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**Research Article**

# GROSS MORPHOLOGICAL STUDIES ON THE AIR SACS (*SACCI PNEUMATICI*) OF GOLDEN PEKIN DUCK (*ANAS PLATYRHYNCHA)*

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## ABSTRACT

The aim of this study was to investigate the anatomical features of the air sacs *(Sacci pneumatici)* in mature Golden Pekin ducks *(Anas platyrhynchos)*. Air sacs of ten adult birds were injected via trachea with Kem-apoxy No 150 and colored latex for polymerization to demonstrate the origin, morphology of the air sacs and invaded bone tissues. They were macerated with concentrated hydrochloric acid (98%) for 2-3 days at room temp., cleaned with tap water, colored by acrylic dyes and photographed. The morphology of the cervical and clavicular air sacs presents no detectable changes from the previous authors. The cranial thoracic air sacs were smaller than the caudal sacs pneumatising the third to seventh ribs by their diverticula. The caudal thoracic air sac had no diverticulum. The right abdominal air sac was bigger than the left air sac. Moreover, the left abdominal air sac had two portions, i.e. the cranial and caudal sacs; the former being smaller and narrower, the latter aerating the last two ribs, synsacrum and femur.

**Key words**: Anatomy, Air sacs, Golden Pekin duck

The respiratory organs of birds differ from mammals in some specific features; mostly associated with requirements of flight, voice production and thermoregulation mechanism (King, 1975; Vollmerhaus and Sinowatz, 1992). The lungs are small and very vascular, but the air sacs are eight in number, namely; unpaired cervical and clavicular sacs, paired cranial and caudal thoracic sacs and abdominal sacs (Nickel *et al*., 1977; Mclelland, 1990; Tasbas *et al*., 1994; Powell, 2000; Duncker, 2004; Demirkan *et al*., 2006a,b; Sawad and Udah, 2012). Air sacs pass among the viscera and even extend into many of the bones (Duncker, 2004; Demirkan *et al*., 2006a,b; Sawad and Udah, 2012). Pekin ducks are transported from Europe to Egypt. The ducks might have a role in distribution of avian influenza virus and can be responsible for avian flu in chickens in Middle East region. Morphology of the air sacs in several avian species has been well documented (Rigdon *et al*., 1958; Lucas *et al.*, 1959; Akester, 1960; King and McLelland, 1984; Dyce *et al.*, 1996; Butler and Bishop, 2000; Demirkan *et al.*, 2006a; Sawad and Udah, 2012). The present study is aimed to investigate the features of the air sacs, and document the differences, if any, to further expand our knowledge with contribution to the literature.

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## MATERIALS AND METHODS

The present work was undertaken on 10 adult Golden Pekin ducks. After anesthetizing the ducks by chloroform in air tight box, three adult ducks were injected via trachea with Kem-apoxy No 150 (consists of 2 solutions A and B, which were mixed in a ratio of 2:1). The injected specimens were left in the open air for 2- 3 days for solidification of Kem-apoxy. The specimens were macerated with concentrated HCL (98%) for 2-3 days for corrosion. Lastly, the specimens were gently washed in running tap water until became free from the macerated tissue. The cast of air sacs was rinsed under running tap water, colored externally by acrylic dyes with different colors and photographed. The remaining seven adult ducks were injected via trachea with colored- latex (using Rotring® ink). The materials were left to become firm and the soft tissues were dissected. Finally, the soft tissues were removed and rinsed with tap water.

## RESULTS AND DISCUSSION

The air sacs were revealed by corrosion cast method and status of their diverticula were observed (Figs. 1, 2 and 3) while the origin of each air sac from the lung was demonstrated by dissecting the latex specimens (Figs. 5, 8 and 9). No sexual differences

Fig 1. A photograph showing colored cast of the lung and air sacs in golden pekin duck (Lateral view)

Fig 2. A photograph showing colored cast of the lung and air sacs in golden pekin duck (Dorsal view)

Fig 3. A photograph showing colored cast of the lung and air sacs in golden pekin duck (Ventral view)

associated with air sacs in ducks were noted in this study. The prominent features of each sac were:

**Saccus Cervicalis:** The cervical sac was bilaterally located lateral to the last two cervical and first two thoracic vertebrae, and medial to the lungs (Fig. 5/B). It communicated with the lungs via the first medio-ventral bronchi (Figs. 5, 8 and 9/B3). The sac had two diverticula; the vertebral diverticula, *diverticula vertebralia* (Figs. 2 and 5/B1), passed along the transverse and vertebral canals of the first two thoracic vertebrae that extended up to the first cervical vertebra, were fully developed and aerated the first two ribs. The

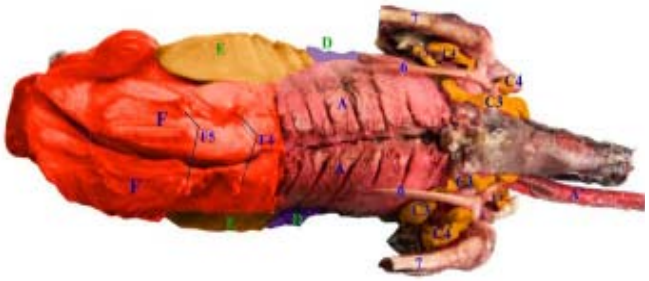

Fig 4. A photograph showing the lung and air sacs in golden pekin duck (Dorsal view)

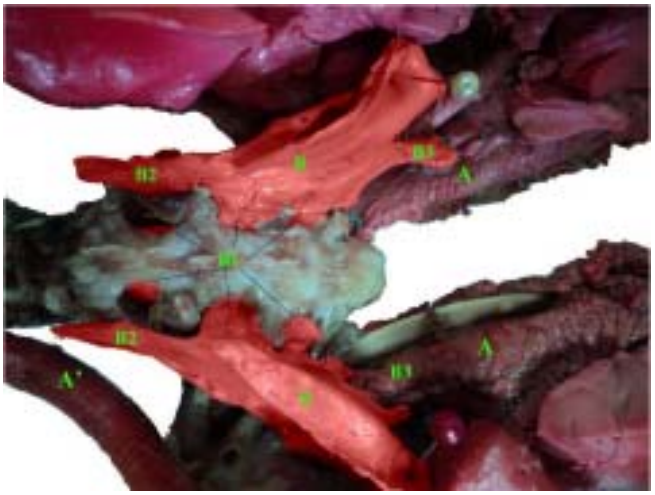

Fig 5. A photograph showing the cervical air sac in golden pekin duck (Ventral view)

second diverticulum was intermuscular diverticula, *diverticula intermuscularia* (Fig. 5/B2**)**, protruded in a spear like shape between the cervical vertebrae and muscles, and measured approximately 1-2 cm long. The cervical sac aerated the first two thoracic and all the cervical vertebrae except the first one. However, the last five thoracic vertebrae were aerated directly by the lungs.

**Saccus Clavicularis:** The clavicular sac was formed by the fusion of the bilaterally located diverticula under the trachea and attachment of the wings to the body (Figs. 1, 2, 3, 6 and 7/C). This sac had connection with the lungs through the third medio-ventral bronchi (Figs. 8 and 9/C7). The sac engulfed by the thoracic girdle, sternum, and heart occupied the entire cranial thoracic aperture.

The clavicular sac possessed six diverticula arranged intra- and extra- thoracic. The cardiac diverticula, *diverticula cardiac* (Fig. 7/C1), seen around the heart, were merged on the median line. The sternal

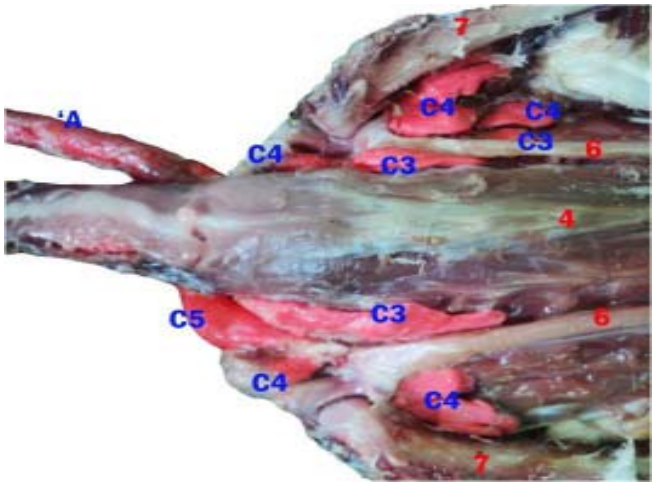


Fig 6. A photograph showing diverticula of clavicular air sac in golden pekin duck (Dorsal view)

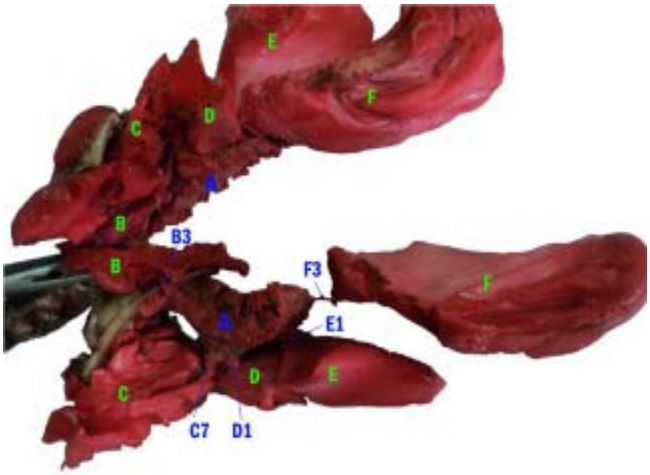


Fig 8. A photograph showing the origins (ostium) of the air sacs in golden pekin duck (Ventral view)

Fig 7. A photograph showing the clavicular, cranial thoracic, caudal thoracic and abdominal air sacs in golden pekin duck (Ventral view)

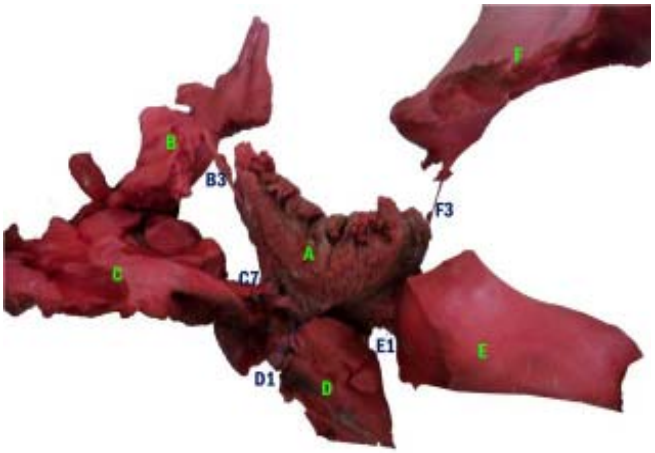


Fig 9. A photograph showing the origins (ostium) of the air sacs in golden pekin duck (Ventral view)

**Legend for the Figures 1-9**

| | | | |
|---|---|---|---|
| A- Lung | C2- Sternal diverticula | E- Caudal thzoracic air sac | H-Heart |
| A'- Trachea | C3- Subscapular diverticula | E1- Caudal thoracic air sac ostium | 1-Clavicle |
| B- Cervical air sac | C4- Axillary diverticula | F- Abdominal air sac | 2-Ribs |
| B1- Vertebral diverticula | C5- Subpectoral diverticula | F1- Abdominal air sac (cranial part) | 3-Sternum |
| B2- Intermuscular diverticula | C6- Suprahumeral diverticula | F2- Abdominal air sac (caudal part) | 4-Cervical vertebrae |
| B3- Cervical air sac ostium | C7- Clavicular air sac ostium sac | F3- Abdominal air sac ostium | 5-Synsacrum |
| C- Clavicular air sac | D- Cranial thoracic air sac | F4- Synsacral diverticula | 6-Scapula |
| C1- Cardiac diverticula | D1- Cranial thoracic air sac ostium | F5- Femoral diverticula | 7-Humerus |

diverticula, *diverticula sternalia* (Figs. 1 and 7/C2), the other intrathoracic diverticula, laid ventral to the former diverticula, aerating the sternum.

Extrathoracic diverticula were observed around the cranial thoracic aperture. Among them were the subscapular diverticula, *diverticulum subscapulare* (Figs. 1, 2, 4 and 6/C3), seen between the scapula and cervical sac as sheet-like structures. Lateral to these, the axillary diverticulum, *diverticulum axillare* (Fig. 1, 2, 4 and 6/C4) was observed beneath the shoulder

muscles. The subpectoral diverticulum, *diverticulum subpectorale* (Figs. 1, 3 and 6/C5), extrathoracic, was located ventral to the first two diverticula, lateral to the first two ribs. The last extrathoracic diverticulum was suprahumeral diverticulum, *diverticulum suprahumerale* (Fig. 1, 2, 3 and 7/C6), which extended ventral to the axillary diverticulum, encircling the head of the humerus with its triangular shape. This diverticulum aerating the humerus was the most developed of all.

**Saccus Thoracicus Cranialis:** The cranial thoracic sac (Figs. 1, 3, 4, 7, 8 and 9/D) aerated by the first, second, and fourth medio-ventral bronchii (Figs. 8 and 9/D1) was symmetrically located under the lateral wall of the body. It was rectangular in shape and smaller than the caudal thoracic sac. It was present ventro-lateral to the lungs, medial to the sternal ribs, and lateral to the heart, liver and the caudal portion of the esophagus. This sac gave diverticula for the third to seventh sternal ribs for aeration.

**Saccus Thoracicus Caudalis:** The caudal thoracic sac (Figs. 1, 2, 3, 4, 7, 8 and 9/E) was also located caudo-ventral to the lungs, receiving air via the fourth medio-ventral and first and second latero-ventral bronchii (Figs. 8 and 9/E1). It was two times larger than the cranial sac, having trace of the last four ribs. The caudal portion of the left caudal thoracic sac had relation with the gizzard. This sac was encircled dorsally by the abdominal sac and ventrally by the cranial thoracic sac and had no diverticulum.

**Saccus Abdominalis:** The abdominal sac, (Figs. 1, 2, 3, 4, 7, 8 and 9/F) occupying most of the coelom, was asymmetrically located as two parts in the abdomen. It extended from the caudal border of the lungs through the cloaca. This sac had connection with the lungs via the second, third, fourth, and fifth latero-ventral brochi (Figs. 8 and 9/F3). Its lateral surface was smooth while the medial surface was irregular. The left abdominal sac was divided into cranial (Fig. 3 and 7/F1) and caudal (Figs. 3 and 7/F2) portions. The cranial portion aerated the last two ribs, synsacrum (Fig. 4/F4) and femur (Fig. 4/F5), medially possessed a trace of the gizzard whereas; the caudal portion was smaller and narrower than the cranial portion. The right abdominal sac was longer than the left one and its body was narrower than the caudal end. Also it gave diverticula for last two ribs, synsacrum (Fig. 4/F4) and femur (Fig. 4/F5).

The most prominent finding of this study was that no sex differences were observed and the air sacs of the Golden Pekin duck showed great differences. The golden pekin duck had eight sacs, as reported earlier in mallard duck (Demirkan *et al.*, 2006a), chicken (Powell, 2000; Duncker, 2004) and Japanese quail (Demirkan *et al.*, 2006b; Sawad and Udah, 2012). However, Funk *et al*. (1992) reported eleven air sacs in goose.

The cervical sac with its diverticula differed from previous studies (Taylor *et al.*, 1962;- King and Mclelland, 1984; Vollmerhaus and Sinowatz, 1992). It was clearly demonstrated, in this study that the second cervical bone, *axis*, and the first two ribs were aerated by this sac in the Golden Pekin duck. This was dissimilar to other species such as domestic chickens (Hogg, 1984; King, 1957). On the other hand, the number of diverticula of the cervical sac were three (vertebral, intermuscular and subcutenous) in the mallard duck (Demirkan *et al*., 2006a) and White Pekin duck (Mannega and Calhoun, 1968). The notable difference in this study was that the subcutaneous diverticulum was not found in golden pekin duck.

Location and number of the diverticula of the clavicular sac was consistent with the published reports in chickens (King, 1957; King, 1984; Vollmerhaus and Sinowatz, 1992). On the contrary, it was notable that the suprahumeral diverticulum was highly developed as compared to the other extrathoracal diverticulum that was similar to earlier findings in chickens (King, 1993) and mallard duck (Demirkan *et al.*, 2006a). The cranial thoracic diverticula were reported not to aerate any bones and not to possess any diverticula in chickens (King, 1993). However in this study, it gave diverticula for the third to seventh ribs.

Lucas *et al.* (1959) reported that the caudal thoracic sac was absent in white Pekin duck, however, there existed large caudal thoracic sacs without any diverticula in this study. The results were consistent with earlier reports in mallard duck (Demirkan *et al.*, 2006a) and Japanese quail (Demirkan *et al.*, 2006b; Sawad and Udah, 2012). In contrast to our findings, Tasbas *et al.* (1994) reported that the cranial thoracic sac was larger than the caudal one in Denizli cock. The left abdominal sac in this study was divided into two portions i.e. cranial and caudal portions as also reported by Demirkan *et al.* (2006a) in mallard duck. The right abdominal sac in

golden pekin ducks was longer than the left one. This finding was similar to earlier studies (King and McLelland, 1984; Vollmerhaus and Sinowatz, 1992; King, 1993) in chickens but was contrary with the findings of Tasbas *et al.* (1994) in Denizli cocks. In conclusion, gross morphology of the air sacs in the golden Pekin duck was closely examined and similarities and dissimilarities with the literature were documented.

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