

A Study on Anatomical Structures of the Larynx, Trachea and Syrinx in Eurasian Eagle Owl (*Bubo bubo*)

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Abstract: In this study the structure of the larynx, trachea and syrinx of 7 eagle owls (3 females and 4 males) were morphologically examined by means of a stereo-microscope. Cone shaped papillae at each side of the mons laryngealis were observed. The caudal part (Mons laryngealis) in comparison to the cranial part was larger and possessed four transverse rows and two sagittal rows. Cartilaginous roof of the larynx was formed by the cricoid, procricoid and double arytenoid cartilages. The trachea passed to the left side of the esophagus at the 1/4 of the neck. The number of tracheal ring changed from 107-110 and all were complete. The sternotracheal muscle arised from the craniolateral process of the sternum and attached to the tracheal ring at the level of the 96th ring. The last 4-5 tracheal rings and the first 1-2 bronchial rings were involved in the formation of the syrinx. The first tracheal ring was complete whereas the dorsal and ventral ends of the last 3-4 tracheal rings were in a shape of open half moon. The pessulus was noted between ventral ends of the second tracheal ring. The tympanium was formed by the last 1-2 tracheal rings and the first bronchial ring. The number of bronchus from syrinx to the lung were observed being between 19 and 20.

Key words: Larynx, trachea, syrinx, eagle owl, formation, Turkey

INTRODUCTION

The Eurasian Eagle Owl (EEO) is one of the members of horned owl resident in much of Europe and Asia (Gooders, 1995). It is the largest and most powerful owl in Europe, about 69 cm (27 inches) in length. The eagle owl has brown upperparts heavily barred and mottled black and buff. Underparts buffy are heavily streaked black, especially over the breast. They have large pale buffy facial disc with paler outer ring, large orange red eyes and large ear tufts. In flight, huge rounded wings are brown and buff and heavily barred; tail always appears short (Gooders, 1995; Lane, 2006).

The respiratory apparatus in birds differs considerably from that of mammals. The larynx occupies a mound on the floor of the pharynx (Bock, 1978; Dyce *et al.*, 1996). It is a short cartilaginous and musculomembranous tube which connects the trachea with the pharynx in quail (Fitzgerald, 1970). The larynx is supported by cricoid, procricoid and paired arytenoid cartilages (Dyce *et al.*, 1996). The thyroid and epiglottic cartilages are absent. The glottis is a narrow slit between two arytenoid cartilages (King and McLelland, 1984; Tasbas *et al.*, 1994). The trachea follows on from larynx covered only by skin and dorsal to the oesophagus, it

runs ventrally along the neck (Nickel *et al.*, 1977) and formed from a series of tracheal cartilages all of which in passerines and some large species are ossified (King and McLelland, 1984). The syrinx is the organ of voice. It lies at the bifurcation of the trachea into the left and right primary bronchi. In most species the syrinx is partly tracheal and bronchial in origin and highly variable in structure between species (Getty, 1975; McLelland, 1990; Baumel *et al.*, 1993).

Differences in structure of the larynx, trachea and syrinx have been proposed to explain morphological structures by several researchers in variety of species including grey parrots (Warren *et al.*, 1996), ducks (Das *et al.*, 1965), long-legged buzzards (Kabak *et al.*, 2007) and Japanese quails (Bayram and Liman, 2000; Cevik Demirkan *et al.*, 2007). Morphology of the larynx was investigated in corvus brachyrhynchos (Bock, 1978) and *Gallus domesticus* (King and Robert, 1965) in details. The tracheal rings were studied in domestic birds (Mennega, 1964; Mathey, 1965) and *Gallus domesticus* (McLelland, 1965). Especially the syrinx (vocal apparatus) were studied in collared doves (Ballintijn and Cate, 1997), falconiformes (Griffiths, 1994a), North American owls (Miller, 1934), fowls (Morejohn, 1966), eiders (Miller *et al.*, 2007) and chicken (Gross, 1964). However, knowledge of

the anatomy of the larynx, trachea and syrinx in Eurasian eagle owls seems to be less sufficient. Thus, study aims at explaining the detailed features of the larynx, trachea and syrinx in EEO (*Bubo bubo*) and to compare the findings with those of other birds.

MATERIALS AND METHODS

A total of seven adult (3 females and 4 males) EEO (*Bubo bubo*) obtained from the Animal Hospital of Afyon Kocatepe University were used in this study. Birds were euthanased with ketamine hydrochloride (Parke-Davis) and xylazine hydrochloride (Bayer) combination (60 and 6 mg kg⁻¹, respectively) by the hospital surgeons due to untreatable firearm wounds and massive wing, leg and eye injuries. The live body weight of birds varied 2.5-3 kg. The larynx, trachea and syringes of three birds were fixed in 10% formaldehyde for anatomical examination. To make cartilages evident, two birds were submerged in 10% alcohol. Then, they were placed in 0.1% methylene blue for 15 min to acquire clear vision followed by 50 and 70% ethyl alcohol solutions (Cevik-Demirkan *et al.*, 2007). A stereomicroscope (Olympus Optical Co. Ltd, Tokyo, Japan) was used for dissections. The photographs were taken using a digital camera (Sony DSCF-717, Japan). *Nomina Anatomica Avium* was used for the nomenclature (Baumel *et al.*, 1993).

RESULTS

Larynx: The laryngeal mound (Mons laryngealis) was observed resembling a plump heart shape that occupied between caudal aspects of the tongue and cranial part of the trachea. The point of larynx directed rostrally into the base of the tongue. There were a lot of cone shaped papillae at each side on the mucosa of the mons laryngealis (Fig. 1a). The caudal part of the mons laryngealis contained four transverse rows more large cone papillae. Two sagittal rows of four or five papillae overlaid the lateral and medial borders of the sulcus laryngealis.

There was only one row of the papilla at the margin of the glottis. The glottis was wide slit-like shape and the average length was 10.05 mm, the width at the beginning point of glottis was 1.06 mm and at the middle point of glottis was 2.24 mm whereas the width at the end point of glottis was 0.80 mm (Fig. 1b). The average length of the sulcus laryngealis, localized at the caudal and as the extension of glottis was 3.45 mm (Fig. 1c).

It was observed that the laryngeal skeleton consisted of four cartilages. The cricoid cartilage and the procricoid cartilage were alone and the arytenoid cartilage was



Fig. 1: Dorsal view of the mons laryngealis. a: Papillae on the dorsal surface of the larynx, b: Glottis, c: Sulcus laryngeus

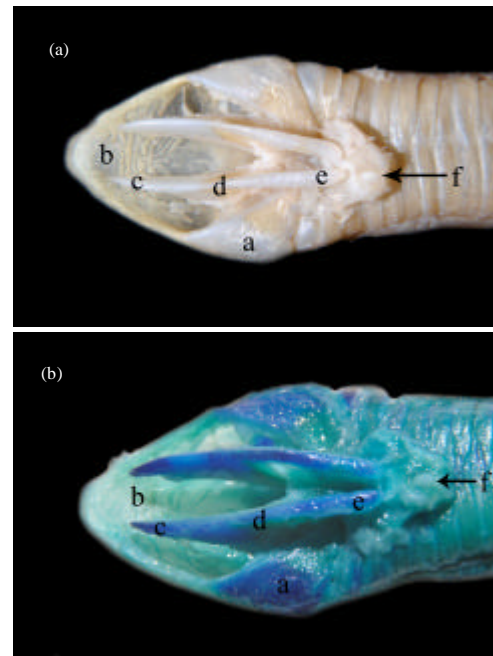


Fig. 2: a) Dorsal view of the larynx cartilages. a: Ala of cricoid cartilage, b: Corpus of cricoids cartilage, c: Rostral process of arytenoids cartilage, d: Corpus of arytenoids cartilage, e: Caudal process of arytenoids cartilage, f: Procricoid cartilage; b) Dorsal view of the laryngeal cartilages (Use make up metylene blue)

paired. The cricoid and arytenoid cartilages became partially ossified but procricoid cartilage was cartilage in nature. The cricoid cartilage supported ventral floor, lateral wall and dorsocaudally the structure of the larynx. It was left and right lateral wings and (Fig. 2a and b/a) a trough-like with a median body (Fig. 2a and b/b). The left and right wing connected dorsally with ligamentum

intercricoideum. There was a groove at middle of the ventral of the body. Posterior edge of the cricoid attached to the first tracheal ring with ligamentum tracheo-cricoideum. The margins of the glottis were shaped by the arytenoid cartilages. It was sickle-like and extended caudally pointing two ends. Each cartilage was formed by a rostral process (Fig. 2a and b/c), a body (Fig. 2a and b/d) and a caudal process (Fig. 2a and b/e). The caudal dorsal process extended up to the third tracheal ring and measured as 5.19 mm. The caudal ventral process was 2.65 mm whereas the rostral process was 3.38 mm in length. The procricoid cartilage was seen of the dorsal aspect of the third tracheal ring and end of the caudal processes of the arytenoid cartilage (Fig. 2a and b/f). It was the smallest of all laryngeal cartilages. The dilator and constrictor muscles were the intrinsic musculature of the larynx. The dilator glottidis muscle originated from caudodorsal and caudo-lateral of the cricoid cartilage wing and caudal process of arytenoid cartilage. This muscle attached to the processus rostralis and the lateral part of process of the arytenoid cartilages at caudal direction. The constrictor glottidis muscle deeply extended to the muscle dilator glottidis. The cricothyroideus dorsalis and ventralis arised from the dorsal and ventral muscle of the basibranchiale and inserted together on the ventral and ventro-lateral aspect of the cricoid cartilage.

Trachea: The trachea run as a gradually narrowing cylindrical tube that extended from the cricoid cartilage of the larynx to its junction with the syrinx (Fig. 3a, b and 5/a). The length of the rings from the right to the left were 9.05 mm at the beginning, 8.8 mm in the middle and 8.3 mm at the terminal. Furthermore the dorso-ventral length of the rings were 4.54 mm at the beginning, 4.23 mm in the middle and 3.95 mm at the terminal. Its length was approximately 12-13 cm.

At the begining, trachea was seen in the lateral plane and at first extended right to the esophagus after at the 1/4 of neck, the esophagus crosswised on the dorsal of the trachea then the esophagus deviated to the right. Thus, the trachea run at the left aspects of the esophagus and ventrally along the neck. The number of tracheal ring was observed changing from 107-110 and all the rings were complete and partially ossified.

There were short interannular ligaments between the rings. A narrowing that located medially at a direction of cranio-lateral length was noted only at the dorsal aspects of tracheal rings. This narrowing was highly prominent between 62nd and 65th of tracheal rings whereas it disappeared towards the caudal direction (Fig. 4a and b/a). The cranio-caudal width of the rings progressively decreased throughout the cranial of the the first 2-3 trachea (About 1.21 mm) and then progressively increased throughout the middle of the trachea (In the

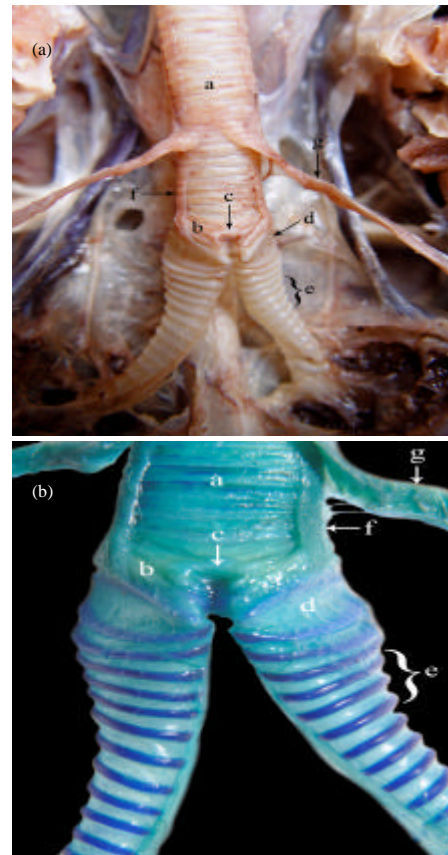


Fig. 3: a) Ventral view of trachea and syrinx. a: trachea, b: Syrinx, c: Pessulus, d: Membrana tympaniformis lateralis, e: Bronchus, f: Tracheolateral muscle, g: Sternotracheal muscle; b) Ventral view of trachea and syrinx (Use make up metylene blue)

widest rings the broad part of the rings was about 1.72 mm) then, decreased throughout the caudal and at last 2-3 of the trachea ring, the width was measured as 0.78 mm. The tracheo-lateral muscle (Fig. 4a, b/b, 4a and b/f) was originated from the lateral surface of the cricoid cartilage of the larynx and attached ventrolaterally to the pessulus. This muscle paired and formed a lateral band along the whole of the trachea. The sternotracheal muscle arised from the cranio-lateral process of the sternum and attached to the 96th tracheal ring (Fig. 3a and b/g). It was approximately 3 mm width and in a flattened band shape.

Syrinx: The syrinx was situated in the median aspects at about 0.3 mm cranial to the heart and dorsal of the sternocoracoid joint (Fig. 3a, b, 5/b). This organ was classified as bronchotracheal type. The last four or five tracheal rings and the first or the second bronchial rings

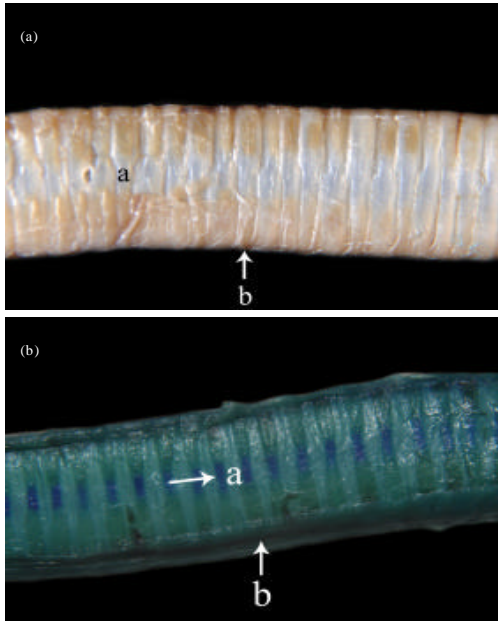


Fig. 4: a) Dorsal view of the trachea. a: Narrowed tracheal cartilages, b: Tracheolateral muscle; b) Dorsal view of the trachea (use make up methylene blue).

was modified in syrinx. The tympanum was the main component of the syrinx. The tympanum produced by the last four or five tracheal syringeal rings. First tracheal ring was complete, the last three or four tracheal rings were in a shape of half moon. The last two tracheal rings possessed ossified cartilages. The ventral ends of the first three tracheal syringeal cartilage was attached to the pessulus but the ventral and dorsal ends of the other cartilage were free.

The pessulus run ventrotransversally at the separation point of the bifurcatio trachea and the ossified bar located in the mid-transversal plane of the ventral ends of the first three tracheal syringeal cartilages (Fig. 3a, b, 5/c). The pessulus was almost an anchor shape. The transversal length of the pessulus measured 5.06 mm and cranio-caudal length of the body was 1.92 mm. The paired lateral tympaniform membrane occupied a place from the last tracheal syringeal cartilage to the first bronchial ring (Fig. 3a, b/d). Its cranio-caudal diameter was 3.49 mm and transversal diameter was 9.14 mm.

On these membranes, neither tracheal bronchial syringeal cartilage involvement nor tie ends of pessulus was noted because the pessulus dwelled at rather cranially of syrinx. The paired medial tympaniform membran was present from the dorsal end of the first tracheal syringeal cartilage to the end medial of the bronchial cartilages (Fig. 5/c). The widest part of this

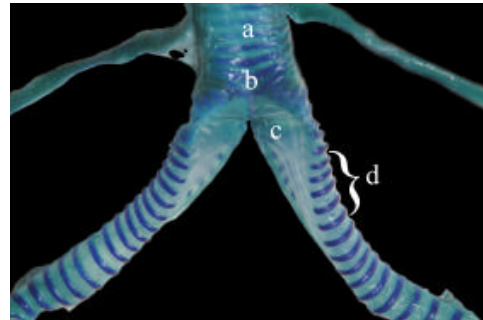


Fig. 5: Dorsal view of trachea and syrinx (Use make up methylene blue). a: Trachea, b: Syrinx, c: Membrana tympaniformis medialis, d: Bronchus

membrane was at the 5th tracheal syringeal ring, afterwards this width was reduced gradually as approaching to the bronchus.

The primary bronchi extended from the syrinx to the lung, its length was 2.3-2.5 cm (Fig. 3a, b/e and 5/d). The rings of primary bronchi were cartilagenous and 19-20 C shaped, opened end being medial and these ends supported the medial tympaniform membrane. The rings were 8.10 mm long at the beginning, 6.41 mm long towards the middle and 3.3 mm long at the end at the primary bronchi. Between the right and left primary bronchi, the ligamentum inter-bronchiale was not observed.

DISCUSSION

In EEO differing from other species such as corvus (Bock, 1978) in turkey (Getty, 1975), long-legged buzzard (Kabak *et al.*, 2007) and Japanese quail (Cevik-Demirkan *et al.*, 2007) had several cone shaped papillae at the each side of the mucosa of the mons laryngealis and margin of the glottis. Bock (1978) reported that laryngeal mound was covered with a number of posteriorly projecting papillae and terminates in a pair of posterior flaps in corvus. Long-legged buzzard possessed two rows of transversal papilla at the caudal of laryngeal mound (Kabak *et al.*, 2007) however, in the study the caudal part was comprised of four transverse rows of the papillae. Moreover in EEO, there were medial row of the papillae within the sulcus laryngeus similar to the findings of Tasbas *et al.* (1994) in penguin and Kabak *et al.* (2007) in long-legged buzzard. However, in this study, numbers of lateral and medial papillae were less than penguin (Seven papillae) and long-legged buzzard (Six papillae). The average length of glottis of EEO was longer and wider than long-legged buzzard (Kabak *et al.*, 2007) but this average length and width was shorter than chicken (Getty, 1975).

Resembling several bird species (Getty, 1975; Bock, 1978; King and McLellend, 1984; Kabak *et al.*, 2007), skeleton of the larynx in EEO consisted of a single cricoid, procricoid cartilages and a pair of arytenoid cartilages. The larynx cartilages in adult birds were partially ossified similar to the literature (King and McLellend, 1984; Baumel *et al.*, 1993). There was a clearly visible groove in the middle at the ventral of the body in cricoid cartilage dissimilar to the corvus (Bock, 1978), *Gallus domesticus* (King and Robert, 1965) and Denizli cock (Tasbas *et al.*, 1994). The cricoid cartilage was in a shape of sugar scoop in domestic fowl (King and McLellend, 1984) in duck (McLelland, 1990) but this cartilage was similar to the corvus (Bock, 1978) and was a trough like in EEO. The arytenoid cartilages lay along the body and (In nonpasserines) the wing of the cricoid cartilage but in the study it extended up the 3rd tracheal ring (Baumel *et al.*, 1993). The procricoid dwelled medially between two arytenoid cartilages in birds (King and McLellend, 1984; Baumel *et al.*, 1993) but in EEO, it was seen at the dorsal aspects of the third tracheal ring. The dilator glottidis muscle run from the cricoid cartilage to arytenoid cartilages as in most of the birds (Bock, 1978; Baumel *et al.*, 1993; Kabak *et al.*, 2007). Zweers *et al.* (1981) reported that the muscle cricothyroideus extended between the hyoid bone as in this study.

The trachea run in the midline ventral to the esophagus at the beginning, after 3-5 cm passed to the right side of the neck ventral to the esophagus according the study of Getty (1975) however, in EEO at the beginning, it run right to the esophagus, after the trachea at the left of the esophagus and paramedian plane. The number of tracheal ring change from species to species. There were 89-96 cartilagine tracheales in long-legged buzzard (Kabak *et al.*, 2007), 108-126 in *Gallus domesticus* (McLelland, 1965) and 112-116 domestic duck (Das *et al.*, 1965) but it was 107-110 in EEO. It was described that the tracheal ring overlapped (Piperno and Peirone, 1975; Mennega, 1964; McLelland, 1965) however, similar to long-legged buzzard in EEO it did not overlap but narrowed at dorsally, differing from long-legged buzzard.

The syrinx of EEO was a tracheo-bronchial type similar to falconidae (Griffiths, 1994b), grey parrot (Warren *et al.*, 1996) and long-legged buzzard (Kabak *et al.*, 2007). But different from domestic duck (Das *et al.*, 1965) situated almost median plane. In coturnix quail (Fitzgerald, 1970), it was a modification of the last three or four tracheal rings and the first bronchial ring but in EEO the last four or five rings and first one or two bronchial rings shaped the syrinx. The tympanium was formed by the last four or five tracheal syringeal rings in EEO but formed by the first four tracheal rings and first bronchial ring in crows (Chamberlain *et al.*, 1968), three or

four tracheal rings in pigeons (Zweers *et al.*, 1981), from three to eight rings in the falconidae (Griffiths, 1994b), four rings in Denizli cocks (Tasbas *et al.*, 1994) and three rings in long-legged buzzard (Kabak *et al.*, 2007). In the study, the first tracheal ring was complete, last three or five tracheal rings were in a shape of half moon. In the falconidae (Griffiths, 1994b), they fused partially or completely near the tracheo-bronchial junction, forming tympanium. In this study, the pessulus ossified bar located in the mid-transversal plane of the ventral ends of the first three tracheal syringeal cartilages and in an anchor shape, however in the falconidae ossified pessulus fused dorsally and ventrally to the tympanium (Griffiths, 1994b). In some subspecies of the North American owls (Miller, 1934) the cartilaginous bar runs dorso-ventrally and marks the beginning of the division of the single tracheal passageway into the bronchial chamber. The pessulus in Japanese quails (Cevik-Demirkan *et al.*, 2007) it attached to the first bronchial and last tracheal rings, in long-legged buzzard (Kabak *et al.*, 2007) dorsal end was pointed and ventral portion was wide. The medial tympaniform membrane in the study and in falconidae (Griffiths, 1994a) was present from the dorsal ends of the first tracheal syringeal ring to the medial aspects of the bronchial cartilages but Nickel *et al.* (1977) and Fitzgerald (1970) stated that arising from both sides of the pessulus this membrane formed the medial wall of the ipsilateral main bronchus, this membrane was common in crows (Chamberlain *et al.*, 1968) and in birds (King and forming the most of the medial surface of the divergent part of the syrinx, being held between the free ends of the bronchial syringeal cartilages. Similar to the study of Bayram and Liman (2000) in EEO, the lateral tympaniform membrane run from the last tracheal syringeal ring to first bronchial ring however, it extended from the caudal edge of the last intermediate cartilage to the cranial edge of the first caudal cartilage being attached dorsally and the ventrally to the pessulus in aves (Getty, 1975) and often it taken the form of indistinct straps between the bronchial syringeal cartilages as in songbirds; more rarely as in domestic fowl, it consists of relatively extensive sheet between the last tracheal syringeal cartilage and the first bronchial syringeal cartilage. The external membrane in falconid (Griffiths, 1994a, b) was located from the second to the fifth bronchial rings.

The bronchial rings of the syrinx in American owls (Miller, 1934), aves (Getty, 1975), fowl (Morejohn, 1966), quail (Bayram and Liman, 2000), collared dove (Ballintijn and Cate, 1997) and in this investigation were in C-shape and between the dorsal and ventral ends of the bronchial rings that were hold by medial tympaniform membrane. In collared dove (Ballintijn and Cate, 1997), the number of bronchial rings, both left and right, a

component that differed significantly between males and females, a significant bilateral asymmetry in the number of bronchial rings occurred in both sex with the right bronchus containing of more rings than the left but in EEO there was no sexual differences. The number of bronchial rings were 19-20.

CONCLUSION

The study shows that the larynx, trachea and syrinx in EEO were investigated and similarities and dissimilarities were compared with other avian species. Morphologically there was no sexual dimorphism among EEOs. Further studies need to be carried out to determine the ultrastructural differences in the larynx, trachea and syrinx in EEO and to elucidate its association with the flight abilities if exists.

ACKNOWLEDGEMENT

This study was financially supported by Scientific Research Projects Coordinating Unit of Afyon Kocatepe University (Project No. 08.VF.09).

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