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Gross, morphometric and histologic study of the lower respiratory tract of the cattle egret *(Bubulcus ibis*)

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Abstract

The cattle egret (*Bubulcus ibis*), a highly adaptable and ecologically successful species, is one of the understudied bird species. This study evaluated the gross morphology, morphometry and histological organization of the lower respiratory tract of the cattle egret. Six apparently healthy adult cattle egrets (three females and three males) were used for the study. Live weights of the birds were measured prior to euthanasia. Thereafter the components of the lower respiratory tract (trachea, primary bronchi and the lungs) were dissected, separated and weighed. Their lengths and diameters were also measured. Tissue samples from the three segments were routinely processed for histological examination, and stained using haematoxylin and eosin. Results showed that the trachea of the cattle egret was a translucent tubular structure composed of complete cartilaginous rings with a mean length of 163.37 ± 2.06 mm in females and 174.0 ± 3.46 mm in males. The mean number of tracheal rings in the females were 156.33 ± 1.20, while the mean number of tracheal rings in the males were 157.33 ± 1.45. The trachea bifurcates into left and right primary bronchi which are short and supported by C-shaped cartilaginous rings. The lungs were shiny pinkish, lobed and wedged shaped organs, which firmly adhered to the thoracic wall, with rib impressions that form costal sulci on the dorsal surface. Histologically, the trachea and bronchi were lined by ciliated pseudostratified columnar epithelium, while the lungs, parabronchi, atria, infundibula and air capillaries were lined by simple squamous epithelium. The lower respiratory tract of cattle egret conforms to the general avian model. There was no significant sexual dimorphism in the gross morphology, morphometry and histology of the lower respiratory system of the cattle egrets studied.

Keywords: Cattle egret (*Bubulcus ibis*); Lower respiratory tract; Trachea, primary bronchi and the lungs; Gross morphology; Morphometry; Histology.

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Introduction

The cattle egret (*Bubulcus ibis)* is of the family Ardeidae (herons and egrets). It is a medium sized heron, characterized by a white plumage, a yellow bill, short dull orange legs, a thick neck and a hunched posture. Earlier reports by Ivory (2000) showed that the length of the bird is between 46 – 56 cm, and its wingspan ranged from 88 – 96 cm, while the body weight ranged from 270 – 512 g. Generally, cattle egrets are small, widely distributed herons that usually nest in large colonies, prefer habitats near water, and typically feed in grasslands. They prey on insects and other invertebrates, especially those that fly after being disturbed by associated large mammals. They also eat ticks, flies and other ectoparasites found on mammals (Ivory, 2000).

In Africa, cattle egrets forage with cattle and a range of other large mammals by following the animals closely, usually near its head. In order to catch their prey, they must keep up with their host, and they often switch animals when the host speed is no longer within their optimal range (Kioko *et al*., 2016). They are sociable birds and tend to settle in large colonies often with other species of birds, and they also migrate with other similar birds. They are commonly seen in association with grazing animals and can be seen hanging around them or following tractors that disturb grassy areas (Ivory, 2000). The remarkable adaptability and foraging behaviours of the cattle egret necessitate a detailed examination of the gross and histological studies of its respiratory tract.

The avian respiratory system is the most efficient gas exchanger. Novel morphological and physiologic adaptation and specialization largely contribute to its functional efficiency (Maina, 2025). Anatomically the avian respiratory system is separated into lungs that serve as organs of gas exchange and air sacs that serve as ventilators. The lung's exceptional ability to transfer oxygen is due to a combination of factors: a very thin blood gas barrier, large surface area for gas exchange, and sufficiently large volume of blood flowing through the lung capillaries (Maina, 2025). These peculiarities result in high overall capacity of the lungs to facilitate the diffusion of oxygen into the bloodstream (Maina, 2025). There is a dearth of information in available literature on the anatomy of the respiratory system of the cattle egret. The present study evaluated the gross morphology, morphometry and histologic organization of the lower respiratory tract of the cattle egret (*Bubulcus ibis*).

Materials and Methods

Study location and sourcing of the cattle egrets: The research was conducted at the Avian and Aquaculture Breeding Centre, Animal Unit of Department of Veterinary Anatomy, Ahmadu Bello University, Zaria (11°4'N, 7°42'E), Zaria, located in the Northern Guinea Savannah zone of Nigeria, with a photoperiod of 12.5 ± 0.5 hours (Ayo *et al*., 1999; Dzenda *et al*, 2011).

Six apparently healthy adult cattle egrets (*Bubulcus ibis*) comprising three male and three females were used for the study (Figure 1). The cattle egrets were purchased from Kano State, Nigeria. The birds were caught around Kano abattoir. Kano State covers an area extending between Latitudes 10º 3'N and 12º 4'N and Longitude 7º 4'E and 9º 3'E. It is bounded to the North West by Katsina State, to the South West by Kaduna and to the North East by Jigawa State, while to the South East by Bauchi State (Mohammed *et al*. 2015).

The cattle egrets were transported by road and delivered to Gross Anatomy Research Laboratory of the Department of Veterinary Anatomy, Ahmadu Bello University. The birds were acclimatized for two days during which they were fed guinea corn and water.

Ethical Considerations: Ethical approval for the study was sought for and obtained from the Ahmadu Bello University Ethical Review Board for use of animals for research, and the Approval Reference Number was ABU/CAUC/2025/047.

Study design: This study adopted a descriptive cross-sectional study design.

Figure 1: Photograph of one of the cattle egrets used for the study.

Anatomical study: The cattle egrets were euthanized using sodium pentobarbital administered at the dose of 0.5 ml/kg. Following euthanasia, each bird was placed on dorsal recumbency and a ventral midline incision was made from the base of the mandible to the vent. The pectoral muscles along with the sternum were dissected using a pair of scissors, and reflected. For each segment of the lower respiratory system (the trachea, primary bronchi and lungs), the position, shape, colour and relationship to surrounding organs and tissues were observed and recorded.

Morphometric measurements: Weight, length and diameter of the different segments of the lower respiratory system were measured using an electronic balance (Model XY30002C, Readability 0.01 g) and digital vernier calipers (with sensitivity of 0.02 mm), respectively. The numbers of cartilaginous rings were also counted.

Tissue processing: The harvested trachea, primary bronchi and lungs tissues were fixed in 10% formalin for 24 hours. The tissues were then dehydrated by immersion in many changes of ascending concentrations of ethanol (70%, 80%, 90%, and 100%) for an hour in each of the concentration strength. Then, the tissues were then cleared in xylene for two hours, and then infiltrated with molten paraffin wax (BDH chemicals Ltd., Poole, England) at 60°C to make a block (Kiernan, 1990). Coronal and sagittal sections of the conducting air ways (trachea and primary bronchi) and the lungs were cut at thickness of 5 micrometre using Jung rotary microtome (Model 42339, Berlin, Germany). The ribbon cut using microtome was placed in water bath before mounting on glass slides. The glass slides were dried and cleared of paraffin.

Histologic Staining: The sections of the trachea, primary bronchi and the lungs were stained using haematoxylin and eosin (H & E). The stained sections were dried before cover slip was mounted using DPX. The slides were the studied using Light microscope (Hund WETZLAR Med-Prax SN: 1025552).

Results

Gross anatomy: The trachea was observed to be a whitish, translucent and flexible conducting tube composed of complete cartilaginous rings, and it extended from the larynx to the tympanum of the syrinx. The trachea lies ventral to the oesophagus on the right side of the neck and then returns to midventral position of the neck as it approached the thoracic inlet. At thoracic cavity, the trachea bifurcated into left and right extra-pulmonary primary bronchi (Figures 2 and 3).

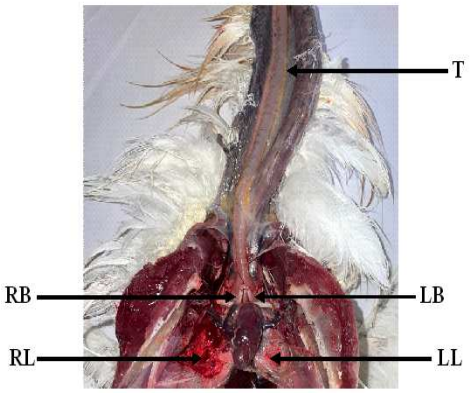

Figure 2: Gross photograph of respiratory tract of cattle egret (*Bubulcus ibis*), showing; T – trachea, LB – left bronchus, RB – right bronchus, LL – left lung, and RL – right lung.

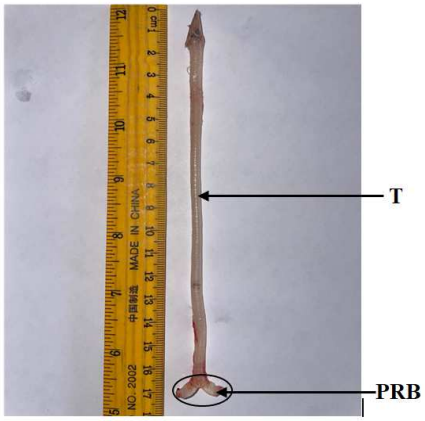

Figure 3. Gross photograph of tubular section of the lower respiratory system of cattle egret (*Bubulcus ibis*), showing; T – trachea, and PRB – primary bronchi.

The primary bronchi were observed to be lying dorsal to the base of the heart and ventral to the lungs in the thoracic cavity. The bronchi branched off from the tracheal bifurcation; they are similar to the trachea but shorter in length. The bronchi are composed of incomplete C-shaped cartilaginous ring bronchus (Figure 3).

The left and right lungs (pulmo sinister and pulmo dexter, respectively) were found to be some wedged shaped, shiny, pinkish organs that were firmly adhered to the thoracic wall by the connective tissue attachment on the dorsal surface, and on the medial surface to the vertebral column (Figure 4). The lungs have three surfaces: dorsolateral surface or costal surface, dorso medial surface or vertebral surface and visceral surface The ribs were observed to be deeply embedded in the lung tissues making deep impression (costal sulcus) on the dorsolateral surface of the lungs, dividing the lungs into five lobes. The lungs were connected to the trachea through left and right primary bronchi.

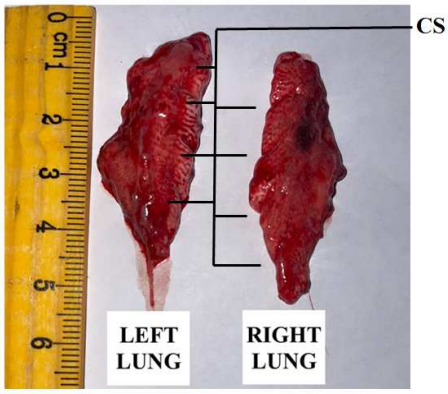

Figure 4. Gross photograph of dorsal surface of left and right lungs of the cattle egret (*Bubulcus ibis*), showing: CS – costal sulci of the lungs.

Morphometric study results: The mean live weights of the females and males were 233.14 ± 19.62 g and 347.54 ± 94.00 g, respectively (Figure 5). There was no significant difference ($p = 0.30$) between the live weight of the females and males, though the females had a relatively lower mean live weight than the males (Figure 5).

The mean lengths of the female and male lower respiratory tract, trachea, right bronchi and left bronchi did not significantly differ ($p > 0.05$), but the length of the right and left lung of females was significantly higher than that of the males (Table 1). Also, the diameter of the trachea and the right and left lung did not significantly differ ($p > 0.05$) between the sexes (Table 1). The mean number of tracheal rings of females and males were 156.33 ± 1.20 and 157.33 ± 1.45, respectively, and there was

no statistically significant ($p > 0.05$) difference between them (Figure 6).

The weight of the whole lower respiratory tract, the bronchi, right and left bronchus and lungs for the females and males are presented in Table 2. There were no significant differences ($p > 0.05$) between the females and males in the mean weight of all these organs (Table 2).

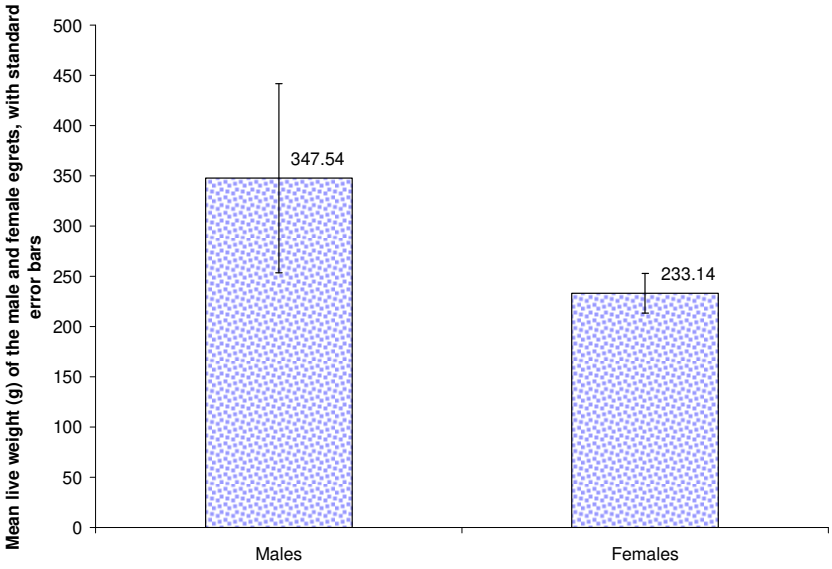

Figure 5. Mean live weights of the male and female cattle egrets (*Bubulcus ibis*) studied.

Table 1. Mean lengths and diameters (mm) of parts of the lower respiratory system of the cattle egret (*Bubulcus ibis*).

Parts of lower respiratory tract measured	Mean ± standard error		P-value
	Males (n =3)	Females (n = 3)	
Length of lower respiratory tract	228.23 ± 5.14	224.7 ± 3.74	0.41
Length of trachea	174.0 ± 3.46	163.37 ± 2.06	0.11
Length of right bronchi	15.50 ± 0.28	14.57 ± 2.92	0.70
Length of left bronchi	10.60 ± 2.65	13.67 ± 2.40	0.52
Length of right lung	38.20 ± 1.87	44.33 ± 2.27	0.04
Length of left lung	40.66 ± 1.53	47.67 ± 1.45	0.05
Diameter of right lung	17.03 ± 1.25	16.73 ± 0.82	0.48
Diameter of left lung	19.03 ± 1.70	16.73 ± 1.19	0.43
Diameter of trachea	6.13 ± 1.18	4.40 ± 0.50	0.29

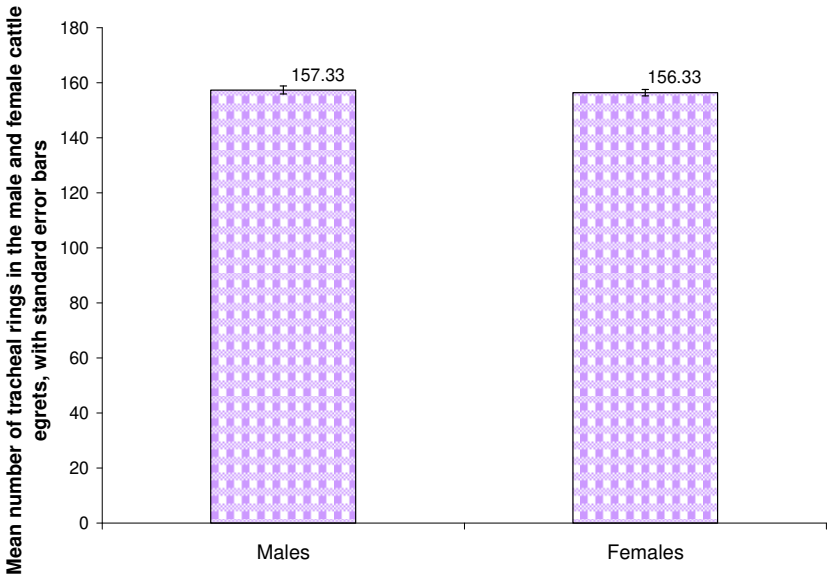

Figure 6. Mean number of tracheal rings of the male and female cattle egrets (*Bubulcus ibis*) studied.

Table 2. Weight (g) of parts of the lower respiratory system of the cattle egret (*Bubulcus ibis*).

Parts of the lower respiratory tract	Mean ± standard error		P-value
	Males (n = 3)	Females (n = 3)	
Weight of whole lower respiratory tract	4.14 ± 0.39	3.77 ± 0.17	0.13
Weight of trachea	1.10 ± 0.27	0.80 ± 0.03	0.39
Weight of bronchi	0.28 ± 0.01	0.16 ± 0.03	0.81
Weight of right bronchus	0.15 ± 0.00	0.08 ± 0.03	0.42
Weight of left bronchus	0.13 ± 0.01	0.12 ± 0.01	0.67
Weight of right lungs	1.64 ± 0.14	1.51 ± 0.06	0.29
Weight of left lungs	1.38 ± 0.11	1.12 ± 0.08	0.09

Histology results: The tracheas of the cattle egrets studied were found to be histologically divided into four distinctive layers: mucosa, submucosa, hyaline cartilage and adventitia (Figure 7). The lamina epithelium of tunica mucosa was lined by ciliated, pseudostratified columnar epithelium (respiratory epithelium) with intraepithelial glands. Below the tunica mucosa was the submucosa. No mucous glands were observed in the submucosa. Below the submucosa was perichondrium that surrounded the cartilaginous layer. In the proximal part of the trachea, the cartilaginous rings were observed to be overlapping. The adventitia covers the outer surface of the cartilaginous rings (Figure 8).

The primary bronchi of the cattle egrets studied were lined by ciliated pseudostratified columnar epithelium, which continued with the submucosa and connective tissue layer. The submucosa continued with the perichondrium that surrounded the hyaline bronchial cartilage. On the outer surface of

the primary bronchi, the perichondrium continued with the adventitia (Figure 9).

The wall of the parabronchi, atria, infundibulum and air capillaries of the lungs were lined by simple squamous epithelium. On the wall of the parabronchi there were several wide openings into the atria which were also lined by simple squamous epithelium. There was smooth muscle under the mucosal lining of parabronchi. The atria continued into narrow opening (infundibulum), which ultimately opened into air capillaries (Figure 9). The air capillaries were lined by simple squamous and collagen fibres, which appeared reddish pink in the lamina propria of the parabronchi. Pulmonary blood vessels and inter-parabronchial blood vessels were seen between the parabronchi. The parabronchi are separated by inter-parabronchial septum (Figure 9).

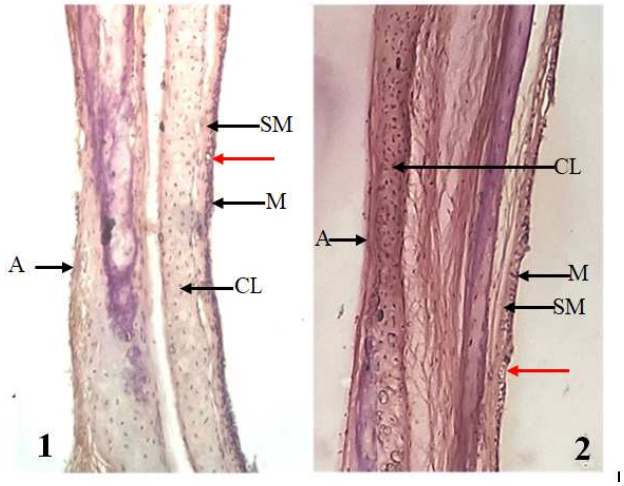

Figure 7. Photomicrograph of the proximal trachea of male (1) and female (2) cattle egret showing; M: Mucosa showing ciliated pseudostratified columnar epithelium with alveolar; SM – Submucosal connective tissue; CL – Cartilaginous layer; A – Adventitia; Red arrow – Intraepithelial gland within respiratory epithelium. [H & E; ×200]

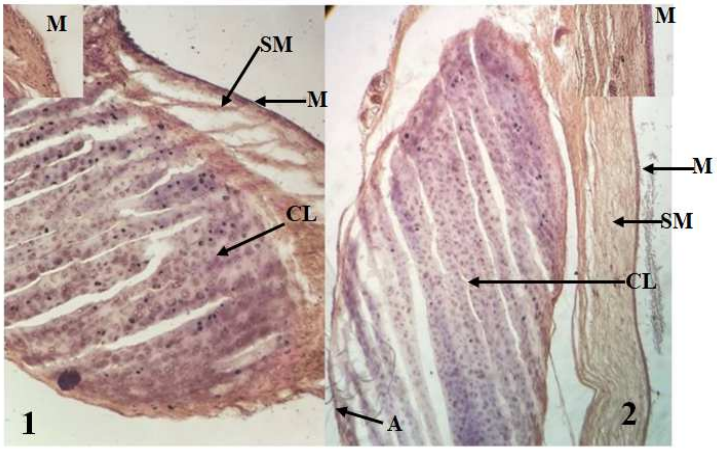

Figure 8. Photomicrograph of bronchi of male (1) and female (2) cattle egret showing; M: Mucosa showing ciliated pseudostratified columnar epithelium, SM: Submucosa showing connective tissue, CL: Cartilaginous layer, A: Adventitia. [H & E; × 200]

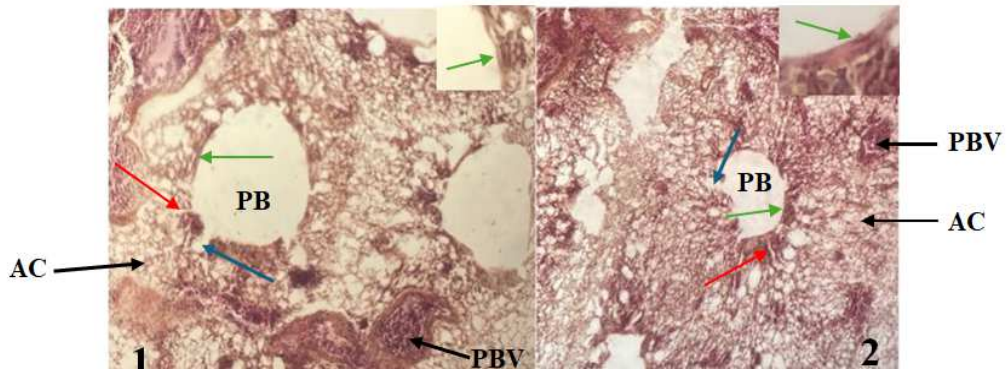

Figure 9. Photomicrograph of lungs of the male (1) and female (2) cattle egret showing; PB – Parabronchi lumen; Green arrow – Mucosa lined by simple squamous epithelium with smooth muscles under the mucosa; Blue arrow – Atria lined by simple squamous epithelium; Red arrow – Infundibulum also lined by simple squamous epithelium; AC – Air capillaries lined by simple squamous epithelium; PBV – Pulmonary blood vessel, [H & E; ×200]

Discussion

The finding in this study that the trachea is a whitish translucent and flexible conducting tube composed of complete cartilaginous rings, and that it extends from the larynx to the tympanum of the syrinx strongly agrees with earlier reports by Mclelland (1990) and Ibe *et al*. (2008). Also, the observation that the trachea lies midventral to the oesophagus at right side of the neck and then returned to midventral position to the neck as it approached the thoracic inlet, concurs with previous reports in geese, cattle egrets and house sparrows by Sakr *et al*. (2022).

In the thoracic cavity, the trachea bifurcated into left and right extra-pulmonary primary bronchi. The primary bronchi were observed to be lying dorsal to the base of the heart and ventral to the lungs in the thoracic cavity. The bronchi branched off from the tracheal bifurcation; they are similar to the trachea but shorter in length. Also, the bronchi were composed of incomplete C-shaped cartilaginous rings; these findings were similar to earlier reports on West African Guinea fowl (Ibe *et al*., 2008) and chicken (König *et al*., 2016). The right bronchi were found to be longer than the left bronchi: this is in agreement with reports on the Wood pigeon (Alumeri *et al*., 2013).

The left and right lungs (pulmo sinister and pulmo dexter, respectively) of the cattle egrets studied were found to be pinkish and wedged shaped, as earlier reported by Ibe *et al*. (2008) and Al-Mussawy *et al*. (2010); and the observation that they were firmly adherent to the thoracic wall by the connective tissue attachment on the dorsal surface and medial surface to the vertebral column is in agreement with earlier reports by Ibe *et al*. (2008) and König *et al*. (2016). The lungs of the cattle egrets studied have three surfaces: dorsolateral surface or costal surface, dorso medial surface or vertebral surface, and visceral surface, as earlier reported by Mclelland (1990). The finding that the ribs were deeply embedded in the lung tissues making deep impression (costal sulcus) on the dorsolateral surface of the lungs dividing the lungs into five lobes, contrasts with earlier reports in chicken (König *et al*., 201), and in West African Guinea fowl, which were reported to have four lobes, signifying interspecies variation (Ibe *et al*., 2008).

The morphometric features of the cattle egrets studied showed no significant sexual

dimorphism: this is in agreement with earlier reports on the West African Guinea fowl, where the mean weight of the major respiratory organs and length of the trachea and primary bronchi had no significant difference in both sexes (Ibe *et al*., 2008). Also, the finding of no significant difference in the number of tracheal rings in females and males, is consistent with earlier reports by Ibe *et al*. (2008).

The finding in the present study that the trachea was composed of four different layers and that the mucosa was lined by ciliated pseudostratified columnar epithelium with intraepithelial glands, is consistent with earlier reports in domestic fowls and Guinea fowls by Bello *et al*. (2018) and on pigeons by Mohsin and Mohammed (2024). The overlapping cartilaginous rings in the proximal trachea agree with the reports by Sakr *et al*. (2022).

The histological findings in the lungs of the cattle egrets studied agree with earlier reports in chicken (Kandyel *et al*., 2022) and turkey (Al-Musaawy *et al*., 2010), and pulmonary blood vessels were also observed as reported by Maina (2025). Histologically the lungs in both females and males did not differ.

Conclusion: The gross and morphological findings revealed that the trachea, primary bronchi and lungs of the cattle egret studied conform to the general avian anatomical model, with distinct specie-specific features such as division of the lungs into five lobes by costal sulci. Morphometric analysis showed no significant sexual dimorphism. However, a statistically significant difference was observed in the length of right lung between females and males, with left lung being longer in females. Histologically, the tissues show typical avian architecture, with the trachea and bronchi lined by ciliated pseudostratified columnar epithelium, and the lungs characterized by parabronchi, atria and air capillaries lined by simple squamous epithelium.

Conflict of Interest

The authors declare no conflict of interests.

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