Anatomical Structure of the Syrinx in the Mallard (*Anas platyrhynchos*)

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Abstract: The aim of this study was to investigate the normal anatomical and histological features of the syrinx in adult male and female mallards (*Anas platyrhynchos*). Eight mallards (five female, three male) weighing 1244±114 g were examined. It was observed that the syrinx in mallard was tracheabronchial type formed by tympanum, cartilagines tracheosyringeales and cartilagines bronchosyringeales. Tympanum and cartilagines tracheosyringeales were formed from four and six cartilage rings, respectively, while cartilagines bronchosyringeales was formed from C-shaped cartilage rings. It was found that pessulus was contained ossified tissue partially and was extended into cavum syrinx as wedge-shaped. It was determined that syrinx in male ducks was found to be asymmetrical and had a large expansion on the left side called bulla tympaniformis. The right and left bronchus primarius were bound together by a tight ligamentum interbronchiale. Membrana tympaniformis medialis was extending from pessulus to the 3th cartilago. bronchosyringealis ring. Membrana tympaniformis lateralis was found to be between the last tympanum ring and the 1st cart. bronchosyringealis ring. Histological examinations of both pesulus as well as syrinx partially ossified structure were determined.
Keywords: *Syrinx, mallard, bulla tympaniformis*

Yeşilbaş Ördekte Syrinx'in Anatomik Yapısı (*Anas platyrhynchos*)

Özet: Bu çalışmada erişkin dişi ve erkek yeşilbaş ördeklerde (*Anas platyrhynchos*) syrinx'in normal anatomik ve histolojik özelliklerinin incelenmesi amaçlanmıştır. Ağırlıkları 1244±114 g olan sekiz adet yeşilbaş ördek (beş dişi, üç erkek) incelendi. Syrinx'in tracheobronchial tip olduğu ve tympanum, cartilagines tracheosyringealis ve cartilagines bronchosyringealis'ten meydana geldiği gözlendi. Tympanum ve cartilagines tracheosyringeales sırasıyla dört ve altı kıkırdak halkasından, cartilagines bronchosyringeales ise "C" şeklinde kıkırdak halkalarından oluşmuştu. Pessulus'un kısmen kemiksel bir yapıda olduğu ve cavum syrinx'in içine doğru kama şeklinde uzadığı saptandı. Syrinx'in erkek ördeklerde asimetrik olduğu ve sol tarafta bulla tympaniformis adı verilen büyük bir genişleme yaptığı tespit edildi. Sağ ve sol bronchus primarius'ların gergin bir ligamentum interbronchiale ile birbirine bağlandığı görüldü. Membrana tympaniformis medialis'in pessulus ile 3. cartilago bronchosyringealis halkası arasında uzandığı saptandı. Membrana tympaniformis lateralis'in son tympanum halkası ile 1. cartilago bronchosyringealis halkası arasında bulunduğu tespit edildi. Histolojik incelemede hem pessulus'un hem de syrinks'in kısmen kemiksel yapıda olduğu belirlendi.
Anahtar Kelimeler: *Syrinx, yeşilbaş ördek, bulla tympaniformis*

Introduction

The syrinx is the vocal organ of songbirds, located at the base of trachea (Koch, 1973; König, 2001; Yıldız et al., 2003). The German anatomist classified bird species by their syringeal anatomy already in 1878 (Müller, 1878). Subsequently, there have been a number of detailed studies of syringeal anatomy (Ames, 1971; Frank et al., 2007; Lockner, 1976). As with the mammalian larynx, sound is produced by the vibration of air flowing through the organ. Like the human larynx, however, the syrinx consists of specialised cartilaginous structures, connective tissue masses, membranes and a number of muscles (Larsen and Goller, 2002). Three different types of syrinx, namely tracheobronchial, tracheal and bronchial, can be found according to distinction between tracheal and bronchial elements of syrinx and topographical position of the main sound producing mechanism (Baumel, 1993; King and Mclelland, 1984; Nickel et al.1977). The embryonic development of the syrinx of the duck and its skeletal anatomy, have been described for both sexes (Broman, 1942; Frank et al., 2007; Joshgard, 1961). The macroscopical structure of the syrinx in songbirds has long been known. The embryonic development of the syrinx of the duck, and its skeletal anatomy, have been described for both sexes (Broman, 1942; Frank et al., 2007; Scala et al., 1990), but detailed information on the anatomy of the syrinx of mallards has generally been lacking. In the present study, we investigated the topographical, anatomical and histological features of the syrinx in this species.

Materials and Methods

A total of eight adult mallards were used in this study. The mallards were provided from the Balıkesir region in Turkey. They included 5 female, 3 male. The mallards had an average weight of 1244±114 g. Firstly, the coelom was opened and the syrinx was observed at the terminal part of the trachea. After pointing out the topographic features precisely, then sections were made 4 cm to the dorsal side of the trachea and 4 cm to the ventral side of syrinx. The tissue was fixed in 10% formalin for at least 48 hours. Peripheral membrane was removed and the morphological characteristics were investigated by means of a magnifying glass. To acquire a clear vision of the cartilagines, terminal part of the trachea and syrinx were left in 70% alcohol for two hours, then in 0.1% methylene blue solution, prepared with water, for 15 minutes and in 50% and 70% alcohol for 1 hour respectively (Taşbaş, 1994).

The syringeal tissues were fixed in 10% neutral buffered formalin and processed routinely for histological examination. Sections (6 µm) were cut and stained with haematoxylin and eosin (H&E). Photographs were taken with Canon EOS 1100D. The International Committee on Avian Anatomical Nomenclature was used for terminology (Baumel et al., 1993).

Results

The syrinxes were observed to extend ventral to the esophagus and between the caudal end of the trachea and the beginning of the primary bronchi (Figure 1). It was tracheobronchial type, which formed tympanum, tracheosyringeal cartilage and bronchosyringeal cartilage respectively. The tracheosyringeal cartilages were composed from six rings. The first two of these rings which are at cranial were oval shaped. The least 4 caudal rings were observed as C-shaped.

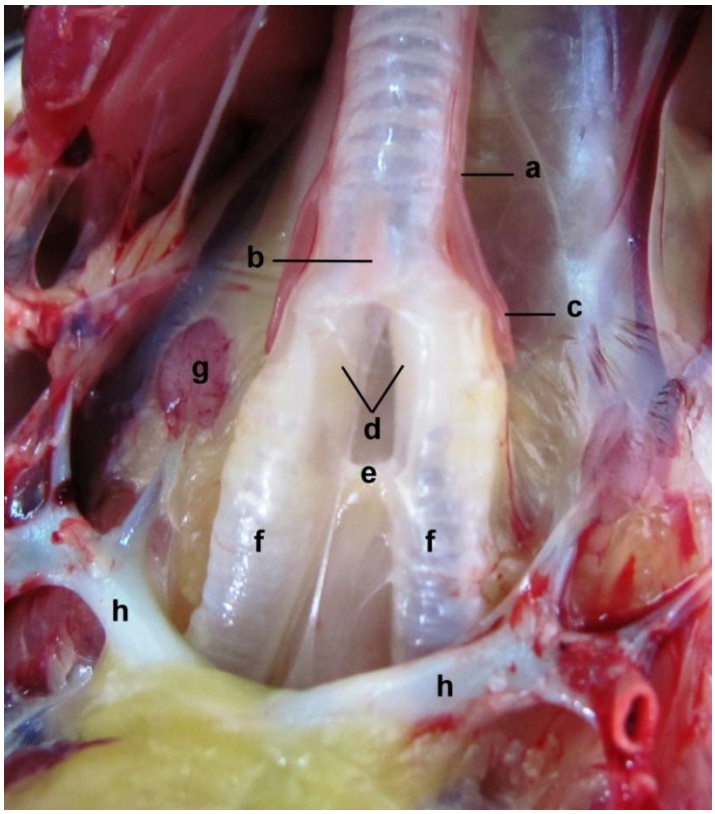

Figure 1. Ventral view of body cavity in the female mallard. Tracheolateral muscle (a), pessulus (b), sternotracheal muscle (c), right and left medail tympaniform membran (d), interbronchial ligament (e), right and left primary bronchi (f), thyroid gland (g), right and left brachiocephalic trunk (h).

The tympanum was formed from four C-shaped cartilage rings. While the dorso-ventral diameters of these rings were increasing caudally, transversal diameters were decreasing. The cranial tracheal notches were not formed in these rings. It was determined that syrinx in male ducks was found to be asymmetrical and had a large expansion on the left side called bulla tympaniformis (Figure 2). Bulla tympaniformis was not observed in female ducks.

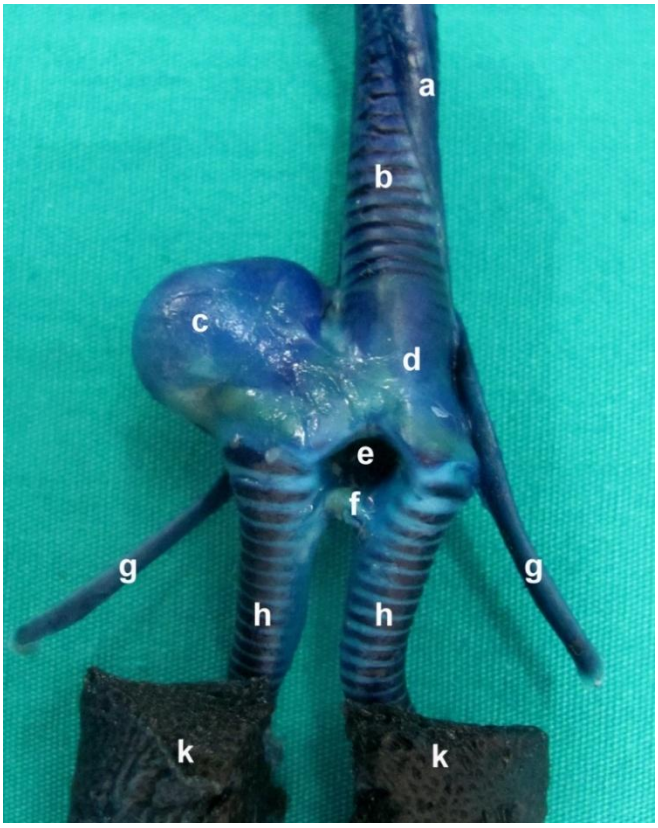

Figure 2. Dorsal view of the syrinx in the male mallard. Tracheolateral muscle (a), trachea (b), syringeal bulla (c), tympanum (d), interbronchial foramen (e), interbronchial ligament (f), sternotracheal muscle (g), right and left primary bronchi (h), lung (k).

The bronchial rings were smaller than the tracheal rings and were incomplete medially**.** It was also determined left and right cartilagines bronchiales were asymmetrical in female ducks. It was observed that the bronchial cartilages on the left were more and greater than the right and were more ossified. Except the first, these cartilages had no relation with pessulus. Both the latero-lateral and dorso-ventral diameters were decreasing caudally.

The medial walls of the right and left bronchus primarius fused at the level of the bifurcatio tracheae and formed quite ossified pessulus, which extending dorsoventrally. Pessulus was observed as wedge-shaped. A strong ligamentum interbronchiale connecting the right and left bronchus primarius was observed. There was a foramen interbronchiale between the ligamentum interbronchiale and the pessulus.

It was observed that membrana tympaniformis medialis was extending from caudal of the pessulus, approximately up to the level of 3th cartilago bronchosyringealis. Membrana tympaniformis medialis covered the medial parts of the C-shaped 1st and 3th cartilago bronchosyringealis tightly. Membrana tympaniformis lateralis stretched between the last tympanum ring and the first cartilago bronchosyringealis, and supported by cartilagines tracheosyringeales from lateral sides. Whereas the intrinsic muscles were lacking in the syrinx, there were two extrinsic muscles (the sternotracheal muscle and the tracheolateral muscle). The tracheolateral muscle was located at the side of the trachea laterally.

In histological sections, tracheal rings and bronchial rings (cartilagines bronchosyringeales) were ossified to various grades in the examined

specimens. In the examined specimens the pessulus was almost completely ossified (Figure 3). The last trachea ring with bronchial the cartilage between the located syrinksin histological structure consist of lamina epithelialis of the mucosa is lined with pseudostratified columnar epithelium. The epithelial layer has settled on the lamina propria consist of dense and submucosa connective tissue. The submucosa consists of rich loose connective tissue, oil cells and small blood vessels. The almost completely ossified rings of syrinx had settled between elastic fibers in submucosa. Below the submucosa, longitudinal run with a thick muscle layer located (Figure 4).

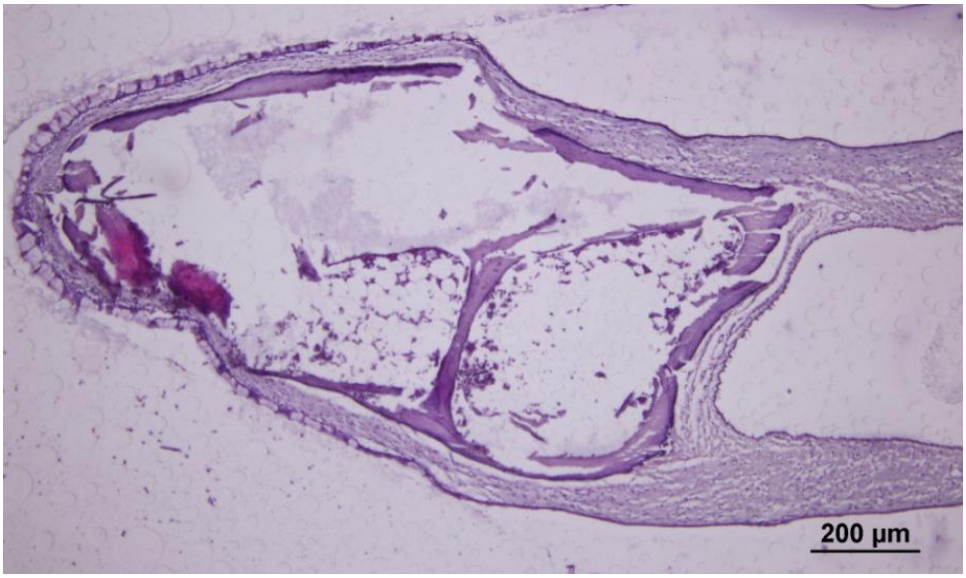

Figure 3. Histological section of the pessulus. H&E, 10x orijinal magnification.

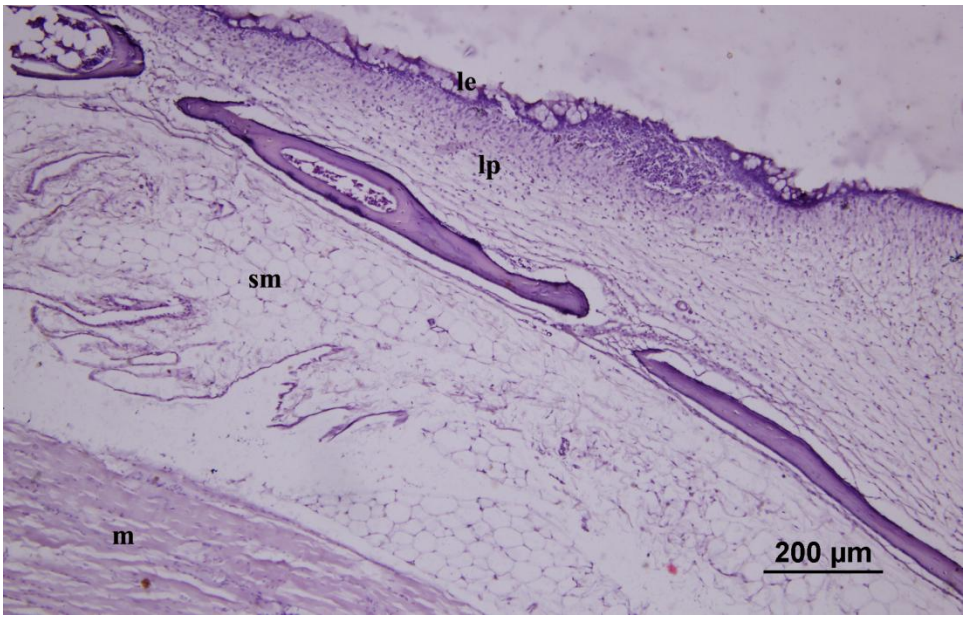

Figure 4. Histological section of the syrinx. H&E, 10x orijinal magnification. Lamina epithelialis (le), lamina propria (lp), submucosa (sm), muscular layer (m).

Discussion

The syrinx in the mallards could be classified to be tracheobronchial type as described in most common birds such as duck (Frank, 2007), hen (Hummel, 2000; King, 1989; Nickel et al., 1977), ostrich (Yıldız et al., 2003), Bursa roller pigeon (Yıldız et al., 2005), white turkey (Arican et al., 2007; Khaksar et al., 2012), goose (Onuk et al., 2010), long-legged buzzard (Kabak et al., 2007) and quails (Bayram and Liman, 2000; Çevik et al. 2007). The topographical findings of the syrinx in the mallards has similarities to those of the turkey (Cover, 1953), Bursa roller pigeon (Yıldız et al., 2005), white turkey (Arican et al., 2007), Denizli rooster (Taşbaş et al., 1994) and goose (Onuk et al., 2010).

There are studies reported that the number of cartilagines tracheosyringeales could be 8 (Lockner and Youngner, 1976; Warner, 1971) or 10 (Frank et al., 2007). Frank et al. described this variation in the number of these rings depends on the fusion of the cartilages. We concluded this variability to be normal in our study due to the structural difference between male and female syrinx.

The tympanum was composed of four tracheal cartilage rings different from those described in the Bursa roller pigeon (Yıldız et al., 2005), long-legged buzzard (Kabak et al., 2007), sea gulls (İnce et al, 2012), goose (Onuk et al., 2010) and Japanese quails (Çevik et al., 2007). The pessulus in the mallard was composed of bone tissue as in singing birds (Frank et al., 2007; Taşbaş et al., 1994; Warner, 1972b), but different from that in ostrich (Yıldız et al., 2003) and chickens (King, 1989).

It was reported that male duck have pear-shaped bulla syringealis in their left brounchus primarius (Frank et al., 2007; König and Liebich, 2001) whereas penguens and ostriches do not have (Yıldız et al., 2003). It was clear in our study that male mallards have this structure. The lateral and medial tympaniform membranes were in the same location as of turkey (Cover, 1953), Denizli roosters (Taşbaş et al., 1994), Japanese quails (Çevik et al., 2007) and ostriches (Yıldız et al., 2003). The medial tympanic membrane covers the open ends of the bronchosyringeal cartilage as reported in some other species (Larsen and Goller, 2002; Nickel et al., 1977). There were two extrinsic muscles, sternotracheal and tracheolateral. They were located at the side of the trachea (Kabak et al., 2007; Taşbaş et al., 1994; Yıldız et al., 2005).

In conclusion, the syrinxes of the mallards were examined. Although the topographical and histological characteristics of the syrinx showed close resemblance to that of other bird species, some differences were observed regarding its anatomy.

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