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Gross anatomy of the oropharyngeal cavity in the ostrich (*Struthio camelus*)

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Summary

There are significant structural differences between the mouth and pharyngeal cavity of birds and mammals. It is usual to refer to a common oropharyngeal cavity of birds because the soft palate, which forms such an obvious delineation between the mouth and pharyngeal cavity, is absent. Six male adult ostriches were used to study the oropharyngeal cavity and its components including the beak, hard palate, pharynx, tongue and the larynx macroscopically. This study revealed that these components in ostrich have different features from other birds. In the ostrich, the beaks are spoon-shaped and the tongue is characterized by a short, broad and semicircular form. The hard palate is concave with a prominent median mucosal fold in its 2/3 rostral area and two oblique choanal slits in its caudal third area. The roof of pharynx presents infundibular slit in midline, a deep concave notch in caudal border and pharyngeal tonsils on its dorsal surface. The larynx protrudes from the floor of pharynx and consists of the unpaired cricoid cartilage and the paired arytenoid cartilages.

Key words: Oropharyngeal cavity, Ostrich, Gross anatomy

Introduction

There is some literature on the macroscopic and microscopic anatomy of oropharyngeal cavity in domestic birds (Nickel *et al*., 1977). The anatomy of the mandibles, tongue and alimentary tract of kakapo and kaka has been studied by Kirk *et al*. 1993. Rossi *et al*. 2005, studied the morphology of beak and tongue of partridge.

The tongue of the little tern pallas, budgerigar, *Gallus domesticus*, white tailed eagle and cormorant was also studied by Iwasaki, 1992; Martinez *et al*. 2003; Purwar, 1977; Jackowiak and Godynicki, 2005 and Jackowiak *et al*. 2006, respectively.

Salivary glands in the house sparrow (Nagato and Tandler, 1986), chicken (Gargiulo *et al*., 1991) and Japanese quail (Liman *et al*., 2001) and larynx in *Corvus brachyrhynchos* (Bock, 1978) and long-legged buzzard (Kabak *et al*., 2007) were also recorded. Since the information on the gross anatomy of oropharyngeal cavity of ostrich is scanty, this study was carried out to determine the anatomical details of all structures in the oropharyngeal cavity of ostrich.

Materials and Methods

Six heads from healthy adult male ostriches (1.5–2-year-old), immediately after slaughtering, were collected from local abattoir. All the heads were cut off at the level of the second cervical vertebra. A piece of wood was put between upper and lower beaks and then the samples were kept submerged in the %10 formalin for 72 h. To open the mouth cavity wider, the beak's angles were incised. Then anatomical position and shape of all the structures included in the mouth and pharyngeal cavity were studied in details. In addition, hyoid apparatus and larynx were dissected to determine the different segments of hyoid and laryngeal cartilages. Finally, measurements were carried out on beaks,

tongue, choanal slit, infundibular opening and glottis by ruler. Results were presented as mean ± SE.

Results

This study revealed that due to the lack of soft palate in ostrich, it is not possible to identify the limit between mouth and pharyngeal cavity. Therefore, it is usual to refer to as a common "oropharyngeal cavity" of ostrich (Fig. 1). The beak consists of the upper and lower beak. The basis of the upper beak is formed by the incisive bone and the lower beak by the rostral part of mandible. Both beaks are covered by a hard horny sheath which is relatively flexible. The edges of both upper and lower beaks are soft and the hard horny sheath of upper beak extends beyond that of the lower beak.

In ostrich, the beak is spoon-shaped and flat with mean ± SE length of 6.3 ± 0.4 cm for upper beak and 2.5 ± 0.3 cm for lower beak. The upper and lower beak include a base and two rami, respectively and both consist of a curved point. The beak curved points have different texture and form a hard horny plate shaped on the dorsum of the upper beak and ventrum of the lower beak. The nostrils without operculum lie at the base of upper beak (Fig. 2). The hard palate that forms the roof of mouth is white, concave in length, and 2/3 rostral part of it is divided into two regions by a prominent median longitudinal mucosal fold. Many paramedian narrow folds extend obliquely from lateral edges of hard palate toward median ridge. The caudal third portion of hard palate shows a semicircular darker area with the surface that is covered by many small delicate papillae. The middle third of this area is transformed into a triangular depression with two choanal slits obliquely in its borders. The right and left choanal slits are separated from each other by a thin median septum and enclosed ventrally by overlapping hard palate over them. A laminar fold originates from each side of median septum and borders choanal slit dorsally. Each choanal slit (2.9 ± 0.29 cm) communicates with related nasal cavity (Figs. 1 and 3).

Behind the median septum, there is an infundibular cleft (1.97 ± 0.32 cm) which divides the roof of the pharynx into two equal parts. The infundibular cleft is a common opening of the two auditory tubes that lies against the base of skull and is limited by the pharyngeal folds. The caudal border of the roof of pharynx in the form of a deep concave notch lies beyond the infundibular cleft (Figs. 1 and 3). At the dorsal surface of the roof of pharynx, near the caudolateral borders, there are two pockets like diverticuli that are bordered by a prominent circular pharyngeal fold. Each pocket has an oval structure, called pharyngeal tonsil (Figs. 4 and 5). The floor of the ostrich's mouth presents a concave depression between the rami of the lower beak and accommodates the tongue in it's caudal third portion. The mucous membrane on the floor of mouth forms a median longitudinal fold which bifurcates caudally and each branch extends toward edge of the tongue. The tongue in ostrich is semicircular, short and quite thick, 1.92 ± 0.15 cm length and 2.92 ± 0.29 cm width. It contains the unpaired broad intraglossal bone which articulates with the basihyoid bone, a blunt round apex, a base and a body. The base consists of a wide "V" shape notch and 2 caudal processes that extend toward larynx. It attaches to the rostral floor of mouth by a thick and short stalk-like fold. The body has dorsal and ventral surfaces. The papillae are not visualized on the tongue (Figs. 1, 6 and 7). The tongue is supported caudally by the hyoid bone. The hyoid bone in ostrich consists of an unpaired basihyoid bone, a paired hyoid rami and a urohyale bone. The basihyoid bone is short, flat and cartilagenous which its rostral and caudal extremities are relatively wide and compressed laterally. It articulates caudally with urohyale bone in a synarthrosis and on each side of it's caudolateral aspect there is an articular surface for the rami. The urohyale bone is a rod-like cartilaginous process which is attached to the ossified plate of cricoid cartilage of larynx. The rami of hyoid bone lie laterally and each hyoid ramus consists of a bony part which joints with the basihyoid rostrally, and a curved cartilaginous part which forms terminal segment (Fig. 8).

The larynx protrudes from the floor of

the pharyngeal cavity. It lies caudal to the tongue with a gap. This gap with 1.9 ± 0.17 cm length is occupied by some irregular mucosal plica. There are many mucosal laminae on floor of oropharynx near to the lateral wall of tongue and larynx. These laminae originate from the lateral wall of tongue toward the caudal of larynx (Fig. 6). The skeleton of larynx in ostrich is composed of the unpaired cricoid cartilage and the paired arytenoid cartilages. A wide triangular slit as glottis with 3.33 ± 0.75 cm length is formed between two arytenoid cartilages. The cricoid cartilage is larger than arytenoid cartilages and forms lateral walls, caudal end and floor of the larynx. It is a complete ring that narrow part of it articulates with arytenoid cartilages dorsocaudally and an ossified ventral plate that is pointed rostrally. The arytenoid cartilages meet each other dorsocaudally and form the roof of larynx. The joined arytenoid cartilages have irregular triangular shape from which three processes originate. These processes extend caudolaterally as rostral, middle and caudal processes. The rostral process is elongated, the middle process is circular and the caudal process is a hemisphere projection that articulates with it's counter part. The medial border of each arytenoid cartilage consists of a thick longitudinal crest which makes the border of the glottis. This crest forms apex or rostral angle of arytenoid cartilages rostrally (Fig. 9).

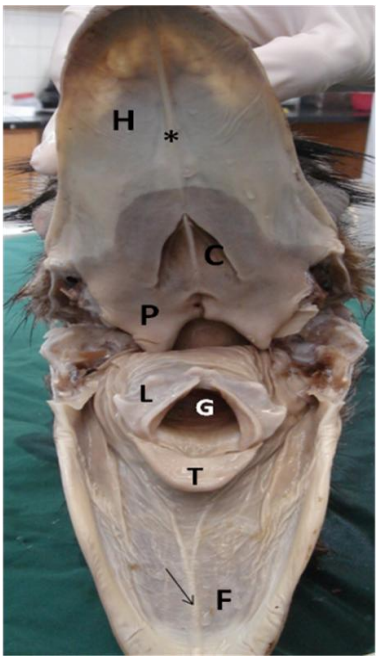

Fig. 1: Ostrich's head: Opened wide mouth showing oropharyngeal cavity. H) hard palate with a prominent median longitudinal mucosal fold (*). C) choanal slits. P) pharynx with infundibular cleft. F) floor of the mouth with median longitudinal fold (arrow). T) tongue. L) larynx with glottis (G)

Fig. 2: The beaks of ostrich. 1) upper beak with plate (*). 2) lower beak with plate (*)

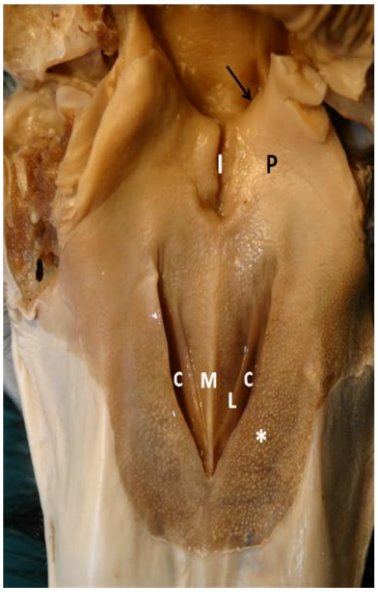

Fig. 3: The caudal third portion of hard palate consisting of small delicate papillae (*). M) median septum. C) choanal slits. L) laminar fold. P) roof of pharynx. I) infundibular cleft and caudal border of pharynx (arrow)

Discussion

It has been shown that it is possible to identify the limit between mouth and pharyngeal cavity in birds. Since the respiratory and alimentary pathways cross in this region, the pharyngeal cavity of birds has the same, or at least, a similar function to that of mammals. If it is necessary to use a collective term in reference to these two segments of alimentary tract in birds, then one should speak of the mouth and pharyngeal cavity (Nickel *et al*., 1977). The size and shape of the beak are related not only to the type of food the birds eat but also to their means of food prehension. The size of beak seems to be an important factor in the regulation of ingestion. In ostrich, the flat spoon-shaped beak is covered by a hard horny but relatively flexible sheath. The

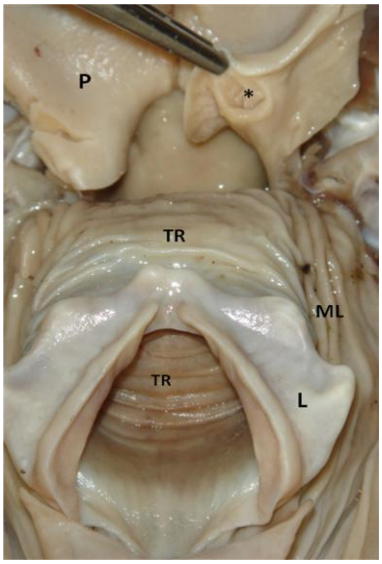

Fig. 4: Pharyngeal cavity of ostrich: L) larynx. P) roof of pharynx with pharyngeal tonsil (*). TR) trachea. ML) mucosal laminae

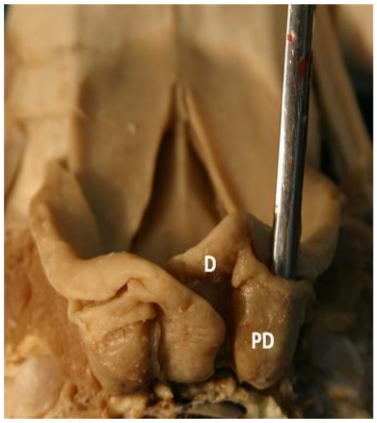

Fig. 5: Pharyngeal roof reflected. D) dorsal surface of pharynx showing pocket-like diverticuli (PD) containing pharyngeal tonsils

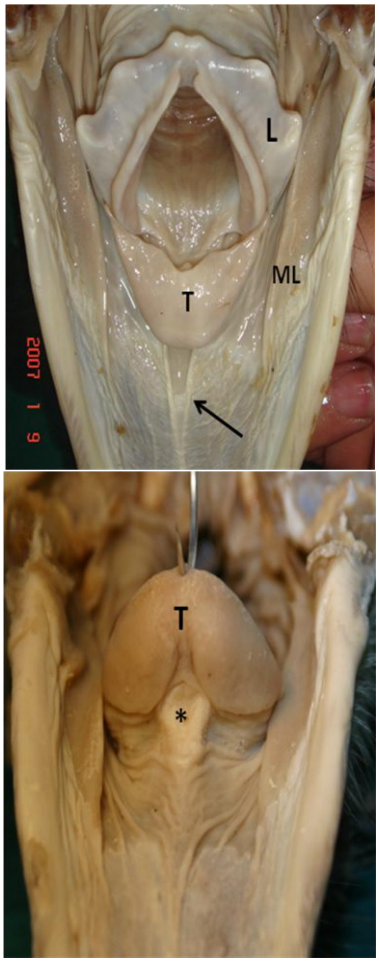

Fig. 6: Floor of mouth in ostrich showing bifurcation of median longitudinal fold (arrow). T) tongue. *) stalk. L) larynx. ML) mucosal laminae

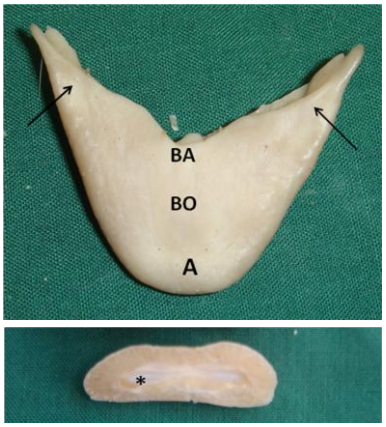

Fig. 7: Dorsal view of tongue in ostrich. A) apex. BO) body. *) intraglossal bone. BA) base and caudal process (arrow)

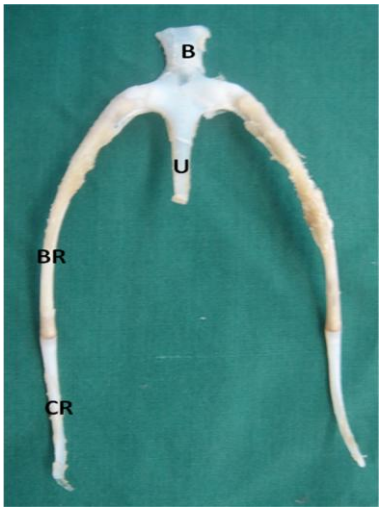

Fig. 8: The hyoid bone of ostrich. B) basihyoid bone. U) urohyal bone. BR) bony part of hyoid ramus. CR) cartilaginous part of hyoid ramus

upper and lower beaks have 6.3 ± 0.4 and 2.5 ± 0.3 cm length, respectively and the edges of both are soft. The beak of partridge of both sexes are curved, flat, hard with a sharp extremity, with mean length of 4.90 cm for the females and 4.80 for the males (Rossi *et al*., 2005). In the fowl and pigeon, the beak is pointed and the hard horny sheath of the upper beak extends in a hook beyond that of the lower beak. The edges of both the upper and lower sheaths are sharp (Nickel *et al*., 1977). In the duck and goose, the spoon-shaped beak is almost completely covered by a soft, yellow waxy skin and the point of beak is of different texture and forms a hard horny plate shaped like a finger nail. Also, they have horny lamellae arranged vertically along the edges of both their upper and lower beaks. When the beak is closed these act as sieves which retain small food particles taken up with the water during foraging (Nickel *et al*., 1977). The feature of ostrich's hard palate is different from that of all birds. In ostrich, we can differentiate a prominent median longitudinal mucosal fold in 2/3 rostral part of hard palate that divides it into two regions which lack papillae. But the caudal third portion of hard palate is covered by small delicate papillae and there are two choanal slits in the caudal area of palate that each communicates with related nasal cavity. One might assume that these are the requirements of more respiration. Whereas in other birds

Fig. 9: Dorsal view of larynx in ostrich. A) dorsal view of arytenoid cartilages. B) dorsal view of cricoid cartilage with ossified plate (*). C) craniodorsal view of larynx. A) arytenoid cartilages and ossified plate of cricoid cartilage (*). TR) trachea

(fowl, pigeon, duck, goose and partridge) the hard palate is incomplete because of the presence of a choanal slit that extends longitudinally in the midline of the caudal half of the palate which connects the oropharynx to the nasal cavity (Getty, 1975; Nickel *et al*., 1977; Rossi, 2005). In these birds there is an anterior part on the palate, lies apical to the choanal slit and a posterior part, which is divided into two regions by the choanal cleft. The hard palate of fowls and pigeons has two lateral palatine ridges, a median swelling and caudally pointing papillae arranged in several transverse rows. But the hard palate of goose has a median

and 2-3 paramedian longitudinal rows of blunt papillae and in the duck, these papillae are confined to the apical region. In these species, however, there is a median longitudinal swelling and also in both the duck and goose the edges of palate carry pointed papillae. The ridges and pointed papillae in hard palate play a role in transport of food (Nickel *et al*., 1977). In the kakapo, kea and kaka small papillae guard the choanal slit (Kirk *et al*., 1993).

Embryological investigations have shown that in birds the region analogous to the boundary between the mouth and pharyngeal cavity of mammals is where the infundibular cleft begins. This cleft that is situated in the roof of pharynx is the common opening of the right and left auditory tubes and leads into the dilated infundibular cavity. Therefore, this part of the bird's alimentary tract, which lies against the base of the skull, corresponds to the mammalian pharynx (Nickel *et al*., 1977).

The characteristic feature of pharynx in the ostrich is similar to that of the other domestic birds except the existence of two oval shaped pharyngeal tonsils on the dorsal surface of pharynx and the lack of a transverse row of papillae caudal to infundibular opening at the junction with the esophagus. The pharyngeal tonsils aid in the protection of the body against invading bacteria, viruses and other foreign bodies. The tonsils are known to be frequent portals of infections. In chicken, turkey, duck and goose, the well developed lymphoid tissue in the walls of the infundibular opening and infundibular cavity forms a pharyngeal tonsil. The mucose membrane of the roof of pharynx has small caudally directed papillae which, at the junction with the esophagus, form a well defined transverse row (Getty, 1975).

In the ostrich, the floor of mouth is a concave depression between the rami of the lower beak and adapts the tongue which in this way is similar to other domestic birds. The shape of tongue is adapted to the lower beak and is therefore very variable (Nickel *et al*., 1977). In the ostrich, the tongue is semicircular, short and broad with 1.92 ± 0.15 cm length and 2.92 ± 0.29 cm width. It's base is attached to rostral floor of pharynx by a short stalk-like mucosal fold and the papillae are not visualized. These features are confined to the transportation and swallowing of food, but not to the prehension of it. Whereas in the pigeon the tongue is narrow and in fowl it is broad, lancet-shaped and does not extend to the full limit of the lower beak. In lamellirostres, it completely fills the floor of mouth and is only slightly narrower apically. In fowls and pigeons the transition between the body and the base of the tongue is marked by a transverse row of upright, backward directed lingual papillae. In the duck and goose, in addition to this row of lingual papillae, there is another row of upright, horny papillae situated at the edges of the tongue. They point towards the pharynx and the gaps between them are occupied by thread-like papillae. This acts as a filter which effectively supplements the lamellae of the lateral edge of the beak (Nickel *et al*., 1977). In penguins, the whole tongue is covered by large, spine-like and caudally directed lingual filiform-like papillae, which are adapted to hold the slippery prey (Kobayashi *et al*., 1998).

Jackowiak and Godynicki (2005) reported that the tongue of the white tailed eagle is elongated with a sharp-ended apex and it's length is 6 cm. There is a deep median sulcus on the surface of the body of tongue, giving the tongue the shape of a drain pipe, while in the posterior part of the tongue there is a row of large, conical papillae with sharp tips. These features indicate the adaptation of the tongue to the swallowing of consumed food. A similar morphology of the tongue was observed in the little tern, but in the anterior part of the tongue there is a median line, and the apex of the tongue is slightly bifurcated (Iwasaki, 1992).

The tongue of the cormorant is a small, fixed structure with a length of 1.4 cm, situated in the middle part of the elongated lower bill. The uniquely shaped tongue resembles a mushroom, with a short base and an elongated dorsal part with sharpened anterior and posterior tips. A median crest can be observed on the surface of the tongue (Jackowiak *et al*., 2006). The tongue in partridge is characterized by a triangular form with mean length of 1 cm for both sexes and sharp extremity. It is located in the

caudal portion of the oral cavity and presents a flat surface. The lingual papillae are not visualized macroscopically (Rossi *et al*., 2005). The tongue of the kakapo is relatively short and wide, whereas the tongue of kaka is comparatively long and narrow (Kirk *et al*., 1993).

Similar to duck and goose, basihyoid bone in ostrich is flattened whereas in fowl and pigeon it is rod-like. It carries an articular surface for the rami on each side and at rostral end there is another articular surface for the intraglossal bone which is single in the ostrich, double in the fowl and shovel-like in the duck and goose (Nickel *et al*., 1997). In the birds, the air leaving the nasal cavity goes through the choanal slit into the larynx which is situated on the floor of the pharyngeal cavity.

The general appearance of the larynx in the ostrich is different from other domestic birds. In the ostrich, the larynx protrudes from the pharynx, contains a wide glottis and the papillae are not visualized on it. But in the turkey, fowl, duck and goose (Getty, 1975), *Corvus* (Bock, 1978) and long-legged buzzard (Kabak *et al*., 2007) the larynx was observed in the form of a mound as laryngeal mound at the caudal of tongue. It contains the glottis and is covered with a number of caudally projecting papillae. Also Kirk *et al*. (1993) reported that in kakapo, kea and kaka small papillae guard the laryngeal opening.

The laryngeal skeleton in ostrich consists of three cartilages which become partly ossified. From these cartilages, the cricoid is single and the arytenoid is paired. Whereas in turkey, fowl, duck, goose (Getty, 1975; King and McLelland, 1975) and long-legged buzzard (Kabak *et al*., 2007), the laryngeal skeleton consists of four different cartilages which the cricoid and procricoid cartilages are single and the arytenoid cartilage is double. Bock (1978) reported that in the *Corvus*, complex of 8 skeletal elements (cartilage, partially or completely ossified) constitute the skeleton of the larynx. These are the cricoid, the paired dorsal cricoids, the procricoid, the paired arytenoids and the paired dorsal arytenoids. The larynx in the ostrich and other birds prevents the entry of foreign bodies into trachea, acts as the airway during inspiration and assists the ingestion of solid particles by quickly movements.

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