MORPHOLOGICAL STRUCTURE OF THE SYRINX IN THE BURSA ROLLER PIGEON (COLUMBA LIVIA)

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Received for publication July 06, 2005.

Abstract

The aim of this study was to investigate the topographical, anatomical and histological characteristics of the syrinx in 18 Bursa Roller Pigeons. The study showed that the syrinx in pigeons was of tracheobronchial type and was composed of tympanum, cartilagines tracheosyringeales, and cartilagines bronchosyringeales. Tympanum and cartilagines bronchosyringeales were formed from 5 cartilage rings, while cartilagines tracheosyringeales were formed from 4 C-shaped cartilage rings. The pessulus was made up of a double-folded mucous membrane extending dorsoventrally from median walls of the bronchus primarius into the cavum syringis. The membrana tympaniformis lateralis filled the distance between the third and fourth cartilagines tracheosyringeales rings. The membrana tympaniformis medialis covered the distance between the medial ends of the cartilagines bronchosyringeales rings. There were 2 syringeal muscles termed tracheolateral and sternotracheal. The lamina epithelialis of the mucosa was lined with non-cornified stratified squamous epithelium.

Key words: pigeons, Columba livia, syrinx, anatomy.

The Bursa Roller Pigeon lives in the South Marmara Region in Turkey. Special attention has been paid by breeders to protect the pureness of this race. Important distinguishing feature of this race is their fastidious vocal organ, called syrinx, allowing them to produce their special song pattern (20, 13, 15). Its morphological structure has been investigated in some bird species. It is located in the terminal part of the trachea and the first part of the two main bronchi (6, 10, 11, 16, 23, 25). Its morphological structure has been investigated in some bird species. It is located in the terminal part of the trachea and the first part of the two main bronchi (6, 10, 11, 16, 23, 25). The skeleton of the tracheobronchial type of the syrinx is composed of 3 different parts, i.e. tympanum, cartilagines tracheosyringeales (CTS) and cartilagines bronchosyringeales (CBS) (2, 15, 16, 24).

Two membranes, membrana tympaniformis lateralis (MTL) and membrana tympaniformis medialis (MTM), are involved in the formation of sound in the bird syrinx (13). The sound can be altered by a complex of extrinsic and intrinsic muscles surrounding the syrinx (16). The syrinx mucosa consists of either bistratified squamous (1), columnar (3, 5, 17), or pseudostratified prismatic epithelium (22).

In our knowledge, up to date no scientific study has been carried out to characterize the structure of the syrinx in the Bursa Roller Pigeon. In the present study, we investigated the topography, anatomy, and histology of the syrinx in this species. The results of this research may useful in operations of the syrinx in this species.

Material and Methods

Eighteen (9 male and 9 female) Bursa Roller Pigeons (Columba livia), which died due to various causes, were obtained from the South Marmara Region pigeon raisers. All the pigeons were 2-year-old and had an average weight of 234.40 ± 11.12 g. Firstly, the body cavity was opened and the syrinx was observed in the terminal part of the trachea. After pointing out the topographic features precisely, sections were made 6 cm to the dorsal side of the trachea and 4 cm to the ventral side of the syrinx. The morphological characteristics were investigated by means of a magnifying glass and measurements made with a digital compass (Mitutuyo Corporation, Kawasaki, Japan). For histological investigation, the tissue was fixed in 10% formalin for at least 72 h. After routine processing and embedding in paraffin, 6 µm tissue sections were cut, stained with haematoxylin and eosin, and 10 µm sections were cut and stained with Pincus acid orcein-Giemsa for the demonstration of the elastic fibers surrounding the cartilages (17). Sections were investigated under a light microscope (Nikon Optiphot-2, Nikon Corporation Imaging Company, Japan) and photographed (Nikon FA-35DX, Nikon Corporation Imaging Company, Japan).

Statistical analysis was performed by Minitab statistical package (for Windows version 11). The ANOVA was used to investigate comparison of the means.

For the terminology, the Nomina Anatomica Avium (14) was used.
Results

The pigeon syringes were observed to lie at the dorsal side of the glandular stomach, ventrally of the oesophagus and between the terminal part of the trachea and bronchus primarius (Fig. 1). On the ventral surface of the syrinx displayed itself the membrana tracheosyringealis associated with the thin tympanum and CTS in the midline. This membrane was not seen on the dorsal surface of the syrinx. The skeleton of the syrinx was composed of 3 different cartilage groups. These were the tympanum, CTS and CBS (Fig. 2). The results of the measurements of the laterolateral (LLD) and dorsoventral (DVD) diameters of these parts are presented in Table 1.

![Image]

**Fig. 1.** Ventral view of the syrinx in the pigeon within the body cavity. Syrinx (s), oesophagus (e), pessulus (p), membrana tympaniformis medialis (m).

**Table 1**

Mean laterolateral and dorsoventral diameters of the syringeal cartilages (mm)

<table>
<thead>
<tr>
<th></th>
<th>First ring</th>
<th>Third ring</th>
<th>Fourth ring</th>
<th>Fifth ring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tympanum</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLD</td>
<td>5.10 ± 0.15</td>
<td>-</td>
<td>-</td>
<td>5.53 ± 0.12</td>
</tr>
<tr>
<td>DVD</td>
<td>3.64 ± 0.11</td>
<td>-</td>
<td>-</td>
<td>4.03 ± 0.09</td>
</tr>
<tr>
<td><strong>CTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLD</td>
<td>5.67 ± 0.13</td>
<td>5.87 ± 0.15</td>
<td>5.22 ± 0.12</td>
<td>-</td>
</tr>
<tr>
<td>DVD</td>
<td>4.33 ± 0.14</td>
<td>5.03 ± 0.14</td>
<td>4.53 ± 0.10</td>
<td>-</td>
</tr>
<tr>
<td><strong>CBS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLD</td>
<td>2.36 ± 0.06</td>
<td>-</td>
<td>-</td>
<td>1.94 ± 0.06</td>
</tr>
<tr>
<td>DVD</td>
<td>4.12 ± 0.15</td>
<td>-</td>
<td>-</td>
<td>3.25 ± 0.12</td>
</tr>
</tbody>
</table>

* P < 0.05; ** P < 0.001; ± SD.
Fig. 2. Dorsal view of the pigeon syrinx. *Tympanum* (t), Fifth *tympanum* ring (t5), *cartilago tracheosyringealis* 3 (ts3), *cartilago bronchosyringealis* (bs), *cartilago bronchosyringealis* 1 (bs1), *membrana tympaniformis lateralis* (l), *membrana tympaniformis medialis* (m), *m. sternotrachealis* (st), *m. tracheolateralis* (tl).

Fig. 3. Histological section of the pigeon syrinx. Non-cornified stratified squamous epithelium (e), mucous gland (g), *lamina propria* (lp), elastic fibres (el), hyaline cartilage (h), *tunica muscularis* (tm). Pincus acid orcein-Giemsa stained, bar 50 µm.
The *tympanum* was formed from 5 oval-shaped cartilage rings pressed dorsoventrally. Because of its cylindrically formed cartilages, it was different from *CTS*. The average length of the *tympanum* was 4.11 ± 0.09 mm and from cranial to caudal, both LLD and DVD of these rings were increasing. In fact, the *CTS* which are generally known as a part of the *tympanum*, in our case appeared as a separate part. Ventral and dorsal ends of *CTS* were not joined each other. The composition of *CTS* was constituted from four cartilage rings having an average length of 5.15 ± 0.13 mm. The *CTS* were ovaly shaped and its LLD were larger than DVD. But, the diameter of the third cartilage was larger than that of the fourth cartilage. The largest distance was 1.72 ± 0.06 mm in middle and 2.84 ± 0.09 mm in the lateral part. The space between the third and fourth ring was filled by a membrane known as *MTL*. The *CBS* consisted of five C-shaped half-rings and their average length was 3.39 ± 0.12 mm. Both the LLD and DVD of these rings decreased caudally. The distance between the medial ends of the rings also decreased caudally from 3.56 ± 0.17 mm to 2.74 ± 0.16 mm and this distance was covered by *MTM* (Fig. 1).

The medial walls of the right and left bronchus primarius fused at the level of the bifurcatio tracheae and formed the *pessulus*, which extended dorsoventrally as a double-folded mucous membrane (average dorsoventral length 4.00 ± 0.17 mm). A *ligamentum interbrachionale* connecting the right and left bronchus primarius was not observed (Fig. 1). Whereas the intrinsic muscles were lacking in the syrinx, there were two extrinsic muscles. The sternotracheal (ST) muscle, one of the extrinsic muscles of the syrinx, was located (average 14.82 ± 0.36 mm) above *pessulus*. The tracheolateral (TL) muscle, another extrinsic muscle was located at the side of the trachea laterally of the ST muscle to *MTL* and it was inserted on *MTL* (Fig. 2).

In histological sections, taken from the level of the third and fourth *CTS*, the *lamina epithelialis* of the mucosa was lined with non-cornified stratified squamous epithelium. There were *cilia* on the apical surfaces of the epithelial cells. The *lamina propria* and the submucosa which were placed under the epithelium were composed of compact elastic fibres and loose connective tissue, respectively. The most peripheral portion of the *propria-submucosa* of *lamina epithelialis* contained small numbers of mucous glands. Pincus acid orcein-Giemsa stain revealed that the submucosa displayed dark-brown stained elastic fibers. Deep to this loose connective tissue was a prominent *stratum* of longitudinally oriented elastic fibers between the hyaline cartilages of the syrinx. A longitudinal muscular layer was found throughout the section. The outermost layer of the section, the *tunica adventitia*, consisted of loose connective tissue. In the trachea, the *lamina epithelialis* of the mucosa was lined with pseudostratified, columnar, ciliated epithelium with goblet cells. The *lamina propria* and the submucosa, which contained loose connective tissue and mucous glands, were found below the epithelium. Throughout the section, a thin longitudinal muscle layer was observed in the trachea (Fig. 3).

**Discussion**

The morphological structure of the syrinx has been described in many bird species (4, 8, 9, 11, 15, 22, 24). This study presents some characteristics of this organ in pigeon. Since both the trachea and bronchus primarius participated in its formation, the syrinx in the pigeon could be classified as of tracheobronchial type comparable to that of chickens (13, 15, 19). This type of syrinx is the most common type in birds (13). The topographical findings of the syrinx in the pigeon were comparable to those of the chicken (6, 7, 15, 19), new world pigeon (4) and ostrich (25).

The *tympanum* was composed of 5 tracheal cartilage rings different from those described in the chicken (2, 6, 7, 15, 18, 19), new world pigeon (4), singing birds (21), and duck (22). The *CTS* are composed of four C-shaped cartilage rings as in chickens (6, 7, 15, 19) and in ostrich (25). Although the *CTS* was described for several species as joined part of the *tympanum* (15), we found out that in Bursa Roller Pigeons *CTS* appeared as a separate cartilage groups. The *CBS* were composed of 5 C-shaped half-rings as described for new world pigeons (4) but different from those in other birds (15, 18, 19, 22, 24, 25).

The *pessulus* in pigeons was composed of connective tissue as described in new world pigeons (4) and ostrich (25). This structure is cartilaginous in chickens (6, 15, 18, 19) and ossified in singing birds (11, 24). The connective tissue structure of the *pessulus* in pigeons is probably due to the fact that the pigeon is not a singing bird and thus neither osseous nor cartilaginous structure is needed to keep the *pessulus* tight.

Vibrating membranes are present in the walls of the bronchi. The *MTL* in pigeons was in the same location as described for the *MTL* of new world pigeons (4) and pigeons (8, 18) and a different location was found out in the chicken (2, 7, 15, 19), gull (15), singing birds (24) and ostrich (25). This membrane is defined as the sound organ in many avian species (15) and the TL muscle inserts to this membrane so it can produce significant sound. The *MTM* covers the open ends of the *CBS* as reported in some other species (2, 4, 6, 8, 9, 10, 11, 15, 19, 23).

The syringleal muscles are paired, lie to the right and left sides of and are divided into two groups, extrinsic and intrinsic. Extrinsic muscles are the ST and TL in domestic fowl. Intrinsic muscles are found in singing birds, suboscine passeriformes, and parrots (2, 16, 21, 23). The TL muscle is found only in the pigeon (18). In this study, extrinsic muscles, TL and ST, were observed in pigeon syrinx. The TL muscle was connected to the *MTL*, so it might vibrate against *MTL* and thus produce the sound. A second muscle, ST, draws the cartilages to each other and so *MTL* is kept under tension.

The histological structure of the syrinx has been investigated in only few bird species. Of those, the
The histological structure of the syrinx in the pigeon was similar to that of the chicken (12), duck (22), and ostrich (25). The mucosa lining, in particular, was the same as that of the chicken and duck (3, 5, 12, 22).

This study presents some of the characteristics of the sound organ in pigeons. 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.

References