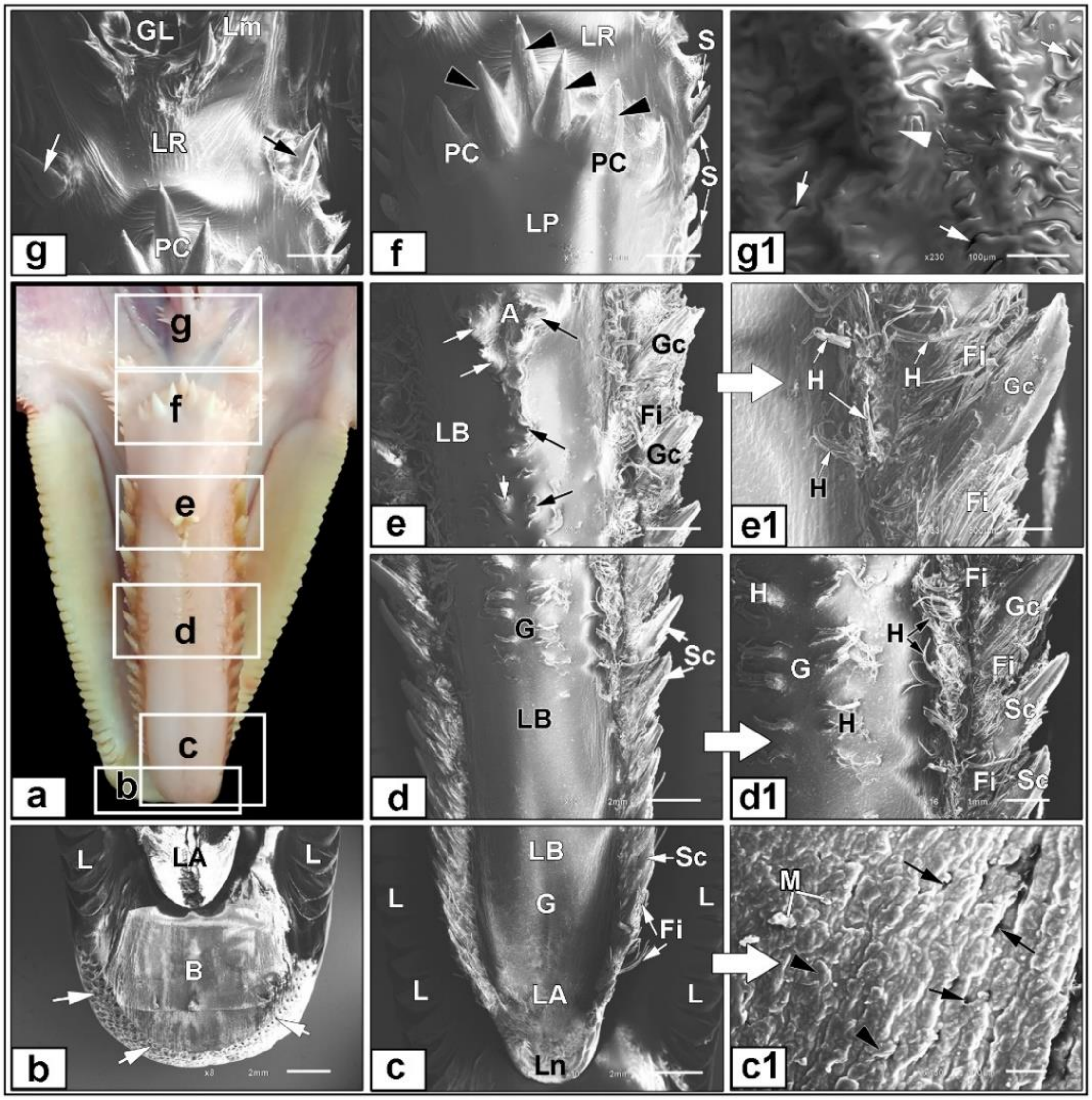

Fig 4. Gross image **(a)** and scanning electron microscopic micrographs **(b, c, c1, d, d1, e, e1, f, g, g1)** showing the tongue within the rostral part of the lower beak of the Egyptian goose. **(a)** Gross image highlighted with white rectangles and corresponding letters of the SEM figures to show the examined areas with SEM. **View (b)** lingual apex **(LA)** leaves a free anterior area of the lower beak **(B),** transversely oriented lamellae **(L)** on sides of the lower beak, and rows of the horny tubule openings **(arrows)** on the anterior rim of the rounded horny bill tip**. View (c)** dorsal surface of the lingual apex **(LA)** and lingual body **(LB)** showed a shallow median lingual groove **(G)** and a flat rounded tip of the lingual apex forming the lingual nail (**Ln)** with laterally distributed filiform papillae **(Fi),** small conical papillae **(Sc),** and the transversely oriented lamellae **(L)** of the lower beak. **View (c1)** a higher magnification of the dorsal surface of the lingual apex and body showing stratification of the surface epithelium with numerous exfoliated superficial cells **(arrowheads)** with numerous micropores represented the openings of the anterior lingual salivary glands **(arrows)** and mucous secretion **(M)**. **Views (d, d1, e, e1)** lingual body **(LB)** with a shallow median lingual groove **(G)** bordered with longitudinal rows of hair-like papillae **(H)** and conical papillae **(arrows)** on its dorsal surface and the lateral edges, there is a row of horny small conical papillae **(Sc)** and giant conical papillae **(Gc)** distributed between the filiform papillae **(Fi)** and hair-like papillae **(H),** the apex of the lingual prominence **(A)** could be identified with few conical papillae. **View (f)** lingual prominence **(LP)** showing a single row of the papillary crest **(PC)** with large conical papillae **(arrowheads)** directed backward toward the lingual root **(LR),** the lateral spinated border of the lingual prominence presented laterally directed spines **(S). View (g)** lingual root **(LR)** behind the papillary crest **(PC)** of the lingual prominence and rostral to the laryngeal mound **(Lm)** and glottis **(GL),** elevated mucosal folds with 4-5 conical papillae **(arrows)** on sides of the lingual root. **View (g1)** a higher magnification of the dorsal surface of the lingual root showing irregular longitudinal mucosal folds **(arrowheads)** with micro-ridges and micropores represented the openings of the salivary glands **(arrows).**

3.2.2. Laryngeal prominence and laryngeal entrance

Grossly, the laryngeal prominence (mound) measured about 25 ± 1.85 mm in length 12.69 ± 1.14 mm in width and appeared as an elevated ovoid structure in the floor of the oropharynx just caudal to the lingual root (Fig. 1b). A longitudinally oriented slit-like laryngeal opening or glottis measured about 13.38 ± 0.74 mm in length and 4.38 ± 0.74 mm in width and located in the midline of the laryngeal mound. The glottic opening was not guarded by the epiglottis or any valves and connected the pharyngeal cavity to the tracheal tube.

By SEM investigation, the glottic opening appeared as an ovoid-shaped, narrow rostrally, and wide caudally (Fig. 5b,c/2). Its anterior part was bounded by elevated mucosal folds of the lingual root with small conical papillae (Fig. 5b/4). Small-sized caudally directed conical papillae with pointed processes were distributed on the edges of the glottic opening (Fig. 5c,d,f/5). Just caudal to this opening, the posterior part of the laryngeal mound contained transverse rows of large-sized pharyngeal papillae arranged linearly as 4-5 papillae on each side and directed back toward the esophagus (Fig. 5d,e/6). These papillae separated the pharyngeal cavity from the beginning of the esophagus.

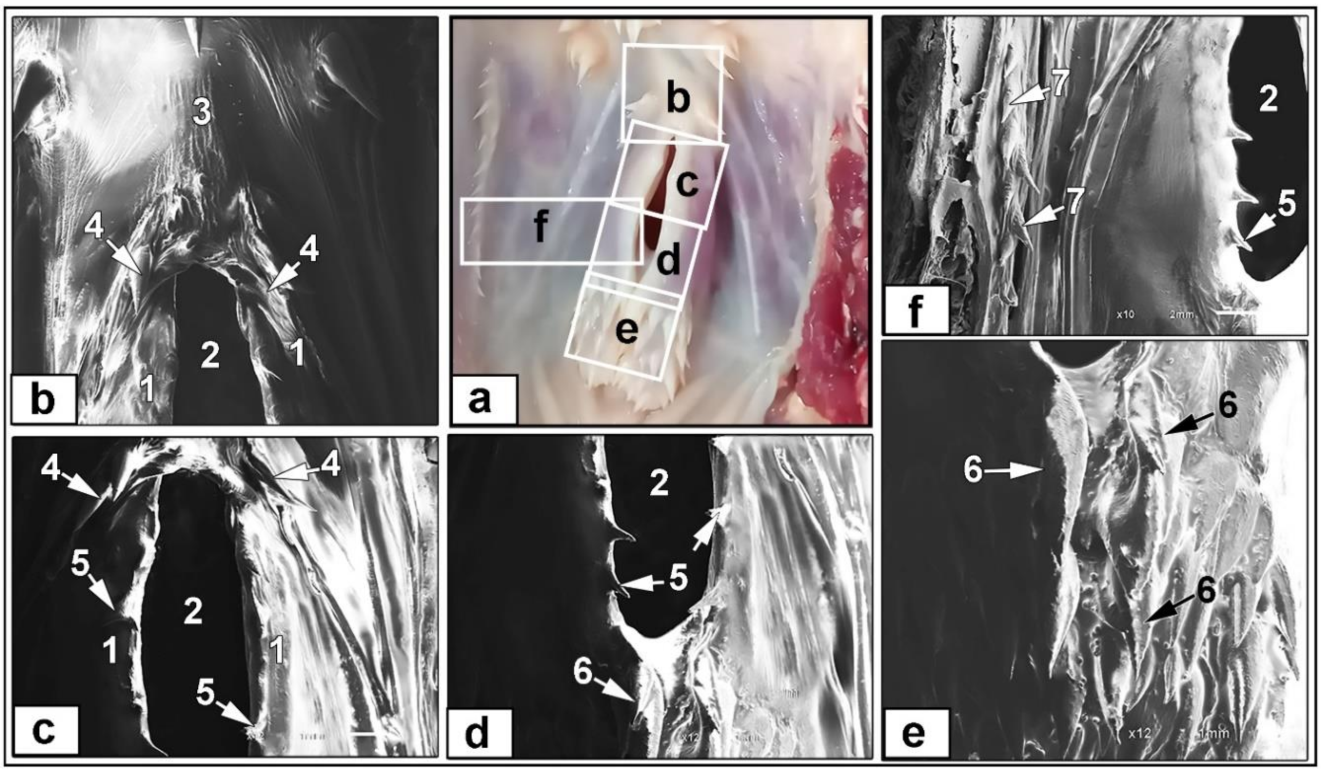

Fig 5. Gross image **(a)** and scanning electron microscopic micrographs **(b, c, d, e, f)** showing the laryngeal mound and glottis of the Egyptian goose. Gross image highlighted with white rectangles and corresponding letters of the SEM figures to show the examined areas with SEM. The laryngeal mound **(1)** surrounded the laryngeal entrance or glottis **(2)** and marked from the lingual root **(3)** by the transverse row of conical papillae **(4),** a row of caudally directed conical papillae **(5)** on the edges of the laryngeal entrance. Moreover, the caudal aspect of the laryngeal mound presented large conical papillae pharyngeal papillae **(6)** linearly distributed as 4-5 papillae on each side and directed toward the esophagus**.** The sides of the pharyngeal wall presented a papillary row **(7)** of caudally directed conical papillae.

4. Discussion

The current study described the anatomical characteristics of the oral cavity and pharynx in the domestic geese (*Anser anser domesticus*) and its adaptation according to the feeding habits and nature of the available food particles. There is little available data describing this structural modification of the oral cavity and pharynx with the feeding mechanisms in different bird species, especially in the domestic geese. Some morphological changes in this particular region in birds are adapted to the feeding mechanism as the filter-feeding apparatus formed by the bill lamellae, mechanical papillae, and the lingual nail in geese as observed in this study and by **Skieresz-Szewczyk and Jackowiak (2014)** or the feeding sieve apparatus in ducks (**Skieresz-Szewczyk and Jackowiak 2016)**, the mechanical papillae on the dorsal surface of the tongue in penguins **(Kobayashi et al. 1998)**, the capillary tube in sunbirds **(Rico-Guevara and Rubega 2011)** and spear in woodpeckers **(Emura et al. 2009).**

The current investigation revealed the existence of a narrow elongated flat tongue of the domestic goose protracted to conform the inner surface of the lower beak, except its anterior part. Similar results were reported in the domestic geese and duck **(Jackowiak et al. 2011; Skieresz-Szewczyk and Jackowiak 2016; Abbasabadi and Sayrafi 2018; Abumandour et al. 2019).** Moreover, the shape of the tongue in birds is species-specific and it is closely conformed to the shape of the lower beak as observed in the current work and by **Emura et al. (2008), Jackowiak et al. (2011), and Abumandour et al. (2019).** Tongues of some birds may be very short and don't fill the whole length of the lower beak such as the Eurasian hoopoe **(Abumandour and Gewaily 2019),** or longer than the limits of the lower beak as in the woodpecker **(Emura et al. 2009).** Most of the avian species have the common triangular shape of the tongue as in the galliform and passerine birds **(Jackowiak et al. 2010; Erdogan and Alan 2012),** house sparrow, and Eurasian hoopoe **(Abumandour 2018; Abumandour and Gewaily 2019).** Other shapes of the avian tongues include the oval and elongated form as in the domestic goose **(Iwasaki et al. 1997; Jackowiak et al. 2011),** the domestic duck **(Ragab et al. 2014; Skieresz-Szewczyk and Jackowiak 2016),** water ducks **(Abumandour et al. 2019),** herbivorous birds **(Abumandour and El-Bakary 2019),** carnivorous birds **(Emura et al. 2008),** Eurasian Coot **(Abumandour and El-Bakary 2017a),** and there are other lingual forms as the mushroom-like tongue in the cormorants **(Jackowiak et al. 2006),** the brush-like tongue in the nectarivorous birds **(Rico-Guevara and Rubega 2011),** the needle-like tongue in the little egret, heron **(Emura 2009a)** and the toothpick-like tongue in the woodpecker **(Emura et al. 2009).**

The morphological structure of the avian lingual apex indicates some environmental accommodation of the tongue to the feeding manner and the different types of ingested food particles, where the morphology of the lingual apex is competent to implement different actions in the food intake mechanism such as collecting and filtering the solid food particles, drinking water, and help in directing the food back towards the esophagus **(Jackowiak et al. 2011).** Anatomically among the avian species, there are different shapes of the lingual apex as the rounded one in ostrich, Egyptian laughing dove, and quails **(Parchami et al. 2010; Pasand et al. 2010; Abumandour and El-Bakary 2019),** or a pointed apex in the Eurasian hoopoe **(Abumandour and Gewaily 2019).** In our study, the lingual apex terminated anteriorly by a rounded tip with a flat rounded lingual nail. The same observations were reported by **Jackowiak et al. (2011), Skieresz-Szewczyk and Jackowiak (2014), Abbasabadi and Sayrafi (2018),** and **Abumandour et al. (2019).** Moreover, it was confirmed that the family Anatidae (geese and ducks) use the lingual nail in association with the transverse lamellae of the beak to grab the grains, where the spoon-like lingual nail is used to raise the small food particles **(Skieresz-Szewczyk and Jackowiak 2014, 2016; Abumandour et al. 2019).** Nevertheless, the tongue of the Eurasian Coot and some water birds lack this lingual nail **(Abumandour and El-Bakary 2017a)** and other birds use a pair of dagger-like processes to raise and eject the seeds toward the lingual groove as in the nutcracker **(Jackowiak et al. 2010).**

SEM observations revealed that no lingual papillae were detected on the smooth dorsal surface of the lingual apex, but only extensive large filiform papillae and hair-like structures on its lateral sides; this was confirmed by **Iwasaki et al. (1997)** and **Jackowiak et al. (2011).**

The current work reported that the body of the tongue was distinguished into three parts: anterior, middle, and posterior. The lateral surface of the lingual body anterior part had small conical and filiform papillae, and the posterior part had giant conical papillae between the dense filiform papillae on its lateral surface, similar observations were reported in domestic goose **(Jackowiak et al. 2011).** Moreover, the tongue of goose and duck has a distinctive lingual prominence on the dorsal surface of its body **(Iwasaki et al. 1997; Jackowiak et al. 2011; Skieresz-Szewczyk and Jackowiak 2016).** Further-more, the anterior part of the lingual prominence had few conical papillae. While its posterior border formed the caudally convex semicircular papillary crest with 8-10 mechanical conical papillae, and the anterior part of the lingual root was slightly overlapped by their pointed processes, similar results were reported by **Jackowiak et al. (2011).** The morphological characteristics of the tongue in domestic geese observed in this study coincide with the explanations offered by **Skieresz-Szewczyk and Jackowiak (2014, 2016)** who reported that both species of Anseriformes (geese and duck) used the bristle-like small and large conical papillae on the sides of the lingual body in contact with the inner border of the serrate bill as a filter-feeding apparatus to grab the grass leaves during the grazing action of the feeding manner.

The dorsal surface of the lingual body exhibited a shallow median groove that could not be detected on the lingual prominence of domestic goose as reported by **Jackowiak et al. (2011)** and Middendorff's bean goose as reported by **Iwasaki et al. (1997).** However, this groove is observed along the entire dorsal surface of the lingual body and its prominence in other species as reported in Northern pintail **(El-Said and El-Bakary 2015)** and the domestic duck **(Skieresz-Szewczyk and Jackowiak 2016)** or restricted only on the caudal part of the lingual body as observed in the house sparrow **(Abumandour 2018).** While this median groove is absent in the penguin **(Kobayashi et al. 1998),** the Egyptian laughing dove **(Abumand-our and El-Bakary 2019),** and the Rhea Americana **(Santos et al. 2011).**

Minor anatomical differences could be observed in the number of the papillary rows forming the lingual crest among a wide diversity of avian species. In the current study, only a single transverse papillary row was observed on the lingual prominence as reported in water duck **(Abumandour et al. 2019),** two transverse papillary rows were detected in the domestic duck, common kestrel, house sparrow, and common quail **(Parchami et al. 2010; Skieresz-Szewczyk and Jackowiak 2016; Abumandour 2018).** Moreover, this papillary crest has a transverse appearance in goose **(Iwasaki et al. 1997),** the V-shape in the quail **(Parchami et al. 2010),** the W-shape in the hoopoe **(El-Bakary 2011),** or the U-shape in the cattle egret **(Al-Zahaby 2016).**

The existence of the mammalian filiform mechanical lingual papillae in avian species is limited. In this study the filiform papillae were laterally distributed on the apex and body of the tongue as observed in goose and duck **(Jackowiak et al. 2011; Abbasabadi and Sayrafi 2018).** While these filiform mechanical papillae were observed on the dorsal surface of the apex and body of the tongue in Eurasian Coot **(Abumandour and El-Bakary 2017a),** common kestrel, and owl **(Abumandour and El-Bakary 2017b),** and the Egyptian laughing dove **(Abumand-our and El-Bakary 2019).** In consequence of a functional view, the presence of these filiform mechanical papillae laterally among the conical papillae on the apex and body of the tongue facilitates the filter-feeding mechanism in such species **(Skieresz-Szewczyk et al. 2014).**

Generally, the lingual root corresponds to the shape of the lingual papillary crest **(Abumandour 2018).** In the current investigation, the lingual root consisted of a smooth triangular middle part surrounded laterally and caudally by spinated parts, while rostrally it was limited by the papillary crest. However, the root of the Eurasian Coot tongue has four parts: the semilunar, the triangular, the round, and the depressing parts **(Abumandour and El-Bakary 2017a**), the root of the house sparrow tongue consists of a V-shaped rostral region that conforms to the shape of the papillary crest and a wide caudal part **(Abumandour 2018)**. Furthermore, the lingual root is V-shaped in owl or U-shaped in common kestrel **(Abumandour and El-Bakary 2017b).**

Generally, the laryngeal prominence and its midline entrance in birds had little attention according to the available literature, except for some recently published research articles **(Abumandour 2018; Gupta et al. 2018; Abumandour et al. 2019; Gewaily and Abumandour 2021).** In domestic goose, there was an ovoid-shaped laryngeal prominence with a median laryngeal cleft on the floor of the pharyngeal cavity. In avian species, the triangular shape is common for the laryngeal mound **(Erdogan and Alan 2012; Abumandour and Gewaily 2019).** The SEM observations of this study revealed that the glottis was bordered by two lateral edges contained the papillary rows of small-sized conical papillae, similar observations were reported in the Egyptian laughing dove **(Abumandour and El-Bakary 2019).** On the other hand, these papillae were not observed on the glottis of the Eurasian hobby and Eurasian Coot **(Abumandour 2014; Abumandour and El-Bakary 2017a).** Caudal to the glottis, the posterior part of the laryngeal mound contained transverse rows of large-sized pharyngeal papillae arranged linearly as 4-5 papillae on each side and directed backward. While these pharyngeal papillae are diamond-shaped with many conical papillae in water ducks **(Abumandour et al. 2019)** or take the heart shape in the Eurasian Coot **(Abumand-our and El-Bakary 2017a).** The existence of these conical pharyngeal papillae was reported in many avian species, as two transverse rows in the Eurasian hobby **(Abumandour 2014)** or completely absent in emu **(Crole and Soley 2010).** These pharyngeal conical papillae direct the ingested food particles toward the esophagus **(Abumandour and El-Bakary 2019).**

Generally, different shapes of the choanal cleft are observed in birds. In this study, the choanal cleft consisted of two parts; a narrow rostral part and a wide caudal part, similar as reported in the water ducks, Eurasian Coot, house sparrow, and Eurasian hobby **(Abumandour 2014, 2018; Abumandour and El-Bakary 2017a; Abumandour et al. 2019).** Moreover, the caudally directed conical papillae were distributed on the edges of the choanal and infundibular clefts, some of these papillae were regularly arranged on the lateral sides of the papillary region as longitudinal papillary rows, while other papillae were arranged randomly between the infundibular cleft and esophagus. Similar results were observed in the Egyptian geese **(Khalaf and Ahmed 2020).** There are two papillary rows arranged longitudinally and completely encircling the choanal cleft as observed in water ducks **(Abumandour et al. 2019)** and house sparrow **(Abumandour 2018).** In the Eurasian Coot, the papillary row surrounds only the narrow rostral part **(Abumandour and El-Bakary 2017a)**. These caudally directed papillae on the edges of the choanal cleft prohibit the entrance of the food particles into the opened cleft **(Abumand-our et al. 2019).** On the other hand, **Tadjalli et al. (2008)** reported that caudal to the infundibular cleft, there are no transverse rows of conical papillae in the pharyngeal roof of ostrich.

In the current study, the roof of the oropharynx had two parts; rostral lamellar and caudal papillary regions, while it is divided into a small rostral non-papillary region and a caudal papillary region in ostrich and Eurasian Coot **(Crole and Soley 2009; Erdogan and Alan 2012; Abumandour and El-Bakary 2017a).** Moreover, in the present study, it was observed that the palate was free from any papillae. While the palate of the fowl and pigeon had caudally pointed papillae that arranged in several transverse rows or confined to the apical region of the palate as observed in ducks **(Emura 2009b).** The anterior two-thirds of the palate in the ostrich contains no papillae, while short slender papillae surrounding the choanal cleft are observed in the caudal part of the palate **(Tadjalli et al. 2008).** There is a species-specific diversity between the avian species in the occurrence, number, and shape of the palatine ridges. In our study, the domestic goose had five longitudinal palatine ridges arranged as one median, two paramedian, and two lateral longitudinal rows of blunt tubercles. In the Eurasian hobby there are two lateral palatine ridges not joined apically **(Abumandour 2014)**. On the other hand, the palatine ridges were completely absent in raven and magpie **(Erdogan and Alan 2012).** The transverse horny lamellae of the bill in domestic goose similar to those found in the Egyptian geese **(Hassan et al. 2010)** and Northern Pintali ducks **(El-Said and El-Bakary 2015)** are used during the collection process and filtering of the food particles.

In conclusion, the morphological features of all anatomical structures in the oral cavity and pharynx of the domestic geese such as transverse lamellae of the beaks, conical papillae on the sides of the body of the tongue, filiform and hair-like papillae, conical papillae of the lingual papillary crest, lingual nail, median lingual groove, palatine ridges, papillae on the laryngeal mound and elongated form of the tongue reflected their adaptation to the feeding process and type of the available food particles.

5. Conflict of interest

No conflict of interest to declare.

6. References

Abbasabadi MB, Sayrafi R (2018). Histomorphological features of the tongue of the Eurasian teal (*Anas crecca*). Anat Histol Embryo. 47(2): 119–123. https://doi.org/10.1111/ahe.12328

Abumandour MMA (2014). Gross anatomical studies of the oropharyngeal cavity in Eurasian hobby (*Falconinae: Falco Subbuteo*, Linnaeus 1758). J Life Sci Scientific Res. 1(4): 80–92.

Abumandour MMA, El-Bakary NER (2017a). Morphological characteristics of the oropharyngeal cavity (tongue, palate and laryngeal entrance) in the Eurasian Coot (*Fulica atra,* Linnaeus, 1758). Anat Histol Embryol. 46(4): 347–358.

https://doi.org/10.1111/ahe.12276

Abumandour MMA, El-Bakary NER (2017b). Morphological features of the tongue and laryngeal entrance in two predatory birds with similar feeding preferences: Common kestrel (*Falco tinnunculus*) and Hume's tawny owl (*Strix butleri*). Anat Sci Int. 92(3): 352–363. https://doi org/ 0.1007/s12565-016-0339-9

Abumandour MMA (2018). Surface ultrastructural (SEM) characteristics of oropharyngeal cavity of house sparrow (*Passer domesticus*). Anat Sci Int. 93(3): 384–393. https://doi.org/10.100 7/s12565-017-0426-6

Abumandour MMA, El-Bakary NER (2019). Anatomical investigations of the tongue and laryngeal entrance of the Egyptian laughing dove *Spilopelia senegalensis aegyptiaca* in Egypt. Anat Sci Int. 94(1): 67–74. https://doi.org/10.1007/s12565-018-0451-0

Abumandour MMA, Gewaily MS (2019). Gross morphological and ultrastructural characteri- zation of the oropharyngeal cavity of the Eurasian hoopoe captured from Egypt. Anat Sci Int. 94(2): 172–179. https://doi.org/0.1007/s12565-018-0463-9

Abumandour MMA, Bassuoni NF, Hanafy BG (2019). Surface ultrastructural descriptions of the oropharyngeal cavity of *Anas querquedula*. Microsc Res Tech. 82(8): 1359–1371. https://doi.org/10.1002/jemt.23288

Abumandour MMA, Kandyel RM (2020). Age-related ultrastructural features of the tongue of the rock pigeon *Columba livia dakhlae* in different three age stages (young, mature, and adult) captured from Egypt. Microsc Res Tech. 83:118–132. https://doi.org/10.1002/jemt.23394

Al-Zahaby SA (2016). Light and scanning electron microscopic features of the tongue in cattle egret. Microsc Res Tech. 79(7), 595–603. https://doi.org/10.1002/jemt.22672

Baumel JJ, King AS, Breazile JE, Evans HE, Berge JCV (1993). Handbook of avian anatomy: Nomina Anatomica Avium 2nd ed. Nuttall Ornithological Club, Cambridge Massachusetts.

Crole MR, Soley JT (2009). Morphology of the tongue of the emu (*Dromaius novae-hollandiae*). II. Histological Features. Onderste-poort J. Vet Res. 76(4): 347–361.

Crole MR, Soley JT (2010). Gross morphology of the intra-oral rhamphotheca, oropharynx and proximal oesophagus of the Emu (*Dromaius novaehollandiae*). Anat Histol Embryol. 39(3): 207–218. https://doi.org/10.1111/j.1439-0264.2010.00998.x

El-Bakary NER (2011). Surface morphology of the tongue of the hoopoe (*Upupa epops*). J. American Sci. 7(1), 394–399.

El-Said N, El-Bakary R (2015). Morphology of the oropharyngeal cavity of northern pintail (*Anas acuta*). Global Vet. 14(4): 459-464. https://doi.org/10.5829/idosi.gv.2015.14.04.93143

Emura S, Okumura T, Chen H. (2008). Scanning electron microscopic study of the tongue in the Peregrine falcon and Common kestrel. Okajimas Folia Anat Jpn. 85(1): 11–15. https://doi.org /10.2535/ofaj.85.11

Emura S. (2009a). SEM studies on the lingual dorsal surfaces in three species of herons. Medical Biol. 153: 423–430.

Emura S (2009b). SEM studies on the connective tissue cores of the lingual papillae of the spot-billed duck. Medical Biol. 153: 63–69.

Emura S, Okumura T, Chen H (2009). Scanning electron microscopic study of the tongue in the Japanese pygmy woodpecker (*Dendrocopos kizuki*). Okajimas Folia Anat Jpn. 86(1): 31–35. https://doi.org/10.2535/ofaj.86.31

Erdogan S, 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*). Microsc Res Tech. 75(3): 379–387. https://doi.org/10.1002/jemt.21067

Erdogan S, Iwasaki S (2014). Function-related morphological characteristics and specialized structures of the avian tongue. Ann Anat. 196(2-3): 75–87. https://doi.org/10.1016/j.aanat. 2013.09.005

Erdogan S, Perez W (2015). Anatomical and scanning electron microscopic characteristics of the oropharyngeal cavity (tongue, palate and laryngeal entrance) in the southern lapwing (*Charadriidae: Vanellus chilensis*, Molina 1782). Acta Zoolog. 96(2): 127–272. https://doi. org/10.1111/azo.12075

Ertas TD, Erdogan S (2019). Investigation of chicken (*Gallus domesticus*) tongue by morpho-metric and scanning electron microscopic methods. Dicle Üniversitesi Veteriner Fakültesi Dergisi. 12(1):8-12.

Gewaily MS, Abumandour MMA (2021). Gross morphological, histological and scanning electron specifications of the oropharyngeal cavity of the hooded crow (*Corvus cornix pallescens*). Anat Histol Embryol. 50(1):72–83. https://doi.org/10.1111/ahe.12602

Gupta V, Pathak A, Farooqui MM, Prakash AJAY (2018). Anatomy of the oropharyngeal cavity of turkey (*Meleagris Gallopavo*). Haryana Vet. 57(2): 178-182.

Hassan SM, Moussa EA, Cartwright AL (2010). Variations by sex in anatomical and morpholo-gical features of the tongue of Egyptian goose (*Alopochen aegyptiacus*). Cells Tissues Organs. 191(2):161–165. https://doi.org/10.1159/000223231

Hugo S (2002). Chapter 1: origins and breeds of domestic geese, in Buckland R, Guy G (eds.), geese: the underestimated species. FAO animal production and health paper, FAO agriculture department, ISSN 0254-6019. Available online at http://www.fao.org/3/V62 00T/v6200T0n.htm

Igwebuike UM, Eze UU (2010). Anatomy of the oropharynx and tongue of the African pied crow (*Corvus albus*). Veterinarski Arhiv. 80(4): 523-531.

Igwebuike UM, Anagor TA (2013). The morphology of the oropharynx and tongue of the muscovy duck (*Cairina moschata*). Veterinarski Arhiv. 83(6): 685-693.

Iwasaki SI, Asami T, Chiba A (1997). Ultrastructural study of the keratinization of the dorsal epithelium of the tongue of Middend-orff's bean goose, *Anser fabalis middendorffii* (Anseres, Antidae). Anat Rec. 247(2):149–163.

Jackowiak H, Andrzejewski W, Godynicki S (2006). Light and scanning electron microscopic study of the tongue in the cormorant Phalacro-corax carbo (Phalacrocoracidae, Aves). Zoolog Sci. 23(2): 161–167. https://doi.org/10.2108/zsj.23.161

Jackowiak H, Skieresz-Szewczyk K, Kwiecinski Z, Trzcielinska-Lorych J, Godynicki S (2010). Functional morphology of the tongue in the nutcracker (*Nucifraga caryocatactes*). Zoolog Sci. 27(7): 589–594. https://doi.org/10.2108/zsj.27.589

Jackowiak H, Szewczyk KS, Godynicki S, Iwasaki SI, Meyer W (2011). Functional morphology of the tongue in the domestic goose (*Anser Anser f. Domestica*). Anat Rec (Hoboken). 294(9):1574–1584. https://doi.org/10.1002/ar.21447

Jayachitra S, Balasundaram K, Iniyah K, Sivagnanam S, Tamilselvan S (2015). Morphology of oropharyngeal cavity in guinea fowl (*Numida meleagris*). Int J Advanced Multidisciplinary Res. 2(4): 99–102.

Khalaf MA, Ahmed Y (2020). Morphological features of pharyngeal roof of Egyptian geese (*Alopochen aegyptiacus*). SVU- Int J Vet Sci. 3(2): 96-105.

Kobayashi K, Kumakura M, Yoshimura K, Inatomi M, Asami T (1998). Fine structure of the tongue and lingual papillae of the Penguin. Arch Histol Cytol. 61(1): 37–46. https://doi.org/ 10.1679/aohc.61.37

König HE, Korbel R, Liebich HG (2016). Avian anatomy, textbook and colour atlas. 2nd ed., 5M Publishing Ltd, Benchmark House, 8 Smithy Wood Drive, Sheffield, S35 1QN, UK, ISBN 978-1-910455-60-9, Pp 92-97.

Moussa EA, Hassan SA (2013). Comparative gross and surface morphology of the oropharynx of the hooded crow (*Corvus cornix*) and the cattle egret (*Bubulcus ibis*). Vet Anat. 6(1): 1–15. https://doi.org/10.21608/jva.2013.44987

Parchami A, Dehkordi RAF, Bahadoran S (2010). Fine structure of the dorsal lingual epithelium of the common quail (*Coturnix coturnix*). World Applied Sciences J. 10(10): 1185–1189.

Pasand AP, Tadjalli M, Mansouri H (2010). Microscopic study on the tongue of male ostrich. Europ J. Biol Sci. 2:24–31.

Ragab S, Farag F, Tolba A, Saleh A, El-Karmoty A (2014). Gross morphological and angioarchitectural study of the oral cavity in the Egyptian domesticated ducks (*Anas platy rhynchos domesticus*). Suez Canal Vet Med J. 9(2): 137-148. https://doi.org/ 10.21608/SCVMJ.2014.65330

Rico-Guevara A, Rubega MA (2011). The hummingbird tongue is a fluid trap, not a capillary tube. Proceed National Acad Sci of USA. 108(23), 9356–9360.

Rossi JR, Baraldi-Artoni SM, Oliveira D, da Cruz C, Franzo VS, Sagula A (2005). Morphology of beak and tongue of *partrigde Rhynchotus rufescen*s. Ciencia Rural, Santa Maria 35 (5): 1098-1102.

Santos TC, Fukuda KY, Guimarães JP, Oliveira MF, Miglino MA, Watanabe L (2011). Light and scanning electron microscopy study of the tongue in Rhea Americana. Zoolog Sci. 28(1): 41–46. https://doi.org/10.2108/zsj.28.41

Skieresz-Szewczyk K, Jackowiak H (2014). Scanning electron microscopy investigation of the filter-feeding apparatus in the domestic goose (*Anser anser f. domestica*) and the domestic duck (*Anas platyrhynchos f. domestica*). Microscopy: advances in scientific research and education, 1:84-88.

Skieresz-Szewczyk K, Jackowiak H (2016). Morpho-functional study of the tongue in the domestic duck (*Anas platyrhynchos f. domestica,* Anatidae): LM and SEM study. Zoomorphology. 135: 255–268. https://doi.org/10.1007/s00435-016-0302-2

Tadjalli M, Mansouri SH, Poostpasand A (2008). Gross anatomy of the oropharyngeal cavity in the ostrich (*Struthio camelus*). Iranian J Vet Res Shiraz Univ. 9(4): 316-323.

Tivane C, Rodrigues MN, Soley JT, Groenwald HB (2011). Gross anatomical features of the oropharyngeal cavity of the ostrich (*Struthio camelus*). Pesq Vet Bras. 31(6):543-550.

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