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RESEARCH ARTICLE

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Para Bronchial System of Kadaknath Fowl - Corrosion Cast

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ABSTRACT

Background: Corrosion cast is an efficient technique used to demonstrate the anatomical structures which are difficult to observe during dissection. Air sacs are unique structures that are present in the avian respiratory system not in other air-breathing vertebrates. Air sacs are very delicate structures to dissect because they are made up of fine squamous cell membranes. They are hard to display unaccompanied by corrosion cast. Perception of the air sac anatomy was unable to succeed in two-dimensional diagrams.
Methods: In this study, adult Kadaknath fowl were collected to demonstrate its air sacs by using 70% rubber latex solution through the corrosion cast method. The shape and size of four paired and one unpaired air sac was observed. The relationship between air sacs, lungs and pneumatic bones was also recorded. Air sacs cast were tinged, laminated and displayed in Museum.
Result: Present study will be helpful to understand the anatomical structure of the air sacs of Kadaknath fowl.

Key words: Air sacs, Corrosion cast, Kadaknath fowl.

INTRODUCTION

Air sacs are blind, thin-walled bronchial system that extended beyond the lungs near the thoracic and abdominal viscera. Diverticula from these air sacs infiltrated into some of the bones and even reached the skeletal muscles (Dyce *et al.*, 2002). According to O'Malley (2005), the air sacs were operated as bellows but did not participate in gaseous exchange. He said that the bellows mechanism provides continuous airflow to the lungs during both respiration and expiration. The air sacs were large, clear structures that interact with the lungs *via* ostia. The air sacs significantly contributed to the large respiratory capacity of fowls (100-200 ml/kg BW).

Jaensch (2015) discovered unpaired clavicular, paired cervical, thoracic (cranial and caudal) and abdominal air sacs in domestic species. Their boundaries, extensions and sizes differed between species based on their flight capacity. In flying fowls, extensions of the air sacs were stretched in and around the bones, as well as into perirenal and subcutaneous areas however it was less common in walking and diving species (Bejdić *et al.* 2021).The interconnections between air sacs and with lungs, bones and cavities were strenuous to showcase in a gross specimen and mystifying to understand. Hence, this study was conducted to create a cast of Kadaknath fowl's air sacs to providea layout for forthcoming studies.

MATERIALS AND METHODS

An 82-week-old Kadaknath fowl was collected right after the death from Livestock Farm Complex, VC and RI, Orathanadu. An incision was made at the ventral neck region to approach the trachea. An intravenous infusion tube (IV) was inserted into the trachea up to its half to draw out as much as air possible. To fill up the air sacs of Kadaknath fowl 250 ml of rubber latex solution was needed. Then, the free end of the IV tube was connected with a 20 ml syringe

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filled with 70% rubber latex solution. The latex solution was injected into the trachea to fill up the lungs and air sacs with their extensions. The latex injected into the trachea was allowed to settle alone by gravity and the carcass was let to macerate by hanging in the air to facilitate latex polymerization (Sivagnanam *et al.*, 2014).

The head of the fowl was tied and hanged for 7 days without any disturbance. After 7 days partially macerated fowl was dropped into a bucket of water for several days, to get complete maceration. After 15 days, a complete corrosion cast of lungs and air sacs was carefully separated from the macerated tissue and cleansed with soap water. Bones of this fowl were collected for skeleton mounting during different stages of the process. Then the cast was dried completely in a hot air oven. Each part of the air sacs was tinged uniquely to make it easy and clear comprehension to students.

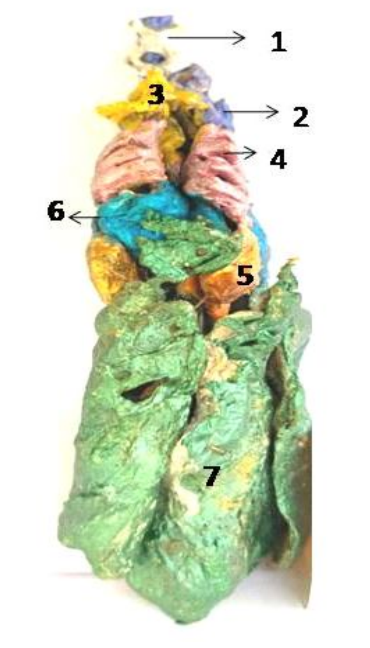
RESULTS AND DISCUSSION

The corrosion cast of Kadaknath's fowl demonstrated the lungs and air sacs with their communications to the bones.

The lungs were located superiorly and extended laterally to fill the thoracic cavity. The vertebral surface was impregnated by three costal grooves; other surfaces were encroached by air sacs. The corrosion cast revealed nine thin-walled and transparent air sacs that were extended from the lungs, penetrating between the viscera and into some bones (Fig 1). They comprised single clavicular, paired cervical, cranial and caudal thoracic and abdominal air sacs (Maina, 2008). Though in some reports it had been explained that there were seven or eight air sacs (Dyce *et al.,* 2002; Konig *et al.*, 2016), it was due to the cervical air sacs were paired during the embryonic period, after hatching it was fused to form one main chamber and two diverticula extending up to cervical vertebrae (Baumel *et al.*1993) in domestic fowl. It leads to differences in interpretation of the number of air sacs. In some reports, clavicular and cervical air sacs were denoted as one which led to a reduction in the number.

Saccus clavicularis

It was a large, convoluted sac that occupied the thoracic inlet and central thoracic cavity that connected to the central cervical chamber dorsomedially. Contrary to Demrkan *et al.* (2006a) the sternum, sternal ribs, humerus, and coracoid bones were penetrated by this sac through diverticula whereas not in Japanese quail. Six diverticula were observed from the main chamber - four extra-thoracicand two intra-thoracic (Fig 2).



1. Cervical Vertebrae, 2. Cervical air sac, 3. Clavicular air sac, 4. Lungs, 5.Cranial Thoracic air sac, 6. Caudal thoracic air sac, 7. Abdominal air sac.

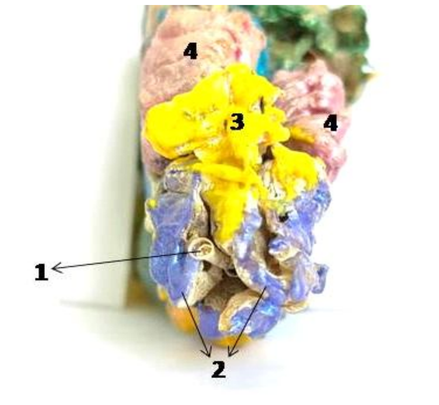
Fig1: A photograph of corrosion cast of kadaknath fowl's air sacs.

Extra thoracic diverticula

Diverticulum subpectorale converged ventrally on both sides, generating a V-shaped expansion that embraced the trachea, oesophagus, blood vessels, nerves and the cervical portion dorsally; ii. *Diverticulum axillare*was ovate in shape and sprang out laterally to the preceding one and also covers the shoulder joint that resembled the results in chick and chine's duck (Duncker 1971 and Mennega and Galhoum 1968); iii. *Diverticula suprahumerale*was much larger and noticed above the axillary and covered the humoral head; iv. The *Diverticulum subscapulare* was the smallest among them and located between the first and second thoracic vertebrae (Fig 3).

Intrathoracic diverticula

The base of the heart and part of the atrial wall was covered by *the Diverticulum cardiac*; ii. A tube-like diverticulum that emerged from the caudo-ventral part and connected to the



1. Trachea with tracheal rings, 2. Cervical air sac, 3.Diverticlum subpectorale of clavicular air sac, 4.Lungs.

Fig 2: photograph showing the relationship between cervical and clavicular air sacs.

1. Diverticula Vertebralia, 2. intermuscularia of cervical air sacs, 3. Clavicular air sac – a. Cardiaca; b. Sternalia; c. subpectorale; d. Suprahumerale, e.Axillare, 4. Lungs, 5.Caudal thoracic air sac, 6. Cranial thoracic air sac, 7. Abdominal air sacs – f. Femorale, g. Perirenal, h. Percloacal.

Fig 3: A Photograph of lateral view of corrosion cast.

1. Central canel, 2. Foramen transversarium, 3. Spicules.

Fig 4: A photograph showing cervical air sacs and Diverticulum vertebralia.

cranial thoracic air sac was called *Diverticula sternalia*. These were called as sterno-cardiac diverticulum by Ragab *et al.* (2016).

SaccusCervicalis

These air sacs were small, elongated, and cranially located on either side of the trachea and lay over the oesophagus. There were three diverticula arising from the centre part namely *Diverticula interpulmonaris* (Ragab *et al.* 2016), *vertebralia* and *intermuscularia* (Bejdić *et al.*2021). i. *Diverticulum interpulmonaris* was a caudal prolongation of the central cavity and extended ventral to the ventral crest of the notarium, between the two lungs and tapered caudally. ii. *Diverticulum vertebralia* passes through the central canal and foramen transversarium on either side of cervical vertebrae (Fig 4). It expanded from the first thoracic vertebrae to an axis, however in rosy-faced parrots it reached only up to eight cervical vertebrae (Bejdic *et al.* 2021).iii. *Diverticulum intermuscularia* was observed in between the lower part of the cervical muscles. As Ragab *et al.* (2016) described, it was communicated with the clavicular partscaudoventrally.

Saccus thoracis

Paired, roughly rectangular sacs were similar in size and symmetrical in position. It had two parts named cranial and caudal thoracic air sacs. The cranial part located within the thoracic cavitywsbounded by the sternal part of the last rib laterally and visceral organs (liver, heart, oesophagus and proventriculus) medially. From the lateral part, small diverticula (*Sternal diverticulum*) emerged and aerated the vertebral part of the ribs, this result was incompatible with the findings of Onuk *et al.,* (2009) which said no diverticula found in long-legged buzzards.The caudal thoracic air sacs were interposed between the abdominal wall and abdominal air sacs lateral and medial surface respectively. Cranio-dorsally, it was related to the septal surface of the lung and medial clavicular air sac. A complex system of diverticulum between muscles, sub-cuties, pneumatic bones of the trunk and pectoral limbs was observed and this result was compatible with O'Connor (2004) in Anseriformes. Among them, caudal air sacs were smaller and oval in shape but absent in Turkey as described by Konig *et al.* (2016). While it's incompatible with Ragab *et al.* (2016) who demonstrated inter-diverticular details of caudal thoracic air sacs in turkey.

Saccusabdominalis

The abdominal air sacs were the largest among all. It occupied all of the space remaining in the abdominal cavity except organs and extended caudodorsally.It started from the posterior border of the lung to the cloaca. This sac reached up to the level of the kidney and adrenal gland dorsally; caudal thoracic sac cranially. Laterally they were enclosed by abdominal and pelvic walls and medially contact with visceral organs. The right abdominal air sac was slightly larger than the left because the side gizzard was locatedon the ventral aspect of the left sac. They gave four diverticula which penetrated the adjacent structures *viz*. *Diverticula femorale*(Os-ilium, ischium, acetabulum), *Perirenal diverticulum* (renal lobes and synsacrum), *Ilio-Limbar Diverticulum*(notarium)and*Periclocal Diverticulum* (lumbosacral canel) (Fig 4).

CONCLUSION

In conclusion, the present study showed that the kadaknath fowl had a specific architecture of air sacs. This technique will be a useful to demonstrate air sacs and their interconnections in practical classes to demonstrate distinct features of air sacs of Kadaknath fowl to students and for museum display.

Conflict of interest

All authors declared that there is no conflict of interest.

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