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Histological Structure of the Kidney in the Iraqi Pin-tailed Sandgrouse *Pterocles alchata* (Linnaeus, 1766) Bird

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Abstract

The current study was conducted on six adult males of the Iraqi pin-tailed sandgrouse, *Pterocles alchata*, to determine the histological structure of the kidneys. The results showed that each kidney consists of three lobes: cranial, middle, and caudal. Histological results showed that the kidneys consist of the cortex and the medullary, and the cortex forms the majority of the kidney, which consists of large and small renal corpuscles. Each renal corpuscle consists of the Bowman capsule, glomerulus, the proximal convoluted tubule, which is lined with simple cuboidal epithelium tissue with a brush border, the distal convoluted tubules, and the collecting tubules, which are lined with simple cuboidal epithelium tissue. The medullary area contains thin and thick segments of the Henle loop, arranged around the medullary cones, and a simple cuboidal epithelium-lined collecting duct from the middle part of the cone.

Keywords: Kidney, cortex, medulla, glomerulus, *Pterocles alchata*.

1. Introduction

Because they provide meat, eggs, and feathers for various uses and play a significant role in the biological control of harmful insects and rodents, domestic birds are considered one of the economically important animalistic fortune rings [1].

The sandgrouse bird belongs to the order Columbiformes, family Pteroclidae, which includes wild birds that inhabit desert areas. It comes in a variety of colors and shapes. The Iraqi large pin-tailed sandgrouse, *Pterocles alchata*, is the most common sandgrouse species in Iraq. This type is characterized by the long central tail feathers and their wild shape, and it feeds on grains [2]. Numerous studies, such as those conducted in [3-5] have demonstrated the importance of the kidneys for organisms.

The urinary system in birds consists of two kidneys and ureters that transport urine from the urinary tract to the cloaca. Most birds do not have a urinary bladder, except ostriches and rheas [1,6]. The kidneys are a basic part of the urinary system that perform important functions to sustain life [7] and contribute to maintaining balance through processes involving filtration,

absorption, and excretion [8]. It also regulates fluid balance within the body, as well as the removal of waste products, excess water, and electrolytes [9, 10]. The kidneys are symmetrically located in the body cavity, where they are located on both sides of the spine, and each is located in a bony depression within the region of the synsacrum called the renal fossa [11]. Morphologically, the kidneys in birds appear as elongated, irregular-shaped organs that are fragile to the touch [12]. The kidneys in birds are larger than those in both mammals and reptiles. Each kidney has three lobes: cranial, middle, and caudal [13]. The kidneys of birds contain two types of nephrons: the cortical type, also known as the reptilian type, which lacks Henle's loop and is located in the peripheral area of the cortex; and the medullary type, which incorporates Henle's loop, penetrates the medullary area, and bears resemblance to the nephrons of mammals [14]. Due to the importance of studies related to the kidneys of birds, this study was conducted to identify the details of the morphological and histological structure of the kidneys in one of the Iraqi birds, the Iraqi pin-tailed sandgrouse *Pterocles alchata*.

Numerous studies on bird kidneys failed to provide a detailed description of the kidney of the Iraqi pin-tailed sandgrouse, prompting this study to delineate the kidney morphology and histology characteristics of this bird, given its significant role in scientific research.

2. Materials and Methods

2.1. Sample collection:

We collected study samples from six adult male Iraqi sandgrouse Pterocles alchata birds from local markets (Al-Ghazal Market, Baghdad), kept them in cages, fed them the same diet for a week, and classified all samples based on [2]. We sacrificed the animal by inhaling chloroform, dissecting it, removing the kidney, and fixing it in a 10% formalin solution, following the histological studies of [15-17].

2.2. Histological preparations:

Paraffin sections were prepared according to the method developed by [18-23], where the dehydration samples were taken through an ascending series of alcohol concentrations, starting with a concentration of 70% and ending with an absolute alcohol concentration of 100%. The xylene was used to clear the samples, then embedded with paraffin wax with a high melting point. After that, the wax mold containing the samples was cut using a rotary microtome with a thickness of 5 μm. After staining the tissue sections with Harris hematoxylin-eosin stain and diluting them with DPX, we photographed the tissue slides using a light microscope and a Canon imaging camera to image the kidney tissue slides.

3. Results

This study found that the sandgrouse bird has two large, flat, hard kidneys that are symmetrically placed on both sides of the ventral surface of the hip bones and lie in the middle of the synsacrum. Each kidney extends cranially to the lung and caudally to the end of the sacral bone. They are each located in a bone depression called the renal fossa, and they are made up of three lobes: the cranial lobe is round to oval, the middle lobe is long, and the caudal lobe is the biggest and has a round shape (**Figure 1**).

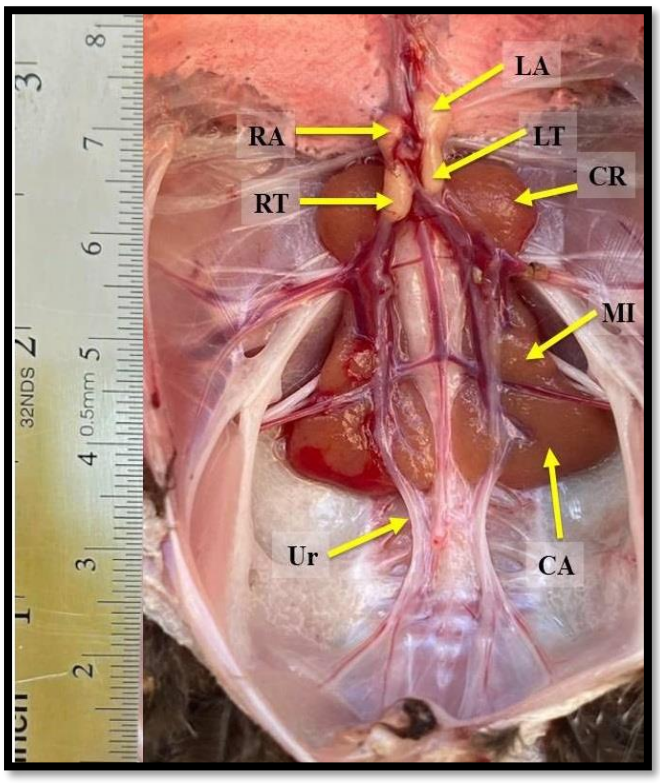

Figure 1. The general morphological of the urinary system in the Iraqi pin- tailed sandgrouse *Pterocles alchata* bird appeared :cranial lobe (CR), middle lobe (MI), caudal lobe (CA), Left Adrenal gland (LA), Right Adrenal gland (RA), Left Testis (LA), Right Testis (RT), Ureter (Ur).

The current study's findings revealed that a thin capsule covers the kidney in the sandgrouse bird**.** The kidney is made up of units known as lobules, each lobule consists of two areas, a cortex above and a medullary below. The cortex occupies a larger area than the medullary, and there are no boundaries between the cortex and the medullary. The capsule is composed of connective tissue containing mostly collagen and elastic fibers (**Figures 2, 3**).

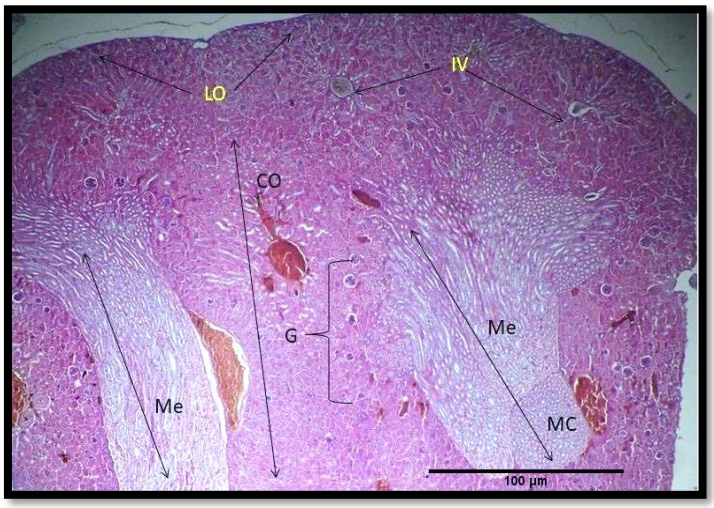

Figure 2. A cross section in the Iraqi sandgrouse bird kidney appeared: kidney lobules (L), cortex (Co), interlobular vein (IV), lobules (LO), medullary cone (MC), medullary (Me), renal Glomeruli (G), H&E stain, 10x.

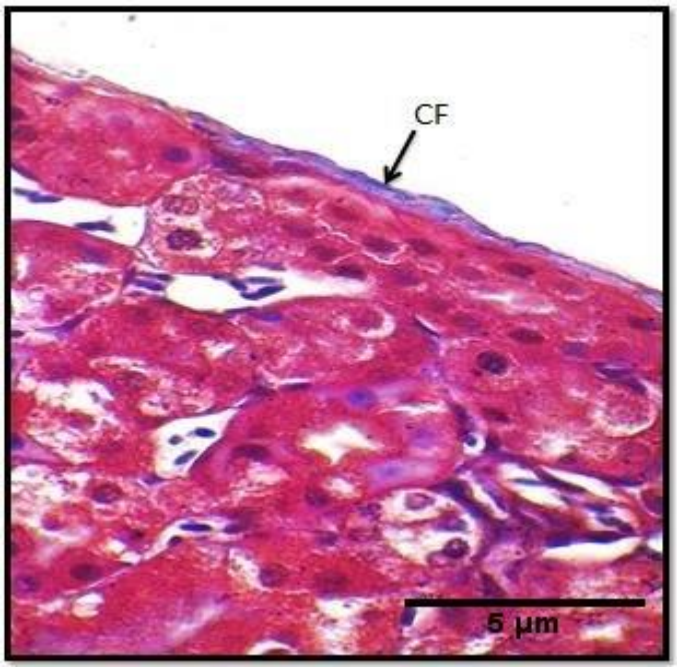

Figure 3. A cross sections in the Iraqi sandgrouse bird kidney appeared: Collagen fiber (CF), Masson's stain, µm (100x).

Renal corpuscles are present in the cortex tissue: the cortical corpuscles, which are located in the peripheral part of the cortex, and the medullary corpuscles, which are located close to the medullary. The distribution of renal corpuscles within the kidney tissue is random, occurring either individually or in adjacent groups of duel or triple, and the cortex area also contains renal corpuscles of two types: the first type is a reptilian type without the loop of Henle, and the other type is mammalian or medullary (**Figures 4, 5**).

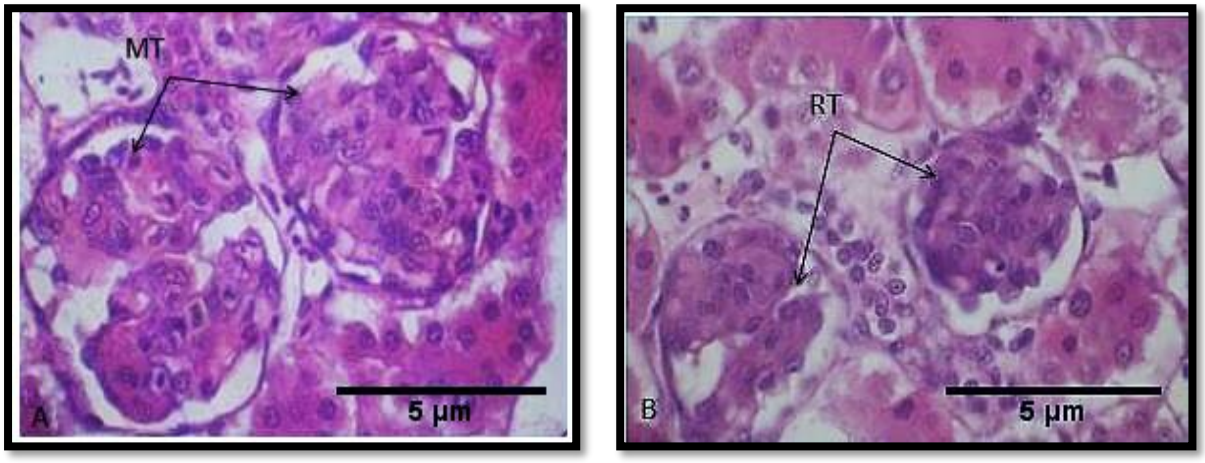

Figure 4. A cross section in the kidney of *Pterocles alchata* bird showing : A-Mammalian glomeruli (MT) 40x, B-Reptilian glomeruli (RT), H&E stained, 100x.

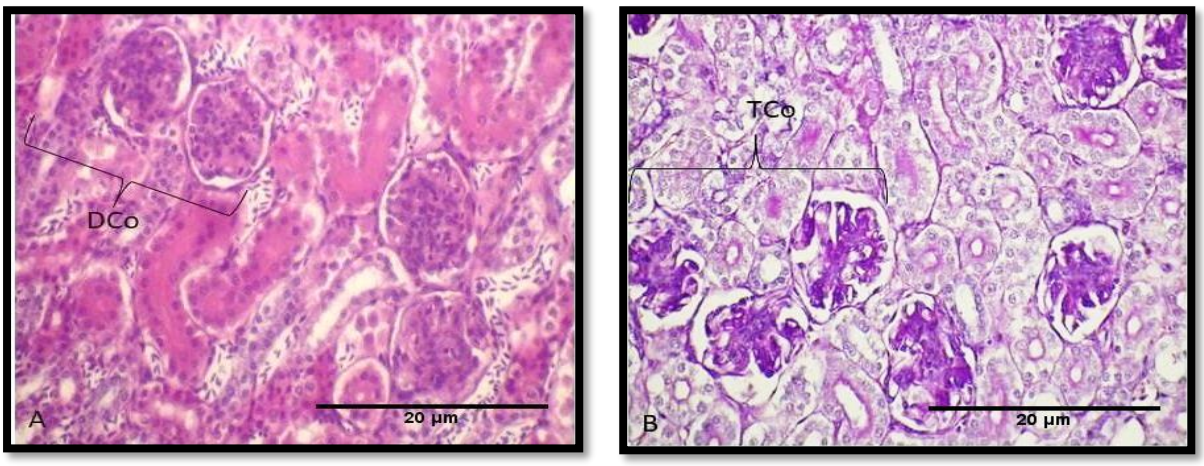

Figure 5. A cross section in the kidney of the *Pterocles alchata* bird showing the A- Duel corpuscles (DCo) H&E Stain (40x), B- Triple corpuscles (TCo), Alcian blue stain, 40x.

A close look through a microscope showed that the renal corpuscles are made up of glomeruli, which are made up of single blood vessels. The urinary pole and vascular pole of each glomerulus connect to efferent arteries and exit afferent arteries. A double-layer capsule (visceral and parietal), known as Bowman's capsule, appeared to surround the glomeruli. Highly specialized epithelial cells make up the visceral layer, the inner layer of Bowman's capsule. These cells have a large round or oval nucleus called a podocytes, which is next to the glomerular blood capillaries. The outer layer, or parietal, consisted of a simple squamous epithelium.

The kidney's urinary pole revealed a space between the two layers known as the Bowman space. The mesenchymal cells appeared as small cells with a relatively large nucleus, adjacent to the central glomerular capillaries (**Figure 6**). There are unique cells with elliptical nuclei at the vascular pole. These are called juxtaglomerular cells, and they touch the macula densa, also shown in this figure mesangial cells are specialized cells in the kidney that make up the mesangium of the glomerulus. Together with the mesangial matrix, they form the vascular pole of the renal corpuscle (**Figure 6**).

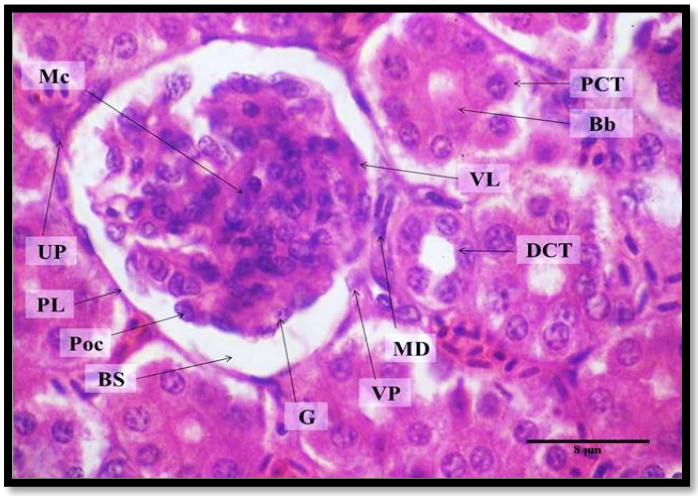

Figure 6. A cross section in the kidney of the *Pterocles alchata* bird showing; Bowman capsule space (BS), brush border (Bb), distal convoluted tubule (DCT), glomerulus (G), macula densa(MD), mesengial cells (Mc), podocyte

(POc), parietal layer (PL), Proximal convoluted tubule (PCT), visceral layer (VL), vascular pole (VP),), urinary pole (UP), H&E stain, 100x.

The results of the current study also showed that the glomerulus is connected at its urinary pole to the proximal convoluted tubule (PCT), characterized by a narrow lumen lined with acidophilic, high-cuboidal cells that possess a brush border with pale oval or rounded nuclei. The results showed a strong positive with PAS stain, comboined PAS, and Alcian blue (**Figures 7, 8**). The histological examination revealed that low cuboidal epithelial cells, lacking a brush border, line the distal convoluted tubule (DCT), giving the lumen a wider appearance than the proximal convoluted tubule.

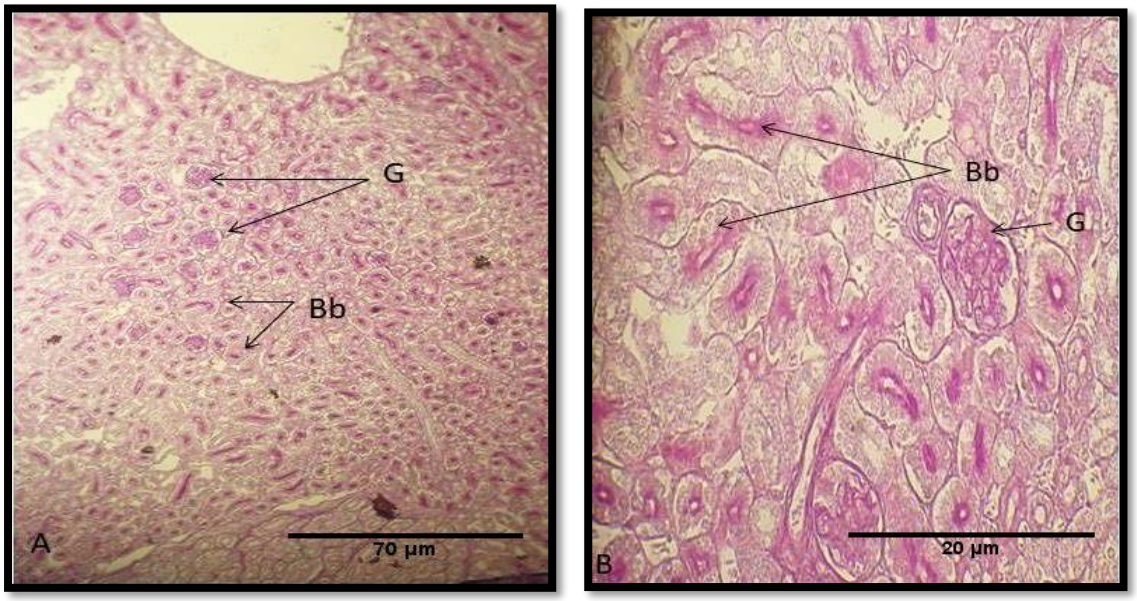

Figure 7. A cross section in the kidney of the *Pterocles alchata* bird showing: brush border (Bb), glomeruli (G), PAS stain, A- 10x, B-40x**.**

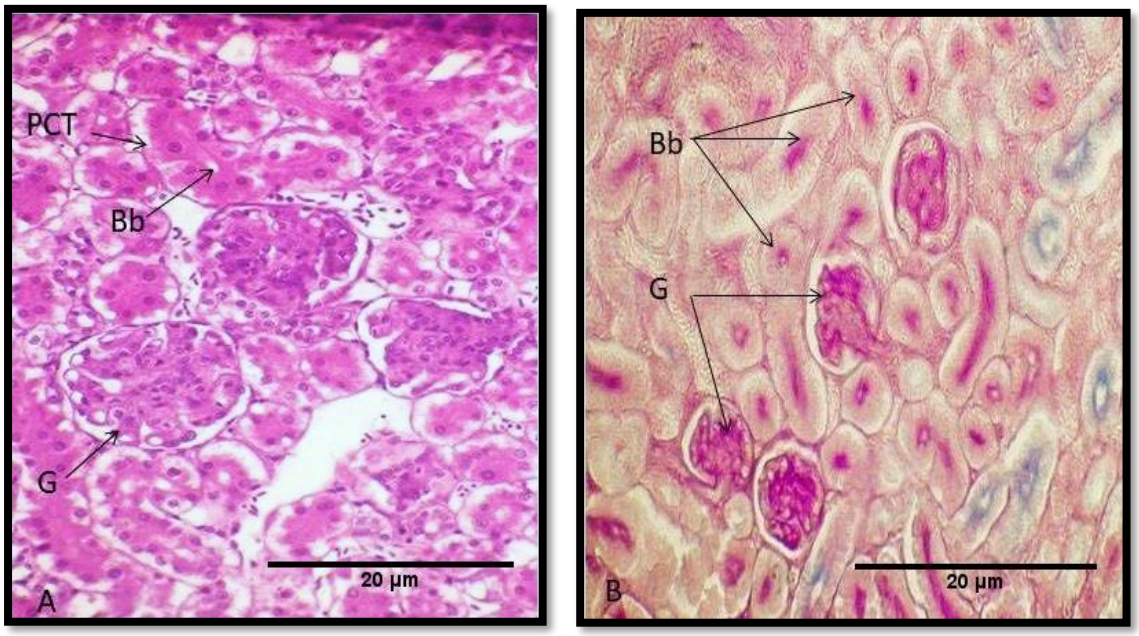

Figure 8. A cross section in the kidney of *Pterocles alchata* showing: brush border (Bb), glomeruli (G), proximal convoluted tubule (PCT), A-H&E stain, 40x, B-Combined Alcian blue and PAS Stain (40x).

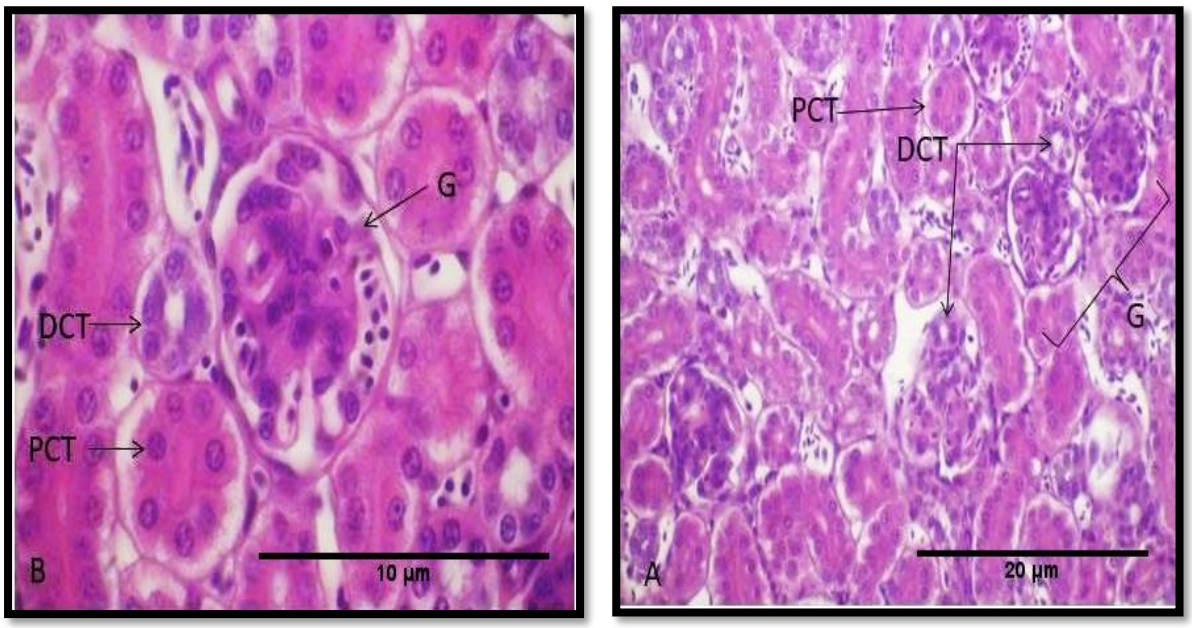

Figure 9. A cross section in the kidney of the *Pterocles alchata* bird showing : distal convoluted tubule (DCT), glomeruli (G), proximal convoluted tubule (PCT), H&E stain, A- 40x, B-100x.

The medullary region underwent microscopic examination, revealing the presence of both thin and thick segments of the Henles loop. The thin segment's epithelium, characterized by flattened cells or low cuboidal cells, lacked a brush border, while the thick segment, lined by a cuboidal cell with a weak reaction to the PAS stain, concentrated the presence of both thin and thick segments in the peripheral part of the medullary cone (**Figures 10, 11**).

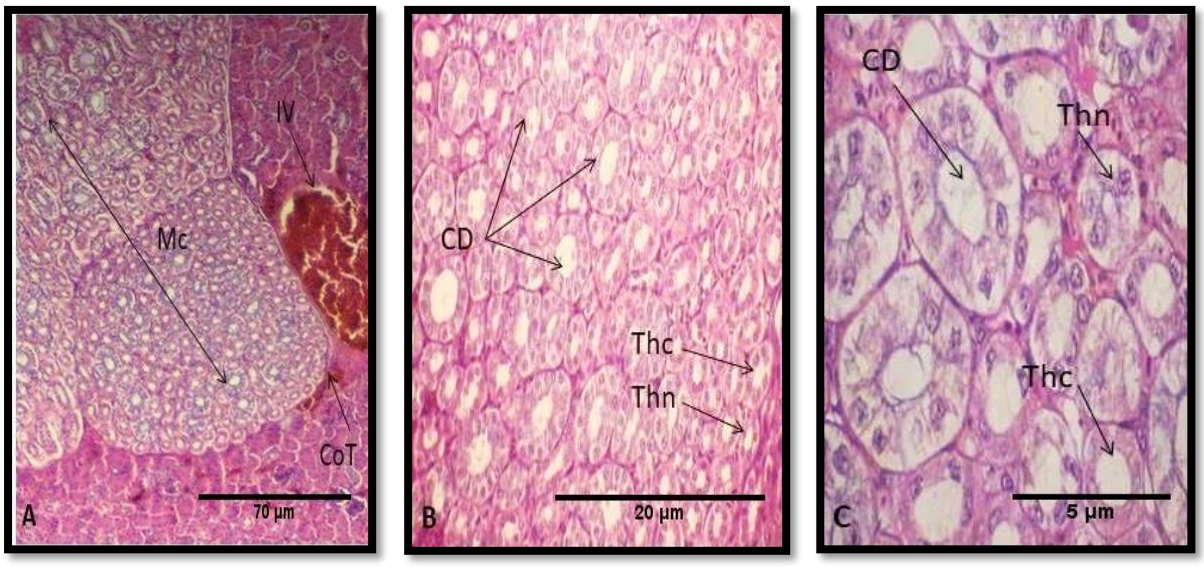

Figure 10. A cross section in the kidney of *Pterocles alchata* bird showing: collecting duct (CD), connective tissue (CoT), interlobular vein (Iv), medullary (Mc), thin segment (Thn), thick segment (Thc) H&E stain, A-10x, B-40x, C-100x.

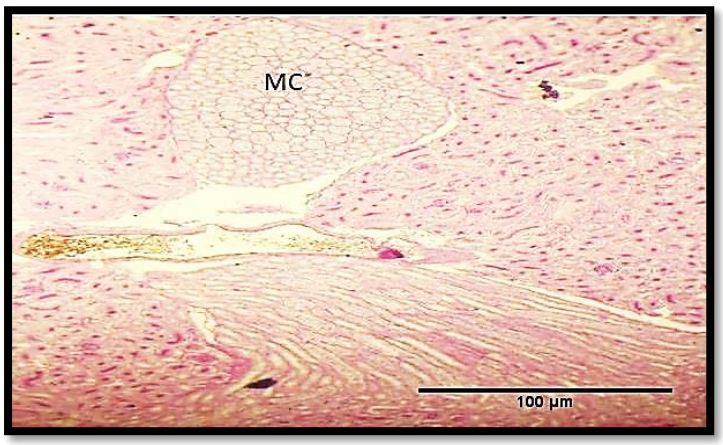

Figure 11. A cross section in the kidney of *Pterocles alchata* bird showing medullary cone (Mc) weak reaction to PAS stain (10x).

Microscopic examination also showed that the lining of the collecting tubules consists of low columnar to simple cuboidal epithelial cells, and its cells have circular nuclei, while the collecting ducts are of a wide diameter and their lining is composed of simple columnar epithelial cells with oval nuclei basal sites, which showed a positive reaction with Alican blue stain (**Figures 12-14**), which indicates that tissues secrete acidic and neutral sugars.

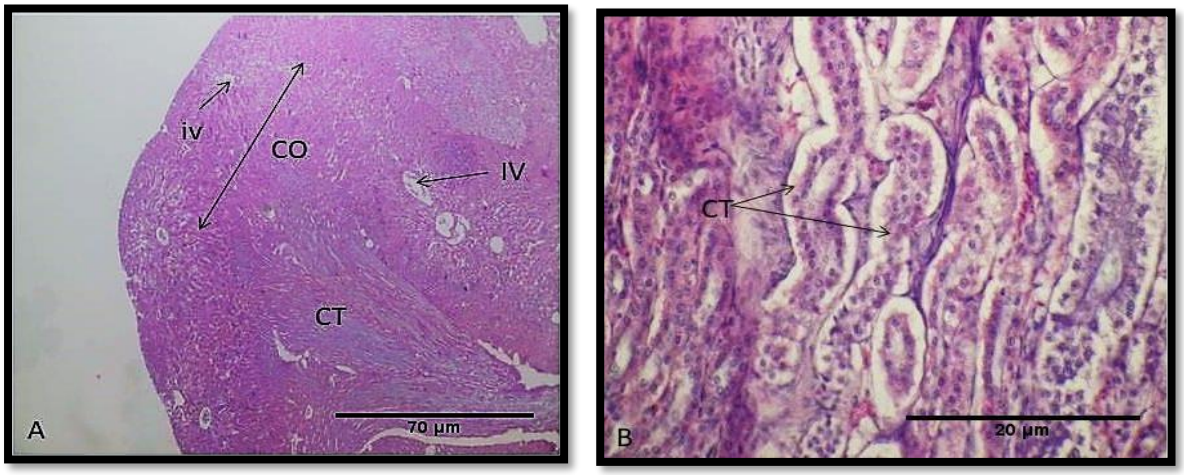

Figure 12. A cross section in the kidney of *Pterocles alchata* bird showing: collecting tubules (CT), interlobular vein (Iv), intralobular vein (iv), H&E stain , A-10x, B 40x.

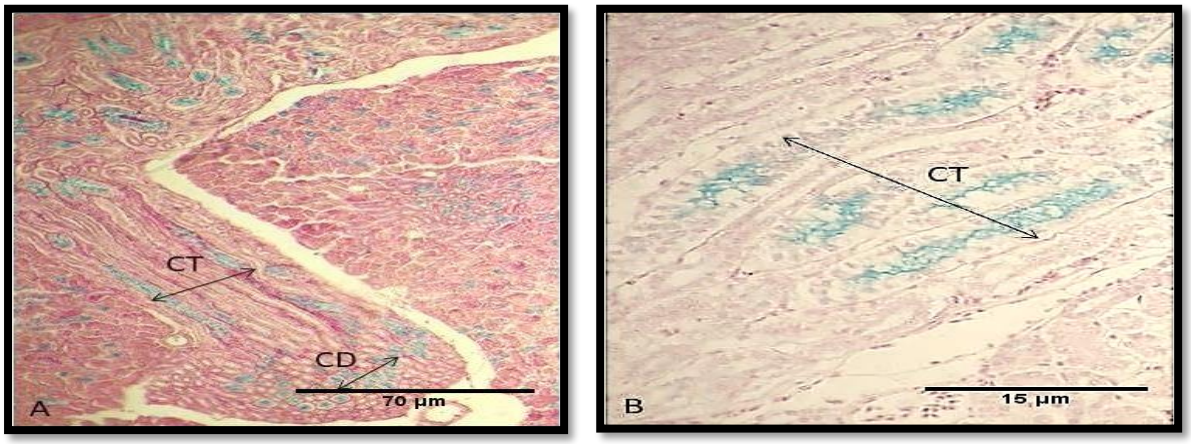

Figure 13. A cross section in the kidney of *Pterocles alchata* bird showing : collecting tubules (CT) and collecting ducts (CD), Alcian blue, A-10x, B-40x.

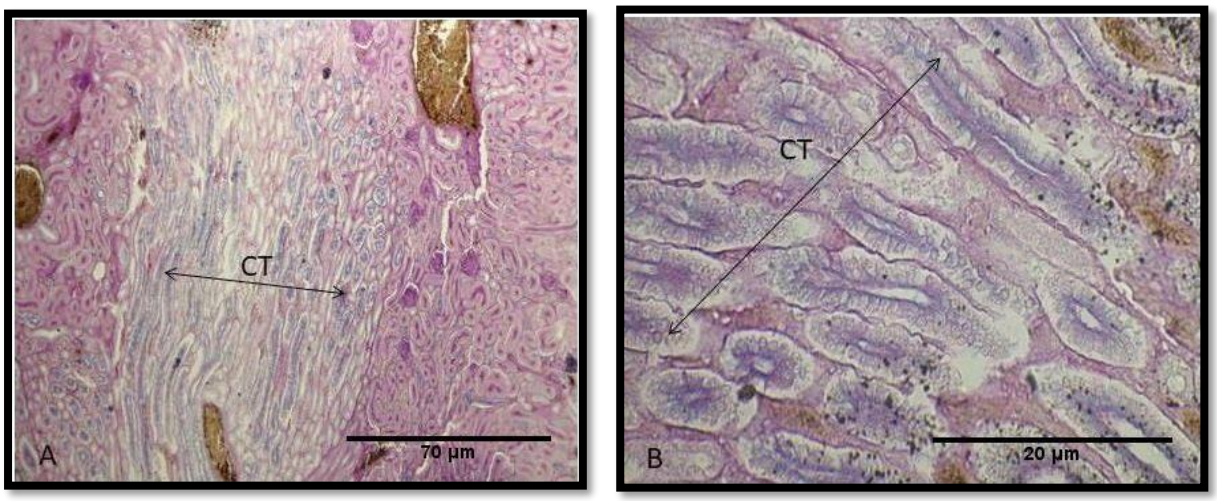

Figure 14. A cross section in the kidney of *Pterocles alchata* bird showing: positive reaction of collecting tubules (CT) with combined Alcian blue and PAS Stain, A-10x, B-40x.

4. Discussion

The results of the current study showed that the Iraqi sandgrouse bird has a pair of large, elongated kidneys that settle in the renal fossa within the synsacrum. The study also indicated that each kidney consists of three cranial, middle, and caudal lobes, and these lobes vary in shape and size. The results agree with [24] in *Circus aueroginosus*, *Gallus domesticus*, and *Anas platyrhuches*. The results also align with the findings of [25] and [26] in the cases of *Gallus gallus* and *Anas platyrhynchos*, where the kidney was found to be red-brown and stable in the renal fossa. These findings also align with those of [27] in the case of *Slreptopelia decaoeta* and [28] in the case of *Numida meleagris*.

The current research demonstrates that a thin capsule of connective tissue encircles the kidney capsule in *Pteroclas alchata*, corroborating findings from studies [29] in fowls and geese, and [30] in Guinea fowl (*Numida meleagris*).

Histological sections of the kidneys showed that the tissue is divided into two areas: the renal cortex and the renal medullary. Unlike mammals [5], there are no clear boundaries between the cortex and medullary areas. The cortex area is larger than the medullary area, which creates a structure called medullary cones that are spread out randomly in the kidney tissue. This observation aligns with the findings of [4], which examined the kidney in the *Dromaius novaehollandiae* bird.

This also aligns with the findings of [31], who studied kidney structures in sparrows living in various environments, and [32], who demonstrated that the cortex area of the kidney in a nectarivorous bird accounts for 90% of the total kidney volume, while the medullary portion makes up 2%. The cortex area in this result also contains renal corpuscles of two types: the first type is a reptilian type without the loop of Henle, and the other type is mammalian or medullary. These results align with the findings of in the *Fulica atra* bird and in *Falcon berigora* [21, 23].

A bilayer capsule known as the Bowman's capsule surrounds both types of renal corpuscles in the cortex, placing them close to the medullary area, in line with [28]. Highly specialized epithelial cells make up the visceral layer, the inner layer of Bowman's capsule. These cells have a large round or oval nucleus called a podocytes, which is next to the glomerular blood

capillaries. The outer layer, or parietal, consisted of a simple squamous epithelium. Between these two layers is a space called the Bowman space, to the inside of which there is a simple network of capillaries called the glomeruli that are arranged around mesengeal cells. These results are consistent with [10-13, 20, 23, 30].

Simple cuboidal epithelial tissue lines the proximal and distal convoluted tubules, proximal convoluted tubule (PCT), characterized by a narrow lumen lined with acidophilic, high-cuboidal cells that possess a brush border with pale oval or rounded nuclei, and the biochemical results showed a strong positive with PAS stain, combined PAS, and Alcian blue (this means presence of acidic and neutral polysaccharide compounds in the parts of the tubule). The distal convoluted tubule (DCT), gives the lumen a wider appearance than the proximal convoluted tubule and low cuboidal epithelial cells, lacking a brush border this result agrees with [10, 19, 33].

This study found the macula densa at the beginning of the proximal convoluted tubule, which aligns with the findings of [23] in the *Fulica atra* and [13] in the pigeon *(Columba livia*). Also, these results confirm that cuboid-shaped cells line the cortical collecting tubules in the peripheral part of the cortex, [18] found that simple columnar epithelial cells or simple cuboidal cells with granular cytoplasm line the cortical collecting tubules in the kidneys of chickens and ducks. These granules secrete mucus that protects the lining cells from urea acidity [5, 11].

The current study demonstrated that the renal medullary system is arranged in the form of cones known as medullary cones, which contain the thin and thick segments of the Henle loop. This arrangement aligns with findings from [10] in great Flamingos, which stated that within the medullary area, the thick and thin segments of Henle's loop are organized in the peripheral region of the medullary cone, with the collecting duct located in the middle part of the cone, all of which are lined with a simple cuboidal epithelium this aligns with the findings of [4] which examined the kidney's structure in an emu bird. It also matches the following birds: *falcon berigora* [33], Harrier (*Circum ouevginosus*), chicken (*Gullus domesticus*) and Mohard duck (*Anas platyrhynchus*) [34], coot bird (*Fulica atra*) [35]. The morphological and histological structure of the kidney in the bird of this study does not differ from that in most birds as explained by [22, 36-38].

5. Conclusion

The current study concluded that the kidney in the Iraqi Pin-tailed sandgrouse bird consists of three lobes, and each lobe consists of a wide cortex area and a small medulla. The biochemical results showed the presence of acidic and neutral polysaccharide compounds in the parts of the tubule.

Acknowledgment

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Conflict of Interest

Nahla A. Al-Bakri declares that she is the editor-in-chief of IHJPAS at the time of submitting the manuscript. The manager and editor of IHJPAS confirms that (Nahla A. Al-Bakri) was excluded from any decisions made regarding this paper..

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Ethical Clearance

The samples were gained according to local Research Ethics Committee approval in the College of Education for Pure Science (Ibn-Al-Haitham), University of Baghdad No.EC-2, Date 4/3/2024.

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