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Morphological Characteristics of the Oropharyngeal cavity in White-breasted Waterhen (*Amaurornis phoenicurus*)

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ABSTRACT

The present study represents the anatomical description of theoropharyngeal cavity of the white breasted water hen. The oropharyngeal cavity of the White-breasted Waterhen is part of its unique anatomical features that help in its feeding and vocalization.The oropharyngeal cavity consisted of roof formed by incomplete hard palate cranially and the pharynx caudally and floor formed by mandible, occupied by the tongue cranially and laryngeal mound caudally. The beak was thinner and more pointed, adapted for foraging in water and mud. The upper and lower beak was almost equal in size, with triangular shaped pointed apex. The roof/palate was divided into two regions: a small rostral non-papillary and a large caudal papillary region. The rostral region was characterized by the presence of three longitudinal ridges.The papillary crest had two paramedian longitudinal papillary rows, the paramedian ridges were separated from the median ridge by shallow grooves on each side. There was a transverse papillary row between the caudal border of the infundibular cleft and oesophagus. The floor of the oropharyngeal cavity was filledwith the tongue and the laryngeal mound. The tongue was typically slender and pointed with a tapered apex that carries a terminal lingual nail. There were no macroscopic lingual projections on the dorsal surface of the tongue. The lingual body had a median lingual sulcus. Macroscopically, the transverse papillary crest with the large mechanical caudally directed conical papillae was located between the lingual body and thelingual root.The lingual root was consisted of four parts: round, triangular, semilunar and depressed parts.The laryngeal mound had an elongated glottic fissure, carrying a single row of papillae at the rear edge. There were caudally directed mechanical large conical pharyngeal papillae at the caudal border of laryngeal mound. The pharyngeal papillae were arranged as W-shaped structure. The pharynx was narrower, longer and more specialized for swallowing small food material

Key words: Goat, Histology , Rectum.

INTRODUCTION

The oropharyngeal cavity plays a crucial role in the feeding, vocalization, and overall physiological functions of birds. Understanding its morphological characteristics provides valuable insights into species-specific adaptations related to diet, behavior, and ecology. The White-breasted Waterhen (*Amaurornis phoenicurus*), a member of the Rallidae family, is a widely distributed wading bird found in wetlands, marshes, and rice fields across South and Southeast Asia. Despite its ecological significance, detailed anatomical studies on its oropharyngeal structures remain limited.This study aims to describe the morphological characteristics of the oropharyngeal cavity in the White-breasted Waterhen, focusing on features such as the tongue, palate, and associated structures. By examining these adaptations, we can gain a better understanding of how this species processes food and interacts with its environment. Such findings contribute to the broader knowledge of avian functional morphology and may have implications for conservation and avian health research.

MATERIALS AND METHODS

Carcass of four adult waterhen was collected from campus, died due to cold & brought to the Department of Veterinary Anatomy, U.P. Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, Mathura, (UP). The heads were thoroughly washed in normal saline and fixed in 10% formalin. After fixation, the heads were washed in running tap water to remove excess of formalin and incised along the commissures of mouth to expose the oropharyngeal cavity. The anatomical position and shape of all the structures located in the oropharyngeal cavity were

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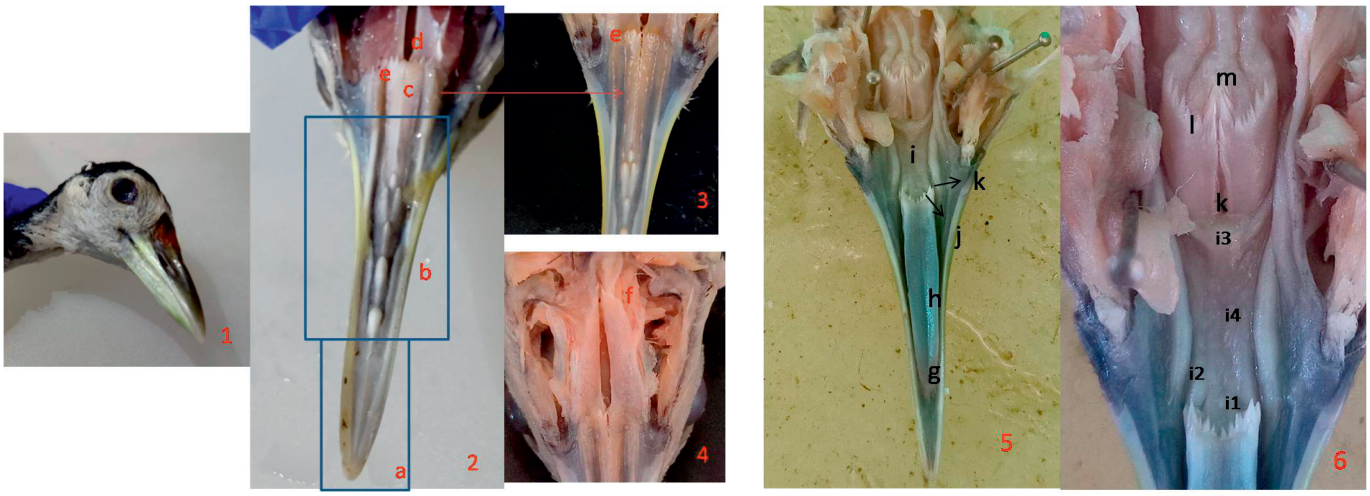

Fig 1. Showing the beak; Figs. 2-4. Showing roof of the oropharangeal cavity, a. non papillary part, b. Papillary part, c. Choanal cleft, d. Infundibular cleft, e. pharyngeal papillae, f. conical papillae; **Figs. 5-6. Showing floor of the oropharangeal cavity**, g. Tip of the tongue, h median furrow on the body of the tongue, i. root of the tongue, i1-4. round, triangular, semilunar and depressed parts of the root, respectively, j. conical papillae, k. Giant papillary, k. laryngeal cleft, l. Laryngeal mound, m. Pharangeal papillae .

studied in detail and recorded.

RESULTS AND DISCUSSION

The oral and pharyngeal cavity of White-breasted Waterhenwas not having clear line of demarcation due to lack of soft palate and so forming a common oropharyngeal cavity as reported earlier by Jayachitra et al., (2015) in guinea fowl, Gupta et al., (2016) in fowl and Gupta et al., (2018) in turkey. This cavity extended from the beak to theoesophagus as mentioned by the Igwebuike and Anagor(2013) in Muscovy duck,Jayachitra et al.,(2015) inguinea fowl and Gupta et al., (2018) in turkey. The oropharyngeal cavity consisted of roof formed by incomplete hard palate cranially and the pharynx caudally and floor formed by mandible, occupied by the tongue cranially and laryngeal mound caudally. McLelland (1979) marked the caudal limit of oral cavity at the level of last caudal transverse row of papillae on the hard palate dorsally and a row of papillae on the base of the tongue ventrally. Ali (2004) noticed that the oropharyngeal roof in ostrich was separated from the oesophagus by a transverse mucosal ridge. The pharyngeal roof extended from the rostral end of the choanal cleft to the pharyngeo-esophageal junction in ducks (Hassouna, 2002) and in turkey (Gupta et al., 2018). The lips and teeth were absent in White-breasted Waterhen and their function was replaced by the edges of the beak and gizzard. These findings are similar to the observations of Mohamed and Zayed (2003)in birds, Abumandour (2014) in Eurasian Hobby, Jayachitra *et al.*(2015) in guinea fowl and Gupta et al., (2018) in turkey.

The bony plate of the upper beak was formed by incisive bone and lower beak was formed by the anterior part of the mandible as described in fowl (Sisson and Grossman, 1975), birds (Nickel et al., 1977) and ostrich (Tadjalli et al., 2008). In white breasted water hen the upper and lower beak was almost equal in size, with triangular shaped pointed apex. The outer surface of both upper and lower beak was convex (Fig.1). Nickel et al., (1977) in fowl and pigeon described that the upper beak completely covered the lower beak in closed mouth. They further stated that in duck and goose the beak was spoon-shaped. Igwebuike and Anagor (2013) in Muscovy duck reported broad and shovel shaped beak. Violet et al.(2023) observed that in flamingo the upper beak is curved, convex and the lower beak was concave, in the budgerigar upper beak is stout, sharp-tipped and strongly curved with pointed tip and closes over with a small blunt lower beak, in peahen the upper and lower beak was almost equal in size, with short thick triangular beak while in emu, beak was very broad with triangular shape. Abumandour and Bakary (2017)mentioned that the habitats of birds were correlated with their feeding habits with respect to food sources. The different feeding habits of avian species was evident on the structure of the oropharyngeal cavity, which was spear in woodpeckers, sieve in ducks, capillary tube in sunbirds, rasp in vulture and barbet in penguin and multiple long processes was present on the rostral border of lingual apex. The nature of food size and

type of food prehension also decides the shape of the beak and size of beak (McLelland, 1979).In white breasted water hen the beaks were thinner and more pointed, adapted for picking up small prey in water or soft soil. The jaw structure supports quick movements necessary for capturing small, moving prey.

Roof of the Oropharynx

The roof of the oropharyngeal cavity was represented by a cartilaginous incomplete palate.It was formed by the hard palatecranially and the pharynx caudally. Nickel et al.,(1977) described that in fowl and pigeon the hard palate was very narrow but in duck and goose it was short with a broad cleft. Violet et al. (2023) in duck reported lamellae on the lateral borders of hard palate.

The hard palate of white breasted water hen had two regions according to the presence of papillae; the small rostral non-papillary region and the caudal large papillary region as described by Crole and Soley (2009), Erdogan and Alan (2012) in ostrich, raven and magpie, respectively (Fig. 2 and b).Gupta et al., (2018) in turkey reported that the palate (palatum) was divided into two parts; rostral and caudal. The line of demarcation between the two parts lay at the junction of the rostral narrow and caudal wide parts of the choanal slit. In present study the small rostral non-papillary region was devoid of any conical papillae but characterized by the presence of one median longitudinal ridge and two lateral paramedian ridges (Fig. 2 a). The median palatine ridge started caudal to the tip of the upper beak and became more prominent in its caudal part. The avian hard palate was characterized by a two lateral palatine ridges and median palatine ridge (Sisson and Grossman, 1974). In turkey, the rostral two thirds of the hard palate was divided into right and left halves by a median palatine ridge (Ruga palatine mediana) and the caudal one third by the choanal cleft (Gupta et al. 2018). In the ostrich, it started from the tip of the beak (Ali, 2004). Gupta et al, (2018) in turkey observed that the median palatine ridge was consisted of two parts *viz.* rostral continuous and the caudal interrupted parts.In buderiger the median palatine ridge was not noticedby Rajalakshmi et al., (2020). In white breasted waterhen the median palatine ridge divided the anterior part into right and left sides. Two lateral paramedian ridges were separated from the lateral edge ofthe upper beak by a clear deep groove as observed by (McLelland, 1990) in birds. The depth of the lateral palatine groove was more in the hard palate of chicken and Japanese quail whereas in turkey the depth was more in the anterior part than the posterior part. In waterhen the paramedian ridges were separated from the median ridge by a shallow groove on each side (Fig. 2). In between the lateral ridges on both side median palatine groove was observed, which was highly concave in chicken and slightly concave in turkey (Violet et al., 2023).

Caudal large papillary region had interrupted conical papillae on median palatine ridge upto the rostral narrow part of the choanal cleft. These papillae were freely distributed and caudally directed. Towards the caudal one third portion of median palatine ridge, one paramedian longitudinal row of papillae was seen on either side of the ridge. The lateral longitudinal palatine ridges were devoid of papillae. These ridges were continuous up to the beginning of transverse rows of papillae (Fig. 2b). In duck along with median longitudinal swelling, caudally directed papillae were restricted to the apical region (McLelland, 1979). The borders of the hard palate had pointed papillae in both duck and goose (Nickel *et al.,* 1977). Gupta et al., (2018) in turkey noticed that the palate was characterized by the presence of a triangular area lying between the caudo-lateral palatine ridges laterally and the most caudal transverse row of the palatine papillae. The apex of this area was directed rostrally and demarcated by the rostral ends of the caudo-lateral palatine ridges .Violet et al., (2023) stated that in fowls and pigeons the hard palate was composed of a median swelling, two lateralpalatine ridges and caudally directed papillae arranged in several transverse rows,whereas the hard palate of the goose had a median and paramedian longitudinal rows of blunt papillae in two to three rows.

The caudal large papillary region of palate possesses a median cleft called choana (choanal cleft, palatine cleft) and infundibular cleft (pharyngeal opening of auditory tube) (Fig. 2 c and d).The choana formed a permanent communication between the oral and nasal cavities and continued into a narrow closely placed groove in the pharyngeal region as reported by Igwebuike and Eze (2010) in African pied crow, Jayachitra et al.,(2015) in guinea fowl, Gupta et al.,(2016) in fowl and Gupta et al., (2018) in turkey. The opening of choanal cleft was narrow and slit-like. The cleft is

very long in fowl and pigeon, short in duck and goose (Nickel *et al.,* 1977) and bell-shaped in ostrich (Catarina et al., 2011).Gupta et al., (2018) in turkey recorded that the cleft was wider caudally than rostrally. In Waterhen, the lateral surface of the choanal cleft also possessed intermittent small papillae (Fig.3). The lateral palatine ridges were present on either side of the median ridge which ran parallel to the median palatine ridge. These ridges were present along the entire length of the hard palate. A single transverse row of large backward directed pharyngeal papillae was observed at the junction between choanal cleft and infundibular cleft which marked the end of the oral cavity (Fig. 2e and 3e). Rajlaxmi et al., (2020) in peahen observed four transverse rows of caudally directed papillae behind the median palatine ridge on either side of the choanal cleft. Nickel et al., (1977) reported that in domestic birds several row of transverse rows of papillae. The choanal cleft was completely encircled by numerous conical papillae in magpie and raven (Erdogan and Alan, 2012), while in southern lapwing (Erdogan and Perez, 2014) and Eurasian Coot (Abumandour and El-Bakary, 2017) the only rostral narrow part was encircled by huge small caudomedially directed conical papillae. Igwebuike and Anagor (2013) in Muscovy duck observed a complete absence of papillae on the hard palate. Jayachitra et al. (2015) in guinea fowl had observed six transverse rows of papillae. However, Gupta et al., (2018) in turkey recorded three to four transverse rows of papillae. In budgerigar, great horned owl, flamingo the region surrounding the post part of the choanal cleft was studded with numerous rows of caudally directed papillae Rajlaxmi et al.,(2020).Thepapillae encircling the choanal cleft and those on the hard palate could have a mechanical function their by obstructing the escape of food into the choanal cleft and thus could aid in movement of food into oesophagus.The caudomedially directed papillaearranged around the choanal cleft obstruct the passage of foods into the cleft and the other caudally directed palatine papillae facilitate the movement of nutrients into oesophagus as noticed by Erdogan and Alan (2012).

Infundibular cleft was located just caudal to the choanal cleft on the roof of pharynx (Fig. 2d). A transverse row of caudally directed conical papillae was observed between the caudal border of the infundibular cleft and the beginning of the oesophagus (Fig. 4f). This is in agreement with the findings of Erdogan andPerez (2014) in Southern lapwing, Jayachitra et al. (2015) in guinea fowl and Gupta et al. (2016) in fowl and Gupta et al., (2018) in turkey. In contrast to this, Tadjalli et al. (2008) mentioned that the ostrich was characterized by the lack of thistransverse row of papillae caudal to infundibular cleft.

Floor of the oral cavity: The floor of the oropharynx contained a concave triangular depression between the rami of mandible and lodged a triangular shaped tongue, pharynx and laryngeal mound as reported by Nickel *et al.* (1977) in domestic birds, Tadjalli *et al.,* (2008) in ostrich, Rodrigues *et al.* (2012) in rhea, Gupta *et al.* (2016) in fowl and `Gupta et al., (2018) in turkey. The avian tongue is species specific. This specification leads to many morphological differences in tongue because there is close relationship with the different life styles, feeding habitats and environmental conditions (Nickel et al., 1977; Parchami et al., 2010a; Erdogan and Alan, 2012; Onuk et al., 2013; Erdogan and Iwasaki, 2014). Short (rudimentary) tongue was described as a vestigial organ and not adapted to the size of lower beak as in cormorant (Jackowiak et al., 2006), ostrich and rhea (Jackowiak and Ludwig, 2008; Crole and Soley, 2009; Santos et al., 2011) or the elongated tonguein wood peckers (Emura et al., 2009).

In present study the tongue was elongated oval shaped and corresponded to the shape of lower beak, but not extended to fill the limit of the lower beak, similar to other lamellirostrate birds (*Anseriformes* or waterfowl)such as duck and goose (Iwasaki et al., 1997; Jackowiak et al., 2011) and cootAbumandour1 and El-Bakary(2017).Whereas, the tongue was triangular in shape in galliform and passerine birds (Iwasaki and Kobayashi,1986; Jackowiak et al., 2010; Parchami et al., 2010a; Erdogan and Alan, 2012; Erdogan et al., 2012b). Elongated tongue was observed in predatory birds such as white-tailed eagle (Jackowiak and Godynicki, 2005), golden eagle (Parchami et al., 2010b), falcon and kestrel (Emura et al., 2008a) and buzzard (Erdogan et al., 2012), brush-like tongue in nectarivorous birds (Rico-Guevara and Rubega, 2011) and the mushroom-like tongue in cormorants (Jackowiak et al., 2006); moreover, the Japanese pygmy woodpecker had a toothpick-like-shaped tongue (Emura et al., 2009) whereas Little Egret, black-crowned night heron and green-backed heron

had a needle-like-shaped tongue (Emura, 2009). The most characteristic appearance was the lip shaped tongue in the scarlet macaw (Emura et al., 2012).

The tongue was divided into three parts as apex, lingual body and root (Fig. 5g,h, i). There were no macroscopic lingual projections on the dorsal surface of the tongue. The Apex of the tongue was pointed. The lingual apex is species specific as it had many anatomical differences according to the feeding style, avian habitats and nature of foods. The shape of the lingual apex exhibits adaptations specific for the collection, manipulation of foods, eating habits and lifestyle in different environments. Emura et al. (2009), in Japanese pygmy woodpecker Erdogan and Alan (2012) in magpie and Abumandour1 and El-Bakary (2017)in coot noticed that the lingual tips was characterized by the presence of the multiple long, rostrally directed acicular processes on its rostral border. The bifurcated lingual apex was only encountered in few avian species as in Eurasian Hobby (Abumandour, 2014), magpie (Erdogan and Alan, 2012), falcon and kestrel (Emura et al., 2008a), owl (Emura and Chen, 2008), red jungle fowl (Kadhim et al., 2011) and little tern (Iwasaki, 1992). However, in nutcracker, Jackowiaket al. (2010) noted that the tongue has a pair ofdagger-like processes “lingual nail” that plays a vital rolein levering up and shelling seeds, and moving them overthe median lingual sulcus.

A well-developed median sulcus was present on the tongue of waterhen from lingual apex and body till the papillary crest which divides the tongue into two halves as noted in other avian species of different feeding behaviours (Iwasaki et al., 1997; Jackowiak andGodynicki, 2005; Erdogan and Perez, 2014), while the median sulcus of raven (Erdogan and Alan, 2012) was short. In contrast, the lingual sulcus was absent in different avian species of different feeding behaviours (Iwasaki and Kobayashi, 1986; Kobayashi et al., 1998; Santos et al., 2011; Erdogan and Alan, 2012).The lateral margins of the tongue were devoid of papillae.

The transverse papillary crest with the large mechanical caudally directed conical papillae was located between the lingual body and the lingual root (Fig. 5j) as observed in some predatory birds such as little tern (Iwasaki,1992), cormorant (Jackowiak et al., 2006), Eurasian Hobby (Abumandour, 2014), falcon and kestrel (Emura et al., 2008a), white-tailed eagle (Jackowiak and Godynicki, 2005) and buzzard (Erdogan et al., 2012a); chicken (Iwasaki and Kobayashi, 1986), quail (Parchami et al., 2010a), goose (Iwasaki et al., 1997), and nutcracker (Jackowiak et al., 2010).However, the papillary crest was absent ratite birds (Crole and Soley, 2010; Santos et al., 2011), penguin (Kobayashi et al.,1998) and woodpecker (Emura et al., 2009).The anatomical presence of the papillary crest with its caudally directed conical papillae helps to prevent regurgitationand to direct food to oesophagus.This papillary crest has some different forms: the commonanatomical form is 'V' shape as noted in many avianspecies (Jackowiak and Godynicki, 2005; Parchami et al.,2010a; Jackowiak et al., 2011; Erdogan et al., 2012b; Abumandour, 2014), while the U-shaped papillary crest wasfound in pigeon (Parchami and Fatahian, 2011).

The longest conical papillae were named'giant papillae' and located at the two lateral ends of the papillary crest, while the smallest papillae were located on the middle part of this crest (Fig.5k). The number of the conical papillae on the papillary crest reaches to 10–12, in addition to the two giant papillae. The ventral surface of the tongue was connected to the floor of the oral cavity by a frenulum at the level of the papillary crest.

The lingual root had a characteristic appearance. The lingual root was consisted of four parts: round, triangular, semilunar and depressed parts (Fig. 6i-1, 2, 3, 4). The round part had two necks; the rostral one was connected to medial part of lingual body at the area of short papillae of the transverse papillary crest, while the other caudally situated neck was connected to the triangular part (i2); the round part (i1) was separated from the triangular part by a groove. The triangular part had two rostrally directed lateral rami connecting to the lateral part of the lingual body at the area of giant papillae of the papillary crest. The semilunar part was presented just rostral to the laryngeal mound and glottis (i3). The depressed part was located between the triangular part and semilunar part (i4). An elevated triangular area called the laryngeal mound (Mons laryngealis) was presented just caudal to the lingual root (Fig.5j).In most avian species, the shape of the lingual root correspondedto the shape of the papillary crest (Erdogan andPerez, 2014).

A prominent elevated triangular projection, the laryngeal mound was located in the caudal part of the floor of the pharyngeal cavity reaching up-to the

first tracheal ring and entrance to the oesophagus as reported in African pied crow (Igwebuike and Eze, 2010), guinea fowl (Jayachitra *et al.*,2015), fowl (Gupta *et al.*, 2016), turkey (Gupta et al., 2018), and Abumandour and El-Bakary,(2017) in Eurasian Coot. The laryngeal mound was consisted of two adjoining, raised, quadrilateral plates as also observed by Kabak *et al.* (2007) in long-legged buzzard and AL- Mussawy *et al.* (2011) in turkey. The laryngeal mound showed middle, elongated triangular opening called glottis or laryngeal cleft, which connected the oropharyngeal cavity to the trachea and not guarded by the epiglottis (Fig.6k). There were caudally directed mechanical large conical pharyngeal papillae at the caudal border of laryngeal mound (Fig.6l). The pharyngeal papillae were arranged as W-shaped structure (Fig.6m).There were no macroscopic papillae on the surface of the laryngeal mound or throughout both the lateral borders of the glottis. A single row of pharyngeal papillae occurred behind the laryngeal mound in red jungle fowl (Kadhim *et al.* 2011), raven and magpie species (Erdoganand Alan 2012) and guinea fowl (Jayachitra *et al.*, 2015). Whereas, two rowsof caudally directed overlapping papillae were observed by Sisson andGrossman (1974) in chicken, Abumandour (2014) in Eurasian Hobby, Gupta *et al.* (2016) in fowl and Gupta et al./, (2018) in turkey. Hassouna, (2002) described 5-7 transverse rows of thin, medium-sized caudally directed papillae in ducks.In ostrich thepapillae are not seen on the larynx (Tadjalli *et al.*, 2008).The caudally directed pointed cornified papillae on themound might be helpful in the ingestion of solid foodparticles and pellets and in raking movement of the larynxduring swallowing (White, 1975; Fitch, 1994).

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