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Morphological and Histological Study of the Lung in the *Pterocles alchata*

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ABSTRACT

The present study was conducted on the Iraqi Pin-tailed Sandgrouse (*Pterocles alchata*) to study the lung's morphological description and histological structure. This study was used 5 samples of adult male sandgrouse bird. The birds were dissected. The lungs were removed from the coelomic cavity, cleaned to remove impurities, and photographed to describe their morphological features. The samples were fixed using formalin (10%) solution for 36-48 hours and then preserved in alcohol (70%) to prepare the microscopic slides. The results showed that the lung of the Iraqi sandgrouse bird is red in color, has a trapezoidal shape and has three surfaces (costal, visceral, and vertebral). The costal surface shows ribs impressions that extend from the first rib to the sixth rib. Histologically, the microscopic sections of the pulmonary lobule revealed the presence of primary bronchioles lined with ciliated pseudostratified columnar epithelium, resting on a layer of connective tissue interspersed with plates of hyaline cartilage; this layer is known as the lamina propria with the submucosa. The parabronchi occupy more than half the pulmonary lobule volume and are lined with simple squamous epithelium supported by a layer of loose connective tissue followed by smooth muscle tissue. The parabronchi also include halls known as atria, which open at their ends into cones, which in turn connect to a complex network of bronchial and blood tubules, and these structures forming the tissue responsible for gasexchange. In conclusion, our study shows are similar to those observed in most birds have some difference (in color, shape, surfaces, and histological structure).

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INTRODUCTION

The Pin-tailed Sandgrouse bird is the most common sandgrouse species in Iraq, although it is less common in winter, when it avoids rain and migrates to desert and semi-desert areas as it prefers dry places. It is a winter visitor bird to Egypt and the countries of the Arabian Peninsula [1]. In addition, the sandgrouse is classified within the order Pteroclidiformes, the family Pteroclididae,

and its scientific name is ***Pterocles Alchata*** [2]. The respiratory system in the birds plays a fundamental role in the process of gas exchange between O2 and CO2, through the processes of inhalation and exhalation [3]. It has a vital role in the body's thermal regulation, and its sensory role in the process of smelling and producing sound, in addition to its assistance in the process of movement and flight [4-6]. In addition, the respiratory system in birds differs from that in mammals. In birds, it consists of the nasal cavity, larynx, trachea, syrinx, bronchi, lung, and many air sacs, while they lack the soft palate, epiglottis, pleural cavity, and diaphragm, in addition to the small in size of the lungs [7,8].

The lungs in birds are a pair of flattened, strong, spongy structures located at the dorsal-cranial end of the coelomic cavity, lung extending from the second to the sixth rib, strongly attached to these ribs causing deep impressions on their dorsal surface [9, 10]. The lung is small in size, and its size is approximately one tenth of the lung size in mammals Not an expanded lung so the ventilation depends on the air sac [11-13].

The lungs in birds show a variation in shape. In chickens and turkeys, are flattened rectangular or wedge shaped, while lungs are triangle in shape in peahen and male are rectangle. Moreover, they also appear in the form of a trapezium, as in African guinea fowl [14,15]. The histological structure of the lung is characterized by the presence of a network system of interconnected bronchioles. This system includes the Extra-pulmonary primary bronchi extending from the trachea to the hillus on the Septal surface of the lung. These bronchioles are known as mesobronchi, and at its end, secondary bronchi arise, which differ in number and name according to their location in the lung Thus, there are three types of secondary bronchi: Dorsal bronchi, Ventral bronchi, and lateral bronchi [13].

The secondary bronchioles branch at the ends to form the tertiary bronchi or parabronchi, which represent a network of tubes within the parenchymal tissue of the lung, and form many units called lobes [16]. The number of tertiary bronchioles in the lung ranges from about 300-400 bronchioles [17]. The gas exchange in the lungs of birds differs from that of mammals, as they lack air alveoli, while they contain special halls known as atria that end in air capillaries, where gas exchange occurs between them and the blood tubules [18].

The study included the collection of five samples of adult male *Pterocles* alchata (Iraqi Pin-tailed Sandgrouse), which obtained from Al-Ghazel Market/Baghdad, and it was confirmed that they were healthy and not infected with any disease including the respiratory diseases. The birds were anesthetized by chloroform and kindly killed by making an incision in the middle of the ventral side of the body, then the Lung removed from coelomic cavity and washed by normal saline solution (0.1%) to remove impurities attached to them during dissection [3], and then the samples were photographed to study their morphological characteristics [19].

Then, the samples were fixed using formalin (10%) for 36-48 hours; after fixation, the samples were washed with tap water for 15 minutes and placed in alcohol (70%). To prepare the tissue slides, the samples were passed through a series of alcohols starting with a 70% concentration and going up to a 100% concentration for one hour, except for a 100% concentration for two hours to remove the water from the sample. After that, the next step is5 clarification stage of the samples, which consists of two stages: the first includes a 1:1 solution of alcohol and xylene for 10 minutes, and the second is the xylene stage for 10-12 minutes. Then, the samples are passed in paraffin wax melted at

60° C degrees for one hour, twice. The samples are embedded in special molds and left for a day at 20° C. After that, the microscopic slides are made by cutting the wax molds using a microtome device to prepare a ribbon of section with 5-6 micron in thickness. The slides were stained using Harris Hematoxylin-Eosin stain to clarify the lung tissue features. The slides were examined using a light microscope connected to a camera to photograph the tissue sections [20].

RESULTS

The morphological description of the lung in the Iraqi sandgrouse showed that it is light red in color, spongy in texture has a trapezoidal or irregular ribbed shape, and is located inside the coelomic cavity in the cranio-dorsal part of the body. In addition, the lung has three surfaces (dorsal, ventral and lateral), the dorsal or so-called costal, due to the presence of impressions in the form of deep grooves that divide the lung into five lobes located between the first rib and sixth rib. The ventral surface, known as the visceral, contains the opening of the hillus and the site of attachment of the primary bronchioles at its apex. The third surface is the septal or vertebral surface, which shows the extent of the ribs' implantation in the lung and their site of attachment to the vertebral column (Fig.1).

The histological sections of the lung lobes revealed that they consist of a conducting system called the bronchial system, which consists of primary bronchi, secondary bronchi, and parabronchi. The primary bronchi appear in histological sections as a ring-shaped structure with the lumen of the bronchus in the middle, consisting of a layer of mucosa composed of ciliated pseudostratified columnar epithelium. The mucosa layer is based on a layer of lamina propria with submucosa composed of loose connective tissue interspersed with sheets of hyaline cartilage surrounded by a layer of the periosteum (Fig. 2). Secondary bronchi are also lined by pseudostratified columnar epithelium. In contrast, the parabronchi occupy more than half of the pulmonary lobule, which represents structural unit of the lung tissue. It appears in a pentagonal or hexagonal shape, with a cavity in the middle known as the parabrachial lumen, surrounded by radially arranged air capillaries (Fig. 3).

The bronchus is composed of a mucosal layer composed of simple squamous epithelium based on a layer of loose connective tissue followed by tissue of smooth muscles known as atrial muscle circumscribing (Fig. 4). The inner wall of the parabronchi opens into several halls called atria lined with squamous epithelium continuous with the bronchial tissue, but absent the muscles bundles. The atria open at their ends into funnel-shaped canals called infundibula, which are also composed of squamous tissue and devoid of muscle cells. These infundibula are open into a complex network of tubules known as air capillaries, composed of simple squamous epithelial tissue supported by a basement membrane. The atria, infundibula, air and blood capillary constitute gas- blood barrier which is responsible for gas exchange in the bird lung (Fig.5).

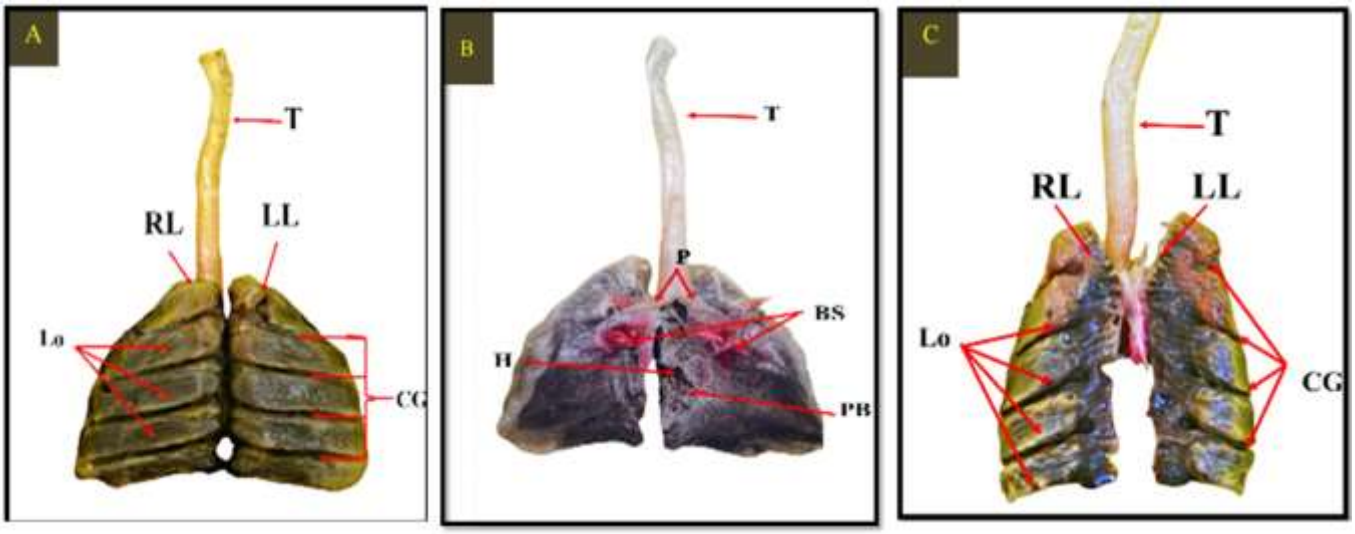

Fig. 1. The surface of the lung, (A): Costal surface, (B): Visceral surface; (C): Septal surface; and showing: Blood supply(BS), costal groove in the costal surface (CG), Hillus (H), left lung (LL), Lobes of lung (5 lobes) (Lo), Primary bronchi(P), Parabronchi(PB), Right lung (RL), Trachea(T).

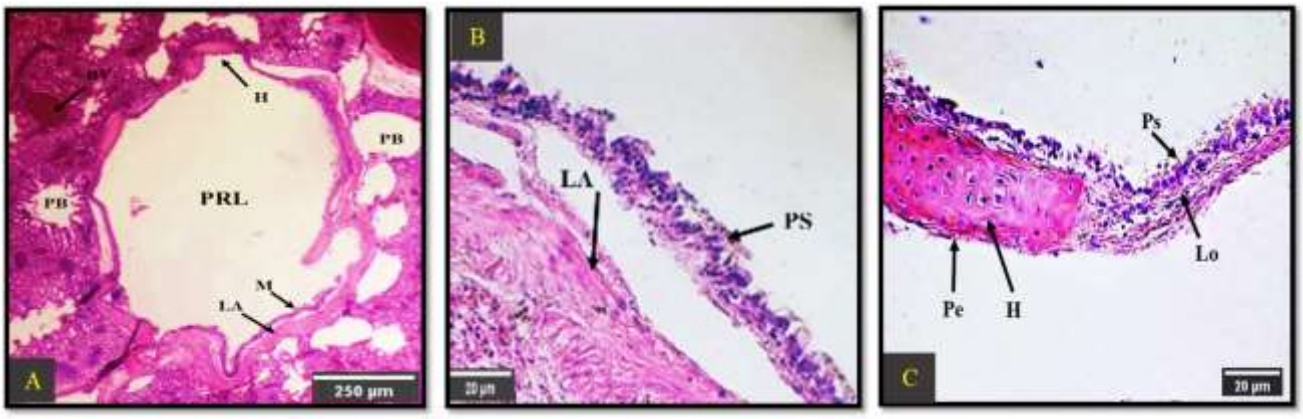

Fig. 2. Cross section through lung showing Primary bronchi: Blood vessel (Bv) , Hyaline cartilage (H), Lamina propria with Submucosa (LA), Loss connective tissue (Lo), Mucosa (M), Parabronchi (PB), Perichondrium (Pe), Primary bronchi lumen (PRL), Pseudostratified columnar epithelial tissue (PS); H&E stain, A (4x), B&C (40x).

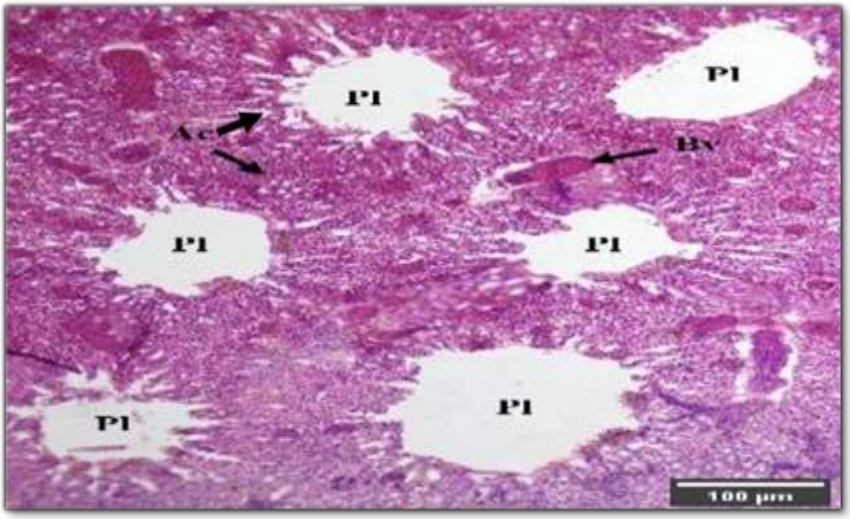

Fig. 3. Cross section through lung showing Parabronchi: Air capillaries (Ac), Blood vessel (Bv), Parabronchial lumen(Pl), H&E stain (10x).

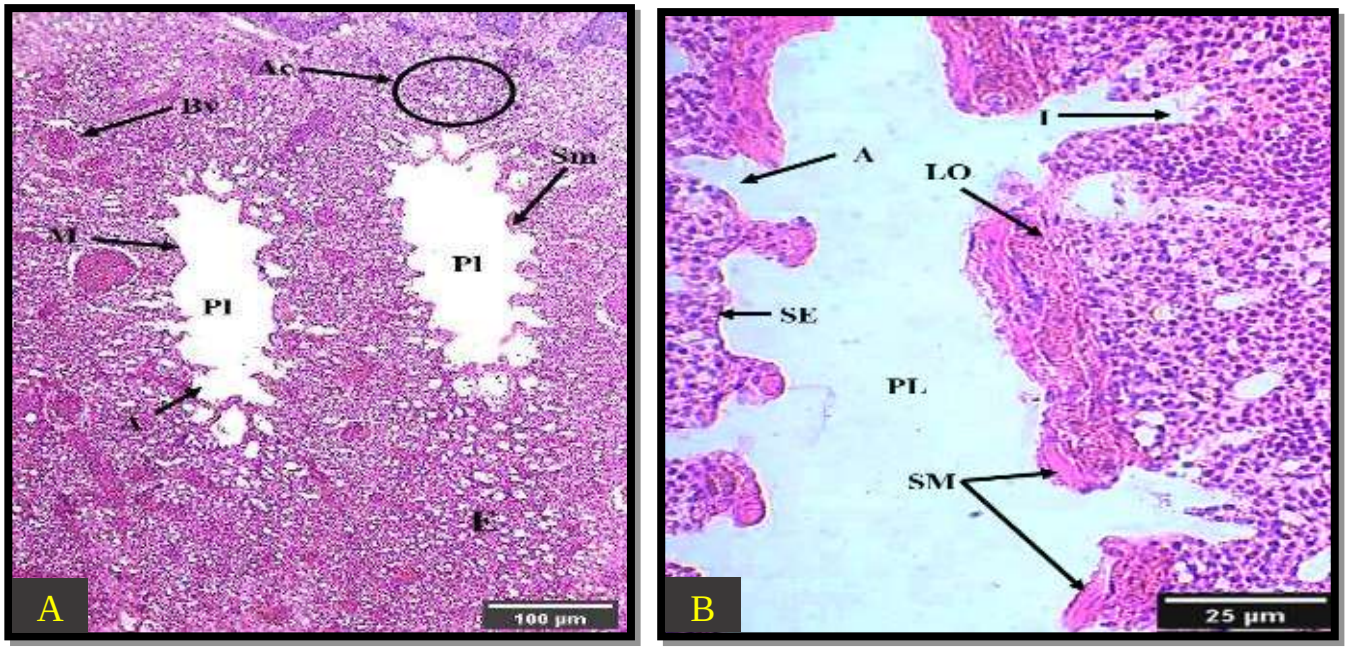

Fig. 4. Cross section through lung showing Parabronchi: Atria(A) Air capillaries(Ac), Blood vessel (Bv), Exchange tissue (E), Infundibula (I), Loss connective tissue (Lo), Mucosa (M) , Parabronchi Lumen (PL), Simple squamous epithelial tissue (SE), Smooth muscles tissue (SM); H&E stain, A(10x), B (40x).

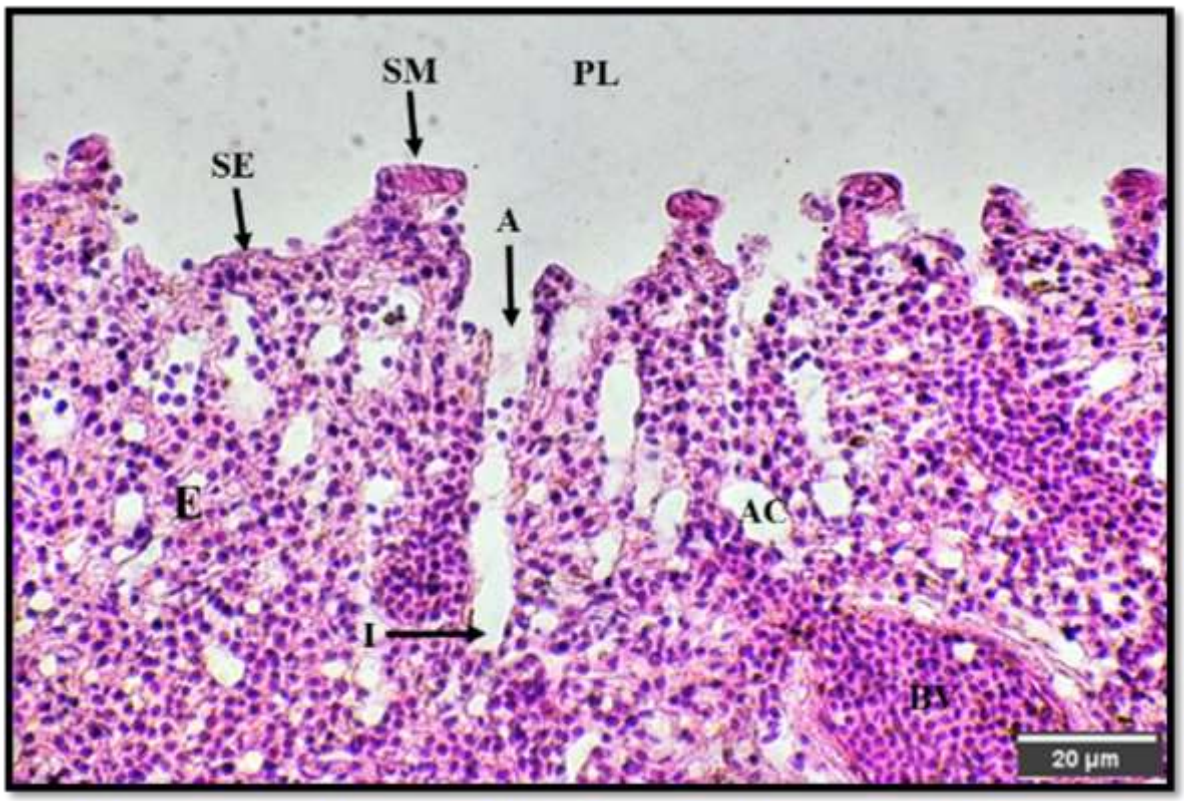

Fig. 5. Cross section through lung showing Gas-blood barrier: Atria(A) Air capillaries(AC), Blood capillaries (Bc), blood vessel (Bv), exchange tissue (E), infundibula (I), parabronchi lumen (PL), simple squamous epithelial tissue (SE), smooth muscles tissue (SM); H&E stain (40x).

DISCUSSION

The result of this study are in agreement with the findings of [21, 22] that that the lung is red in Japanese quail (*Coturnix japonica*), while it is not consistent with the result of [23] that observed the lung is pink in local chicken. Furthermore, the lung of the Iraqi sandgrouse appears to be in agreement with the African guinea fowl (*Numida meleagris*) [15] in its trapezoidal shape, while its shape was rectangular and triangular in male and female peacocks [14], and pyramidal in shape in the jungle pigeon[24]. It was found that the lung in the Iraqi sandgrouse extends from the first rib to the sixth rib, as is the case in the turkey rooster (*Meleagris* spp.) [25] and the duck [26], and differs from its extension in the local chicken, which extends from the second rib to the sixth rib [23]. Whereas in the peacock, it extends from the second rib to the fifth rib [14]. This result is consistent with the turkey rooster [25] and the duck [27] in that the lung has three surfaces (dorsal, ventral, and vertebral), while the lung of the jungle pigeon has only two surfaces [24].

Histologically, it was found that the lung of the Iraqi sandgrouse is composed of a bronchial system found in all bird species [28]. The present result showed that the wall of the primary bronchus consists of a mucosal layer composed of ciliated pseudostratified columnar tissue based on a layer of lamina propria with submucosa containing loose connective tissue interspersed with pieces of hyaline cartilage, and this is consistent with findings of [18, 29, 30]. The histological sections of the lung lobule showed the

presence of a central region that constitutes the vast majority of the lung tissue and appears in a pentagonal and hexagonal shape, and this is in agreement with the results [31, 32]. The tertiary bronchioles appear adjacent to each other and are not separated by connective tissue barriers. This is consistent with the study [33] that studied the lung in peacocks, and also with [3] that studied the lungs in pigeons. In contrast, the current result is not consistent with the previous studies [34,35 25], where it was found that the Parabronchi in the lung tissue of turkeys, domestic chickens and hoopoe (*Upupa epops*) are separated from their counterparts by septa of connective tissue called Interparabronchial lumen septa. The tertiary bronchioles are lined with simple squamous epithelium based on a layer of loose connective tissue followed by a layer of smooth muscles. This result is in agreement with the observations of previous studies [18, 24, 36, 37], while it is not consistent with [34,38,39, 25] which indicated that the histological structure of the lung in turkey rooster, domestic chickens and ducks are lined with simple cuboidal epithelium. It has been found that the gas exchange in birds, including the Iraqi sandgrouse, occurs within a special tissue known as exchange tissue. This tissue consists of special halls open to the cavity of the tertiary bronchus and is surrounded by smooth muscles called Atria that open at their ends into funnel-shaped canals known as Infundibula, which in turn open into a complex network of interconnected air and blood capillaries. All these structures are lined with simple squamous epithelial tissue to facilitate the process of gaseous exchange, and this is consistent with the results of [3, 18, 23, 35]. On the other hand, birds differ from mammals in their lack of pulmonary alveoli responsible for the process of gaseous exchange in mammals [40].

CONCLUSIONS

In conclusion, our study shows that the morphological and histological feature of Iraqi Pin-tailed sandgrouse lungs are similar to those observed in most birds but some difference (in color, shape, surfaces, and histological structure). The lung of the Iraqi sandgrouse is red in color, has a trapezoidal shape and has three surfaces and extends from the first rib to the sixth rib. Histologically showed the presence of a bronchial system composed largely of parabronchi, the lung components of birds correlated with the metabolic demands of the animals and effects on animal life style. The components of the lung in birds are linked to the metabolic processes of animals and their effects on animal life style. this explains why there are no barriers between the parabronchi, and also the large bronchial lumen, which is due to the provision of a tissue for extreme gas exchange.as very efficient because of an extremely thin blood gas barrier than that of the domestic birds lung, This could be attributed to the requirement of enormous energy by Iraqi -pin tailed sandgrouse which live desert place.

CONFLICTS OF INTEREST

The authors declare there is no conflict of interest.

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